IMPACTS ON WATER QUALITY FROM PLACEMENT OF COAL COMBUSTION WASTE IN PENNSYLVANIA COAL MINES

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This Report is the product of the Pennsylvania Minefill Research Project undertaken by the Clean Air Task Force. The Task Force is a nonprofit organization dedicated to restoring clean air and healthy environments through scientific research, public education and legal advocacy.

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In addition to assisting in the research and writing of select portions of this report, Mr. Norris and Mr. Gadinski certified the scientific assessments of impacts to sites in this report as Professional Geologists licensed by the Commonwealth of Pennsylvania.

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The Clean Air Task Force takes responsibility for the contents of this report and will consider additional review comments for future publication or additional efforts derived from this report.

PHOTOS:

CD Label – Steam rises from FBC culm ash being dumped in the bottom of the Springdale Pit, Schuylkill County, PA. Provided by Army for a Clean Environment, Tamaqua PA. Taken November 2003.

Front Cover – Ernest Mine, in Indiana County, PA. Since 1996, the dark gray coal refuse (gob) has been remined from this site and replaced with approximately 2 million tons of reddish-brown FBC gob ash from the Cambria Cogen Plant. Photo by Jeff Stant, August 2007.

Executive Summary

> "All of the Department's monitoring at the numerous ash reclamation sites **demonstrates no harmful components leaching into the groundwater due to ash.**"
>
> "An investigation of [ash placement sites in Western Pennsylvania where groundwater contamination was alleged] revealed that water contamination is resulting from acid mine drainage that existed prior to the remining and reclamation of the sites, and that this degraded water has not been further impacted by the use of coal ash."
>
> > Pennsylvania Department of Environmental Protection, Fact Sheet, "*Coal Ash and Dredge Sediment in Mine Reclamation*," August 2003. (Emphasis added.)

For over 20 years, the Pennsylvania Department of Environmental Protection (PADEP) has been promoting the placement of large volumes of coal combustion waste (CCW) in active and abandoned coal mines as a method of addressing acid mine drainage, increasing soil fertility and filling mine pits and voids. There is growing concern, however, that placement of CCW in mines may be contaminating groundwater and surface waters with harmful levels of toxic chemicals, including aluminum, chloride, iron, manganese, pH, sulfate, total dissolved solids and toxic levels of trace elements such as arsenic, nickel, selenium, lead, mercury, molybdenum, cadmium, copper, chromium, antimony, boron and zinc. Congressional concern about potential adverse impacts of coal ash in mines lead to the recent study of this issue by the National Academies of Science. Many have raised concerns that CCW contamination could result in water quality that is more deteriorated than the adverse conditions created by acid mine drainage.

The purpose of this report is to test PADEP's oft-repeated claim that the use of CCW in coal mine reclamation, as permitted by the PADEP under their beneficial use program, does not result in the pollution of groundwater or surface water. The report tests this claim by examining monitoring data from 15 minefill sites to determine if any degradation of groundwater or surface water has occurred. The hypothesis being tested is whether the data allow one to state definitively, as does PADEP, that the use of CCW has not caused or contributed to contamination. Even if the data are merely inconclusive, this hypothesis must be rejected and the practice of CCW minefilling, as permitted in Pennsylvania, may not be declared a proven success from the standpoint of water quality protection.

It is fair to state the hypothesis this way and to assign the "burden of proof" in this manner for two reasons. First and most fundamentally is the "precautionary principle," a rule of decision under which doubts are resolved against an activity that might cause harm to people or the environment and which places the burden of proof on the proponent of the activity to demonstrate that it is safe. Second, the hypothesis fairly states the claim being made by PADEP, which has become a focal point of the national debate over the impacts and regulation of CCW minefilling.

The thorough and detailed analyses in this report, nevertheless, allow the authors to go further than merely rejecting the above hypothesis. Our report states affirmatively that the monitoring data indicates permitted CCW minefilling in Pennsylvania has resulted in groundwater and/or surface water contamination. The data reveal such water quality degradation at two-thirds of the mine sites analyzed in this report.

This report examines 15 coal mining permits issued by PADEP allowing the placement of CCW. To arrive at the 15 mine sites, 110 coal mining permits allowing CCW placement in the bituminous and anthracite coalfields were inspected for monitoring data. Twenty-one permits were reviewed for closer analysis on the basis of coal ash tonnage, number of monitoring points and duration of monitoring. Nineteen of these had adequate levels of information to facilitate an examination of possible impacts of CCW on groundwater quality and, in some instances, on surface water quality. Fifteen permits were chosen to review for this report because of time and resource constraints.

Detailed analysis of the 15 minefills revealed: (1) characterization of sites insufficient to establish monitoring systems that will detect pollution from ash; (2) inadequate numbers of groundwater and surface water monitoring points; (3) not enough baseline data; (4) insufficient frequency of data collection; (5) significant lapses in data collection; (6) analysis of monitoring samples at detection limits too high to monitor the creation of toxic conditions; (7) failure to monitor indicator parameters that would readily differentiate ash contamination from mine pollution; (8) inadequate records describing dates, quantities, and locations of ash placement; and (9) the absence of monitoring after the completion of ash placement. Despite these deficiencies, which occurred in varying degrees in all permits, substantive evidence exists of degradation of groundwater and/or surface water from CCW *in two-thirds of the permits*, based on rising trends in concentrations of CCW contaminants at relevant ash monitoring points. Specifically, the authors found that in 10 of the 15 minefills studied, coal ash contributed to degraded water quality. In three other cases, degradation was occurring but the data were insufficient to differentiate the causes of the degradation. For one minefill, water quality improvement occurred in some parameters as a result of gob removal and ash placement while coal ash appeared to cause degradation in other parameters, and at one mine site, water quality improvement occurred as a result of remining and ash placement. Even in these last two cases however, the authors found that post-project monitoring was far too brief to assert that water quality improvements were more than temporary.

The import of this finding goes far beyond the implications for the health of Pennsylvania waters. There is currently a national debate over the need for federal regulation of placement and disposal of CCW in mines. Central to that debate are the two key issues explored in this report. The first is the adequacy of state programs to prevent adverse environmental impacts from CCW placement. The second is the degree to which coal ash placement poses a threat to the environment.

This debate is not a new one. The United States Environmental Protection Agency (US EPA) expressed serious concern over CCW minefilling in its 2000 Regulatory Determination on Wastes from the Combustion of Fossil Fuels.[1] US EPA specifically noted that more information was needed on minefilling practices, impacts and "the ability of government oversight to ensure that human health and the environment are being adequately protected." The Agency stated:

> "We are aware of situations where coal combustion wastes are being placed in direct contact with ground water in both underground and surface mines. This could lead to increased releases of hazardous metal constituents as a result of minefilling. Thus if the complexities related to site-specific geology, hydrology, and waste chemistry are not taken into account when minefilling coal combustion wastes, we believe that certain minefilling practices have the potential to degrade, rather than improve, existing groundwater quality and can pose a threat to human health and the environment.[2]

Recognizing the importance of this debate, Congress in 2004 directed the National Academies of Science (NAS) and its National Research Council to study the issue of coal placement in mines. The NAS Report, published in 2006, concluded that "that the presence of high contaminant levels in many CCR [coal combustion residue] leachates may create human health and ecological concerns at or near some mine sites over the long term."[3] The National Research Council further concluded that placement of CCW in coal mines may be a viable option *only if*:

> "(1) CCR placement is properly planned and is carried out in a manner that avoids significant adverse environmental and health impacts and (2) the regulatory process for issuing permits includes clear provision for public involvement."[4]

Lastly, the NRC concurred with USEPA that enforceable federal regulations were necessary to guarantee that state programs minimized such threats to health and the environment by implementing safeguards, such as sufficient monitoring, site and waste characterization, isolation measures, corrective action standards and public participation.

The authors of this report recognize that Pennsylvania, as well as other states in the Appalachian Region, face serious environmental and public safety concerns as a result of coal mining. This legacy includes acid mine drainage, dangerous headwalls, and blighted landscapes. Yet it is also the authors' opinion that the solution to these problems should not create additional, serious environmental problems that threaten future

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[1] U.S. Environmental Protection Agency, Regulatory Determination on Wastes from the Combustion of Fossil Fuels, 65 Federal Register 32214, May 24, 2000.

[2] *Id*. at 32228.

[3] Committee on Mine Placement of Coal Combustion Wastes, National Research Council. , Managing Coal Ash Residues in Mines. National Academies of Science, March 1, 2006 at page 1.

[4] *Id.*

generations. It is with this concern that this detailed analysis of Pennsylvania's minefilling program was undertaken.

PADEP Secretary Kathleen McGinty has commented, "DEP has more than 20 years in mine reclamation expertise. Our policies and procedures are the best in the nation, literally the model for federal rules."[5] This report examines this model very closely and finds it lacking in several critical respects, including the failure to recognize degradation from the use of CCW, the failure to implement a program where such impacts are easily detected and the failure to prevent such degradation. It is important that the nation learn from the 20 years of CCW minefilling in Pennsylvania. Further examination of the degradation of groundwater and surface water occurring from CCW placement in Pennsylvania coal mines and of the deficiencies of the PADEP beneficial use program will inform the national debate, lead to improvements, and afford greater environmental protection in Pennsylvania, and by example, the nation.

Based on the findings of this report, the authors make the following specific recommendations for the Pennsylvania Coal Ash Beneficial Use Program:

1. **PADEP should require that accurate and thorough waste characterization is completed prior to permitting the use of coal ash in mines.**
2. **PADEP should require that accurate and thorough site characterization is completed prior to permitting the use of coal ash in mines. PADEP should require the integration and updating of waste and site characterizations as new information becomes available so that placement of wastes with clearly dangerous leaching potentials in specific sites is avoided, site hydrologies are understood and monitoring is adjusted to account for changes in water movement.**
3. **PADEP should require comprehensive and long-term water quality monitoring at all coal ash mine placement sites.**
4. **PADEP should include enforceable corrective action standards for coal ash parameters at monitoring points in all coal ash mine placement permits and address degradation that occurs from coal ash at mine placement sites.**
5. **PADEP should issue NPDES permits for mine ash placement sites that monitor and control ash contaminants in surface discharges from these sites.**
6. **PADEP should require financial assurance sufficient to address potential long-term water quality problems at coal ash mine placement sites.**
7. **PADEP should require isolation of coal ash from groundwater at all coal ash mine placement sites.**
8. **PADEP should update its permit system with a modern database that is better organized and more publicly accessible.**

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[5] Statement of Kathleen A. McGinty, Secretary, Pennsylvania Department of Environmental Protection, before the House Environmental Resources and Energy Committee, April 1, 2004.

9. **PADEP should require that all coal ash placement permits in mines actually achieve a measurable beneficial result.**
10. **PADEP should require ecological monitoring at all coal ash mine placement sites as a condition of the permit.**
11. **PADEP should establish enforceable requirements for coal ash placement permits in state regulations to replace the current system of unenforceable guidance documents.**
12. **PADEP should conduct a statewide programmatic review of its coal ash beneficial use program to determine whether any coal ash minefills permitted by the state are posing a threat to health or the environment and reevaluate the purpose and justification for this program.**
13. **PADEP should establish a program to promote the safe reuse of coal ash, *prior to issuing or renewing permits for coal ash minefills*, and only if such safe and beneficial recycling is unavailable, permit the placement of coal ash in Pennsylvania mines with these aforementioned safeguards.**

This is a very critical time in this important debate. The Office of Surface Mining recently published in March 2007 an advanced notice of proposed rulemaking concerning placement of coal ash in mines.[6] The Office of Surface Mining's proposed rulemaking is purportedly a response to the National Academies of Science's 2006 Report, yet its proposal, which recommends only minimal changes to the federal Surface Mining Control and Reclamation Act, stands in direct contravention of the National Academies' directives. We hope that the conclusions of this report, in terms of the substantial degradation found at mine sites from coal ash placement, the serious deficiencies found in Pennsylvania's program and the specific recommendations articulated above, will inform this federal rulemaking so that stronger federal requirements are indeed forthcoming before additional damage occurs throughout the United States.

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[6] Advance Notice of Proposed Rulemaking on Placement of Coal Combustion Byproducts in Active and Abandoned Coal Mines, 72 Fed. Reg. 12026, March 14, 2007.

CAPTION - Winter in the massive Springdale Pit portion of the Lehigh Coal and Navigation (LCN) surface mine. This pit has a capacity of 80 million cubic yards (one cubic yard of ash is roughly equivalent to one ton) which the operator has advocated filling with contaminated freshwater, brackish, and marine dredge materials, cement kiln dust, lime kiln dust and coal ash, and received a statewide General Permit from PADEP for such purposes in 2004. A permit issued in 2005 to expand ash disposal operations in this pit from 300,000 tons of ash to 1 million cubic yards of ash and dredge material annually was appealed by a local environmental group and has been returned by LCN to PADEP. This site was not studied in the report. Photo from PADEP provided by Army For a Clean Environment, Tamaqua, PA.

Introduction

> "Requests for a moratorium on the use of fly ash for reclamation, in effect, seek protection from a danger that does not exist."
>
> Pennsylvania Joint Legislative Air and Water Pollution Control and Conservation Committee in its Report on the Use of Fly Ash in Mine Reclamation Projects, February 5, 2004

The goal of this report is to assess the monitoring data of groundwater and surface waters downgradient of coal combustion waste (CCW) mine placement sites in Pennsylvania to determine whether increases in contaminant concentrations may be attributed to CCW placement. The CCW involved is composed of fly ash and bottom ash generated by conventional pulverized coal power plants and fluidized bed combustion power plants.

To understand the potential for CCW to degrade groundwater and surface waters in Pennsylvania coal mines, this report reviews research documenting environmental harm and the potential for harm from CCW (Chapter 1). Also included in Chapter 1 is a discussion of the geology and hydrology of coal mines where the CCW is being placed and the chemical makeup of the CCW minefilled in Pennsylvania. Chapter 2 describes the methodology used to examine minefill permits, explains the presentation of the data in this report and summaries the results of site examinations. The backbone of the report, Chapters 3, 4, and 5, examines groundwater and surface water monitoring data collected at 15 CCW minefills to discern trends in concentrations of contaminants and thereby measure the effects of ash on water quality.

Chapters 3 through 5 address 12 CCW minefill permits in the bituminous coalfield of western Pennsylvania and three in the anthracite coalfield of eastern Pennsylvania. The manner of placement, geology and water movement at each site is discussed. A map depicts the ash placement area, direction of relevant water flow and locations of ash monitoring points for which data are examined. Concentrations of major elements, including iron, manganese and sulfates, and trace metals, primarily arsenic, selenium, cadmium, and lead, are graphed as a function of time at upgradient and downgradient ash monitoring points. Additional "ash parameters" such as calcium, magnesium, chloride, sodium and others are also assessed and graphed as well as major parameters such as Total Dissolved Solids, specific conductance, acidity, alkalinity and pH. Trend lines in these graphs depict increases or decreases in average concentrations of contaminants. Loading data were also analyzed and plotted at seven sites.

Monitoring data for nearly all (14 of the 15) permits reviewed indicate sustained increases in contaminant concentrations downgradient of ash placement areas after that placement began. Chapter 3 describes 10 mine sites where the data indicate that degradation occurred partially if not primarily as a result of ash placement. Chapter 4 describes three sites where degradation occurred but available data were not sufficient to draw conclusions regarding the impact of ash on water quality. Chapter 5 describes two CCW minefills where water quality improved, at least in part, after ash placement.

Deficiencies of the Pennsylvania CCW beneficial use program became evident through the research and analysis of these mine sites. Many of these deficiencies are systemic and result from failures of the Pennsylvania regulatory program. Chapter 6 of this report discusses these deficiencies, including the failure of the Pennsylvania program to require (1) adequate waste and site characterization; (2) isolation of the waste to avoid contamination ; (3) long term, effective groundwater monitoring; (4) corrective action when degradation is discovered; and (5) sufficient financial assurance to address contamination of water resources. The researchers also discovered serious administrative deficiencies. In several cases significant data gaps in state permit files made it difficult or impossible to determine trends for ash contaminants at ash placement sites.

Lastly, Chapter 7 summarizes the results and conclusions of this report and presents recommendations for improvement of the Pennsylvania coal ash minefill program. Following Chapter 7, the reader will find three useful appendices: Appendix 1, which describes the Pennsylvania regulatory scheme governing beneficial use of coal ash in mines, Appendix 2 which includes the monitoring data graphed in the figures in the site examinations in Chapters 3, 4, and 5, and Appendix 3 which includes the tabulations of monitoring points and data from the each site that are summarized in Tables 2, 3 and 4 in Chapter 2.

In sum, this report presents valuable data and important recommendations concerning the placement of coal ash in mines. Yet this inquiry into the impact of CCW minefilling on Pennsylvania waters has only scratched the surface. It is the intention of the authors that this report be a beginning and not an end. It is our goal that the findings of this report launch a larger and more thorough investigation into the science, law, and policy governing this potentially damaging practice. The health of coalfield communities and their water resources depend on the open and honest assessment of the environmental impact of placing coal combustion waste in mines.

CHAPTER 1: OVERVIEW: COAL COMBUSTION WASTE AND MINEFILLING IN PENNSYLVANIA

1.1 Introduction

To understand the behavior of CCW in mines, one must consider many factors, including the behavior of CCW in other disposal environments, its chemical composition, and CCW's propensity to change over time. To understand the motivation to place CCW in mines, one must examine the relationship between abandoned mine lands (AML), acid mine drainage (AMD), waste coal plants, and the economics of waste disposal in Pennsylvania. This chapter first reviews numerous studies describing how, why, and where CCW has caused adverse environmental impacts. Next the processes by which coal ash is produced and the chemical makeup of various types of ash are described. Lastly, this chapter briefly examines the complex relationship between coal ash placement in mines, AML, AMD and waste coal plants in Pennsylvania.

1.2 Adverse environmental impacts from coal combustion waste: review of the literature

The burning of coal produces large amounts of fly ash, bottom ash, boiler slag and flue gas desulfurization sludge that are collectively called coal combustion wastes or CCW. Today CCW is the second largest industrial waste stream in America, surpassed only by mining waste. As efforts to control emissions from coal combustion increase, so have the volumes of CCW. For example, the volume of CCW produced nationally increased by 30 - 40% to approximately 130 million tons annually in 2004 largely due to requirements in the Clean Air Act Amendments of 1990 to control acid rain.[1] These amendments resulted in the use of emission control devices known as scrubbers that are now generating approximately 26 million tons of flue gas desulfurization sludge (scrubber sludge) annually. The recently promulgated Clean Air Interstate Rule (CAIR) and the proposed rule to control mercury are likely to increase total CCW generation further with estimates of as much as 170 million tons being generated annually by 2015.[2] The disposal of CCW has caused a variety of environmental problems particularly to soils and waters, due to an extreme pH and high concentrations of soluble salts, trace metals and other pollutants that leach from different CCWs.

Coal and CCW have been analyzed and characterized by a number of researchers. The composition of coal and coal combustion wastes varies widely. According to Block and

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[1] Degeare, Truett, U.S. Environmental Protection Agency, Office of Solid Waste. Overview of U.S. Environmental Protection Agency Coal Combustion Waste (CCW) Mine Fill Issues. Undated. http://www.mcrcc.osmre.gov/PDF/Forums/CCB3/5-1.pdf

[2] U.S. EPA, Clean Air Markets Division. Memorandum to the Docket entitled Economic and Energy Analysis for the Proposed Interstate Air Quality Rulemaking. January 28, 2004

Dams (1976), the composition of fly ash is "significantly different from the original coal composition." For example, in comparison to coal, fly ash is relatively enriched in elements such as chlorine, copper, zinc, arsenic, selenium, and mercury (Block and Dams, 1976). According to Carlson and Adriano (1993), fly ash is also enriched in boron, strontium, molybdenum, sulfur, and calcium. Trace elements in the ash are concentrated in the smaller ash particle sizes.

In a pilot study by the Electric Power Research Institute (1983), chemical analysis of coal, bottom ash, and fly ash from a southwest U.S. power plant burning southwestern subbituminous coal revealed large quantitative differences in elemental concentrations of the three materials:

	Aluminum (ppm)	Arsenic (ppb)	Barium (ppm)	Chromium (ppm)	Iron (ppm)	Magnesium (ppm)	Lead (ppb)	Silicon (ppm)
Coal	29100	7100	71.8	6.1	5130	1130	11000	50200
Bottom Ash	142000	24100	2830	29	28100	4640	23000	260000
Fly Ash	144000	32750	3110	31	24800	5260	51500	258000

A quantitative evaluation of the mobilization of trace metals from coal-burning power stations in Europe, including stack emissions and the quantities retained by the electrostatic filters, and thus present in the ash residue, was completed by G. Bignoli (Bignoli, 1989). Bignoli notes that modern electrostatic filters can filter out 99.8% of particulate matter and thus the environmental impact of most of the metals from coal-burning power plants will be due mostly to the potential releases from solid wastes. (Sabbioni, Goetz and Bignoli, 1984) Analyses of trace metals present in the coal revealed that of the total mobilization of these metals in the combustion process the great majority of the metals were retained in the solid waste and only a very small percent were present in the atmospheric stack emissions. For example, for trace metals, arsenic, cadmium, chromium, lead, antimomy and selenium, 97%, 97.2%, 99%, 97.5%, 97.7% and 91.5% of the total mobilization of each of these metals, respectively, was retained and concentrated in the coal ash.

Vorre (1986) has described the nature of mineral matter in coal. This matter includes the minerals present in the original plants that were altered over time to produce coal. Geologic events such as subsidence and volcanic eruptions provided additional inorganic material. These biological and geologic processes contributed to the formation of coals each with their own signature suite of minerals.

The mineral and trace element content of CCW can vary substantially depending on the locations of parent coals within different coal basins, different coal seams within the same basin, and different locations within single coal seams. Using the Lower Kittanning Coal seam in western Pennsylvania, Rimmer and Davis (1986) analyzed the physical, chemical and biological processes that affected the mineral composition of coals. The Lower Kittanning Coal seam demonstrates lateral variations in mineral compositions that were related to the depositional environments.[3] Research by Lindahl and Finkelman (1986) and Harvey and Ruch (1986) support the variability model of the mineral content within and between coal seams and between regional basins. For example, the mean concentrations of lead, chromium, nickel, and arsenic are three to five times higher in Appalachian and Illinois Basin coals than in coals of the Rocky Mountains and Northern Plains.

Numerous researchers have documented adverse environmental impacts caused by CCW to groundwater[4] and surface waters, plants, aquatic life, and other organisms. Carlson and Adriano (1980) maintain that the major environmental impacts of CCW include: leaching of potentially toxic substances into soils, groundwater and surface waters; hindering effects on plant communities; and the accumulation of toxic elements in the food chain. Adriano et al. (1980), Elseewi et al. (1980), Phung et al. (1979), and Menon et al. (1990) analyzed the chemical and physical composition of fly ash under various experimental conditions to determine the environmental impact of inorganic constituents at disposal sites, such as the release of trace elements in water and treated soils. Sandhu et al. (1993) specifically studied the leaching of nickel, cadmium, chromium, and arsenic from coal ash impoundments of different ages. The general conclusion indicated that leaching produces a measurable release of metals into the environment from both old and new ash deposits: "[A]sh deposits…weathered and leached for over 10 years, yet still may provide a source of metal contamination to infiltrating water. Thus, ash disposal basins may be potential sources of ground water contamination for many years after ash deposition has ceased" Sandhu et al. (1993).

Researchers such as Rowe et al. (2002) documented the negative effect of coal combustion waste on the physiology, morphology and behavior of aquatic organisms and the health of aquatic ecosystems. According to Rowe et al (2002), the "release of CCR [coal combustion residues such as fly ash] into aquatic systems has generally been associated with deleterious environmental effects. A large number of metals and trace elements are present in CCR, some of which are rapidly accumulated to high concentrations in aquatic organisms. Moreover, a variety of biological responses have been observed in organisms following exposure to and accumulation of CCR-related contaminants. In some vertebrates and invertebrates, CCR exposure has led to numerous histopathological, behavioral and physiological (reproductive, energetic and edocrinological) effects." [5]

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[3] For example, high pyrite concentrations occurred in areas where the overlying shale indicated brackish, swamp-like, anoxic conditions. High quartz content in the northern part of the coal seam coincided with a source area where quartz was transported into the swamp by water and/or air from a topographic high area.

[4] Groundwater is particularly important because half of the population of the United States relies on groundwater as its source of potable water either through public or domestic supplies (Solley et al., 1998).

[5] Rowe et al. (2001) studied the adverse impact of trace metals from CCW on the standard metabolic rate of crayfish (*Procambarus acutus*). Other researchers such as Hopkins et al. (2000) studied the detrimental impact of trace elements on lake chubsuckers (*Erimyzon sucetta*). Fish exposed to lake sediments polluted with coal ash exhibited "substantial decreases in growth and severe fin erosion."

Lemly (1999) found that selenium leaching from coal ash landfills posed a great danger to fish populations and documented the elimination of a diverse fish population at Belews Lake, North Carolina from such contamination. Rowe et al. (2000) studied the effects on southern toads living in an environment polluted by coal ash concluding that major reductions occurred in local populations because less food algae could survive in the polluted water and the toxicity of coal ash trace elements in the sediments and surviving food algae killed larval toads. The study suggests that the widespread practice of disposing of coal ash in open aquatic basins may result in sink habitats for some amphibian populations. Cherry (2000) and coworkers, after evaluating the level of toxicity at 32 CCW sites throughout the world, concluded that coal combustion wastes have adverse impacts on ecosystems. Namely, trace elements and other constituents such as sulfates, chlorides, sodium, boron, manganese, iron, selenium, arsenic, lead, chromium, nickel, copper and zinc leach from CCW ash particle surfaces at toxic levels into groundwater and surface water and threaten human and aquatic life.

Elseewi et al. (1980) maintain that solutions from fly ash are mostly alkaline, have a high salt content primarily due to the dissolution of Ca^{2+} and OH^- ions, and contain an elevated concentration of boron that may be toxic to plants. According to Adriano et al. (1980), "…coal ash usually is not suitable for agricultural uses due to the high cost of handling and transportation from the source, very low C [carbon] and N [nitrogen] contents, and usually high pH and toxic B [boron] contents. Thus, if lands are to be used for fly ash disposal purposes, application rates should be balanced between environmental impacts and economics of waste disposal. Massive applications are usually associated with adverse effects to soils and growing plants."

There has been very little research undertaken on the environmental impacts of organic constituents in CCW. Researchers have long known that coal fly ashes contain a number of polyaromatic hydrocarbons (PAHs), (Griest and Guerin, 1979) (Hanson et al, 1983, citing Sucre et al, 1979) (Bennett et al, 1979) (Hanson et al, 1979, 1980 & 1981). Examples of these PAHs include naphthalene, acenaphthylene, anthracene, dibenzofuran, fluorene, and fluoranthene. A number of the PAHs in CCW are toxic, mutagenic and/or carcinogenic in laboratory studies. Their bioaccumulation appears to be limited due to metabolism. The metabolism itself, however, may produce oxidation damage in tissues and breakdown products that are more mutagenic than their precursors. Researchers have documented that fly ashes from both pulverized coal combustion and fluidized bed combustion contain PAHs that readily cause bacteria to mutate, (Hanson et al., 1983, citing Chrisp et al, 1978, Fisher et al, 1979, Kubitschek and Haugen, 1980, Clark and Hobbs, 1980, Hill et al, 1981, and Wei et al, 1982). Hansen et al, 1983 documented that treatment of FBC fly ash with N2O4 increased its mutagenic potency by as much as 3200 times on a laboratory strain of salmonella bacteria. They concluded that potent, direct acting mutagens such as dinitropyrenes and dinitrofluoranthenes in fly ash from fluidized bed combustion power plants might be products of reactions between PAHs in the ash with nitrogen oxides in combustion gases. However, Harrison et al, 1986, concluded that the concentrations of PAHs detected in fly ash probably would not pose an environmental hazard, although they acknowledged difficulties in their ability to detect and measure

PAHs in the fly ash. Griest and Guerin, 1979, concluded similarly that PAHs adhere strongly to ash, making analysis of their quantities and types in CCW difficult**.**

In its Report to Congress on Wastes from the Combustion of Fossil Fuels, (March, 1999), the US EPA cited data collected by the Electric Power Research Institute in 1997 showing that coburning of petroleum coke wastes, coal gasification wastes, mixed plastics, tire-derived fuels and other organic wastes with coal generates CCW with detectable levels of benzene, chlorobenzene, cyanide, dioxins, furans, PCBs, chlorophenol, and polycyclic aromatic hydrocarbons. Despite documentation of the existence of harmful organics in CCW, monitoring for organics in groundwater and surface water surrounding CCW sites is extremely rare. Thus little is known about actual impacts to the environment from organic compounds in CCW.

Although the US EPA exempted CCW from hazardous waste regulatory classification in its May 2000 Regulatory Determination on Waste from the Combustion of Fossil Fuels, it documented concerns in the Determination about the potential adverse impacts from placement of CCW in coal mines.[6] US EPA concluded that safeguards were likely needed to prevent adverse impacts on water quality. US EPA also found that more research and information addressing the impacts to water quality and the environment from minefilling is needed to determine the nature of these safeguards.

1.3 Pennsylvania coalfield geology

Coals are technically not classified as rocks but as *fossils* composed of compacted plant remains. The sedimentary rock types found with coals in the bituminous coalfields include *conglo-merate, sandstone, siltstone, shale, claystone, limestone* and *coal*. Most of these rocks are composed of mineral grains locked together by some cement, usually calcite, quartz, or clay.

The bituminous coalfield in Pennsylvania covers most of the western half of the state, eastward to the Allegheny Front. This area is known as the Allegheny Plateau physiographic province and is subdivided into the Pittsburgh Low Plateau, Pittsburgh High Plateau, Allegheny Mountain, and Mountainous High Plateau provinces. Its bituminous coalfield extends into Ohio and West Virginia and represents the largest bituminous coal reserve in the United States. The coal-bearing sedimentary rocks in this coalfield are of Pennsylvanian and Permian ages, 330 to 290 million years ago (mya) and 290 to 250 mya, respectively.

In western Pennsylvania, almost all of these coals are included in the lower Allegheny Group of the Pennsylvanian time period. These include three major coal beds, the deepest being the Clarion, followed by the Kittanning, with the Freeport bed closest to the surface. Only one of the permits in western Pennsylvania analyzed in this report, the Hartley Strip, involved the mining of younger coal beds (from the Permian time period) not in this group. The coals in the lower Allegheny Group were formed in near-shore

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[6] US EPA, Regulatory Determination on Waste from the Combustion of Fossil Fuels. Final Rule. Federal Register, Volume 65, number 99, page 32213. May 22, 2000.

marine and/or brackish conditions and contain more sulfur than younger coals. Higher sulfur coals contribute more to the AMD problem. Younger coals including those higher in the Allegheny Group were generally deposited in more fresh water, terrestrial environments, resulting in lower sulfur contents.

The anthracite coalfield is found within the Ridge and Valley physiographic province of eastern Pennsylvania. This province contains most of the anthracite found in the United States. All of the numerous coal beds in the eastern Pennsylvania anthracite region have low sulfur contents due to post-depositional metamorphism (changes to rocks from heat and pressure) and generally produce lower levels of acidity than coal beds in western Pennsylvania's bituminous region.

The coal and other sedimentary layers from the Pennsylvanian Period in western Pennsylvania are generally flat-lying, except for some folds or "humps" (*anticlines*) towards the eastern margin of the bituminous coalfields. Further east, the coals and rock layers in the Anthracite field show steeply pitching geometries due to a more intense folding activity closer to the collision margin between the continental plates of North Africa and North America occurring about 250 mya.

Water movement through coal-bearing sedimentary rocks is affected by four major variables: (1) local rock structure; (2) ability of water to flow through different rock types; (3) topography; and (4) man-made activities. Due to higher permeabilities, certain rocks such as limestones and sandstones convey enough water to be considered aquifers. Due to high degrees of fracturing, coal veins may also be aquifers. Natural contacts between rock layers, joints, and faults are also pathways of enhanced groundwater flow. The structural tilt (a.k.a. "dip") of coals and surrounding rock layers also strongly influences the rate of groundwater flow. Groundwater flow through shallow, unconfined earth above the sedimentary layers generally follows the topography.

Human activities such as coal mining can greatly affect the direction and rate of groundwater flow. Coal seams mined out from deep mining can become major man-made conduits for underground water movement, known as "mine pools," that can provide pathways for groundwater exit from a site at different elevations and rates than occurred at original points of discharge. Other fractures from blasting and overburden removal operations can also become man-made conduits. Furthermore when the broken up overburden or spoil from strip mining is placed back in the working pit as mining progresses, it will transmit groundwater at a much greater rate than undisturbed rock due to the greater amount of void space in this broken material. Since many surface mines in Pennsylvania have been previously mined and mining activity can change the direction and flow of groundwater, a thorough study of water movement is needed at proposed coal mine ash placement sites to develop effective monitoring systems, as groundwater behavior and the often substantial changes in that behavior from previous and proposed mining will be site specific.

Understanding chemistry of the specific ash and the geochemistry of the coal mine sites in which the ash is to be placed is also an important step to predicting impacts to water quality that will result from minefilling. The depositional environment in which the coal or coals were formed at these sites must be understood. In the case of previously mined sites, chemical analysis not only of overburden but also of coal mine spoils and coal refuse should be undertaken when assessing the potential for acidity and other water quality impacts. Care must also be taken to calculate the net alkalinity available in coal ash that will be exposed indefinitely to this acidity and to design placement of ash that will maximize the buffering benefits of that alkalinity. Additional knowledge of the different leaching potentials for major constituents, minor metals and trace elements in the ash and surrounding mine materials when major factors such as pH and the redox environment are changing is also important to predicting results of importing large volumes of ash into coal mines. All of these geochemical variables will be very site specific and ash specific and should be addressed on a site-to-site basis.

1.4 CCW used in Pennsylvania coal mines

1.4.1. Types of CCW: Conventional Pulverized Coal Ash, Fluidized Bed Combustion Ash and Waste Coal CCW

CCW is a waste product resulting from the combustion of coal to generate electricity. Coal is composed mostly of carbon, volatiles (oxygen and hydrogen) and non-combustible materials including clay (aluminum silicates), silica (SiO_2), pyrite and marcasite (FeS_2), and other metallic oxides. After the coal is burned, these non-combustible components are discarded as ash or CCW.

There are two types of coal ash that are the focus of this report: 1) Conventional power plant ash from a pulverized coal (PC) plant and 2) Fluidized Bed Combustion (FBC) power plant ash. Both of these coal ashes are further divided into bottom ash and fly ash. PC bottom ash and fly ash are generated from burning primarily mine run coal, and FBC bottom and fly ashes are primarily generated by burning mixtures of coal and waste coal. There are two different types of waste coal. “Coal refuse” or “gob” is waste coal originating from bituminous coal. Waste coal from anthracite coal is called “culm.” Waste coal consists of the impurities cleaned from mined coal to prepare it for burning.

Fly ash and bottom ash are easily distinguished. Bottom ash particles are larger and heavier than fly ash particles and do not become airborne as a result of the combustion process. Thus bottom ash is generated on the grate of the boiler. Fly ash is very fine grained and becomes airborne during combustion. In PC plants, fly ash is captured by pollution control devices such as electrostatic precipitators and bag houses installed inside and adjacent to the stacks, and bottom ash is taken out of the furnace using a conveyor type of grate. Another major type of CCW, flue gas desulfurization sludge, also known as “scrubber sludge,” is generated by spraying lime or other highly alkaline material in a liquid or powderized state across flue gases to remove sulfur dioxide and other pollutants. Pennsylvania’s beneficial use regulations exclude scrubber sludge from the definition of “coal ash,” (See 25 PA Code Section 287.1) and therefore do not permit its placement in coal mines under the state’s beneficial use program.

The FBC ash studied in this report typically results from burning coal piles, which are comprised of waste coal and broken overburden rock (also called spoils) left in abandoned mine areas. These piles contain less than 50% coal, the remainder is composed of waste coal and spoils. In the bituminous coal field of western Pennsylvania, some previously unexcavated coal is often also mined along with the removal of the waste coal piles. The mined mixture is crushed and then injected into the furnace combustion chamber and kept airborne by heated air insuring complete burning of most of the coal. The waste material mixed with the coal is also burned if there is any "coaly" material in this waste rock. During the combustion process, limestone ($CaCO_3$) is introduced into the combustion chamber and burns to form CaO (lime). The addition of lime to the FBC ash increases its alkalinity, thus improving its potential for use as AMD remediation material. Larger incombustible particles are eventually removed from the furnace as FBC bottom ash, while lighter fly ash is captured in bag filters. Because the average ash content of waste coals is two to three times higher than parent coals and because limestone is injected into the combustion process, FBC power plants produce several times more CCW per megawatt of power than PC power plants. While FBC plants produce only 8% of the total megawatts generated by all Pennsylvania coal-fired plants, FBC ash constitutes over 60% of the CCW produced by all plants.[7]

1.4.2. Chemical Composition of CCW

An accounting of all the chemical phases of coal before and after the coal is burned can provide a better understanding of the final chemical makeup of the CCW that is being placed in Pennsylvania coal mines. The major elements in coal are carbon, hydrogen and oxygen. The hydrogen and oxygen are volatilized and escape the boiler furnace as gasses when the coal is burned. The carbon is also burned or oxidized, with the resulting heat of combustion that boils water into steam and drives electrical generators. During combustion, the carbon reacts with the oxygen in the coal and oxygen from the atmosphere to produce carbon monoxide (CO) and carbon dioxide (CO_2), both of which escape as gasses. Trace amounts of carbon are left behind in fly ashes as polyaromatic hydrocarbons and other organic compounds. These compounds usually form as products of incomplete combustion when emissions cool in the flue gasses.

The minor components in coal, sulfur, iron, silica, and clay are also heated, but all is not burned or oxidized. The sulfur is burned to form sulfur dioxide (SO_2), which, depending on the type of combustion, can escape as gas, be collected to produce gypsum, or be left in various oxidation states in the ash. The trace metals (many of which occur in pyrite) are separated from the sulfur and occur in the resulting ash as elemental metals and oxides. The iron is usually oxidized to form iron oxide, FeO. The shaley, or boney material in coal, particularly in FBC processes, contains silica (quartz or SiO_2) and clays, which are complex hydrated aluminum silicates. The water in the clays is driven off by

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[7] According to DOE EIA data for 2002, waste coal burning plants in Pennsylvania total 1,559.5 MW in nameplate capacity while all other coal-fired plants in Pennsylvania total 18,920.2 MW in nameplate capacity. EIA 2002 data was not available for Pennsylvania's newest waste coal facility in Seward, PA. 521 MW was used as the nameplate capacity for that plant.

the heat of combustion, leaving aluminum oxides, and the silica does not react, initially. The small quartz grains fuse together in a process somewhat similar to the glassmaking process.

During combustion in a FBC plant, limestone is added in the furnace and is burned to lime, as outlined above. This lime reacts to form gypsum, thus removing most of the sulfur dioxide from the system. Some of the lime reacts with the silica to form calcium silicates. The excess lime is incorporated into the ash, increasing alkalinity. This lime, after the ash has been placed in a mine, *can* react with groundwater to form a cemented ash bound together by portlandite, $Ca(OH)_2$. Portlandite forms by hydrating lime: $CaO + H_20 = Ca(OH)_2$.

The greater the amount of limestone added to the furnace in a FBC plant, the higher the alkalinity of its ash, with most FBC ashes having significantly higher alkalinity than the alkalinity in conventional PC ashes. FBC ash also contains aluminum silicates, along with fused silica. Some sulfur is incorporated into the ash as anhydrite, $CaSO_4$. Its metals can be incorporated, or "locked up" in some of the silicate minerals, or they can exist as oxides and sometimes as elemental metals.

Whether burned in PC or FBC plants, most metals in coal, including trace metals, are not volatilized during the burning process and remain in the ash. Their concentrations therefore increase as the coal volume reduces to ash volume, with a resulting higher metal component in coal ash than in the original coal. For example, data from the Electric Power Research Institute (1983) shows that aluminum, arsenic, chromium, magnesium, lead, and silicon have concentrations approximately five times greater in coal ash versus coal. Barium concentrations are 42 times higher in the ash than in the coal. Only detailed mineralogical analysis can determine which mineral phases of these constituents are soluble and mobile in groundwater, or fixed and relatively insoluble.

1.4.3. Analysis of coal ash chemistry in PADEP minefill permits

There are two methods used to analyze coal ash being placed in Pennsylvania coal mines: a bulk chemical analysis and a leaching test. Bulk chemical analysis reports most of the constituents that make up the ash as elemental concentrations. Sulfur is reported as sulfate. The analysis makes no attempt to determine the mineral phases that contain the constituents or the stabilities of those phases in the environment. Mineral phase identification (using X-ray diffraction and X-ray fluorescence techniques) has been used for CCW characterization to a small extent and would be a good focus for future studies.

A leaching test is used to determine the mobility of trace heavy metals and other metal oxides, as well as more prevalent inorganic constituents in the ash such as sulfate, chloride, and sodium. Pennsylvania requires the use of the Synthetic Precipitation Leaching Procedure (SPLP), described as Method 1312 in US EPA's Test Methods for Evaluating Solid Waste, SW-846. In the test, a set amount of the CCW, usually 100 grams, is ground to a specified particle size and placed in a container in an extraction fluid that is 20 times the amount of the ash by weight. The extraction fluid has a pH of

4.2 Standard Units. The container is rotated end over end at 30 rotations per minute for 18 hours. The resulting fluid in the mixture, called leachate, is filtered and analyzed for dissolved concentrations of 15 metals and four other inorganic constituents. For a coal ash to be certified for placement in a Pennsylvania coal mine, the concentrations of these constituents cannot exceed maximum acceptable leachate concentrations set by the PADEP in guidelines for the beneficial use of coal ash in mines.[8] Those concentrations are normally 25 times the "groundwater parameter," equivalent to Pennsylvania's drinking water standard, for metals and 10 times the groundwater parameter for nonmetals. Organic constituents are not analyzed in the test. Results of these tests are regularly reported pursuant to the section of PA mining permit permits called Module 25.

While this test determines the quantity of inorganic constituents that leach out of a coal ash sample under controlled laboratory conditions for short periods, it is not designed to simulate actual conditions in the coal mines where CCW is placed. The actual conditions in mines are far more geochemically complex. University researches and several federal agencies, including US EPA, Department of Energy, and the Office of Surface Mining, as well as state regulators, admit that standard leaching tests, like the SPLP, cannot adequately predict how CCW will behave in a mine or any other real-life disposal environment. Concentrations of metals and other constituents in groundwater from CCW in disposal environments are often markedly different from concentrations generated in leachate from CCW in tests such as the SPLP. These deficiencies in the bulk analysis and leaching test used by PADEP cause environmental protection advocates to fear that CCW minefilling permits in Pennsylvania are not sufficiently characterizing the potential of CCW to contaminate groundwater or pollute surface waters. (See detailed discussion of the adequacy of CCW characterization in Chapter 6, infra.)

1.4.4. Use of CCW as Alkaline Addition to treat AMD

Current regulatory programs in many eastern states allow for the treatment of AMD with alkaline materials (often lime and sometimes CCW) to effect neutralization and metal precipitation prior to discharge. Alkaline CCW is placed directly against or blended with AMD-forming rock, spoils and coal refuse to permanently treat AMD in situ. It is considered by officials in the coal and electric utility industries and some federal and state government agencies such as the PADEP to be an appropriate and economically sound alternative to conventional AMD treatment.

When ash is used for alkaline addition in a Pennsylvania coal mine, the total amount of calcium in the ash (equated to calcium carbonate found in overburden rock that can neutralize acidity) is ascertained through bulk analysis to derive the net neutralization potential of the ash. This neutralization potential is then measured against the deficiency in alkalinity in overburden rock in the mine to determine the amount of ash needed to neutralize acidity in the mine, usually with an additional amount of ash to assure that enough alkalinity is being applied. However, there is no attempt to quantify the physical availability of the alkalinity in the ash to actually buffer the acidity that will be generated

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[8] PADEP, *Certification Guidelines for Beneficial Uses of Coal Ash,* 563-2112-224, BMR PGM Section II, Part 2, Subpart 24.xxxxxx

from the spoils or coal refuse in the mine. When more pozzelanic or cementaceous CCW such as FBC ash is placed in solid configurations and not blended with the acidic materials in the mine, environmental protection advocates fear that alkalinity bound up in hardened deposits will not be available in amounts sufficient to neutralize high amounts of acidity in mines. Even worse, the CCW placement could result in the mobilization of additional metals from the ash into mine waters if the alkalinity of the ash is eventually exhausted by the AMD.

An extensive four-year column leaching study by Stewart, Daniels and Zelazny (1996) found that bulk-blending alkaline eastern bituminous coal fly ash with acid-forming coal refuse might present a disposal option that could control AMD. However, they concluded, “Our data clearly indicated that ash alkalinity and refuse potential acidity must be balanced to insure long term water quality protection from ash/refuse co-disposal practices and that the breakthrough of acidic leachates may take greater than five years under certain co-disposal scenarios as modeled in our study.” Stewart (1996) stated that “it is evident that most eastern fly ash does not contain sufficient alkalinity to be safely co-disposed with acid-forming coal refuse without addition of supplemental alkalinity.” In addition, exposing ash to strong acidic leaching environments increased the leaching of potentially hazardous trace metals. The leached amounts of metals such as manganese, iron, and copper increased proportionately with the total amount of ash applied (Stewart, 1996).

1.5 CCW, AML, AMD and Waste Coal Burning in Pennsylvania

1.5.1. Historical Perspective

It has been stated “Pennsylvania carries the heaviest burden of abandoned coal mines in the country.”[9] Serious environmental and safety problems associated with AML include water-filled pits, dangerous vertical highwalls, subsidence and drainage problems, open shafts, abandoned gob and culm piles and, of course, AMD.

These problems represent the legacy of historic mining practices. Pennsylvania has been very successful over the last three decades, through SMCRA and extensive state-sponsored research, in preventing AMD from coal mining. A measure of this success is the relative rarity of AMD generation at new SMCRA-permitted mines. According to PADEP, 17% of the mining permits issued between the years 1977 and 1983 produced post-mining discharges related to AMD. That rate dropped to 2.2% for the period between 1987 and 1996.[10] A large part of the success in preventing AMD in new mines can be attributed to the rigorous state program requiring pre-mining prediction of post-mining water quality. Based on that prediction, permits are customized to prevent AMD formation, or in some cases, permits are denied when prevention appears unlikely.

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[9] Pennsylvania General Assembly, Joint Legislative Air And Water Pollution Control and Conservation Committee, Report on a Proposed Moratorium on the use of Fly Ash in Reclamation Projects, February, 2004.

[10] PADEP, Evaluation of Mining Permits Resulting in Acid Mine Drainage, 1987-1996: A Post Mortem Study, March, 1999

Although modern surface mining permitting decisions and operational practices have largely eliminated AMD as a problem in new mines, the legacy of past practices remains. PADEP estimates that AML constitutes about 250,000 acres in Pennsylvania.[11]. AMD in Pennsylvania is a problem almost entirely associated with AML.[12]

It should be noted, however, that even in mine settings that generate large amounts of AMD, acidity, and the high levels of metals and sulfates associated with it, usually decline significantly with time. In surface mines, as mining breaks apart pyrite-bearing rocks and coals, increasing their surface area and exposure to oxygen, the acid products are leached from rocks exposed to weathering usually within 10 to 20 years (Meek, F.A. 1996). Leaching of most acidity-producing pyrites and alkalinity-producing carbonates occurs within 20 meters of the surface due to weathering (ATRI, Prediction of Water Quality at Surface Coal Mines, ATRI).

Thus the degree of exposure to air is a key, if not primary, factor involved in the creation of AMD in coal mines. A study by Ziemkiewicz and Meek of eleven, 400-ton piles of acid-producing sandstone and shale in an Upshur County, WV coal mine treated with various amendments of alkaline materials found that concentrations of sulfates exiting all of the piles from AMD declined dramatically (between ~ 85-97%) over an 11-year period and that the rates of sulfate exit from the original pyrite mass in the piles were fairly constant. The study's authors concluded, "It appears that gross physical phenomena, independent of pyrite forms, surface area, amendment, pH or micro properties of the rock control the rate of pyrite oxidation within relatively narrow limits. Since the rate increased with the proportion of sandstone, oxygen diffusion is the likely candidate."[13] At the same time, whether in active or abandoned surface mines, pyrite oxidation near the surface of large piles of spoils or refuse produces a rind of precipitates from chemical reactions that along with the settling of the piles tends to limit oxygen exposure and therefore retard pyrite oxidation farther beneath the surface of those piles.

Acid discharges from underground mines usually last longer than AMD from surface mines. However, underground mines that are below regional water tables set by creeks and rivers ("below drainage" mines), usually lose their acidity significantly faster than underground mines above the water table. This is because the pyrite reacts at much slower rates and produces only small amounts of acid when left in more anaerobic conditions underwater in flooded underground mines (Evangelou 1995, Fennemore et al. 1998, as cited by Demchak, Skousen and McDonald, 2003). In fact, researchers have found that within 30 years after closure, water in flooded underground mines in the UK, rose from an acidic to a neutral pH and iron concentrations decreased by over 80% (Wood et al. 1999). Other researchers found that iron and sulfate concentrations declined

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[11] PADEP, "Healing the Land and Water, Pennsylvania's Abandoned Mine Reclamation Program," http://www.dep.state.pa.us/dep/deputate/minres/reclaimpa/healinglandwater.html.

[12] But it is important to recognize that not all AML has AMD. AMD is only a subset of the environmental problems associated with AML

[13] Ziemkieweicz, Paul F. and F. Allen Meek, Jr. Long Term Behavior of Acid Forming Rock: Results of 11-Year Field Studies. Presented at the International Land Reclamation and Mine Drainage Conference and the Third International Conference on the Abatement of Acidic Drainage, Pittsburgh, PA, April 24-29, 1994.

by approximately 50 % over 25 years after closure and flooding in two below drainage mines in the Uniontown Syncline of Pennsylvania and concluded that water changed from acidic to alkaline within 30 years after closure and flooding of these mines (Lambert and Dzombak, 2000). A study of the Montour mine, a Pittsburgh coal seam underground mine in Pennsylvania found that a section that was flooded in 1982 changed from being strongly acidic (pH of ~3.0, acidity of 2,200 mg/L) to net alkaline (pH of 6.4, net alkalinity of 200 mg/L) only seven years after flooding, an improvement likely hastened by good quality water from a separate part of the mine that flooded in 1970, (Donovan et al. 2000).

Even most underground mines that are "above drainage" appear to undergo major improvements in water quality with time. These mines experience significant longer term oxygen exposure and more tenacious acidity than surface mines or below drainage underground mines. Yet a 2003 study of 44 such mines in northern West Virginia by Demchak et al. found significant improvements in water quality in 34 of the 44 mines between 1968 and 2000. Reductions in acidity, iron, and sulfate ranged from 50 to 80%. Thus while the AMD problem is very real, it is abating with time. Treatment programs should be designed with this eventuality in mind. Time and reduction in oxygen exposure are two critically important factors for addressing AMD.

1.5.2. Approaches to Remediation

The remediation of AMD has been a major concern in Pennsylvania for decades. Hundreds of miles of Pennsylvania streams have been, and are being, improved and even cleaned to near pristine conditions by these efforts. Two traditional approaches have proven extremely effective. The first is surface reclamation, which involves regrading and revegetating a site. The second is passively treating AMD using one of a number of constructed features such as wetlands, open limestone channels and anoxic limestone drains. When designed site specifically and adjusted to improve actual performance, these techniques are virtually 100% successful. [14]Both of these approaches, although highly effective, require the expenditure of commonwealth funds.

It is estimated that the price of reclamation and remediation of AML and AMD in Pennsylvania approaches several billion dollars. Federal funding from Title IV of SMCRA, the mainstay of reclamation efforts, amounts to approximately $25 million annually. To supplement inadequate federal funding, PADEP has sought ways to encourage private industry to reclaim AML. The lynchpins of these efforts have been the promotion of remining at AML sites where refuse piles can be remined (and the accompanying use of coal ash as an alkaline addition and/or fill) and the permitting of waste coal-burning power plants. Both of these actions have led to today's burgeoning practice of coal ash placement in mines.

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[14] Milavec, Pamela J., undated, "Abandoned Mine Drainage Abatement Projects: Successes, Problems and Lessons Learned," Bureau of Abandoned Mine Reclamation, on PADEP website at http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm, last revised 1/17/03.

In the 1990s, Pennsylvania instituted mining regulations that specifically addressed remining areas impacted by AMD. These regulations provide regulatory relief and incentive for mining companies that reclaim problematic AML as a part of remining activities. A large percentage of the coal ash placement in mines occurs at remined sites, because CCW is often used as alkaline addition at these sites to treat AMD or as fill to achieve approximate original contour at the sites.

However, the success of remining as a means of remediating AMD is significantly less than the virtual 100 % success rate from passive treatment and the near 98 % success rate from preventing AMD at the permitting stage. An in-depth study of PA remining projects showed a success rate of 87%, or 21 of 24 sites evaluated.[15] A broader PADEP study of 110 completed remining operations found net acidity loads were improved or eliminated in 47% of discharges, unchanged in 52 % of discharges and became worse in 1% of discharges. Although the number of discharges with reduced loads of iron, aluminum, manganese and sulfate was always substantially greater than those showing increased loads, 10% of discharges had higher loads of sulfates and 9% of discharges had higher loads of manganese. Furthermore, postmining manganese concentrations in aggregate at these sites actually increased, indicating that virtually all Mn load reductions and most of the reductions in Fe and SO4 were due to flow reductions.[16]

The degree to which coal ash was used in the remining sites in these studies is not clear. However, the standards for defining success in these cases do not include measurement of groundwater quality nor concentrations of trace elements or other constituents that might migrate from coal ash to surface waters regardless of improvements in loadings for acidity, iron, aluminum, manganese and sulfates.

Second, several factors, including the drive to hasten reclamation, have encouraged the proliferation of FBC waste coal-burning plants. The initial driving force for the development of this industry was the passage of the Public Utilities Regulatory Policies Act (PURPA) in 1978. Created in response to the energy crisis in the 1970s, PURPA required electric utility companies to buy the power generated by facilities using non-traditional fuel, such as waste coal. PURPA required electric utilities to purchase this electricity at a rate that matched the traditional power plant cost to produce the electricity. PURPA spawned 16 FBC waste coal plants in Pennsylvania, most built between 1987 and 1995. Today this industry is experiencing a second boom. Reliant Energy's Seward Plant, the largest FBC waste coal plant in Pennsylvania, came on line in 2004. At least 2 more large plants, including the Nemacolin plant in Greene County (with slightly larger capacity than the Seward plant), plan to commence operations over the next few years. The Seward plant alone increases the amount of waste coal burned in Pennsylvania and the amount generated from this combustion by approximately 50%.

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[15] Hawkins, Jay. W. "Characterization and Effectiveness of Remining Abandoned Coal Mines in Pennsylvania," 1995. Report of Investigations 9562, U.S. Department of Interior.

[16] Smith, Brady and Hawkins. "Effectiveness of Pennsylvania's remining program in abating abandoned mine drainage: water quality impacts," 2002, Society for Mining, Metallurgy, and Exploration, Inc

Pennsylvania's "Alternative Energy Portfolio Standard" legislation, enacted in 2004, also encourages the burning of waste coal. Act 213 requires a certain percentage of the energy sold in Pennsylvania be derived from "alternative energy sources," which included by definition waste coal. PADEP clearly sees waste coal plants/minefilling as a "win/win" proposition. According to PADEP, "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."[17] FBC plants are the touchstone of the minefilling program; approximately 79% of the coal ash placed in mines is generated by FBC plants.[18]

The economics of waste disposal also increasingly motivate conventional coal-burning power plants to dispose of their CCW in mines. Seven of the permits examined in this report involved conventional CCW. In Pennsylvania and other coal mining states, coal operators offer attractive haulback provisions that reduce disposal costs for electric utilities. The 21 conventional coal-fired power plants in Pennsylvania produce about 5 million tons of coal ash each year. Over 1.3 million tons of this ash is placed annually in Pennsylvania mines.[19]

1.5.3. Driving Economic Forces vs. Environmental Concerns

The environmental community has raised concerns about the lack of safeguards for mine placement and disposal. The waste coal industry has responded with stiff resistance to any proposed change in their waste handling practices. Waste coal operators claim that any imposition of safeguards for the placement of coal ash in mines would result in closure of their plants.[20] This assertion is based on the increased disposal costs that would be incurred if the plants were to dispose of CCW in a residual waste landfill. Proponents of this argument assert that cost of landfilling the 5 million tons of CCW produced each year by the waste coal plants would be in excess of 300 million dollars. By their own estimation, the industry admits that minefilling CCW reduces their disposal costs by 89 to 95% over landfilling.[21] Because waste coal plants must burn a substantially higher volume of waste coal, and produce a significantly higher volume of ash than PC plants, the plants are more susceptible to disposal cost increases.[22] Conventional coal plants, because they produce a much smaller volume of ash relative to the power they produce, do not face the same landfilling costs as waste coal plants do.

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[17] PADEP Coal Ash Report, 2004.

[18] Ibid.

[19] Ibid. Chapter 1.

[20] Joint Legislative Report on Coal Ash.

[21] Joint Legislative Committee Report states that "This conclusion is drawn with the understanding that the disposal cost per ton of material at a commercial residual waste facility (landfill) is between $45 and $90, including transportation….Taking the midrange of cost to be $67.50 per ton, the cost of landfilling 5 million tons of ash produced each year by the Commonwealth's waste coal facilities would be approximately $337.5 million per year."

[22] Cogeneration plants are not permitted to increase prices to reflect increased operation costs. Under PURPA, cogeneration and other small power production facilities are entitled to sell electricity to utilities at a negotiated price. Utilities purchase this electricity through long-term (typically 20 years) contracts at a fixed price per kilowatt hour.

While no one questions the objective of reducing AMD through proper reclamation of active mines, regrading and revegetating abandoned mines and using passive treatment of acid discharges, the dispute centers on whether use of CCW with unstable pH, elevated levels of metals and soluble salts is a prudent long term approach to solving the AMD problem. In particular, PADEP and other proponents of the waste coal industry point out that the electricity produced and the reclamation of AML achieved by burning waste coal would not be economically possible if they have to meet the same disposal standards that generators of CCW must meet when disposing CCW outside of coal mines. However, environmental protection advocates question whether the fundamental objective of protecting and restoring the hydrologic balance in coal mines under SMCRA should be compromised by this economic objective and ask why public funds for reclamation of abandoned mines should not be significantly increased to address the objective of abating AMD on these lands.

CAPTION - The reddish, tan, brown FBC waste coal ash placed in many Pennsylvania Mines stands out against darker gray and black coal refuse. Coal refuse and waste coal are one and the same and called “culm” if from anthracite coal or “gob” if from bituminous coal. Here FBC culm ash is being piled on top of culm and mine rock at the AC Fuels Co Mine in northern Schuylkill County, a site not examined in this report. Photo by Steven Dreyer, McAdoo, PA.

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 remining 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 Pollutional 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.

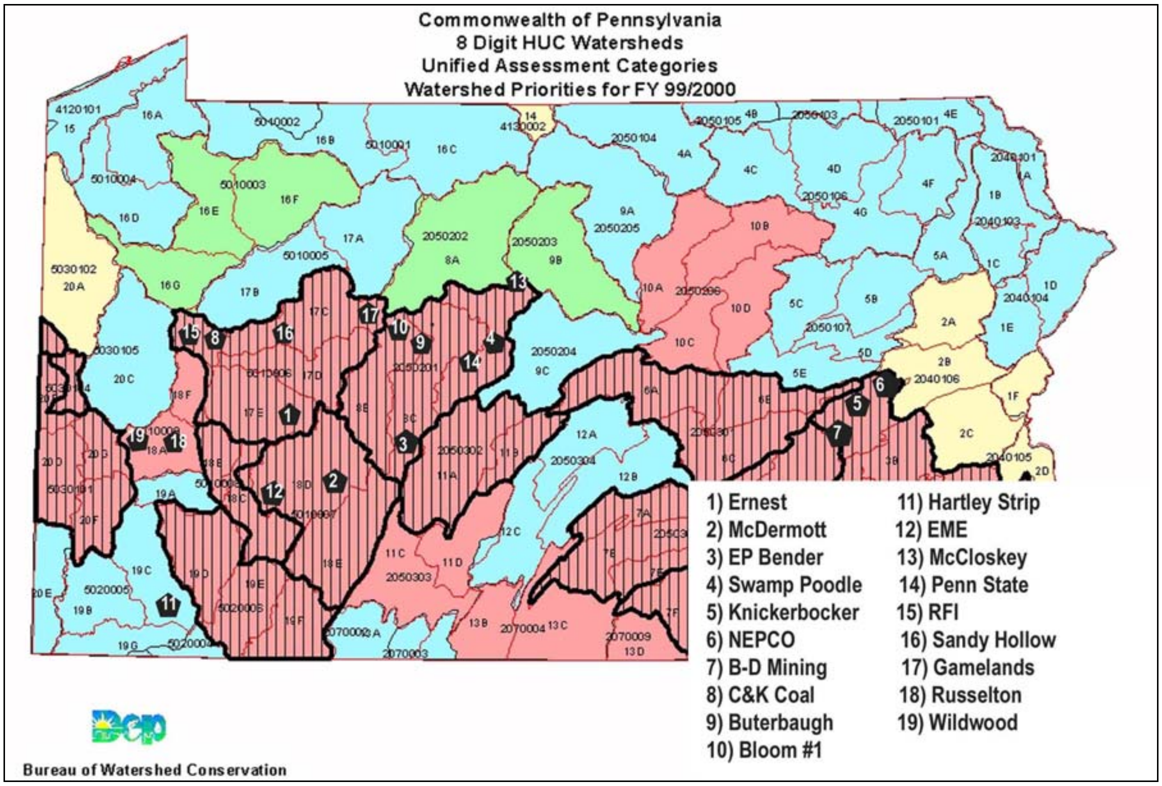
2.2. Selection of Permits

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.[1] 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. [2] 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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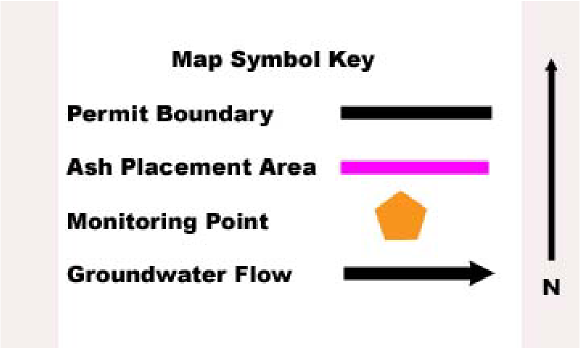
[1] See http://climate.met.psu.edu/data/state.php.

[2] 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.[3] 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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[3] 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 remining 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.[4]

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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[4] 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.[5] 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.[6] 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. [7]

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[5] 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.

[6] 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.

[7] 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.[8] 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.[9]

Table 1 (below)

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[8] See 25 Pa. Code § 96.3(d).

[9] 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.

TABLE 1: **Permit Name** **Number** **County**	**Permit Type & Placement Purpose**	**Ash Type & Quantity**	**Degradation of Water Post-Ash Placement**	**Acidity/ Alkalinity**	**Monitoring Deficiencies & Other Problems, PADEP Responses to Problems**
Ernest Mine **32950201CM** **Indiana County**	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. Data indicate ash is responsible. 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.
McDermott **11950102 CM** **Cambria County**	Active mining, Subchapter F, alkaline addition on 73 acres	FBC ash (waste bituminous coal) 316,930 tons	Yes. Data indicate ash is responsible. 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.

TABLE 1: **Permit Name** **Number** **County**	**Permit Type & Placement Purpose**	**Ash Type & Quantity**	**Degradation of Water Post-Ash Placement**	**Acidity/ Alkalinity**	**Monitoring Deficiencies & Other Problems, PADEP Responses to Problems**
EP Bender **11930102 CM** Cambria County	Subchapter F, Active mining, alkaline addition, 270 acres permitted, 104 acres affected	FBC ash (waste bituminous coal) 65,000 tons	Yes. Data indicate ash is responsible. 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.
Swamp Poodle **17950115 MO** **Clearfield County**	Active surface mining, alkaline addition, 50 acres	FBC ash (waste bituminous coal) 214,090 tons	Yes. Data indicate ash is responsible. 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.

TABLE 1: **Permit Name** **Number** **County**	**Permit Type & Placement Purpose**	**Ash Type & Quantity**	**Degradation of Water Post-Ash Placement**	**Acidity/ Alkalinity**	**Monitoring Deficiencies & Other Problems, PADEP Responses to Problems**
Ellengowan - **Knickerbocker 54793206 PV** **Schuylkill County**	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. Data indicate ash is responsible. 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.
Silverbrook - Big Gorilla **54920201 PV** **Schuylkill & Carbon Counties**	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. Data indicate ash is responsible. 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 upgrdient well. No monitoring for B & Sb.

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BD Mining **54850202 PV** **Schuylkill County**	Refuse Re-processing, Placement for surface reclamation	FBC ash (anthracite waste coal) 3.7 million tons over 125 acres.	Yes. Data indicate ash is responsible. 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.
EME Generation **32753702 CA Indiana County**	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. Data indicate ash is responsible. 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

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			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 placemt. started. Leachate evap. pond pH is ~3.0 units but rising slightly.	at the site.
Hartley Strip Mine **30713008 GN** **Greene County**	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. Data indicate ash is responsible. 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

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					draining area is heavily contaminated with B, Mo, and sulfate.
Bloom #1 **17950111MO** **Clearfield,** County	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. Data indicate ash is responsible. 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.

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TDK Sandy Hollow **16910104 KX** **Clarion County**	Active Surface mining, Subchapter F permit, Alkaline addition	FBC and PC ash (bituminous coal and waste coal) 342,000 tons	Yes. Data insufficient to differentiate causes. 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 placemt area. No pore mon. well. No monitoring for B, Mo & Sb.
C&K Coal **16703006KX** **Clarion County**	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. Data insufficient to differentiate causes. 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.

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				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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Buterbaugh **17990112MO** **Clearfield County**	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. Data insufficient to differentiate causes. 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.
Russelton **02930201GN** Allegheny County	Refuse reprocessing, Subchapter F permit, Alkaline addition	FBC ash (waste bituminous coal) 1,500,000 tons over 50+ acre gob pile being remined	No. Overall improvement shown from data. 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.

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Wildwood **02940201 GN** **Allegheny County**	Refuse re-processing, Subchapter F permit, Alkaline addition	FBC ash (waste bituminous coal) 454,000 tons over 30+ acre gob pile being remined	No. Overall improvement 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.

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					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.[10]

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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[10] 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.[11]

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.[12] Of these, 48 are downgradient and 10 are upgradient.[13] 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.[14] 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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[11] These are the Penn State site, Permit # 17820104, and the McCloskey site, Permit #17793044.

[12] 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.

[13] 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.

[14] 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.

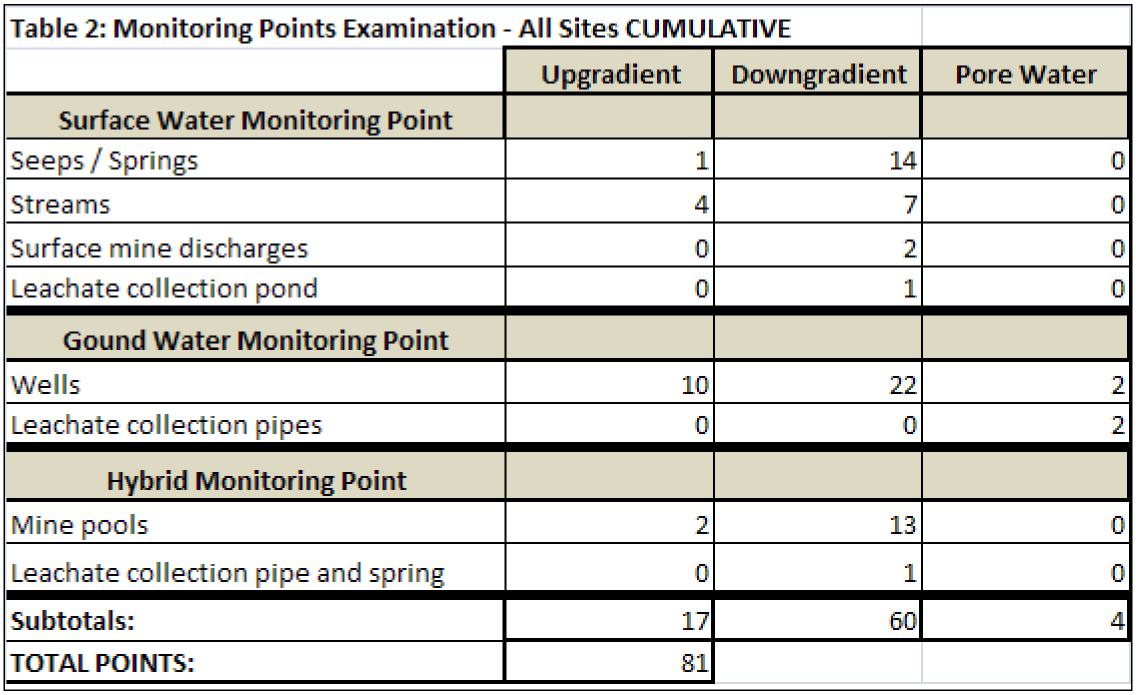

Table 2: Monitoring Points Examination - All Sites CUMULATIVE

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

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[15] 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,

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[15] 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.

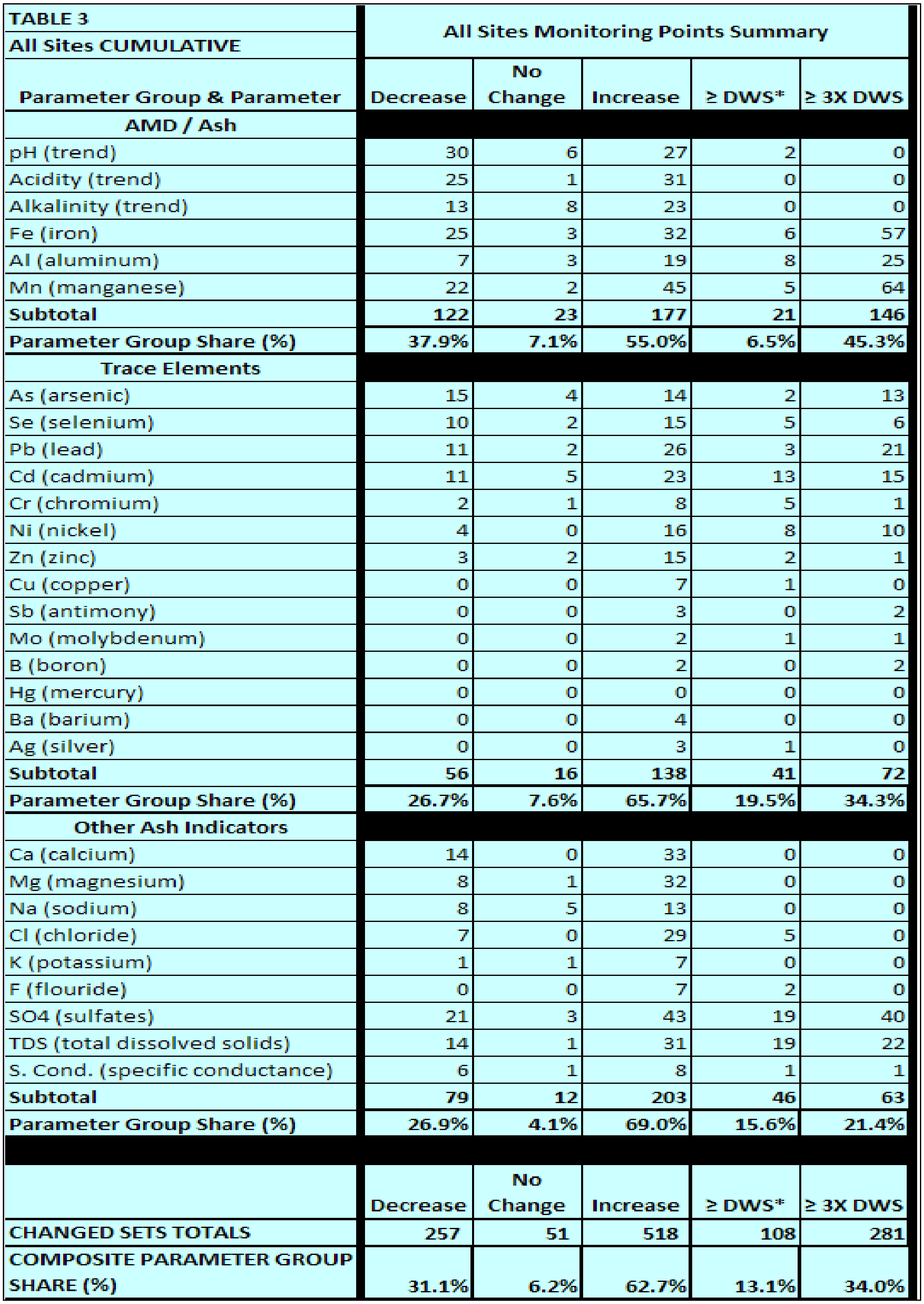

TABLE 3 All Sites CUMULATIVE	All Sites Monitoring Points Summary				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash					
pH (trend)	30	6	27	2	0
Acidity (trend)	25	1	31	0	0
Alkalinity (trend)	13	8	23	0	0
Fe (iron)	25	3	32	6	57
Al (aluminum)	7	3	19	8	25
Mn (manganese)	22	2	45	5	64
Subtotal	**122**	**23**	**177**	**21**	**146**
Parameter Group Share (%)	**37.9%**	**7.1%**	**55.0%**	**6.5%**	**45.3%**
Trace Elements					
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
Subtotal	**56**	**16**	**138**	**41**	**72**
Parameter Group Share (%)	**26.7%**	**7.6%**	**65.7%**	**19.5%**	**34.3%**
Other Ash Indicators					
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
Subtotal	**79**	**12**	**203**	**46**	**63**
Parameter Group Share (%)	**26.9%**	**4.1%**	**69.0%**	**15.6%**	**21.4%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**257**	**51**	**518**	**108**	**281**
COMPOSITE PARAMETER GROUP SHARE (%)	**31.1%**	**6.2%**	**62.7%**	**13.1%**	**34.0%**

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

TABLE 4 All Sites CUMULATIVE	Cumulative UPGRADIENT Site Monitoring Points Summary					Cumulative DOWNGRADIENT Site Monitoring Points Summary				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash										
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
Subtotal	**24**	**8**	**33**	**7**	**32**	**98**	**15**	**144**	**14**	**114**
Parameter Group Share (%)	**36.9%**	**12.3%**	**50.8%**	**10.8%**	**49.2%**	**38.1%**	**5.8%**	**56.0%**	**5.4%**	**44.4%**
Trace Elements										
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
Subtotal	**12**	**1**	**13**	**4**	**4**	**44**	**15**	**125**	**37**	**68**
Parameter Group Share (%)	**46.2%**	**3.8%**	**50.0%**	**15.4%**	**15.4%**	**23.9%**	**8.2%**	**67.9%**	**20.1%**	**37.0%**
Other Ash Indicators										
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
Subtotal	**19**	**6**	**20**	**8**	**6**	**60**	**6**	**183**	**38**	**57**
Parameter Group Share (%)	**42.2%**	**13.3%**	**44.4%**	**17.8%**	**13.3%**	**24.1%**	**2.4%**	**73.5%**	**15.3%**	**22.9%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**55**	**15**	**66**	**19**	**42**	**202**	**36**	**452**	**89**	**239**
COMPOSITE PARAMETER GROUP SHARE (%)	**40.4%**	**11.0%**	**48.5%**	**14.0%**	**30.9%**	**29.3%**	**5.2%**	**65.5%**	**12.9%**	**34.6%**

* 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).[16] 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).[17] 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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[16] 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.

[17] 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).[18] 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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[18] 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.

Certification

Pursuant to Pennsylvania Code Chapter 39, Section 37.59, I herewith sign and seal those portions of the permit data reviews and assessments that fall under the rubric of Pennsylvania's registration regulations for Professional Geologists.

Charles H. Norris
Professional Geologist PG003994
Expires 30-SEP-07

Charles H. Norris
PG003994

Charles H Norris

This report was reviewed by me, Robert A. Gadinski. It contains my professional opinions relevant to the report entitled, Impacts On Water Quality From Placement Of Coal Combustion Waste In Pennsylvania Coal Mines(July 2007). I developed and hold opinions described herein based on data provided me for review. The water quality data presented was reduced by others which was subject to my review and comment. The opinions have been developed using generally accepted scientific principles, practice or methods and each represents a reasonable degree of scientific certainty.

Date: July 25, 2007

Robert Gadinski

Robert A. Gadinski, PG
Pennsylvania Professional Geologist
License Number PG000007G
Expires September 30, 2009

Report on a Review of the Pennsylvania Minefill Study
Submitted by W. D. Richey, Professor Emeritus of Chemistry, Chatham College, Pittsburgh PA

At the request of Jeff Stant, Project Director of the PA Minefill Research Project, for the Clean Air Task Force, I reviewed the PA Minefill Study, as it neared completion. I am trained as a physical chemist, and have taught physical chemistry and analytical chemistry on the college level. For a number of years, I had summer and leave research appointments at the Federal energy laboratories near Pittsburgh (now the National Energy Technology Laboratories (NETL)). I worked on projects related to the liquefaction of coal and to acid rain, and in the general context of coal chemistry.

My emphasis in the review was on the treatment of chemical aspects of the study. I read other sections as a concerned citizen scientist. In my opinion, the treatment of the chemistry is straight forward and systematic, doing all that can be done with the analytical data available, and presented so that problems with sampling and the absence of blocks of data are apparent. The language systematically points to trends and suggests conclusions, which, given the problems with locations of sampling points and the sparseness of the data, is as much as can be done. The sites, the mine spoils, and the ashes are each, in their own ways complex, as are their interactions, site by site. What is clear to me from the study, is that the waters flowing from the sites are not "improved", and often bear the trace metals concentrated in the ashes, at well above acceptable levels.

If I were approaching fresh the completed study (I saw it on-line, some twenty megabytes of material), I would surely start with Chapter 7, Conclusions and Recommendations. In my opinion, the evaluation of the water chemistry presented in Chapter 7 is supported in the detailed discussions of the sites which make up the bulk of the study. Some of the site studies were being revised at the time of my review, but I examined fifteen of them in detail.

I feel that it important to stress that the analytical data being discussed were extracted from the public records, the site permit files of the PADEP, not generated by the authors of the PA Minefill Study. The data for the fifteen sites, surely from a minimum of fifteen analytical groups, were accumulated over more than a decade.The conclusions inferred in the study seem chemically justifiable. This is a work of "synthesis", true, it is an analysis of analytical data, but that should not shift fault with data to the current authors. To attempt further statistical analysis would not be useful. The analysis can not be better than the sample, "statistics", in this case, would obscure the problems.

Chapter 3 - Mine Sites Degraded From Ash Placement

CAPTION - Polluted seep at the property boundary of the McDermott Mine, where 316,000 tons of alkaline FBC ash failed to stop rampant acid mine drainage from remining, and the operator went into bankruptcy, leaving PADEP to reclaim the site. In addition, levels of selenium and cadmium previously undetected, now exceed drinking water standards and water quality standards regularly in this mine’s discharges. Photo by Jeff Stant, August 2007.

CAPTION: Aside from its cloudy appearance, water quality of this drainage from the Ernest Deep Mine underlying the Ernest site has worsened steadily since remining started here 11 years ago with rising acidity, iron, manganese, aluminum and sulfate, while these constituents, with the exception of manganese, have not increased in water in the Deep Mine upgradient from the site's remining and ash placement operations. Trace elements are not monitored in the Deep Mine's discharges. Photo by Jeff Stant, August 2007.

Permit Review 1

ERNEST MINE (PERMIT # 32950201)

Site Summary

The Ernest Mine operation is located in White and Rayne Townships, Indiana County, Pennsylvania. The mine is found in the Cowanshannock-Crooked Creek Priority Watershed 17E as delineated in the Priority Watersheds of the Commonwealth of Pennsylvania State Water Plan. Mining of the Upper Freeport Coal, which began in 1903, left a refuse pile that contained some 9.0 million tons of abandoned coal waste over an area of 94 acres. The permit was issued to the Cambria Reclamation Company on November 22, 1995. The Ernest mine is permitted as a subchapter F remining site. The operation is removing this refuse pile and is also utilizing FBC waste coal ash for alkaline addition to treat AMD. The refuse material is taken out, transported to the Cambria CoGeneration power plant, and FBC coal ash produced from burning the refuse is returned and placed on the site. Ultimately the volume of the ash placed on the site will equal between 85%-100% of the material removed, approximately seven to nine million tons, although the actual ash volumes that have gone to the site to date have been considerably less than this amount. Ash placement commenced in October 1996 and has continued to the present. Records at the PADEP's Harrisburg Office indicate that 1,437,282 tons of FBC ash from the Cambria Plant were placed at the Ernest site from 1998 through 2004.

Geology

The geology of the site consists of the Upper Freeport Coal, which demarcates the top boundary of the Allegheny Group and the bottom of the Glenshaw Formation of the Conemaugh Group. These groups are part of the Pennsylvanian System. The Upper Freeport Coal rests on nonmarine limestone and was formed on a delta plain. As the sea regressed, the area was covered with a layer of sandstone (the Lower Mahoning). Generally, the sulfur content is lower in coals that are overlain by nonmarine conditions and accordingly this applies to the Upper Freeport Coal.

Topography

The topography of the site consists of steep valleys with flat-topped hills consistent with the general topography of southwestern Pennsylvania. Surface waters on the site run in radial patterns into several small streams, seeps, and rills - point sources that ultimately discharge into McKee Run, northwest of the site. McKee Run serves as the water supply to the town of Ernest located upstream from the site. Based on a site inspection, McKee Run is AMD-impacted.

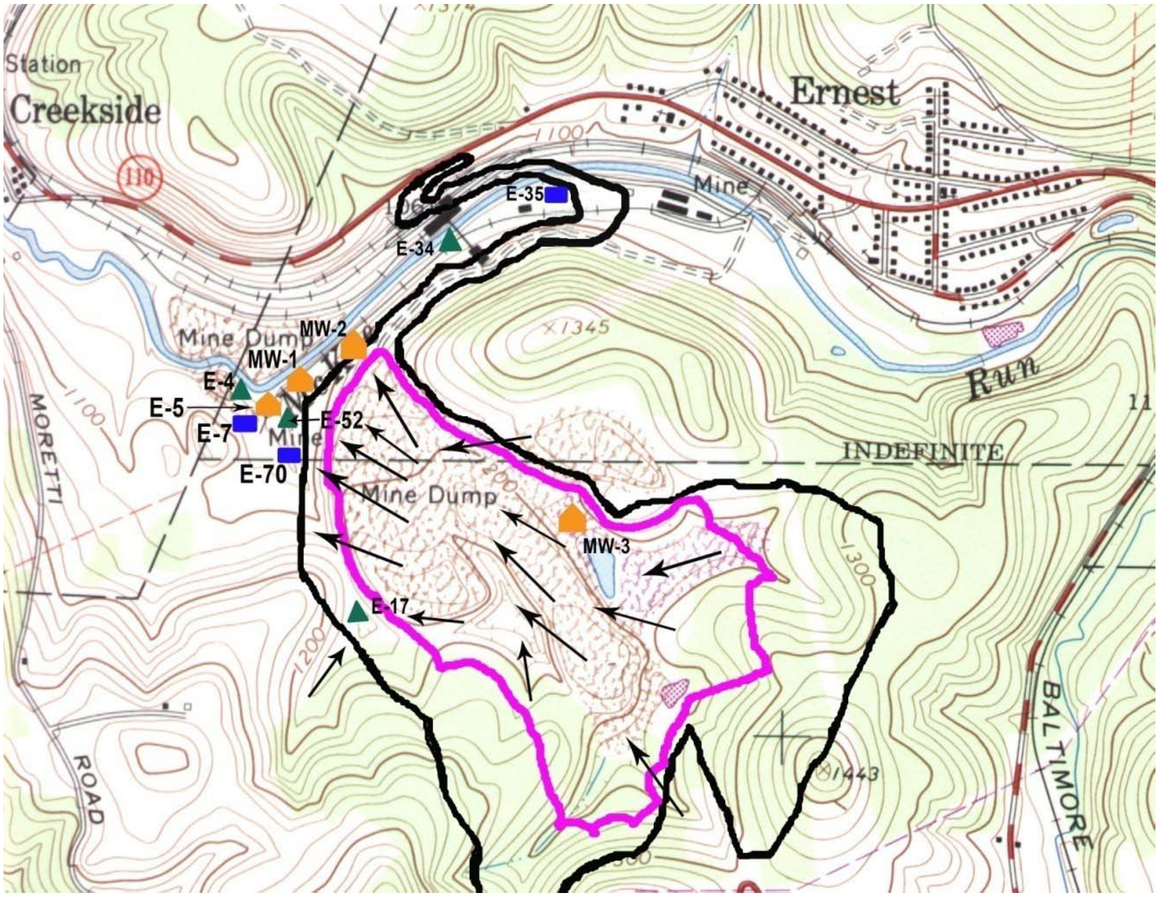
Groundwater

Groundwater flow occurs within the joints, bedding planes, and other discontinuous rocks. The background monitoring and the drilling data provided in the permit indicate that there is a groundwater perch associated with the Freeport Coal seam. More precisely, the perched groundwater table is associated with the clay underlying the Freeport Coal (mostly likely the Bolivar clay), which acts as an aquitard. The water table fluctuates according to seasonal discharges and recharges.

The McKee Run anticline runs through the center of the permit area. The trend of the axis of the anticline runs in a southwest-northeast direction. To the northwest, the strata of the McKee Run anticline dip (tilt) at a rate of 90 feet per mile toward the Elders Ridge syncline. To the southeast, the strata of the McKee Run anticline dip at a rate of 70 feet per mile toward the Dixonville syncline. Regional groundwater flows in the direction of the dipping strata on both sides of the McKee Run anticline. A site-specific shallow groundwater system accumulates on the valley floor at the base of the refuse pile due to the differential permeability between the ground and the refuse pile. *This shallow groundwater, which is the focus of this report, is topographically controlled and flows in a west and northwest direction toward McKee Run.* The plans for the final grade of the ash placement area will divert all surface waters down to McKee Run.

The Upper Freeport coal seam has been extensively deep mined. This deep mine, known as the Ernest No. 2 Mine, lies from 50 to 150 feet below the permit area and forms a deep mine pool that under drains an area of approximately 14,000 acres. According to materials in Modules 8 and 25 in the permit, this deep mine water is, to a great extent, isolated from the shallow ground water emanating from the base of the refuse pile. Monitoring data also indicates the water quality in this deep mine is not as deteriorated as polluted water draining from the Ernest refuse pile. Nonetheless in a June 30, 2005 letter to the Clean Air Task Force concerning a draft of this report, PADEP stressed that the dominance of this deep mine and its large discharge near the Ernest refuse pile must be taken into account in the assessment of the impact of this operation on the area's hydrogeology and downstream water quality. Further assessment of the mine pool water quality is on pages 75 through 79 of this report.

Site Map: Ernest



Map Symbol Key

Permit Boundary	▬
Ash Placement Area	▬
Ash Monitoring Point	⬟
Shallow Groundwater Flow	→
Surface Water Monitoring Point	▲
Minepool Monitoring Point	■

↑ N

Ernest Operation (Permit # 32950201)
Scale: 1” = Approximately 1000’

Monitoring Data: Discussion

Ash monitoring points – pollutant concentrations:

This assessment of water quality for ash impacts is primarily comparing concentrations of numerous parameters in the baseline quality of the shallow groundwater in the refuse pile to concentrations of those parameters occurring after ash placement had been underway for several years. A series of three monitoring wells were installed in locations that, according to the permit, are well suited to monitor impacts to that groundwater from ash placement. These wells and a surface seep, also monitoring the shallow groundwater into which the ash is being placed, are designated officially in the permit as the sole ash monitoring points. At the northwestern end of the refuse pile, the two downgradient monitoring wells, MW1 and MW2, were drilled through the base of the Upper Freeport Coal seam. According to the permit's Module 25, MW1 and MW2 collect samples of the local shallow groundwater discharge from the base of the refuse pile as well as some discharge from the Ernest No. 2 mine pool at the level of McKee Run. E5 is the shallow groundwater seep discharge located downgradient from the ash placement area at the northwest end of the refuse pile. E5 is not influenced by the Ernest No. 2 deep mine pool waters.

MW3 is an upgradient well that was drilled near the crest of the anticline. Although the requirements in the permit call for a monitoring well to be "placed at a point hydraulically upgradient from the mining/ash placement area, and which is capable of representing groundwater quality unaffected by the mining/ash placement activity" (Permit 32950201, page 25-17), MW3 was dry from the moment that it was drilled and was not replaced with another upgradient well. The lack of upgradient monitoring well data has hindered the objective of comparing groundwater quality at a point unaffected by the mining/ash placement activity with downgradient well data that are presumably affected by this activity.

An unnamed intermittent tributary to McKee Run flows along the western side of the refuse pile on which the ash is placed. This tributary is the local base level stream that forms the northwest boundary of the permit area. Several monitoring points have been placed along this tributary to McKee Run. Of these, E52, located near the mouth of the tributary at McKee Run, and to a lesser extent, E17, located further upstream on the tributary, have generated sufficient data to assist in an analysis of water quality impacts. While these monitoring points are not officially designated as ash monitoring points, they are in locations that should readily pick up water quality impacts from activities along the western side of the refuse pile. In fact, E17 is approximately 1000-2000 feet from the southeast section of the pile where the majority of the ash has been placed; MW1, MW2 and E5 are 2200-2400 feet from that southeast section.

The permit issued on November 22, 1995 established "trigger levels" to delineate levels of ash contaminant concentrations that if exceeded at the downgradient ash monitoring points would prompt measures to address degradation from the ash. Trigger levels were set at concentrations that were the higher of PA drinking water standards or the highest baseline concentration measured for the contaminant. The use of these trigger levels was discontinued, however, when the permit was renewed on May 21, 2002 (Part C, Subsection G special condition #12). There is no discussion or documentation in the permit file of the reasons for discontinuing the use of the triggers in the permit.

The following discussion of trends in water quality data at these monitoring points covers data generated from the beginning of baseline sampling in November 1994 to June 2003, nearly seven years after ash placement commenced at the Ernest Mine. An exception is data for trace elements which includes sampling through June 2004. Unless indicated otherwise, trend lines account for data collected after ash placement commenced.

Unless otherwise indicated, concentrations for trace elements graphed at the ash monitoring points in this report are total values rather than dissolved values. In the large majority of cases, we found total and dissolved values for trace elements to be nearly identical (i.e., within a few parts per billion) in water quality monitoring reports from the Ernest site.

MW1

In June, 2002, PADEP issued a report on the Ernest site responding to public concerns about water quality degradation from this operation. Page 5 of this report differentiates the water quality at downgradient ash monitoring point, MW1 from the water quality in the minepool underneath the Ernest site in the following discussion: *"The water quality in MW-1 is indicative of a strong influence from the refuse pile in that it is worse than other water associated with the Ernest No. 2 deep mine and the concentrations of pollutants are more typical of what is seen emanating from refuse piles."*

As seen in the pH graphs in figure 1.1, there are substantive differences in readings between the field and laboratory pH measured at MW-1. Field pH readings decreased throughout the monitoring period by approximately a half unit from 4.5 to 4 while the laboratory readings decreased only by approximately a tenth of a unit from 3.7 to 3.6, suggesting more alkalinity in the water than revealed by field readings.

These differences are significant if one considers that the pH scale is logarithmic. A difference of 1 unit on the pH scale indicates a ten-fold difference in the hydrogen ion activity. Assuming that both field and laboratory meters are equally well calibrated, the field measurement is considered more indicative of the in-situ solution in part because pH is temperature-dependent, therefore ambient water temperature is immediately taken into account during a field test. For example, at 60˚C the neutral point is 6.51 while at 10˚C it is 7.26, a difference of three fourths of a unit. Thus the pH of a sample measured at field temperature is more likely to represent the true pH in the site water than the pH measured in that sample at a different temperature in the laboratory. Changes in dissolved gas content in a sample as its transported from the field to the laboratory can also change pH, again making the measurement of pH in the lab not as accurate a representation of the actual pH as that measured in the field. Notwithstanding these limitations in lab pH measurements, PADEP's 2002 Report states on page 5 that, "*field pH determinations over the past several years have been done using a colorimetric kit which does not yield sensitive results. The field pH data should not be relied upon*." Thus although this report's authors prefer field pH readings generally, they have graphed both field and laboratory values in this report where significant differences in measurements have occurred.

Underscoring the pH decline, acidity (figure 1.2) rose steadily. This implies that AMD is affecting a system that already has a substantial quantity of acidity and also some alkalinity. Concentrations of iron rose steadily after ash placement started, but then dropped sharply starting in September 2000 (figure 1.3). Similarly, manganese concentrations rose slightly and then started dropping in September 2000 (figure 1.4). Concentrations of sulfate (figure 1.5) show a generally constant upward trend for the duration of the sampling period. The rises in these common AMD parameters further suggest the presence of AMD due to the breakdown of iron pyrite.

Iron, manganese and sulfate are also prolific in most CCW and are found in significant quantities in the ash dumped at this site. Manganese and sulfate have readily leached in the SPLP leach test conducted on the ash from the Cambria Co Gen Plant pursuant to the permit although iron, while present in the ash, has not readily leached in the test. While this SPLP test does not simulate the more complex geochemical leaching conditions under which many elements will become mobile (dissolve into water), it does give an indication of the leachability of constituents under more dilute, simple laboratory conditions.

Of note, however, is the sharp drop of 4,000 mg/L CaCO3 equivalence in acidity (figure 1.2) recorded during several samplings, culminating with the acidity concentrations dropping below the lowest baseline reading to 1415 mg/L on September 13, 2000. Other than the large volume of FBC ash that had been placed on the Ernest site by mid-2000, there is no other readily explainable source of alkalinity that could have been responsible for this degree of drop in acidity, particularly while remining operations should have been increasing acidity. While the authors of this report could not find figures on the total volumes received at the site in 1996 and 1997, records in the central office of PADEP in Harrisburg indicate that at least 750,000 tons of FBC ash was placed on the Ernest refuse pile from 1998 through 2000. Thus as the permit explicitly intended, the drop in acidity from 1999 through 2000 suggests that the ash is in fact affecting water quality to some extent. Concurrent with the drop in acidity were rises in a number of other constituents, including a spike in chloride concentrations (figure 1.6) to a level exceeding the DWS (250 mg/L) and higher calcium concentrations (figure 1.7). These two parameters are associated with ash leachate but not mine drainage from this refuse pile.

Magnesium is another ash leachate parameter that typically follows calcium concentrations at FBC ash sites in coal mines. Magnesium rose in MW1 from an average concentration of 184 mg/L before ash placement to 214 mg/L after ash placement, with the highest concentration, 280 mg/L, measured in September 1999; three years after ash placement began. The higher concentrations of calcium, magnesium and chloride after ash placement provide more evidence suggesting an impact on water quality from the FBC coal ash. Calcium, magnesium and chloride have readily leached from the FBC ash placed at this site in the permit leach test.

MW1 trace element data (figure 1.8) show a sharp increase (8 times trigger levels) in the concentration of lead in samplings from 1999 to 2001. However, concentrations in the September 1999 and June 2000 samplings reflect a detection limit of 0.400 mg/L (80 times the PA MCL for lead) used by the laboratory rather than actual determined values. This same high detection limit disguised actual lead concentrations for samplings at MW2 and E5 on these dates. Still, actual lead concentrations at MW1 of 0.170 mg/L in September 2000 and 0.131 mg/L in June 2001 at MW1 exceed the highest baseline (before ash placement) concentration (0.012 mg/L) by more than 10 times and all other baseline concentration samplings by more than 13 times. These lead concentrations are more than 8 times the federal MCL (Action Level) for lead of 0.015 mg/L and more than 26 times the PA MCL of 0.005 mg/L for lead. None of the baseline lead levels exceed the federal MCL. This increase in the lead concentration was measured during a period in which acidity dropped significantly at MW1, suggesting that the ash may be the source of these higher lead levels.

Lead has also readily leached in a number of the leach tests on the ash disposed at this site. For example, the SPLP tests performed on a sample of FBC fly ash from the Cambria plant collected in August 1994 for the Ernest Permit leached a lead concentration of 0.180 mg/L, 12 times the federal drinking water standard (0.015 mg/L). An April 1999 sample of FBC fly ash collected as part of the operator's *Semi-Annual Report of Ash Placement* at the Ernest site leached a lead concentration of 0.25 mg/L, more than 16 times the federal drinking water standard. The FBC bottom ash sampled as part of that report leached a lead concentration of 0.35 mg/L, more than 23 times the federal drinking water standard.

High detection limits for selenium prevented its concentrations from being analyzed at any of the three ash monitoring points (MW1, MW2 and E5). Selenium leached above detection limits in some of the permit's leach tests. Selenium was also found in March 2002 at 0.016 mg/L and in April 2002 at 0.020 mg/L in samples taken from a surface impoundment that received drainage from the ash placement area.

Arsenic concentrations regularly exceeded baseline concentrations and the federal and state MCLs after ash placement. However, in its June 2002 report, PADEP indicated that a very large spike in the concentration of arsenic (to more than 70 times the MCL) occurred in June 1996, four months before ash placement on the refuse pile at Ernest actually began. This implies that baseline conditions had the potential to generate significantly higher arsenic levels than were typically measured. The same can be said of chromium, which has had elevated concentrations before and after ash placement at MW1. Arsenic and chromium have also leached in a number of the leach tests on the ash disposed at this site.

It is not clear to this report's authors when exactly ash was first placed at the Ernest site and therefore whether high trace metal concentrations at ash monitoring points prior to October, 1996 might not have been caused by the ash despite PADEP's statement that *regular* ash shipments were not actually underway until that date. The last baseline monitoring sampling at ash monitoring points was officially taken on October 19, 1995. The permit was issued on November 22, 1995. The site was "activated" by the operator in the spring of 1996 with construction of an access road and erosion and sediment control structures. Researchers have found an ash placement report for the first half of 2002 which states that Cambria Cogen ash was used in "haul road construction and maintenance." A major if not the primary access road and haul road leading into the Ernest site passes within 300-800 feet of these ash monitoring points. Details on the timing, use and locations for earlier use of ash on this road are not spelled out in the Module 10 of the permit which outlined the operation at the site. Nonetheless presumably the haul road would have been constructed before ash shipments to Ernest for reclamation of the refuse pile would have commenced. Furthermore according to the 2002 PADEP report (page2):

> "In July 1996, a large thunderstorm caused massive erosion on the northwestern flank of the pile, washing some refuse onto adjacent property. Cambria Reclamation regraded that face of the pile to repair erosion damage and, according to inspection reports, hauled a very small amount of ash onto the site. However, refuse recovery and ash placement did not begin until October 1996."

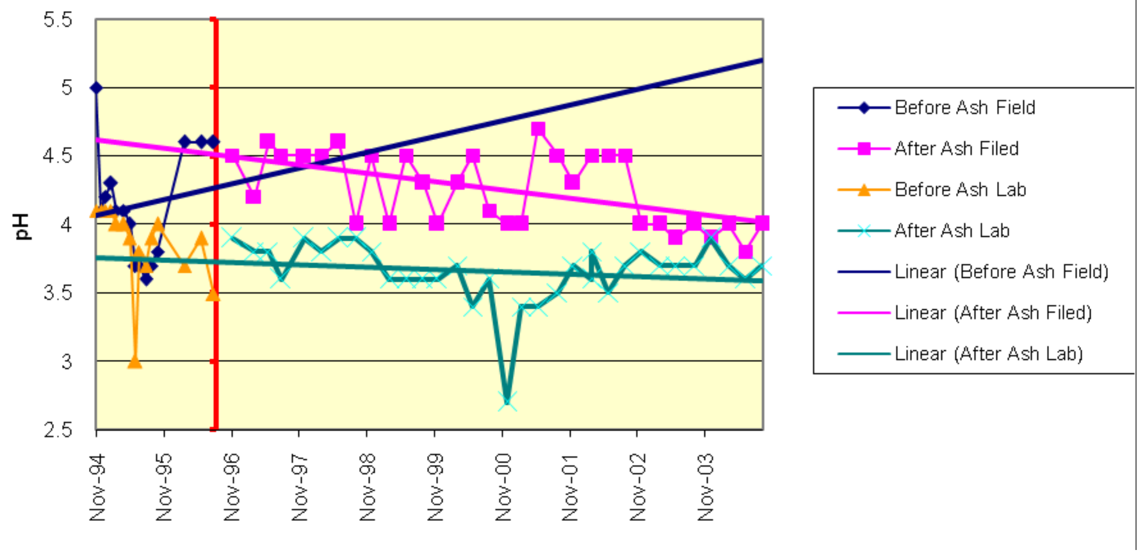
The ash monitoring points are located adjacent to the northwestern flank of the pile.

Until 2003, cadmium samplings resulted in measurements below detection limits, including those in figure 1.8 for 1999 and 2000. Then in June, 2003, cadmium was measured at 0.043 mg/L at MW1. This is 4.5 times the highest level of cadmium recorded before ash placement and over 8 times the state and federal MCL for cadmium of 0.005 mg/L. In June of 2004 cadmium was measured at 0.066 mg/L at MW1, over 13 times the allowable state and federal MCL. Cadmium is a designated ash parameter that is found in the ash being placed at this site, although it has not readily leached in most of the leach tests done on the ash.

Concentrations of aluminum (figure 1.9), nickel (figure 1.10) and zinc (figure 1.11) measured at MW1 have also steadily increased during the monitoring period beyond baseline levels (measured prior to ash placement). Aluminum rose from levels hundreds of times the federal secondary MCL before ash placement to thousands of times this standard after ash placement. Nickel rose from baseline levels 7 to 9 times the old federal MCL of 0.100 mg/L to levels 10 to 22 times this standard after ash placement. The highest level, 0.220 mg/L, was measured in September 2000. PADEP considers these three parameters to be indicative of AMD but also designates them as ash leachate parameters in the Module 25 monitoring reports for this permit and other CCW minefill permits. Aluminum, nickel and zinc are known to readily leach from FBC coal ash. While aluminum has leached in some of the leach tests on the ash at this site, nickel and zinc have leached more consistently in those tests.

In addition, copper concentrations have risen at MW1 slightly from an average of 0.029 mg/L before ash placement to an average concentration of 0.051 mg/L after ash placement. The highest copper concentration measured was 0.220 mg/L in June 1998. Removing the two highest figures from the data to compare the more typical concentrations resulted in an average copper value before ash placement of 0.023 mg/L, compared to an average value after placement of 0.027 mg/L. Copper has been identified as an AMD parameter by PADEP, but it is also a designated ash parameter that is found in the ash being placed at this site. Copper has readily leached in some, but not all of the leach tests done on the ash at this site.

Figure 1.1 32950201-MW1-Ernest pH



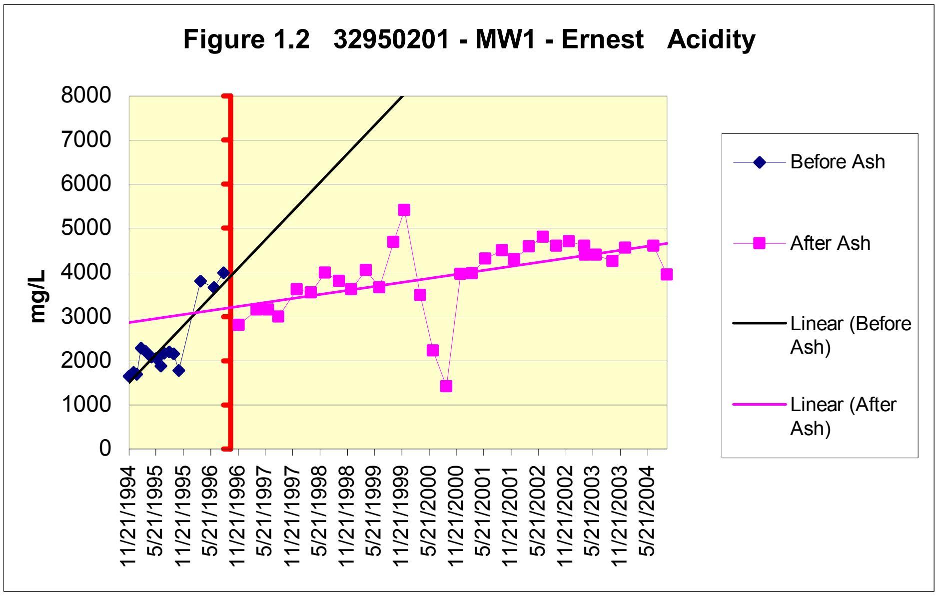


Figure 1.2 32950201 - MW1 - Ernest Acidity
mg/L
8000
7000
6000
5000
4000
3000
2000
1000
0
11/21/1994
5/21/1995
11/21/1995
5/21/1996
11/21/1996
5/21/1997
11/21/1997
5/21/1998
11/21/1998
5/21/1999
11/21/1999
5/21/2000
11/21/2000
5/21/2001
11/21/2001
5/21/2002
11/21/2002
5/21/2003
11/21/2003
5/21/2004
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

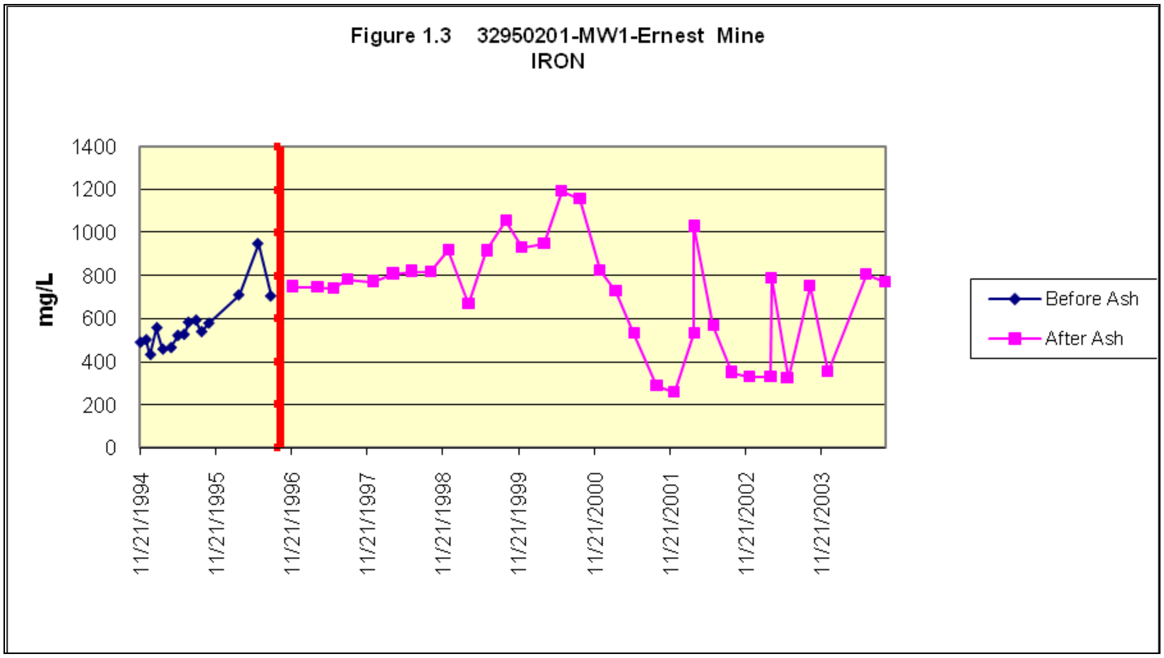


Figure 1.3 32950201-MW1-Ernest Mine IRON
mg/L
1400
1200
1000
800
600
400
200
0
11/21/1994
11/21/1995
11/21/1996
11/21/1997
11/21/1998
11/21/1999
11/21/2000
11/21/2001
11/21/2002
11/21/2003
Before Ash
After Ash

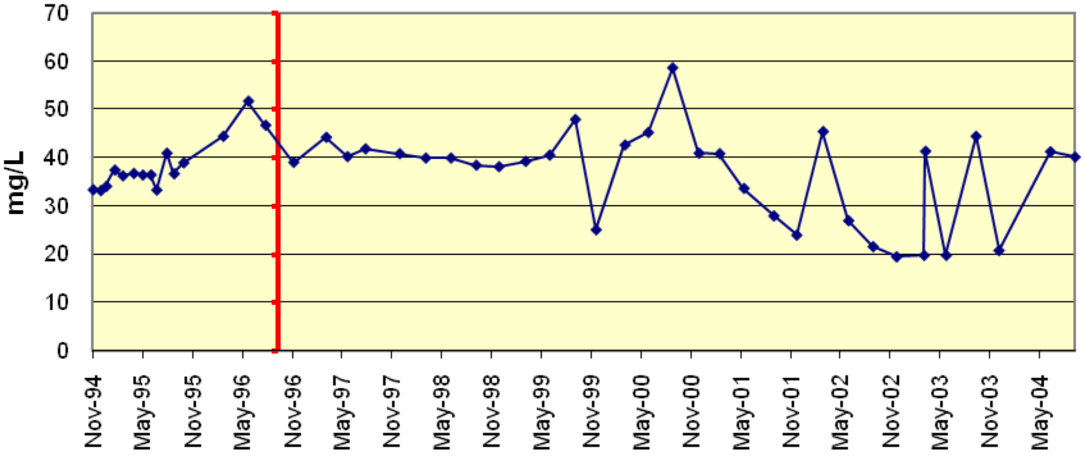


Figure 1.4 32950201-MW1-Ernest Mine
MANAGANESE

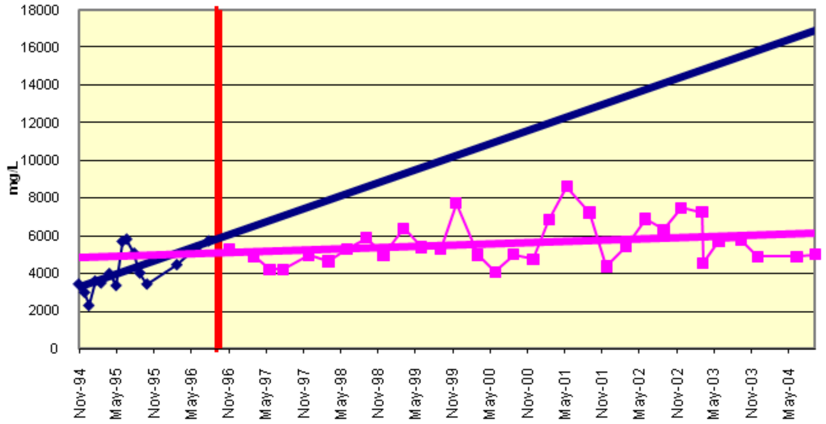


Figure 1.5 32950201-MW1-Ernest Mine
SULFATES

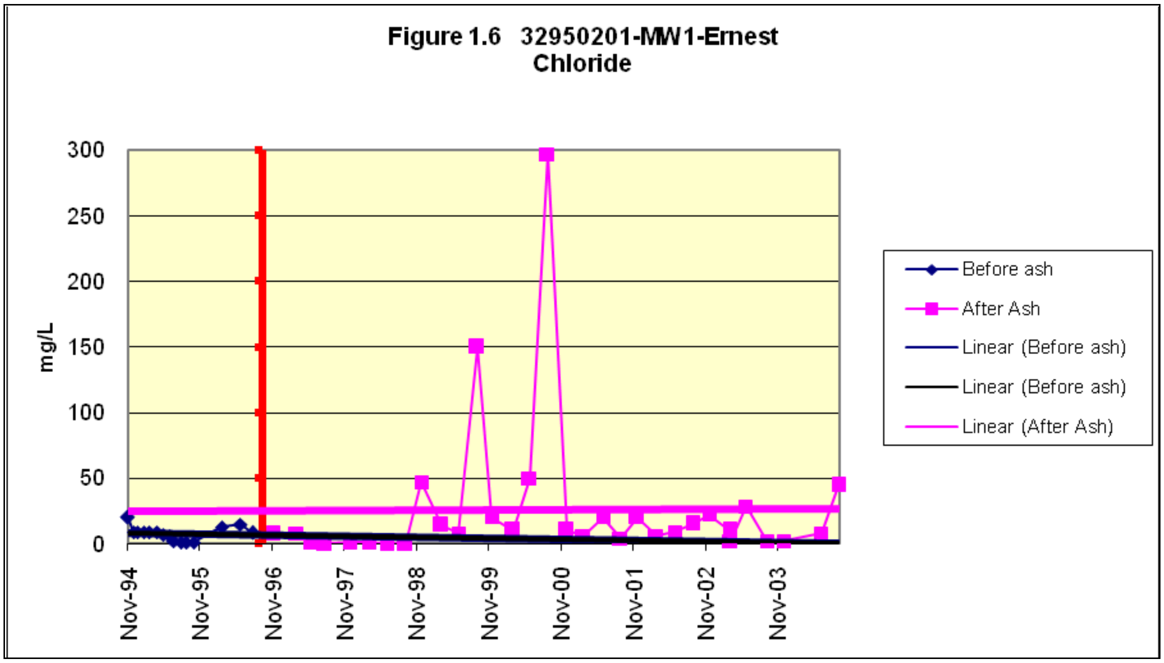


Figure 1.6 32950201-MW1-Ernest
Chloride
mg/L
300
250
200
150
100
50
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After Ash
Linear (Before ash)
Linear (Before ash)
Linear (After Ash)

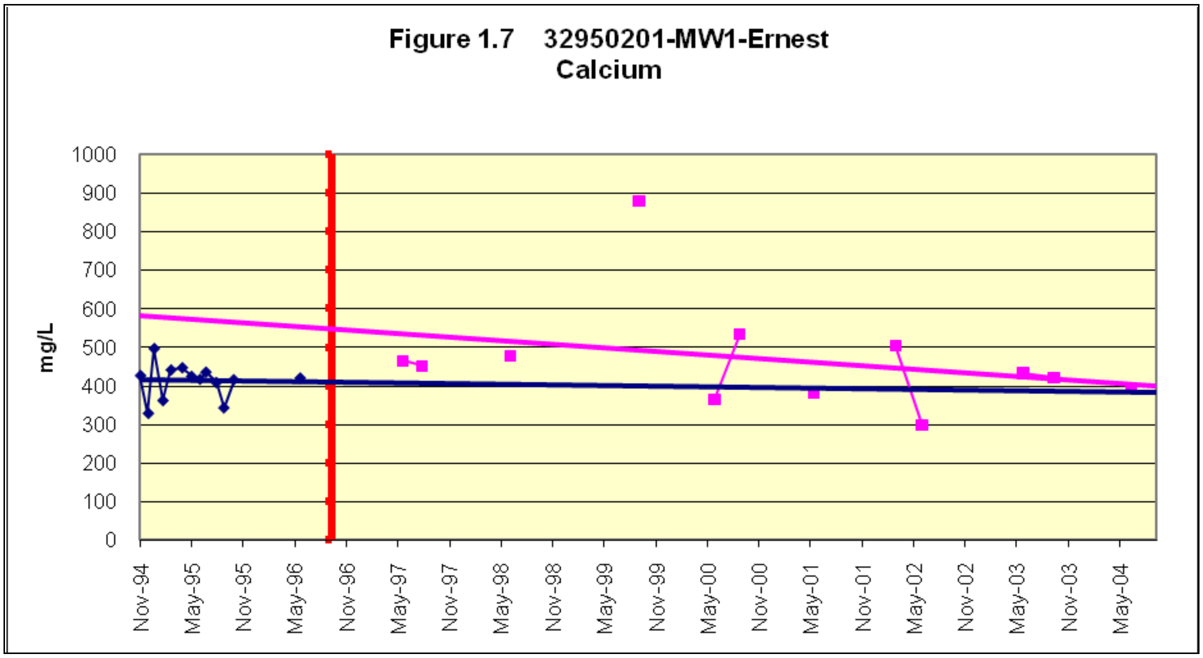


Figure 1.7 32950201-MW1-Ernest
Calcium
mg/L
1000
900
800
700
600
500
400
300
200
100
0
Nov-94
May-95
Nov-95
May-96
Nov-96
May-97
Nov-97
May-98
Nov-98
May-99
Nov-99
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04

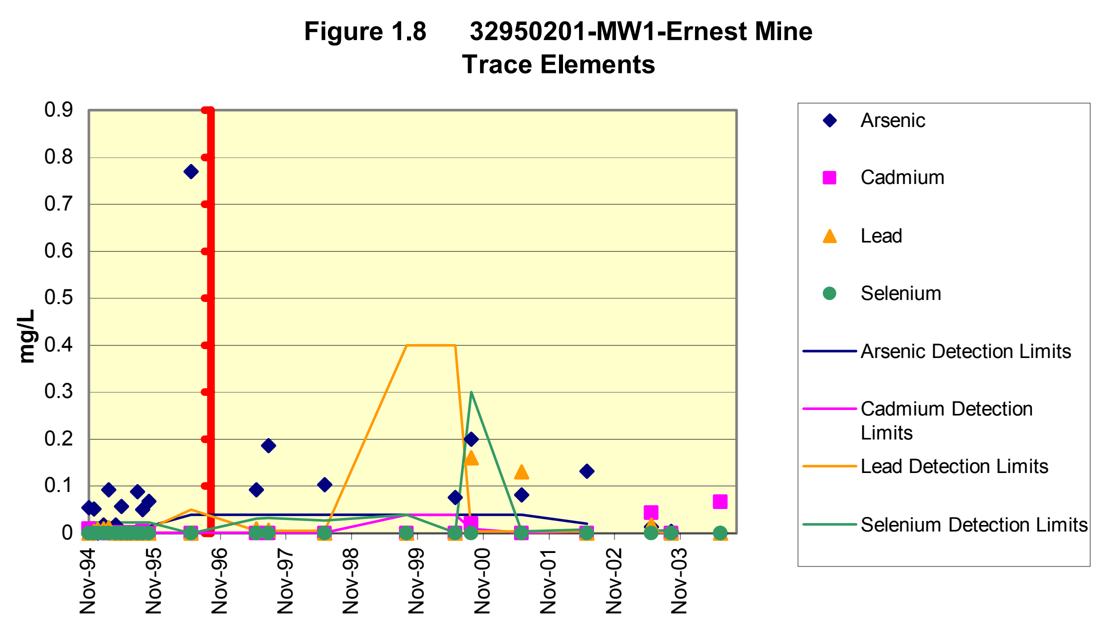


Figure 1.8 32950201-MW1-Ernest Mine
Trace Elements
mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Arsenic
Cadmium
Lead
Selenium
Arsenic Detection Limits
Cadmium Detection Limits
Lead Detection Limits
Selenium Detection Limits

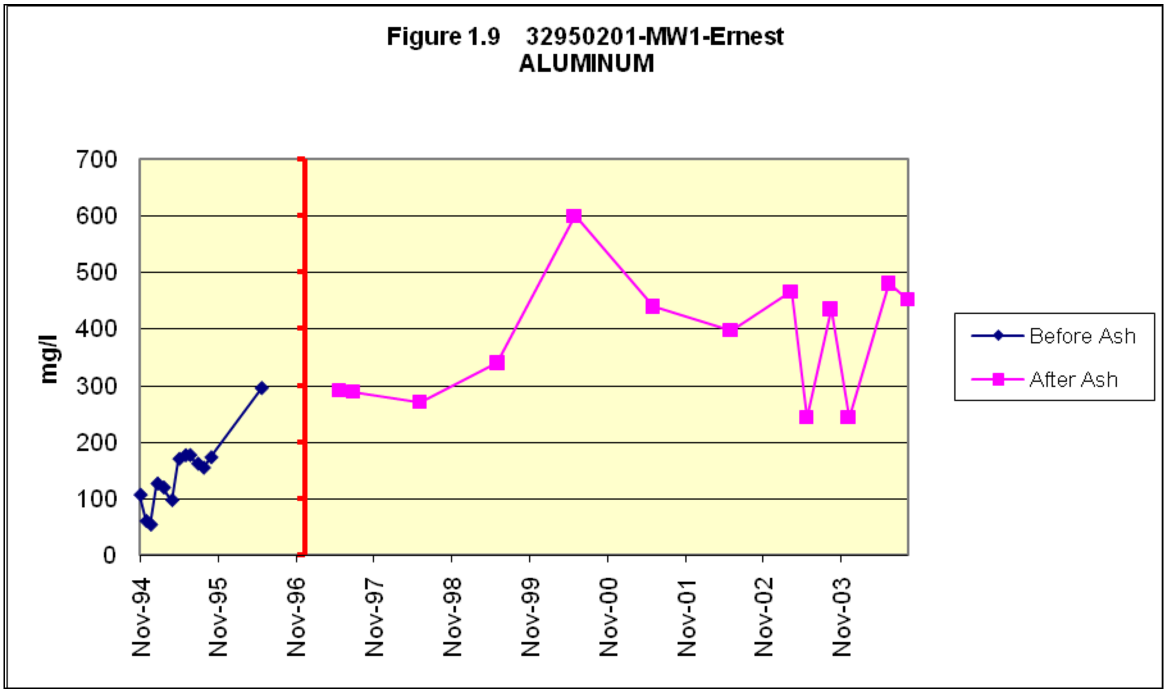


Figure 1.9 32950201-MW1-Ernest
ALUMINUM
mg/l
700
600
500
400
300
200
100
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash
After Ash

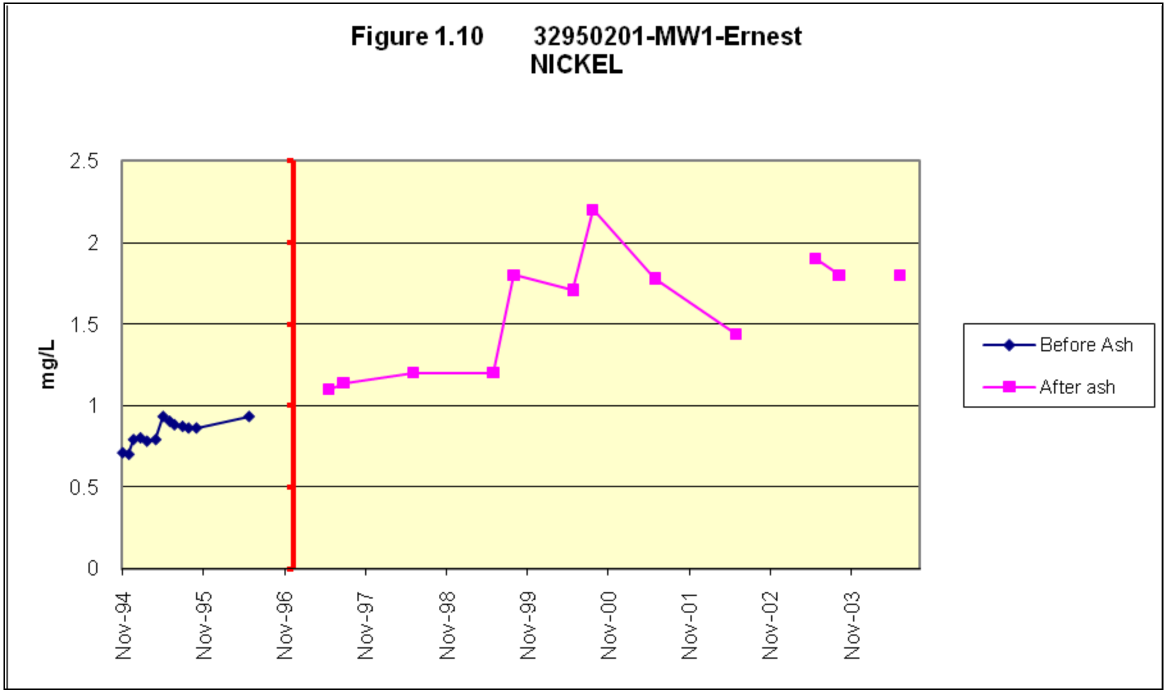


Figure 1.10 32950201-MW1-Ernest
NICKEL
mg/L
2.5
2
1.5
1
0.5
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash
After ash

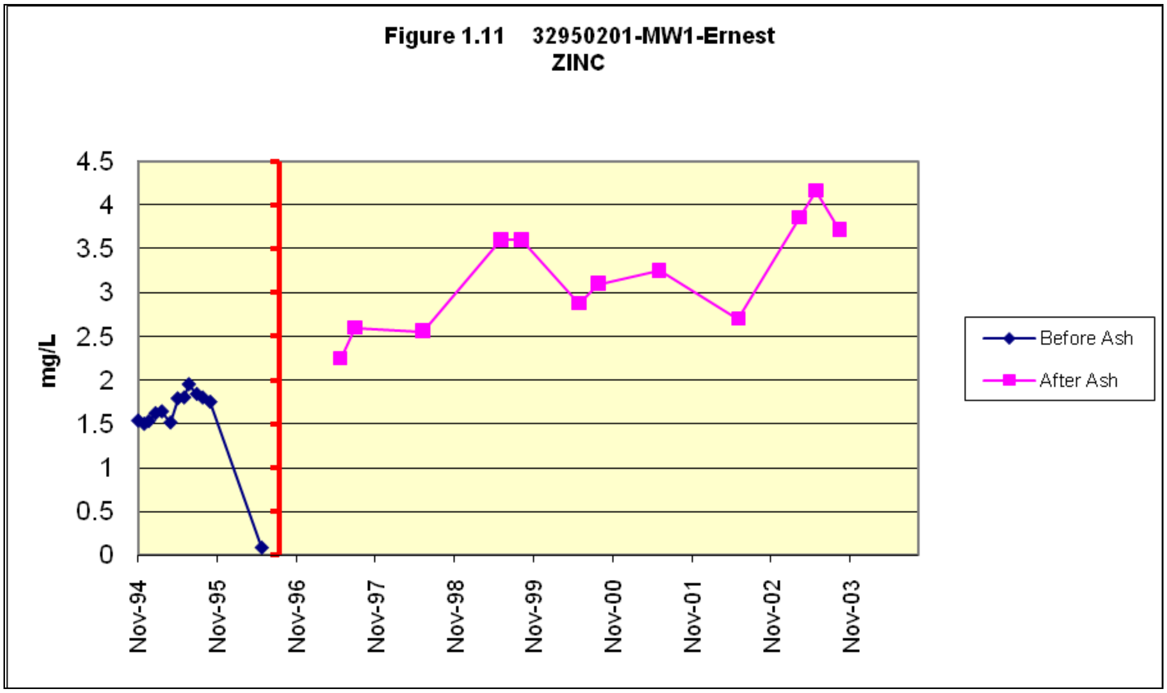


Figure 1.11 32950201-MW1-Ernest
ZINC
mg/L
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash
After Ash

E-5

The downgradient ash monitoring point E-5, is a refuse pile discharge point. According to the PADEP 2002 Report (page 9), "*E-5 seeps directly from the Ernest Mine refuse piles, and is not influenced by the Ernest No. 2 deep mine pool.*"

The pH data (figure 1.11a) show a very pronounced difference between field and lab readings at E-5. The field readings show a decrease towards the end of the sampling period from approximately 4.5 to 4.0 units while the lab pH readings rose in the same period, late 2003 and 2004, by nearly one and a half units from below 2.5 to nearly 4.0 units. The data shows a slow increase in acidity (figure 1.12) during the monitoring period. The rise in AMD and/or the ash may have contributed to rising sulfate (figure 1.13) and manganese (figure 1.14) concentrations, although iron declined during the monitoring period. Again, like MW1, there was a major yet temporary decline in acidity (and AMD) from a high of 5100 mg/L before ash placement, rising to 5660 mg/L in December 1997, before declining eventually to 955 mg/L in September 2000 in the same sampling as the lowest concentration of acidity occurred at MW1.

Calcium concentrations rose after ash placement (figure 1.15) and nearly doubled, rising from 279 mg/L in June 2000 to 536 mg/L in September 2000, during the period of declining acidity. In the previous quarter the chloride concentration (figure 1.16) rose to 3 times its preceding concentrations, although it had fallen back to the previous concentration when the lowest acidity was measured in September 2000. The overlap of rising concentrations of calcium and chloride and of declining acidity at E-5 suggests once again an impact from the FBC ash at this site, which contains high alkalinity and high leachable amounts of calcium and chloride. The average magnesium concentration in E-5 rose from 72.52 mg/L before ash placement to 81.81 mg/L after ash placement with the highest concentrations surpassing 100 mg/L, after ash placement.

Trace element data from E-5 (Figure 1.17) show a sharp rise in lead during the same time period when lead was observed to rise at MW1. As with MW1, the 0.400 mg/L value reported in the September 1999 and June 2000 samplings was actually the laboratory detection level, not a measured concentration. However, lead levels of 0.130 mg/L and 0.146 mg/L actually measured in September 2000 and June 2001, respectively, were at least 13 times higher than all lead levels measured at E-5 before ash was placed at the site and 26-29 times higher than the PA MCL for lead. As was observed at MW-1, this degradation from higher lead concentrations coincided with the drop in acidity at E-5, suggesting that the ash may be the source of these higher lead levels.

The monitoring data at both MW-1 and E-5 show that several other metals reached significant peaks or maximum concentrations during this drop in acidity in 2000. A high arsenic level of 0.480 mg/L at E-5 before ash placement rose to even higher levels after ash placement started, rising to 0.497 mg/L in June 1998 and 0.513 mg/L in September 2000. However, the average arsenic concentration at E-5 declined from 0.186 mg/L before ash placement to 0.173 mg/L after ash placement.

Chromium concentrations at E-5 (figure 1.18) were elevated in baseline concentrations but rose after ash placement. An average chromium concentration of 0.115 mg/L before placement rose to 0.145 mg/L after placement with the highest readings of 0.240 mg/L in September 1999 and September 2000, nearly 2.5 times the federal MCL for chromium.

Cadmium concentrations rose at E-5 (figure 1.19) from levels approximating 1-2 times the federal MCL of 0.005 mg/L in the baseline period to 4 to 6 times this drinking water standard (0.024 mg/L to 0.030 mg/L) in September 2000 and June 2003 and to 0.074 mg/L in the second quarter of 2004, the latest measurement available in the permit file. This concentration is 14.8 times the MCL.

Copper levels rose significantly at E-5 (figure 1.20) since ash placement started and most of the higher concentrations were measured after 2000. Average concentrations rose from 0.392 mg/L before ash placement to 0.497 mg/L after ash placement. Five copper concentrations after ash placement exceeded the highest baseline copper concentration measured. The highest concentration, 0.75 mg/L, was measured in September 2000. The federal secondary MCL (action level) for copper is 1.300 mg/L.

The degradation from aluminum at E-5 (figure 1.21) was severe prior to ash placement, with most measurements exceeding the highest end point of the federal secondary MCL standard (0.050 to 0.200 mg/L) by at least 1500 times and the highest baseline measurement (575 mg/L) exceeding this standard by 2875 times. However, after mining and ash placement began aluminum levels surpassed this highest baseline concentration with the highest concentration (783 mg/L in September 2000) exceeding the secondary MCL by 3915 times.

Concentrations of nickel (figure 1.22) and zinc (figure 1.23) rose significantly above baseline levels at E-5 after ash placement began. Zinc values from 1999 to mid-2003 were usually twice as high as the average baseline concentrations. The zinc concentration sampled in September 2000 of 5.60 mg/L exceeded a concentration trigger in the Ernest permit as well as the federal secondary MCL for zinc of 5.00 mg/L. Nickel concentrations exceeded the highest baseline concentration of 1.49 mg/L in seven out of 12 samplings after ash placement started, each time surpassing the concentration trigger set at this high baseline level. The highest nickel measurement reached 3.40 mg/L in September 2000, 34 times the old federal MCL for nickel. Note that like lead, arsenic, aluminum, cadmium, chromium, copper, and zinc, this very high concentration of nickel coincided with the lowest level of acidity measured at E-5.

Levels of aluminum, arsenic, cadmium, chromium, nickel and lead exceeded the concentration triggers established in this permit at these ash-monitoring points at least 17 time before the triggers were removed from the permit in May 2002. These triggers were set in PADEP ash mine placement permits prior to April 1998 to provide a threshold of pollution which could not be exceeded without an agency response. The researchers of this report could find no documentation of responses to these trigger exceedances by PADEP.

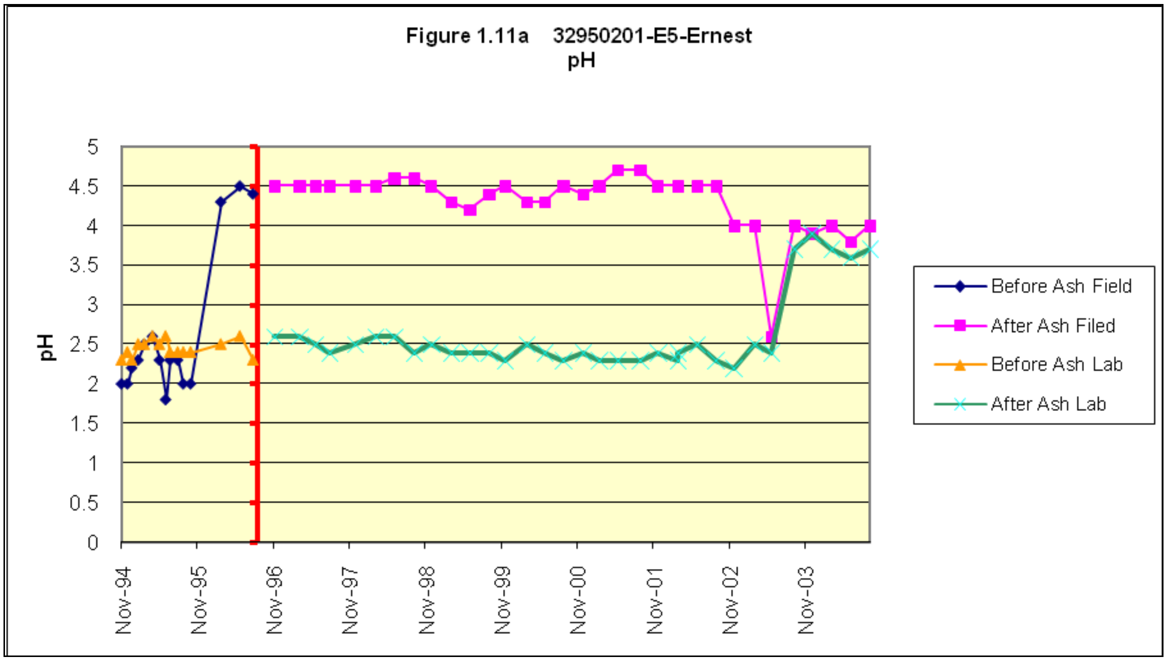


Figure 1.11a 32950201-E5-Ernest
pH
pH
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash Field
After Ash Filed
Before Ash Lab
After Ash Lab

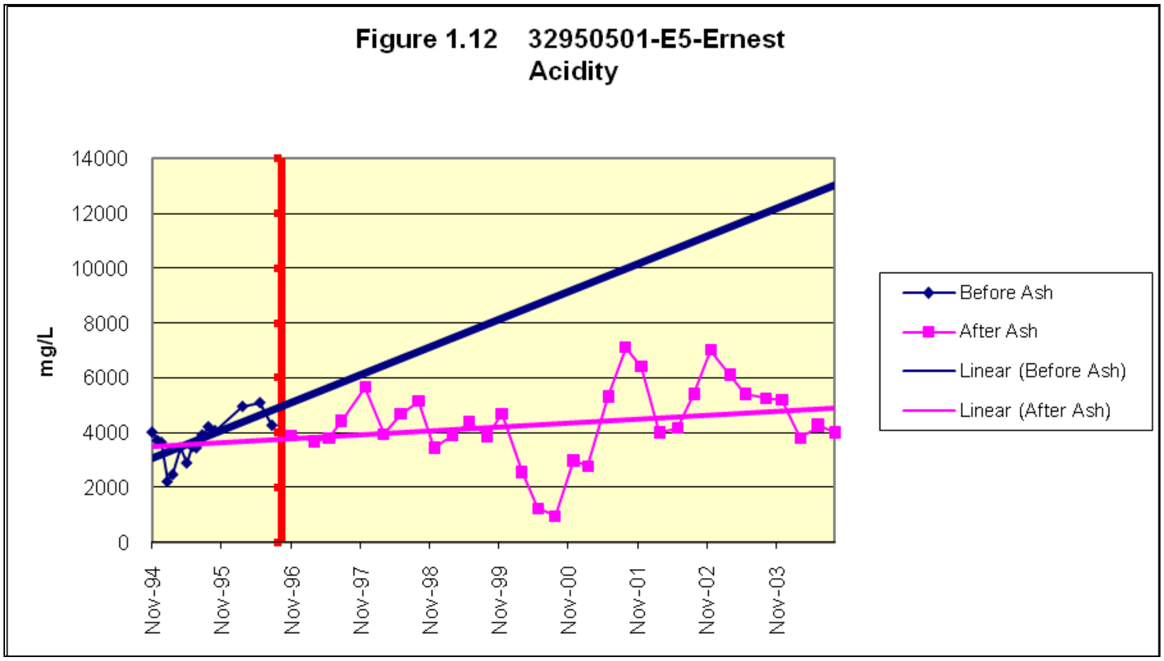


Figure 1.12 32950501-E5-Ernest
Acidity
mg/L
14000
12000
10000
8000
6000
4000
2000
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

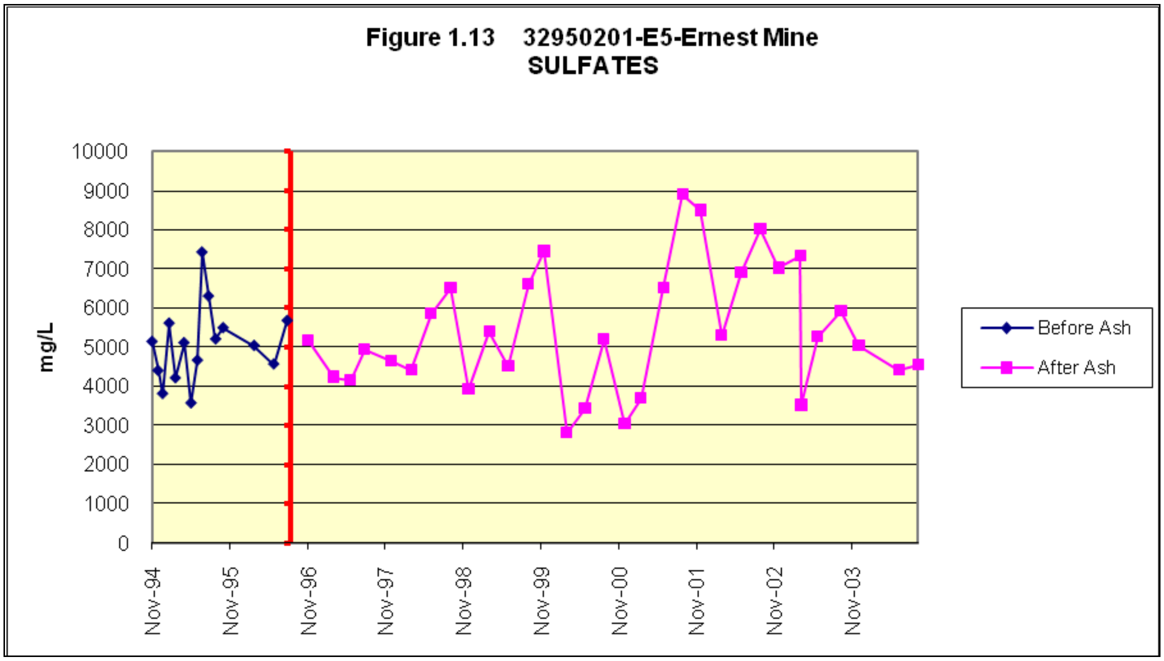


Figure 1.13 32950201-E5-Ernest Mine
SULFATES
mg/L
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash
After Ash

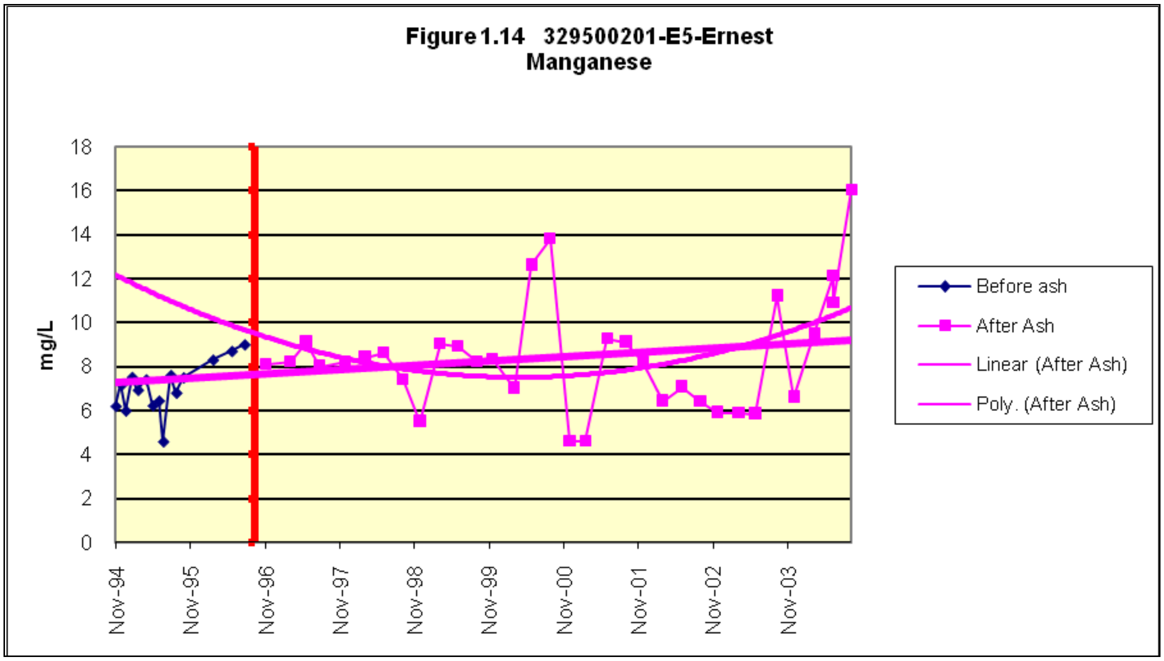


Figure 1.14 329500201-E5-Ernest
Manganese
mg/L
18
16
14
12
10
8
6
4
2
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After Ash
Linear (After Ash)
Poly. (After Ash)

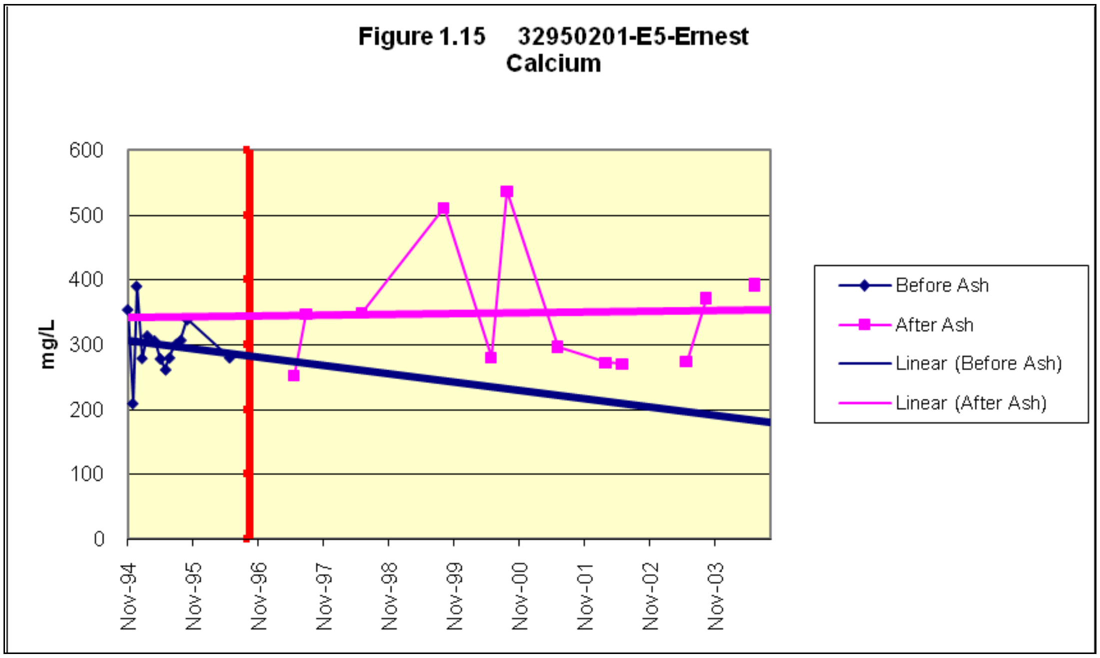


Figure 1.15 32950201-E5-Ernest
Calcium
mg/L
600
500
400
300
200
100
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

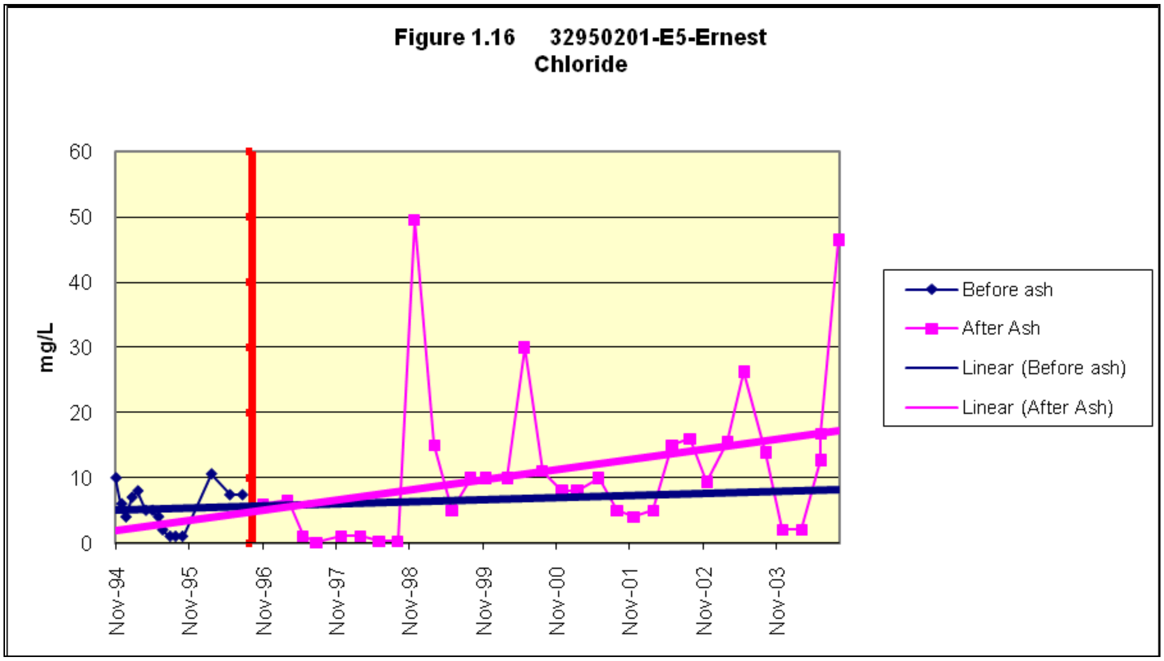


Figure 1.16 32950201-E5-Ernest
Chloride
mg/L
60
50
40
30
20
10
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After Ash
Linear (Before ash)
Linear (After Ash)

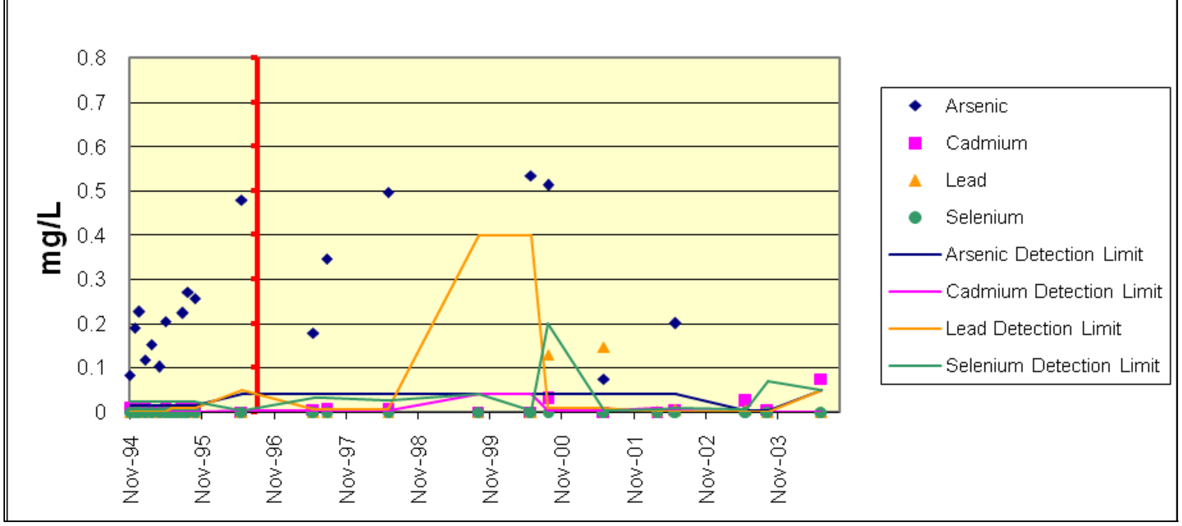


Figure 1.17 32950201-E5-Ernest Mine Trace Elements

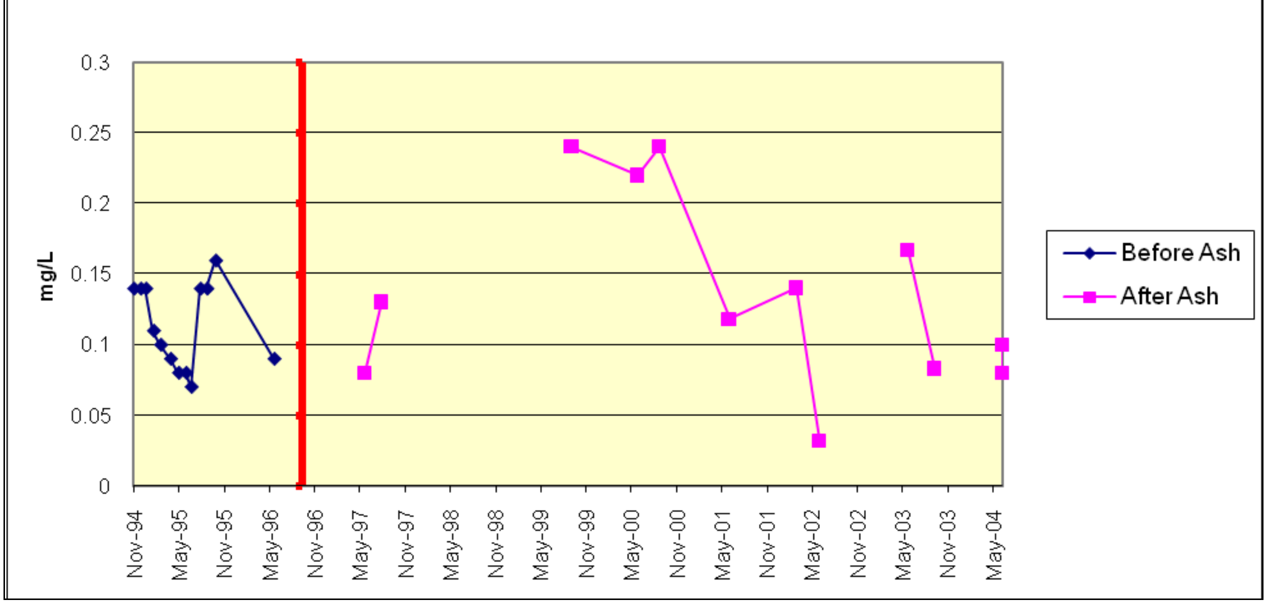


Figure 1.18 32950201-E5-Ernest Chromium

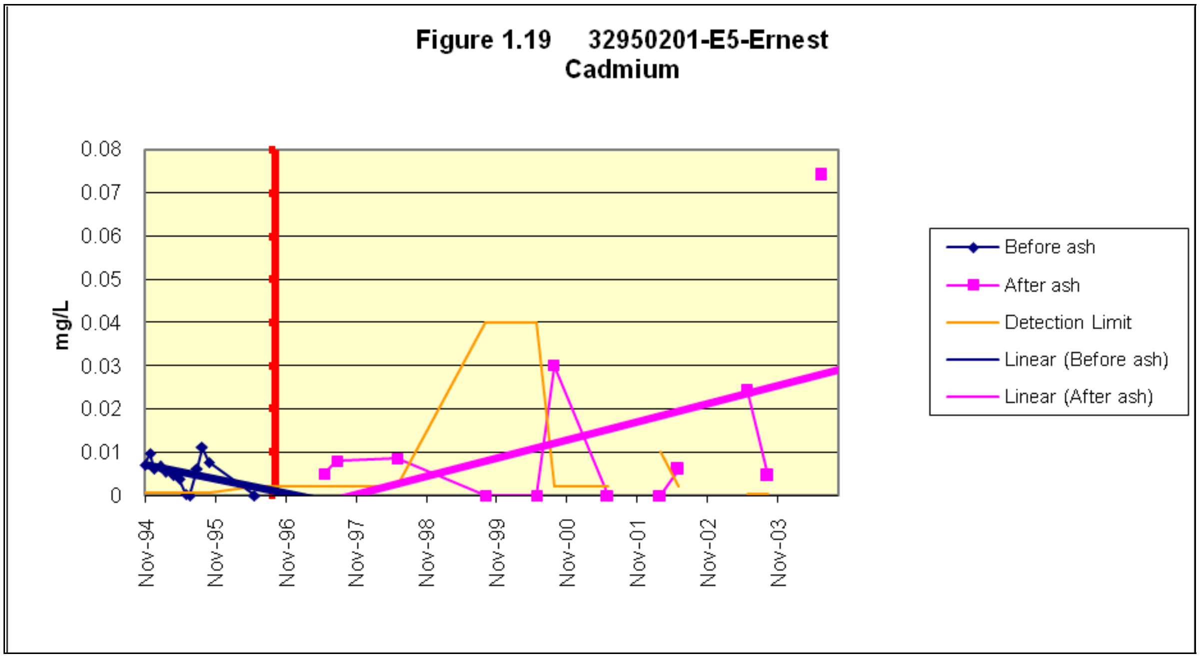


Figure 1.19 32950201-E5-Ernest
Cadmium
mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After ash
Detection Limit
Linear (Before ash)
Linear (After ash)

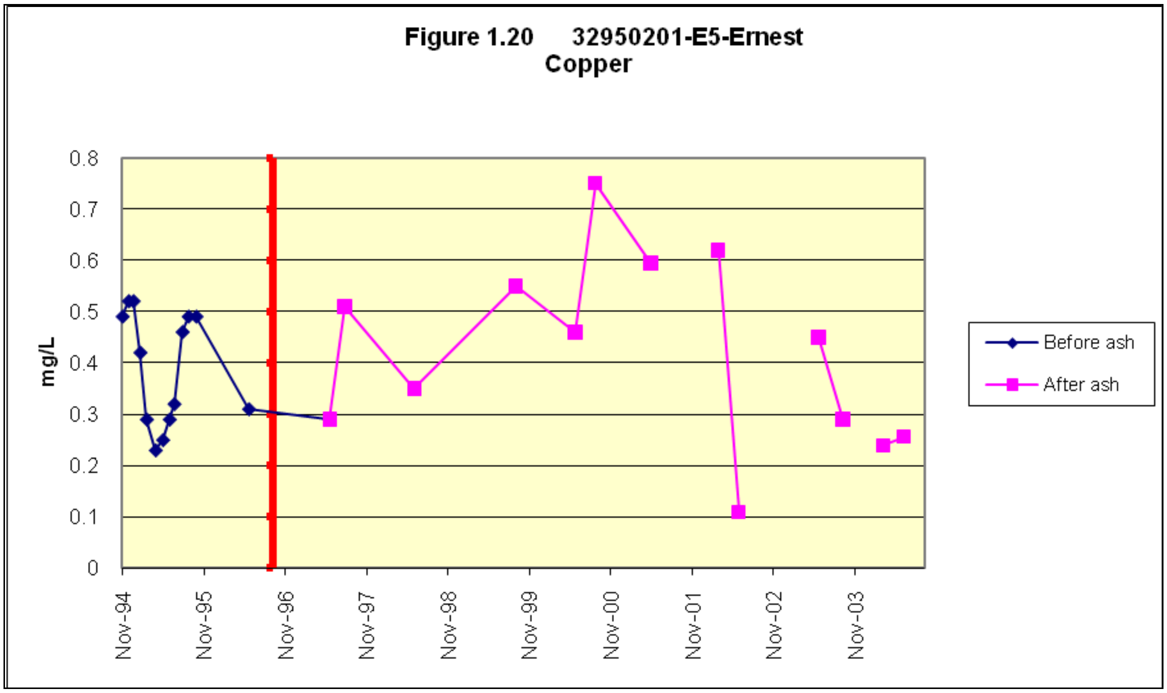


Figure 1.20 32950201-E5-Ernest
Copper
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After ash

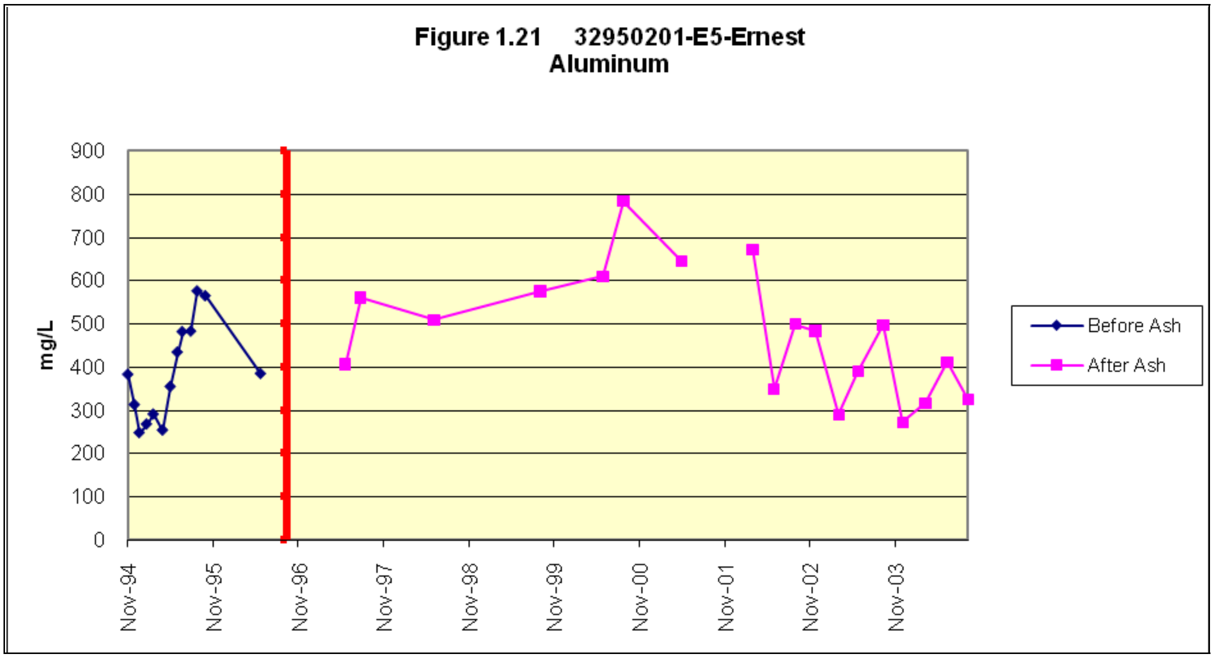


Figure 1.21 32950201-E5-Ernest
Aluminum
mg/L
900
800
700
600
500
400
300
200
100
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash
After Ash

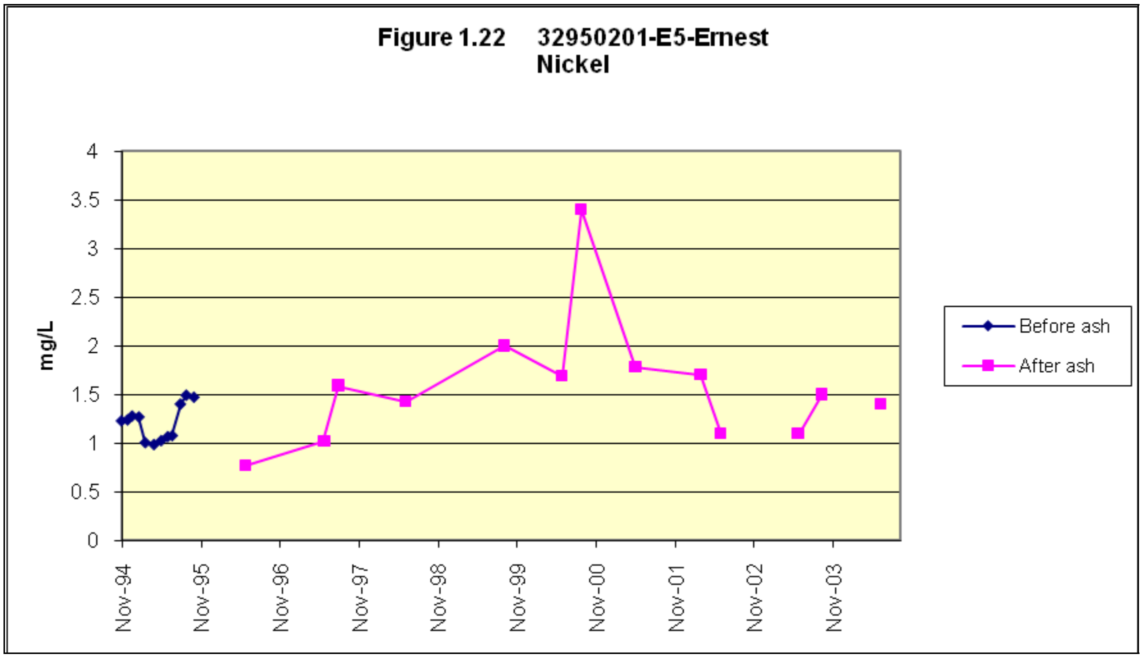
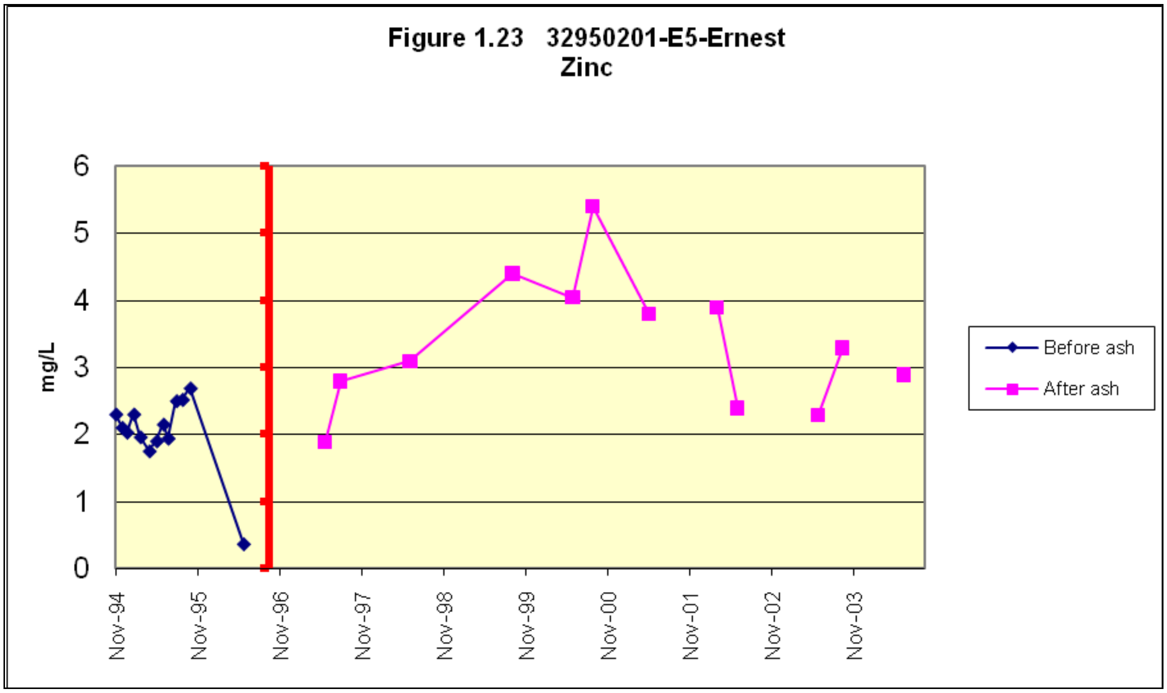


Figure 1.22 32950201-E5-Ernest
Nickel
mg/L
4
3.5
3
2.5
2
1.5
1
0.5
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After ash



MW2

Like MW1, MW2 intercepts the shallow groundwater flow from the base of the refuse pile to its discharge point, McKee Run. However, according to the 2002 PADEP report (page 7), MW2 is more influenced by cleaner water from the mine pool of the Ernest No. 2 deep mine than MW1 or E5. While the report states that MW2 is not as directly downgradient of the refuse pile as MW1 and E5, it states, nevertheless, that background data for this point show that "it was severely degraded by acid mine drainage" prior to permitting of the current operation. The report states on page 7:

> *"As does MW-1, MW-2 intercepts groundwater flow between the base of the pile and the local shallow groundwater discharge point, McKee Run. MW-2 is also influenced by the mine pool of the Ernest No. 2 deep mine. ... The background data for well MW-2 show that it was severely degraded by acid mine drainage prior to permitting of the Ernest Mine refuse pile by Cambria Reclamation Corporation. However, the location of MW-2 is not as directly downgradient from the refuse pile as is MW-1, which may account the lesser concentration of acid mine drainage in MW-2 as compared to MW-1."*

The average field pH (figure 1.23a) readings dropped from approximately 4.4 to 4.1 after ash placement commenced while the average lab pH reading rose from approximately 3.5 to 3.7. Unlike MW1 and E5, at MW2 average acidity (figure 1.26) remained unchanged over the monitoring period, and concentrations of sulfates (figure 1.24) and TDS (figure 1.25), after initial increases, gradually declined. These concentrations had been rising during baseline measurements. In line with this decline in trends, after ash placement, calcium (figure 1.27) concentrations rose and chloride (figure 1.28) concentrations peaked 6 times to levels 4-10 times above the highest baseline concentrations. The combination of moderating trends in acidity with rising calcium and chloride suggests that coal ash is contributing to the impacts seen in groundwater at this monitoring point.

Concentrations of iron (figure 1.29) and manganese (figure 1.30) at MW2 gradually decreased over the sampling period. However, average aluminum concentrations increased over average baseline concentrations at MW 2 (figure 1.31), reaching levels more than 500 times the federal secondary MCL in four samplings after ash placement started.

MW2 data for trace elements (figure 1.32), like the data for MW1 and E5, show the same high levels of lead during the same period of time (September 1999 through June 2001). As with the other monitoring points, while the first of these data points are artifacts of a high laboratory detection level, the sampling of 0.052 mg/L in June 2001 exceeded all levels measured at MW2 before ash was placed at the site, as well as the state and federal action levels for lead by more than three times. While one high measurement of selenium during the baseline period (0.2230 mg/L in July 1995) was found at MW2, selenium values reported during ash placement never rose above detection limits that were as high as four times the DWS. Cadmium and arsenic concentrations declined from the highest levels that were measured during the baseline period although both were measured at levels more than twice as high as their DWS during ash placement. A chromium concentration measured in September 1999 of 0.110 mg/L was more than twice as high as all chromium concentrations previously measured at this point, but other chromium concentrations did not exceed baseline levels. Barium concentrations exceeded the highest baseline concentrations twice since ash placement began. Nickel (figure 1.33) concentrations rose noticeably at MW2 after ash placement started, exceeding the highest baseline concentration seven times, usually reaching 0.400-0.600 mg/L. This is 4-6 times the former federal MCL for nickel of 0.100 mg/L. Zinc concentrations also rose at MW2, and like nickel, exceeded the highest baseline concentration 8 times.

TDS is a broad indicator parameter of water quality that measures major cations (such as calcium, magnesium, sodium, potassium), anions (such as chloride, sulfate, carbonates), minor constituents (such as iron, manganese, fluoride, nitrate, strontium, boron), and trace elements (such as arsenic, lead, cadmium, chromium) dissolved in the water. At two of the three ash monitoring points, MW1 (figure 1.34) and E5 (figure 1.36), TDS concentrations have increased steadily throughout the monitoring period, while they have gradually declined at MW2, after an initial rise above baseline levels (figure 1.35). No TDS data were collected in the unnamed tributary that borders the western side of the refuse pile and ash placement area.

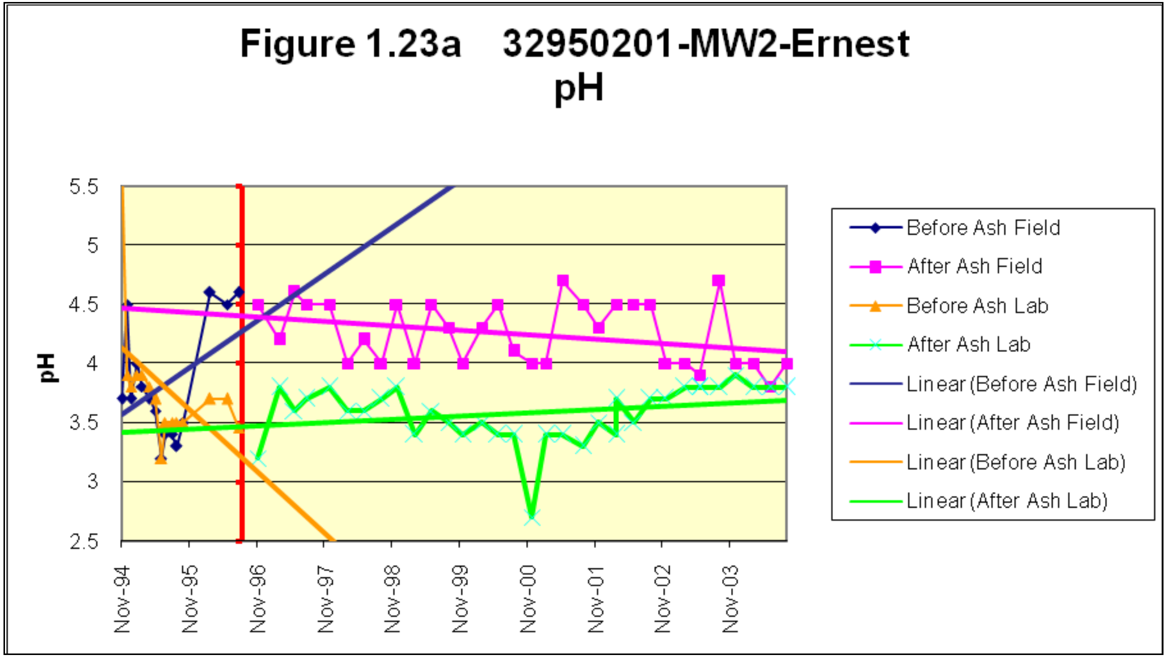


Figure 1.23a 32950201-MW2-Ernest
pH
pH
5.5
5
4.5
4
3.5
3
2.5
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before Ash Field
After Ash Field
Before Ash Lab
After Ash Lab
Linear (Before Ash Field)
Linear (After Ash Field)
Linear (Before Ash Lab)
Linear (After Ash Lab)

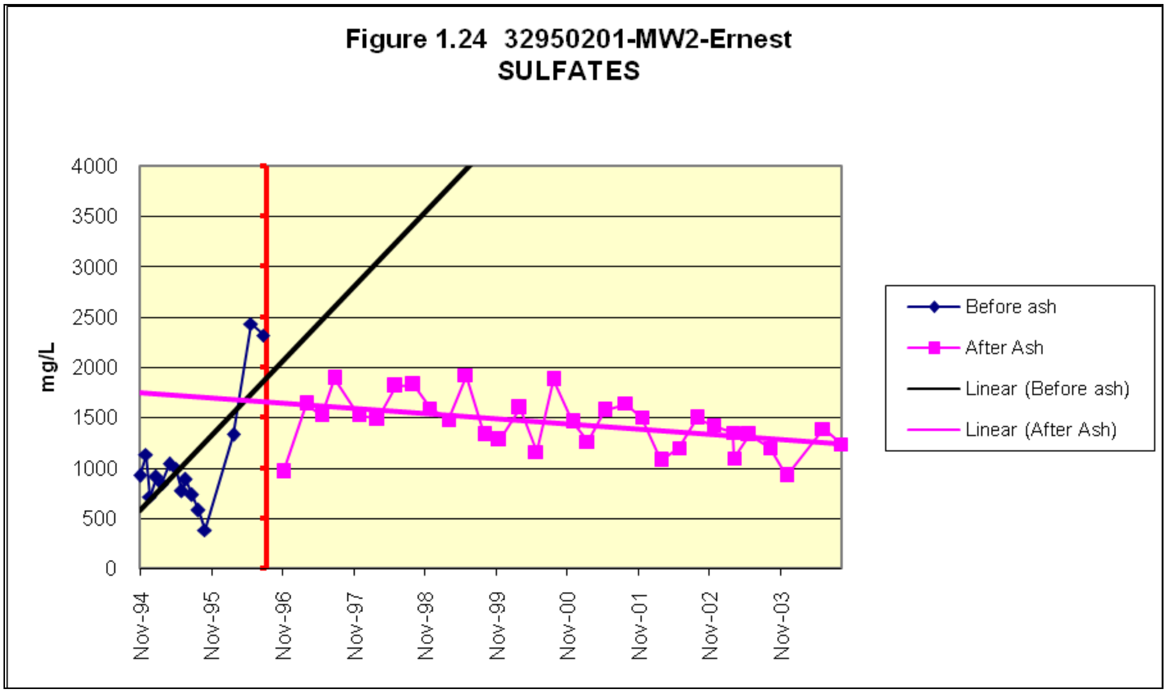


Figure 1.24 32950201-MW2-Ernest
SULFATES
mg/L
4000
3500
3000
2500
2000
1500
1000
500
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After Ash
Linear (Before ash)
Linear (After Ash)

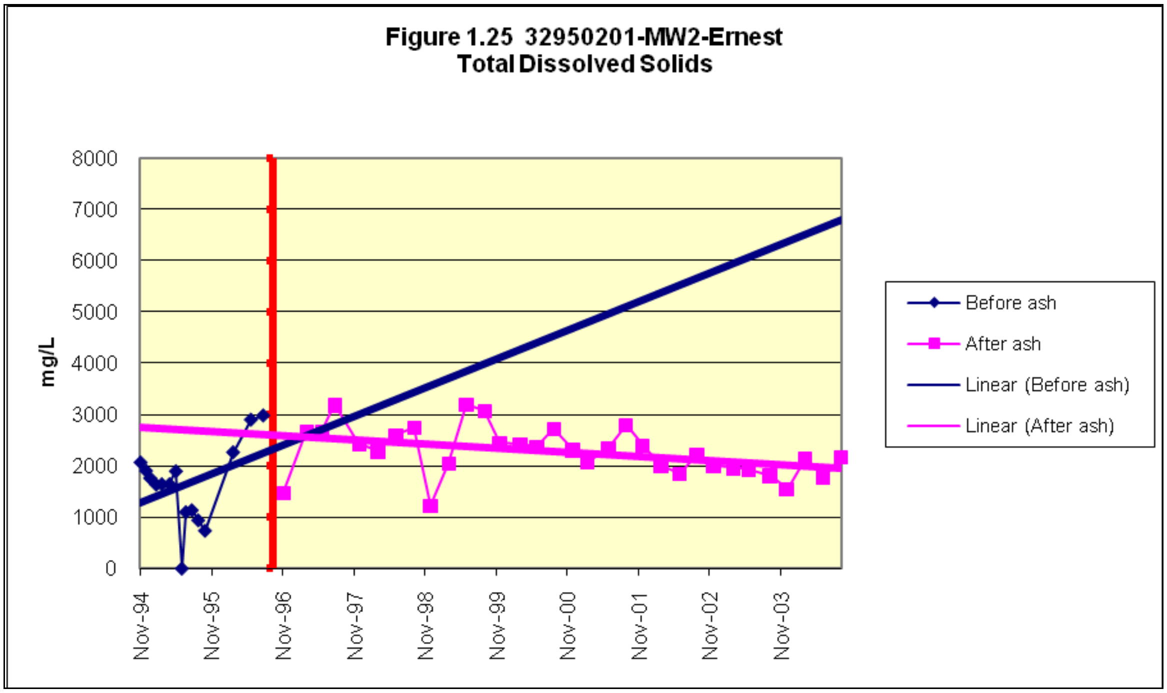


Figure 1.25 32950201-MW2-Ernest
Total Dissolved Solids
mg/L
8000
7000
6000
5000
4000
3000
2000
1000
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After ash
Linear (Before ash)
Linear (After ash)

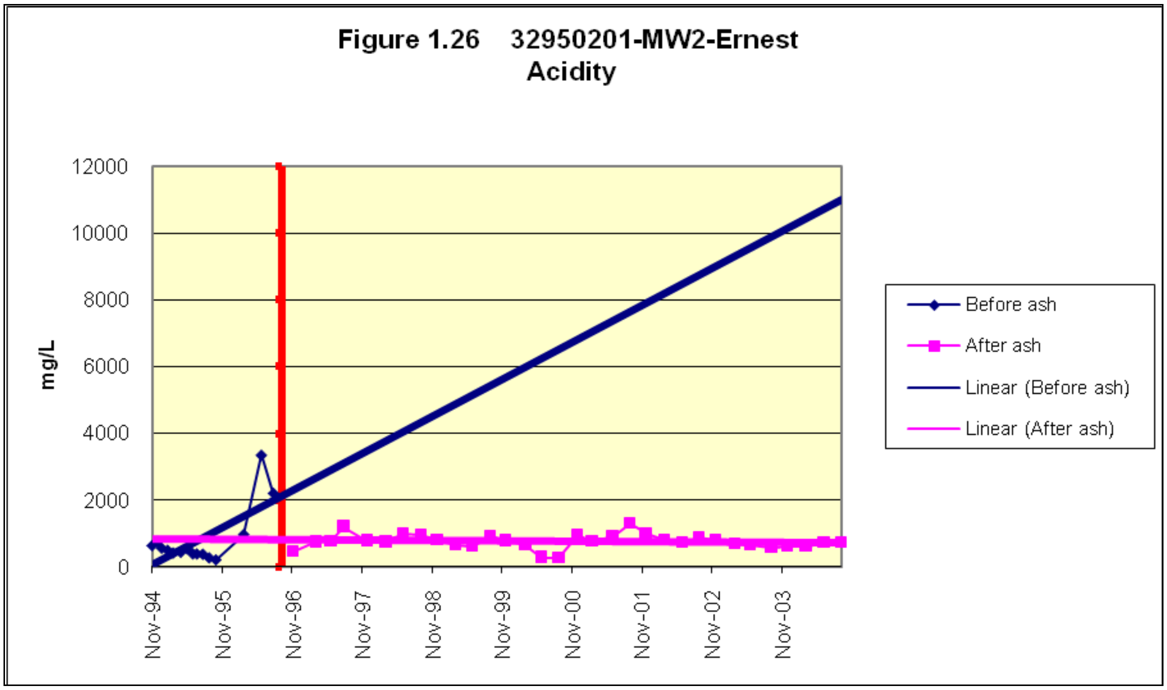


Figure 1.26 32950201-MW2-Ernest
Acidity
mg/L
12000
10000
8000
6000
4000
2000
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Before ash
After ash
Linear (Before ash)
Linear (After ash)

Figure 1.27 32950201-MW2-Ernest
Calcium

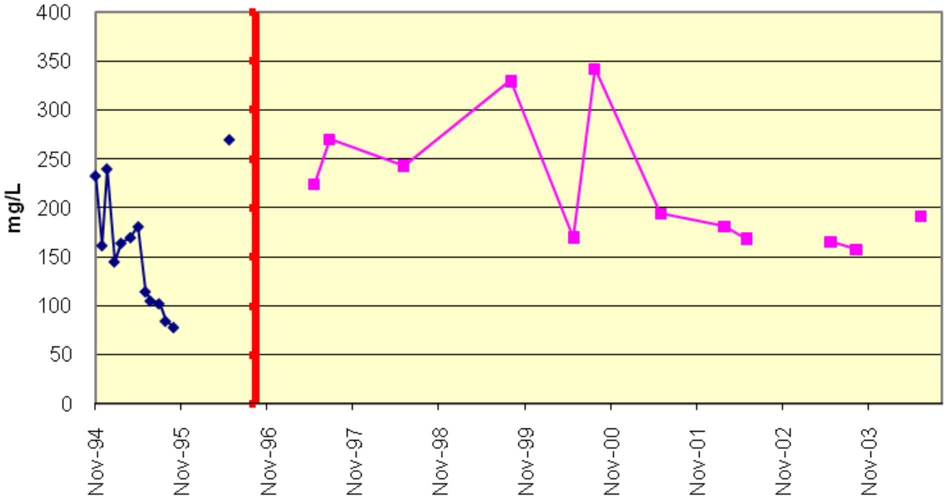
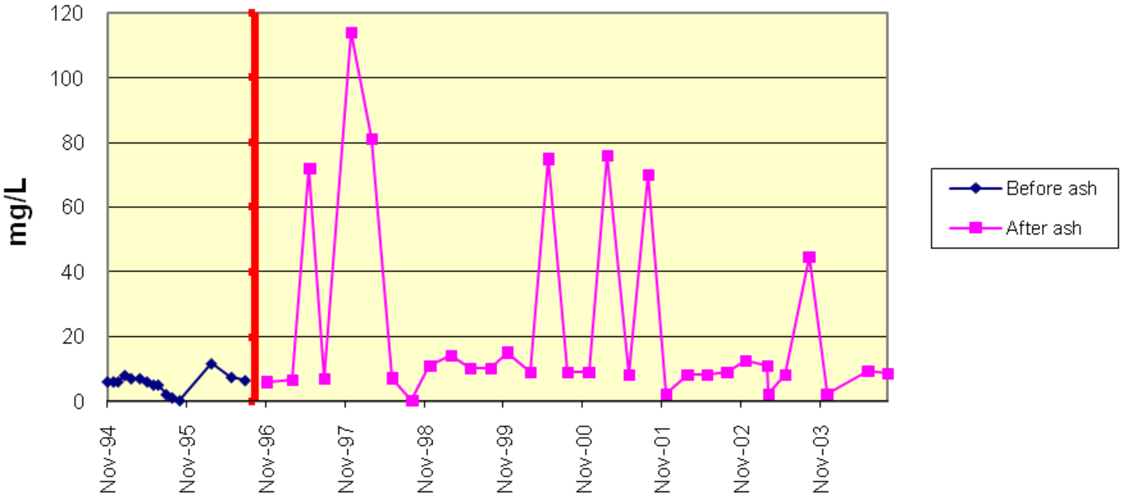


Figure 1.28 32950201-MW2-Ernest
Chloride



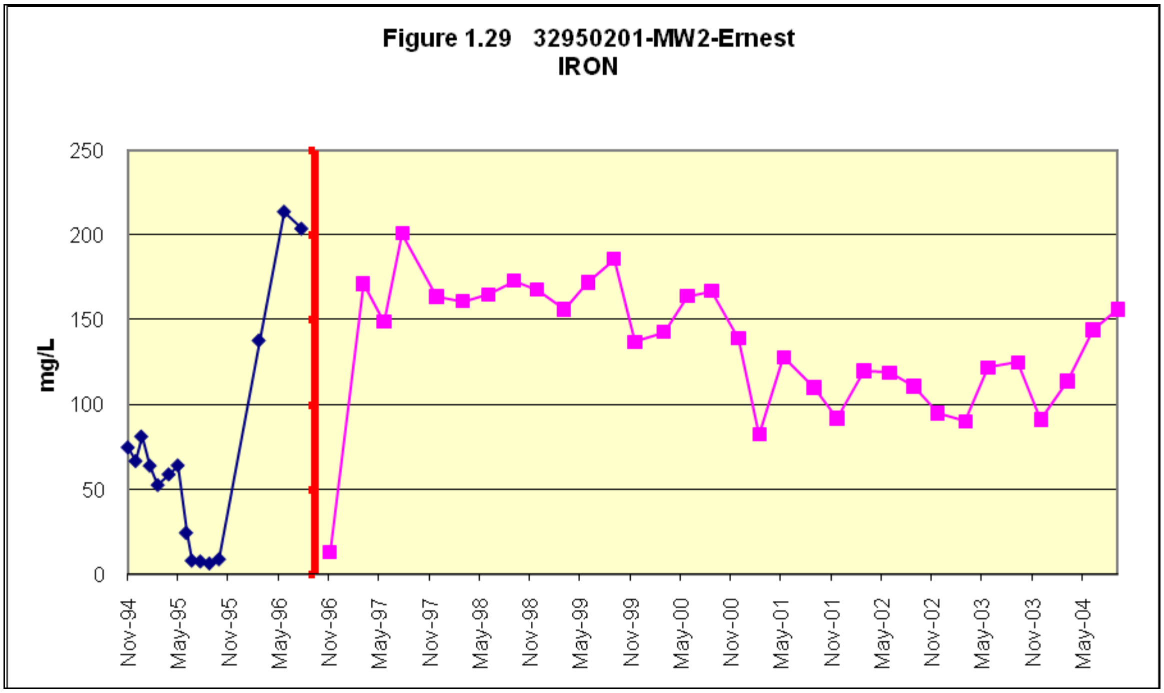


Figure 1.29 32950201-MW2-Ernest
IRON
mg/L
0
50
100
150
200
250
Nov-94
May-95
Nov-95
May-96
Nov-96
May-97
Nov-97
May-98
Nov-98
May-99
Nov-99
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04

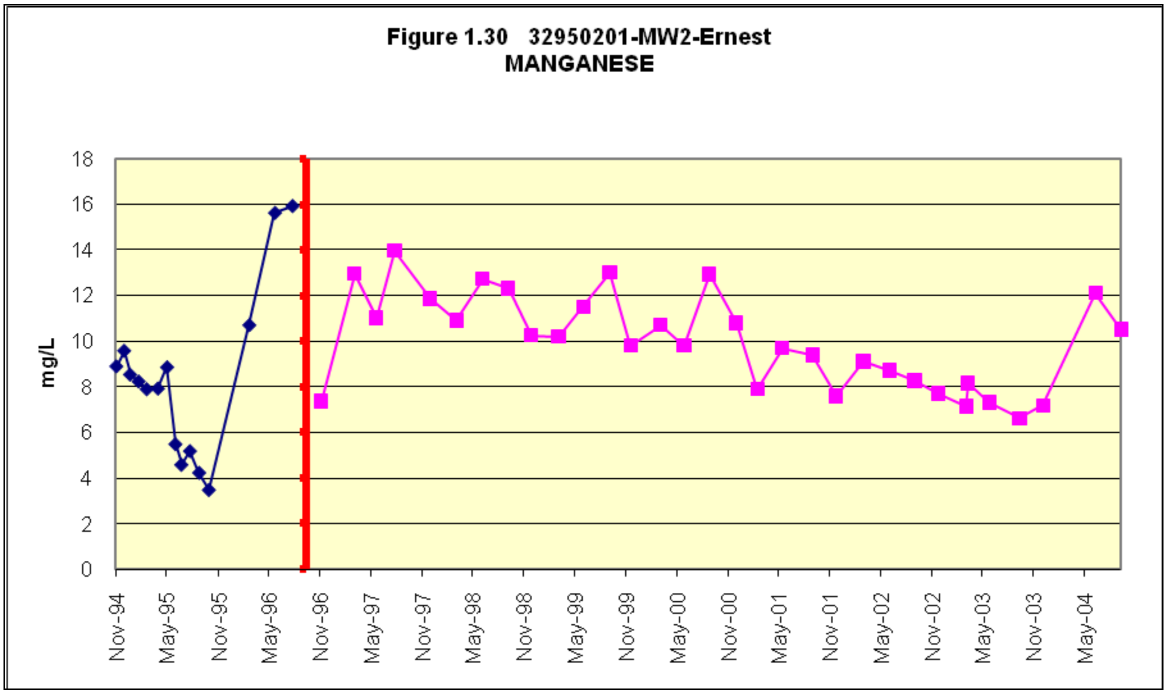


Figure 1.30 32950201-MW2-Ernest
MANGANESE
mg/L
0
2
4
6
8
10
12
14
16
18
Nov-94
May-95
Nov-95
May-96
Nov-96
May-97
Nov-97
May-98
Nov-98
May-99
Nov-99
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04

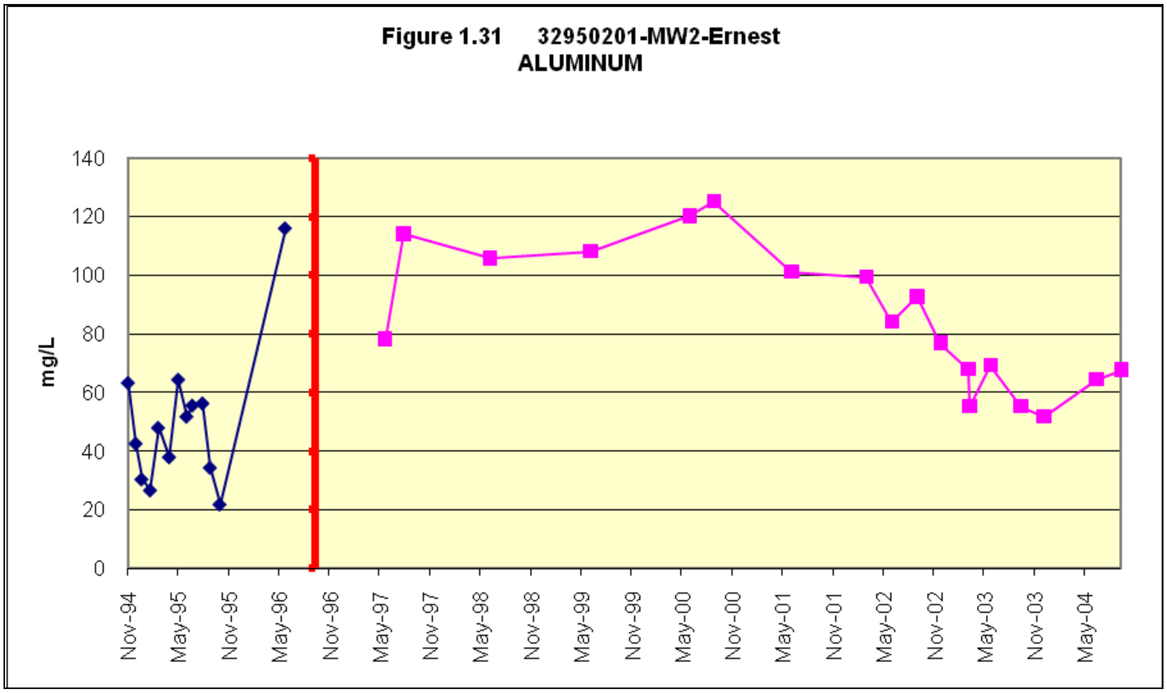


Figure 1.31 32950201-MW2-Ernest
ALUMINUM
mg/L
140
120
100
80
60
40
20
0
Nov-94
May-95
Nov-95
May-96
Nov-96
May-97
Nov-97
May-98
Nov-98
May-99
Nov-99
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04

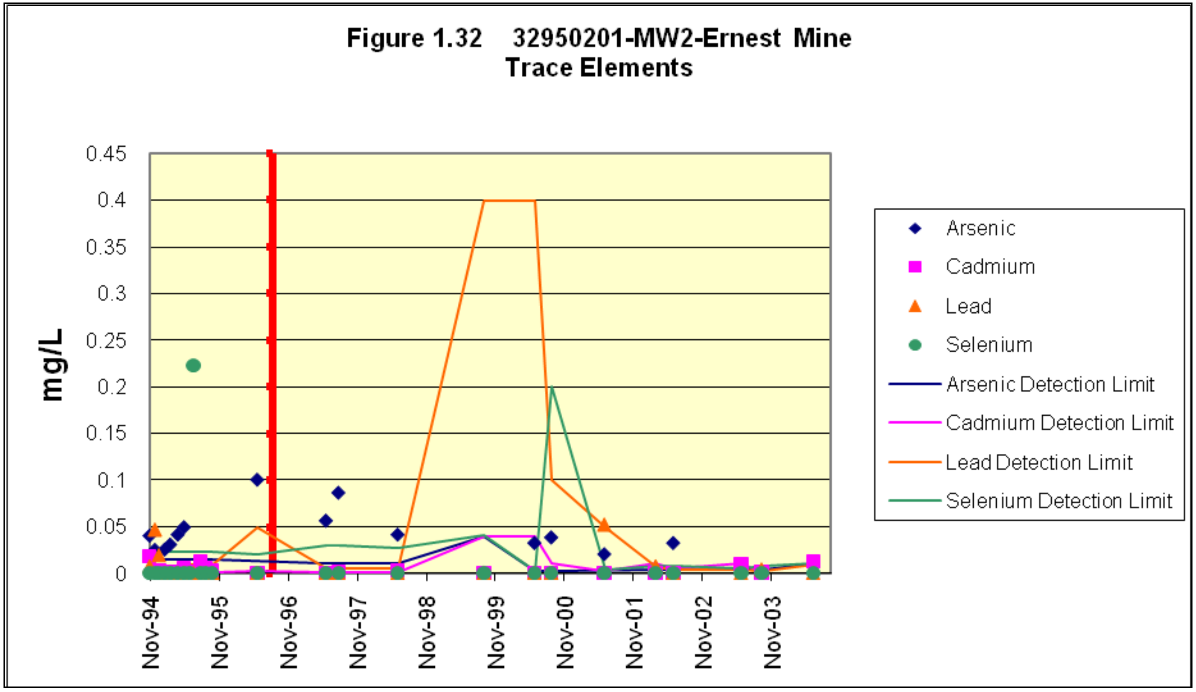


Figure 1.32 32950201-MW2-Ernest Mine
Trace Elements
mg/L
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Arsenic
Cadmium
Lead
Selenium
Arsenic Detection Limit
Cadmium Detection Limit
Lead Detection Limit
Selenium Detection Limit

Figure 1.33 32950201-MW2-Ernest
Nickel

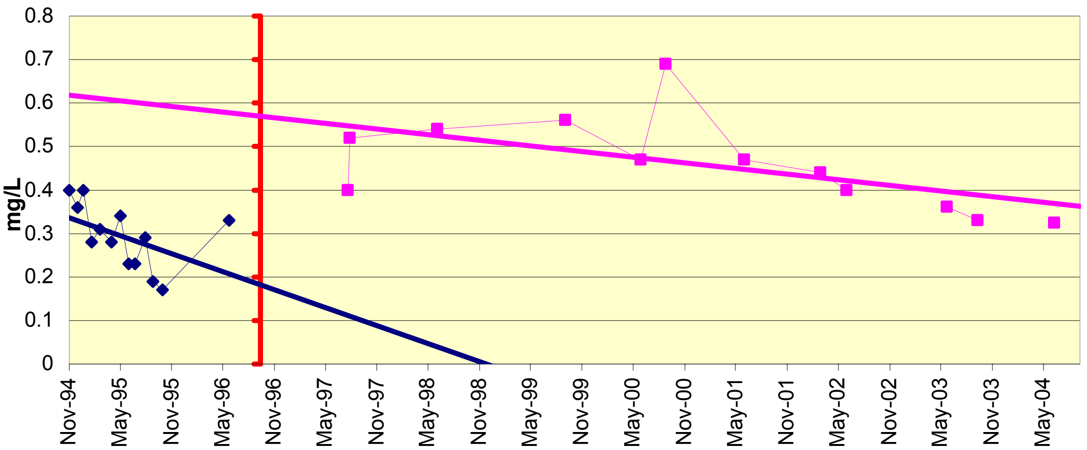
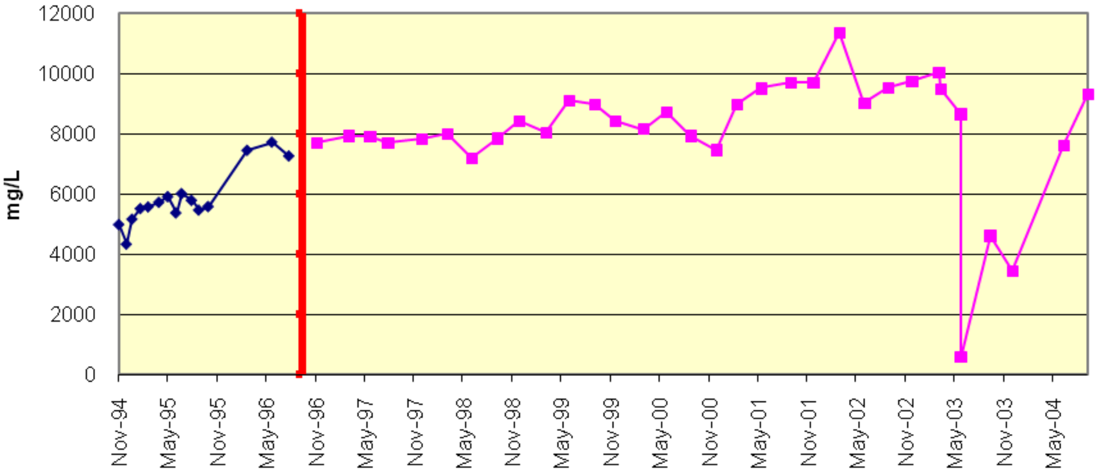
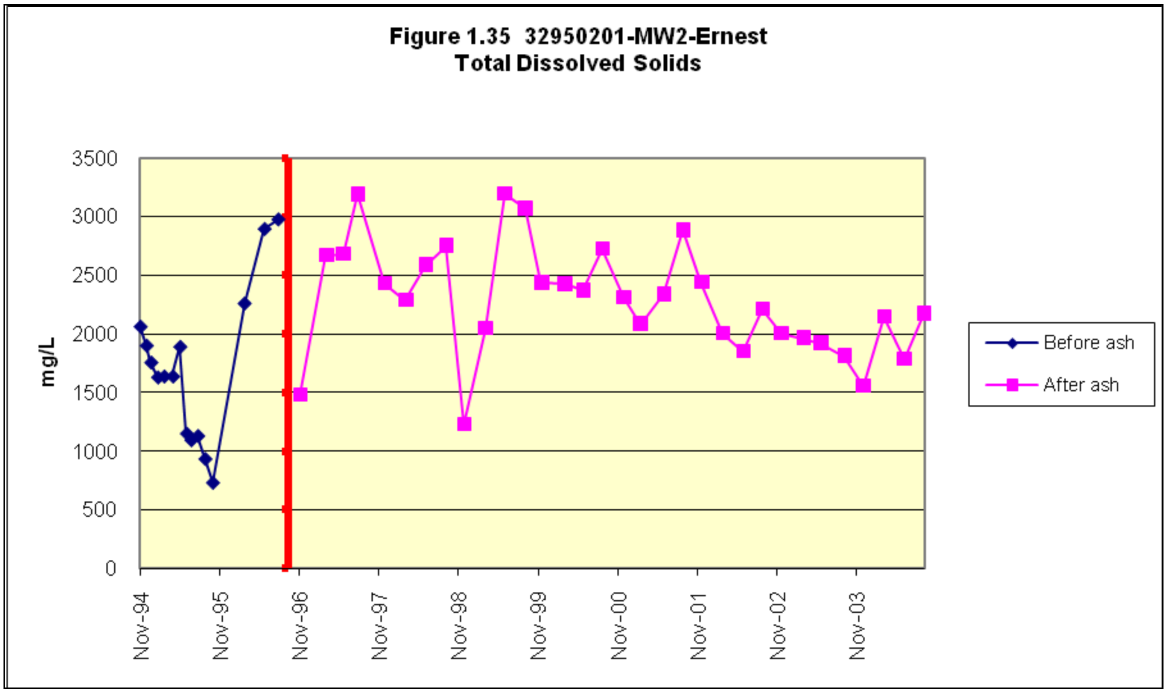
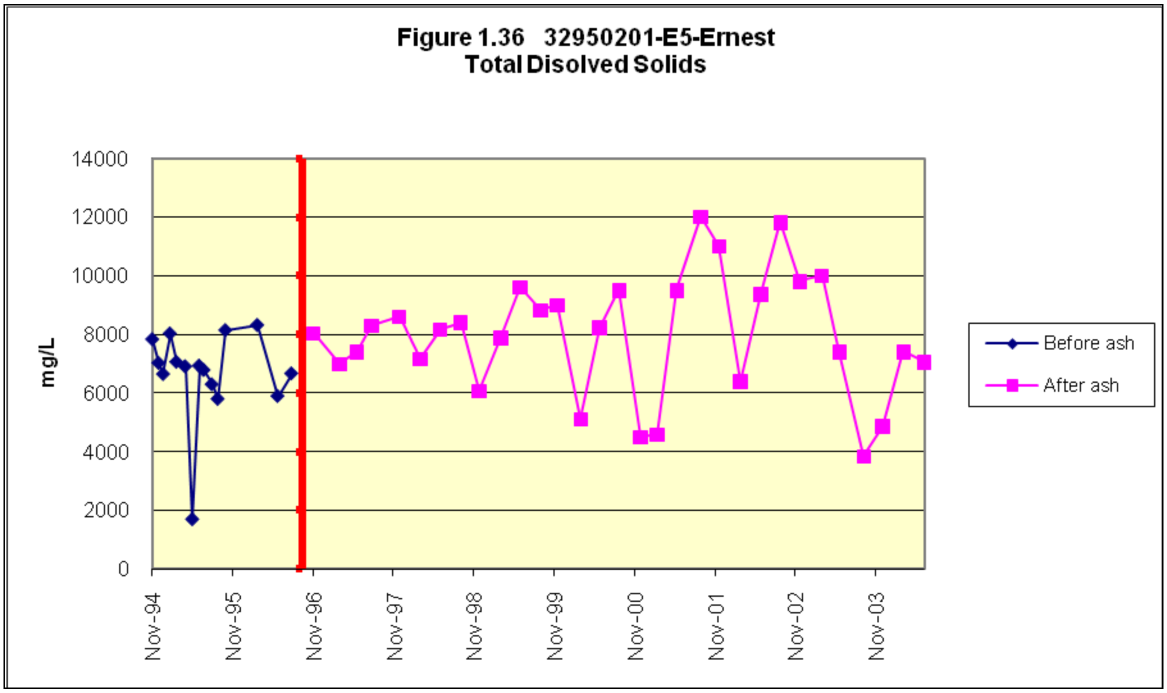


Figure 1.34 32950201-MW1-Ernest
Total Dissolved Solids







Pollutant Loadings

In contrast to concentration data (mass per unit volume), load data measure the weight per unit time of a pollutant flowing past a given point and, therefore, tell the actual amount of a constituent that is being discharged in surface waters. While monitoring for concentrations is important for measuring the immediate impacts of pollutants on aquatic life, monitoring for loads enables regulators to identify the entire mass of pollutants entering surface waters at a mine site and thus gain a better understanding of its potential longterm impact to the aquatic environment. Like concentration data, measuring load data for parameters more typical of the ash leachate, instead of both ash leachate and mine drainage would help determine the impact of ash at the site. Unfortunately, most of the loading data at the Ernest site measured only the loads of acidity/alkalinity, aluminum, iron, manganese, and sulfates as parameters typically found in mine drainage which happen also to be found in ash leachate. An exception is in data at E5 where loads for trace elements were measured. The large majority of ash monitoring points at these sites are monitoring wells and thus are not producing flow data. Although trace element loads could be calculated at other ash monitoring points that are surface water monitoring points, such information is not being done as part of the pollution monitoring effort at these sites.

Subchapter F monthly loading data (in lbs/day) at the Ernest site were collected by measuring flows from multiple monitoring points grouped in three “hydrologic units.” The data collected from these hydrologic units, according to Module 26 of the permit, were based on “preexisting pollutional discharges occurring on areas located within or hydrologically connected to the Surface Mining Permit Area and Pollutional Abatement Area which will be affected by the proposed remining operation.”

The permit’s monitoring program assesses impacts from loadings in terms of cumulative trends observed in these hydrologic units. Yet each monitoring point on the site is unique in terms of the setting and hydrological regime that it is measuring. The bunching of different monitoring points into hydrologic units does not allow a reviewer of the permit file to readily discern the variations in effluents emanating from an individual monitoring point. Indeed, there are major differences occurring in the flows of specific points within these hydrologic units that may go unrecognized if monitoring reports and loading triggers under the subchapter F program focus only on the total load of pollution emanating from the units.

Hydrologic unit #1, for example, consists of the cumulative load data from monitoring points E1 and E2, which collect effluent from three seeps that flow into McKee Run and emanate from the level of the Freeport coal in the northwestern corner of the permit area. The seeps, located immediately east of McKee Run, are between McKee Run and the refuse pile. Although hydrologic unit #1 is categorized as the cumulative load from monitoring points E1 and E2, it is evident from the data that the load contribution from E2 is at best, negligible; for all practical purposes, hydrologic unit #1 has always monitored only point E1. Monitoring point E2 was discontinued in 1996.

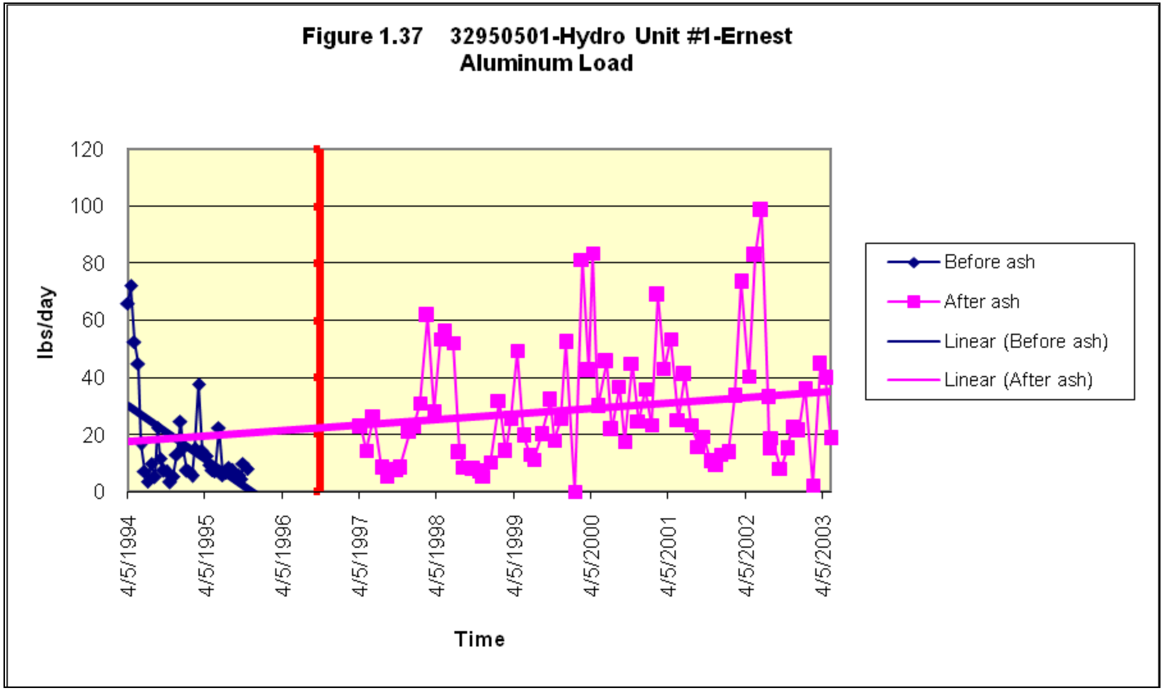
Loading data for hydrologic unit #1 (E1) indicates an overall worsening trend in aluminum load between 1994 and 2003 (figure 1.37). Before ash placement, the trend (1994-1995) was decreasing (figure 1.38); after ash placement commenced (1997-2003), the aluminum loading reversed producing higher absolute values and an increasing trend (figure 1.39). The same pattern is seen with the iron, sulfates and acidity loading data for hydrologic unit #1; decreasing loads before ash placement and then increasing loads after ash placement. At a minimum this indicates the total amount of pollution from the refuse pile has been increasing since pile disturbance and ash placement began.

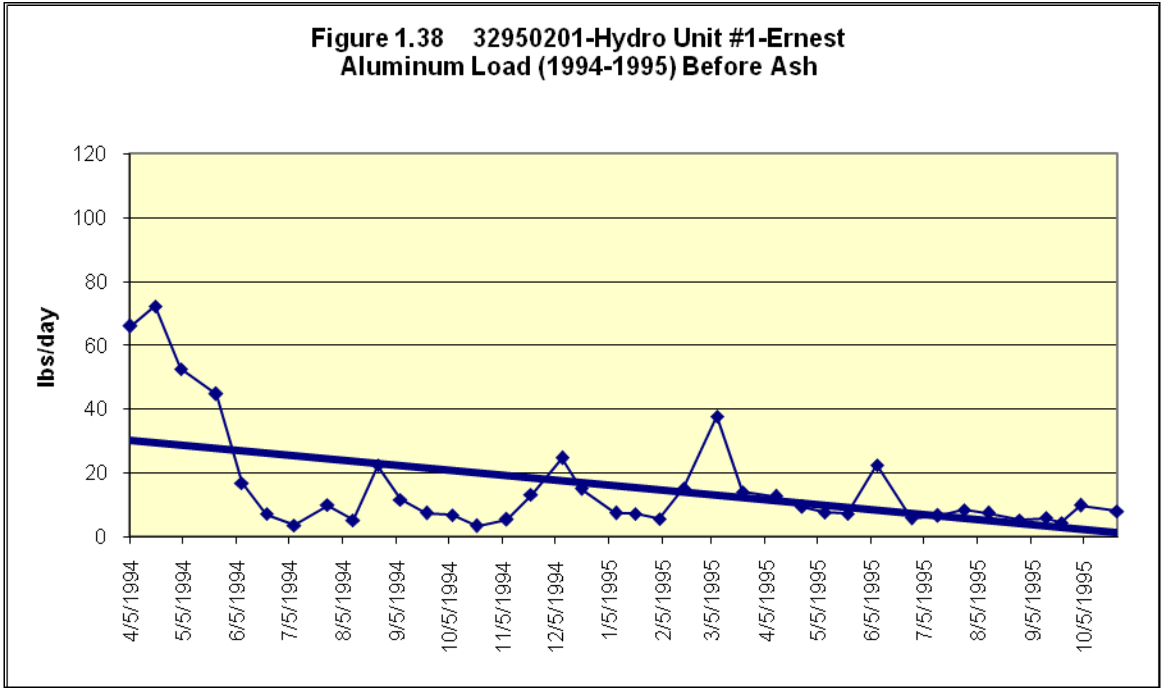
Hydrologic unit #2 consists of the cumulative loading data of monitoring points E3, E5 (one of the ash monitoring points), E6, E10, E12, E13, E14, and E65, all of which monitor discharges from the refuse pile to the south of E1 and E2 and immediately above the lower reaches of the unnamed tributary to McKee Run. Similar to unit #1, the impact of individual monitoring points can be masked by examining only total loads from this unit. As a result, reports state the aluminum load for hydrological unit #2 (figure 1.40) shows a downward trend, even though a closer look indicates that the aluminum load emanating from E5 which is included in hydrologic unit #2, is rising (figure 1.41).

The designation of E5, a surface seep, as an ash monitoring point and a subchapter F monitoring point, has generated flow and concentration data that has allowed for loadings of trace elements to be monitored, providing information that is rarely generated at the ash minefill sites examined in this project. The result has been substantially higher loads of trace metals and calcium measured at E5 after mining and ash placement began than were measured before these activities got underway as shown by graphs for arsenic (figure 1.42a), lead (figure 1.42b), barium (figure 1.43), cadmium (figure 1.44), calcium (figure 1.45), chromium (figure 1.46), and zinc (figure 1.47) and as occurred for other pollutants such as magnesium, copper, and nickel. The addition of 2004 data makes the rising trends in cadmium and chromium loads particularly visible.

It should be noted, however, that these increased loadings are based on flow data taken only from *annual* samplings after October 1996 in contrast to monthly samplings before that date, and therefore are not as reliably representative of flow conditions after ash placement started. Nonetheless, the increased loads do appear to imply that the total impact at E5, the only designated ash monitoring point measuring impacts to surface waters, is increasing from parameters indicative of both ash leachate and mine drainage as well as parameters indicative more exclusively of ash leachate. Loadings for these trace elements as well as loadings for calcium and magnesium are not measured at the other points in hydrologic unit #2 making it impossible to assess cumulative loadings in these parameters over this hydrologic unit.

E52 concentration and loading data for acidity (figures 1.48a and 149b), and loading data for manganese (figure 1.49), sulfate (figure 1.50), aluminum (figure 1.51), and iron (figure 1.52) show the same pattern: a large spike recorded in March 1996 and then, after a drop in loading rates, a steady increase in those rates. Loading data from E17, the upstream monitoring point on the tributary, are sporadic, although they corroborate these trends and further show a rise in alkalinity loading (figure 1.53) along with sulfate (figure 1.54) and aluminum (figure 1.55) after ash placement has started. All the data was collected during the ash placement period. Presumably this rising alkalinity originates from the ash given the acidic drainage from this refuse pile that this permit is attempting to abate. Given the strategic location and trajectory of this unnamed tributary collecting discharge off the western side of the site, the rising loads at its monitoring points after ash placement starts are a notable sign of decreasing water quality resulting from permitted activity. Rising alkalinity loads at E17 suggests the ash is contributing to that degraded water quality.





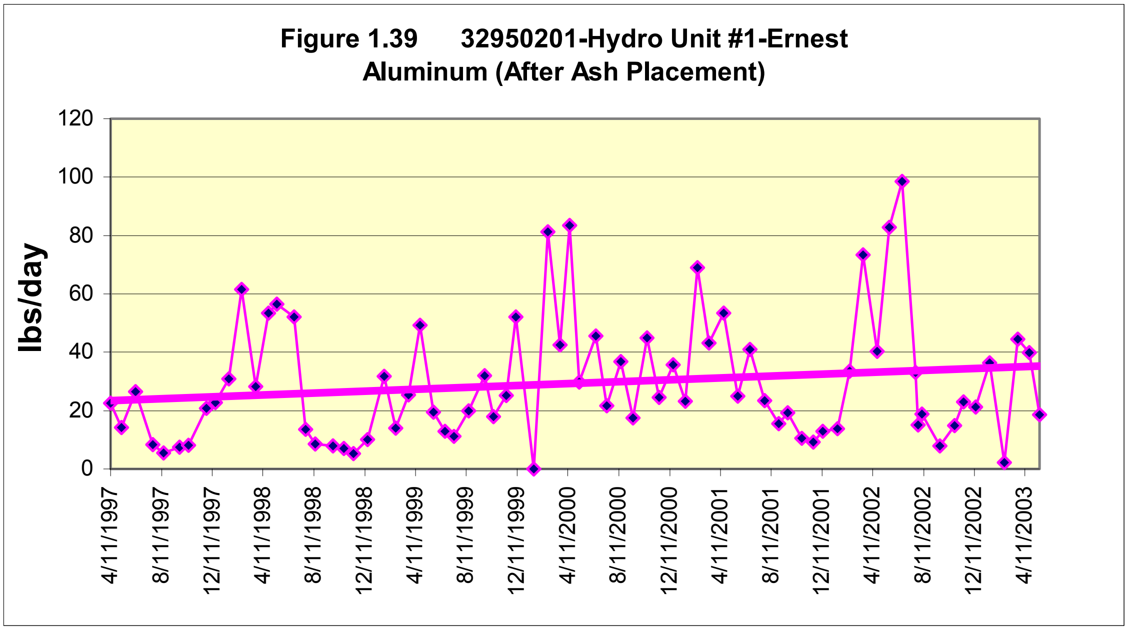


Figure 1.39 32950201-Hydro Unit #1-Ernest
Aluminum (After Ash Placement)
lbs/day
0
20
40
60
80
100
120
4/11/1997
8/11/1997
12/11/1997
4/11/1998
8/11/1998
12/11/1998
4/11/1999
8/11/1999
12/11/1999
4/11/2000
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8/11/2002
12/11/2002
4/11/2003

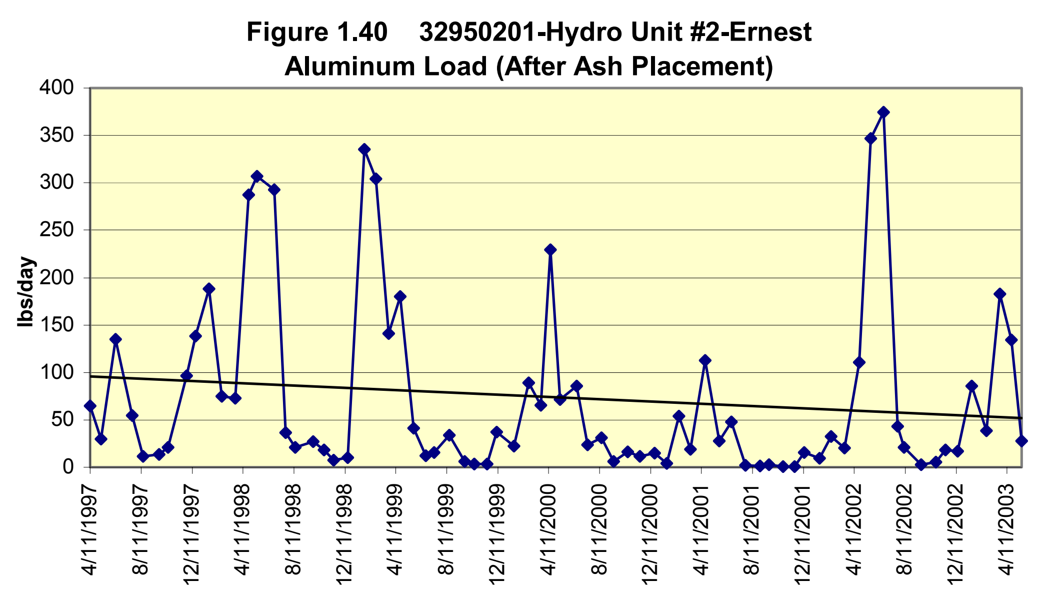
Figure 1.40 32950201-Hydro Unit #2-Ernest
Aluminum Load (After Ash Placement)
lbs/day
0
50
100
150
200
250
300
350
400
4/11/1997
8/11/1997
12/11/1997
4/11/1998
8/11/1998
12/11/1998
4/11/1999
8/11/1999
12/11/1999
4/11/2000
8/11/2000
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8/11/2002
12/11/2002
4/11/2003

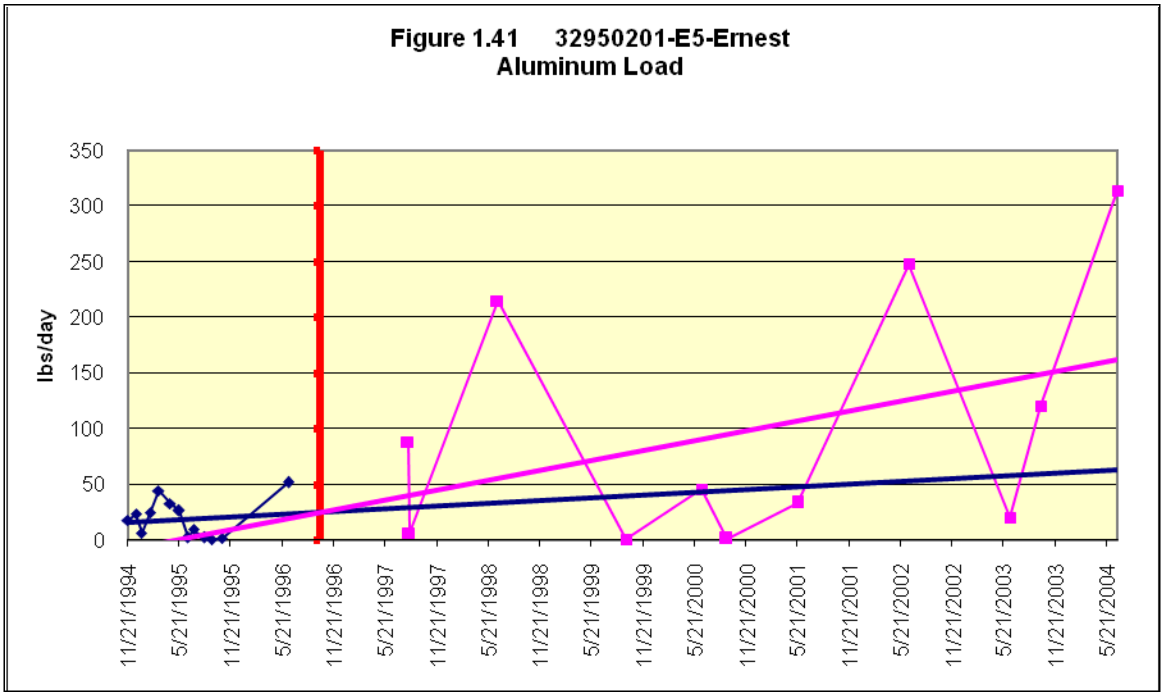


Figure 1.41 32950201-E5-Ernest
Aluminum Load
lbs/day
350
300
250
200
150
100
50
0
11/21/1994
5/21/1995
11/21/1995
5/21/1996
11/21/1996
5/21/1997
11/21/1997
5/21/1998
11/21/1998
5/21/1999
11/21/1999
5/21/2000
11/21/2000
5/21/2001
11/21/2001
5/21/2002
11/21/2002
5/21/2003
11/21/2003
5/21/2004

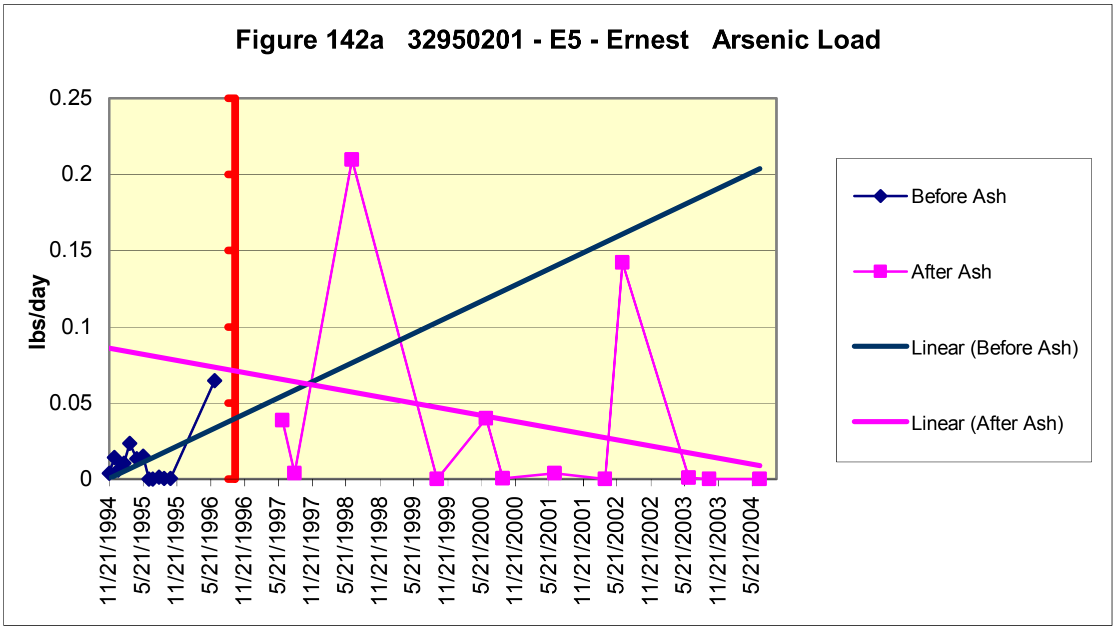


Figure 142a 32950201 - E5 - Ernest Arsenic Load
lbs/day
0.25
0.2
0.15
0.1
0.05
0
11/21/1994
5/21/1995
11/21/1995
5/21/1996
11/21/1996
5/21/1997
11/21/1997
5/21/1998
11/21/1998
5/21/1999
11/21/1999
5/21/2000
11/21/2000
5/21/2001
11/21/2001
5/21/2002
11/21/2002
5/21/2003
11/21/2003
5/21/2004
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

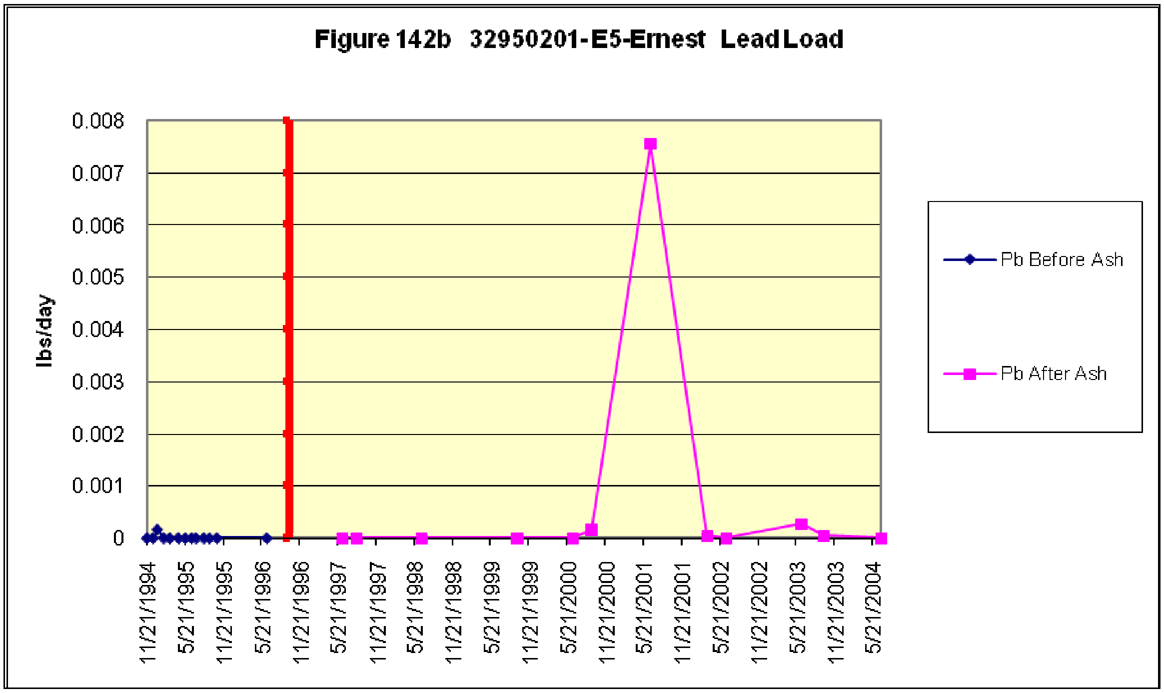


Figure 142b 32950201-E5-Ernest Lead Load
lbs/day
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
11/21/1994
5/21/1995
11/21/1995
5/21/1996
11/21/1996
5/21/1997
11/21/1997
5/21/1998
11/21/1998
5/21/1999
11/21/1999
5/21/2000
11/21/2000
5/21/2001
11/21/2001
5/21/2002
11/21/2002
5/21/2003
11/21/2003
5/21/2004
Pb Before Ash
Pb After Ash

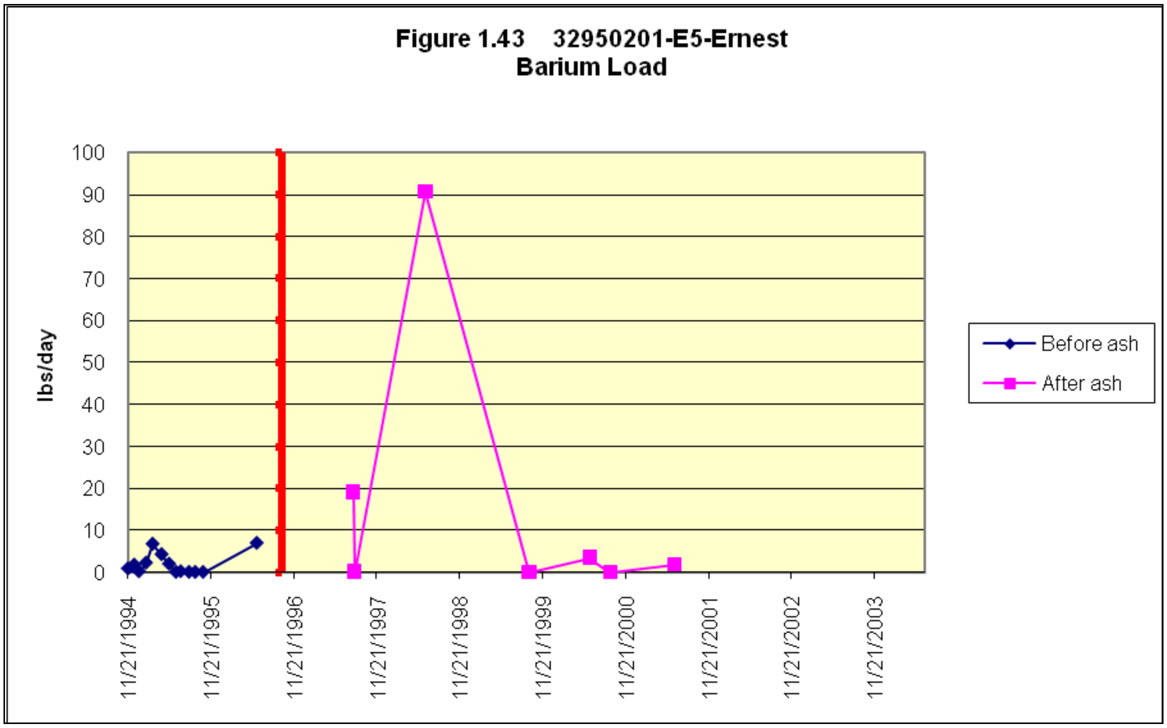


Figure 1.43 32950201-E5-Ernest
Barium Load
lbs/day
100
90
80
70
60
50
40
30
20
10
0
11/21/1994
11/21/1995
11/21/1996
11/21/1997
11/21/1998
11/21/1999
11/21/2000
11/21/2001
11/21/2002
11/21/2003
Before ash
After ash

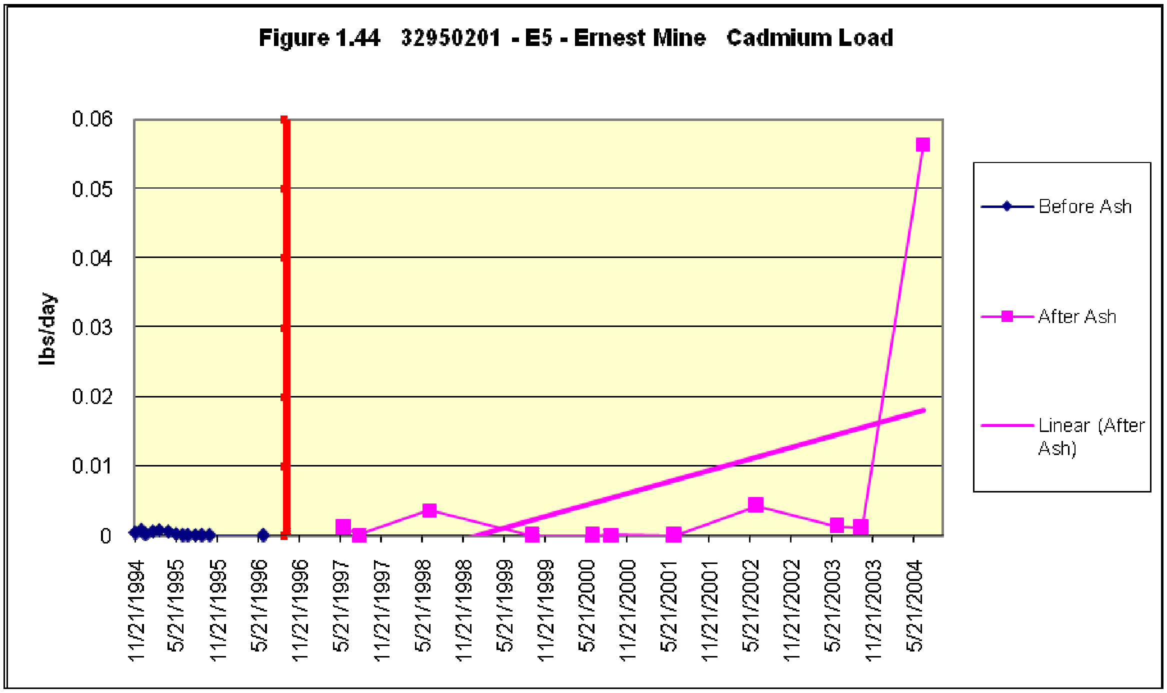


Figure 1.44 32950201 - E5 - Ernest Mine Cadmium Load
lbs/day
0.06
0.05
0.04
0.03
0.02
0.01
0
11/21/1994
5/21/1995
11/21/1995
5/21/1996
11/21/1996
5/21/1997
11/21/1997
5/21/1998
11/21/1998
5/21/1999
11/21/1999
5/21/2000
11/21/2000
5/21/2001
11/21/2001
5/21/2002
11/21/2002
5/21/2003
11/21/2003
5/21/2004
Before Ash
After Ash
Linear (After Ash)

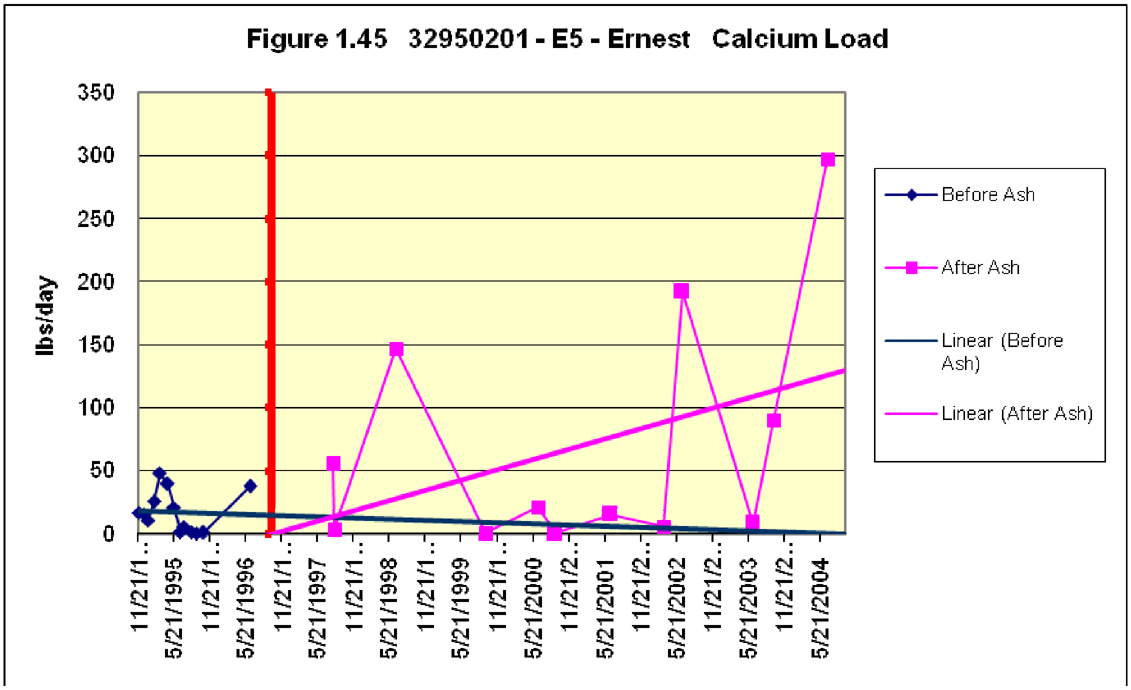


Figure 1.45 32950201 - E5 - Ernest Calcium Load
lbs/day
350
300
250
200
150
100
50
0
11/21/1...
5/21/1995
11/21/1...
5/21/1996
11/21/1...
5/21/1997
11/21/1...
5/21/1998
11/21/1...
5/21/1999
11/21/1...
5/21/2000
11/21/2...
5/21/2001
11/21/2...
5/21/2002
11/21/2...
5/21/2003
11/21/2...
5/21/2004
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

Figure 1.46 32950201 - E5 - Ernest Chromium Load

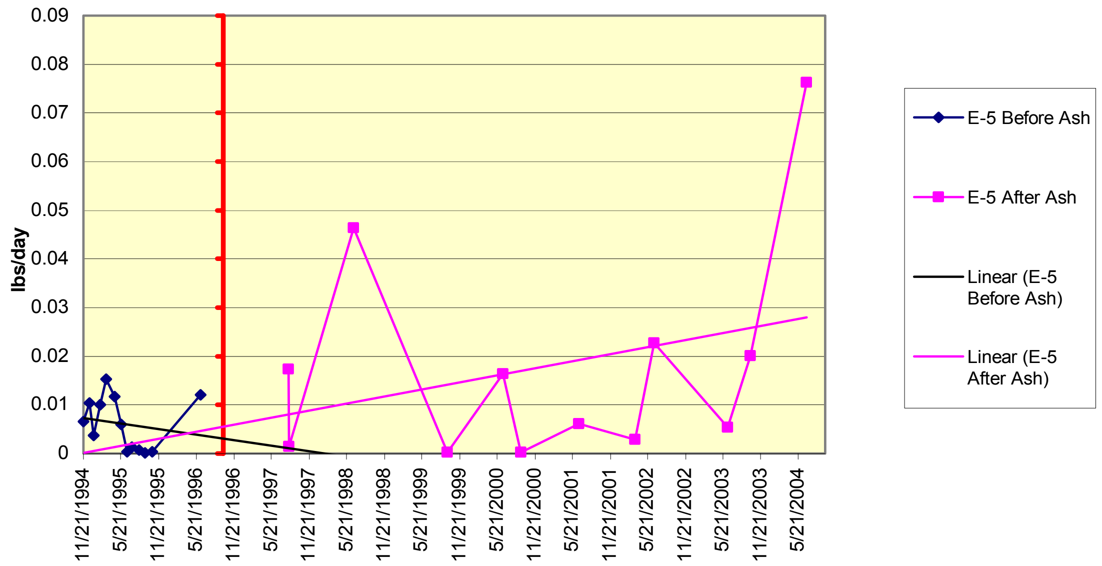
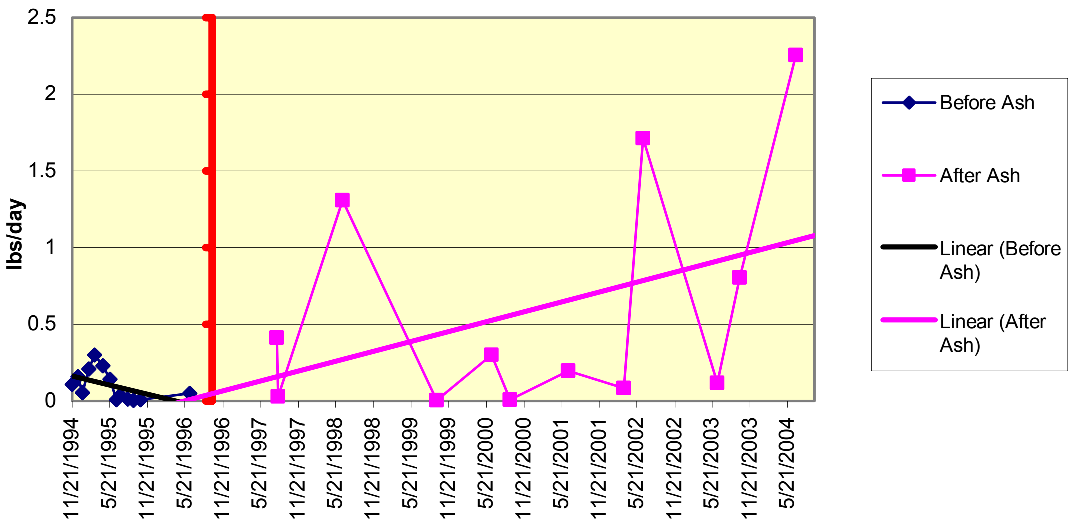


Figure 1.47 32950201 - E5 - Ernest Mine Zinc Load



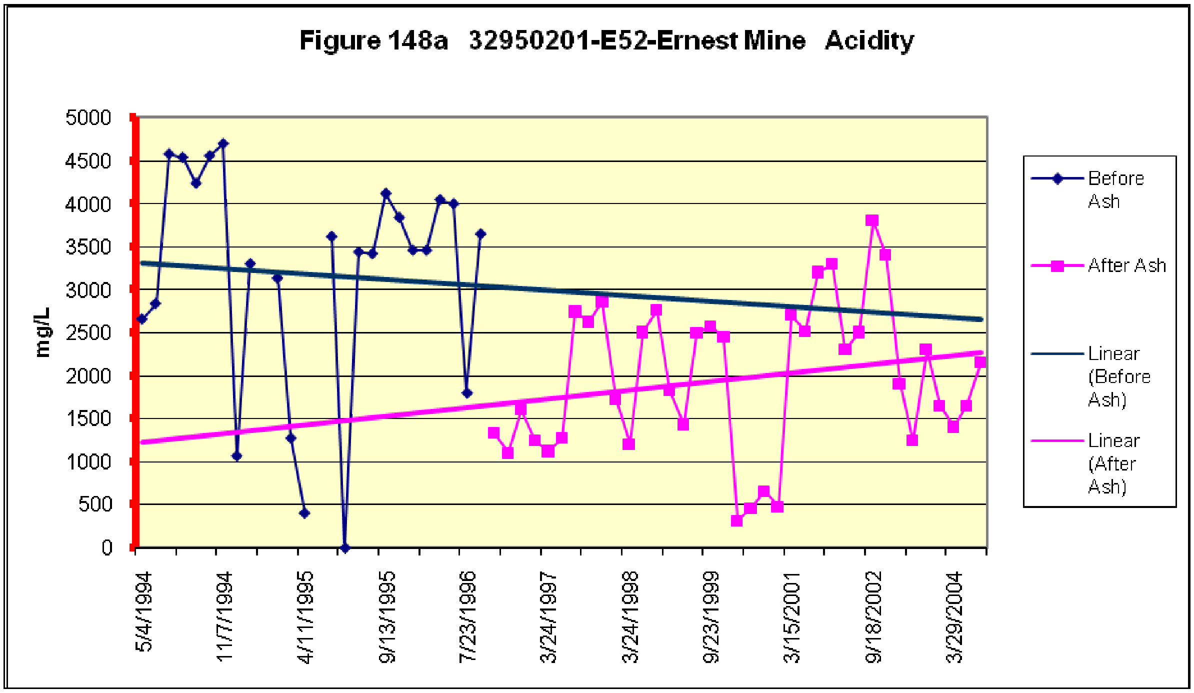


Figure 148a 32950201-E52-Ernest Mine Acidity
mg/L
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5/4/1994
11/7/1994
4/11/1995
9/13/1995
7/23/1996
3/24/1997
3/24/1998
9/23/1999
3/15/2001
9/18/2002
3/29/2004
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

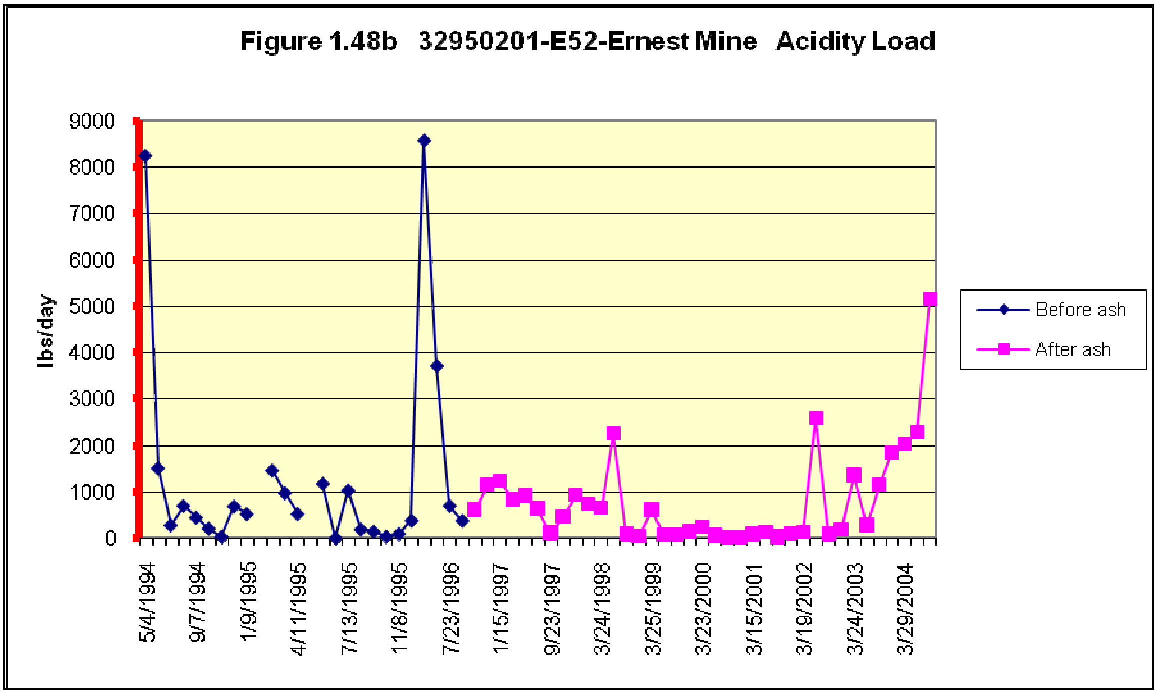


Figure 1.48b 32950201-E52-Ernest Mine Acidity Load
lbs/day
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
5/4/1994
9/7/1994
1/9/1995
4/11/1995
7/13/1995
11/8/1995
7/23/1996
1/15/1997
9/23/1997
3/24/1998
3/25/1999
3/23/2000
3/15/2001
3/19/2002
3/24/2003
3/29/2004
Before ash
After ash

Figure 1.49 32950201-E52-Ernest
Manganese Load

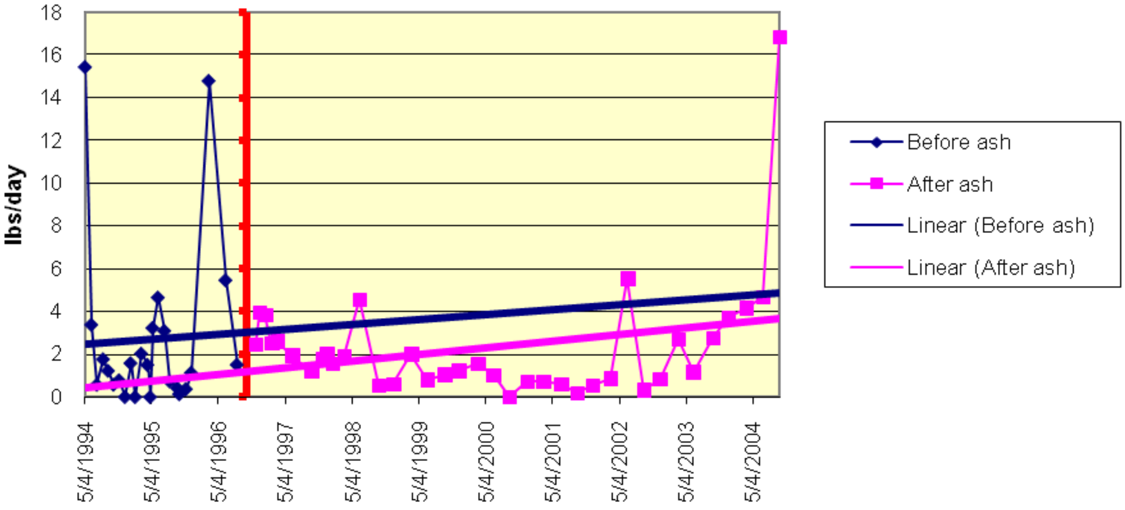
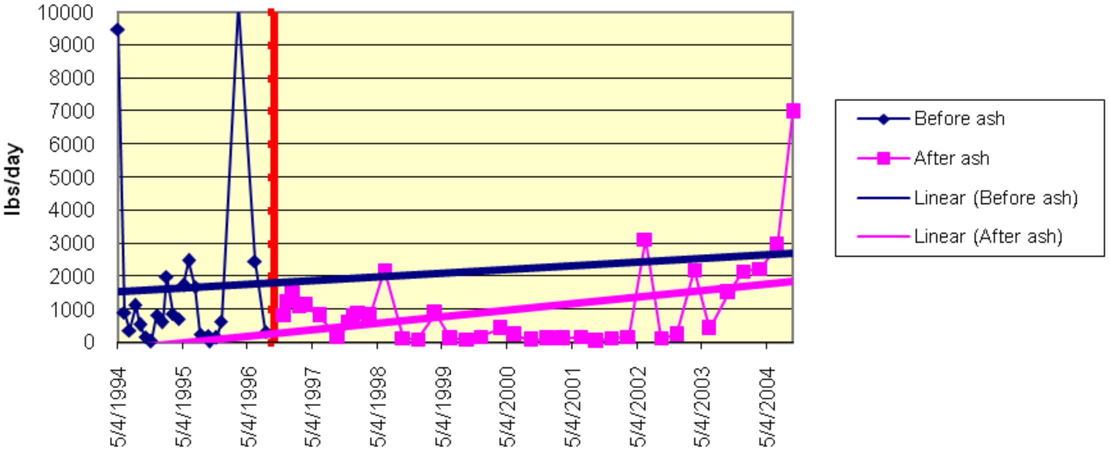


Figure 1.50 32950201-E52-Ernest
Sulfate Load



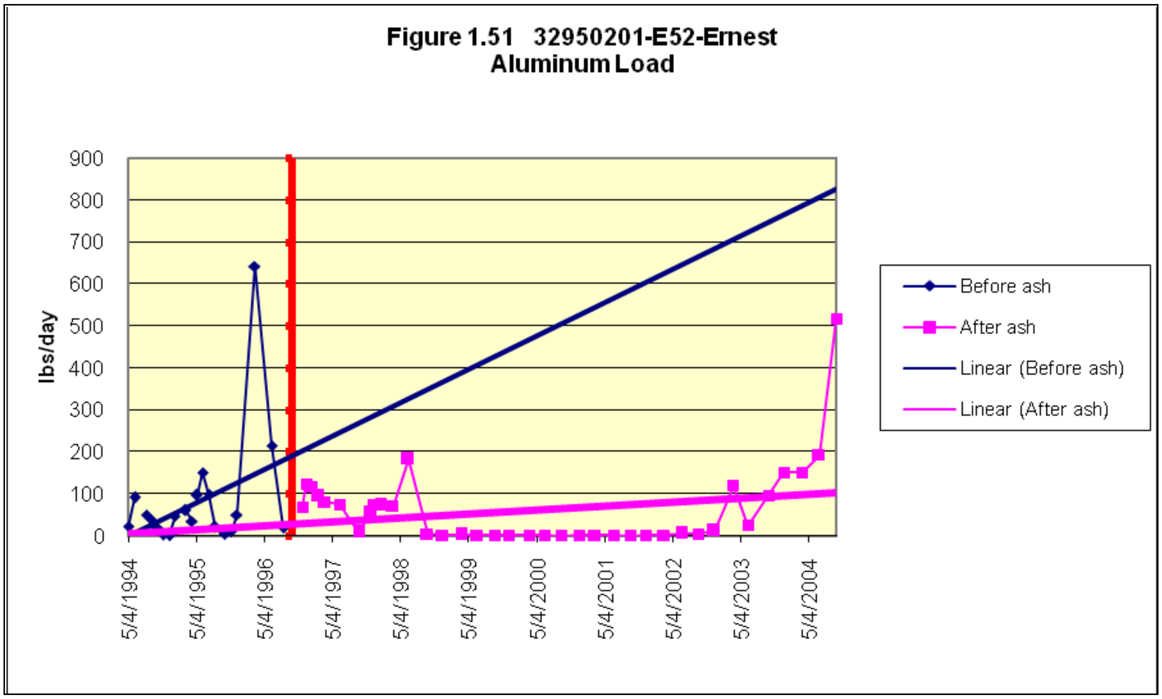


Figure 1.51 32950201-E52-Ernest
Aluminum Load
lbs/day
900
800
700
600
500
400
300
200
100
0
5/4/1994
5/4/1995
5/4/1996
5/4/1997
5/4/1998
5/4/1999
5/4/2000
5/4/2001
5/4/2002
5/4/2003
5/4/2004
Before ash
After ash
Linear (Before ash)
Linear (After ash)

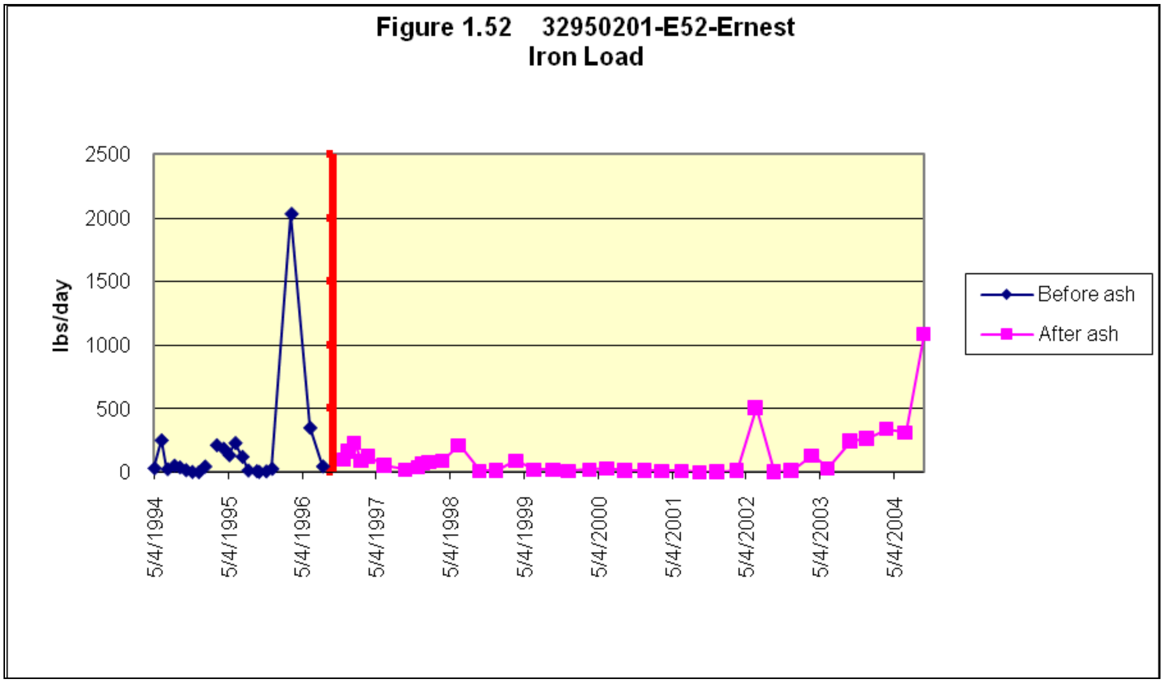


Figure 1.52 32950201-E52-Ernest
Iron Load
lbs/day
2500
2000
1500
1000
500
0
5/4/1994
5/4/1995
5/4/1996
5/4/1997
5/4/1998
5/4/1999
5/4/2000
5/4/2001
5/4/2002
5/4/2003
5/4/2004
Before ash
After ash

Figure 1.53 32950201-E17-Ernest
Alkalinity Load After Ash Placement

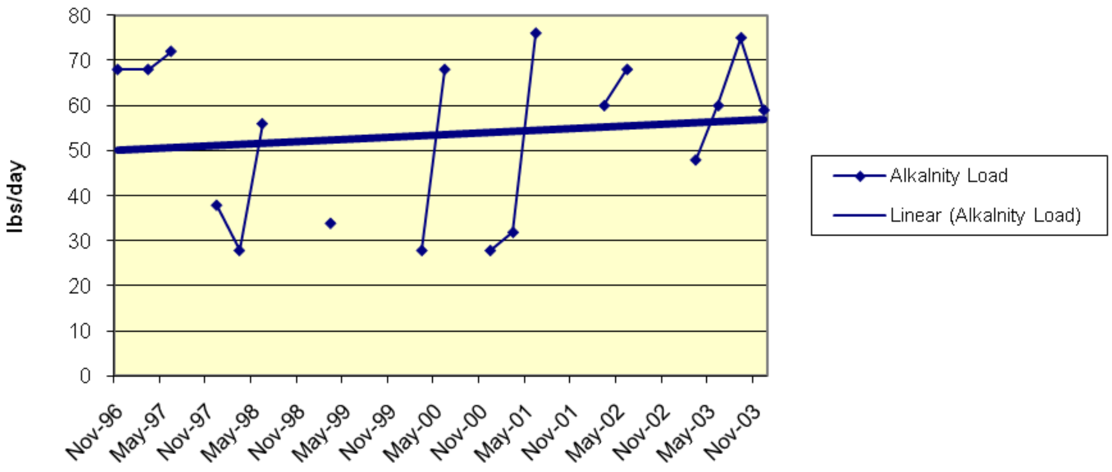


Figure 1.54 32950201-E17-Ernest
Sulfate Load After Ash Placement

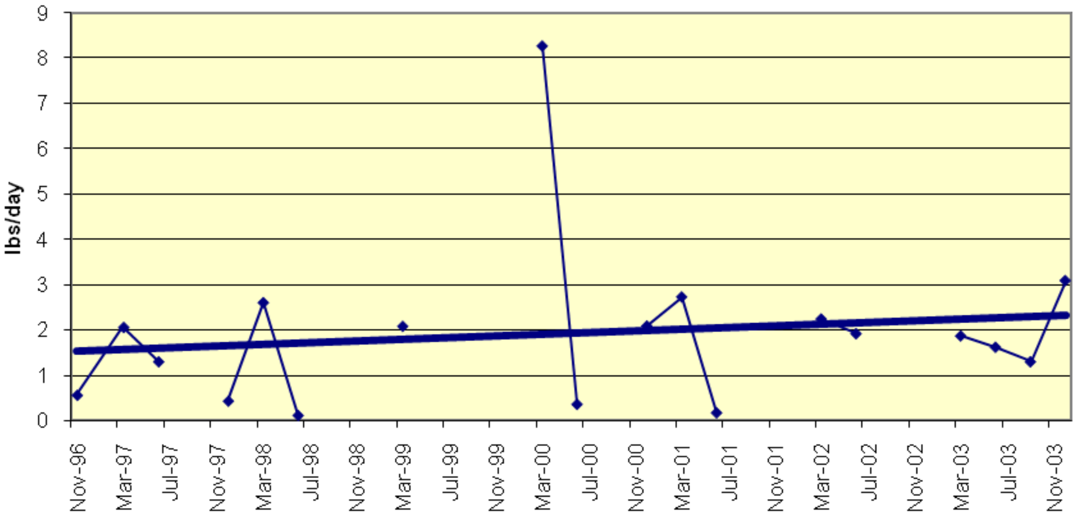
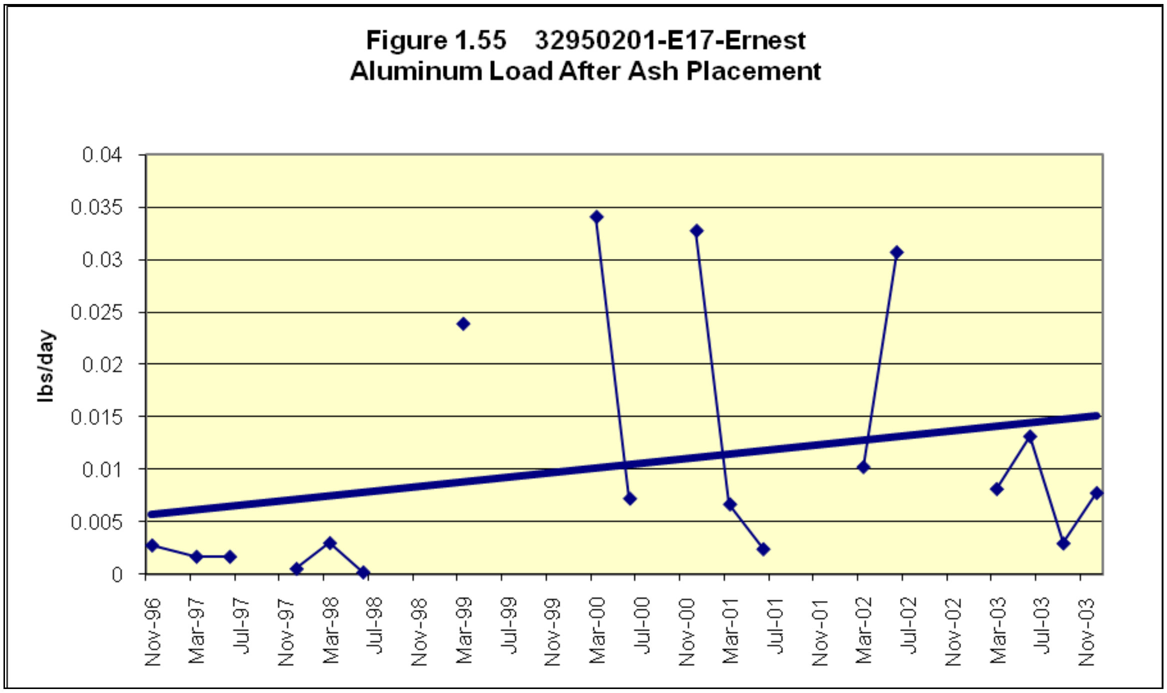


Figure 1.55 32950201-E17-Ernest
Aluminum Load After Ash Placement

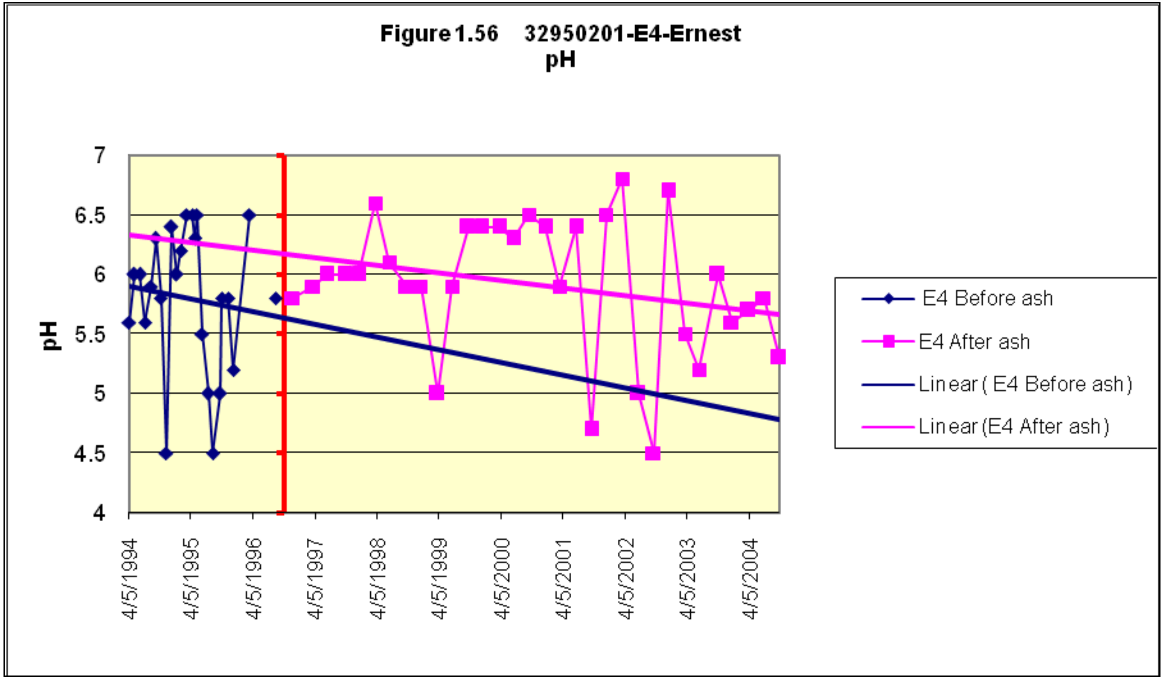


Upstream vs. Downstream: E34 and E4-McKee Run

Monitoring point E34 samples the surface waters of McKee Run upstream from the ash disposal site. E4 samples the surface waters of McKee Run downstream from the ash placement site. The alkaline buffering influence of the ash is evident in the surface waters at downstream E4. These effects are occurring when and where one would expect monitoring to show a more precipitous drop in pH from remining activity if the ash were not chemically reactive at this Subchapter F site. As depicted by the pink trend line, the field pH (figure 1.56) values after ash placement in E4 are declining over time but at a lesser rate than the pH values before ash placement. This moderation in the drop in pH values at E4 is mirrored by the rise of alkalinity (figure 1.56a). The specific conductance values (figure 1.57) at E4 are higher than at E34 reflecting the greater levels of dissolved salts coming from the ash placement area. The difference in these values is growing with time as indicated by noticeably higher peaks in specific conductance at E4 than E34 in 2001 to 2003. This result should be expected due to the greater volume of ash placed at the site, growing extent of that placement with time and lack of cover over much of the ash, all of which create conditions for ample generation of leachate from direct contact of precipitation with the ash. When comparing the pH values of upstream E34 and downstream E4 (figure 1.58), it is evident that the ash appears to have moderated declines in pH values of the downstream monitoring point while the upstream values are more static from before to after ash placement. The impact on water quality by the ash is also evident by the higher concentrations of aluminum (figure 1.59) and sulfates (figure 1.60) at the downstream monitoring point. Water quality standards that are being met at E34

(0.75 mg/L for Al and 250 mg/L at the point of water supply intake for SO4) are being exceeded for aluminum and possibly exceeded for sulfate at E4.

These figures indicate that the Ernest operation is polluting the waters of McKee Run and that the FBC ash being placed in that operation is contributing to this pollution. Monitoring at E4 and E34 for constituents that are found more exclusively in leachate of the ash being placed at this site would help determined the extent of that contribution.



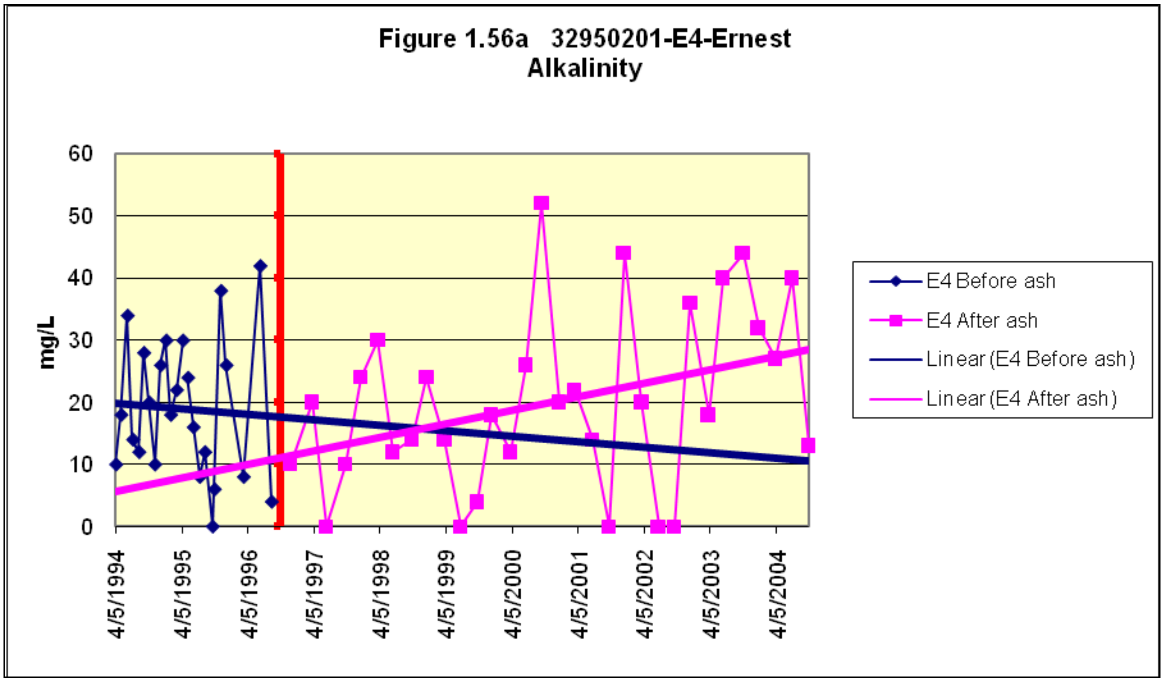


Figure 1.56a 32950201-E4-Ernest
Alkalinity
mg/L
0
10
20
30
40
50
60
4/5/1994
4/5/1995
4/5/1996
4/5/1997
4/5/1998
4/5/1999
4/5/2000
4/5/2001
4/5/2002
4/5/2003
4/5/2004
E4 Before ash
E4 After ash
Linear (E4 Before ash)
Linear (E4 After ash)

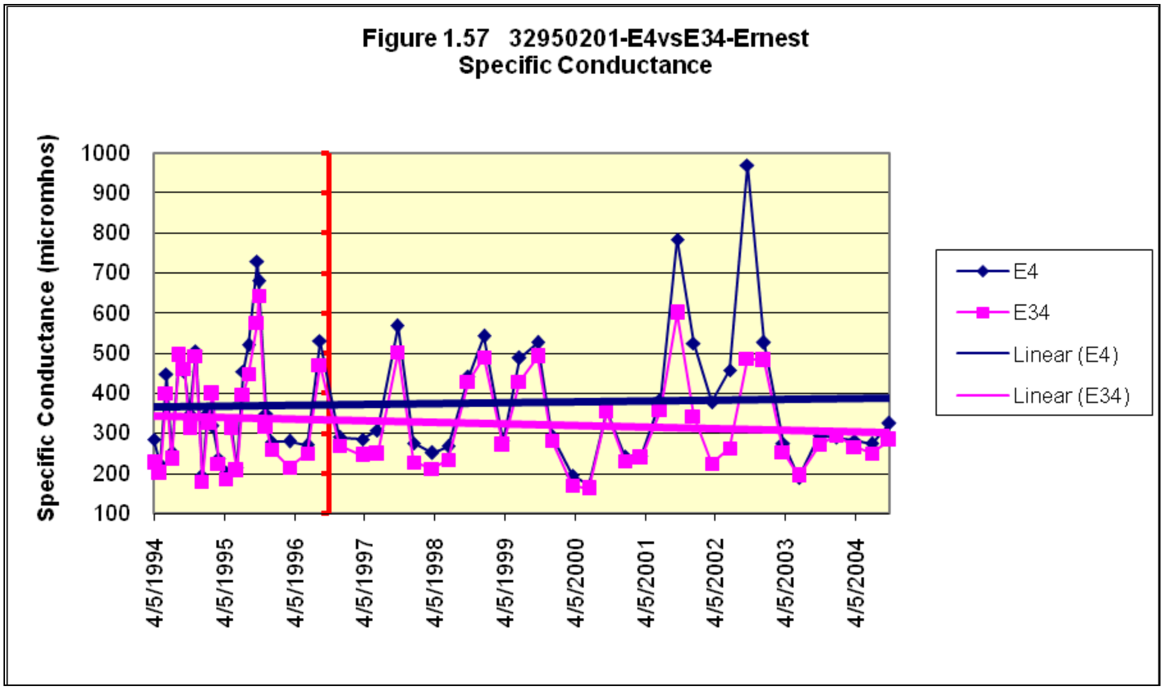


Figure 1.57 32950201-E4vsE34-Ernest
Specific Conductance
Specific Conductance (micromhos)
100
200
300
400
500
600
700
800
900
1000
4/5/1994
4/5/1995
4/5/1996
4/5/1997
4/5/1998
4/5/1999
4/5/2000
4/5/2001
4/5/2002
4/5/2003
4/5/2004
E4
E34
Linear (E4)
Linear (E34)

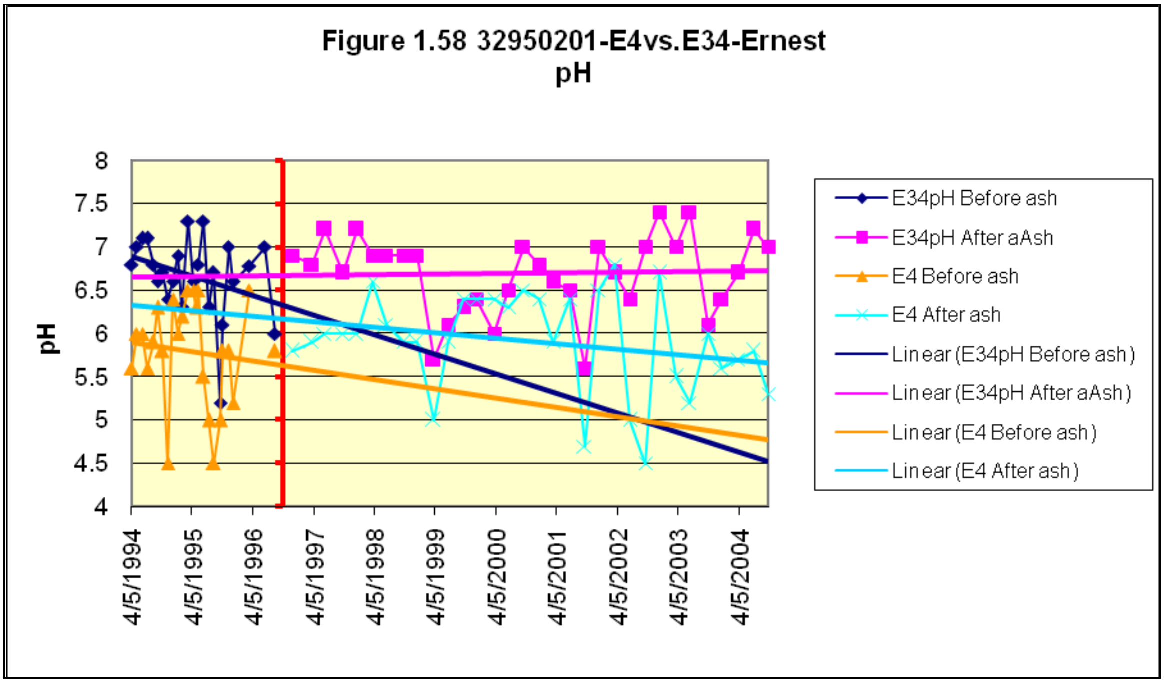


Figure 1.58 32950201-E4vs.E34-Ernest
pH
pH
8
7.5
7
6.5
6
5.5
5
4.5
4
4/5/1994
4/5/1995
4/5/1996
4/5/1997
4/5/1998
4/5/1999
4/5/2000
4/5/2001
4/5/2002
4/5/2003
4/5/2004
E34pH Before ash
E34pH After aAsh
E4 Before ash
E4 After ash
Linear (E34pH Before ash)
Linear (E34pH After aAsh)
Linear (E4 Before ash)
Linear (E4 After ash)

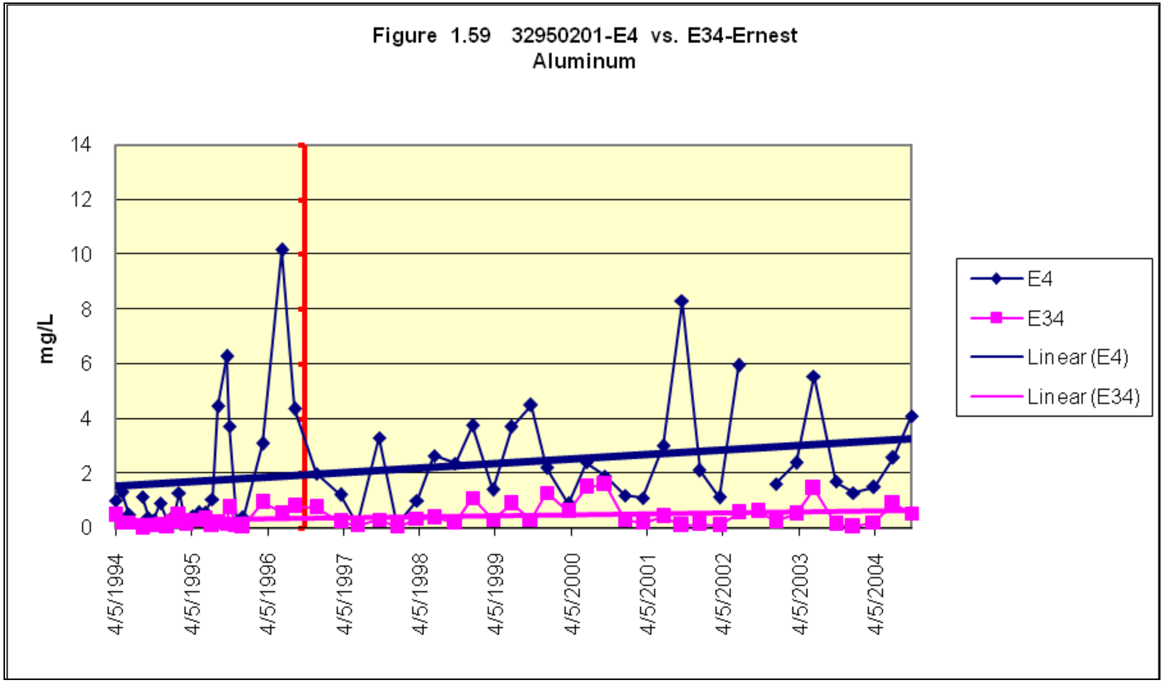
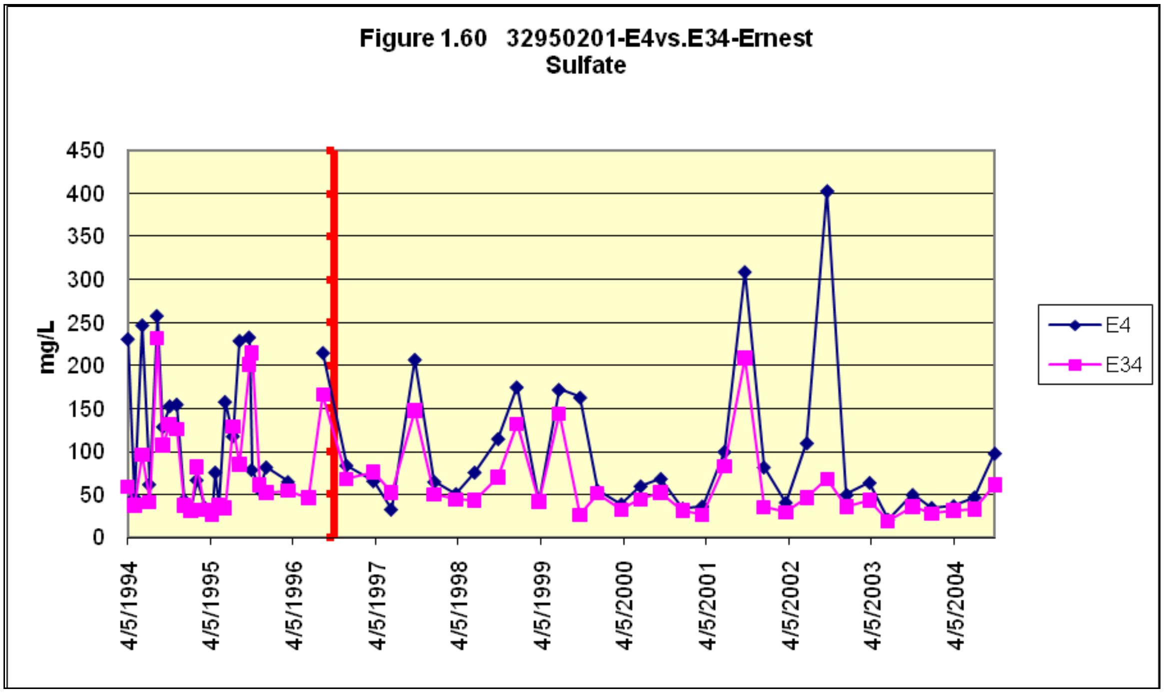


Figure 1.59 32950201-E4 vs. E34-Ernest
Aluminum
mg/L
14
12
10
8
6
4
2
0
4/5/1994
4/5/1995
4/5/1996
4/5/1997
4/5/1998
4/5/1999
4/5/2000
4/5/2001
4/5/2002
4/5/2003
4/5/2004
E4
E34
Linear (E4)
Linear (E34)



Mine Pool

Analysis of monitoring points in the deep mine reveals that the quality of discharges from the shallow water associated with the refuse pile is worse than water quality in the Ernest No. 2 deep mine pool. Despite this difference, this analysis reveals further that water quality in this mine pool closest to the refuse pile has been deteriorating during the refuse remining and ash placement operation while water quality at the monitoring point in the mine pool upgradient of the refuse pile has not deteriorated.

There are three monitoring points in the mine pool depicted on EXHIBIT 9 OPERATIONS MAP for SMP 32950201, stamped with the date of July 23, 1999. They are E35, E7 and E70. E35 monitors a discharge from the minepool into McKee Run approximately one third of a mile upstream to the northeast from the Ernest site at a point considered to be upgradient of impacts from the Ernest refuse pile. E7 and E70 monitor discharges from the mine pool that are flowing to McKee Run, approximately 400 feet and 100 feet respectively west of the northwest flank of the refuse pile. These two monitoring points are located very close to the shallow groundwater flow from the refuse pile (within a few hundred feet of E5 and MW1) and thus in a position likely to be influenced by those discharges. The Module 25 in the Ernest permit indicates that there is a hydrologic connection between the mine pool and the shallow groundwater flow from the refuse pile sampled by the ash monitoring points. That connection is most clearly born out by the similarity in concentrations measured at MW2 with concentrations measured at E70. Unless otherwise indicated, the monitoring period and trends at ash monitoring points in this discussion pertains to data gathered after mining and ash placement had begun at the Ernest refuse pile while data from the mine pool monitoring points includes one sample from August 1996, before those activities had begun.

Acidity concentrations at E35 have averaged near zero during the monitoring period (August 1996 to October 2004) while at E7 average acidity has remained below 450 mg/L and at E70 average acidity has risen from around 650 to 1400 mg/L (figure 1.61). This compares to acidity levels of between 3000 and 5000 mg/L at MW1 and E5. While acidity is noticeably lower in the mine pool, with the highest levels being only one-third the acidity measured at these ash monitoring points, it is undergoing a notable rise at E70, the monitoring point in the mine pool that is closest to the refuse pile. The acidity at E70 is in the same range as acidity levels at MW 2 typically between 500 and 1200 mg/L.

Field pH over the eight years of monitoring data in figure 1.62 has dropped only slightly at E35 with average values staying largely between 5.8 and 6, and its trend has remained flat at E7 at an average value of around 4.8 At E70 however the field pH has declined by almost one and a half units from an average of 4.8 to 3.4. This compares to field pHs that have dropped from an average of 4.5 to 4 at MW1 and E5 and from 4.4 to 4.1 at MW2. Similar to ash monitoring points, lab pHs in the minepool have been roughly a half to two units below field values. However, unlike the lab pHs which increased notably at E5 and somewhat at MW2, the lab pHs in the mine pool have either remained unchanged or moved downward with the decline in field pH.

The highest iron concentrations in the mine pool (figure 1.63), measured at E70 of 400 to 500 mg/L, reach about half the highest iron concentrations at E-5 and MW1 which are between 900 to 1200 mg/L, while iron averages close to 100 mg/L at E7 and 10 mg/L at E35. Of note is that while iron concentrations have leveled off or declined at the ash monitoring points, average iron levels have been rising at E70 from near zero in 1997/98 to 225 mg/L as of October 2004. This range in concentrations was close to the range of iron measured at MW2 (from approximately 10 to 200 mg/L). Average manganese concentrations of between 1 and 4 mg/L in the mine pool (figure 1.64) have been a fourth to a half of average manganese concentrations at MW1 and MW2 and a much smaller fraction of manganese levels at E5 which have risen to as high as 59 mg/L in the fall of 2000 and never fallen below 19 mg/L. The highest aluminum concentrations in the minepool (figure 1.65) are one-third as high as the highest aluminum concentrations at E5 and MW1 while they are often in the same range as concentrations at MW2.

Sulfate concentrations have averaged around 200 mg/L at E35 throughout the monitoring period while they have risen from approximately 700 to 900 mg/L at E7 and from approximately 700 to 1800 mg/L at E70 (figure 1.66). This compares to rising sulfate concentrations at MW1 that range from 4,000 to nearly 9,000 mg/L and rising concentrations at E5 that range from approximately 2,800 to nearly 9,000 mg/L. Again however, concentrations at MW2 although declining, have ranged from approximately 950 mg/L to 1950 mg/L, roughly equivalent to those at E70, the most polluted mine pool monitoring point.

Specific conductance levels (figure 167) are a good measure for overall pollutant content in the absence of TDS data which has not been collected from the mine pool. Specific conductance values have remained fairly constant around an average of 500 micromhos at E35 and an average of 1500 micromhos at E7. At E70 however, average specific conductance has risen from approximately 1500 micromhos to 3500 micromhos during the monitoring period and actual values have ranged from 600 to 5700 micromhos. These values are well below the average values at MW1 which had risen to 8205 micromhos in the most recent six measurements as of June 2003 and average values at E5 which had risen to 9298 micromhos as of that same point in time. However they are above the average specific conductance at MW2 which had fallen to 2030 micromhos by the last six measurement up to June 2003.

An 89 percent reduction in flow volumes at E-35 from the beginning to the end of the monitoring period should be noted. The average flow for the first six measurements taken from August 1996 to December 1997 was 92.25 gallons per minute (GPM) whereas the average flow for six measurements from March 2002 to June 2003 was 11.48 GPM. Average flows at E70 and at E7 (which at more than 1000 GPM are by far the largest of the three monitoring points) did not change nearly as significantly, but nonetheless increased by 20 and 3 percent in these same samplings respectively, suggesting that more surface water is reaching the minepool near the refuse pile. Flow data for latter 2003 and 2004 was not available for this assessment. More investigation is needed to determine the causes for changing flows, particularly the decreased flows from the Ernest No. 2 Deep Mine upstream of the Ernest refuse pile.

Cumulatively this data demonstrates that water in the mine pool is cleaner than water being monitored at ash monitoring points MW1 and E5 and not likely to be the source of deteriorating water quality at those points. Furthermore the steady rises in specific conductance, acidity, iron, and sulfates at the mine pool monitoring point closest to these points, E70, indicates this remining operation is polluting the mine pool significantly despite its large drainage area. There has been no monitoring for trace elements or other more ash specific parameters at the mine pool monitoring points of this permit.

Figure 1.61 32950201-E7/E35/E70-Ernest Mine
Acidity

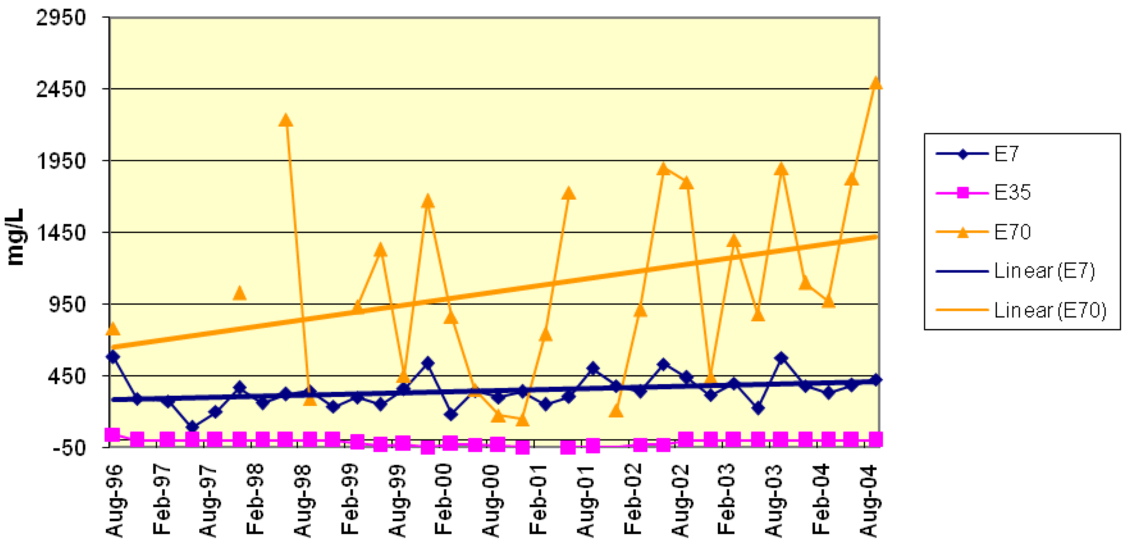


Figure 1.62 32950201-E7/E35/E70-Ernest Mine
Field pH

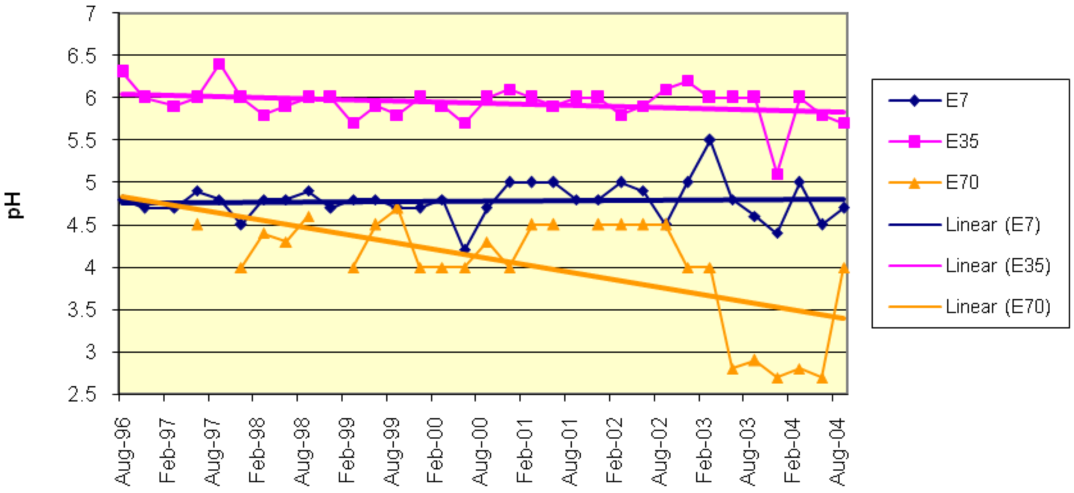


Figure 1.63 32950201-E7/E35/E70-Ernest Mine
IRON

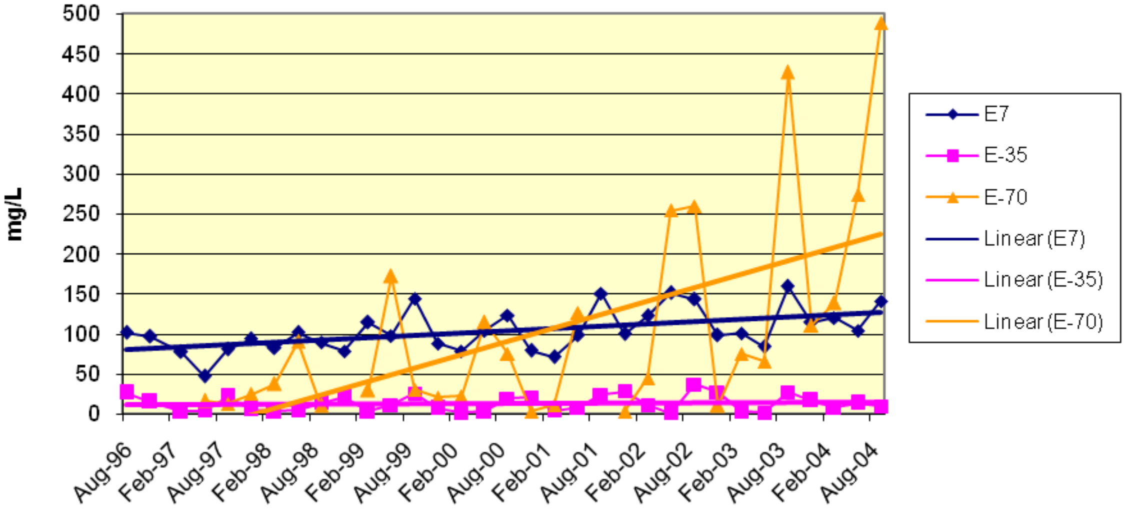
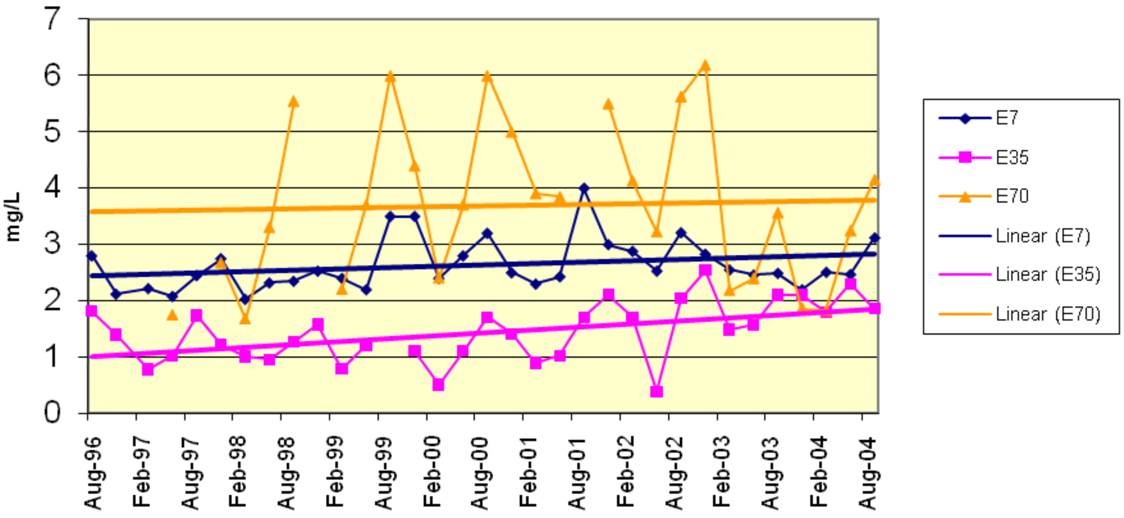


Figure 1.64 32950201-E7/E35/E70-Ernest Mine
Manganese



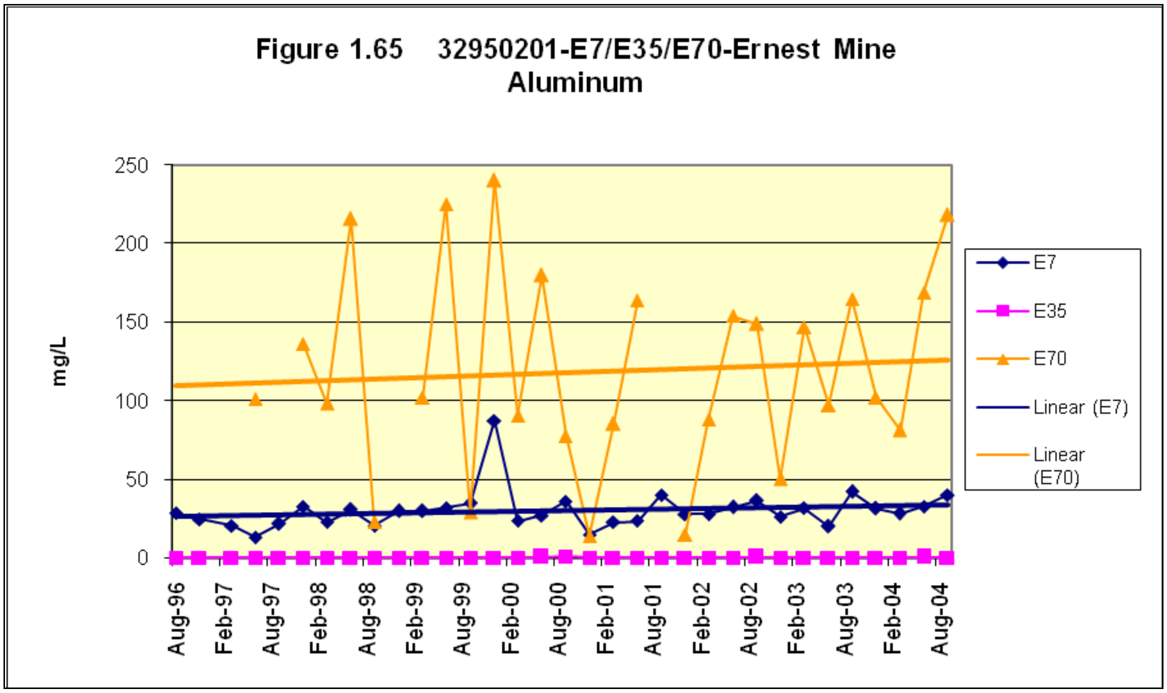


Figure 1.65 32950201-E7/E35/E70-Ernest Mine
Aluminum
mg/L
250
200
150
100
50
0
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
E7
E35
E70
Linear (E7)
Linear (E70)

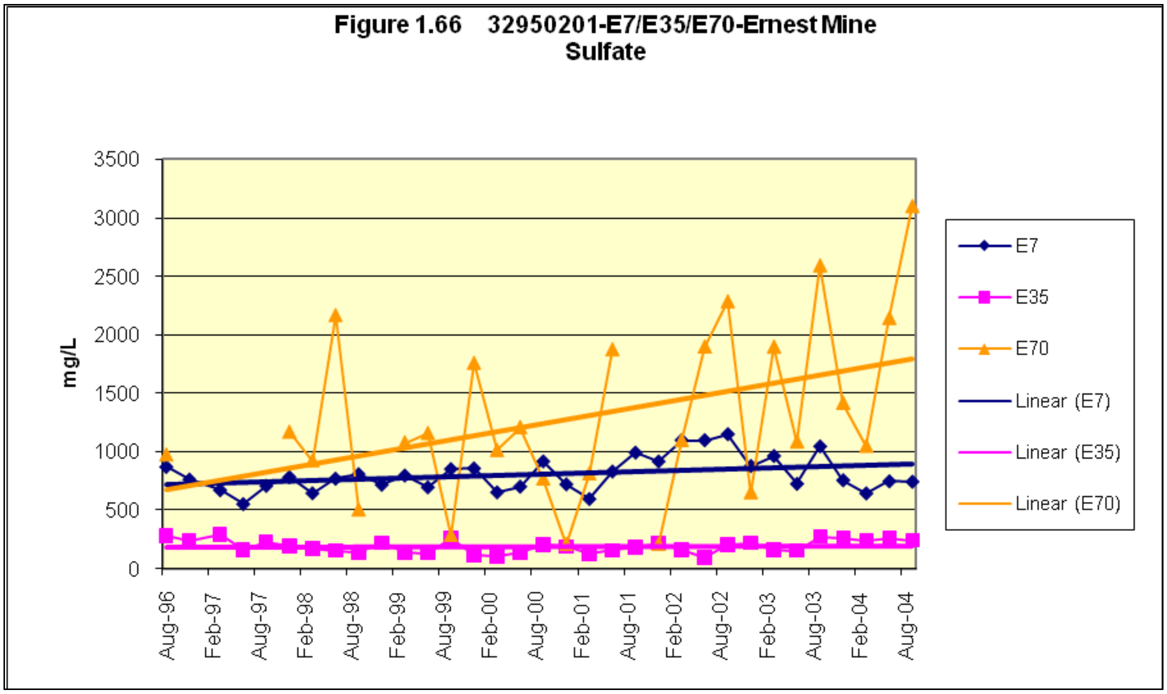
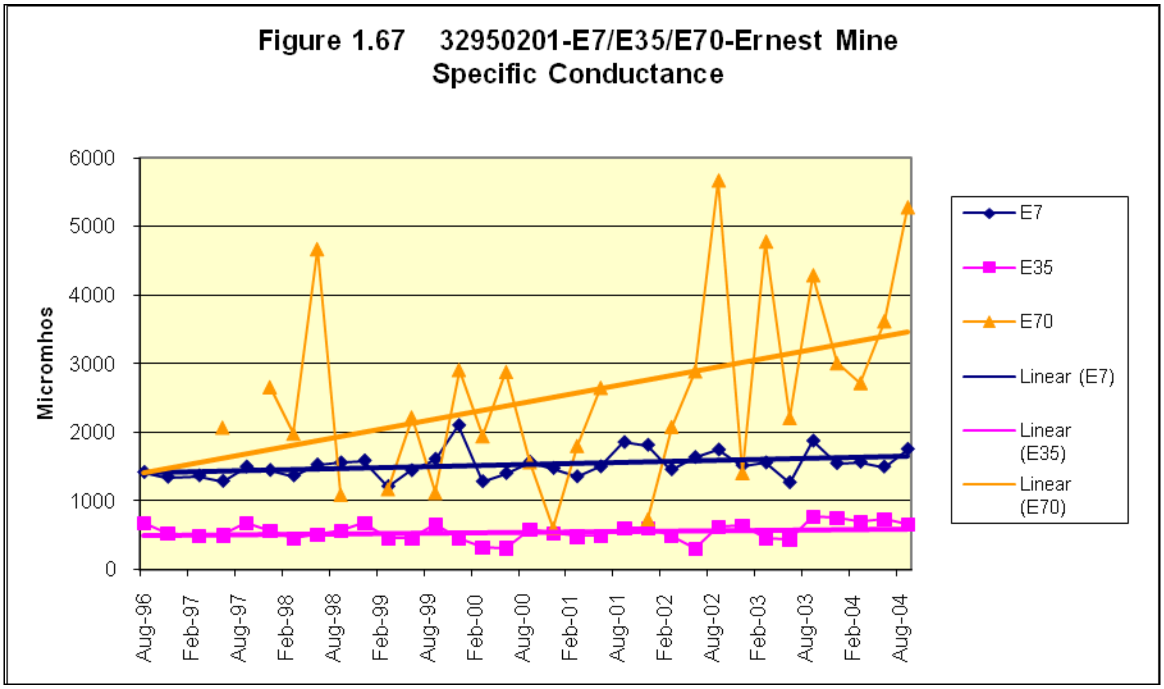


Figure 1.66 32950201-E7/E35/E70-Ernest Mine
Sulfate
mg/L
3500
3000
2500
2000
1500
1000
500
0
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
E7
E35
E70
Linear (E7)
Linear (E35)
Linear (E70)



Conclusion

A June 10, 2002 Report of the PADEP concedes that some degradation in water quality is occurring at the ash monitoring points at Ernest. The report asserts, however, that none of this degradation is coming from ash and that the degradation is not serious enough to adversely effect water quality on nearby McKee Run, the major stream that drains the surrounding watershed and is a local public water supply upstream of the Ernest site.

While the PADEP Report states that the ash monitoring points at Ernest are too far from the ash at the southeastern corner of the refuse pile to detect impacts from the ash, PADEP concedes that coal refuse piles are porous and permeable and that this refuse pile in particular has the consistency of sand and gravel. (Personal communication from PADEP staff, Cambria District Office, February 10, 2005) Furthermore, to date the ash has not been capped at Ernest, allowing for large quantities of precipitation to percolate directly through the ash downhill toward the ash monitoring points. The interconnected pores readily allow for the flow of water through this pile both vertically and horizontally. Although the 2002 PADEP report states that groundwater movement on the site between the ash placement area and the monitoring points has been "slight," PADEP has never generated hydraulic conductivity data or otherwise conducted groundwater flow assessments in the permit area after the permit was issued. In our judgment, it is safe to assume that ash-affected discharge originating in the southeastern portion of the refuse pile reaches the designated monitoring points located on the western and northwestern parts of the site.

The concentration measurements at the MW1, MW2, and E5 monitoring points strongly suggest the influence of ash-affected effluent in the geochemical system on the site. For example, it is difficult to account for the increases in chloride concentrations across the board at all the ash monitoring points after ash placement began, unless one attributes these increases to the Cambria FBC ash, which contains a large amount of chloride and readily leaches chloride in the permit's leach test. According to PADEP, the coal refuse at this site does not contain appreciable amounts of chloride. The static and decreasing concentrations of acidity coupled with rises in calcium and chloride concentrations at MW2 indicate a contribution from coal ash to water quality degradation. MW1 and E5 data also showed increases in calcium, chloride and TDS when measured acidity levels sharply declined in 1999 and 2000, indicating this same contribution.

Concentrations of aluminum and trace elements such as lead, arsenic, chromium, copper, nickel and zinc reached their highest levels, usually several to many times above drinking water standards, during the lowest point of this decline in acidity at MW1 and E5 in September 2000, four years after ash placement started. Although cadmium was below detection level at MW1 in September 2000, the measurement for cadmium at E5 in September 2000 was the second highest concentration recorded for this element at E5. These trace elements are all ash parameters that regularly leach above detection levels in the leach tests required by the permit. This clearly suggests that the ash is degrading water quality at the Ernest site.

In addition, the ash has affected the surface impoundments found on the site closer to the ash placement areas. Analysis of the only two water samples collected at Impoundment #4, which the 2002 PADEP Report states is influenced by the ash, demonstrates the same approximate levels of aluminum, sulfates, calcium, chloride, sodium, arsenic and TDS that were in the effluent at the monitoring points discussed above. Citing potassium levels in this water, the 2002 PADEP Report states that the water quality in this impoundment "is strongly influenced by the ash placed at the site." Potassium was also found to leach from the ash in the permit test. However, there is no data set of regular potassium concentrations that has been gathered at the ash monitoring points at Ernest. Therefore the assertion that one or two samples of effluent from ash monitoring points do not have similar potassium levels as that those found in Impoundment #4 cannot be substantively examined or assessed.

Subchapter F loading data reflect the amount of some constituents released into the aquatic environment at the Ernest site. Hydrologic unit #1 (E1) is strategically located at the northwest base of the site. The data show that the loads for aluminum, iron, acidity, and sulfates were decreasing before ash placement commenced and then exhibited an overall steady increase in loadings and associated water quality degradation after mining and ash placement began. Loading data for these constituents and manganese at E52, located at the mouth of the unnamed tributary along the western border of the site, show the same pattern: a large spike recorded in March 1996 and then, after a drop in loading rates, a steady increase in those rates up to the most recent monitoring. Loads of alkalinity, aluminum and sulfates at E17, further upstream on this tributary and significantly closer to the ash, rose once ash placement started. Given the strategic location and trajectory of this tributary collecting discharge off the western side of the pile, these rising loads further suggest a contribution of CCW to the degradation of water quality emanating from the Ernest site. Finally loading data collected from ash monitoring point E5 reveal substantially higher loads of calcium, aluminum and trace metals such as arsenic, barium, cadmium, chromium, copper, lead, nickel and zinc discharging from the base of the refuse pile several years after mining and ash placement got underway that had never been previously measured.

There is substantive debate about the primary causes of the degradation of water quality at the Ernest site. PADEP suggested in a response to an earlier draft of this report that the mine pool of the Ernest No. 2 Deep Mine has a dominant effect on the area's hydrogeology and downstream water quality on McKee Run. However monitoring data indicates that this permit is negatively impacting the mine pool rather than vice versa. A much clearer understanding of the causes could be attained if more monitoring points were established closer to and in the ash collecting pore water data and if monitoring included more parameters distinctive to *this ash's leachate* as opposed to being focused on parameters that can leach from mining and coal refuse on the site as well as the ash. Although this may necessitate further analysis of the characteristics of the coal refuse at this site, such ash indicator parameters would likely include potassium, boron, molybdenum and antimony. In addition to the current ash monitoring points and the above suggested additional points, concentrations of ash leachate parameters should be regularly measured at upstream and downstream monitoring points on McKee Run such as E34 and E4, at monitoring points on the unnamed tributary along the western perimeter of the refuse pile, in the mine pool underneath the site, in surface impoundments receiving drainage from the ash placement area as it advances across the refuse pile and at the discharge points for the NPDES permit regulating this site. If possible, an upgradient monitoring point capable of differentiating impacts exclusively from movement of the coal refuse should also be established at this site.

EDITOR'S NOTE: A follow up retrieval of data in April 2007 from ash monitoring points at the Ernest Site for the period from the second quarter of 2004 through the first quarter of 2007 reveals that high total concentrations of cadmium and chromium are continuing to occur at the E5 seep and downgradient monitoring well MW1. Of particular note are chromium concentrations at E5 which have exceeded the Drinking Water Standard of 0.100 mg/L in five samples with the highest concentration, 0.193 mg/L, measured in a June 30 2005 sample. An additional sample collected on that date measured chromium at 0.123 at E5. There have also been five samples exceeding the DWS for cadmium at E5, with the highest being 0.045 mg/L in a June 26, 2006 sample, 9 times higher than the DWS.

At MW1, one of two samples collected on June 30, 2005 had a chromium concentration at the DWS, 0.100 mg/L while chromium in the other sample was below a detection limit of <0.050 mg/L. The first sample also had a cadmium concentration of 0.0740 mg/L, 14.8 times higher than the DWS. A sample collected on June 26, 2006 had a cadmium concentration of 0.061 mg/L, 12.2 times the DWS.

Several of these samples also exceeded DWS for arsenic with one each exceeding by more than four times at E5 and MW1, and lead also exceeded the DWS by nearly two times in two samples at MW-1.

A -

B -

CAPTION - A – The drainage along the western perimeter of the Ernest Refuse pile is contaminated with high levels of aluminum, iron, manganese, and sulfate, pollutants found in both AMD and ash leachate. B – Ash monitoring point E-5, reflected in the water of this seep before it empties into the drainage in A, has revealed that these waters are also carrying increasing levels of cadmium, lead, chromium, calcium, magnesium, chloride and other pollutants more indicative of ash leachate. Alkalinity has also increased in this drainage. Photos by Jeff Stant, August 2007.

A -

B -

CAPTION - A- Cloudy water from the Ernest Deep Mine discharge at monitoring point E-7 suggest high Total Suspended Solids. Deep Mine points have monitored increasing acidity, iron, sulfate, manganese, and aluminum since remining of the Ernest Refuse pile started although pH in this discharge has remained steady at 4-5 units. Parameters more exclusive of ash are not monitored in this water. B – Discoloration occurs where the Deep Mine discharge enters McKee Run a few feet from the where the drainage shown on the previous page enters from the western side of the refuse pile. According to PADEP (communication with Ebensburg Staff, August 2007), aquatic life in McKee Run is being harmed by the Deep Mine discharge. Photos by Jeff Stant, August 2007.

Permit Review 2

LAUREL LAND DEVELOPMENT, MCDERMOTT MINE
(Permit# 11950102)

Site Summary

The 85-acre McDermott site is located in Jackson Township, Cambria County, Pennsylvania. The project involved surface mining of the Lower Kittanning, Middle Kittanning and Lower Freeport coal seams under a permit that included a Subchapter F abatement plan for preexisting acid discharges. The Lower Kittanning seam was previously surface and deep mined. The project mined through (daylighted) deep mines on the site. The operator, Laurel Land Development, put 316,930 tons of alkaline FBC ash on the site: 28,775 tons from the Colver Power Plant in Colver, PA and 288,155 tons from the Cambria CoGen Plant in Ebensburg, PA. By placing approximately 6,600 tons of alkaline ash per acre on the site, a primary objective was to mitigate substantive acid mine drainage. During the mining process the operator placed ash on the pit floor, differentially mixed the ash with the mining spoils depending on the seam and added ash to the surface prior to spreading topsoil. Some 73 acres were planned to be affected by the mining operation, nearly all of it subject to ash placement.

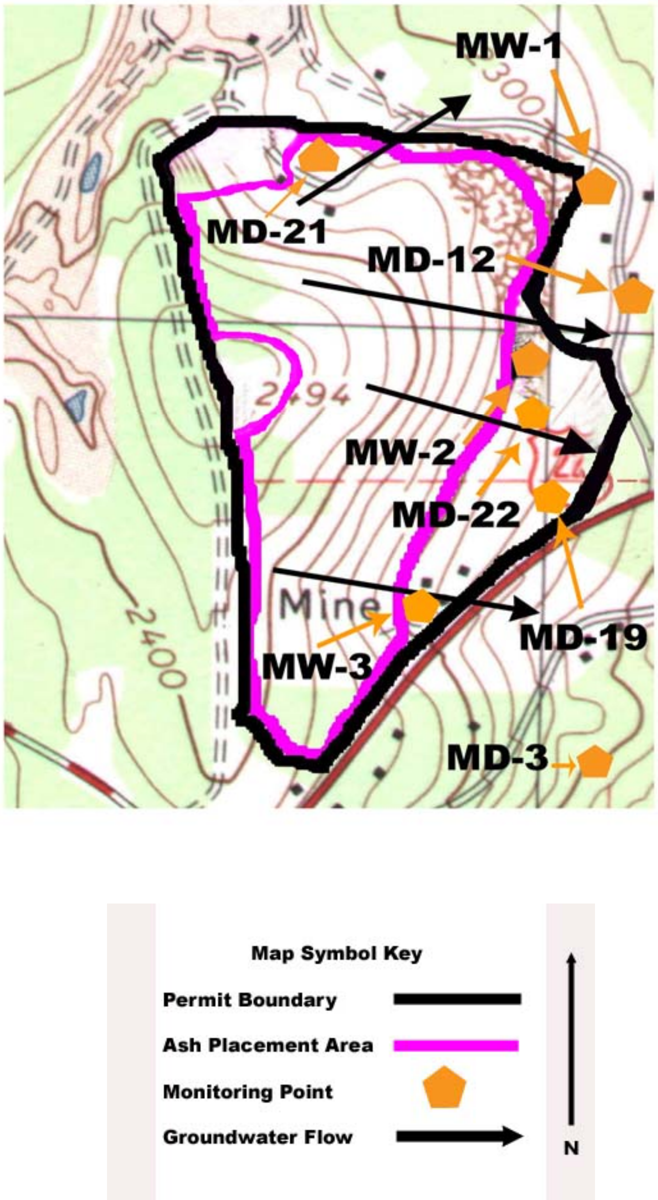
Geology

The McDermott Mine site lies in the Allegheny Mountain section within the Appalachian Plateau physiographic province, between the Laurel Hill Anticline to the west and the Johnstown Syncline to the southeast of the site. The crest of the anticline plunges to the northeast. The strata in the area dip from the crest of Laurel Hill to the axis of the syncline at a rate of approximately 600′ per mile. The coals mined under the permit were the Lower Kittanning, Middle Kittanning and the Lower Freeport all part of the Allegheny Formation of the Pennsylvanian System.

Groundwater

Typically, groundwater in the site would have been perched on each of the seams of coal. The lowest of these perched water tables would be associated with Lower Kittanning. Another groundwater table is 40′ below the Lower Freeport coal. The regional water table is estimated to be located much lower than the level of the Lower Kittanning coal, at the level of Hinckston Run. Flow paths, however, cannot be accurately determined from the information in the permit modules. Nonetheless, the fairly steep dip in strata combined with the greatly increased permeability caused by the breaking up of earth from mining and the increased drainage of surface waters to underground pathways from the daylighting of deep mines should have resulted in an enhanced flow rate of groundwater through and away from the site, once mining and ash placement operations were underway. Based on a permit map labeled as “exhibit 6.2” the regional ground water flows down dip 2.3˚ to the east and east southeast. Local surface and shallow ground water flow, according to the map, follows topography flowing perpendicularly to contour lines also to the northeast, east and southeast. However, no information on site specific ground or surface water flow is found in the permit that depicts flow patterns before and after ash placement. Connections between shallow groundwater and the mine pool under the site that would have been established when deep mines under the site were breached or daylighted by the mining operation are left to be surmised.

Site Map: McDermott



Laurel Land Development, McDermott Operation (Permit # 11950102)
Scale: 1" = Approximately 650'

Groundwater Monitoring Data:

Monitoring was done on groundwater associated with (1) strata above the Lower Kittanning and below the Lower Freeport and (2) the Lower Kittanning highwall and below. The water table found 40' below the level of the Lower Kittanning coal are monitored by monitoring wells MW1, MW2, MW3, a seep at MD19 and MD12 which samples a spring beyond the eastern border of the mine, downhill from the ash placement area. Before the water quality of this spring was contaminated by this operation, the spring was used as a private water supply by the property owner adjacent to the mine. All these monitoring points are downgradient. There are no functional upgradient monitoring points on the site. MD21, a well in the northwest corner of the site, was supposed to sample upgradient groundwater, but data for this point are not in the monitoring reports in the permit file. Impacts to water quality have been gauged by comparing monitoring data collected after the initiation of ash placement to baseline data that was collected in 1995 and early 1996 before ash placement began.

The water table associated with the Lower Kittanning coal has also been monitored by deep mine discharge sampling points MD1, MD2, MD22 and MD3. Point MD1 was eliminated by mining in mid-1997 and very few data were generated from it. Point MD2 has a pronounced paucity of data. MD22 monitors effluent emanating from a 10" PVC pipe that drains at the foot of the Lower Kittanning highwall. This pipe and the limestone trench it sits in were installed two years after the mining and ash placement.began. Its purpose was to divert polluted water that was developing on the site to settling ponds. This monitoring point, directly intercepting waters that would be moving through the ash, is well-positioned to monitor immediate groundwater impacts that have resulted from the placement of the ash on the site. MD3, located downgradient three hundred yards beyond the boundaries of the permit area to the southeast, monitored the discharge of the deep mine that would have been impacted by permit operations.

MW1- ash monitoring well off the northeast corner of the permit area

Data from MW1, downgradient of the northeastern corner of the ash placement area, show steady increases throughout the sampling period (1995-2003) in manganese (figure 2.1), sulfates (figure 2.2), calcium (figure 2.3), magnesium (figure 2.4), and sodium (figure 2.6). Manganese and sulfates rose to concentrations several to many times over the state and federal secondary MCLs (hereafter called Drinking Water Standards, DWS). By the end of the sampling period (2002 and 2003), both constituents had risen to levels 3-4 times their highest baseline concentrations. Thus waters already degraded with manganese concentrations as high as 132 times the DWS became more degraded with manganese levels up to 484 times the DWS after ash placement. Sulfate levels that were below the DWS before ash placement rose to 5 times the DWS after ash placement making waters that had potable levels of sulfate, also nonpotable from the standpoint of this pollutant.

Calcium concentrations rose steadily (figure 2.3), increasing 6-fold during the monitoring period from 1995 to 2003. Other readily soluble signature parameters for the FBC ash placed at this site, magnesium (figure 2.4), chloride (figure 2.5), and sodium (figure 2.6) rose to three to seven times baseline levels at MW1 after ash placement started. Not all rises were sustained however. Chloride concentrations appeared to undergo an early flush, promptly rising from 2 mg/L during the baseline period to 14 mg/L by March, 1998 and then declined to between 5-7 mg/L during the last two years of monitoring data (September 2001 to September 2003).

The calcium and magnesium values in figures 2.3 and 2.4 for June and September of 2000 and 2003 are total instead of dissolved concentrations as there are only total values provided in monitoring reports. Total instead of dissolved values for calcium and magnesium are reflected in these four samplings at other monitoring points as well, although when both values are reported there is little difference between them.

Calcium in the calcite form is commonly found in nonsilicate mineral cements of siliciclastic sedimentary rocks such as sandstones, shales and associated mudstones of this site. However, the primary components of most cements in siliciclastic sedimentary rocks are non-calcium based silicate minerals. On average by far the most abundant chemical constituent of sandstones, shales and related mudstones is silicon (SiO_2). Conversely, one of the least abundant chemical constituents of siliciclastic sedimentary rocks such as sandstones and shales is calcium. According to Pettijohn (1975, Sedimentary Rocks, Harper & Row: New York), the average composition of different sandstones shows that calcium bearing constituents such as CaO account for 1.6% in quartz arenite, 6.2% in lithic arenite, 2.5% in greywacke, and 2.7% in fedspathic arenite. The chemical composition of average shales and related mudrocks shows that the CaO constituent in these rocks is equally low (on the average about 3%). Although a chemical analysis of the sandstones and shales on the site has not been made, it is highly unlikely that the decisive rise in the concentrations of calcium at MW1 and all other monitoring points examined in this report is coming from the in-situ sandstone, shale and siltstone formations found on the site. The source of the calcium can be safely assumed to be the ash, given the acute deficiency in carbonates and low neutralization capacity of site spoils. The drill hole overburden data also shows a paucity of alkaline material. Discussion and data in a PADEP site report on the McDermott permit dated August 2, 2002 and in the PADEP Report, <u>Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania</u> (December 2004, Chapter 5, pages 135-145) corroborate the conclusion that there are no naturally occurring alkaline strata in the site overburden and that calcium, magnesium, chloride and sodium are likely markers of the FBC ash at this site.

Iron behaved differently than manganese and sulfate. Iron concentrations fluctuated seasonally to a great degree throughout the sampling period (figure 2.7) reaching peak concentrations twice as high as the highest baseline levels during third quarter samplings (in August and September) but other concentrations falling well below most baseline levels resulting in a slightly declining trend during mining and ash placement. TDS (figure 2.8) followed the sulfate and manganese trend rising throughout the sampling period from levels approximately 1.6 times the DWS (secondary MCL) to 4.5 times the DWS in the final year of mining and ash placement monitored for this assessment.

The influence of the ash is also indicated by the acidity trend (figure 2.9) that drops on average by 60 mg/L at MW1 during mining and ash placement. However, alkalinity values remained at zero throughout the baseline and ash placement periods. Nevertheless although average field pH dropped from approximately 4.75 to 4 units during ash placement monitoring, the trend for lab pH remained static (unchanging) at 3 units (figure 2.9a). A geochemical system in which acidity is declining while sulfate, manganese and TDS concentrations are rising far above secondary DWS and pre-ash levels suggests something other than the creation of acidity (oxidation of pyrite) must be the primary source for the increases in these pollutants. Major rises in constituents such as calcium, magnesium, sodium and chloride that are more exclusively associated with the ash, coupled with this drop in acidity is, at the very least, strong evidence that the large additions of alkaline FBC ash are contributing to this degradation if not the primary source of the sulfate, manganese and TDS. This finding is underscored by the fact that the geological strata in that system were predicted to generate a substantial increase in acidity from mining authorized with the ash placement and have done so at other monitoring points but not at MW1 even though the acidity measured before mining and ash placement at MW1 was noticeably higher than the acidity measured at all other monitoring points in this report except MD3. According to Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania, (Chapter 5, p. 143), "MW1 was located directly downgradient of a small abandoned surface mine, and its background water quality showed an influence from mine drainage pre-McDermott (Fig 5.11)."

The trace element data from MW1 (figure 2.10) shows the highest concentration for dissolved lead was the first measurement recorded during baseline sampling, 0.0593 mg/L in July 1995 (12 times the PA DWS of 0.005 mg/L and four times the federal DWS or Action Level of 0.015 mg/L). The remaining baseline measurements were less than half this concentration. After ash placement commenced, there were 19 measurements of lead in excess of the federal DWS with the first measurement of 0.0349 mg/L in August 1996 being the highest.

There was one concentration of dissolved cadmium measured at MW1 over detection limits, 0.01 mg/L in March 2003, twice the DWS. There were two concentrations of dissolved selenium recorded at MW1, 0.0075 mg/L in June 2002 and 0.012 mg/L in December 2002. These are notable given that no actual concentrations for selenium or cadmium were measured during the baseline sampling period. All values before ash placement fell below a detection limit of <0.007 mg/L for selenium and <0.010 mg/L for cadmium. This detection limit for cadmium is twice the DWS and therefore too high to tell whether cadmium was already occurring at levels of concern.

All arsenic levels were measured at below detection limits. In the last quarter of 1998 and first quarter of 1999 however detection limits for arsenic (<0.040 mg/L) and selenium (<0.070 mg/L and <0.077 mg/L) were too high to discern whether these trace elements were occurring at levels of concern (near or over the DWS of 0.010 mg/L for arsenic and 0.050 mg/L for selenium).

The gap of data in figure 2.10 from the second quarter of 2000 through the first quarter of 2001 was confirmed in a September 28, 2005 meeting with PADEP staff at the Cambria District Mining Office.

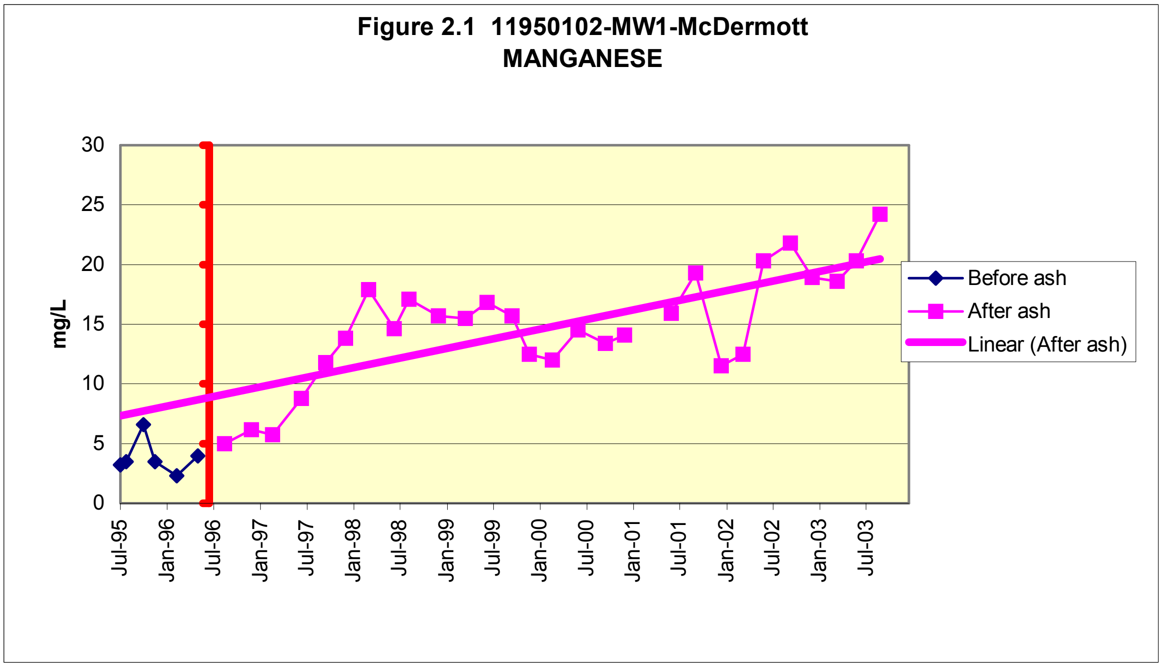


Figure 2.2 11950102-MW1-McDermott SULFATES

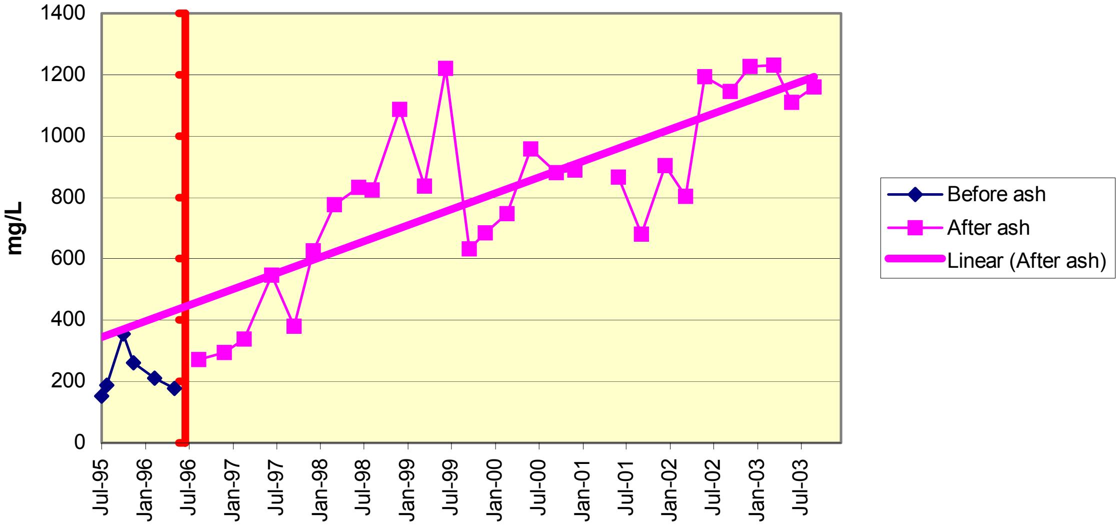
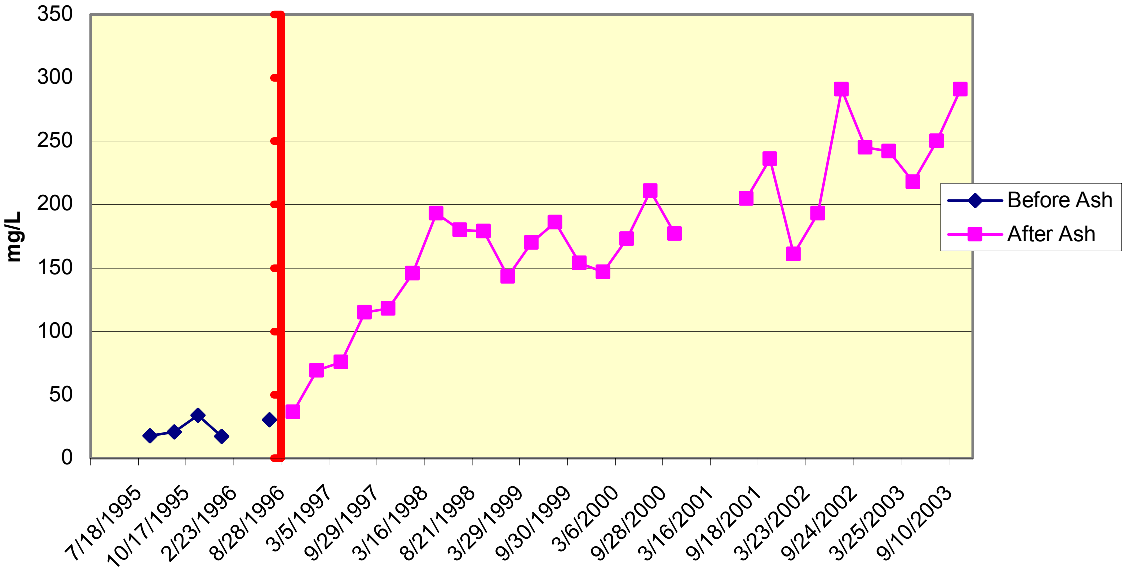


Figure 2.3 11950102-MW1-McDermott Calcium



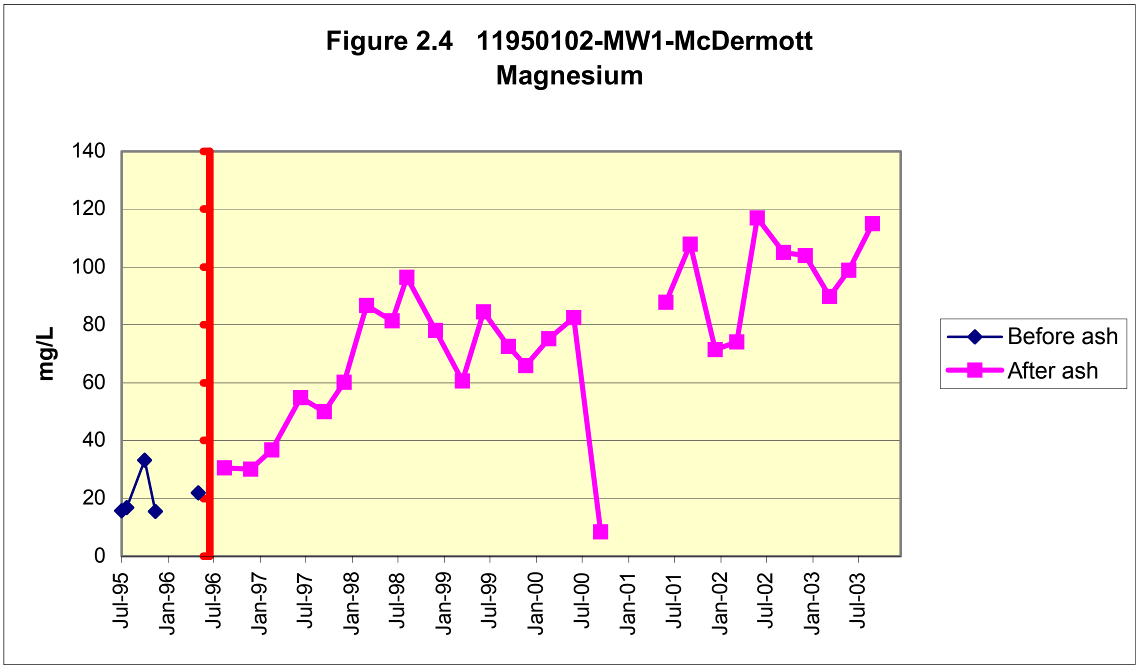


Figure 2.4 11950102-MW1-McDermott
Magnesium
mg/L
0
20
40
60
80
100
120
140
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Before ash
After ash

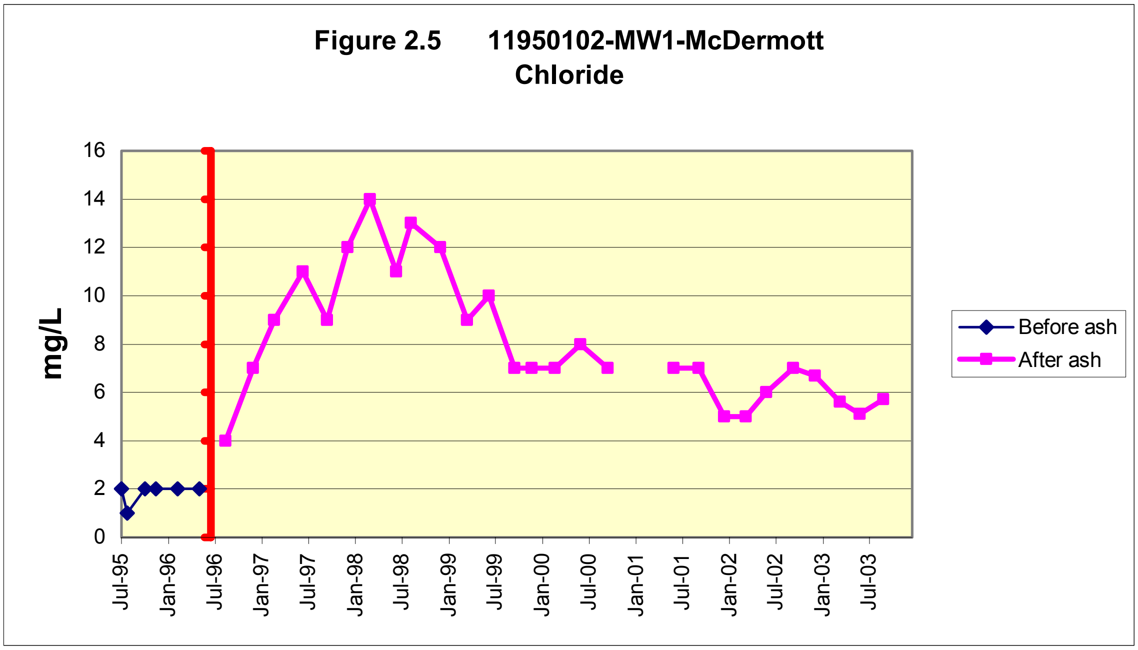


Figure 2.5 11950102-MW1-McDermott
Chloride
mg/L
0
2
4
6
8
10
12
14
16
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Before ash
After ash

Figure 2.6 11950102-MW1-McDermott
Sodium

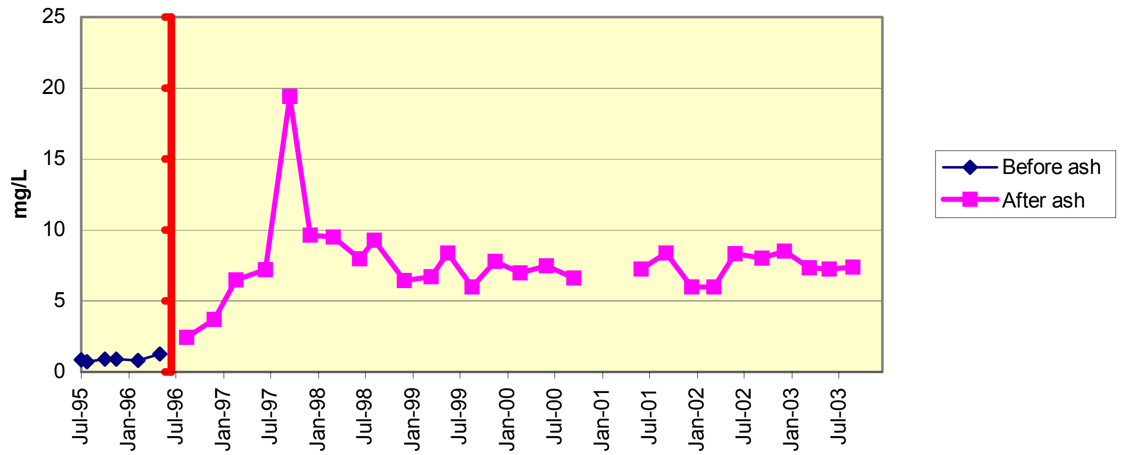
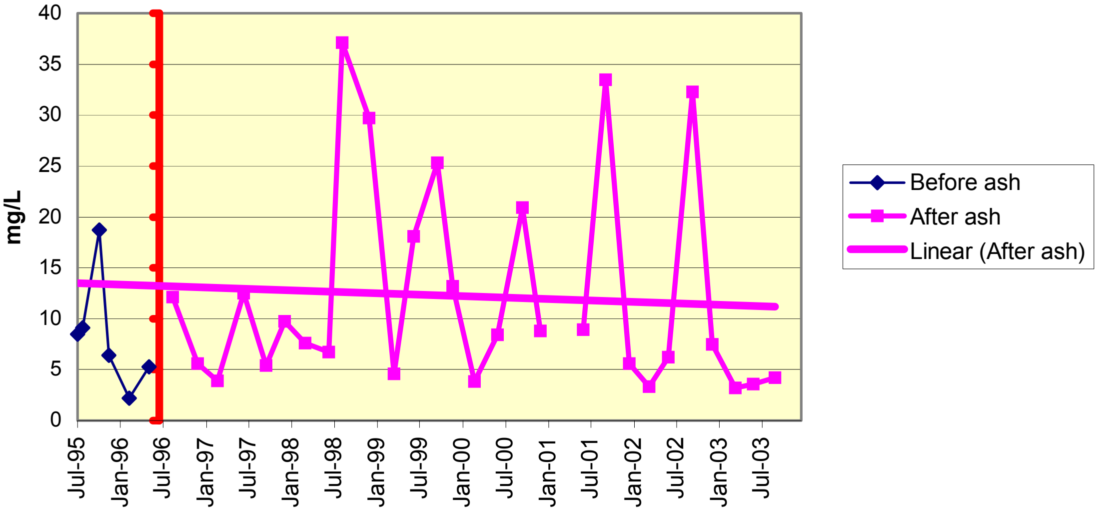


Figure 2.7 11950102-MW1-McDermott
IRON



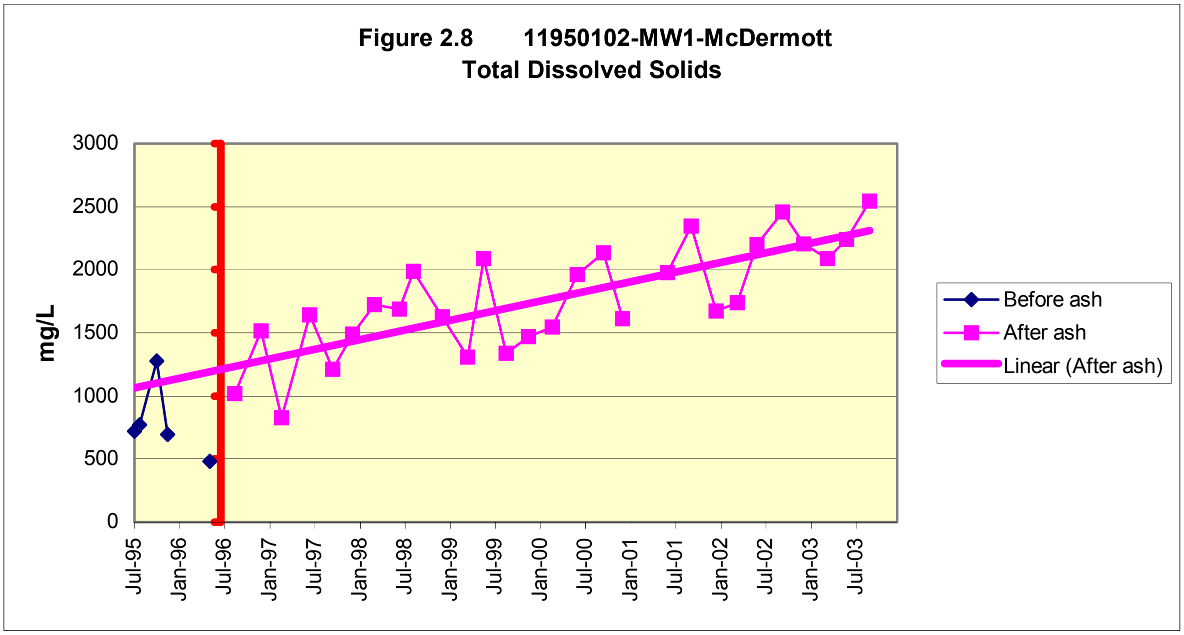


Figure 2.8 11950102-MW1-McDermott
Total Dissolved Solids
mg/L
3000
2500
2000
1500
1000
500
0
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Before ash
After ash
Linear (After ash)

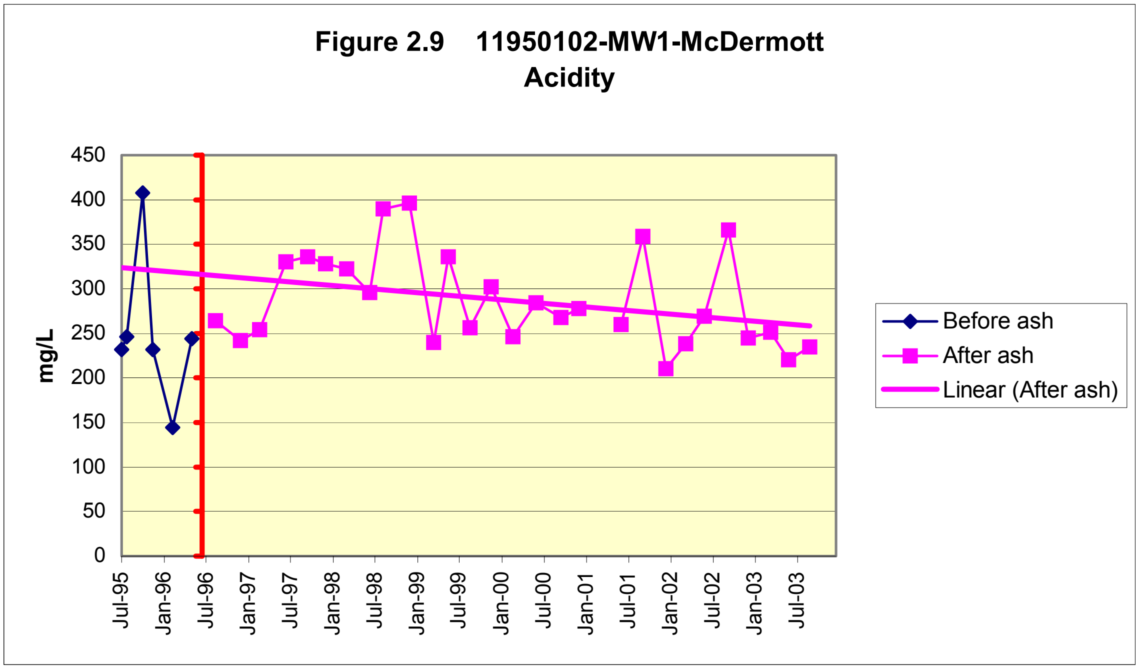


Figure 2.9 11950102-MW1-McDermott
Acidity
mg/L
450
400
350
300
250
200
150
100
50
0
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Before ash
After ash
Linear (After ash)

Figure 2.9a 11950102-MW1-McDermott pH

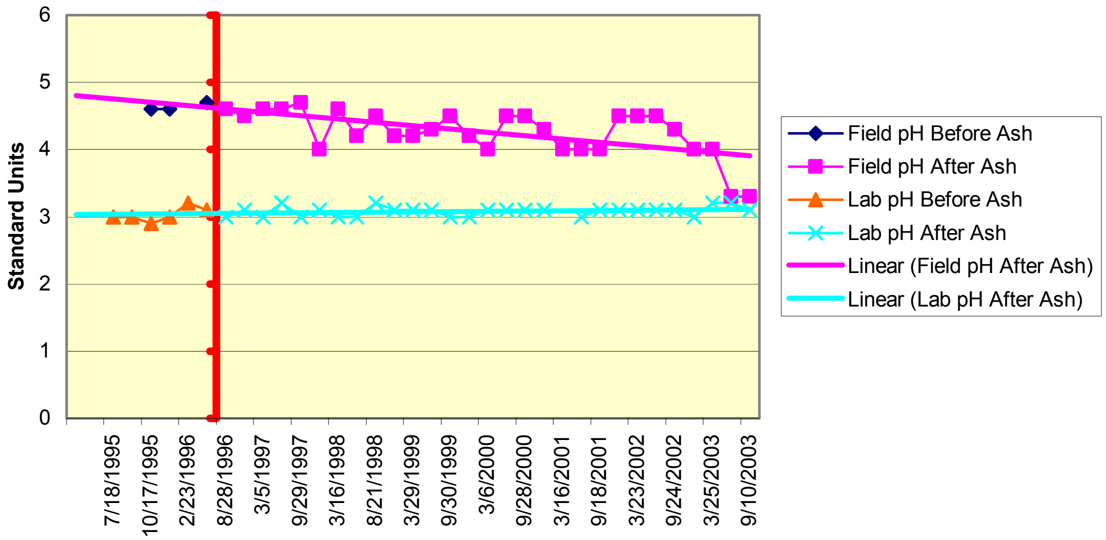
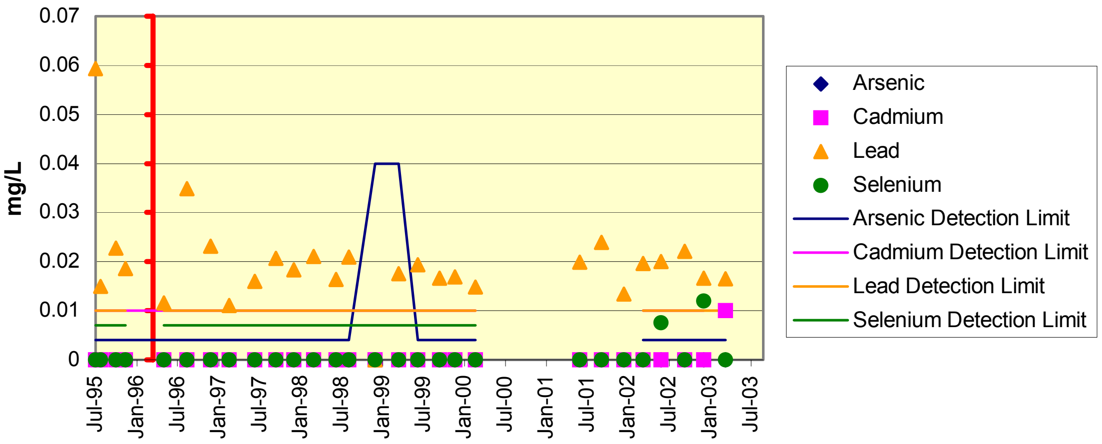


Figure 2.10 11950102-MW1-McDermott
Trace Elements



MW2-ash monitoring well immediately east of the ash

A substantial deterioration of water quality after mining and ash placement started was also revealed at MW2 located at the eastern end of the site in the immediate vicinity of the ash. The acidity (figure 2.11a) rose markedly in MW2 immediately after mining and ash placement commenced from a range of 6.6 to 120 mg/L during baseline monitoring to a peak of 458 mg/L in June 1997. However, acidity declined in the most recent monitoring from levels usually well over 300 mg/L in 2000-2002 to levels under 280 mg/L throughout 2003. Alkalinity levels (ungraphed) averaged 10.8 mg/L during the baseline period, but after one measurement during mining and ash placement of 7.8 mg/L, alkalinity dropped to zero for the remainder of monitoring at MW2. Field pH (figure 2.11b) reflected this dominance of acidity at MW2, declining from an average of 5.3 units during the baseline period to annual averages of 4.6 units in the first year of mining and ash placement and 3.8 units in the seventh and final year of monitoring (Dec. 2002 through Sept. 2003) studied in this assessment. However, after dropping from an average of 5.2 units during the baseline period to an average of 3.6 units in the first year of mining and ash placement, lab pH (figure 2.11b) changed only slightly to an average of 3.53 units in the final year of monitoring.

Figure 2.12 shows that concentrations of both manganese and iron increased notably above baseline levels at MW2. Iron concentrations rose from levels just below the DWS (secondary MCL) during baseline monitoring to over 500 times this drinking water standard after ash placement. Likewise, the concentrations of manganese rose from 4 times the DWS before ash placement to 800 times the DWS after ash placement. The MW2 data for sulfate (figure 2.13) also show a pronounced increase from below the DWS before placement to nearly 8 times the DWS after ash placement commenced. Average TDS levels at MW2 rose by 33 times (figure 2.13a) from an average of 82 mg/L during the baseline period to 2703 mg/L during the seventh year after ash placement reflecting the large increase in pollution at this monitoring point as a result of the operations authorized by this permit. The latter average is 5.4 times the secondary DWS for TDS (500 mg/L).

The trace element data from monitoring well MW2 (figure 2.14) show that dissolved lead concentrations jumped from baseline levels that were always under the federal DWS (0.015 mg/L) to as high as 0.0841 mg/L in June 1997, 5.6 times the federal DWS and nearly 17 times the PA MCL during ash placement. This is the highest concentration of lead measured at any of the monitoring points after mining and ash placement began with only one higher level measured at MW3 during baseline monitoring. Although lead concentrations fall after this measurement to a low of 0.022 mg/L in March 2003, they still remained well above the federal DWS throughout the ash placement period.

Dissolved cadmium rose above baseline levels that were all at <0.010 mg/L four times to a high of 0.018 mg/L in August 1998, nearly four times the DWS. There were also higher levels of dissolved selenium measured during ash placement with the highest being 0.0109 mg/L in December 2002. A very high detection limit was used for selenium in the December 1998 sampling of <0.070 mg/L. As with MW1, figure 2.14

reveals a one year gap in data from MW2 for trace elements (dissolved concentrations) that according to monitoring reports were not collected from the second quarter of 2000 through the first quarter 2001. There was also no data for dissolved concentrations collected in the first quarter of 2002 or for the second and third quarters of 2003. Nonetheless, with the exception of arsenic which remained at detection limits throughout the baseline and ash placement periods (albeit with a high detection limit of<0.040 mg/L reported in December 1998), the data that was collected indicates that mining and ash placement mobilized higher trace element concentrations at this monitoring point.

Despite the marked rise in acidity and absence of alkalinity, other parameters characteristic of the ash placed at this site, such as calcium, magnesium, sodium and chloride rose sharply after mining and ash placement began. Their rises at MW2 were similar to what occurred at MW1 and other monitoring points, attesting to the fact that the ash has been chemically reactive at this site readily releasing its soluble constituents. Average calcium levels (figure 2.14a) during the baseline period of 9.9 mg/L increased to 157 mg/L in the first year of ash placement and 291 mg/L in the fourth year of ash placement and remained at 266 mg/L in the seventh year of ash placement. Average magnesium levels (also figure 2.14a) increased from 3.7 mg/L during the baseline period to 70 mg/L in the first year of ash placement and 137 mg/L in the fourth year of ash placement and remained at 136 mg/L in the seventh year after ash placement started. Average sodium levels (ungraphed) rose from 0.548 mg/L during the baseline period to 4.56 mg/L in the first year of ash placement, 13.48 mg/L in the fourth year of ash placement, and 16.08 mg/L in the seventh year after ash placement started. Average chloride levels (ungraphed) increased from 1.8 mg/L during the baseline period to 5.8 mg/L during the first year of ash placement, 22 mg/L in the fourth year of ash placement and 21.7 mg/L in the seventh year after ash placement started. Given dissolved concentrations were not recorded in a number of samplings for these more soluble ash parameters, the above averages are based on total rather than dissolved concentrations although the two were usually close if not identical in most samplings where both total and dissolved fractions were recorded.

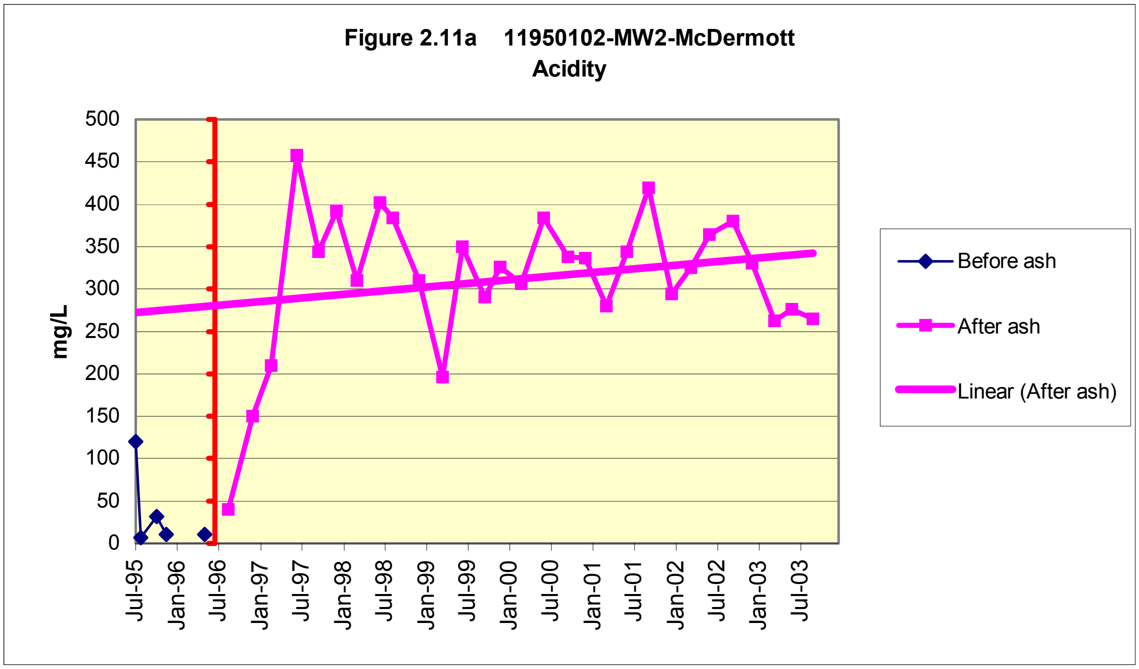


Figure 2.11a 11950102-MW2-McDermott Acidity

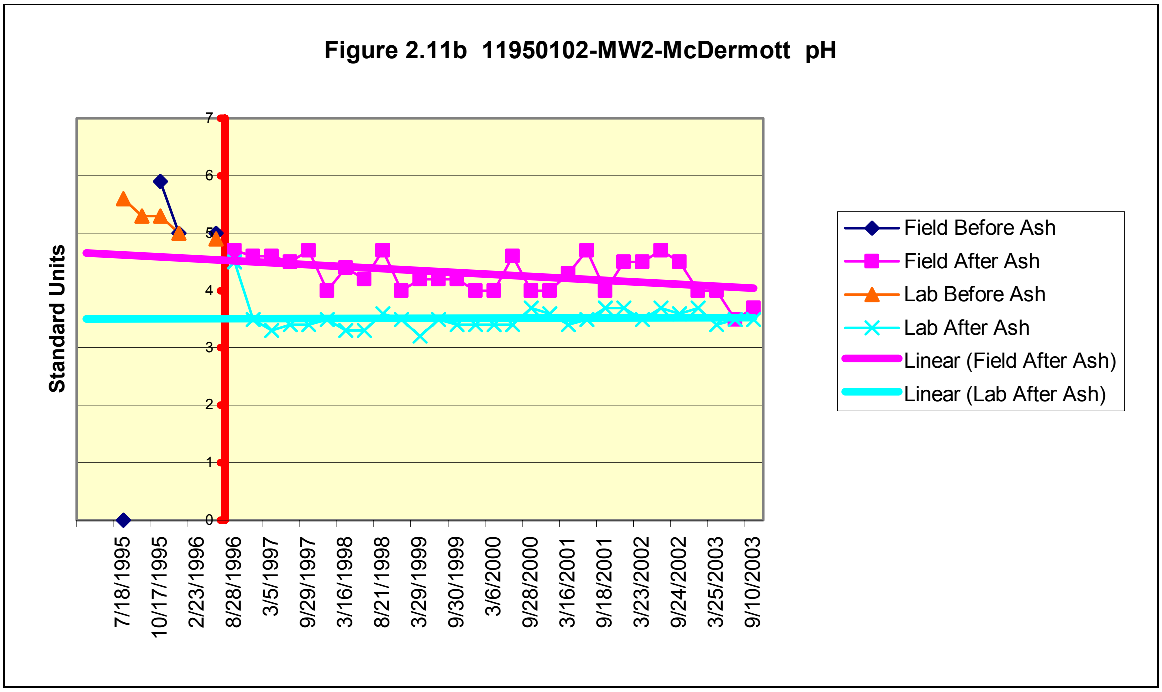


Figure 2.11b 11950102-MW2-McDermott pH

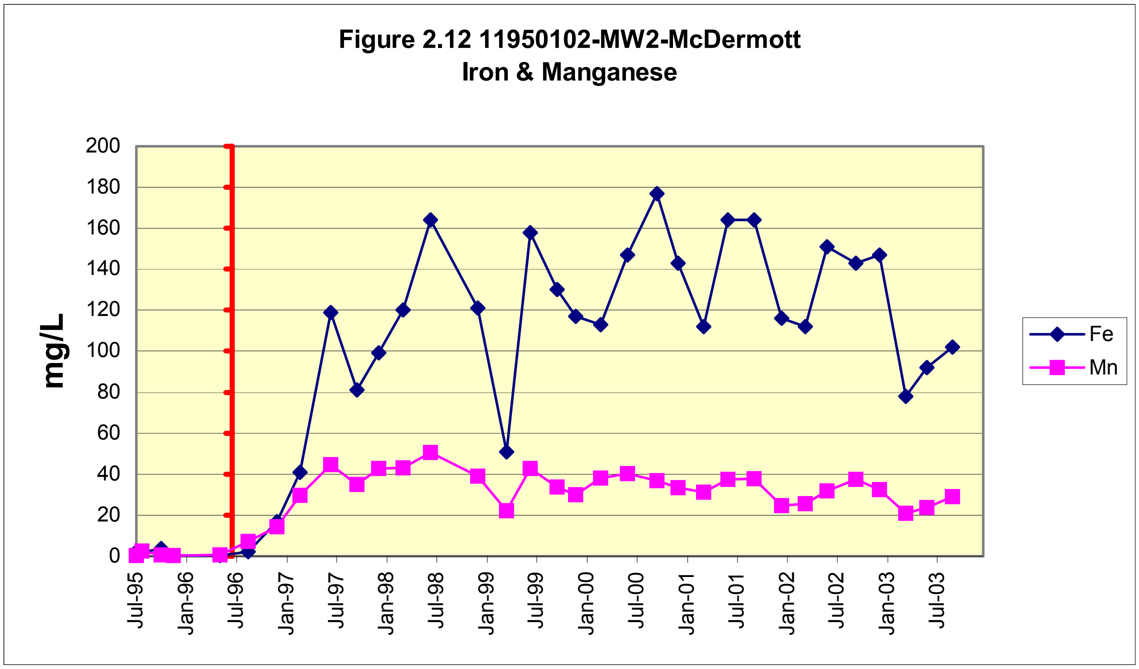


Figure 2.12 11950102-MW2-McDermott
Iron & Manganese
mg/L
0
20
40
60
80
100
120
140
160
180
200
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Fe
Mn

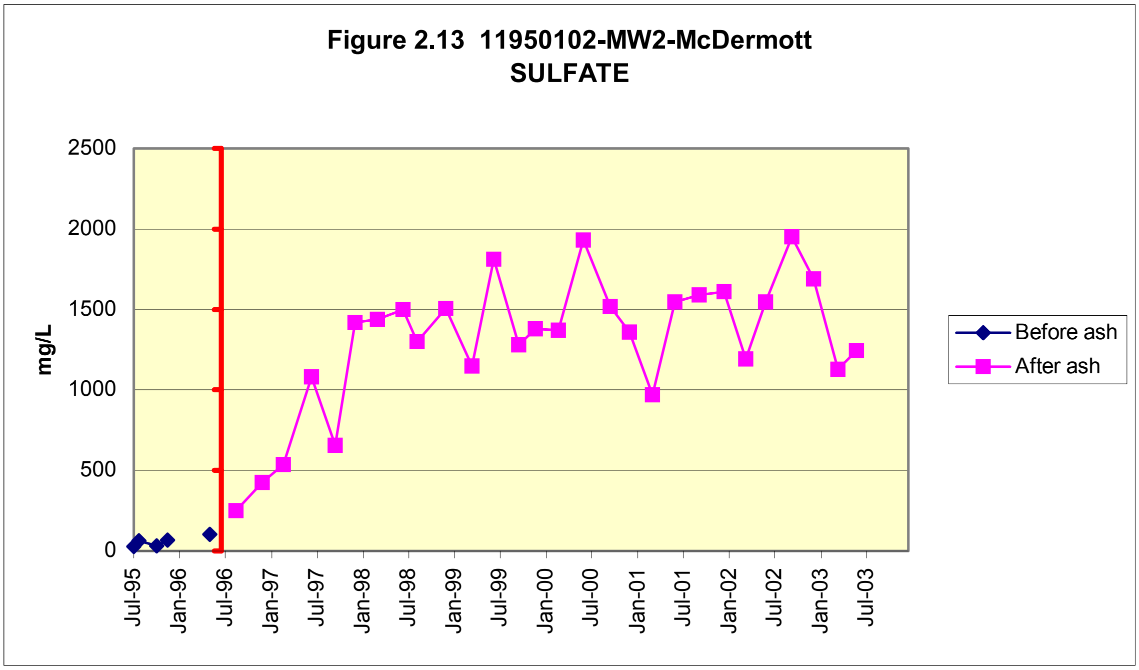


Figure 2.13 11950102-MW2-McDermott
SULFATE
mg/L
0
500
1000
1500
2000
2500
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Before ash
After ash

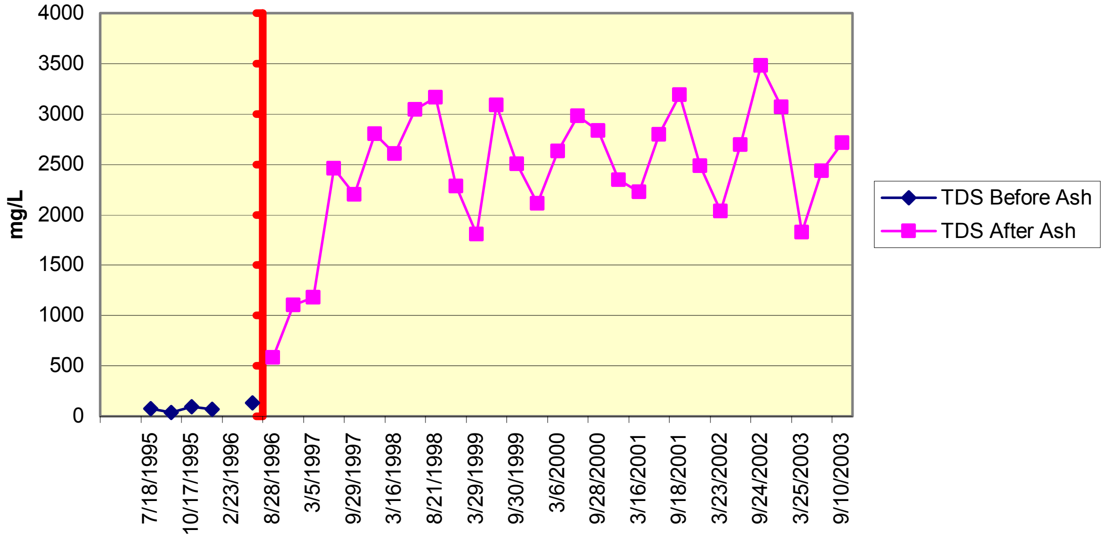


Figure 2.13a 11950102-MW2-McDermott TDS

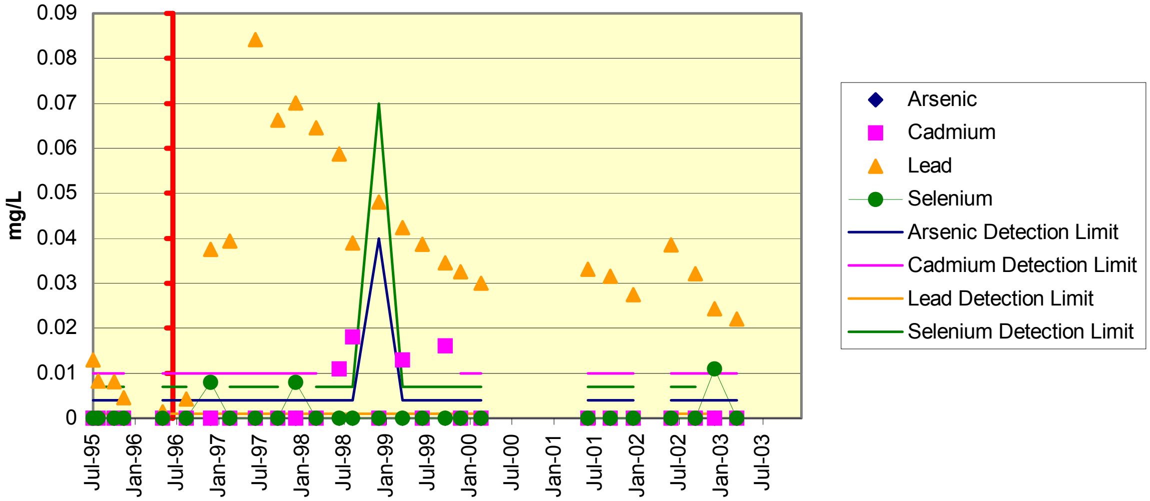
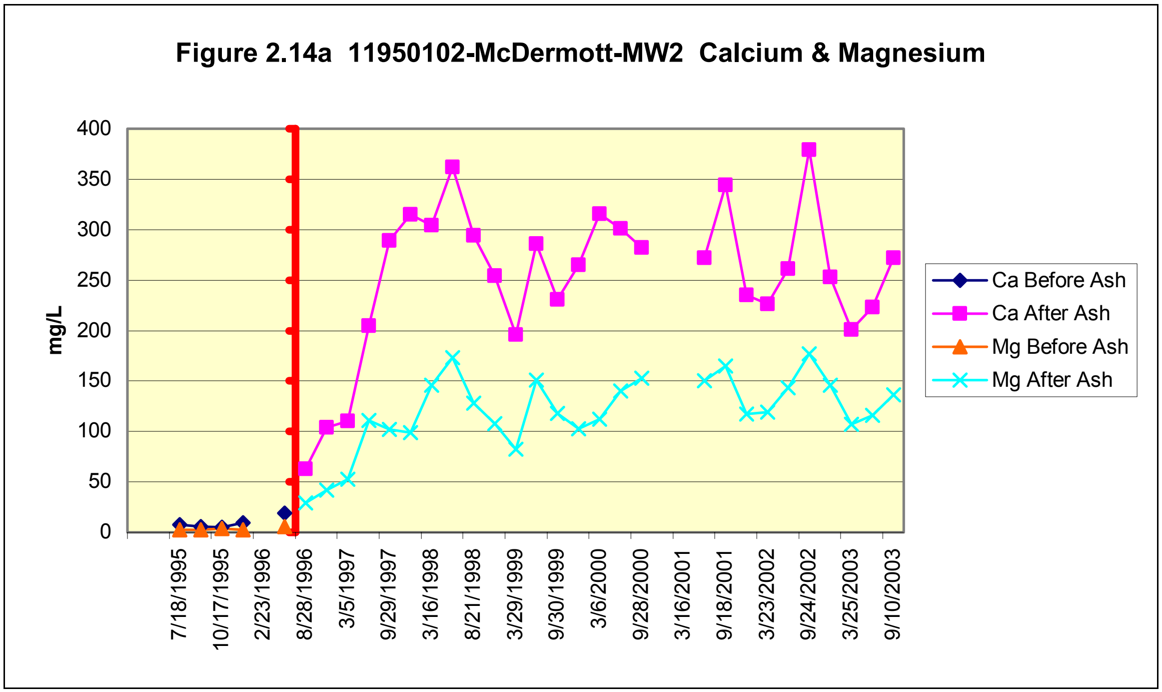


Figure 2.14 11950102-MW2-McDermott
Trace Elements



MD12 – downhill spring beyond the permit boundary

Data from this spring monitoring point show sharp increases in several constituents, especially in manganese concentrations (figure 2.15) which rose from levels close to the DWS before ash placement to more than a thousand times the DWS after mining and ash placement began. The data also show pronounced increases in sulfate concentrations from well below the DWS during baseline monitoring to 5 times the DWS, while mining and ash placement occurred (figure 2.16).

The rise in these pollutants was accompanied by a sharp rise in acidity (figure 2.16a) at MD12 from an average of 25 mg/L during baseline monitoring to 192 mg/L in the first year of mining and ash placement which then declined to 122 mg/L in 2002-2003, the final year of monitoring examined in this report. Alkalinity was already dominated by acidity prior to mining and ash placement with an average concentration of 7 mg/L and declined to 0.0 mg/L after these operations began. The field pH (figure 2.16b) reflected the sharp initial increase in acidity from mining, declining from an average of 4.75 units during baseline monitoring to an average of 4.42 units in the first year of mining and ash placement with a trend thereafter remaining fairly static averaging 4.38 units in 2002-2003. These averages reflect only two field pH measurements during the baseline period. Average lab pH values (figure 2.16b) declined more precipitously from 4.56 units during baseline monitoring to 3.5 units in the first year of mining and ash placement but then rose to an average of 4.2 units in 2002-2003. Thus after a decisive initial jump in acidity in the first year of mining, a 70 mg/L decline in average acidity levels from the first to the last year of ash placement as well as the steady rise in lab pH from the first to the seventh year of ash placement suggests a mitigating effect on AMD from the ash.

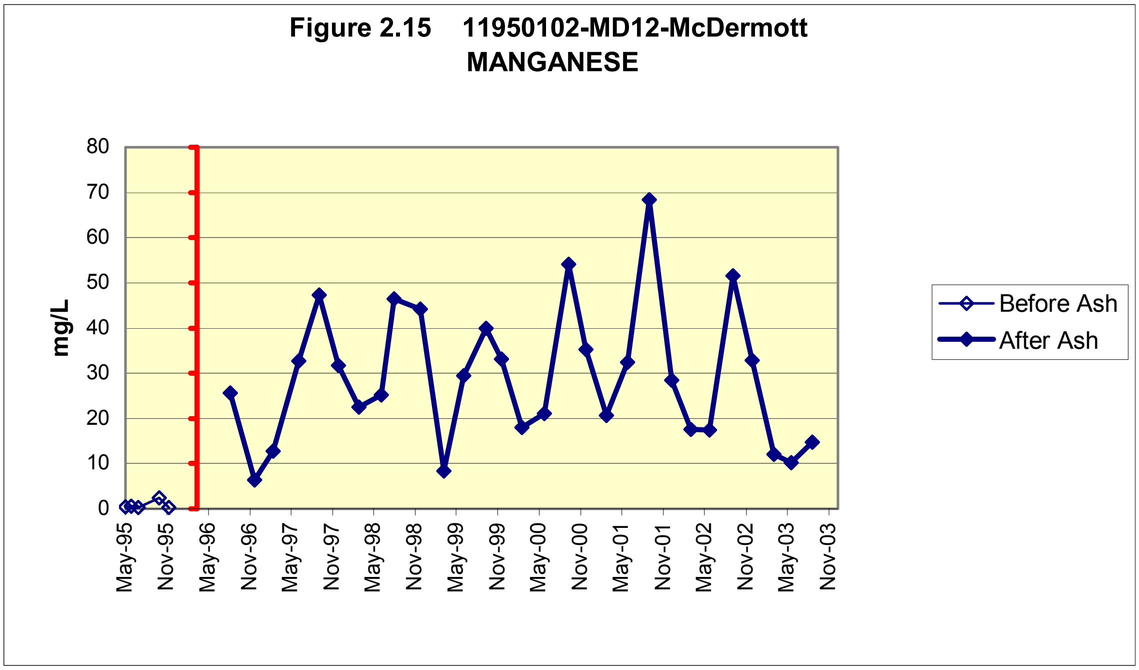
The available trace element data for MD12 (figure 2.17) show that dissolved lead concentrations rose sharply upon the commencement of mining and ash placement to a high concentration of 0.0629 mg/L in September 1997, more than 12 times the PA MCL and over four times the federal DWS. Lead concentrations remained above the federal DWS (.015 mg/L) throughout 1998 before dropping below the DWS for the remainder of the monitoring examined at MD12. While high concentrations of lead were measured in baseline line water quality at MW1 and MW3, the elevated concentrations of lead leaching from the SPLP tests performed on the FBC ash being placed at this site from the Cambria power plant suggest that the ash has the potential to exacerbate the lead pollution resulting from permitted operations at this site (see page 45, Permit Review 1, Ernest Mine).

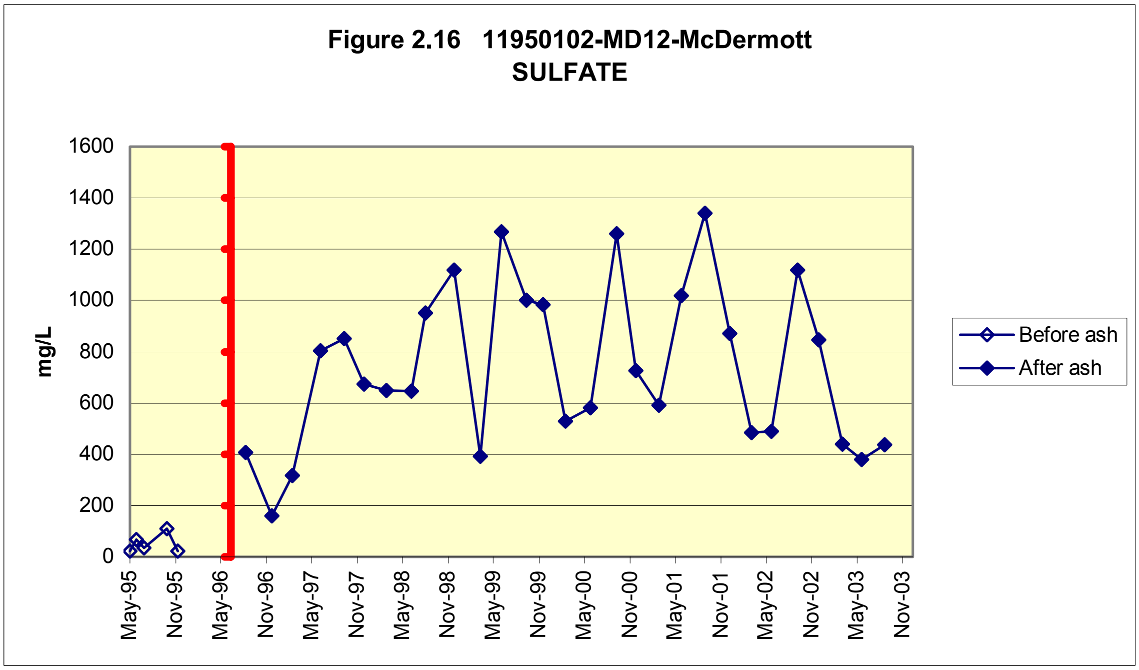
There were no dissolved concentrations for arsenic, cadmium and selenium recorded at MD12 above detection limits. However there was one measurement of total cadmium at 0.013 mg/L more than twice the DWS, in September 1999, and total arsenic was measured at 0.0072 mg/L in June 2003 and 0.0063 mg/L in September 2003. These levels were higher than total concentrations for arsenic and cadmium measured during the baseline monitoring which were consistently <0.004 mg/L and <0.010 mg/L respectively.

Similar to other monitoring points, data for dissolved concentrations of trace elements are missing at MD12 for the second quarter of 2000 through the first quarter of 2001.

As occurred at other monitoring points, levels of Module 25 ash parameters that are readily soluble from the FBC ash placed at this site rose substantially from baseline levels at MD12. Average calcium concentrations were more than 12 times higher in the seventh and final year of monitoring during ash placement (2002-2003) than before ash placement, and average magnesium concentrations were 21 times higher in 2002 –2003 than before ash placement (Fig. 2.17a). Average sodium and chloride levels (ungraphed) were 11 and more than 7 times higher in 2002-2003 than before ash placement respectively.

It should be recognized that this spring is well beyond the property line for the McDermott Mine, and yet the activities authorized by this permit rendered the waters of this spring, which were a potable and used domestic water supply, nonpotable. Aside from individual constituents (manganese, sulfate and lead), this is aptly reflected by the rise in TDS (ungraphed) at this spring from an average level of 129 mg/L before mining and ash placement to an average of 1186 mg/L in 2002-2003. Thus the concentration of total pollution reflected by this parameter rose beyond the property line from barely one fourth the secondary DWS before permit activities to more than twice the secondary DWS after those activities had been underway for six years. An alternative water supply was provided to the home owner. However a plan that was put in place in the late 1990s to divert leachate from the mining and ash placement area away from this spring to settling ponds has not succeeded in bringing down the levels of pollution on a sustained basis.





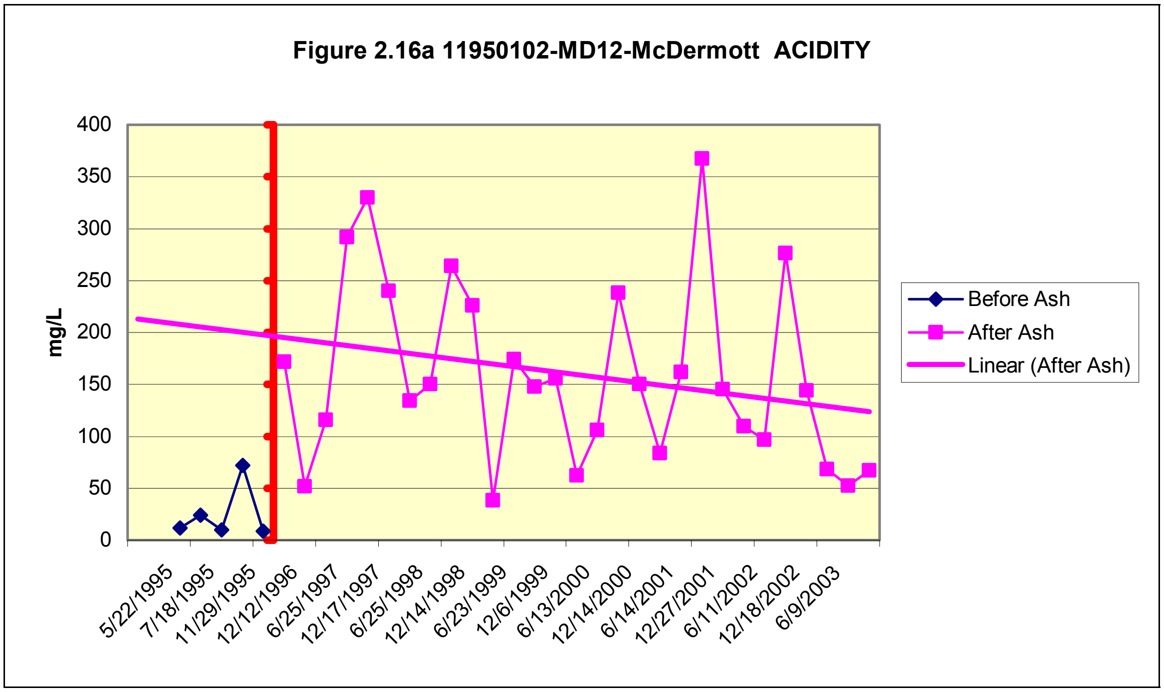


Figure 2.16a 11950102-MD12-McDermott ACIDITY
mg/L
400
350
300
250
200
150
100
50
0
5/22/1995
7/18/1995
11/29/1995
12/12/1996
6/25/1997
12/17/1997
6/25/1998
12/14/1998
6/23/1999
12/6/1999
6/13/2000
12/14/2000
6/14/2001
12/27/2001
6/11/2002
12/18/2002
6/9/2003
Before Ash
After Ash
Linear (After Ash)

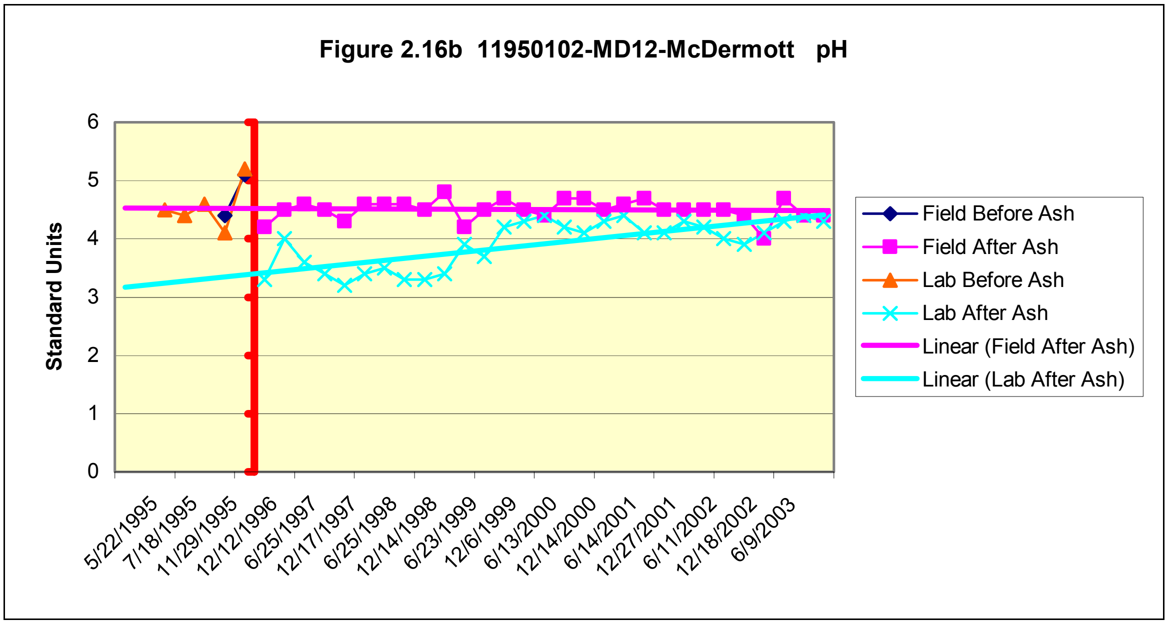


Figure 2.16b 11950102-MD12-McDermott pH
Standard Units
6
5
4
3
2
1
0
5/22/1995
7/18/1995
11/29/1995
12/12/1996
6/25/1997
12/17/1997
6/25/1998
12/14/1998
6/23/1999
12/6/1999
6/13/2000
12/14/2000
6/14/2001
12/27/2001
6/11/2002
12/18/2002
6/9/2003
Field Before Ash
Field After Ash
Lab Before Ash
Lab After Ash
Linear (Field After Ash)
Linear (Lab After Ash)

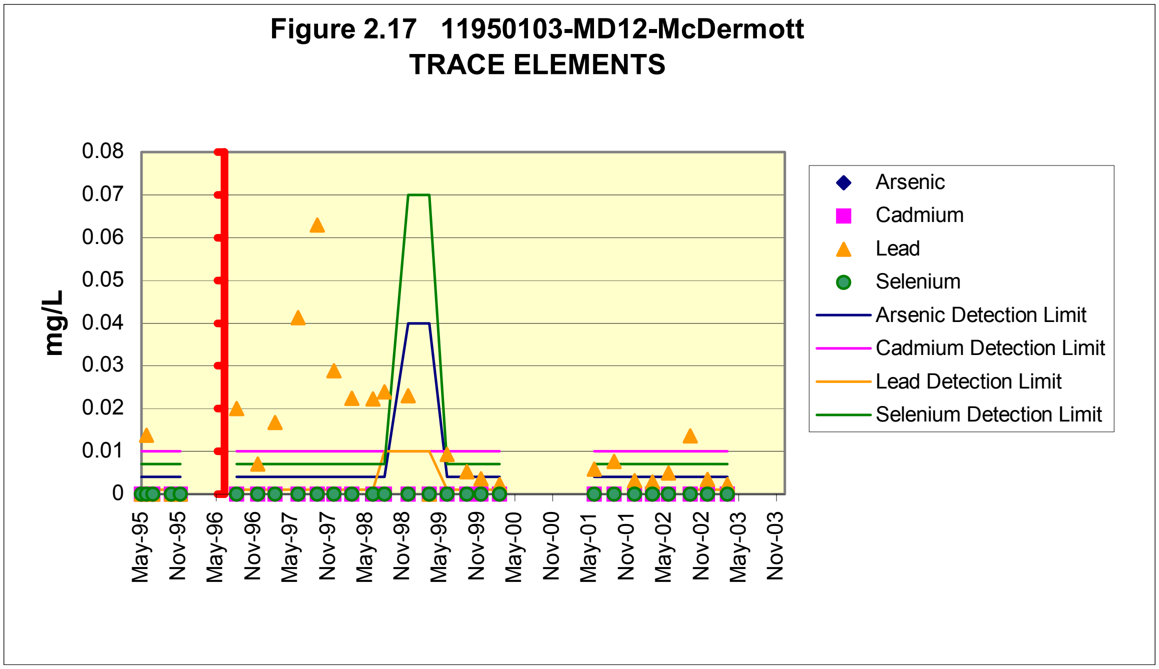


Figure 2.17 11950103-MD12-McDermott
TRACE ELEMENTS
mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
May-95
Nov-95
May-96
Nov-96
May-97
Nov-97
May-98
Nov-98
May-99
Nov-99
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
Arsenic
Cadmium
Lead
Selenium
Arsenic Detection Limit
Cadmium Detection Limit
Lead Detection Limit
Selenium Detection Limit

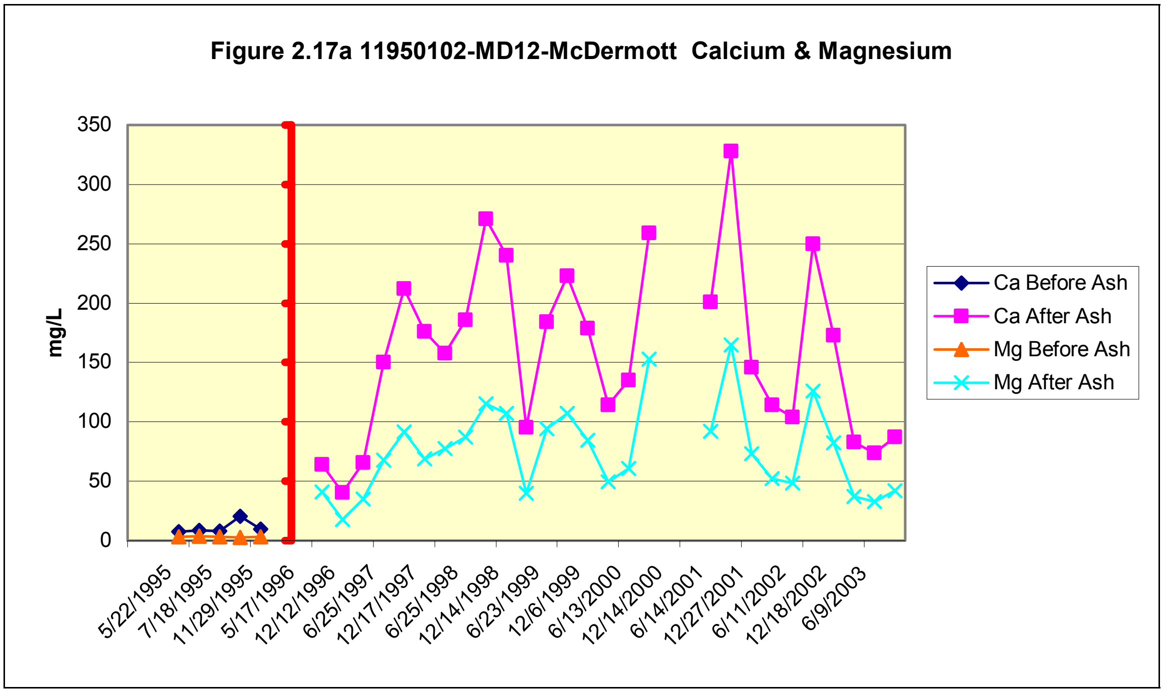


Figure 2.17a 11950102-MD12-McDermott Calcium & Magnesium
mg/L
350
300
250
200
150
100
50
0
5/22/1995
7/18/1995
11/29/1995
5/17/1996
12/12/1996
6/25/1997
12/17/1997
6/25/1998
12/14/1998
6/23/1999
12/6/1999
6/13/2000
12/14/2000
6/14/2001
12/27/2001
6/11/2002
12/18/2002
6/9/2003
Ca Before Ash
Ca After Ash
Mg Before Ash
Mg After Ash

MD22 – ash leachate collection drain

Data from MD22, which monitors the drain installed at the bottom of the Lower Kittanning highwall where ash was placed, show clearly increasing concentrations of manganese (figure 2.18), sulfates (figure 2.19), total dissolved solids (figure 2.20), and iron (figure 2.21) throughout a monitoring period that began in 1998 two years after ash placement had already begun in this part of the mine. The levels of these constituents are several to several hundred times over the secondary DWS indicating that ash placement is achieving the opposite of its stated objective to clean up mining degraded waters. No baseline data were collected at this monitoring point. The flow measured from this drain varied from 0.1 to 60 gallons per minute and averaged 18 gallons per minute indicating that the pond receiving waters from this drain is receiving a considerable pollution load.

While both the ash and the mining could be the sources for the rises in these constituents, rises in the more exclusive ash indicator parameters demonstrate clearly that the ash is dramatically affecting the geochemistry of waters in this drain. Chloride (figure 2.22) and sodium (figure 2.23) levels are higher than the levels of these constituents at all other monitoring points examined in this report except MD3, the most downgradient minepool monitoring point at the site, and have been rising since sampling began. Again, high and rising concentrations of chloride and sodium, both acknowledged by PADEP to be leachate parameters from the FBC ash disposed at McDermott and both of which are highly soluble in the SPLP leach tests performed on this ash, identify the ash as contributing to the water quality degradation seen at MD22. The chloride has not risen to levels causing concern. Its highest level was 138 mg/L in September 2002 well under chloride’s secondary DWS of 250 mg/L and the recommended federal chronic water quality standard for surface waters for chloride of 230 mg/L.

On the other hand sodium has risen to levels of regulatory concern for water quality for this parameter. While EPA has established no DWS and recommended no water quality standard for sodium, it has published a Drinking Water Equivalent Level for sodium of 20 mg/L (DWEL – see Drinking Water Regulations and Health Advisories, US Environmental Protection Agency, Office of Water, Washington D.C., EPA 822-B-96-002, October 1996, page i). The DWEL is defined as: “A lifetime exposure concentration protective of adverse, non-cancer health effects, that assumes all of the exposure to a contaminant is from a drinking water source.” Every level of sodium measured at MD22 exceeded the DWEL with the maximum value, 62 mg/L in September 2002, exceeding it by more than three times. Although the waters in this drain are clearly not destined to be a drinking water source, their levels of sodium nonetheless are unhealthy and not found in waters less affected by ash at this site.

Although average calcium levels are declining (figure 2.23a), their values are the highest recorded anywhere on the site, with four measurements between 600-700 mg/L and an average value, 550 mg/L, higher than the highest calcium measured at all other monitoring points. In fact, the lowest calcium measured at MD22, 464 mg/L in June 1999, is still higher than the highest calcium found at all other monitoring points except MD19, a dowgradient seep to be discussed next. Likewise the six highest magnesium values anywhere at the McDermott site were measured at MD22, and the average magnesium concentration in this drain, 187.31 mg/L is higher than the highest magnesium levels at all but one other monitoring point, MD3.

Of note also are the levels of dissolved selenium showing up at MD22 (figure 2.23b) and to a lesser extent dissolved levels of arsenic and cadmium. Selenium was found above detection limits in seven of fifteen samplings with the higher concentrations in more recent samplings and the highest, 0.0234 mg/L measured in December 2002. While this value is still under the DWS (0.050 mg/L), it is nearly five times the water quality standard for chronic toxicity 0.005 mg/L (known as the Continous Chronic Criterion or CCC) recommended by the US EPA for surface waters under Section 304 of the Clean Water Act (see National Recommended Water Quality Criteria, US Environmental Protection Agency, Office of Water, Washington D.C., 4304T, 2006). This surface water standard is as relevant as the DWS given the waters at MD22 are draining directly to surface waters in a nearby settling pond.

Cadmium was measured once at MD22 at 0.018 mg/L in March 1999. This is more than three times the DWS, nine times the water quality standard for acute toxicity (Continuous Maximum Concentration or CMC) recommended by US EPA and 72 times the water quality standard for chronic toxicity (CCC of 0.00025 mg/L). Arsenic was measured three times above detection limits although the highest level, 0.0062 mg/L in December 2002 was under the DWS (0.010 mg/L). This value is also well under EPA's water quality standard (CCC) of 0.150 mg/L, although well over the water quality standard for arsenic recommended for protection of human health in surface waters that serve as a source of drinking water and fish for consumption (0.000018 mg/L). The highest lead was 0.004 mg/L in March 2000, well under the high lead levels found at other monitoring points but still exceeding EPA's recommended water quality standard (CCC) of 0.0025 mg/L.

The acidity and alkalinity levels (figure 2.24) fluctuate strongly during ash placement, one rising while the other is falling and vice versa. The highest levels of alkalinity at any of the monitoring points examined in this report were found at MD22, with the maximum value of 188 mg/L measured in August 1998, the first sampling at this monitoring point. However the peaks of alkalinity declined steadily to levels between 100 and 120 mg/L and then disappeared altogether as acidity rose to seven peaks between 250-350 mg/L. A decided fluctuation in both acidity and alkalinity values indicates that the strong acidity of the site was meeting some buffering resistance from the alkalinity in the ash at MD22. Alkalinity peaks coincided with a decline in flow from the drain to levels less than 14 gallons per minute while acidity peaks occurred nearly always when the drain's flows ranged from 20 to 60 gallons per minute. A decline in both lab and field pH (figure 2. 25a) from an average of 6.3 units to 5 units during the five years of monitoring at MD22 nevertheless reveals that acidity was dominating alkalinity even in the immediate vicinity of the ash in waters that should have been the most effected by the ash's alkalinity.

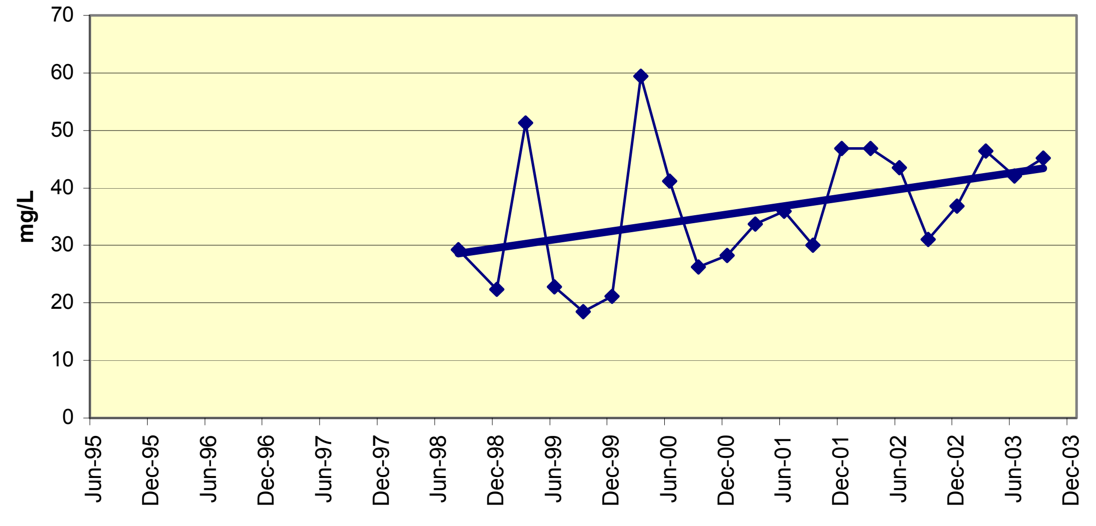


Figure 2.18 11950102-MD22-McDermott
Manganese

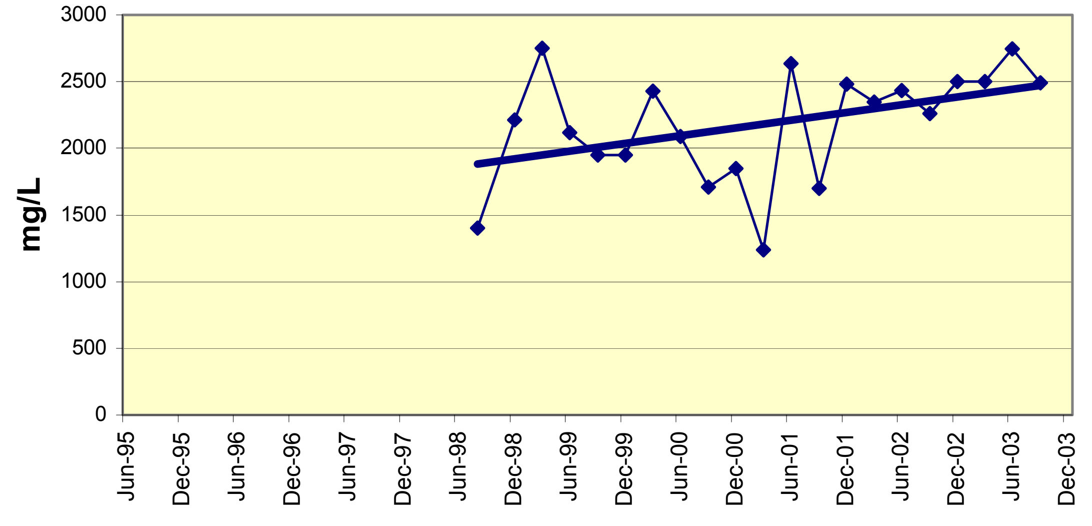


Figure 2.19 11950102-MD22-McDermott
Sulfates

Figure 2.20 11950102-MD22-McDermott
Total Dissolved Solids

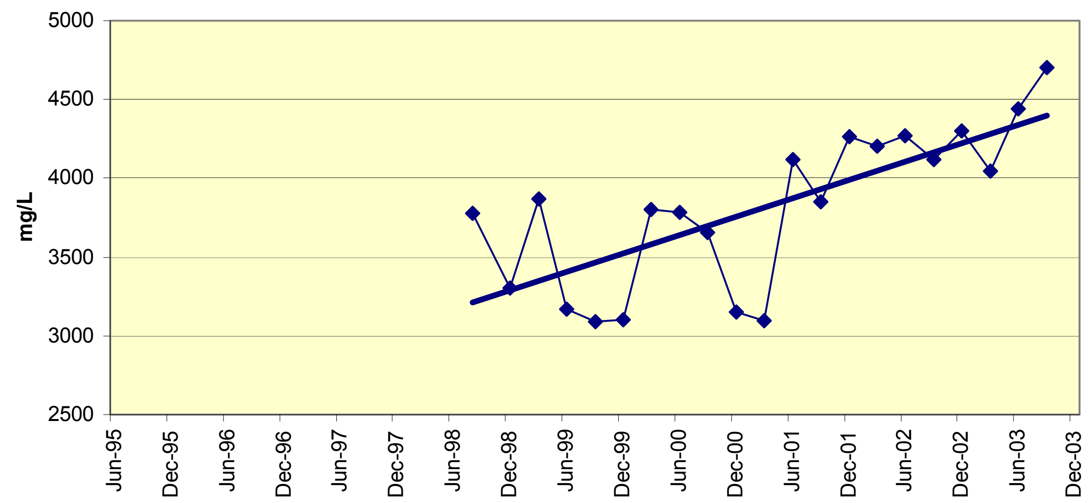
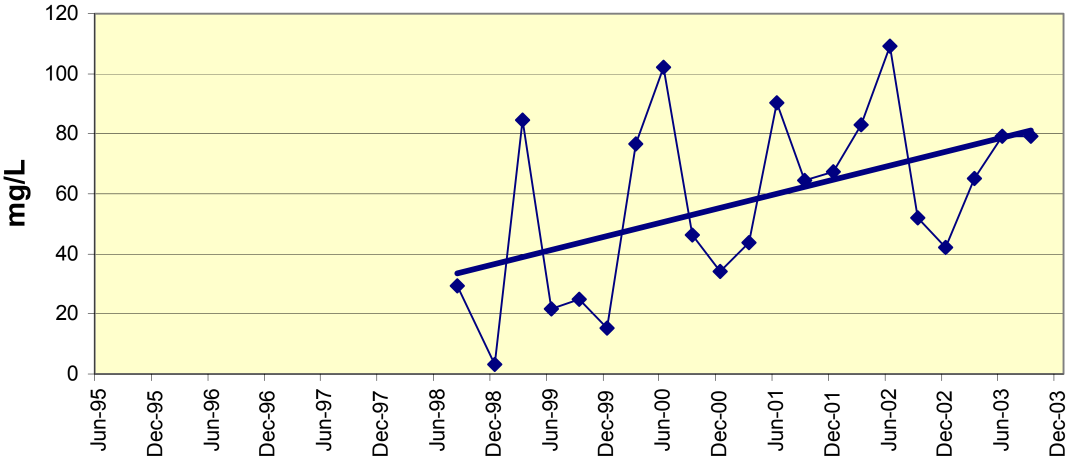


Figure 2.21 11950102-MD22-Ernest
Iron



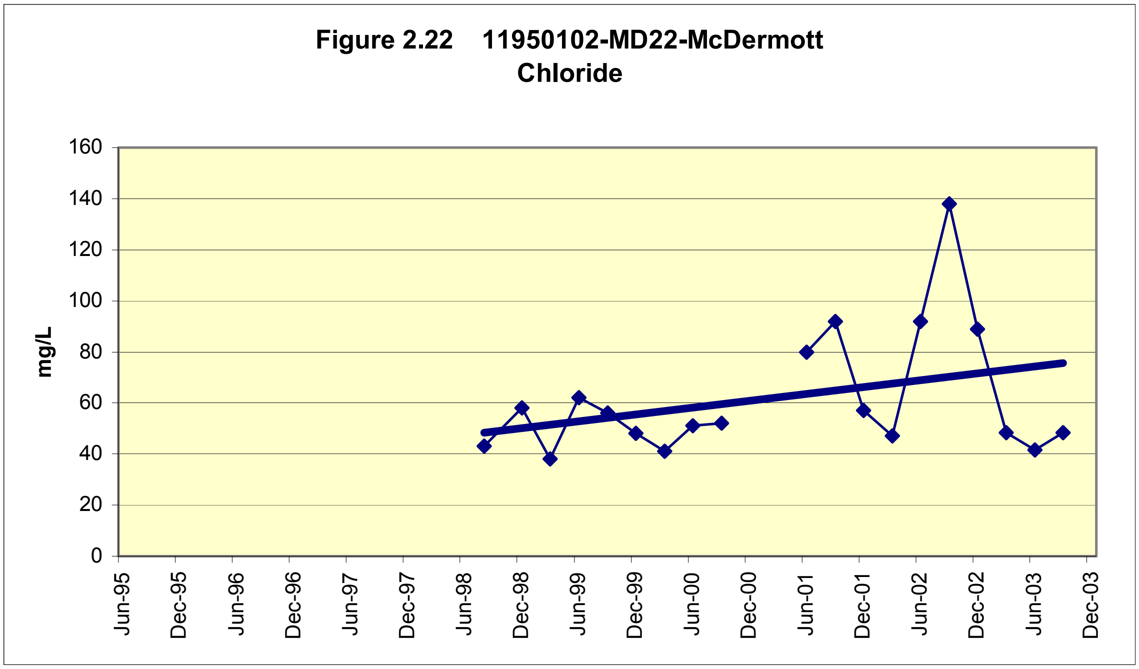


Figure 2.22 11950102-MD22-McDermott
Chloride
mg/L
160
140
120
100
80
60
40
20
0
Jun-95
Dec-95
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03

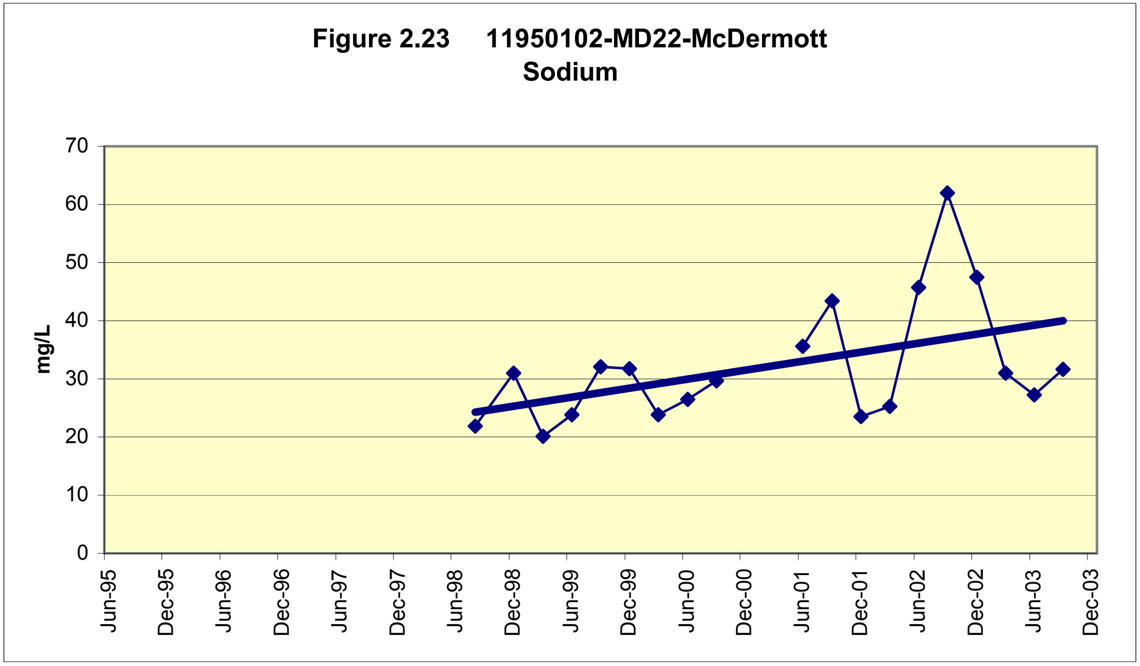


Figure 2.23 11950102-MD22-McDermott
Sodium
mg/L
70
60
50
40
30
20
10
0
Jun-95
Dec-95
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03

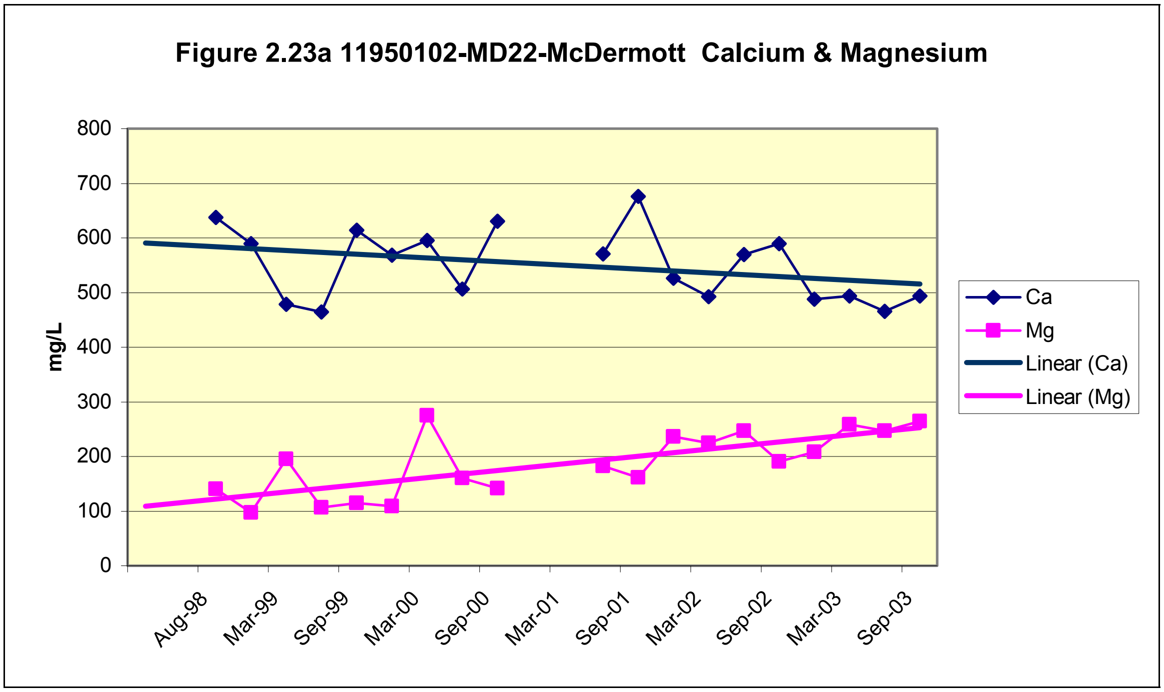


Figure 2.23a 11950102-MD22-McDermott Calcium & Magnesium
mg/L
800
700
600
500
400
300
200
100
0
Aug-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Ca
Mg
Linear (Ca)
Linear (Mg)

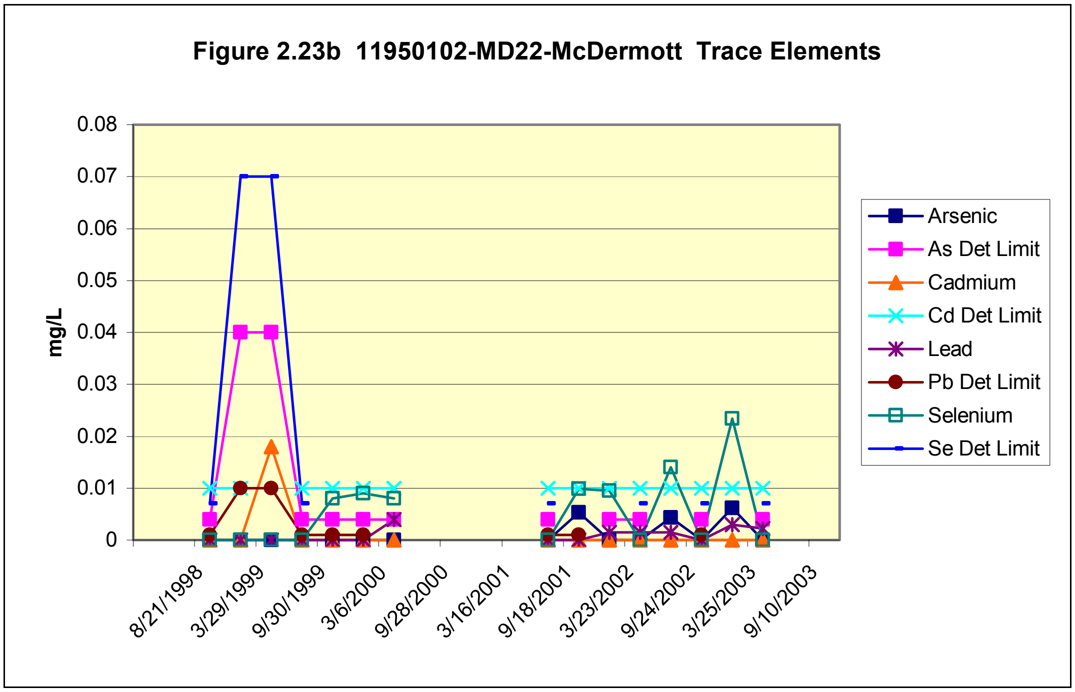


Figure 2.23b 11950102-MD22-McDermott Trace Elements
mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
8/21/1998
3/29/1999
9/30/1999
3/6/2000
9/28/2000
3/16/2001
9/18/2001
3/23/2002
9/24/2002
3/25/2003
9/10/2003
Arsenic
As Det Limit
Cadmium
Cd Det Limit
Lead
Pb Det Limit
Selenium
Se Det Limit

Figure 2.24 11950102-MD22-McDermott Acidity & Alkalinity

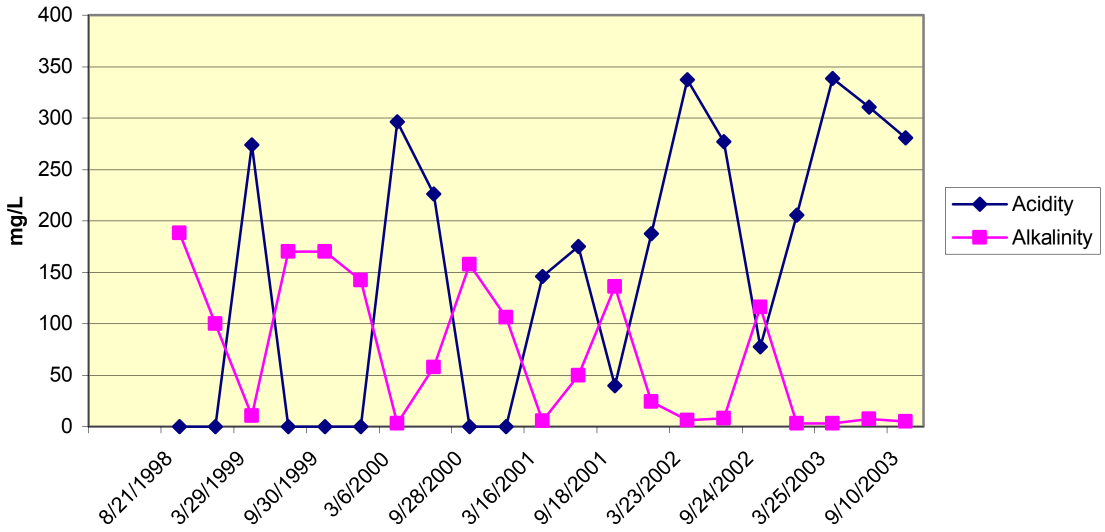
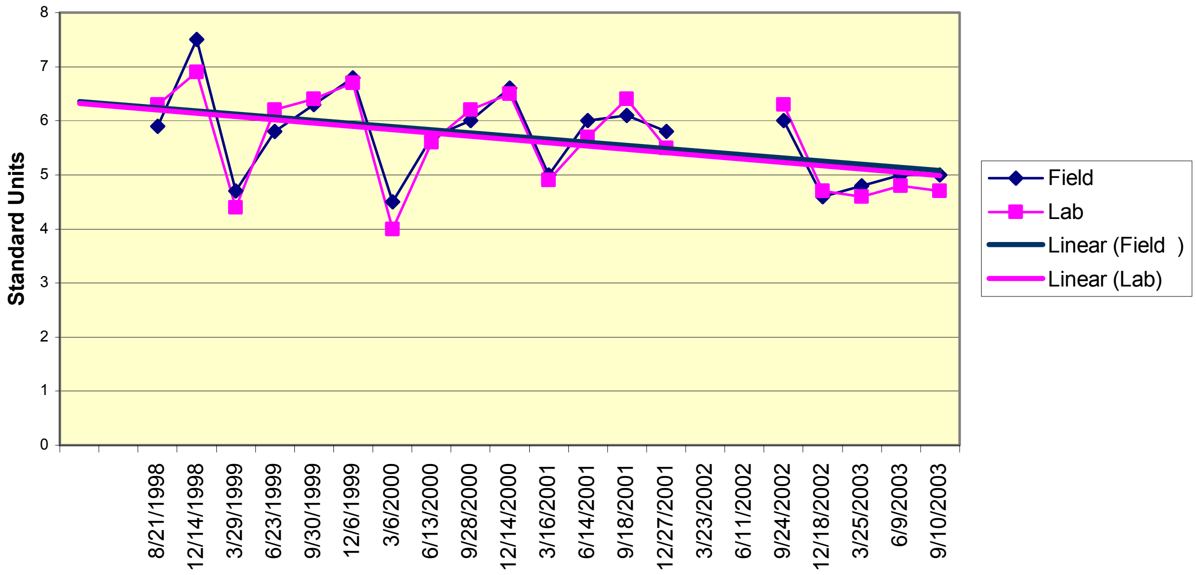


Figure 2.25 11950102-MD22-McDermott pH



MD19 – seep downhill at the property line

Effects of ash placement are apparent at MP19, a downgradient seep located approximately 100 feet inside the eastern border of the permit and nearly half way between its northern and southern borders. According to the permit's Exhibit MP19 OPERATIONS MAP (dated April 7, 2004) and monitoring reports, the seep at MP19 surfaces about 300 feet outside of the boundary of the ash placement area and about 40 feet downhill and immediately flows into a pond. According to the permit's Module 25 (p. 25-29), MD19 is monitoring the same "intermediate water table" in direct contact with the ash and spoils that have been mixed with the ash that is being monitored by MW1, MW2, MW3 and MD12.

The figures below demonstrate that major impacts from mining and ash placement were first reflected decisively by the data from this seep in 1999 at least two years after mining and ash placement started at the McDermott site. Although this timing correlates roughly with the direction of permit operations proceeding from the northern to the southern ends of the permit area, a two year gap in data from March 1997 to March 1999 prevents a finding of exactly when conditions began to deteriorate. According to monitoring reports however, this gap occurred after permit operations started because the seep dried up, implying that the mining operations may have changed the flow regime diverting water away from the seep until the spring of 1999. Flow rates ranged from no flow to 6 gallons per minute during baseline monitoring and from no flow to 5 gallons per minute during the mining and ash placement period.

Once flow resumed at the seep in March 1999, figure 2.26 shows that manganese concentrations had jumped from previous levels consistently well below the DWS (0.050 mg/L) to 5.59 mg/L, 112 times the DWS. Manganese remained far above the DWS from then on, ranging from 2.46 mg/L to 30.8 mg/L (616 times the DWS) in March 2000. Figure 2.27 shows that sulfate and TDS levels also jumped in March 1999 from previous levels usually one tenth their respective DWS to 1230 mg/L for sulfates, (nearly five times the DWS) and 1710 mg/L for TDS, (more than three times the DWS). From then on, sulfate levels ranged from 500 mg/L to 2197 in March 2003 and exceeded 1000 mg/L (four times the standard) in seven samplings. TDS levels ranged from 896 mg/L to 3496 mg/L in March 2003 and exceeded 2000 mg/L (four times the standard) in six samplings. Unlike most other monitoring points, iron levels (ungraphed) rose slightly from baseline concentrations but remained fairly low, always under 1.4 mg/L and usually under 1.0 mg/L, except for one anomalously high value of 154 mg/L (a dissolved concentration) measured in December 2001. Notwithstanding iron, the above data reveal that waters which were potable in the seep at MD19 became very nonpotable from March 1999 onward as a result of the activities authorized by this permit.

Average acidity levels also overtook alkalinity levels at MD19 in March 1999 (figure 2.28). This change was in turn reflected by a drop in field and lab pH values (figure 2.29) by nine tenths of a unit from approximately 6 to 5 units.

Calcium and magnesium concentrations in the resumed flow of March 1999 at MD19 had jumped from March 1997 levels by 49 times for calcium (to 310 mg/L) and 58 times for magnesium (to 62.9 mg/L), and these constituents continued to increase in subsequent monitoring (figure 2.30). Chloride and sodium (ungraphed) increased markedly also. Average chloride jumped from 1.33 mg/L during the baseline period and before the seep dried up to 39.63 mg/L after flow resumed with a high of 95 mg/L measured in June 2002. Average sodium jumped from 0.513 mg/L to 21.48 mg/L with a high value of 51.30 mg/L in March 2003. The last four measurements handily exceeded the DWEL (20 mg/L).

The degradation occurring after March 1999 extended to some trace elements (figure 2.31). Most notably, dissolved selenium rose from levels below detection (usually <0.007 mg/L) to five concentrations ranging from 0.009 mg/L to 0.183 mg/L in June 2002. This latter concentration is nearly four times the DWS and more than 36 times US EPA's current water quality standard of 0.005 mg/L for selenium. The other three selenium concentrations were much closer to the lower concentration, ranging from 0.0118 mg/L to 0.0138 mg/L, but these levels are still more than twice as high as the water quality standard, which in this case is the more relevant standard as the waters at MD19 are surface waters draining directly into a pond approximately 100 feet from the boundary of the permit area.

There was also one measurement of dissolved cadmium at MD19 in September 1999 at 0.012 mg/L. This is six times the acute water quality standard of 0.002 mg/L, 48 times chronic water quality standard of .00025 mg/L and more than twice the DWS for this trace element. There were no measurements of arsenic above detection limits and lead levels remained no higher than 0.0032 mg/L, not as high as the high concentrations of lead measured at monitoring points in the northern portion of the permit area (MW1, MW2, and MD12).

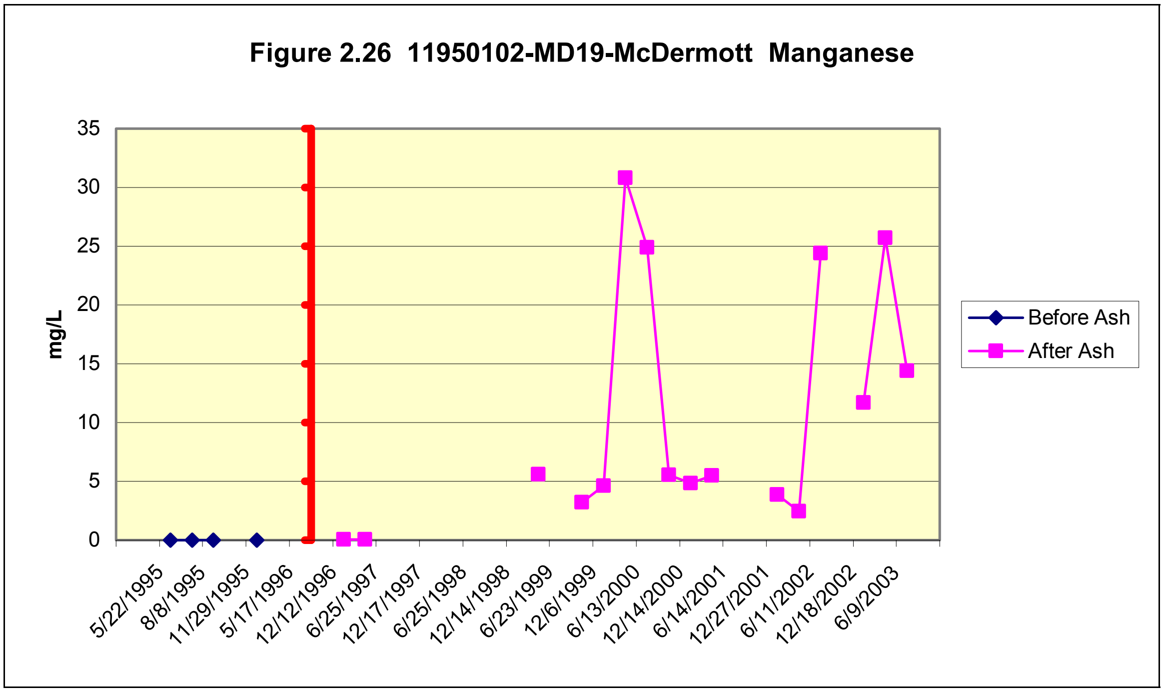


Figure 2.26 11950102-MD19-McDermott Manganese
mg/L
35
30
25
20
15
10
5
0
5/22/1995
8/8/1995
11/29/1995
5/17/1996
12/12/1996
6/25/1997
12/17/1997
6/25/1998
12/14/1998
6/23/1999
12/6/1999
6/13/2000
12/14/2000
6/14/2001
12/27/2001
6/11/2002
12/18/2002
6/9/2003
Before Ash
After Ash

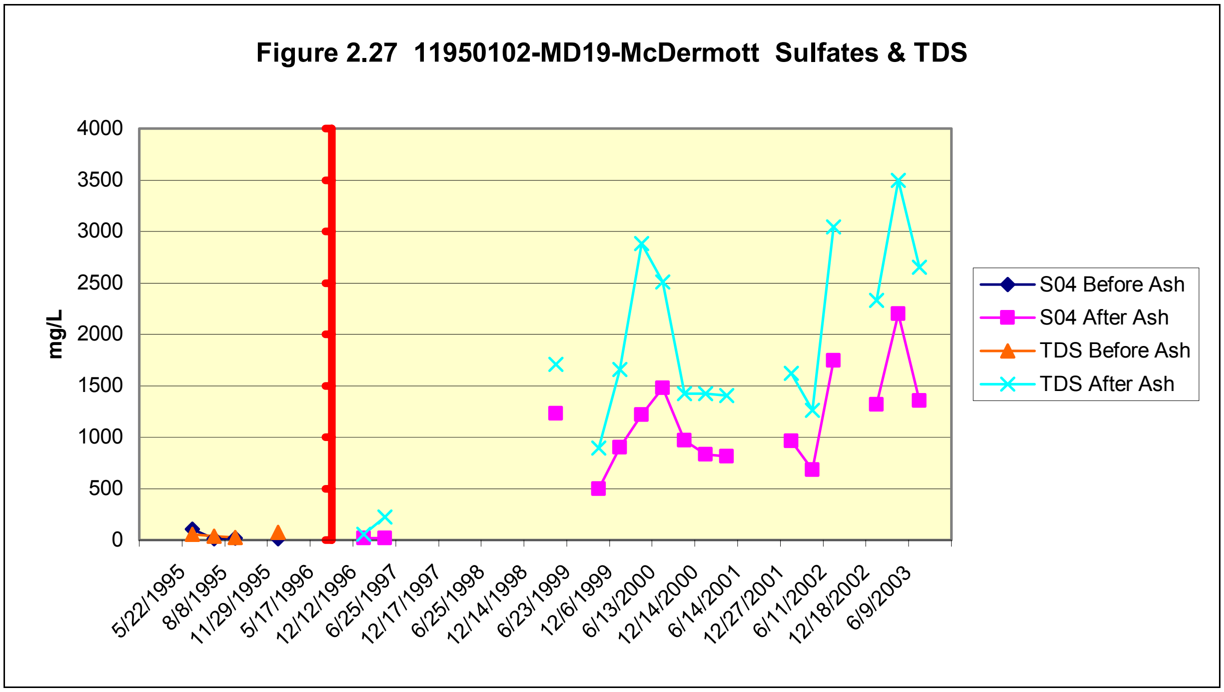


Figure 2.27 11950102-MD19-McDermott Sulfates & TDS
mg/L
4000
3500
3000
2500
2000
1500
1000
500
0
5/22/1995
8/8/1995
11/29/1995
5/17/1996
12/12/1996
6/25/1997
12/17/1997
6/25/1998
12/14/1998
6/23/1999
12/6/1999
6/13/2000
12/14/2000
6/14/2001
12/27/2001
6/11/2002
12/18/2002
6/9/2003
S04 Before Ash
S04 After Ash
TDS Before Ash
TDS After Ash

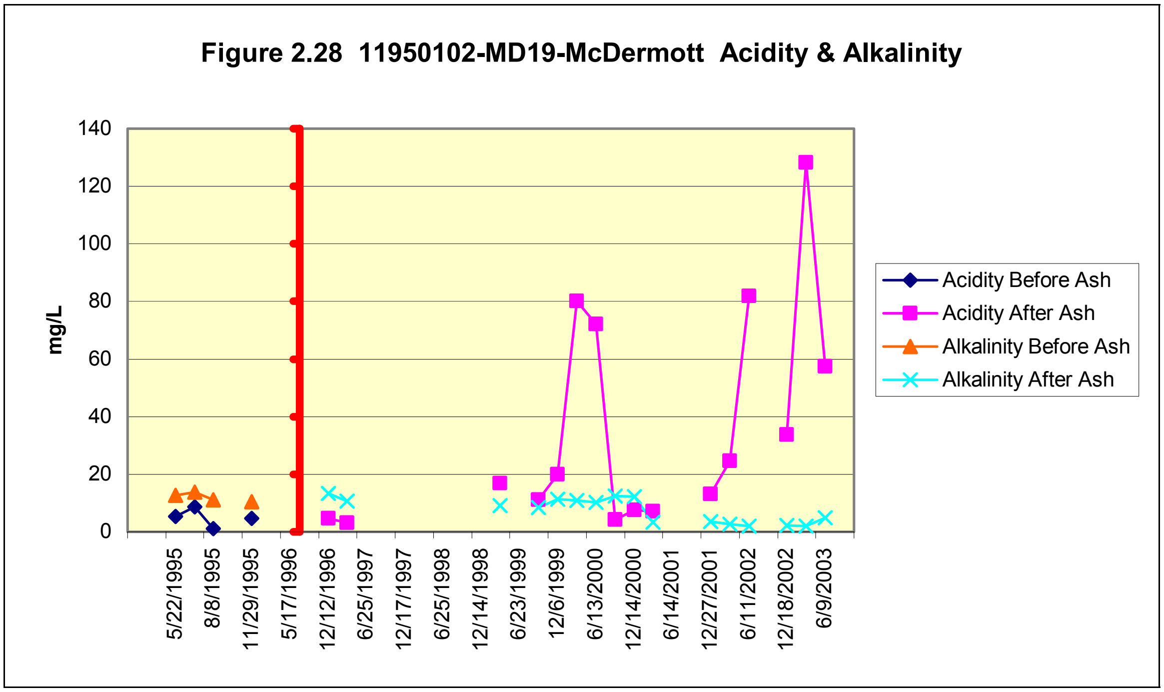


Figure 2.28 11950102-MD19-McDermott Acidity & Alkalinity
mg/L
0
20
40
60
80
100
120
140
5/22/1995
8/8/1995
11/29/1995
5/17/1996
12/12/1996
6/25/1997
12/17/1997
6/25/1998
12/14/1998
6/23/1999
12/6/1999
6/13/2000
12/14/2000
6/14/2001
12/27/2001
6/11/2002
12/18/2002
6/9/2003
Acidity Before Ash
Acidity After Ash
Alkalinity Before Ash
Alkalinity After Ash

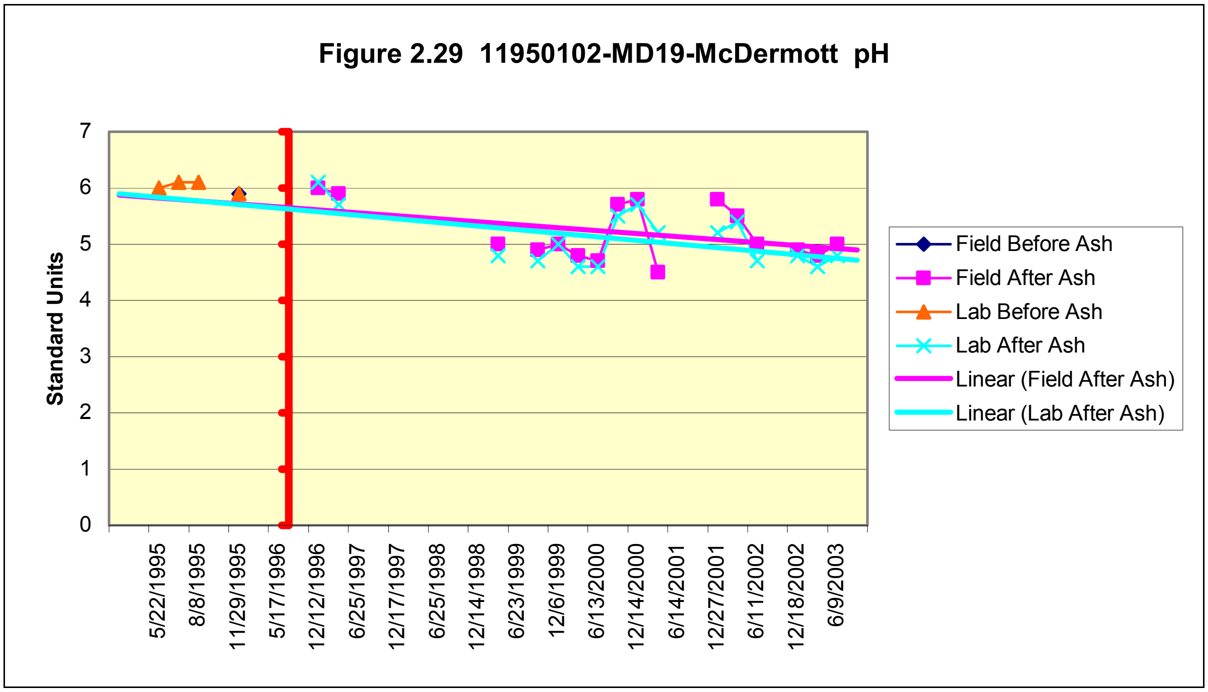


Figure 2.29 11950102-MD19-McDermott pH
Standard Units
0
1
2
3
4
5
6
7
5/22/1995
8/8/1995
11/29/1995
5/17/1996
12/12/1996
6/25/1997
12/17/1997
6/25/1998
12/14/1998
6/23/1999
12/6/1999
6/13/2000
12/14/2000
6/14/2001
12/27/2001
6/11/2002
12/18/2002
6/9/2003
Field Before Ash
Field After Ash
Lab Before Ash
Lab After Ash
Linear (Field After Ash)
Linear (Lab After Ash)

Figure 2.30 11950102-MD19-McDermott Calcium & Magnesium

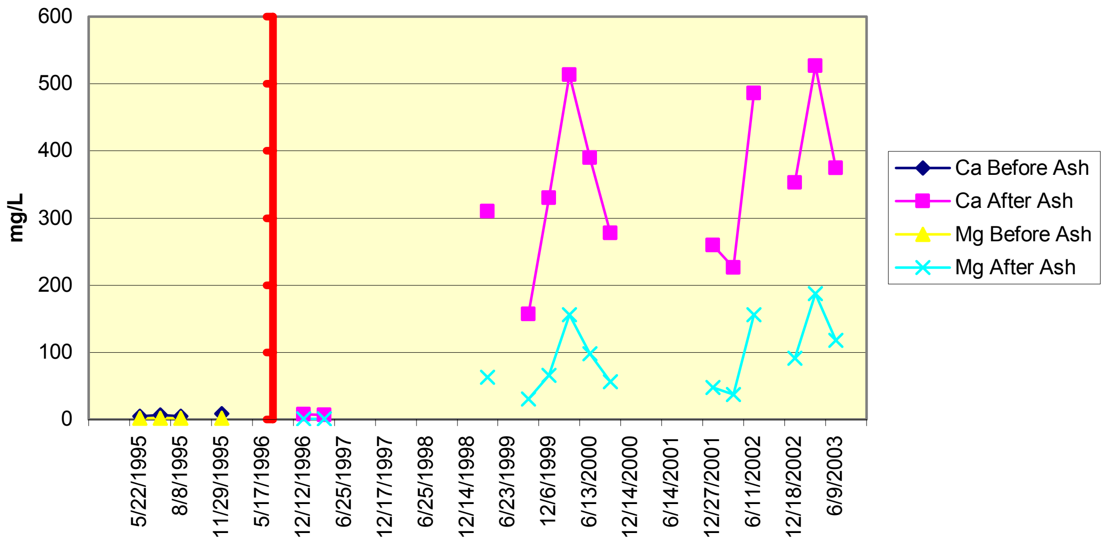
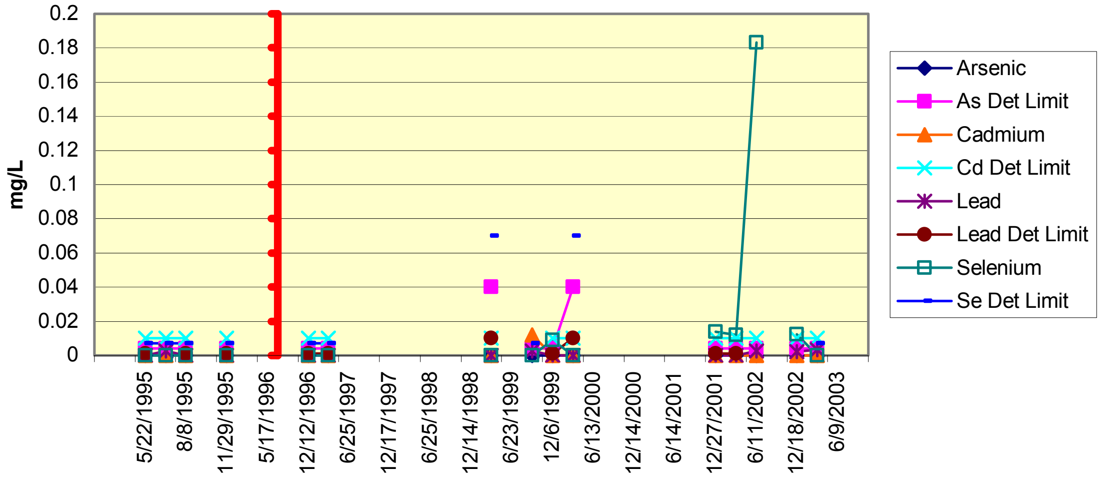


Fig. 2.31 11950102-MD19-McDermott Trace Elements



MW3-monitoring higher ash application rates at the southern end

MW3 is a downgradient ash monitoring well installed in the southern third of the site. This part of the site was mined after the northern portion of the permit area. Ash application rates were increased by 50 percent or more in the central and southern parts of the site in an attempt to address AMD problems that occurred in the northern area despite the initial ash application at the site according to permit documents and Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania (Chapter 5, p 143).

However the increase in ash did not appear to have much beneficial effect on water quality as the same stark rises in acidity and other major parameters indicative of ash and/or AMD occurred at this point. In fact the acidity rose to higher levels at this point than at any other monitoring point examined in this report except for MD3 which monitored deep mine waters flowing from underneath the site. Furthermore the trace element cadmium became noticeably more elevated at MW3 rising from below detection during the baseline period to harmful levels during mining and ash placement.

During the baseline period and for the first six samplings afterwards when mining was occurring in the northern part of the permit area, acidity (figure 2.32) was roughly equivalent to or below alkalinity (figure 2.32a), measuring between 3 and 16 mg/L in eight of eleven samplings. Then in March 1998 acidity jumped to 264 mg/L and continued rising to a peak of 656 mg/L in December 1999. From September 1999 onward, 14 of 17 samplings at MW3 measured acidity at greater than 500 mg/L. Alkalinity levels increased also but to only a small fraction of this amount (16.2 mg/l) before dropping in March 2001 to levels between 0 and 8.2 mg/L for the rest of monitoring assessed in this report. Average lab and field pH levels remained static at around 5 units throughout monitoring after mining and ash placement started.

Major parameters such as manganese, iron and sulfate as well as TDS all rose sharply with the jump in acidity in March 1998 from levels near their respective secondary DWS to levels several to many times over the DWS for the remainder of the monitoring assessed at MW3. Manganese (figure 2.34) rose from 0.222 mg/L (over 4 times the DWS) in December 1997 to 7.65 mg/L (153 times the DWS) in March 1998 and reached its peak in September 2002 at 19.7 mg/L (394 times the DWS). Iron (figure 2.35) jumped from 11.3 mg/L (38 times the DWS) in December 1997 to 186 mg/L (620 times the DWS) in March 1998 and reached a peak concentration of 396 mg/L (1320 times the DWS) in December 1999. Iron reached higher concentrations handily at MW3 than at any of the six other monitoring points examined in this report with 14 samplings exceeding 300 mg/L. Sulfate (figure 2.36) jumped to 468 mg/L (nearly twice the DWS) in March 1998 from <0.20 mg/L in December 1997 and continued rising to a peak of 1528 mg/L (more than six times the DWS) in September 2002. TDS (figure 2.36) jumped from 100 mg/L (one fifth the DWS) to 1030 mg/L (more than twice the DWS) in March 1998 and continued rising to a peak of 2818 mg/L (nearly six times the DWS) in June 2003

As occurred at the other monitoring points, the ash was most clearly implicated in this water quality deterioration at MW3 by the concentrations of calcium and magnesium which rose sharply also in the March 1998 sampling (figure 2.37). Calcium rose by nearly ten times from 5.63 mg/L in December 1997 to 53.6 mg/L in March 1998 and continued rising to a maximum concentration of 212 mg/L in March 2003. Magnesium rose by nearly 20 times from 2.12 mg/L in December 1997 to 40.3 mg/L in March 1998 and continued rising to a maximum concentration of 101 mg/L in September 2002 and March 2003.

Levels of sodium and chloride rose also (figure 2.38), although their rises started in the winter of 1997 for sodium and the summer of 1998 for chloride. Sodium started rising in December 1997 from below 1.0 mg/L to 8.55 mg/L and eventually to 16.5 mg/L in December 2002 and June 2003. Chloride started rising in August 1998 from below 1.0 to 7.00 mg/L and eventually to 33 mg/L in December 2002.

Rising levels of the toxic trace metal, cadmium, further implicate ash as a source of water quality degradation at MW3. Unlike lead, there was not one measurement of total or dissolved cadmium recorded above the detection limit of <0.010 mg/L (twice the DWS) during the baseline period at any of the seven monitoring points examined in this report or other monitoring points checked by researchers for this report. However, after mining and ash placement had begun and reached the southern portion of the permit area, dissolved cadmium was measured above this detection limit at least six times at MW3. These measurements started in June 1998 with a concentration of 0.018 mg/L, more three times the DWS and included 0.026 mg/L in March 1999, more than five times the DWS, 0.050 mg/L in September 1999, ten times the DWS, and 0.068 mg/L in March 2003, almost 14 times the DWS. These concentrations are far over water quality standards, but such standards are more relevant to surface waters than groundwaters.

There were no measurements of selenium above detection limits and only two measurements above detection limits of dissolved arsenic at MW3, 0.005 mg/L in March 2002 and 0.0044 mg/L in June 2002. However as occurred at the other monitoring points, detection limits of <0.040 for arsenic and <0.070 mg/L for selenium in monitoring results for December 1998 and March 1999 were too high to discern whether these trace elements were occurring at levels of concern (near or above the DWS).

Although the highest dissolved lead level found in all of the monitoring data examined in this report was the first measurement during the baseline period at MW3, 0.138 mg/L, subsequent levels of lead during mining and ash placement reached a high of only 0.010 mg/L and thus were well below the lead measured at monitoring points at the northern end of the site (MW1, MW2, and MD12).

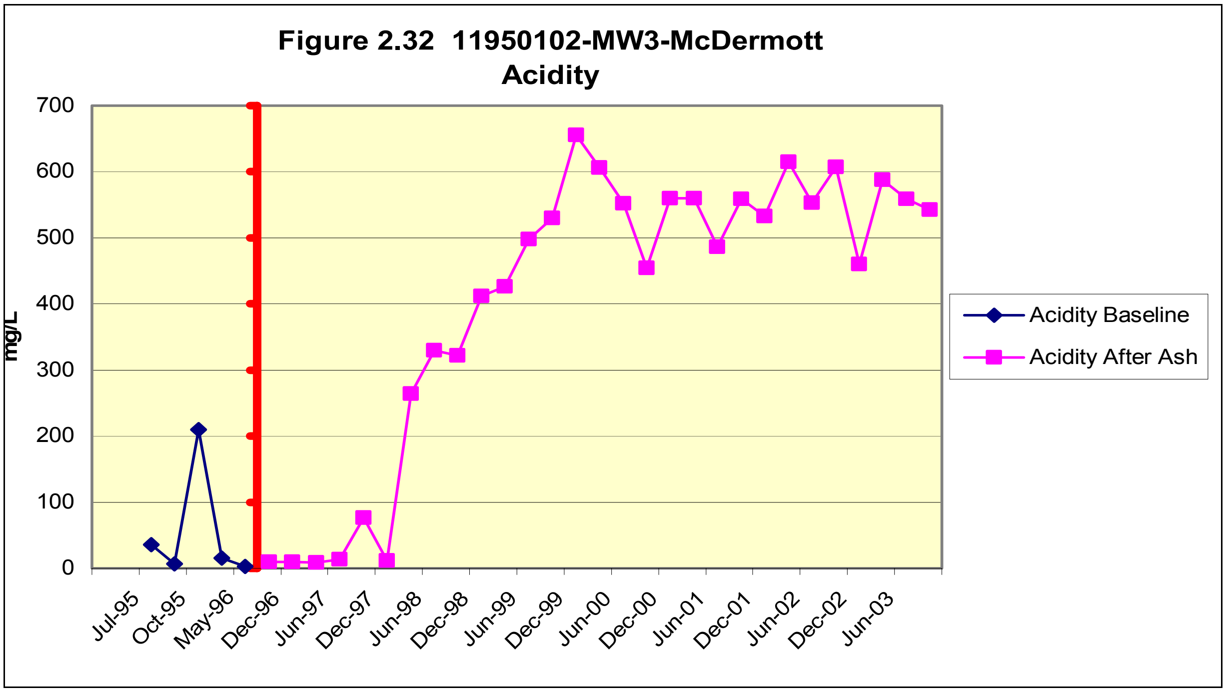


Figure 2.32 11950102-MW3-McDermott Acidity

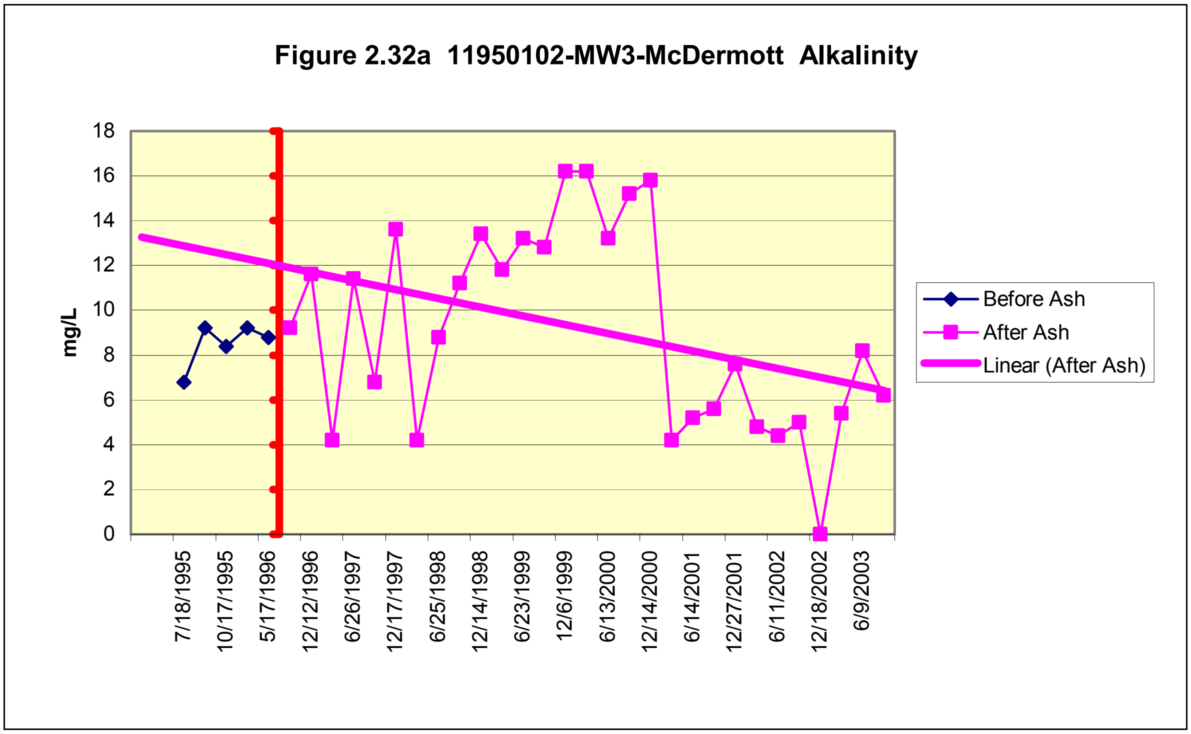


Figure 2.32a 11950102-MW3-McDermott Alkalinity

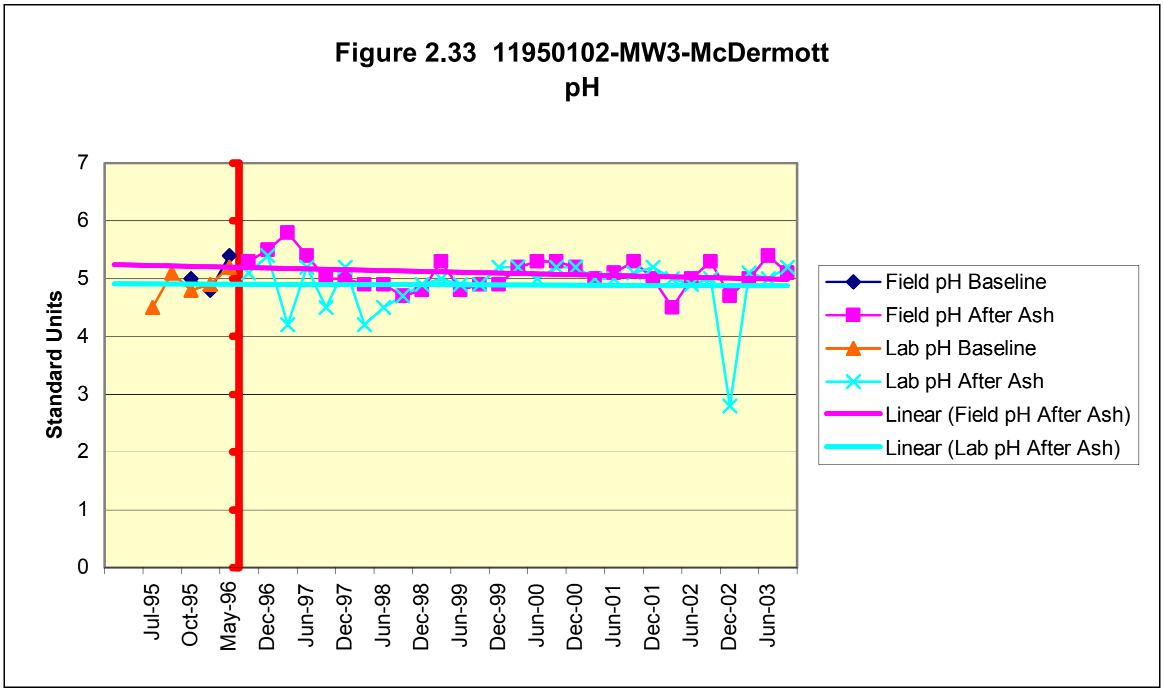


Figure 2.33 11950102-MW3-McDermott
pH
Standard Units
0
1
2
3
4
5
6
7
Jul-95
Oct-95
May-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Field pH Baseline
Field pH After Ash
Lab pH Baseline
Lab pH After Ash
Linear (Field pH After Ash)
Linear (Lab pH After Ash)

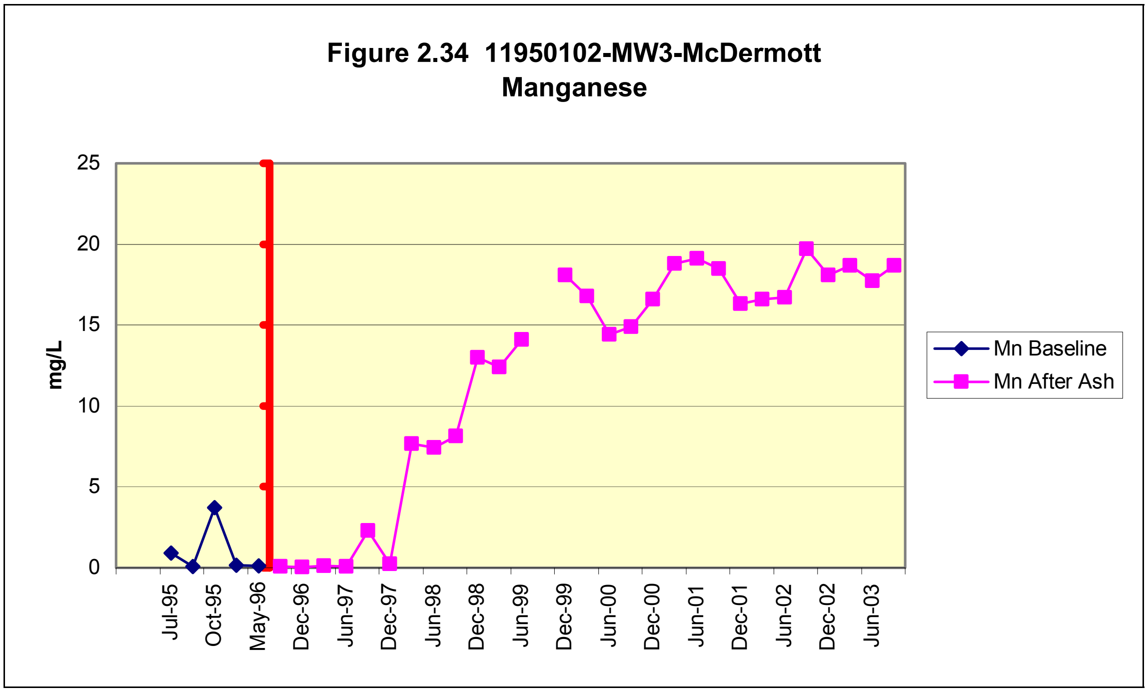


Figure 2.34 11950102-MW3-McDermott
Manganese
mg/L
0
5
10
15
20
25
Jul-95
Oct-95
May-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Mn Baseline
Mn After Ash

Figure 2.35 11950102-MW3-McDermott Iron

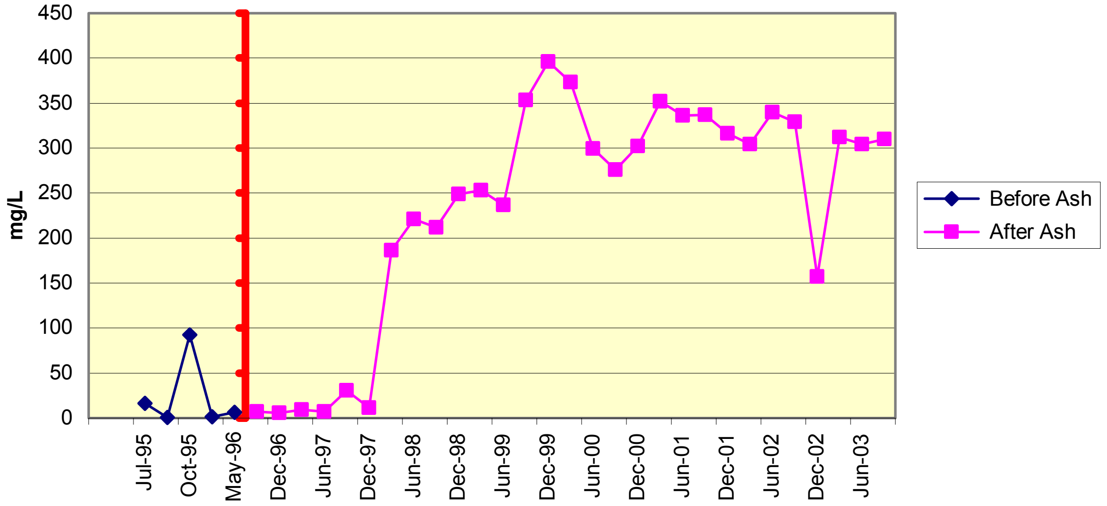
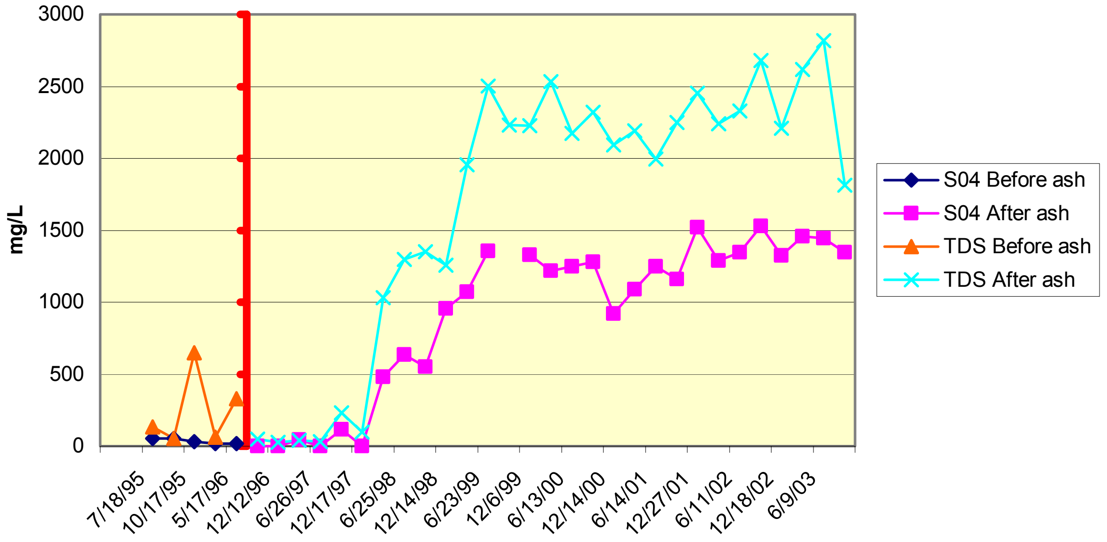


Figure 2.36 11950102-MW3-McDermott Sulfate & TDS



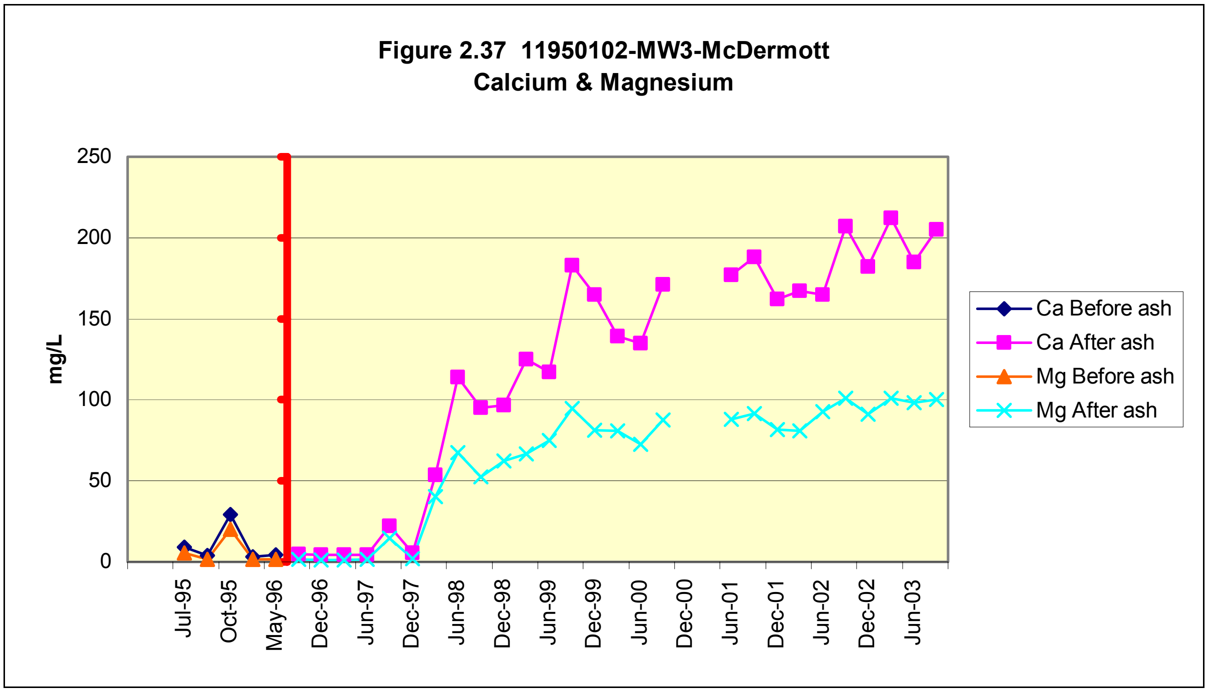


Figure 2.37 11950102-MW3-McDermott
Calcium & Magnesium
mg/L
250
200
150
100
50
0
Jul-95
Oct-95
May-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Ca Before ash
Ca After ash
Mg Before ash
Mg After ash

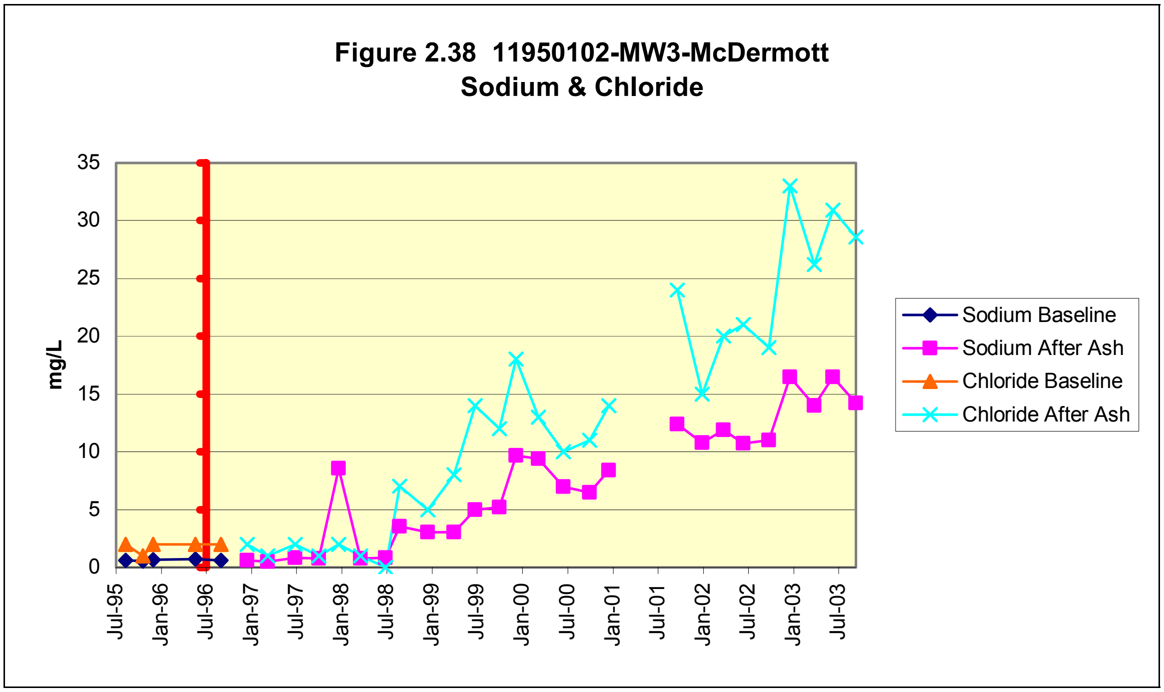


Figure 2.38 11950102-MW3-McDermott
Sodium & Chloride
mg/L
35
30
25
20
15
10
5
0
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
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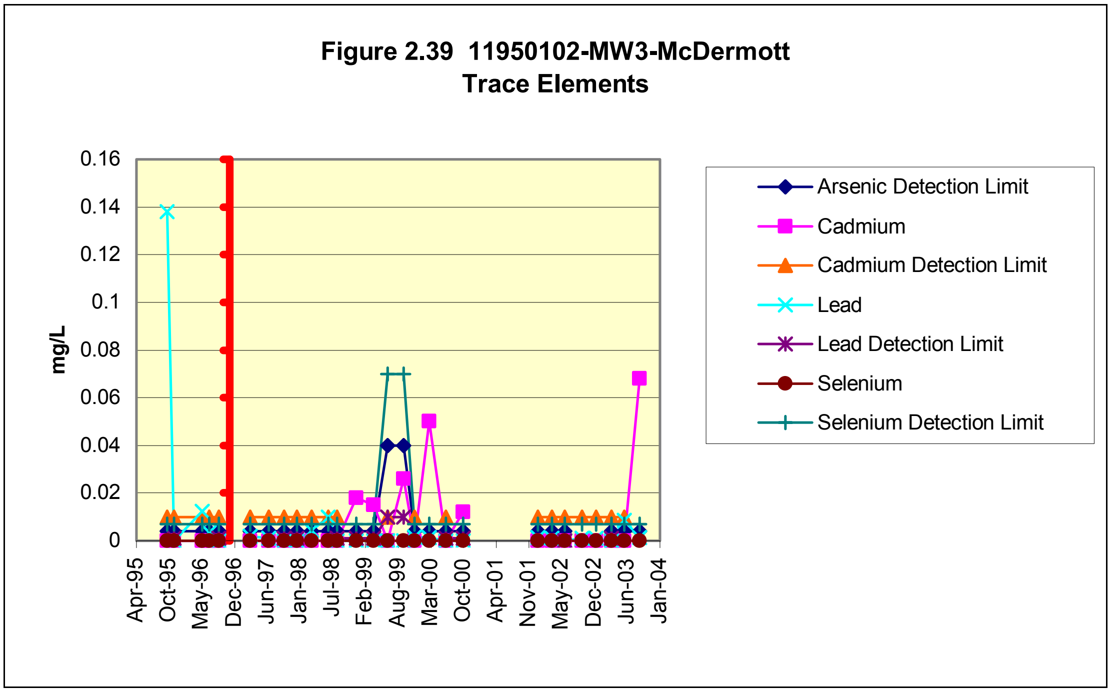
Jan-03
Jul-03
Sodium Baseline
Sodium After Ash
Chloride Baseline
Chloride After Ash



MD3-deep mine discharge beyond the permit area

MD3 is the most downgradient monitoring point at this site sampling deep mine discharges into an unnamed tributary to Hinckston Run, 900 feet southeast of the southeastern border of the permit area. These discharges are emanating from an abandoned underground mine in the aquifer associated with the Lower Kittanning coal which is being mined and filled partially with ash on the site. At a surface elevation of 2185 feet, MD3 is strategically located: it is at local base level, 80 to 100 feet below the surface elevations of the other monitoring points inside the permit area and its waters are 30 to 50 feet below the elevations of the groundwaters being monitored by the ash monitoring wells (MW1, MW2 and MW3) on the site; therefore, potentially MD3's data can tell us the most about the impact to water quality on the site.

Baseline monitoring reveals a more deteriorated water quality at MD3 than was found at other monitoring points during the baseline period. Acidity was as high as 900 mg/L and sulfates, manganese and TDS were already several to many times over their DWS and applicable water quality standards in this discharge before mining and ash placement had started at McDermott. Sodium and chloride levels were elevated also during the baseline period, with sodium reaching 46.1 mg/L and chloride reaching 79 mg/L in November 1995. Nevertheless the levels of all of these pollutants climbed to substantially higher concentrations in the discharge at MD3 as a result of mining and ash placement. Additionally trace elements which were low or below detection during the baseline period, rose to detectable and in some instance harmful levels starting in the spring of 1999.

Acidity concentrations at MD3 (figure 2.40) reached the highest levels of any recorded at the McDermott site and spanned the greatest range in values of the seven monitoring points examined in this report. Highest acidity reached 942 mg/L in December 1999 and the lowest value was 157 mg/L in June 2003 although average acidity values followed a rising trend during mining and ash placement from approximately 500 to 600 mg/L. Alkalinity values were 0 mg/L throughout all monitoring at MD3. Field pH declined on average by three fourths of a unit during mining and ash placement from approximately 4.75 units to 4 units while lab pH showed no trend remaining at 2.75-2.80 units throughout mining and ash placement (figure 2.41).

There were pronounced rises at MD3 in manganese (figure 2.42), sulfates (figure 2.43) and TDS (figure 2.44) during mining and ash placement. Manganese began to rise above its highest baseline concentration (16.4 mg/L) in September 1999 and reached a peak of 46.0 mg/L in June 2002. Sulfate rose above its highest baseline concentration (734 mg/L) in June 1999 and reached its highest concentration during mining and ash placement of 1999 mg/L in June 2002. TDS (figure 2.44) first rose above its highest baseline concentration of 2698 mg/L in September 2000 and reached a maximum concentration of 3654 mg/L in June 2003.

There were also clearly increasing trends at MD3 for ash indicators, sodium, chloride, calcium and magnesium. Starting in December 1997, sodium and chloride increased beyond their highest baseline concentrations five times with sodium's highest concentration peaking at 74.3 mg/L in March 2000 and chloride's highest concentration peaking at 133 mg/L in March 1999 (figure 2.45). Three of the five sodium values measured before mining and ash placement were below the DWEL of 20 mg/L whereas only 5 of the 25 values after mining and ash placement started remained below the DWEL, and most of these values exceeded 30 mg/L.

Unlike trends reflective of most FBC ash, during the baseline period and for the first two years after mining and ash placement started, magnesium concentrations exceeded calcium concentrations at MD3 (figure 2.46). The average baseline magnesium concentration was 33 mg/L while the average calcium concentration during baseline was 28 mg/L. This trend reversed itself however - as these two constituents started rising in 1998 – becoming reflective of the higher calcium to magnesium seen at other points downgradient of the FBC ash at this and other sites studied in this report. Calcium rose beyond its highest baseline concentration in June 1998 and reached its highest level at MD3 in June 2003 of 293 mg/L after a sharp rise in the fourth quarter of 2001. The first measurement of magnesium after mining and ash placement started in August 1996 was above its highest baseline concentration. But the highest magnesium concentration at MD3 was also measured in June 2003 at 233 mg/L when the higher peak in calcium was measured and also after a sharp rise in magnesium levels in the last quarter of 2001.

Trace elements cadmium and selenium rose from below levels of detection during baseline monitoring at MD3 to levels of concern during mining and ash placement (figure 2.47). Cadmium was measured as high as 0.019 mg/L in September 1999 (total cadmium was 0.024 mg/L). This is more than nine times the federal acute water quality standard, 76 times the federal chronic water quality standard and nearly 4 times the DWS. Two other samplings in 1999 documented cadmium at 0.012 mg/L, six times the acute water quality standard, 48 times the chronic water quality standard and more than twice the DWS.

Selenium was measured at 0.025 mg/L in June 2002, 5 times the federal chronic water quality standard, and found in three other samplings in 2000-2002 at between 0.0089 and 0.0097 mg/L, nearly twice this water quality standard. There is not enough information from the monitoring data to discern whether these values were exceeding the published federal numeric water quality standard for acute toxicity for selenium (e.g., fractions of the total selenium that were selenate versus selenite).

The flow volumes at MD3 ranged from 7 to 127 gallons per minute and averaged 58 gallons per minute when these measurements occurred. This makes such concentrations of cadmium and selenium particularly of concern because the small volume of water likely in the unnamed tributary to Hinckston Run that MD3 flows into could make it incapable of absorbing these concentrations at safe levels for aquatic life, and the higher flow during these concentrations suggests there will be a longer term loading impact on Hinckston Run.

Selenium was measured above the chronic water quality standard at 0.028 mg/L in June 2003 and at 0.013 mg/L in September 2003 at MD3, but these values were of total concentrations (dissolved values were not reported) and therefore were not graphed in Figure 2.47. The same was true for cadmium measured at 0.007 mg/L in the September 2003 sampling. There was one measurement of dissolved arsenic above the detection level of <0.004 mg/L in June 2002 at 0.0053 mg/L and one level of total arsenic in June 2003 also at 0.0053 mg/L (ungraphed) but no dissolved arsenic value reported from that sampling.

The range of dissolved lead levels increased from 0.0011-0.0037 mg/L during baseline monitoring to 0.0017-0.0078 mg/L during mining and ash placement. Most lead levels during 1999 and the first quarter of 2000 were higher than baseline concentrations and all measurements in this period were higher than the federal chronic water quality standard for lead of 0.0025 mg/L. Unlike cadmium, selenium and arsenic however, lead concentrations were actually measured (found above detection limits) during the baseline monitoring period at MD3 whereas these three trace elements were not measured above detection limits at MD3 or other monitoring points at the McDermott site before ash placement occurred.

Figure 2.40 11050102-MD3-McDermott Acidity

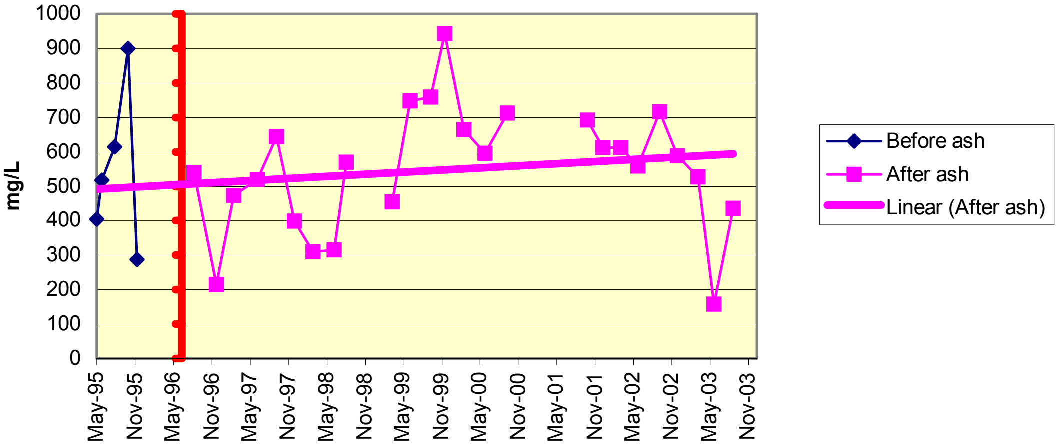


Figure 2.41 11950102-MD3-McDermott pH

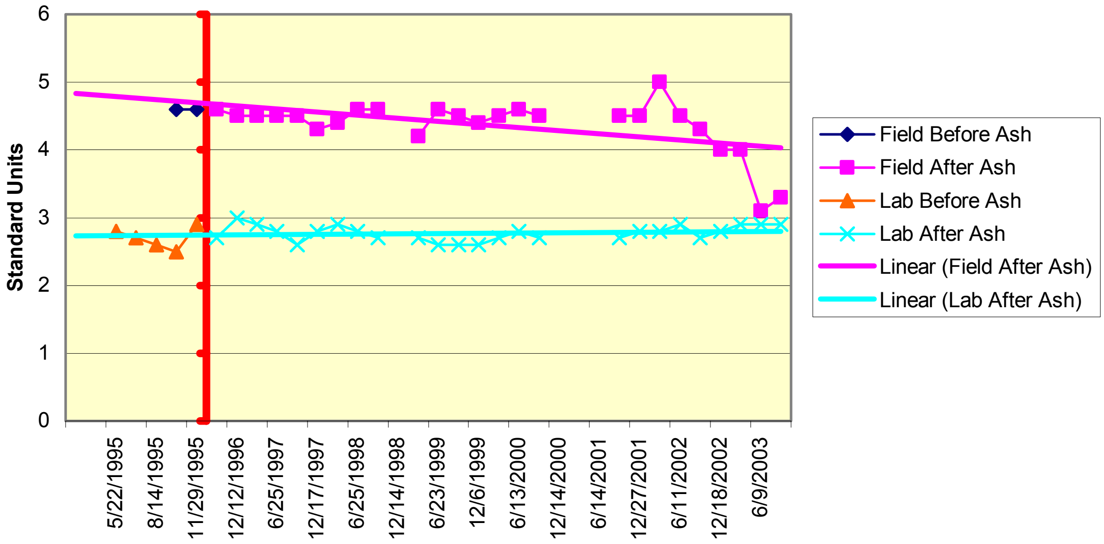


Figure 2.42 11950201-MD3-McDermott
Manganese

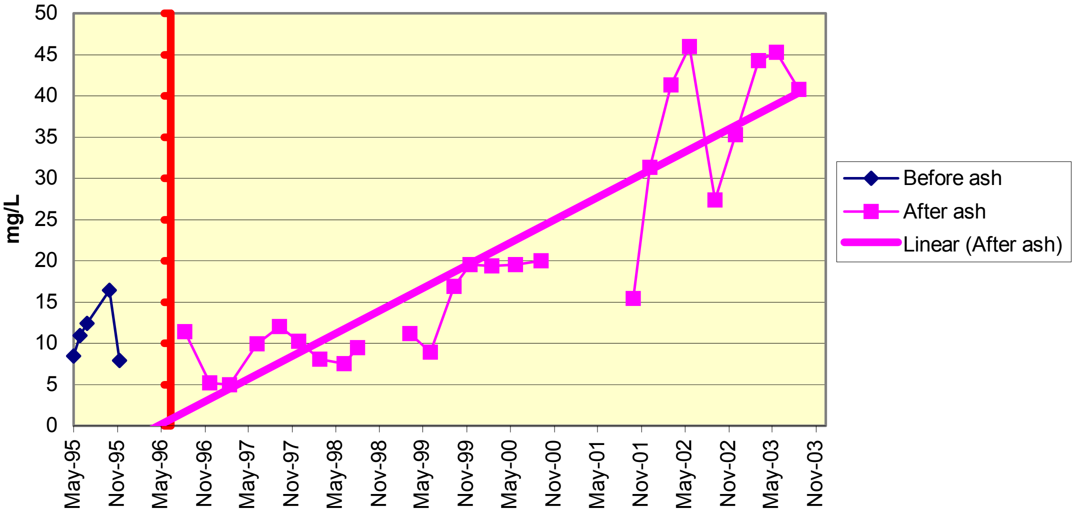


Figure 2.43 11950201-MD3-McDermott
Sulfates

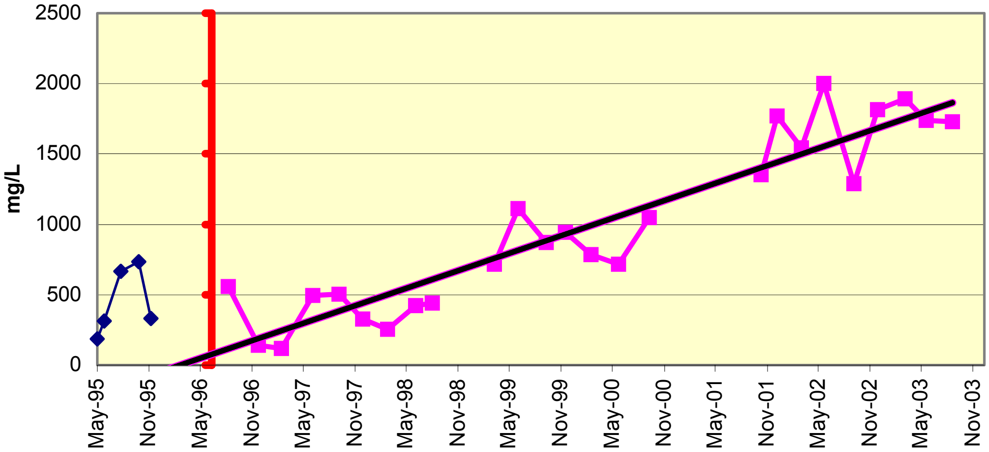


Figure 2.44 11950102-MD3-McDermott TDS

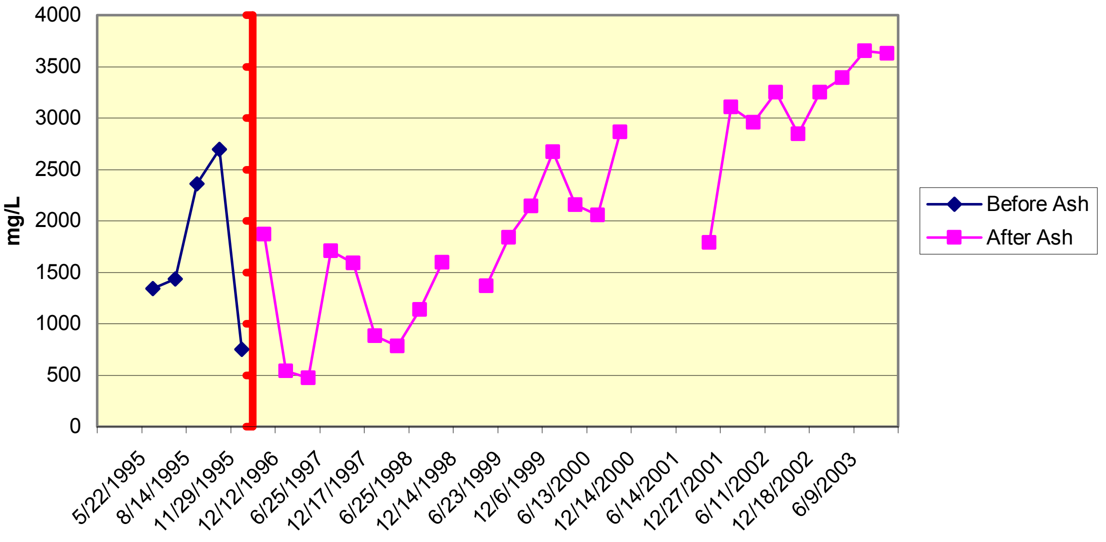


Figure 2.45 11950102-MD3-McDermott Chloride & Sodium

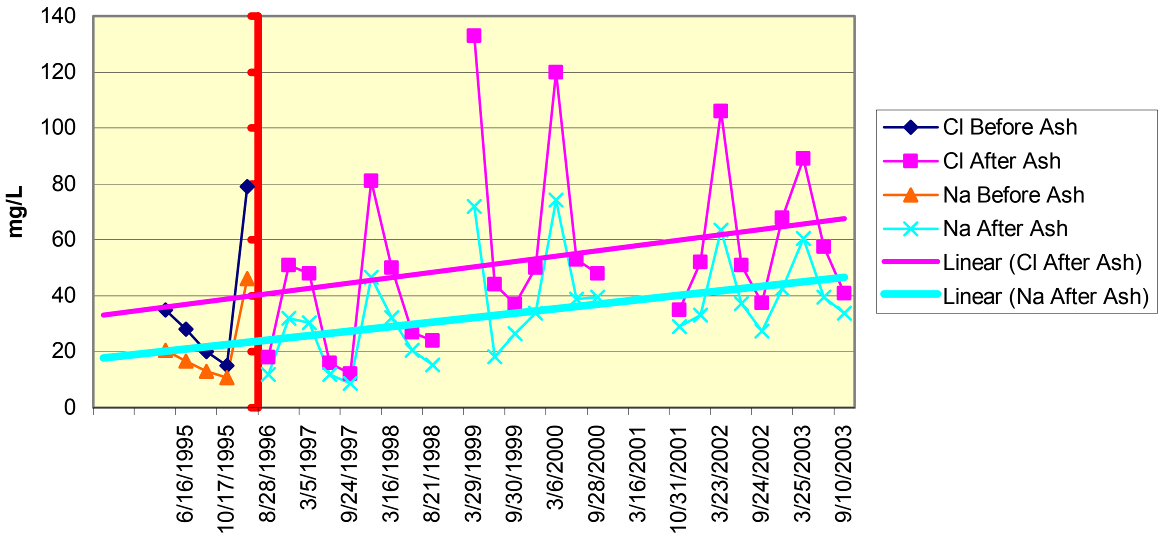


Figure 2.46 11950102-MD3-McDermott Calcium & Magnesium

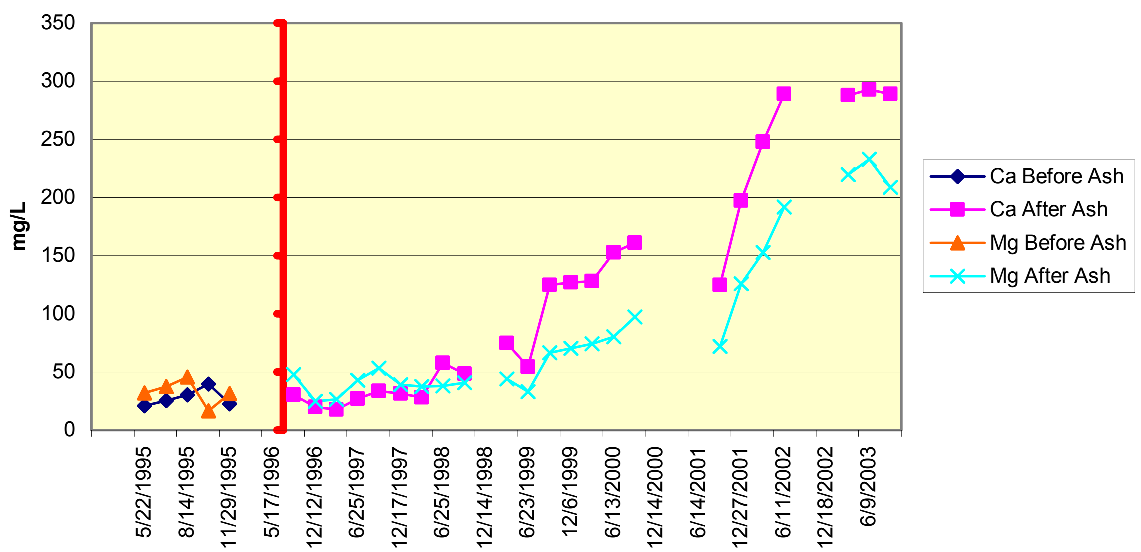
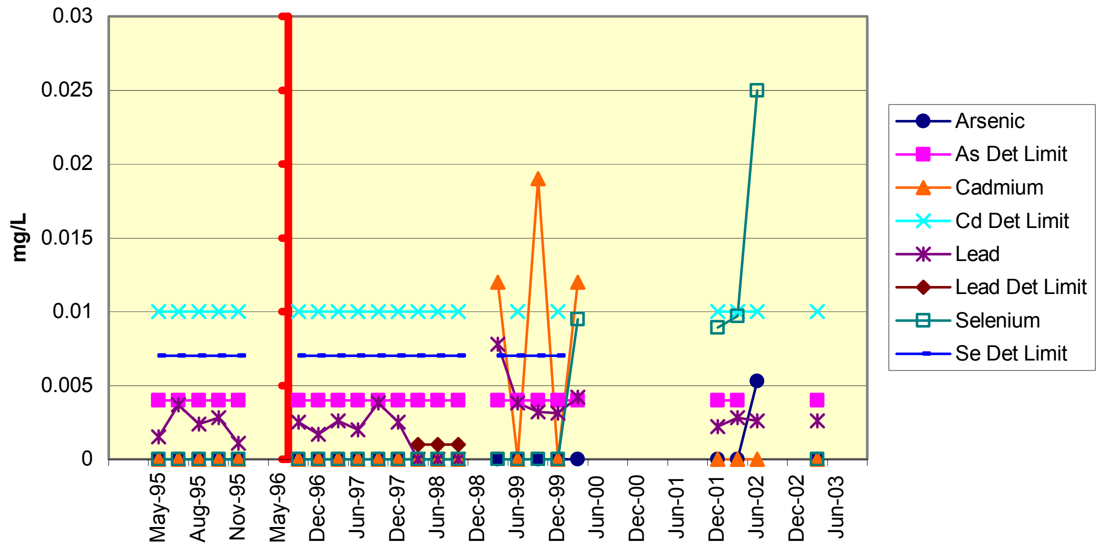


Figure 2.47 11950102-MD3-McDermott Trace Elements



Conclusion

The operations approved under Permit 11950102 have caused considerable damage to groundwater and surface waters draining the McDermott Mine, and there is ample, substantive evidence that FBC coal ash is contributing to that damage.

Unfortunately there are no upgradient monitoring points that would allow a more precise determination of the impact of ash placement on water quality. Nonetheless there are ample data from multiple points downgradient of the ash that show substantial rises beyond baseline concentrations of numerous parameters associated with the ash placed at this site.

To begin with, site inspection from the periphery readily reveals that the FBC ash has not produced the positive benefit that it was supposed to produce. Despite the placement of 316,000 tons of highly alkaline FBC ash containing more than three times the amount of alkalinity reportedly needed to neutralize the acidity at this site according to the acid-base accounting in the permit, acid mine drainage (AMD) generated from the mining approved with this ash placement, is visibly discharging with the effluent from the site into nearby drainages of Hinckston Run. While data at monitoring points closest to the ash such as MD22, show the FBC ash has contributed alkalinity to groundwater draining through this ash, the data also show that with the possible exception of the northeast corner of the site at MW1, this alkalinity has never been sufficient to buffer the acidity for more than temporary periods (one to two monitoring quarters) under the best circumstances, i.e. at points immediately adjacent to the ash. The asserted acid mitigation capabilities of the ash at this site have clearly not worked despite attempts to place the ash in sufficient volumes and in different manners, including mixing it with spoils, spreading it across pit floors and using it as an infiltration barrier beneath cover soils on the site. Only at MW1 have average acidity levels come down since ash placement began, yet the field pH at MW1 has declined by approximately three fourths of a unit and alkalinity remained at zero throughout the mining and ash placement.

In discussing the McDermott site in Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania, the PADEP states that "a review of the water quality data for this site shows no evidence of contamination from ash utilization." (Chapter 5, p. 145) In fact, a review of the water quality data clearly refutes this assertion. Substantial increases in calcium, magnesium, chloride and sodium at all downgradient monitoring points clearly demonstrate that the ash is a significant contributor to the geochemical system at this site. These constituents are conceded by PADEP in the above report to be probable indicators of the FBC ash at this site and are absent in significant quantities in the site's overburden according to the geologic cores and other relevant materials in the permit file. Sodium and chloride readily leach at high levels (6 mg/L to >100 mg/L) in the SPLP tests on this FBC ash (which do not test for calcium or magnesium although these constituents are major components in the limestone and therefore expected to leach readily from nearly all PA FBC ashes). Without having a more thorough characterization of the FBC ash from the Colver and Cambria power plants than a bulk analysis and a benchmark laboratory leaching test (the SPLP), it is reasonable to assume that if this ash is contributing these constituents readily to acidic site waters, that it would likely be contributing other constituents such as sulfate, manganese and TDS to those waters as well. Indeed the high levels of calcium, magnesium, chloride and sodium coincide in every instance at every downgradient monitoring point with adversely high levels of sulfates, manganese and TDS that did not exist in the baseline period site even in the most acidic waters at this site.

Sulfate and manganese leach readily from eastern conventional and FBC power plant coal ashes when their neutralization potentials have been exhausted (see *Metal Release From Fly Ash Upon Leaching With Sulfuric Acid or Acid Mine Drainage*, J. Skouzen and D.K. Bhumbla, West Virginia University, May 1998, and *The Influence of Fly Ash Additions on Acid Mine Drainage Production From Course Coal Refuse*, B. Stewart, W. Daniels and L. Zelazny, Virginia Tech, March 1996). Both sulfate and manganese have leached repeatedly from the Colver and Cambria Plant FBC ashes placed at this site in the SPLP test required by Permit #11950102 and Permit #32950201 for the Ernest Mine. In the case of sulfates, that leaching has been prolific (usually beyond 1000 mg/L) while manganese is clearly less soluble, leaching in most tests but at fairly dilute levels (usually between 0.03 and 1.00 mg/L).

Given the (1) substantial rises in sulfates, manganese and TDS to levels far exceeding baseline concentrations and hundreds of times over secondary DWS at monitoring points downgradient of ash at this site; (2) the marked rises of calcium, magnesium, chloride and sodium in the same waters experiencing these rises in manganese, sulfate and TDS and at the same time; (3) the high levels of manganese and sulfur in the permit's bulk analyses on the FBC ashes at this site: and (4) the fact that sulfate and manganese have leached regularly in the dilute conditions, acidic leaching fluid (pH – 4.2), and short time span (18 hours) in the SPLP test performed on the site's ashes, the PADEP has not established a scientific basis for its assertion that "there is no evidence of contamination from ash utilization at this site." Indeed PADEP's assertion seems particularly questionable in the face of data from MW1, which showed manganese, sulfate, and TDS levels sharply increasing as acidity declined. Average iron levels were also declining. In that chemistry, the primary source of sharply increasing manganese and sulfates could not be AMD if it were decreasing.

In <u>Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania</u>, the PADEP also emphasizes that the FBC ash is not contaminating ground water or surface water with heavy metals:

> In addition to the monitoring points discussed in detail in this chapter, a downgradient spring (MD-19) and two other downgradient abandoned deep mine discharges (MD3 and MD-5) were further degraded by the McDermott operation. The degradation is in terms of mine drainage parameters, and there is no significant increase in any heavy metal, including lead, or other parameter attributable to the ash placement on the site. Data for MD3, MD-5 and MD-19 are available in Appendix 5.C. (Chapter 5, p. 144)

The data in the monitoring reports in the McDermott permit file also contradict this statement repeatedly. A review of the data in Appendix 5.C shows that in a large number of instances, PADEP has not included data reported in the monitoring reports by the mine operator or changed the values of that data from dissolved to total even though the monitoring reports explicitly identify the values as dissolved. We find no communications or other information in the permit file that would explain these inconsistencies. While it is not clear what PADEP means by "no significant increase in any heavy metal, including lead, or other parameter," there have been clear, unmistakable increases in dissolved cadmium and selenium at MW1, MW2, MW3, MD-22, MD-19, and MD3 above baseline (a.k.a. background) concentrations to levels of concern. These increases as well as those for manganese, sulfate, TDS, sodium, and lead at these monitoring points clearly meet the threshold in PADEP regulations (Section 287.1) that defines "groundwater degradation" as "a measurable increase in the concentration of one or more contaminants in groundwater above background levels for those contaminants." Increases at most of these monitoring points beyond baseline concentrations for copper, nickel and zinc appear to meet this threshold also, but these three constituents were not examined in this report.

PADEP's assertion that high lead levels at the McDermott site stem from the impacts of mining on overburden is supported by baseline data that documented higher lead levels at MW1 and MW3 before ash arrived than after ash placement started near these monitoring points and numerous lower concentrations of lead at other monitoring points during the baseline period. Nonetheless, the rises in dissolved lead at MW2 and MD12 to levels well beyond baseline concentrations and exceeding the DWS by as much as 5.6 times at MW2 and 4 times at MD12 is a matter of concern. The FBC ash from the Cambria plant which comprises more than 90 percent of the ash at the McDermott site has leached high levels of lead in several SPLP tests (e.g. Cambria bottom ash approved for placement at the Ernest Mine leached 0.350 mg/L of lead in an April 1999 test -- see Permit Review 1, ERNEST MINE for details on other SPLP test results). This demonstrates its potential to exacerbate a lead leaching problem at this site. Furthermore the spring sampled by MD12 is 300-400 feet beyond the boundaries of the McDermott Mine property and was serving as a domestic water supply.

Cadmium is also a heavy metal. However, unlike lead there was not a single instance in which cadmium, dissolved or total, was reported above a detection limit of <0.010 mg/L during baseline monitoring at any of the monitoring points at the McDermott Mine. Yet after permit operations began, dissolved cadmium was measured at least once and usually several times at every monitoring point downgradient of the FBC ash, (that was assessed in this report), usually a few to several years after mining and ash placement were underway.

The highest cadmium levels in groundwater at McDermott were observed at MW3 AFTER mining and ash placement reached the groundwater being monitored by this point. There were six measurements of dissolved cadmium subsequently at this monitoring point that exceeded the DWS by at least 2 times. The higher of these included 0.018 mg/L in June 1998, more than 3 times the DWS, 0.026 mg/L in March 1999, more than 5 times the DWS, 0.050 mg/L in September 1999, 10 times the DWS, and 0.068 mg/L in March 2003, almost 14 times the DWS.

There was one concentration of dissolved cadmium at MW1 at 0.01 mg/L in March 2003, twice the DWS. There were four measurements of dissolved cadmium above detection limits at MW2 with the highest being 0.018 mg/L in August 1998, nearly 4 times the DWS.

And there was one measurement of dissolved cadmium at MD1 (not studied in this report) in August 1996, at 0.020 mg/L, 4 times the DWS. This was after ash placement had started near MD1, before it was eliminated by mining in June 1997. The text of the Module 25 for this permit makes a particularly pertinent point about MD1:

> c) Deep mine discharges MD-1 and MD-2 represent the aquifer associated with the Lower Kittanning coal. As such they should be the first monitoring points to detect any ground water changes that may result from the CFB ash placement. (p. 25-30)

The higher levels of cadmium have migrated to surface waters draining from ash areas as well. There was one measurement of dissolved cadmium at MD19 in September 1999 at 0.012 mg/L. In addition to being more than twice the DWS, this is 6 times US EPA's water quality standard for acute toxicity (CMC, i.e., Criterion Maximum Concentration) of 0.002 mg/L and 48 times the federal water quality standard for chronic toxicity (CCC, i.e., Criterion Continuous Concentration) of 0.00025 mg/L and therefore a gross exceedance of the Clean Water Act's water quality standards in a seep at the property boundary. Dissolved cadmium was measured once in the ash drain waters at MD22 at 0.018 mg/L in March 1999, more than 3 times the DWS, 9 times the acute water quality standard and 72 times the chronic water quality standard.

Perhaps of greatest concern, in the surface waters emanating at MD3, 900 feet beyond the property line of the McDermott mine, dissolved cadmium was measured as high as 0.019 mg/L, more than 9 times the acute water quality standard, 76 times the chronic water quality standard and nearly 4 times the DWS in September 1999. It was found in two other samplings in 1999 at MD3 at 0.012 mg/L, 6 times the acute water quality standard, 48 times the chronic water quality standard and more than 2 times the DWS.

At all of these monitoring points and at the spring, MD12, there were also measurements of total cadmium during ash placement that were not discussed or graphed in this report and that were usually higher than any dissolved measurements reported with them. In several cases, only results for total cadmium were submitted in monitoring reports.

Selenium is not a heavy metal but is often discussed with heavy metals given the toxic impacts it poses in small doses in the environment. There was not a single instance in which selenium, dissolved or total, was reported above a detection limit of <0.007 mg/L during baseline monitoring at any of the monitoring points at the McDermott Mine. However, selenium is well known as one of the trace elements that leaches from alkaline eastern coal ashes and has leached (as has cadmium although to a lesser extent) specifically from the FBC ashes disposed at McDermott in several of the SPLP tests.

After mining and ash placement started, dissolved selenium was measured at levels exceeding the <0.007 mg/L detection limit, at MW1, MW2, MD22, MD19 and MD3. Except for MW2, these levels of selenium did not show up until mining and ash placement had been underway near the respective monitoring point for 2-3 years. At that point in time, selenium concentrations were repeatedly exceeding EPA's chronic surface water quality standard of 0.005 mg/L at the respective surface water monitoring points. At MD22, the ash leachate drain discharging to a collection pond, dissolved selenium was measured above the detection limit in seven of fifteen samplings. Higher concentrations occurred in more recent samplings. The highest, 0.0234 mg/L in December 2002 was nearly 5 times the chronic water quality standard.

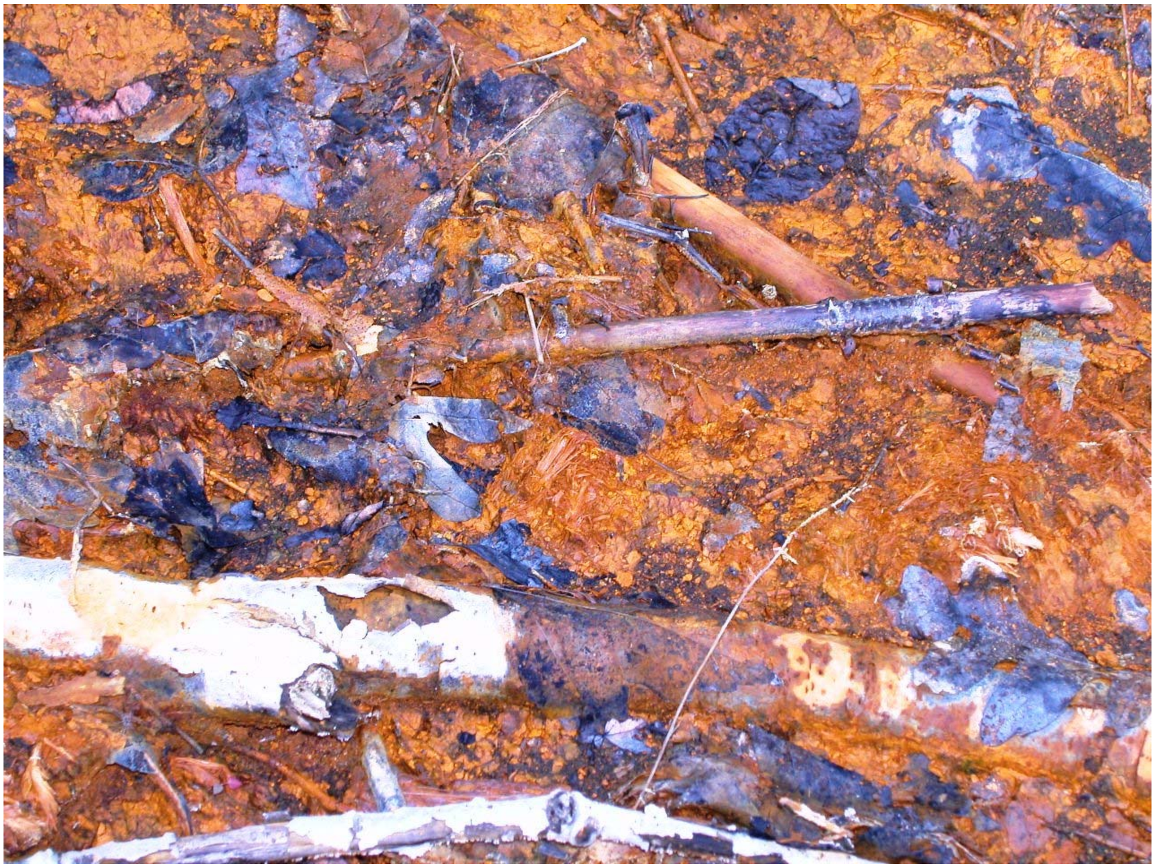
At MD19, the seep at the property boundary, dissolved selenium exceeded the detection limit 5 times with the highest level at 0.183 mg/L in June 2002 being 4 times the DWS and more than 36 times the chronic water quality standard. Lower levels were more than twice the water quality standard. And well beyond the property line at MD3, dissolved selenium was measured at 0.025 mg/L in June 2002, 5 times the chronic water quality standard, and found in three other samplings in 2000-2002 at between 0.0089 and 0.0097 mg/L, nearly twice this water quality standard.

The volume of flow emanating from MD3 averaged 58 gallons per minute and was as high as 127 gallons per minute when these higher levels of selenium and cadmium were measured, raising the question of whether the unnamed tributary to Hinckston Run receiving this discharge can safely assimilate the concentrations and loads of these trace elements. Thus beyond refuting PADEP assertions that no increases in harmful pollutants (attributable to ash) are occurring, this data suggest that trace elements including metals in the ash are being mobilized in amounts sufficient to pose a threat to aquatic life far beyond the property boundary of the McDermott Mine in the watershed of Hinckston Run. At a minimum, unlike lead, the toxic impacts posed by rises in cadmium and selenium correlate with the rises in other ash parameters at this site and cannot be attributed to baseline conditions.

EDITOR'S NOTE: Data subsequent to the completion of this site assessment documents that high trace element concentrations have continued to be measured at McDermott monitoring points. Most notable have been total selenium concentrations at MD3, the downgradient mine discharge 900 feet beyond the McDermott property boundary. Dissolved concentrations were not available. Monitoring reports obtained from April 2004 through January 2006 indicate the federal water quality standard for chronic toxicity (Criterion Continuous Concentration of 0.005 mg/L) established to protect aquatic life in the nation's surface waters, has been exceeded at least seven times at MD3 in this period. The highest exceedances were 0.070 mg/L measured in a November 2004 sample, 14 times over the WQS, 0.0182 mg/L in a February 2005 sample (more than 3 times the WQS) and 0.0176 mg/L in a April 2004 sample (more than three times the WQS). These exceedances along with additional exceedances of this WQS occurring at other seeps at this site highlight continuing concerns about the impact of this minefill on aquatic life in Hinckston Run.

A -

B –



CAPTIONS - A - A polluted discharge leaves the eastern property boundary of McDermott Mine. B - A closer look at this discharge. While acidity rose sharply at McDermott monitoring points, so did calcium and magnesium even though no carbonate rocks were mined through in the operation. This suggests that Cambria Cogen FBC ash placed here, which is prolific source of these pollutants, is also responsible for the toxic levels of selenium and cadmium in these discharges. Photos by Jeff Stant, August 2007.

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Permit Review 3

E.P. BENDER COAL CO. (PERMIT # 11930102)

Site Summary

The E.P. Bender "Job 54" Mine is located in Reade Township, Cambria County, Pennsylvania. This surface coal mining operation is found within the Clearfield Creek Watershed 8C, as delineated in the Priority Watersheds of the Pennsylvania State Water Plan. The permit covers 270 acres located on the properties of the Pennsylvania Game Commission State Game Land 184 and was originally authorized to affect 103.8 acres. E.P. Bender Coal Company mined the Clarion, Lower Kittanning, and Middle Kittanning coal seams. The operation daylighted abandoned Clarion and Lower Kittanning deep mines. The operation utilized FBC ash from a cogeneration plant, the Colver Power Plant in Colver, PA, for "beneficial use and abandoned mine reclamation." After the coal was removed, the FBC ash was placed on the pit floor and intermixed with mine spoils. Approximately 800,000 tons of coal were removed from the site and replaced with 65,000 tons of FBC ash. The site was subsequently backfilled and contoured. Beginning and end dates of the remining operation were not available in the permit. However, baseline data were collected between February 1992 and August 1993, and ash placement started in 1996 and terminated in 2002.

Geology

The E.P. Bender site lies at the easternmost part of the Appalachian Plateau, the Allegheny Mountain section. This physiographic section lies between the Allegheny Front to the east and Chestnut Ridge to the west. The rock strata (layers) in the permit area dip slightly (4°) to the northwest. A commonly postulated conceptual model for this area is that this dip controls the groundwater movement. There are no other naturally occurring structural features, such as fractures or faults, in the permit area that would affect groundwater flow. The exploited coal seams, the Clarion, the Lower Kittanning and the Middle Kittanning are part of the Allegheny Formation of the Pennsylvanian system. The Clarion seam is the bottommost coal on the site. The Lower Kittanning, according to drill hole data on the site, is found about 25 feet above the Clarion. The uppermost coal seam is the Middle Kittanning some 80 feet above the Clarion.

Groundwater and Topography

As mentioned above, it is postulated that groundwater movement is controlled mainly by the dip or tilt of the rock strata. However, stratigraphy is also important. The presence of lower permeability underclay under portions of the coals also contributes to the groundwater flow patterns in the permit area. Groundwater cannot filter through this layer as easily as it moves laterally through the coals and other more permeable beds. The groundwater accumulates on the low-permeability layers at different heights. These groundwater accumulations are known as "perches," if unsaturated zones develop beneath them.

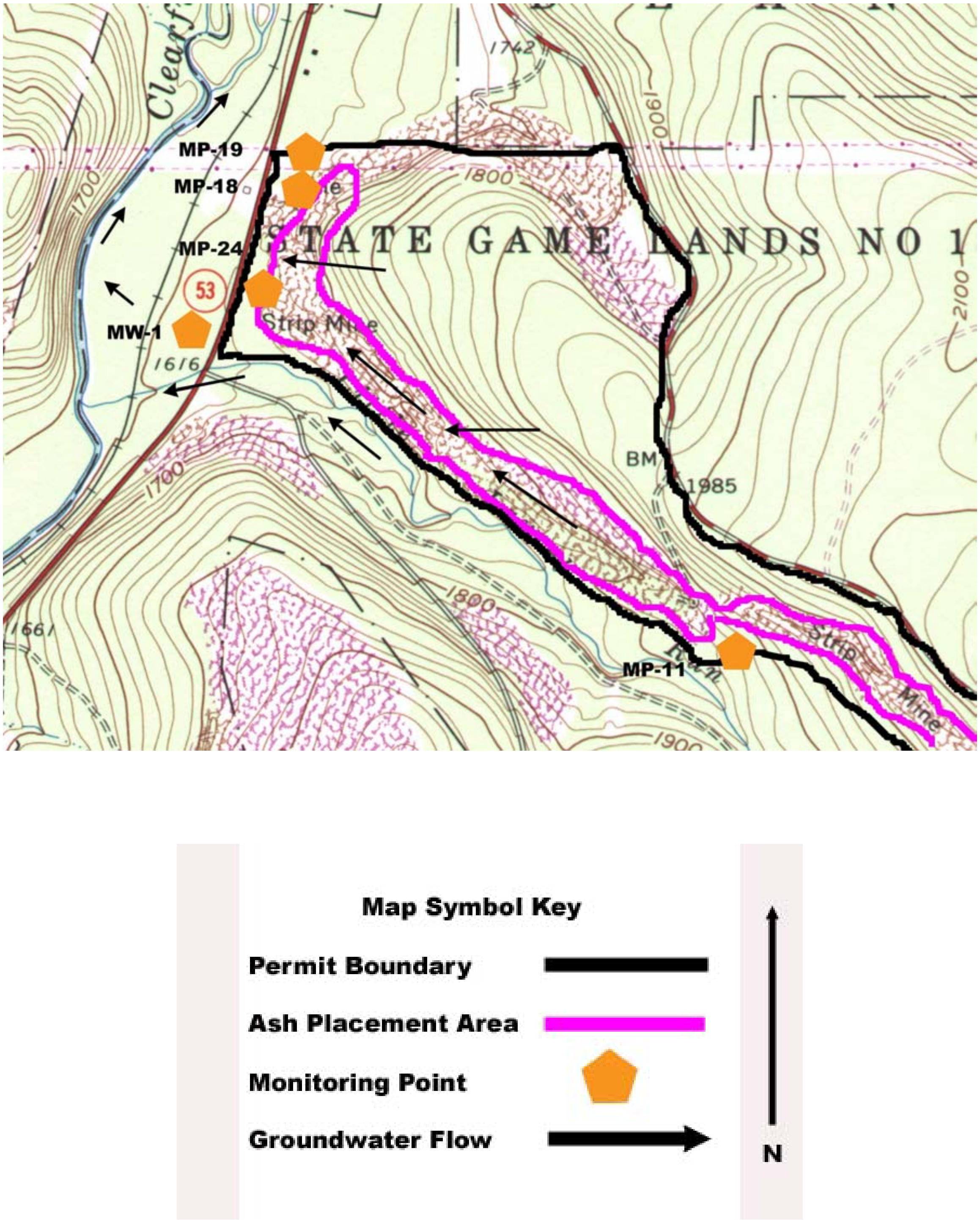
There may be three groundwater perches on this site, one associated with each coal zone. The lowest potential groundwater perch is an aquifer associated with the Clarion Coal, part of a regional groundwater table located at the level of Clearfield Creek at approximately 1600 feet elevation. Groundwater aquifers are both above and below the Clarion coal seam. The head of water above the Clarion is about 5 feet above the base of the coal. The next potentially perched water is associated with the Lower Kittanning coal and its underclay. These heads can be as high as 25 to 63 feet above the base of the coal. The uppermost potentially perched water table is associated with Middle Kittanning coal, and the surface of the table can be as high as 32 feet above the base of the coal.

Most of the groundwater flows discharge locally and drain relatively small geographic areas (less than a square mile). It is likely that some of the strata above empty deep mines have collapsed, fracturing and reducing the effectiveness of the low-permeability layers and reducing the chance of true perched zones. This increases infiltration rates and accelerates discharge rates of groundwater through aquifers and to the surface. As a result of the surface mining in this permit, these perched aquifers now contribute to a single spoil aquifer, and groundwater in this spoil aquifer discharges to the surface. In turn, surface waters drain from the area to Clearfield Creek, which flows in a north-northeast direction.

Groundwater Monitoring Data: Discussion

Deep mine discharges are monitored by monitoring points MP18 and MP19 and strip mine discharges are monitored by monitoring point MP24. All three of these monitoring points have been designated as “Subchapter F” points. They are located downgradient of the mining and ash placement operations in the northwestern most part of the site. All three points monitor discharges from the aquifer associated with the Clarion coal. They are strategically located and, therefore, “they should be the first monitoring points to detect any groundwater changes that may result from the CFB ash placement” (25-28 of Permit 11930102). Monitoring well MW-1 is another downgradient monitoring point designed to detect impacts on the aquifer located below the Clarion Coal. Monitoring point MP11, also associated with discharges from the Clarion Coal aquifer, is located approximately 4800 feet upgradient, to the southeast of MP18. Baseline concentrations and baseline Subchapter F loading rates were calculated from 18 samples collected from February 24, 1992 through August 13, 1995. The red Y-axis in the figures below delineates the end of the baseline-monitoring period before ash placement commenced.

<u>Site Map: EP Bender</u>



EP Bender Coal Co., Job 54 Operation (Permit # 11930102)
Scale: 1" = Approximately 1500'

Acidity, Alkalinity and pH

Acidity concentrations rose at downgradient monitoring points MP18 (figure 3.1), MP19 (figure 3.3), and MP24 (figure 3.5) after ash placement commenced. The overall average acidity concentration at MP19, however, was lower after ash placement than the average concentration before ash placement. A steady rise in acidity before ash placement became considerably more gradual after ash placement at this monitoring point. Acidity loads at MP18 (figure 3.2) and MP19 (figure 3.4) show a similar pattern: a decrease in loading during baseline sampling before ash placement and a rise in loading rates after ash placement.

The alkalinity concentration at MP18 (figure 3.6) showed an increasing trend before ash placement followed by a decreasing trend after ash placement and a flat alkalinity profile at MP19 before ash placement was succeeded by a declining trend after ash placement. Nonetheless the average alkalinity concentration at MP19 jumped by two to five times after ash placement started. The concentration trend at MP24 (figure 3.8) showed that alkalinity continued to increase in this discharge after mining and ash placement started, but the increase was less steep than before these activities. This reduction in the rate of increase was probably because MP24 was monitoring effluent directly from the active surface mine authorized by the permit.

A dropping pH trend at MP18 (figure 3.9) reflected the steadily rising concentration and loading rate of acidity and the decreasing concentration of alkalinity after ash placement. A dropping pH trend after ash placement at MP24 (figure 3.11) was somewhat reflected by the moderated rise in alkalinity at this point. An exception to this occurred in 1999 when the pH at MP24 jumped from 4 units to 10 units. The pH trend at MP19 (figure 3.10) gradually increased after ash placement by about a half unit over the monitoring period.

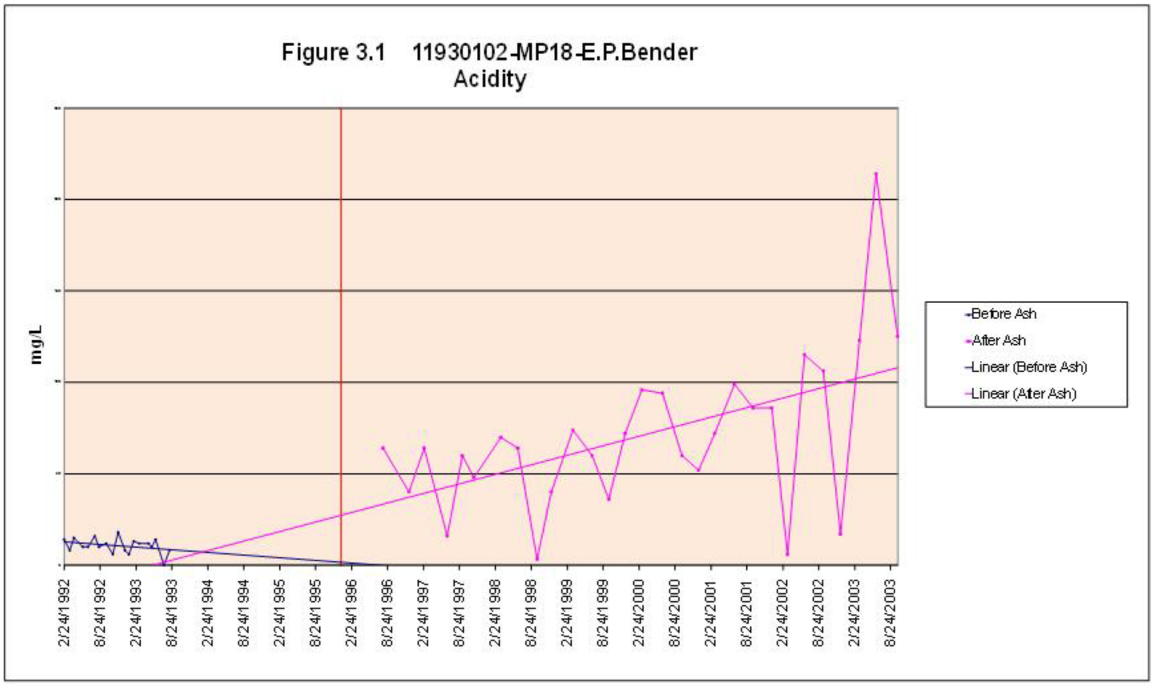


Figure 3.1 11930102-MP18-E.P.Bender
Acidity

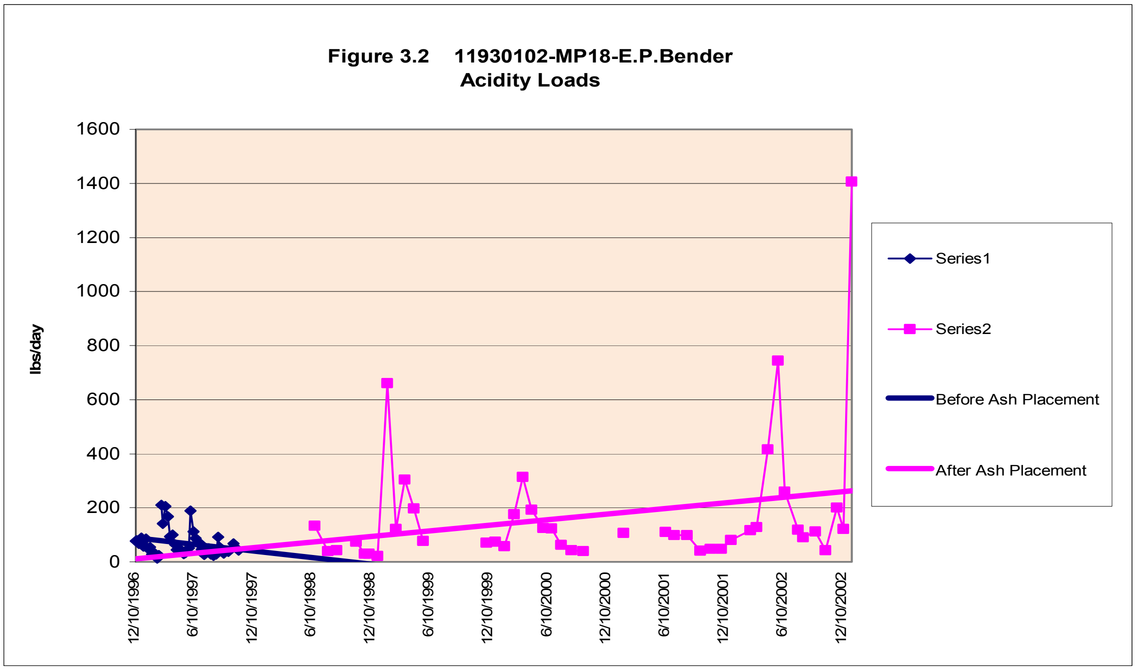


Figure 3.2 11930102-MP18-E.P.Bender
Acidity Loads

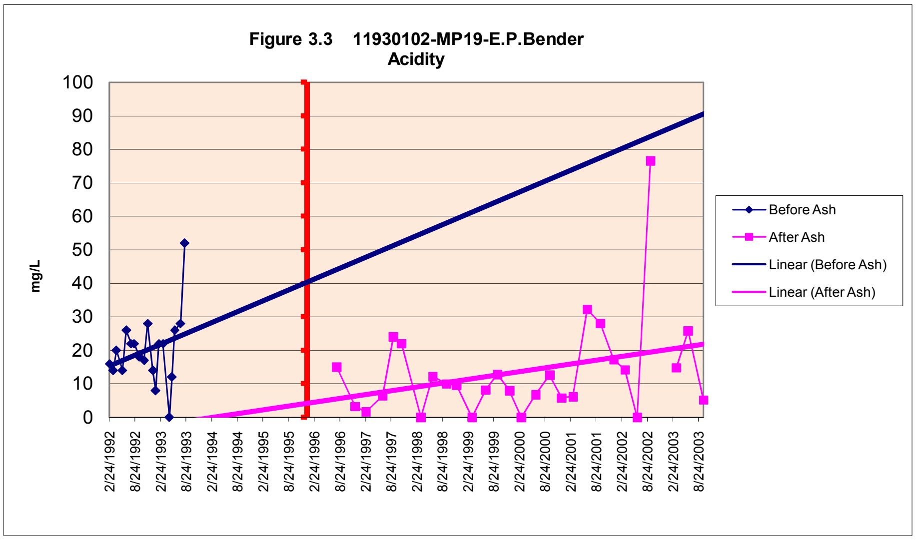


Figure 3.3 11930102-MP19-E.P.Bender
Acidity
mg/L
100
90
80
70
60
50
40
30
20
10
0
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
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8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
8/24/2001
2/24/2002
8/24/2002
2/24/2003
8/24/2003
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

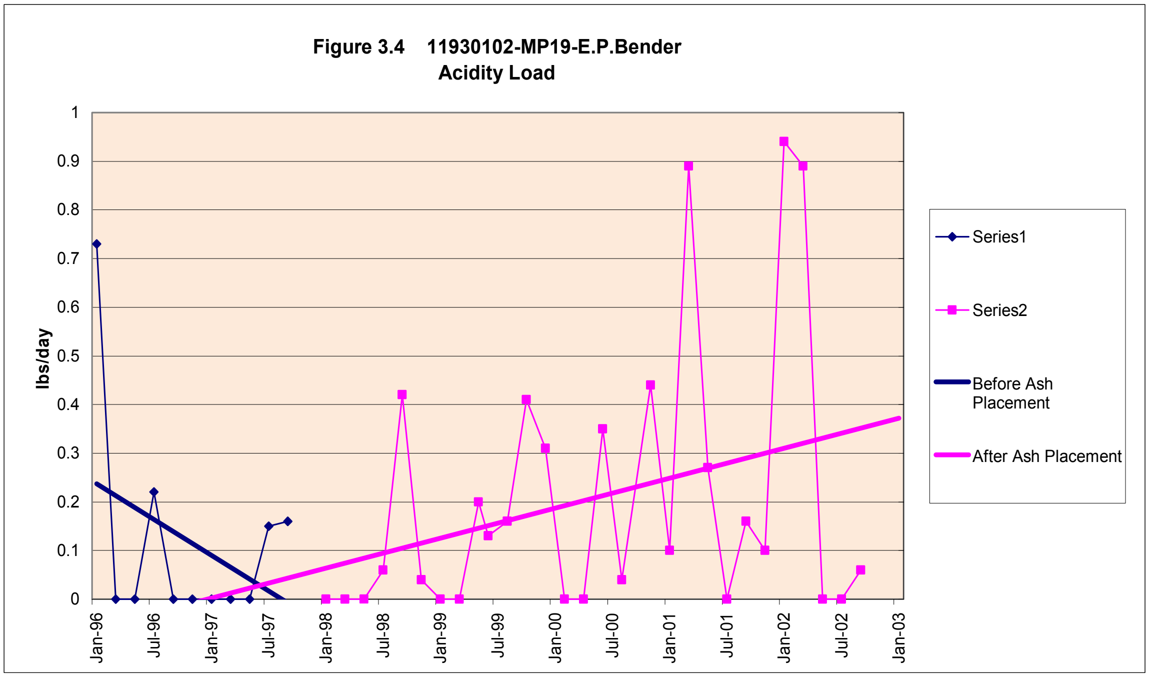


Figure 3.4 11930102-MP19-E.P.Bender
Acidity Load
lbs/day
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Series1
Series2
Before Ash Placement
After Ash Placement

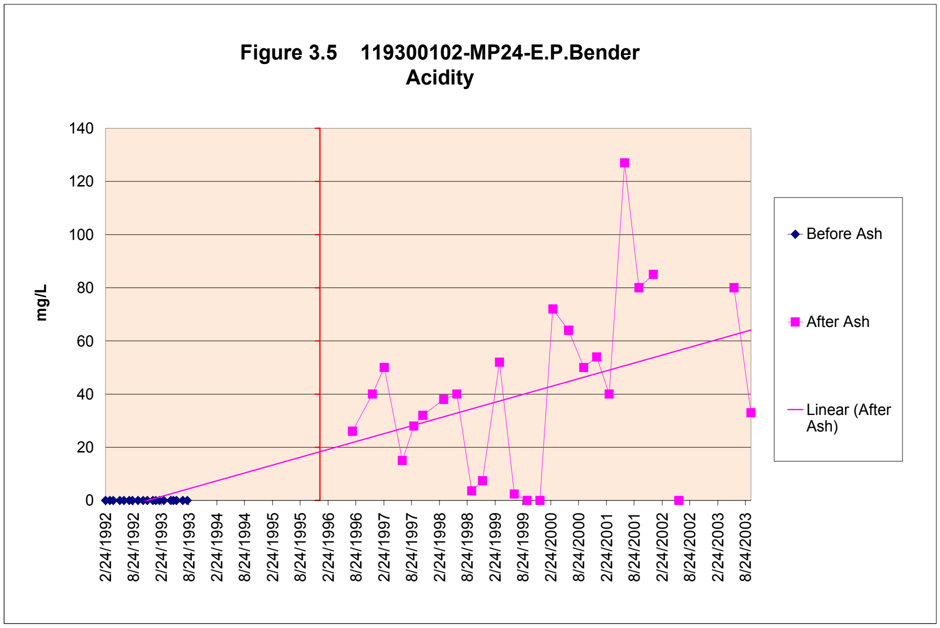


Figure 3.5 119300102-MP24-E.P.Bender
Acidity

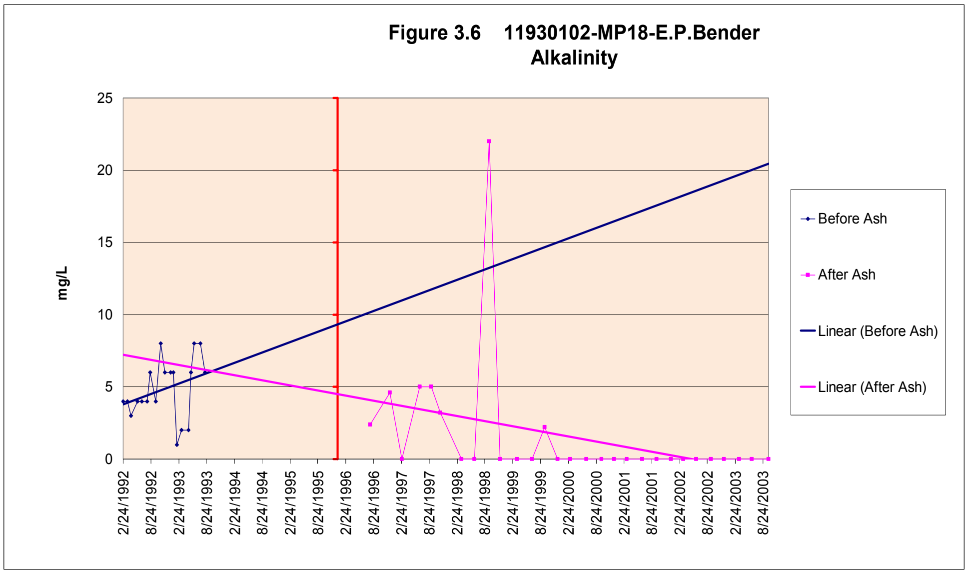


Figure 3.6 11930102-MP18-E.P.Bender
Alkalinity

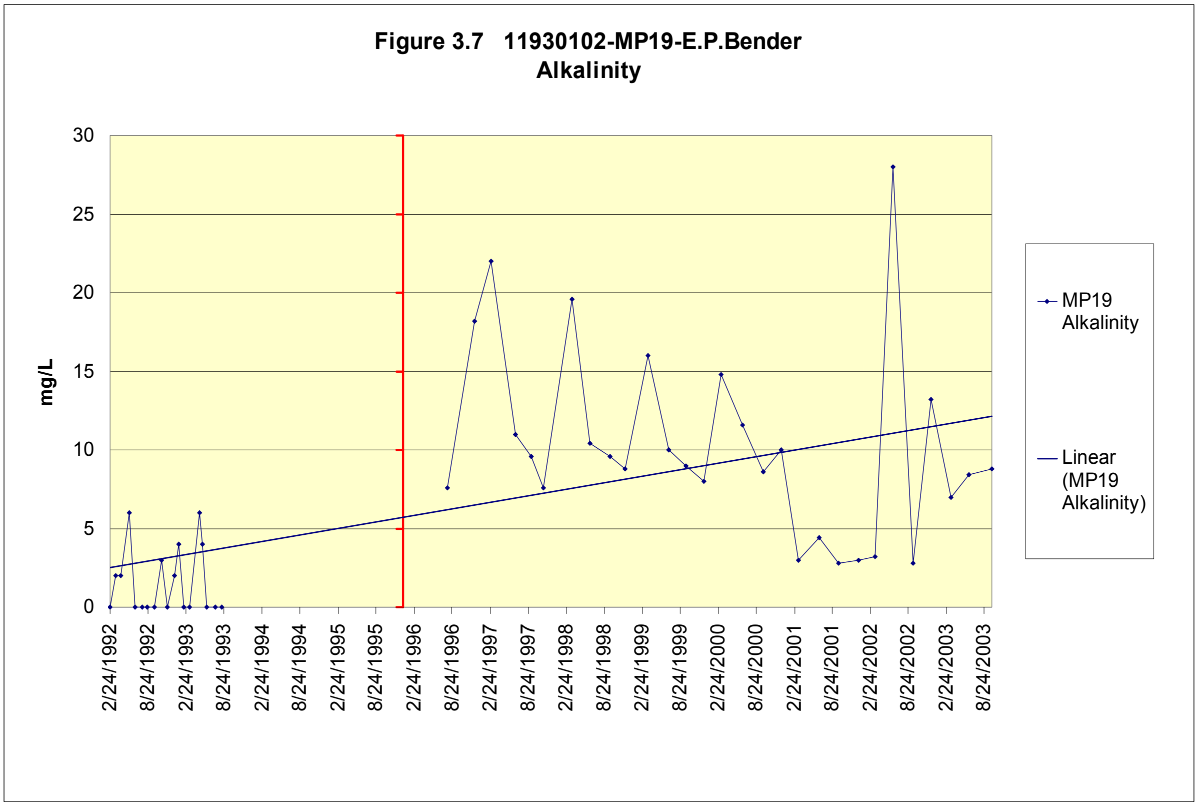


Figure 3.7 11930102-MP19-E.P.Bender Alkalinity

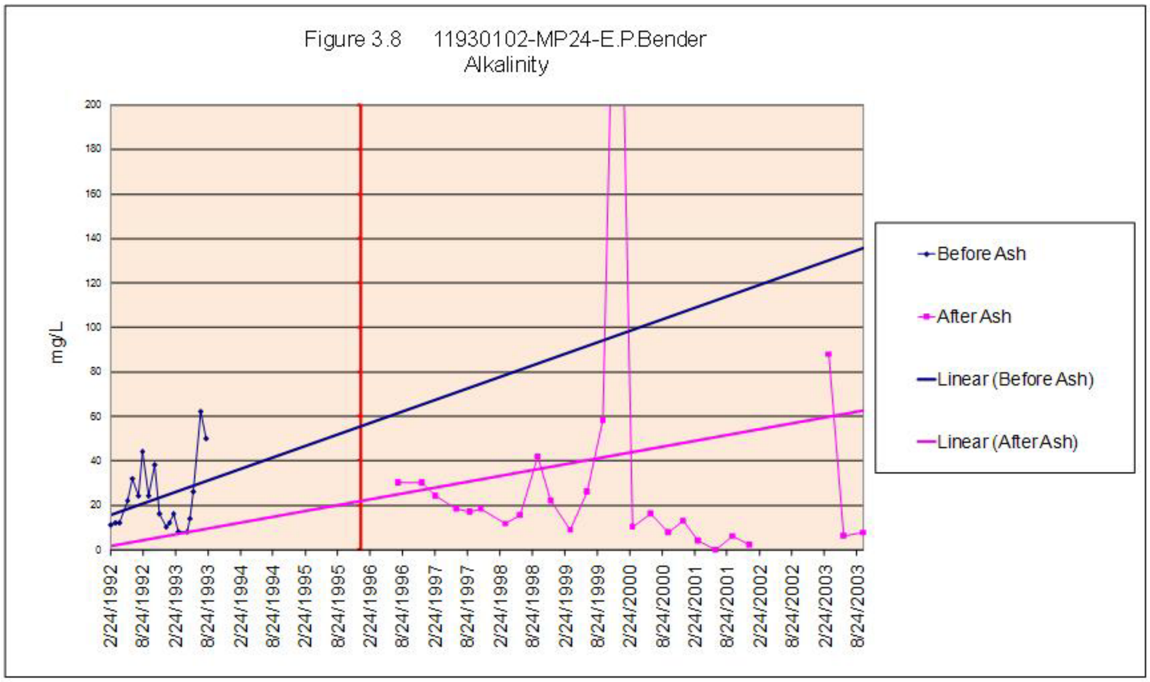


Figure 3.8 11930102-MP24-E.P.Bender Alkalinity

Figure 3.9 11930102-MP18-E.P.Bender
pH

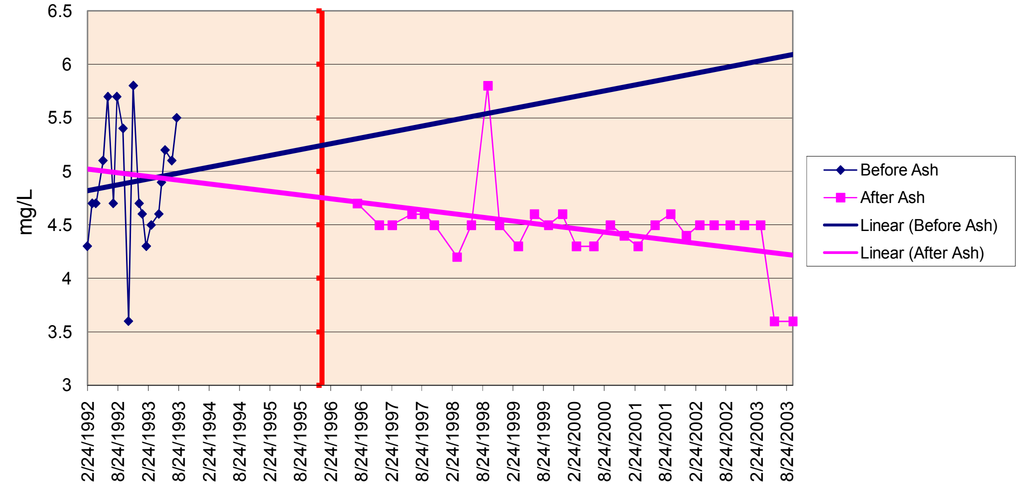
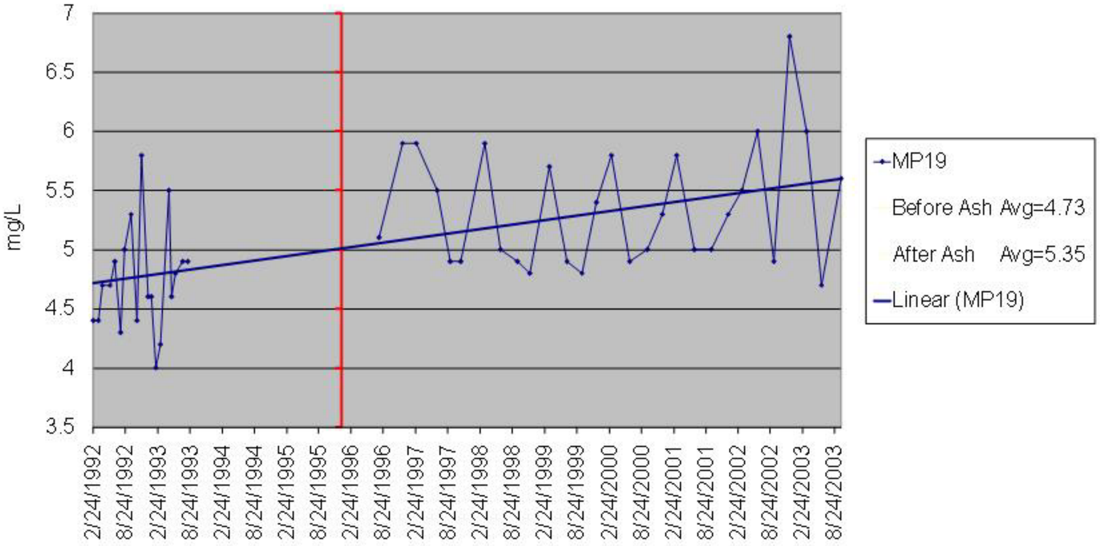
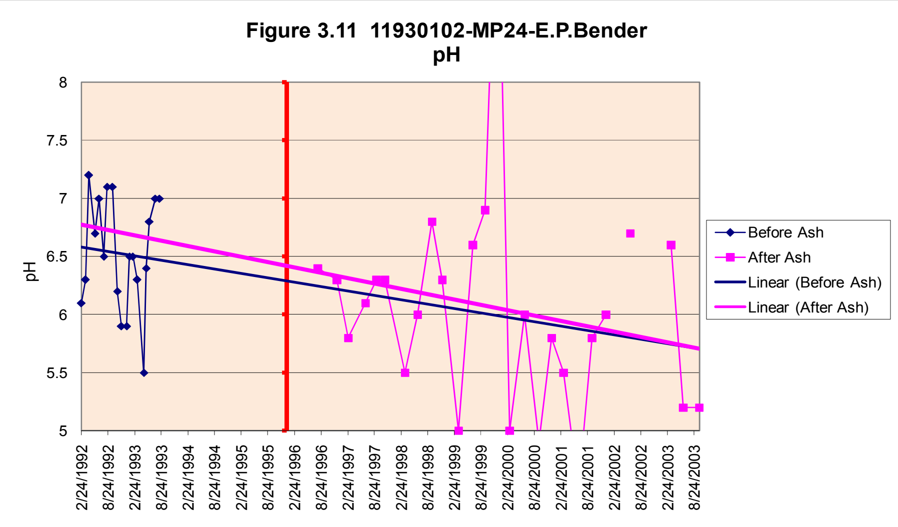


Figure 3.10 11930102-MP19-E.P.Bender
pH





Sulfates, Manganese, and Iron

Significantly rising sulfate concentrations coincide with ash placement at all three monitoring points, MP18 (figure 3.12), MP19 (figure 3.13) and MP24 (figure 3.14). Increases in manganese concentrations also coincide with ash placement at MW1 (figure 3.15), MP18 (figure 3.16), MP19 (figure 3.18), and MP24 (figure 3.20). Concentrations of manganese rose well above trigger levels and drinking water standards (as much as 480 times the federal secondary MCL). Trend lines at all three monitoring points show significant increases in concentrations over time. These patterns are mirrored in the loading rates of monitoring points MP18 (figure 3.17) and MP19 (figure 3.19). Strip mine monitoring point MP24 (figure 3.21) shows decreasing trends in manganese loading after ash placement, although the loading rates are well above baseline levels and drinking water standards.

Iron concentrations and loading rates show marked increases that again coincide with ash placement. Concentrations rise in MW1 (figure 3.22). Concentrations of iron at MP18 increase from baseline levels around the drinking water standard to levels that peak at more than 26 times the standard (figure 3.23). Iron loads similarly increase at MP18 (figure 3.24). Data from strip mine monitoring point MP24 show marked increases in iron concentrations (figure 3.25) and loads (figure 3.26), although the loading trend has been decreasing slowly during the monitoring period. MP 19 (figure 3.27) shows great variations in iron loads over the monitoring period.

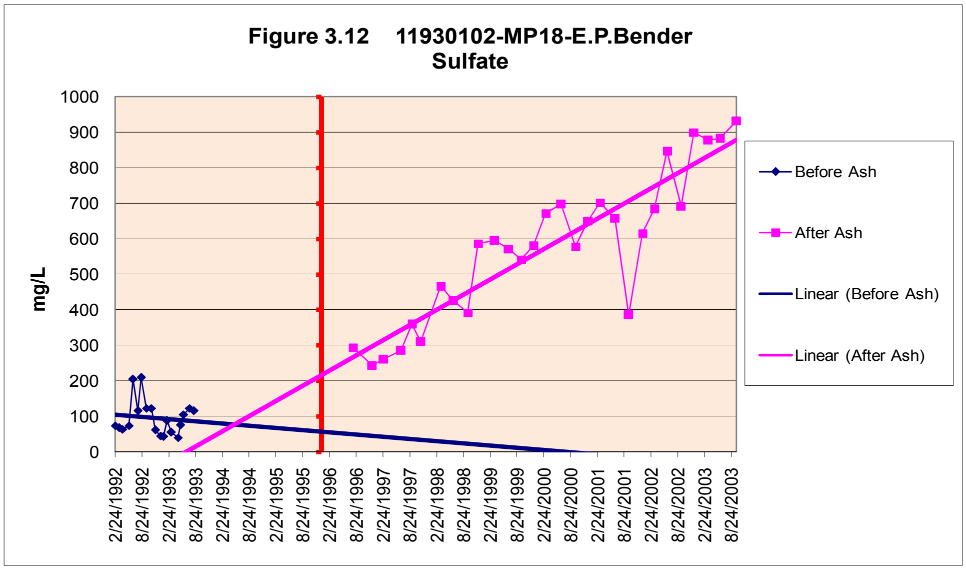


Figure 3.12 11930102-MP18-E.P.Bender
Sulfate

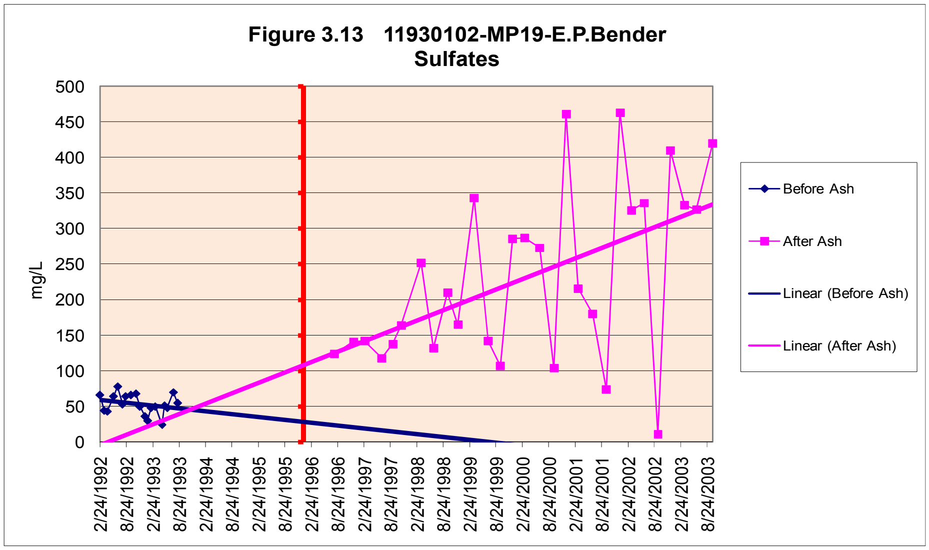


Figure 3.13 11930102-MP19-E.P.Bender
Sulfates

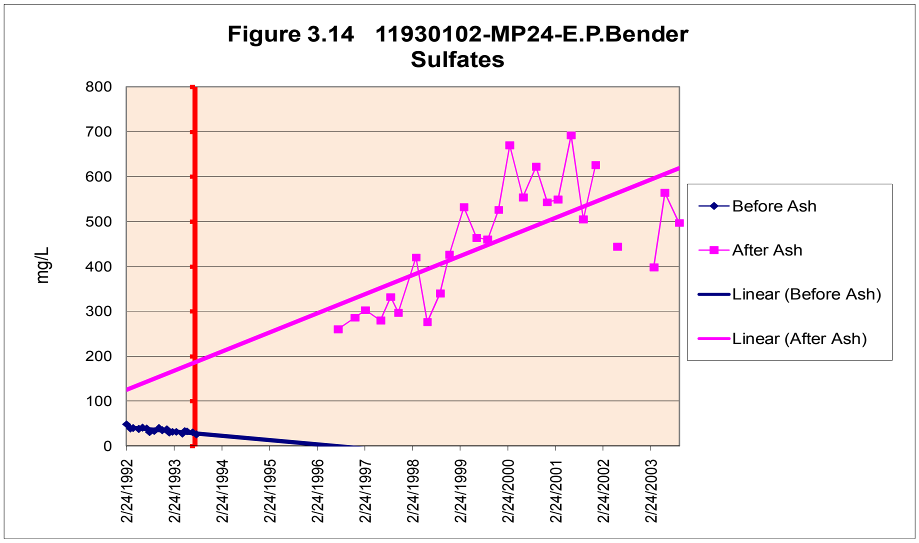


Figure 3.14 11930102-MP24-E.P.Bender
Sulfates
mg/L
800
700
600
500
400
300
200
100
0
2/24/1992
2/24/1993
2/24/1994
2/24/1995
2/24/1996
2/24/1997
2/24/1998
2/24/1999
2/24/2000
2/24/2001
2/24/2002
2/24/2003
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

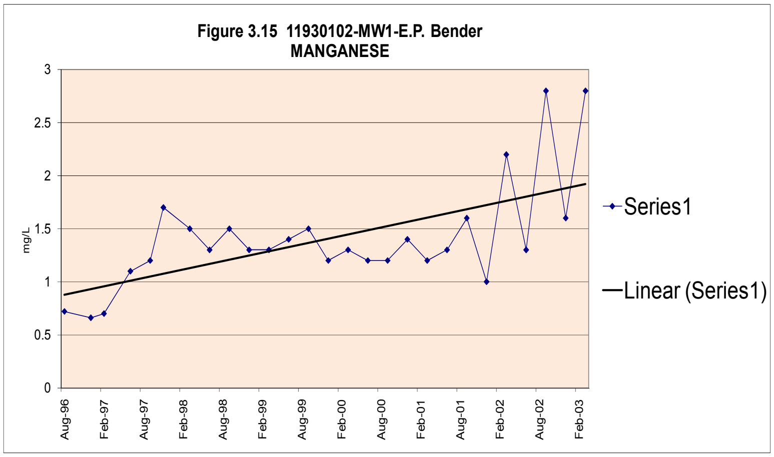


Figure 3.15 11930102-MW1-E.P. Bender
MANGANESE
mg/L
3
2.5
2
1.5
1
0.5
0
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Series1
Linear (Series1)

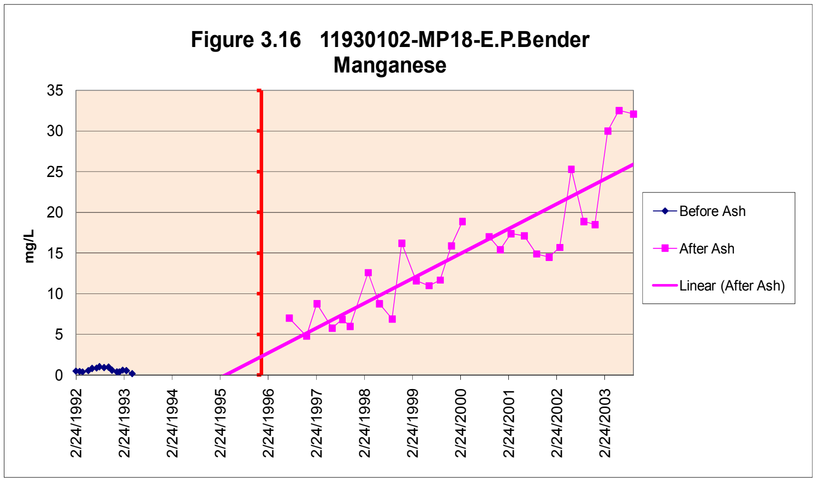


Figure 3.16 11930102-MP18-E.P.Bender
Manganese

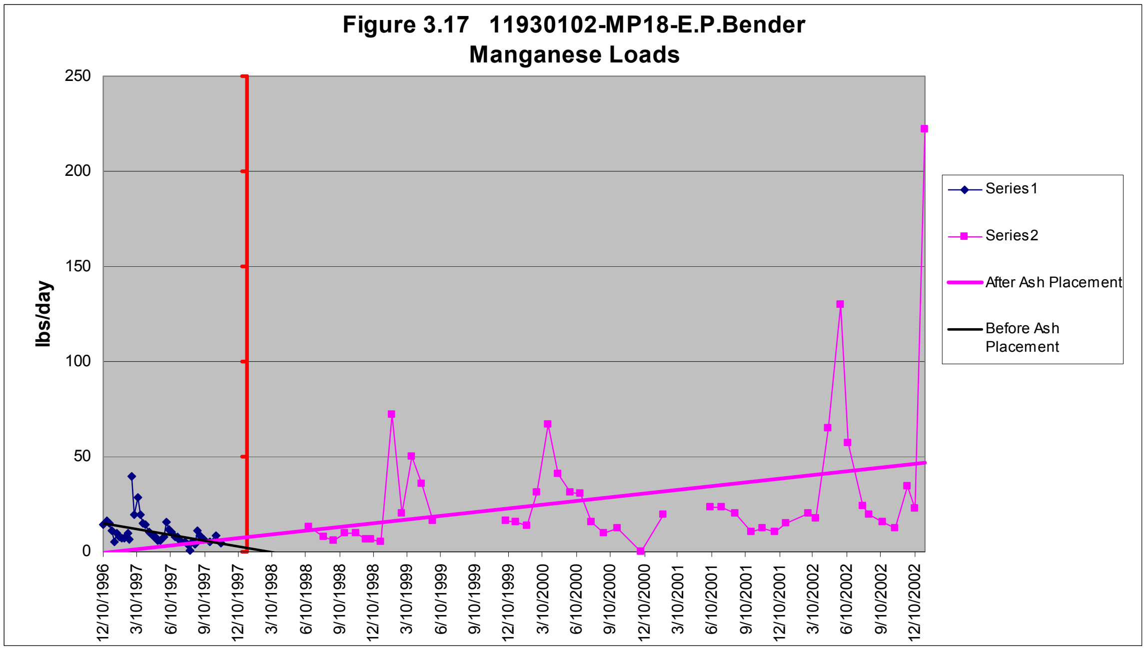


Figure 3.17 11930102-MP18-E.P.Bender
Manganese Loads

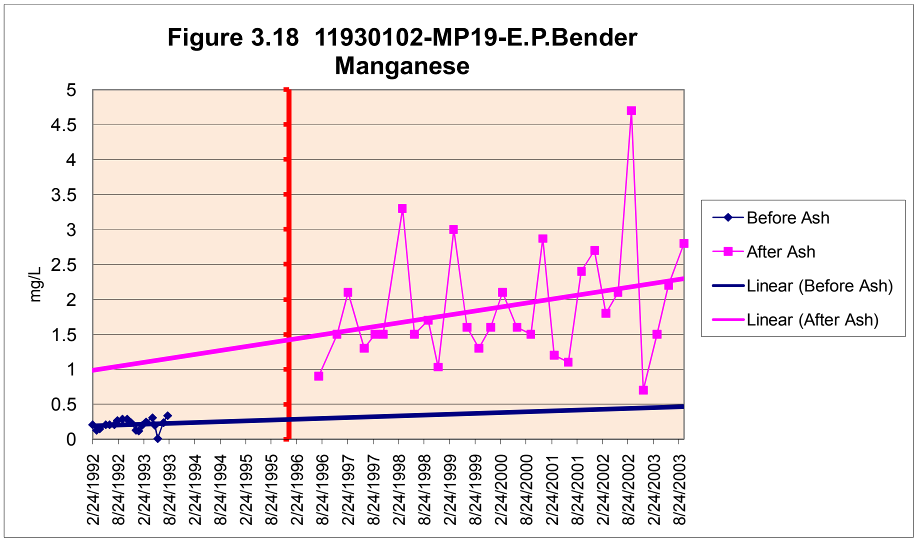


Figure 3.18 11930102-MP19-E.P.Bender
Manganese
mg/L
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
8/24/2001
2/24/2002
8/24/2002
2/24/2003
8/24/2003
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

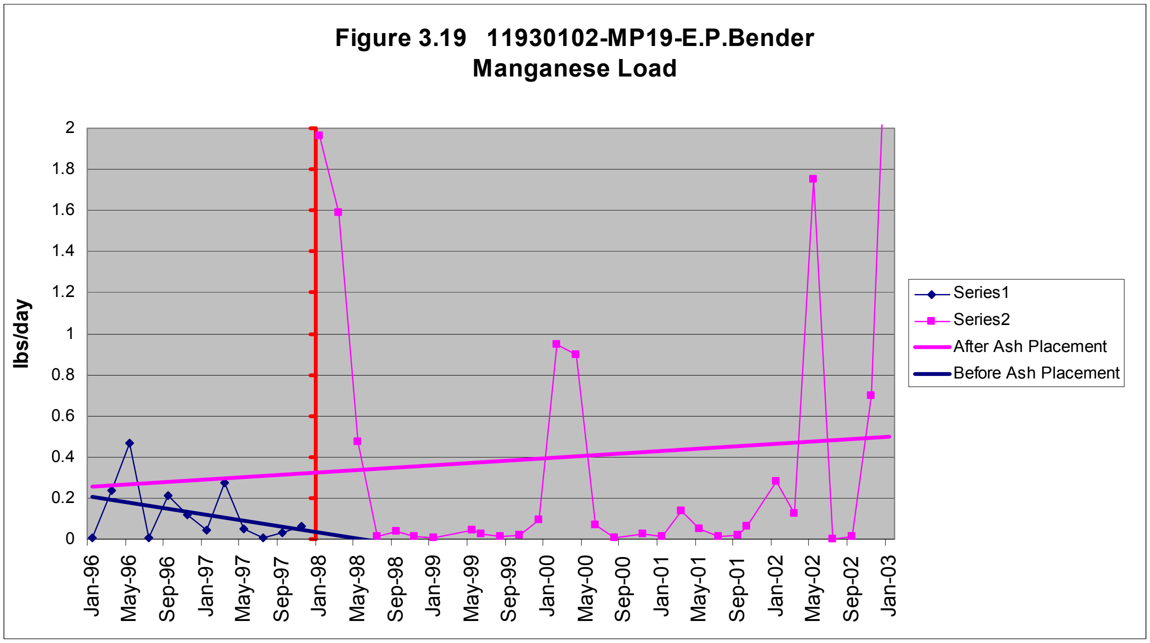


Figure 3.19 11930102-MP19-E.P.Bender
Manganese Load
lbs/day
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan-96
May-96
Sep-96
Jan-97
May-97
Sep-97
Jan-98
May-98
Sep-98
Jan-99
May-99
Sep-99
Jan-00
May-00
Sep-00
Jan-01
May-01
Sep-01
Jan-02
May-02
Sep-02
Jan-03
Series1
Series2
After Ash Placement
Before Ash Placement

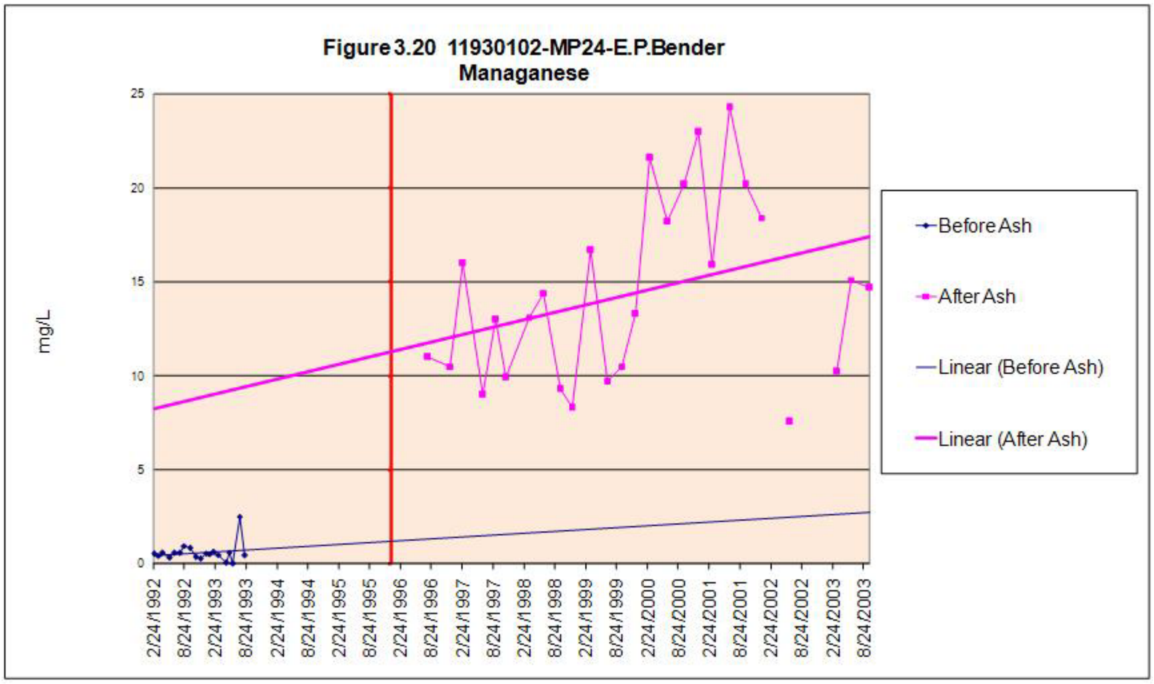


Figure 3.20 11930102-MP24-E.P.Bender
Managanese

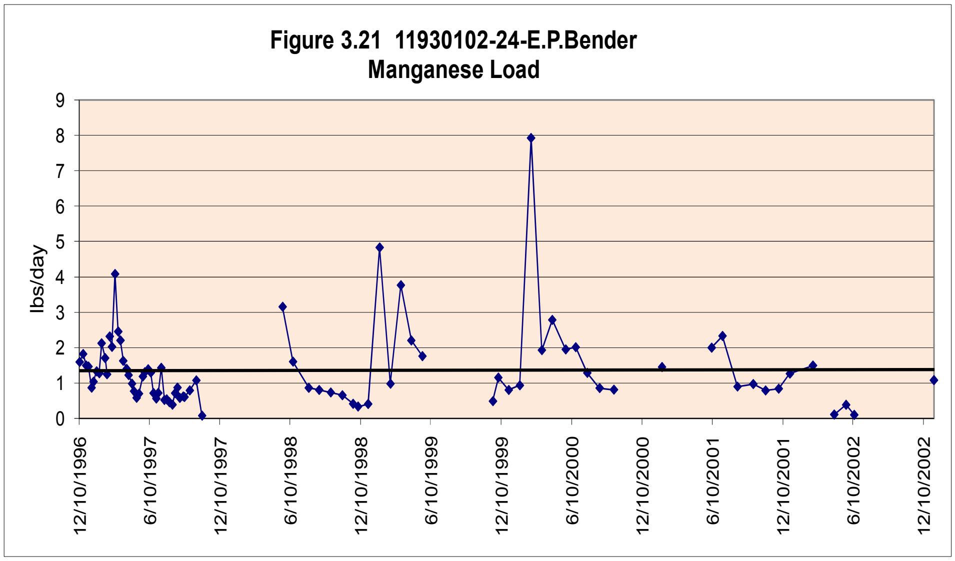


Figure 3.21 11930102-24-E.P.Bender
Manganese Load

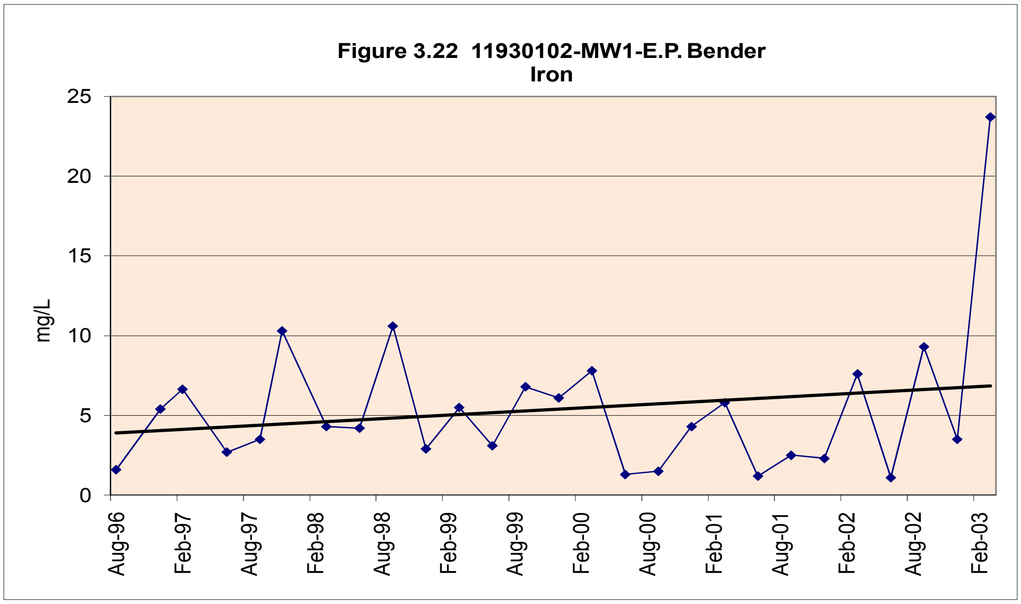


Figure 3.22 11930102-MW1-E.P. Bender
Iron
mg/L
0
5
10
15
20
25
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03

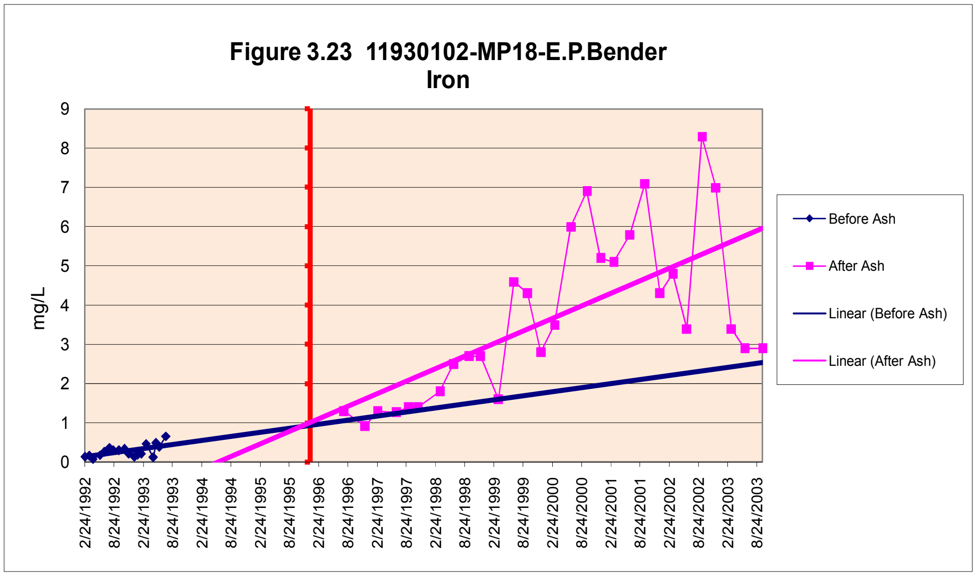


Figure 3.23 11930102-MP18-E.P.Bender
Iron
mg/L
0
1
2
3
4
5
6
7
8
9
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
8/24/2001
2/24/2002
8/24/2002
2/24/2003
8/24/2003
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

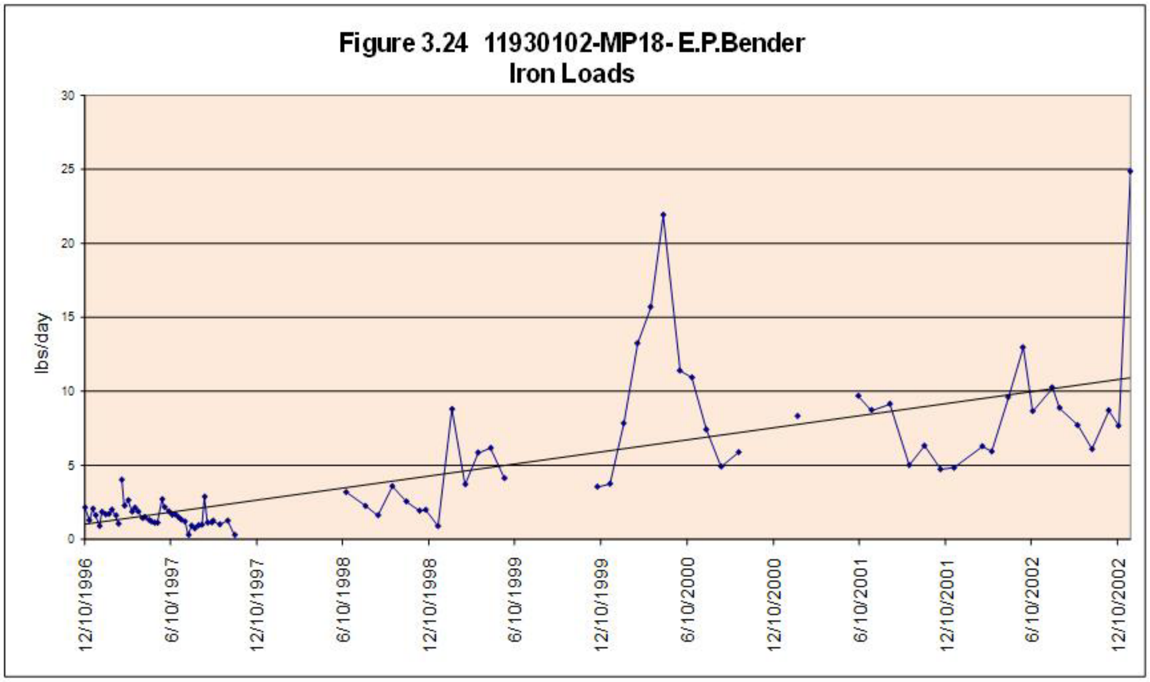


Figure 3.24 11930102-MP18- E.P.Bender
Iron Loads

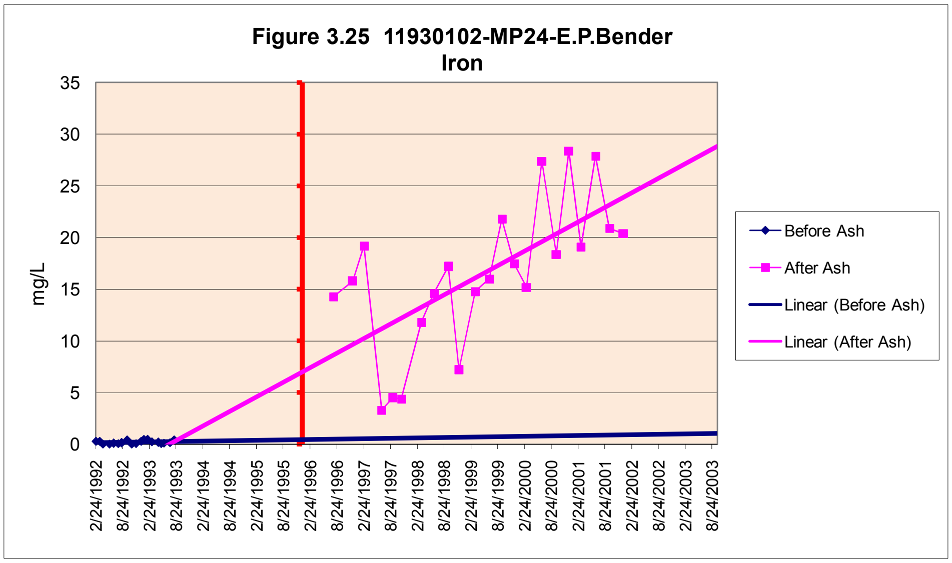


Figure 3.25 11930102-MP24-E.P.Bender
Iron

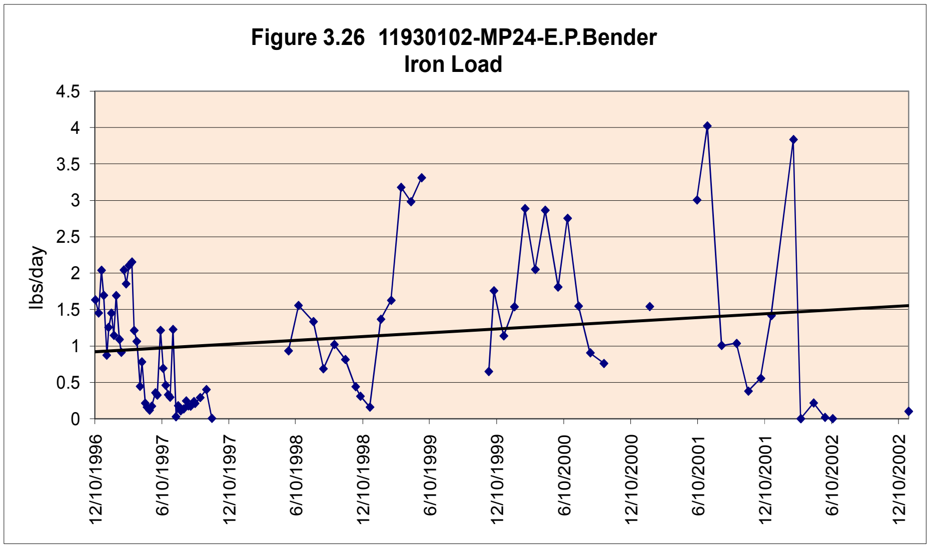


Figure 3.26 11930102-MP24-E.P.Bender
Iron Load
lbs/day
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12/10/1996
6/10/1997
12/10/1997
6/10/1998
12/10/1998
6/10/1999
12/10/1999
6/10/2000
12/10/2000
6/10/2001
12/10/2001
6/10/2002
12/10/2002

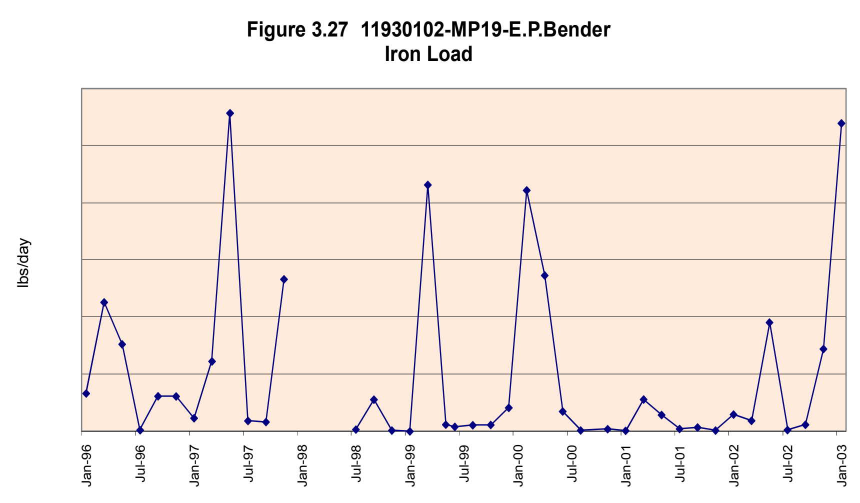
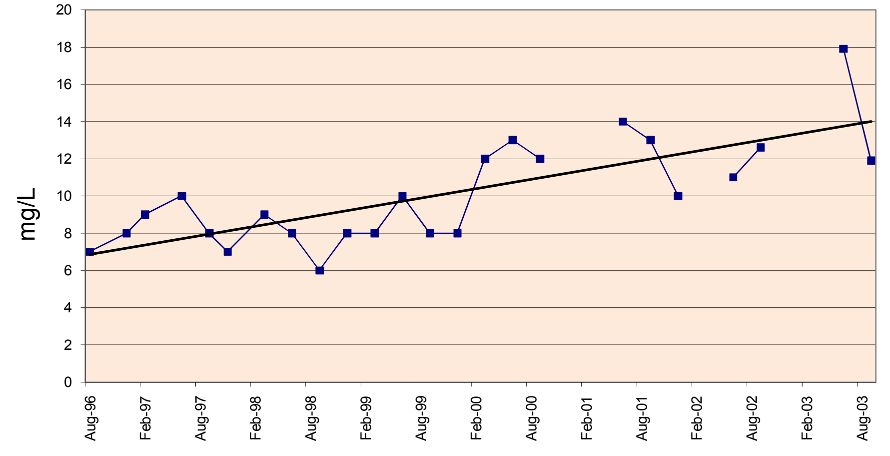


Figure 3.27 11930102-MP19-E.P.Bender
Iron Load
lbs/day
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03

Chloride, Aluminum, and Specific Conductance

Increased concentrations of chloride (figure 3.28) and aluminum (figure 3.29) coincide with ash placement at MP18. Concentrations of aluminum exceed the drinking water standard by 60 times. Chloride is almost exclusively leached by ash. Road salt, brines and salt contents in the country rock at this site are remote possibilities. Overall pollution, as measured by specific conductance, also rose significantly above baseline levels at MP18 after ash placement commenced (figure 3.30).

Figure 3.28 11930102-MP18-E.P.Bender
Chloride



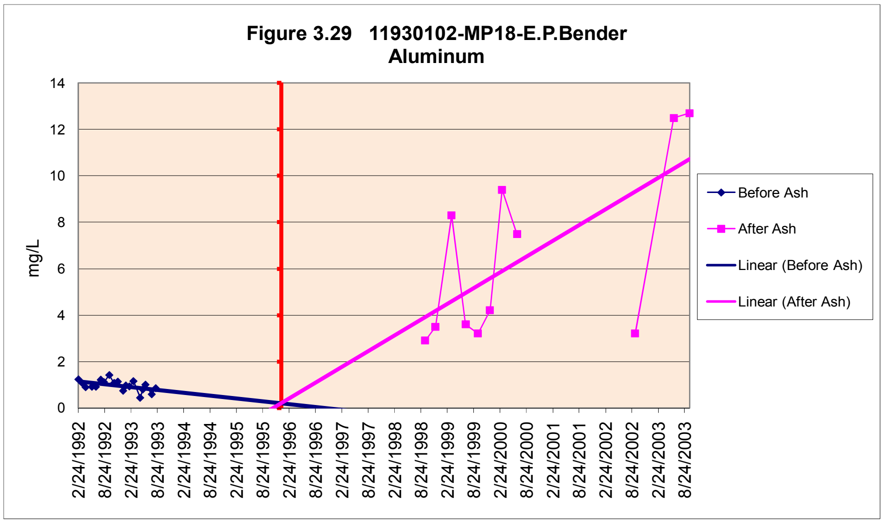


Figure 3.29 11930102-MP18-E.P.Bender
Aluminum

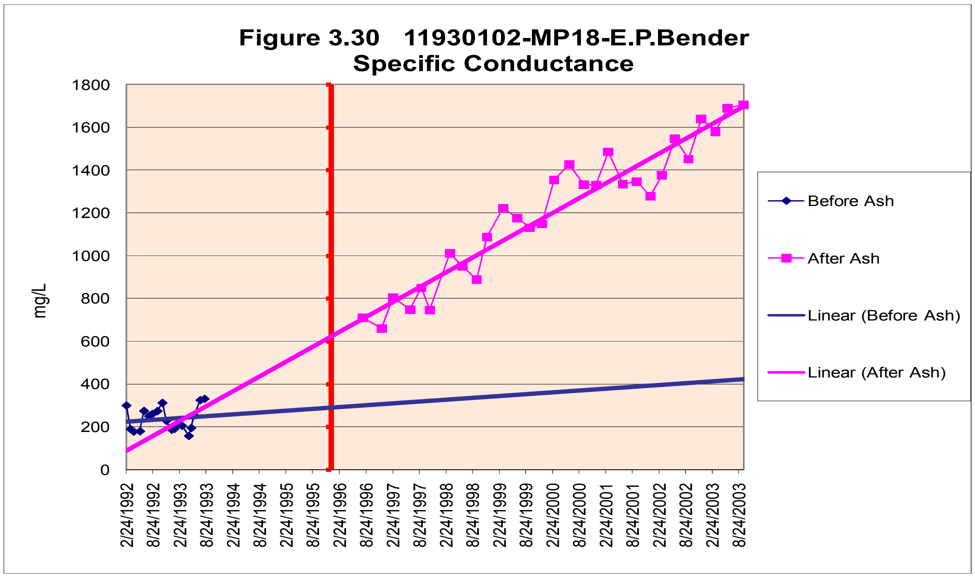


Figure 3.30 11930102-MP18-E.P.Bender
Specific Conductance

Comparison of Upgradient Monitoring Points to Downgradient Monitoring Points

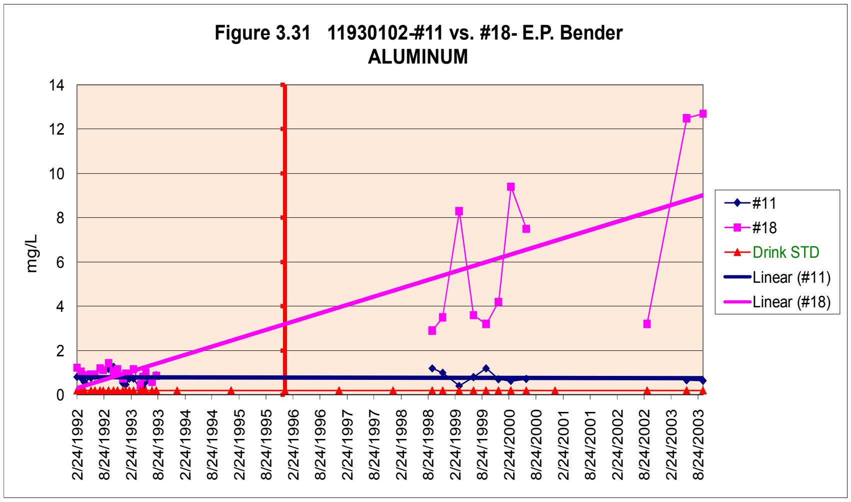
Deep mine discharge points MP11, MP18, MP19, and MP24 monitor effluents associated with the placement of the FBC ash. Upgradient MP11 is almost a mile from the downgradient discharges, but all four monitoring points measure discharges from the aquifer above the Clarion Coal pit floor. Upgradient MP11 is near the topographic peak of the ash placement area at an elevation of 1860 feet. Downgradient MP18 is at the bottom of the ash placement area at an elevation of 1610 feet and down dip from the ash and monitoring point MP11. Downgradient MP19 is at an elevation of 1615 feet, and downgradient MP24 is at an elevation of 1630 feet, both also down dip from the ash and monitoring point MP11. Concentrations of major, minor, and trace elements were graphed for these monitoring points on the same graphs to illustrate the difference in element concentrations between the upgradient and downgradient points over time.

Figure 3.37 shows how the concentration of iron in the effluent groundwater differs between MP11 and MP18. The graph clearly shows that before the placement of ash (1992-1993) the concentrations of iron at monitoring points MP11 and MP18 were about the same. Once ash placement commenced, pronounced differences began to appear (from 1997 to 2002). The same can be said for the concentrations of manganese (figure 3.38) and sulfates (figure 3.39). In all three cases, concentrations for these elements rose from levels at secondary drinking water standards before ash placement at both upgradient MP11 and downgradient MP18 to concentrations far exceeding the drinking water standards during and after ash placement at downgradient MP18, while concentrations remained much closer to or below the drinking water standards at the upgradient MP11 over the same time period.

Pronounced differences between MP11 and MP18 developed after ash placement in their concentrations of aluminum (figure 3.31), calcium (figure 3.36), nickel (figure 3.32), and zinc (figure 3.34). Since calcium is almost exclusively attributable to the ash, calcium's rise at MP18 confirms the involvement of ash in the degradation of water quality. The source is the calcium-rich limestone used in the fluidized bed combustion process. There is also a dramatic increase in acidity at MP18 over time (figure 3.35) compared to MP11. The increasing differences in TDS (figure 3.33) indicate that the total concentration of pollution increases in water that moves down through the ash placement area. These graphs establish a basis for the assertion that the increases in the concentrations of major, minor, and trace elements in the effluent groundwater on the permit site are attributable to the placement of FBC ash.

This inference is strengthened by the differences between monitoring point MP11 and monitoring points MP19 and MP24. The higher and rising pH values in the downgradient MP19 versus the lower and declining pH in MP11 (figure 3.40), along with the greater alkalinity (figure 3.40a), lower acidity (figure 3.35a), and higher concentrations of calcium (figure 3.36a), sulfate (figure 3.39a), nickel (figure 3.32a), and TDS (figure 3.33a) at MP19 suggest the FBC ash is imparting significant alkalinity as well as harmful concentrations of other constituents to water quality. The higher pH (figure 3.40b), substantially higher alkalinity (figure 3.40c), and higher concentrations of calcium (figure 3.36b), sulfate (figure 3.39b), iron (3.37a), manganese (figure 3.38b), nickel (figure 3.32b), and TDS (figure 3.33b) in MP24 compared to MP11 also suggest adverse impact from the FBC ash. The body of evidence produced in these comparisons strongly indicates that the FBC ash is having a major deleterious impact on water quality at this site.

Of note, also, are the rising concentrations of iron, manganese, sulfates, calcium, nickel, acidity, and TDS at MP11 in the last two years of the monitoring period, sometimes from levels below or near DWS to well above DWS. This is not surprising given that the latest Operation Map for the permit indicates that some of the FBC ash has been placed at and well above the elevation of MP11 and directly upgradient of this point as the mining entered its final Phase (2002-2005) on ground 50 to 100 feet uphill of MP11. This ash placement should change MP11 from an upgradient to a downgradient monitoring point. The rises seen at MP11 are likely due to the influence of mining and leachate from FBC ash that would have reached this point from 2002 onward.



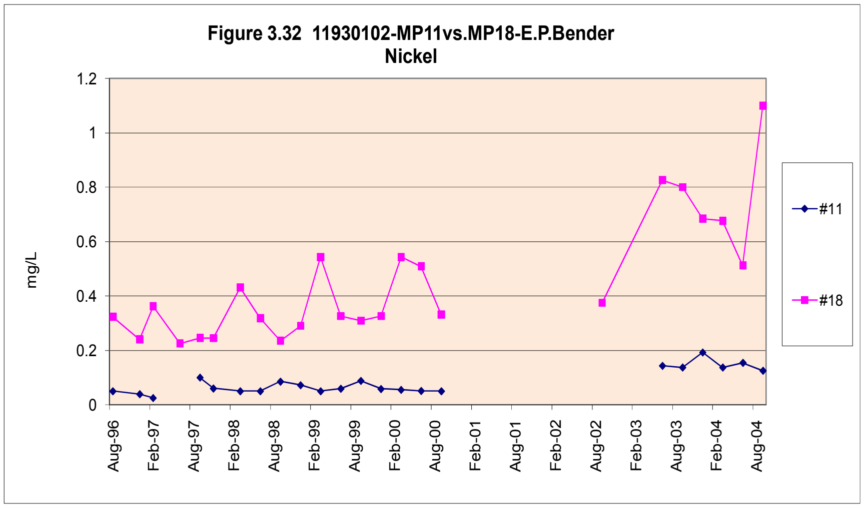


Figure 3.32 11930102-MP11vs.MP18-E.P.Bender
Nickel
mg/L
1.2
1
0.8
0.6
0.4
0.2
0
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
#11
#18

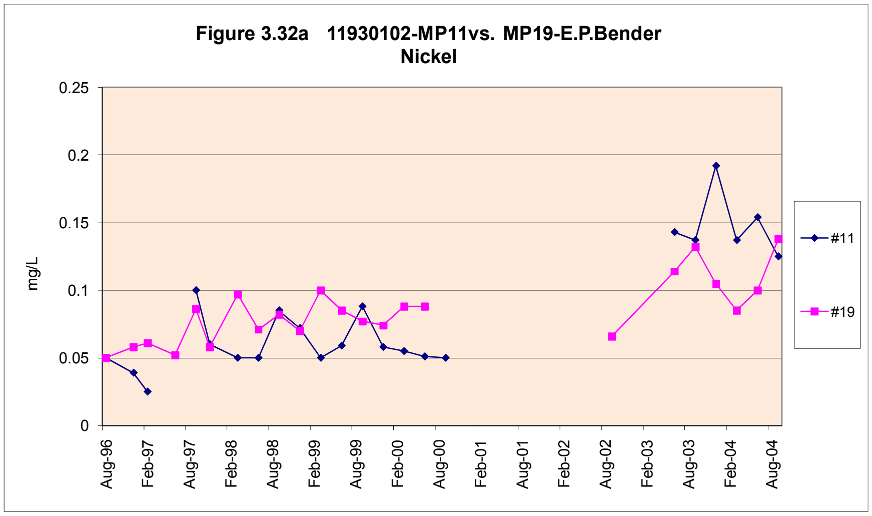


Figure 3.32a 11930102-MP11vs. MP19-E.P.Bender
Nickel
mg/L
0.25
0.2
0.15
0.1
0.05
0
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
#11
#19

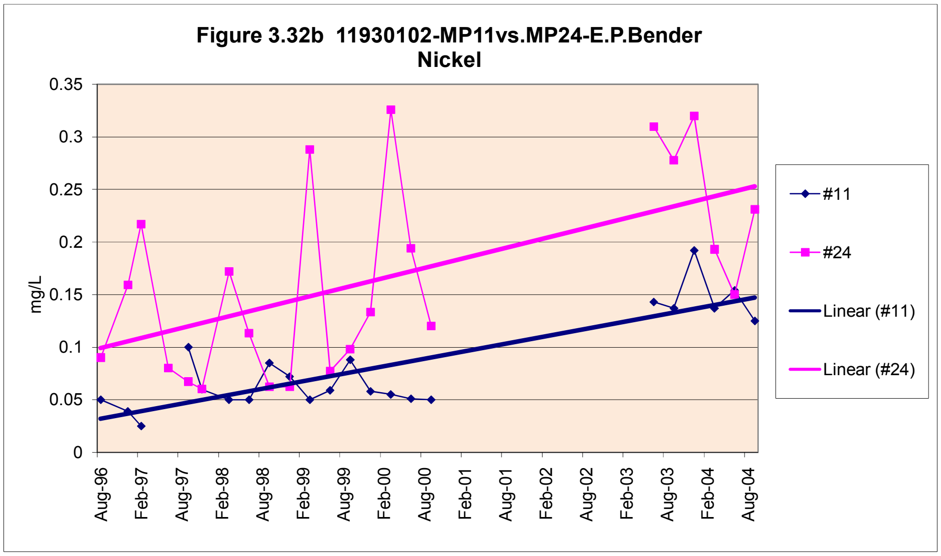


Figure 3.32b 11930102-MP11vs.MP24-E.P.Bender
Nickel
mg/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
#11
#24
Linear (#11)
Linear (#24)

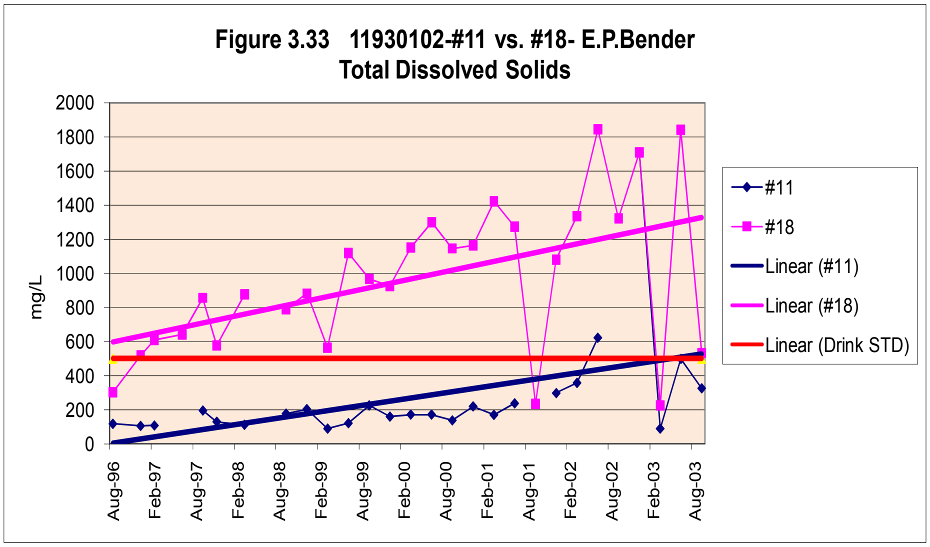


Figure 3.33 11930102-#11 vs. #18- E.P.Bender
Total Dissolved Solids
mg/L
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
#11
#18
Linear (#11)
Linear (#18)
Linear (Drink STD)

Figure 3.33a 11930102-MP11vs.MP19-E.P.Bender
Total Dissolved Solids

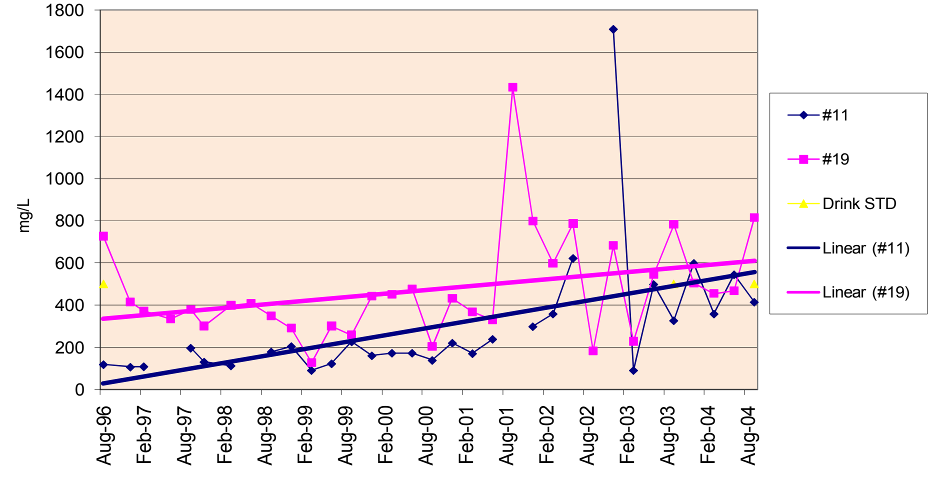
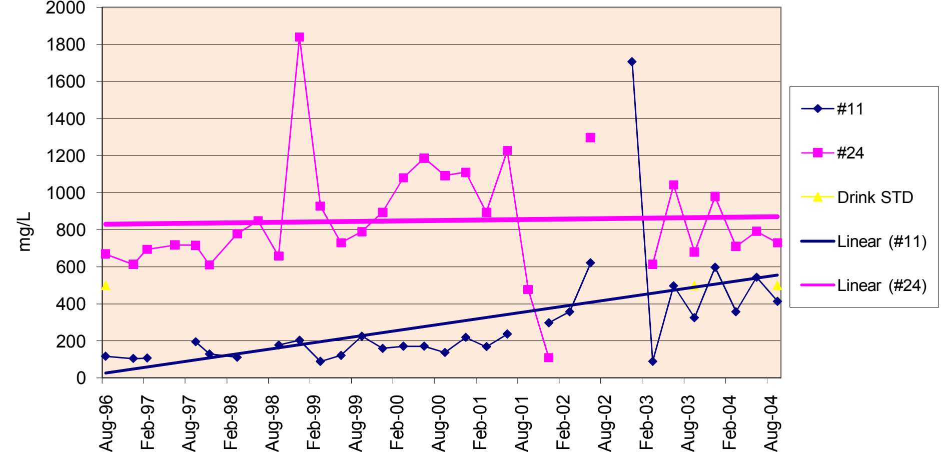


Figure 3.33b 11930102-MP11vs.MP24-E.P.Bender
Total Dissolved Solids



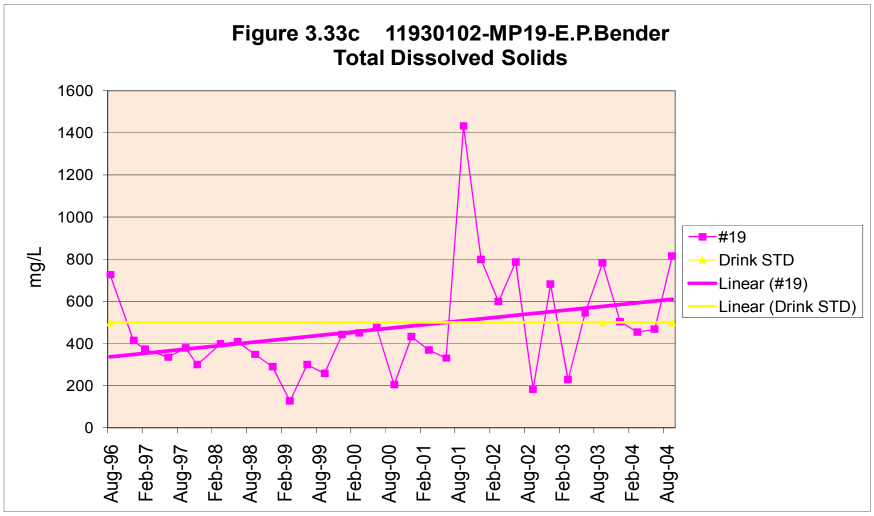


Figure 3.33c 11930102-MP19-E.P.Bender
Total Dissolved Solids
mg/L
0
200
400
600
800
1000
1200
1400
1600
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
#19
Drink STD
Linear (#19)
Linear (Drink STD)

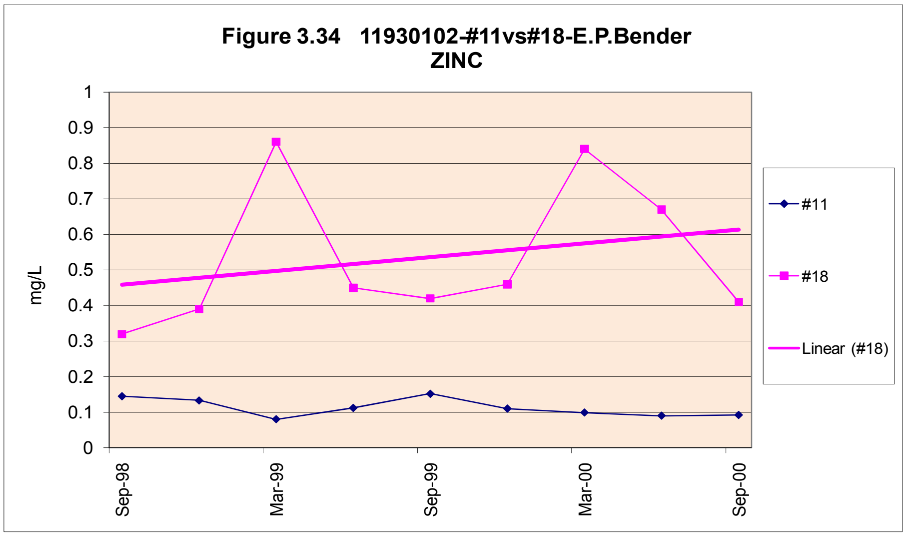


Figure 3.34 11930102-#11vs#18-E.P.Bender
ZINC
mg/L
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
#11
#18
Linear (#18)

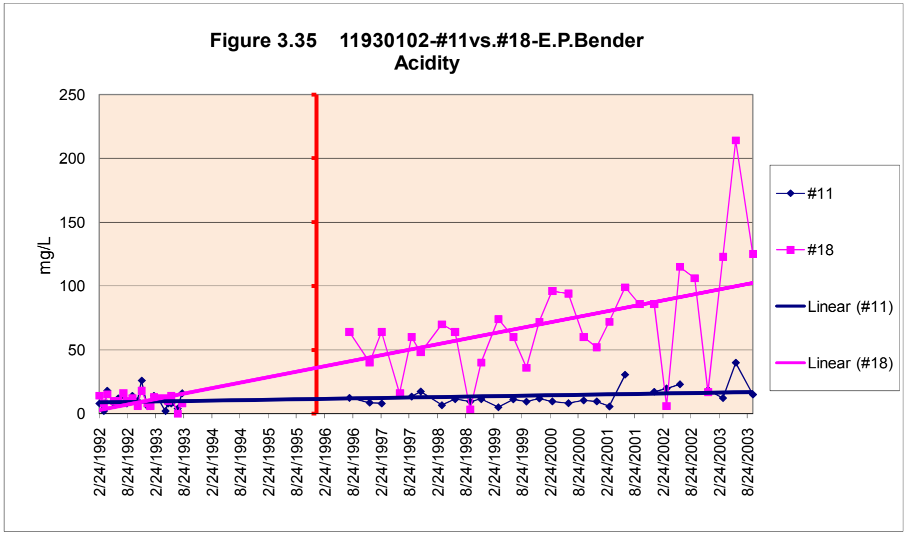


Figure 3.35 11930102-#11vs.#18-E.P.Bender
Acidity
mg/L
250
200
150
100
50
0
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
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2/24/2003
8/24/2003
#11
#18
Linear (#11)
Linear (#18)

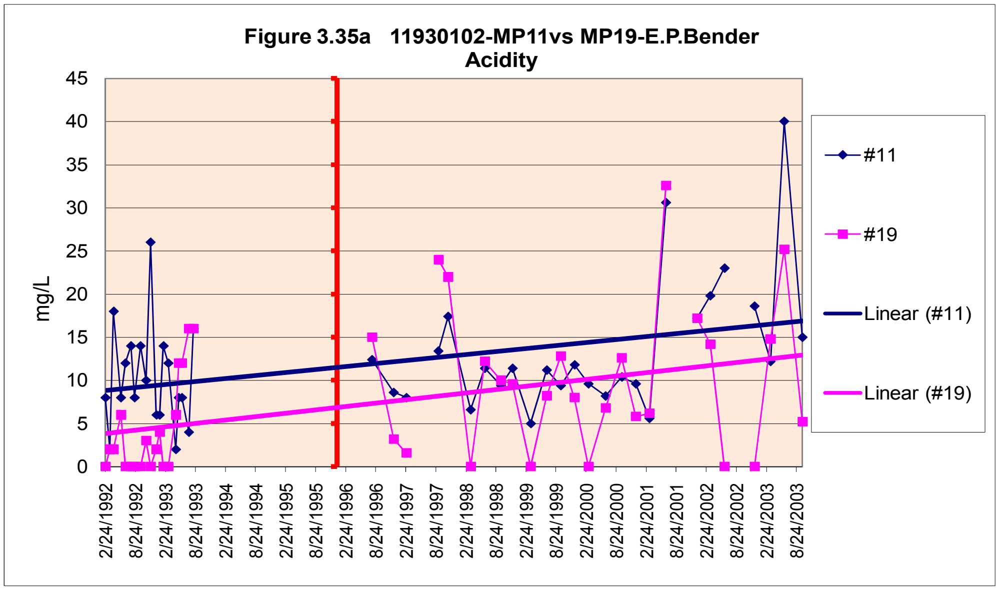
Figure 3.35a 11930102-MP11vs MP19-E.P.Bender
Acidity
mg/L
45
40
35
30
25
20
15
10
5
0
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
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8/24/2003
#11
#19
Linear (#11)
Linear (#19)

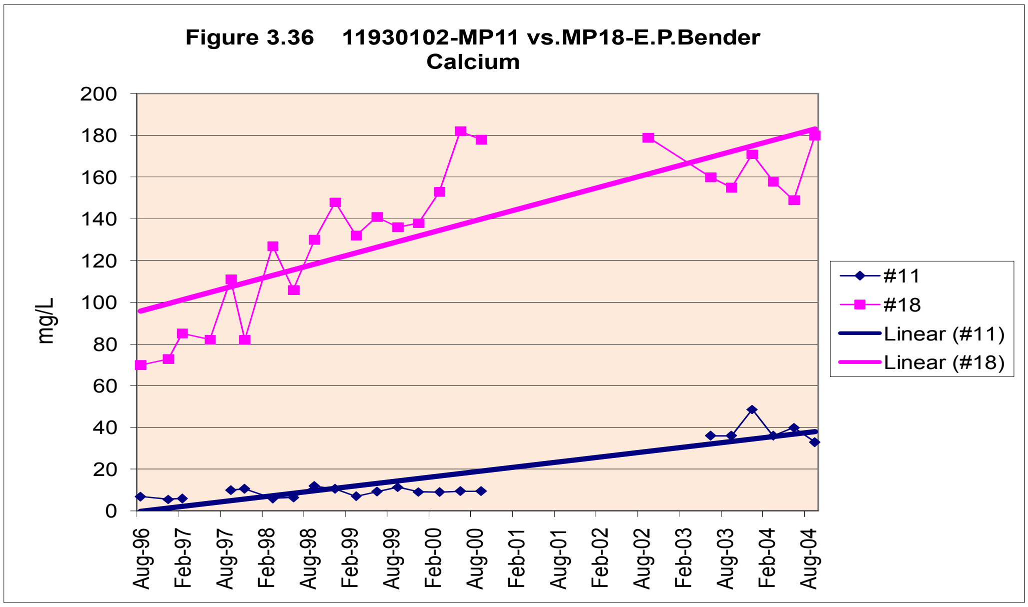
Figure 3.36 11930102-MP11 vs.MP18-E.P.Bender
Calcium
mg/L
0
20
40
60
80
100
120
140
160
180
200
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
#11
#18
Linear (#11)
Linear (#18)

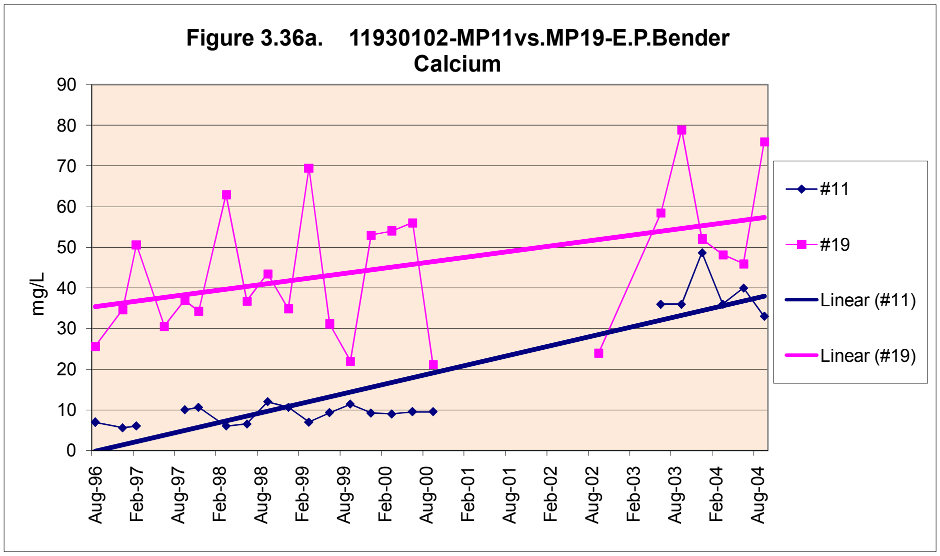
Figure 3.36a. 11930102-MP11vs.MP19-E.P.Bender
Calcium
mg/L
0
10
20
30
40
50
60
70
80
90
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
#11
#19
Linear (#11)
Linear (#19)

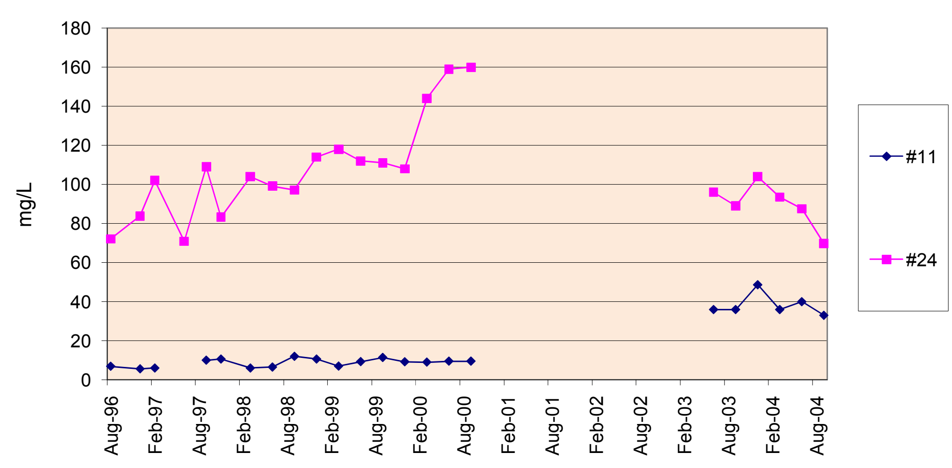

Figure 3.36b 11930102-MP11vs.MP24-E.P.Bender
Calcium

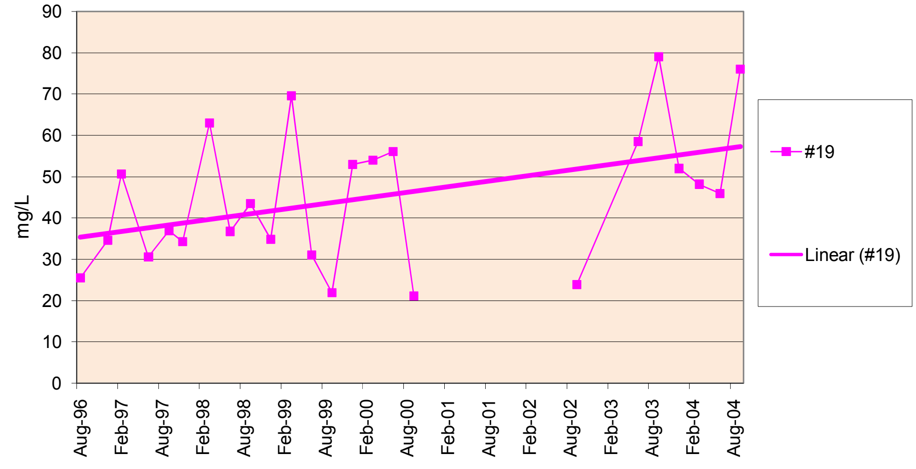

Figure 3.36c 11930102-MP19-E.P.Bender
Calcium

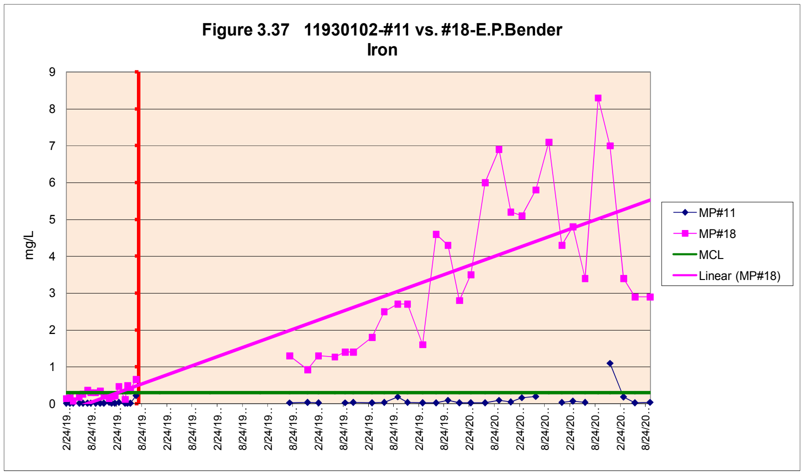

Figure 3.37 11930102-#11 vs. #18-E.P.Bender
Iron

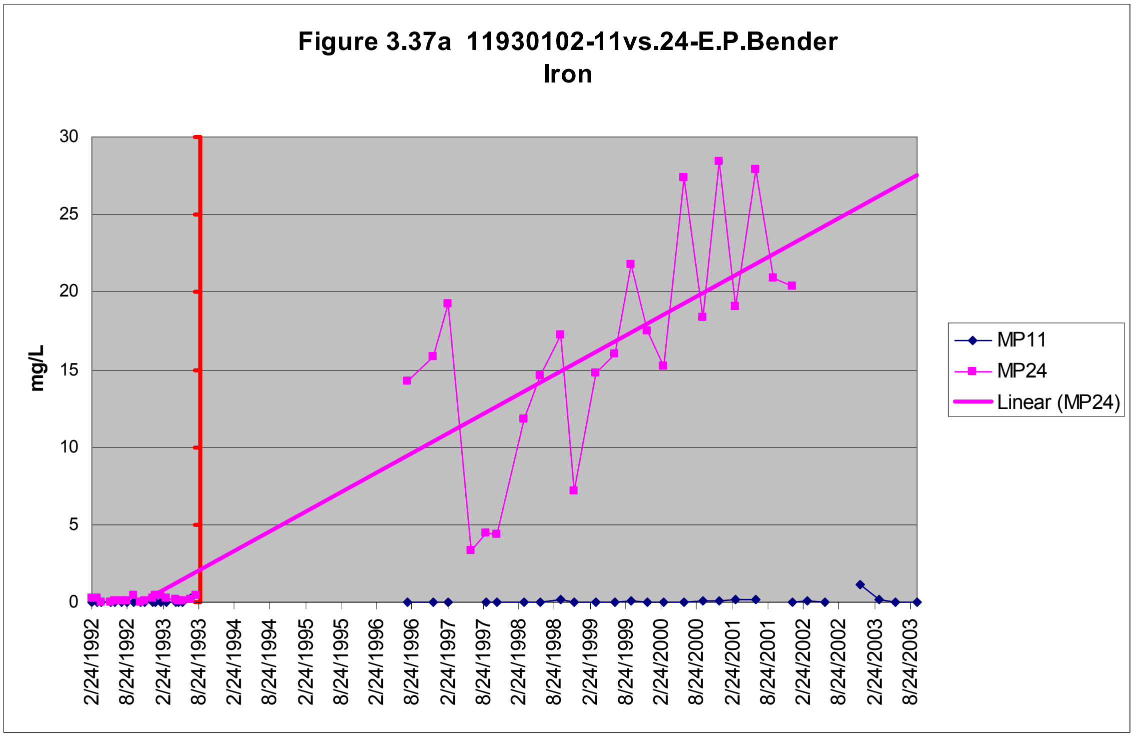

Figure 3.37a 11930102-11vs.24-E.P.Bender
Iron

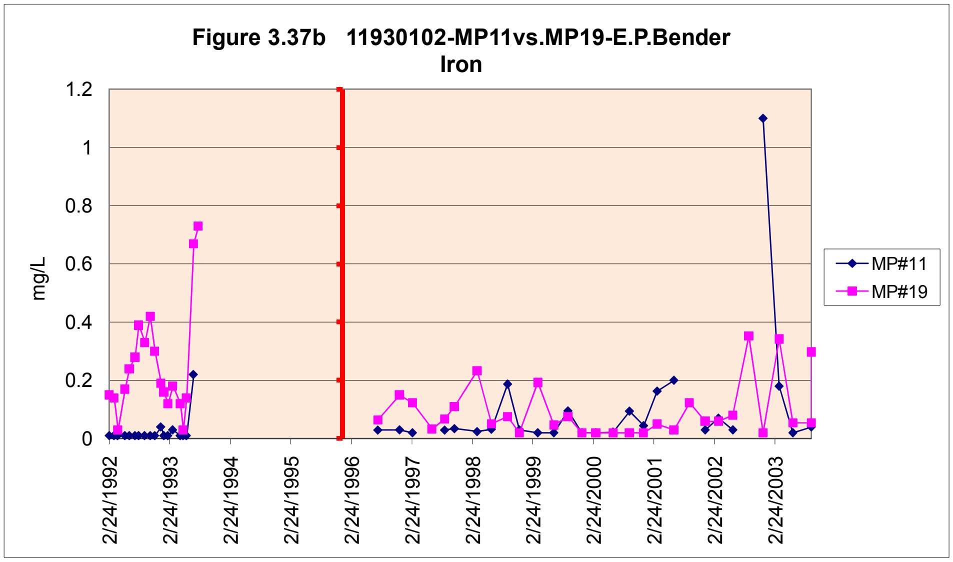
Figure 3.37b 11930102-MP11vs.MP19-E.P.Bender
Iron
mg/L
1.2
1
0.8
0.6
0.4
0.2
0
2/24/1992
2/24/1993
2/24/1994
2/24/1995
2/24/1996
2/24/1997
2/24/1998
2/24/1999
2/24/2000
2/24/2001
2/24/2002
2/24/2003
MP#11
MP#19

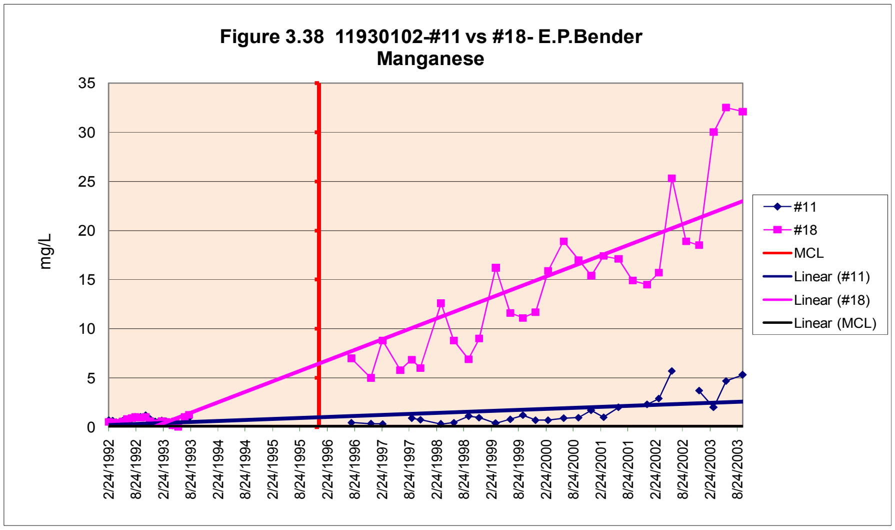
Figure 3.38 11930102-#11 vs #18- E.P.Bender
Manganese
mg/L
35
30
25
20
15
10
5
0
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
8/24/2001
2/24/2002
8/24/2002
2/24/2003
8/24/2003
#11
#18
MCL
Linear (#11)
Linear (#18)
Linear (MCL)

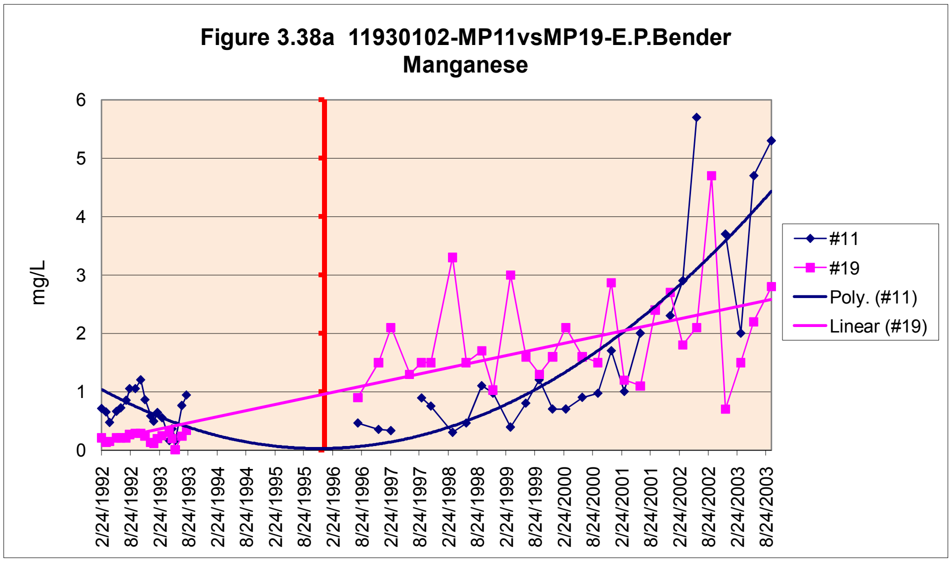
Figure 3.38a 11930102-MP11vsMP19-E.P.Bender
Manganese
mg/L
6
5
4
3
2
1
0
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
8/24/2001
2/24/2002
8/24/2002
2/24/2003
8/24/2003
#11
#19
Poly. (#11)
Linear (#19)

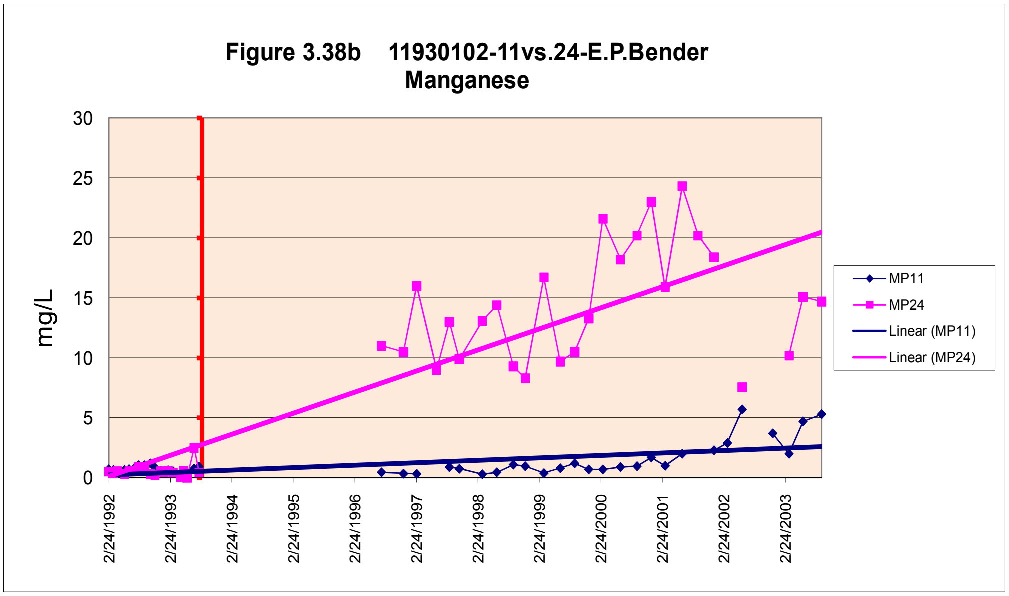
Figure 3.38b 11930102-11vs.24-E.P.Bender
Manganese
mg/L
30
25
20
15
10
5
0
2/24/1992
2/24/1993
2/24/1994
2/24/1995
2/24/1996
2/24/1997
2/24/1998
2/24/1999
2/24/2000
2/24/2001
2/24/2002
2/24/2003
MP11
MP24
Linear (MP11)
Linear (MP24)

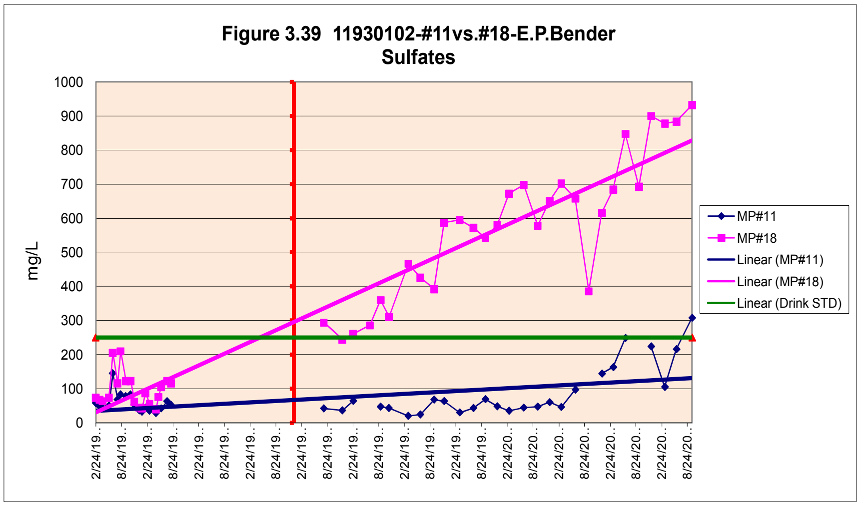
Figure 3.39 11930102-#11vs.#18-E.P.Bender
Sulfates
mg/L
1000
900
800
700
600
500
400
300
200
100
0
2/24/19..
8/24/19..
2/24/20..
8/24/20..
MP#11
MP#18
Linear (MP#11)
Linear (MP#18)
Linear (Drink STD)

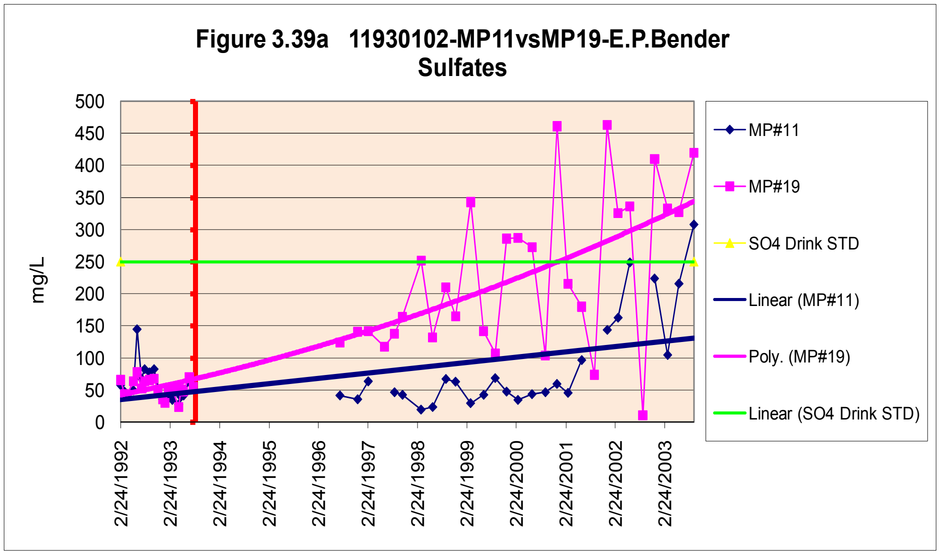
Figure 3.39a 11930102-MP11vsMP19-E.P.Bender
Sulfates

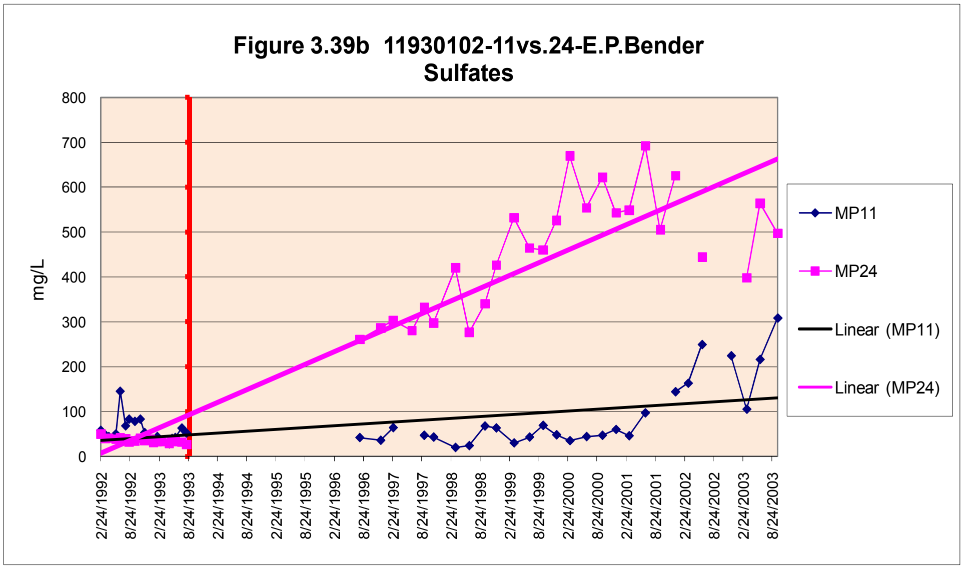
Figure 3.39b 11930102-11vs.24-E.P.Bender
Sulfates

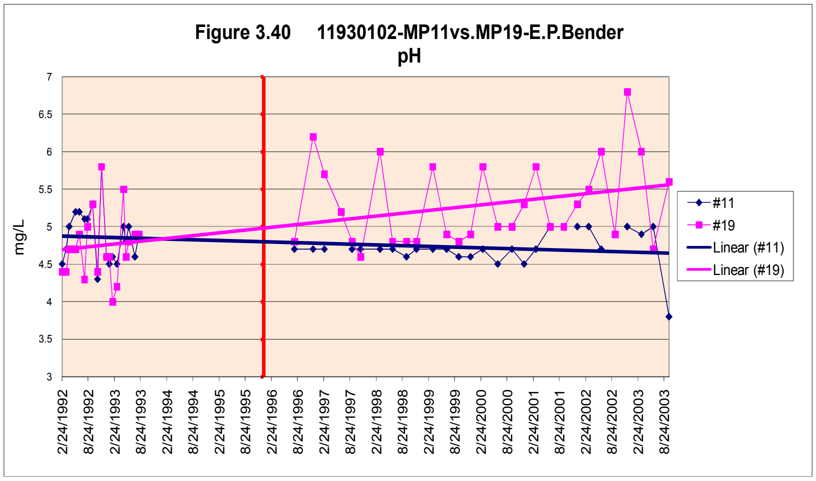

Figure 3.40 11930102-MP11vs.MP19-E.P.Bender
pH

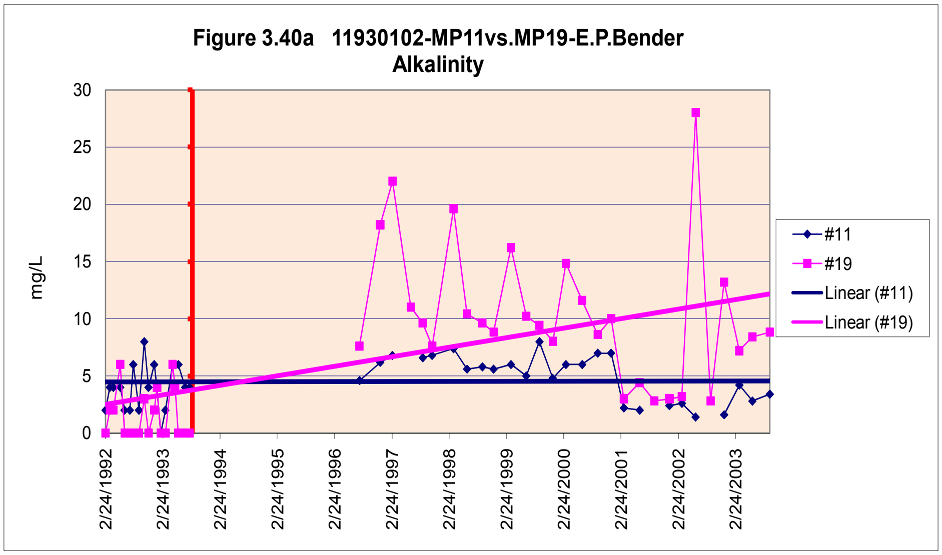

Figure 3.40a 11930102-MP11vs.MP19-E.P.Bender
Alkalinity

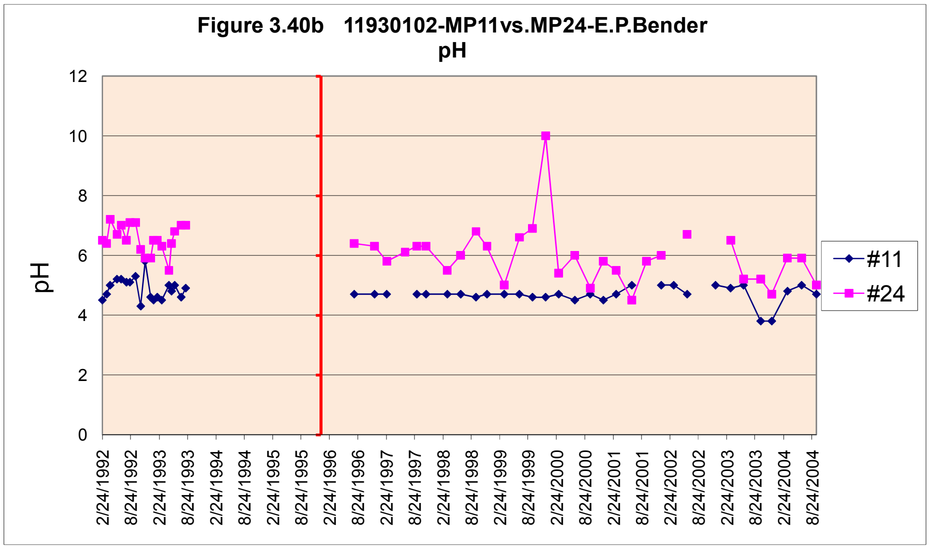
Figure 3.40b 11930102-MP11vs.MP24-E.P.Bender
pH
pH
0
2
4
6
8
10
12
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
8/24/2001
2/24/2002
8/24/2002
2/24/2003
8/24/2003
2/24/2004
8/24/2004
#11
#24

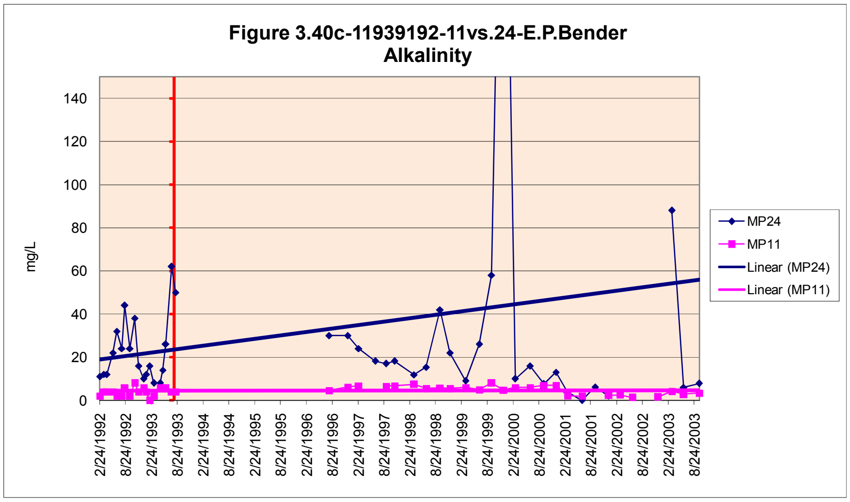
Figure 3.40c-11939192-11vs.24-E.P.Bender
Alkalinity
mg/L
0
20
40
60
80
100
120
140
2/24/1992
8/24/1992
2/24/1993
8/24/1993
2/24/1994
8/24/1994
2/24/1995
8/24/1995
2/24/1996
8/24/1996
2/24/1997
8/24/1997
2/24/1998
8/24/1998
2/24/1999
8/24/1999
2/24/2000
8/24/2000
2/24/2001
8/24/2001
2/24/2002
8/24/2002
2/24/2003
8/24/2003
MP24
MP11
Linear (MP24)
Linear (MP11)

Conclusion

The EP Bender "Job 54" mine is predominantly a groundwater discharge area. Discharge is controlled by a geologic structure manifested by the slight dip of the rock strata to the northwest, by the relatively impermeable clays that underlie much of each of the major coal seams, and by the mining operation. Discharge is also facilitated by coal mining activities that have taken place previously.

By any chemical measure, the proposed and implemented mining and reclamation plan at E.P. Bender is an environmental failure. The data show that there are marked increases in concentrations of sulfate, manganese, iron, aluminum, calcium, nickel, chloride, and TDS and loading rates for several of these constituents at downgradient monitoring points. These concentrations and loading rates began to increase approximately a year after ash placement began and have risen steadily without abatement. There are also marked increases in concentrations of some of the above constituents at downgradient MW1, the single monitoring well at the site that is screened in the aquifer underneath the mine. In several instances at MW1 and at downgradient surface water points, these constituents have increased from levels near or below secondary drinking water standards to levels far above these standards. Stark and often growing differences in the concentrations of major, minor, and some trace elements between the upgradient MP11 and downgradient points MP18, MP19, and MP24 from before to after FBC ash placement and growing concentrations of chloride and calcium at the downgradient monitoring points indicate that the ash is a significant contributor to this contamination of surface water discharges. The significantly higher pH, higher alkalinity and lower acidity at MP19 and MP24, compared with MP11, reinforce this evidence.

While there were no substantial upward trends found in trace metals at this site aside from nickel, there have been isolated detections of cadmium, chromium, lead and selenium at downgradient monitoring points after mining and ash placement began. In some instances measured values for these metals were close to or exceeding DWS. For example at MP24, a dissolved cadmium concentration of 0.012 mg/L (DWS is 0.005 mg/L) was measured in December 1999, and a dissolved chromium concentration of 0.088 mg/L (DWS is 0.100 mg/L) was measured in June 1997. At MP19, a dissolved cadmium reading of 0.011 mg/L was measured in December 1999. At MP14, a strip mine discharge point downgradient of the ash that was often dry during sampling, dissolved chromium was measured at 0.114 mg/L in June 1997 exceeding the drinking water standard. Total cadmium concentrations have been measured between 0.004 and 0.006 mg/L at least five times in 2003 and 2004 at MP14. Low levels of cadmium have been measured at MP25 downstream of the site in Little Laurel Run since ash placement began. With the exception of lead, these trace elements were never found above detection limits during the baseline monitoring at these points and have never been detected at upgradient monitoring points. Arsenic measurements have been below a detection level of 0.004 mg/L at all points during the entire monitoring period with the exception of one measurement of total arsenic at MW1 in November 1995 (just before ash placement was to have started) of 0.0059 mg/L. Nonetheless, chromium and cadmium have been measured several times at levels of concern since ash was brought to this site in waters draining from where the ash was placed.

The failure of the implemented mining and reclamation plan at E.P. Bender cannot merely be attributed to ineffective or insufficient placement of the FBC ash. There are several converging lines of evidence that indicate that the ash itself materially contributes to the degradation. First, the increases of ash-specific constituents such as chloride and calcium, after ash placement commenced, strongly implicate ash as a direct contributor to water quality degradation for these and presumably other constituents. Second, although there was not a universal dominance of alkalinity over acidity at the downgradient surface water monitoring points, pH did undergo an overall rise at one of these points during the monitoring period. Furthermore alkalinity was substantially higher at two of the three downgradient points than at the upgradient surface water point and had an increasing trend throughout the monitoring period at these downgradient points, while alkalinity concentrations remained unchanged at the upgradient point. This, too, represents a direct chemical contribution from the FBC ash and an overall chemical environment that should not have led to unabated increases in sulfates, manganese and other constituents from AMD. Finally, this continued rise in concentrations, possibly at an accelerating rate when last observed after mining ceased and reclamation was the predominant activity, suggests a chemical system that is atypical of normal acid mine drainage. Properly graded and drained mines are expected to show the worst conditions at the end of the disturbance and declining or at least not worsening degradation as the reclamation, which occurs at a contemporaneous pace behind the face of the mining operation, takes over. Water monitoring data suggest that such improvement is not occurring at this site and that the difference may be due to the addition of the FBC ash into the "reactor." This concern is amplified by the observation that degradation is not limited to the mined horizons, but also includes the next underlying aquifer where exposure to oxygen should be a less significant factor.

Clearly, there is a need to extend the monitoring period, install additional monitoring points, and monitor for additional parameters indicative of the leachate of ash placed at this site. PADEP has required the operator at this site to build sediment ponds at the base of the site that divert most of the polluted leachate from wetlands near Clearfield Creek to a passive treatment system. While reviewers have not seen data on the quality of discharges from those ponds, the evidence they have examined indicates that the addition of ash to this site has contributed to, if not been a primary cause of, pollution that violates the fundamental tenet of the Subchapter F program to avoid degrading water quality beyond preexisting conditions. The reviewers hope monitoring points are being established on Clearfield Creek, upstream and downstream of the site, to regularly assess and respond to any adverse effects on water quality that may reach this watercourse. Monitoring of the degradation from iron, manganese and possibly other parameters that has occurred in the aquifer underlying the mined horizons as seen by MW1 should also be expanded to additional upgradient and downgradient points and should continue until this degradation is abated or subsides naturally. Monitoring should analyze for more ash indicator parameters including boron, molybdenum, antimony, and potassium.

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Permit Review 4

LARSON ENTERPRISES, INC., SWAMP POODLE MINE (PERMIT # 17950115)

Site Summary

The Larson Enterprises Inc. Swamp Poodle Mine was an active surface mine located in Morris, Graham, and Cooper Townships, Clearfield County, Pennsylvania in the Moshannon – Mosquito Creek Priority Watershed 8D. Approximately 214,090 tons of FBC ash was placed on 50.1 acres at the Swamp Poodle mine, contemporaneous with surface mining operations. This precise amount of ash was confirmed by a letter dated April 19, 1999 from Larsen Enterprises to the PADEP. The FBC ash came from the Piney Creek Project (a waste coal facility) located in Clarion, Pennsylvania. Six coal seams were surface mined at this site, and some abandoned deep mine workings were daylighted. Four groundwater-monitoring wells were drilled and all of them are discussed in this report. The total area of the site was not specified in the permit.

The permit for this operation was issued in February 1996, with ash placement and coal mining activity starting in that month. Mining and ash placement ceased in April 1999 and the latest monitoring data in the permit file were collected in September, 1999. The final inspection and bond release occurred on May 3, 2004. The ash was placed on the site ostensibly as an alkaline addition to remediate acid mine drainage.

Geology

The six coal beds mined at the Swamp Poodle site are (from lowest and oldest, to highest and youngest) the Lower Kittanning Coals # 3 and #4, the Middle Kittanning Coals #1, #2, and #3, and the Upper Kittanning Coal. The structure of the sedimentary beds is a gentle dip (slope) to the southeast, which most likely is an indication of the original geometry of the depositional basin. The Lower Kittanning #3 Coal seam is the thickest and was deep mined prior to surface mining operations. This coal seam was deposited under marine and brackish swamp conditions, with a resulting high sulfur content that contributes greatly to AMD problems.

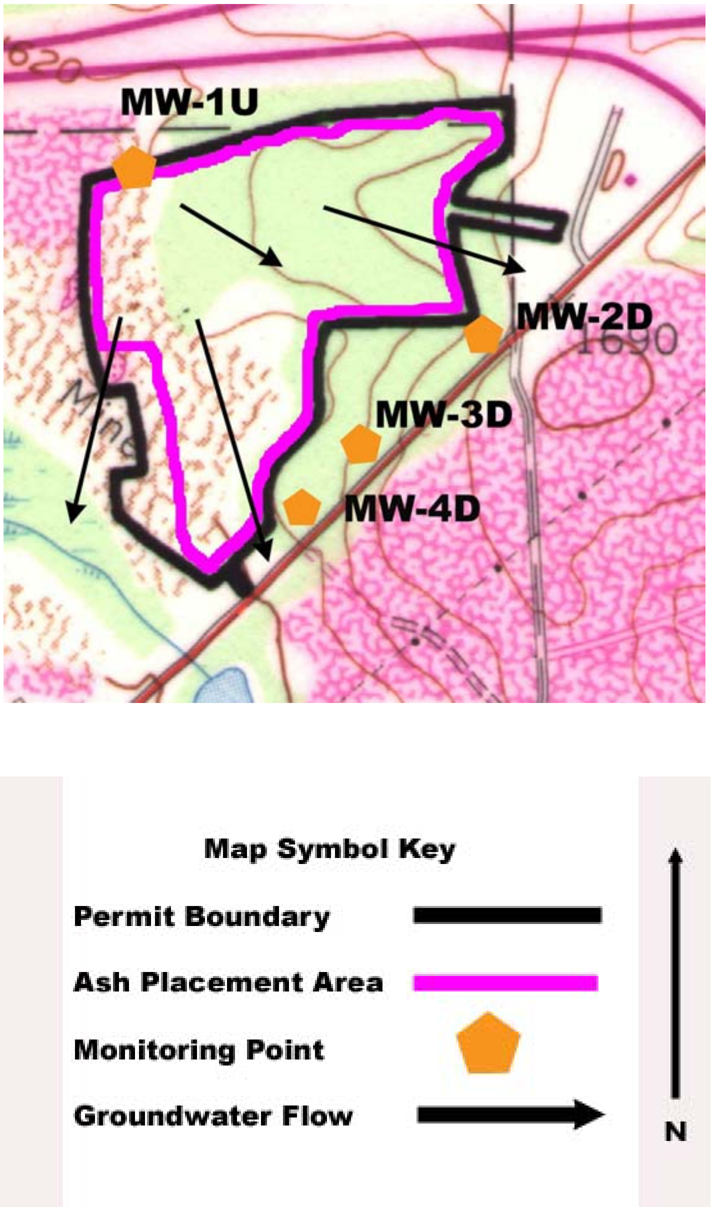
Topography

The Swamp Poodle site is located in the Pittsburgh Low Plateau physiographic province of Pennsylvania (figure 1). The site area is on the northwest side of a low, flat-topped hill (see map below), and the relief is slight; the highest elevation is 1680 feet above sea level, and the lowest is about 1590 feet. The north side of the mine is bounded by the I-80 highway.

Groundwater

The surface water and shallow groundwater flows off the hill to the north, west, and south. The east side of the site is a slight incline. Surface drainage is poor, especially towards the west and south where there is a swamp that is drained by Flat Run. The deeper groundwater that is the focus of this report is drained by the abandoned underground coal mine in the Lower Kittanning #3 Coal. Unlike other sites studied in this project, this water follows the rock structure flowing in a different direction than the surface and shallow groundwater down the dip towards the southeast exiting the site underground and ending up in Sulfur Run, (not shown on

Site Map: Swamp Poodle



Larson Enterprises, Inc. Swamp Poodle Operation (Permit # 17950115)
Scale: 1" = Approximately 700'

map), a small stream southeast of the mine. Some portions of the underground mine have been daylighted. The Lower Kittanning 3 Coal elevation represents the base flow for the site. Base flow is the lowest elevation that local groundwater flows occupy when leaving the site boundaries.

Groundwater Monitoring Data: Discussion

The four monitoring wells drilled on the Swamp Poodle property are MW-1U (upgradient), MW-2D (downgradient), -MW-3D (downgradient), and MW-4D (downgradient). MW1-U sampled water from the mine pool that was already somewhat degraded from past deep mining but which is located upgradient of the area affected by the surface mining and ash placement in this permit. (MW-2D sampled the degraded mine pool water that should have additionally been affected by this permit's activities, and MW-3D sampled more diluted mine pool water that should also have been affected by this permit's activities. MW-4D sampled more diluted mine pool water also although its concentrations appear more diluted than MW-3D. All four of these wells were drilled slightly below the level of the Lower Kittanning #3 Coal into the underground workings of this seam. Analysis of the permit's coal structure map and information provided in Module 25 of the permit confirms the upgradient and downgradient positions of these wells. MW-1U is at the northwest corner of the site while MW-2D , MW-3D, and MW-4D are on the southeast edge of the mine. The wells were screened in the solid coal pillars in the underground workings as pointed out in the Module 8 Addendum, page 8-6G, of the permit. As the coal has many joints, its permeability is high, and thus the presumption is that water collected from these wells will reveal the quality of surrounding minepool water. However given the contrasting hydraulic conductivity between the coal pillar and the minepool and presumed increased residence times of water in the pillars versus the rapid turnover experienced in some mine pools, it would have been preferable to see data demonstrating the same quality which was not available in the permit file.

MW-1U

The major elements iron, manganese, and sulfate are graphed for MW-1U in figures 4.1, 4.2, and 4.3 respectively. The 1995 data points represent baseline values. Compared to other coal mine monitoring data in western Pennsylvania, these values are extremely high, except for manganese. Iron (figure 4.1) generally decreased from a high of 230 mg/L during the baseline monitoring period, which is over 750 times the PA Act 2 criteria and the federal secondary MCL for drinking water (hereafter the drinking water standard or DWS) of 0.3 mg/L. Some data for 1998 was not collected due to dry conditions.

Manganese (figure 4.2) fluctuated with a high value of almost 6 mg/L, 120 times the DWS, measured in the spring of 1996 after mining and ash placement had begun followed by a decreasing trend inconcentration. Sulfate (figure 4.3) was high for an upgradient well, but declined with concentrations fluctuating from over 1000 mg/L (4 times the DWS) to about 100 mg/L. The trends are downward, although for all three of these constituents, concentrations increased in the last sampling taken in September 1999. Nonetheless despite its location within a previously mined spoil area, MW-1U's results should portray groundwater in an area of the site that is not disturbed by the surface mining or ash placement under the permit.

The acidity value trend is declining and close to that of sulfates, indicating that weathering of sulfide minerals is the main contributor to acid conditions (figure 4.4). The pH shows a very slight downward trend, with the average being about 3.1 (figure 4.5). The trend lines for both pH and acidity are derived from concentrations measured after ash placement. The alkalinity values (not plotted) are below the practical detection limits of the measuring instrument.

Unlike other parameters the chloride concentrations rose 3 to 8 times from baseline values over the monitoring period (figure 4.6A), and total dissolved solids (TDS) also increased (figure 4.6). The permit authors attribute the rising chloride to road salt, which appears to be the most probable source of chloride, due to the site's proximity to Interstate Route 80 on the northern border, an interchange on I-80 adjacent to the site's northeast corner, and State Route 53 on the southeast border of the site.

Figure 4.1 17950115 MW-1U Swamp Poodle
Iron

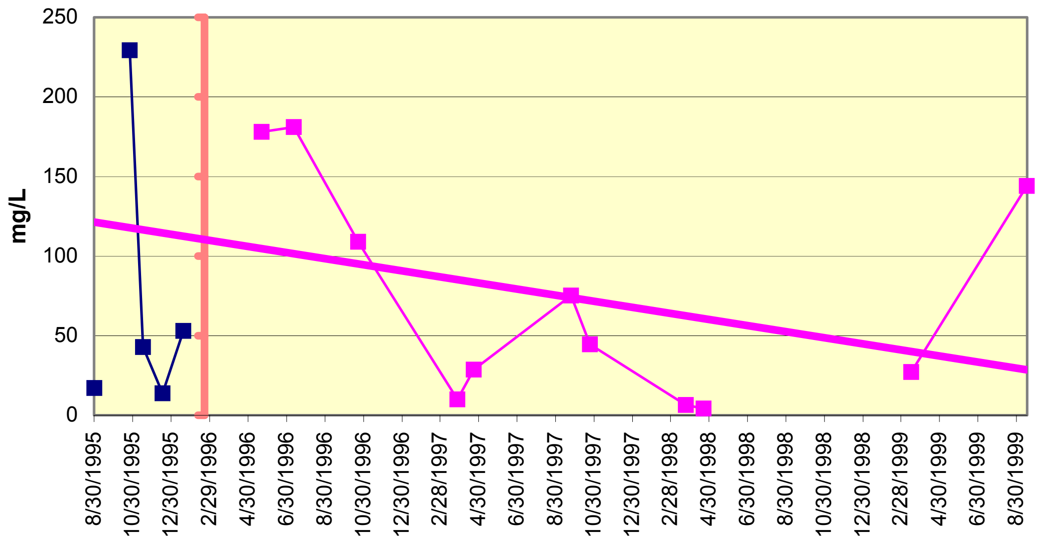


Figure 4.2 17950115 MW-1U Swamp Poodle
Manganese

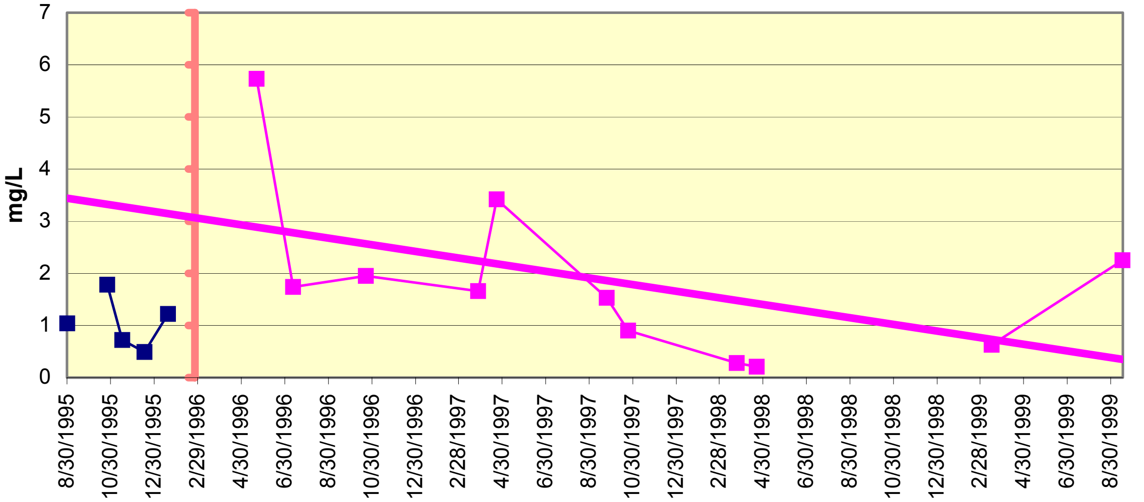
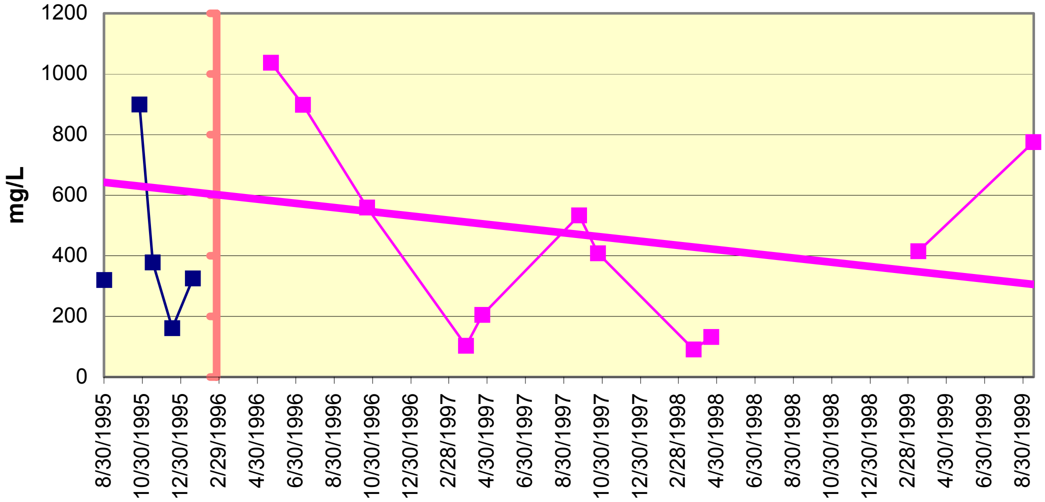


Figure 4.3 17950115 MW-1U Swamp Poodle
Sulfates



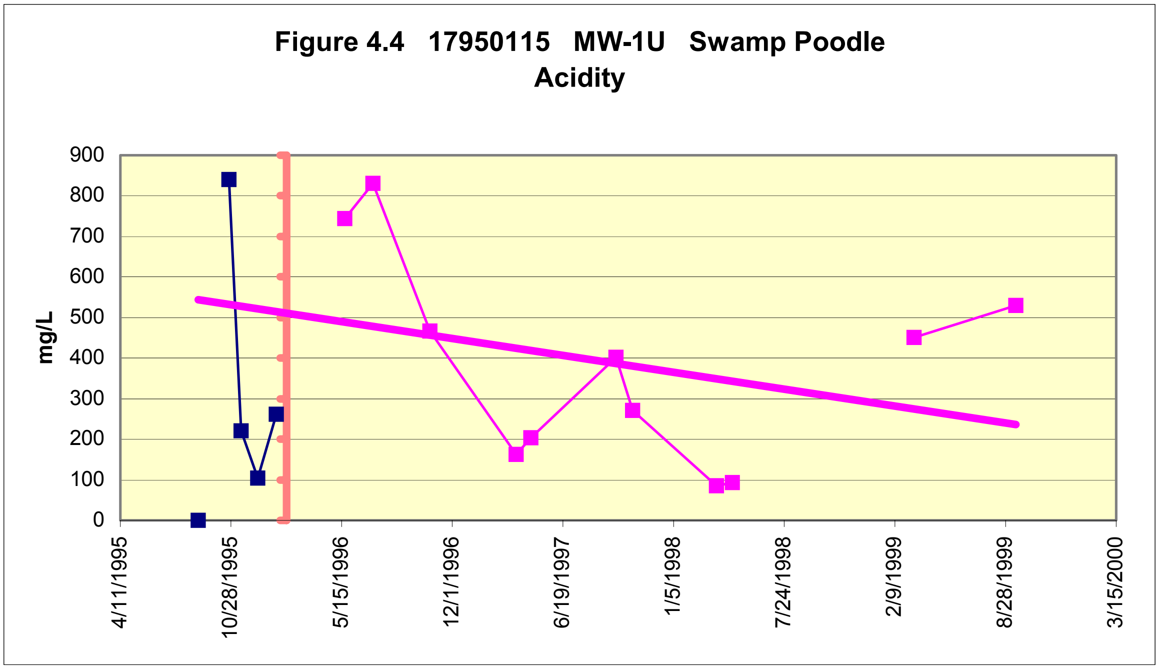


Figure 4.4 17950115 MW-1U Swamp Poodle
Acidity
mg/L
900
800
700
600
500
400
300
200
100
0
4/11/1995
10/28/1995
5/15/1996
12/1/1996
6/19/1997
1/5/1998
7/24/1998
2/9/1999
8/28/1999
3/15/2000

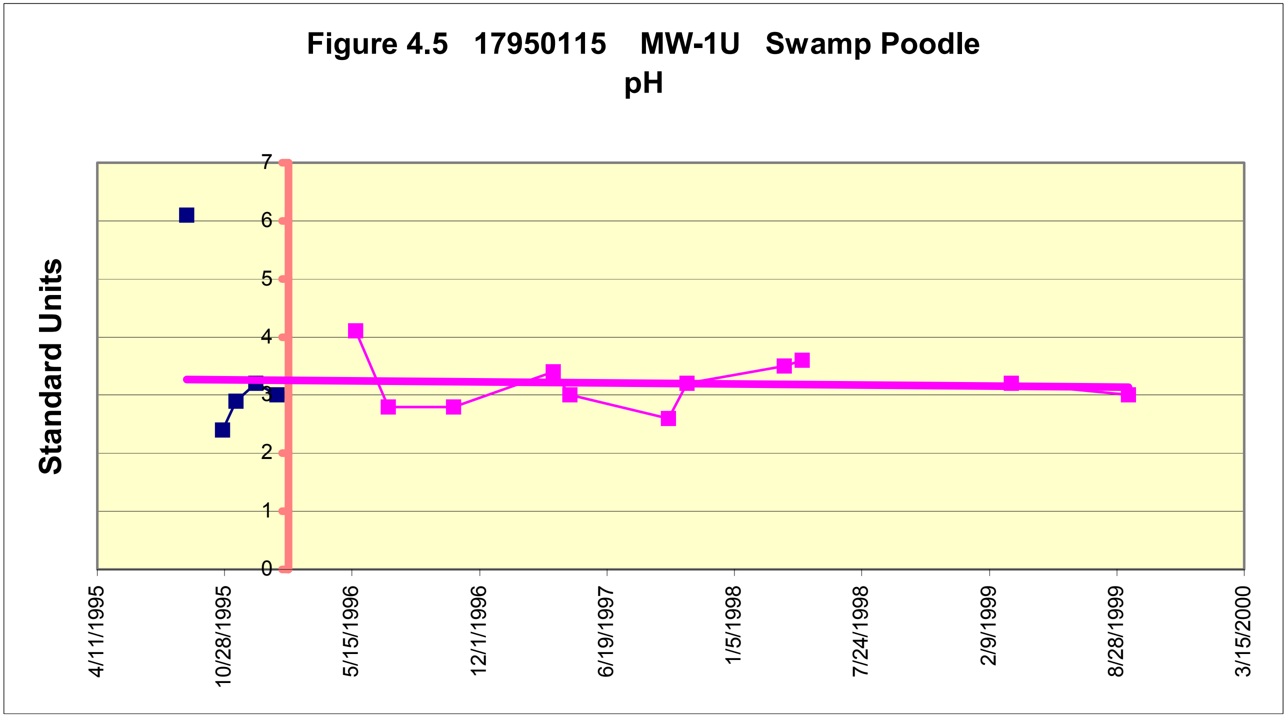


Figure 4.5 17950115 MW-1U Swamp Poodle
pH
Standard Units
7
6
5
4
3
2
1
0
4/11/1995
10/28/1995
5/15/1996
12/1/1996
6/19/1997
1/5/1998
7/24/1998
2/9/1999
8/28/1999
3/15/2000

Figure 4.6 17950115 MW-1U Swamp Poodle
TDS

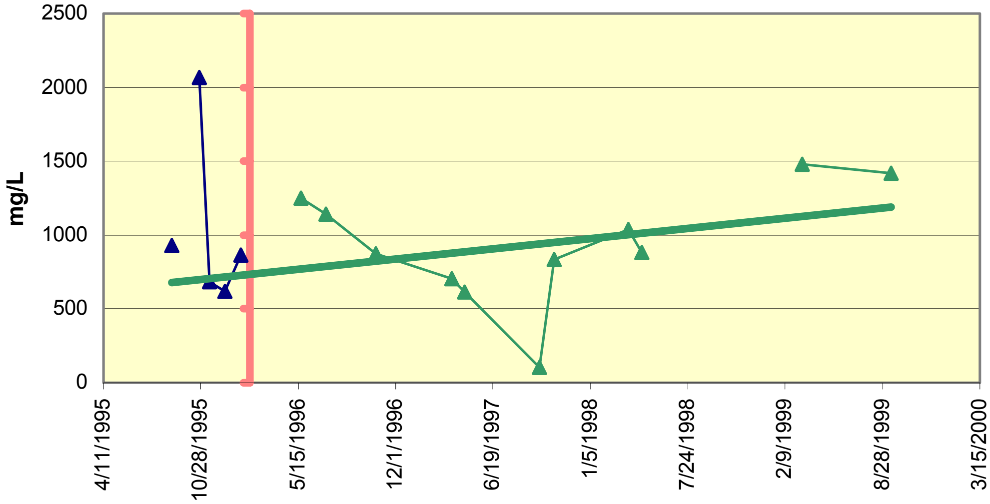
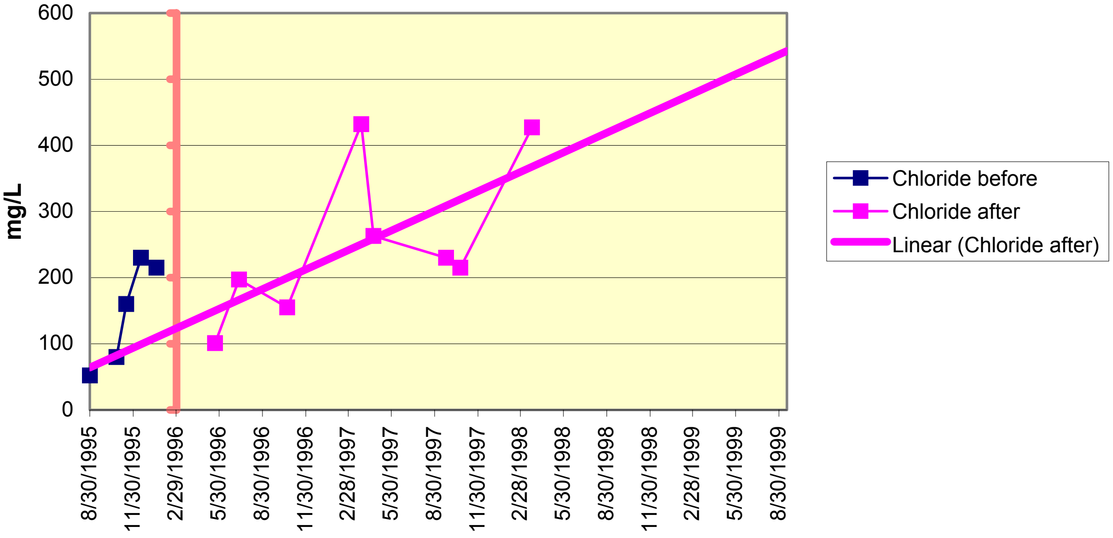


Figure 4.6A 17950115 MW-1U Swamp Poodle
Chloride



While the two highest calcium concentrations were measured during the baseline period, calcium values appear to have undergone rising trends after baseline monitoring, and magnesium values were also slightly higher after baseline monitoring (figure 4.7) at MW-1U. However there were only three annual samplings during the ash placement period for these two constituents making assessment difficult. Thus these concentrations of calcium and magnesium may not reflect much more than negligible changes from baseline levels.

Notwithstanding this question, the levels of magnesium and calcium at MW-1U are lower than magnesium and calcium levels measured at the downgradient points implying an added source for these constituents across the site. The permit states that there are no calcareous overburden rocks at the site. The FBC ash is likely a ready, soluble source of these constituents.

Although elevated in some instances, dissolved concentrations of trace elements at MW-1U (arsenic, cadmium, lead, and selenium) (figure 4.8) were never above 0.1 mg/L. Many of the trace element concentrations are reported below detection levels. Arsenic fluctuates above and below detection levels with a high concentration of 0.0830 mg/L measured during the baseline period; selenium is below detection levels in all measurements after the first one during baseline monitoring, and is measured at a concentration of 0.016 mg/L only in March 1999 during ash placement. Cadmium is measured at levels below the DWS during the baseline period. However because the detection level for cadmium was raised after the baseline period to <0.030 mg/L, six times the DWS, it is not possible to determine whether cadmium increased to levels of concern during ash placement. Lead is measured above and below baseline concentrations with its highest value reaching 0.038 mg/L in March 1997 more than a year after mining and ash placement had begun. As with the data for the major elements, these data appear to reflect groundwater that was not affected by ash placement.

At all monitoring points, the discussion and graphing of trace element concentrations in this assessment focuses on dissolved values only. In some cases, total values were considerably higher.

Figure 4.7 17950115 MW-1U Swamp Poodle
Calcium & Magnesium

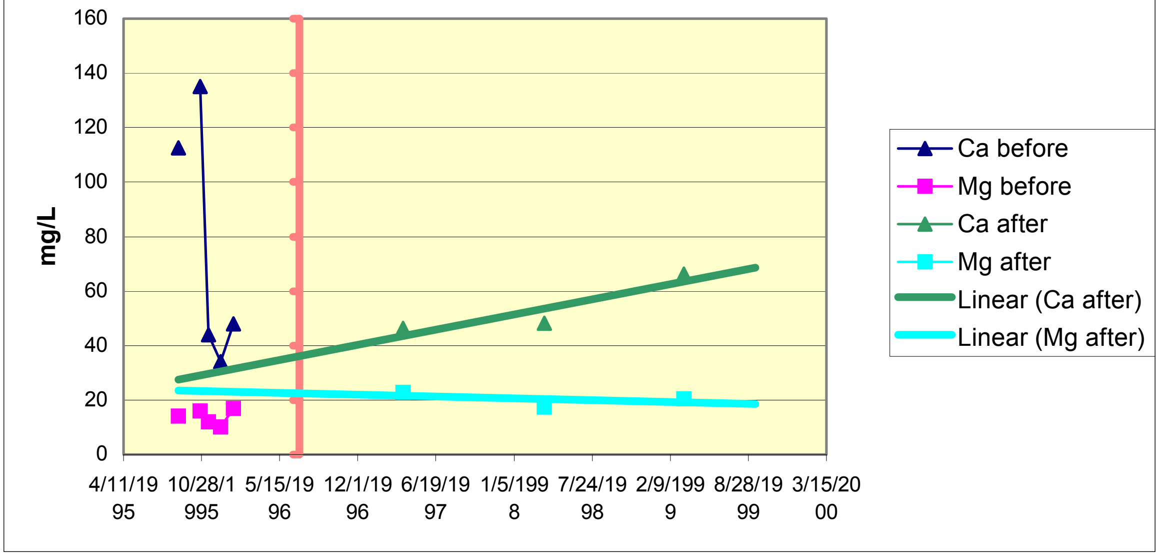
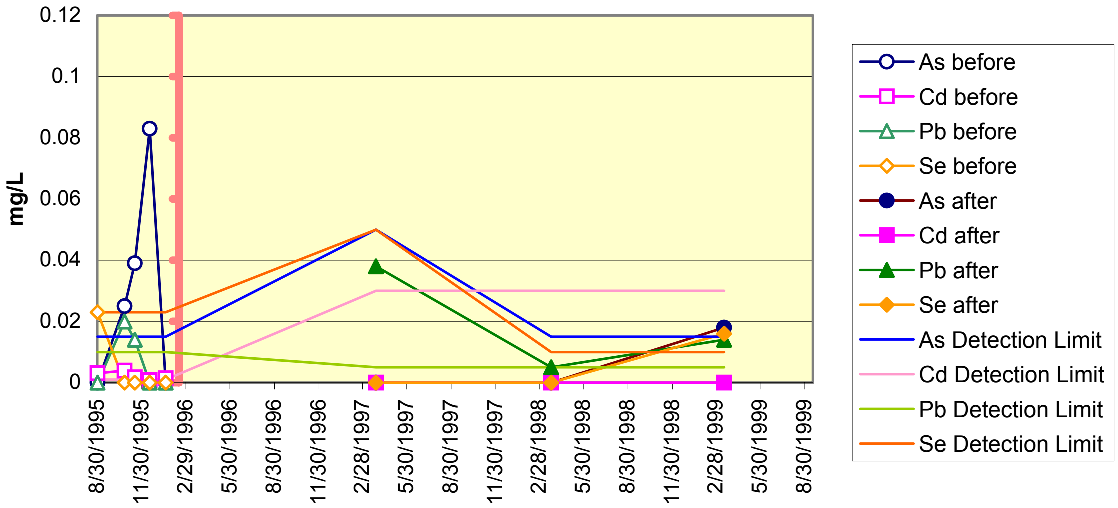


Figure 4.8 17950115 MW-1U Swamp Poodle
Trace Elements

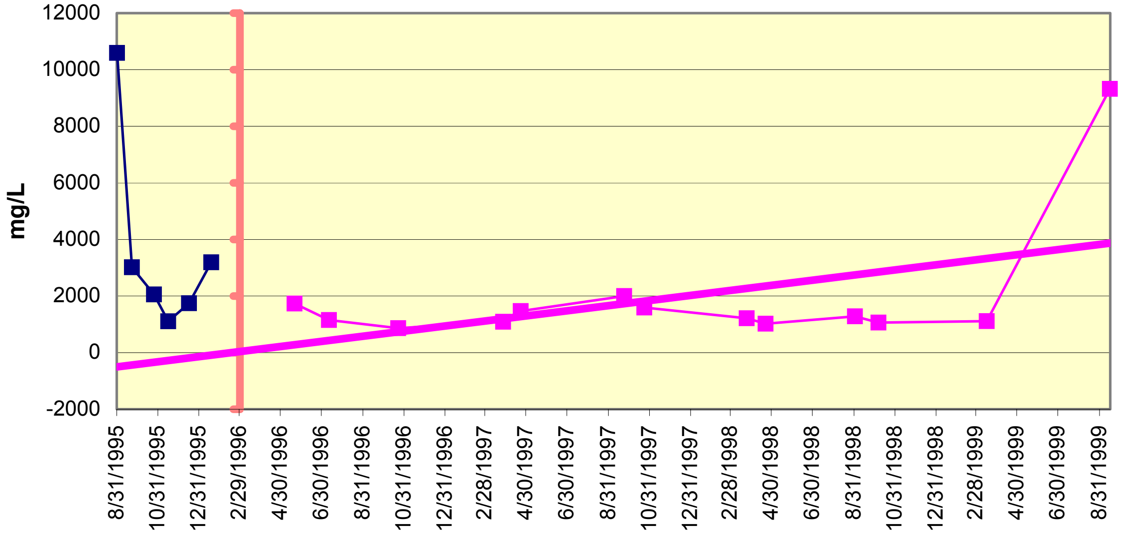


MW-2D

Major element data for downgradient MW-2D (figures 4.10, 4.11, and 4.12) show extremely high concentrations of iron, manganese, and sulfate. The DWS for iron, manganese, and sulfate are 0.3 mg/L, 0.05 mg/L, and 250 mg/L respectively. The trends for iron and manganese match generally, with baseline iron values starting at over 10,000 mg/L and the highest manganese baseline concentration at almost 100 mg/L. Iron "settles down" to between 1000 and 2000 mg/L, and manganese to between 6 and 22 mg/L. Then at the end of the sampling period, iron rises to 9320 mg/L in September 1999 and manganese rises to 50.7 mg/L. One thousand mg/L iron is over 3000 times the DWS for iron, and 50.7 mg/L is 1014 times the DWS for manganese.

Sulfates (figure 4.12) start at 15,192 mg/L, fluctuate somewhat, and then show a downward trend averaging in the 5000 mg/L range before falling to 99 mg/L in the last sampling in March 1999. Sulfate concentrations of 5000 mg/L are 20 times the DWS. This major element data indicates severely degraded groundwater. This well, according to the permit description, is monitoring raw, undiluted mine pool water downgradient from the mining and ash placement.

Figure 4.10 17950115 MW-2D Swamp Poodle
Iron



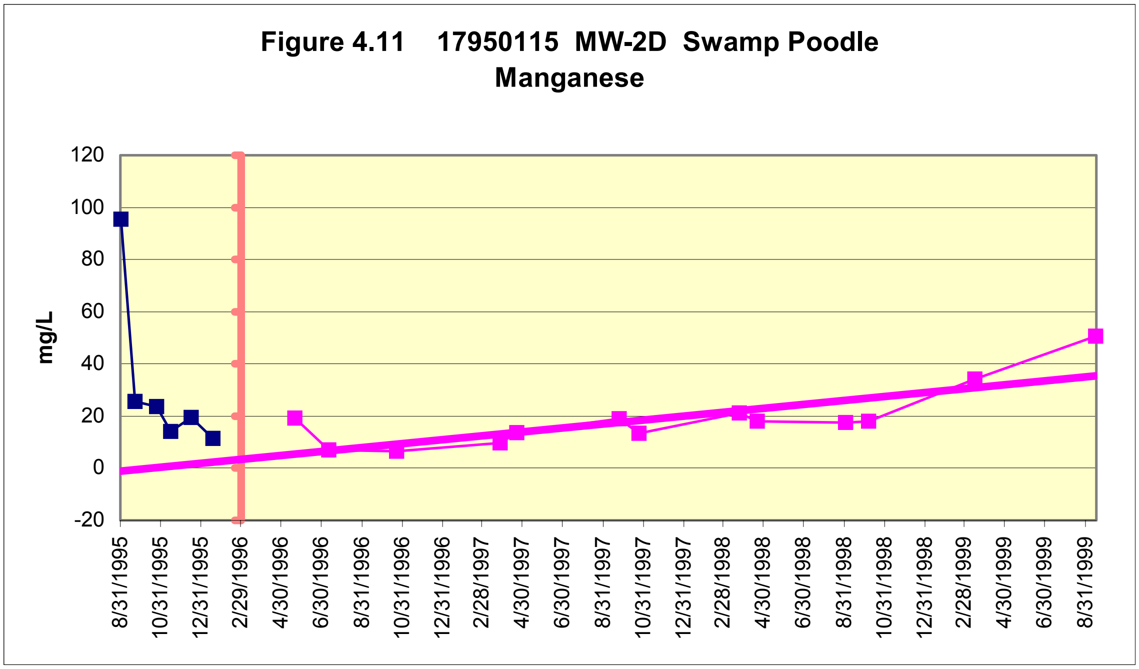


Figure 4.11   17950115 MW-2D Swamp Poodle
Manganese

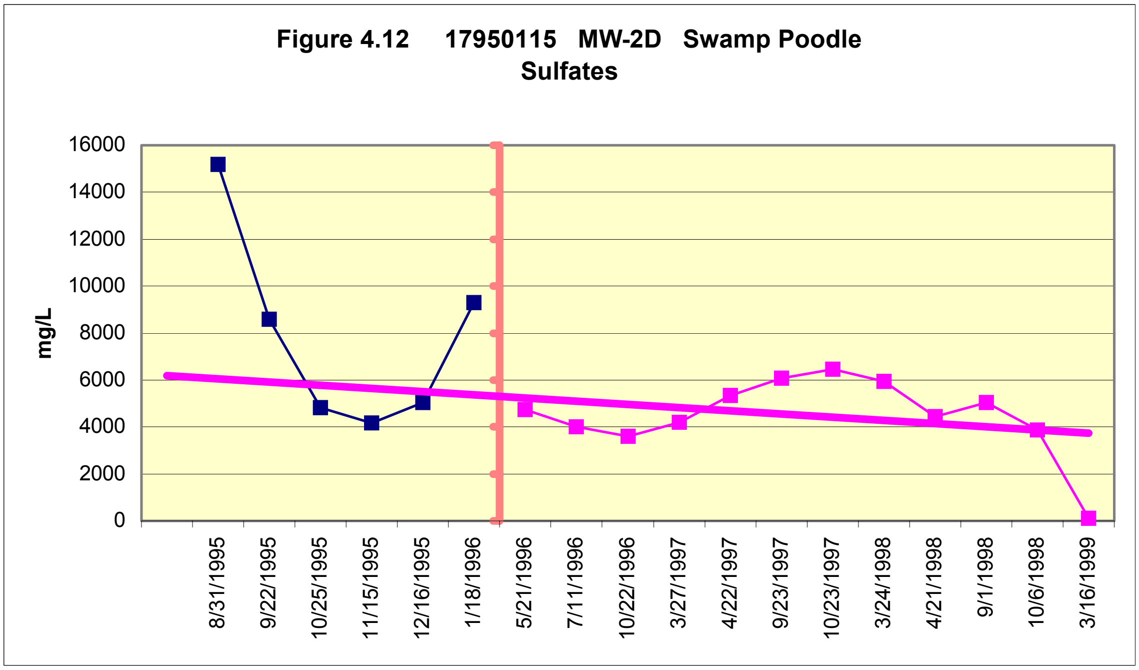


Figure 4.12   17950115   MW-2D   Swamp Poodle
Sulfates

The acidity concentration trend (figure 4.13) at MW-2D drops after mining and ash placement begin and is close to the trend of sulfates, as was the case at MW-1U. The field pH (figure 4.14) shows a more modest downward trend from an average of 3 down to 2.3, with one "spike" of 7.8 in January 1996. The alkalinity is below instrument detection limits. TDS (figure 4.15) follows the sulfate trends, suggesting that sulfates are the main contributors to the dissolved constituents leaving the site, given the sulfate concentrations are in the same magnitude as TDS concentrations.

Figure 4.13 17950115 MW-2D Swamp Poodle Acidity

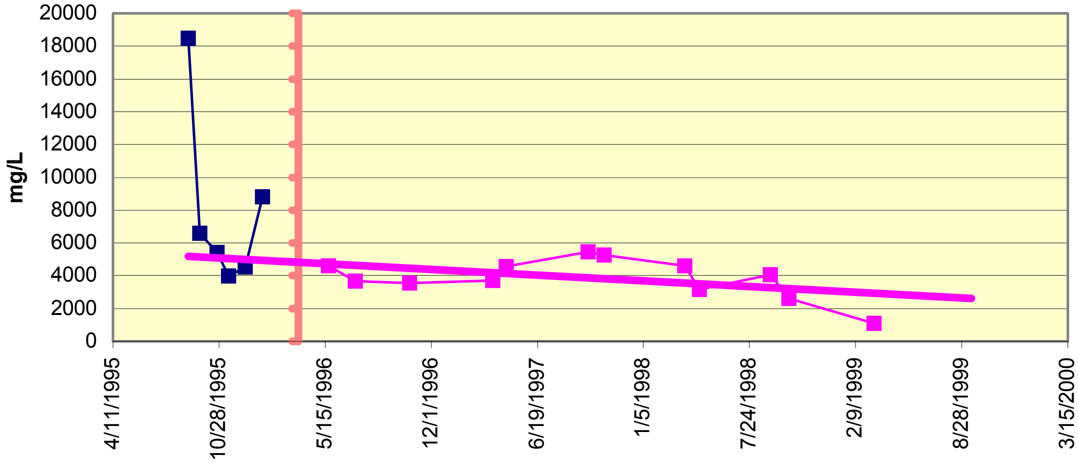
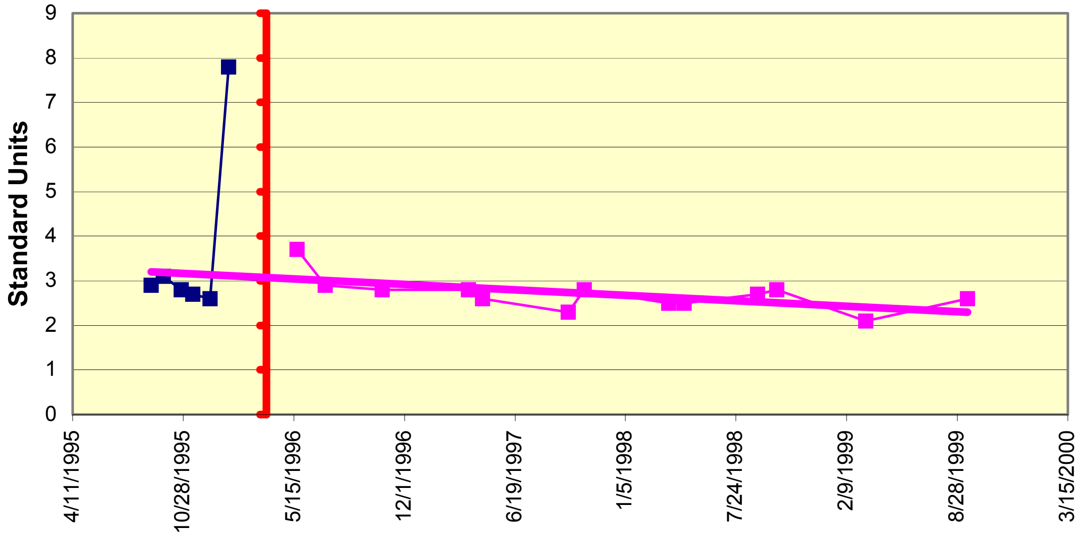
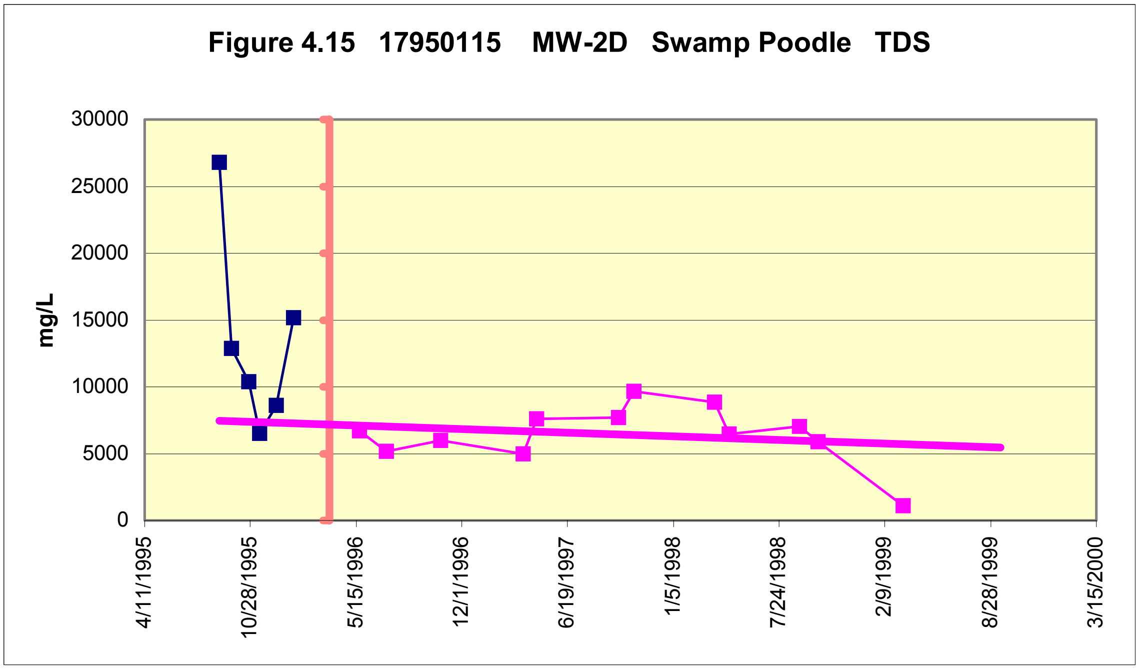


Figure 4.14 17950115 MW-2D Swamp Poodle pH





Chloride (figure 4.16) and magnesium (figure 4.17) have trends sloping upward at MW-2D, with chloride exceeding the DWS of 250 mg/L in the fall of 1997. A large anomalous spike of 2400 mg/L occurs in December, 1995.

Calcium concentrations (figure 4.17) have a downward sloping trend. The calcium values after ash placement are equal to or slightly below baseline values. The magnesium averages are slightly higher than baseline concentrations. As at MW-1U, however, there are too few samplings after ash placement to assess whether significant changes in overall concentrations of calcium and magnesium are occurring after the baseline period. On their face, the three measurements of calcium after ash placement suggest that if the ash is adding calcium to the system, it is leaving the site faster than it is being liberated from the ash.

Figure 4.16 17950115 MW-2D Swamp Poodle Chloride

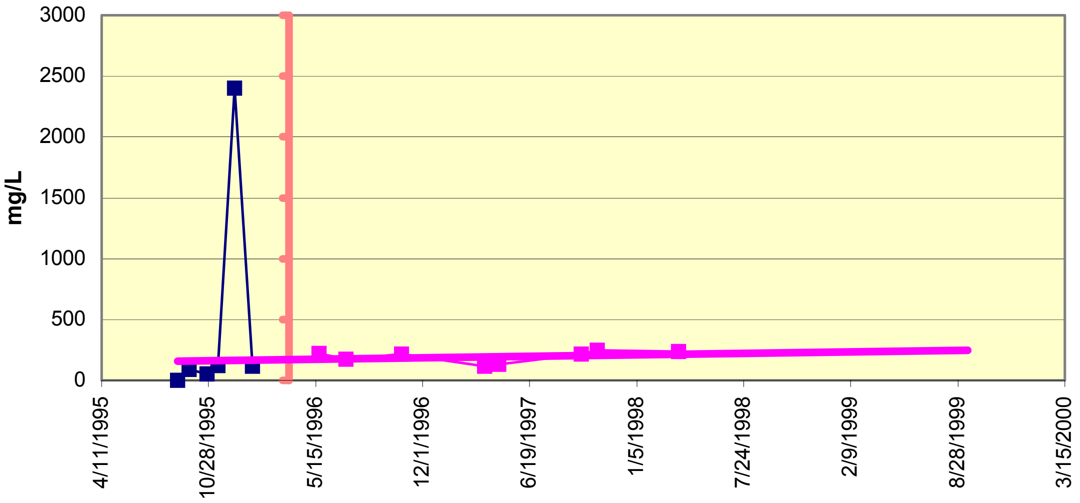
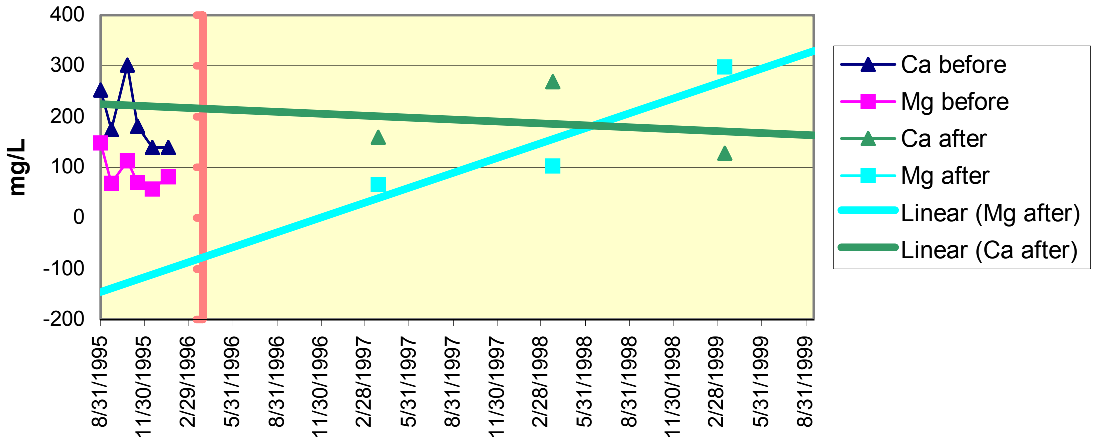
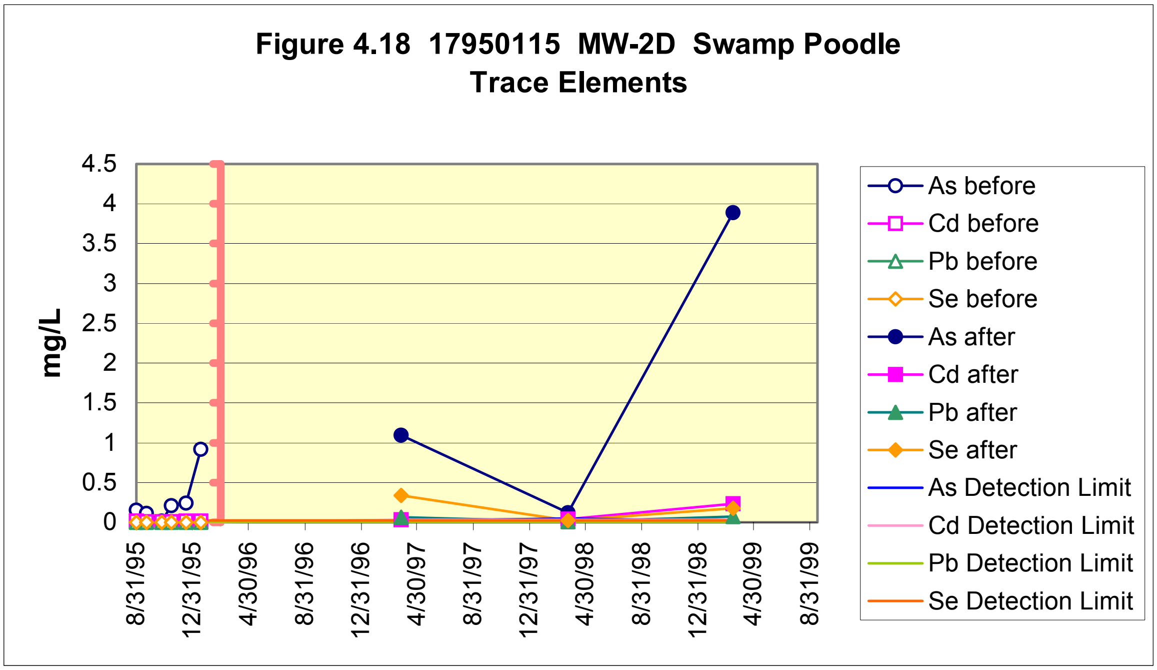


Figure 4.17 17950115 MW-2D Swamp Poodle Calcium & Magnesium



Concentrations of the trace elements at MW-2D (figure 4.18) undergo marked increases after mining and ash placement. However, as occurred with calcium and magnesium, a reduction in sampling to an annual basis after the baseline period and the termination of monitoring after only three measurements were collected does not enable reviewers of this data to gain a firm understanding of trends that may be occurring. Concentrations below detection limits for selenium and lead were reported mostly in the baseline monitoring period at <0.0230 mg/L and <0.0100 mg/L respectively. Arsenic levels at this monitoring point were already high during the baseline monitoring period. A very high level of arsenic, 0.9180 mg/L, was measured in January 1996, 4-6 times higher than all other baseline concentrations and reportedly measured just before the mining and ash placement operation began. However in March 1999, three years into ash placement, arsenic sharply increases to 3.89 mg/L, 389 times higher than the DWS of 0.01 mg/L (effective January 23, 2006), and 78 times higher than the former DWS. This increase appears to be a result of contamination from the ash and is so high that it masks the high levels of other trace elements. Cadmium rises from 1-3 times its DWS in baseline measurements to 8 times its DWS in 1998 and 46 times its DWS in 1999. Selenium is below detection limit during baseline monitoring and then rises to more than 6 times its DWS in 1997 and more than 3 times the standard in 1999. Lead concentrations are 6-7 times the detection limit measured in baseline monitoring in March 1997 and March 1999.



The table below illustrates the trace metal concentrations at MW-2D after mining and ash placement began along with the DWS (federal MCL) for these metals. The 1997 measurement for cadmium and the 1998 measurement for lead were below detection limits.

	MCL Mg/L	**1997 mg/L**	**1997 X MCL**	**1998 mg/L**	**1998 X MCL**	**1999 mg/L**	**1999 X MCL**
Arsenic	0.010*	1.095	109.5 X	0.119	11.9 X	3.89	389 X
Cadmium	0.005	<0.03	6 X	0.04	8 X	0.23	46 X
Lead	0.015	0.063	4.2 X	<0.005	Below MCL	0.069	4.6 X
Selenium	0.05	0.334	6.68 X	0.024	Below MCL	0.177	3.54 X

effective 1/23/06

In the above chart, the first column designates the trace metal, and the second column contains the DWS concentrations (Maximum Contaminant Level) for each element. The third column contains the measured concentrations for each element at MW-2D for the year 1997, and the fourth column is the factor that the measured concentration exceeds the MCL value. For example, the MCL for arsenic (effective 1/23/06) is 0.01 mg/L; the measured amount recorded in 1997 at MW-2D was 1.095 mg/L. The number of times the measured amount exceeds the MCL is displayed in column four. A number followed by an "X" means that this is the factor by which the MCL is exceeded. For the arsenic example in 1997, the value is 109.5 X. This means that the arsenic number recorded from MW-2D in 1997 is 109.5 *times* the MCL value. The columns for 1998 and 1999 data were calculated in the same fashion as for 1997.

The fact that only annual sampling for trace metals was undertaken after ash placement began hampers assessment of the causes of these elevated levels of trace elements, although such levels are not unusual at downgradient sampling points around non-mine coal ash disposal facilities. Their occurrence simultaneously with the sharp drop in acidity, sulfate and TDS at MW-2D is of note. These levels of trace elements decisively underscore why more than three years of monitoring much less monitoring only once each year is needed for trace elements at mine coal ash placement sites.

MW-3D

The major element graphs for MW-3D (figures 4.20, 4.21, and 4.22) show lower values than MW-2D, but the trends more clearly indicate degradation. Iron, manganese, and sulfates have increasing concentrations over time. In the case of manganese (figure 4.21) and sulfates (figure 4.22), the groundwater was degraded substantially beyond the poor water quality shown in baseline measurements. The iron and manganese values rose to many times over the DWS, while the sulfates rose from twice to over 8 times the DWS. These values reflect the diluted mine pool water being sampled at this well whereas undiluted mine pool water was monitored at MW-2D, as indicated in the permit text.

Figure 4.20 17950115 MW-3D Swamp Poodle Iron

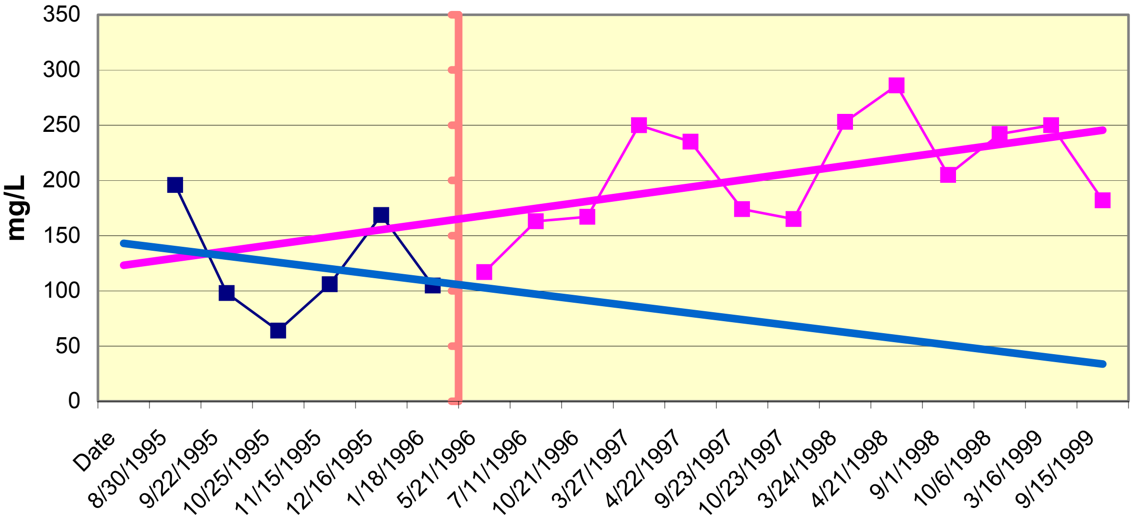


Figure 4.21 17950115 MW-3D Swamp Poodle Manganese

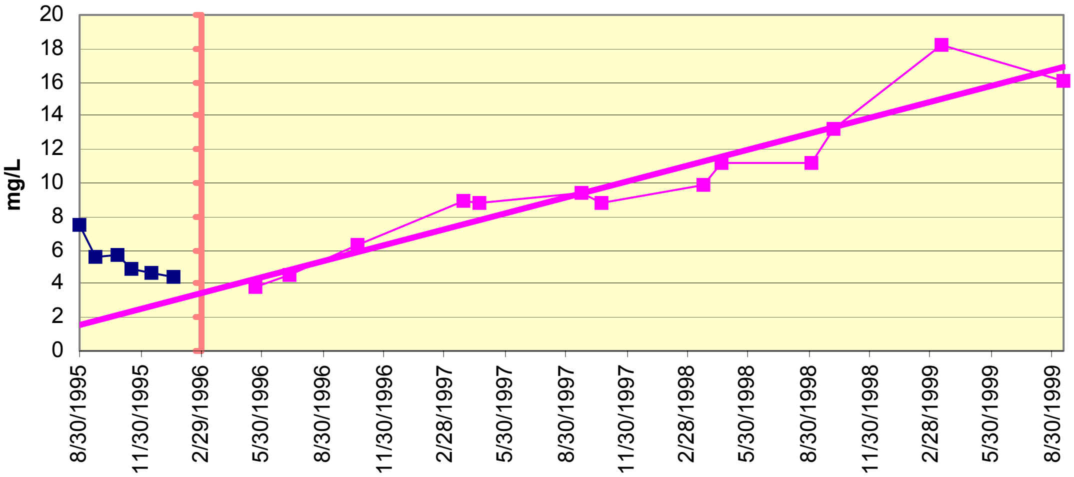
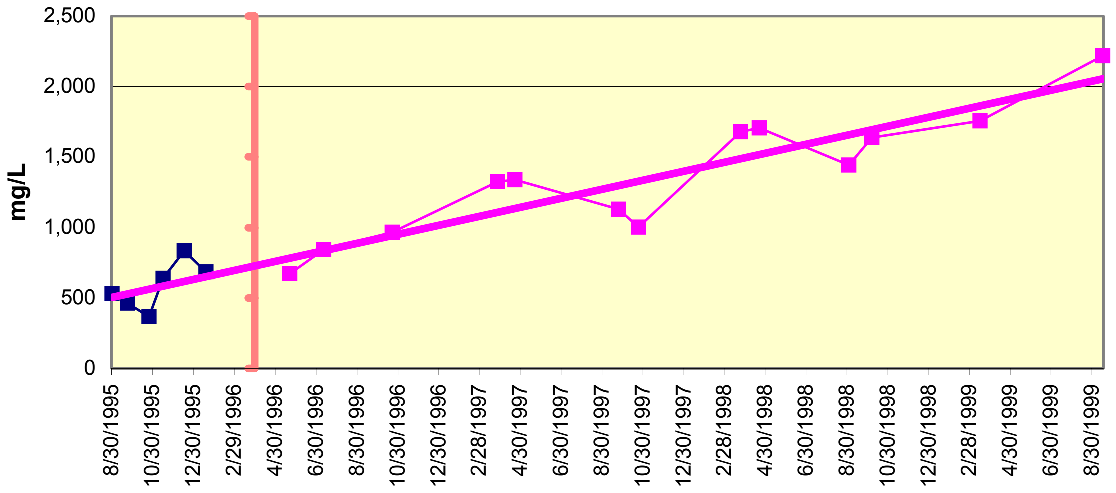
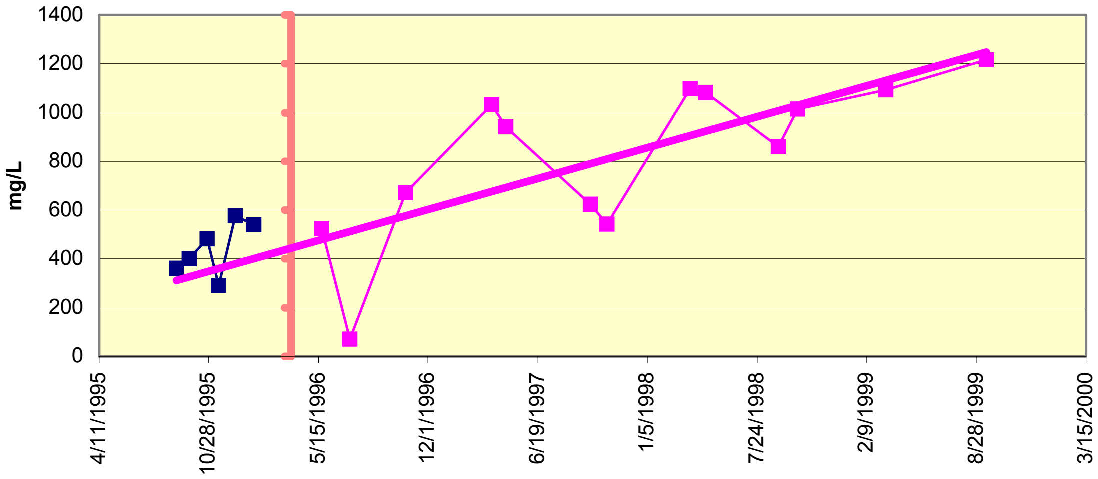


Figure 4.22 17950115 MW-3D Swamp Poodle Sulfates



Acidity has a strong upward trend (figure 4.23) at MW-3D along with TDS (figure 4.25), which increases by nearly 3 times from baseline levels during the three-year monitoring period while ash placement occurred. These values are probably dominated by the sulfate input. The average field pH dropped by about a half unit over this three year period (figure 4.24) from 3.5 to below 3, despite a large "spike" to 7.8 in January 1996, and the alkalinity was below detection limits except for the first baseline reading of 4 mg/L.

Figure 4.23 17950115 MW3-D Swamp Poodle Acidity



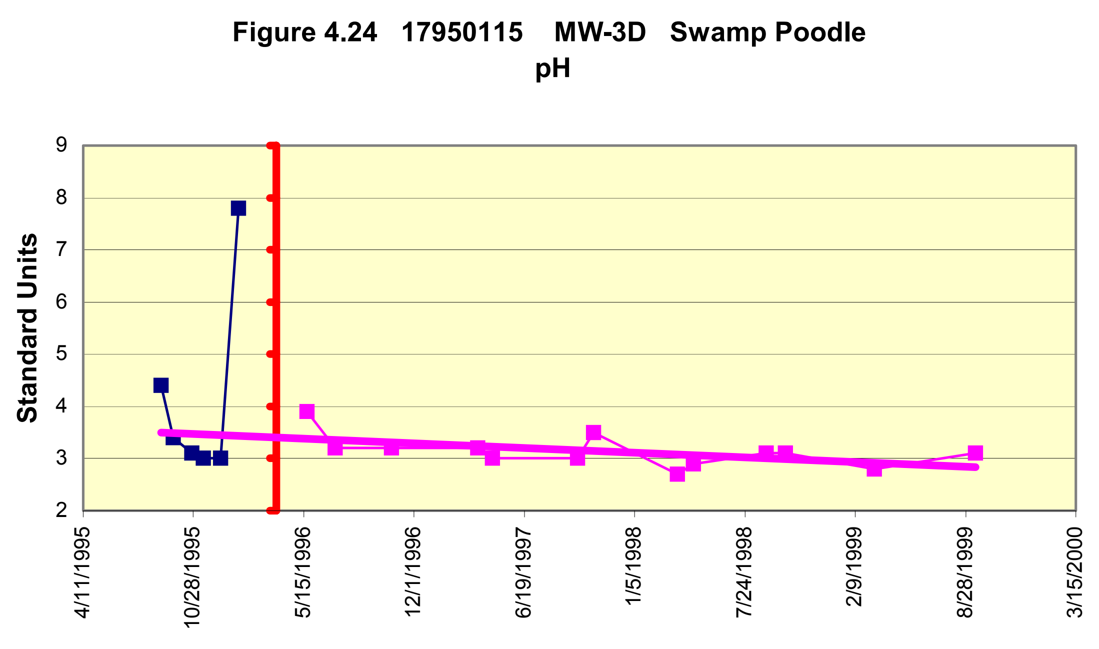
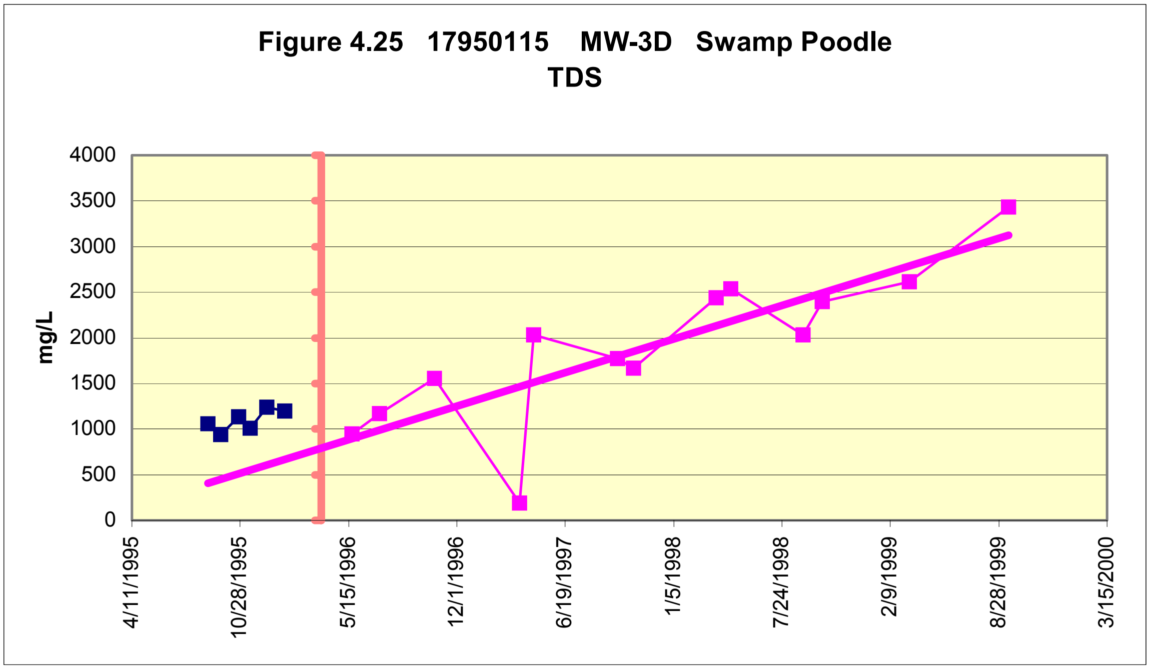
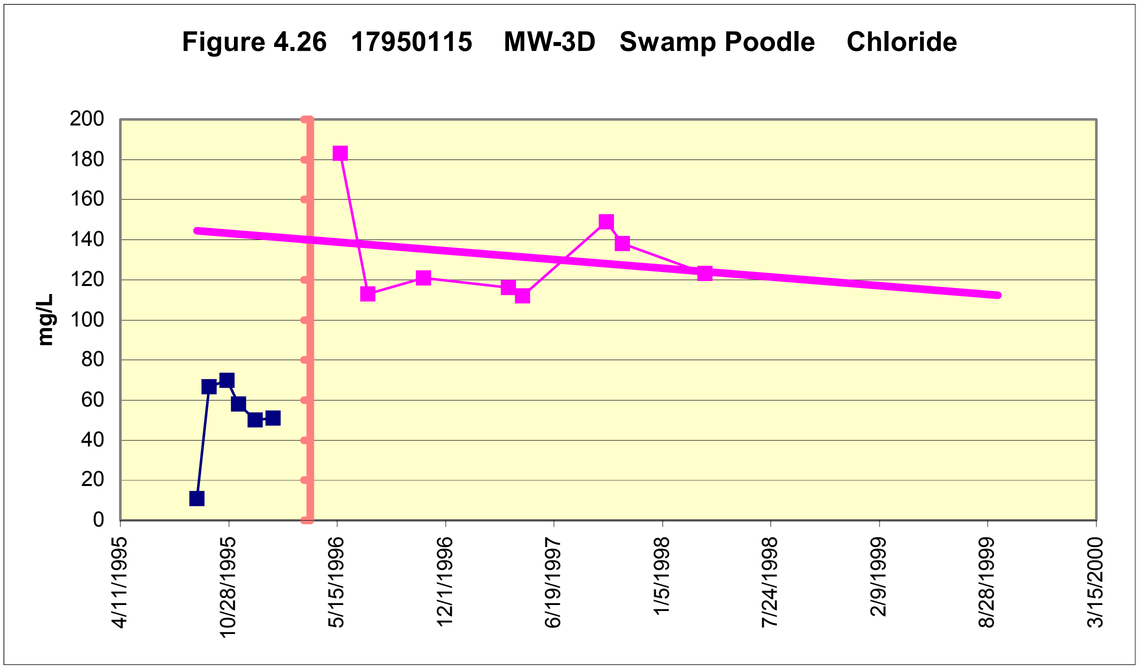
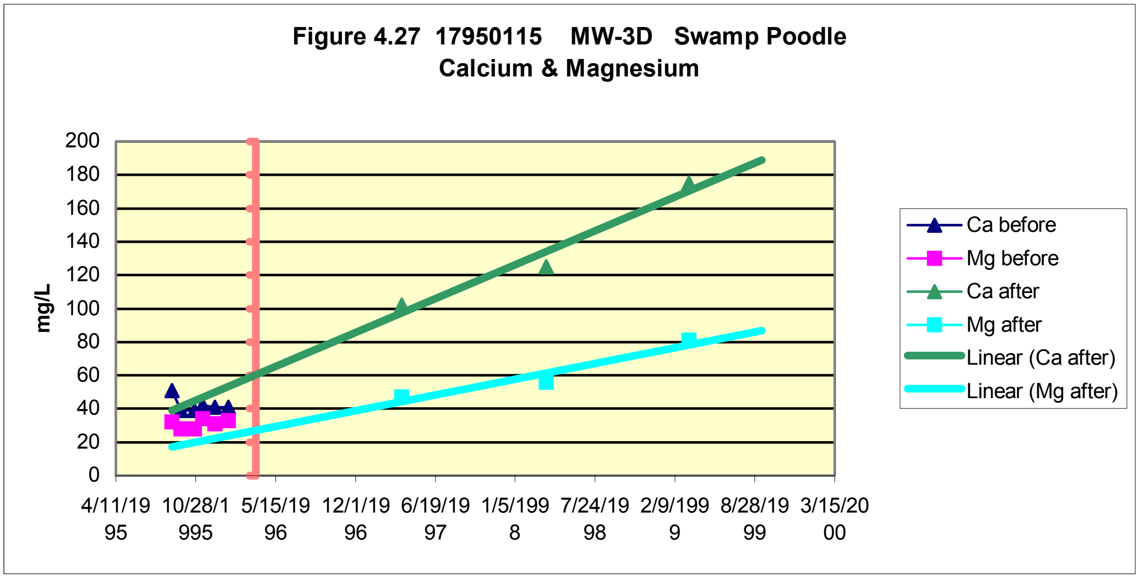


Figure 4.24 17950115 MW-3D Swamp Poodle
pH
Standard Units
9
8
7
6
5
4
3
2
4/11/1995
10/28/1995
5/15/1996
12/1/1996
6/19/1997
1/5/1998
7/24/1998
2/9/1999
8/28/1999
3/15/2000



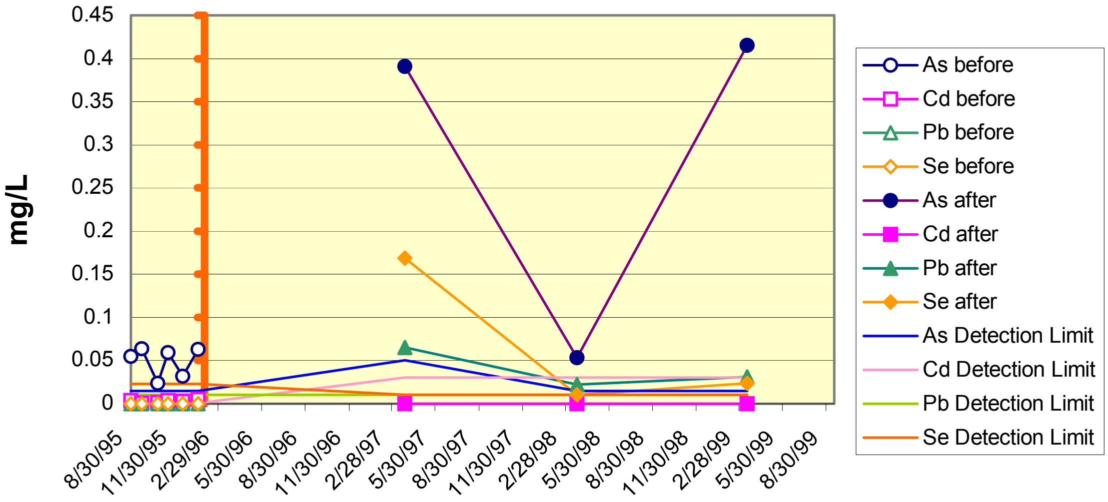
The chloride concentrations (figure 4.26) at MW-3D had a negative trend with average values falling from 140 mg/L to 115 mg/L. However concentrations during ash placement were approximately twice the concentrations before ash placement started. The calcium and magnesium (figure 4.27) had positive trends, probably due to ash leachate. The calcium rose from 100 mg/L to 175 mg/L after baseline measurements. As stated previously, more than three measurements over a three year period of ash indicator parameters such as calcium, magnesium, and trace metals are needed to gain a more firm understanding of trends in their levels at any site. Still one would expect to see higher concentrations of ash parameters in water downgradient of the ash when ash constituents are being mobilized in that water.





The trace elements, arsenic, cadmium, lead, and selenium, are graphed in figure 4.28 for MW-3D. As was the case at MW-2D, measured concentrations for each of these elements are notably higher after ash placement than during the baseline monitoring period. While 4 of the 6 baseline measurements for arsenic exceeded the DWS, arsenic exceeded the highest of these baseline concentrations by more than six times in March 1997 (at 0.391 mg/L) and March 1999 (at 0.415 mg/L). Baseline selenium and lead values represent instrument detection levels of 0.023 and 0.01 mg/L respectively. Actual measured concentrations of selenium during the ash placement period reach 7.3 times the baseline detection level in March 1997 (at 0.169 mg/L), and lead concentrations exceed baseline detection levels by 2.2 to 6.5 times. Post ash placement cadmium values are below a detection level of <0.03 mg/L. which is six times the DWS and 7.5 to 30 times higher than actual concentrations of cadmium measured during the baseline period. Thus a high detection level does not allow one to discern if the water at MW-3D is being contaminated with cadmium at levels that would make the water harmful for people to consume. The maximum values for these trace elements, while substantially higher than baseline values, drinking water standards and most concentrations measured at upgradient MW-1U, are still lower than the maximum concentrations measured at MW-2D after ash placement began.

Figure 4.28 17950115 MW-3D Swamp Poodle
Trace Elements



The chart below summarizes the factors by which the concentration levels at MW-3D exceed the DWS after mining and ash placement begin. The exception is cadmium values which were reported at below a detection limit of <0.030 mg/L during the ash placement period. These numbers are presented and calculated in the same manner as those in the chart for the MW-2D trace elements.

	MCL mg/L	1997 mg/L	1997 X MCL	1998 mg/L	1998 X MCL	1999 mg/L	1999 X MCL
Arsenic	0.010*	0.391	39 X	0.053	5.3 X	0.415	41.5 X
Cadmium	0.005	<0.03		<0.03		<0.03	
Lead	0.015	0.065	4.3 X	0.022	1.4 X	0.031	2.1 X
Selenium	0.05	0.169	3.38 X	0.010	Below MCL	0.024	Below MCL

* effective January 23. 2006

MW-4D

MW-4D is located southwest of MW-3D (see map) and is one of the three downgradient ash monitoring wells on the site.

The iron concentrations at MW-4D (figure 4.29) show a decreasing trend after ash placement. The first iron measurement, at 78 mg/L, is about the same as the average baseline value; then a rise to 176 mg/L in the summer of 1996 before iron concentrations decline to slightly above to well below baseline levels in 1997 and late 1998. This trend is opposite that of iron at MW-3D. The manganese concentrations are plotted in figure 4.30, and show a rising trend after baseline monitoring. This trend is similar to that at MW-3D, but the values at MW-4D are not quite as high. The sulfates also show levels that exceed baseline levels and a rising trend (figure 4.31) after mining and ash placement start similar to MW-3D, but also with lesser average values.

Acidity increases over time at MW-4D (figure 4.32), but the highest average concentrations represented by the trendline rise at most about 70 mg/L above baseline values. Usually, the sulfates contribute most heavily to acidity, but the sulfate trend average rises nearly 500 mg/L above baseline; some element(s) in the groundwater at MW-4D appear to be buffering acidity to some extent.

The field pH (figure 4.33) shows a downward average trend, from an average value of 3.7 down to about 2.8. These pH numbers represent a very acidic groundwater environment, and the trends and values for pH at MW-4D are similar for those at MW-3D and MW-2D.

The plot for TDS (Total Dissolved Solids) (figure 4.34) is almost identical to that of sulfates for MW-4D, except that the average TDS values are about 225 mg/L higher than the sulfate concentrations. As the graph curves have very close shape relationships, the TDS behavior is probably controlled chiefly by the sulfate concentrations.

Figure 4.35 illustrates the chloride concentrations over time, and shows a slightly decreasing average trend. All of the values, except for the 310 mg/L peak in June 1996, are below the highest baseline point of 280 mg/L. This high level of chloride relative to levels seen at most other sites studied in this project as well as the influx of chloride in June 1996 is probably due to road salt contamination, from the proximity of State Route 53 to MW-4D; the edge of the highway is less than 100 feet from the well.

The calcium and magnesium values and trends for MW-4D are shown in figure 4.36. This graph illustrates the usual six baseline points, and just three yearly monitoring results provided for ash parameters at the Swamp Poodle site. The calcium trend is increasing, with values well above baseline concentrations, showing that ash probably contributed much of this calcium. The magnesium trend is very slightly downward, but there is still a significant jump in magnesium concentrations above baseline values, indicating a fast change in the groundwater chemistry after ash placement.

Figure 4.29 17950115 Swamp Poodle MW-4D Iron

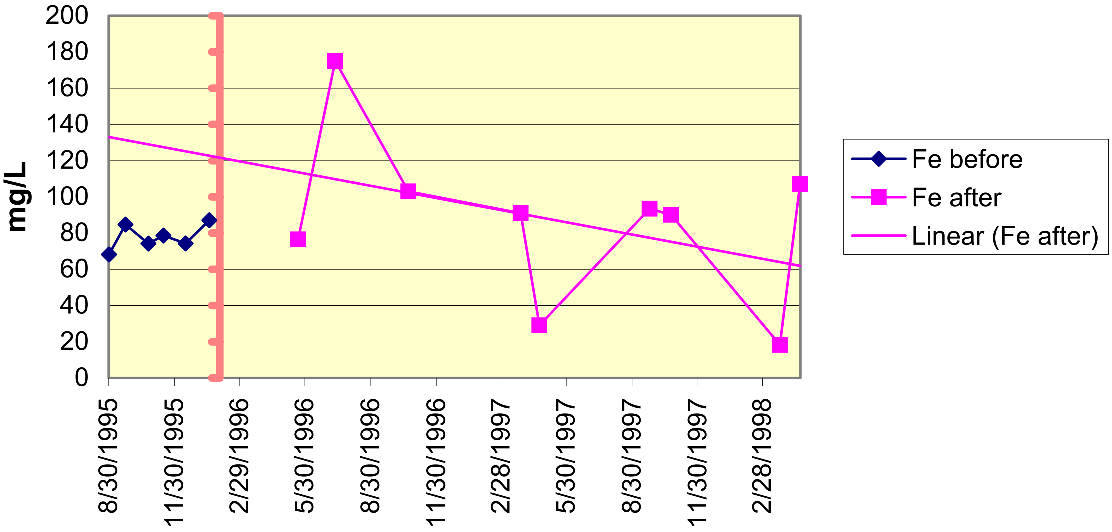


Figure 4.30 17950115 Swamp Poodle MW-4D Manganese

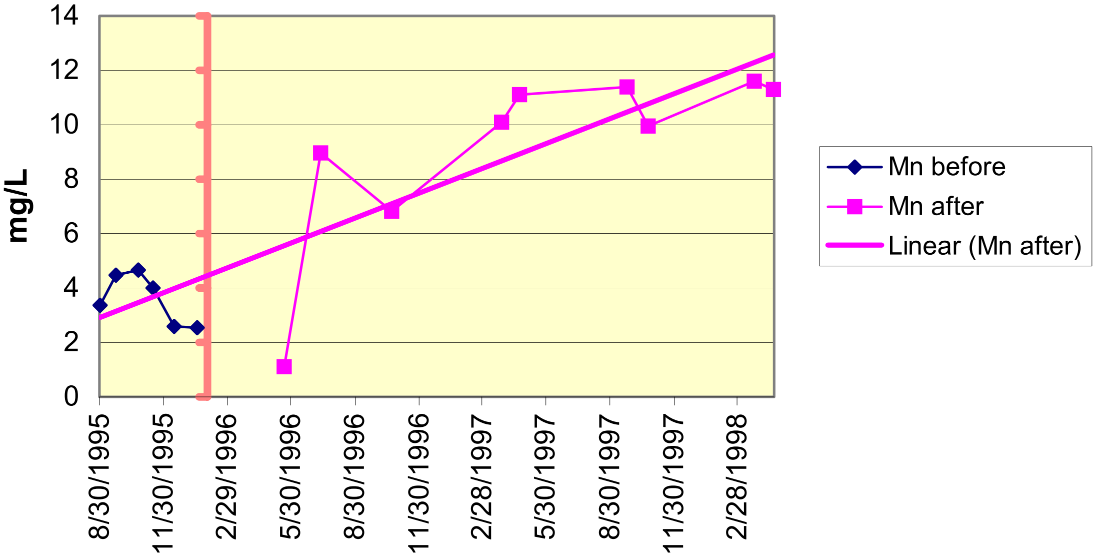
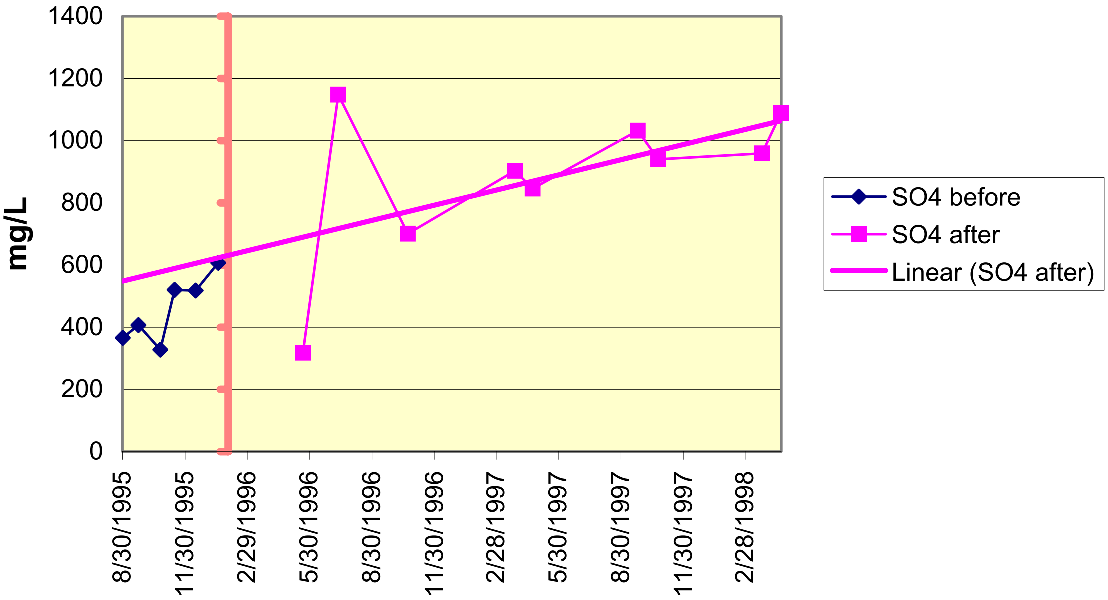


Figure 4.31 17950115 Swamp Poodle MW-4D Sulfates



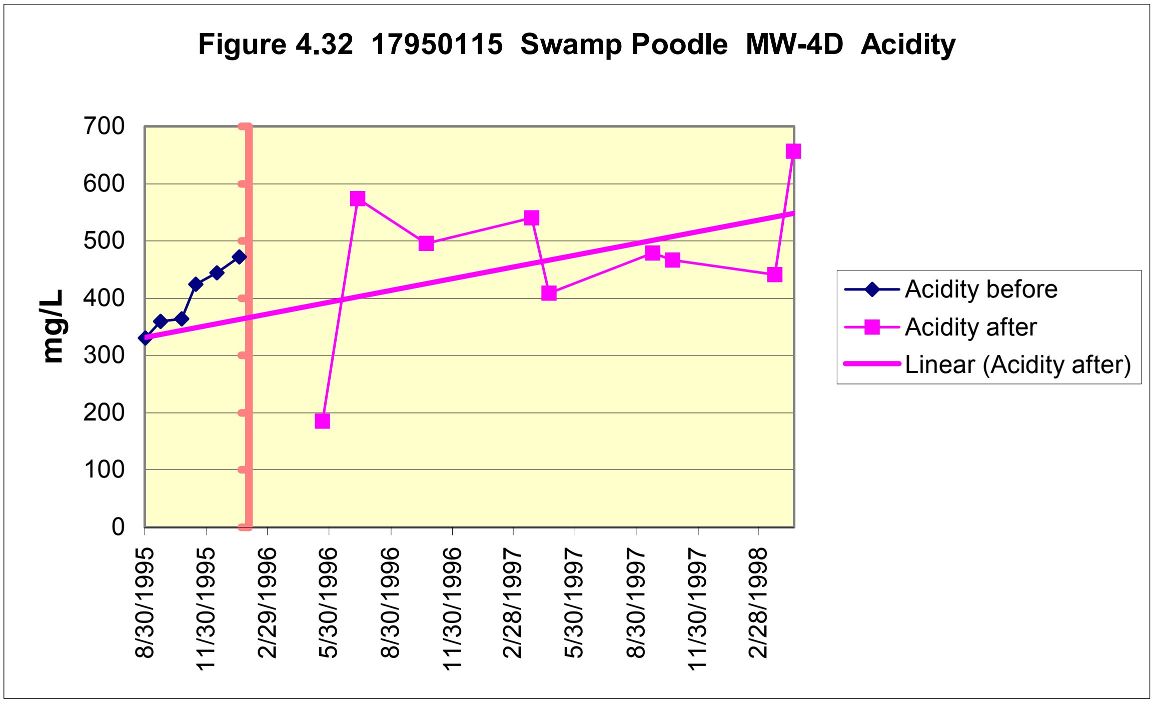


Figure 4.32 17950115 Swamp Poodle MW-4D Acidity
mg/L
0
100
200
300
400
500
600
700
8/30/1995
11/30/1995
2/29/1996
5/30/1996
8/30/1996
11/30/1996
2/28/1997
5/30/1997
8/30/1997
11/30/1997
2/28/1998
Acidity before
Acidity after
Linear (Acidity after)

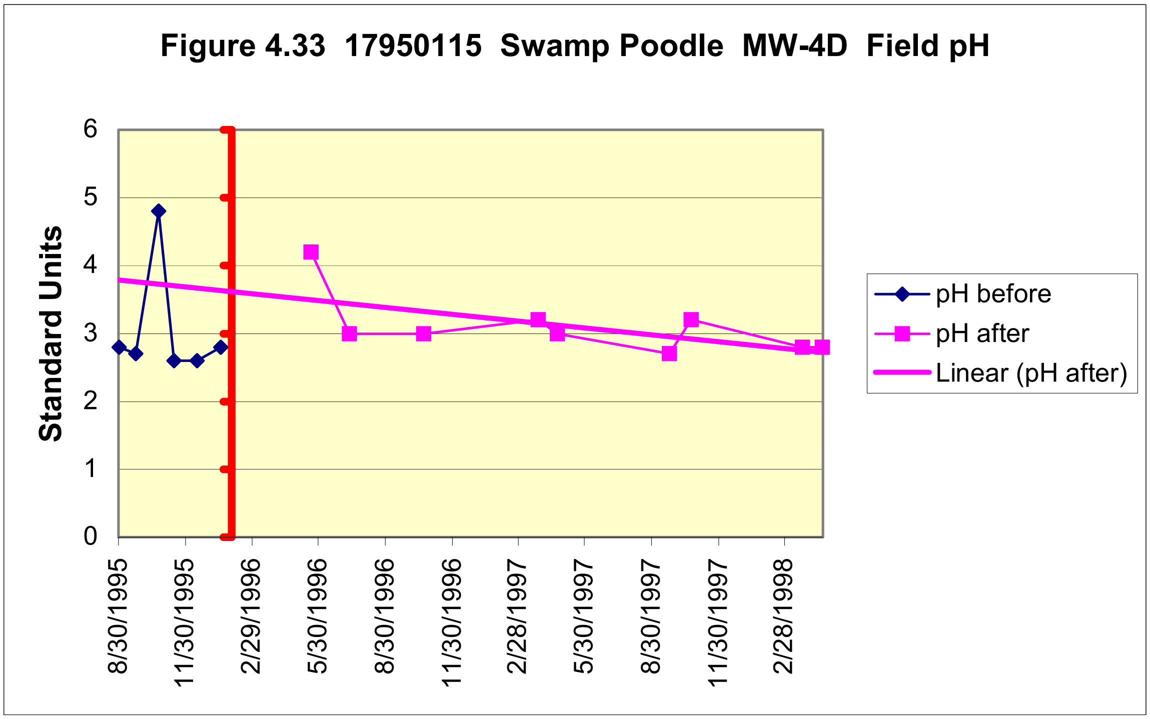


Figure 4.33 17950115 Swamp Poodle MW-4D Field pH
Standard Units
0
1
2
3
4
5
6
8/30/1995
11/30/1995
2/29/1996
5/30/1996
8/30/1996
11/30/1996
2/28/1997
5/30/1997
8/30/1997
11/30/1997
2/28/1998
pH before
pH after
Linear (pH after)

Figure 4.34 17950115 Swamp Poodle MW-4D TDS

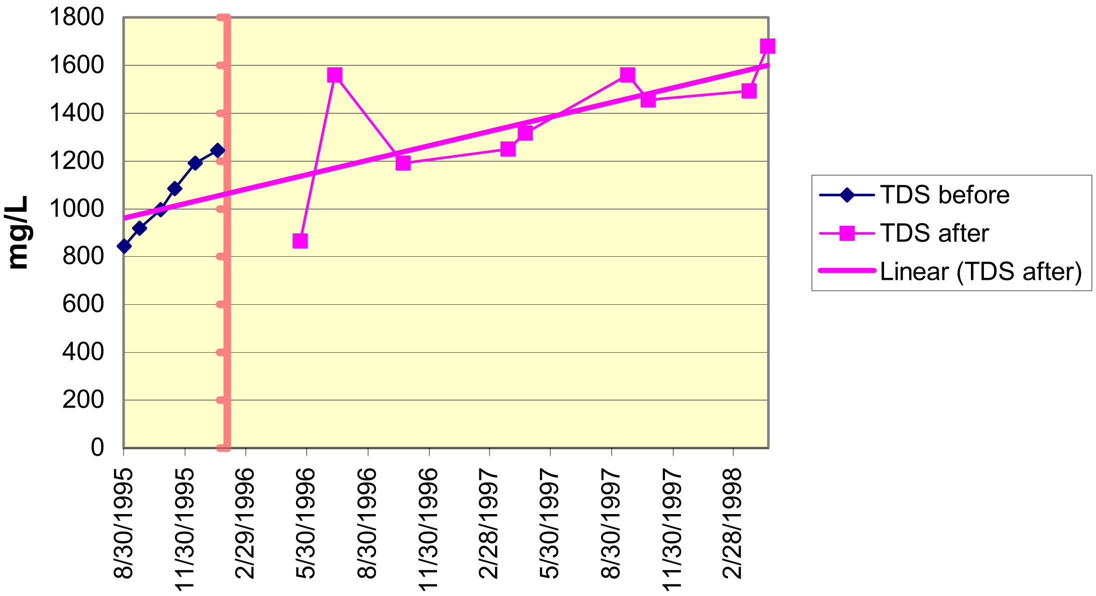


Figure 4.35 17950115 Swamp Poodle MW-4D Chloride

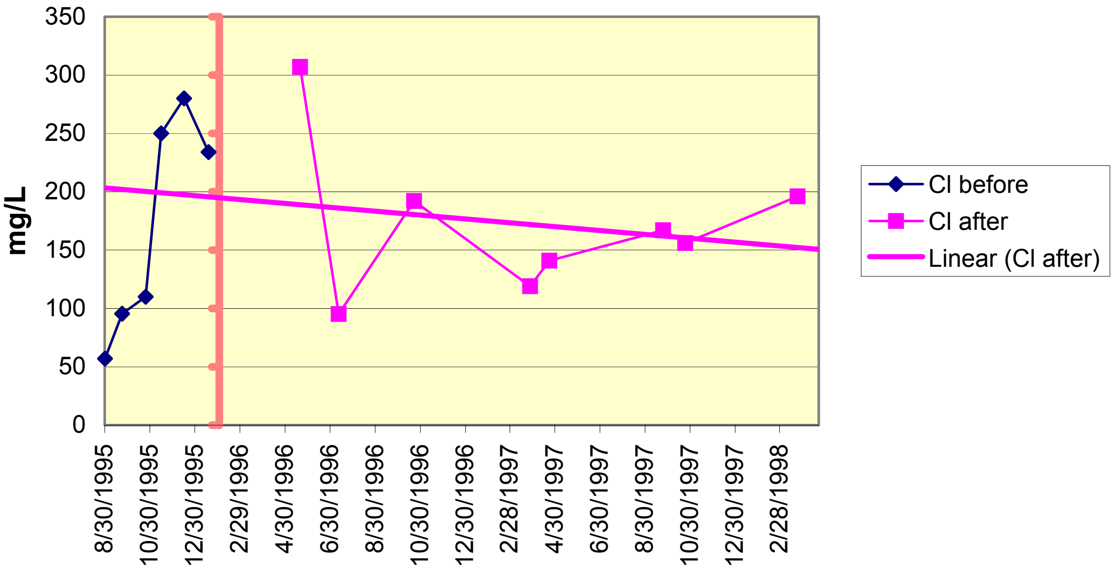
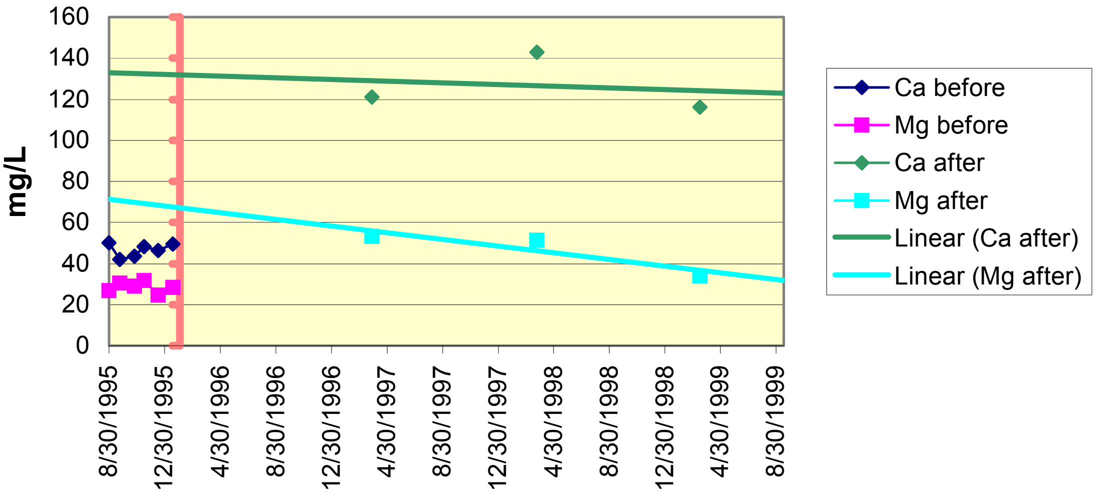


Figure 4.36 17950115 Swamp Poodle MW-4D
Calcium and Magnesium



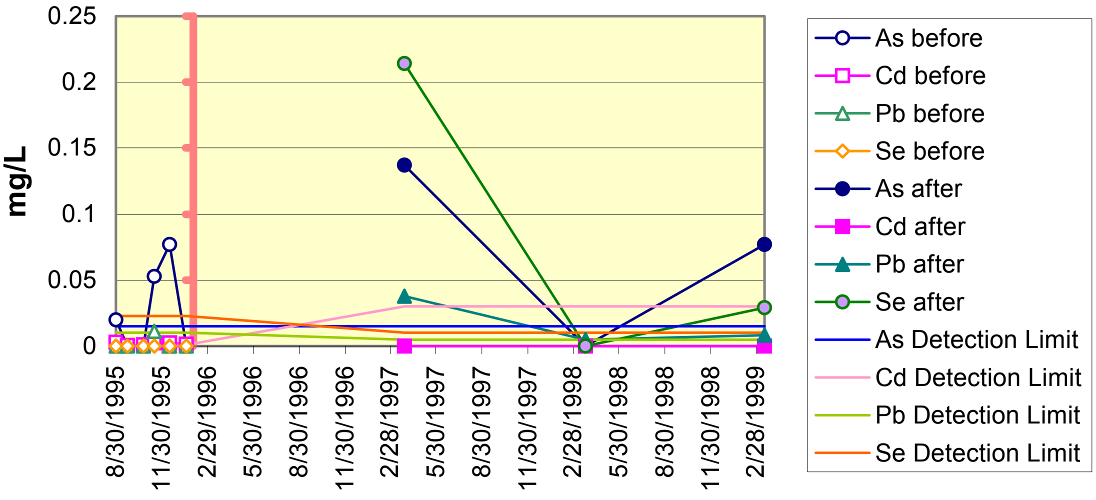
The trace elements arsenic, cadmium, lead, and selenium are plotted in figure 4.37. As has been the case at the other downgradient wells, measured concentrations are notably higher after ash placement than during the baseline monitoring period. The highest concentrations of arsenic, lead and selenium measured at MW-4D occur during the first sampling event in the ash placement period (March 1997), a year and two months after ash shipments first arrived. At 0.137 mg/L arsenic is nearly twice the highest baseline level (0.077 mg/L), almost 14 times the DWS and nearly 3 times the former DWS. Lead is measured at 0.038, nearly four times baseline detection levels and almost 3 times the DWS. Selenium was measured at 0.214 mg/L in March 1997, more than 9 times higher than baseline detection levels, more than 4 times the DWS and higher than the highest selenium concentration at MW-3D, 0.169 mg/L also in March 1997. However, unlike MW-2D and MW-3D, measurements for these trace elements at MW-4D in 1998 and 1999 were not above baseline concentrations. An exception was selenium which was measured at 0.029 mg/L in the March 1999 sampling while all baseline measurements were <0.0230 mg/L.

Values recorded during the baseline monitoring at MW-4D were usually below instrument detection levels of <0.015 mg/L for arsenic, <0.0100 mg/L for lead and 0.0230 mg/L for selenium. In contrast, as occurred at MW-3D, actual measurements of cadmium concentrations during the baseline monitoring at MW-4D were replaced during the ash placement period with measurements below detection limits of <0.30 mg/L in 1997 and <0.03 mg/L in 1998 and 1999. These are 11 to 600 times above the actual baseline concentrations and 6 to 60 times over the DWS, making it impossible to know whether concentrations of cadmium have been rising to harmful levels from this monitoring.

While concentrations of trace elements at MW-4D are higher than concentrations at the upgradient MW-1U, they are significantly lower than concentrations at MW-2D and, with the exception of selenium, somewhat lower than concentrations at MW-3D. This may reflect the location of MW-4D at a point more isolated from ash than the other two downgradient points.

The higher concentrations of arsenic and selenium at MW-4D in March 1997 nonetheless suggest the ash is contributing these trace metals to the groundwater. However as also occurred at the other monitoring points (including MW-1U), concentrations of these trace elements dropped substantially in most instances in March 1998 at MW-4D. Either the direction of water flow shifted or slackened from the source(s) of contamination, dilution from inflows to these monitoring points occurred or these trace elements in the ash or surrounding mine materials tended to remain more insoluble in a very acidic groundwater environment. In 1999 however most of the trace metal concentrations at MW-4D increased again similar to the pattern at other monitoring points, again possibly reflecting changes in the flow regime or ash placement operations at the site.

Figure 4.37 17950115 Swamp Poodle MW-4D
Trace Elements



Conclusion

Further study is warranted for this site, as the ash placement appears to be contaminating groundwater and adding to the degradation caused by mining at the site. This is indicated most clearly by the higher concentrations after ash placement of arsenic, cadmium, selenium, lead, chloride, and manganese at downgradient monitoring well MW-2D and higher concentrations of arsenic, selenium, lead, chloride, and manganese as well as calcium and magnesium at downgradient monitoring well MW-3D after ash placement. Similar higher concentration trends in manganese, sulfate, calcium and TDS are seen at downgradient monitoring well MW-4D during the period of ash placement but with lower or slightly lower average values..

Steadily rising levels of sulfate and TDS at MW-3D and MW-4D appear to correlate with rising acidity at these points from mining but still could reflect the release of sulfate and other constituents of ash due to that acidity. The amount of ash placed, 214,000 tons, was not enough to neutralize the severe AMD, as evidenced by very high sulfate and acidity levels and further supported by already low pH values that fell slightly during placement. The ash and possibly other mining reclamation activities do appear to have caused a significant decline in acidity at MW-2D.

There are three potential sources for water contamination at the Swamp Poodle site; (1) the water in the abandoned underground workings of the Lower Kittanning Coal, commonly referred to as the "mine pool" water; (2) contamination from the mining operation; and (3) contamination from the placed ash. Using the data from the four selected monitoring wells, the sources of the water degradation can be distinguished to some degree.

MW-1U clearly represents upgradient mine pool water that has not been greatly affected by the strip mining operations or ash placement under this permit, although its water quality does appear to be somewhat impacted from previous mining at its location. The water flows underground from this well toward the strip mine-ash placement operation authorized under this permit. Thus the data from MW-1U demonstrates the contribution the mine pool would be making to rising contaminant levels at the downgradient points. This mine pool water is still degraded as many of the concentrations measured for major elements and some of the concentrations for trace elements at MW-1U are well above DWS. However, with the exception of chloride, the overall concentrations of these elements are lower than the concentrations at MW-2D, MW-3D, and MW-4D.

Ash leachate trends are often suggested by significant rises in calcium, magnesium and chloride in downgradient monitoring points. However, chloride rises in MW-1U to the highest levels seen in all of the wells. Statements in the permit file indicating that road salt is the source of elevated chloride levels are plausible given the vicinity of an interstate, an exit exchange onto the interstate and a state highway on the immediate perimeter of the permit area as well as the timing of high chloride levels being measured in the winter through late spring when residues from road salts might still be washing from soils and entering fluctuating water tables and the mine pool underneath the site. Still, notwithstanding this evidence as well as the acidic conditions that overshadow these elements, rising concentrations of calcium, magnesium and chloride are clearly discernable at MW-3D after ash placement started. MW-4D also shows noticeably higher calcium concentrations and magnesium concentrations that are higher than levels recorded in baseline monitoring.

Further degradation from ash is suggested by trace element concentrations that are substantially higher in MW-2D and MW-3D than in MW-1U and considerably higher from the baseline period to the ash placement period. Initially the arsenic values from MW-2D are 20 times those from the upgradient mine pool, and arsenic from MW-3D are 10 times upgradient mine pool values. In March 1999 arsenic levels at MW-2D are 205 times higher than arsenic levels in the upgradient mine pool, and arsenic levels in MW-3D are 22 times higher than arsenic levels in the upgradient mine pool. The occurrence of high trace elements coinciding with sharply declining acidity, sulfates, and TDS and declining iron at MW-2D suggests that the coal ash rather than AMD is contributing the trace elements. Clearly if more than three samplings had occurred during the ash placement period, a more definitive analysis of the causes for trace element concentrations would be possible. Nonetheless the concentrations that were sampled revealed levels of arsenic, cadmium, lead and selenium that are usually below or close to drinking water standards at the upgradient monitoring point, MW-1U, compared to levels for these elements that are several to many times over drinking water standards at the downgradient monitoring points, MW-2D and MW-3D. The difference in trace element concentrations was not as sharp at MW-4D where only arsenic and selenium were noticeably above baseline concentrations and concentrations at MW-1U and in only one of the three samplings that took place for trace elements after ash placement began.

Nonetheless the fact that trace element concentrations are substantially higher at the downgradient points after mining and ash placement began than before ash placement, is significant and becomes more notable when one considers that those higher levels were found with fewer measurements spread over a longer period (three measurements over four years after ash placement began as opposed to six measurements over five months before ash placement). This suggests a higher probability that the higher levels after mining and ash placement were indicative of actual trends.

Trace element concentrations are often below the detection limits of the analytical instrument measuring the concentrations for lead and selenium during the baseline monitoring period and for cadmium during the ash placement period. High detection levels for cadmium may be hiding concentrations and trends or patterns that reflect adverse impacts to water quality from this toxic trace element.

In addition to differing concentrations in trace elements, a comparison of trend lines for other contaminants at MW-1U, MW-3D, and MW-4D reveals a flat or decreasing average at MW-1U compared to increasing trends and/or higher concentrations after mining and ash placement are underway at MW-3D and MW-4D. This fact clearly shows that with the exception of chloride that appears to come from upgradient road salt close to MW-1U, the upgradient mine pool water is improving in quality and is not contributing to the degradation of water observed in MW-3D.

The same should apply to distinguishing differences between the impacts of the mining and ash placement at this site. Contaminants such as sulfate, iron, and manganese usually rise sharply during strip mining and then settle down as the site is reclaimed and mine spoil is compacted by natural processes. While the rocks at the Swamp Poodle site produced a lot of AMD when mined, the very large reduction in acidity, sulfate, and TDS measured in MW-2D at the end of monitoring support this model.

However, data from MW-3D and MW-4D do not support this model. In the Swamp Poodle operation, ash placement was contemporaneous with strip mining as the ash was placed in the mined-out benches at the Lower Kittanning Coal level. Unlike MW-2D, the trends in all major elements at MW-3D continue to rise at the conclusion of mining and ash placement, suggesting that the placed ash did not contain sufficient alkalinity to neutralize the strongly acidic conditions and that contaminants from the ash were being mobilized in the reclaimed environment. Many of the major concentrations show similar increases at MW-4D also.

As is the case for most of the permits reviewed in this report, monitoring was stopped prematurely at the conclusion of mining and ash placement. Monitoring, however, should be reinstituted and expanded at this site to include: additional monitoring points upgradient, downgradient and in the ash; monitoring for more constituents exclusive to the leachate of ash disposed in this mine; and sampling on at least a quarterly basis for these constituents. These steps will help explain the substantial groundwater degradation from baseline conditions found at the three downgradient monitoring wells.

Permit Review 5

READING ANTHRACITE COMPANY ELLENGOWAN MINE, (PERMIT # 54793203), AND KNICKERBOCKER DEMONSTRATION PROJECT

Site Summary

The 3,038-acre Ellengowan Surface Mine operated by Reading Anthracite Company is located in Mahanoy Township, Schuylkill County, Pennsylvania in the Mahanoy-Shamokin Creeks Priority Watersheds 6B. As of the end of 2003, some 12,145,743 tons of CCW from burning culm (waste anthracite coal) remined from within this permit area and the surrounding region had been placed in three pit areas in this mine over the previous 17 years, making this the largest CCW minefilling operation studied in this Report. This review will first assess the impacts of dumping slurried CCW into the eastern most pit used for ash placement in this mine starting in 1998. It will then discuss the complexities of mine pool flow and monitoring in the area and the potential effects of deep mine fires on baseline water quality at coal ash monitoring points, particularly points further west in the permit area. Former PADEP hydrogeologist, Robert Gadinski, PG, has contributed much of this discussion. The review will then examine water quality impacts at two points monitoring the mine pools under ash placed in middle and western pits in the mine which placement has been underway since 1989. And finally it will compare the water quality through the third quarter of 2006 at all Ellengowan Permit ash monitoring points to the water quality found at points hydrologically connected to the south in the minepool under the neighboring BD Mining operation where an additional 3.7 million tons of CCW (also culm ash) was placed from early 1988 onward. This comparision will also evaluate water quality found at the furthest downgradient ash monitoring point designated by the Ellengowan permit, a deep mine discharge five to six miles west of the permit area.

Geology

The site is located in the eastern part of the Western Middle anthracite field. This field is part of a northeast trending syncline that dominates the local geological structure. Previous mining operations within the site exploited several veins of coal including Little Buck Mountain, Buck Mountain, Seven Foot, Skidmore, Mammoth, Little Primrose, Primrose, and others. The Primrose, Mammoth and Buck Mountain veins have also been deep mined underneath the neighboring BD remining operation.

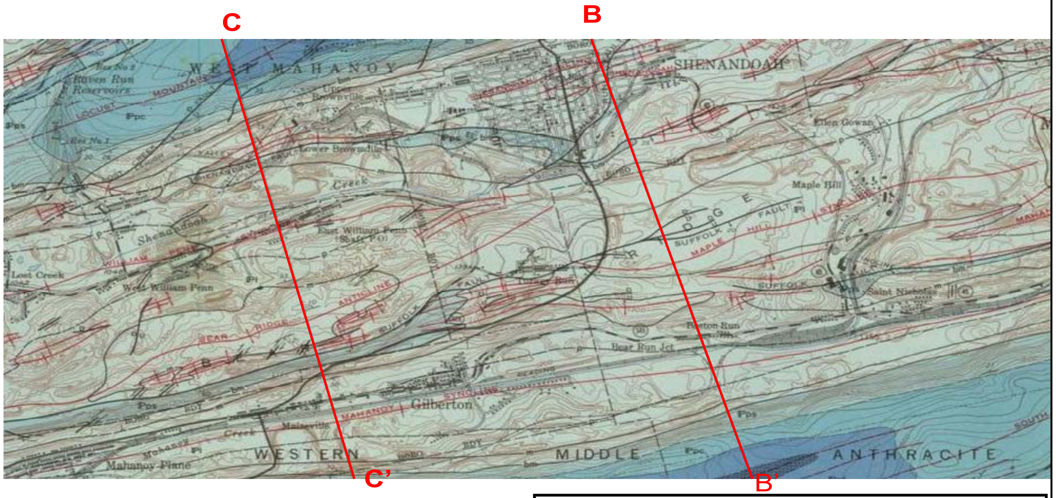
Groundwater Monitoring Discussion

Groundwater in the area is completely dominated by the flow of mine pools through a complex of interconnected mine workings, a man-made karst environment in which water flow behaves more like that of a surface water regime rather than that of groundwater. According to Chapter 7 of the PADEP's Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania (Dec. 2004, Sec. 7.2.3, Fig. 7.5, pp. 213&214), the mine pool water flows in an easterly direction from the water filled Shen Penn Pit (the submerged opening to Indian Ridge Deep Mine) east of the town of Shenandoah to the Knickerbocker Pit and then turns south and southwest toward the Maple Hill Colliery. The flow then reportedly travels west for some six miles toward a local base discharge at the Packer V outfall flowing into the confluence of Mahanoy Creek with Shenandoah Mahanoy Creek at Girardville. PADEP maintains that Packer V is the most downgradient monitoring point of the entire 8000 acre watershed that includes the Ellengowan surface mine and the deep mines beneath it.

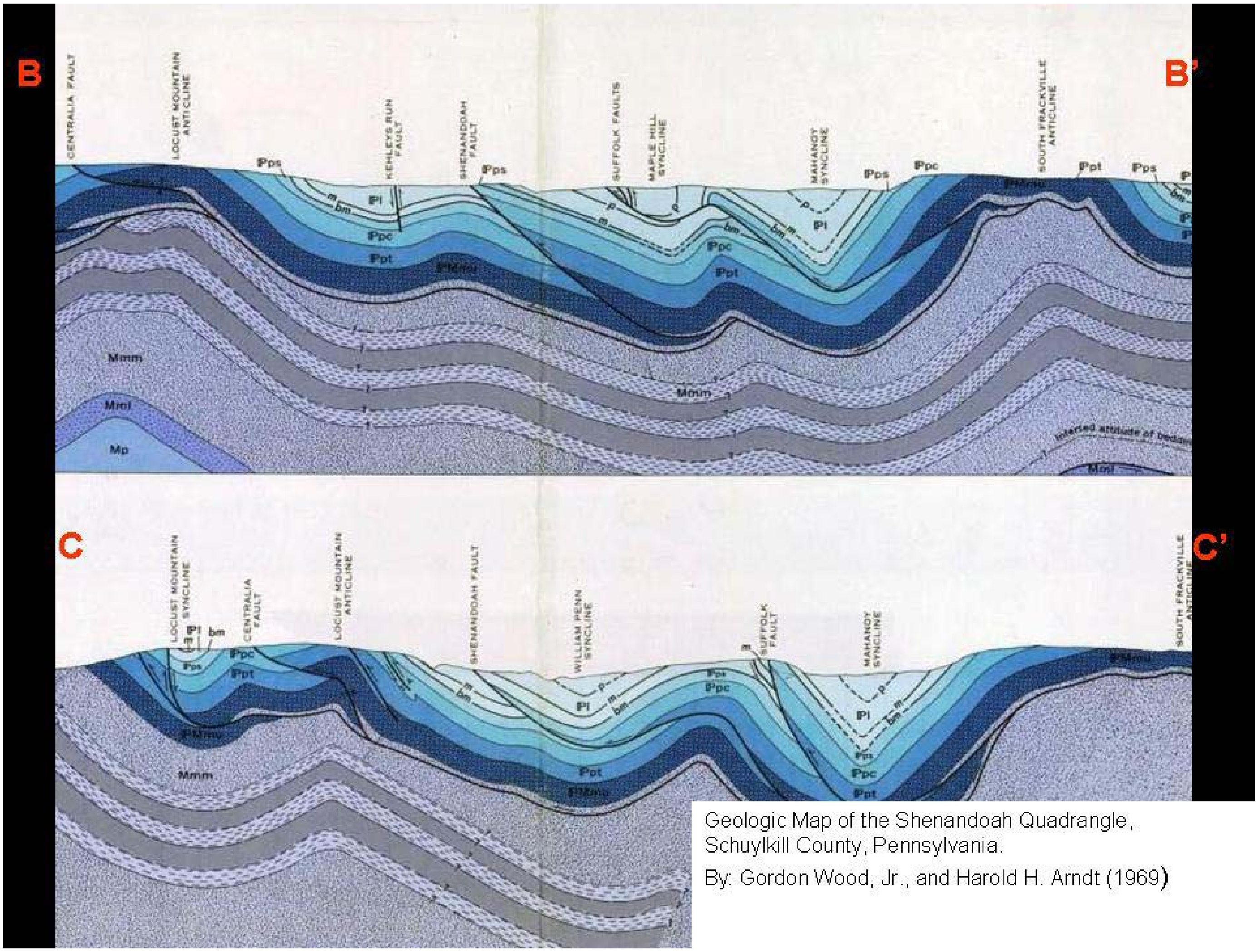
However, an examination of deep mine maps and cross sections from the Pottsville District Office of PADEP calls into question this postulated westerly component of uninterrupted mine pool flow from the Ellengowan permit area paralleling Shenandoah Creek to the Packer V discharge. See MAP 4151-Western Middle Field, Location of Barrier Slope and Shaft Pillars, Mahanoy Division (April 1937) and MAP 4112-Shenandoah Valley Drainage Elevations (Circa. 1959), respectively. These maps do not indicate a reliable hydrologic connection among the West Shenandoah Colliery (deep mine workings) of Reading Company and Packer 3 Colliery of the Girard Estate workings which drains through the Packer III, IV, and V Outfalls (see the Diagram reconstructed from Map 4112 below). Rather they reveal a more clear deep mine drainage connection from the West Shenandoah Colliery to the Maple Hill Colliery. Map 4112 indicates that the Maple Hill Shaft was proposed and used in the 1950s as a major location for pumping deep mine water to the surface to control mine water in the Shenandoah District. Water from collieries as far to the west as the West Shenandoah Colliery was to be "pumped to the surface at Maple Hill." This design implies that any western connection of these deep mine waters to Packer V through the Girard Estate Collieries west of Shenandoah would have been marginalized and only in effect if pumping at Maple Hill was stopped or reduced enough to let mine pools rise high enough to flow west through passageways at higher elevations in the West Shenandoah Colliery. Active pumping at both the Maple Hill Shaft and Gilberton Shaft immediately southeast of the Ellengowan Permit area for the past several decades to control mine pool levels in addition to providing water for two power plants for the past 17-18 years should have precluded this scenario from occurring for any extended times during the operating period of the Ellengowan Permit that this report is examining.

Information on the structural geology of the area further discounts a connection of the Ellengowan mine pool waters to the Packer V discharge. Shenandoah Creek and the deep mines that feed the Packer discharges to it are confined to a separate syncline, the William Penn Syncline that parallels the Mahanoy Syncline underlying Mahanoy Creek and the deep mines under the Ellengown permit area (See Wood and Arndt, below). These parallel synclines are separated by the Bear Ridge Anticline which presents a structural geologic barrier between the Shenandoah Creek and Mahanoy Creek watersheds. It is apparent that this anticlinal structure did contain some mineable coal units in the Llwellyn formation but at a much higher elevation than in the adjacent synclines. Based on Cross Section C below, it is apparent that very few coal seams exist on this anticline with most being eroded since the orogeny. Furthermore, the coal seams dip away from the anticlinal axis in the direction of either the William Penn or Mahanoy Synclines. Consequently, since there is neither a structural or deep mine connection at a low enough elevation to facilitate steady flow between the Maple Hill Complex and

Packer V., the designation of Packer V as the lowest, primary downgradient monitoring point for the Ellengowan Permit and Knickerbocker Demonstration site becomes questionable and problematic.

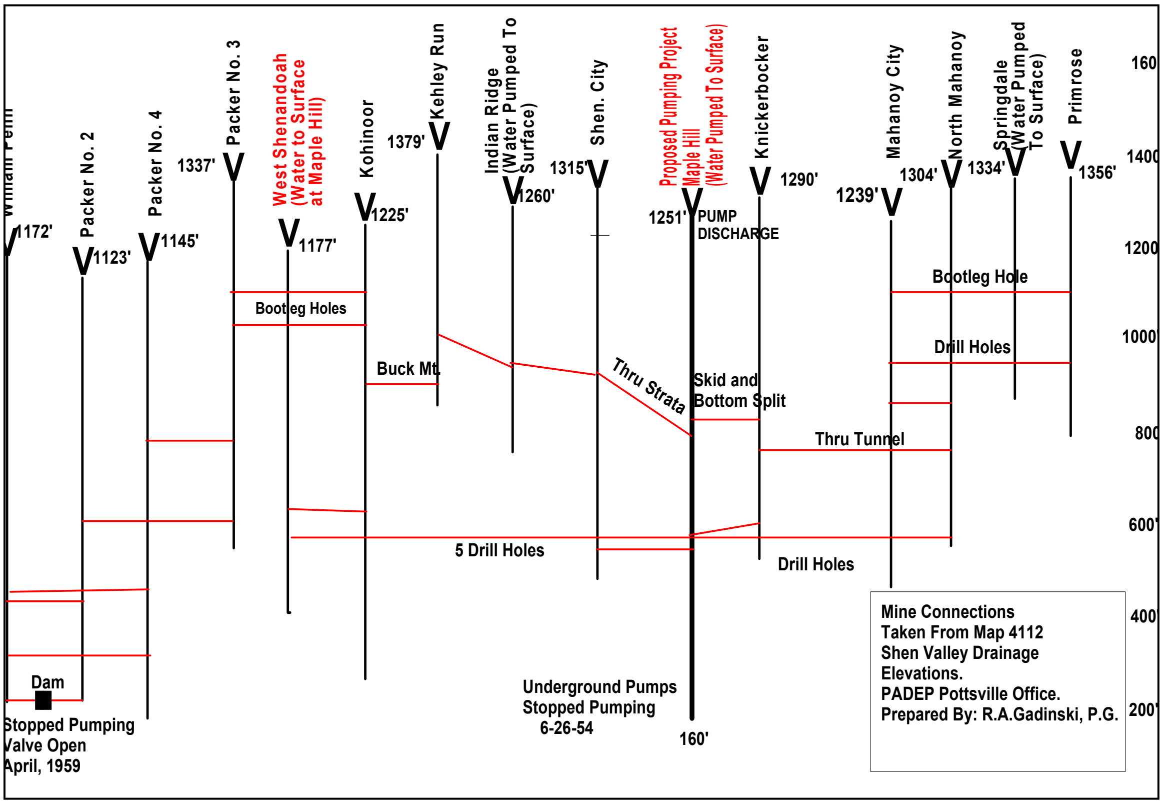


Geologic Map of the Shenandoah Quadrangle,
Schuylkill County, Pennsylvania.
By: Gordon Wood, Jr., and Harold H. Arndt (1969)



Geologic Map of the Shenandoah Quadrangle, Schuylkill County, Pennsylvania.

By: Gordon Wood, Jr., and Harold H. Arndt (1969)



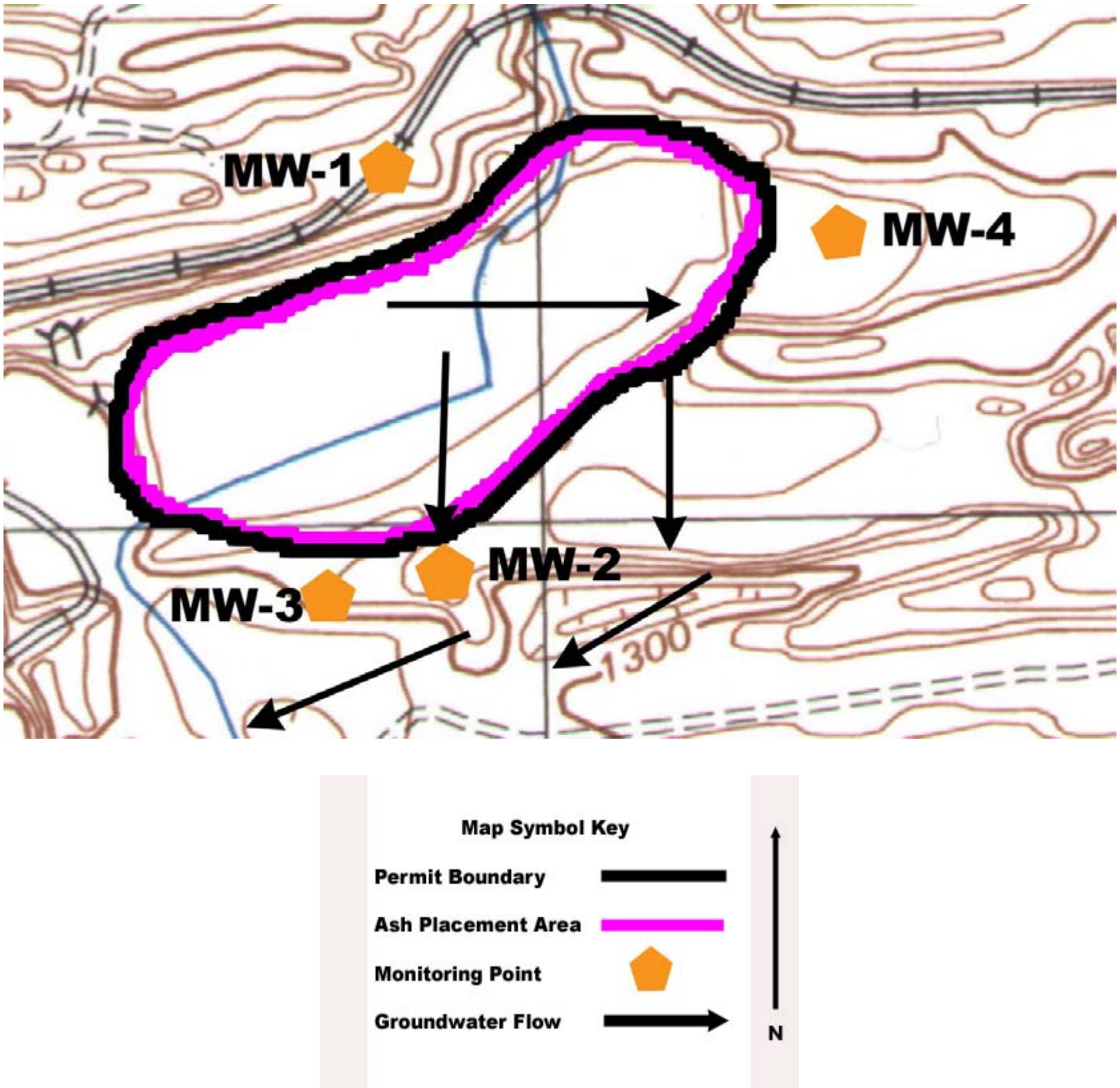
Knickerbocker Demonstration Project

On July 21, 1998, PADEP Solid Waste Management Permit # 301301 was issued for the construction of an ash disposal demonstration facility within the Ellengowan operation known as the Knickerbocker Pit Demonstration Facility. The Knickerbocker Pit permit area is comprised of 44 acres. This waste management demonstration permit authorized an estimated disposal of 2,400,000 cubic yards of slurried FBC ash into the Knickerbocker Pit, a dry site above the water table, to examine the effects of putting wet ash into dry disposal settings. The slurry was composed of 60% mine pool water (by volume) and 40% ash and was piped into the placement area via a 10-inch polyethylene pipe. Sources for the FBC ash were to include the Schuylkill Energy Resources Power Plant, Logan Generating Plant, and the AES Thames Cogeneration Plant although whether any ash from the latter two sources was used is unclear. A January 27, 2004 report from Reading Anthracite indicates that total ash slurried to the Knickerbocker Pit was 3,035,757 wet tons by the end of 2003.

Four wells monitored the impact of the slurry placement on groundwater. Baseline monitoring extended from the fall of 1994 until July 1998. Monitoring of ash placement started September 1998 and has continued through September 2006. The discussion below discusses data collected through August 2004, with data subsequently collected from 2004 through 2006 discussed later in the report. Because of the proximity of the monitoring wells to the Knickerbocker Pit and the fact that no mining or remining activities that might generate additional permitted sources of water quality degradation were occurring in or around this pit for the duration of this demonstration project, the data from this demonstration project should have provided for a clear analysis of the impact of ash placement on coal-mine water quality unconfused by mining impacts. However, the placement of CCW and burning rock into the Shen Penn Pit to address the Kehley Run Mine fire in the 1970s may have already influenced the baseline water quality at all Knickerbocker monitoring points. The Shen Penn Pit is a major conduit of surface water flow into the Indian Ridge deep mine, and directly upgradient of the deep mine underneath the Knickerbocker Pit as PADEP maintains.

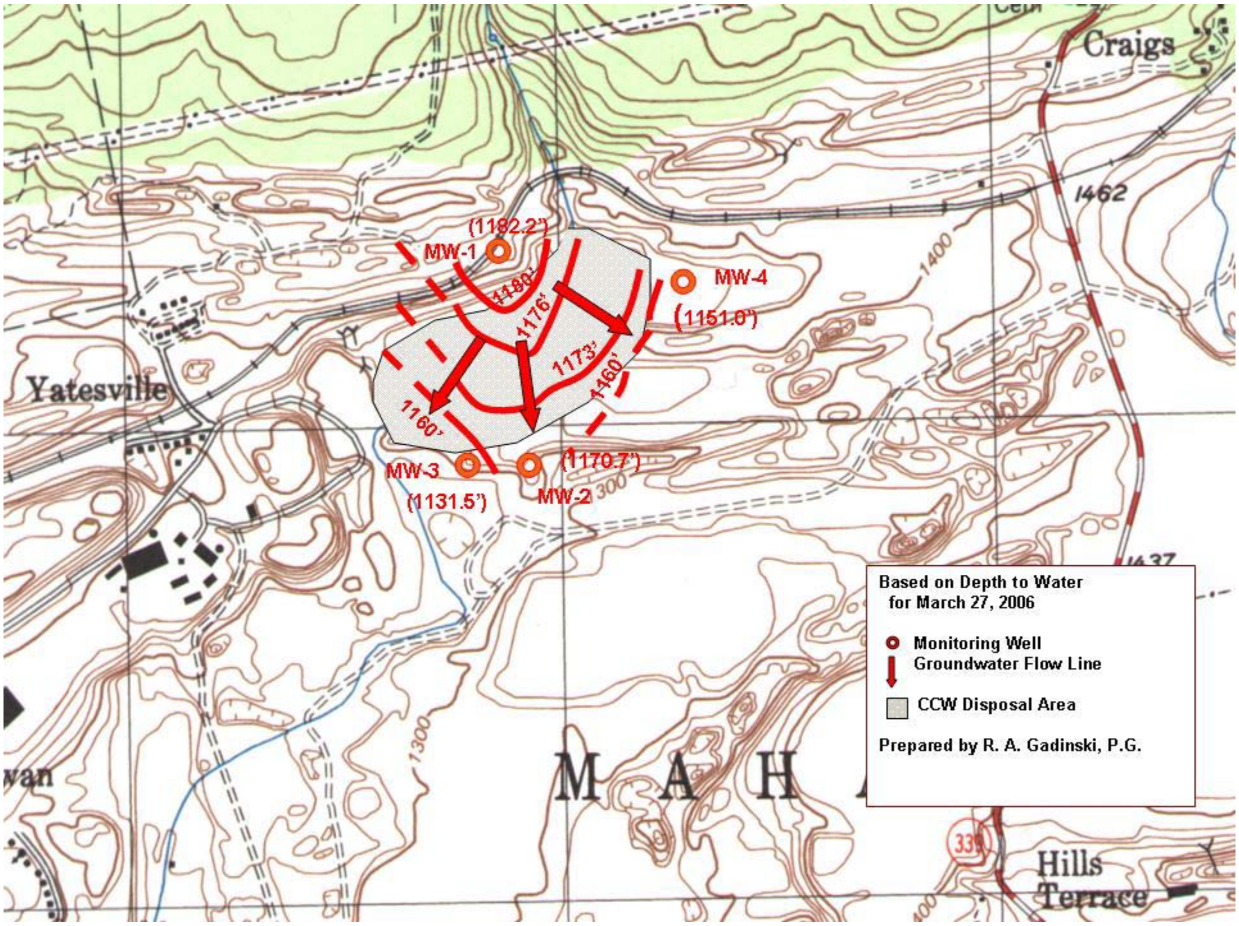
There are four groundwater monitoring wells on the Knickerbocker site: MW1, MW2, MW3 and MW4. Monitoring point MW1 is the only designated upgradient well. The flow of water in the vicinity of the Knickerbocker Pit is from MW1 north of the pit to MW2 and MW3 south of the pit respectively. MW4 is located to the east of the pit, somewhat side-gradient to this flow.

Site Map: Ellengowan



Reading Anthracite Co., Knickerbocker Pit (Permit # 54793206)
Scale: 1" = Approximately 600'

While water elevation data for the Knickerbocker monitoring points are missing from most monitoring reports and the permit files, the existence of such data in monitoring reports submitted in 2006 allowed for these general flow directions to be confirmed as shown on the map below.



MW1 vs. MW2

A comparison of sampling data at MW1 to data at MW2 shows high concentrations of iron (figure 5.1) well over the DWS before the ash slurry arrived at the Knickerbocker Pit indicating degraded conditions in the minepool below the pit before the demonstration project. These conditions continued at both monitoring points during the project with iron concentrations at the downgradient MW2 usually substantially higher than concentrations at upgradient MW1. The same can be said of manganese concentrations (figure 5.2) with the addition that during 1997 (a year before the slurry project) manganese concentrations at MW2 spiked to four measurements ranging from 33 mg/L to 46 mg/L, between 600 and 1000 times the DWS. This iron and manganese data suggest the pit was a source of degradation to the underlying minepool before the ash slurry project. Upon commencement of the project however, iron and manganese concentrations increased from most pre-project levels at MW2 but then dropped sharply in September 2001.

Sulfate (figure 5.3) concentrations showed a more decisive effect from the project, staying below the DWS (SMCL of 250 mg/L) at MW1 while rising noticeably in the downgradient MW2 from levels before the project that were usually at or below the

DWS to levels exceeding 1000 mg/L, ten times after the ash slurry arrived. Concentrations reached a peak of 1510 mg/L in March 2001 before dropping precipitously in September 2001. Nevertheless average sulfate levels at MW2 that were approximately 4.9 times average sulfate levels at MW1 before the ash slurry increased to 27.7 times average sulfate levels at MW1 after the ash slurry arrived suggesting a significant adverse impact from the ash.

Alkalinity (figure 5.4), as measured by the concentration of CaCO3, was greater at MW2 than MW1 and had increasing trends at MW2 before and after ash placement. An increasing trend was not very evident at MW1 after ash placement even though average alkalinity at MW1 was about twice what it was before ash placement. The average alkalinity at MW2 throughout the period after ash placement began was 136.8 mg/L, 5.8 times the average alkalinity at MW1 (23.7 mg/L). This compares to an average alkalinity at MW2 before ash placement of 128.1 mg/L that was 10 times the average alkalinity at MW1 (12.8 mg/L). While the difference in alkalinity from before to after ash placement at MW2 seems slight, it is noticeably greater (107 vs 137 mg/L) when two measurements substantially higher than the rest of the alkalinity levels at MW2 before ash placement (in August 1997 and March 1998) are subtracted from the picture. In fact only those two measurements exceeded 200 mg/L at MW2 before ash placement whereas some 10 alkalinity measurements exceeded 200 mg/L at MW2 after ash placement. Furthermore during the first year of sampling after ash placement, the average alkalinity at MW2 was 1.3 times the average alkalinity at MW1 while during the last year of sampling, despite a decline that mirrored declines of iron, sulfate and manganese, the average alkalinity at MW2 was 2.9 times the average alkalinity at MW1. The increasing alkalinity at MW2 as well as this increasing difference in alkalinity between downgradient MW2 and upgradient MW1 after ash placement started provides evidence of the impact of the ash slurry on water quality.

Alkalinity dominated acidity (figure 5.4a) at both MW1 and MW2 before and after the ash slurry demonstration project got underway. There were a few isolated peaks of acidity over alkalinity during the baseline period, one in December 1995 at MW2 when acidity was 124 mg/L and alkalinity was 6.50 mg/L and the other in October 1997 at MW1 when acidity was 118 mg/L and alkalinity was 1.96 mg/L. Before the project, several acidity levels also surpassed alkalinity in 1994 and 1995 at MW1, and acidity was comparable or greater than alkalinity in several samplings at MW2 in 1999. However these measurements were all below 60 mg/L and did not persist for more than a year. There was also a little acidity at MW1 in 2000 and 2001 and a small peak in 2004 to 36.70 mg/L and a peak in acidity at MW2 to 89.40 mg/L in March 2001 when alkalinity was 36.50 mg/L. Otherwise, 112 of 137 total measurements of acidity at MW1 and MW2 were below 1.00 mg/L in contrast to 62 of 70 alkalinity measurements at MW1 that ranged from 9.85 mg/L to 45.50 mg/L and and 35 of 67 alkalinity measurements at MW2 that ranged from 100 mg/L to 564 mg/L.

The substantial differences in the total dissolved solids (TDS) concentrations at MW1 and MW2 (figure 5.5), which became more dramatic after ash slurry arrived, also demonstrate that the overall influence of the ash was too increase the total concentration of pollution in the underlying minepool. To be certain however the highest TDS measured at MW2 was 2020 mg/L in December 1995, three years before the ash slurry arrived in Knickerbocker Pit, and it reflected the highest iron and second highest sulfate concentrations measured at MW2. Nonetheless before the ash slurry arrived, 21 of 30 samplings at MW2 had TDS levels between 300 and 700 mg/L with only this December 1995 peak above 1,000 mg/L. After the ash slurry arrived, TDS exceeded 1,000 mg/L in 20 of 36 samplings at MW2 and exceeded 1,500 mg/L, 3 times the DWS, in 10 of those samplings. Furthermore before the ash slurry, TDS levels were measured below the DWS 14 times at MW2, whereas after the ash slurry arrived, TDS levels were below the DWS only 4 times with the lowest measurement, 281 mg/L, in June 2001.

In contrast, before ash placement the highest TDS measured at MW1 was a peak of 684 mg/L, but otherwise average TDS levels at MW1 were 80 mg/L. After ash placement began, the highest TDS measured at MW1was 169 mg/L in March 2000.

Of note is the significant drop in concentrations of iron, manganese, sulfates, and TDS that took place at MW2 from late 2001 through 2004. From early 2002 until the latest sampling available from PADEP (in August 2004), iron and manganese levels at MW2 remained approximately equal to concentrations at MW1. Sulfates began to rise again at MW2 to 362 mg/L in August 2004 and ranged from 3.1 to more than 400 times greater than sulfates at MW1 in these last two years of monitoring. TDS remained approximately 4-60 times higher at MW2 than at MW1 during this period.

Static water elevation data at MW2 is missing entirely from PADEP's monitoring data base and permit files from 1996 to 2003. PADEP's data base indicates that MW2 was dry in no less than six samplings from 2001 through 2004, MW 3 was dry in three samplings in the latter half of 2002 and MW 4 had water in it in only three of 19 samplings after August 2000 while upgradient MW1 was never dry. This suggests a significant change in the hydraulic regime under the site, perhaps as a result of the project.

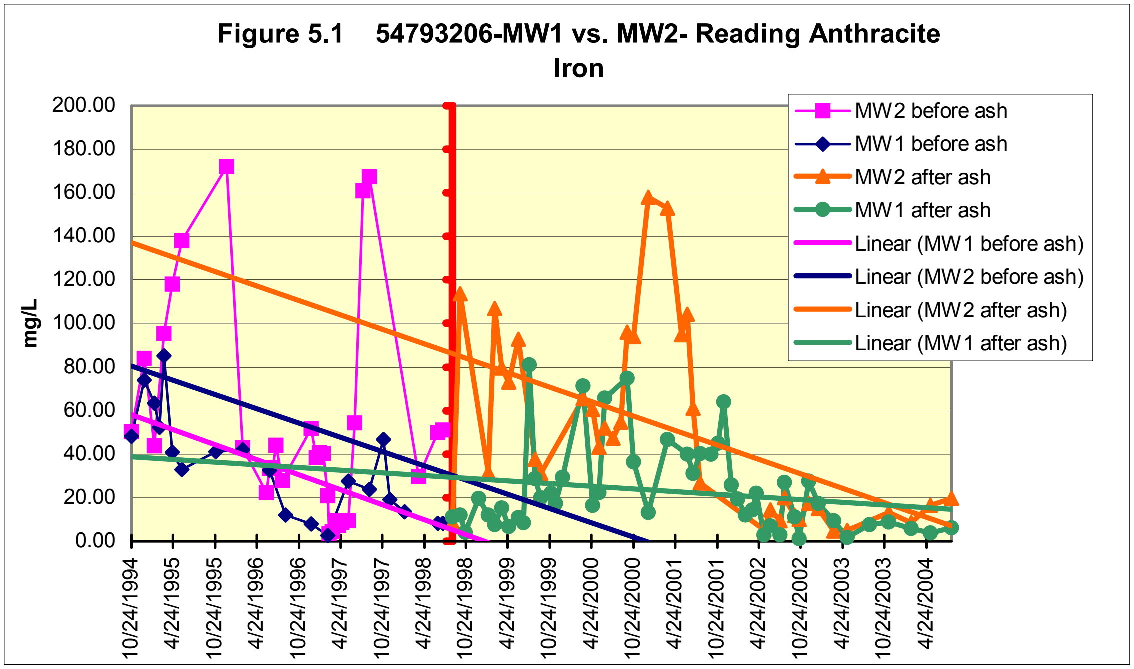


Figure 5.1 54793206-MW1 vs. MW2- Reading Anthracite
Iron
mg/L
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
10/24/1994
4/24/1995
10/24/1995
4/24/1996
10/24/1996
4/24/1997
10/24/1997
4/24/1998
10/24/1998
4/24/1999
10/24/1999
4/24/2000
10/24/2000
4/24/2001
10/24/2001
4/24/2002
10/24/2002
4/24/2003
10/24/2003
4/24/2004
MW2 before ash
MW1 before ash
MW2 after ash
MW1 after ash
Linear (MW1 before ash)
Linear (MW2 before ash)
Linear (MW2 after ash)
Linear (MW1 after ash)

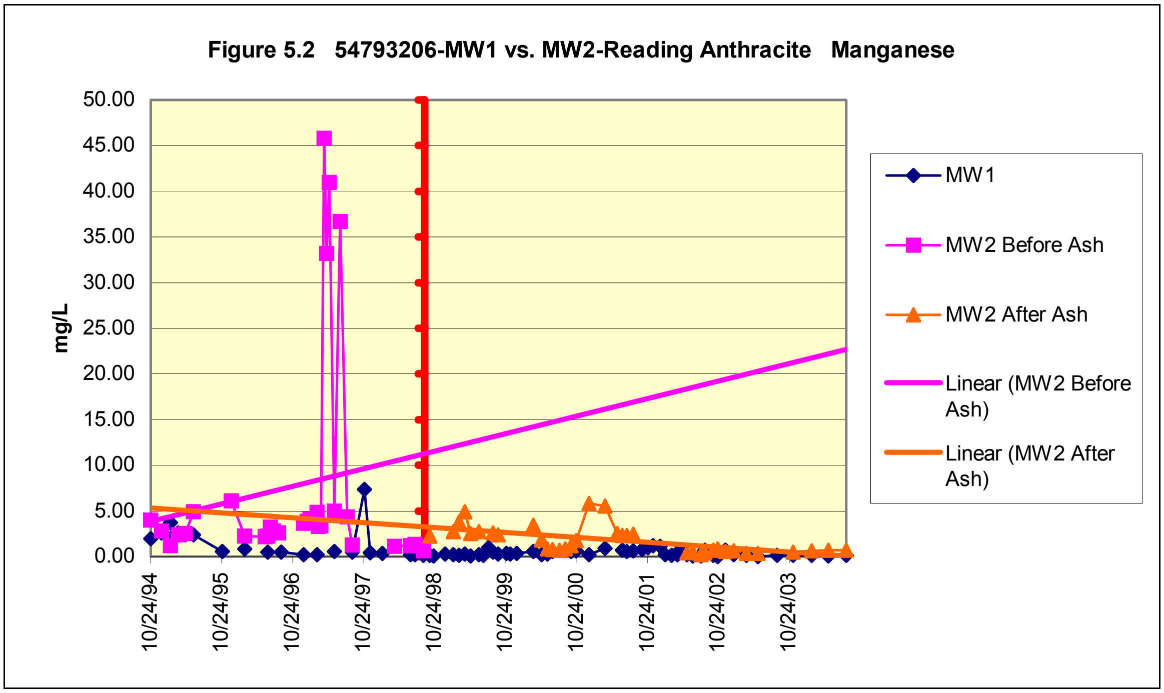


Figure 5.2 54793206-MW1 vs. MW2-Reading Anthracite Manganese
mg/L
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
10/24/94
10/24/95
10/24/96
10/24/97
10/24/98
10/24/99
10/24/00
10/24/01
10/24/02
10/24/03
MW1
MW2 Before Ash
MW2 After Ash
Linear (MW2 Before Ash)
Linear (MW2 After Ash)

Figure 5.3 54793206-MW1 vs. MW2-Reading Anthracite Sulfate

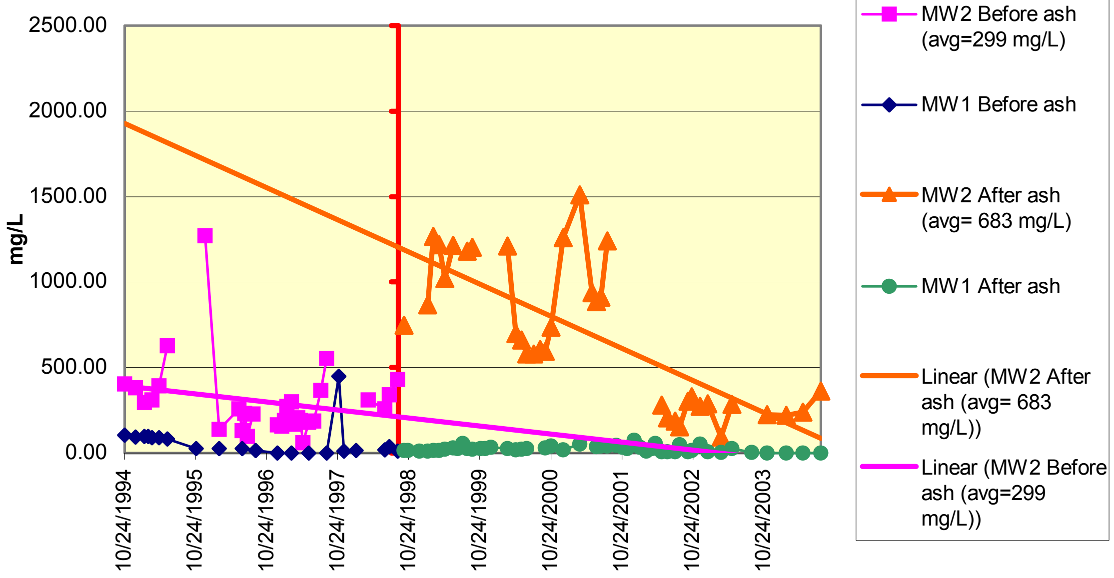
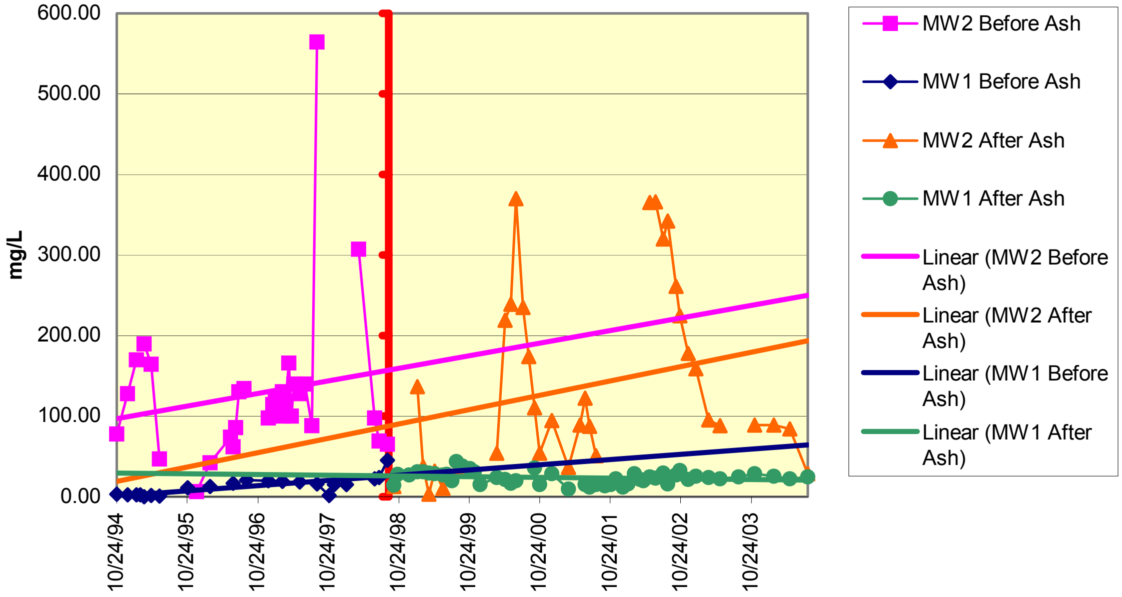


Figure 5.4 54793206-MW1 vs. MW2-Reading Anthracite Alkalinity as CaCO3



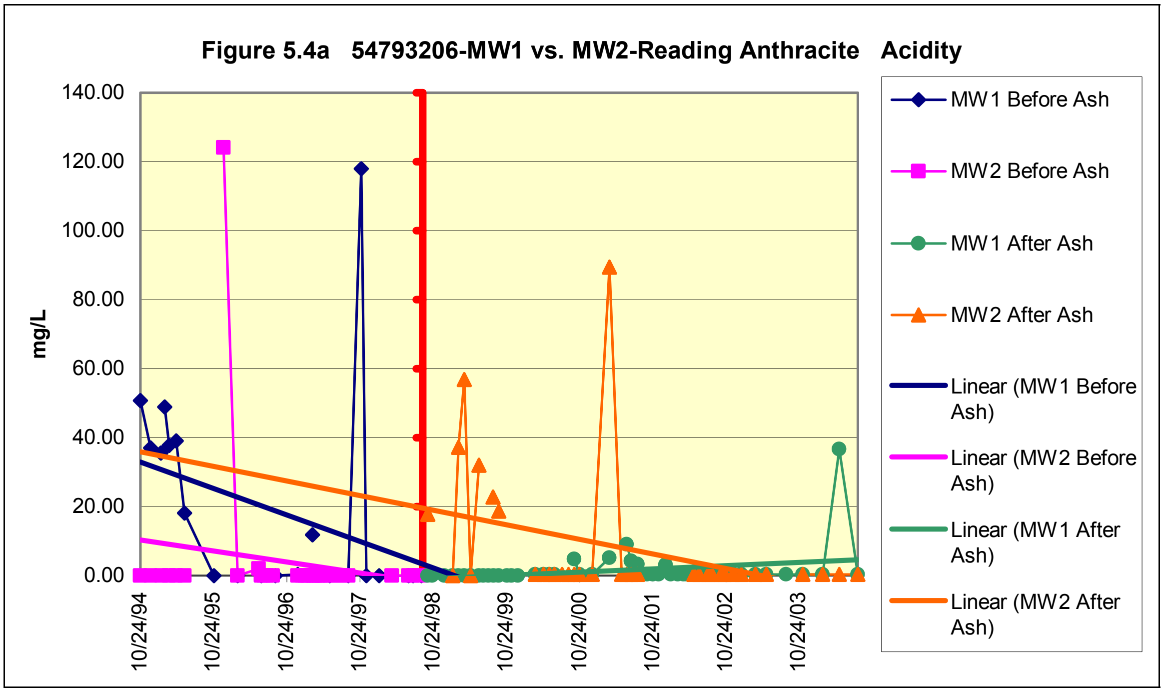


Figure 5.4a 54793206-MW1 vs. MW2-Reading Anthracite Acidity
mg/L
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
10/24/94
10/24/95
10/24/96
10/24/97
10/24/98
10/24/99
10/24/00
10/24/01
10/24/02
10/24/03
MW1 Before Ash
MW2 Before Ash
MW1 After Ash
MW2 After Ash
Linear (MW1 Before Ash)
Linear (MW2 Before Ash)
Linear (MW1 After Ash)
Linear (MW2 After Ash)

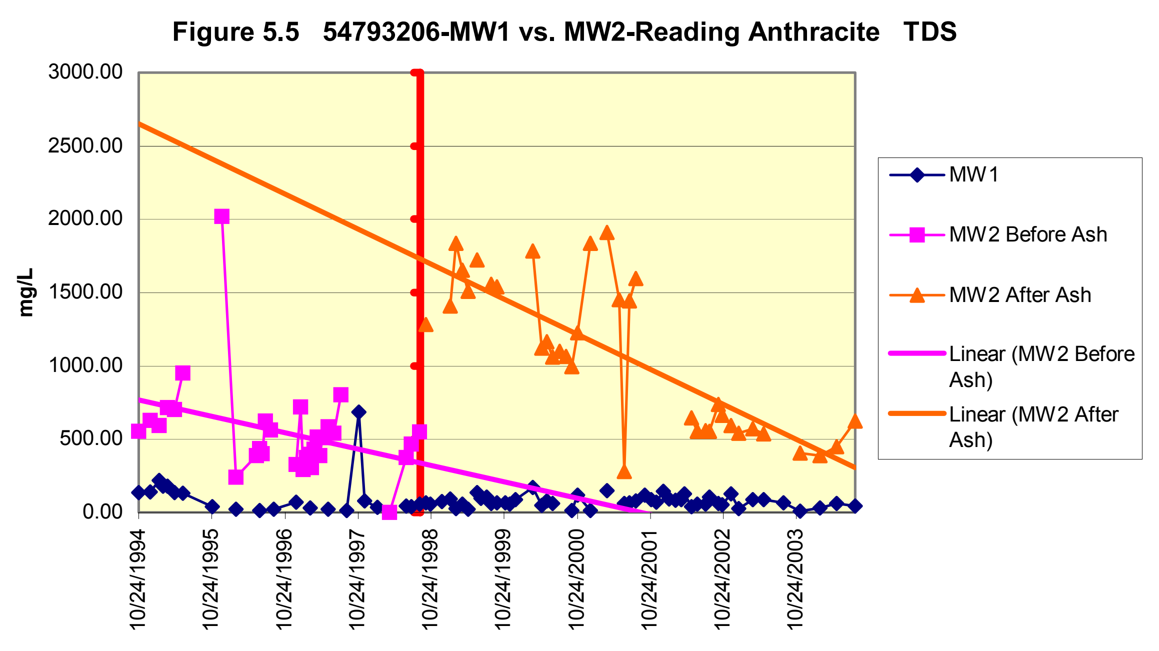


Figure 5.5 54793206-MW1 vs. MW2-Reading Anthracite TDS
mg/L
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
10/24/1994
10/24/1995
10/24/1996
10/24/1997
10/24/1998
10/24/1999
10/24/2000
10/24/2001
10/24/2002
10/24/2003
MW1
MW2 Before Ash
MW2 After Ash
Linear (MW2 Before Ash)
Linear (MW2 After Ash)

MW1 vs. MW3

The differences in concentrations between upgradient and downgradient monitoring points are also clear when comparing MW1 with MW3 and in some respects the effects of the project are more clear in this comparison than that between MW1 and MW2. Concentrations of iron (figure 5.6) and manganese (figure 5.7) were initially at roughly the same levels between these monitoring points but became progressively greater at the downgradient MW3 than at the upgradient MW1 particularly in the final years of monitoring. Before the project and for the first three years after ash slurry arrived, most iron concentrations at MW3 were at or below iron concentrations at MW1. The highest iron levels measured at MW1 were 85.20 mg/L in March 1995 and 81.20 mg/L, 271 times the DWS, measured in July 1999. Up through May 2002, 18 of 56 iron measurements at MW1 were above 40 mg/L, compared to only six of 68 iron measurements at MW3 above 40 mg/L. However from June 2002 until the final sampling in August 2004, iron rose at MW3 to an average of 97 mg/L with the highest concentration measured in November 2002 at 335 mg/L, 1117 times the DWS. In contrast, iron levels declined at MW1 after ash slurry placement started, with average iron levels from June 2002 to August 2004 of 10 mg/L. Both MW3 and MW2 are proximal to the southern edge of the pit although MW3 is about 100 feet further away from the pit.

The trends for manganese (figure 5.7) were similar to that for iron, although manganese levels were usually slightly higher at MW3 than at MW1 until the last two years of monitoring. Furthermore a spike in manganese levels occurred in the spring of 1997 from levels between 0 and 2 mg/L to 77.6 mg/L on April 3 and 44.10 mg/L on April 15, 1997. This spike coincided with the spike in manganese to similar levels at MW2. Finally from June 2002 through August of 2004, manganese concentrations rose at MW3 to levels ranging from 16.5 times to 96.3 times higher than their coinciding concentrations at MW1. The highest measurement at MW 3 was 11.90 mg/L in November 2002, 238 times the DWS. The highest measurement at MW1 was 0.72 mg/L, 14 times the DWS, also measured in November 2002.

As was the case between MW1 and MW2, sulfate levels at MW3 (figure 5.8) were higher than the sulfates at MW1 before ash placement started, and the disparity became more pronounced after ash placement. Sulfate concentrations actually declined at MW1 after ash slurry arrived at Knickerbocker, from an average of 61.3 mg/L before the demonstration project to 24.4 mg/L after ash slurry arrived. While there was a peak in sulfate to 448 mg/L in October 1997 (the only measurement exceeding the drinking water standard) that contributes to this disparity, the range of sulfate values was also substantially higher before the ash slurry project. In other words, before the ash slurry arrived, sulfate exceeded one third the DWS in one third of the samplings (7 of 21) at MW1. After the ash slurry arrived, no measurements were greater than one third the DWS; in fact some 24 of 49 samplings at MW1 measured less than one tenth the DWS. By comparison after the ash slurry arrived at Knickerbocker, a declining trend in concentrations at MW3 eventually reversed and average sulfate levels at MW3 increased from 387 mg/L to 419 mg/L. After dipping from pre-project sulfate levels, sulfate rose sharply starting in July 2002 to three measurements exceeding 1000 mg/L and reaching a high of 1790 mg/L in November 2002, more than 7 times the DWS. Thus the overall average level for sulfate at MW3 increased from 6.3 times the average sulfate at MW1 before the demonstration project to 17 times the average sulfate level at MW1 during the project. The rising levels of sulfate as well as iron and manganese are also reflected in the rise of TDS concentrations at MW3 (figure 5.8a).

Note that the sharp rises in iron, manganese, sulfates, and TDS beginning in June and July 2002 at MW3 occurred six to twelve months after the decline in their concentrations were measured at MW2 in roughly the same amounts. As is the case at MW2, there is a lack of static water elevation data from 1996 to 2003 at MW3. MW3 was reported as dry in samplings in August, September and October of 2002, although PADEP's data base does not indicate that MW3 was ever dry in 2003. MW2 was dry in the August 2003 sampling in addition to being dry in five samplings in 2001 and 2002. These concentration trends in combination with the lack of water reported more frequently at MW2 and at different times between these monitoring points reinforce the evidence that some event or combination of events changed the path of contaminant flow from the pit away from MW2 toward MW3.

While the differences are not quite as stark as at MW2, alkalinity at MW3 (figure 5.9) is noticeably higher than at MW1 and clearly rising compared to the relatively flat alkalinity trend at MW1. The overall average alkalinity at MW3 throughout the ash slurry placement was three times the average alkalinity at MW1. The difference was most pronounced from March of 2001 through January of 2003 when the average alkalinity at MW3 was more than 5.3 times the average alkalinity at MW1. This is also when sulfate, TDS and iron were peaking at MW3 and manganese was increasing. The alkalinity at MW3 was not quite as high as at MW2, with only nine readings exceeding 100 mg/L and the highest being 279.20 mg/L in April 2002 compared to 16 readings over 100 mg/L at MW2 and the highest being 370 mg/L in June 2000. However, the countervailing acidity at MW3 (figure 5.9a) also appeared to be weaker than the acidity at MW2 and MW1 with only five measurements recording any acidity. The highest acidity at MW3 was 24.20 mg/L in June 2001 which surpassed alkalinity at 19.60 mg/L, and the second highest was 12.20 mg/L in August 2003 which was equal to alkalinity at MW3 in that sampling. All other acidity measurements at MW3 were 0.00 mg/L or <0.40 mg/L.

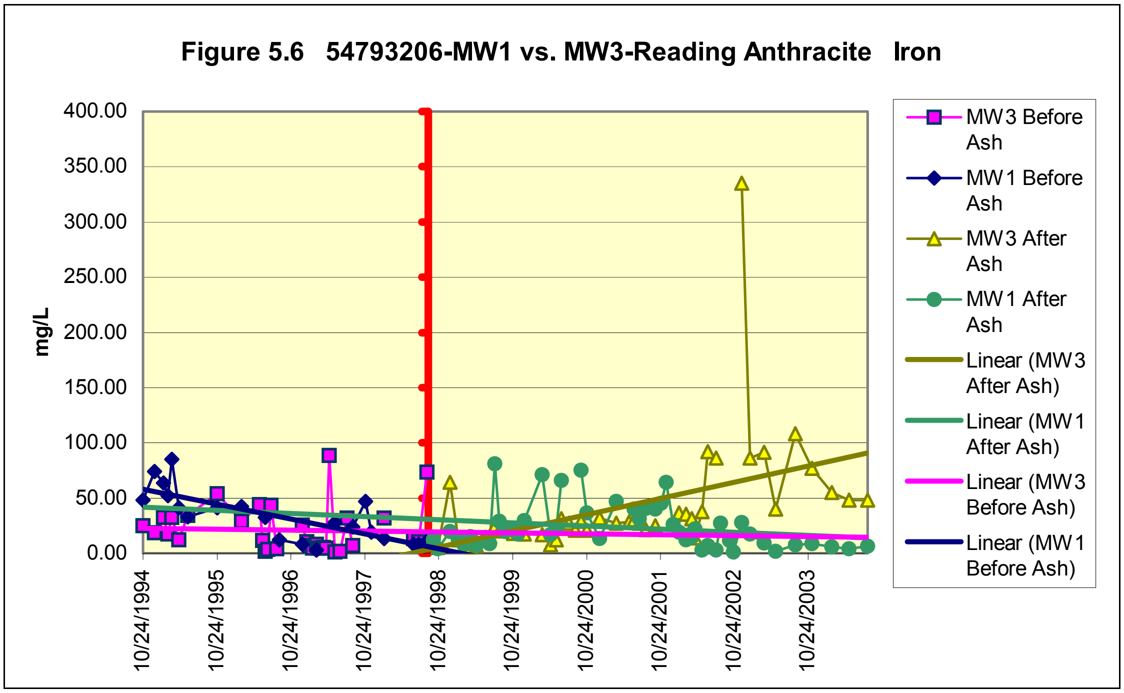


Figure 5.6 54793206-MW1 vs. MW3-Reading Anthracite Iron
mg/L
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
10/24/1994
10/24/1995
10/24/1996
10/24/1997
10/24/1998
10/24/1999
10/24/2000
10/24/2001
10/24/2002
10/24/2003
MW3 Before Ash
MW1 Before Ash
MW3 After Ash
MW1 After Ash
Linear (MW3 After Ash)
Linear (MW1 After Ash)
Linear (MW3 Before Ash)
Linear (MW1 Before Ash)

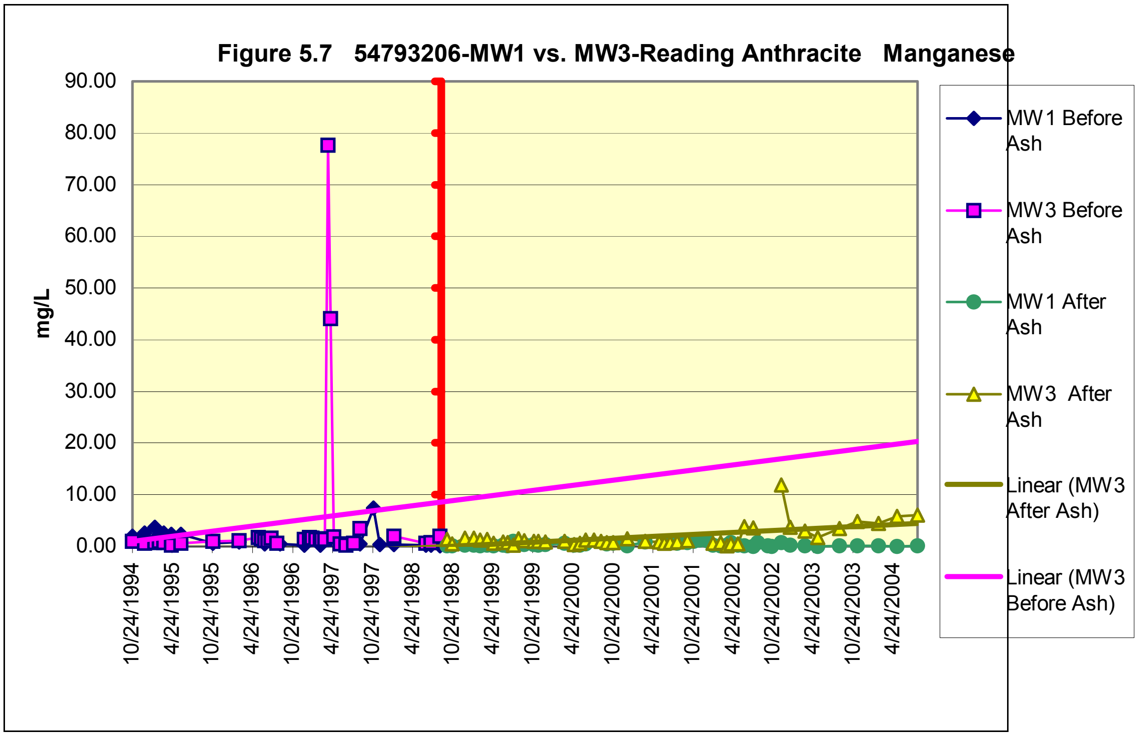


Figure 5.7 54793206-MW1 vs. MW3-Reading Anthracite Manganese
mg/L
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
10/24/1994
4/24/1995
10/24/1995
4/24/1996
10/24/1996
4/24/1997
10/24/1997
4/24/1998
10/24/1998
4/24/1999
10/24/1999
4/24/2000
10/24/2000
4/24/2001
10/24/2001
4/24/2002
10/24/2002
4/24/2003
10/24/2003
4/24/2004
MW1 Before Ash
MW3 Before Ash
MW1 After Ash
MW3 After Ash
Linear (MW3 After Ash)
Linear (MW3 Before Ash)

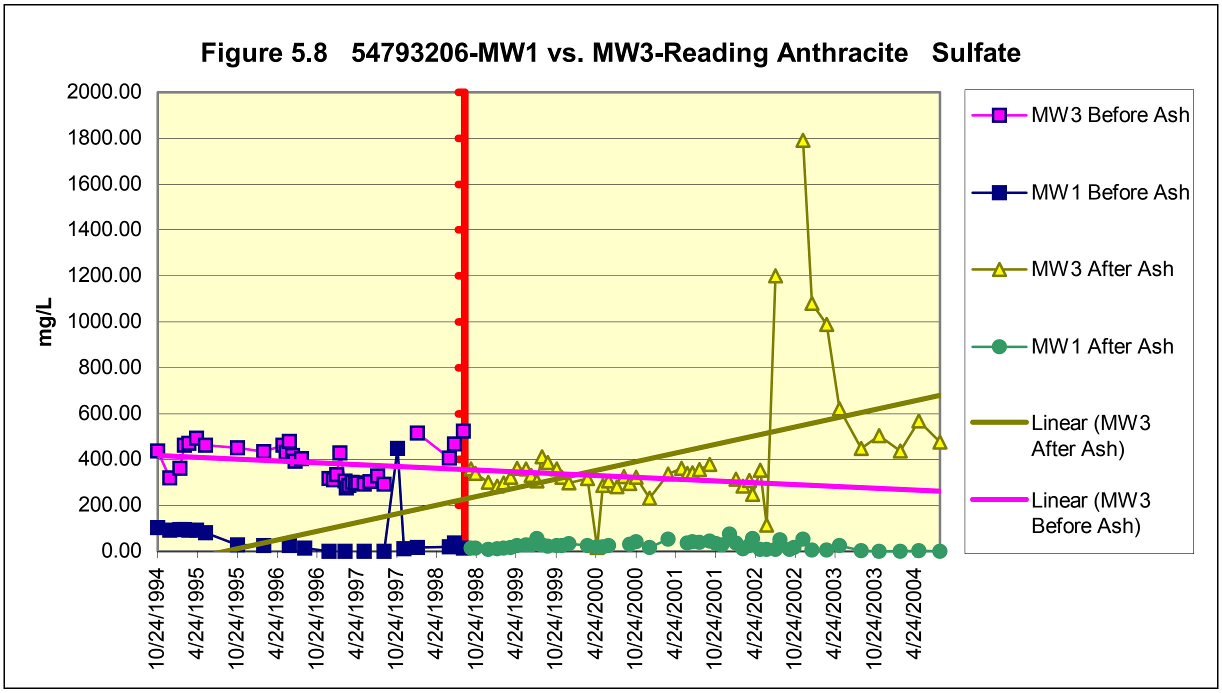


Figure 5.8 54793206-MW1 vs. MW3-Reading Anthracite Sulfate

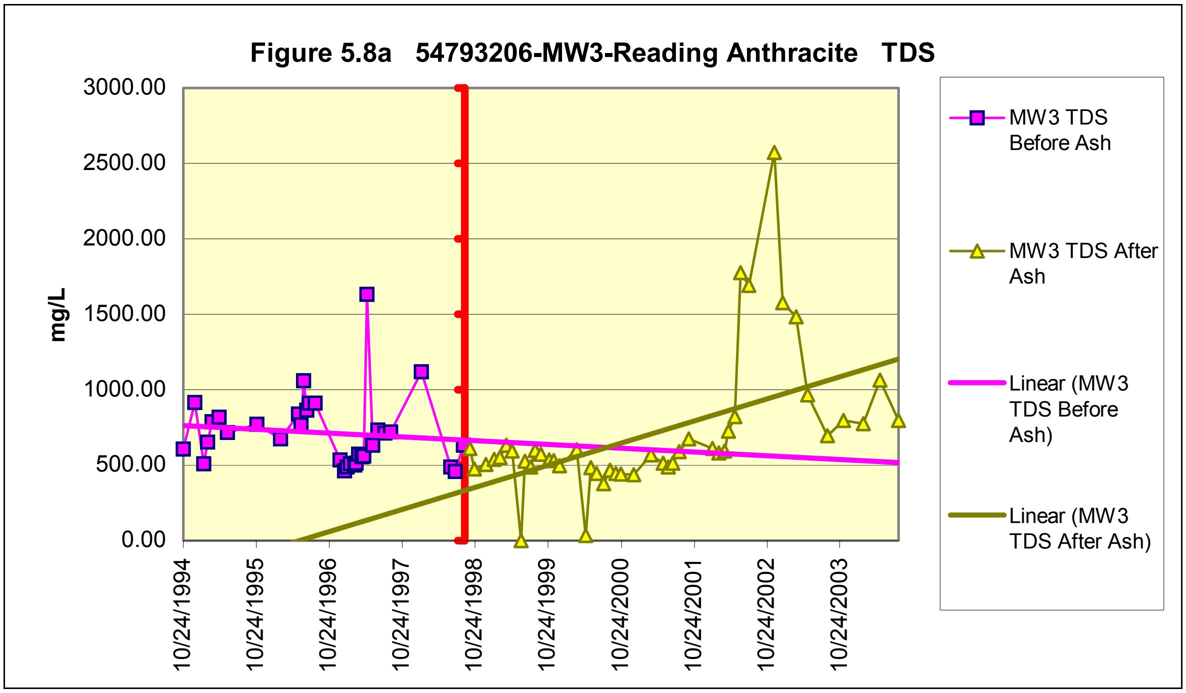


Figure 5.8a 54793206-MW3-Reading Anthracite TDS

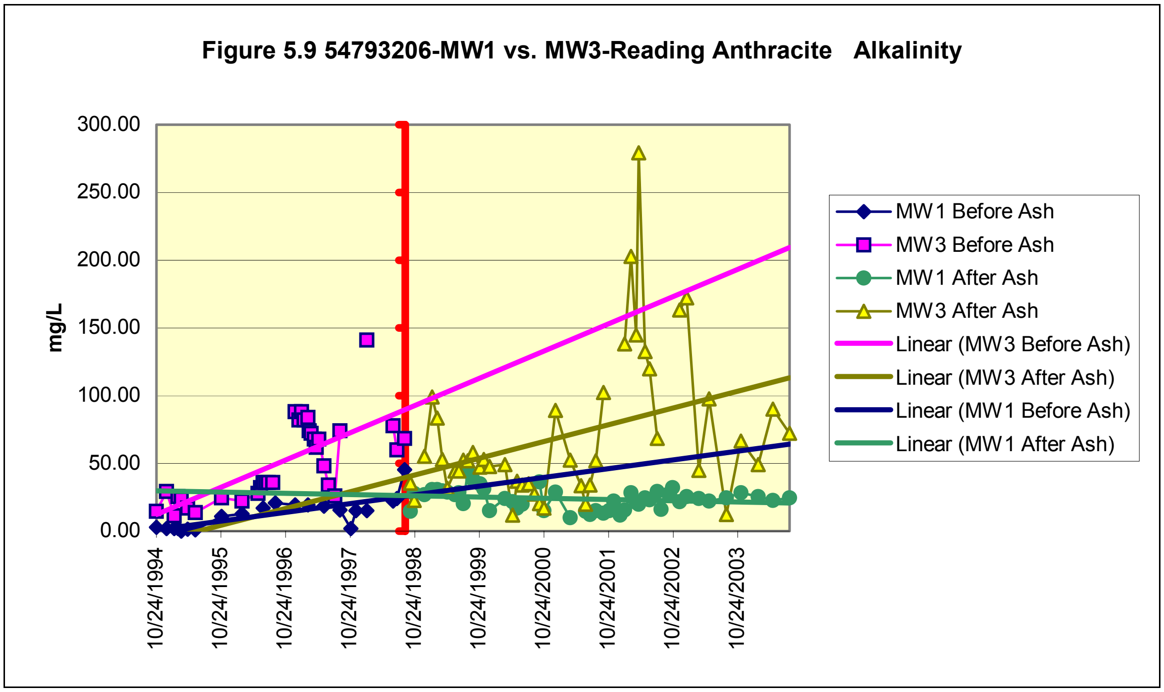


Figure 5.9 54793206-MW1 vs. MW3-Reading Anthracite Alkalinity
mg/L
300.00
250.00
200.00
150.00
100.00
50.00
0.00
10/24/1994
10/24/1995
10/24/1996
10/24/1997
10/24/1998
10/24/1999
10/24/2000
10/24/2001
10/24/2002
10/24/2003
MW1 Before Ash
MW3 Before Ash
MW1 After Ash
MW3 After Ash
Linear (MW3 Before Ash)
Linear (MW3 After Ash)
Linear (MW1 Before Ash)
Linear (MW1 After Ash)

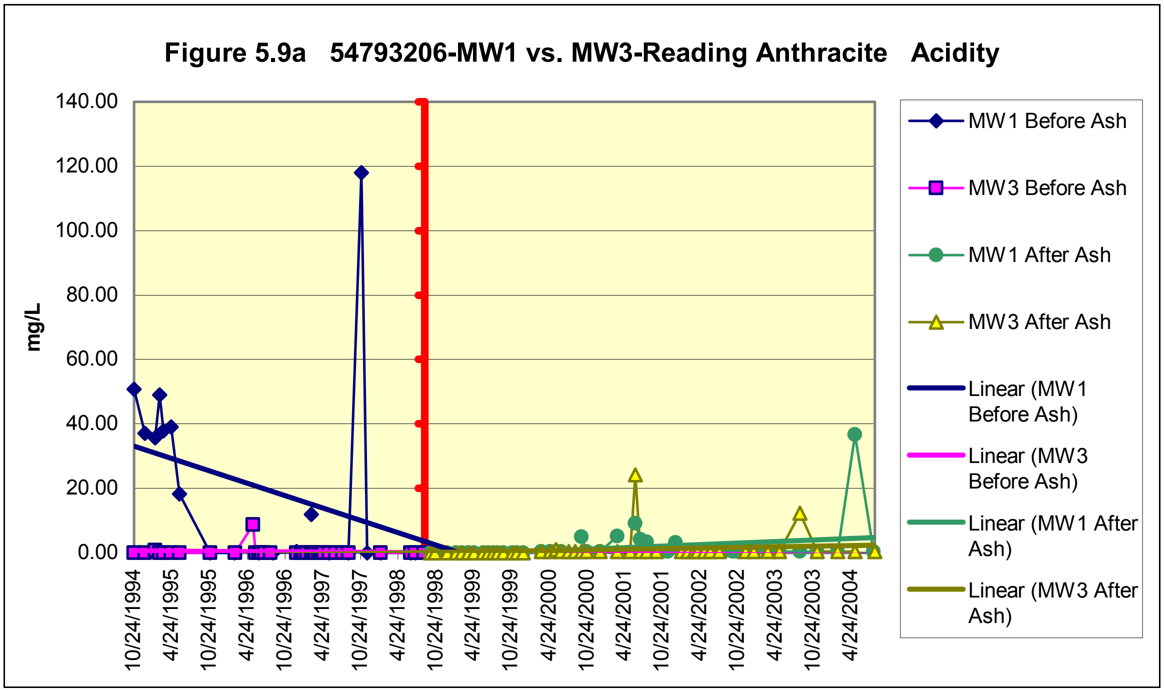


Figure 5.9a 54793206-MW1 vs. MW3-Reading Anthracite Acidity
mg/L
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
10/24/1994
4/24/1995
10/24/1995
4/24/1996
10/24/1996
4/24/1997
10/24/1997
4/24/1998
10/24/1998
4/24/1999
10/24/1999
4/24/2000
10/24/2000
4/24/2001
10/24/2001
4/24/2002
10/24/2002
4/24/2003
10/24/2003
4/24/2004
MW1 Before Ash
MW3 Before Ash
MW1 After Ash
MW3 After Ash
Linear (MW1 Before Ash)
Linear (MW3 Before Ash)
Linear (MW1 After Ash)
Linear (MW3 After Ash)

MW1 vs. MW2 and MW3

Lab pH was consistently measured at the Knickerbocker monitoring points while field pH was measured only sporadically. Average lab pH rose during the baseline period and ash slurry placement at MW1 and MW2 yet declined at MW3 both in the baseline and ash slurry placement periods. At upgradient MW1 (figure 5.10), lab pH rose steadily upward from 7 measurements between 5 and 6 Units in October 1994 through June 1995 to a high of 9.02 Units in June 1998. During the slurry placement, after a dip, pH rose again from 10 readings between 6.25 and 6.91 Units (in all but one measurement) from March 2001 through March 2002 to 10 readings between 9.06 to 9.75 Units from May 2002 through November 2003 (in all but two measurements). This data suggests an alkaline addition from the minepool upgradient of the Knickerbocker Pit and possibly an impact from the project.

At MW2 (figure 5.11), lab pH readings before and during the demonstration project rose slowly until 2002. During the baseline period, 27 of 31 total measurements were between 6.20 and 6.70 units. Toward the end of ash slurry placement, there was a noticeable jump in pH that occurred after MW2 had been dry in five samplings from September 2001 through April 2002. Before this dry period, the average pH was 6.41 Units at MW2, while afterwards, average pH was 8.25 Units.

Note that the average lab pH at MW3, (figure 5.12), dropped from 7.62 Units before May 2002 to 6.41 Units from May 2002 through August 2004. As explained earlier MW3 was dry in August, September and October of 2002. Clearly a significant change occurred in the spring of 2002 when pH jumped at MW1 and MW2 and dropped at MW3. These dry samplings at MW2 occurred right before this pH jump yet during the pH drop at MW3 raising as many questions as answers about the effect of filling this dry pit with alkaline ash on the pH of the underlying mine pool.

The influence of the ash is suggested in higher concentrations of magnesium (figure 5.13) and chloride (figure 5.15) at MW2 and MW3 than occurred at MW1 after the ash slurry arrived at Knickerbocker Pit. While there were not many measurements for these parameters, the highest concentrations at MW2 and MW3 were also measured after ash placement was well underway. Magnesium and chloride tend to be more soluble in the coal ash than the spoil or AMD at the bituminous and anthracite remining sites reviewed in this report.

However the few measurements of calcium (figure 5.14) were less suggestive of this impact. At MW3 the highest concentration of calcium (134.00 mg/L in January 2003) occurred after the project was underway, but this measurement was not much higher than the highest concentration before the project (105.80 mg/L in June 1995), while the highest concentrations of calcium at MW2 occurred well before the demonstration project was underway. Calcium is a good ash indicator parameter at one of the other anthracite remining sites assessed in this report (see Permit Review 6, NEPCO Silverbrook Site, figure 6.8) and all of the bituminous remining sites studied in this report as it leaches readily from the FBC waste coal ashes at these sites. Calcium levels are usually closely associated with magnesium levels although usually higher than magnesium, reflecting the greater component calcium makes up of most limestone used in the FBC plants. While calcium rises and falls at MW3 in 2002 and 2003 when magnesium is rising and falling at MW3, the proportions of the two constituents change, with magnesium concentrations higher than calcium concentrations in some measurements but lower in others. At other remining sites, the proportions between these two ash indicator parameters remain fairly consistent.

Furthermore, despite the large amount of FBC culm ash placed in this area, calcium does not appear to be associated with significant neutralization of acidity at Knickerbocker's monitoring points or at the other monitoring points in the Ellengowan permit area (see figures 5.19 and 5.27 through 5.29). This is perhaps an indication that the calcium in the ash from Schuylkill Energy FBC plant is not dominantly in the form of highly soluble calcium oxide and is not, therefore, as able to impact the pH of the site waters or the underlying minepool. Calcium also does not appear to be readily associated with visible effects in pH chemistry at ash monitoring points in the neighboring BD Mining site (see Permit Review 7, Figures 7.4, 7.6, 7.7, and 7.12). Rather than occurring dominantly as calcium oxide, it may predominantly occur in less reactive species such as gypsum or anhydrite. In addition to more sampling for calcium in the ash pore water as well as at the monitoring points, more information on the grades of limestone or dolomite used in the Schuylkill Energy and Gilberton FBC plants and studies of the mineralogy of these ashes could help explain the observed concentration patterns of calcium at the Ellengowan and BD Mining sites. The leaching tendencies of calcium and magnesium from the ash of these plants under the range of conditions at this site should be fully researched.

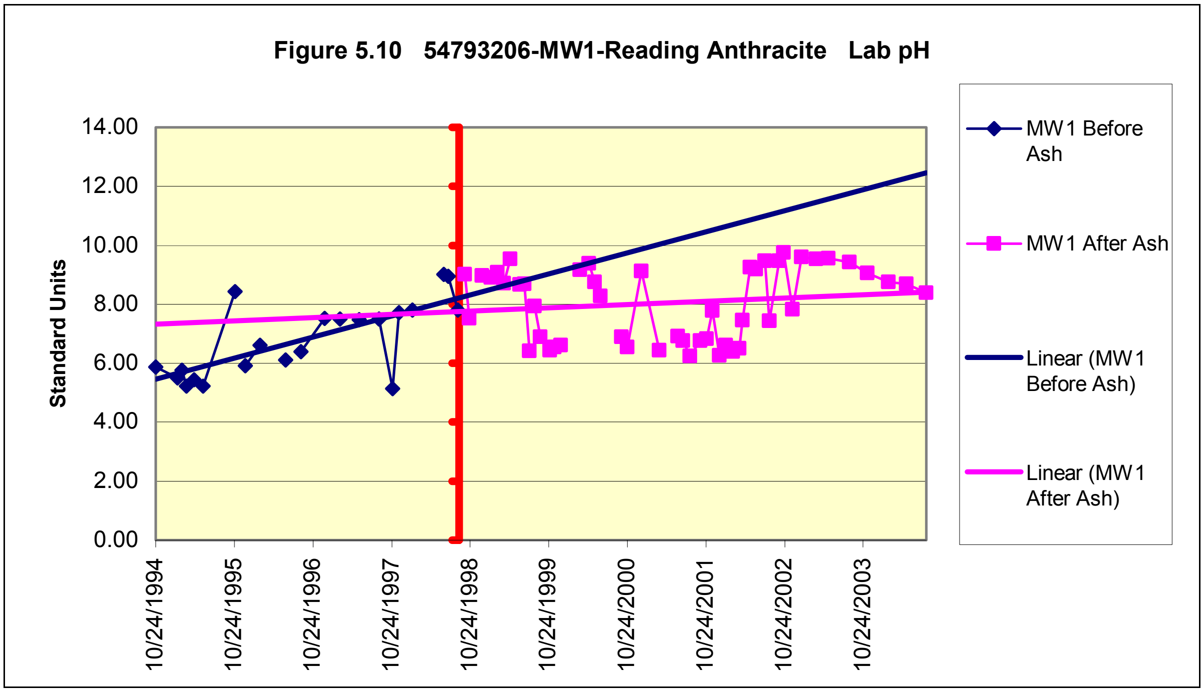


Figure 5.10 54793206-MW1-Reading Anthracite Lab pH
Standard Units
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
10/24/1994
10/24/1995
10/24/1996
10/24/1997
10/24/1998
10/24/1999
10/24/2000
10/24/2001
10/24/2002
10/24/2003
MW1 Before Ash
MW1 After Ash
Linear (MW1 Before Ash)
Linear (MW1 After Ash)

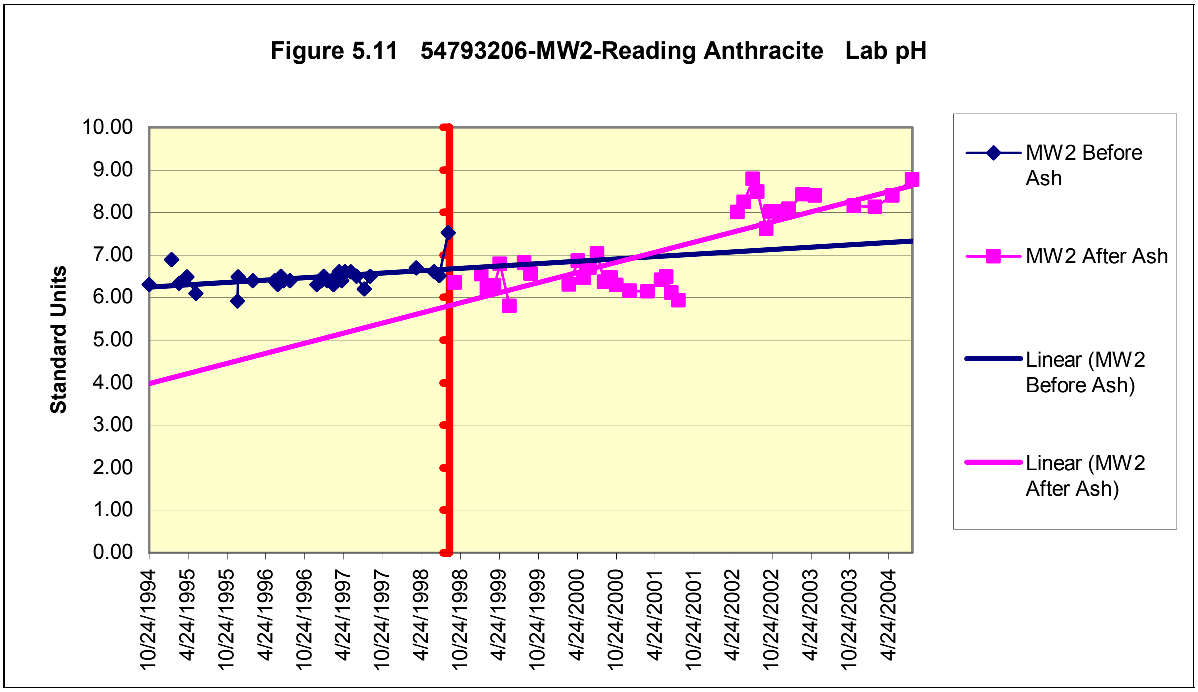


Figure 5.11 54793206-MW2-Reading Anthracite Lab pH
Standard Units
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
10/24/1994
4/24/1995
10/24/1995
4/24/1996
10/24/1996
4/24/1997
10/24/1997
4/24/1998
10/24/1998
4/24/1999
10/24/1999
4/24/2000
10/24/2000
4/24/2001
10/24/2001
4/24/2002
10/24/2002
4/24/2003
10/24/2003
4/24/2004
MW2 Before Ash
MW2 After Ash
Linear (MW2 Before Ash)
Linear (MW2 After Ash)

Figure 5.12 54793206-MW3-Reading Anthracite Lab pH

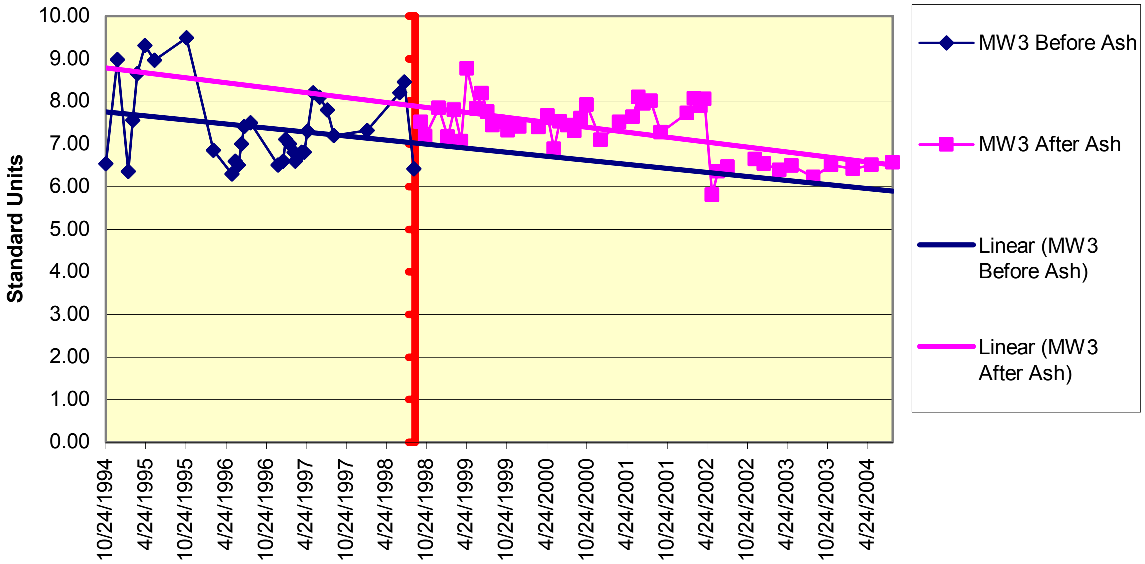


figure 5.13 54793206-MW1vs.MW2 & MW3-Reading Anthracite Magnesium

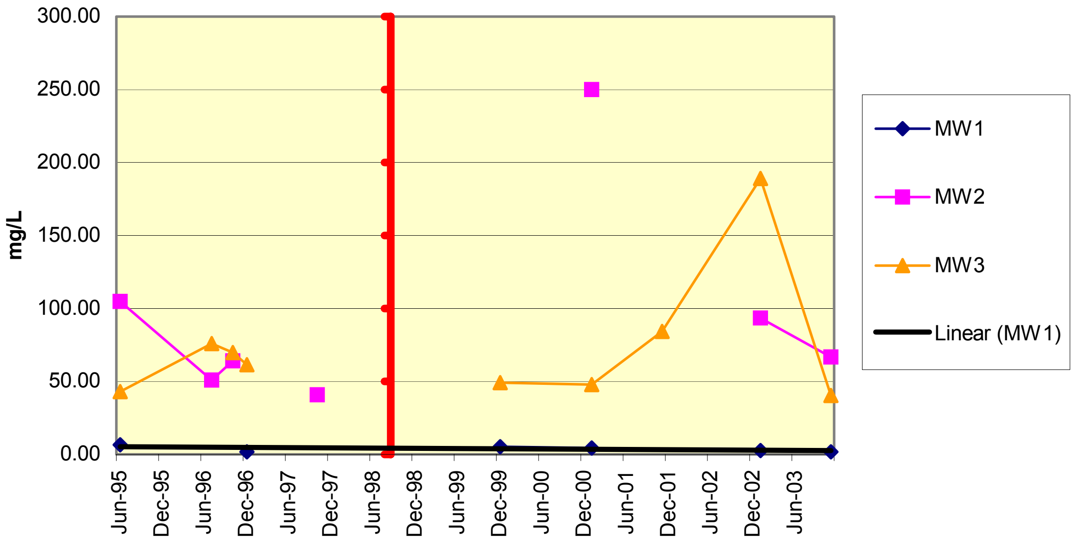


Figure 5.14 54793206-MW1 vs. MW2 & MW3-Reading Anthracite Calcium

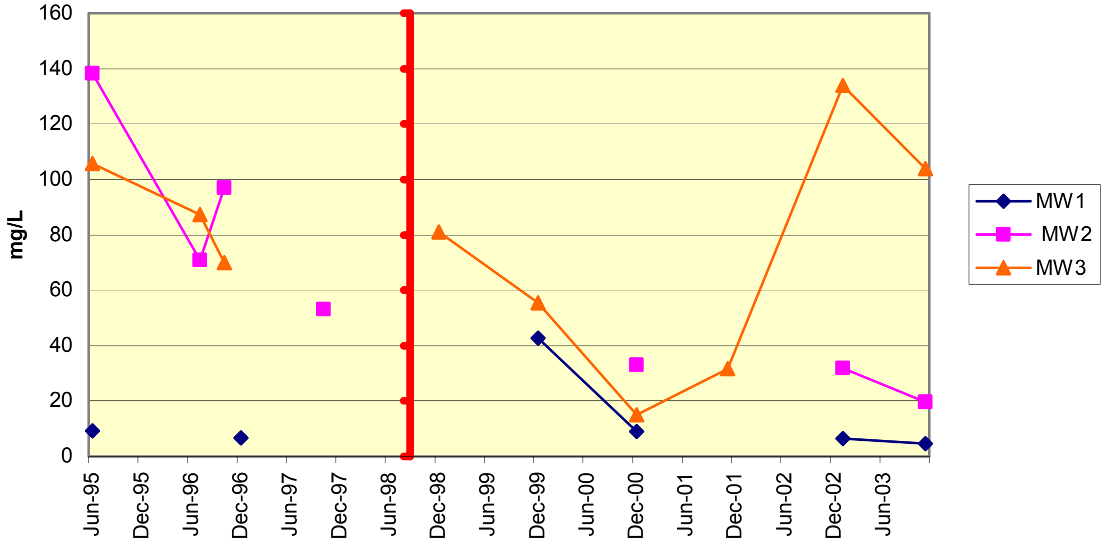
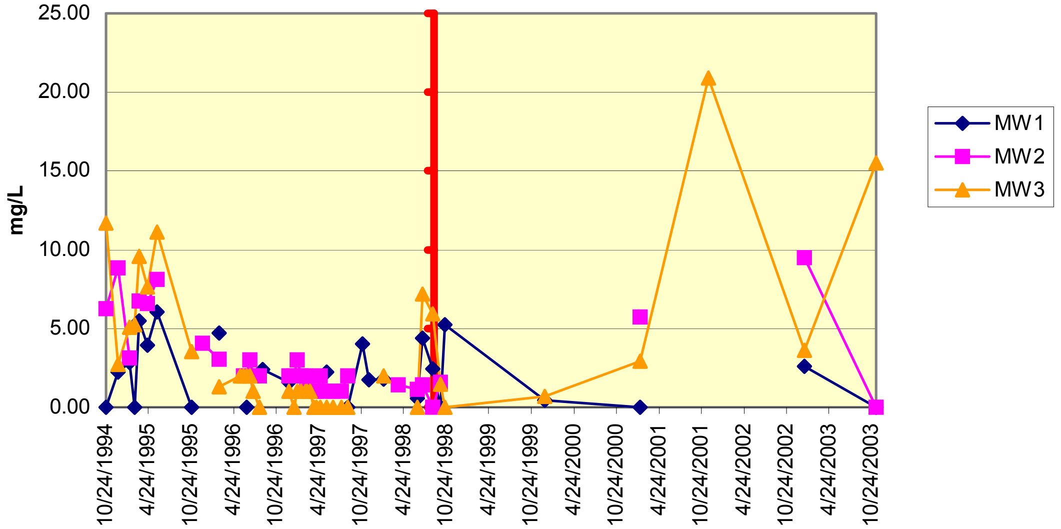


Figure 5.15 54793206-MW1vs.MW2&MW3-Reading Anthracite Chloride



As with magnesium and calcium, there are only annual measurements for trace elements in PADEP's data base, too infrequent to provide an adequate picture of the extent to which dangerous levels of constituents such as lead, cadmium, chromium, arsenic or selenium are leaching into the underlying minepool as a result of this project. However monitoring data discussed later in this report reveals very high levels of lead at downgradient Knickerbocker monitoring points in 2006 after 10 years of monitoring had scarcely revealed any lead at these points. See the discussion on trace elements in Water Quality at Packer V Outfall vs. Ellengowan & BD Mining Monitoring Points through 2006 (page 49).

The exceedances of DWS for sulfate in every one of 12 samples of surface water from four test cells constructed in ash on the surface of the reclaimed Knickerbocker Pit (PADEP Report, pages 239-240, Table 8.4) reinforces evidence that the increasing sulfate in the minepool immediately downgradient of Knickerbocker Pit is coming from the slurried ash. These cells were part of a project designed to, "evaluate the potential for the enhancement of the mechanical properties of the cogeneration ash by the additions of cement kiln dust (CKD)." (PADEP Report, page 232) The slurried Schuylkill ash was mixed with combinations of 5%, 10% and 20% CKD to study the cementitious reactions and packing strength of the mixtures in the cells. Sulfate levels exceeding 1,000 mg/L at MW2 and MW3 after the demonstration project got underway approach the range of sulfate in the water samples from these cells which was from 1,350 to 3,100 mg/L. Flouride concentrations ranging from 3.1 to 6.3 mg/L in nine of those twelve samples exceeded the primary (4.0 mg/L) and secondary (2.0 mg/L) DWS, however PADEP's data base does not include any measurements for fluoride from the Knickerbocker monitoring points beyond October 1998, only one month after the demonstration project began. Calcium in the 12 test cell water samples ranged from 760 to 1,300 mg/L. However according to PADEP, "The pH values of the ash/CKD mixture were between 11.8 and 13.1, probably due to CaO in both the ash and the CKD." This is considerably higher than the pH at the Knickerbocker monitoring points (over 8.5 to 10 in several measurements at MW1 and MW2).

Monitoring ash downgradient to the Knickerbocker Pit -

Mine Pool Monitoring

The monitoring of water quality impacts from ash placement in the Ellengowan and BD Mining areas has been done entirely by sampling points located in several interconnected deep mine pools created in abandoned deep mines such as Maple Hill, West Shenandoah, Boston Run, St. Nicholas, and Gilberton. Information on water levels in these minepools is extremely scant. Information collected for the neighboring BD Mining Permit (B-D MINING COMPANY SMP 54850202 MODULE 25 ASH DISPOSAL, ATTACHMENT 2, MAY 1990) indicate the "average water elevation" in the St. Nicholas (permit materials use "Saint Nicholas" and "St. Nicholas" interchangeably) mine pool was 1119 feet while the "average water elevation" in the Gilberton mine pool was 1097 feet as of May 1990. Water elevations in the Maple Hill mine pool from two measurements during baseline monitoring (at the Maple Hill Shaft) under the Ellengowan Permit were 1115.47 feet on January 3, 1989 and 1129.88 feet on

December 22, 1989. On those same dates, water elevations further west (at Monitoring Holes South) located approximately in West Shenandoah mine pool were 1106.75 feet and 1117.55 feet respectively, i.e., 9-12 feet below those in the Maple Hill mine. Thus assuming these measurements are reflective of average minepool levels, they indicate that the primary direction of mine pool flow under most of the Ellengowan and BD Permit areas is toward the west and the southwest. The discussion below indicates some additional flow occasionally to the north as one moves from mine pools under the BD Mine to mine pools under the Ellengowan Mine.

These mine pools are drained into by pools from other deep mine collieries such as the Turkey Run, Shenandoah City, Indian Ridge, Ellengowan, Knickerbocker, and North Mahanoy mines to the west, north and east under the Ellengowan permit area and the Tunnel Ridge mine under the neighboring BD Mining operation to the southeast. An additional 3.7 million tons of FBC culm ash has been disposed over 175 acres at the BD Mining site directly over the Boston Run mine. Water elevations in the Boston Run mine were identified in the May 1990 BD Mining Permit ATTACHMENT 2 as those established by water levels in an abandoned strip pit in the area which had a maximum high level of 1136 feet with recent elevations ranging from 1114 to 1120 feet. Average minepool elevations to the northeast in the Tunnel Ridge mine were 1140 feet according to ATTACHMENT 2, corroborating flow direction to the west although a barrier pillar in the BD Mining Permit area appears to be forcing that flow to the north into the St. Nicholas Mine.

The scarcity of water level elevation data from ash monitoring points at the Ellengowan and B-D Mining sites hampers effective grasp of the direction of water flow in relevant mine pools which in turn hinders the ability to pin point the sources for increased concentrations in analytes, particularly trace elements in data from Ellengowan ash monitoring points due to their lower, annual frequency of monitoring. Other than three water level elevations provided for the two ash monitoring points in the Module 25 of the Ellengowan permit and only two of those provided on the same dates to allow for comparison between the points, water level elevations are largely absent from subsequent monitoring data for these points in the PADEP permit files until 2005 and 2006. Furthermore there are no well logs or diagrams that provide details on the construction and screening or sample collection depths for Ellengowan ash monitoring points downgradient of the Knickerbocker monitoring wells in the permit files. The absence of this information was confirmed at a May 19, 2005 meeting with staff of the PADEP's Pottsville District Mining Office.

Aside from the Knickerbocker monitoring wells, there are only two ash monitoring points for other ash sites in the Ellengowan Permit even though nearly three fourths of all ash dumped inside the Ellengowan permit area has been dumped at these other sites. One is the Maple Hill Shaft designated as the "upgradient ash monitoring point" (relative to the elevations above and thus flow direction). This point is located south and slightly east of the "Conveyor Ash Site." The other is Monitoring Holes South designated as the downgradient point and located southwest of the "Truck Ash Site" and approximately 6,000 feet west-southwest of the Maple Hill Shaft.

However, both historical and more recent data on mine pool elevations and water flow between underground mines indicates that the Maple Hill Shaft should not be considered an upgradient monitoring point for the purpose of evaluating impacts of ash placement in the Ellengowan and B-D Mining permit areas. A study of the Mahanoy Creek Watershed completed in 1975 under Pennsylvania's Operations Scarlift program[1] found the elevation of the pool to the south of the Maple Hill mine in the St. Nicholas and Boston Run mines underneath the current BD Mining ash placement area to be 26 feet above the Maple Hill mine pool. This study also found the elevation in the Gilberton mine pool further west in the B-D Mining area to be 21 feet above the pool in the Maple Hill Mine. The direction of underground water flow mapped in this study shows water from the North Mahanoy, Knickerbocker, and Shenandoah City underground mines to the east and north of the Maple Hill mine flowing into the Maple Hill mine pool, (see Figure 16, p. 73, MINE POOLS AND UNDERGROUND FLOW IN THE MAHANOY CREEK WATERSHED, MAHANOY CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT, OPERATION SCARLIFT).

Mine Maps discussed earlier in the report also call into question the designation of the Maple Hill Shaft as an upgradient ash monitoring point. Rather these maps indicate that the minepools in the collieries north of, east of and directly under the Ellengowan permit area are interconnected and flow to the Maple Hill Shaft as a central location and low point in the elevation of the dominant syncline of this area. The connections are explicitly stated on Map 4151 and further supported by Map 4112. In the case of two mine fires to be discussed in the next section, the Indian Ridge Colliery is connected to Shenandoah City Colliery through the Shenandoah City Air Shaft and Shenandoah City Colliery to the Maple Hill Colliery further downdip near the Ellengowan Shaft. Additionally, these maps indicate the Knickerbocker Colliery is connected to Maple Hill Colliery and North Mahanoy Colliery by driven tunnels. The North Mahanoy Colliery is then connected to the Maple Hill Shaft (Map 4112). Further south interconnections that include at least one tunnel are noted connecting the St. Nicholas, Suffolk and Boston Run Collieries with Maple Hill Colliery.

More recent data on water level elevations in these mine pools maintained by the PADEP Bureau of Abandoned Mine Reclamation in Wilkes-Barre suggests a complex picture with respect to water flow between the Ellengowan monitoring points and those monitoring the mine pools under the B-D Mining site. Data was obtained from this office for water elevations measured at boreholes into these minepools from November 1986 through November 1991 on a quarterly basis and from November 2000 through August 2003 on an annual basis. Borehole 2 is dug into the same mine pool as the Maple Hill Shaft and the closest measuring point to this monitoring point (within 1800 feet) (see MODULE 25, EXHIBIT 1, B-D MINING COMPANY, SMP NO. 54850202, MINE POOL LOCATIONS, confirmed by telephone discussion with staff of the Bureau of

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[1] - MAHANOY CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT, OPERATION SCARLIFT, COMMONWEALTH OF PENNSYLVANIA, Milton J. Shapp, Governor, DEPARTMENT OF ENVIRONMENTAL RESOURCES, Dr. Maurice K. Goddard, Secretary, SL 197, SANDERS AND THOMAS, INC., CONSULTING ENGINEERS, POTTSVILLE, PA

Abandoned Mine Reclamation, PADEP Wilkes-Barre, October 18, 2005). Water levels at Borehole 2 are higher than the limited measurements of water levels at Monitoring Holes South. However they switch back and forth between water levels at Borehole 5 which is approximately 2500 feet south of Borehole 2 and 1000 feet from MP007, a monitoring point immediately downgradient of the ash placement area at the B-D Mine. Borehole 5 is measuring water levels in the Boston Run and St. Nicholas mine pools, being monitored by MP007. From May 12, 1987 to February 1, 1989, the water at Borehole 2 was an average of 5.59 feet higher (above sea level) than the water at Borehole 5 in eight consecutive measurements. However in the ensuing five measurements from May 1, 1989 to May 8, 1990, the water at Borehole 2 was an average of 9.04 feet below the water at Borehole 5. The levels switched again in six consecutive readings from August 8, 1990 to November 12, 1991 which found water at Borehole 2 an average of 4.48 feet above the water at Borehole 5. Water elevations from November 1991 to November 2000 are apparently hand written only and could not be obtained for this report.

However, annual measurements taken in November 2000 and September 2001 found the water in Borehole 5 to be 5.17 feet and 5.07 feet above the water in Borehole 2 respectively. In June 2002 the water in Borehole 5 was 1.87 feet above the water level in Borehole 2 and in August 2003, the water at Borehole 2 was once again above the water in Borehole 5 by 4.13 feet. PADEP staff explain that depth measurements this close (within several feet) should essentially be considered the same elevation given the level of accuracy of the sensor equipment used in measuring these water levels, (telephone discussion with Bureau of Abandoned Mine Reclamation staff, October 18, 2005). Nonetheless, assuming these similar yet switching water elevations between boreholes infer changes in flow directions of water in interconnected mine pools, it is probable that waters from the mine pools under the adjacent B-D ash placement area are flowing into the mine pools monitored by Monitoring Holes South and at times, the Maple Hill Shaft.

Thus for the past 15 years some 5-6 million tons of ash have been placed in two pits (the Conveyor Site and Knickerbocker Demonstration Pit) that drain directly into the Knickerbocker and Shenandoah City mine pools from which water according to the Ellengowan Permit, still flows into the Maple Hill mine pool on its way west and southwest to the Monitoring Holes South and Gilberton Mine discharge points. Given this fact along with the probable occasional flow into Maple Hill from the St. Nicholas and Boston Run mine pools under the B-D Mining ash placement area to the south, it must be assumed that Maple Hill Shaft is NOT an upgradient monitoring point relative to ash placement areas, and that this monitoring point and Monitoring Holes South as well as the ultimate downgradient monitoring point on the B-D site, the Gilberton Shaft (MP-006), sample water quality impacted by the ash in both permit areas.

The lower elevation and apparent larger pumping operation at the Gilberton Shaft should draw water from the Maple Hill mine pool westward to the Gilberton mine pool today. PADEP documents state repeatedly that waters in the St. Nicholas Colliery flow west to the Gilberton Shaft which is pumped continuously to control mine pool levels, prevent flooding in the town of Gilberton, and provide water for the Gilberton Power Plant (See Permit Review 7, B&D Mining Permit #54850202 and Coal Ash Beneficial

Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania, Chapter 4). The Gilberton Shaft has also served as a downgradient monitoring point for the Turkey Run Municipal Waste Landfill (Permit ID No. 100799) from the 1970s through the early 1990s, which is located in an abandoned mine over the Turkey Run minepool which also drains south into the Ellengowan Permit area.

However there are at least four other groundwater withdrawal operations from the minepools underneath the BD and Ellengowan permit sites in the Mahanoy City and Shenandoah vicinities and several permitted discharges to these minepools making broad assumptions that minepool water is always flowing to the west questionable. In fact maps maintained by the PADEP's Geospatial Data Center (www.emappa.dep.state.pa.us/emappa) identify the Maple Hill Shaft presently as a permitted site for withdrawal of mine groundwater (Sub Facility ID # 277046), a discharge point for septic water (SF ID # 277047) and a groundwater recharge point (with water being discharged into the Shaft as apparently authorized by SF ID # 277048). Presumably most of this activity has been undertaken to accommodate the Schuylkill Energy Resources (SER) Plant and the Knickerbocker Demonstration Project. A Report, Use of Mine Pool Water for Power Plant Cooling, (U.S. D.O.E., National Energy Technology Laboratory, contract W-31-109-Eng-38, September 2003, Table 5-1, page 26), indicates that the withdrawal rate of water from the Maple Hill mine by the SER Plant is 1,100 gallons per minute. This is almost equal to the volume of the discharge from the Packer V outfall reported in PADEP's Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania (Dec. 2004, Chapter 2, Table 2.1, page 48) as 1,200 gallons per minute. However it is well below the volume of water being pumped from the Gilberton Shaft throughout most of the 1990s, reported to range from 6,000 to 11,300 gallons per minute according Gilberton pump records maintained in the Wilkesbarre Regional Office of PADEP. The authors do not know the volume of water being withdrawn from two other "Ground Water Withdrawal" points on PADEP's Maps (EMAPPA). These are each adjacent to a "Point of Air Emission" (presumably an industrial facility or power plant) that appear to be located over the Boston Run and St. Nicholas mines east of the Gilberton Shaft. Furthermore one of these withdrawal points southeast of Maple Hill, in the St. Nicholas vicinity is located next to another "Discharge" point. Thus depending upon the amount of water being withdrawn from versus discharged into the Maple Hill Shaft as well as the rates of such operations at these other points, these activities could have significant dynamic effects on mine pools. The degree of these effects is impossible to discern because most monitoring reports as well as the PADEP's monitoring data base lack static water level information for the Ellengowan and BD monitoring points. Furthermore there is no reporting on pumping rates or discussion of related activities at these points in the Ellengowan or BD Mining permit files. Even monitoring reports for the last quarter of 2005 and first three quarters of 2006 that have divulged water level information for the Knickerbocker monitoring points and Monitoring Holes South lack water level elevations for the Maple Hill or Gilberton Shafts.

These reports do indicate nonetheless that water level elevations at Monitoring Holes South average 24.5 feet below the lowest water elevations at Knickerbocker

Monitoring points which are found at MW3. Thus absent substantive new water elevation data that would contradict these reports or the few available baseline measurements from 17 years ago indicating the Gilberton Shaft mine water levels were 18-33 feet below mine water levels at Maple Hill Shaft, the authors assume that mine pool flows are generally still toward the west and southwest across the Ellengowan permit area from the Knickerbocker monitoring points toward Maple Hill Shaft and then past Monitoring Holes South toward the largest documented source of continuous withdrawal from area minepools at the Gilberton Shaft. However the specific degrees to which monitoring points at Maple Hill and Gilberton are reflecting zones of influence from pumping are matters of speculation.

Possible Impacts of Mine Fires on Mine Pool Water Quality

Shenandoah Boro, Schuylkill County, had been plagued by the presence of two deep mine fires within the boro boundaries. The most notable was the Kehley Run Mine Fire that was extinguished by the Commonwealth of Pennsylvania during the time frame 1971-1977. The second fire (Circa. 1995) was located in the Shenandoah City workings and was evaluated by the PADEP through borings drilled into the mine workings. This fire was deemed under control and did not constitute an environmental hazard; consequently no mitigative action was taken. The Map below illustrates the locations of these fires.

The Kehley Run fire was extinguished because of the nuisance odors and hazardous gases that were emanating from the burning of the coal and culm in the area of the Shen Penn Pit (the entrance to the former Indian Ridge workings) and because this fire had the potential of spreading beneath Shenandoah Boro proper which would have led to a similar disaster and relocation as occurred in Centralia Boro in adjoining Columbia County. In both of these situations the burning coal seams trended beneath the respective communities endangering residents living above.

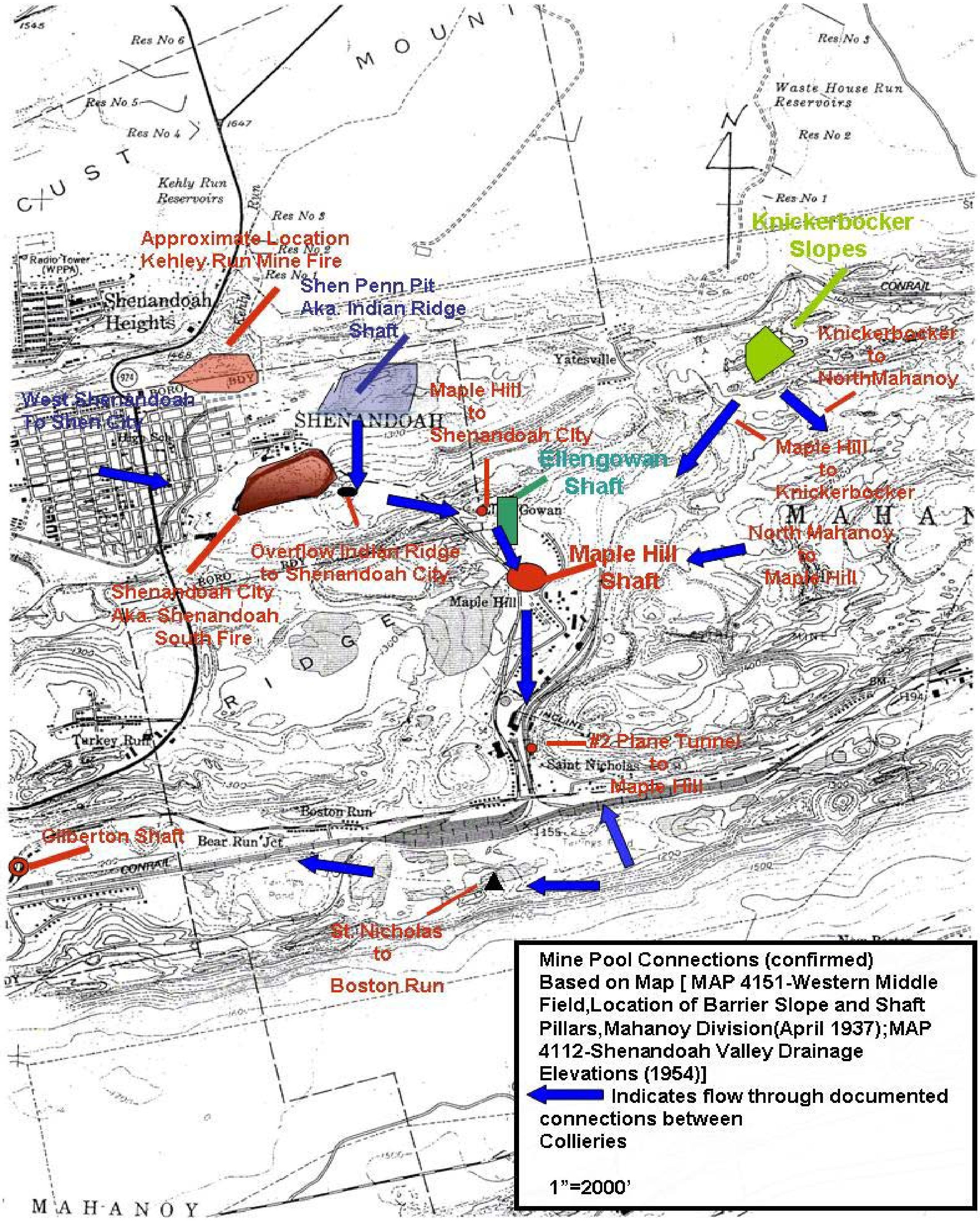
Based on files reviewed in the Wilkes Barre Office of PADEP, attempts to restrict the spread of the Kehley Run fire included the attempted application of an incombustible barrier in the affected coal measures thought by PADEP staff to be composed of either fly ash or sand. During this time period, flyash was being promoted as a mine flushing material in mining operations. Records indicate some 34,452 cubic yards and 21,511.6 cubic yards of “incombustible” material were injected into the Buck Mountain Vein apparently east and west of the Kehley Run mine fire, respectively. The total volume of incombustible material used was 55,963.6 cubic yards. Conservatively assuming a conversion factor of .70, this would be roughly equivalent to 39,175 tons of this material. No identity or analysis of the quality of the incombustible materials used at Kehley Run was found but considering the concentration of toxic metals and other constituents in coal ash and the complex but potentially high leaching potential of coal ash with time in the environment, it is quite possible if this material was made up even partially of ash, that it could have impacted the quality of the Kehley Run mine pool with toxic metals and other ash constituents. The Kehley Run mine pool is hydrologically connected to the Indian Ridge mine pool which drains to the Knickerbocker minepool and is also connected to other minepools to the south.

Similar to the problems with the Centralia fire, this approach apparently did not work because the steeply dipping strata caused the barrier material to flow too far downdip; consequently, a more radical approach had to be used, that of physically removing the burning culm and coal and extinguishing it with water.

Because of the proximity of the Kehley Run site to the Shen Penn Pit, the “hot” burning coal and ash was dumped directly into the exposed mine pool in this Pit. Files in Wilkes Barre only had excavation records for the year 1971 which indicated that the “hot material” was disposed of in the pit and the “cold material” dumped at a “Northeast Dumping Area” which was not identified in the existing files. This project was conducted over a 6 year period from 1971-1977. A “Daily Accomplishment Report”, dated September 3, 1971 indicates that 618 loads of “hot” material was disposed of in the Shen Penn Pit on that date. The total volume of “hot” material disposed of in the Shen Penn Pit over the lifetime of this abatement project is unknown.

The second fire was found to the southeast of Shenandoah in the Shenandoah City workings (Circa, 1995) (see Map). Smoke and venting was apparent in this area. A subsurface evaluation was conducted by the PADEP to determine the extent of this fire and if it posed a threat. PADEP files indicate six borings were drilled in the area to ascertain the limits of this suspected fire. Data obtained indicated the presence of elevated temperatures in the borings that ranged from approximately, 55º F. to 182 º F. Borehole B.H.6 had a total depth of 237’ and a water level of 207, which translates into 30’ of water column. It is possible that this boring was advanced into the mine pool underlying this area. The temperatures measured from these borings indicate that there was some smoldering of coal and/or culm in this area, but this combustion did not achieve the threshold temperature of +200º F. used by the federal Office of Surface Mining to determine the presence of an active mine fire.

These minefires and the resulting abatement measures should have left considerable quantities of coal combustion residue and ash directly in the minepools flowing under the Ellengowan Permit area. In the case of the Kehley Run Fire, there is no question of this fact as significant (albeit unknown) quantities of burning coal and related rock were dumped into Shen Penn Pit directly into the Indian Ridge mine pool for an extended period of time in the early to mid1970s to extinguish this combustion.



Mine Pool Connections (confirmed)
Based on Map [MAP 4151-Western Middle Field,Location of Barrier Slope and Shaft Pillars,Mahanoy Division(April 1937);MAP 4112-Shenandoah Valley Drainage Elevations (1954)]

⬅ Indicates flow through documented connections between Collieries

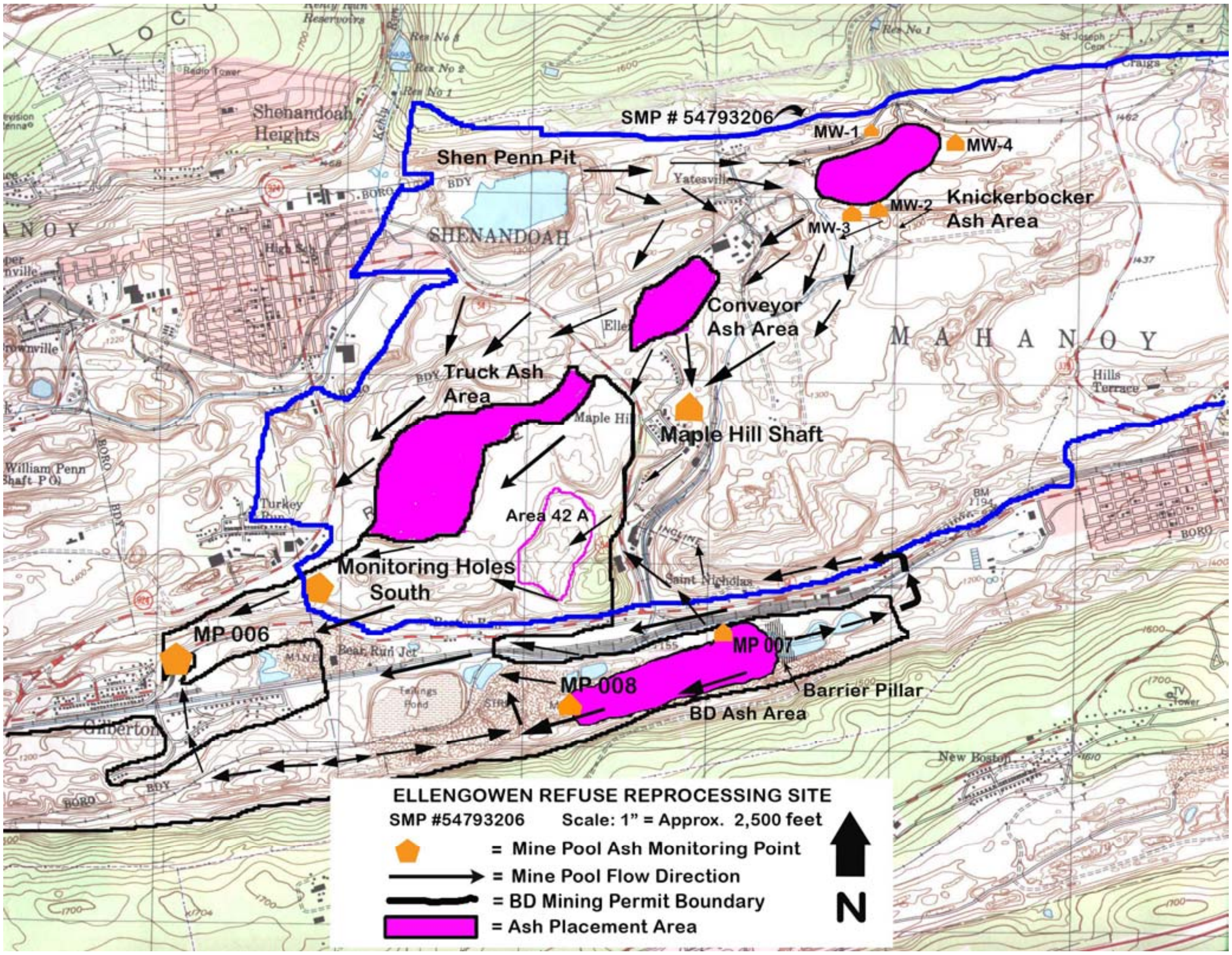
1"=2000'

Ellengowan Mine: Truck and Conveyor Ash Sites

Ash placement had been going on under the Ellengowan Refuse Bank Permit for almost nine years prior to ash arriving at the Knickerbocker Pit Demonstration area. On December 22, 1986, Surface Mining Permit 54793206 was revised to allow the disposal of fly ash and bottom ash in two abandoned strip pits in the Ellengowan Permit area (see map). These two strip pit sites are situated to the southwest of the Knickerbocker ash placement area in the Maple Hill basin. The site immediately to the southwest of the Knickerbocker site, known as the "Conveyor Site," is 32 acres. The other site, known as the "Truck Site," is 144 acres and is located further to the southwest across State Road 54 on Bear Ridge. The operation under this permit called for coal refuse reprocessing, whereby culm (waste anthracite coal) on the site is mined and burned at the Schuylkill Energy FBC Power Plant, and the resulting ash is then placed back in the mine in these two pits. Based on information from bi-annual ash reports from Reading Anthracite Co., ash was first placed in these pits starting with 29,315 tons in 1989. The reports do not specify the actual starting date but do indicate that by the end of 2003, 9.1 million tons of ash had been deposited in them. The reports also indicate that two thirds of this quantity went to the Truck Site and that all ash shipments from 1989 through 1996 went to this larger disposal site.

The map below of the Ellengowan Refuse Reprocessing Permit area reflects a boundary change that transferred part of the Ellengowan Permit area to the neighboring BD Mining Permit area (Permit # 54850202) to accommodate a new 51 acre ash disposal site, known as Area 42A added to the BD Mining Permit in October 2002. This ash disposal area is north of the Gilberton-Mahanoy City Highway, (SR4030) and south of the Truck Ash Area and authorized to take 4 million tons of ash. Area 42A has only just begun operating and also is utilizing the Maple Hill Shaft and Monitoring Holes South as its two sole monitoring points. BD Mining Permit materials identify Maple Hill Shaft as "RAC-MP#1" and Monitoring Holes South as "RAC-MP#2". How the PADEP intends to insure that the monitoring system for this new site can differentiate impacts from ash placed in Area 42A from the impacts of some 15 million tons of ash already placed in the Ellengowan and BD Mining permit areas is unclear.

Although the baseline period (demarcated by the vertical red line) concluded by the middle of 1989 in figures 5.16 through 5.34, it should be understood that regular ash placement was underway by March, 1988 in the BD Mining permit (see Permit Review 7) adjacent to this permit and that both monitoring points assessed below are in positions to detect water quality impacts from the earlier BD ash placement in addition to the deep mine fires of the 1970s and 1990s. Monitoring Holes South also appears to be in a downgradient position to the Turkey Run Municipal Landfill which was a disposal site according to PADEP records for coal fly ash and other industrial wastes in the 1970s. Given the lack of understanding of when ash first arrived at the Truck and Conveyor Pits in 1989 as well as the likelihood of impact from other coal ash to baseline concentrations, trend lines in figures 5.16 through 5.34 are for all monitoring data collected and do not differentiate between baseline and ash placement periods. The data discussed in these figures extends through January 2003 for trace elements and August 2004 for major constituents. An update on water quality extending through September 2006 at these and other monitoring points is presented in a following section in figures 5.35 through 5.50.



Maple Hill Shaft and Monitoring Holes South

Data is available for a substantially longer time in PADEP's monitoring data base from the Ellengowan monitoring points, Maple Hill Shaft and Monitoring Holes South, than from the Knickerbocker Demonstration monitoring points, and it reveals higher levels of the some of the same trace elements that are found in high concentrations at the BD Mining ash monitoring points, the most notable being cadmium, chromium and lead. Additionally arsenic concentrations have been higher at the Ellengowan monitoring points than at the BD monitoring points.

Assessment is hampered somewhat by an inconsistent rounding of values for trace element concentrations reported in the data base from the Ellengowan monitoring points. For example lead concentrations in the data base have been rounded from the tenth (one place to the right of the decimal) to the ten thousandth place (four places to the right of the decimal). Often values are rounded to the hundredths place, i.e. to 0.00 mg/L which is too high to determine whether concentrations for some trace elements, such as cadmium are approaching the DWS (0.005 mg/L) or exceeding water quality standards (the continous chronic criterion for cadmium is 0.00025) which would be relevant for mine discharges to surface waters. Whether this is a laboratory analysis or reporting problem or a deficiency in transcribing data from monitoring reports is not clear.

Notwithstanding such limitations, arsenic concentrations (figure 5.16) at Maple Hill Shaft increased dramatically in 1988 and 1989 to a peak of 0.240 mg/L in April, 1989, 24 times above the revised federal DWS and nearly five times the older DWS. This peak and a subsequent peak in arsenic of 0.22 mg/L in October of 1989 occurred when water elevations at deep mine boreholes suggests water direction in the minepools would have been changing to flow from the BD ash site to the Maple Hill Shaft (see earlier discussion on Monitoring ash downgradient to the Knickerbocker Pit - mine pool monitoring). While these peaks of arsenic would have likely preceded the influence of ash dumped in the Truck Pit of the Ellengowan Permit, they occurred more than a year after ash placement was underway at the BD site. At Monitoring Holes South, concentrations of arsenic were lower; they were measured five times above detection levels all after March 1988 when ash placement started at the BD site. In three of those instances, levels exceeded 0.010 mg/L, the new DWS. The highest level measured was 0.042 mg/L in December 1989 after ash placement was underway at both the BD and Ellengowan pits. The overall trend at Maple Hill is decreasing, whereas, at the Monitoring Holes South arsenic levels are slightly increasing.

Cadmium concentrations (figure 5.17) spiked at Maple Hill to 0.160 mg/L, 32 times the DWS, in June 1988 but were not measured above 0.010 mg/L in subsequent measurements. June 1988 was before ash placement was documented to have started at the Ellengowan Pits, but it was three months after regular ash placement had started at the BD ash pit according to inspection reports for the BD permit. Cadmium levels of 0.03 and 0.02 mg/L were measured in September 1988 at Monitoring Holes South, again probably before ash placement had started at Ellengowan but six months after placement had started at the BD site. While cadmium levels have been decreasing at Maple Hill they have been increasing at Monitoring Holes South reaching 0.07 mg/L in November 2001, 14 times above the DWS. According to an April 5, 1991 PADER memo from the Bureau of Waste Management in Wilkesbarre, leach tests performed on two SER ash samples in February 1990 produced leachate from the bottom ash with 0.32 mg/L of cadmium and leachate from fly ash also with 0.32 mg/L of cadmium. This is 64 times the DWS and was "above regulatory limits" according to the memo.

At Monitoring Holes South some 19 high concentrations of chromium (figure 5.18) were measured from September 1987 (the first sampling result available) through December 1989. The measurements ranged from 0.13 to 0.58 mg/L (more than 5 times the DWS of 0.1 mg/L) with this highest measurement found in an April 1989 sample, 13 months after ash placement was underway in the BD ash area. However the concentrated occurrence of chromium levels began at least six months before regular ash placement was reported to be underway at either Ellengowan or BD ash placement areas indicating that another source was contributing chromium to the minepool before the culm ash authorized for placement at these mines. After December 1989, chromium levels dropped significantly at Monitoring Holes South, staying below the DWS (0.100 mg/L) for the rest of monitoring. Several high readings of chromium (as high as 0.32 mg/L) also occurred at Maple Hill Shaft from January 1989 through December 1990. These hits started nine months after ash placement was underway at the BD mine and overlapped with the start of ash placement in the Ellengowan pits. As with arsenic, the highest readings among these measurements occurred in April 1989 when water elevation data at the closest Boreholes suggest water would have been switching directions to flow toward the Maple Hill Shaft from the BD ash pit. Chromium was found at 0.232 mg/L in November 1991 and 0.099 mg/L in September 1995 at MP007 immediately adjacent to the BD ash pit. At least 10 samples of fly ash and bottom ash from the Gilberton Plant placed in the BD pit, have leached over the DWS for chromium. The highest level, 0.32 mg/L, (3.2 times the DWS) leached from a September 1988 sample of fly ash from Boiler #2 (see Chapter 4, Table 4.2, page 92, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania).

The Kehley Run mine fire which resulted in large albeit unspecified quantities of burned rock and ash being dumped into the Indian Ridge Mine pool during the 1970s may also be a source for these high chromium levels in the early measurements at Monitoring Holes South. The disposal of fly ash, plating wastes, aluminum hydroxide sludges and other industrial wastes at the Turkey Run Landfill at undisclosed dates, approximately a decade before the current minefilling operations began in 1989 at Ellengowan, poses an additional potential source for this chromium. The Turkey Run Landfill sits above the Turkey Run deep mine that drains into the minepools monitored by Monitoring Holes South and the Gilberton Shaft, a designated downgradient monitoring point for this Landfill. These additional ash sources could also explain the higher levels of arsenic and cadmium found in baseline monitoring at these monitoring points.

It is also possible that the parent materials for the ash dumped at these mines, the culm, coal silt, coal or other toxic forming materials in the spoil may be a significant source(s) of these metal levels. However, the high incidence of their occurance between 1987 and 1990 suggests a plume of contamination from a more concentrated source in minepool waters that washed through the system and/or has been subsequently diluted to background levels or diverted to unmonitored pathways. If the site materials were contributing these trace elements to the minepool, one would expect their high levels to be encountered more evenly throughout the monitoring period and at higher volume discharge points such as the Gilberton Shaft and Packer V discharge reflecting the ambient quality of mine pool waters, neither of which is the case (with one exception of .0631 mg/L of arsenic measured at the Gilberton Shaft in June 1995).

Lead (figure 5.19) concentrations are trending upwards in both monitoring points to levels many times above the DWS (federal action level of 0.015 mg/l). The highest lead concentration, 0.70 mg/L, (more than 46 times the DWS) occurred in April 1989 at

Monitoring Holes South, probably before significant ash placement had occurred at the Ellengowan pits but 12-13 months after regular placement of Gilberton Cogeneration Station ash had started at the B-D pit. After ash placement had commenced in the Ellengowan pits, lead levels have been measured at 12 times, 22 times, more than 8 times and more than 26 times above the DWS at Monitoring Holes South, with this last concentration measured in November 2001. Levels in the Maple Hill Shaft monitoring point have been measured as high as 12 times above the DWS. These levels at both monitoring points are similar to lead levels measured at the BD Mining ash monitoring points and higher than lead levels normally seen in anthracite mine drainage (see discussion entitled "High Lead Levels" on pages 197-200 in Permit Review 7 and comparison of the Packer V discharge with other monitoring points later in this review).

Leach tests performed under the permit on the ash disposed in the Truck and Conveyor sites from the SER Plant have demonstrated that this ash has the potential to leach high levels of lead in short periods. A sample of SER bottom ash taken in January 1990 leached 0.42 mg/L (28 times the DWS) in the 18 hour Synthetic Precipitation Leachate Procedure (SPLP) test, and a sample of "Conditioned Fly Ash" taken on the same date from the SER Plant leached 0.44 mg/L in the test (see Table 4.3, page 96, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania). Tested samples of combined fly and bottom ash from the SER plant leached 0.09 mg/L of lead in April 1991 and 0.12 mg/L of lead in October 1998.

In addition according to a data base maintained by the US Department of Energy, the Gilberton ash has leached higher lead levels than any other coal ash in leach tests on ashes tested at numerous minefills in Pennsylvania (see Permit Review 7, Conclusion, pages 201 and 202 for details on these leach tests). Thus the potential for both of the primary ashes dumped in pits upgradient to both of these monitoring points to contaminate water with lead has been well established. This would particularly be the case at Monitoring Holes South which according to available water elevation data is consistently downgradient (below the elevations of) of the St. Nicholas and Boston Run mine pools under the BD ash pit.

As occurred with other metals however, it should also be noted that lead levels of 0.10 mg/l in February 1987 at Maple Hill Shaft and 0.20 mg/L in September 1987 at Monitoring Holes South point to another source (or at least an additional source) of lead in the water as these results were recorded before PADEP records indicate appreciable amounts of FBC culm ash were being placed in either the BD Mining or Ellengowan permit ash areas. Other sources could include residual ash from mine fires, the Turkey Run Landfill's fly ash, and culm, coal silt and/or mine spoils at the Ellengowan and BD sites.

Figure 5.16 54793206-Maple Hill & Holes South-Reading Anthracite Arsenic

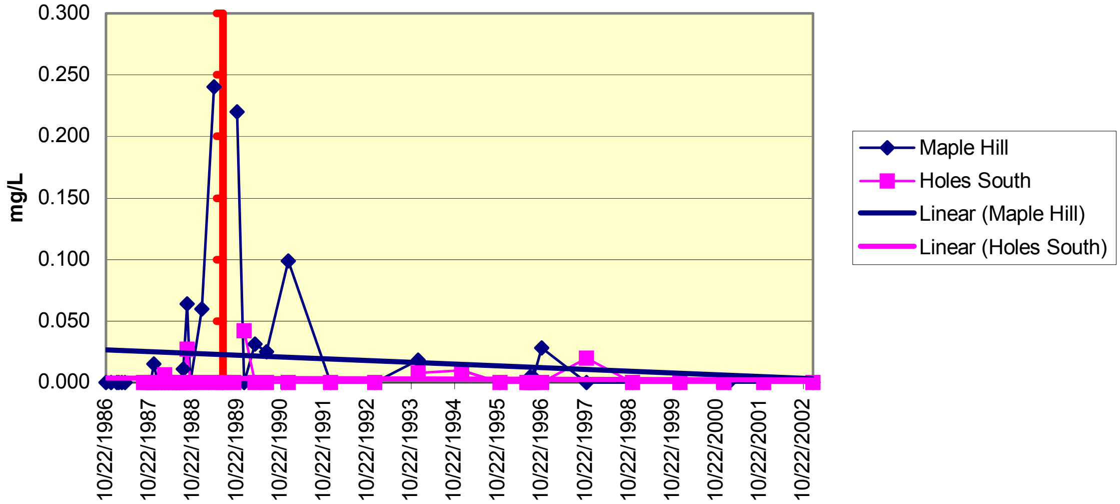


Figure 5.17 54793206-Maple Hill & Hole South-Reading Anthracite Cadmium

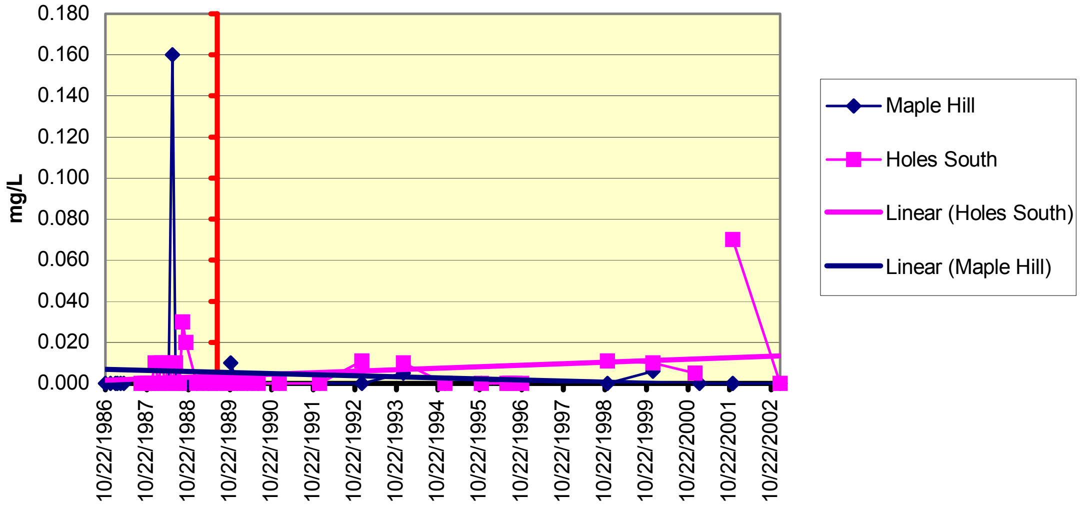


Figure 5.18 54793206-Maple Hill & Holes South-Reading Anthracite Chromium

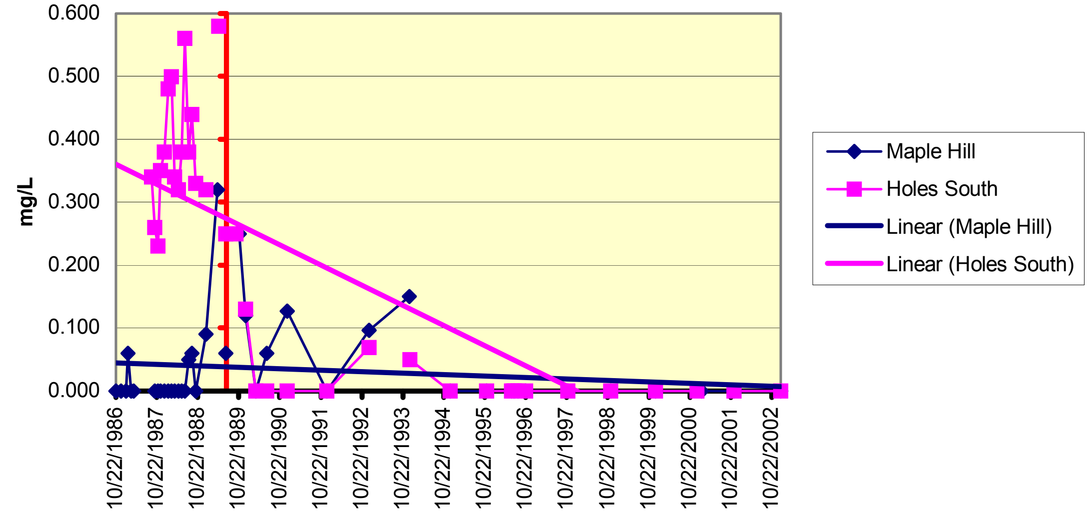
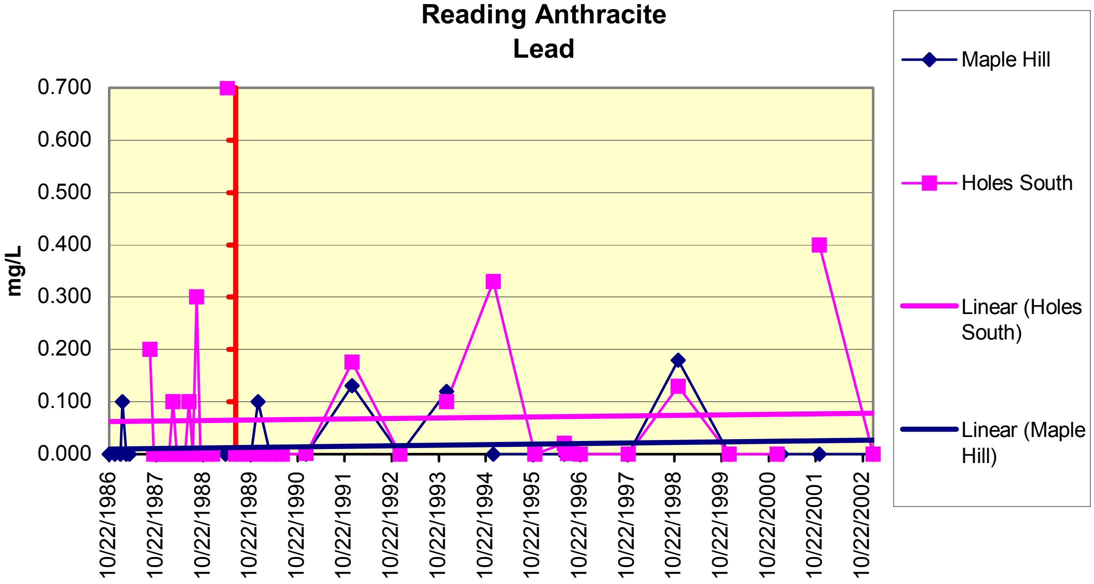


Figure 5.19 54793206-Maple Hill & Holes South-Reading Anthracite Lead



Calcium (figure 5.20) concentrations are decreasing at both monitoring points from December 1994 to January 2003, the data available from PADEP's data base. Unlike at other remining sites studied in this report, the declining calcium is occurring as pH is rising and alkalinity is dominating acidity at both Maple Hill Shaft and Monitoring Holes South (see figures 5.27 through 5.29). There was no data collected for calcium from these points prior to December 1994 making a more complete assessment of trends impossible.

Average magnesium concentrations (figure 5.21) have been declining at Monitoring Holes South and rising at Maple Hill Shaft while ash placement has ocurrred in the Ellengowan Pits. As occurred with arsenic, chromium, cadmium and lead, elevated levels of magnesium were being contributed by some discreet source to the Monitoring Holes South monitoring point in 1987 and 1988 before ash placement was documented to be underway at the Ellengowan or BD ash areas. While the magnesium trend at Maple Hill Shaft does not appear to match the calcium trend (see figure 5.20), the absence of calcium data before 1994 prevents a conclusion to this effect, and there are some roughly parallel rises and declines between these constituents after 1995.

Chloride concentrations (figure 5.22a) appear to be increasing at both monitoring points but more at Monitoring Holes South. Fluoride concentrations (figure 5.22b) are increasing at Monitoring Holes South but declining at Maple Hill Shaft. A measurement of 1.0 mg/L in December 1993 could be due to a sampling or analysis error given its simultaneous occurance at both monitoring points. There were four measurements at Maple Hill from June to August 1996 that were between .20 and .40, approximately twice as high as the baseline concentrations measured at this point, but a large number of samplings measuring no fluoride resulted in a downward trend in average concentrations at this point. However, some 15 measurements at Monitoring Holes South from May 1996 through August 1997 in the same range, twice baseline concentrations, resulted in an increasing average trend at this point. While these concentrations are well below the DWS for fluoride (primary standard is 4.0 mg/L and secondary is 2.0 mg/L), the failure to record further measurements for fluoride at these monitoring points after July 1998 or at the Knickerbocker monitoring points after ash/slurry placement began is disconcerting given this rise at Monitoring Holes South and exceedances of the DWS for fluoride in most measurements from surface waters on top of the Knickerbocker ash (see the end of the Knickerbocker discussion).

Figure 5.20 54793206-Maple Hill & Holes South-Reading Anthracite Calcium

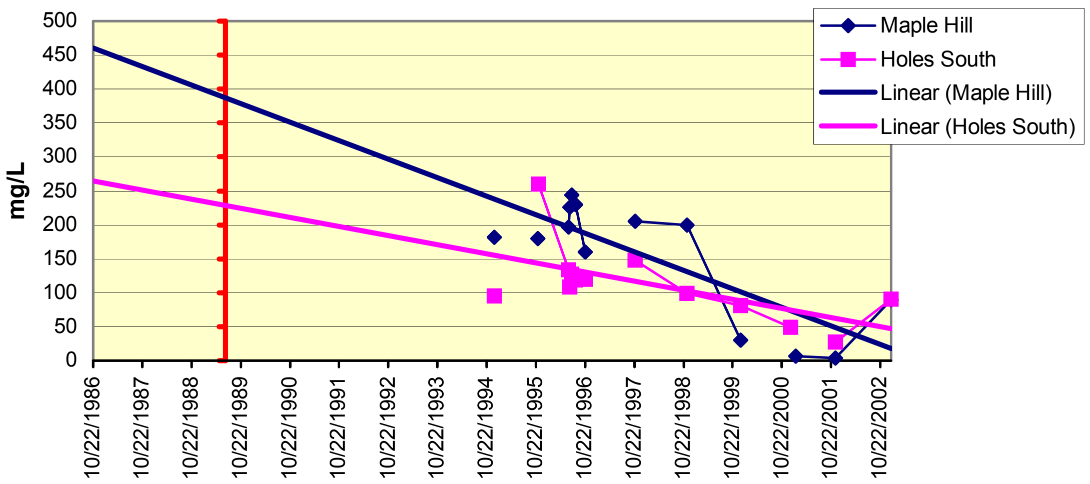
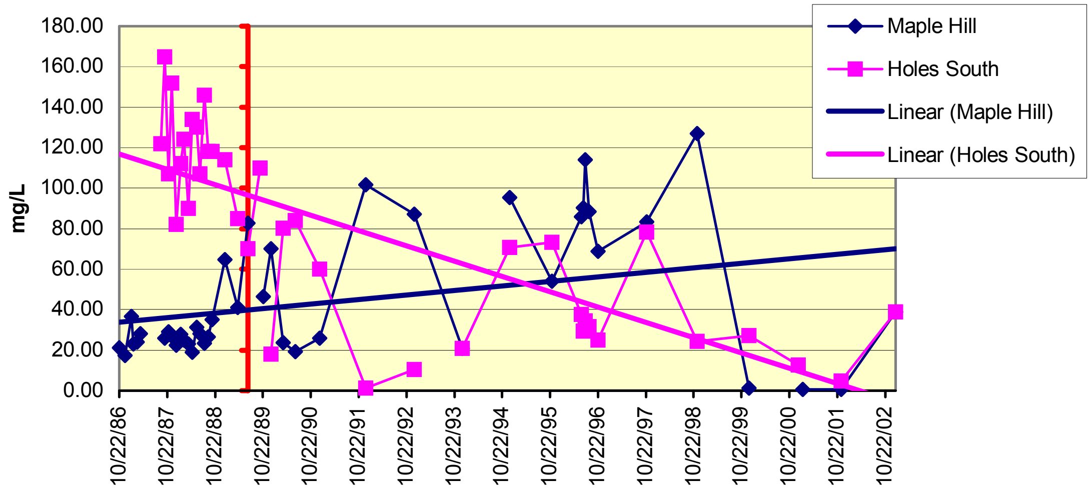


Figure 5.21 54793206-Maple Hill & Holes South-Reading Anthracite Magnesium



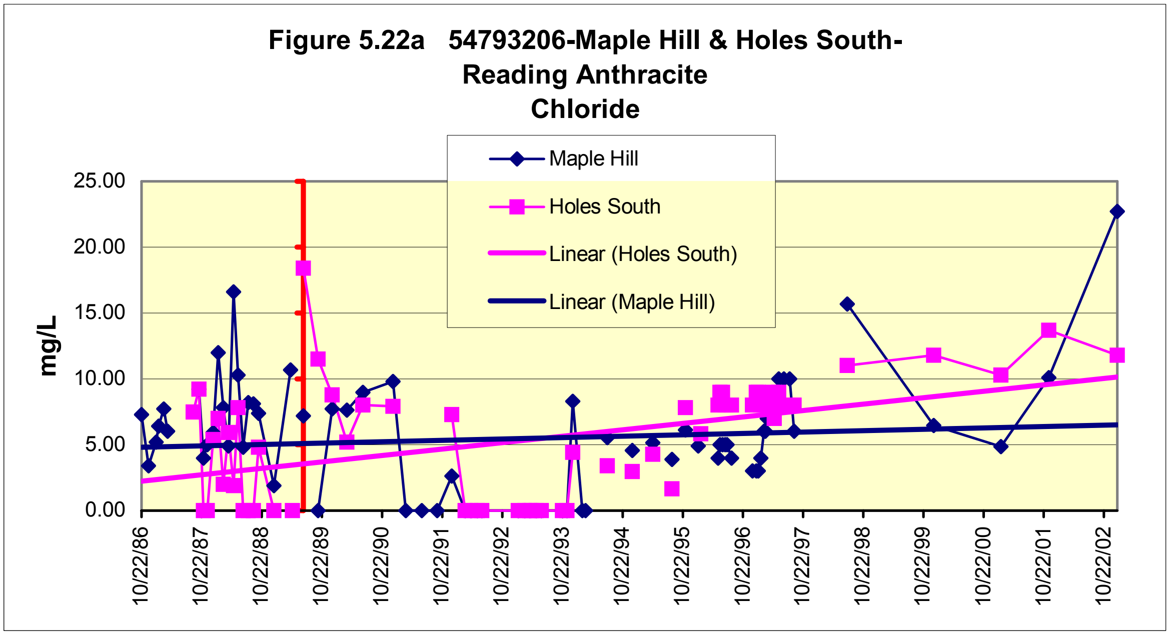


Figure 5.22a 54793206-Maple Hill & Holes South-Reading Anthracite Chloride

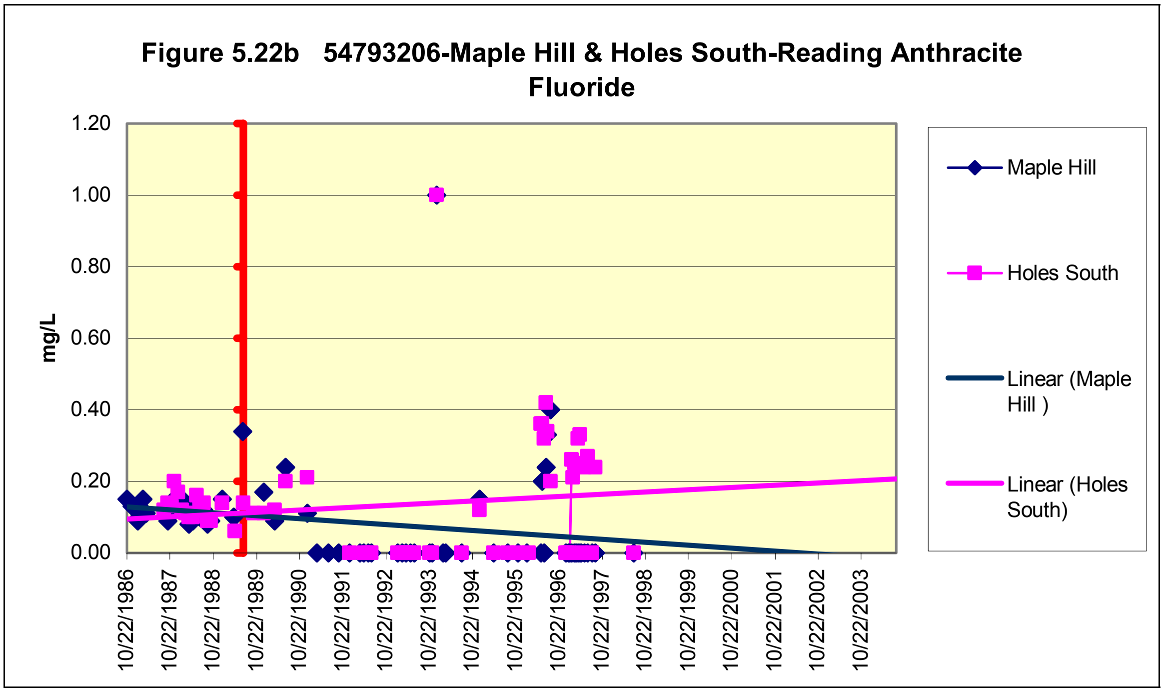


Figure 5.22b 54793206-Maple Hill & Holes South-Reading Anthracite Fluoride

Average aluminum concentrations (figure 5.23) are similar if not nearly identical at the Monitoring Holes South and Maple Hill Shaft monitoring points. An exception is a very high spike (34.90 mg/L) in aluminum measured in October 1997 at Monitoring

Holes South eight years after ash placement was underway at the pits upgradient from this point.

Copper (figure 5.24) concentrations are also trending upwards in both monitoring points, but more noticeably at Monitoring Holes South. A peak of 1.72 mg/L of copper was measured at Monitoring Holes South in the same sampling in October 1997 (October 28, 1997) in which the peak was measured in aluminum. The DWS (federal action level) for copper is 1.3 mg/L.

Data for nickel available only from December 1994 on (figure 5.25) indicate nickel concentrations have been declining at both monitoring points with the exception of a spike to 2.78 mg/L (28 times the old DWS) at Monitoring Holes South in the October 28, 1997 sampling from which the spikes in copper and aluminum were measured. Average zinc levels (figure 5.26) levels have been rising at Monitoring Holes South and also spiked in the October 1997 sampling to 52 mg/L, more than 10 times the DWS. Lower zinc concentrations at Maple Hill Shaft have been slightly rising. Aluminum, nickel, copper and zinc are often highlighted as AMD parameters but can also leach from ash deposits in substantial amounts and have leached in high amounts quickly from ash of the Gilberton Plant. For example, aluminum concentrations in the leachate from the 18 hour SPLP test on six samples of mixed fly ash and bottom ash from the Gilberton Plant taken from 1990-1999 ranged from 5.0 to 10.8 mg/L (Table 4.2, page 92, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania). Aluminum leached from a fly ash sample taken in September 1988 from Boiler #1 at the Gilberton Plant at 23.90 mg/L, and aluminum leached from a fly ash sample taken in September 1990 from this Boiler at 15.83 mg/L (in the SPLP tests). A September 1988 fly ash sample from Boiler #2 at the Gilberton Plant leached 20.60 mg/L, and an October 1990 fly ash sample from Boiler #2 leached 16.62 mg/L. Five separate samples of fly and bottom ash taken in 1988-1990 from both Gilberton Boilers leached over 1 mg/L of zinc (a trace element) in the SPLP test.

Figure 5.23 54793206-Maple Hill & Holes South-Reading Anthracite Aluminum

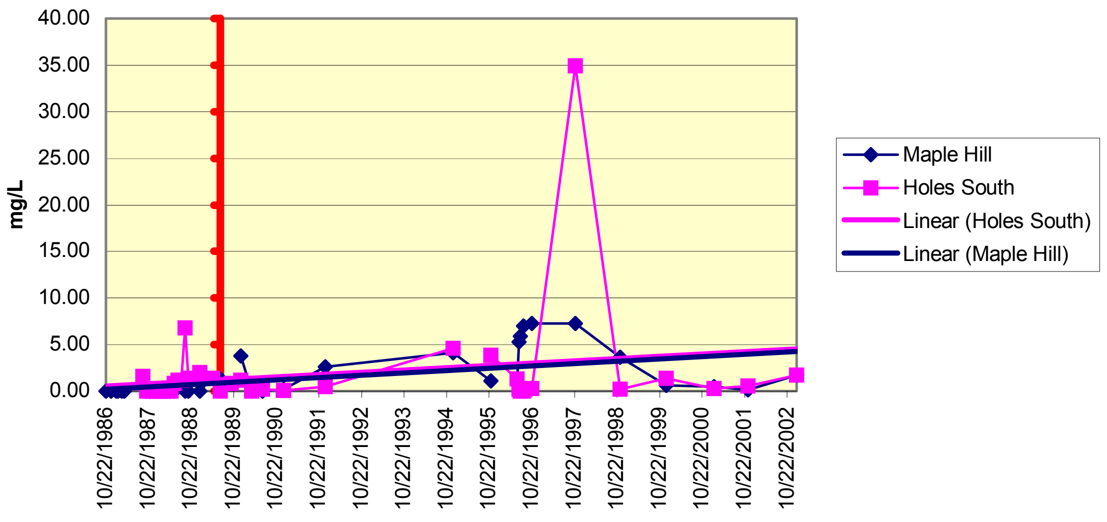
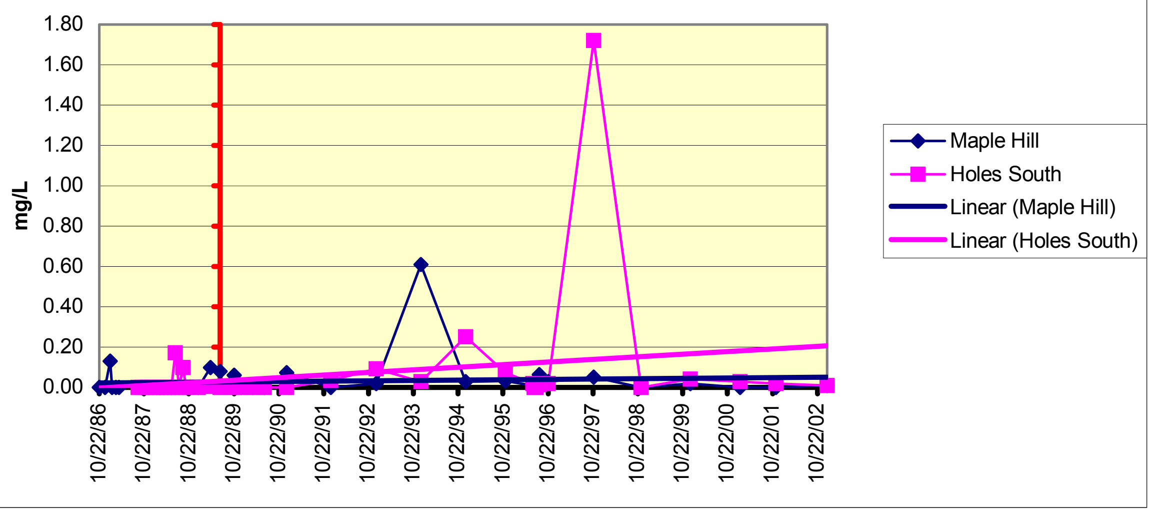


Figure 5.24 54793206-Maple Hill & Holes South-Reading Anthracite Copper



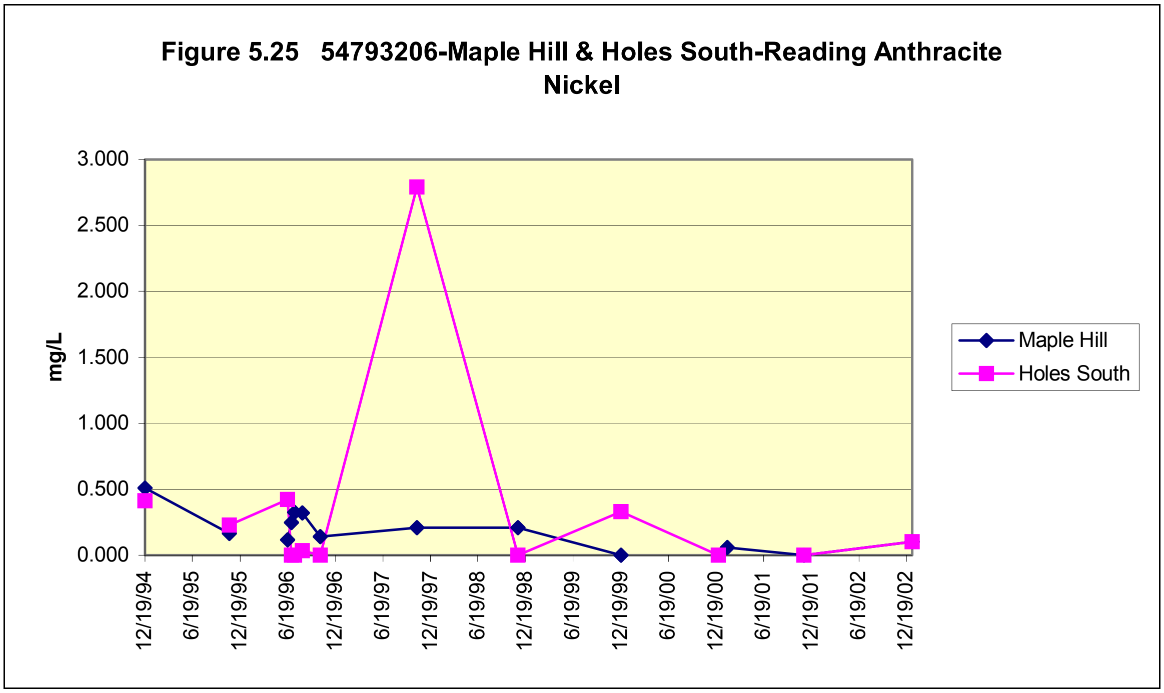


Figure 5.25 54793206-Maple Hill & Holes South-Reading Anthracite Nickel

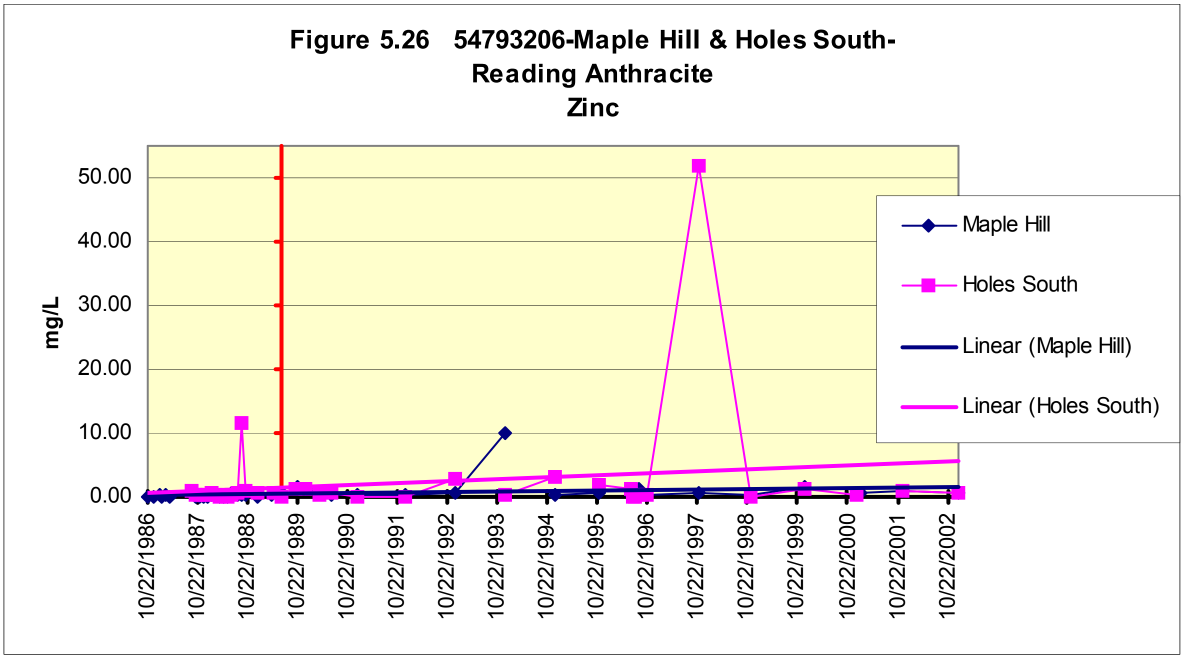


Figure 5.26 54793206-Maple Hill & Holes South-Reading Anthracite Zinc

Laboratory pH (figure 5.27) (there was no data available for field pH) has been increasing significantly at both monitoring points. In fact, the rise in pH at Monitoring Holes South was the greatest pH rise found at any monitoring point of the permit sites studied in this report, increasing from a low value of 4.42 units in May 1992 to a high of

9.58 units in March 2003. This increase at Monitoring Holes South started decisively in late 1997 to early 1998; the lab pH measured in August 1997 of 6.80 increased to 8.87 in July 1998, the next measurement. This was after the average pH at Monitoring Holes South of 6.21 during baseline monitoring decreased to 5.99 from the start of ash placement through 1997. However from 1998 through August 2004, the average pH value was 8.36 at Monitoring Holes South with 10 actual measurements exceeding the secondary DWS of 9.00.

A modest increase at Maple Hill Shaft occurred with average lab pH during baseline monitoring of 6.01 falling to 5.67 through 1997 and then rising to 6.60 from 1998 through the August 2004. The average pH at both monitoring points declined by a unit or more from 2001-2002 to 2003-2004.

The rise in pH coincided roughly with the piping of ash slurry into the Knickerbocker Pit which was underway actively by the fall of 1998. The higher pH rise at Monitoring Holes South might also be resulting from the confluence of mine pool waters from underneath ash pits in the B-D Mining and Ellengowan Permits that might be more steady and consistent at this point thus reflecting the alkalinity contributions and acidity buffering effects from the ash at both permit sites more clearly.

Average alkalinity (figure 5.28) dropped precipitously before ash placement but remained around 20 mg/L after ash placement at Monitoring Holes South. Average alkalinity at Maple Hill Shaft declined after ash placement began from around 30 to 20 mg/L, although actual levels oscillated between 0.00 mg/L and 97.00 mg/L more than at Monitoring Holes South. Acidity (figure 5.29) levels dropped substantially at Monitoring Hole South and dropped somewhat at Maple Hill Shaft after ash placement commenced at the Ellengowan pits to levels approaching 0.00 mg/L in 1998-1999 while most alkalinity measurements at both monitoring points remained between 10 and 60 mg/L. The discrepancy between alkalinity and acidity measurements was stronger at Monitoring Holes South, thus corroborating the stronger pH rise in 1998 at this monitoring point than at Maple Hill Shaft and further suggesting an impact of the FBC ash.

Average trends in specific conductance (figure 5.30) showed some improvement at both monitoring points although the declining levels for this broad indicator of pollution were more steady at Monitoring Holes South. The declining trend at Maple Hill Shaft appears to be due specific conductance dropping to nearly zero from mid1999 through mid 2002 before rising sharply to levels between 1300 and 1400 micromhos for the remainder of monitoring. There are no measurements for specific conductance in PADEP's monitoring data prior to December 1990, however assuming low concentrations of TDS (below 500 mg/L) that predominated at the Maple Hill Shaft earlier than that date reflected low specific conductance, the actual trend in this broad indicator parameter likely increased from the baseline period to the latest monitoring at this point (see figure 5.34 for TDS).

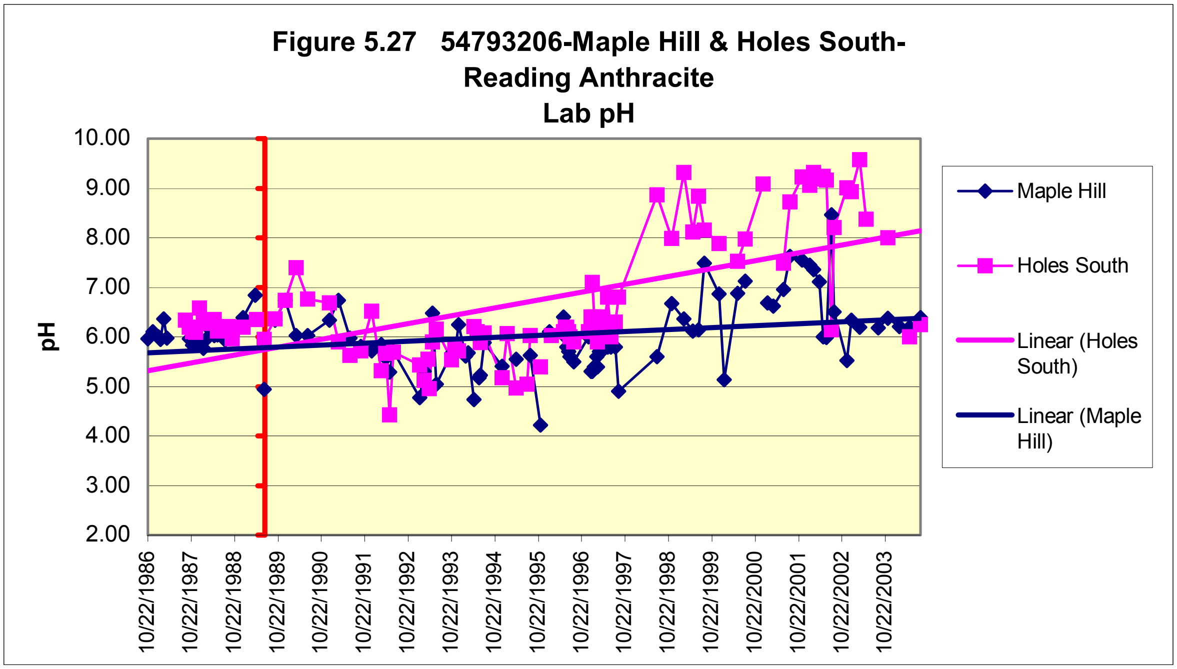


Figure 5.27 54793206-Maple Hill & Holes South-Reading Anthracite
Lab pH
pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
10/22/1986
10/22/1987
10/22/1988
10/22/1989
10/22/1990
10/22/1991
10/22/1992
10/22/1993
10/22/1994
10/22/1995
10/22/1996
10/22/1997
10/22/1998
10/22/1999
10/22/2000
10/22/2001
10/22/2002
10/22/2003
Maple Hill
Holes South
Linear (Holes South)
Linear (Maple Hill)

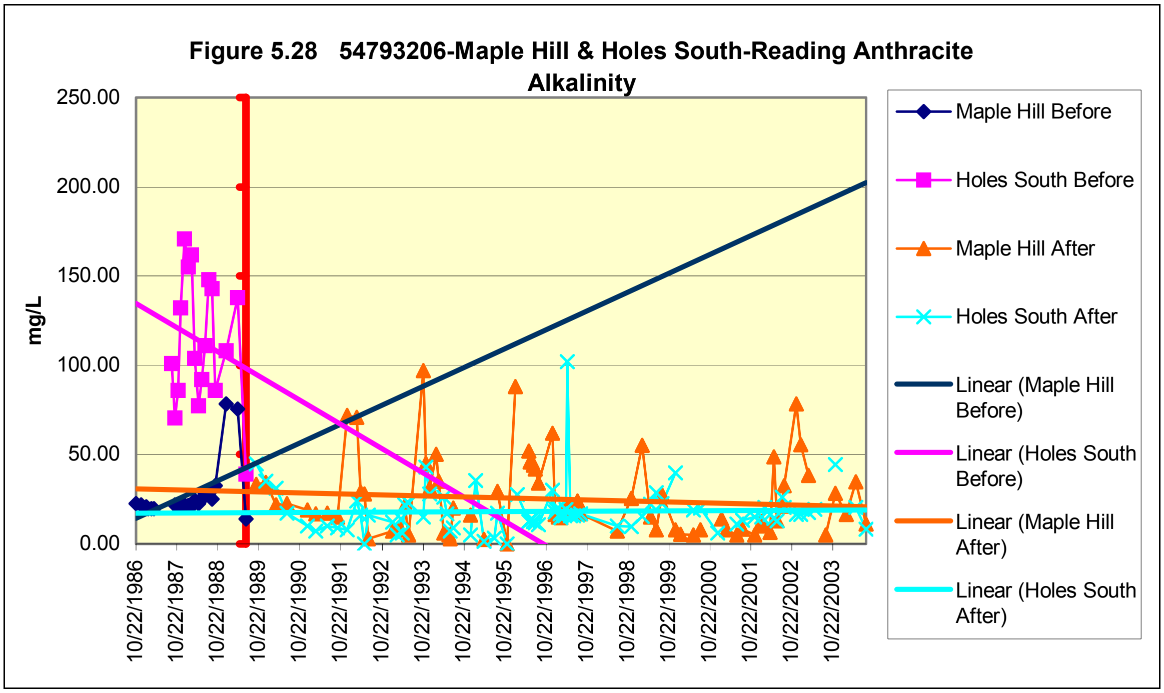


Figure 5.28 54793206-Maple Hill & Holes South-Reading Anthracite
Alkalinity
mg/L
250.00
200.00
150.00
100.00
50.00
0.00
10/22/1986
10/22/1987
10/22/1988
10/22/1989
10/22/1990
10/22/1991
10/22/1992
10/22/1993
10/22/1994
10/22/1995
10/22/1996
10/22/1997
10/22/1998
10/22/1999
10/22/2000
10/22/2001
10/22/2002
10/22/2003
Maple Hill Before
Holes South Before
Maple Hill After
Holes South After
Linear (Maple Hill Before)
Linear (Holes South Before)
Linear (Maple Hill After)
Linear (Holes South After)

Figure 5.29 54793206-Maple Hill & Holes South-Reading Anthracite Acidity

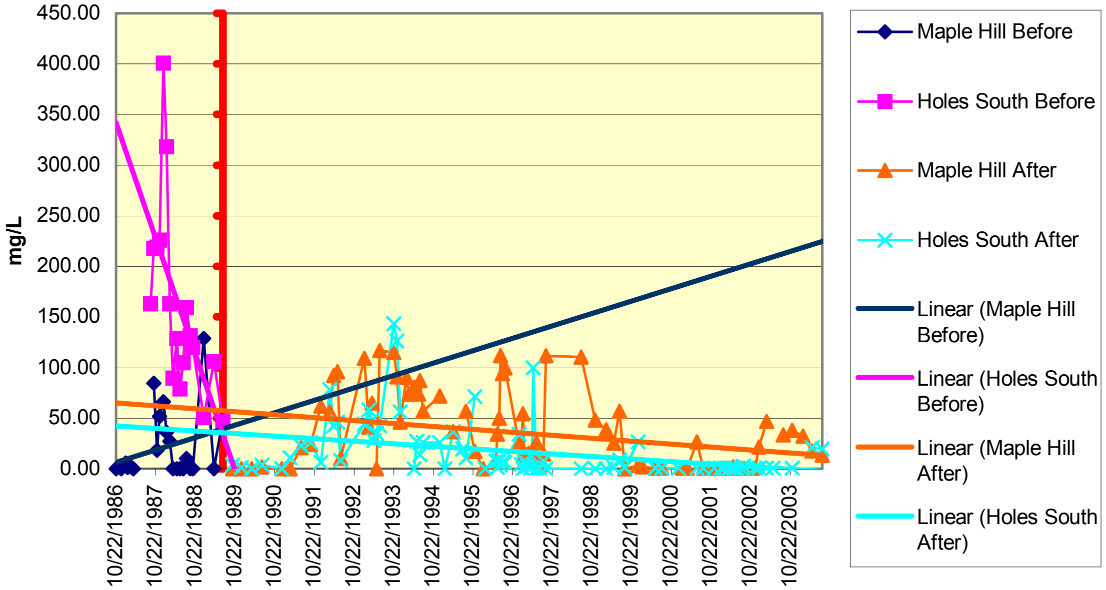
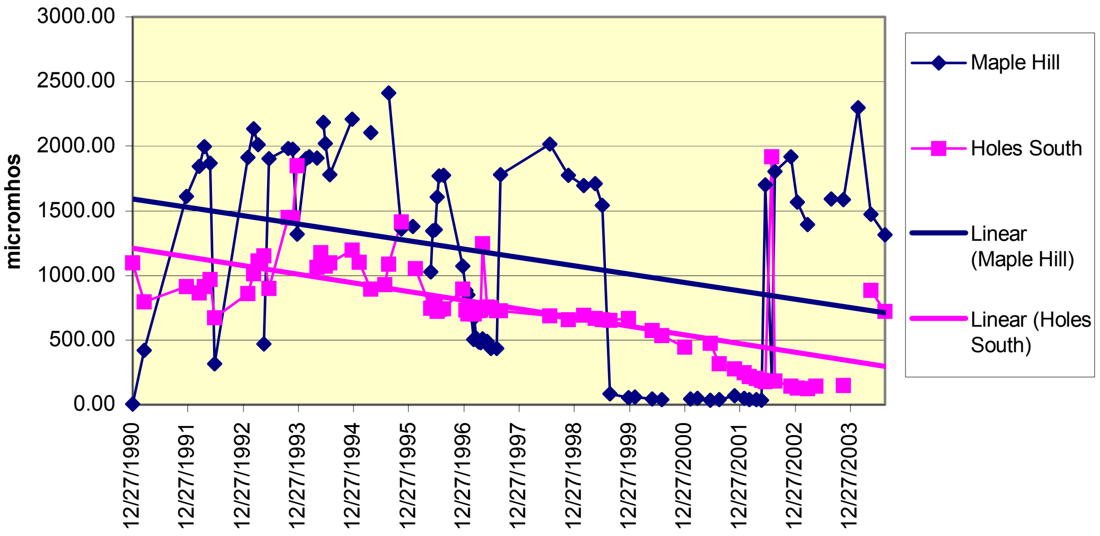


Figure 5.30 54793206-Maple Hill & Holes South-Reading Anthracite Specific Conductance



Average iron (figure 5.31), manganese (figure 5.32), and sulfate (figure 5.33) concentrations have been declining at Monitoring Holes South and increasing at the Maple Hill Shaft. At Monitoring Holes South, there were 10 oscillations in iron concentrations of 30 to 130 mg/L between single measurements from 1991 to 1996. These measurements were usually only one month apart and on two occasions were only 2 weeks apart. Overall however there was a substantial decrease in iron at Monitoring Holes South from baseline concentrations typically ranging between 140 and 190 mg/L to levels between 2 and 52 mg/L from 2000 through 2004. This contrasts with an increase in iron at Maple Hill Shaft from baseline concentrations that were usually below 2 mg/L before 1989 to concentrations exceeding 50 mg/L eight times after ash placement was underway in the Ellengowan Pits and always above 24 mg/L in the last two years of monitoring

Huge increases in manganese at Monitoring Holes South to 254 mg/L on April 15, 1997 and 387 mg/L on April 29, 1997 (figure 5.32a) are 400 to nearly 4000 times higher than almost half of the other manganese levels measured at this monitoring point (the 46 of 97 samplings that were under 1 mg/L). The higher of these two measurements is also 6.65 times higher than the highest manganese measured at Monitoring Holes South before these peaks (58.20 mg/L in December 1991) and more than 49 times higher than the highest manganese measured subsequently at this monitoring point. These two manganese peaks at Monitoring Holes South also occurred when peaks in manganese were measured at MW-2 and MW-3 in the mine pool under the Knickerbocker Pit upgradient of Monitoring Holes South and at the Packer V Discharge identified in the permit as the most downgradient monitoring point for this site, although the highest of the peaks at these other monitoring points, 116 mg/L at Packer V, was less than half the lower of the peaks at Monitoring Holes South. It should be noted that the April 3, 1997 sampling at Monitoring Holes South also measured a very high level of manganese, 32.90 mg/L, foreshadowing the peaks of April 15 and April 29, and that peak measurements also occurred on April 3 at the other monitoring points just mentioned. Finally it should be noted that manganese levels at Maple Hill Shaft were also very high in the same three April samplings (26-31 mg/L, roughly 2 to 30 times over all other measurements at Maple Hill) and that four months later (in the August 26, 1997 sampling), a peak in manganese was measured at Maple Hill Shaft of 104 mg/L. Thus either these extraordinarily high peaks at Monitoring Holes South are anomalous values attributable to human error in samplings that occurred with several measurements at all the monitoring points or some event or set of conditions resulted in a very large release or releases of manganese into the minepools under the Ellengowan site in the spring and summer of 1997. There were no samplings in April 1997 at the only upgradient monitoring point in the Ellengowan Permit, MW-1 at the Knickerbocker Pit, although samplings in February and May of 1997 recorded manganese levels of only 0.20 mg/L and 0.57 mg/L respectively at this point.

Despite the high peaks, the smaller vertical scale in figure 5.32b reveals a decline that was occurring in average manganese levels at Monitoring Holes South. A decline in average manganese might also have been exhibited in the trend line for Maple Hill Shaft had the August, 1997 peak not occurred at this monitoring point.

There were no peaks in the manganese concentrations at BD monitoring points. There was however a drop in manganese levels at MP008 (the dowgradient BD monitoring point closer to the BD ash) from the spring of 1998 through the spring of 2002 to levels below 1 mg/L in 14 of 16 measurements that coincides roughly with drops in manganese to the same levels (most measurements below 1 mg/L) during the same approximate period at Monitoring Holes South and Maple Hill Shaft.

Substantial degradation occurred at Maple Hill Shaft from sulfate levels usually well below the DWS before ash placement started in the Ellengowan pits rising to three to five times the DWS in the last year of monitoring (figure 5.33). There were also oscillations in sulfate concentrations of more than 1000 mg/L from one sampling to the next. In contrast, at Monitoring Holes South sulfate levels dropped from levels 3-4 times the DWS before ash placement to levels below the DWS in the last two years of monitoring. Total dissolved solids concentrations (figure 5.34) have also been worsening at Maple Hill Shaft while improving at Monitoring Holes South in close correlation with sulfate concentrations**.** These trends imply either that the ash in the Truck Pit has been becoming less reactive or that flow directions, perhaps due to pumping at the Maple Hill Shaft, have been carrying ash impacted water from the Truck Pit east to the Maple Hill Shaft rather than west past Monitoring Holes South.

Of note is a decisive drop in concentrations of sulfate, TDS, Specific Conductance, iron, manganese, acidity and to a lessor extent alkalinity that occurred from 1999 through 2002 at Maple Hill Shaft. This was followed by equally decisive increases in all of these analytes in 2002 and 2003 that restored their increasing trends at this monitoring point. Calcium and magnesium levels at Maple Hill Shaft appeared to decline similarly before increasing in their last sampling in January 2003, although there were only 4 measurements between 1997 and 2003 for these two analytes, too few to be certain of this trend. Nonetheless in addition to manganese, a similar decisive drop occurred at MP008 immediately downgradient of the BD ash area for the same analytes (sulfate, TDS, Specific Conductance, iron, acidity, alkalinity, calcium, and magnesium) starting in the spring of 1998 and ending in July 2002 in most cases. Subsequent decisive rises in concentrations also restored increasing trends in average concentrations for these analytes at MP008. Given the drop in concentrations of these analytes at MP008 occurred 1-2 years ahead of their drop at Maple Hill Shaft, this suggests that water quality at MP008 is influencing water quality at the Maple Hill Shaft.

The water at Maple Hill Shaft during these declines was more dominated by alkalinity than the water at MP008. Lab pH averaged around 7.13 at Maple Hill Shaft while it averaged 5.93 at MP008 in the heart of the respective declines at these points (May 2000 to April 2002 at Maple Hill Shaft and May 1998 to June 2000 at MP008). The only higher readings (over the DWS) of trace elements during this decline at Maple Hill Shaft in major and minor constituents were for lead measured at 0.18 mg/L in November 1998 and cadmium measured at 0.01 mg/L in December 1999. However there are only 4 measurements for trace elements in the PADEP data between 1997 and 2003, and in two of the remaining three measurements for lead, results were reported under detection limits that were 2 to 6.6 times the DWS, marginalizing the small amount of data that was gathered. At MP008, lead and cadmium were found in several measurements at several or more times over the DWS during this drop in major and minor constituents and chromium and selenium were each measured once at elevated levels (just below their DWS).

The levels of degradation in sulfate and TDS at Maple Hill Shaft in 2002 and 2003 are higher than at levels seen at MP008 in the BD Mining site but in the same range of concentrations for sulfate and TDS measured at downgradient monitoring points at the Knickerbocker Pit Demonstration site, particularly at MW-2 in 2000 and 2001. This along with the higher alkalinity at Maple Hill Shaft suggests that waters from the Knickerbocker Pit may have reached the Maple Hill Shaft in the last several years adding to degradation that could have been contributed to this point from the BD ash site.

The rising levels of these parameters as well as the spike in manganese concentrations to 104.00 mg/L in August 1997 at Maple Hill Shaft also coincided with the placement of major volumes of ash at the Conveyor Site starting with 709,459 tons in 1997 according to a January, 2004 “bi-annual ash placement report” from Reading Anthracite Company. From then on, ash shipments switched entirely from the Truck Site to the Conveyor Site, further east. The Conveyor Site is approximately 1000 feet north of the Maple Hill Shaft and sitting over mine pool water that appears to drain directly to this monitoring point.

The absence of water levels in the data recorded from these monitoring points hampers assessment of whether changes in flow regimes may have contributed to changes in concentrations. In a May 14, 2003 sampling, the PADEP’s data base states that the Maple Hill Shaft was a dry well. In a sampling on August 21, 2003 the data base states that the Monitoring Holes South well was dry, and in the sampling on February 17, 2004, the data base states that the Monitoring Holes South “well collapsed.”

Figure 5.31 54793206-Maple Hill & Holes South-Reading Anthracite Iron

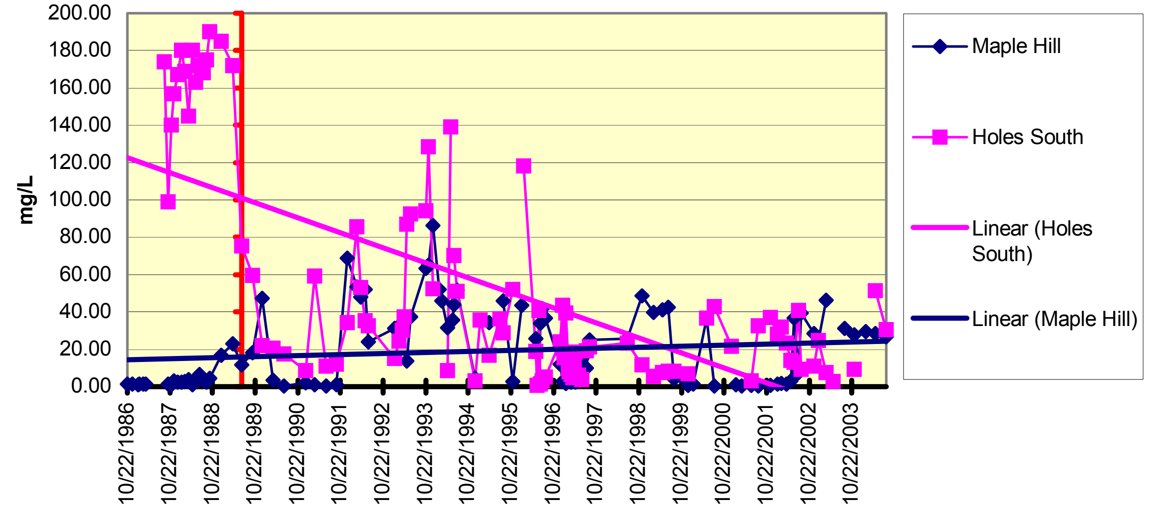
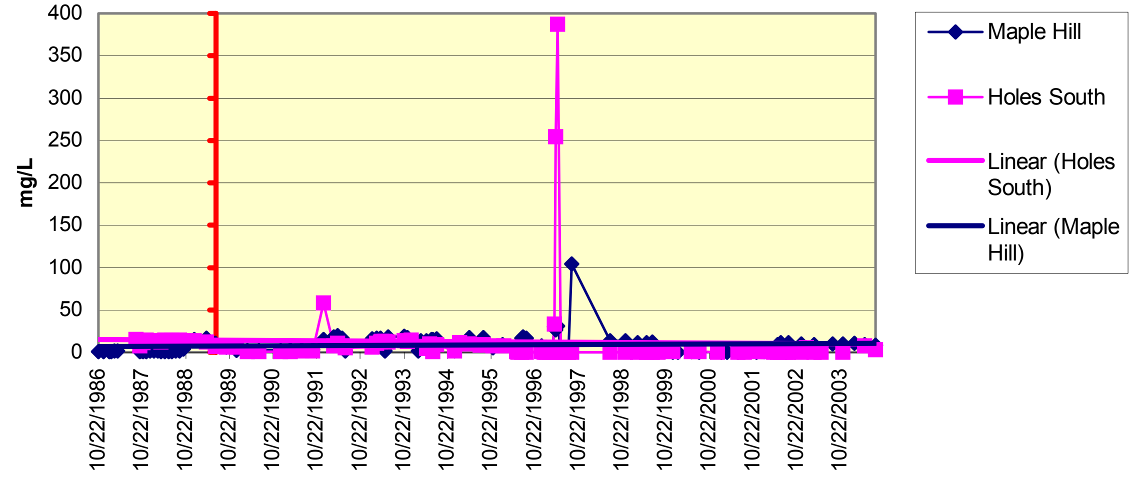


Figure 5.32a 54793206-Maple Hill & Holes South-Reading Anthracite Manganese



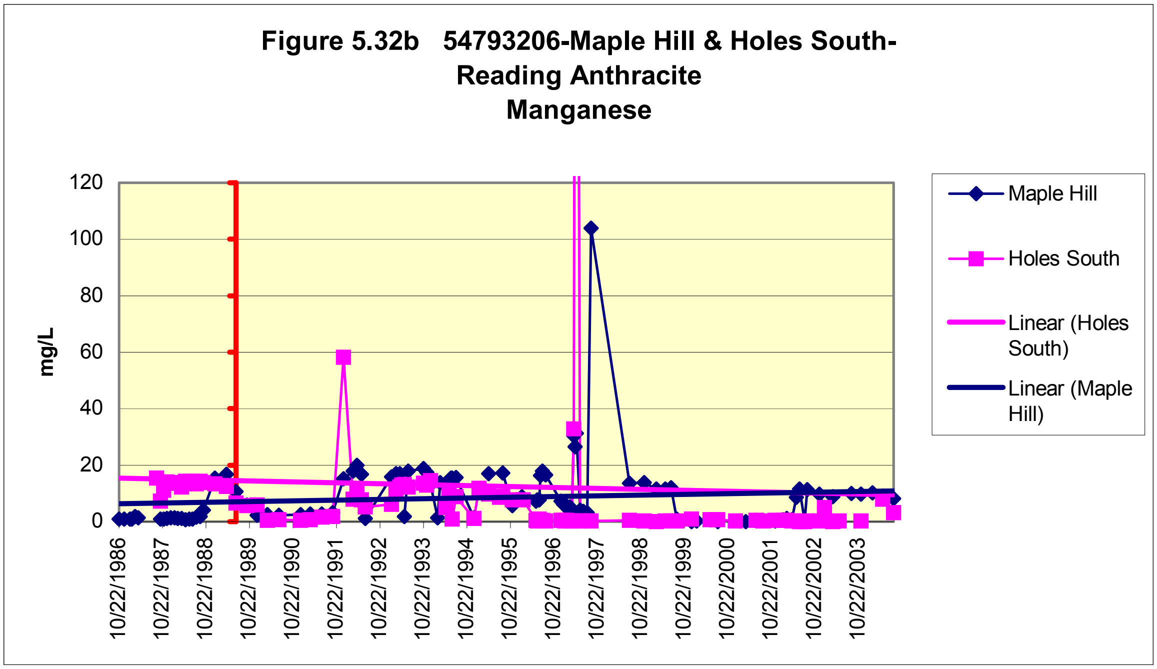


Figure 5.32b 54793206-Maple Hill & Holes South-
Reading Anthracite
Manganese
mg/L
120
100
80
60
40
20
0
10/22/1986
10/22/1987
10/22/1988
10/22/1989
10/22/1990
10/22/1991
10/22/1992
10/22/1993
10/22/1994
10/22/1995
10/22/1996
10/22/1997
10/22/1998
10/22/1999
10/22/2000
10/22/2001
10/22/2002
10/22/2003
Maple Hill
Holes South
Linear (Holes South)
Linear (Maple Hill)

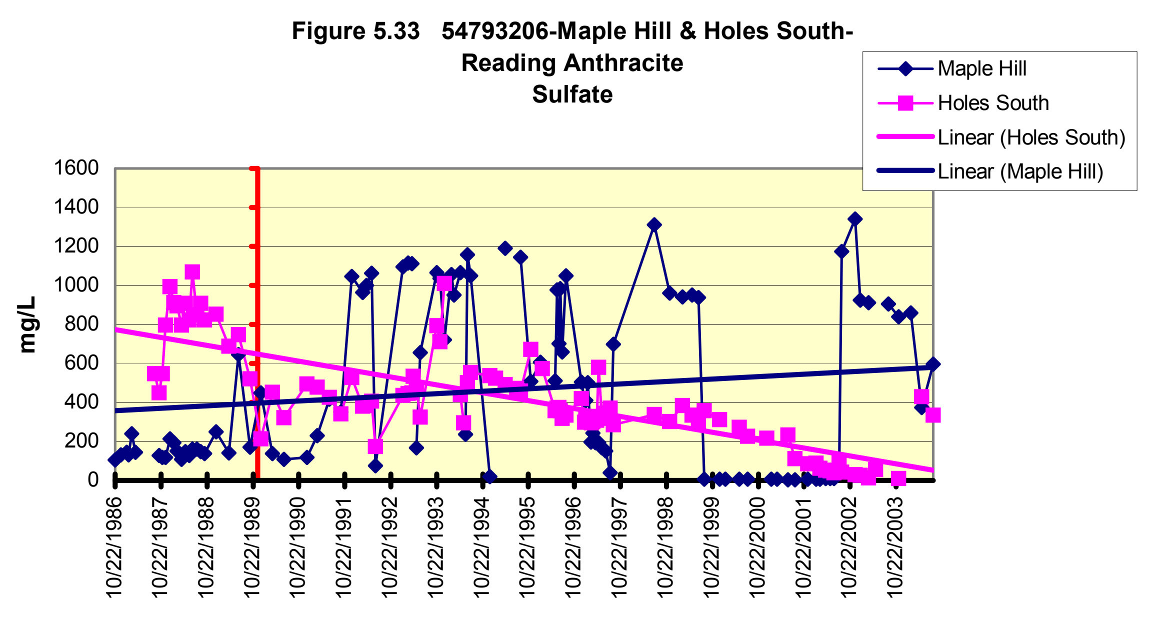


Figure 5.33 54793206-Maple Hill & Holes South-
Reading Anthracite
Sulfate
mg/L
1600
1400
1200
1000
800
600
400
200
0
10/22/1986
10/22/1987
10/22/1988
10/22/1989
10/22/1990
10/22/1991
10/22/1992
10/22/1993
10/22/1994
10/22/1995
10/22/1996
10/22/1997
10/22/1998
10/22/1999
10/22/2000
10/22/2001
10/22/2002
10/22/2003
Maple Hill
Holes South
Linear (Holes South)
Linear (Maple Hill)

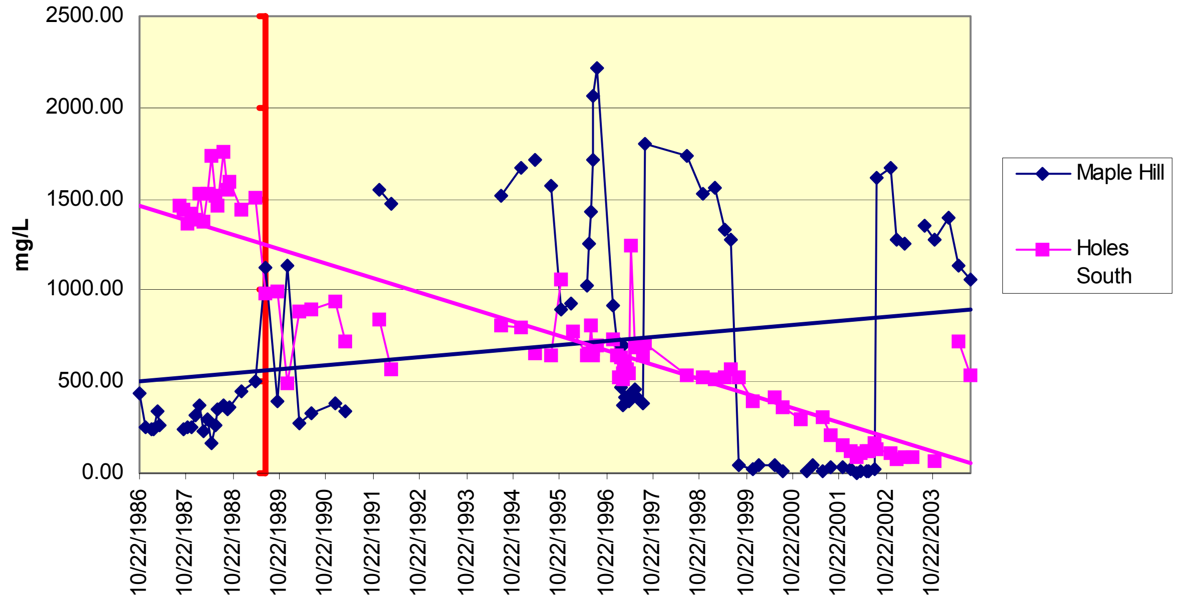


Figure 5.34 54793206-Maple Hill & Holes South-Reading Anthracite TDS

Water Quality at Packer V Outfall vs. Ellengowan & BD Mining Monitoring Points through 2006

To gain a more comprehensive view of mine pool water quality, this review now examines the PADEP's designation of the distant Packer V Outfall as the most downgradient ash monitoring point for the Ellengowan permit site and compares its water quality to that of monitoring points inside the Ellengowan and BD Permit areas. A recent file review at the PADEP Pottsville Office was conducted to update the data in this report through 2006 and locate any additional data on trace element concentrations at the Ellengowan, BD and Packer V monitoring points. The figures below present concentrations of analytes over the past twelve years at the Packer V discharge, all ash monitoring points inside the Ellengowan permit area and the two primary ash monitoring points in the adjacent BD Mining permit area, the Gilberton Shaft (MP006 in Permit Review 7) and MP008. The figures include concentration values for MW4 at the Knickerbocker Pit as this monitoring point was no longer dry from November 2004 onward. Given the absence of data prior to the last quarter of 1994 from the Packer V Outfall or the Knickerbocker Pit monitoring points, the time period in these figures starts in October of 1994. This is after many of the higher trace element concentrations were measured at monitoring points such as Monitoring Holes South, Maple Hill Shaft, the Gilberton Shaft and MP007, a monitoring point at the BD Mining site replaced by MP008.

The data reveals wide variations in concentrations at monitoring points closer to ash disposal areas that are not seen at the two higher volume discharge monitoring points, Packer V and the Gilberton Shaft. This is effectively illustrated by the wide range of concentrations in sulfate (figure 5.35) which correlate closely with wide ranges in TDS (figure 5.36) at the Maple Hill Shaft, MW2 and MW3. There are also wide iron concentrations ranges (figure 5.37) at Monitoring Holes South, MW2, MW3, MW4, and MP008 which are not exhibited at Packer V or Gilberton. This is not the case with manganese where in most instances Packer V concentrations were higher than at other monitoring points. Very high concentrations were also measured at Packer V in the fall of 1997 when manganese peaked at other monitoring points. Nonetheless wider ranges might be shown more clearly for other analytes were they sampled more frequently than the annual sampling done in the Ellengowan permit. These variations show that water quality closer to the ash can become substantially more concentrated and degraded while water quality at Packer V and Gilberton appears to be more stable.

It should be noted that a reduction in the scale of the vertical axis for the iron graph to 250 mg/L to more easily discern concentration differences between monitoring points leaves out a measurement of 335 mg/L at MW3 in November, 2002 in Figure 5.37. In the case of manganese (figure 5.38), a reduction in the scale of the vertical axis to 40 mg/L to better discern differences between monitoring points leaves out nine values ranging from 41 mg/L to 387 mg/L measured over three samplings in April 1997 at Monitoring Holes South, MW2, MW3 and Packer V and 104 mg/L measured in August 1997 at Maple Hill Shaft.

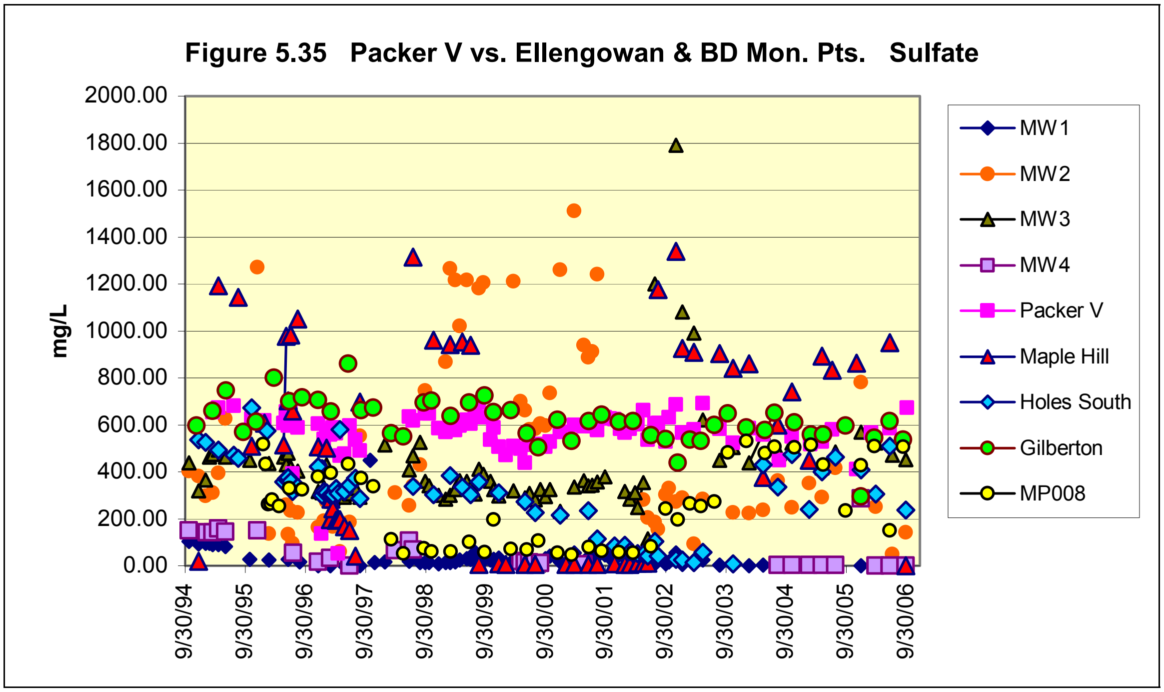
Concentrations at Packer V and the Gilberton Shaft are very similar, particularly when comparing sulfate (figure 5.35), TDS (figure 5.37) and metals such as manganese (figure 5.38), calcium (figure 5.45), magnesium (figure 5.46) and sodium (figure 5.47). Iron, aluminum, trace metals and TSS are usually higher at the Gilberton Shaft than at Packer V, and pH and alkalinity are usually higher at Packer V than at Gilberton.

Water quality trends at Monitoring Holes South that were improving for major parameters through 2003 have reversed. Sulfate and TDS have been rising above the DWS in 2005-2006 and iron and manganese rising to seriously degraded levels above the Gilberton and Packer V concentrations and far above the DWS in latest measurements. Assuming water has been moving to the west past this monitoring point for the last three years, the regular ash placement underway for the past four years in Area 42A due east and therefore directly upgradient of Monitoring Holes South, could be the source for this degradation. Similar trends have occurred at MP008 in the BD Mining Permit area.

Substantial increases in laboratory pH (figure 5.39) to levels exceeding 8 units have occurred at Monitoring Holes South and MW2, and lesser increases have occurred at Maple Hill Shaft, MW3 and MW4 that have not occurred at Packer V, the Gilberton Shaft or MP008 in the BD permit area. In fact there were 10 measurements of pH at Monitoring Holes South from late 1998 through early 2003 that exceeded the secondary DWS of 9 units and at least 12 measurements at MW2 from early 2002 through mid 2005 between 8 and 9 units.

However pH levels at the only monitoring point upgradient to ash disposed under the Ellengowan Permit and Knickerbocker Demonstration Project, MW1, exceeded the secondary DWS some 17 times from June, 1998 to November 2003. Subsequent readings at MW1 declined to between 6.58 and 8.8 units. The high measurements at MW1 along with five high readings at MW3 in 1994 and 1995 well before the ash slurry placement started at Knickerbocker, indicate a substantial alkaline drainage flowing from the Shen Penn Pit through the Indian Ridge mine pool. This contrasts with most pH readings at Packer V and Gilberton which have long remained between 6 and 7, and pH readings at MP008 largely between 4 and 6. With the exception of a measurement of 8.95 units at MW3 in December 2005, pH at all Ellengowan monitoring points declined in 2005 and 2006 to levels similar to those at Packer V (around 6.5) or in the case of MW1, one to two units higher.

Despite the higher pHs at Ellengowan monitoring points, alkalinity has usually been highest at Packer V (figure 5.40), initially rising to between 150 and 200 mg/L in 1996 and 1997 and then gradually declining to between 100 and 150 mg/L in 2005 and 2006. Only at MW2 and MW3 were alkalinity values higher, mostly during the height of ash slurry placement in the Knickerbocker Pit in 2000-2002. Interestingly, even though the Knickerbocker ash slurry appears to have had a major effect on MW4 which dried up once the demonstration project was started, high alkalinity values have not been found at MW4 from 2004 through 2006 since water has been found again in this monitoring well.



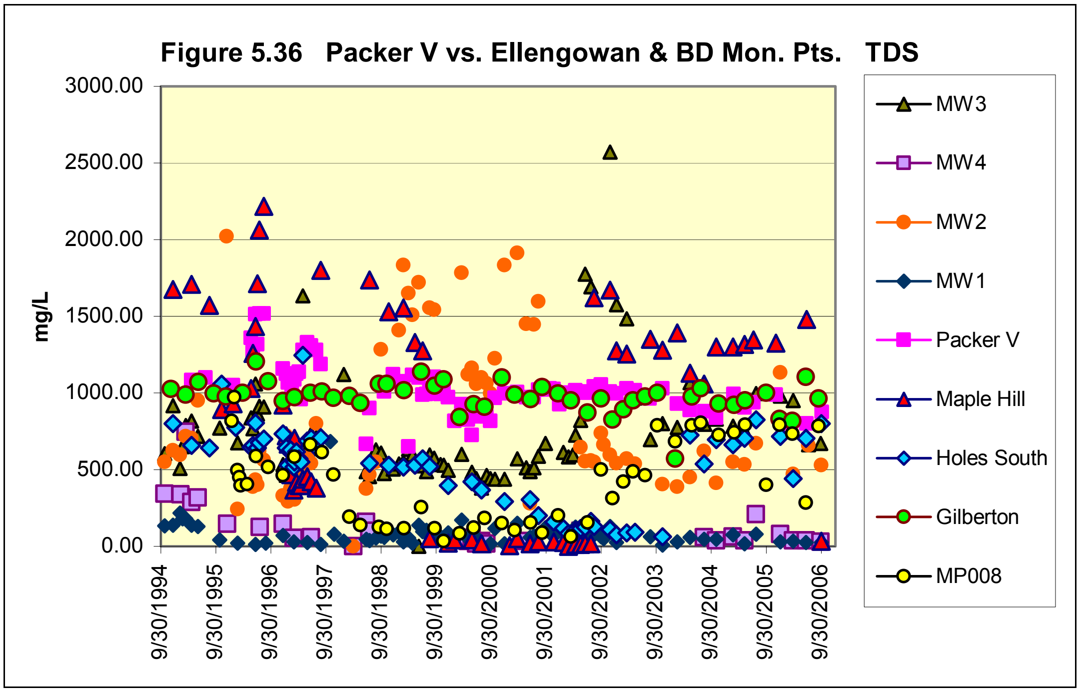


Figure 5.36 Packer V vs. Ellengowan & BD Mon. Pts. TDS
mg/L
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
MW3
MW4
MW2
MW1
Packer V
Maple Hill
Holes South
Gilberton
MP008

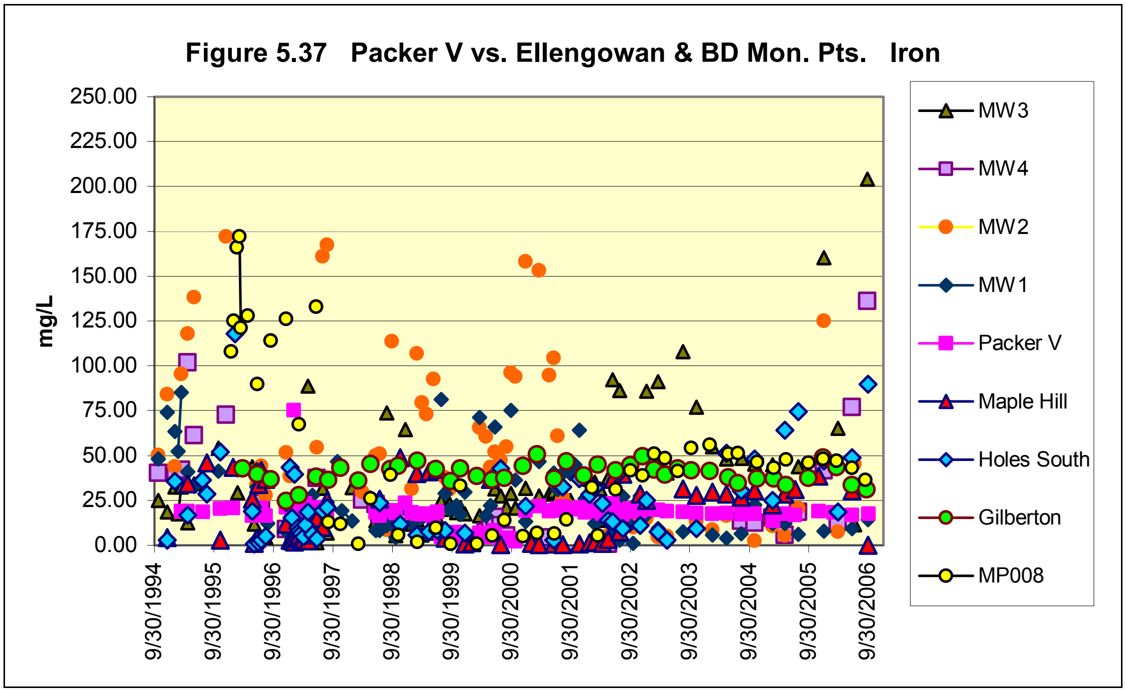


Figure 5.37 Packer V vs. Ellengowan & BD Mon. Pts. Iron
mg/L
250.00
225.00
200.00
175.00
150.00
125.00
100.00
75.00
50.00
25.00
0.00
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
MW3
MW4
MW2
MW1
Packer V
Maple Hill
Holes South
Gilberton
MP008

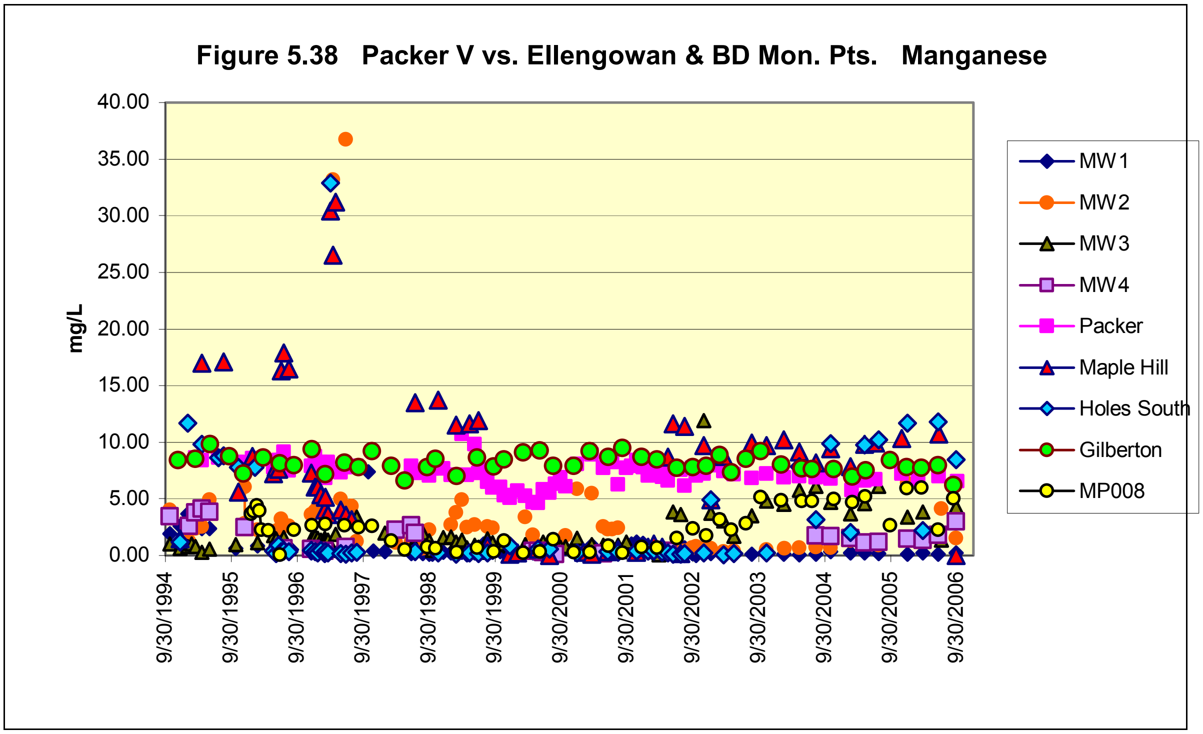


Figure 5.38 Packer V vs. Ellengowan & BD Mon. Pts. Manganese
mg/L
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
MW1
MW2
MW3
MW4
Packer
Maple Hill
Holes South
Gilberton
MP008

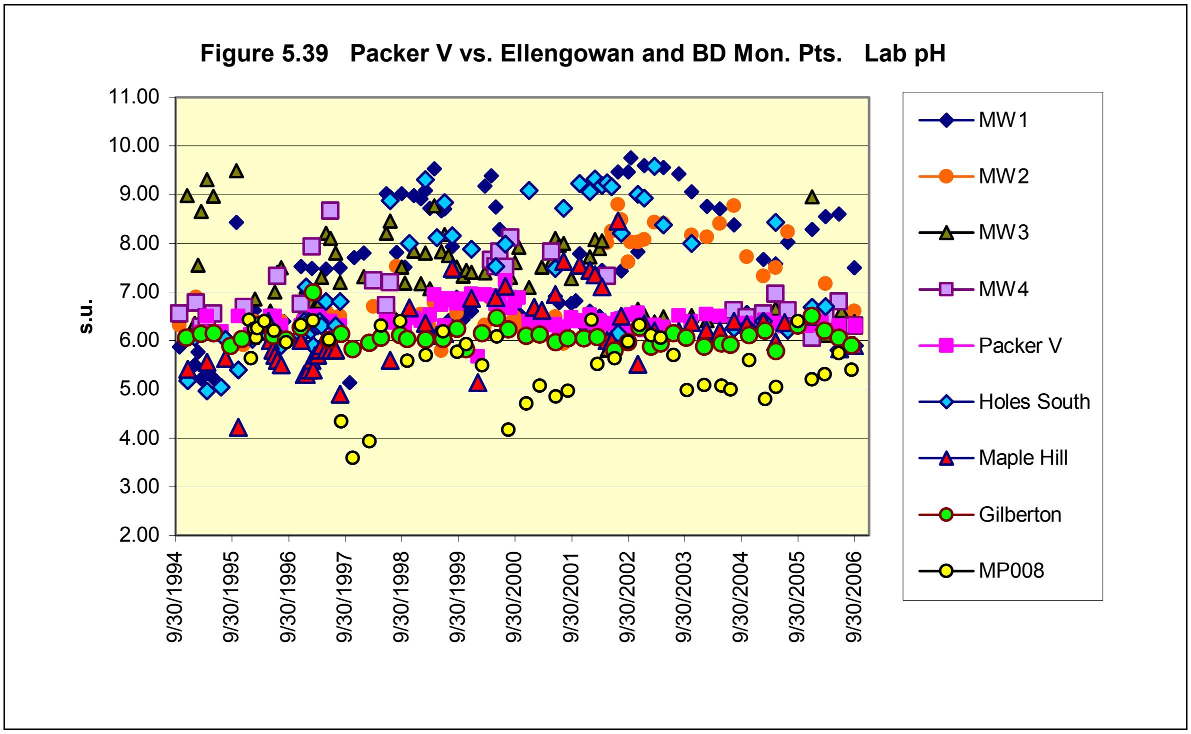
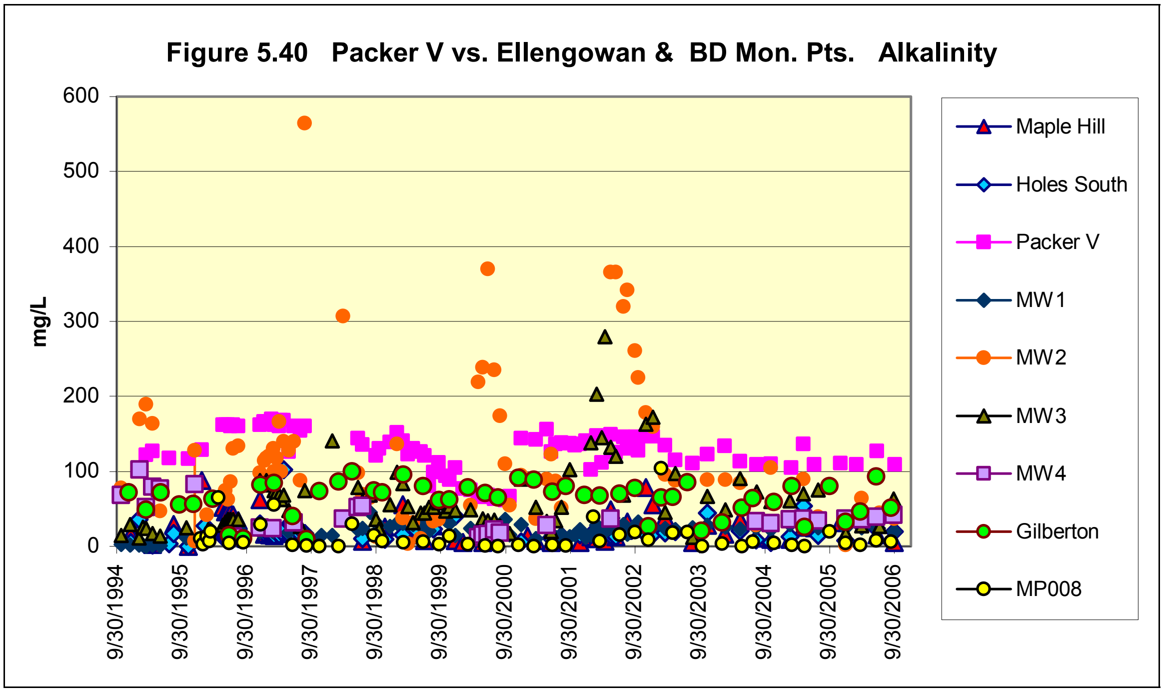


Figure 5.39 Packer V vs. Ellengowan and BD Mon. Pts. Lab pH
s.u.
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
MW1
MW2
MW3
MW4
Packer V
Holes South
Maple Hill
Gilberton
MP008



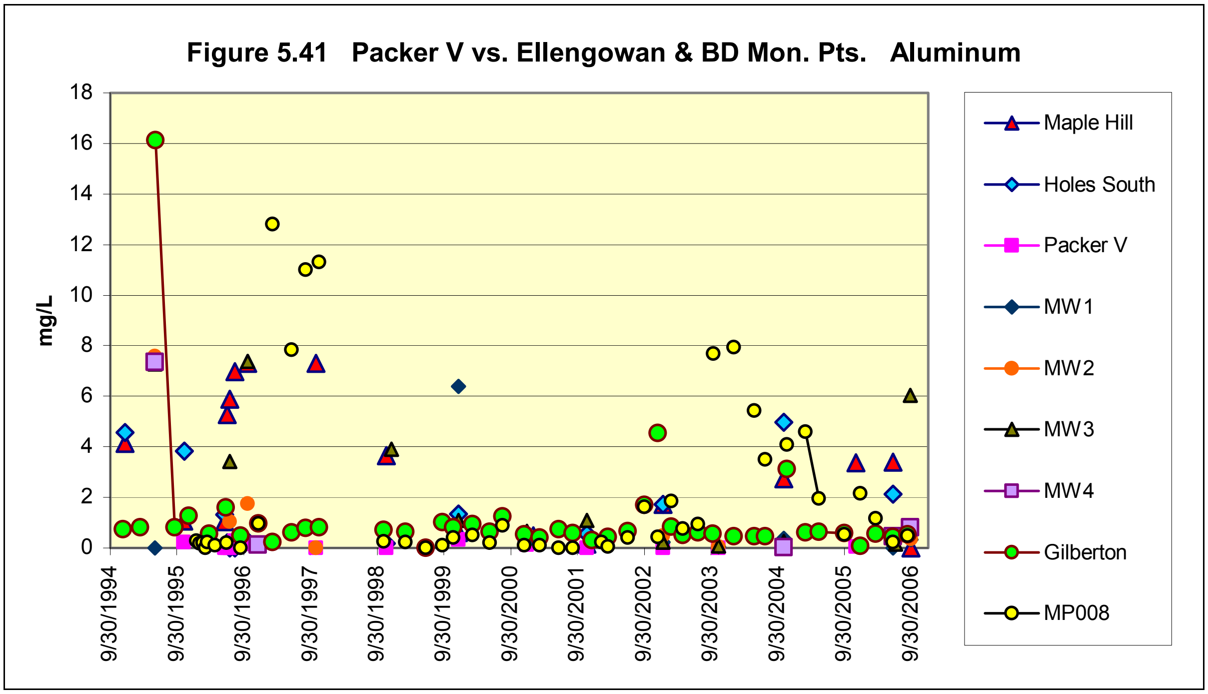
Concentrations of aluminum (figure 5.41) have been consistently lower at Packer V than at all monitoring points in the Ellengowan and BD permit areas. The majority of measurements at Packer V are below the upper limit of the secondary DWS (0.2 mg/L) while the majority of measurements at all monitoring points within the Ellengowan and BD permits are above the secondary DWS and substantially above this standard (>10 times over) at Maple Hill Shaft, Monitoring Holes South, MW3 and MP008. Aluminum measurements of 34.90 mg/L in October 1997 and 26.00 mg/L in September 2006 at Monitoring Holes South are not depicted in figure 5.41 due to the scale of the vertical axis.

The highest concentrations of the trace metal zinc (figure 5.42) have been measured at Monitoring Holes South, and elevated levels have also been found at Maple Hill Shaft, MW3, MW4 and the Gilberton Shaft. Concentrations of 52 mg/L in October 1997 and 30.90 mg/L in September 2006 at Monitoring Holes South are not depicted in figure 5.42 due to the scale of the vertical axis. These measurements as well as 5.56 mg/L in November 2004 at Monitoring Holes South exceed the secondary DWS (5.0 mg/L) and longterm health advisories for children (3.0 mg/L) and adults (2.0 mg/L). The lowest levels of zinc were measured at Packer V where the highest value was 0.30 mg/L in July 1996 and 7 of 15 values were 0.00 or <0.005 mg/L. Values this low were not found at any other monitoring point.

The highest copper (ungraphed) was measured at Monitoring Holes South in October 1997 at 1.72 mg/L exceeding the DWS (action level of 1.3 mg/L). The second highest value was 0.589 mg/L measured in September 2006 also at Monitoring Holes

South. All other values at all monitoring points have been less than one third the DWS during this twelve year period. As with aluminum and zinc, copper concentrations were notably lowest at Packer V. In fact there was only one measurement above detection limits or 0.00 mg/L for copper at Packer V, 0.006 mg/L in November 2004, while measurements at all monitoring points in the Ellengowan and BD permit areas exceeded this concentration in the large majority of samplings.

The highest nickel (figure 5.43) has also been measured at Monitoring Holes South where values of 2.79 mg/L in October 1997 and 1.02 mg/L in September 1996 are more than 27 and 10 times over the old DWS (0.10 mg/L - remanded) respectively. These values are not depicted in figure 5.43 due to the scale of the vertical axis. There were five additional measurements of nickel exceeding the old DWS at Monitoring Holes South. At Maple Hill Shaft, 12 of 18 measurements exceeded the old DWS. Yet the number of exceedances of the old DWS was greatest at the Gilberton Shaft where 27 of 45 measurements were beyond 0.10 mg/L and another ten of these were at 0.10 mg/L. However the highest value at Gilberton, 0.21 mg/L in March 2001, was below the higher exceedances at Monitoring Holes South and Maple Hill Shaft which, except for the September 1996 value, were all recorded before 2000. Nonetheless the high values at Gilberton contrast with values at Packer V where only 1 of 15 measurements exceeded the old DWS. There were no exceedances of the old DWS for nickel measured at the Knickerbocker monitoring points.



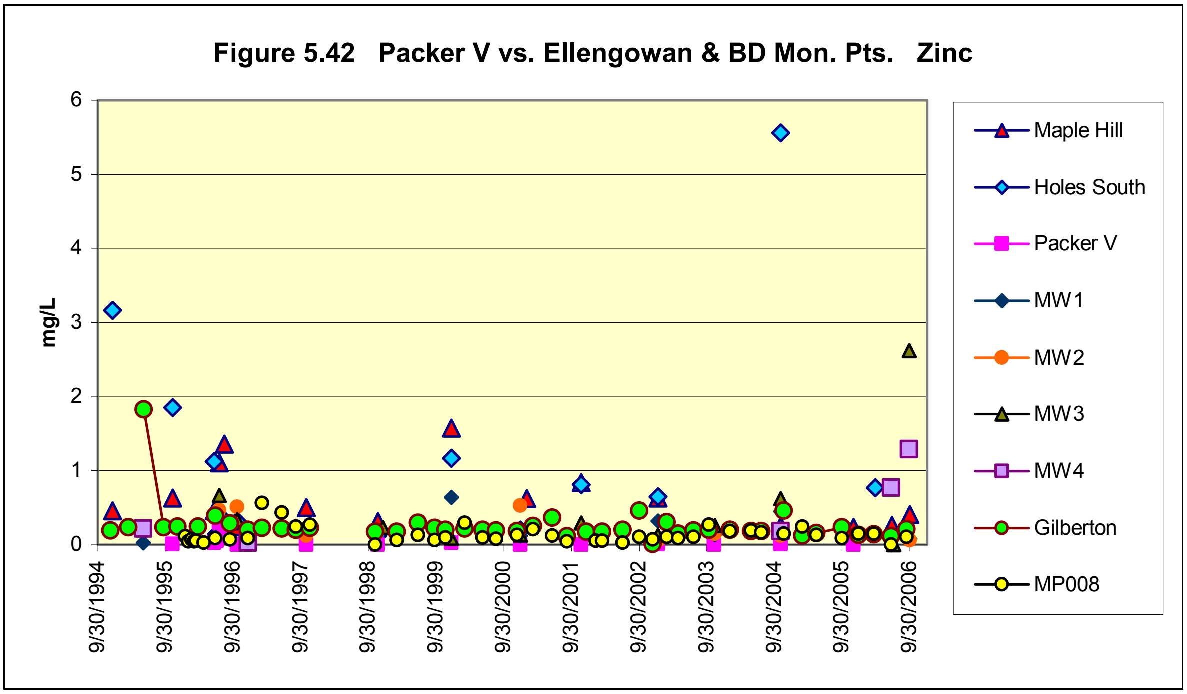


Figure 5.42 Packer V vs. Ellengowan & BD Mon. Pts. Zinc
mg/L
0
1
2
3
4
5
6
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
Maple Hill
Holes South
Packer V
MW1
MW2
MW3
MW4
Gilberton
MP008

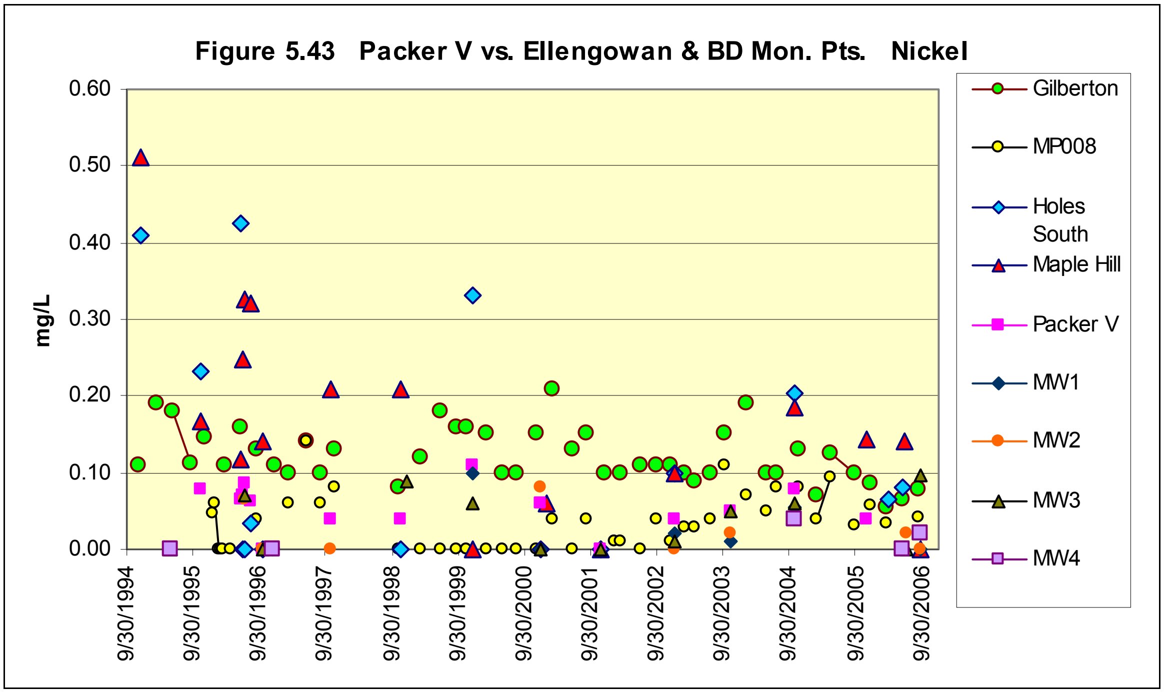


Figure 5.43 Packer V vs. Ellengowan & BD Mon. Pts. Nickel
mg/L
0.00
0.10
0.20
0.30
0.40
0.50
0.60
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
Gilberton
MP008
Holes South
Maple Hill
Packer V
MW1
MW2
MW3
MW4

Of the RCRA trace elements, there are numerous detections and exceedances of DWS for lead and cadmium but less detections of arsenic and chromium and far less detections of selenium during the twelve years examined in these graphs, and the concentrations that were found for these trace elements were not as high (relative to the DWS) as those for lead and cadmium. Despite a rash of high readings earlier for arsenic and chromium at Ellengowan and BD monitoring points, in the 170-175 samplings during this period, arsenic was detected in 22 samples and chromium was detected in 18 samples with all measurements being below the earlier readings. Perhaps due to the higher frequency of sampling, most of these detections were measured in the BD Permit area, with 12 detections for arsenic at the Gilberton Shaft and 10 detections for chromium at MP008. Of these detections, there were four exceedances of the DWS for arsenic and one of those exceeded the older DWS (0.050 mg/L), 0.0631 mg/L at the Gilberton Shaft in June 1995. There were no exceedances of the DWS for chromium. However there was nearly an exceedance at MP007 of 0.099 mg/L measured in September of 1995 when ash was being placed very close to this monitoring point, and chromium was measured at 0.232 mg/L at MP007 (>2.3 times the DWS) in November 1991, almost three years after ash placement was underway in the BD Ash pit. Chromium was also detected at MW2 and MW3 during the Knickerbocker project, but at levels below the DWS, with the highest being 0.02 mg/L at MW3 in November 2003.

Selenium which had not been not detected appreciably before this 12 year period, continued to be largely absent above detection limits of <0.010 mg/L at any of these monitoring points. There were only four samplings from which selenium was detected. Two of the four were at MP008, 0.041 mg/L (just under the DWS of 0.050 mg/L) in June 1999 and 0.01 mg/L in September 1999. Selenium was also detected at 0.017 mg/L at the Gilberton Shaft in the same June 1999 sampling and found in December 1994 at 0.0069 mg/L at the Maple Hill Shaft.

By comparison, lead (figure 5.44) was detected in 36 of 174 samplings, and cadmium (figure 5.45) detected in 35 of 170 samplings at monitoring points during this period. Furthermore two thirds of the detections of lead exceeded the DWS (the Federal Action Level of 0.015 mg/L), and four fifths of the detections of cadmium exceeded the DWS. Numerous measurements for each constituent exceeded the DWS by several times. Lead concentrations had a greater range and reached higher levels than cadmium concentrations.

At Ellengowan monitoring points, all of the samples in which lead was measured exceeding 0.045 mg/L were taken from September through December during this twelve year period, while at BD points such higher measurements were split between spring and fall samplings. Most nondetections and levels measured below the DWS were measured from samples taken in the summer although there were fewer samples taken at that time of the year. Similar timing occurred for the cadmium exceedances with all but one of the exceedances occurring from September through January at Ellengowan monitoring points, while cadmium exceedances at BD points were spread more evenly throughout the seasons.

Lead concentrations were more than three times the DWS in 22 samples. Furthermore the incidence of lead detections and number of samples with higher concentrations may have been significantly greater but the PADEP's acceptance of such high detection limits for lead in the analysis of these samples prevented this from being determined. For example in 27 of 90 samples taken from the Gilberton Shaft and MP008, the reported values are less than detection limits that are above the DWS. In one of those samples, a detection limit of <0.50 mg/L, was used, more than 33 times the DWS. In 17 other samples, the detection limit was <0.10 mg/L, 6.7 times over the DWS. In 29 of the 84 samples taken from the Ellengowan monitoring points (including those from Packer V), detection limits used in the analysis were above the DWS. In nine of those samples, the detection limit was <0.10 mg/L, 6.7 times the standard. Thus in 92 samples, more than half the samples taken at these monitoring points over the last twelve years, lead has either been measured above the DWS or reported under detection limits that were above the DWS.

Despite such high detection limits, lead was measured in 8 of 16 samplings at Monitoring Holes South, more often than at any other monitoring point. Lead was found in 5 of 17 samplings at Maple Hill Shaft although three of the measurements were below the DWS. Lead was found at MW3 in 3 of 12 samplings, at Packer V in 2 of 15 samplings, MW1 in 2 of 9 samplings, MW2 in 2 of 10 samplings, and MW 4 in 1 of 5 samplings. Despite the greater frequency of sampling, the incidence of lead was not much higher at BD monitoring points during this twelve year period; lead was found in 6 of 45 samplings at MP008 (the same detection rate as at Packer) and 7 of 45 samplings at the Gilberton Shaft.

Of seemingly more significance however, are the very high lead levels found for the first time at the Knickerbocker monitoring points in the latest sampling (September, 2006) with 0.53 mg/L measured at MW3 and 0.43 mg/L at MW4. These are 35 times and 29 times greater than the DWS respectively. Lead was also measured at MW2 at 0.08 mg/L and MW1 at 0.05 mg/L in the September, 2006 sampling and was measured at slightly lower, elevated levels at these two monitoring points in November 2003 (0.06 mg/L at MW2 and 0.028 mg/L at MW1). The advent of elevated and then very high levels of lead after lead had only been found once in eight years of sampling at any of the four Knickerbocker monitoring points and at a much lower level, (0.0069 mg/L at MW3 in July 1996), suggests a mobilization of lead from the ash slurried into this pit.

The highest lead concentration at any monitoring point in the 12 year monitoring period was 0.58 mg/L at MP008 in September 2001, 39 times above the DWS. There were also measurements of 0.33 mg/L in December 1994, 0.40 mg/L in November 2001, and 0.21 mg/L in September 2006 at Monitoring Holes South.

There were multiple additional high measurements of lead before the 1994-2006 period at Gilberton Shaft, MP008 (and MP007 and MP005 in the BD permit area), Maple Hill Shaft and Monitoring Holes South. These include 0.7 mg/L (47 times the DWS) in April 1989 at Monitoring Holes South, the highest concentration measured at any monitoring point to date in the Ellengowan and BD Mining permit areas. This reading occurred 13 months after regular ash placement was underway at the BD ash pit, but before such such placement was occurring at the Ellengowan ash pits according to available PADEP records.

While measurements of trace metals are not available from the Packer V Outfall or upgradient MW1 before December 1994, the two samplings at Packer V that have measured lead, 0.12 mg/L in November 1998 and 0.055 mg/L in November 2005, and the two samplings at MW1 that have measured lead, 0.028 mg/L in November 2003 and .05 mg/L in September 2006, were notably below the higher values observed at downgradient monitoring points close to ash within the Ellengowan and BD permit areas.

There were 11 measurements of cadmium in the past twelve years that exceeded the DWS by more than three times (occurring at MW3, MW4, MW1, Monitoring Holes South, Gilberton Shaft, and MP008). There were substantially fewer high detection limits used in the analysis of this metal than for lead, with some 70 samples measuring cadmium at <0.005 mg/L (the DWS) while 8 samples were analyzed at a detection limit of <0.010. There was not a single actual cadmium measurement below the DWS, while the highest cadmium concentration measured was 0.07 mg/L, 14 times the DWS. This occurred at Monitoring Holes South in November 2001. The second and third highest cadmium values were 0.053 mg/L in October 1996 and 0.034 mg/L in September 2006, both measured at MW3. The highest incidence of cadmium concentrations were also measured at these two points, with 7 of 12 measurements finding cadmium at MW3 and 6 of 15 measurements finding cadmium at Monitoring Holes South. The only samples that found cadmium at MW4 were taken in 2006 finding 0.008 mg/L in June and 0.018 mg/L in September 2006. These measurements and the high measurement at MW3 in 2006 suggest cadmium is being mobilized from the Knickerbocker ash.

More than one third of all cadmium measurements during this twelve year period, 12 of 35 total samplings in which cadmium was found, occurred in the thirteen months from November 1998 to December 1999 starting two months after ash slurry placement began at the Knickerbocker Pit. Four of these measurements occurred at MP008 and two at the Gilberton Shaft in the BD Mining area. This was also when six high concentrations of lead were found at monitoring points in the two permit areas. Interestingly, the highest lead and cadmium measured at Packer V occurred in this period, 0.12 mg/L of lead in November 1998 and 0.013 mg/L of cadmium in December 1999.

Monitoring points with the fewest incidences of cadmium in the twelve year period were Packer V, MW2 and Maple Hill Shaft. There were only two measurements of cadmium at Packer V out of 14 samplings. Perhaps due mostly to the lack of water at MW2 during the latter part of the Knickerbocker project, there was only 1 measurement of cadmium out of 9 samplings at MW2, 0.007 mg/L in December 2000, even though this monitoring point is very close to MW3 where the highest incidence of cadmium detections took place. Also notable was the mere single detection of cadmium out of 16 samplings at Maple Hill Shaft, 0.006 mg/L in December 1999, given that cadmium was found earlier in several measurements at Maple Hill, including 0.160 mg/L in June 1988, the highest concentration measured at any monitoring point in the Ellengowan and BD Mining permits at 32 times the DWS. This occurred before PADEP records indicate ash placement was occurring at Ellengowan but three months after regular placement had started at the BD site. There were 7 measurements of cadmium in 45 samplings at both Gilberton and MP008 during the last twelve years.

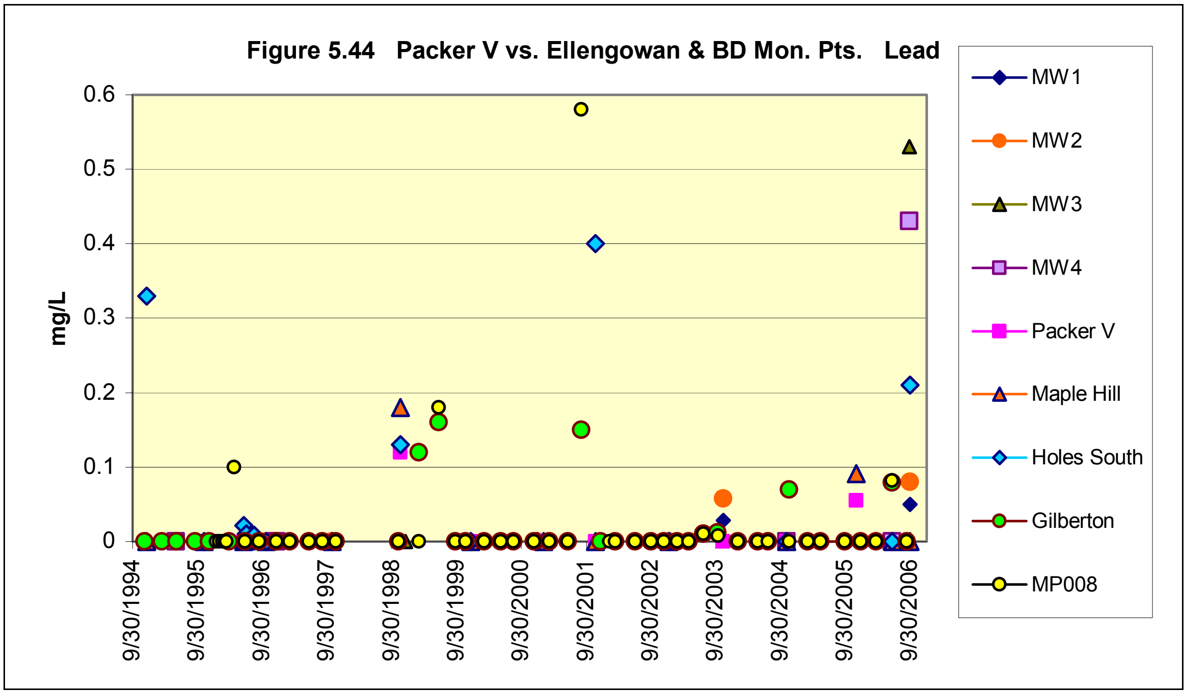
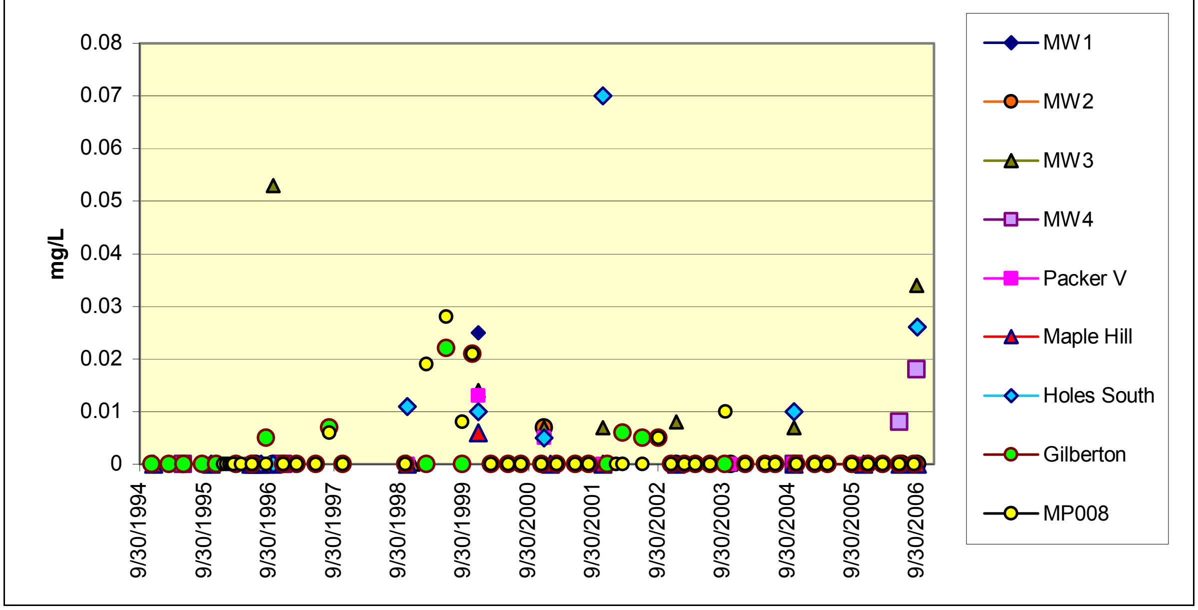


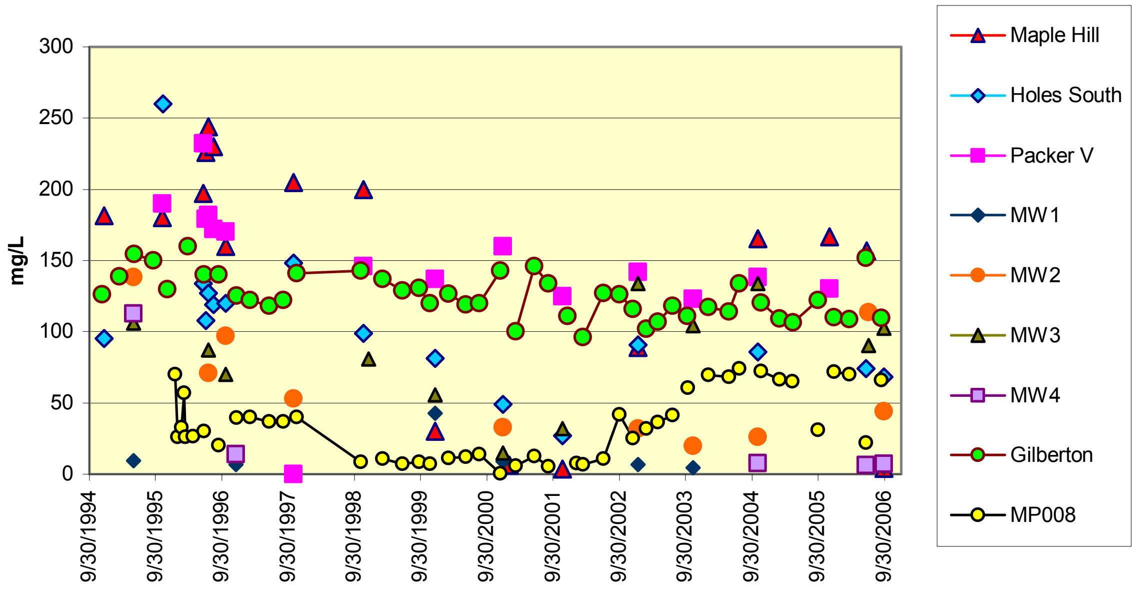
Figure 5.45 Packer V vs. Ellengowan & BD Mon. Pts. Cadmium



Calcium (figure 5.46) and magnesium (figure 5.47) concentrations were stable and similar at Packer V and Gilberton and erratic at Maple Hill Shaft, Monitoring Holes South and the Knickerbocker monitoring points. Calcium concentrations at Packer V that were between 150 and 250 mg/L before 1997 then declined to between 100 and 160 mg/L for the rest of monitoring. These remained usually 10-20 mg/L above those at Gilberton. Magnesium concentrations at Packer V and Gilberton were still more constant, largely between 50 and 100 mg/L throughout the monitoring period with Packer concentrations usually about 10-15 mg/L above those at Gilberton. Particularly at Maple Hill and to a lessor extent at Monitoring Holes South, concentrations of both of these analytes that were at or above the Packer and Gilberton concentrations before 1997 followed a trend downward that started at MP008 in 1998 and then rose back to Packer and Gilberton levels or higher from 2002 through 2006. Calcium levels at MW2 and MW3 followed this trend generally. However magnesium levels spiked to 250 mg/l in December 2000 at MW2 and 189 mg/L in January 2003 at MW3. There were only 5 measurements at MW4 for calcium and magnesium; the first sample in June 1995 had relatively high calcium at 112.70 mg/L and magnesium at 77.90 mg/L, but low levels (6-14 mg/L for calcium and 3-5 mg/L for magnesium) of both analytes were measured in the other four samples.

Although they have declined, high levels of sodium (seven measurements over 50 mg/L) at the Maple Hill Shaft (figure 5.48) have not been replicated at any other monitoring point except for two measurements at MW3 in the last quarter of 1994 and one measurement at MP008. This measurement of 192 mg/L at MP008 in December 2002 was the highest concentration recorded at any monitoring point. Choride levels have generally been rising although rarely measured above 30 mg/L at any monitoring point. There have been no monitoring results recorded for potassium until March 1999 in the BD Permit and December 1999 in the Ellengowan Permit. Potassium levels since then have been low, usually between 0.2 and 2.0 mg/L at all monitoring points, although modest rises above 3.00 mg/L at MW3 and above 4.00 mg/L at MP008 have occurred in the past three years, corroborating other evidence that these monitoring points are seeing effects of ash. Multiple elevated fluoride levels have only been recorded at the Monitoring Holes South and Maple Hill Shaft monitoring points. As discussed earlier, multiple fluoride levels that exceeded the primary and secondary DWS were found in surface waters on top of test cells of Knickerbocker ash mixed with cement kiln dust. Oddly, despite this data, no analysis appears to have been done for fluoride at the Knickerbocker monitoring points after the demonstration project began. A single measurement of fluoride at 2.42 mg/L in January 1996 at MP008 (exceeding the secondary DWS of 2.00 mg/L) was the highest measurement for this analyte at any monitoring point and fluoride was also measured at 1.0 mg/L at the Gilberton Shaft in June 1995. Fluoride has never been detected in the Packer V Discharge.

Figure 5.46 Packer V vs. Ellengowan & BD Mon. Pts. Calcium



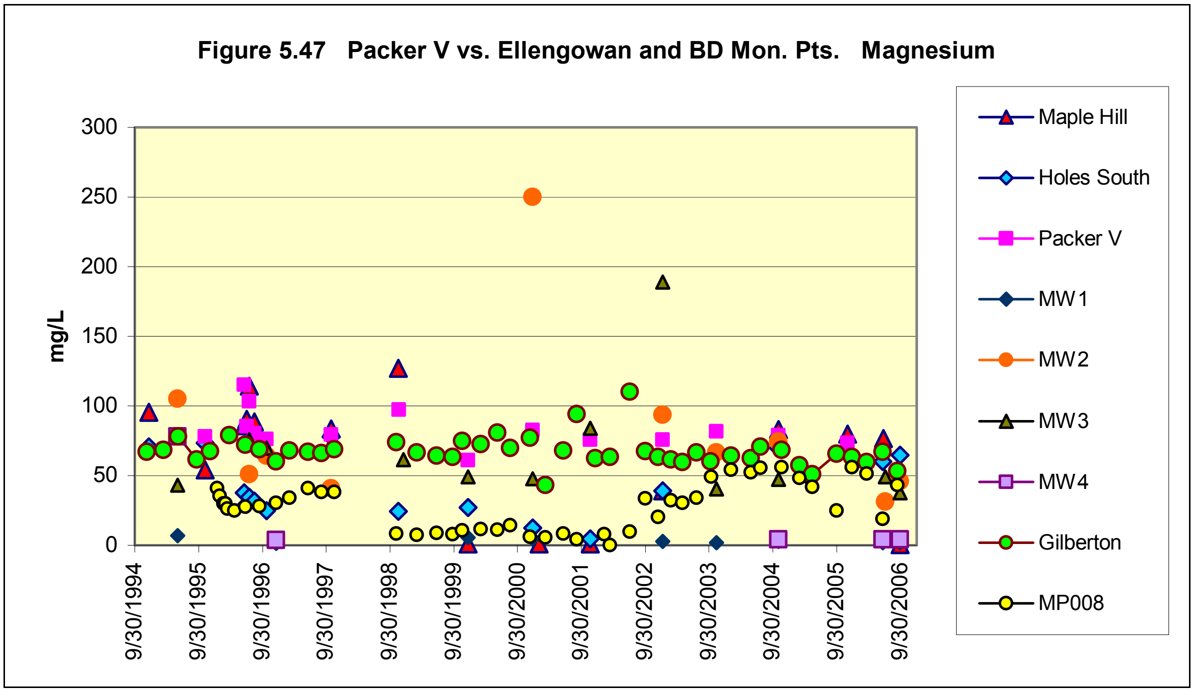


Figure 5.47 Packer V vs. Ellengowan and BD Mon. Pts. Magnesium
mg/L
300
250
200
150
100
50
0
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
Maple Hill
Holes South
Packer V
MW1
MW2
MW3
MW4
Gilberton
MP008

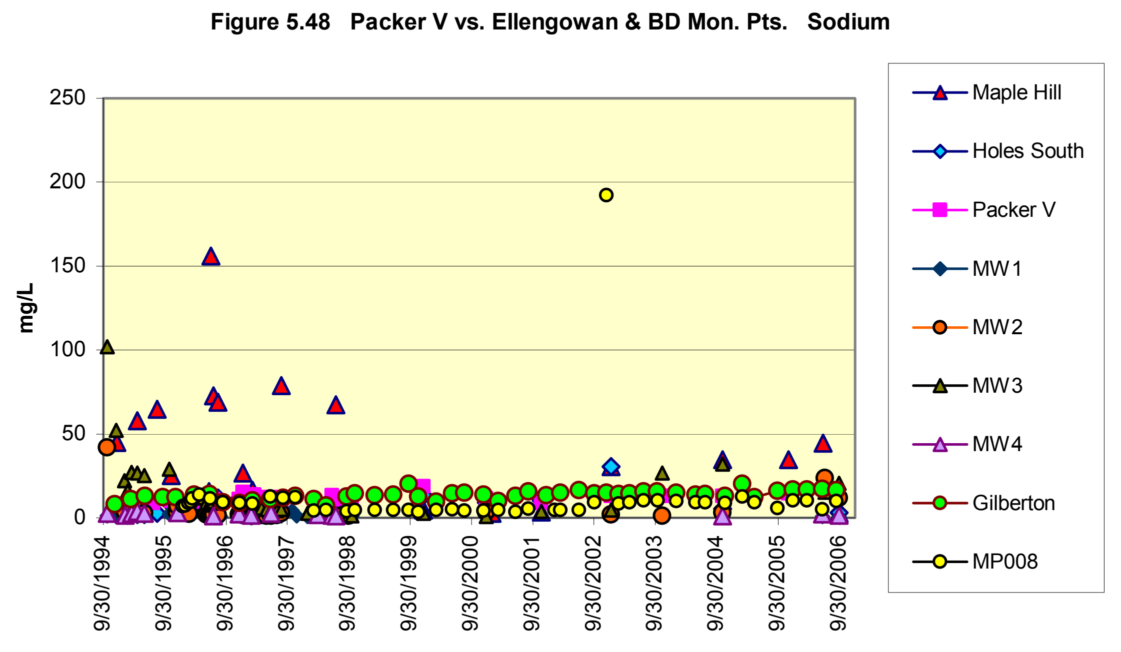


Figure 5.48 Packer V vs. Ellengowan & BD Mon. Pts. Sodium
mg/L
250
200
150
100
50
0
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
Maple Hill
Holes South
Packer V
MW1
MW2
MW3
MW4
Gilberton
MP008

There are noticeably higher concentrations of Total Suspended Solids (TSS-figure 5.49a) at Knickerbocker monitoring points than at other monitoring points in the Ellengowan and BD areas. Three measurements of TSS at MW2 and two at MW3 exceeded 1000 mg/L in 1995 with the highest being 1665 mg/L in June at MW3. These levels of TSS are the highest seen at any minefill site studied in this report although they occurred three years before the Knickerbocker Demonstration Project started. TSS levels at MW1 during 1995 were elevated though not nearly as high, reaching 136 mg/L in March. The data indicates that the upgradient minepool was already carrying significant amounts of pollutants toward the Knickerbocker Pit, but that activities in or around the Knickerbocker Pit were adding large amounts of undissolved material to the underlying minepool in 1995.

Nevertheless although subsequent TSS levels were well under 1000 mg/L, the number of samples with elevated TSS levels increased at MW1, MW2 and MW3 after ash slurry placement began in the Demonstration Project. For example, at MW1, there were three measurements exceeding 100 mg/L in the four years prior to the Demonstration Project, but twelve such measurements in the four years after ash slurry placement began. At MW2, the number of samples exceeding 100 mg/L increased from 9 samples in the four years preceeding ash slurry placement to 21 samples in the four years following the start of that placement. At MW3, there was a delay in the increase. Elevated TSS levels declined from 11 samples exceeding 100 mg/L before the project to only four that exceeded 100 mg/L in the first four years after slurry placement started but then increased in the next four years (2002-2006) when some 12 samples exceeded 100 mg/L. This trend mirrored the delay in the rise of iron, manganese, TDS, sulfur and alkalinity at MW3. Only at MW4 were there more high TSS readings before the Demonstration Project than after, although the extended periods of dry samples appear to be the reason as three TSS levels over 100 mg/L have been measured at MW4 in the last two years including 199 mg/L in September 2006.

The high levels of TSS at Knickerbocker points stand in stark contrast to TSS levels at Packer V. Of 87 samples taken at Packer V, TSS levels exceeded 30 mg/L in only four with the highest TSS being 53 mg/L in May 2000. This compares to 58 of the 75 samples taken at MW2 exceeding 30 mg/L in TSS, 31 of those exceeding 100 mg/L and seven samples exceeding 200 mg/L. At MW3, TSS in 66 of 87 samples exceeded 30 mg/L, TSS in 27 of those exceeded 100 mg/L and TSS in 11 samples exceeded 200 mg/L.

TSS levels at other monitoring points inside the Ellengowan and BD areas were higher than those at Packer but still below those at the Knickerbocker points with the occasional exception of TSS levels at MP008. With a reduced vertical scale, Figure 5.49b illustrates the lower levels of TSS at Packer V relative to other monitoring points more clearly. At Maple Hill, in 57 samples (all of which were analyzed for TSS), TSS exceeded 30 mg/L in 21 of them and exceeded 100 mg/L once at 115 mg/L in March 2003. At Monitoring Holes South, of 60 samples, TSS exceeded 30 mg/L in 40 of them and surpassed 100 mg/L in seven samples with the highest level being 176 mg/L recorded both in May and July of 2005. At the Gilberton Shaft, TSS exceeded 30 mg/L in 12 of 48 samples and exceeded 100 mg/L once, reaching 195 mg/L in June 1995. Other than the Knickerbocker monitoring points, the only other point at which TSS levels exceeded 200 mg/L was MP008. Of 48 samples from MP008, 32 had TSS levels exceeding 30 mg/L, 11 had TSS exceeding 100 mg/L and four had TSS exceeding 200 mg/L. The highest TSS at MP008 was 566 mg/L measured in March 1997 and the second highest was 434 mg/L in October 2003.

While the baseline data from Knickerbocker points indicate that sources have been contributing TSS to the minepools in this area prior to the ash placement regulated in these permits, the increasing incidence of high TSS levels at the Knickerbocker Monitoring Points after the ash slurry project began and the high TSS levels at MP008, the other monitoring point that is immediately downgradient of an ash disposal pit, suggest that the placement of large volumes of ash in pits is contributing large volumes of suspended material to the minepool.

Temperature data (figure 5.50) was found in monitoring reports for the last quarter of 2005 through the third quarter of 2006. Temperature measurements are not in the PADEP data base or in earlier monitoring reports in the permit file. Thus there are too few measurements to make more than tentative observations. Nonetheless temperatures at downgradient ash monitoring points in the Ellengowan permit during 2005-2006 are noticeably higher than at upgradient MW1 or the Packer V discharge suggesting an impact to the system from ash or coal combustion. For example, on June 22, 2006, the temperature of a sample from the Packer V discharge was 59.54 degrees Fahrenheit. A day earlier, the temperature of a sample from MW4 at the Knickerbocker Pit was 66.38 degrees Fahrenheit and a day later, the temperature of a sample from the Maple Hill Shaft was 83.66 degrees Fahrenheit. Plausible explanations include: a) exothermic reactions from the ash, i.e. the heat generated from the setting of calcium oxide in the ash. A good example would be the noticeably higher temperatures at MW4 which has been dry in most previous samplings due presumably to solidifying ash/slurry; b) escaping heat that was trapped in hot ash when it was placed and then covered by more ash; c) heat from continued mine fires; and/or d) heat from cooling waters or other waste waters from Cogen power stations being discharged to the minepool. A good example for this would be in the discharges from the Schuylkill Energy Plant into the Maple Hill Shaft whose water temperatures were the highest in these monitoring reports.

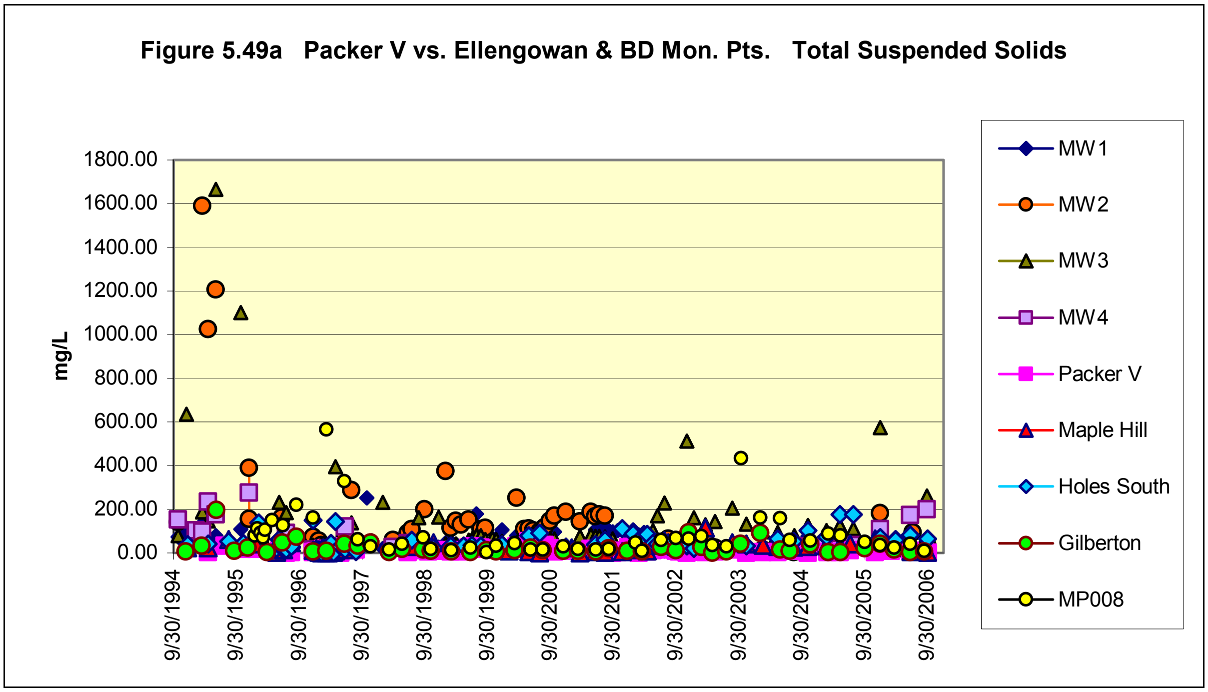


Figure 5.49a Packer V vs. Ellengowan & BD Mon. Pts. Total Suspended Solids
mg/L
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
9/30/2005
9/30/2006
MW1
MW2
MW3
MW4
Packer V
Maple Hill
Holes South
Gilberton
MP008

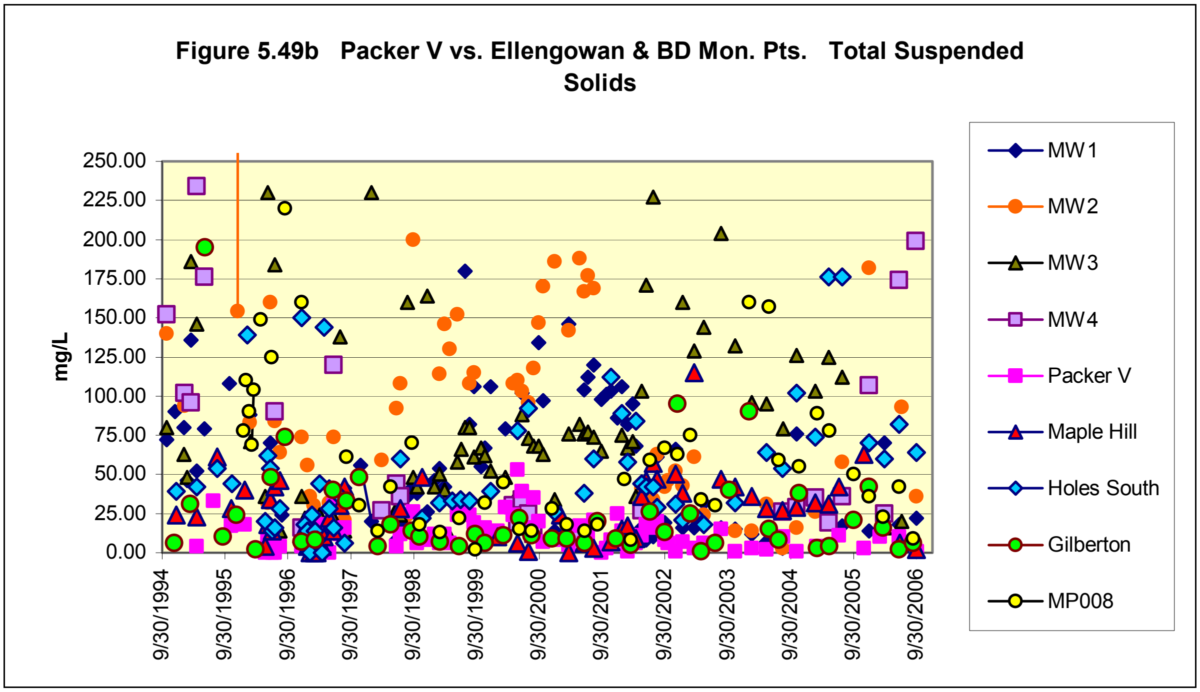


Figure 5.49b Packer V vs. Ellengowan & BD Mon. Pts. Total Suspended Solids
mg/L
250.00
225.00
200.00
175.00
150.00
125.00
100.00
75.00
50.00
25.00
0.00
9/30/1994
9/30/1995
9/30/1996
9/30/1997
9/30/1998
9/30/1999
9/30/2000
9/30/2001
9/30/2002
9/30/2003
9/30/2004
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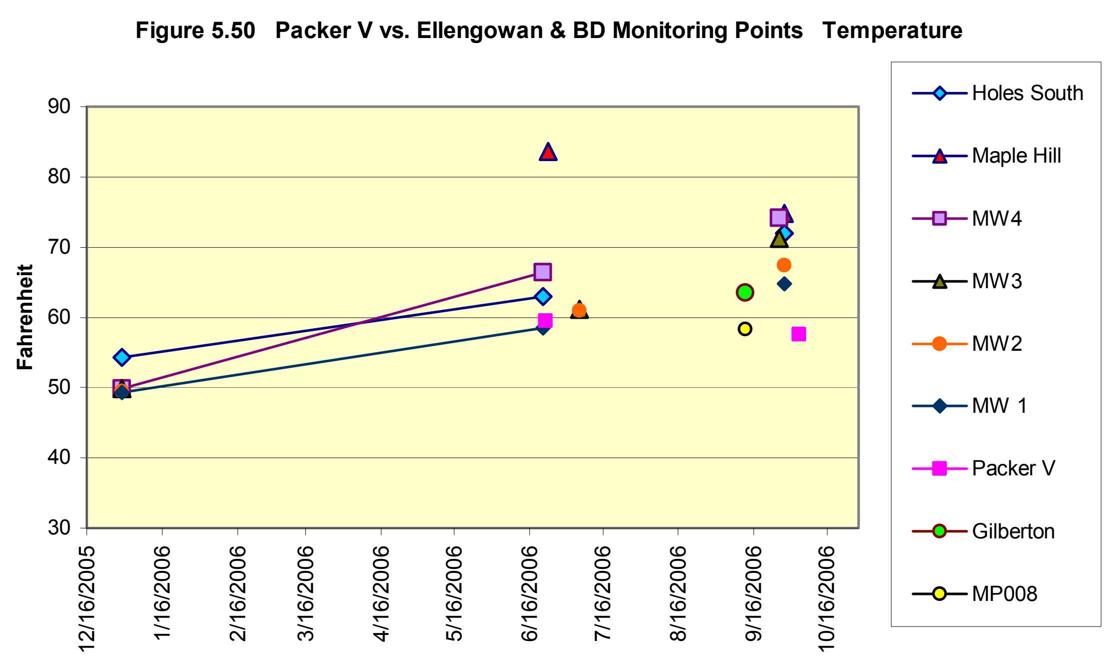
9/30/2006
MW1
MW2
MW3
MW4
Packer V
Maple Hill
Holes South
Gilberton
MP008



Conclusion

Monitoring data reveal substantive adverse effects on water quality from toxic trace metals and major and minor constituents at all downgradient monitoring points at the Ellengowan Permit site that coincide with higher pH and alkalinity and lower acidity resulting from placement of very large quantities of anthracite culm ash at this site. Nonetheless, as is the case at other sites, limited data, the absence of information in the permit file and a minimal monitoring system hampers understanding of the role that ash is playing in the degradation of water quality.

Regarding the Knickerbocker Demonstration Site: Water quality data, especially for trace metals and other ash-specific constituents such as calcium, magnesium, potassium, chloride, and sodium, were meager and water elevation data absent in most cases in the data sets for the monitoring wells at the Knickerbocker Pit. Without water elevation data one cannot even be assured that MW1 located approximately 100-150 yards horizontally from the Knickerbocker ash and screened presumably well below the elevation of ash in the pit, is in fact consistently upgradient of water in the ash. Assuming this is the case, a better understanding of the history of activities upgradient to the Knickerbocker Pit's monitoring wells is still needed before the designation of MW1 as an "upgradient" monitoring point that would not be seeing the effects of ash can be accepted. In particular, past activities at the Shenn Pen Pit and the record of burning coal, rock and culm and coal ash that was placed in its waters in the 1970s need to be fully understood. This and an improved understanding of the history of the Knickerbocker Pit prior to the Demonstration Project are necessary to establish that coal ash may not have contributed high baseline concentrations of manganese, iron, sulfate, TDS, TSS, pH and alkalinity to downgradient monitoring points.

A closer examination of site activities in 2001 and 2002 and of water quality and movement is also needed to fully understand the impacts of this FBC ash slurry demonstration project. This would reveal the rates and timing of slurry disposal and collect additional data of water table elevations and water levels and pollutant concentrations at the Knickerbocker monitoring points. It would establish other monitoring points in the minepool below the pit in addition to collecting water quality data from within the ash itself. The identification of any sources of dilution in the monitored water could shed further light on concentrations and the cause(s) for their changes after 2000.

According to PADEP's Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania, "[t]he objective of the Knickerbocker wet-to-dry demonstration was to establish the technology and economics of placement of ash via a water/solids slurry without impacting the environment in an inverse manner." (Chapter 8, page 239) Overall, however this demonstration project has resulted in noticeable increases in concentrations of iron, manganese, sulfate, TDS, TSS and alkalinity in the mine pool underneath the Knickerbocker Pit flowing toward the center of Ellengowan permit area. To be certain, although acidity was low, there were degraded conditions such as high iron concentrations and peaks of manganese and TSS in the mine pool underneath the Knickerbocker Pit prior to the project. However, the data that have been collected show that water quality is degraded to levels exceeding drinking water standards for iron, manganese, sulfates, and TDS much more substantially and frequently at the points below this ash slurry pit than at the sole designated upgradient monitoring point above the pit. Degradation is also apparent when one compares pre- (1994 to 1998) and post- (1998 to 2006) ash slurry placement values and sees the incidences of high values for these constituents increase. Manganese, sulfate and TDS have risen from levels generally below or within 1-2 times the secondary DWS to levels exceeding those standards by several to many times. Iron has risen from degraded levels to very degraded levels in the underlying mine pool.

In the case of Total Suspended Solids, TSS, although the highest values were measured before the Demonstration Project, the incidence of high levels increased from before to after ash slurry placement at MW1, MW2 and MW3. The measured levels (numerous measurements exceeding 100 mg/L) are far beyond the levels of TSS in influent water considered acceptable for boiler/steam generation (TSS < .025 mg/L - see Section 3.5, pages 20, 21 and 26, Table 3-1 and 5-1, Use of Mine Pool Water for Power Plant Cooling, U.S. D.O.E., National Energy Technology Laboratory, September 2003) and necessitate treatment of this mine pool water for cooling or other purposes at the SER and Gilberton Power Plants.

The role played by constituents in mine pool water that was mixed with the ash to create the slurry is not clear, but the increasing concentrations of constituents and rising alkalinity suggest that a mobilization with time is occurring from ash in this water.

Unlike other permits studied in this report and other ash sites further downgradient in the Ellengowan permit area, there was no mining, remining, or waste coal movement associated with the Knickerbocker demonstration project, only the addition of 3 million cubic yards of very wet ash to a dry pit. This strongly suggests that increases in concentrations of ash-specific constituents such as chloride and magnesium and increases in iron, manganese, sulfates, alkalinity, and TDS in the downgradient wells (MW2 and MW3) that did not occur in the upgradient well (MW1) came from the massive quantity of FBC ash slurried to this site. The high levels of sulfate measured in surface water samples from SER ash/CKD test cells on top of the Knickerbocker pit's ash that are in the same range as rising levels of sulfate at MW2 and MW3 reinforce this evidence. High fluoride levels in this surface water also demonstrate the potential for fluoride to be leaching from the slurried ash into the mine pool in amounts exceeding the DWS. The lack of fluoride data from Knickerbocker monitoring points leaves regulators and the public unaware of whether such degradation is occurring. Although monitoring for trace elements has been scant, data from 2006 suggests that lead and cadmium are finally being mobilized from the Knickerbocker ash as discussed below.

Regarding impacts further downgradient in the Ellengowan and BD Permit areas: Monitoring data also suggests that degradation is occurring from ash placement in two pits southwest of the Knickerbocker Pit, where some 9.1 million tons of FBC culm ash has been dumped from 1989 to 2004. The pits are known as the "Truck site" (144 acres) and the "Conveyor" site (32 acres). There are only two points monitoring water quality effects of the ash in these pits, both in the mine pools underneath them. One point, Monitoring Holes South, is immediately to the southwest of the more western Truck site and is identified as a downgradient ash monitoring point. The other point, Maple Hill Shaft, is south of the Conveyor site and southeast of the Truck site and labeled as an upgradient ash monitoring point. Despite this designation, recent water level elevation data as well as historic information on flow directions, deep mine connections and pumping operations in these underground mines, document that the mine pool sampled by the Maple Hill Shaft has been and remains downgradient of the Knickerbocker Demonstration Pit and the Conveyor site and from time to time is also downgradient of the BD ash placement area where 3.7 million tons of ash has been dumped in a 175 acre pit. This raises the prospect that high levels of trace elements and other pollutants in both Ellengowan monitoring wells may be coming from ash of the Gilberton Power Station dumped in the older BD ash site. All told, deep mine maps document that the mine pools being monitored by these two points are interconnected to numerous other mine pools that collectively flow directly under some 16-17 million tons of FBC ash placed in four pits.

The exact direction of flow in these mine pools is a matter of speculation. There are several major facilities withdrawing water from the mine pools and other facilities that appear to be discharging water to them according to information maintained by the PADEP's Geospatial Data Center (www.emappa.dep.state.pa.us/emappa). The largest water withdrawal operation unquestionably appears to be at the Gilberton Shaft in the southeast corner of these two permit areas, although Maple Hill Shaft in the center of the area is also the site of major withdrawal of mine pool water and an apparent discharge of water to the mine pool. The pumping rates or withdrawal operations at these points are not divulged in the Ellengowan or BD Permit files but rather must be found or surmised by looking in other PADEP programs and sources of information. Complicating the analysis further is the fact that water level elevations, particularly at the Gilberton Shaft and Maple Hill Shaft, are absent from the BD and Ellengowan permit files from 1990 onward. Despite these limitations, the size of the pumping operation at the Gilberton Shaft (at least four times the withdrawal volumes estimated at Maple Hill) appears to establish that the primary direction of flows in these mine pools is to the southwest and west. The occasional flow to the north as one moves from the mine pools under the BD Mining permit area to the mine pools under the Ellengowan permit area should not be overlooked.

The few measurements of water elevations that are available from permit files corroborate these flow directions. The connections among the Maple Hill, West Shenandoah and Gilberton mine pools, whether to pools in the Turkey Run, Shenandoah City, Indian Ridge, Knickerbocker, and North Mahanoy mines to the west, north, and northeast, or to mine pools in the St. Nicholas, Boston Run and Tunnel Ridge mine pools to the south and southeast are documented on deep mine maps. These maps demonstrate hydraulic communication among all of the collieries in this area based not only on structural geology and past mining but further affected by pumping. The direction, rate of flows and pollutant transport times should be driven by mine pool pumping operations that will make these monitoring points more downgradient at some times than other times but never completely upgradient of significant volumes of ash. The hydrologic system being monitored is predominantly that of a more turbulent surface water flow through mine caverns rather than a slower groundwater flow through aquifers.

In addition to the complex subterranean mine pool flow, the history of the area raises questions about when influences from ash on water quality first occurred and whether any of the baseline data collected in the late 1980s for the Ellengowan permit presents a valid representation of water quality unaffected by coal ash. An active mine fire burned for years at Kehley Run until being quenched between 1971 and 1977 when the burning coal and culm was dumped into the waters of the Shen Penn pit, the bottom of which opens into the Indian Ridge Colliery. Deep mine Maps 4151 and 4112 establish that the Indian Ridge Colliery is connected to Shenandoah City Colliery through the Shenandoah City Air Shaft and Shenandoah City Colliery to the Maple Hill Colliery near the Ellengowan Shaft in the immediate vicinity of the Conveyor ash site. The effects of placing untold but likely large volumes (at least thousands of tons) of burning coal, coal wastes and rock into the mine pool as well as the effects of the ash created by this action on mine pool quality were apparently not documented at the time of this activity. However, it would be counter intuitive to assume that placing highly reactive, alkaline ash into a different, more acidic mine environment would not result in reactions that would release toxic trace metals into the mine pool.

A similar situation has existed in the mine pool in the 1990s under Shenandoah City South where smoldering coal refuse and rock vented for years. Infiltrating surface water percolating through the residual ash from this combustion could carry dissolved metals into the Shenandoah City mine pool. This fire was located immediately adjacent to and under the western boundary of the Ellengown Permit area and thus may be a source of the elevated trace metals and other ash constituents at Monitoring Holes South in addition to FBC ash.

Thus the same limitations in the data that hamper analysis of the Knickerbocker project's effects extend to the other monitoring points in the Ellengowan Permit. Assuming water quality at MW1 and other Ellengowan monitoring points has been affected by the ash and burning rock from the Kehley Run fire, there has been no upgradient monitoring point established anywhere in the Ellengowan permit area with which to compare downgradient data. Furthermore, in addition to this mine fire, given the existence of the Turkey Run Landfill upgradient to Monitoring Holes South, a disposal site for industrial wastes including coal ash in the decades preceding the Ellengowan Permit, the baseline data that was collected for Ellengowan monitoring points cannot be relied upon to reflect the absence of influence from ash or other wastes. Impacts from ash must be evaluated purely on the basis of trends in concentrations of ash parameters and the incidence of higher concentrations at monitoring points closer to the ash compared to concentrations at monitoring points further away from the ash.

Clearly declining levels of acidity and substantively rising pH over an extended period at Monitoring Holes South and Maple Hill Shaft while remining operations have been occurring upgradient to these monitoring points indicate that the ash is impacting water at both of them. At Monitoring Holes South, pH has risen from a low of 4.42 units in May 1992 to a high of 9.58 units in March, 2003, the largest rise in pH seen at any downgradient ash monitoring report in the sites examined in this report. There were a total of 26 pH measurements above 7 units at Monitoring Holes South, and 25 of them occurred after June 1998. Ten of those measurements exceeded 9 units. At Maple Hill Shaft, pH also rose noticeably although to a lesser extent. Measurements ranged from a low of 4.22 units in November 1995 to a high of 8.46 units in July 2002 with 8 values over 7 units, all of which occurred after July 1999.

Thus even without upgradient monitoring data, downgradient data indicate that the 16-17 million tons of alkaline FBC ash dumped in these two mines from 1988 through 2006 has been having a major impact on water quality. While the disruption of culm, coal silt and spoils have likely contributed to the degradation, it appears that ash placement has markedly driven up the pH of mine pool waters and generated more erratic and at times, higher concentrations of major and minor constituents at monitoring points closer to the ash in the Ellengowan and BD Mining Permit areas than are occurring at large volume mine discharges at the Gilberton Shaft or the distant Packer V outfall. This is best illustrated by the higher concentrations of sulfate, TDS, iron, manganese, pH, aluminum, sodium and TSS at Maple Hill Shaft than are found at the Gilberton Shaft or the Packer V Discharge. The withdrawal of mine pool water and discharges into Maple Hill Shaft associated with operations at the SER power plant are also likely to have a decisive impact on pollutant concentrations at this monitoring point.

One sees this tendency also at Knickerbocker monitoring points however with more erratic concentrations and higher peak concentrations occurring than at the large volume discharge points. PADEP implies in Chapter 7 of Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania (pages 217-218) that higher clay and portlandite content in SER ash produced a cementitious effect in this ash slurried to a 14 acre section of the silt settling basin that eventually became part of the Conveyor ash site. This effect apparently displaced water in the basin and prevented its immediate infiltration through the ash. This could explain the dry samples and decisive drops and increases that occur in concentrations at Knickerbocker monitoring points as contaminant pathways are altered by ash in different stages of setting and breaking down in the Knickerbocker pit.

Indeed there was a noticeable drop in most major and minor pollutant concentrations (e.g., iron, manganese, sulfate, TDS, calcium, magnesium and sodium) from the latter 1990s through 2001-2002 at monitoring points closer to ash sites in both permit areas. One exception was MW2 where levels of these pollutants as well as alkalinity climbed during the latter 1990s and dropped after 2000.

As this decline ended, water quality trends for major and minor constituents at Monitoring Holes South that were improving through 2002 reversed. Sulfate and TDS have been rising above the DWS in 2004-2006 at this monitoring point, and iron and manganese have risen to seriously degraded levels that are above the Gilberton and Packer V concentrations and far above the DWS in latest measurements. The ash placement underway for the past five years in Area 42A due west and directly upgradient of Monitoring Holes South may be a source for this degradation. Similar trends have occurred at MP008 in the BD Mining Permit area.

Framed by this decline and subsequent rise in pollutant concentrations, the general signature of degradation from major and minor constituents at Monitoring Holes South appears to be similar to the degradation at ash monitoring points MP007 and MP008 in the BD Mining area, while degradation from major and minor constituents at the Maple Hill Shaft is more similar to degradation seen at the downgradient monitoring points of the Knickerbocker ash site.

The highest concentrations of toxic trace elements have also been found at monitoring points closest to the ash, most noticeably in recent years at Monitoring Holes South, MP008 and MW3. Lead and cadmium are the two trace elements showing up the most and unlike other trace elements, their detections are measured above the DWS in the large majority of cases. In most cases, the highest concentrations have been measured in the fall and winter. High lead and cadmium levels have also been found at the BD Mining ash monitoring points although their incidence has been spread more evenly between the spring and fall.

The highest lead levels have been measured at Monitoring Holes South (0.7 mg/L in April 1989), MP008 (0.58 mg/L in September, 2001), MW3 (0.53 mg/L in September, 2006) and MW4 (0.43 mg/L in September, 2006). These levels range from 47 to 29 times the DWS. The monitoring point where the greatest number of detections were measured was Monitoring Holes South with 15 out of 41 samples finding lead. The second greatest lead detection rate was at MW3 with 3 of 12 samplings finding lead. The third greatest lead detection rate was at Maple Hill Shaft with lead measured in 9 of 47 samples. Some 22 of these 27 detections measured lead exceeding the DWS.

The highest cadmium levels have been measured at Maple Hill Shaft (0.160 mg/L in June, 1988), Monitoring Holes South (0.07 mg/L in November, 2001) and MW3 (0.053 mg/L in October, 1996 and 0.034 mg/L in September 2006). These measurements range from 6 to 32 times the DWS.
The monitoring points where the greatest detection rate of cadmium occurred were MW3 with cadmium found in 7 of 12 samples, MW 4 with cadmium found in 2 of 5 samples, and Monitoring Holes South with cadmium found in 14 of 40 samples. Some 21 of these 23 samples detected cadmium exceeding the DWS. All but one of the cadmium detections at Knickerbocker points (0.005 mg/L at MW1 in December 2000) exceeded the DWS. Ironically as mentioned above, the only detection of cadmium at a Knickerbocker point prior to the slurry placement was the highest value found at these points, 0.053 mg/L at MW3 in October 1996.

Nonetheless what this data shows is that the monitoring points that are closest to the ash in the Ellengowan and BD permit areas are where the highest levels of lead and cadmium have been found. In the Ellengowan permit area, these monitoring points are also where the greatest number of high concentrations are found while in the BD permit area, the incidence of high concentrations is evenly distributed between MP008 and the Gilberton Shaft.

In addition, the advent of extremely high levels of lead at Knickerbocker monitoring points in 2005 and 2006 for the first time in 10 years of monitoring suggests that these lead levels are not an artifact of past mining practices or mine drainage at this site. These results also demonstrate why long term monitoring is needed to detect mobilizations of trace elements around ash minefill sites.

Two points should be reckoned with by those who might dismiss these lead levels as part of mine drainage. The first is that such high concentrations of lead (0.100 to 0.700 mg/L) are not normally found in other anthracite mine pools. Background water quality monitoring from landfills and at least one superfund site (Marjol Battery) in the anthracite coal fields of eastern Pennsylvania demonstrates that lead is not found in total or dissolved levels this high in the anthracite coal measures, anthracite mine drainage, or culm leachate. Discreet sources of human activity put the lead there. See the discussion on high lead in Permit Review 7 for further details about the occurance of lead in eastern Pennsylvania groundwater and anthracite mine pools. The second is that permit leach tests on the ashes generated by the Gilberton and SER power plants have established that both ashes have the potential to quickly leach harmful levels of lead. No such potential has been demonstrated for the culm, coal silt, coal, or spoils of the Ellengowan or BD sites.

The incidence of higher concentrations closer to the ash has also applied to arsenic which was measured in several high levels at the Maple Hill Shaft (up to 4.8 times the DWS) and chromium, which was measured in high levels in 19 samplings at Monitoring Holes South (up to 5.8 times the DWS) and 5 samplings at Maple Hill Shaft. However in both cases the high measurements for these trace elements were concentrated during baseline monitoring and for the first 2-4 years of ash placement but then subsided. One observation that may help explain this pattern based on the deep mine maps reviewed in this report (in particular Map 4151), is that in addition to the Shen Penn Pit and its direct conduit into the Indian Ridge mine pool, the Knickerbocker and Conveyor Ash sites are located very near if not directly above the opening to the Knickerbocker Slopes deep mine and the Ellengowan Shaft respectively which would afford direct conduits of FBC ash and FBC ash contaminated water directly into the underlying mine pools. The same conduit was likely afforded to the Boston Run mine pool which according to permit materials, had surfaced in the bottom of the BD ash disposal area. Thus once in the mine pool whether from FBC ash, other ash or another source of pollution, the contaminated water would flow as surface water in the direction of the connections between the collieries influenced by the dynamic stresses of pumping at the Maple Hill Shaft and further west at the Gilberton Shaft. This may explain contamination from chromium and arsenic that seemed to appear suddenly during baseline monitoring in the 1980s and move quickly through site monitoring wells. Such concentrated occurrences of high levels suggests a plume of contamination from a more concentrated source in mine pool waters that washed through the system and/or has been subsequently diluted to background levels or diverted to unmonitored pathways. If site materials such as culm or coal silt were contributing this arsenic and chromium to the mine pool, one would expect the high levels measured to be encountered more evenly throughout the monitoring period and at higher volume discharge points such as the Gilberton Shaft and Packer V discharge reflecting the ambient quality of mine pool waters, neither of which is the case.

The PADEP maintains that the Packer V discharge six miles to the west of Ellengowan Permit site is the lowest downgradient monitoring point for this site (see Chapters 4, 7, & 8, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania). Cross sections of the coal measures and maps of deep mine connections in the eastern end of the Western Middle Anthracite Field raise basic questions about the reliability of this designation. The control of mine pool levels by aggressive pumping operations at the Gilberton Shaft, Maple Hill Shaft and possibly other mine pool withdrawal points in the Ellengowan and BD Permit areas adds to these questions. Furthermore the characteristics of this mine pool flow more predominantly reflect a turbulent surface water movement than a slower groundwater movement. The dilution and input from other mine pools that would occur in waters from Ellengowan mine pools that comprise large volumes to begin with, flowing through an additional six miles of mine channels raise serious questions about the ability of any monitoring point this far "downstream" to detect downgradient impacts of the ash at Ellengowan.

It is worth noting that the concentrations of lead and cadmium as well as chromium and arsenic are lower at the Packer V discharge than at any of the downgradient ash monitoring points inside the boundaries of the Ellengowan and BD Mining Permit areas with exception of MW2. This includes the concentrations of these constituents at the Gilberton Shaft. Furthermore the concentrations of aluminum, zinc, copper and nickel are decisively lower in the Packer V discharge than at any of the monitoring points in the Ellengowan and BD Mining permit areas. This is also generally corroborated by concentrations of these constituents at "upgradient" MW1 which are lower than at downgradient monitoring points. An exception occurred in the December 1999 sample from MW1, which recorded higher than normal levels of aluminum, cadmium, zinc, copper and nickel that were above levels of these constituents at some other points. Nonetheless the noticeably higher levels of these trace metals and aluminum at downgradient ash monitoring points, including the Gilberton Shaft, than at the Packer V or "upgradient" MW1 provides more evidence that these constituents are not present in ambient mine pool water at the levels seen directly downgradient of the FBC ash and that the FBC ash and/or other ash or wastes disposed in the area is therefore responsible for toxic levels of lead, cadmium, aluminum, zinc, and other metals in the mine pools underneath these sites.

Finally although laboratory leach tests should never be relied upon to predict the behavior of coal ashes in the disposal setting, such tests required in the Ellengowan and BD Mining permits have at least established the potential for the SER ash to quickly leach toxic levels of cadmium in addition to lead and the Gilberton ash to quickly leach toxic levels of chromium, zinc and aluminum in addition to lead.

Additional monitoring points are needed at this site and at the neighboring BD ash site, upgradient, downgradient and in the ash. Water level elevations should be regularly recorded along with water quality data to verify flow directions. The rate of contaminant movement in the mine pools and between monitoring points should be determined. A thorough chemical and mineralogical characterization of the ashes, coal silt, culm and spoils and potential geochemical interactions among them is needed. Parameters exclusive of the leachate from ashes dumped in these mines as well as constituents that may be mobilized in the geochemical interactions between the ash and site materials should be identified and tracked in the monitoring program to differentiate impacts among these potential pollution sources. Surface waters draining ash areas should be monitored regularly for these parameters. An enforceable plan of corrective responses to pollution should be implemented.

A –

B –

CAPTION - These pictures of the Big Gorilla Pit in the Silverbrook Refuse Site show the dry-to-wet placement of approximately 3 million tons of FBC ash into standing mine water. A – Shows the Big Gorilla in the midst of this filling and B is an aerial shot of the Big Gorilla Pit filled with the ash. These photos and this Caption are from Figure 2.8 of the National Research Council Report, Managing Coal Combustion Residues in Mines, 2006, page 53. Photo A was provided to that Report courtesy of Barry Scheetz, Pennsylvania State University and Photo B was provided by Daniel Koury, of the Pennsylvania Department of Environmental Protection.

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Permit Review 6

NORTHEASTERN POWER COMPANY- SILVERBROOK (BIG GORILLA) (PERMIT # 54920201)

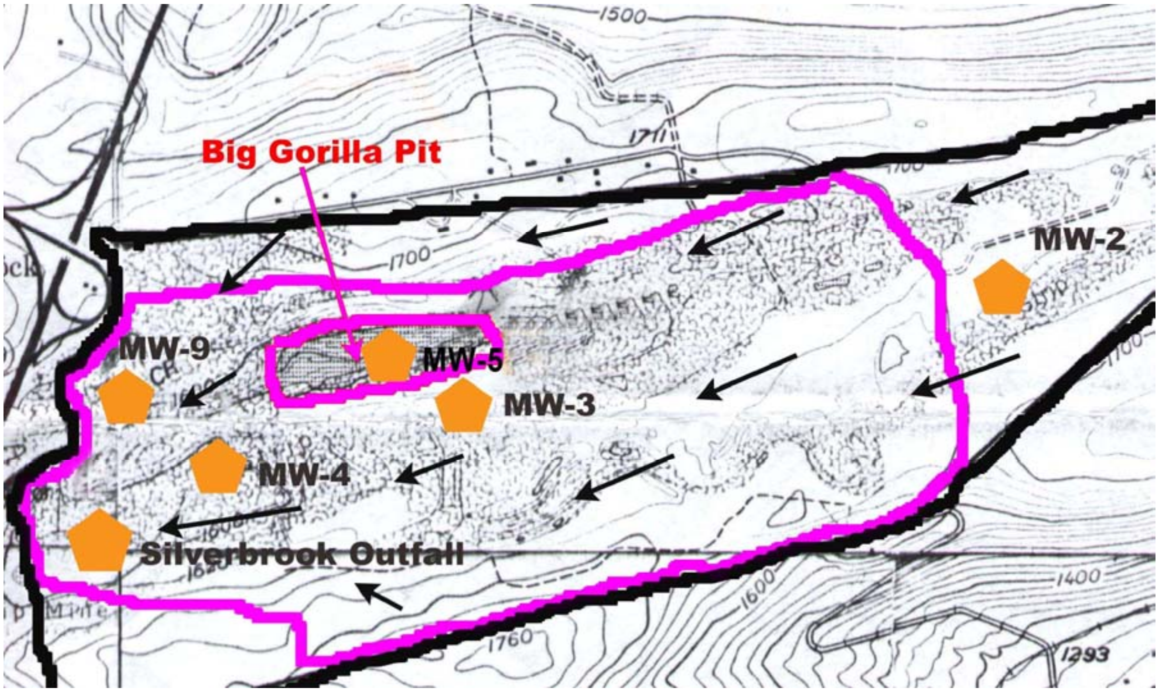
Site Summary

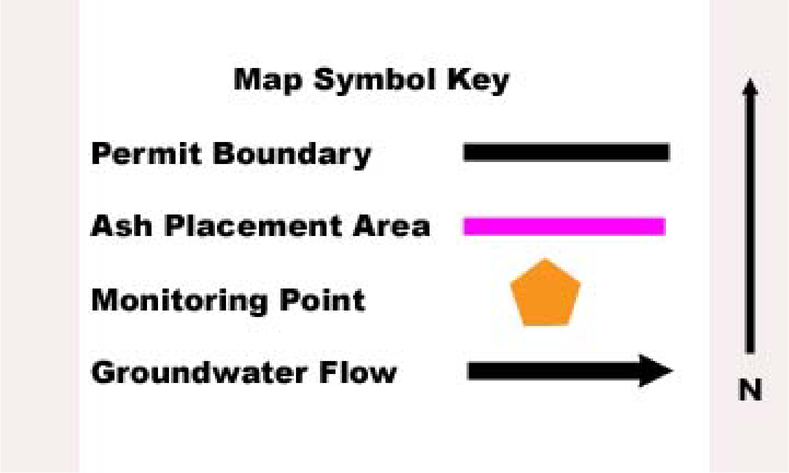
Northeastern Power Company's (NEPCO) Silverbrook Refuse Project is located partly in Kline Township, Schuylkill County and partly in Packer Township, Carbon County, Pennsylvania in the Silverbrook Basin. The Silverbrook Basin is about five miles long and a mile wide and is located between the eastern Middle and Southern anthracite fields. The drainage of the basin discharges into the Little Schuylkill River, which is designated as watershed 3A in the Priority Watersheds of the Commonwealth of Pennsylvania State Water Plan.

A permit (Solid Waste Management Permit #301304) issued in June 1997 to NEPCO allowed for a "demonstration" involving the use of residual waste (FBC fly ash, bottom ash and filter cake) generated at NEPCO's Co-Generation Plant to reclaim a 16.6-acre water-filled mine pit named "Big Gorilla," located within the Silverbrook Refuse Project permit. The "Big Gorilla" project is found in the Kline Township, Schuylkill County portion of the Silverbrook Refuse Project. The plan called for disposal of the FBC coal ash into the pit to displace the pit's acid water in order to promote "public safety, adjust acidic water pH, and reduce acid mine drainage." The Big Gorilla Pit was approximately 1400 feet long, 400 feet wide, and 90 feet deep and intersected a mine pool where coal was removed from the Mammoth seam. It held approximately 120 million gallons when the water level in the pool was at 1570 feet msl. Ash placement into the pit began in August 1997, and the pit was entirely filled by 2004. It took three million tons of FBC ash to fill the Big Gorilla.

The Silverbrook Refuse Project permit encompasses a total area of 876 acres. According to permit maps, the ash disposal plan for the Silverbrook permit area outside of the Big Gorilla Pit is to be implemented in five phases and involves an area of approximately 250 acres. The ash disposal area is prepared by removing loose coarse overburden. Loose fine soil in the areas being excavated is stockpiled. Concurrently, culm deposits throughout the permit area are removed for burning at the power plant. The ash generated from this combustion is placed in a two-foot layer in the excavated areas and compacted with a roller. A final four-feet of cover is placed on top of the ash and vegetated. NEPCO has been placing fly and bottom ash on the site since 1989. However, the permit file contained only limited data concerning the amount of ash placed. In 2000, an estimated 310,000 tons of ash were disposed; in 2003, approximately 371,909 tons were disposed at the site. Both of these estimates are for ash placed outside of the Big Gorilla Project but within the 250 acres authorized for ash placement in the Silverbrook Refuse Permit area. Prior to 1997, "disposal reports" indicate 1,221,711 cubic yards had been deposited in the permit area. Maps of the permit indicate this ash has been placed primarily to the south and southeast of the Big Gorilla Pit. No total tonnage data for the life of the Silverbrook Refuse project were found in the permit file. Nevertheless permit materials indicate a considerable amount of FBC ash, at least 1.5- 2 million tons, has been placed near the surface of the ground outside of the Big Gorilla Pit within the Silverbrook Refuse Project permit area over the past 15 years.

Site Map: Silverbrook





Northeastern Power Co., Big Gorilla Operation (Permit # 54920201)
Scale: 1” = Approximately 1600’

Geology

The site is located between the Eastern Middle and Southern anthracite fields adjacent to the northeastern section of the Southern Anthracite field of Schuylkill County. According to a cross-section of the McAdoo area in the permit, the geology of the site is composed of the Delano and Silverbrook synclines that trend east-west. Under the synclines, several major faults (Pottchunk, Centralia, Bears Head and Lofty) run northwest-southeast from Silverbrook Ridge north of the site to an area near the Kline/Rush Township border south of the site. The Buck Mountain vein was the main coal seam exploited on the site. Other coal beds mined included the Mammoth and Skidmore veins. Indeed, the area has been highly worked and it is also highly fractured. Therefore the groundwater flows between interconnected mine pools within the different coal beds. Any contaminants in one mine are free to flow into other mine pools and unmined coal beds and then eventually into the local base level, the Silverbrook Outfall, and on to the Little Schuylkill River. The Big Gorilla Pit was recharged by precipitation and discharged as groundwater. The groundwater flow path from the pit, according to Silverbrook permit information and the 2005 PADEP report entitled, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania (hereinafter "PADEP Report") has not been delineated in any detail (PADEP Report, Chapter 9).

Groundwater Monitoring

Although subsurface pathways are not clearly delineated, permit matierals indicate the shallow groundwater flow across the permit site is from the east torward the west and southwest. The groundwater on the site was monitored at several shallow monitoring wells: MW2, MW3, MW4, MW5, MW9, and the Silverbrook Outfall. MW3 is located 100-150 feet to the south of the Big Gorilla mine pool, monitoring possible groundwater inputs from the Big Gorilla pit. MW4, drilled into the Buck Mountain vein in July 2001, is designated "downgradient" and is situated west of the Big Gorilla mine pool. The purpose of MW4 is also to intersect groundwater moving from the Big Gorilla Pit. MW5 was drilled in August 2003 directly into the Big Gorilla ash to sample ash leachate. MW9 was drilled to monitor effluents associated with a Superfund site located at the western end of the basin. Finally, the Silverbrook Outfall is the most strategically important monitoring point in the basin. The Silverbrook Outfall drains the entire basin and, at 1537 feet msl, it is considered the most "downgradient" base level point on the site.

MW2 is of particular importance as the only designated "upgradient" well due to its position as the easternmost functioning well on the site. However MW2 may not be entirely upgradient of all ash deposits in the Silverbrook Permit area as shown by an ash placement map entitled NORTHEAST POWER COMPANY, SILVERBROOK OPERATION, ANNUAL ASH REPORT, EXHIBIT 25C dated January 2002 which indicates that ash placement had been completed by December 31, 2000 in an area about 800 feet southeast of MW2 with a final surface elevation about 40 to50 feet uphill from the surface elevation of this monitoring point (1656 feet msl). Its validity as an upgradient monitoring point is further called into question by EXHIBIT 6.2-9-15 ENVIRONMENTAL RESOURCE, OPERATIONS & LAND USE MAP dated June 8, 1992 in the permit file which states “fly ash disposal” was to take place in areas identified as “Proposed Phases 3, 4 and 5” to the north and east of MW2. Given MW2 is designated by PADEP in the permit’s Module 25 monitoring reports as upgradient of the ash in Big Gorilla Mine Pit Demonstration Project, it is therefore theoretically assumed to be unaffected by the effluents associated with this project but not necessarily upgradient of other ash placed at this site under Silverbrook Permit #54920201. However, even these assumptions cannot be stated with certainty given the subterranean pathways at this site that are admittedly not well understood by PADEP.

Due to the highly altered structure and highly fractured and faulted geology, it is difficult to establish precise groundwater flow patterns in the permit area. According to the PADEP Report, the connection between the Big Gorilla mine pool and the Silverbrook outfall is “undetermined” (page 288, Chapter 9). No tracer tests have been performed to determine flow patterns. Before ash placement, however, the Big Gorilla mine pool experienced a 20-foot seasonal fluctuation in water level. According to the PADEP Report, despite the placement of 3,000,000 tons of ash in the Big Gorilla Pit, this mine pool’s water levels continued to fall and rise “not with ash placement, but with the season, at levels seen in past years. There has yet to be any consistent change in the water level in the mine pool.” (Chapter 9, pg. 256) It appears that the ash placed in the Big Gorilla Pit is not blocking water flow through the mine pool connected to the pit. In any event, the previously documented 20-foot fluctuation in the mine pool’s water level translates into the seasonal movement of approximately 84 million gallons of water. Considering the location of the Big Gorilla mine pool perched above the Silverbrook outfall, the fractured and faulted geologic structures within the basin, the underlying man-made karst-like system of mined out tunnels, and the massive 84 million-gallon seasonal water fluctuation within the Big Gorilla mine pool, a hydraulic connection between the Big Gorilla pool and the Silverbrook Basin system (and therefore the Silverbrook outfall) can be safely assumed.

The values in the graphs for the monitoring points in this report were taken from the PADEP’s electronic data base of monitoring data lifted from Module 25 Reports submitted by anthracite minefill site operators. Only total values are recorded in this data base (PADEP Pottsville District Office Staff Communication, June 13, 2006). Nonetheless, a check of some Module 25 reports from the permit files reveals that in the large majority of samplings the dissolved and total fractions are very close if not virtually identical at this site. Evidence of this is further suggested by the low levels of total suspended solids (TSS) in the large majority of data reported. For example, of the 116 measurements of TSS at the Silverbrook Outfall, some 80 are 2 mg/L or less. The highest TSS was 18 mg/L in May, 2002 and only 6 measurements were 10 mg/L or higher.

MW2 vs. Silverbrook Outfall

According to the PADEP report, the "Silverbrook outfall's chemistry is key to understanding the net chemical result of the reclamation processes in the Silverbrook Basin." (pg 288, Chapter 9). Comparing data from the most "upgradient" monitoring point (MW2) with the most "downgradient" monitoring point (Silverbrook Outfall) reveals the impact of the ash placed in the basin under the Silverbrook Refuse permit and the Big Gorilla project. The graphs below incorporate a red vertical axis that delineates the periods "before" and "after" ash placement into the Big Gorilla Pit.

Sulfate (figure 6.1), total dissolved solids (TDS) (figure 6.2), and specific conductance levels (figure 6.3) are significantly higher in the Silverbrook Outfall than at MW2. Prior to the Big Gorilla Demonstration Project, concentrations of these constituents at the Silverbrook Outfall were generally 2 to 3 times the concentrations of sulfate, TDS, and specific conductance at MW2. These higher levels reflect the disturbance from culm mining and ash placement that has been ongoing since 1989 in the Silverbrook permit area on ground to the east of the Silverbrook Outfall and mostly to the south of the Big Gorilla Pit that drains into mine pools discharging at the outfall. Perhaps due to some positive effects of reclamation, sulfate levels in the Silverbrook Outfall appeared to be on a gradual downward trend before ash placement in the Big Gorilla project. However, in 1998, approximately one year after ash placement started in the Big Gorilla Pit, sulfate, TDS, and specific conductance levels increased steeply. Sulfate concentrations rose up to 12 times higher, TDS concentrations rose up to 11 times higher, and specific conductance levels rose up to 8 times higher at the Silverbrook Outfall than at MW2 after ash placement in the Big Gorilla. Sulfate and TDS levels that were well under secondary drinking water standards at the Silverbrook Outfall rose to secondary DWS or higher five times for sulfate and two times for TDS after ash placement started in the Big Gorilla Pit.

Other constituents that were elevated at the Silverbrook Outfall compared to MW2 behaved similarly. Before ash placement, aluminum (figure 6.4) concentrations were up to 10 times higher at the Silverbrook Outfall than at MW2. Iron (figure 6.5) concentrations were more then 20 times higher at the Silverbrook Outfall than at MW2. Yet average Silverbrook Outfall concentrations of aluminum and iron increased further after ash placement at Big Gorilla: aluminum rising from 3.03 mg/L to 6.47 mg/L and iron rising from 8.98 mg/L to 16.52 mg/L. Manganese (figure 6.6) concentrations showed a moderate version of the same pattern. Overall significantly higher levels at the Silverbrook Outfall than at MW2 were replaced by even higher average concentrations at the Silverbrook Outfall after ash placement (1.6 mg/L vs. 1.2 mg/L). Thus culm mining, overburden excavation, and ash placement had already degraded water quality in the Silverbrook basin with harmful levels of sulfate, aluminum, iron, manganese, and TDS and, the addition of large amounts of ash in the Big Gorilla Pit appears to have exacerbated this degradation. For example, aluminum levels at the Silverbrook Outfall rose from 60 times the drinking water standard (DWS) before the Big Gorilla ash placement to 130 times the DWS after ash placement.

Due to the apparent affect of the ash, the Silverbrook Outfall effluent became slightly more alkaline (figure 6.7) after the Big Gorilla Project started. Before ash placement, average lab pH was 3.79, whereas, after ash placement, the average lab pH reading rose to 4.14. At the upgradient point MW2, lab pH readings remained almost unchanged at around 5.0 throughout the entire monitoring period. A jump in pH to 6.90 in the Silverbrook effluent occurred in February 1999 reflecting a jump in alkalinity to 64 mg/L and a fall in acidity to 0.00 mg/L, although this alkalinity rise was temporary with most alkalinity measurements remaining at 0.00 mg/L while acidity ranged typically between 50-150 mg/L. Lab rather than field pH was compared in figure 6.7 because the large majority of reported values in the PADEP data base during ash placement in Big Gorilla were only of laboratory pH.

More ash-specific constituents such as calcium (figure 6.8) and chloride (figure 6.9) showed sharp increases in concentrations at the Silverbrook Outfall after ash placement started in Big Gorilla. Spikes in calcium levels at MW2 to 34.60 mg/L in May 2001 and 88.70 mg/L in December 2003 indicate the effects of ash placement perhaps outside of the Big Gorilla Pit on this “upgradient” well or sampling problems. Higher magnesium (figure 6.10) and zinc (figure 6.11) concentrations also suggest the impact of the ash on the Silverbrook effluent. Average magnesium concentrations were 30% higher in the Silverbrook discharge after ash placement (9.99 vs. 6.34 mg/L) started in Big Gorilla. Likewise, average zinc concentrations increased substantially after ash placement (0.39 mg/L vs. 0.25 mg/L) at the Silverbrook Outfall. A peak of zinc to 3.41 mg/L in the Silverbrook effluent in November 1998 may have been an outlier or sampling anomaly, however other zinc measurements at both the Silverbrook Outfall and at MW-2 were noticeably higher after ash placement started at the Big Gorilla Pit. There were only two nickel measurements (ungraphed) recorded in the data base prior to ash placement at Big Gorilla at these monitoring points, but nickel concentrations at the Silverbrook Outfall averaged more than three times as high as nickel concentrations at MW2 after ash placement started in the pit (0.089 mg/L vs. 0.027 mg/L). Nickel levels exceeded the former DWS of 0.100 mg/l in the Silverbrook Outfall six times whereas the highest nickel measured at MW2 was 0.055 mg/L in August 1998. Although potassium (figure 6.12) data was only been gathered after ash placement started in the pit, its concentrations, although relatively low, rose steadily throughout the sampling period at the Silverbrook Outfall.

Concentrations of another ash-associated analyte, sodium, rose from an average of 10.95 mg/L before ash placement started at Big Gorilla to 18.73 mg/L afterwards at the Silverbrook Outfall. This higher average after ash placement does not include an anomalously high level of 232 mg/L measured on September 10, 2002 in the same sampling that anomalously high levels of sodium (17-138 times over all other sodium concentrations), were found at MW4 (322 mg/L), MW 3 (214 mg/L), and MW9 (228 mg/L). Calcium and potassium concentrations in this sampling at the Silverbrook Outfall were also the highest measured, and specific conductance and TDS levels in this sampling were among the highest levels at Silverbrook. However these other analytes were not measured at their highest or near highest levels in the September 10, 2002 sampling at the other monitoring points raising a question about whether any of the extremely high sodium levels in this sampling accurately reflected sodium concentrations in the water. Chloride levels in the September 2002 sampling were not high at any of the monitoring points. Nevertheless the PADEP Report states that the rising calcium at the Silverbrook Outfall is due to reclamation of the surrounding watershed with FBC ash from the NEPCO power plant and that rising sodium in this outflow is likely from local salting of roads and "possibly from land reclamation using fly ash and bottom ash." (page 269, Chapter 9)

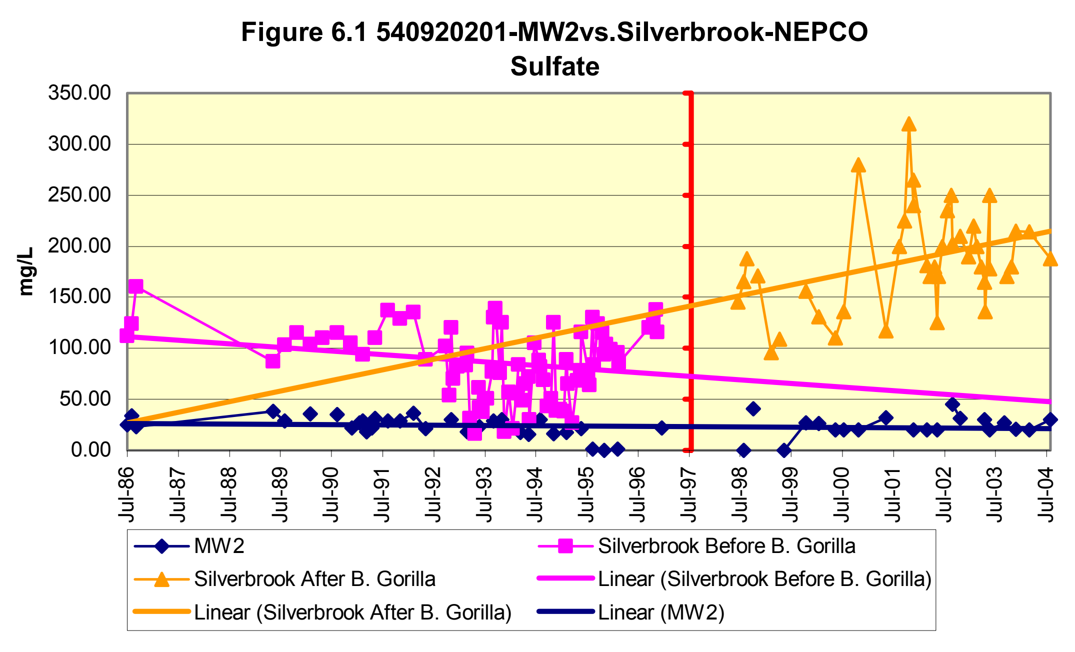


Figure 6.1 540920201-MW2vs.Silverbrook-NEPCO Sulfate

Figure 6.2 54920201-MW2vs.Silverbrook Outfall Total Dissolved Solids

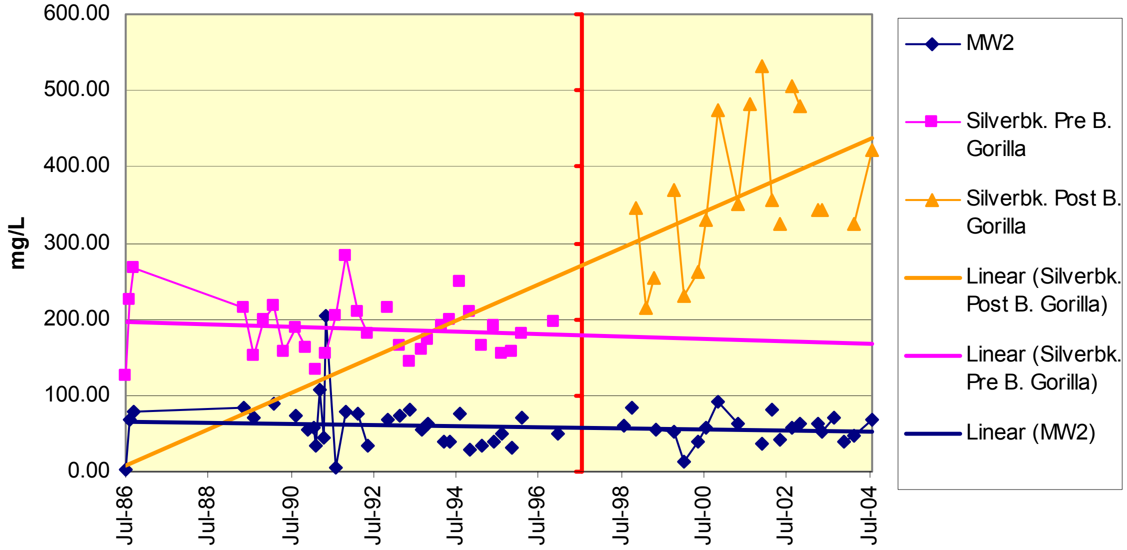
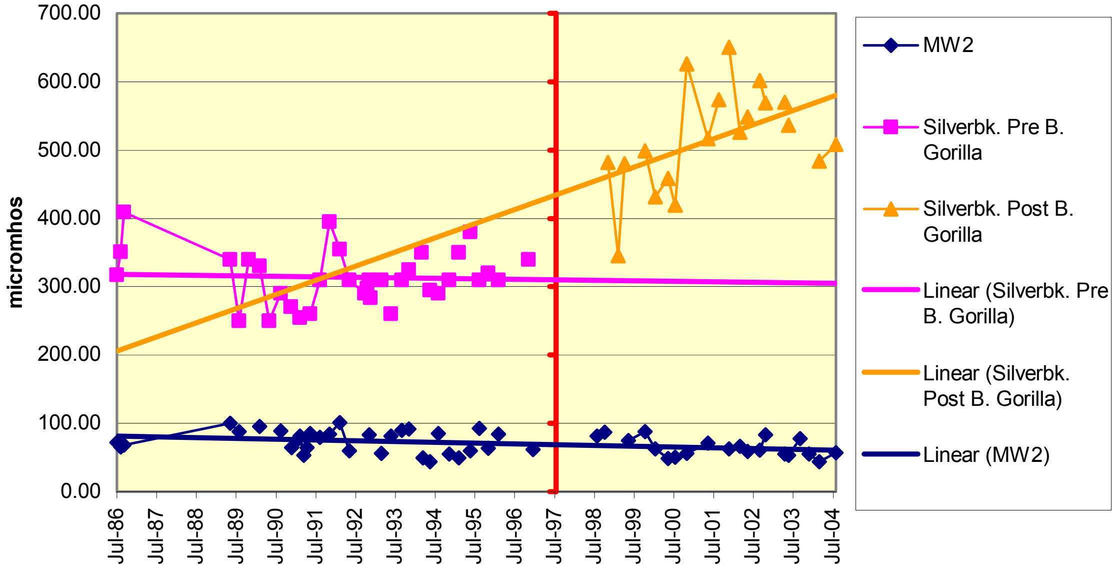


Figure 6.3 54920201-MW2vs.Silverbrook Outfall-NEPCO Specific Conductance



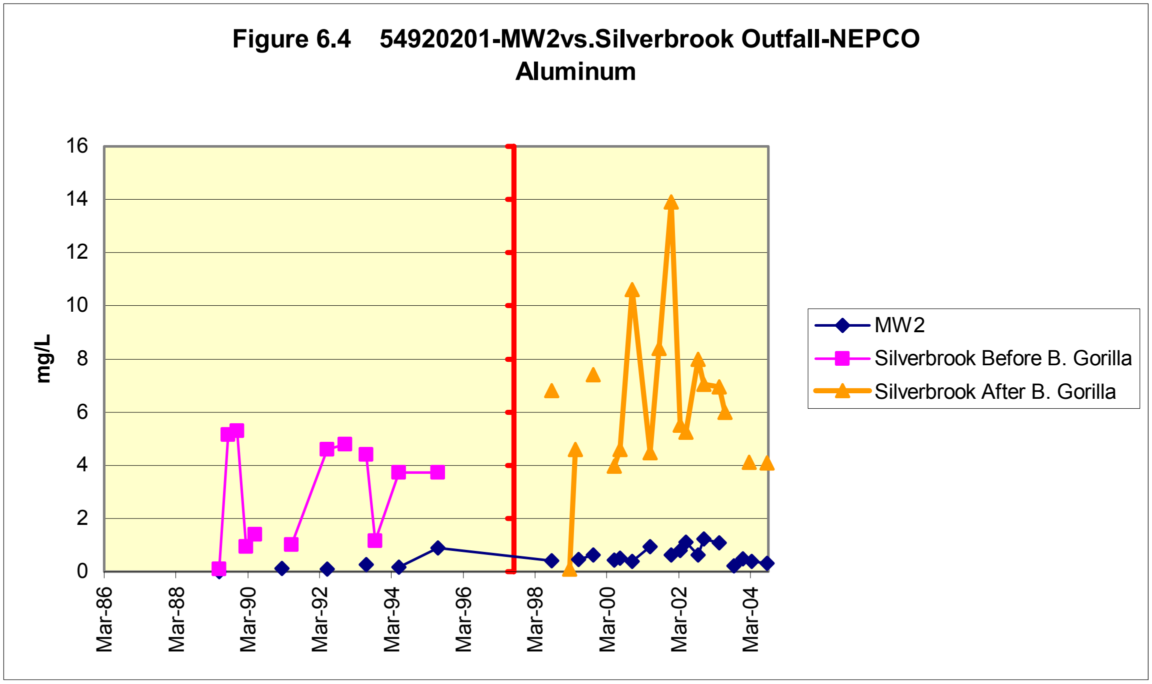


Figure 6.4 54920201-MW2vs.Silverbrook Outfall-NEPCO
Aluminum
mg/L
16
14
12
10
8
6
4
2
0
Mar-86
Mar-88
Mar-90
Mar-92
Mar-94
Mar-96
Mar-98
Mar-00
Mar-02
Mar-04
MW2
Silverbrook Before B. Gorilla
Silverbrook After B. Gorilla

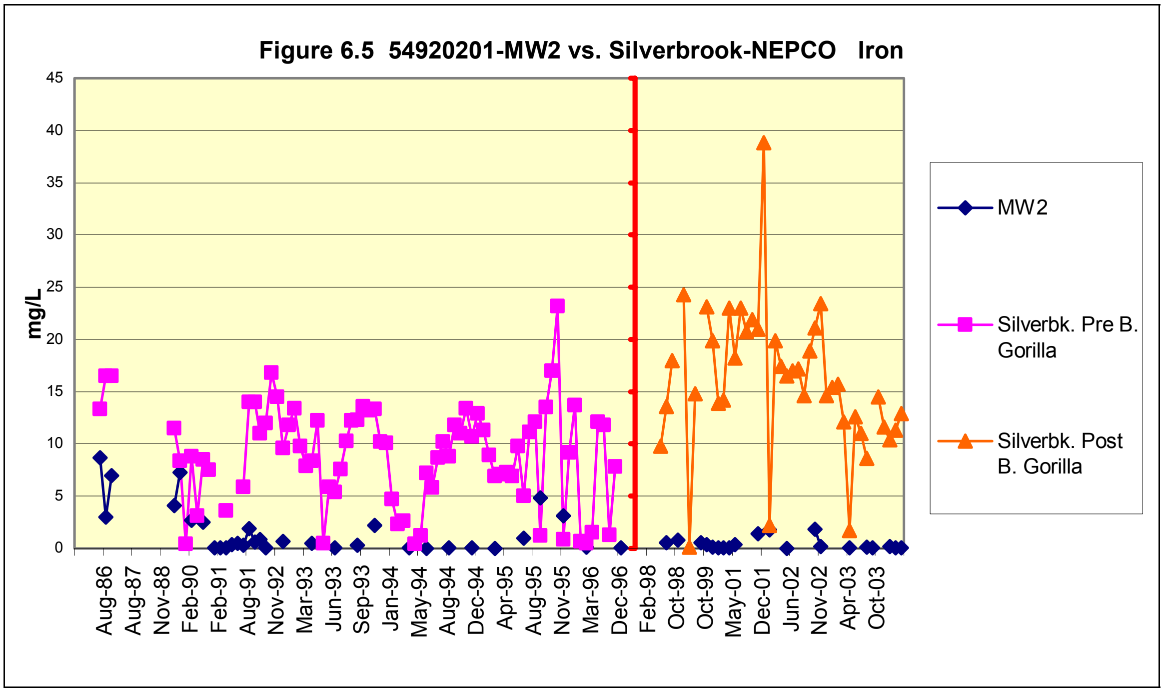


Figure 6.5 54920201-MW2 vs. Silverbrook-NEPCO Iron
mg/L
45
40
35
30
25
20
15
10
5
0
Aug-86
Aug-87
Nov-88
Feb-90
Feb-91
Aug-91
Nov-92
Mar-93
Jun-93
Sep-93
Jan-94
May-94
Aug-94
Dec-94
Apr-95
Aug-95
Nov-95
Mar-96
Dec-96
Feb-98
Oct-98
Oct-99
May-01
Dec-01
Jun-02
Nov-02
Apr-03
Oct-03
MW2
Silverbk. Pre B. Gorilla
Silverbk. Post B. Gorilla

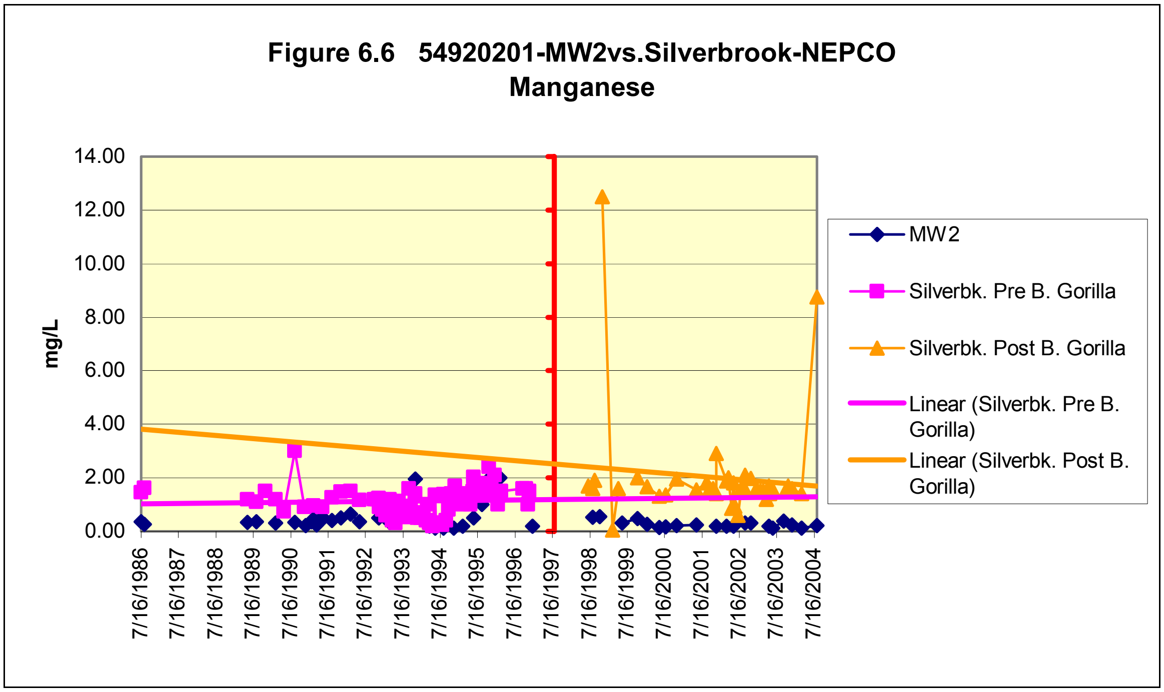


Figure 6.6 54920201-MW2vs.Silverbrook-NEPCO Manganese
mg/L
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
7/16/1986
7/16/1987
7/16/1988
7/16/1989
7/16/1990
7/16/1991
7/16/1992
7/16/1993
7/16/1994
7/16/1995
7/16/1996
7/16/1997
7/16/1998
7/16/1999
7/16/2000
7/16/2001
7/16/2002
7/16/2003
7/16/2004
MW2
Silverbk. Pre B. Gorilla
Silverbk. Post B. Gorilla
Linear (Silverbk. Pre B. Gorilla)
Linear (Silverbk. Post B. Gorilla)

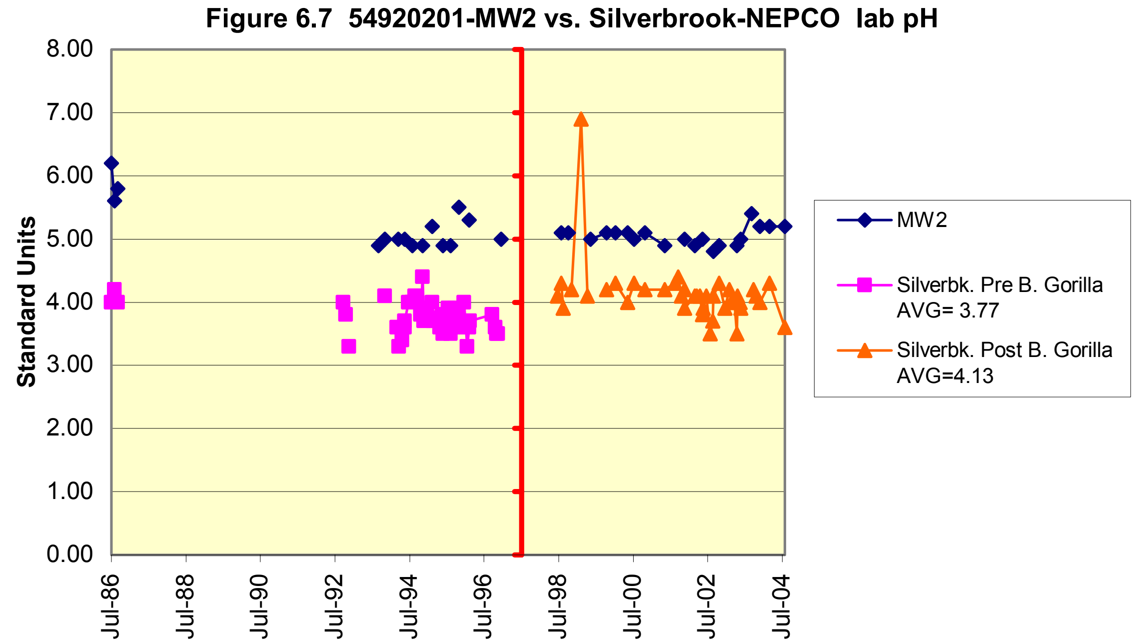


Figure 6.7 54920201-MW2 vs. Silverbrook-NEPCO lab pH
Standard Units
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jul-86
Jul-88
Jul-90
Jul-92
Jul-94
Jul-96
Jul-98
Jul-00
Jul-02
Jul-04
MW2
Silverbk. Pre B. Gorilla AVG= 3.77
Silverbk. Post B. Gorilla AVG=4.13

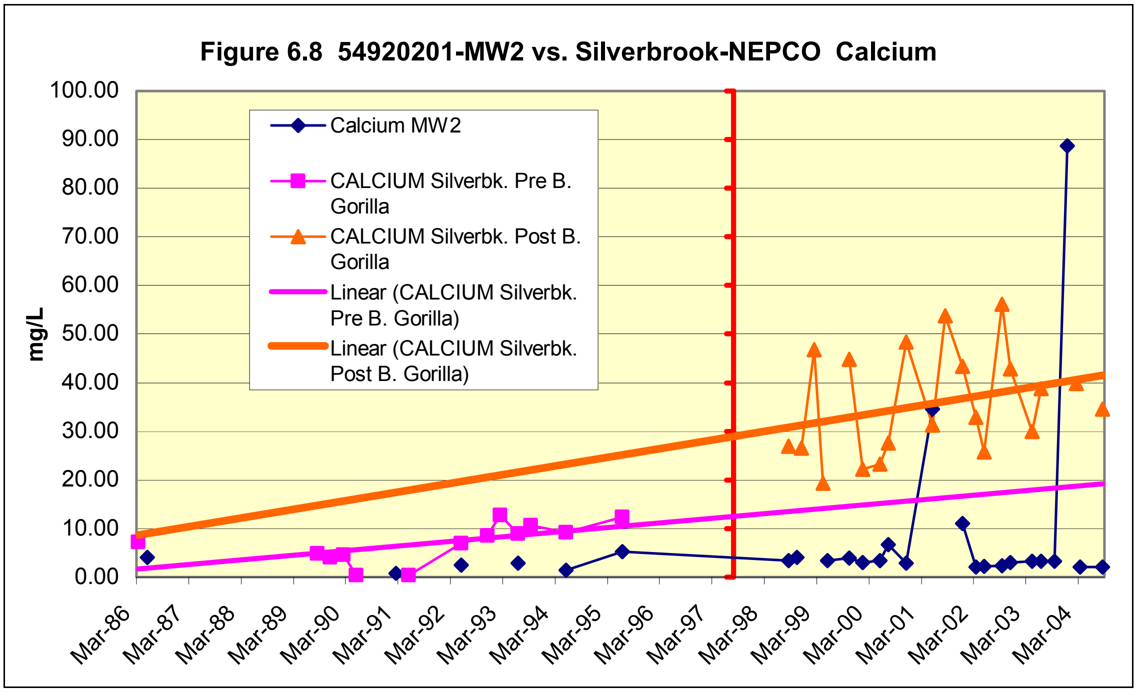


Figure 6.8 54920201-MW2 vs. Silverbrook-NEPCO Calcium
mg/L
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Calcium MW2
CALCIUM Silverbk. Pre B. Gorilla
CALCIUM Silverbk. Post B. Gorilla
Linear (CALCIUM Silverbk. Pre B. Gorilla)
Linear (CALCIUM Silverbk. Post B. Gorilla)
Mar-86
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04

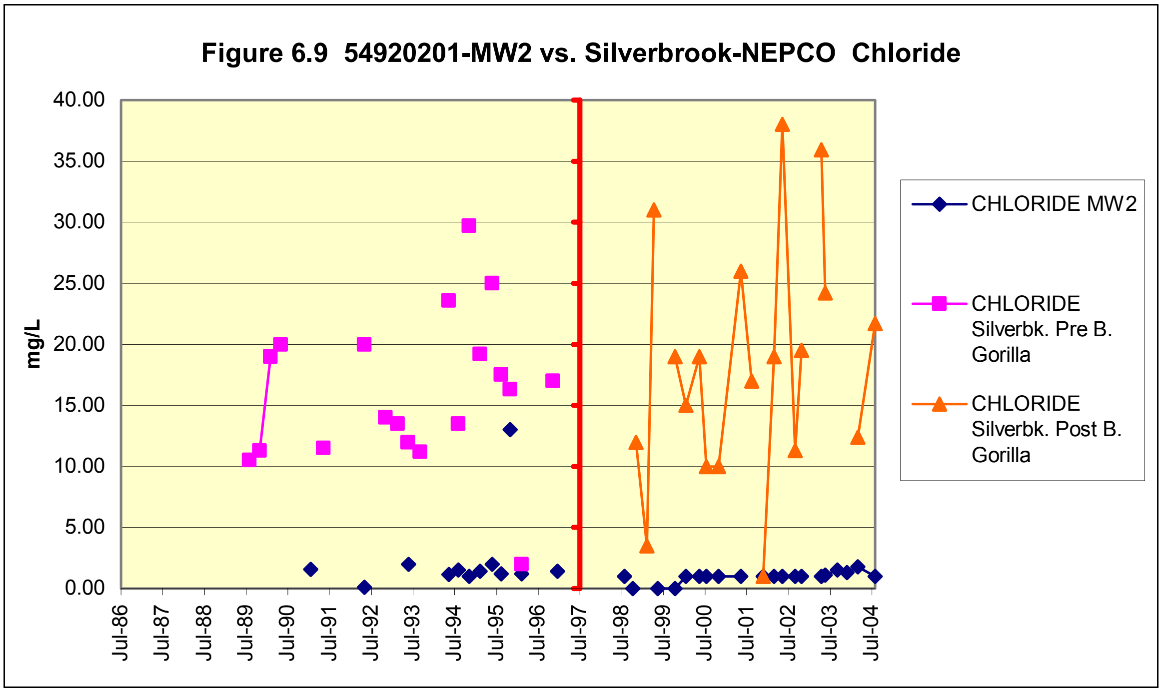


Figure 6.9 54920201-MW2 vs. Silverbrook-NEPCO Chloride
mg/L
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
CHLORIDE MW2
CHLORIDE Silverbk. Pre B. Gorilla
CHLORIDE Silverbk. Post B. Gorilla
Jul-86
Jul-87
Jul-88
Jul-89
Jul-90
Jul-91
Jul-92
Jul-93
Jul-94
Jul-95
Jul-96
Jul-97
Jul-98
Jul-99
Jul-00
Jul-01
Jul-02
Jul-03
Jul-04

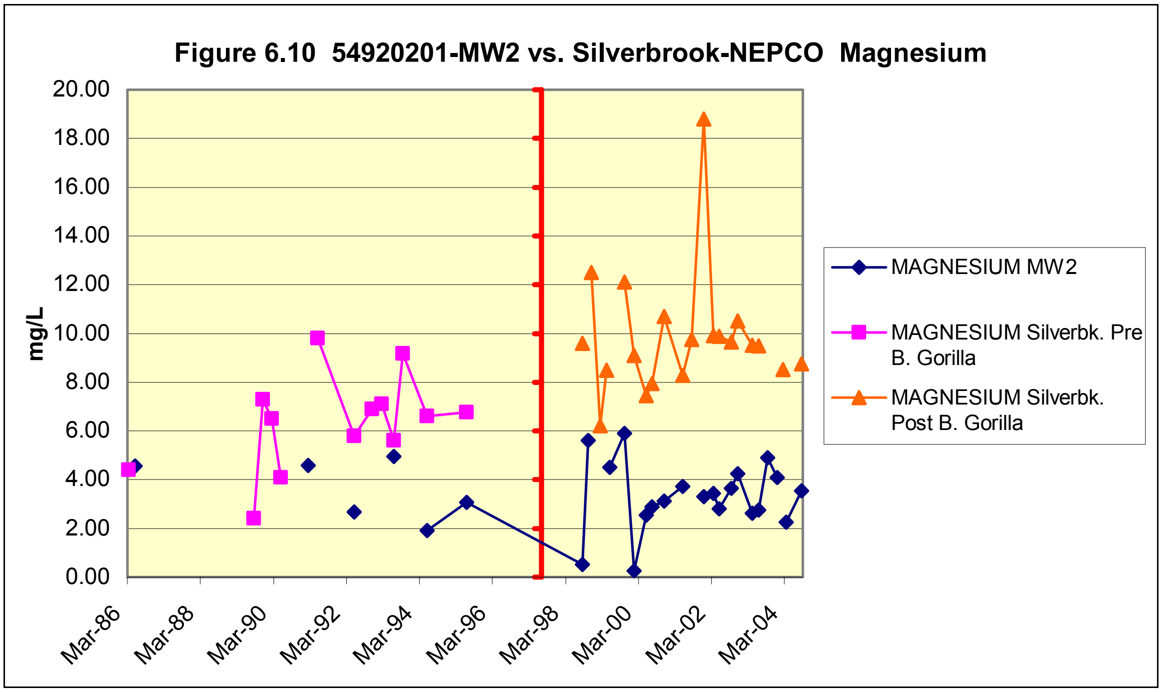


Figure 6.10 54920201-MW2 vs. Silverbrook-NEPCO Magnesium
mg/L
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Mar-86
Mar-88
Mar-90
Mar-92
Mar-94
Mar-96
Mar-98
Mar-00
Mar-02
Mar-04
MAGNESIUM MW2
MAGNESIUM Silverbk. Pre B. Gorilla
MAGNESIUM Silverbk. Post B. Gorilla

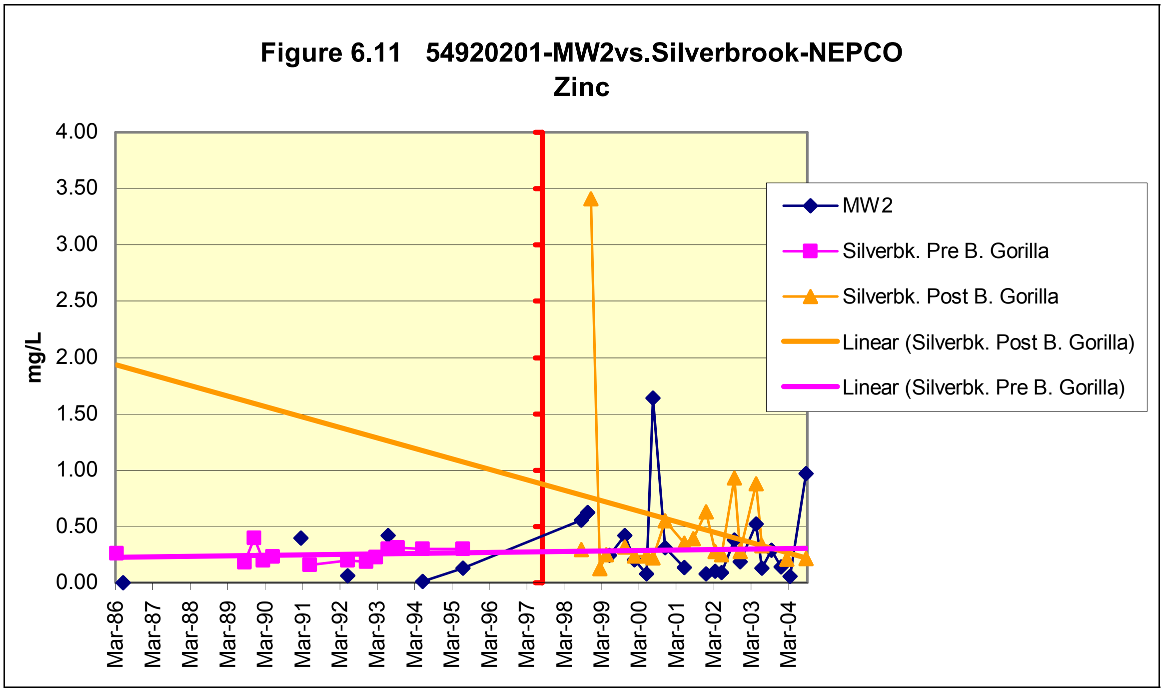


Figure 6.11 54920201-MW2vs.Silverbrook-NEPCO Zinc
mg/L
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Mar-86
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
MW2
Silverbk. Pre B. Gorilla
Silverbk. Post B. Gorilla
Linear (Silverbk. Post B. Gorilla)
Linear (Silverbk. Pre B. Gorilla)

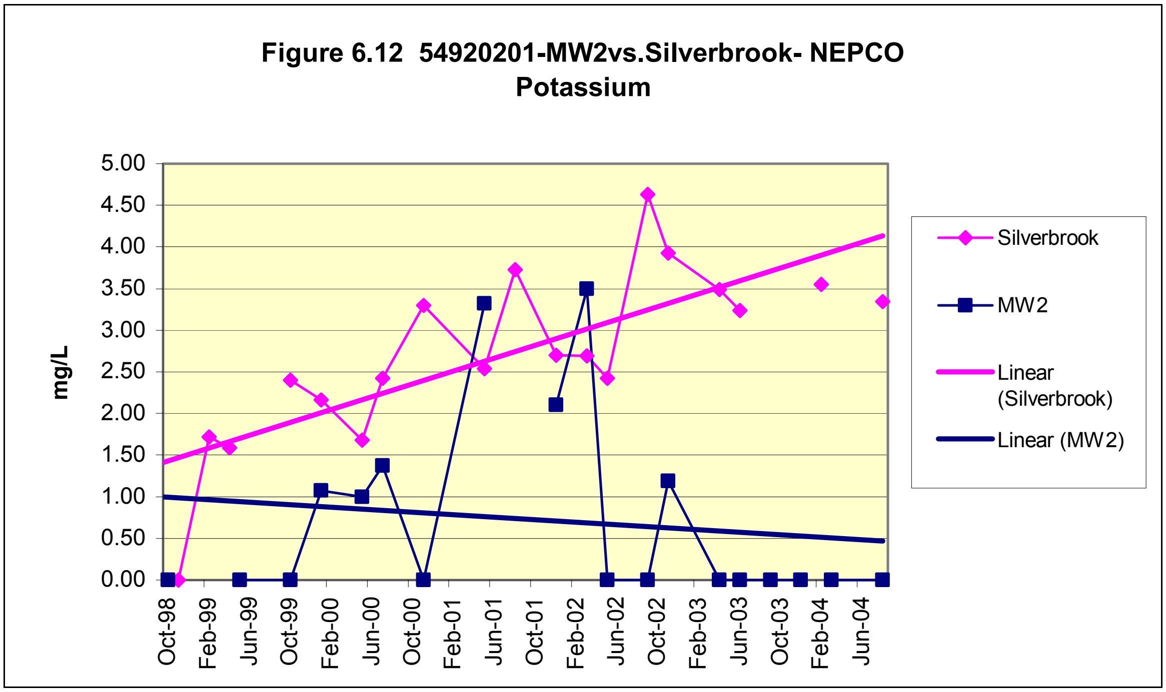


Figure 6.12 54920201-MW2vs.Silverbrook- NEPCO
Potassium
mg/L
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-98
Feb-99
Jun-99
Oct-99
Feb-00
Jun-00
Oct-00
Feb-01
Jun-01
Oct-01
Feb-02
Jun-02
Oct-02
Feb-03
Jun-03
Oct-03
Feb-04
Jun-04
Silverbrook
MW2
Linear (Silverbrook)
Linear (MW2)

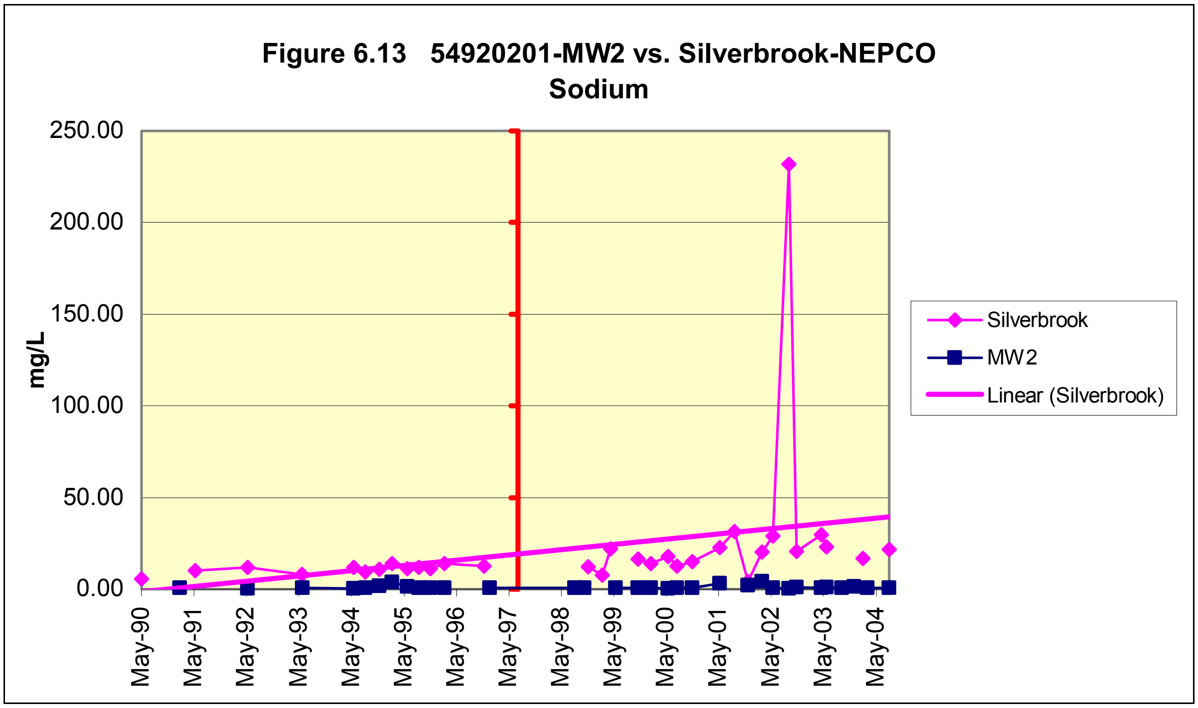


Figure 6.13 54920201-MW2 vs. Silverbrook-NEPCO
Sodium
mg/L
250.00
200.00
150.00
100.00
50.00
0.00
May-90
May-91
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
Silverbrook
MW2
Linear (Silverbrook)

MW2 vs. MW4

Although PADEP states that it does not know where groundwater goes from the Big Gorilla Pit, MW4 was placed west of the pit as ash placement in the pit was nearing completion, specifically to monitor the impact of the ash placed in the Big Gorilla mine pool. MW4 is closer than the Silverbrook Outfall to the Big Gorilla project and MW2. However, MW4 is located in an area dominated by large deposits of culm (anthracite waste coal), and it monitors a more constricted and specific hydrological regime then the Silverbrook Outfall.

Monitoring data from March 2002 to October 2003 show marked concentration differences between the upgradient MW2 and MW4. Water at MW4 has higher concentrations of aluminum (figure 6.14), calcium (figure 6.15), magnesium (figure 6.16), sodium (figure 6.17), iron (figure 6.18) and manganese (figure 6.19) than at MW2. Spikes in calcium levels at MW2 to 34.60 mg/L in May 2001 and 88.70 mg/L in December 2003 were uncharacteristic of the levels otherwise measured at this upgradient monitoring point which averaged 3.45 mg/L without these spikes. This compares to an average of 32.40 mg/L in calcium at MW4. The average sodium level at MW4, not counting the spike to 322 mg/L in September 2002, was 5.51 mg/L, more than five times the average sodium level at MW2 of 1.06 mg/L. The spikes in calcium at MW2 as well as higher iron levels in 1986-1990 and higher manganese levels from 1993-1996 at MW2, suggest the effects of mining and ash placement do occasionally reach the waters sampled by MW2.

Nonetheless concentrations of aluminum, iron, and manganese were on average 5 to 10 times higher at MW4 than at MW2. In most cases aluminum, iron and manganese levels at MW4 were significantly above drinking water standards, while close to or meeting the DWS at MW2.

Average sulfate levels (figure 6.20) were eight times higher and average TDS levels (figure 6.21) were more than 6.5 times higher at MW4 than at MW2. While both of these constituents were elevated at MW4, except for a TDS concentration of 516 mg/L in March 2002, neither reached levels exceeding the DWS. Specific conductance (figure 6.22) at MW4 was also generally 5 to 6 times the levels at MW2. Although the lab pH (figure 6.23) at MW4 was approximately 1-2 units lower than at MW2, it rose in the last several monitoring periods at MW4.

The deterioration at MW4 from aluminum, iron, manganese, sulfates, and TDS is similar to the degradation seen at the Silverbrook Outfall and attests to a general level of degradation seen as one moves from east to west across the Silverbrook permit. Like water at the Silverbrook Outfall, the higher levels of calcium, magnesium, and sodium at MW4 than at MW2 suggest that ash is playing a hand in that degradation.

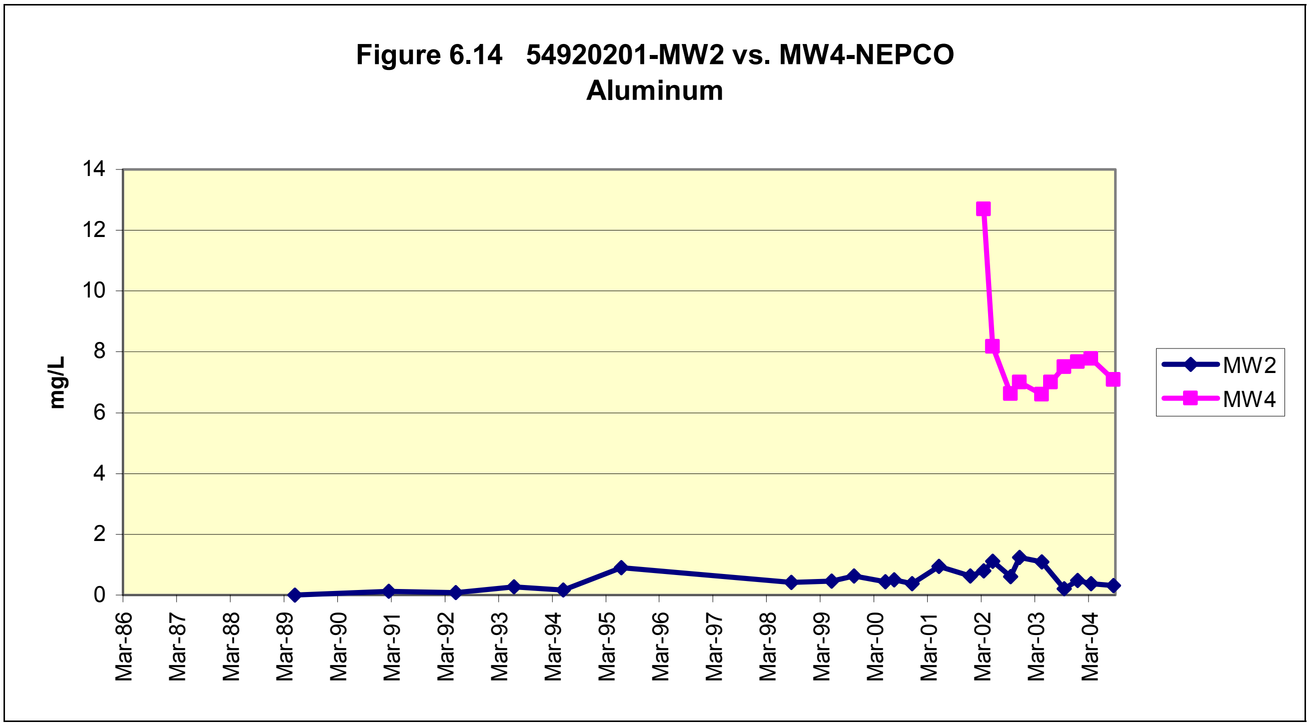


Figure 6.14 54920201-MW2 vs. MW4-NEPCO
Aluminum
mg/L
0
2
4
6
8
10
12
14
Mar-86
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
MW2
MW4

Figure 6.15 54920201-MW2vs.MW4-NEPCO Calcium

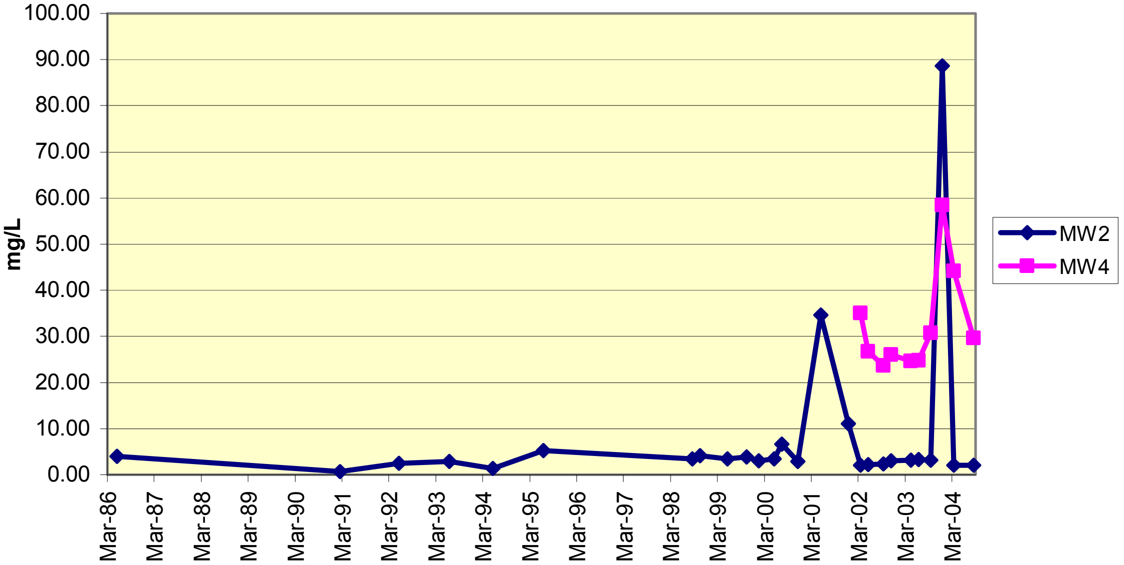


Figure 6.16 54920201-MW2 vs. MW4-NEPCO Magnesium

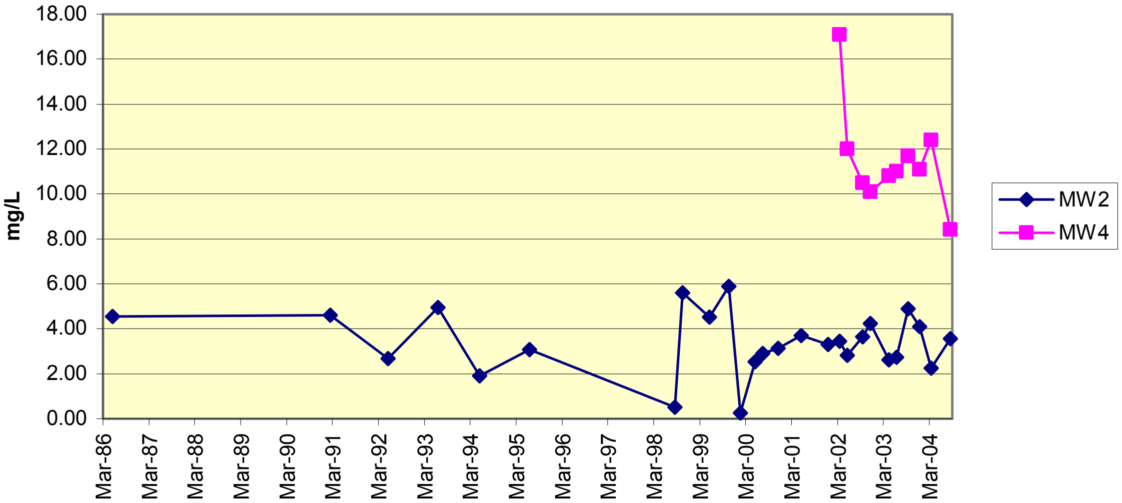


Figure 6.17 54920201-MW2vs.MW4-NEPCO
Sodium

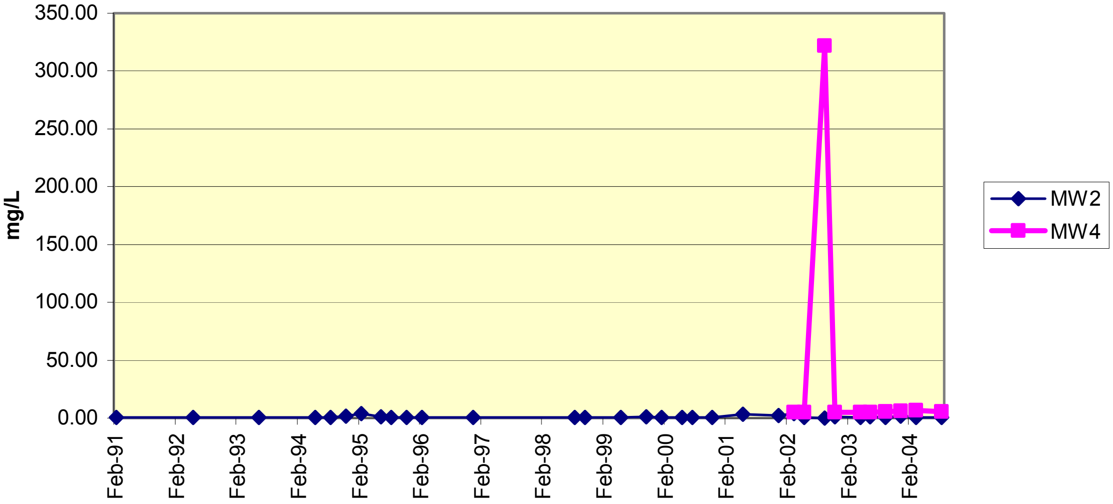
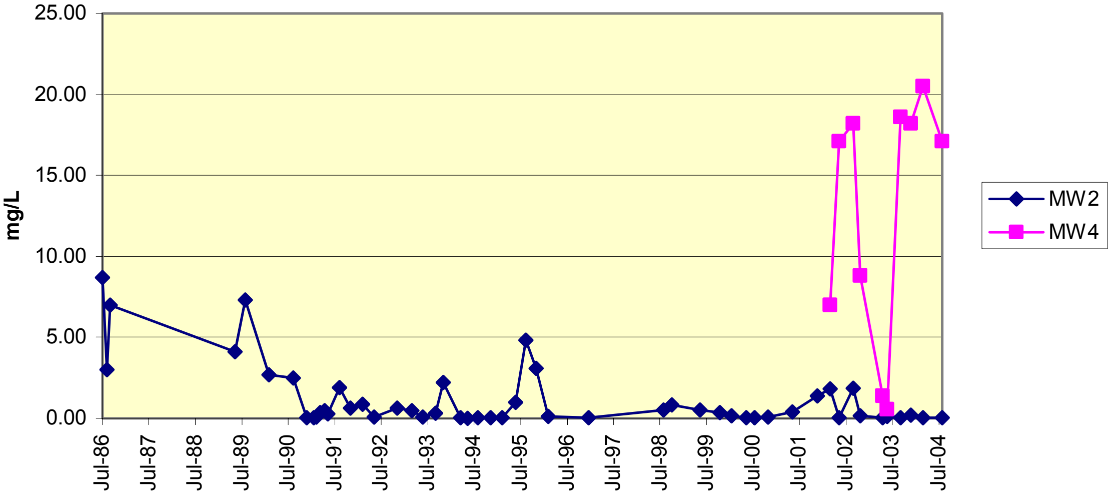


Figure 6.18 54920201-MW2vs.MW4-NEPCO
Iron



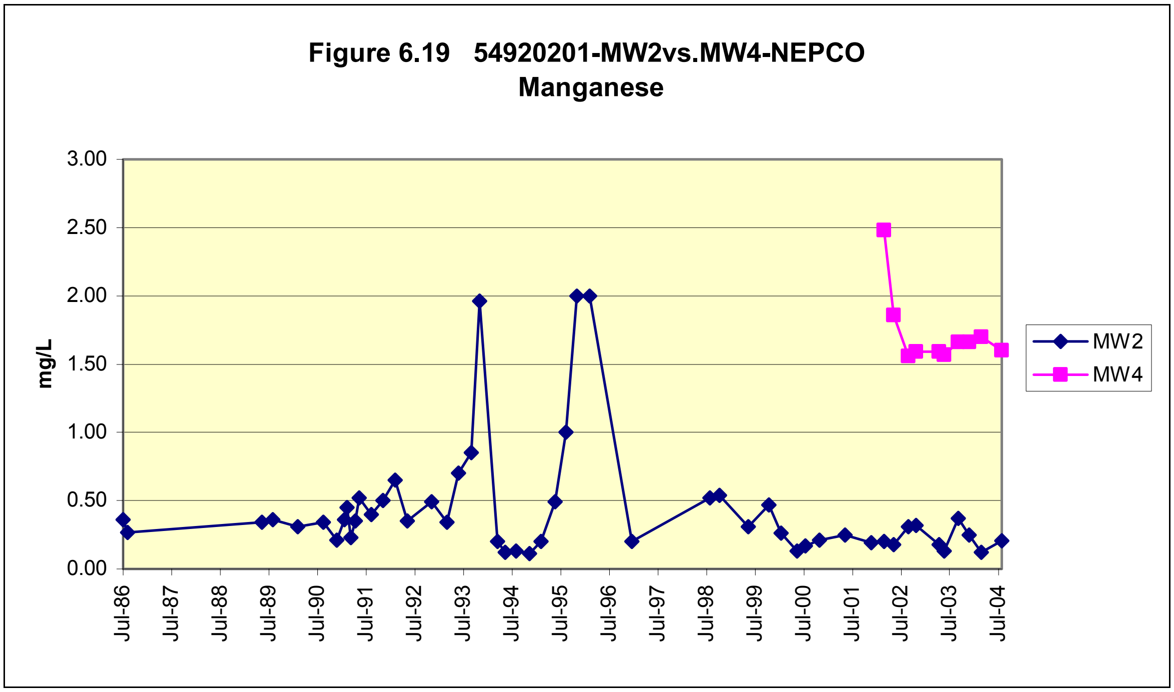


Figure 6.19 54920201-MW2vs.MW4-NEPCO
Manganese
mg/L
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jul-86
Jul-87
Jul-88
Jul-89
Jul-90
Jul-91
Jul-92
Jul-93
Jul-94
Jul-95
Jul-96
Jul-97
Jul-98
Jul-99
Jul-00
Jul-01
Jul-02
Jul-03
Jul-04
MW2
MW4

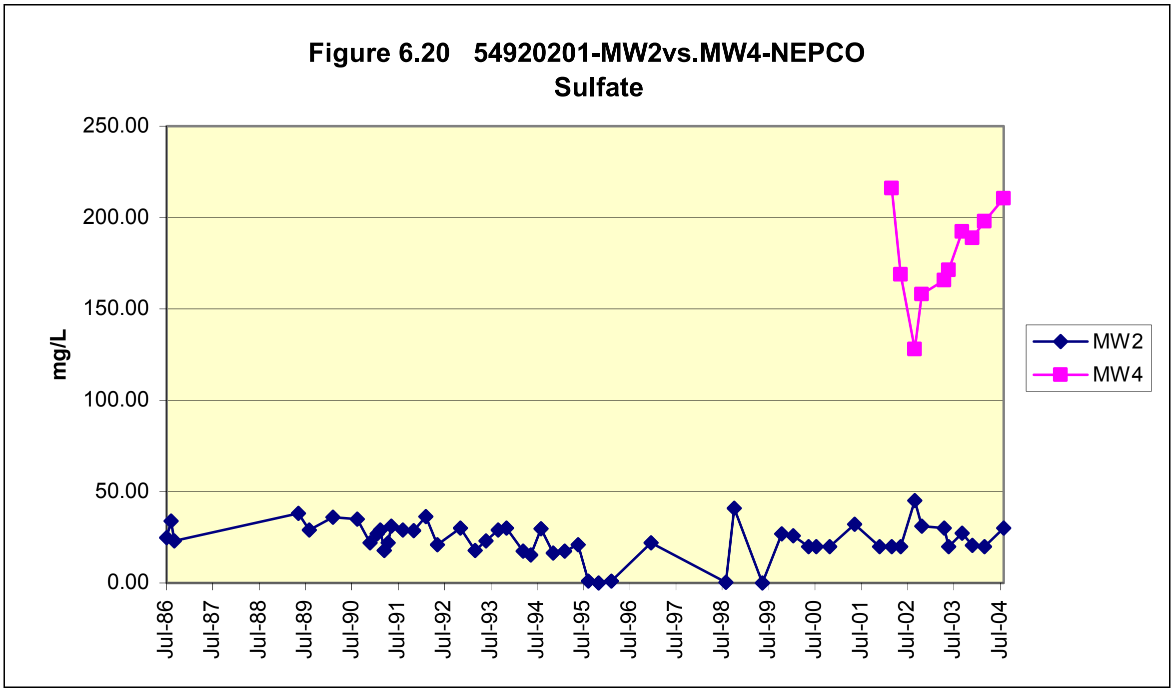


Figure 6.20 54920201-MW2vs.MW4-NEPCO
Sulfate
mg/L
250.00
200.00
150.00
100.00
50.00
0.00
Jul-86
Jul-87
Jul-88
Jul-89
Jul-90
Jul-91
Jul-92
Jul-93
Jul-94
Jul-95
Jul-96
Jul-97
Jul-98
Jul-99
Jul-00
Jul-01
Jul-02
Jul-03
Jul-04
MW2
MW4

Figure 6.21 54920201-MW2vs.MW4-NEPCO
Total Dissolved Solids

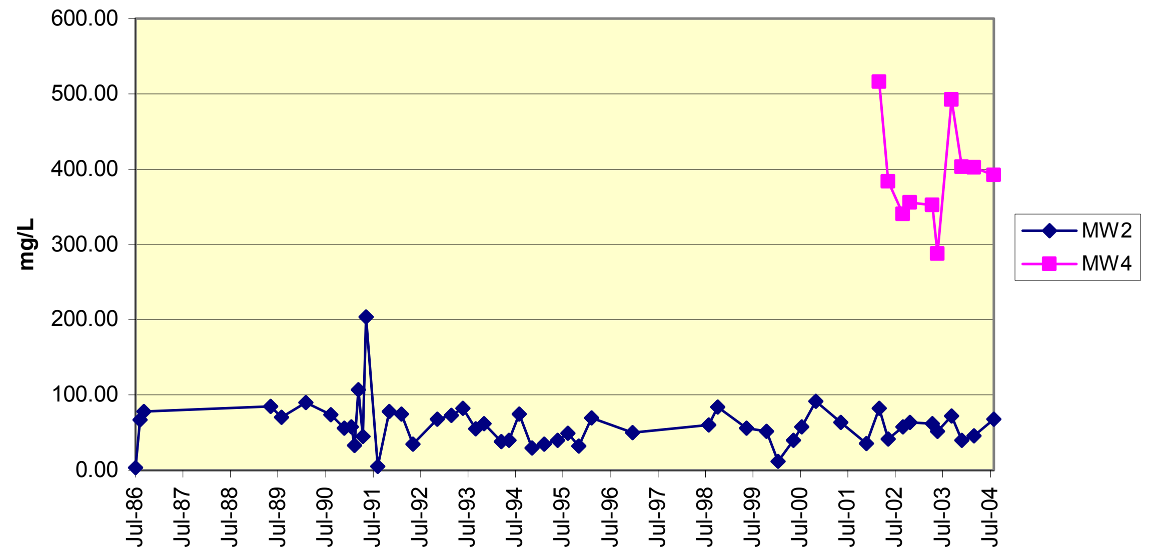
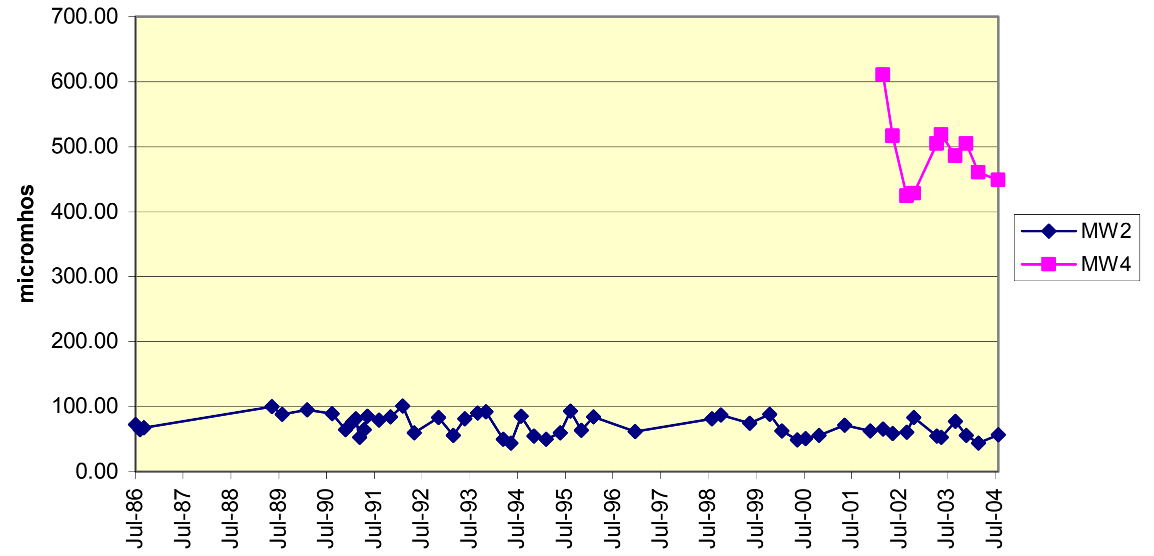
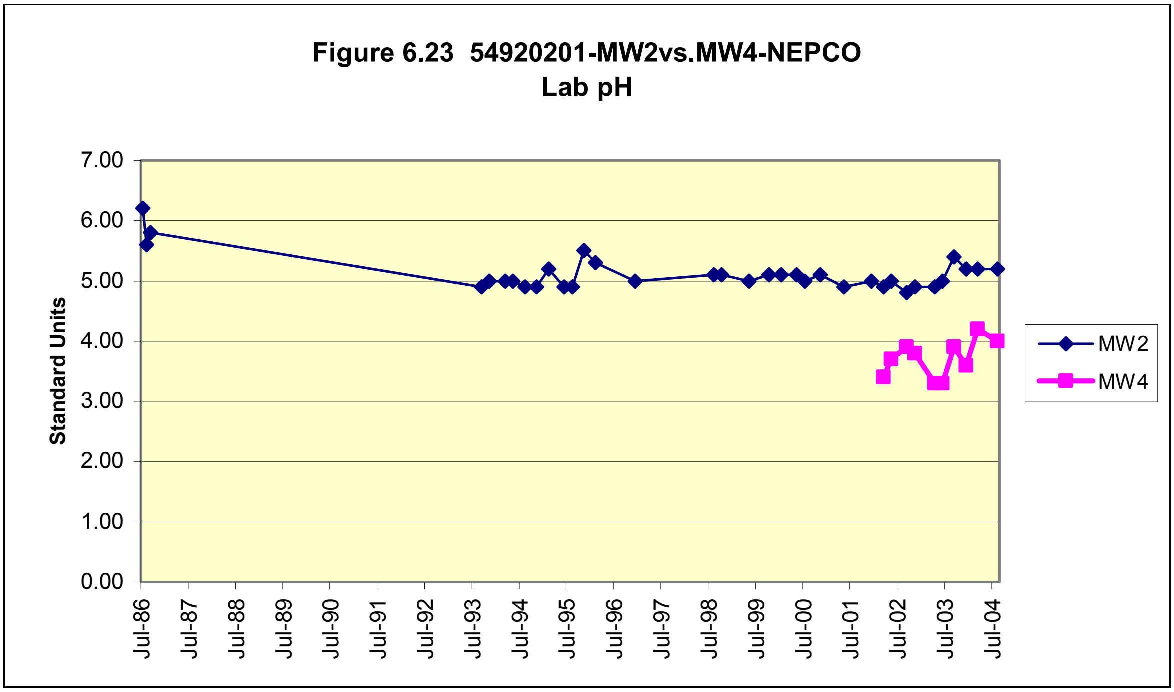


Figure 6.22 54920201-MW2vs.MW4-NEPCO
Specific Conductance





MW5

MW5 was drilled in August 2003 in the ash placed in the Big Gorilla Pit. According to the permit, the purpose of MW5 was to specifically sample the ash leachate in the post-ash placement Big Gorilla water table. Although data from only six samplings at MW5 were available for this review (and only four of those six samplings were provided in time to be graphed), when comparing this data to data from other monitoring points and provided in the PADEP Report, it is readily evident that the Big Gorilla ash is providing a concentrated source of soluble constituents whose levels were substantially lower in the pre-ash environment of the pit, in the coals mined in the Silverbrook area and in the active culm mining environment within the NEPCO permit boundaries. TDS concentrations are up to 20 times higher after ash placement at MW5 than before ash placement. Sulfate is up to 6 times the DWS and 20 times higher in the water at MW5 than it was in the acid pit water before ash placement. Calcium concentrations are up to 130 times higher in post-ash placement leachate than in pre-ash mine pool water.

Acidity in MW5 as expected, was less than half the acidity in the pre-ash mine pool water although still present in half the readings with levels as high as 24.40 mg/L. Alkalinity levels at MW5 ranged from only 13.60 to 25.40 mg/L, already far below the levels as high as 600 mg/L reported in the Big Gorilla pit water during ash placement according to the PADEP Report. Despite its location directly in the ash pore water, total suspended solids at MW-5 were high in only the first of the six samplings (454 mg/L in September 2003). Remaining TSS measurements ranged from 6 to 30 mg/L implying that large fractions of constituents in the pore water were likely dissolved concentrations.

According to the PADEP Report (pgs 285-288, Chapter 9), after ash placement, several toxic metals were found in the Big Gorilla pit water at concentrations significantly greater then the concentrations measured in the groundwaters of the Llewellyn and Pottsville coals mined in the area and in the acid water in the Big Gorilla pit prior to ash placement. For example, chromium concentrations in Big Gorilla pit water during periods of ash placement were as high as 0.260 mg/L, more than 5 times greater than the highest concentrations detected in the groundwater associated with the coals from the Llewellyn and Pottsville formations and in the pre-ash Big Gorilla pit water. This concentration is also nearly 3 times the DWS for total chromium. The portion of this concentration that is the more toxic hexavalent chromium is not indicated although hexavalent chromium is known to mobilize as an oxyanion under higher pH conditions such as those that were created with ash placement in the Big Gorilla water (PADEP Report, pg. 285, Chap. 9, Fig. 937 citing Jones, 1995).

While the PADEP report did not cite background levels of selenium in the coals, selenium levels measured in the pit water during the ash placement period (1997 to 2002) were up to 0.101 mg/L, 50 times higher than the highest selenium levels measured in the pit water before ash placement. This level is more than twice the DWS and 20 times the federal water quality standard (chronic aquatic life criteria) for selenium.

The highest arsenic levels sampled in the Big Gorilla pit water from 1997 to 2002 were 0.022 mg/L, not terribly high, but still more than 4 times greater then the highest concentrations measured in the pre-ash Big Gorilla water or groundwater in the area's coals and more than twice the new federal DWS.

The PADEP Report asserts that of these three trace elements, only chromium rose in direct response to ash placement episodes in the pit. Nonetheless, these levels of chromium, selenium, and arsenic demonstrate that the alkaline conditions created in the Big Gorilla pit water after ash placement (and presumably still existent in the water table in the ash in the pit today) were mobilizing some metals at concentrations posing a new and increased liability to the environment.

It should also be noted that while the maximum concentration of copper (0.132 mg/L) measured in the Big Gorilla water after ash placement was less than one fifth the DWS, it was still 3 to 4 times higher than the highest copper levels measured in the coals and in the Big Gorilla water before ash placement.

Since the above measurements were taken, the ash pore water at MW5 has registered concentrations of several constituents that are higher and some cases much higher than at any of the other monitoring points at this site. Although these levels are based on just six samplings, they are similar to levels of the same constituents measured in pore water from two borings drilled into the ash in the pit, as well as waters draining off of other ash placement sites examined in this report.

The differences are the starkest between the ash pore water and the upgradient monitoring point. Potassium concentrations at MW5 (figure 6.24) have been some 60 times higher than at MW2. With the exception of one measurement at MW2 of 0.096

mg/L in May 1994, three of the selenium concentrations at MW5 (figure 6.25) have ranged from more than 7 to more than 17 times greater than selenium concentrations at MW2 and more than twice the DWS. Sulfate (figure 6.26) concentrations were over 60 times greater than at MW2 and over 6 times above the DWS. Alkalinity (figure 6.27) was 4 to 5 times higher than at MW2 (with the exception of two peaks in alkalinity at MW2 measured in November 1993 and July 1986). TDS concentrations (figure 6.28) were over 30 times greater than at MW2 and over 5 times the DWS. Specific conductance (figure 6.29), which measures the concentration of dissolved salts in effluent waters, was 30 times greater at MW5 than at MW2.

The MW5 concentrations were also much higher than the concentrations at the most downgradient point, the Silverbrook Outfall, although the differences were usually not quite as stark. For example, again with the exception of one measurement of selenium at Silverbrook of 0.260 mg/L also in May 1994, levels of selenium (figure 6.30) at MW5 were some 15 times greater than at the Silverbrook Outfall. Sulfate levels at MW5 (figure 6.31) were approximately 7 times greater than at the Silverbrook Outfall. Other data show that calcium concentrations were 10 times higher, chloride concentrations 2 times higher, sodium concentrations 4.6 times higher (not counting the spike in sodium at Silverbrook to 232 mg/L in Sept. 2002) and potassium concentrations 20 times higher in the ash pore water at MW5 than at the Silverbrook Outfall (after ash placement started in the Big Gorilla Pit).

Additional data since reviewed indicates that selenium levels while still readily exceeding selenium at the other monitoring points, were at 0.60 mg/L in the fourth quarter of 2004 and 0.030 mg/L (below the DWS of 0.050 mg/L) in the first quarter of 2005 at MW5. On the other hand, lead levels in the ash pore water have increased above the DWS (0.015 mg/L) to 0.020 and 0.030 mg/L in those quarters respectively, yet were still below the highest lead levels measured at the Silverbrook Outfall which reached 0.40 mg/L (more than 26 times the DWS) in February 1990. Also of note at MW-5 are arsenic concentrations (ungraphed) four of which exceeded the DWS (0.010 mg/L) ranging from a high of 0.023 mg/L in September 2003 to a low of 0.0118 mg/L in August 2004. Other than one measurement of 0.04 mg/L for arsenic at MW2 in May 2000, there has not been a single measurement of arsenic at any other monitoring point at the NEPCO site exceeding 0.005 mg/L and the large majority of measurements have been below a detection limit of <0.004 mg/L. Chromium has also been measured at 0.050 mg/L, half the DWS, in the September 2003 and March 2006 samplings at MW5. These are equal to the highest levels of chromium found at any other monitoring points.

Levels of other constituents that are prevalent in AMD and usually concentrated in coal ashes were not found to be that soluble in the ash pore water at MW5. Aluminum and manganese concentrations at MW5 were relatively low, usually close to the DWS and below concentrations at the other monitoring points. Iron concentrations at MW5 were roughly the same as iron measured at MW2 and MW3, above iron at MW9 and below iron at MW4 and the Silverbrook Outfall.

Data from two samplings of two test borings drilled into the ash in the Big Gorilla Pit in 2001 and 2002 shows similar results to the data from MW-5. Dissolved concentrations of calcium, potassium, barium, selenium, cadmium, molybdenum, strontium, sodium, chloride, fluoride, sulfate, and nitrogen dioxide were significantly higher in the ash pore water from these borings than in two samplings of a boring drilled concurrently into the water table in culm to the west of the pit (PADEP Report, Chapter 9, pg. 296, Table 9.11). Two out of four measurements in the ash pore water found levels of molybdenum, a known contaminant from many coal ashes in water systems, at 0.70 mg/L, 14 times the highest health advisory level set by USEPA.

The PADEP Report states that data indicate the possible presence of Ettringite, in the Big Gorilla ash (e.g., see pages 265, 295 & 296). Ettringite is known for binding oxyanionic trace elements such as selenium, hexavalent chromium, boron, vanadium and molybdenum in alkaline ash leachate and thus taking them out of solution, a scenario that PADEP's report implies may happen in the groundwater in the Big Gorilla ash.

Ettringite is a hydrated calcium and aluminum sulfate. Its chemical formula is:

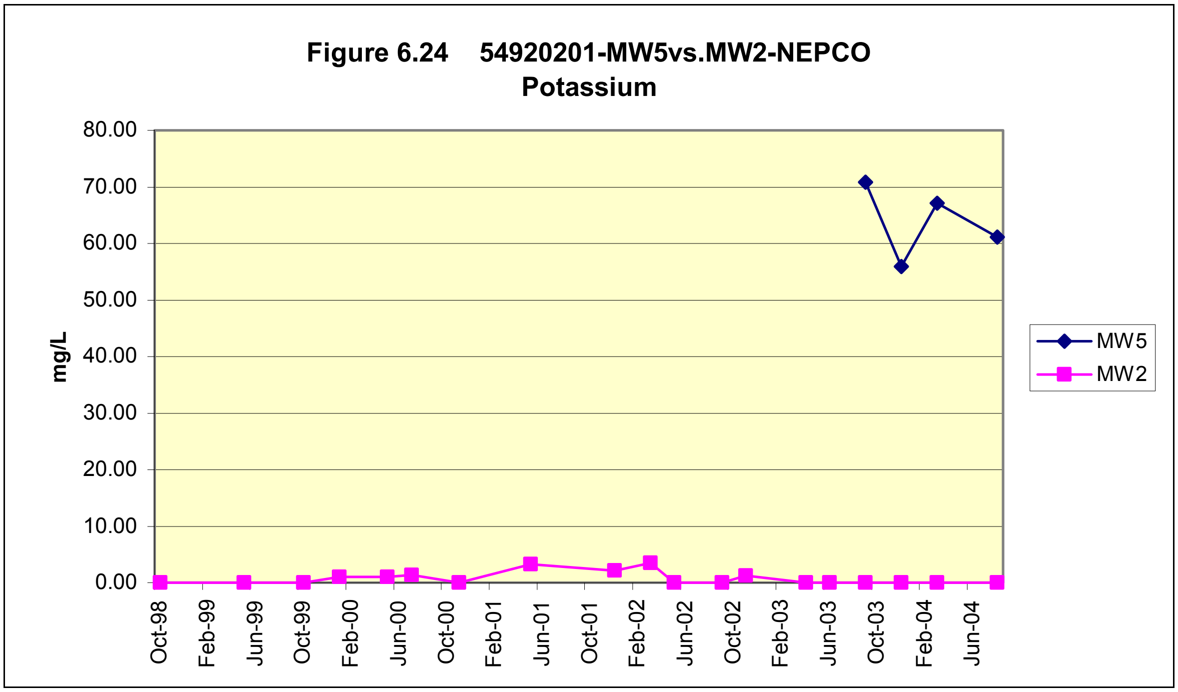
$$\mathbf{Ca_6\,[Al(OH)_6]_2\,(SO_4)_3 \cdot 26H_2O}$$

General conditions for Ettringite formation include: 1) a presence of soluble calcium, aluminum, and sulfate; 2) a source of alkalinity, with a pH environment from about 11 to 12.5; and 3) a source of water, as Ettringite is 38% water by weight. These conditions are present in varying degrees throughout the Big Gorilla ash. The field pH measured in the ash test borings ranged from 11.37 to 11.42 units (PADEP Report, Table 9.11)

Under the right conditions, Ettringite can incorporate some trace elements into its crystal structure, substituting for the $(SO_4)^{2-}$ anion complex. These trace elements must exist as oxyanions in aqueous solution. Ettringite has an anion incorporation preference in the order $B(OH)^{4-} > SeO_4^{2-} > CrO_4^{2-} > MoO_4^{2-}$.

However, research also demonstrates that below a pH of 11, Ettringite starts to become unstable. If the pH containing Ettringite drops below about 10, the mineral breaks down, and any trace metal oxyanions are released into the surrounding water. The tendency for high pH to attenuate to lower pH in the surrounding environment and the limited, extreme conditions under which Ettringite forms and remains stable do not present solid assurance that high levels of oxyanionic trace elements will not be mobilized from ash in the Big Gorilla Pit. Indeed six pH measurements at MW-5 between September 2003 and to March 2005 after ash placement in the pit was completed, produced values ranging from 9.20 units in September 2003 to a low of 7.00 units in August 2004. This is well below the range of pH needed for the formation and maintenance of Ettringite in ash within the Big Gorilla Pit water table.

Collectively, the data from the Big Gorilla Pit water during ash placement, the 2001 and 2002 test borings in the Big Gorilla ash, and MW5 demonstrate that unhealthy levels of major and minor constituents and trace elements such as selenium, arsenic, chromium, lead and molybdenum have readily dissolved from this ash and that there is a consistent water table in the ash. Thus groundwater does leave the Big Gorilla Pit with potentially harmful levels of constituents through unknown and, therefore, largely unmonitored pathways.



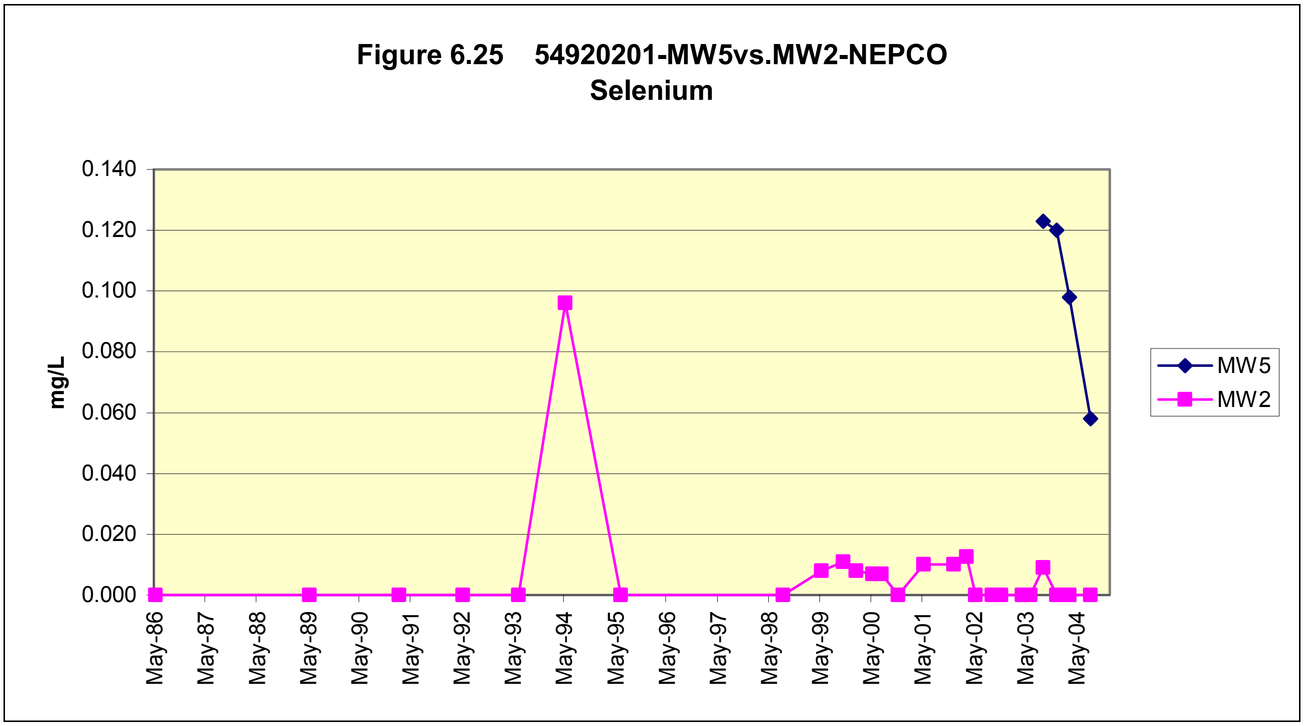


Figure 6.25 54920201-MW5vs.MW2-NEPCO
Selenium
mg/L
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
May-86
May-87
May-88
May-89
May-90
May-91
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
MW5
MW2

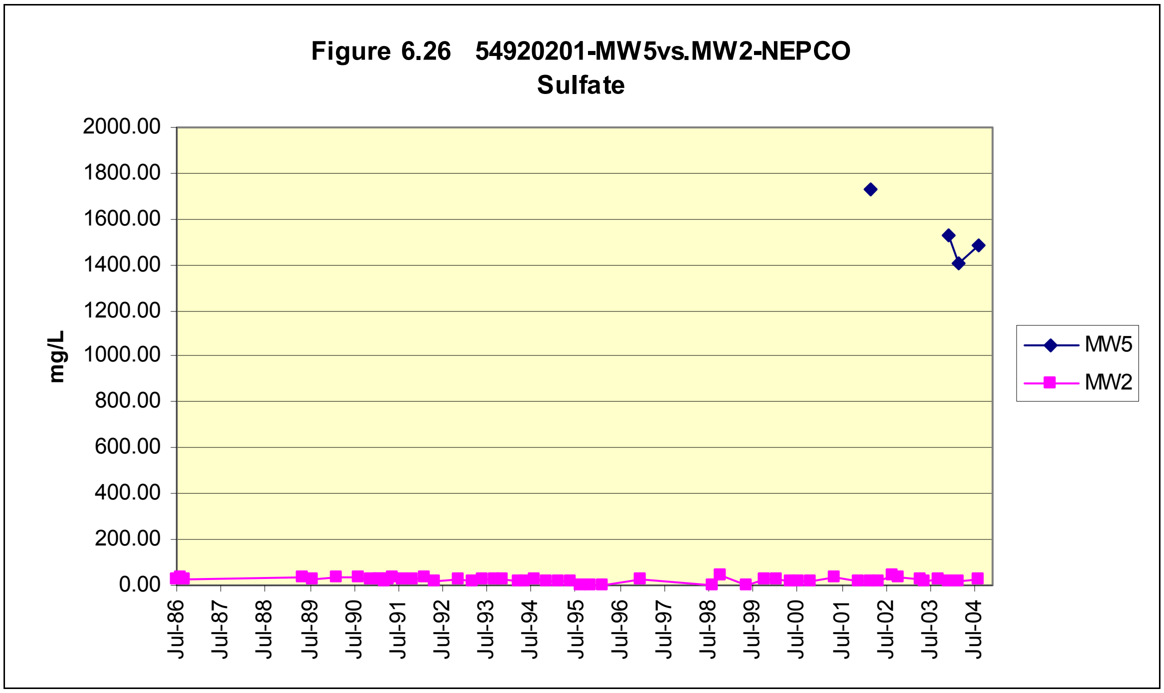


Figure 6.26 54920201-MW5vs.MW2-NEPCO
Sulfate
mg/L
2000.00
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
Jul-86
Jul-87
Jul-88
Jul-89
Jul-90
Jul-91
Jul-92
Jul-93
Jul-94
Jul-95
Jul-96
Jul-97
Jul-98
Jul-99
Jul-00
Jul-01
Jul-02
Jul-03
Jul-04
MW5
MW2

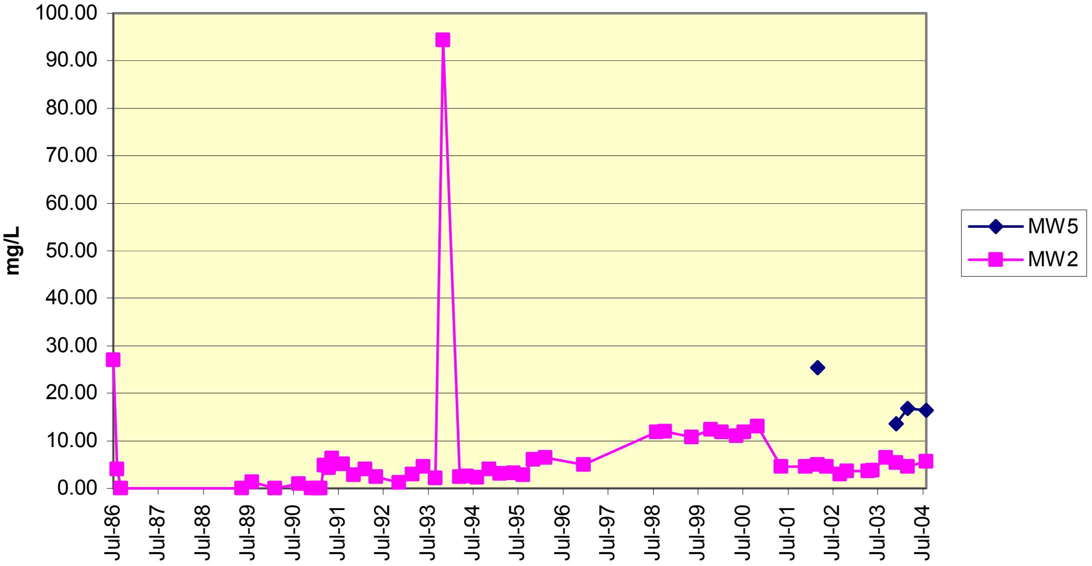


Figure 6.27 54920201-MW5vs.MW2-NEPCO
Alkalinity as CaCO3

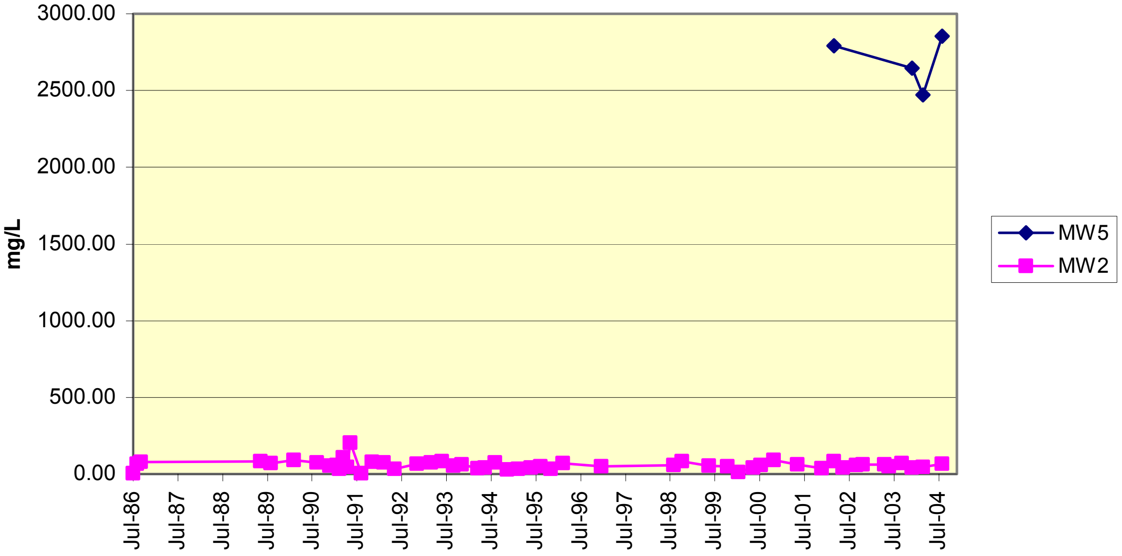


Figure 6.28 54920201-MW5vs.MW2-NEPCO
Total Dissolved Solids

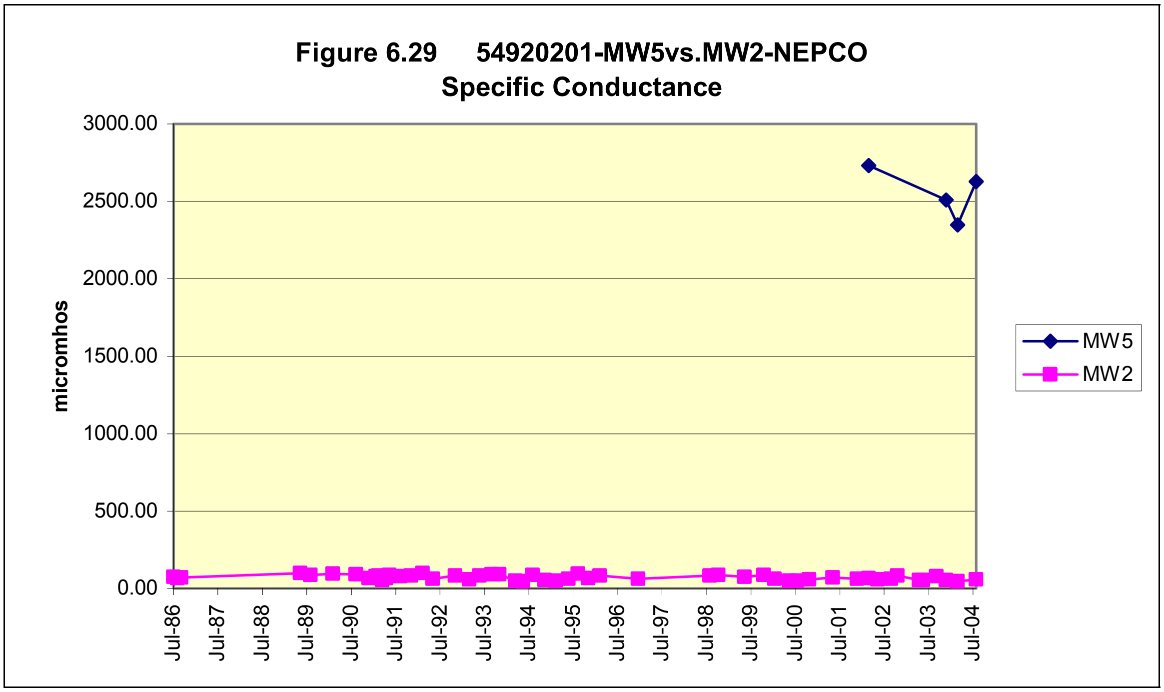


Figure 6.29 54920201-MW5vs.MW2-NEPCO
Specific Conductance
micromhos
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Jul-86
Jul-87
Jul-88
Jul-89
Jul-90
Jul-91
Jul-92
Jul-93
Jul-94
Jul-95
Jul-96
Jul-97
Jul-98
Jul-99
Jul-00
Jul-01
Jul-02
Jul-03
Jul-04
MW5
MW2

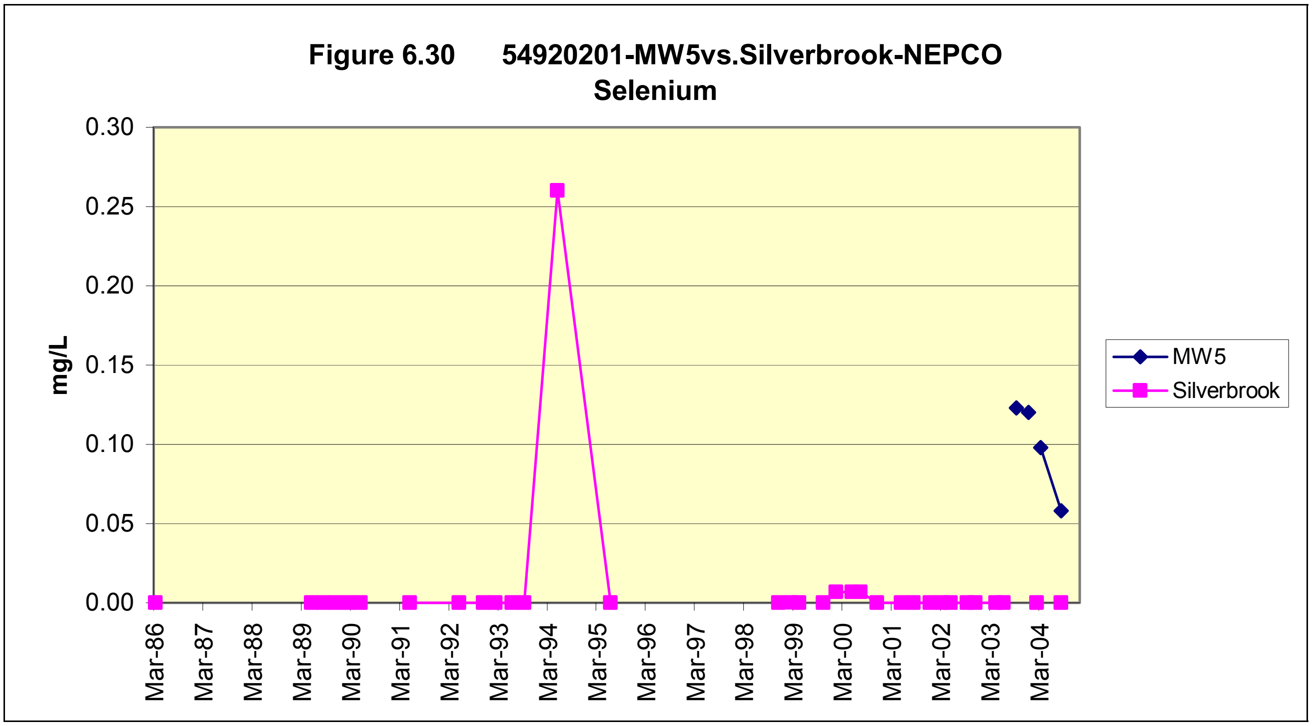
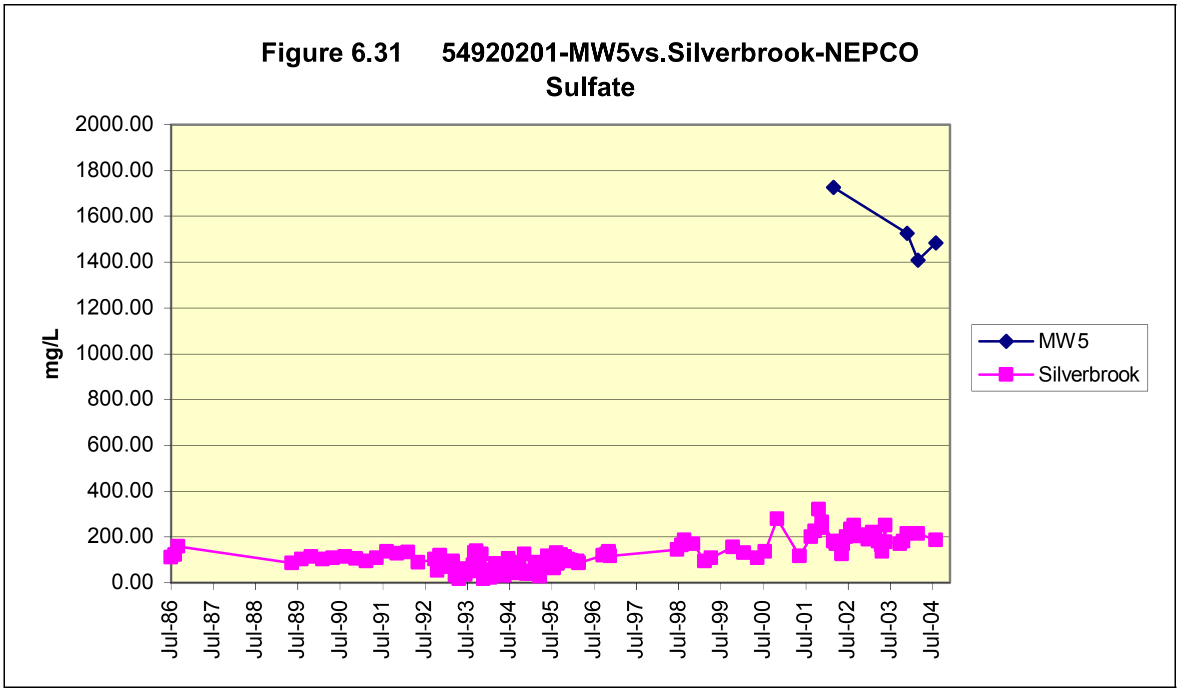


Figure 6.30 54920201-MW5vs.Silverbrook-NEPCO
Selenium
mg/L
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mar-86
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
MW5
Silverbrook



Conclusion

Information in the permit files for the Silverbrook Refuse Site and the Big Gorilla Demonstration Project is very scattered and disorganized and essential data and information are absent. Details describing when, where, and how much ash was disposed on the site are either missing or inadequate. Descriptions of monitoring wells are also missing and their locations (latitude/longitude) are in some instances incorrectly depicted or not even shown on the permit maps.

For such a large and important project, the paucity of data and absence of essential information is disconcerting. The predominant pathways for groundwater movement from the Big Gorilla Pit have yet to be delineated. Other than at the Silverbrook Outfall, the permit file gives little indication that there is any surface water monitoring either on the premises of the permit area beyond the Silverbrook Outfall or in the surrounding lotic environments such as Quakake Creek, Still Creek, or the Little Schuylkill River. There are no loading data being collected at the Silverbrook Outfall.

Nonetheless the data show that concentrations of several constituents (calcium, chloride, magnesium, sodium, aluminum, manganese, iron, total dissolved solids, sulfates, chromium, arsenic, selenium, and zinc) became substantively higher in pit water and/or at downgradient monitoring points after ash placement started in the Big Gorilla project. The increases of these constituents are above background concentration fluctuations that might have been caused by the culm disturbances, remining, and ash placement that began in 1989. Increases in these constituents after 1997 at the lowest downgradient monitoring point for the entire permit area, the Silverbrook Outfall, include rises in pH and ash-specific constituents such as calcium, chloride, magnesium, potassium, and sodium. Rises in these constituents implicate ash as a source of rises in more troublesome trace elements such as selenium, arsenic, lead and chromium at this outfall or at other downgradient points.

PADEP asserts that there is no evidence of adverse impact on water quality at the Silverbrook Outfall from FBC ash in the Big Gorilla Pit. Granted, given that detailed groundwater flow paths from the Big Gorilla pit are not known, it is impossible to definitively determine the contributions that ash, culm, overburden disturbance, and mine pools are making to the degradation evident at the Silverbrook Outfall. Yet considering the location of the Big Gorilla mine pool perched above the Silverbrook Outfall, the fractured and faulted geologic structures within the basin, the underlying man-made karst-like system of interconnected mined-out tunnels, and the massive 84 million-gallon seasonal water fluctuation within the Big Gorilla mine pool, a hydraulic connection between the Big Gorilla pool and the Silverbrook Basin system (and therefore the Silverbrook Outfall) can safely be assumed to exist. Indeed markedly increasing concentrations of ash-specific constituents at the Silverbrook Outfall within a year of the start of ash placement in the Big Gorilla Pit appear to be evidence of that connection. What is clear is that water does migrate through the three million tons of FBC ash that now fill the Big Gorilla Pit. That migration readily generates leachate with high concentrations of sulfates, trace elements, and other constituents, some well in excess of drinking water and water quality standards. Given its strategic location at the headwaters of the Little Schuylkill River and the lack of measures that isolate it from the environment, at a minimum, this great mass of ash that readily generates harmful leachates poses a high polluting potential to the surrounding environment. The clearly rising levels of degradation at the Silverbrook Outfall suggest that some of this pollution has already started.

Enhancements are needed in the monitoring system around the Silverbrook Refuse remining and ash placement site to pin point and remediate the sources of this pollution. This should start with a thorough hydrologic characterization of the site to enable regulators to establish sufficient numbers of monitoring points in locations adequate to detect all water pollution exiting the site. It should also include a characterization of the ash from the NEPCO plant as well as culm and overburden materials at the site that will enable regulators to establish sufficient monitoring parameters to effectively differentiate the sources of that water pollution. Additional parameters to monitor for, depending on the results of that characterization, could include molybdenum, antimony, and boron. Monitoring of off site human and ecological receptors should be undertaken, given the adjacent residential communities, volume of surface water exiting the site at the Silverbrook Outfall and public water supply reservoir directly to the south of this site.

Permit Review 7

BD MINING (PERMIT # 54850202)

Site Summary

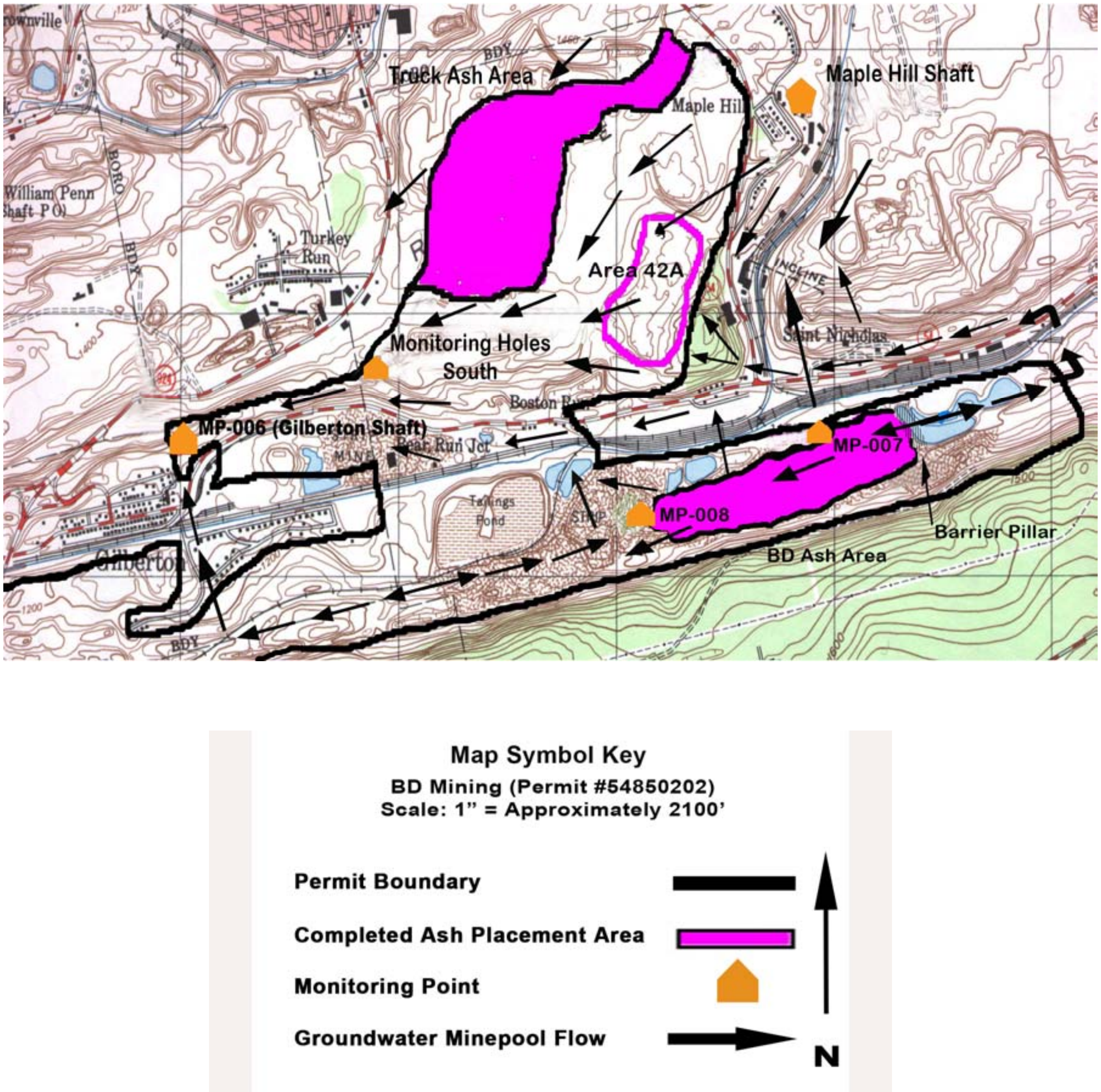
This refuse reprocessing (culm mining) site is located in Gilberton Borough, Mahanoy Township, Schuylkill County. The site lies in the eastern part of the Western Middle Anthracite Field in the Mahanoy-Shamokin Creeks Priority Watershed 6B. This is the southernmost site of a complex of ash disposal areas that include the Knickerbocker Pit Demonstration Project and two other ash disposal areas in the Ellengowan Mine permit area to the north (Permit #54793206, see Permit Review 5). The current on-going ash disposal is filling abandoned strip pits and a former silt dam. The goal of the project is to regrade the contours of the area with the ash reestablishing surface runoff patterns to reduce the inflow of water into existing mine pools, thus making the purpose or "beneficial use" of ash in this case simple placement.

Ash from burning primarily culm is being hauled in from FBC power plants operated by Gilberton Power Company, Panther Creek Partners, UGI Hunlock Creek, and AES Thames Inc., as well as from the Logan Generating Plant. The permit encompasses a total of 1,590 acres of which 809 acres are slated for coal refuse removal and 175 acres are slated for FBC coal ash placement. This is a refuse reprocessing operation where culm remined from the site is burned at the Gilberton cogeneration FBC plant, and then the ash is returned to the site. While there are other ash generators using the BD Mining site, the Gilberton plant has been the primary source of ash deposited there. The 175-acre ash disposal site primarily overlies the Boston Run Colliery (an underground mine complex). The rest of the permit acreage overlies some eight different collieries. The permit authorizing ash placement was approved on December 23, 1987. The Gilberton Plant was in operation undergoing test-firing as early as January 1988, although according to inspection reports, regular shipments of its ash (approximately 120-130 tons/day) were not arriving at the BD Mining site until at least mid-March, 1988. By the end of 2002 some 3.7 million tons of ash had been placed at the site.

Geology

According to the permit the site is honeycombed with deep mines. Several coal beds have been deep mined in the Llewellyn Formation at this site including the Diamond, Orchard, Primrose, Holmes, Mammoth, and Buck Mountain Veins. Several other coal beds in the Lykens Valley coal zone of the Pottsville Formation were also deep mined at the site. This man-made, karst-like underground structure accounts for a hydrologically complex system: an interconnected system of mine pools. Aside from the impact of the ash, the water quality in these mine pools is affected by surface waters that flow into abandoned strip pits and through mine shafts and percolate their way into the mine pools through permeable spoils and culm banks and natural structures such as faults, joints, fractures, and cleavages.

Site Map: BD Mining



Groundwater Monitoring Data: Discussion

Groundwater in the area consists of the mine pools in the abandoned Gilberton, Tunnel Ridge, Saint Nicholas and Boston Run Collieries. These pools are interconnected with at least 11 more upgradient collieries, and the combined water flow of these pools ultimately discharges locally at the Gilberton Shaft pumps. The Gilberton Shaft pumps were installed for the purpose of preventing flooding in the Borough of Gilberton. The flow of water has been documented by the U.S. Bureau of Mines. The RAC disposal area in the northern part of the BD Mining permit has only just begun operating and thus only a few measurements from monitoring points, RAC MP#1 and RAC MP#2, was available for this review. Accordingly, this review focuses on monitoring data from the ash placement area that has been operating for 18 years in the southeastern portion of the BD permit area.

Unfortunately, according to permit materials, there are no monitoring points that are located upgradient or hydrologically above this ash disposal area, and therefore no monitoring points that are unaffected by the ash. Three BD Mining ash monitoring points assessed in this report are or have been monitoring deep mine pools under the site, and additional more limited review has been undertaken of a fourth monitoring point that was monitoring surface waters also in the refuse remining/ash placement area. According to the permit, MP006 is the downgradient monitoring point located at the Gilberton Shaft pumps. While there is scant information on water levels at these monitoring points in the BD permit files, according to data for the period from 1986 to 2003 from the PADEP Bureau of Abandoned Mine Reclamation, measurements from boreholes nearest to these monitoring points reveal that water level elevations at MP006 are from 15 to 48 feet lower than at MP007 and MP008. Although MP007 and MP008 are labeled as "upgradient" in the permit, they are upgradient relative to the Gilberton Shaft pumps only but clearly downgradient of BD's ash placement area as PADEP explains in its report, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania. [1] and as is stated in ATTACHMENT 2, GROUNDWATER MONITORING SUPPLEMENTAL INFORMATION dated May 1990. Therefore, MP007 and MP008 are classified as "downgradient" for the purpose of assessing impacts of ash on minepool water quality in this report.

MP007 was sampled from March 1988 to September 1996. MP007 was displaced when the ash filling operation moved over it. MP008, which replaced MP007 and lies approximately 2,750 feet west-south-west of the older well's location, was sampled from January 1996 to the present. The latest data available for this report, however, extended to a sampling on July 22, 2004. Both MP007 and MP008 have been monitoring mine pool water not only downgradient of the ash disposal area but in proximity to the ash as its placement has advanced from east to west. ATTACHMENT 2 provides a diagram of their construction and text which indicates they are cased in solid material to 120 feet and extend into the "Top Split Vein Workings" to total depths of approximately 225 feet for MP007 and 250 feet for MP008.

Maps of the permit depict the Gilberton Shaft monitoring point, MP006, as approximately 6000 feet west of MP008, and text indicates this monitoring point is sampling the cumulative discharge from pools of several collieries that converge in the Gilberton Colliery and comprise a very large, albeit unspecified, volume of water, (BD Mining Company, SMP NO. 54850202, MINE POOL LOCATIONS, MODULE 25, EXHIBIT 1, ESTIMATED DIRECTION OF MINE POOL FLOW RVN MAY 1990 and Figure 4.9, Chapt. 4, PADEP, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania, Dec. 2004). PADEP records indicate that an average of 3,172,249,000 gallons (approximately 16 million cubic yards) of water were pumped annually from the Gilberton Shaft from 1992 through 1997. These volumes were

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[1] PADEP, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania., (Chapter 4, Section 4.3.3: BD Mining – Overall Plant Site and Reading Anthracite – Ellengowan Site), December 2004.

removed by pumps automatically operated to keep mine pools at lower levels than have been allowed subsequently and should therefore be more reflective of the actual volumes of water in the mine pool than more recent figures which reflect smaller volumes removed to maintain the mine pool at a higher level. Thus, while the actual volume of water monitored at MP006 is unknown, it is clear that rising concentrations of pollutants at this monitoring point would reflect the degradation of a lot of water and should be a matter of major concern. It should be noted further that since these collieries also extend extensively under the neighboring Ellengowan mine, MP006 is also downgradient from three other ash placement sites that have received more than 12 million tons of CCW since 1989, most of it also FBC ash from burning culm in the surrounding area. Data has been collected from MP006 from February 1987 to the present although the latest data available for this report also extends only to the July 2004 sampling.

The data assessed and depicted in this report came from a data base (in excel files) of the monitoring data for anthracite coal ash minefills maintained by PADEP's Pottsville District Mining Office staff. Telephone conversations with PADEP staff have divulged that these data reflect total rather than dissolved concentrations. While high total concentrations of pollutants in and of themselves are a matter of concern regardless of the fraction of those concentrations that are dissolved in the water and available for immediate uptake by organisms, the absence of data on dissolved concentrations also does not support any assumption that concentrations discussed in this report are simply suspended but not dissolved in the water. Levels of Total Suspended Solids (TSS) measured at the assessed monitoring points are usually relatively low compared to high levels of Total Dissolved Solids (TDS) suggesting that the larger components of most concentrations in these data are dissolved rather than undissolved fractions. Some 89 percent of all samplings at MP006 had TSS levels below 50 mg/L while 95 percent of the samplings at MP006 had TDS levels more than ten times that high (> 500 mg/L). Some 85 percent of all TSS measurements at MP007 were below 50 mg/L while 98 percent of samplings at this monitoring point had TDS levels more than ten times that high. However at MP008, less than half the measurements, (47.5 percent), had TSS levels below 50 mg/L and less than one third, (30 percent), had TDS levels more than 500 mg/L. Still the large majority of TDS levels measured at MP008 were at least several times the TSS levels measured in the same samplings. In 28 of 40 total samplings at MP008, TDS was at least four times TSS while in only five samplings was TDS less than twice TSS. Average TDS levels at MP008 were approximately 7.95 times greater than average TSS levels.

MP006 and MP007/008

Comparing iron concentrations at monitoring point MP006 (figure 7.1) with the iron concentrations at monitoring points MP007/008 shows that the initial concentrations at MP007/008 were higher than at monitoring point MP006. Then in mid 1997 there was an abrupt decline in iron levels at MP008. Although iron concentrations at the further downgradient MP006 stayed relatively constant, iron concentrations at MP008, as the trend line shows, dropped precipitously well below the levels at MP006. Then in 2002 iron levels at MP008 rose back to levels at MP006 and surpassed those levels in 2003 and 2004 to a high of 56 mg/L in February 2004, 187 times the DWS (secondary MCL).

Figure 7.2 compares concentrations of manganese between the monitoring points. Unlike iron, most manganese concentrations are higher at MP006 than at either MP007 or later at MP008. Nonetheless there is a declining trend in manganese levels at MP006 from around 10 mg/L to 8 mg/L, 160 times the DWS (secondary MCL), over the duration of the monitoring period while the overall trends at MP007 and MP008 are rising gradually despite a strong decline in concentrations in the mid 1990s. Manganese concentrations dropped 3-fold in the decline at MP007/008 while concentrations at MP006 dropped off much more slowly. As happened with iron, the decline in manganese concentrations at MP007/008 was followed by a rise in manganese levels from 2002 through 2004 at MP008.

A similar pattern occurred with sulfate (figure 7.3) whose concentrations underwent a reversal in trends and declined markedly in the mid to late 90s at MP007/008 while higher concentrations at MP006 exhibited an almost flat trend line throughout the monitoring period. Nonetheless sulfate concentrations at MP008 also climbed back from levels less than half the DWS (secondary MCL) in 2002 to over 500 mg/L in 2004, twice the DWS.

The pH (figure7.4) is almost unchanged at MP006 at 6 standard units during the sampling period. Given the large volume of the water body being sampled at MP006, a steady pH would be expected, absent major disruptions in the hydrologic system feeding that monitoring point. The MP007/008 data however show that the pH in groundwater closer to the ash is more varied, spanning levels that both surpass and fall well below the pH at MP006 suggesting more turbulent conditions at MP007/008 from the culm removal and ash placement that may also be diluted by less water. The values in figure 7.4 are of lab rather than field pH as there were several year periods when field pH measurements are not provided in the PADEP data files. Those field pH values that are provided appear to follow the same trends as lab pH although they are in most cases below the lab pH values by approximately one tenth to three fourths of a unit.

The differences in specific conductance (figure 7.5) between MP006 and MP007/008 again demonstrate the pattern described above: a trend reversal in the mid to late 90s at MP007/008, amidst a flat trend line depicting relatively unchanging but higher specific conductance measurements at MP006. After that reversal, the MP006 specific conductance readings were up to 8 times higher than at MP008 where specific conductance dropped precipitously from around 700 micromhos in November 1997 to 200 micromhos in March 1998. Of note however is the rise in specific conductance again in the last three years of monitoring at MP008 to between 400 and 1000 micromhos.

Figure 7.1 54850202-MP006 vs. MP007/008-B-D Mining Iron

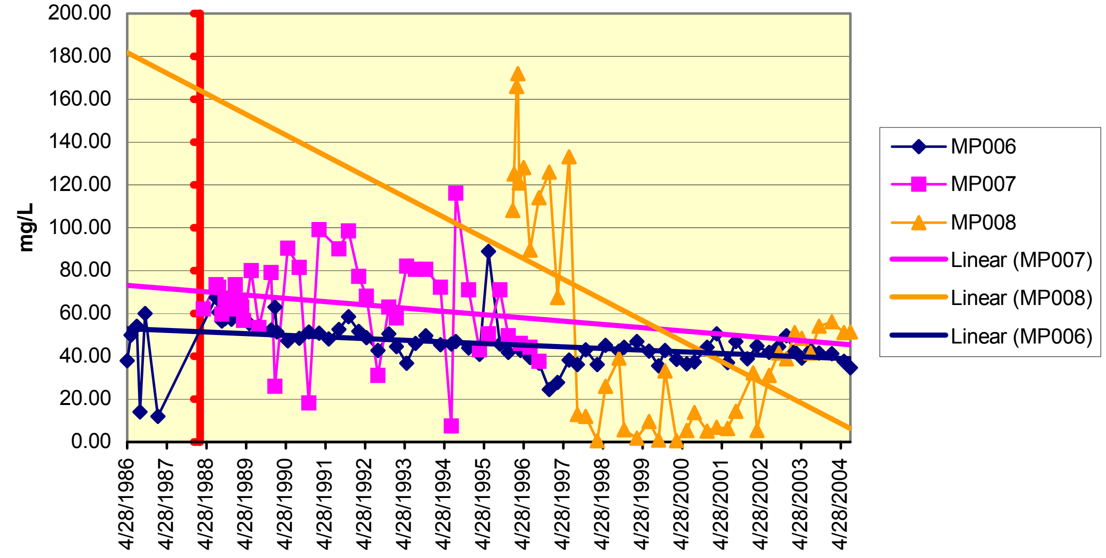
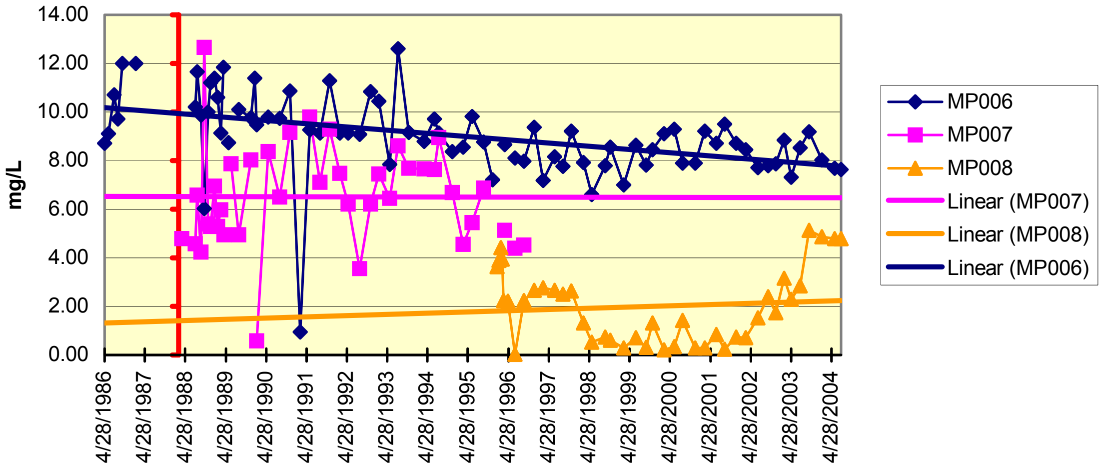


Figure 7.2 54850202-MP006 vs.MP007/008-B-D Mining Manganese



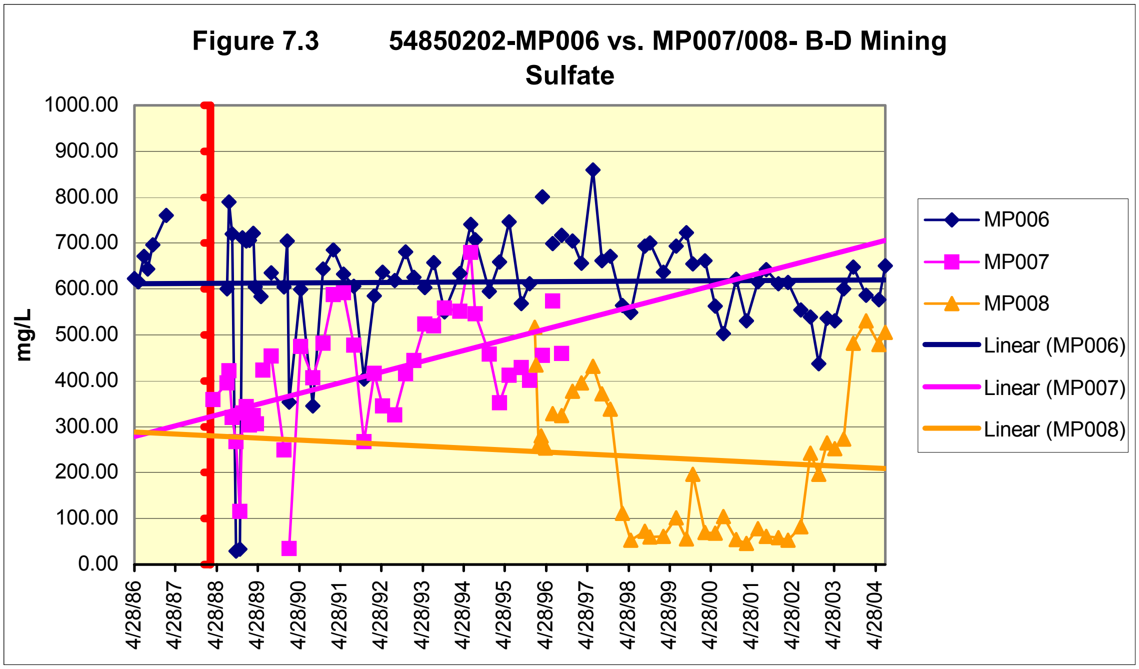


Figure 7.3 54850202-MP006 vs. MP007/008- B-D Mining Sulfate

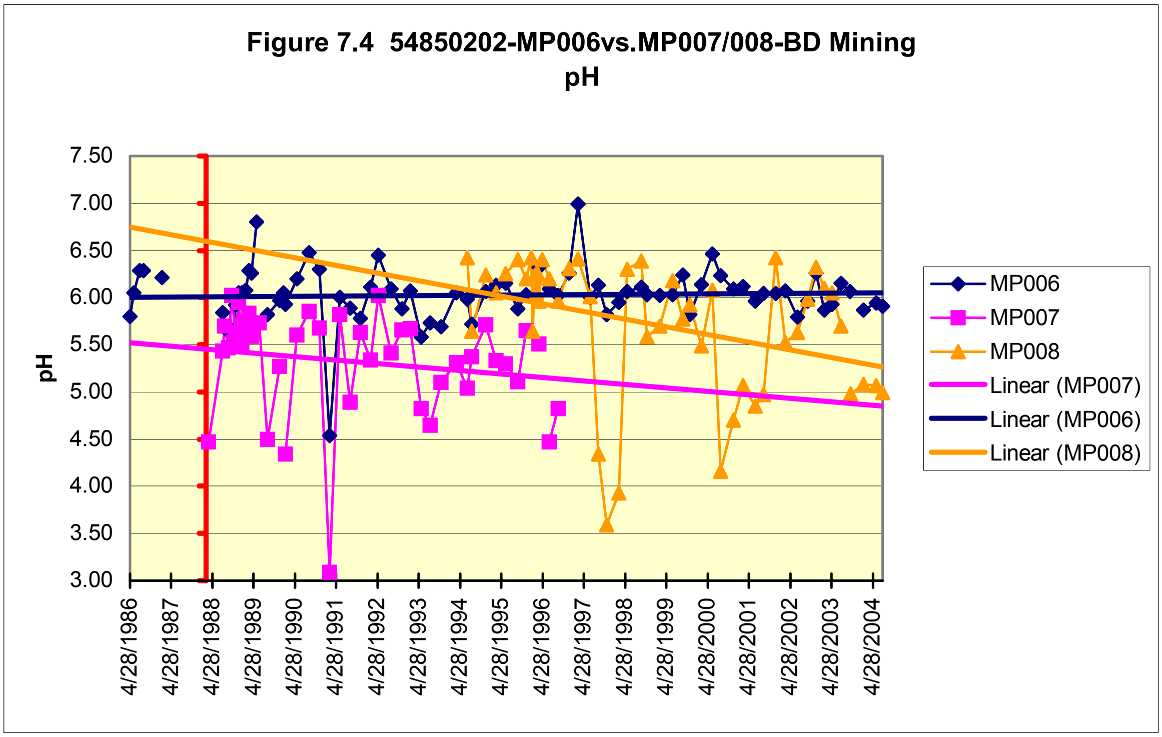
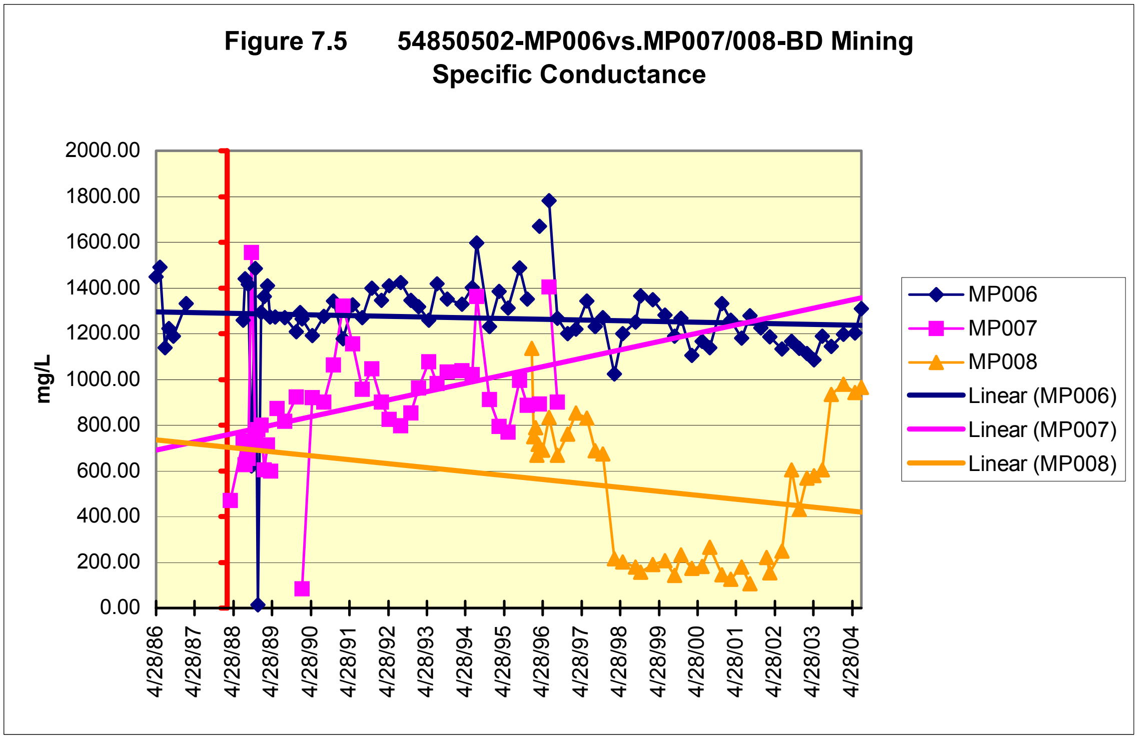


Figure 7.4 54850202-MP006vs.MP007/008-BD Mining pH

Figure 7.5 54850502-MP006vs.MP007/008-BD Mining Specific Conductance



The average alkalinity (figure 7.6) at MP006 was some three times higher than at MP007/008 and was increasing at MP006, decreasing at MP007 and remaining static at MP008. Nonetheless the highest alkalinity was measured at MP008 towards the end of the sampling period in 2003. Acidity (figure 7.7) concentrations decrease at the monitoring points although variations of acidity are more pronounced at MP007/008, probably reflecting their closer proximity to the culm remining and alkalinity of the ash. The variations in acidity and alkalinity as well as their overall trends at these monitoring points suggest that the ash is having some effect on the water at both MP007/008 and MP006 despite the large volume of water at this more downgradient monitoring point.

TDS (figure 7.8) concentrations displayed the same general pattern: a decline in 1997/98 of concentrations at MP007/008 and only slightly changing higher concentrations at MP006 that remained around 1000 mg/L. Specifically TDS concentrations dropped precipitously at MP008 in March 1998 from concentrations in the range of 400 to 700 mg/L to concentrations between 30 and 250 mg/L. These latter concentrations were one fourth to one tenth the concentrations then measured at MP006. However, in the last four samplings at MP008, TDS concentrations rose sharply to between 600 and 800 mg/l.

Magnesium (figure 7.9) concentrations also display this pattern. A drop in the concentrations sampled at MP007/008 in the mid to late 90s was followed by an abrupt rise in concentrations in the last two to three years of the monitoring data. Higher concentrations of magnesium at MP006, experienced some variations but had a flat overall trend throughout the monitoring period.

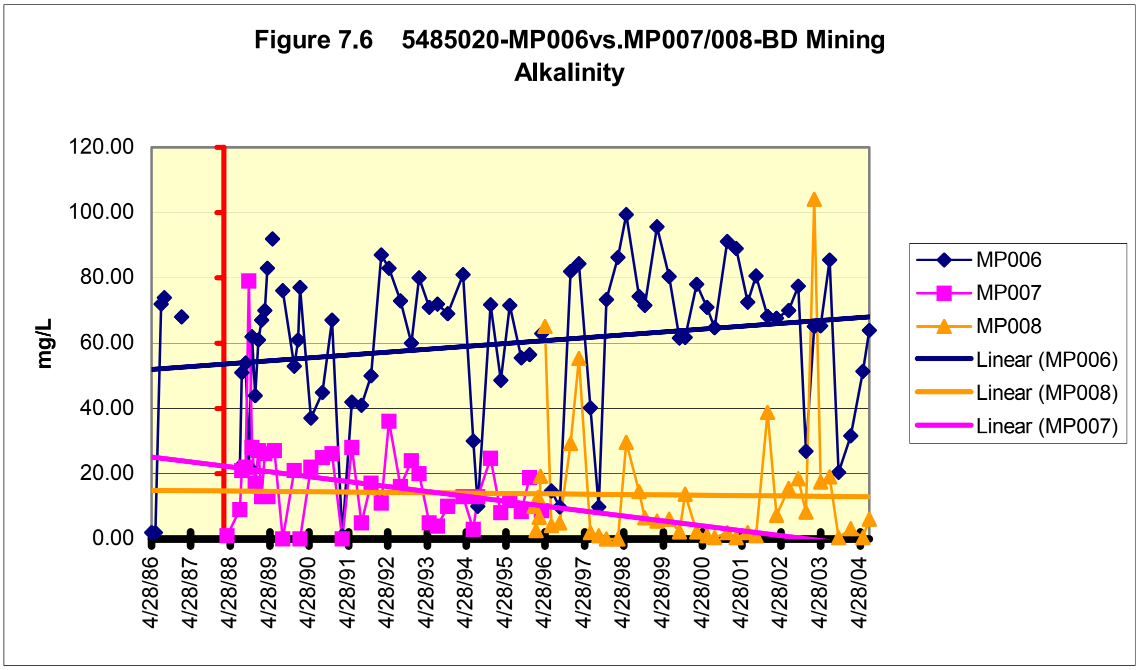


Figure 7.6 5485020-MP006vs.MP007/008-BD Mining
Alkalinity
mg/L
120.00
100.00
80.00
60.00
40.00
20.00
0.00
4/28/86
4/28/87
4/28/88
4/28/89
4/28/90
4/28/91
4/28/92
4/28/93
4/28/94
4/28/95
4/28/96
4/28/97
4/28/98
4/28/99
4/28/00
4/28/01
4/28/02
4/28/03
4/28/04
MP006
MP007
MP008
Linear (MP006)
Linear (MP008)
Linear (MP007)

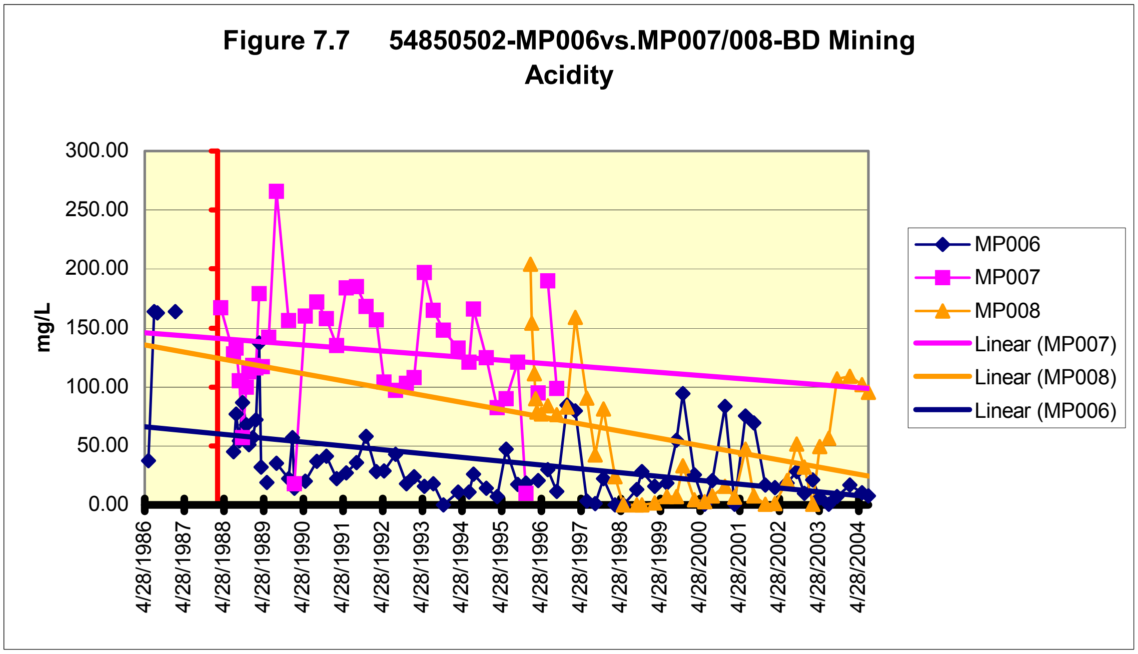


Figure 7.7 54850502-MP006vs.MP007/008-BD Mining
Acidity
mg/L
300.00
250.00
200.00
150.00
100.00
50.00
0.00
4/28/1986
4/28/1987
4/28/1988
4/28/1989
4/28/1990
4/28/1991
4/28/1992
4/28/1993
4/28/1994
4/28/1995
4/28/1996
4/28/1997
4/28/1998
4/28/1999
4/28/2000
4/28/2001
4/28/2002
4/28/2003
4/28/2004
MP006
MP007
MP008
Linear (MP007)
Linear (MP008)
Linear (MP006)

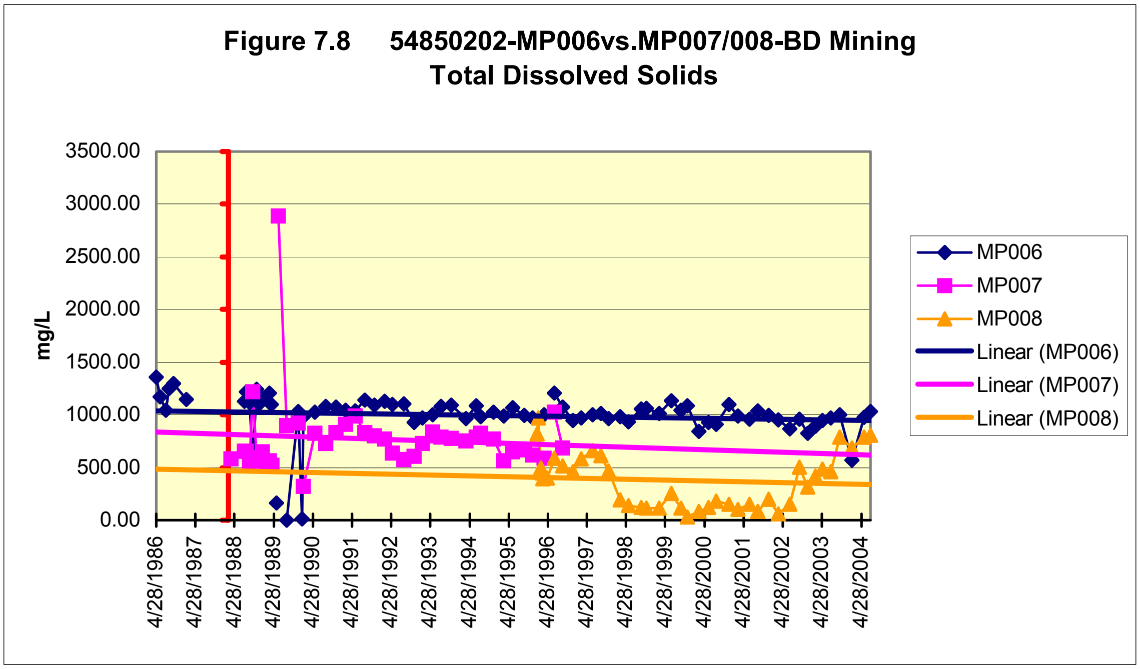


Figure 7.8 54850202-MP006vs.MP007/008-BD Mining
Total Dissolved Solids
mg/L
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
4/28/1986
4/28/1987
4/28/1988
4/28/1989
4/28/1990
4/28/1991
4/28/1992
4/28/1993
4/28/1994
4/28/1995
4/28/1996
4/28/1997
4/28/1998
4/28/1999
4/28/2000
4/28/2001
4/28/2002
4/28/2003
4/28/2004
MP006
MP007
MP008
Linear (MP006)
Linear (MP007)
Linear (MP008)

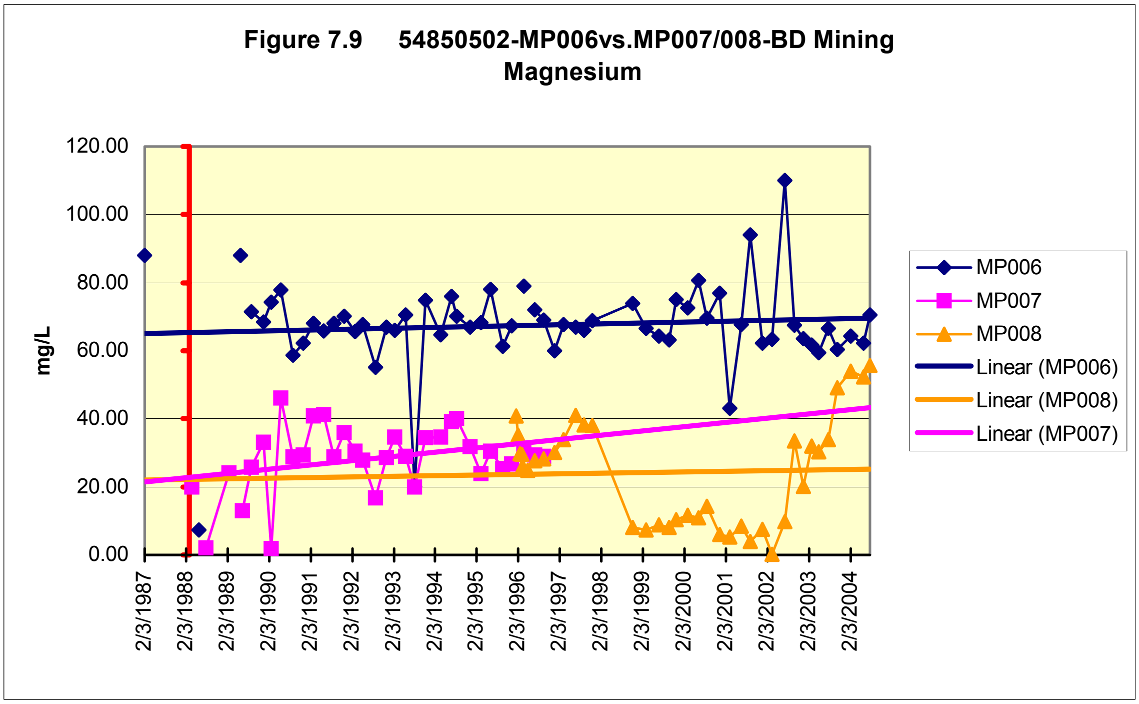


Figure 7.9 54850502-MP006vs.MP007/008-BD Mining
Magnesium
mg/L
120.00
100.00
80.00
60.00
40.00
20.00
0.00
2/3/1987
2/3/1988
2/3/1989
2/3/1990
2/3/1991
2/3/1992
2/3/1993
2/3/1994
2/3/1995
2/3/1996
2/3/1997
2/3/1998
2/3/1999
2/3/2000
2/3/2001
2/3/2002
2/3/2003
2/3/2004
MP006
MP007
MP008
Linear (MP006)
Linear (MP008)
Linear (MP007)

However while magnesium levels at MP006 were on average twice as high (around 70 mg/L) as at MP007 (around 35 mg/L), their last four measurements at MP006 were only 10 mg/L higher than magnesium concentrations at MP008 which rose from around 10 mg/L from 1999-2002 to over 50 mg/L in 2004.

The same drop in concentrations in 1998 followed by a rise in 2002 to previous if not higher concentrations occurred at MP008 for nickel (figure 7.10), sodium (figure 7.11), and calcium (figure 7.12). In the case of sodium, an anomalously high value of 192 mg/L in December 2002 was 6.7 times higher than the next highest values that occurred at any of the three monitoring points and thus nearly hides the smaller but definite increase in other concentrations of sodium in figure 7.11 that occurred at MP008 in 2002. Both sodium and chloride (figure 7.13) concentrations were usually a little higher at MP007 than at MP006 while being lower in most instances at MP008 than at MP006. Zinc concentrations (figure 7.14) were substantially higher at MP007 than at MP006 and also dropped in 1998 at MP008 but did not rise as noticeably as other constituents at MP008 at the end of the monitoring period.

The drop in concentrations of so many consituents at MP007 in 1996 and at MP008 in 1997 and 1998 followed by rises at MP008 after 2001 back to levels that mirror earlier concentrations at MP007 suggests a response to the culm remining and ash as its placement advanced gradually toward MP008 from the east. The changing concentrations could have also resulted from changing conditions in the minepool underneath the remining and ash placement that could have temporarily changed the directions of water flow at MP007 and MP008. Water level data maintained by PADEP indicate that from 2000 through 2003 annual water level elevations changed by as much as nine feet between boreholes closest to MP007 and the Maple Hill Shaft monitoring point in the adjacent Ellengowan Mine to the north, with the Maple Hill Shaft water levels rising from five feet below levels at MP007 in 2000 and 2001 to a level four feet above the level at MP007 in 2003 (see the section, Groundwater (Mine Pool) Monitoring in Truck and Conveyor Ash Sites in Permit Review 5, Reading Anthracite Company, Ellengowan Mine). While these boreholes are as much as 1000 feet from the monitoring locations, and "annual measurements" of instantaneous levels are clearly too few in number to characterize minepool levels with much accuracy, the changes in water elevations at them suggests that flow directions might have been changing in the minepool at MP007. Nonetheless without more detailed information such as records of the continuous pumping rates at the Gilberton Shaft or at least monthly water levels measured at these monitoring points from 1996 to the present, the authors of this report can only speculate on causes for this pattern of changing concentrations.

Figure 7.10 54850202-MP006vs.MP007/008-BD Mining Nickel

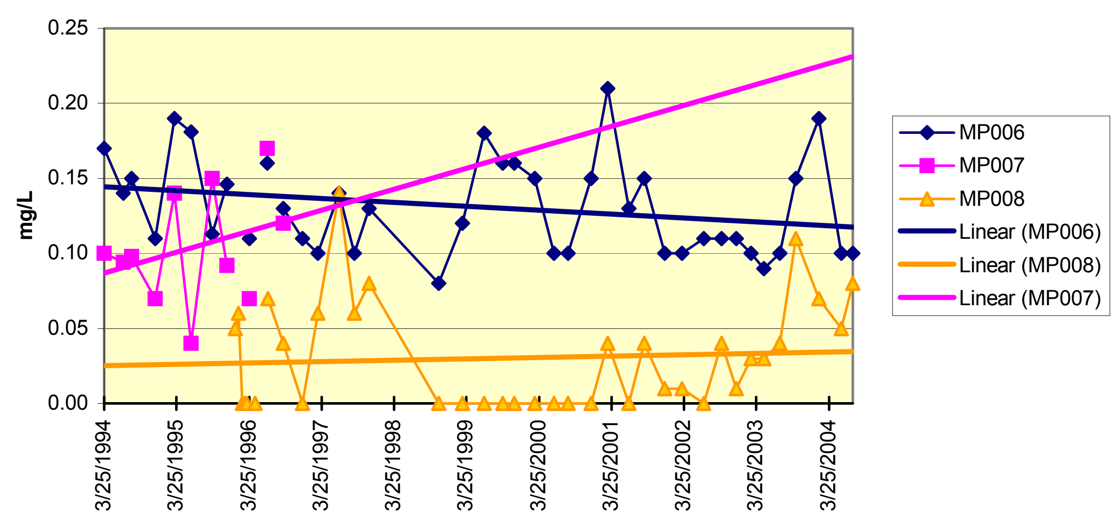


Figure 7.11 54850202-MP006vs.MP007/008-BD Mining Sodium

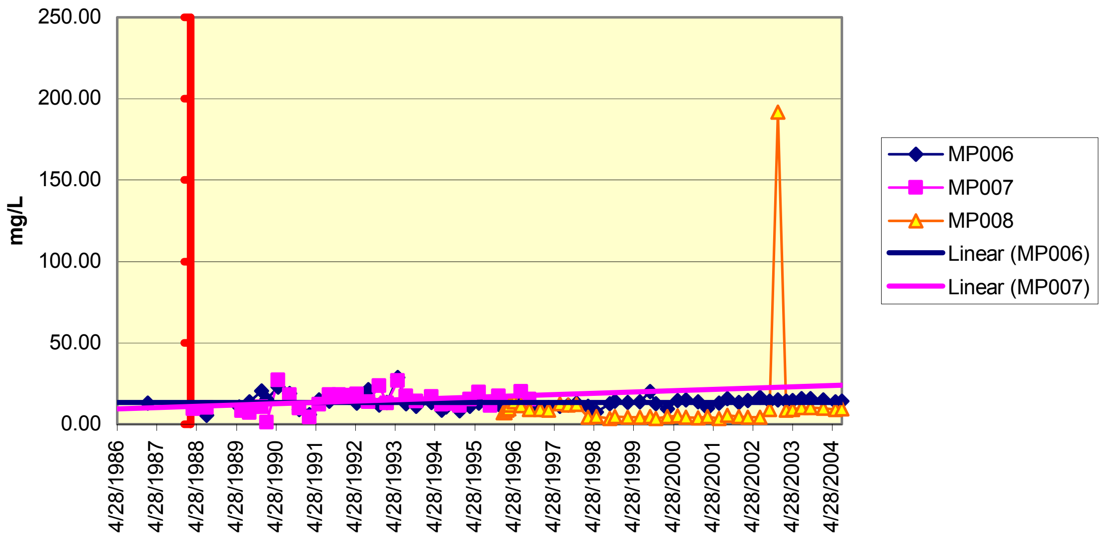


Figure 7.12 54850202-MP006vs.MP007/008-BD Mining Calcium

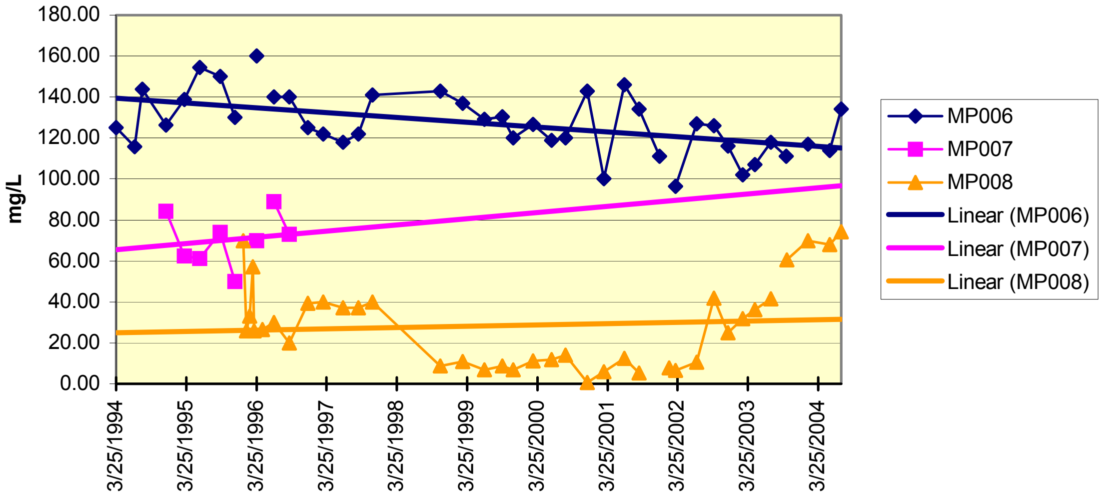
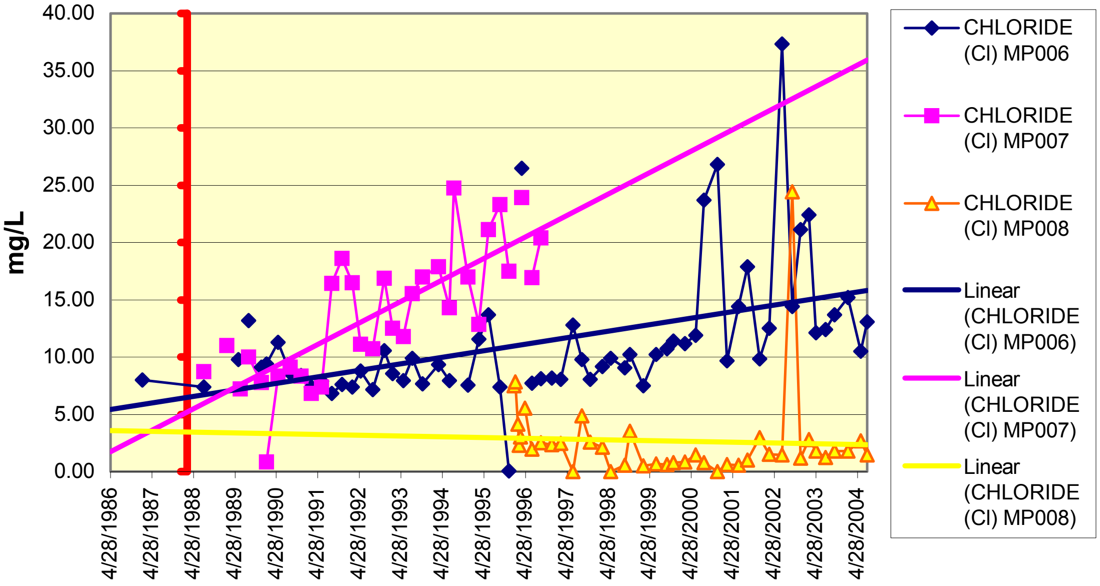
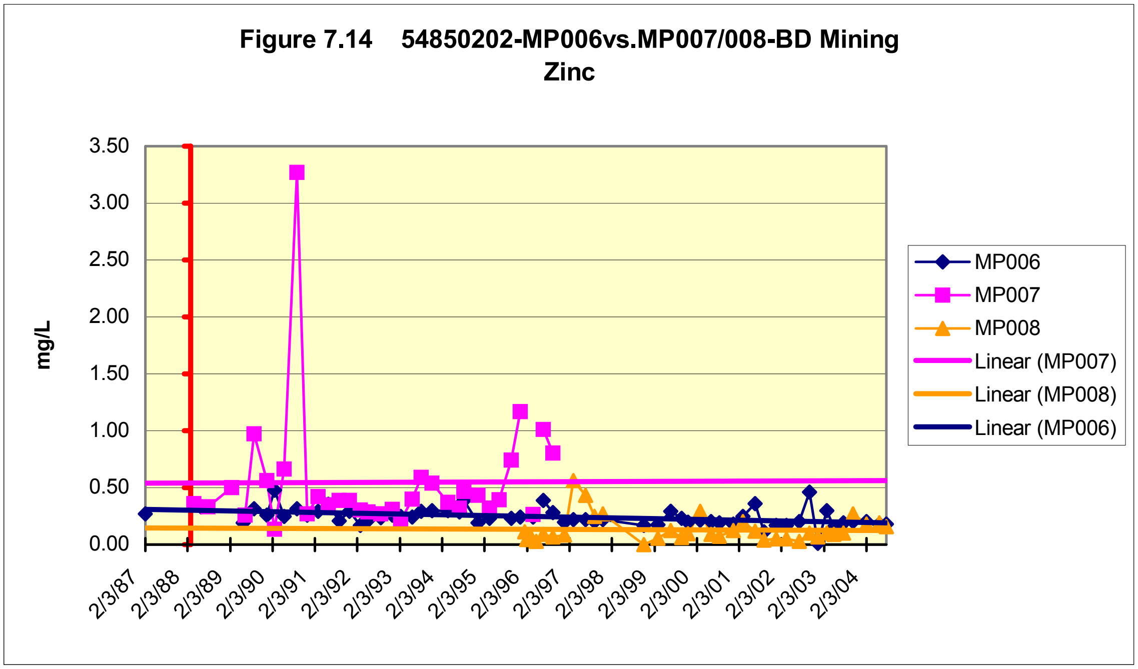


Figure 7.13 54850202-MP006vs.MP007/008-BD Mining Chloride





RCRA Trace Elements

The pattern of declining concentrations in the 1990s is not reflected in data on other trace elements which reached high concentrations at these monitoring points in multiple samplings during ash placement. In many instances these concentrations are far beyond the DWS.

However the absence of a monitoring point upgradient of the ash placement area as well as the existence of only one data point reflecting a concentration measured by the mining operation during the baseline period (in February 1987 - one year before the start of regular ash placement in March, 1988) fundamentally hinder assessment of whether the ash is the source of these metals. The authors have added data from three measurements of trace elements taken from the "Gilberton Shaft Pump" in the monitoring performed for the Turkey Run Landfill to the following figures to assist in the evaluation of baseline concentrations for trace elements. This solid waste landfill, closed in the 1990s, is approximately 2000 feet east-north-east of the Gilberton Shaft (Permit I.D. # 100799, West Mahanoy Township, Turkey Run Landfill Site Map, Exhibit 4 Monitoring Points, EDWARD J. GAYDOS, INC., Consulting Engineer & Surveyor, Orwigsburg, PA). The Turkey Run measurements are depicted as data points for MP006 (also identified as the Gilberton Shaft Pump in the BD Mining Permit) although it is not known if they were taken at the exact location at which MP006 is sampled. Even with these additional measurements however, the amount of baseline data is deficient for making definitive comparisons to post ash placement concentrations. Nonetheless in every instance, the four baseline concentrations measured at the Gilberton Shaft or MP006 (one by BD Mining and three by the North Schuylkill Landfill Association for the Turkey Run Landfill) are well below the high concentrations that occur during ash placement at MP006. In the cases of lead and cadmium, the highest concentrations were measured several years after ash placement was underway.

It should be noted also that in multiple instances detection limit values that were equal to or up to many times over the DWS for trace elements have been accepted by PADEP in this monitoring data. To present a less confusing picture of actual concentrations measured, all of these detection limit values are portrayed on the x axis (as 0.00 mg/L) in the figures below.

Lead concentration increases present evidence of serious degradation of water quality at this site (figure 7.15). At all three minepool monitoring points MP006, MP007, and MP008, lead was measured at levels many times DWS during ash placement. Starting at MP007, the monitoring point closest to the ash, lead was measured at 0.220 mg/L, more than 14 times over the DWS in June 1989, 15 months after regular shipments of ash to the site had gotten underway. Three subsequent measurements at MP007 measured between 0.120 mg/L and 0.160 mg/L, 8 to 11 times the DWS through November 1991. These high lead levels then began to show up at MP006 with four measurements from November 1991 through May 1993 between 0.100 mg/L and 0.140 mg/L. The next high lead level measured was 0.100 mg/L at MP008 in April 1996. Lead was measured again at MP008 at 0.100 mg/L and at MP006 at 0.120 mg/L, 6.7 and 8 times over the DWS, respectively, in March of 1999. Lead rose further at MP008 to 0.180 mg/L in June 1999, 12 times the DWS. It was then measured at 0.580 mg/L at MP008 in September 2001, 39 times the DWS. Additional high lead concentrations were measured at MP006 in June 1999 (0.160 mg/L) and in September 2001 (0.150 mg/L). Many other measurements at the three monitoring points were below limits of detection which ranged from 0.030 to as high as 0.500 mg/L and thus are depicted in the figure as dots on the x axis or as 0.000 mg/L. Detection levels like these that are twice and more than 30 times over the DWS respectively do not allow reviewers to discern whether harmful lead levels are in the water in those samplings.

However, lead was also actually measured at least four times from February 1990 to May 1993 at 0.120 mg/L to 0.180 mg/L at another downgradient monitoring point, MP005. According to the PADEP monitoring data base, MP005 was monitoring waters in a strip pit in the ash placement area. According to the engineer for BD Mining (WJP Engineers, Pottsville PA), MP005 sampled ponded surface waters in a strip pit between MP007 and MP008 where coal refuse reject material from the Gilberton Cogen Plant was placed until the pit was eliminated by ash backfilling operations. Monitoring of MP005 did not take place while ash was being placed in the pit as there was no water left to sample at this location at that time (WJP Engineers, August 29, 2006 telephone conversation). Nonetheless, MP005 is identified by PADEP in its monitoring data base as a downgradient monitoring point and presumably water in this pit would have had ample contact with water moving through ash being deposited at the site. There are no baseline measurements from MP005. According to the PADEP monitoring database, monitoring at MP005 took place from August 28, 1989 through May 17, 1993.

Chromium concentrations (figure 7.16) at MP006 and MP007 measured 0.239 mg/L and 0.232 mg/L respectively in November 1991, more than twice the DWS for Total Chromium (0.100 mg/L). The highest measurement of chromium at MP005 also occurred in that sampling at 0.061 mg/L. Chromium was measured at 0.099 mg/L at MP007 in September 1995 and at 0.09 mg/L at MP006 in September 1997. Chromium values at MP008 however were usually measured below instrument detection limits of 0.05 mg/L (from March 1999 through September 2001) or 0.01 mg/L (from February 2002 through July 2004). Exceptions included actual measurements at MP008 of chromium at 0.06 mg/L in June 1997 and September 1999, 0.01 mg/L in July 2002 and February 2004, and 0.02 mg/L in May 2004. The first baseline measurement of chromium applicable to MP006 from Turkey Run Landfill data was 0.06 mg/L in November 1985 but subsequent baseline values were below instrument detection limits. A very high chromium measurement of 0.78 mg/L was recorded also in November 1985 from the Turkey Run Landfill's monitoring point at a deep mine discharge in Girardville approximately two miles west of MP006. However this monitoring point would appear to be more affected by a commercial hazardous waste facility waste impoundment (the Keystone Chemical Company), immediately upgradient of the discharge. This facility had a monitoring program for chromium and other trace metals.

Cadmium concentrations (figure 7.17) also reached unacceptable levels after ash placement with maximum concentrations in June 1999 more than 5 times the DWS at MP008 (0.028 mg/L) and more than four times the DWS at MP006 (0.022 mg/L). Many cadmium measurements at these monitoring points were below a detection limit of 0.01 mg/L (twice the DWS of 0.005 mg/L). It should also be noted however that the single baseline measurement of cadmium collected under the mining permit at MP006 was also an actual concentration of 0.010 mg/L in February 1987, approximately one year before regular ash shipments arrived at the site. Actual concentrations of cadmium at MP007 were first measured at 0.006 mg/L and 0.01 mg/L in February and May of 1990, respectively and again at 0.01 mg/L in February 1993. Five nearly identical measurements (ranging from 0.006 mg/L to 0.011 mg/L) occurred at MP005 during this same period. Even the lowest of these measurements, 0.006 mg/L, is three times the federal water quality standard for acute toxicity of cadmium to aquatic life (CMC) of 0.002 mg/L and 24 times the federal water quality standard for chronic toxicity of cadmium to aquatic life (CCC) of 0.00025 mg/L (National Recommended Water Quality, USEPA, published pursuant to Section 304(a) of the Clean Water Act). Whether the surface waters at MP005 were discharging entirely to the minepool or offsite to other surface waters is not known. The levels of cadmium recorded substantially further beyond these water quality standards at MP006 would also be a concern given the discharge of these waters to Mahanoy Creek at this sampling point.

Figure 7.18 shows appreciable levels of arsenic at MP006, MP007 and MP005. A measurement of 0.0631 mg/L in June 1995 at MP006 exceeded the old DWS (0.05 mg/L) and exceeded the new DWS (0.01 mg/L) by more than six times. The second highest concentration of arsenic at MP006 was 0.032 mg/L in March 1994. The highest arsenic at MP007 was 0.05 mg/L measured in a March 27, 1988 sampling during the first month of regular ash placement at the site. The second highest arsenic concentration at MP007 was 0.021 mg/L in June 1996 the second to last measurement at this monitoring point. The highest arsenic at MP005 exceeded the new DWS at 0.01281 in August 1991. Arsenic concentrations at MP008 were measured at zero or below instrument detection levels equal to the new DWS in all but one instance when an actual value of 0.007 mg/L was measured in April 1996 and hence were not graphed.

Selenium concentrations, (ungraphed) were less noticeable, usually below a detection limit of 0.010 mg/L or close to 0.00 mg/L at all monitoring points. However there were several higher selenium concentrations measured including 0.041 mg/L in MP008 and 0.017 mg/L in MP006 in June 1999. The DWS for selenium is 0.05 mg/L and the water quality standard (federal standard for chronic exposure of aquatic life) is 0.005 mg/L. Selenium exceeded this water quality standard also in the August 28, 1991 measurement at MP005 which was 0.00832 mg/L.

Figure 7.15 54850202MP006vs.MP007/008/005-BD Mining Lead

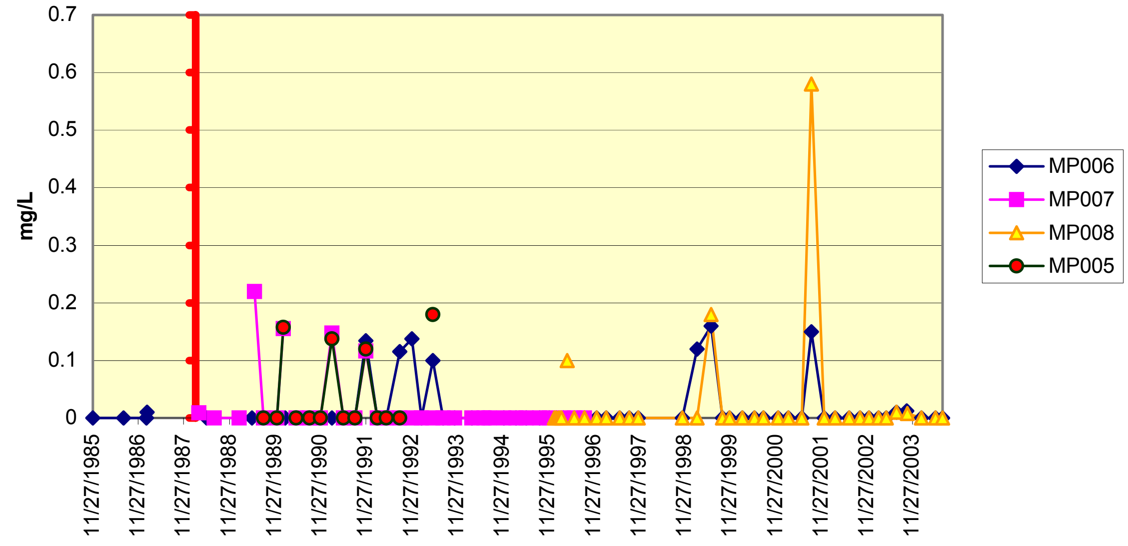


Figure 7.16 54850202-MP006vs.MP007/008/005-B-D Mining Chromium

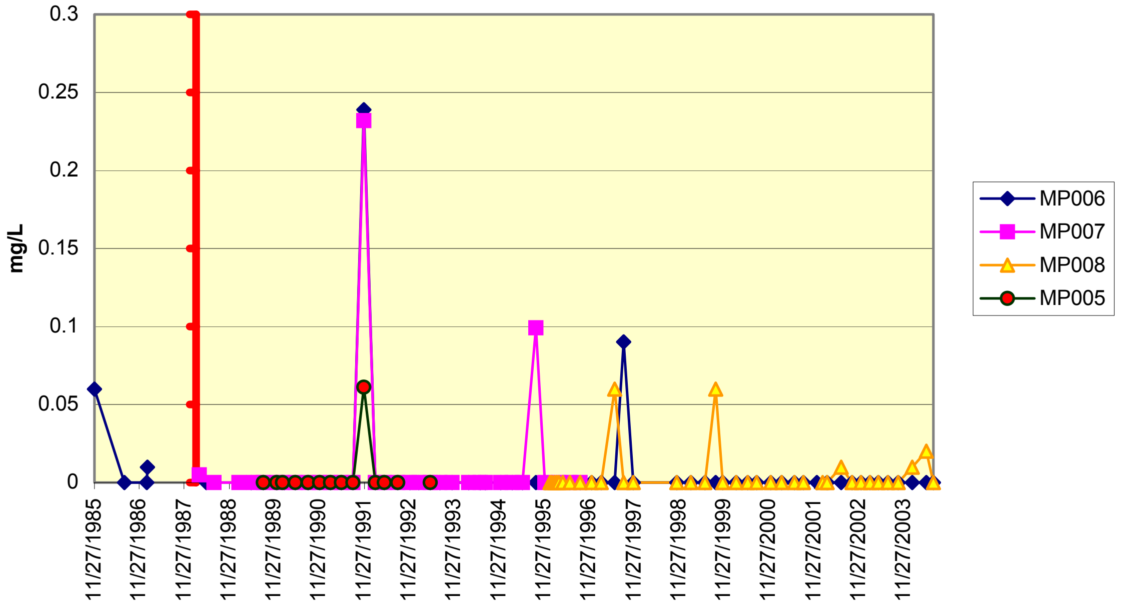
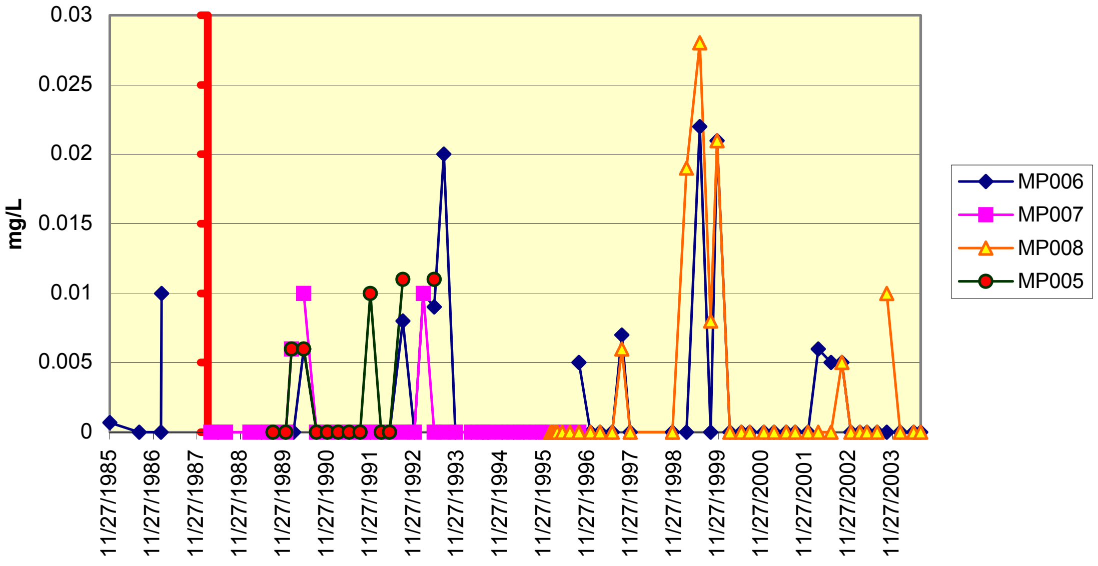
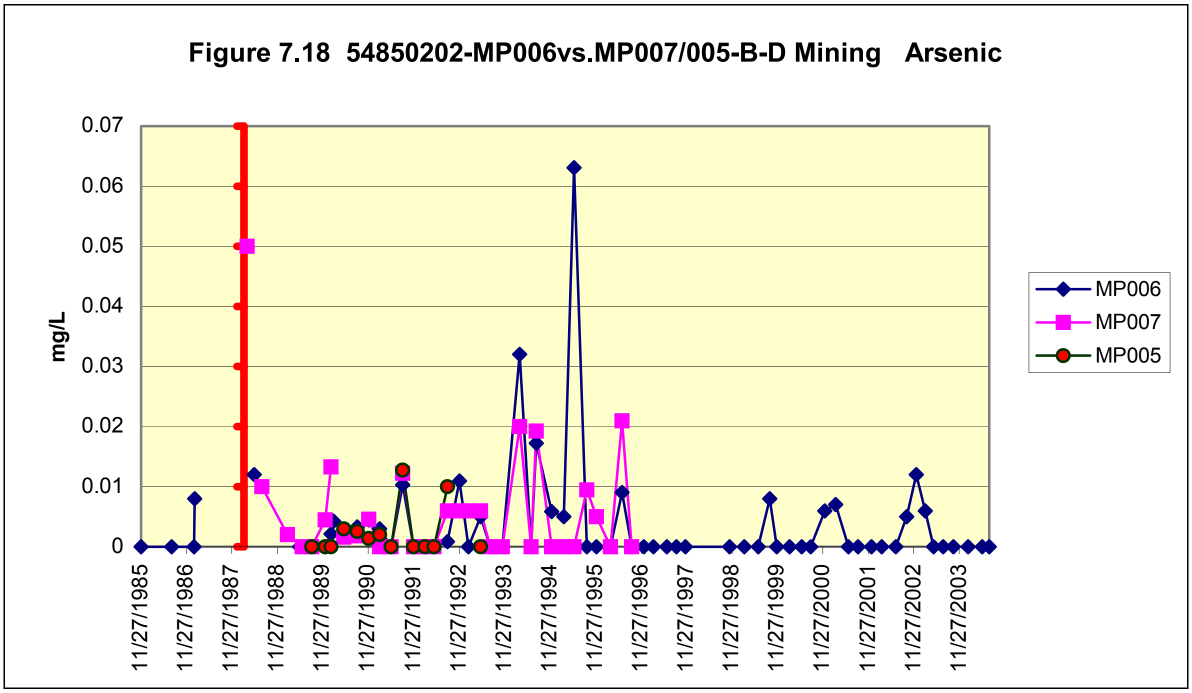


Figure 7.17 54850202-MP006vs.MP007/008/005-B-D Mining Cadmium





High Lead Levels

The lead levels found after ash placement began at the BD Mining monitoring points (figure 7.15) are not found naturally in Pennsylvania groundwater and do not appear to be an artifact of anthracite mining in eastern Pennsylvania. Out of 144 measurements at BD Mining's ash monitoring points for total lead, 18 measurements, 12.5 %, exceeded the DWS (federal Action Level of 0.015 mg/L). These exceedances ranged from 0.10 mg/L (6.7 times the DWS) to 0.58 mg/L, (38.7 times the DWS). This compares to 210 out of 6762 measurements or 3.1% of all measurements for total lead exceeding the DWS in Summary of Groundwater Quality Monitoring Data (1985-1997) from Pennsylvania's Ambient and Fixed Station Network (FSN) Monitoring Program, Selected Groundwater Basins in Southwestern, Southcentral and Southeastern Pennsylvania, (PADEP, June 1998). This survey of ambient groundwater quality examined concentrations of 27 analytes from 1089 monitoring points over a twelve year period in 46 designated higher priority Groundwater Basins in southern Pennsylvania. Table 7 (page 14) in this Report identifies lead as a constituent of "potential ecological concern," under the Pennsylvania Land Recycling and Environmental Remediation Standards Act of 1995 (also called Act 2) and states, "Natural water seldom has values >5 ug/L (0.005 mg/L of lead)." (details in parentheses added)

Total lead levels measured in the water under the ash at BD Mining have repeatedly reached levels well beyond total lead levels observed in the four Groundwater Basins studied in this Report that are closest to the BD Mining Site. The closest Basin is

Groundwater Basin #49 in Berks County approximately 15 miles south of the BD site. According to Appendix 2 of the Report, 41 monitoring points generated 78 samples assessed for analytes including total lead in this Basin. Box plot graphs of the data in Appendix 3 of the Report indicate that the highest total lead value was approximately 0.023 mg/L, one of four values exceeding the DWS in this Basin. Whether the dots in these graphs represent just one measurement or more than one measurement is not explicitly spelled out in the Report. Nonetheless the box plot reveals very little variation in the data with the median data point at 0.004 mg/L and the 90th percentile data point being <0.010 mg/L.

The next closest Basin, Groundwater Basin #36 further east in Berks and Lehigh Counties, contains 41 monitoring points that generated 881 samples. Nine lead values exceeded the DWS and the highest of these according to the graphs in Appendix 3 was approximately 0.050 mg/L. The entire range of data up to the 75th percentile value was below the median data value of 0.004 mg/L and the 90th percentile value was below the DWS.

Bordering this Basin to the north in Lehigh and Northampton Counties is Groundwater Basin #35. It contains 35 monitoring points that generated 710 samples. Three lead values exceeded the DWS. The highest of these was approximately 0.0375 mg/L. Again there was little variation in the data with 75 percent of the concentrations being below the median data value of 0.004 mg/L and the 90th percentile value below the DWS.

The fourth closest Basin, Groundwater Basin #53, is about 20 miles due south of the BD Mining site in Lebanon and Berks Counties. Nineteen monitoring points in this Basin generated 23 samples assessed in the Report. The highest lead concentration at 0.040 mg/L, was the only value that exceeded the DWS in this Basin. The box plot graph indicates there was virtually no variation in the data with the 90th percentile value being <0.005 mg/L and the median value at approximately 0.001 mg/L.

In summary, out of the 1692 samples surveyed in this Report from Groundwater Basins closest to the BD Mining ash site, the highest total lead concentration found was half the lowest of eighteen concentrations of total lead measured from the BD ash monitoring points that exceeded the DWS. Furthermore, the PADEP Report indicates that values below detection limits were used to discern median values and perform other calculations with the data, so it is not even clear whether the highest lead concentration graphed in Appendix 3 from these four Groundwater Basins was an actual value or a detection limit artifact.

A survey of data from other sites in eastern Pennsylvania reveals that the lead concentrations from the BD wells in excess of the DWS are generally an order of magnitude above lead concentrations measured from wells in minepools from other mines and around other waste management facilities in the anthracite coal fields. For example at the CES Landfill, (Permit I.D. #101615), in Schuylkill County, Foster Township in the southern anthracite field close to its border with the central anthracite field (which includes the Western Middle Field in which the BD Mining operation is located), the highest total lead level found in a monitoring well located in the minepool under this site in a seven year period (from 9/1/1998 to 6/2/2005) was 0.003 mg/L. At the John Fry Landfill Tract 2, (Permit I.D. #101400) also in Schuykill County, Foster and Reilly Townships, (adjacent to the CES Landfill) the highest total lead found in a recent two year period (2001-2003) was 0.007 mg/L in a monitoring well and 0.014 mg/L in a stream downgradient of the site.

A review of data in a Regional Groundwater Database analyzed in the cleanup of lead contamination from the Marjol Battery Superfund site in Lackawanna County also documents substantially lower lead levels in the vast Scranton Mine Pool in the northern anthracite field (see Appendix E, SUPPLEMENTARY RFI ACTIVITIES REPORT, MARJOL BATTERY SITE, Advanced GeoServices Corp., Project Number 92-002-AP, July 17, 1995). The Scranton Mine pool was created from deep mining coals in the Llewellyn Formation that was also mined predominantly under the BD site. The highest lead in this data base from monitoring points at the Coalbrook Mine, Gravity Slope Mine, Old Forge Bore, and Duryea Breach is 0.0920 mg/L of dissolved lead (total lead for this sampling is listed as 0.0000 mg/L) at the Duryea Breach in April 1987. The next highest lead levels are 0.0200 mg/L at the Old Forge Bore and Gravity Slope Mine in October 1969 and April 1971. Exceptions to these lower lead concentrations in this Regional Database are total lead levels in minepool monitoring wells at the Lackawanna Refuse site (Old Forge Borough, Lackawana County) and Keystone Landfill (Dunmore Borough, Lackawanna County) which are in the same range (0.100-0.600 mg/L) as levels in the BD wells. However discussions with staff who oversee these facilities in the PADEP's Waste Management Program (Wilkes Barre Regional PADEP Office) indicate that Lackawanna Refuse is a major superfund site where some 15,000 drums, much of it hazardous waste containing high levels of heavy metals, were buried in an abandoned strip mine pit. These drums are reportedly the source of the high lead levels in this site's minepool monitoring wells. These staff also state that a battery manufacturing plant (Gould Battery) upgradient of the Keystone Landfill is the source of the lead contamination in its minepool wells. PADEP Waste Management staff in the Wilkes Barre and Bethlehem District Offices stated in multiple discussions with the authors of this report in November and December 2005 and in the first half of 2006, that they do not normally see high lead levels (at or exceeding the DWS of 0.015 mg/L) in acid mine drainage from anthracite mines and therefore would expect the lead levels in the BD Mining wells to be coming from other human activity.

Yet the PADEP has no knowledge of the existence of industrial plants, waste disposal facilities or illegal dumps draining into the Boston Run, St. Nicholas or Gilberton Minepools that are sources of lead pollution. Several inquiries to PADEP's waste management program staff turned up two facilities closer to the BD Mining site in the Mahonoy Creek watershed of northern Schuylkill County that could have been sources of high lead levels in minepools. One of these facilities, the Keystone Chemical Company's property, is approximately 2 miles west of the Gilberton Shaft monitoring point (MPOO6). The facility was closed in the early 1990s. According to information in the archived files of that facility (PAD # 000647735, Butler Township) the groundwaters under this facility are draining into minepools that are discharging toward the west into the Girardville area, not flowing east to MP006. Nonetheless this commercial hazardous waste facility contains a waste disposal impoundment that was required to be monitored for lead and other trace metals. The highest lead found in five quarters of monitoring data reviewed between December 1987 and April 1992 was 0.017 mg/L (a dissolved value) at two monitoring points. One monitoring report indicates a background concentration of 0.036 mg/L was found in January 1988 at an upgradient monitoring point (MW-1).

Perhaps more relevant data comes from the other of these facilities, the Turkey Run Landfill given its location 2000 feet east-north-east of MP006 in the BD Mining site, its use of the Gilberton Shaft Pump also as a monitoring point and its history as an abandoned anthracite strip mine pit labeled by the PADEP and the USEPA in an assessement as a "mine acid drainage area." The Turkey Run Landfill (Permit I.D. # 100799, West Mahanoy Township) was operated by the North Schuylkill Landfill Association as an unlined "natural renovation site" that received mainly commercial and municipal wastes including industrial waste water sludges such as aluminum hydroxide sludges, spent acids and other plating wastes. An examination of archived files for the Turkey Run Landfill located a one page PADEP (at that time the Pennsylvania Department of Environmental Resources) approval dated March 28, 1978, of Application 5477201 from the "Reynolds Plant" of Altas Powder Company in Walker Township, Schuylkill County to dispose "Solid waste material generated from a lime neutralization facility producing settleable floc containing ferric hydroxide and fly ash" at the Turkey Run Landfill. No other information identifying the fuel source of the "fly ash" or documenting the extent of ash disposal at the Landfill could be found.

The highest lead measured in six quarters of data from Turkey Run monitoring points spanning from November 1985 to March 1994 was 0.00508 mg/L in Total Recoverable Lead from an undisclosed location in March 1994 at the "Turkey Run Landfill/Transfer Station." The next highest lead measurement was measured at the Gilberton Shaft at <0.05 mg/L in November 1985 which level was also recorded at the other two monitoring points at this facility. The rest of the lead measurements in this data are below detection limits usually set at <0.005 mg/L or less. The Turkey Run data provides three additional recorded concentrations of total lead from the Gilberton Mine shaft before ash placement started at the BD Mining site which are assessed as baseline data in this report reflecting pre-ash conditions in the Gilberton Mine Pool. Under the PADEP mine ash placement permit, only one baseline measurement was recorded for lead at MP006 (the Gilberton Shaft) of 0.01 mg/L in February 1987. In addition to the <0.05 mg/L measured in November 1985, the additional measurements at the Gilberton Shaft from the Landfill include <0.005 mg/L in July 1986 and <0.005 mg/L in January 1987. Thus the Turkey Run data gives additional weight to the concern that the high lead seen at the BD Mining ash monitoring points was not being contributed by AMD from anthracite mining and not in the minepools under the BD Mining site before large scale ash placement started under the mining permit.

Conclusion

Data generated by the ash monitoring points at this site demonstrates unquestionably that the large mine pool downgradient of the BD ash placement area is being substantively contaminated with toxic levels of lead. Concentrations of cadmium, chromium and arsenic have also been measured above DWS in the mine pool after ash placement although their levels have not reached the magnitude or frequency of exceedances of the DWS measured for lead.

However there are basic defects in the monitoring system at this site that are of serious concern given the size of the ash disposal operation it contains and the high levels of toxic metals that are being exhibited in the underlying mine pools. The approved disposal in areas 1 and 2 at the BD Mining site totaled 3,551,429 cubic yards of coal ash. For the past 10 years, this large mass of ash has only been monitored by monitoring points MP006 and MP008. MP007, a well on the western perimeter of the ash placement area, was monitored for the first eight and a half years after ash placement started before it was buried by the ash and replaced by MP008. MP005 was a surface water point monitored for less than four years in the strip pit before this pit was filled with ash.

Even worse, there are no monitoring points upgradient of the ash placement area which is located above the mine pool that subsequently drains into monitoring points MP008 and MP006. Therefore, the monitoring system at this site has never been capable of assessing mine pool water quality unaffected by ash. This deficiency is exacerbated by the extremely limited baseline monitoring that produced only 1 data point at MP006 that reliably reflects pre-ash placement conditions for many trace elements and other Module 25 ash parameters prior to the beginning of ash placement at this site. Not a single concentration of these constituents is recorded in the PADEP's data base for the monitoring results at this site or accessible in the public files of the BD Mining Permit for any of the monitoring points near the ash at this site (MP007, MP005, and MP008). Three additional measurements for total concentrations of lead, chromium, cadmium and arsenic at the Gilberton Shaft pump (presumably adjacent to or directly from MP006) as part of the monitoring for the Turkey Run Landfill from 1985 through 1987 have been included in the assessment of baseline water quality in this Report, but even four measurements is an inadequate number for characterizing baseline concentrations of these trace elements. There were also no monitoring points established to measure water quality in the pore water in the ash to help differentiate impacts of ash on water quality from impacts of culm and coal silt. While reviewers can speculate about the sources of high trace metals and other pollutants, these deficiencies do not allow the causes for the degradation of mine pool water quality occurring under this site to be definitively identified.

Given the position of MP006 in the Gilberton mine pool which receives flow from a several other mine pools and more than one mile downgradient of MP007 and MP008, there is presumably a significantly greater quantity of water being monitored at

MP006 than at MP007/008. This accounts for why there is greater variability in concentrations at MP007/008 and why constituents at MP007/MP008 fell to levels below MP006 as their measurements appear to have been reflecting more concentrated pulses that go past their sampling points. A spike in alkalinity to 105 mg/L in the spring of 2003 suggests an ash influence at MP008. Rising levels of other ash indicator parameters such as calcium, magnesium and trace metals and parameters indicative of both mining and ash placement, such as manganese, sulfates, TDS and specific conductance in the last three years of monitoring at MP008 also suggest the advance of the ash filling operation closer to this monitoring point.

The numerous high levels of lead exceeding the DWS by several times (at the minimum) at the monitoring points beginning about one year after ash placement should be of serious concern to PADEP. High lead levels were first measured at MP007 and MP005 some two and a half years and two years respectively prior to high lead levels being measured at MP006. Lead also reached higher levels at MP007, MP005 and MP008 (as high as 0.22 mg/L in June 1989 at MP007 and 0.58 mg/L in September 2001 at MP008) than at MP006. These results would be expected given the greater distance between the ash and MP006 and the greater volume of water and dilution of pollutant levels that MP006 should be monitoring. Nevertheless at MP006, total lead reached 0.16 mg/L on June 23, 2001, more than 10 times the DWS (federal action level), and 0.15 mg/L on September 4, 2001, 10 times the DWS. These levels are particularly disconcerting because MP006 is monitoring a very large mine pool more than one mile downgradient from the ash. This mine pool is either the regional water table for the entire area or likely to be hydraulically connected to it. Furthermore assuming hypothetically that 0.16 mg/L was measured throughout the year on a sustained basis in a mine pool discharge of at least 3 billion gallons (less than the average amount of water withdrawn annually from the Gilberton Shaft during most of the 1990s), more than 4,000 pounds of lead would have been discharged annually from this pump into Mahanoy Creek and the surrounding watershed. The impact of lead discharges from the Gilberton Shaft pump on water quality standards and aquatic life in Mahanoy Creek is not being documented or assessed in the permit files for the BD Mining site and has yet to be acknowledged as even a potential problem publicly by PADEP.

The authors of this report know of no data either from monitoring points or other characterizations of mine drainage in the anthracite coal basins that indicates these lead levels are coming from anthropogenic sources such as waste disposal sites, industrial plants or anthracite mining practices in the Mahanoy Creek Watershed.

On the other hand, data from the permit leach tests on the primary ash being placed at the BD Mining site, FBC ash from the Gilberton Cogen Plant, definitely suggests a likelihood that this ash is one source if not the source of the lead in the mine pool. While laboratory leach tests like the SPLP should never be considered reliable predictors of what coal ash will do in different placement settings absent other site information, the SPLP leach test is the only means PADEP uses to assess the potential for an ash to cause water quality problems prior to its placement in a mine site. According to a data base of results from 83 leach tests on ashes compiled from PADEP minefill permits in 2000 by the US Department of Energy, the Gilberton Cogen ash leaches a high level of lead. In fact, data indicate that the Gilberton Cogen ash leaches more lead than any of the other coal ashes whose tests results are in this database. The average lead concentration leached in 12 tests on the Gilberton ash was 0.271 mg/L compared to an average lead concentration of 0.14 mg/L leached in 71 tests on other Module 25 ashes. Perhaps more telling than average leaching concentrations, the range of lead concentrations leached from the Gilberton ash was 0.128 mg/L to 0.520 mg/L compared to a range of 0.001 mg/L to 0.49 mg/L of lead leached from all of the other ashes in this data base.[2]

After ash placement began at the BD site, chromium concentrations rose also to more than twice the drinking water standard near the ash and in the mine pool further downgradient of the ash. Cadmium concentrations rose to levels 4 times higher than its DWS in MP006 and nearly 6 times higher than the DWS in MP008 in 1999. Arsenic exceeded the current DWS at three of the four monitoring points (MP005, MP007 and MP006). Arsenic levels exceeded 0.020 mg/L, more than twice the DWS, at MP007 andMP006, and arsenic was measured at 0.0631 mg/L, more than six times the DWS, at MP006 in a June 1995 sample.

These high trace element levels have occurred in water that is slightly to moderately acidic (pH of 5-6) although acidity has been declining at all three of the groundwater monitoring wells studied and alkalinity increasing or remaining static at two of these three wells. Over seventeen years since ash placement started, average lab pH remained steadily at 6 units at MP006 but has decreased from 5.4 to 4.9 units from the start of monitoring at MP007 to the latest monitoring available from MP008. The rising alkalinity and declining acidity to average concentrations below 10.0 mg/L at MP006 as well as the spikes in alkalinity at MP007 and more recently at MP008 suggest an impact to the minepool water from the FBC ash. Rises in calcium and magnesium, two well known markers for PA FBC waste coal ashes, to their highest levels at MP008 in the last two years of monitoring are further evidence of this impact. These changes in water chemistry along with the high solubility of lead in the SPLP test on the Gilberton ash and the absence of data indicating high levels of lead as a normal occurrence in anthracite mine drainage or high levels of lead coming from other human activities in the Mahanoy Creek Watershed together provide a credible basis for suspecting the lead in the mine pool under this site has come from the large volume of ash placed here.

However, without more baseline data, data from points monitoring only disturbance of culm and the coal silt on the site, and/or substantive pore water data collected from within the ash, site materials independent of the ash (if not affected by it) cannot be dismissed as a potential source of the lead in the mine pool. Indeed, most of

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[2] Cardone, Carol R. and Ann G. Kim, 2000, Assessment of Coal Combustion By-Products and Water Quality Variations at Mine Sites, U.S. Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA in Proceedings of the Use and Disposal of Coal Combustion By-Products at Coal Mines: A Technical Interactive Forum. Ed. Vories, Kimery C. and Dianne Throgmorton, U.S. Department of the Interior, Office of Surface Mining, April 10-13, 2000, Morgantown WV. www.ott.wrcc.osmre.gov/library/proceed/ccb2000/back.pdf.

the ash placed at the BD Mining site has come from culm and coal silt generated at this site from previous mining. Aside from the limestone added during combustion, the parent material for these three materials is the same anthracite coal from this area.

At the least, the high concentrations of total lead at downgradient ash monitoring points establish that the culm remining and FBC ash from burning this culm and other culm in the surrounding region is having a significant toxic impact on water quality that is reaching well beyond the boundary of the ash placement area at the BD Mining site. As at other sites, an enhanced program that monitors from more points, upgradient, downgradient and in the ash, and from points on surface waters for trace elements and other ash parameters is needed to more effectively assess the causes for toxic metal contamination in the mine pool and develop corrective remedial responses.

Permit Review 8

EME GENERATION, HOMER CITY COAL PROCESSING CORP.
(PERMIT # 32753702)

Site Summary

The Homer City Coal Refuse Disposal Site (hereinafter "EME disposal site") owned by Homer City Coal Processing Corporation is located in Center Township, Indiana County, Pennsylvania. The site is in the Conemaugh Blacklick Creek Priority Watershed 18D. Conventional (PC) fly ash and bottom ash generated by the Homer City Generating Station is disposed on a large coal refuse pile at this site. The refuse in the pile comes from coals from multiple mines that are transported to this power plant and cleaned at an adjacent washing facility.

Coal ash placement on the pile was approved in a revision to the refuse disposal permit effective September 17, 1996. The revision authorized 250,000 to 350,000 tons per year of ash to be placed on the pile to improve water quality negatively impacted by AMD from the refuse pile. Ash placement started by the beginning of 1997 and is proceeding through four different phases that have increased the height, width, and length (or "foot print") of the pile and capped older portions. The ash is placed and compacted with coal refuse. The blending of refuse with the ash is done using earth moving equipment or by pneumatic injection of ash into a hopper which is then mixed with coal refuse and spread over the permit area. The pile also serves as an ash disposal area above and beyond the amount needed for alkaline addition treatment of AMD. According to records maintained in the Harrisburg Office of PADEP, at least 2,464,815 tons of CCW have been transported to this refuse pile from 1998 through 2004. Given this tonnage does not include undisclosed volumes sent there in 1997, 2005, and 2006, the total amount of CCW deposited at the EME site is somewhat greater than this volume. Unlike other SMCRA-permitted ash placement sites, most of the EME refuse pile is underlain by a liner and leachate collection system.

According to PADEP California District Mining Office staff, coal refuse (gob) placement operations had been ongoing for many years (at least since the late 1980s) at this site before ash placement started. Thus unlike other sites in the report wherein movement of ash and gob started during roughly the same period of time, a good baseline of monitoring data reflective of impacts from gob disturbance alone on water quality (prior to 1997) exists for this site. Consequently a comparison of these data with later monitoring data after ash placement started should effectively differentiate impacts of ash from gob on water quality.

Geology

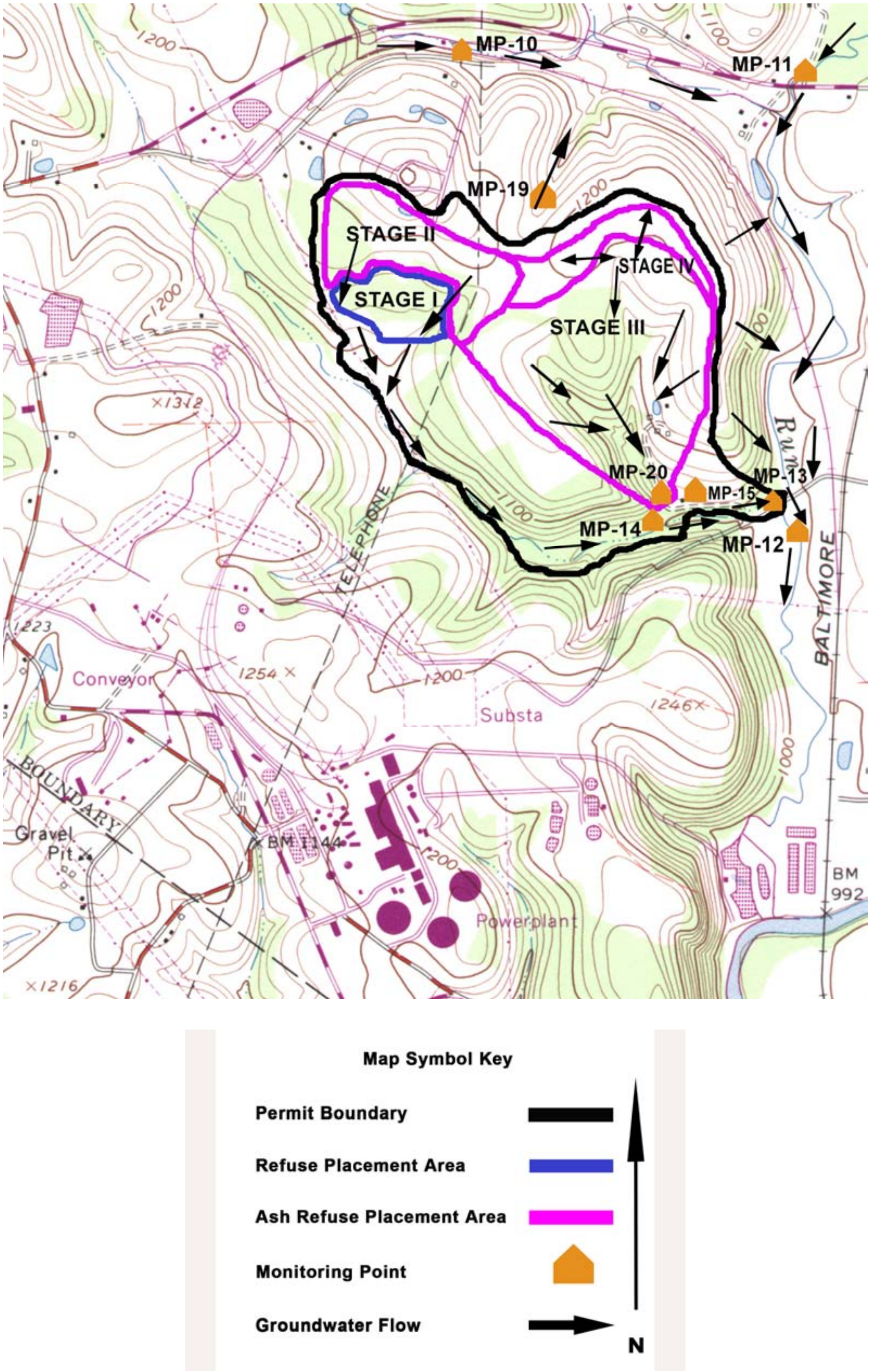
Since there are no open pits, exposed coal seams, or tunnel openings on the site, the rock types and structures have little effect on water quality relative to this assessment. Shallow groundwater flow toward the south out of a valley underneath the pile could be impacted by infiltration of leachate through breaches in the pile's liner system. Although the authors can identify no groundwater monitoring wells that would measure this infiltration, such infiltration would likely surface in the springs being monitored by MP-15 and MP-19 and in baseflow to an unnamed tributary monitored at MP-13 which points are assessed in this report.

Topography

The Homer City Coal Refuse Disposal Site is in the Pittsburgh Low Plateau physiographic province of Pennsylvania. The original topography is now buried under the coal refuse pile. Underneath the refuse was a north-south trending valley, with a small stream in the bottom that flowed south. The mouth of this valley is at about 1000 feet elevation, and the top of the natural hill, to the north, is at about 1225 feet elevation. The top of the refuse pile is flat and is 25 feet higher than the hill, at 1250 feet.

Groundwater

Virtually all of the shallow groundwater exits the pile at the original low point, where the small stream exits the valley. Since a synthetic impermeable liner has been placed on the valley floor and along its sides, the leachate from the waste pile should be isolated from the environment. Precipitation on the waste pile percolates down to the liner and then exits into a lined sedimentation pond in the valley south of the refuse pile. Water then evaporates from this pond, and is also withdrawn from it periodically for use at the coal washing facility and power plant. Presumably such withdrawals prevent overflows from occurring from the pond into the unnamed tributary that drains this valley into Cherry Run.



EME Generation, Homer City Coal Processing Corp. (Permit # 32753702)
Scale: 1” = Approximately 1200’

Monitoring Data: Discussion

Eight monitoring points, one monitoring well, six surface water monitoring points, and a leachate collection point have been selected for this assessment, and their locations were taken from the Environmental Resource Map, drawing number E-744-3013, in the EME permit (Permit #32753702). The surface water points monitor three stream sites, a sediment pond, a seep and a spring and a leachate collection pipe. There are multiple locations given on different maps for two of the monitoring points, MP-19 and MP-20. Seven of these locations were confirmed verbally with PADEP personnel at the California District Office on September 1, 2005, and the eighth point (MP-19) was confirmed by extrapolating from latitude and longitude coordinates provided in monitoring reports. The locations of three of these that are designated ash monitoring points are also described in the text of the Module 25 in the permit.

MP-10 is a designated upgradient monitoring well that is northwest of the Phase III/IV disposal area (see map for monitoring locations). MP-11 is the upstream sampling point on Cherry Run, northeast of the permit site, and MP-12 is the downstream Cherry Run sampling point located south of the disposal area. MP-13 samples an unnamed tributary discharge that flows east from the disposal pile into Cherry Run, upstream of point MP-12 and downstream of MP-11. MP-14 samples the surface of the leachate pond that collects runoff and leachate from the Stage III and IV portions of the disposal pile.

MP-15, MP-19 and MP-20 are identified as Module 25 ash monitoring points and thus provide data for trace metals and other ash parameters such as calcium, magnesium and chloride not collected from the other monitoring points. MP-15, just southeast of the pile's Stage III/IV disposal area, is at the end of a collector pipe that carries water from a spring and an underdrain that collects groundwater from beneath the eastern portion of the disposal pile liner. MP-19 is a seep from "unconsolidated overburden" in "the upstream reach of the natural drainage swale that lies northeast of the Stage I/II disposal area, north to northwest of the Stage III/IV disposal area and south of the Baltimore and Ohio Railroad embankment." (MODULE 25/PERMIT AMENDMENT – REVISION 2 PROPOSED BENEFICIAL USE OF COAL ASH, July 1996, pages 25-26 & 25-27) MP-20 "represents a composite of discharges from the three (3) Stage I/II underdrain outlet pipes, and provides a monitoring point analogous to location 15 at the Stage III/IV disposal area." (MODULE 25, page 25-27) These three monitoring points were selected "to evaluate water quality changes possibly related to the placement of fly ash in the HCCPC disposal facility" (MODULE 25, page 25-26) and are considered downgradient of ash placement operations in the three Stages of the pile where ash has or is being placed (II, III and IV). Data from MP-20 measuring the quality of leachate generated by the older Stage I and II sections of the pile, is discussed to a lesser extent as it was not assessed until the final drafts of this report**.**

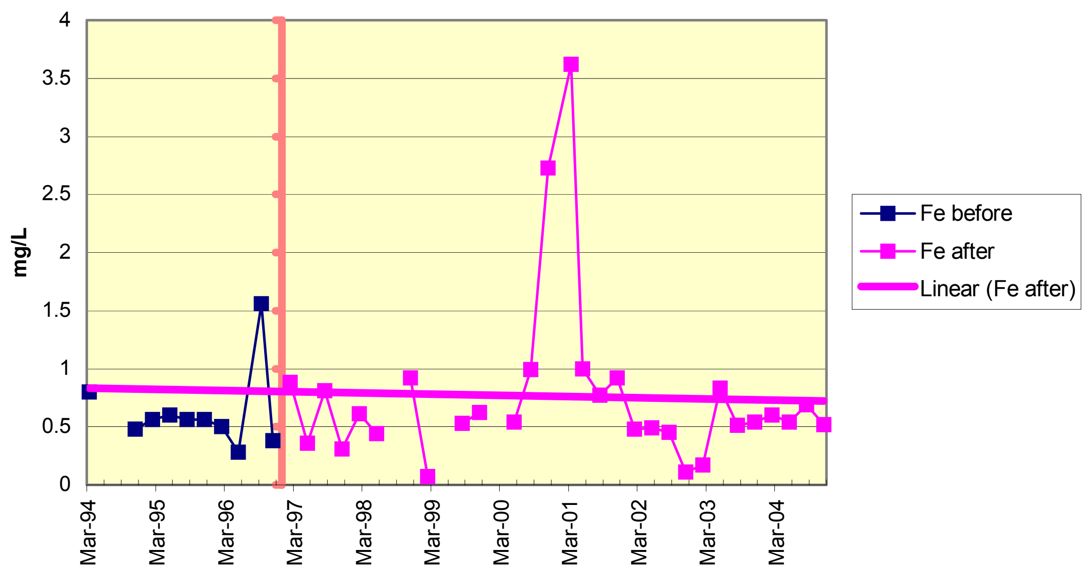
All of the above monitoring points contain concentration data from 1994 to 2004, and points MP-11, MP-12, MP-13, and MP-14 additionally have loading data. The data for these monitoring points have only minor gaps during very dry periods. As in the other reviews, the time period on the graphs to the left of the vertical red line is referred to as the baseline period. The trend lines in the following discussion usually represent behavior of a certain element *after* ash placement starts although graphs of data from MP11, MP12, and MP13 include trend lines for concentrations and loads measured during baseline periods. These lines allow a closer look at trends at monitoring points in the key positions measuring offsite impacts to water quality from the refuse pile on Cherry Run.

MP-10 (Upgradient Monitoring Well)

Figures 8.1, 8.1a and 8.1b are graphs of concentration data from the upgradient monitoring well MP-10. Figure 8.1 represents iron, 8.1a represents manganese, and 8.1b represents aluminum over time. After ash placement, iron and aluminum have a slightly decreasing trend, and manganese has a trend that is inceasing albeit very slightly. The concentrations of iron and manganese are consistently greater than their federal secondary and Pennsylvania drinking water standards (hereinafter DWS) of 0.3 mg/l and 0.05 mg/l, respectively. Concentrations of aluminum are on average greater than the DWS of 0.2 mg/l. Although many of the concentration values are above the drinking water standards, they do not reflect badly degraded water. The trends indicate that the levels of iron and aluminum are slowly improving with time while manganese (figure 8.1a) may be slightly worsening. There was a significant temporary increase in concentration during early 2001 in all three of these constituents.

The sulfates (figure 8.2) have a decreasing trend after ash placement, and average concentrations are less than a tenth the DWS of 250 mg/L.

Figure 8.1 32753702 MP-10 EME Generation Iron



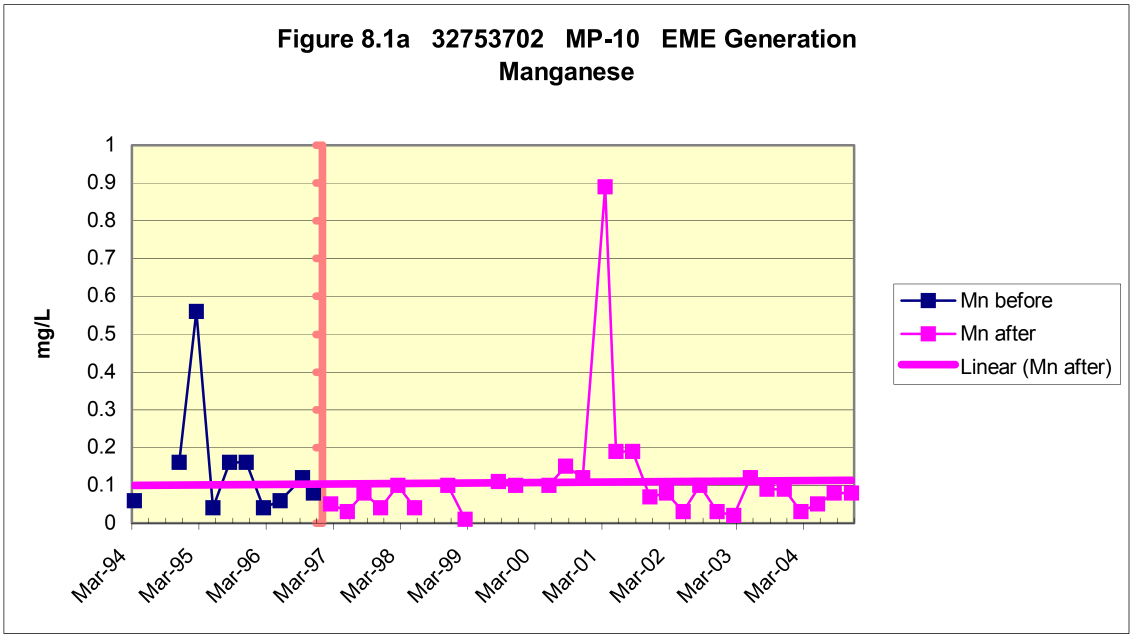


Figure 8.1a 32753702 MP-10 EME Generation
Manganese
mg/L
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Mn before
Mn after
Linear (Mn after)

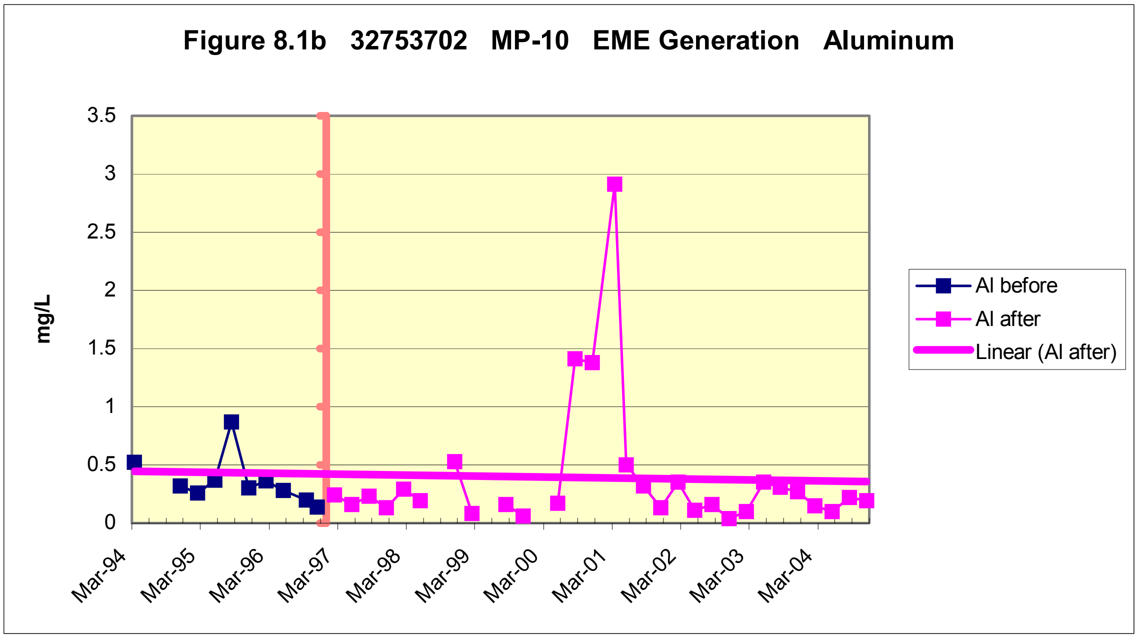
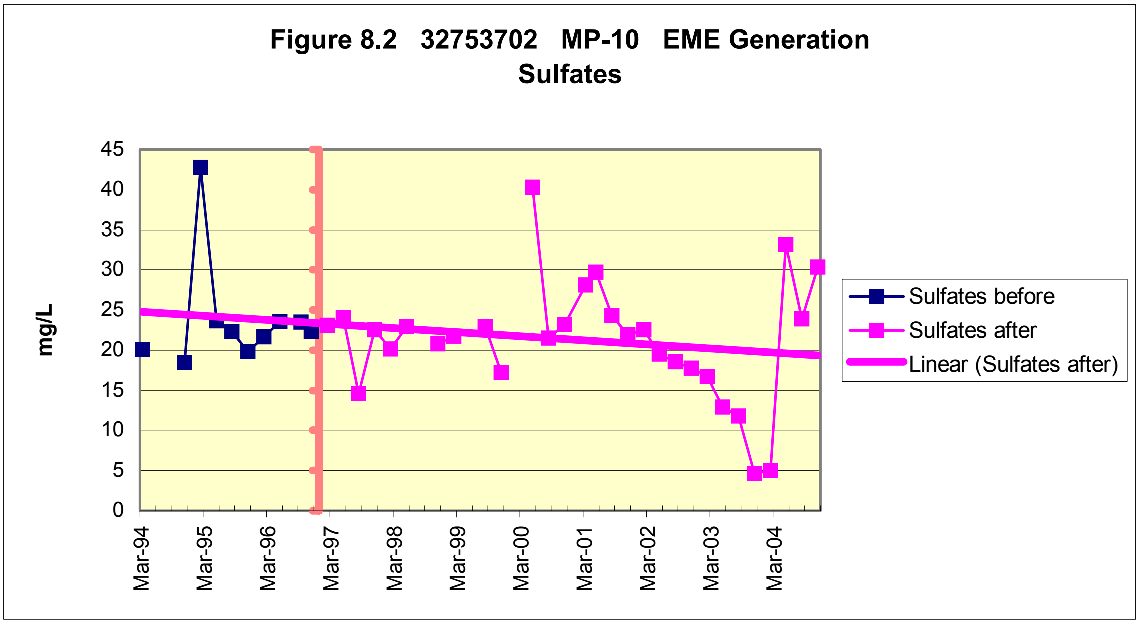


Figure 8.1b 32753702 MP-10 EME Generation Aluminum
mg/L
3.5
3
2.5
2
1.5
1
0.5
0
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Al before
Al after
Linear (Al after)



The alkalinity and acidity concentrations for MP-10 (figure 8.3) are almost mirror images of each other with alkalinity values falling slightly over time. The average concentration of alkalinity is between 70 and 80 mg/l throughout the monitoring period, while the average concentration for acidity remains flat at approximately –65 mg/L indicating alkaline conditions. The acidity and alkalinity concentrations at MP-10 are relatively low with few fluctuations, suggesting a comparatively stable groundwater environment.

The pH of the groundwater from MP-10 (figure 8.5) is within the neutral range, varying from 7.1 to 7.5. The general trend is of a slightly increasing pH. .

All of the pH measurements used for this report are those taken in the field, as these numbers best represent conditions of groundwater in its natural setting. Laboratory pH numbers may be slightly more accurate, due to more sophisticated instrumentation (laboratory pH meters vs. portable apparatus used in field measurements), but pH changes during sample transport to the lab probably offsets this accuracy advantage of the lab. In general, the trends of field pH parallel those of laboratory Ph in the data for this site.

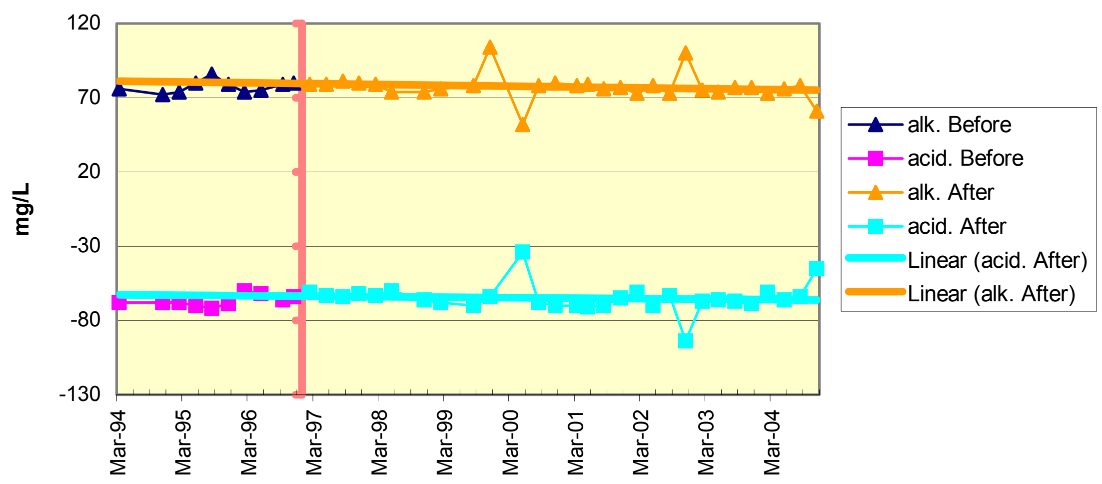


Figure 8.3 32753702 MP-10 EME Generation Alkalinity & Acidity

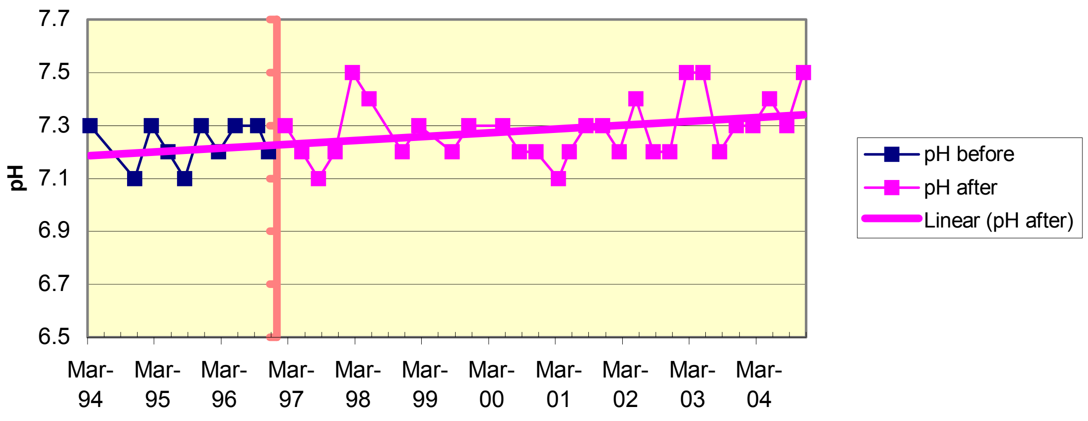


Figure 8.5 32753702 MP-10 EME Generation pH

MP-11 (Upstream Monitoring Point)

MP-11 monitored surface water in the upstream portion of Cherry Run. None of the dissolved material in the water at this point originated from the EME disposal site, and any concentration or loading trends were expected to be a result of mining or other activity upstream of the site.

Figures 8.9, 8.9a and 8.9b are charts of iron, manganese, and aluminum concentrations over time. Similar to MP-10, the trends of the three metals are decreasing with time. Their impact at this monitoring point should be assessed in terms of water quality standards (also known as “criteria”) under the Clean Water Act instead of DWS under the Safe Drinking Water Act given the surface waters this point is monitoring. The concentrations of the three metals vary above and below the applicable Pennsylvania ambient water quality criteria (AWQC) for surface water of 1.00 mg/L for iron, 0.1 mg/L for manganese, and 0.750 mg/L for aluminum. Manganese concentrations are consistently greater than the Pennsylvania AWQC. In comparison to MP-10, iron concentrations and trend are similar, but manganese and aluminum concentrations are generally slightly greater.

Figure 8.9 32753702 MP-11 EME Generation Iron

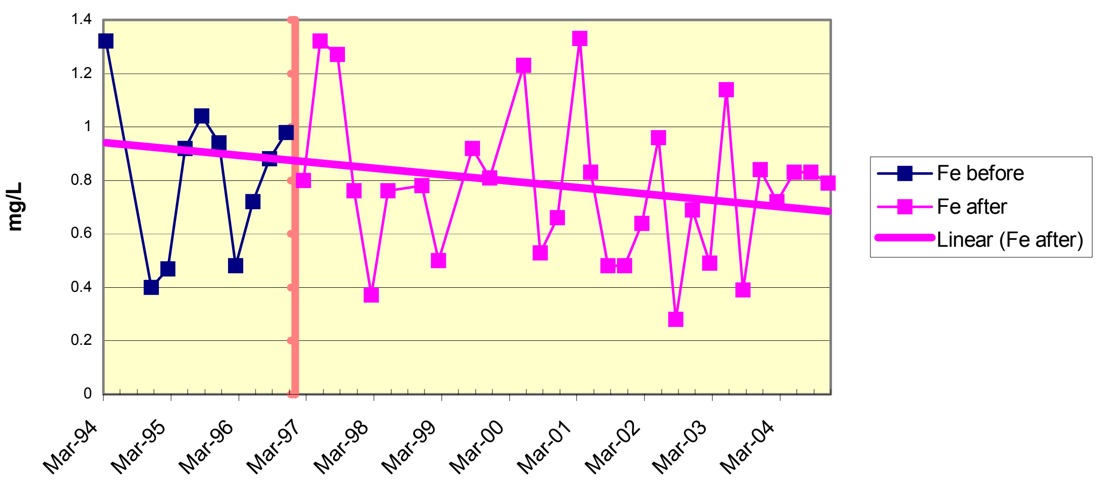
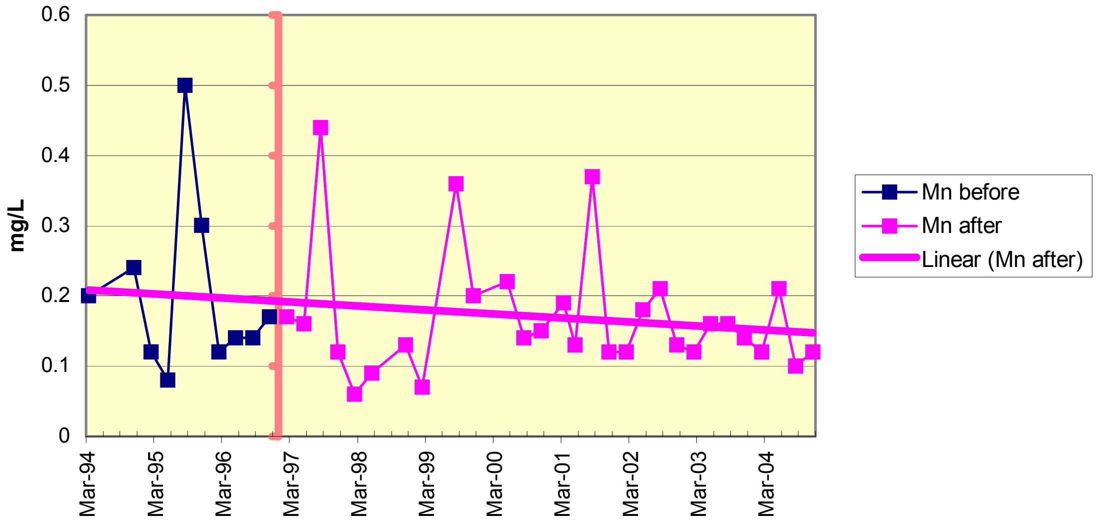
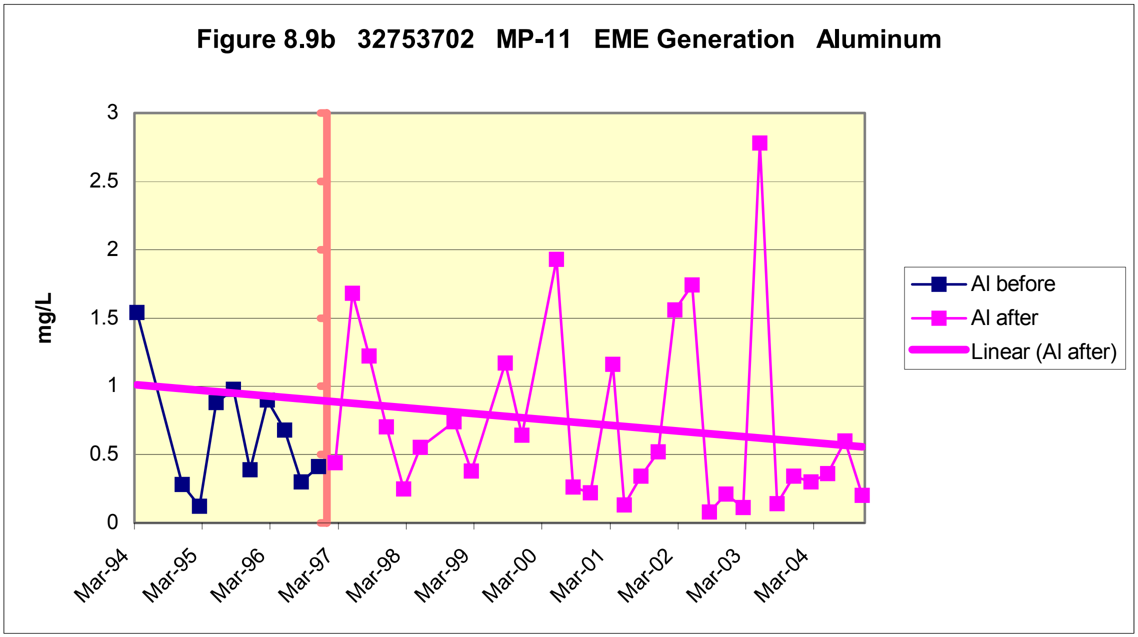
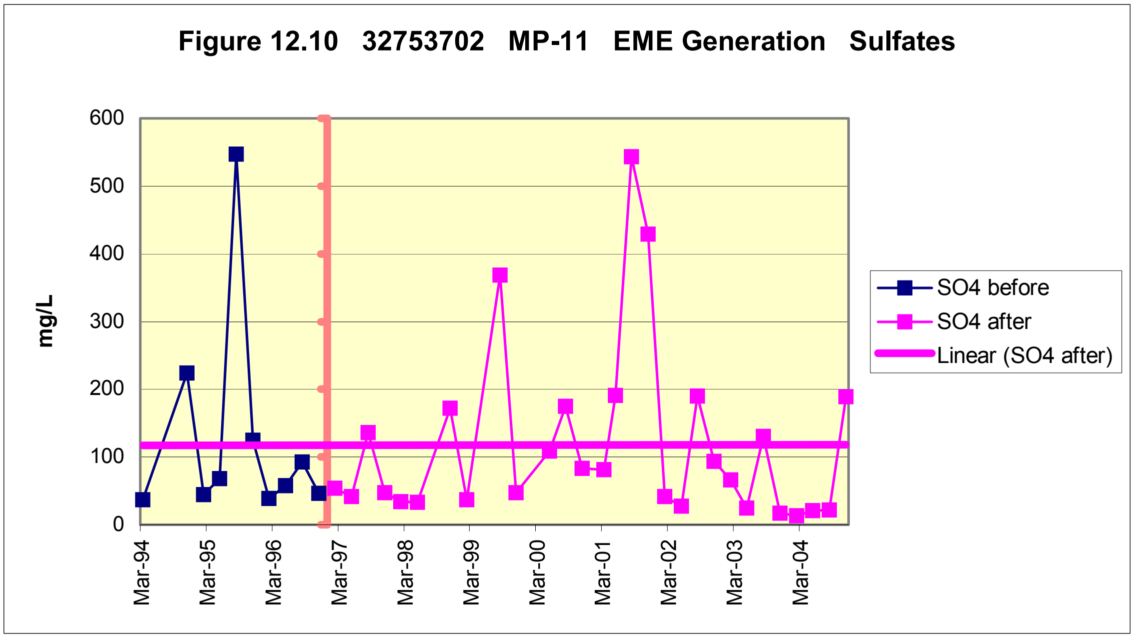


Figure 8.9a 32753702 MP-11 EME Generation Manganese





The sulfate concentration plot (figure 8.10) has a flat trend although its average concentration of 117 mg/L is approximately 5 times the average sulfate in the groundwater at MP-10, and the range of sulfate concentrations at the surface waters of MP-11 are far greater, from 13.6 mg/L to 543 mg/L. With the exception of three measurements, all concentrations are below the AWQC of 250 mg/L.



Alkalinity and acidity are shown in figure 8.11 with the average alkalinity trend gradually increasing and the acidity trend flat.

The behavior of pH (figure 8.12) is similar to alkalinity, with a slow average rise. The pH values are within the neutral range, but three values have been less than 7.0 (as low as 6.3 in March 1994) and the most recent measurement was the highest at 7.6.

The alkalinity, acidity, and pH data sets suggest an upstream source of ash, alkaline rock layers, or other factors contributing to an alkaline environment. There are few limestone beds that are thick enough upstream to make any significant contribution to alkalinity. Some of the local sandstones in the Middle Conemaugh Group, which are exposed in the area, are naturally cemented with calcite and may be responsible for the alkalinity trends.

Figure 8.11 32753702 MP-11 EME Generation
Alkalinity & Acidity

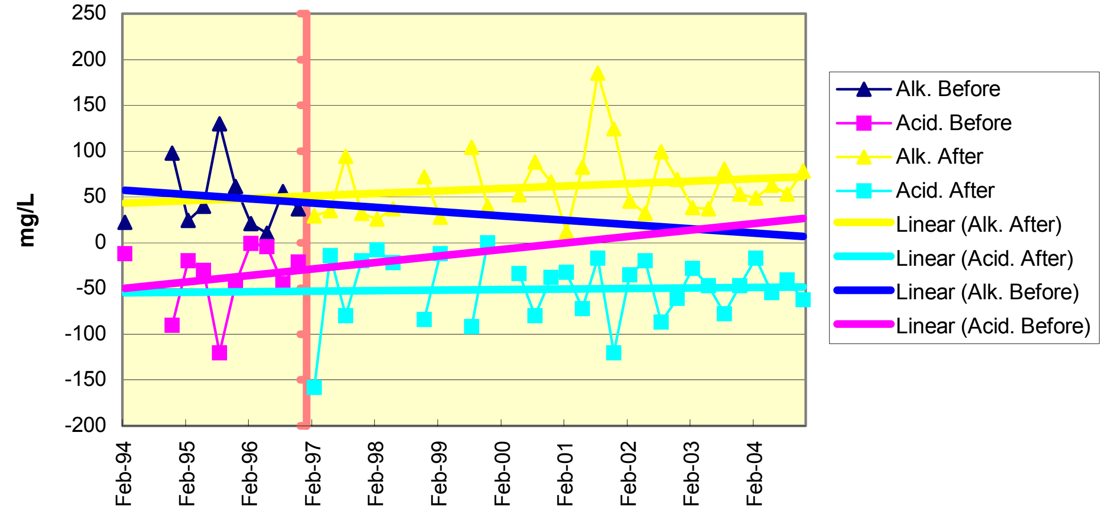
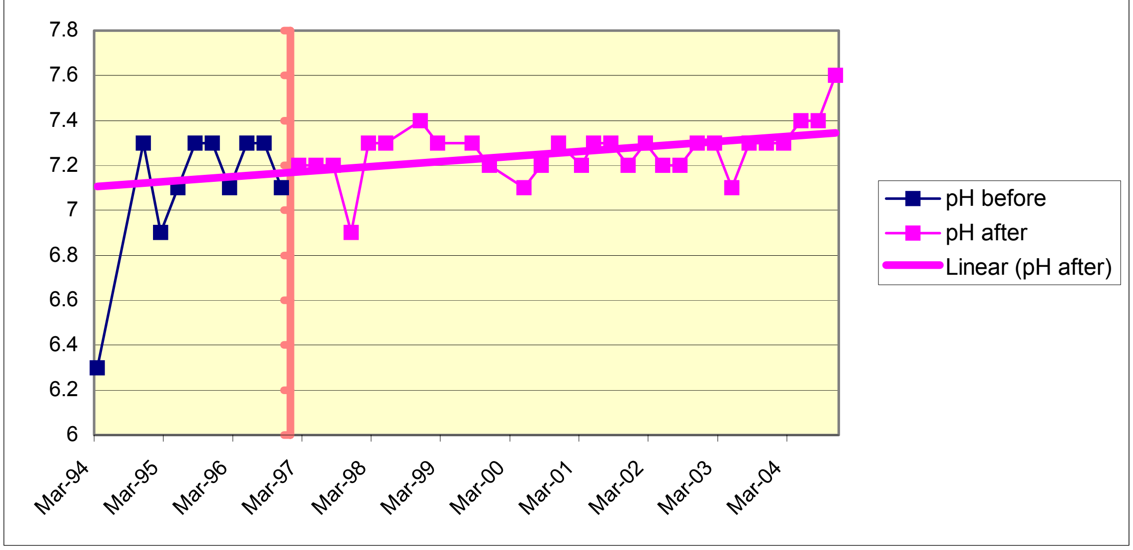


Figure 8.12 32753702 MP-11 EME Generation pH



The stream flow at MP-11 is graphed as gallons per minute (GPM) versus time in figure 8.15. The strong decline in average flow volume after 1996 can only be explained by local weather patterns and is corroborated by regional climate data maintained at Penn State University, which shows that annual precipitation amounts have declined significantly in this part of Pennsylvania from the first half of the 1990s (1990-1996) to the later 1990s and early 2000s (1997-2002) (See www.climate.met.psu.edu/data/state.php.) The details of this decline are described in Chapter 2, page . After a drop from flow levels that averaged 1545 GPM in the first half of the 1990s, the trend of stream flow exhibits a gradual increase from an average of approximately 500 GPM in February 1997 to an average of 617 GPM in November 2004.

Figure 8.16 shows the loading trends of dissolved iron in Cherry Run. The amount of iron Cherry Run carries has slightly increased over time after the baseline period from about 5 to 6 lbs/day presumably due to the slight increase in stream flow. The loading, expressed in pounds per day (lbs/day), was calculated by multiplying the flow by iron concentration by a coefficient of 0.012 used in PADEP's permitting procedures:

Loading (lbs/day) = *Concentration* (mg/L) x *Flow* (gallons per minute) x 0.012

The sulfate loading (figure 8.17) also has a gradually increasing trend from approximately 500 lbs/day at the beginning of ash placement on the refuse pile to an average of 549 lbs/day by the latest monitoring data assessed in November 2004. This upstream loading and concentration data can be compared to downstream loading data to gauge the effect of any leachate contribution from the EME site.

Figure 8.15 32753702 MP-11 EME Generation
Stream Flow (GPM)

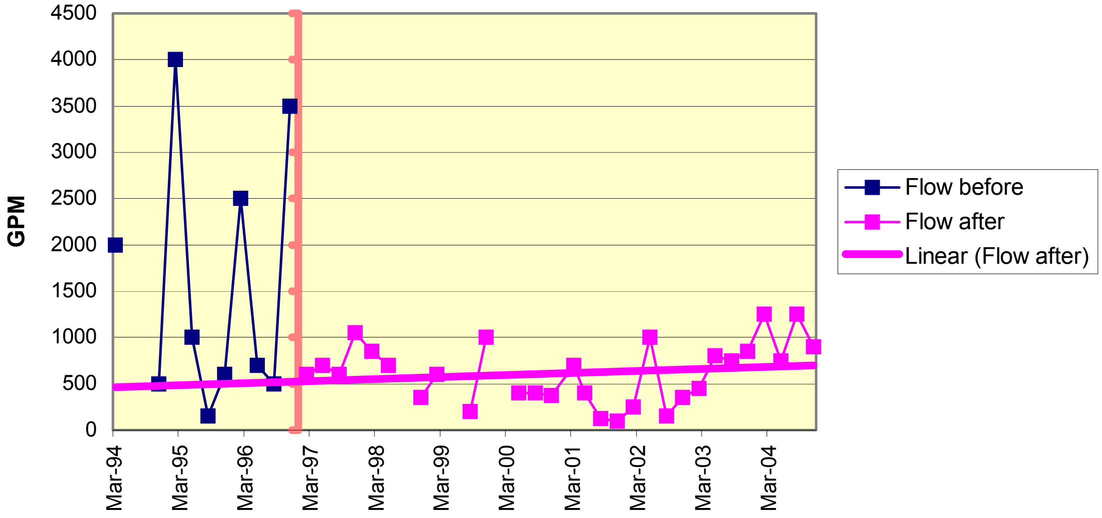


Figure 8.16 32753702 MP-11 EME Generation
Iron Loading

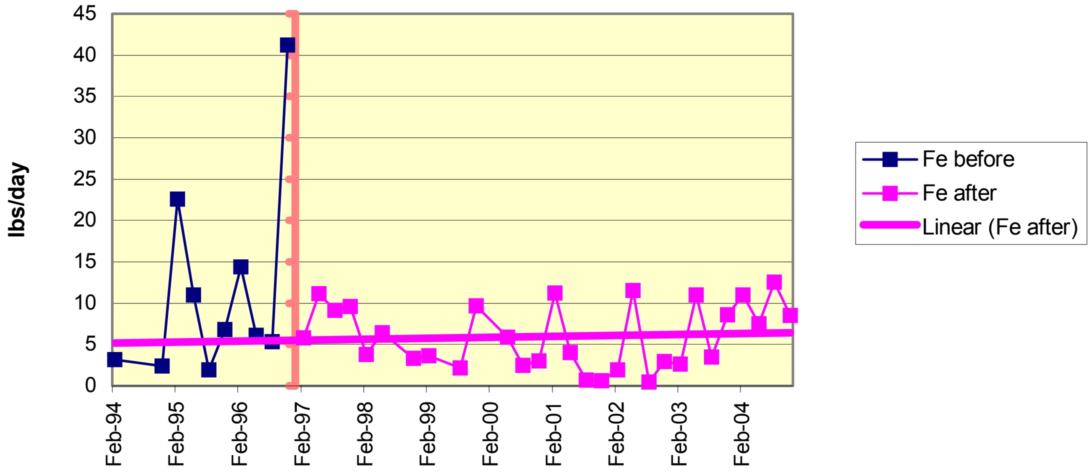
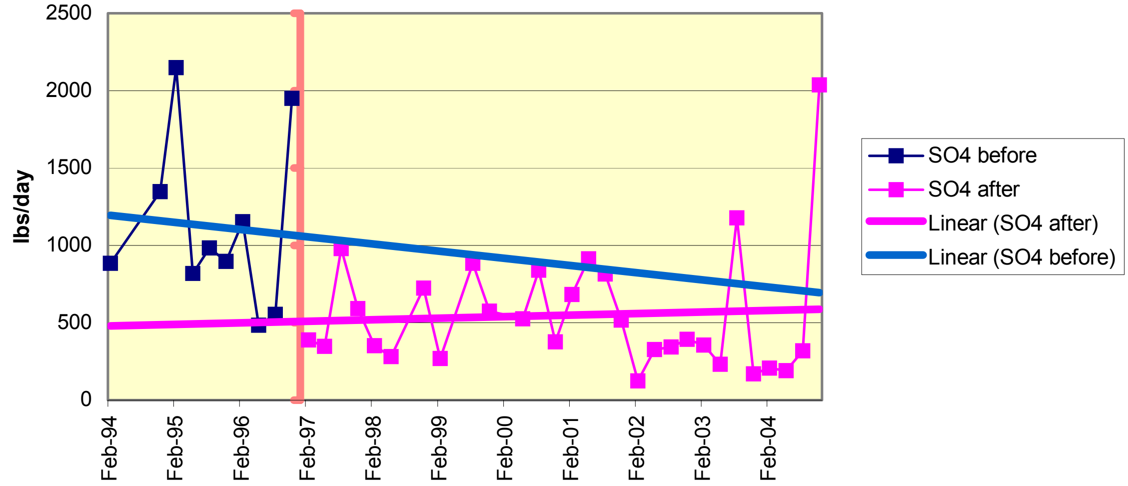


Figure 8.17 32753702 MP-11 EME Generation
Sulfate Loading



MP-12 (Downstream Cherry Run)

MP-12 is monitoring the waters of Cherry Run, downstream of the EME disposal site. The data at this point should reflect the amount of contamination leaving the EME disposal site and entering the stream.

Figures 8.20, 8.20a and 8.20b are plots of iron, manganese, and aluminum concentrations over time. Their concentrations were in the same range as concentrations measured at MP-11 and had decreasing average trends after ash placement commenced although the seven highest iron concentrations occurred during ash placement, and the trends for manganese and aluminum were decreasing at a slightly higher rate before ash placement than after ash placement. Furthermore soon after ash placement started, aluminum concentrations rose sharply up to 2.34 mg/L in August 1997. During 2001 and 2003, aluminum fluctuated between three spikes in concentration that surpassed 1.5 mg/L. Before ash placement, the highest aluminum value was 1.39 mg/L. The AWQC for aluminum is 0.750 mg/L.

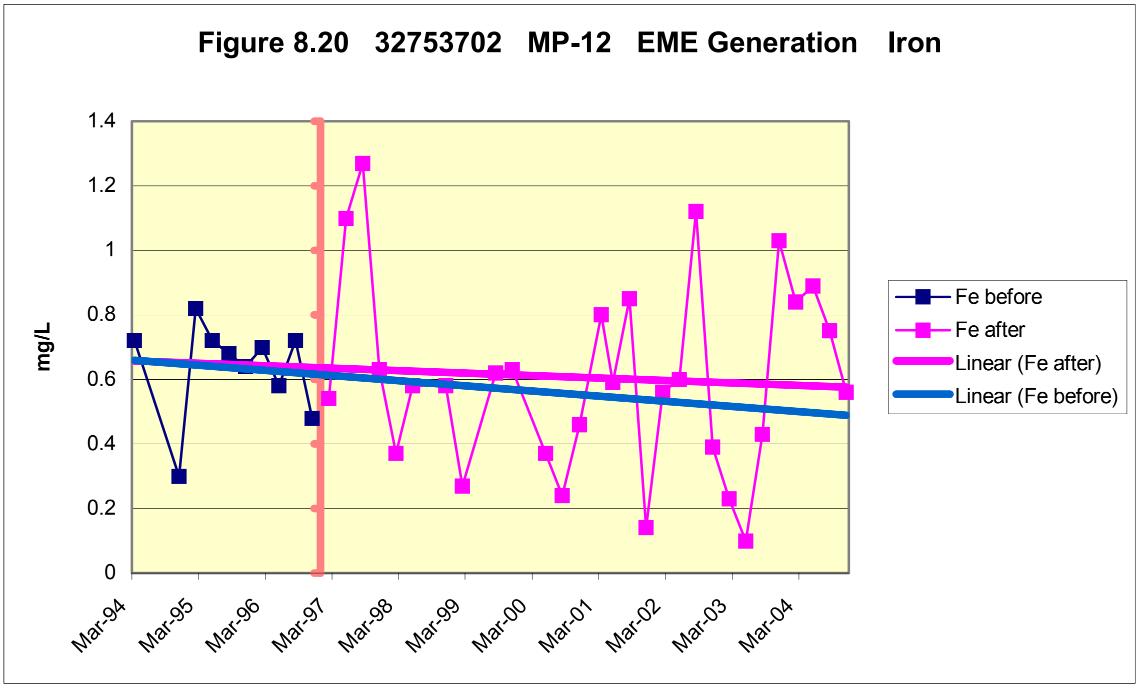


Figure 8.20 32753702 MP-12 EME Generation Iron
mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Fe before
Fe after
Linear (Fe after)
Linear (Fe before)

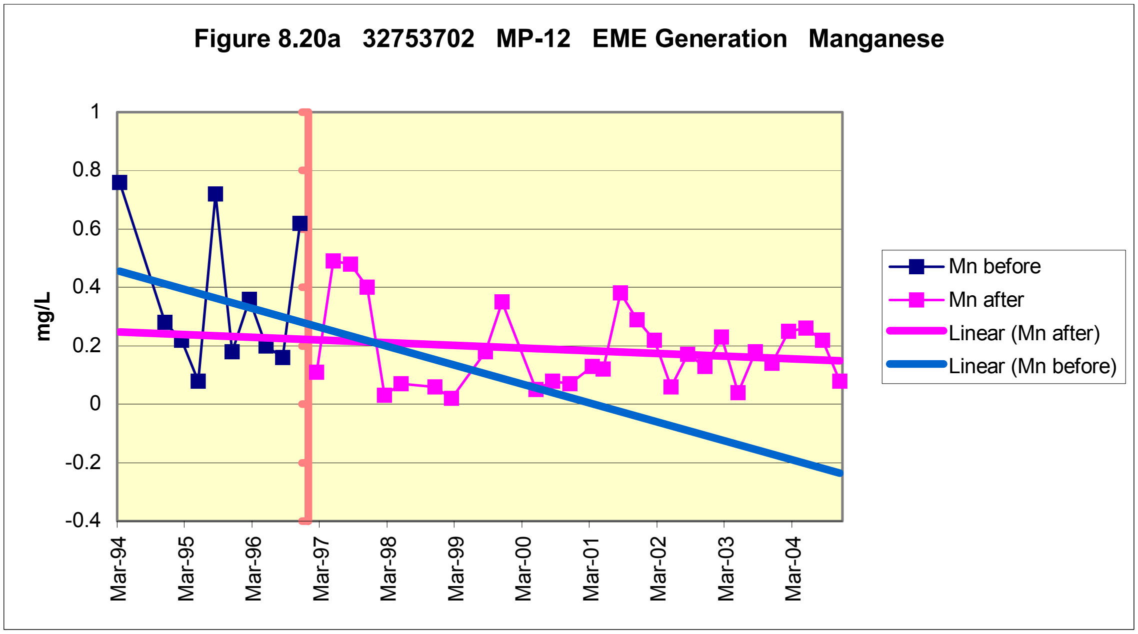
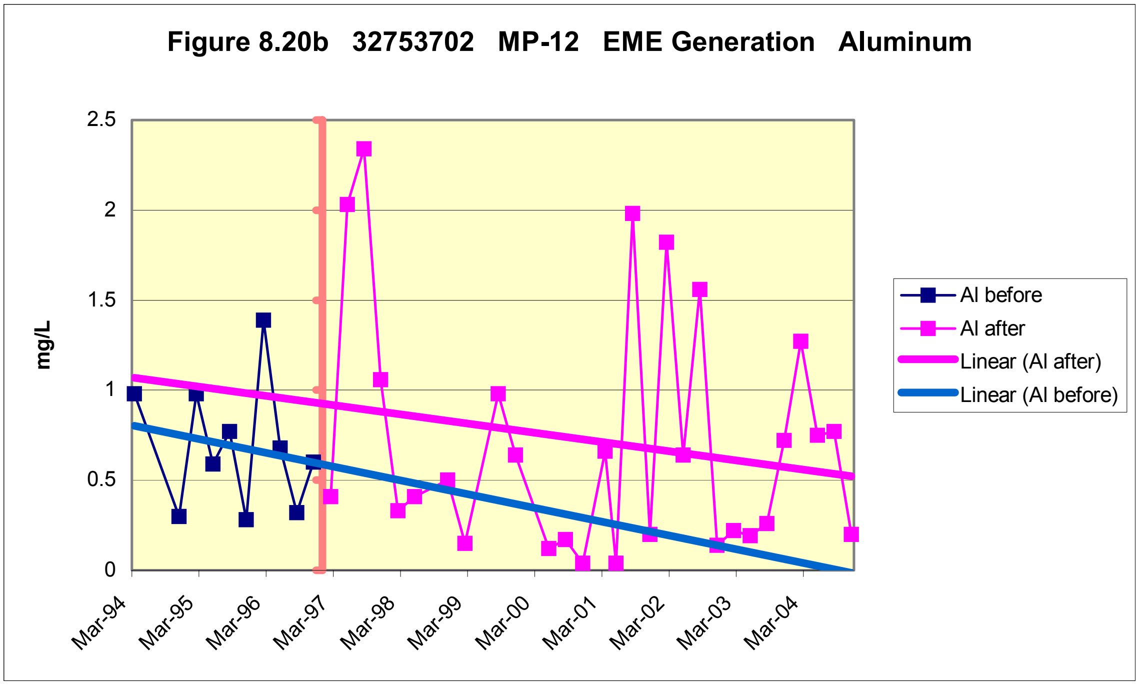


Figure 8.20a 32753702 MP-12 EME Generation Manganese
mg/L
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Mn before
Mn after
Linear (Mn after)
Linear (Mn before)



In contrast, sulfate concentrations at MP-12 rose significantly after ash placement started (figure 8.21) from usually potable levels during baseline monitoring with an overall average of 225 mg/L to an overall average after ash placement of 255 mg.L and a final average measurement of nearly 400 mg/L. The overall average at MP-12 during ash placement was more than twice as high as the overall average sulfate at MP-11 (118 mg/L), and the trend in average sulfate concentrations was not rising at MP-11. Furthermore from early 2000 on sulfate levels at MP-12 oscillated more widely with eight measurements substantially exceeding the standard for potability (250 mg/L -- also known as the secondary drinking water standard under the federal Safe Drinking Water Act). The highest of these was 1655 mg/L nearly seven times the potability standard in November 2001 and the second highest was 887 mg/L in August 2001, 3.5 times this standard. The water quality standard for sulfate in Pennsylvania surface waters is equivalent to the potability standard and applies at the point of a water supply intake. Before ash placement, the sulfates showed a decreasing trend, whereas following placement an increasing trend is observed, suggesting the ash as the cause for rising concentrations. If the rise in sulfate concentration was due to AMD, the iron and manganese values would likely rise as well. However, iron and manganese did not rise at MP-12.

Furthermore although the trends were relatively small, after ash placement started, acidity stopped increasing and started decreasing at MP-12, while alkalinity stopped decreasing and started increasing (figure 8.22). Also pH had a gentle rising trend (figure 8.24), indicating an alkaline contribution from ash placement. While these trends in acidity and alkalinity and pH are not that different than the trends upstream at MP-11, the clear rise in sulfates nonetheless is taking place amidst a decline in acidity. Coupled together, these data strongly suggest that the ash is causing the adverse rise in sulfates in Cherry Run at MP-12.

Figure 8.21 32753702 MP-12 EME Generation
Sulfates

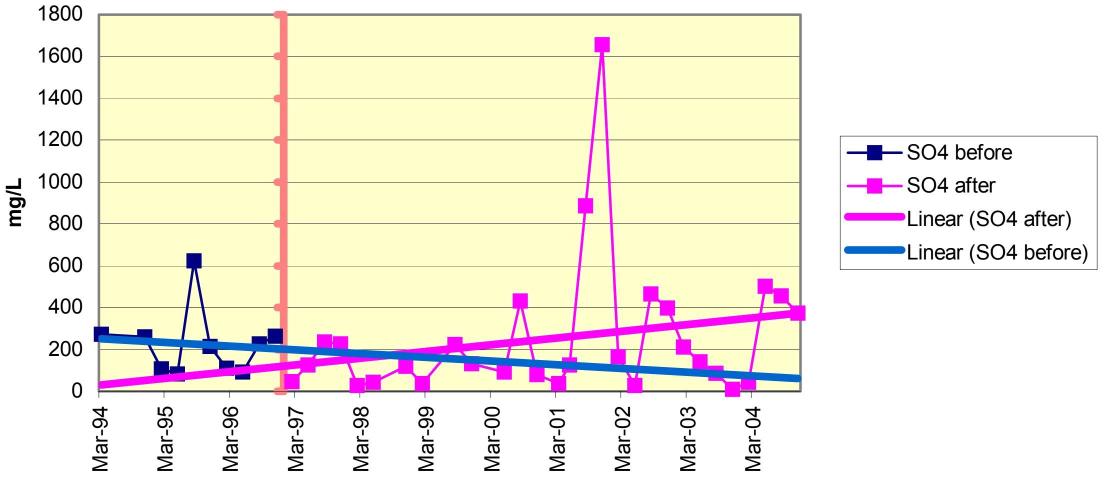


Figure 8.22 32753702 MP-12 EME Generation
Acidity & Alkalinity

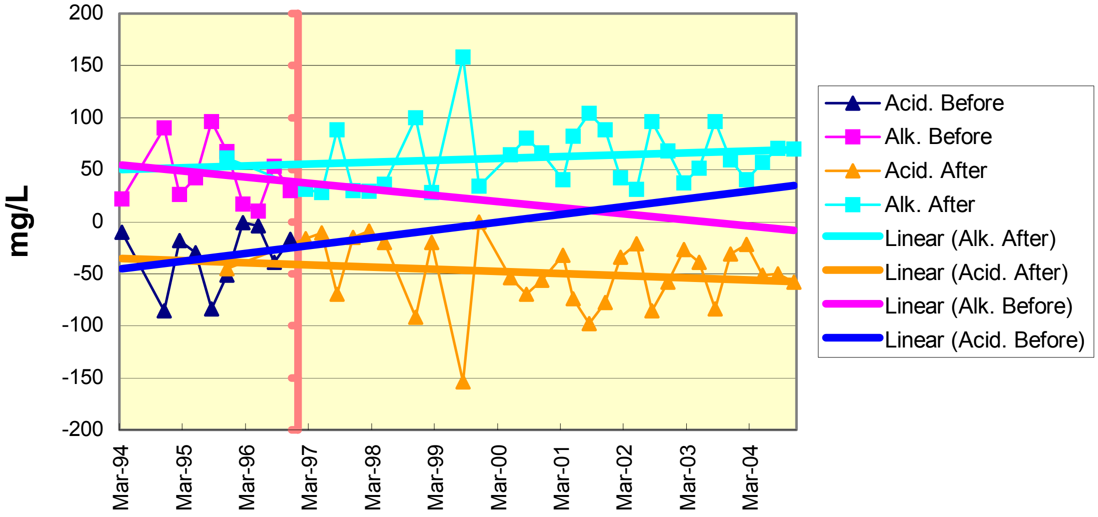


Figure 8.24 32753702 MP-12 EME Generation pH

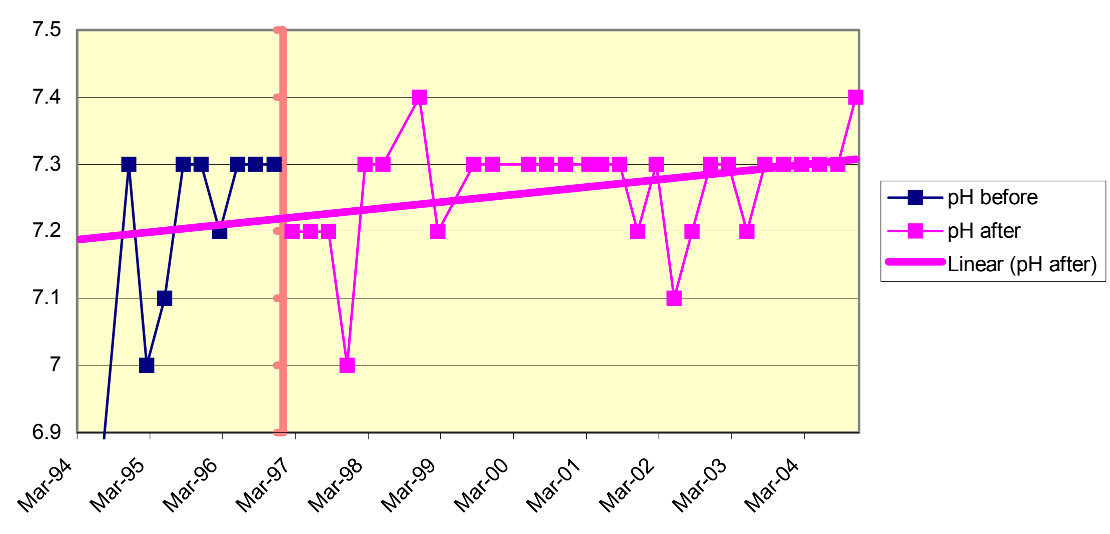


Figure 8.25 shows the stream flow for point MP-12 was about one fourth again larger in volume than the flow at MP-11 (see figure 8.15) yet rising in the same very gradual pattern after ash placement from an average of approximately 700 GPM in February 1997 to an average flow of 821 GPM in November of 2004. This increase also occurred after a significant initial drop from baseline flows recorded at MP-12 which had an overall average volume of 2070 GPM and four volumes that were 2 to 3 times the highest volumes recorded at MP-12 during the ash placement period.

The iron loads (figure 8.26) at MP-12 followed the flow volume closely and barely rose from loads measured upstream at MP-11, increasing to between 13 and 15 lbs/day in 2003 and 2004 (vs 10-12 lbs/day at MP-11), indicating that the EME disposal site is not adding much if any iron to the stream.

Figure 8.25 32753702 MP-12 EME Generation
Stream Flow (GPM)

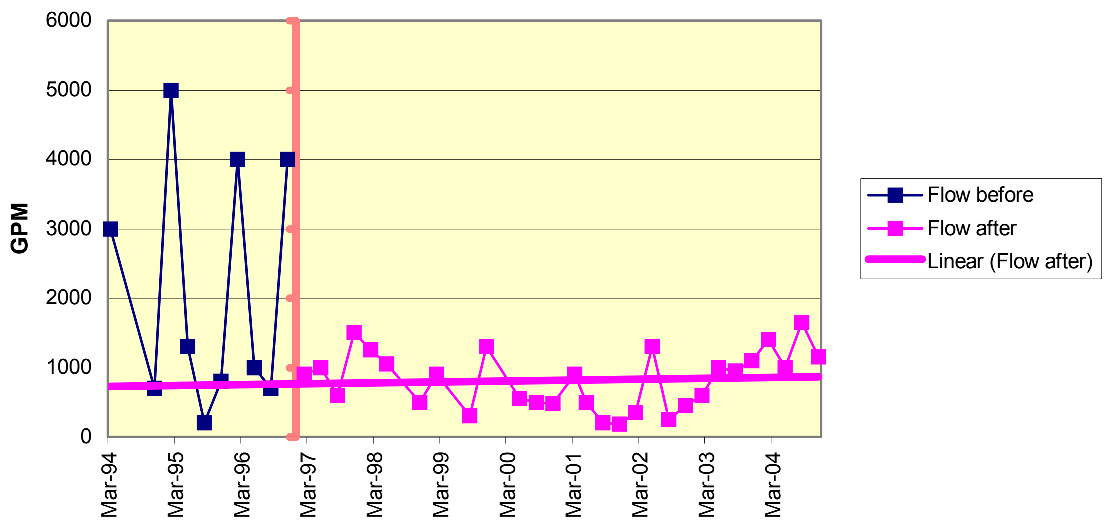
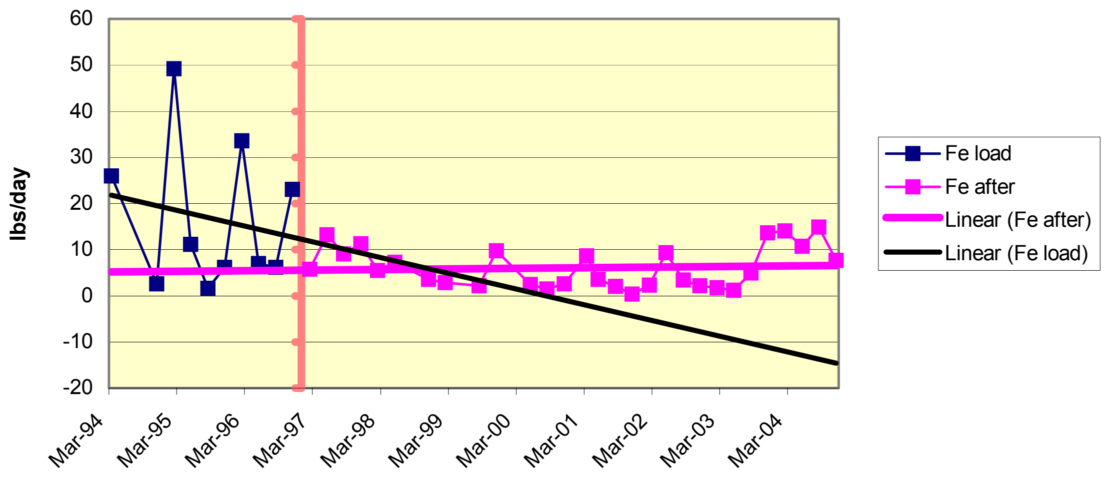
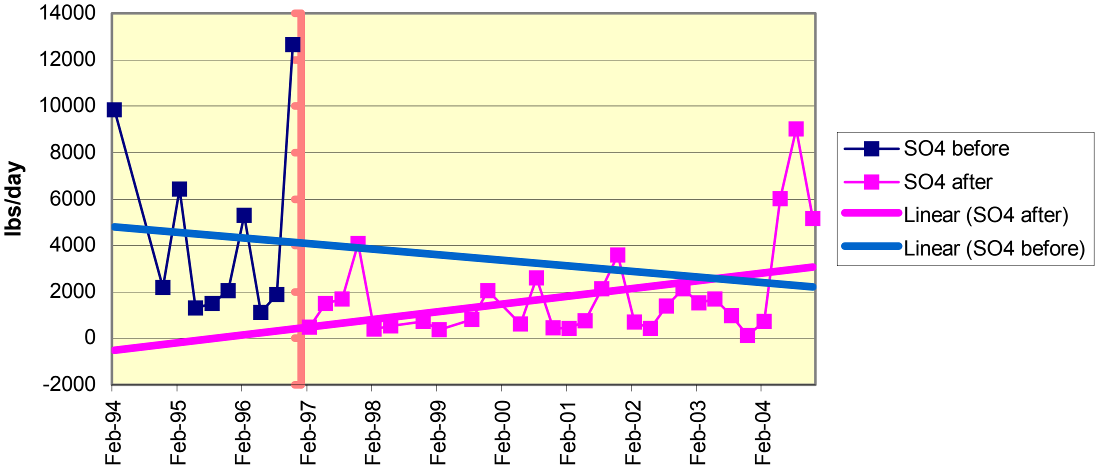


Figure 8.26 32753702 MP-12 EME Generation
Iron Loading



In contrast, the sulfate loading data (figure 8.27) showed a steadily increasing average trend once ash placement started. Average loading at MP-12 increased from about 490 lbs/day at the beginning of ash placement to 3000 lbs/day by the latest measurement with an overall average of 1830 lbs/day during ash placement and a peak measurement of 9018 lbs/day recorded in August 2004. The upstream average loading for sulfate started at 500 lbs/day at the beginning of ash placement and increased to 549 lbs/day by the latest measurement. This indicates an average influx of about 2451 lbs/day of sulfate into Cherry Run between MP-11 and MP-12 in 2004. With only a 25% increase in average flow volume between these monitoring points during this period, the increase in average sulfate loads from MP-11 to MP-12 by more than five times suggests that the EME disposal site and/or other points downstream of MP-11 are contributing significant amounts of sulfate into this stream. Dramatically rising concentrations of sulfate at MP-13 (see figure 8.31) indicate that the refuse and ash pile is the source of the problem.

Figure 8.27 32753702 MP-12 EME Generation
Sulfate Loading



MP-13 (Tributary Monitoring Point)

MP-13 monitors a small tributary that flows eastward from the disposal site into Cherry Run, upstream of MP-12 and downstream of MP-11. The tributary thus serves as a major route for contaminant flow from the refuse pile into Cherry Run.

Figures 8.30, 8.30a, and 8.30b are graphs of iron, manganese, and aluminum concentrations over time. The average trend of each metal is decreasing after ash placement, even though there was a large amount of fluctuation during ash placement and rises in all three elements in the last year of monitoring.

After an initial measurement of 1.89 mg/L, iron concentrations fall generally below the AWQC of 1.00 mg/L until the last year of monitoring when they rise to levels as high as 1.22 mg/L (in February 2004). Although these iron concentrations are slightly higher than those at MP-12 and slightly below those at MP-11, the decline in iron at MP-13 has resulted in a steeper decline in average concentrations (i.e. a steeper declining trend line) at this point than at MP-11 or MP-12

Manganese concentrations also undergo a decline from initial levels more than 10 times the Mn AWQC of 0.1 mg/L in 1997 and 98 and then rise again to their highest level in February 2004 of 2.7 mg/L. Nonetheless even during this decline, all but one measurement for Mn remained above the AWQC. While there is some overlap in the range of concentrations, the average concentrations of manganese at MP-13 are generally three or more times greater than manganese levels at either MP-11 or MP-12.

The highest measurement for aluminum occurs initially in a spike to 6.3 mg/L in March 1997. Aluminum levels then decline to measurements mostly below the AWQC of 0.750 mg/L from 1999 through 2003 before rising to between 1 and 5 mg/L throughout 2004. The levels of aluminum measured before and after this decline are 2-3 times higher than the highest aluminum measured at MP-11 or MP-12.

Figure 8.30 32753702 MP-13 EME Generation Iron

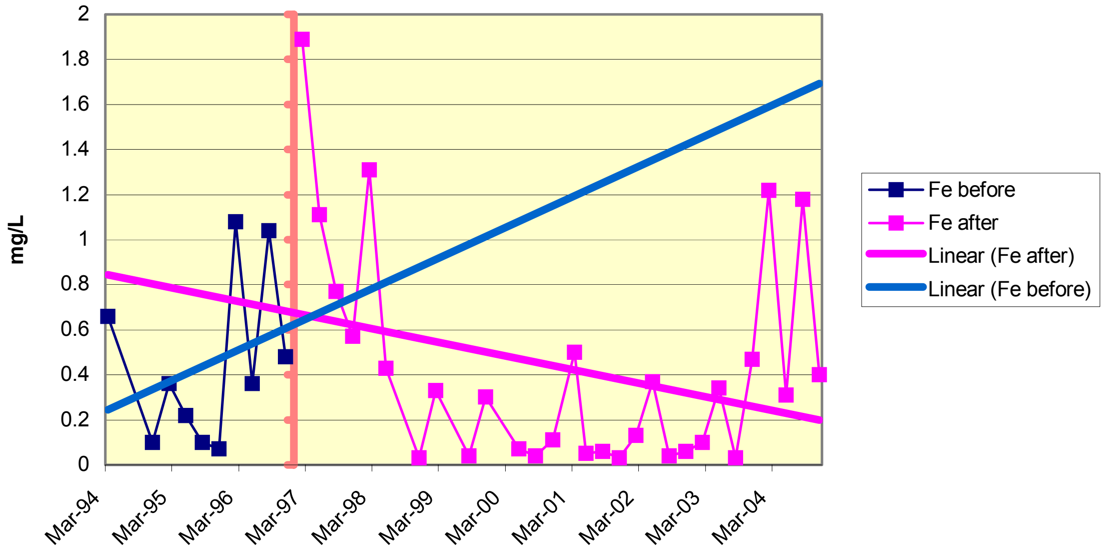


Figure 8.30a 32753702 MP-13 EME Generation Manganese

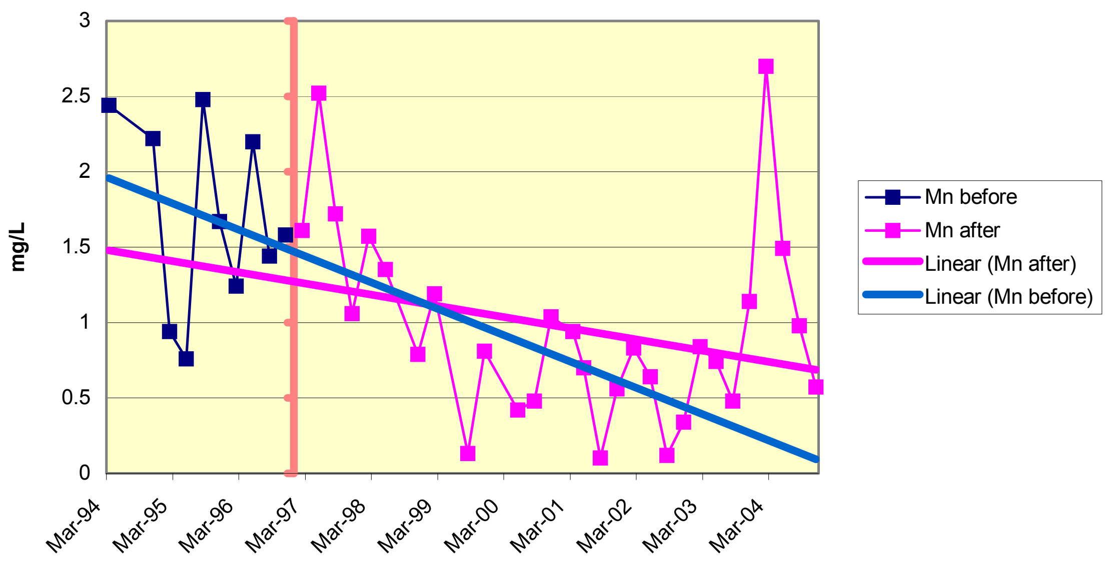
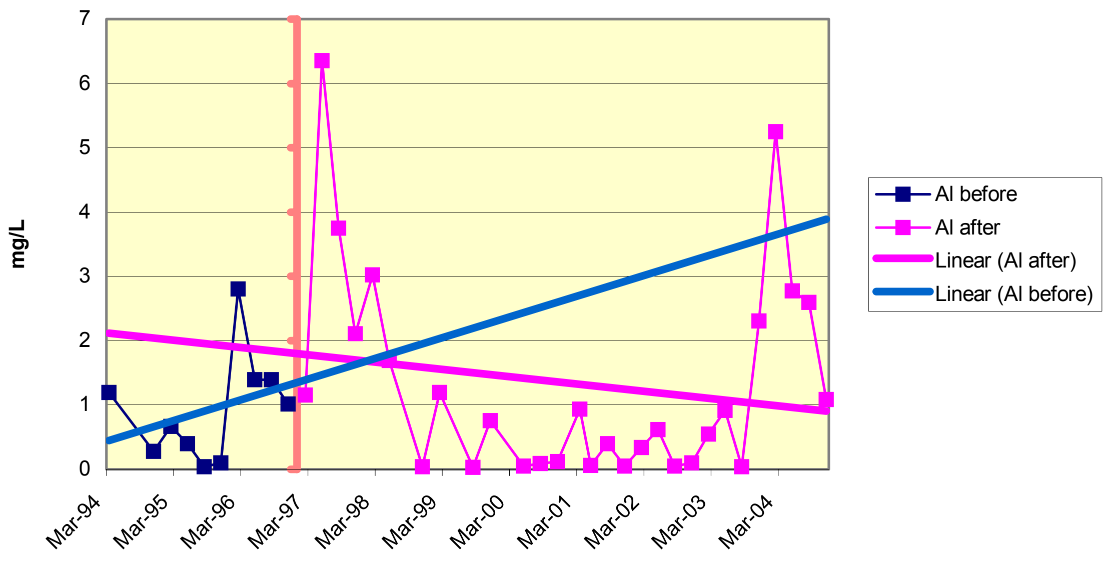
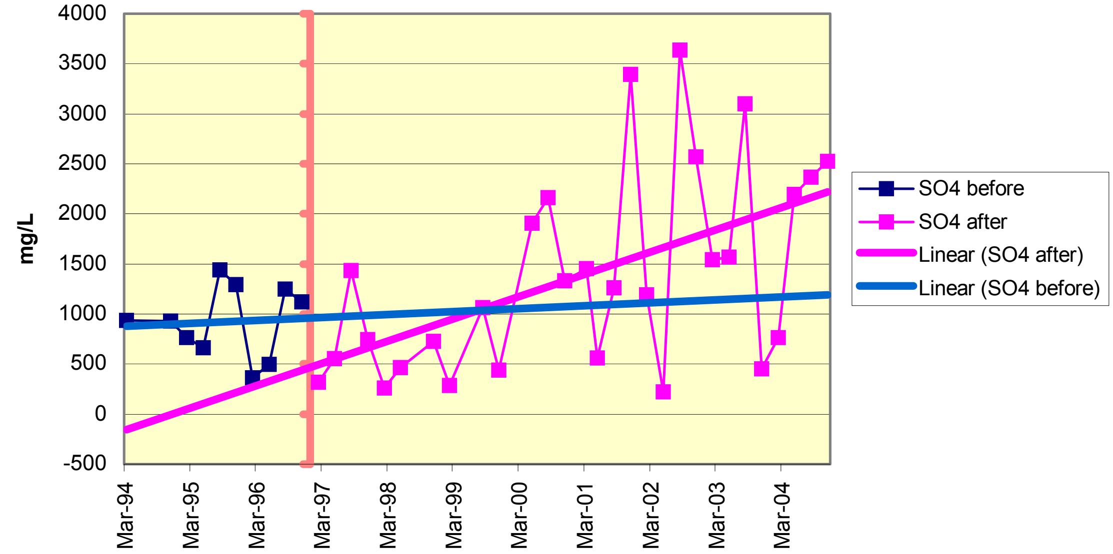


Figure 8.30b 32753702 MP-13 EME Generation Aluminum



Sulfate concentrations rose steadily after ash placement (particularly after 2000), from an average of about 500 mg/L in early 1997 to 2524 mg/L by the end of 2004, with an overall average of 1396 mg/L during ash placement, 5.6 times the AWQC of 250 mg/L (figure 8.31). During the baseline period, the trend in sulfate concentrations was only slightly increasing. Three years into the ash placement period, the sulfate concentrations increased sharply surpassing the highest concentrations measured during the baseline period 12 times. The highest sulfate concentration, 3635 mg/L in August 2002, is 2.5 times the highest baseline concentration (1443 mg/L in August 1995). This climbing level of sulfates likely reflects water degraded from the addition of large volumes of ash to the pile that had been deposited by 2000.

Figure 8.31 32753702 MP-13 EME Generation Sulfates



Acidity decreased and alkalinity increased at MP-13 in a gradual pattern very similar to MP-12 (figure 8.32). The actual alkalinity concentrations, however were slightly lower and acidity concentrations slightly higher at MP-13 than at MP-12 indicating that higher acidity in waters closer to the refuse pile is buffered by the environment the further those waters migrate from the refuse pile. Like MP-12, the pH at MP-13 (figure 8.33) rose gradually after ash placement from an average of 7.0 standard units to about 7.15 standard units with a total range of 6.7 to 7.3 standard units. However, the pH was also averaging about one tenth of a unit below the pH at MP-12 in line with the slightly higher acidity at MP-13. Still the trends of increasing alkalinity and pH and decreasing acidity at MP-13 indicate that the substantial rise in sulfates in this tributary is coming from ash rather than AMD in the refuse pile.

Figure 8.32 32753702 MP-13 EME Generation
Acidity & Alkalinity

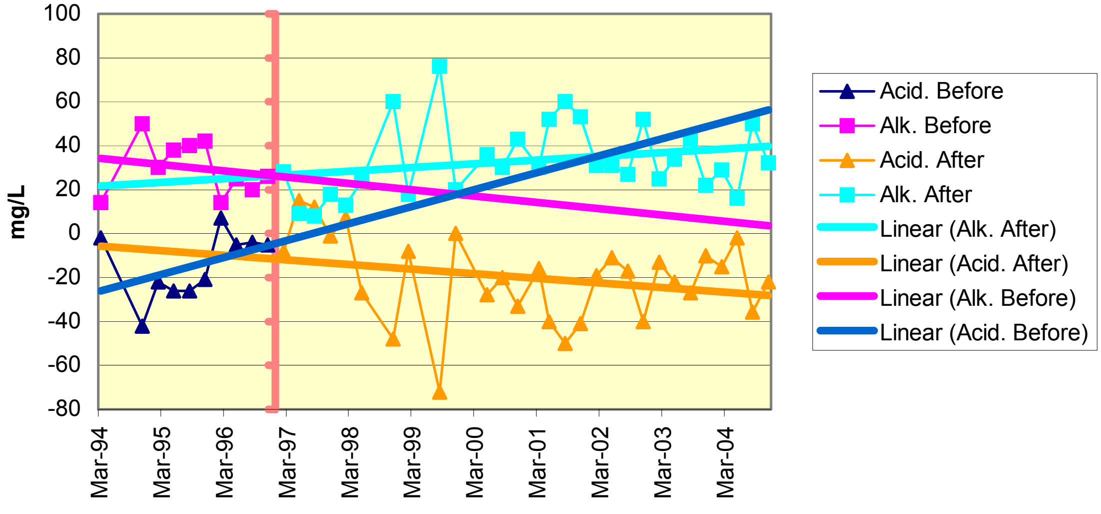
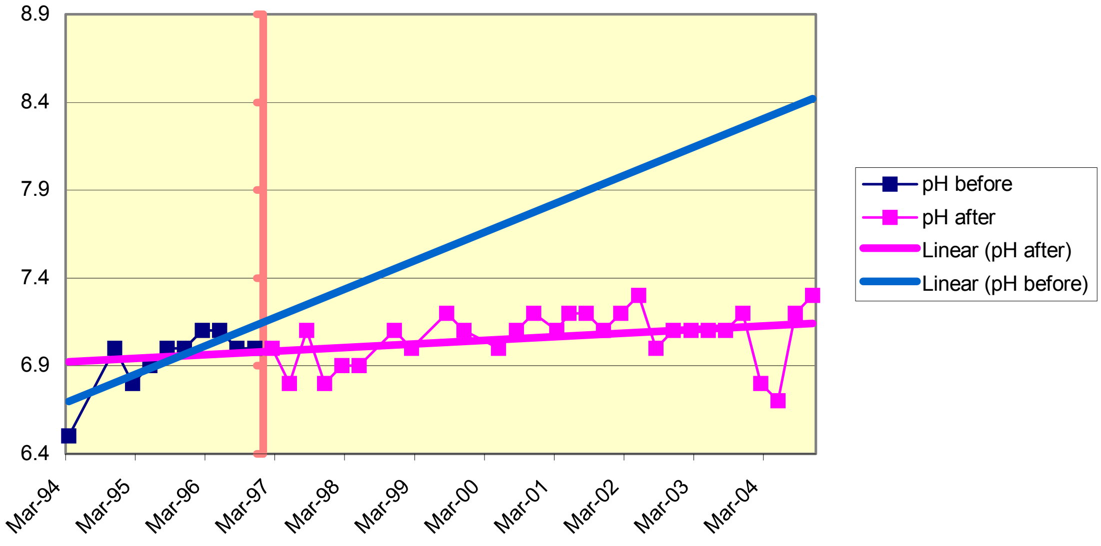


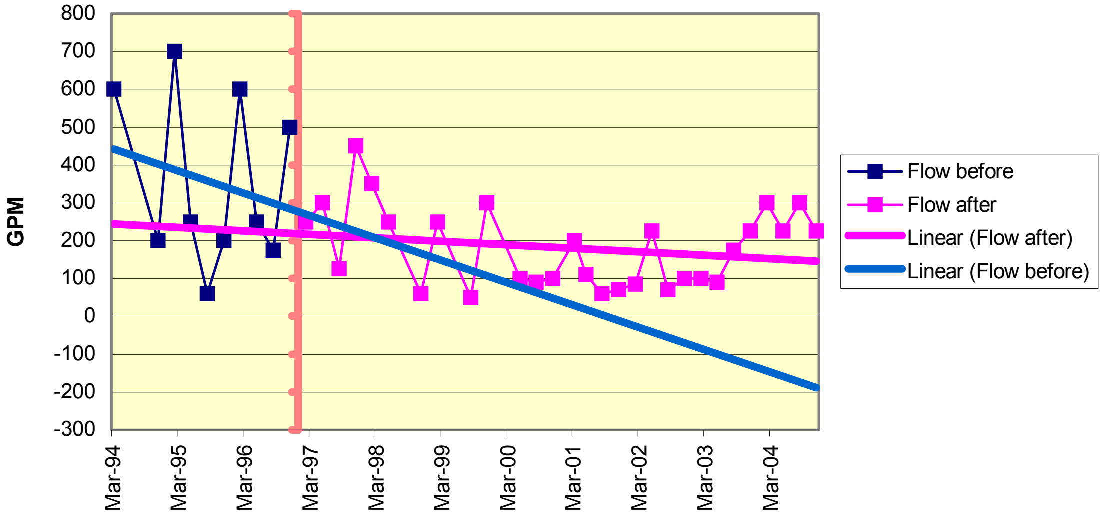
Figure 8.33 32753702 MP-13 EME Generation pH



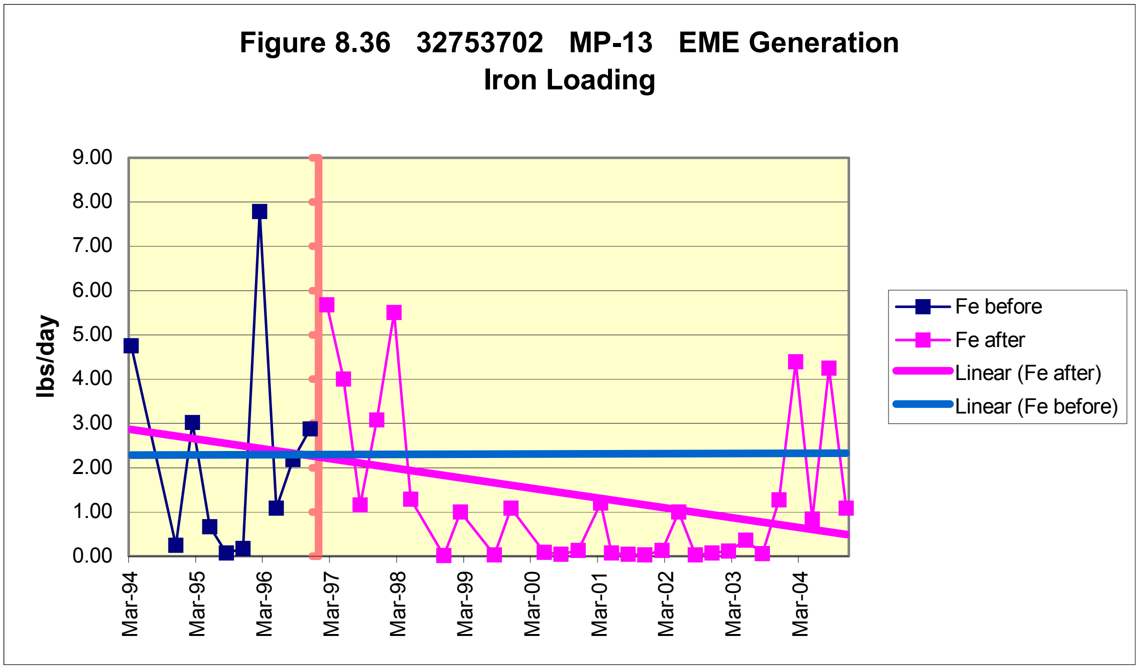
The average stream flow in this tributary (figure 8.35) is 20 to 25% the flow at MP-12 on Cherry Run. Like the flow at MP-11 and MP-12, there are higher and greater oscillations in flows before the ash placement period at MP-13. Unlike the flows in

Cherry Run however, the data at MP-13 indicate a more moderated decline in flows occurred in this tributary immediately after ash placement began (in 1997 and 1998). The effect of higher flows initially during ash placement produced an overall decreasing rather than an increasing trend in average flows throughout the ash placement period. There was however an increase in flows from 2002 through 2004 at MP-13 similar to the increases that occurred at MP-11 and MP-12.

Figure 8.35 32753702 MP-13 EME Generation Stream Flow (GPM)



The average iron loading at MP-13 (figure 8.36) is steadily declining and substantially less than the loading at Cherry Run at MP-12. This indicates again that the EME disposal site is not a significant contributor of iron to Cherry Run, whose iron load is approximately the same from upstream MP-11 to downstream MP-12.



In contrast, the sulfate loading at MP-13 (figure 8.37) increased on average, from less than 1000 lbs/day at the beginning of ash placement to approximately 4100 lbs/day in 2004 with an overall average loading of 2507 lbs/day during the ash placement period. The highest loadings that were measured were 8530 lbs/day in August 2004 and 6819 lbs/day in November 2004, even though the flow for these measurements were roughly half the flow measured before ash placement began when the highest loadings reached just 6739 lbs/day. This points to the rising concentration of sulfate that was driving the increased loading at MP-13 and indicates further that this tributary's discharge was clearly driving the increase in sulfate loading at MP-12 which unlike iron, increased dramatically from the amount of sulfate loading at upstream MP-11.

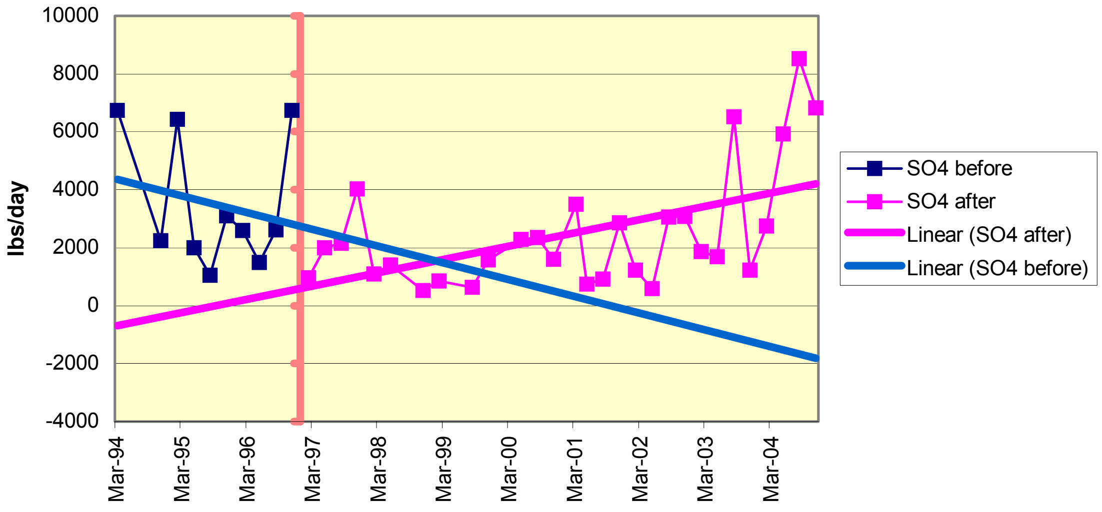


Figure 8.37 32753702 MP-13 EME Generation
Sulfate Loading

MP-14 (Settling Pond)

MP-14 monitors one of several lined settling ponds that receives the leachate collected above the liner in the Phase III and IV disposal area. This water is pumped on an irregular basis back to the generating facility for reuse. Otherwise the water should leave the ponds by evaporation only, resulting in the concentrating of contaminant levels in the ponds.

Figures 8.40, 8.40a and 8.40b are graphs of the iron, manganese, and aluminum concentrations respectively at MP-14. Baseline concentrations of all three metals were very high, up to nearly two thousand times the AWQC for iron and several hundred times the AWQCs for manganese and aluminum. After a substantial initial decline, iron rose back to levels as high as 895 mg/L during ash placement, nearly 900 times the AWQC. Aluminum had baseline concentrations as high as 168 mg/L, 224 times the AWQC, fell to between 23 mg/L and 77 mg/L from the start of ash placement through 2001 and then rose to its highest measured level, 212 mg/L in August 2002, 283 times the AWQC (figure 8.40b). Manganese had a decreasing average trend from levels as high as 57 mg/L before ash placement started, 570 times the AWQC, to levels as low as 9.5 mg/l during the ash placement period, still 95 times the AWQC. Twenty of the twenty-nine measurements for manganese during the ash placement period were between 9.5 and 20 mg/L. Since iron, manganese, and aluminum had much lower concentrations at MP-13, this suggests that contaminated water in the settling pond is not leaking in any large amount into the tributary or Cherry Run.

Sulfate values at MP-14 were very high before and during ash placement although their highest values are before ash placement started. Nonetheless, the data shows an increasing trend during the ash placement period (figure 8.41). The average overall concentration of sulfate during ash placement was 3,841 mg/L, more than 15 times the AWQC. Given the far lower concentrations of iron, manganese, aluminum and acidity at MP-13 than at MP-14, the sulfate concentrations at MP-13 are probably not coming from the settling pond.

Figure 8.40 32753702 MP-14 EME Generation Iron

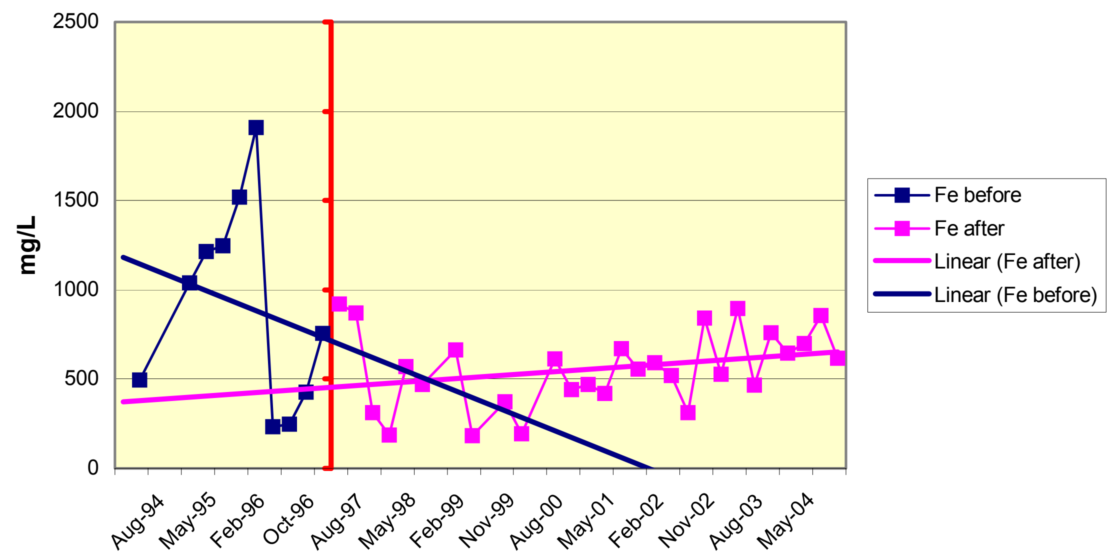


Figure 8.40a 32753702 MP-14 EME Generation Manganese

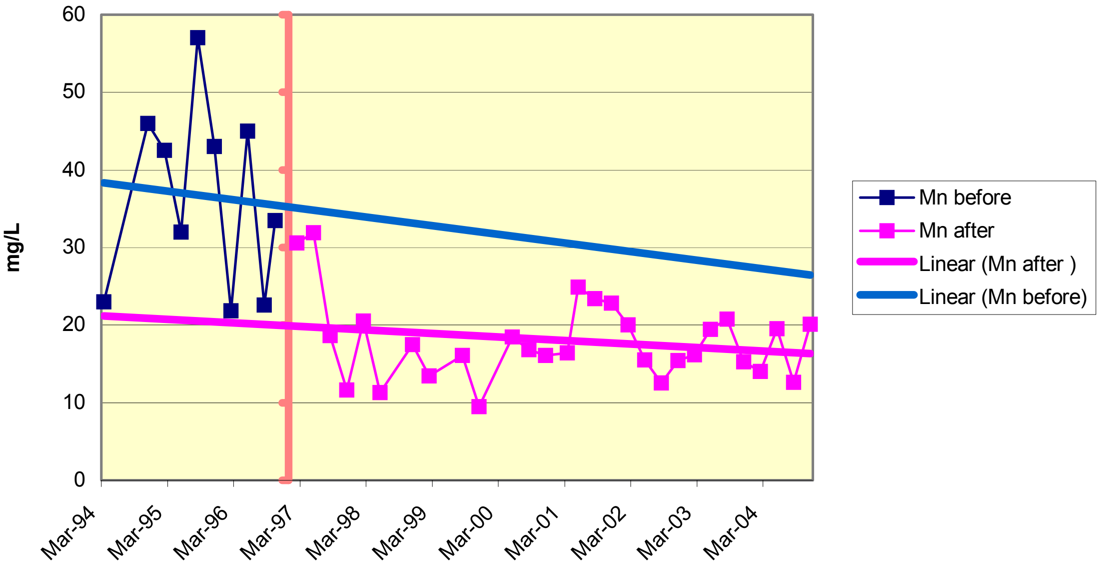
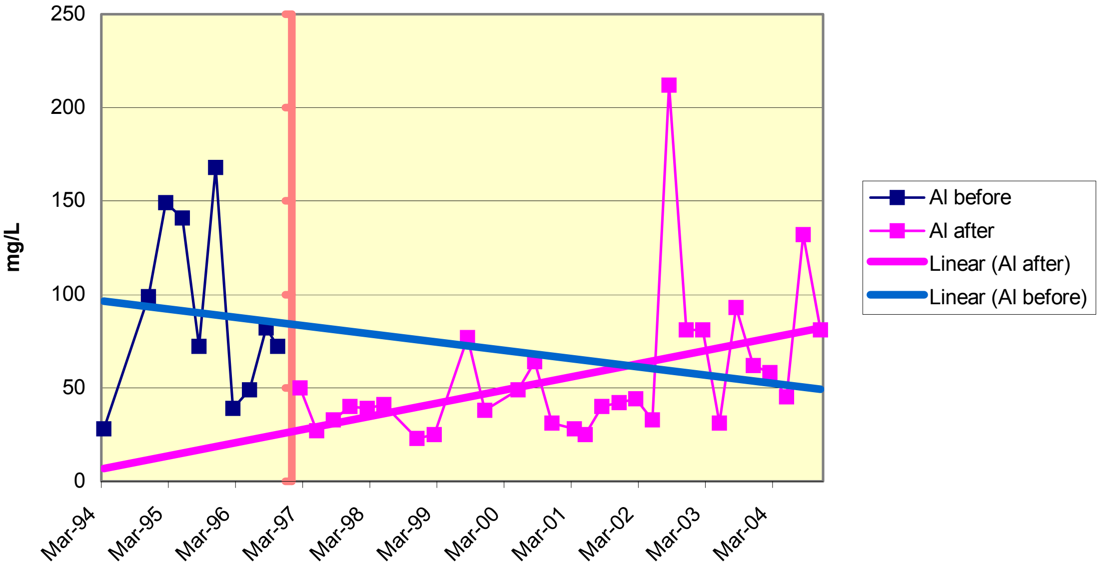
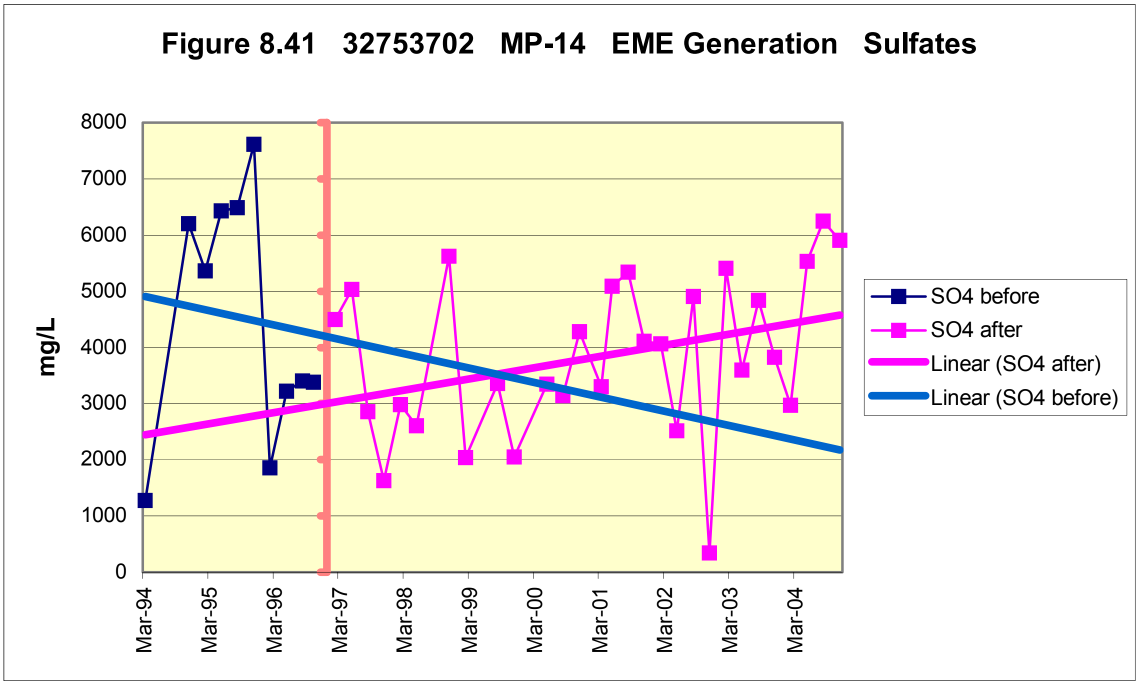
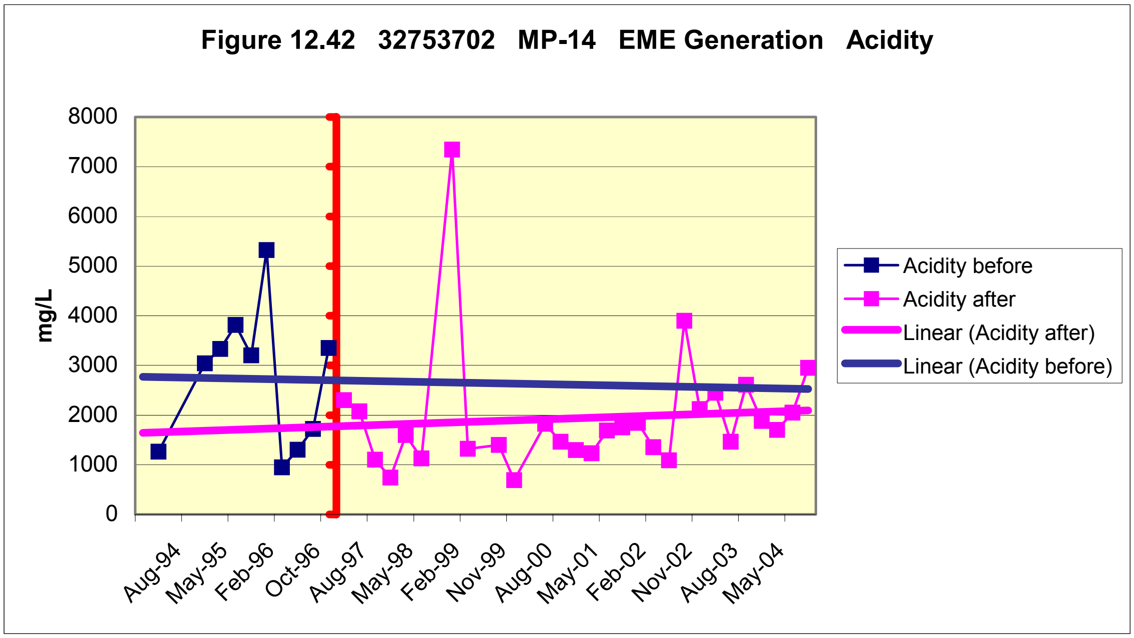


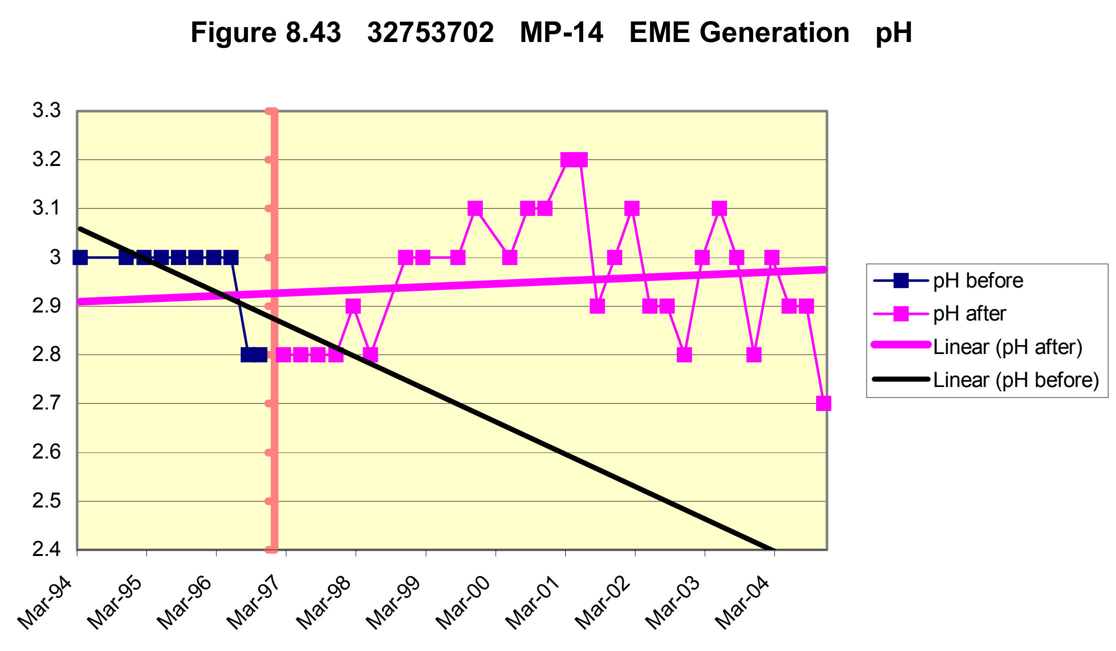
Figure 8.40b 32753702 MP-14 EME Generation Aluminum





The acidity in the settling pond was very high (figure 8.42). The average trend after ash placement increased from 1700 mg/L to about 2100 mg/L. Alkalinity (not plotted) was zero at MP-14, indicating there is no alkaline buffering capacity in this water. Nevertheless while the values of pH were very low (less than 3.3), they had a rising trend after ash placement (figure 8.43), suggesting some neutralization of AMD from the placed ash.





The flow from the pipe into the settling pond was sporadic, oscillating between 50 and 500 GPM (figure 8.45), but it showed an upward trend after early 2002. These trends are similar to the iron loading data (figure 8.46) for discharges from this pipe, which reached a high value of almost 2 tons per day (3698 lbs/day) in August 2004. The complete absence of values approaching this magnitude in the stream surface loading data attests to the isolation of the degraded water in the settling pond from the environment.

Sulfate loading was also high (figure 8.47) but decreased after ash placement to values ranging from 8836 lbs/day in May 2000 to as low as 749 lbs/day in November 2002 before abruptly rising again in 2003 and 2004 to values averaging 17,963 lbs/day. The highest value was 37,509 lbs/day, nearly 19 tons per day, of sulfate coming into this pond in August, 2004.

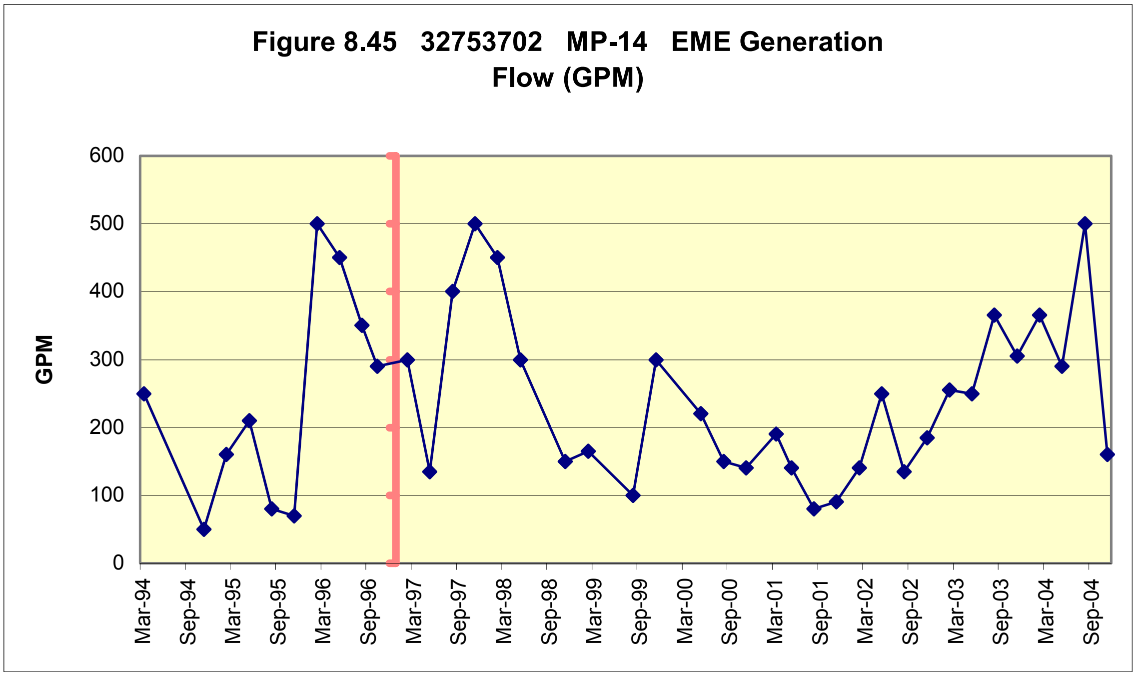


Figure 8.45 32753702 MP-14 EME Generation
Flow (GPM)
GPM
0
100
200
300
400
500
600
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
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Mar-03
Sep-03
Mar-04
Sep-04

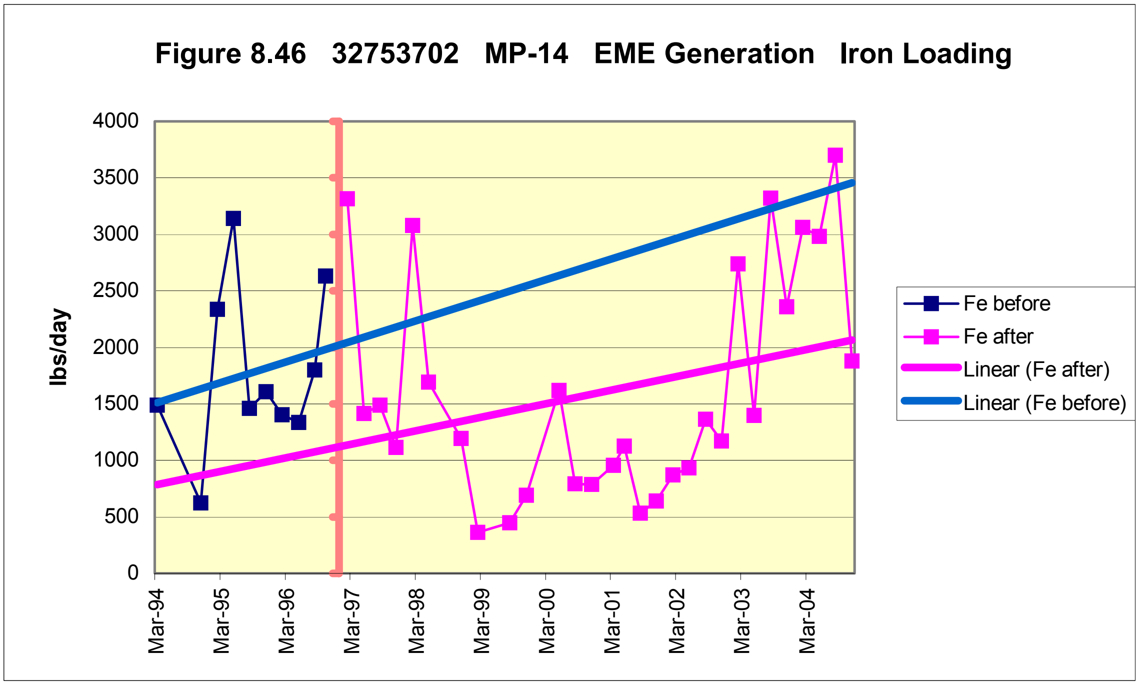
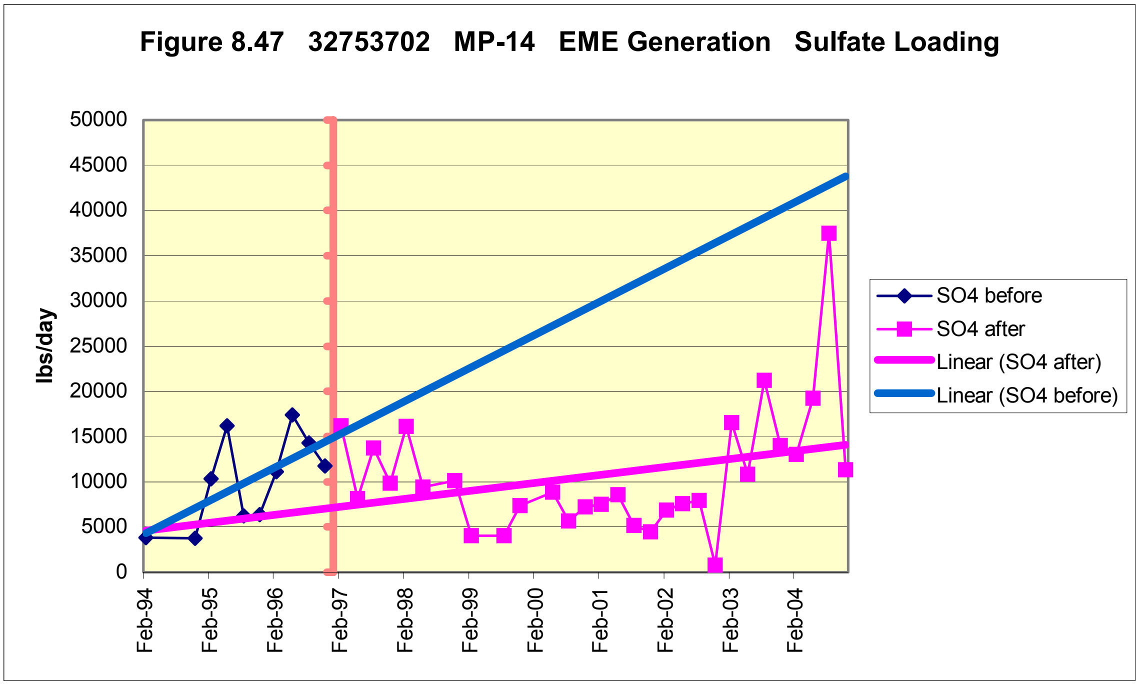


Figure 8.46 32753702 MP-14 EME Generation Iron Loading
lbs/day
0
500
1000
1500
2000
2500
3000
3500
4000
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Fe before
Fe after
Linear (Fe after)
Linear (Fe before)



Designated Module 25 Ash Monitoring Points:

MP-15 (Spring and Collector Pipe)

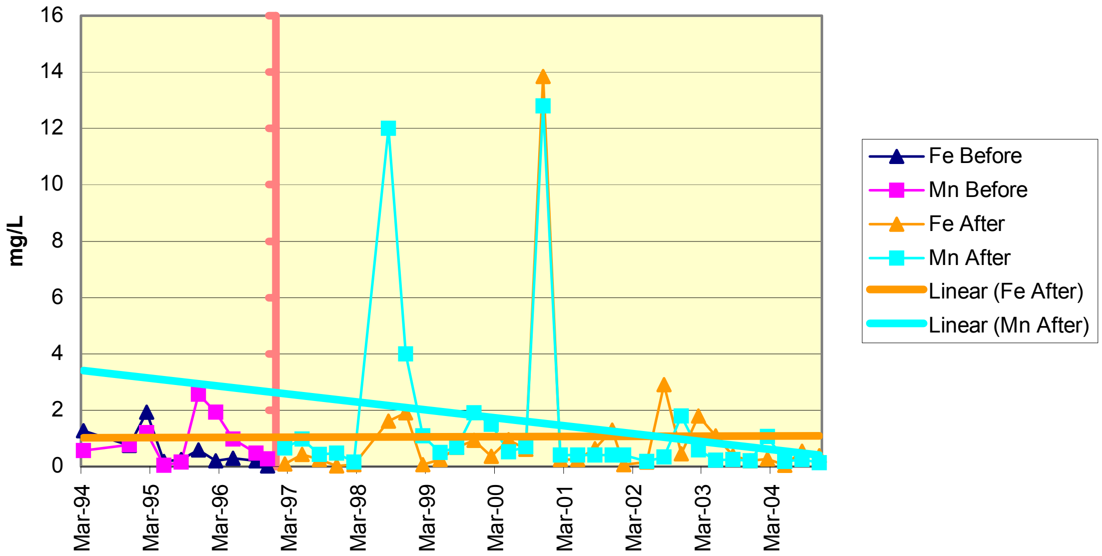
MP-15 is a collector pipe that drains a now-buried spring and leachate that may collect under the liner. The permit refers to this point as an "underdrain." For monitoring points MP-15 and MP-19, the monthly baseline sampling ends in March 1996, and quarterly sampling starts in August 1996. This contrasts with the other monitoring datasets for the EME site, in which baseline monthly sampling ended in November 1996, and quarterly sampling began in February 1997. The reason for this difference in demarcation of the baseline sampling period between monitoring points could not be located in the permit files although it should be noted that these two points are designated as Module 25 ash monitoring points while the other monitoring points are not. Nonetheless for consistency of comparison, the baseline monitoring period in figures for MP-15 and MP-19 remains extended through the end of 1996.

Figure 8.50 is a chart of iron and manganese concentrations over time. The highest concentrations for both constituents reached 12-14 mg/L. The average iron concentrations increased slightly. Average manganese levels decreased after ash placement even though the three highest actual manganese concentrations were measured after ash placement. These concentrations were much less than the concentrations of iron and manganese measured in the settling pond (MP-14) although their peak concentrations were significantly higher than the highest iron and manganese levels at MP-13 which were in the 1-3 mg/L range. Aluminum levels (ungraphed) remained relatively low with average concentrations of 0.95 mg/L in the first three years of the ash placement period (November 1996 through November 1999) declining slightly to 0.84 mg/L in the last three years of monitoring that were assessed in this report (November 2001 through November 2004).

Sulfates, although rising, were substantially lower in concentration at MP-15 (figure 8.51) than at MP-13 (where a majority after ash placement started were between 1,000 and 3500 mg/L) and much lower than sulfate concentrations at MP-14 (where all but two measurements after ash placement started were between 2000 and 6500 mg/L). The highest concentrations reached 878 mg/L in August 1998 and 814 mg/L in November 2000. These peaks coincided with peaks in manganese and iron concentrations as well as higher acidity and lower alkalinity and pH values (shown below) indicating an AMD impact.

Alkalinity and acidity (figure 8.52) had large overall trend increases and decreases, respectively; however, these trends appeared to reverse somewhat in late 2003 and 2004. The overall increase in alkalinity and decrease in acidity are probably due to ash leachate. The values of pH (figure 8.53) also rose after ash placement from about 6.9 to 7.2 on average. These values indicate neutral to slightly alkaline conditions.

Figure 8.50 32753702 MP-15 EME Generation Iron & Manganese



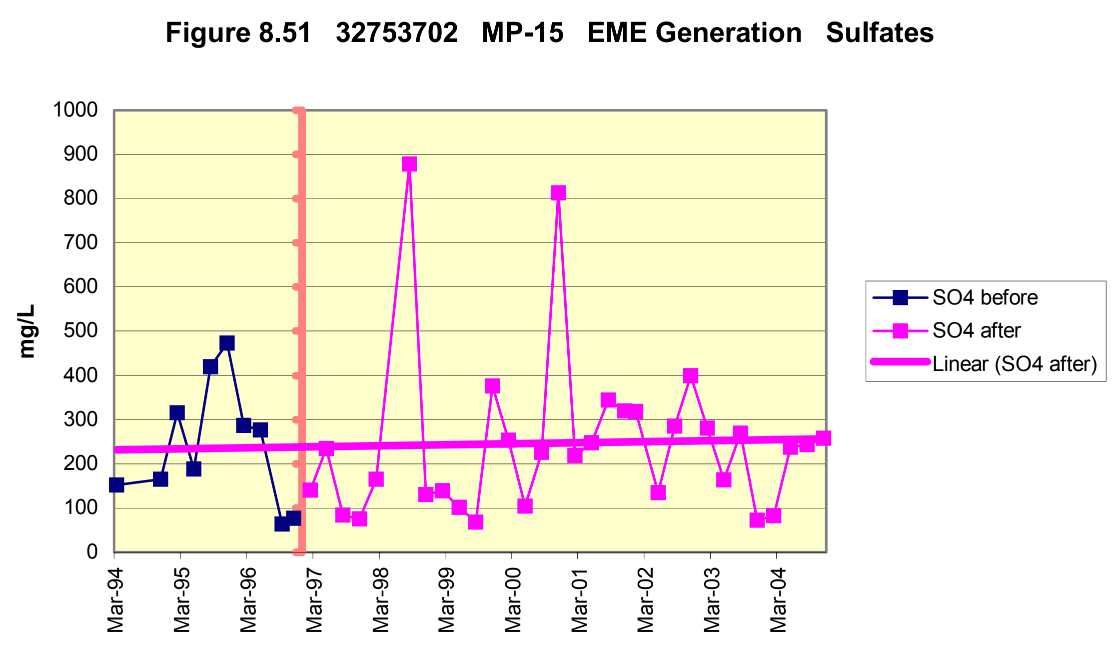


Figure 8.51 32753702 MP-15 EME Generation Sulfates
mg/L
1000
900
800
700
600
500
400
300
200
100
0
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
SO4 before
SO4 after
Linear (SO4 after)

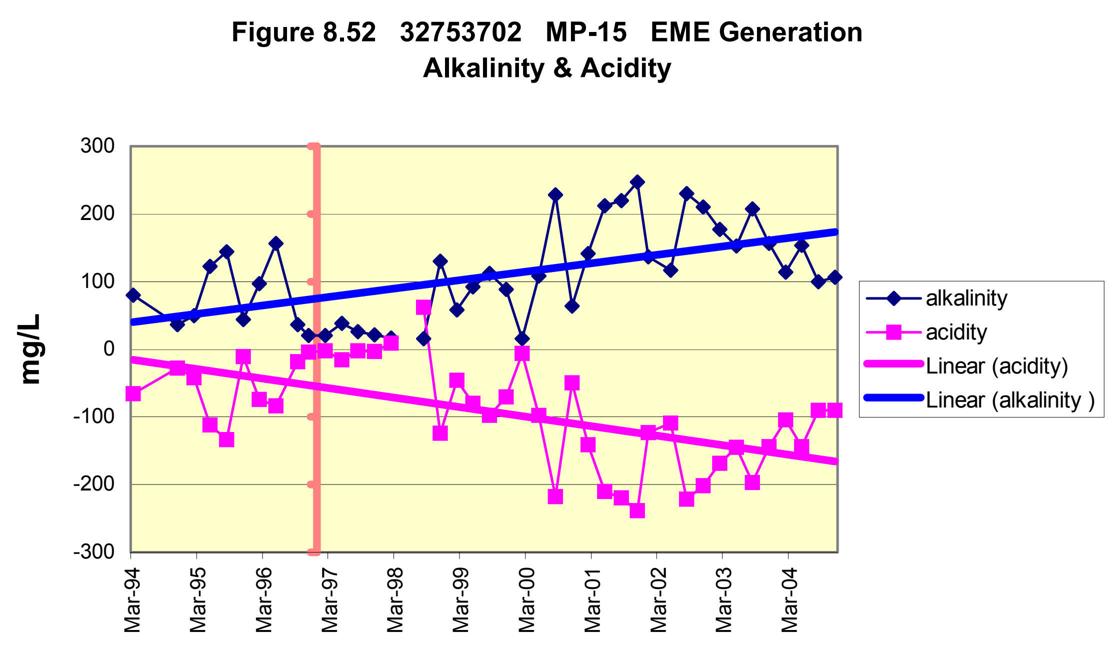
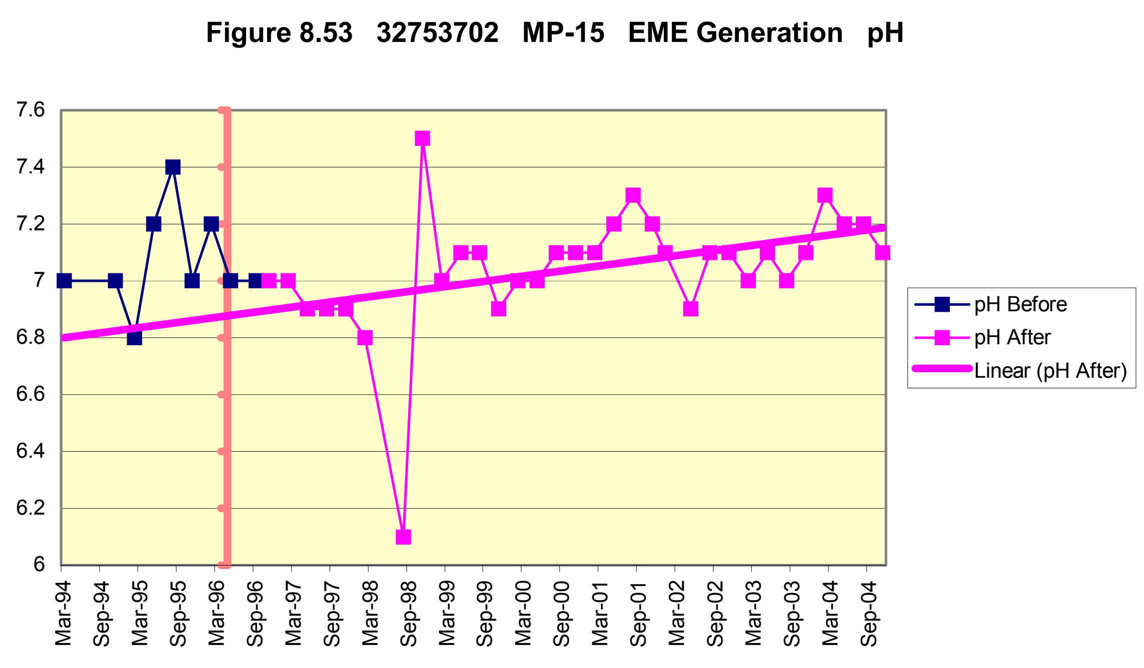


Figure 8.52 32753702 MP-15 EME Generation
Alkalinity & Acidity
mg/L
300
200
100
0
-100
-200
-300
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
alkalinity
acidity
Linear (acidity)
Linear (alkalinity)

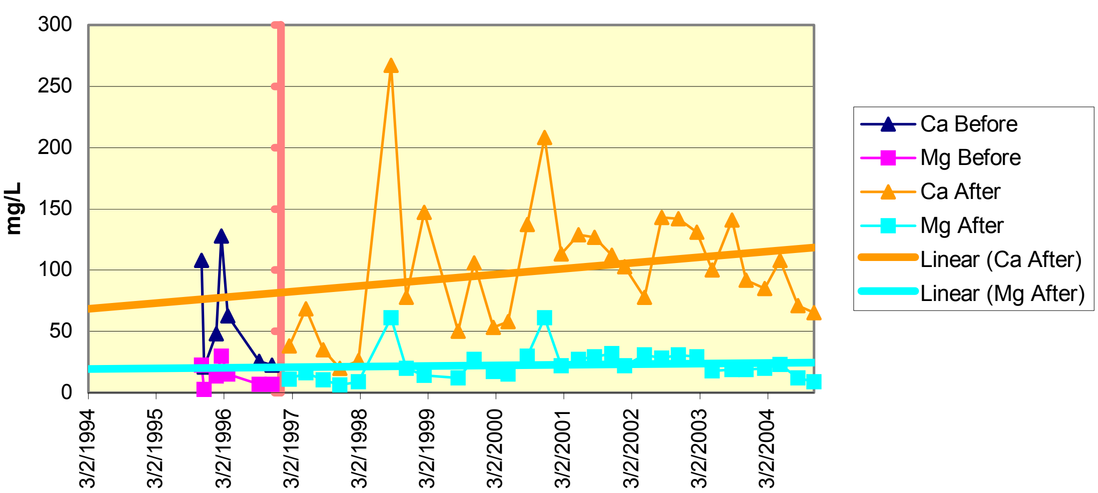


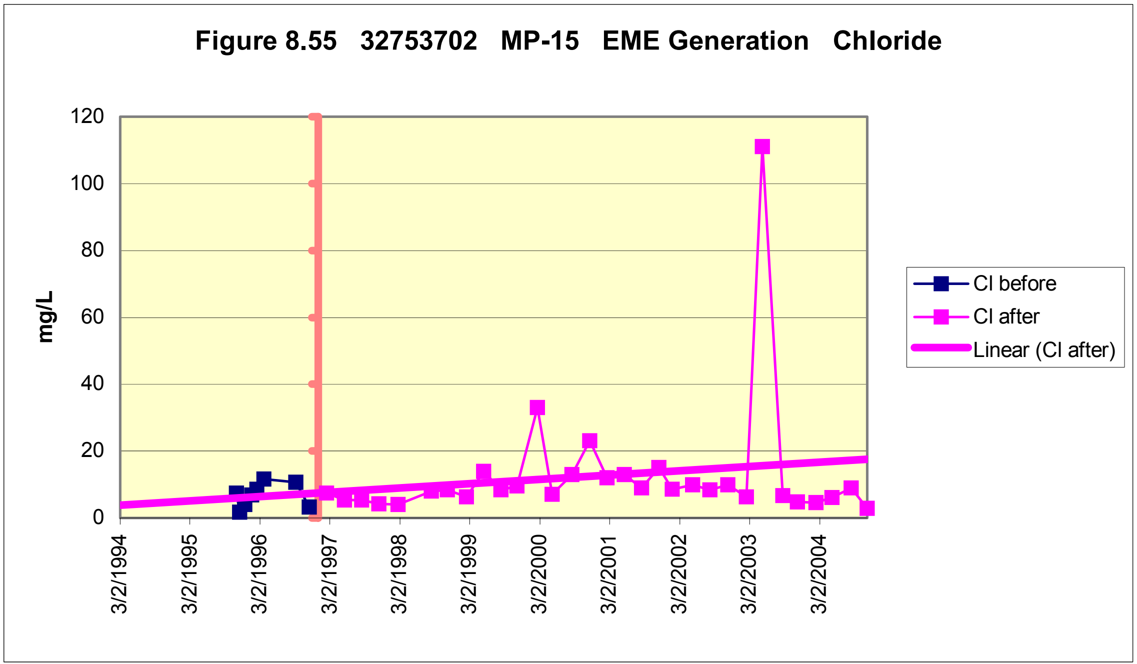
Data for Module 25 parameters more exclusive of ash impacts such as calcium, magnesium, chloride, sodium, potassium and trace elements were collected for MP-15 as well as MP-19 (discussed further below). Calcium and magnesium both showed rising trends at MP-15 (figure 8.54) during the ash placement period and declined in the last year of monitoring coinciding with the decline in alkalinity, suggesting that that these two elements may be leaching from ash. Chloride concentrations (figure 8.55) had an increasing trend primarily due to one concentration measured in May, 2003 of 111.07 mg/L, 10-20 times higher than the large majority of other chloride concentrations. However, even without this anomalously high value, chloride levels in the middle of the monitoring period (1999-2001) rose to 4-6 times the levels measured in the beginning and ends of the period. These higher values in the ash placement period also suggest reactivity from the ash which is frequently a source of chloride at minefill sites.

Two other highly soluble ash parameters showing signs of ash impact at MP-15 include sodium and potassium. Neither is graphed. While baseline concentrations were not available for this assessment, sodium levels at MP-15 increased from an average of 9 mg/L in the first three years of ash placement to 22 mg/L in the last three years of ash placement with three readings between 50 and 65 mg/L in the last four years of ash placement. Potassium was measured at MP-15 only in the last four years of ash placement and did not have an increasing trend. Nonetheless, this parameter was recorded at 35.5 mg/L, more than ten times over most other potassium levels, in November 2000 when peaks of calcium, magnesium and sodium and a high level of chloride were also measured at MP-15.

The concentration of all pollution reflected by Total Dissolved Solids (TDS - ungraphed) rose during the ash placement period at MP-15 from an average of 367 mg/L in 1996-1999 to an average of 578 mg/L in 2001-2004. The highest TDS concentration, 1386 mg/L, however occurred at the midpoint of the ash placement monitoring period in November 2000 reflecting the peak in sulfate and other more exclusive ash parameters discussed above.

Figure 8.54 32753702 MP-15 EME Generation Calcium & Magnesium





The trace metals, arsenic, cadmium, lead, and selenium, have flat trends that are at the detection limits of the analyzing apparatus (figure 8.56a) with the exception of arsenic which rose from <0.002 to 0.004 mg/L in the baseline period and cadmium which rose from <0.002 mg/L during baseline sampling to 0.01 mg/L (twice the DWS of 0.005 mg/L and AWQC of 0.0055 mg/L) during late 2002 and 2003. However of three cadmium readings at 0.01 mg/L, two that occurred in November 2002 and May 2003 were at instrument detection levels while a February 2002 reading of 0.01 mg/L was an actual concentration. All trace element values depicted in figures and discussed in this report reflect total rather than dissolved concentrations. In most cases only total values were reported or reports did not differentiate between total and dissolved concentrations.

Actual concentrations of other trace metals (as opposed to detection limits) were measured at MP-15 that exceeded their highest baseline concentrations at MP-15 during ash placement. These include nickel, barium, copper and silver. Nickel (figure 8.56b) was graphed as it reached levels of concern (over DWS). Its highest measurement, 0.86 in May 2000, 11 times higher than the highest baseline measurement and 8.6 times the old DWS for nickel, oddly was measured also at another ash monitoring point, MP-20 in the same sampling. Barium exceeded the baseline concentrations in ten samples, with the highest measurement, 0.12 mg/L also in May 2000, being at least four times over the highest baseline measurement (<0.03 mg/L) but still less than a tenth the DWS (2.0 mg/L). Barium results were not reported from monitoring after this sample. Neither were any more results for silver which was measured at 0.03 mg/L in this sample and measured at 0.01 mg/L in an August 1998 sample while the baseline measurements for silver were always <0.01 mg/L. These levels are well under the secondary DWS for silver (0.1 mg/L) but appear to be well in excess of the federal recommended water quality standard for silver (freshwater acute standard or CMC of 0.0032 mg/L in National Recommended Water Quality Criteria, US EPA Office of Water, 2006. This standard is of dissolved silver in the water and is hardness dependent). Copper exceeded its highest baseline concentration (0.07 mg/L) in two samples with the highest measurement, 0.16 mg/L in May 1997, approximately one eighth the DWS (1.3 mg/L). In addition, although the highest zinc concentration at MP-15, 0.65 mg/L, was measured during the baseline period, there were three measurements of zinc during ash placement that exceeded the second highest baseline zinc concentration of 0.12 mg/L.

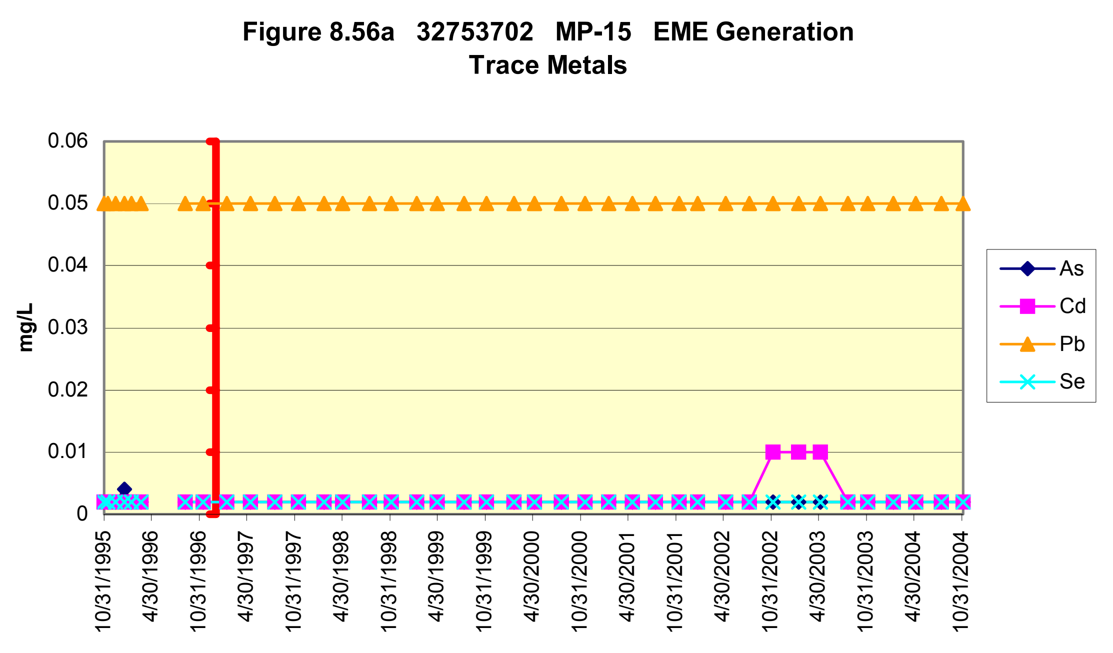
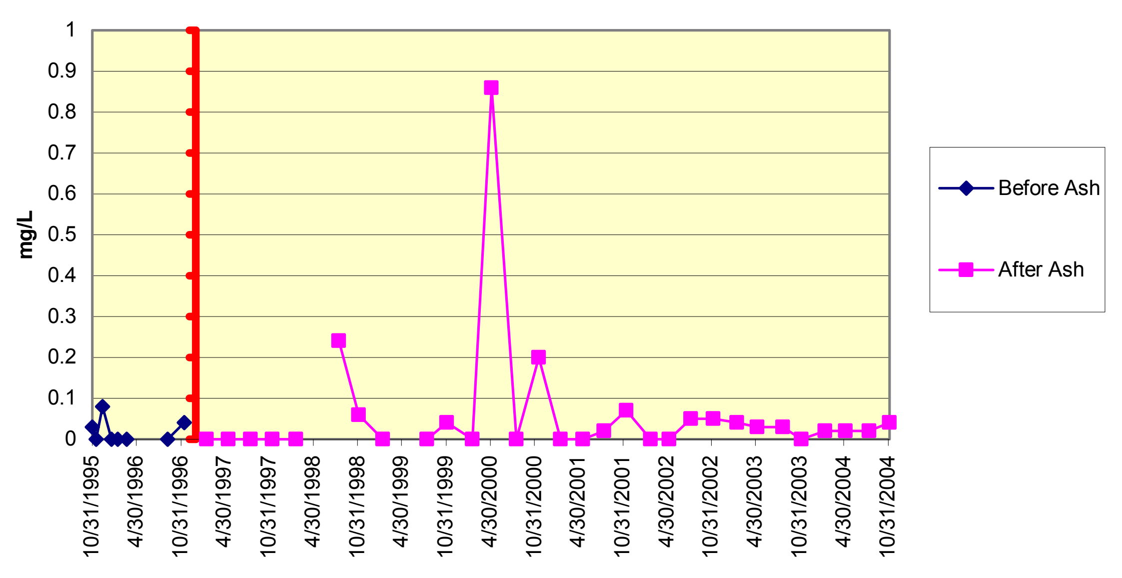


Figure 8.56b 32753702 MP-15 EME Generation Nickel

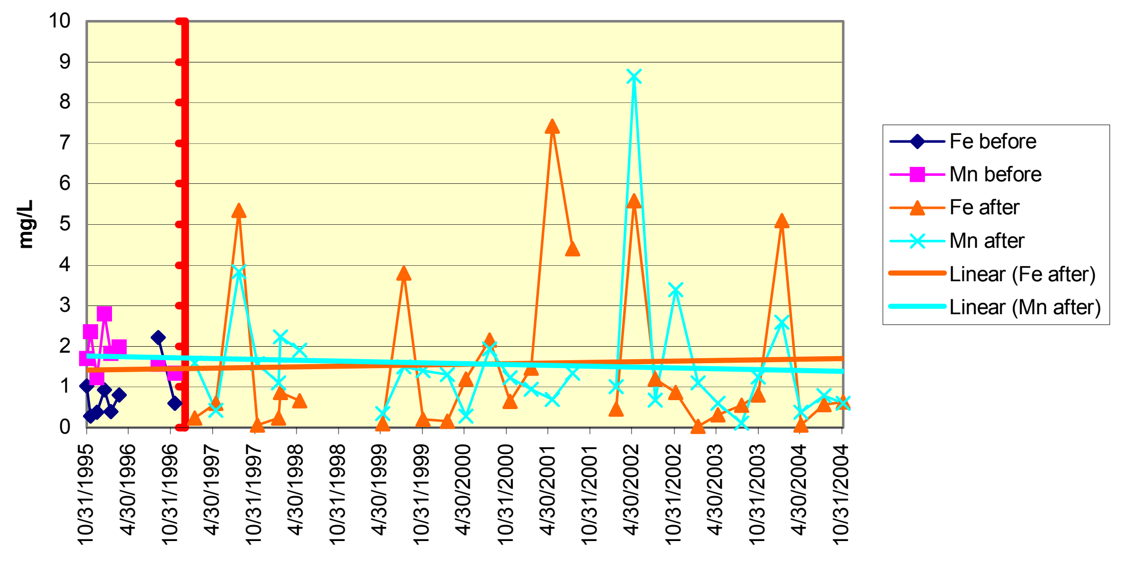


MP-19 (Seep Into Northern Swale)

There have been conflicting sources of information regarding the location of MP-19 provided by PADEP. Permit maps such as Environmental Resources Map (drawing number E-744-3013) show it in two different locations. These are labeled as “a Background Monitoring Point for 1985 Repermitting” adjacent to a spring under what is now the Stage III disposal area and as a “Monitoring Point for Stages III & IV” on the unnamed tributary flowing eastward along southern perimeter of the EME site. A telephone conversation on September 1, 2005 with staff of the PADEP who oversee this permit in California District Mining Office, established the location of MP-19 on the southern tributary, but those staff could not verify that location in a subsequent visit to the California Office. According to the PADEP’s June 30, 2005 written critique of a draft of this site report, MP-19 is in the swale on the northern perimeter of the site between the Stage I/II and III/IV disposal areas. Given the Module 25’s description of MP-19 in this latter location and latitude and longitude coordinates in monitoring reports that place MP-19 closest to this northern location, the authors of this report are assuming this northward draining seep is the correct location.

MP-19’s contaminant concentrations and trends were similar to MP-15. Average iron concentrations increased slightly after ash placement from about 1.4 mg/L to 1.6 mg/L (figure 8.60) above the AWQC of 1.0 mg/L. Average manganese concentrations decreased slightly with an overall average of 1.5 mg/L, well above the AWQC of 0.1 mg/L. After ash placement began, iron spiked to notably higher values six times with the highest value at 7.4 mg/L in May 2001 while manganese had a high value of 8.6 mg/L in May 2002 and seven values that exceeded the highest baseline values.

Figure 8.60 32753702 EME Generation MP-19 Iron & Manganese



Aluminum (not graphed) underwent a slight decrease from an average concentration of 6.4 mg/L during 1996-1999 to an average of 5.0 mg/L during 2001-2004.

The sulfate values at MP-19 (figure 8.61) are similar to those at MP-15: the average sulfate climbed from about 196 mg/L in the first full year of ash placement (1997) to 250 mg/L as of the last monitoring results, with an overall average during ash placement of 201 mg/L. Five measurements were higher than the AWQC of 250 mg/L with the highest concentration of 774 mg/L in May 2002.

Figure 8.62 is a plot of alkalinity and acidity. Acidity dominated alkalinity in the beginning and ends of the ash placement period while alkalinity appears to dominate during the middle of this period. The pH at MP-19 (figure 8.63) underwent the most significant average rise measured during the ash placement period at any of the monitoring points examined in this assessment from approximately 4.75 to 5.9 units. The range of actual measurements encompassing this increase is large, from 4 to 7.1. The data appears to reflect conditions abated from being moderately to mildly acidic.

TDS levels (ungraphed) rose significantly at MP-19 during ash placement, from an average of 300 mg/L in 1996-1999 to an average of 822 mg/L in 2001-2004. Spikes in concentration to 1381 mg/L in May 2002 and 4722 mg/L in February 2004 resulted in much of this increase although all but two of the actual values in the latter period were higher than the average value in the earlier period (300 mg/L).

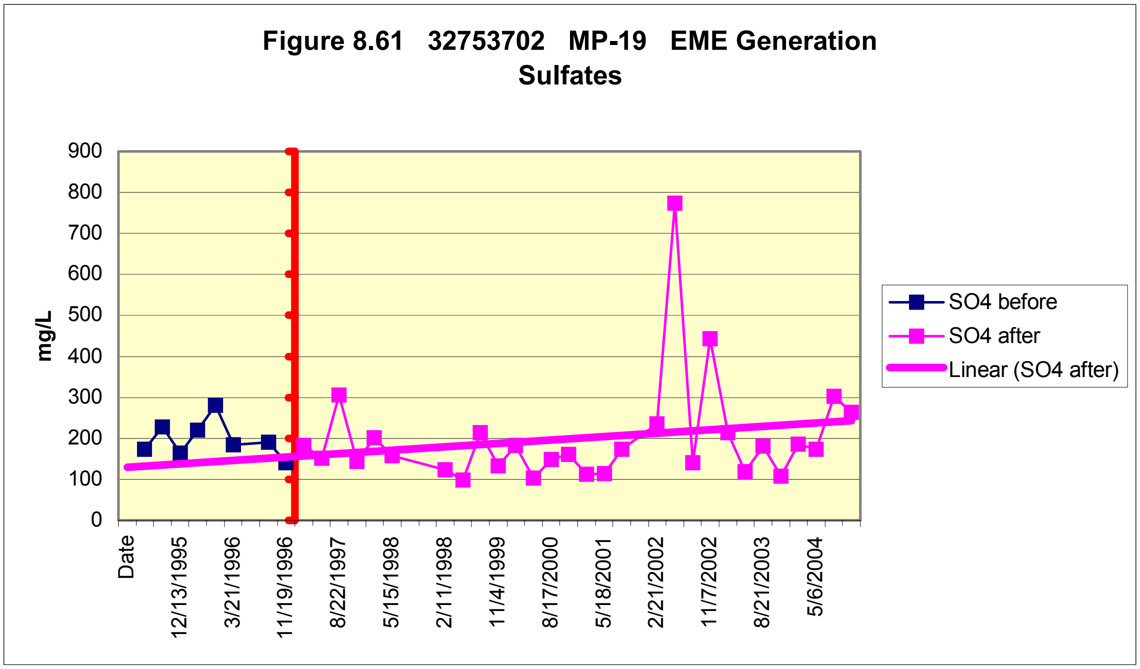
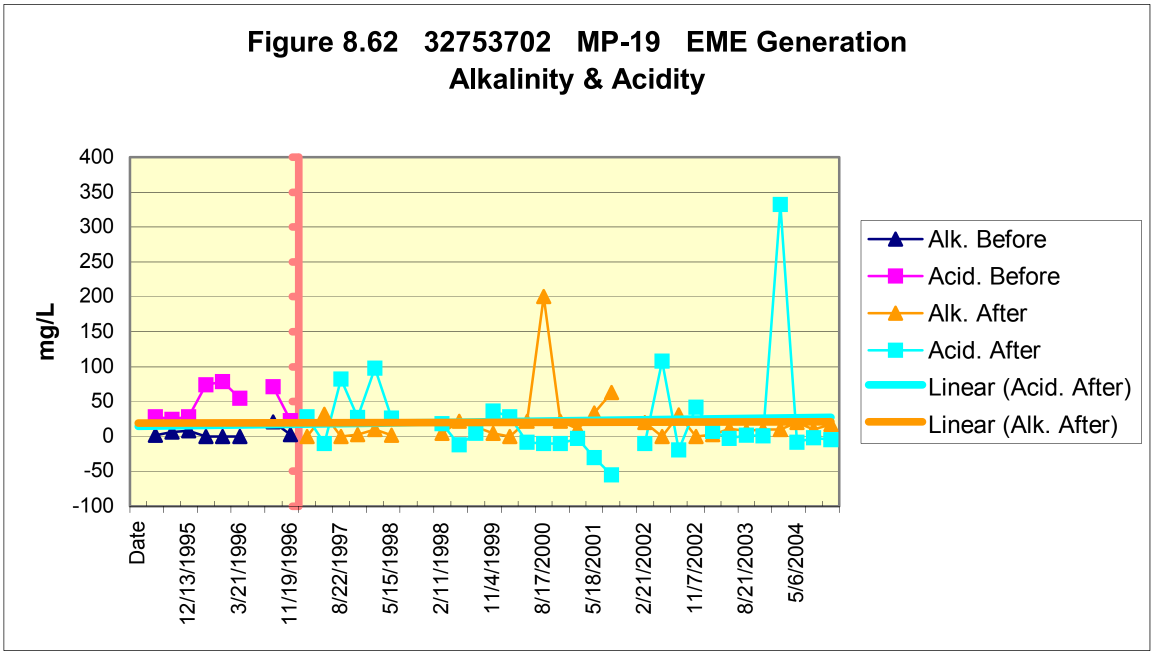
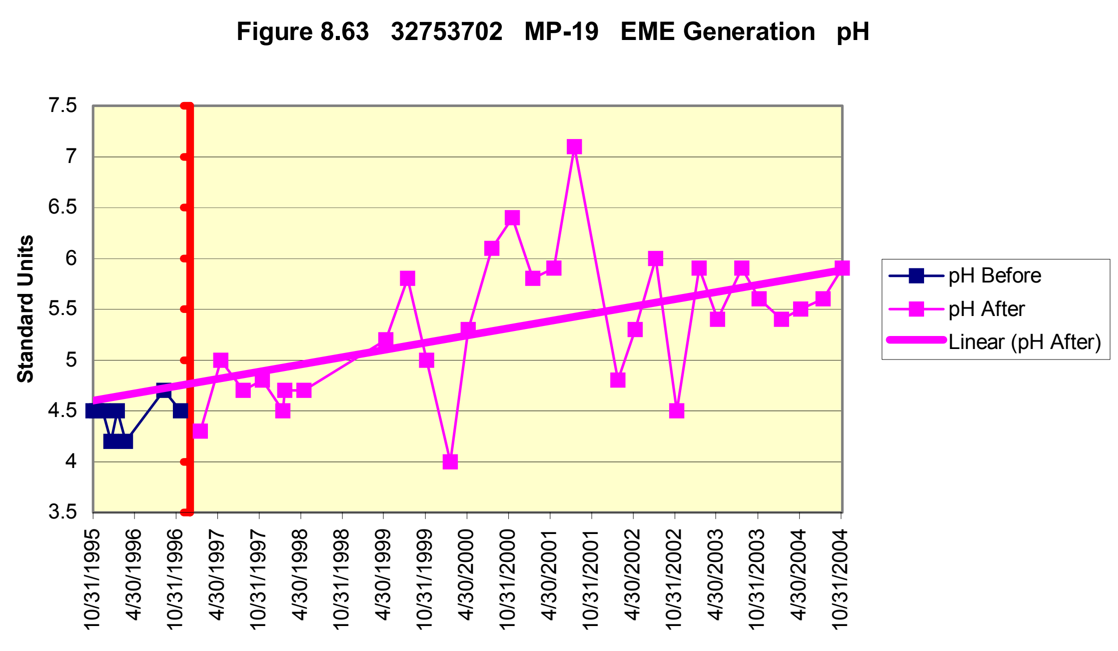


Figure 8.61 32753702 MP-19 EME Generation
Sulfates
mg/L
900
800
700
600
500
400
300
200
100
0
Date
12/13/1995
3/21/1996
11/19/1996
8/22/1997
5/15/1998
2/11/1998
11/4/1999
8/17/2000
5/18/2001
2/21/2002
11/7/2002
8/21/2003
5/6/2004
SO4 before
SO4 after
Linear (SO4 after)





Average concentrations of both calcium and magnesium rose after ash placement (figure 8.64), suggesting input from ash leachate, particularly in 2001, 2002, and 2003, when concentrations reached levels six to nearly twenty times the highest calcium and magnesium concentrations measured during the baseline monitoring. The average chloride values increased during ash placement (figure 8.65). A very high chloride level of 70.23 mg/L was measured in February 2004 when a spike in calcium and magnesium concentrations was also measured.

Concentrations of sodium (ungraphed) at MP-19 rose during the ash placement period from levels between 4.10 and 18.80 mg/l in the first three years of ash placement to levels exceeding 25 mg/L five times in the last three years of ash placement. These included 80.09 mg/L in May 2002 and a spike to 395 mg/L in February 2004 in the same sampling in which very high levels or spikes of calcium, magnesium and chloride were measured. Potassium, analyzed at MP-19 (ungraphed) in only the last four years of the ash placement period, spiked to 77.0 mg/L in this February 2004 sampling from levels normally between 1 and 4 mg/L. The spikes in this sampling in multiple parameters that are highly soluble constituents in many eastern coal ashes suggests a contaminant plume from ash leachate emerging through this point into the ravine beyond the north central perimeter of the site. A spike of acidity to 332 mg/L in this sampling appears to have enhanced this solubility. Iron and manganese levels jumped in this sampling although sulfate did not.

Figure 8.64 32753702 MP-19 EME Generation
Calcium & Magnesium

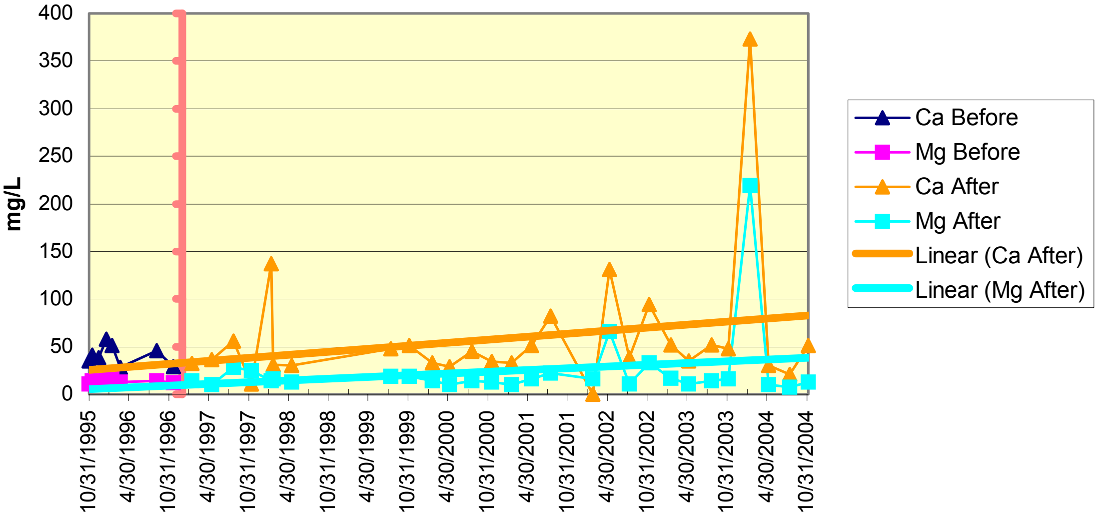
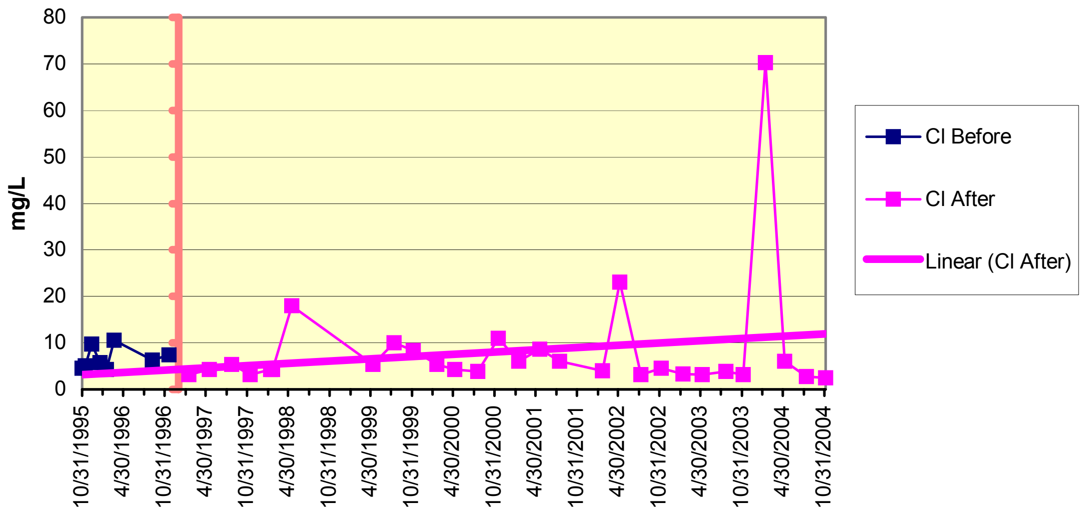


Figure 8.65 32753702 MP-19 EME Generation Chloride

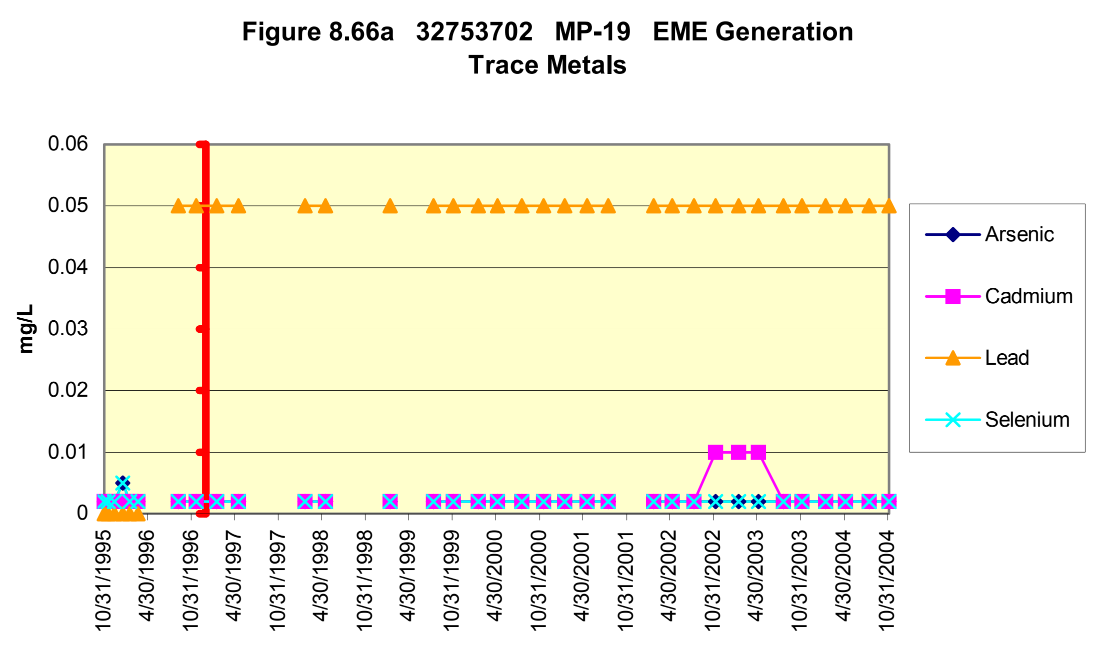


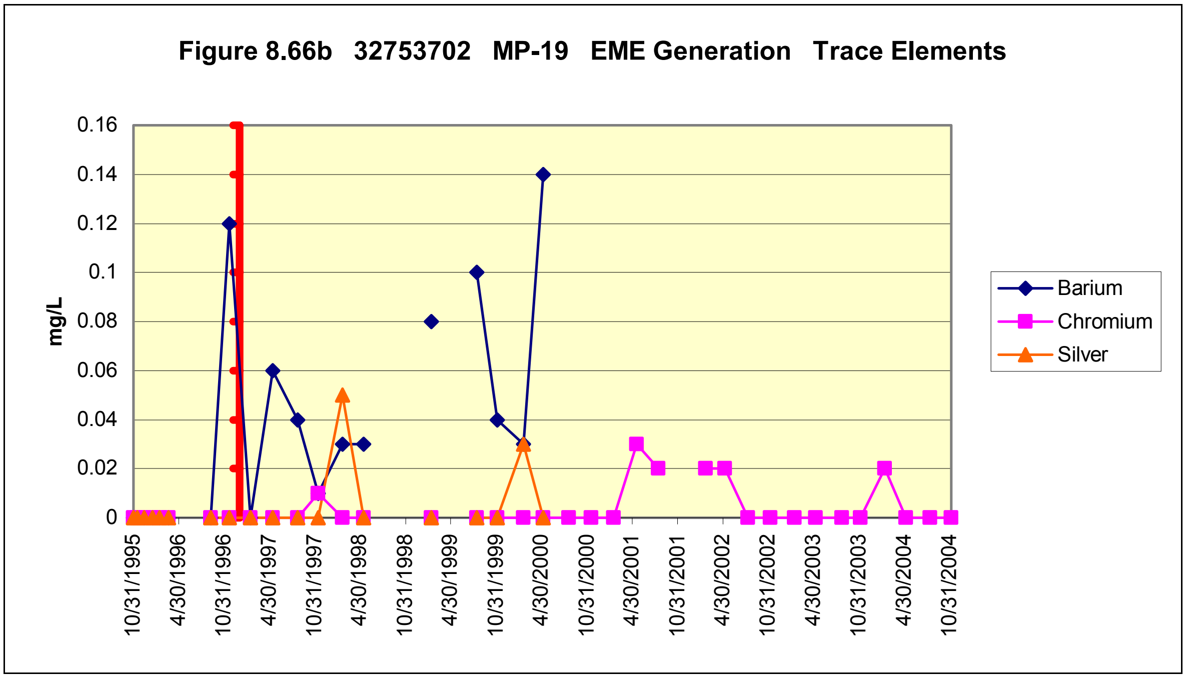
The trace metal plots for total concentrations of arsenic, cadmium, lead, and selenium are almost identical to those at MP-15 (figure 8.66a). Arsenic and selenium were below laboratory detection limits of 0.002 mg/L for selenium and 0.002 mg/L and 0.01 mg/L for arsenic, except for one measurement of both of these trace elements at 0.005 mg/L in early 1996. Like MP-15, there were three measurements of cadmium at 0.010 mg/L again in November 2002, February 2003 and May 2003 although all of these measurements were below a detection limit set at this level. As at MP-15, the lead values were below a detection limit of 0.05 mg/L, which is more than three times the federal DWS. This level is too high to discern whether lead may be leaching from the ash or coal refuse at levels of concern. A lower detection level should be used so that any increasing trends can be identified as soon as possible.

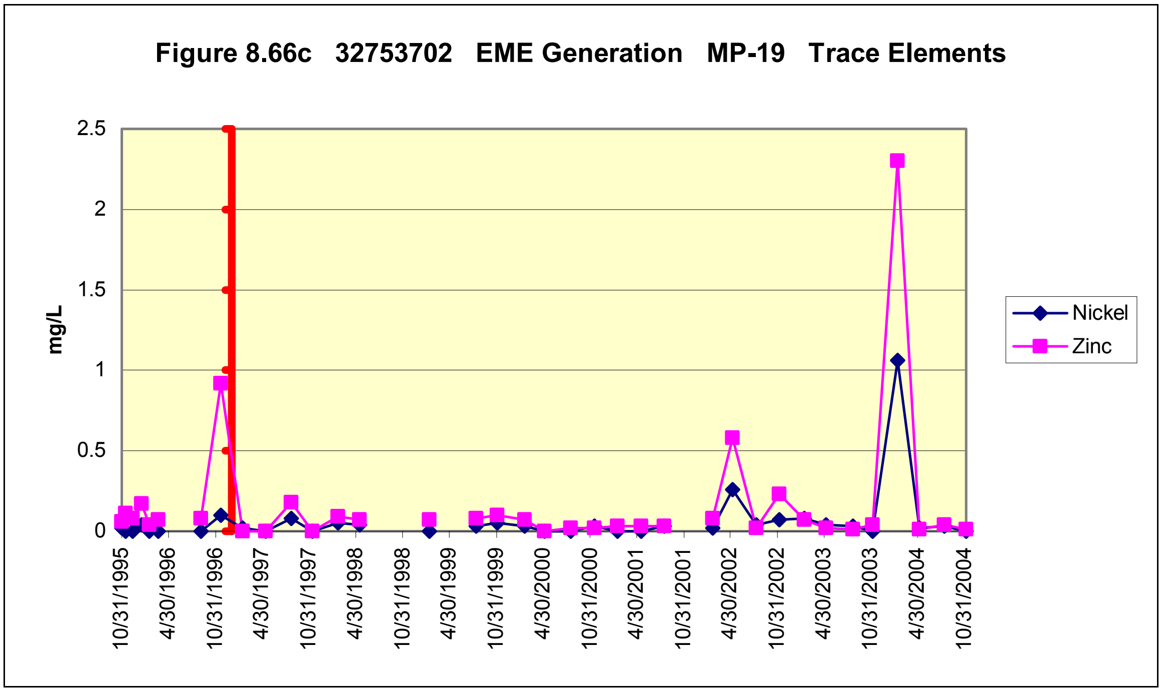
Six other trace metals were measured during ash placement at MP-19 at levels exceeding their highest baseline concentrations in multiple samplings. These were barium, chromium, silver, nickel, zinc, and copper.

Of these, nickel was measured above the old DWS twice. These included one concentration of 1.06 mg/L, more than 10 times this DWS and the highest nickel measured at any monitoring point at any time in the same February 2004 sampling in which very high levels of other ash parameters were found. Levels of nickel and zinc tracked up and down together consistently (figure 8.66c). The highest zinc level at MP-19 was also found in this February sampling at 2.30 mg/L, more than 13 times higher than the highest baseline concentration for zinc.

The sole measurement of copper exceeding its highest baseline concentration was found in this February 2004 sampling at 0.07 mg/L. Chromium (figure 8.66b) was found at 0.02 mg/L in this sampling while all baseline chromium levels were >0.02 mg/L. Despite rises from baseline levels, barium and silver (figure 8.66b) were not analyzed for after May 2000. Sharp increases in concentrations of barium, nickel and zinc in the November 19, 1996 sampling, two months after the permit revision authorizing ash placement became effective (Sept. 17, 1996), suggests an impact from the operation before the beginning of 1997 which is identified as the end of the baseline period in the figures in this permit review.







MP-20 (Older Stage I/II Leachate)

The highest levels of trace elements have been identified at MP-20 which is identified in monitoring reports as a downgradient Module 25 ash monitoring point that samples leachate from pipes under the older Stages I and II of the Refuse Pile. Due to the late assessment of data from MP-20, impacts at this monitoring point have not been evaluated as substantively in this report. Nonetheless of note are elevated levels of chromium, barium, silver, nickel, zinc and copper that occurred during the ash placement period at this monitoring point. Chromium levels (figures 8.67a and 8.67b) rose beyond the highest baseline level of 0.050 mg/L in November 1996, five times during ash placement. Its highest measurement, a peak of 0.490 mg/L in February 1997, was 4.9 times the DWS for chromium (0.10 mg/L). Most chromium measurements were between 0.030 and 0.070 mg/L. If the November 1996 sample is considered reflective of the ash placement period, chromium levels exceeded the highest baseline measurements 15 times during the ash placement period. With the February 1997 peak value deleted, this rise in chromium concentrations from baseline levels is more visible in figure 8.67b. There are no measurements of concentrations for the more toxic chromium species, hexavalent chromium.

The same rise in concentrations after September 1996 is noticeable for barium and silver at MP-20 (figure 8.67c). Silver levels exceeded the highest baseline level of 0.04 mg/L in five samples after September 1996. The highest silver concentration, 0.10 mg/L in November 1996, was equal to the secondary DWS. This concentration occurred before the baseline period ends in figure 8.67c but two months after the ash placement permit was issued. Four subsequent measurements of silver that were higher than baseline levels suggest this highest silver concentration may have also been a result of operations starting under the ash placement permit. Barium exceeded its highest baseline concentrations in 11 of 12 samplings after September 1996.

Nickel concentrations at MP-20 exceeded their highest baseline concentration in 26 of 32 samplings after September 1996 and zinc concentrations exceeded their highest baseline concentration in 28 of those samplings (figure 8.67d). Thirty of those samplings measured nickel above its old DWS with the highest being 0.86 mg/L in May 2000, 8.6 times the old DWS, which concentration was also measured at MP-15 in the same sampling. The highest zinc at MP-20 was measured in this sampling at 3.0 mg/L (the DWS is 5.0 mg/L). This was highest zinc concentration found at this site. The rises in both of these constituents in latter monitoring at MP-20 are evident. The nine highest nickel concentrations occurred from 2000 onward and the 20 highest concentrations of zinc occurred from 1999 onward.

Copper concentrations at MP-20 (figure 8.67e) also exceeded their highest baseline concentration seven times during ash placement. The highest copper concentrations occurred from 1999 onward but remained between one sixth and one tenth the DWS (1.3 mg/L).

Measurements of other trace elements at MP-20 were lower during ash placement. Baseline concentrations of arsenic, cadmium and selenium at MP-20 reached the highest measured at any monitoring point in this permit, yet did not remain as elevated during ash placement. Arsenic concentrations ranged from 0.004 to 0.067 mg/L from October 1995 to March 1996. Arsenic was then found at 0.032 mg/L in November 1996, the highest arsenic recorded at a monitoring point during ash placement in this permit but then measured only once above detection limits for the duration of monitoring at MP-20 at 0.004 mg/L in November 1997. The first cadmium measurement during the baseline period was 0.030 mg/L, six times the DWS. All subsequent measurements were <0.002 mg/L until the latter monitoring during ash placement when cadmium reached 0.010

mg/L in August 2002 and February 2003. Selenium was measured 0.015 mg/L in November 1996 compared to the highest baseline measurement being 0.037 mg/L also occurring in the first sampling in October 1995. All selenium measurements after November 1996 were <0.002 mg/L. Lead concentrations at MP-20 were always <0.05 mg/L, more than 3 times the DWS (0.015 mg/L).

The water at MP-20 is leachate emanating directly from the pile and thus is substantially more acidic and polluted with major constituents than are found in the waters at MP-15 or MP-19. In fact the average concentrations of iron, sulfates and manganese are approximately twice as high at MP-20 as they are at MP-14, the settling pond where pollutants in leachate from Stages III and IV of the pile are concentrated by evaporation.

However a decline in concentrations has been occurring at MP-20 for most major pollutants over the ash placement period. This decline has coincided with a decline in very high acidity from an average of 5198 mg/L from November 1996 through November 1999 to an average acidity of 2976 mg/L from November 2001 through November 2004 (alkalinity measurements have remained negligible, virtually always 0 .00 mg/L at this monitoring point). Of note, however is that field pH actually declined nearly a half unit from an average of 3.56 to an average of 3.17 units between these periods suggesting an environment becoming more acidic. Iron levels averaging 1696 mg/L from 1996-1999 declined to an average of 1381 mg/L in 2001-2004. Sulfate levels declined from an average of 8291 mg/L in 1996-1999 to an average of 6574 mg/L in 2001-2004. Presumably these declines were related to the substantial decline in acidity.

On the other hand, average manganese concentrations increased slightly between these periods from 33.7 to 35.8 mg/L. And average aluminum concentrations increased from 37.3 to 50.8 mg/L between these periods.

Noticeably higher levels of sodium, calcium, magnesium and potassium persisted throughout the ash monitoring period but also declined somewhat from initial levels. Average calcium levels declined from 389 mg/L during the first three years of ash placement to 346 mg/L in the last three years of monitoring. Average magnesium levels slipped from 359 mg/L in the first three years of ash placement to 263 mg/L in the last three years. Average sodium concentrations fell from 775 mg/L in the first three years of the ash placement period to 664 mg/L in the last three years of monitoring. During the period in which potassium was monitored at MP-20, (2001-2004), its levels remained usually in the 9-12 mg/L range rather than the 1-3 mg/L range normally found at MP-15 and MP-19. Somewhat similar to MP-15, chloride levels jumped at MP-20 during the middle of the monitoring period in late 2000 and 2001 from levels in the 21-29 mg/L range to levels between 30 and 92 mg/L but declined back to earlier levels in the last three years of monitoring.

The decline in major parameter concentrations at MP-20 is reflected in the decline in TDS and Specific Conductance at this point. TDS levels dropped from an average of 12,433 mg/L in 1996-1999 to 9140 mg/L in 2001-2004. Specific Conductance declined from an average of 7008 micromhos in 1991 to 5023 micromhos in 2001-2004.

Thus while most major parameters have declined in the leachate from the older portions of the refuse pile at this monitoring point, there has also been a greater mobilization of several trace elements after ash placement started on the pile. Among them, chromium, silver and nickel have reached levels of concern.

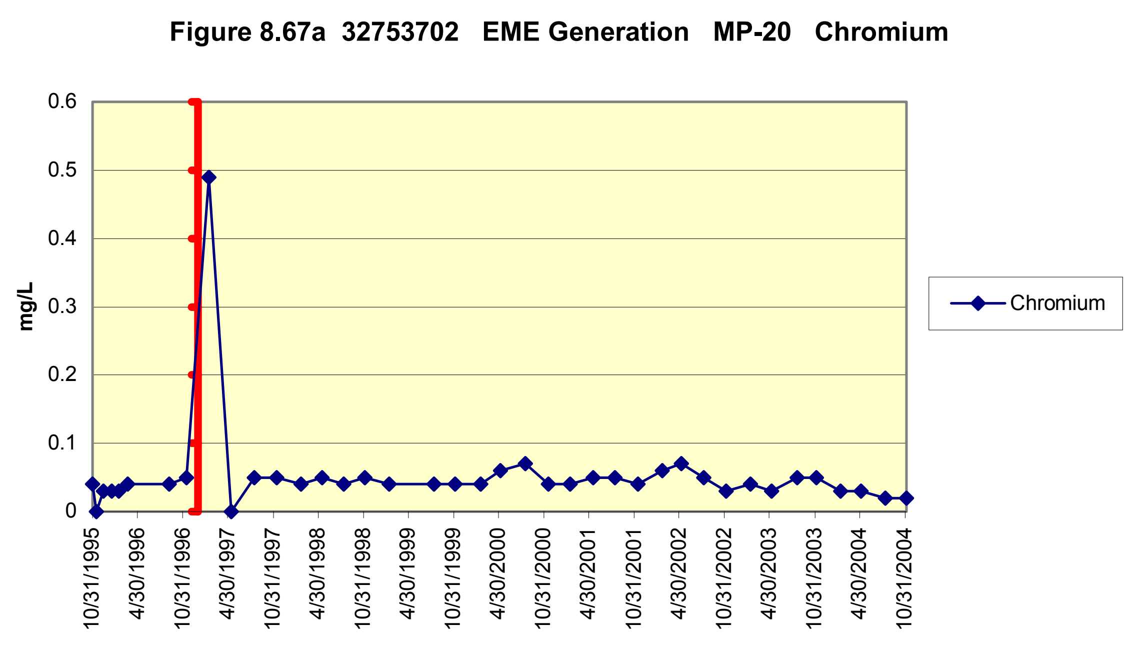


Figure 8.67a 32753702 EME Generation MP-20 Chromium
mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0
10/31/1995
4/30/1996
10/31/1996
4/30/1997
10/31/1997
4/30/1998
10/31/1998
4/30/1999
10/31/1999
4/30/2000
10/31/2000
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4/30/2004
10/31/2004
Chromium

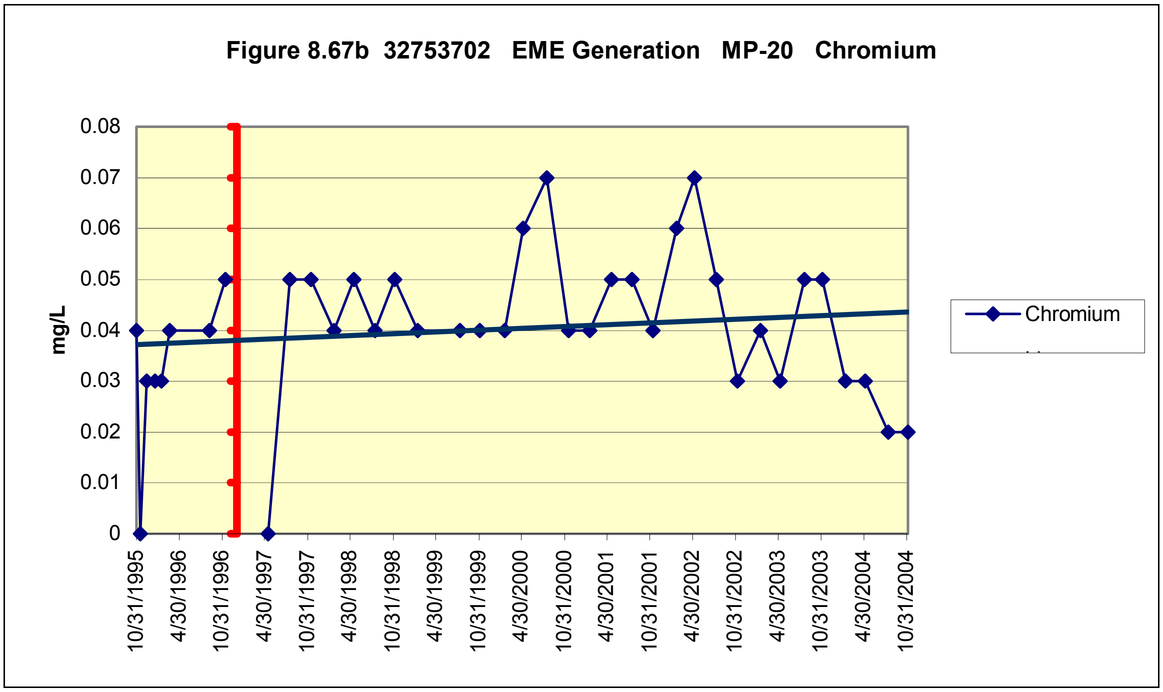
Figure 8.67b 32753702 EME Generation MP-20 Chromium
mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
10/31/1995
4/30/1996
10/31/1996
4/30/1997
10/31/1997
4/30/1998
10/31/1998
4/30/1999
10/31/1999
4/30/2000
10/31/2000
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4/30/2004
10/31/2004
Chromium

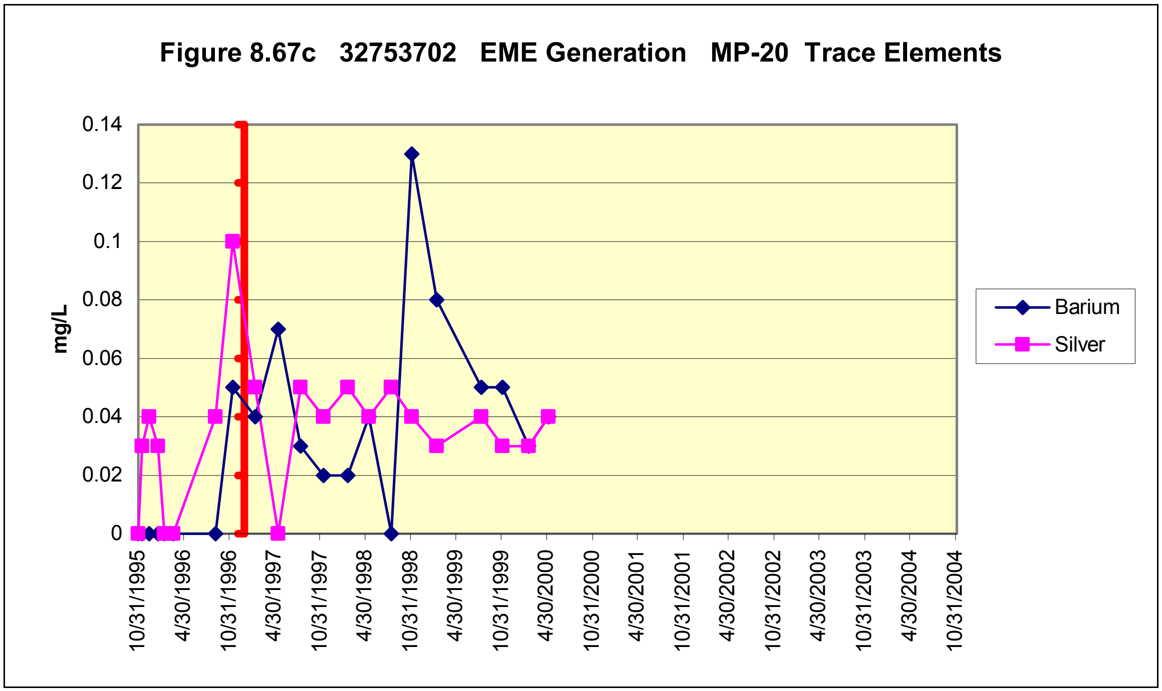


Figure 8.67c 32753702 EME Generation MP-20 Trace Elements
mg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10/31/1995
4/30/1996
10/31/1996
4/30/1997
10/31/1997
4/30/1998
10/31/1998
4/30/1999
10/31/1999
4/30/2000
10/31/2000
4/30/2001
10/31/2001
4/30/2002
10/31/2002
4/30/2003
10/31/2003
4/30/2004
10/31/2004
Barium
Silver

Figure 8.67d 32753702 MP-20 EME Generation Trace Elements

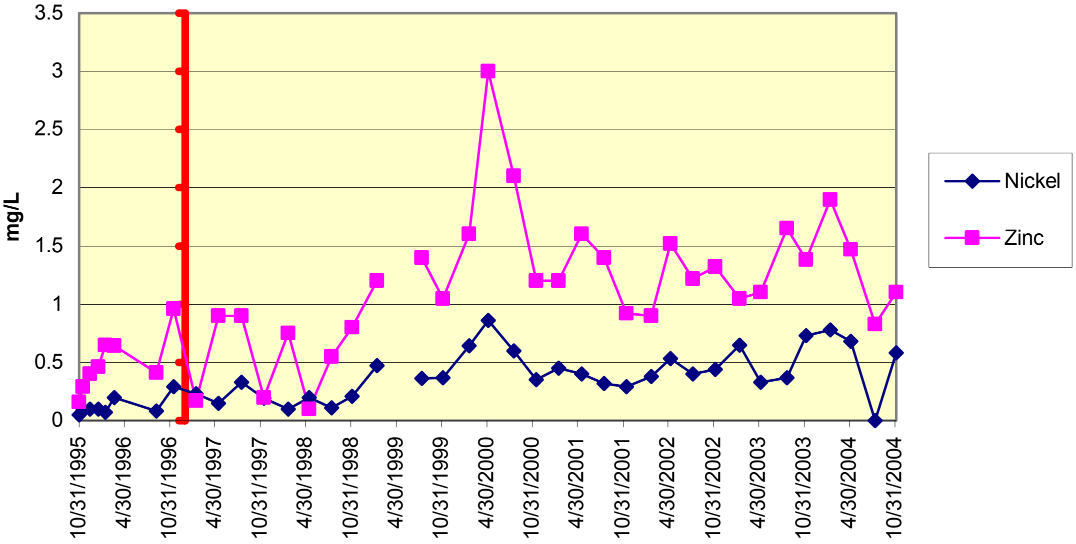
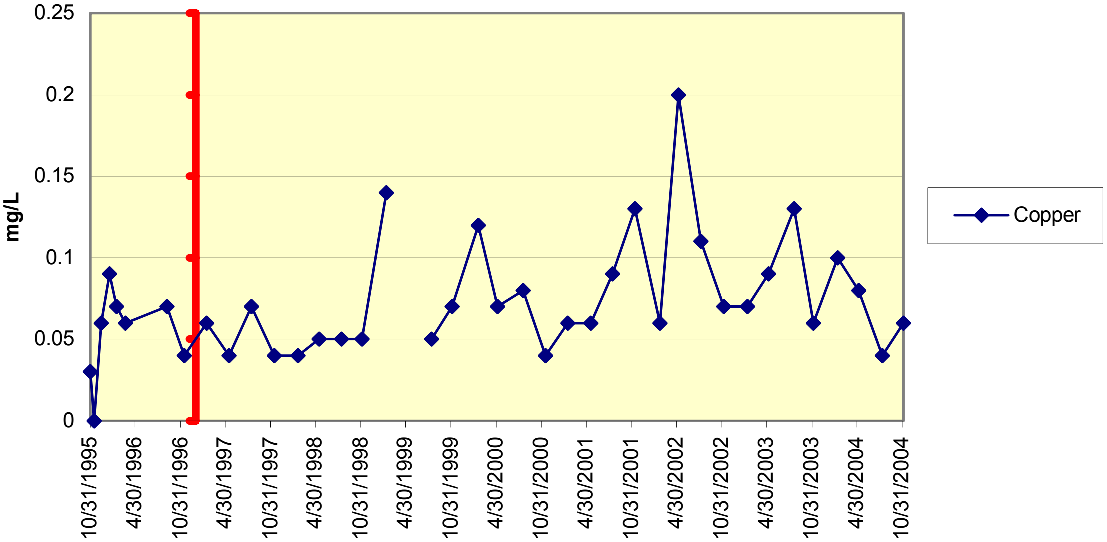


Figure 8.67e 32753702 MP-20 EME Generation Copper



Conclusion

Aside from the absence of data for more exclusive ash indicator parameters from points directly monitoring Cherry Run, the completeness of the data sets in this permit allowed easier analysis of ash placement impacts at the EME Refuse Disposal Site compared to most of the other ash placement permits examined in this report. When the data from surface water samples before and after ash placement are compared at upstream and downstream monitoring points, it is evident that the coal ash at the EME disposal site is the source of rising levels of sulfates in Cherry Run. These rising levels are significantly degrading Cherry Run. Concentrations exhibit increasing trends with values as high as six times Pennsylvania's AWQC of 250 mg/L. While Pennsylvania's water quality standard for sulfate in surface waters applies only when such waters are used as a drinking water source, the presence of this amount of sulfate in Cherry Run indicates that ash at the refuse pile at this site is degrading the quality of the downstream waters of Cherry Run and rendering it not potable.

There is much that is still unknown about the impacts on Cherry Run. No data for calcium, magnesium, chloride, sodium, potassium or trace element concentrations were collected at the stream monitoring points, MP-13, MP-11, and MP-12. Such data would allow a better assessment of the full impact of ash placement on the stream.

Data for Module 25 ash parameters such as calcium, magnesium, and trace elements were only collected at MP-15, MP-19 and MP-20 The former two monitoring points are sampling waters immediately downgradient from the ash placement area while the latter point is sampling leachate collected from the older portion of the pile where ash was placed in the upper portions in mixtures with coal refuse and as a cover. The data suggest that contamination of groundwater with sulfates is occurring possibly from ash at MP-15 and MP-19. This is corroborated further by coinciding peaks of highly soluble ash parameters such as calcium, magnesium, chloride, sodium and potassium and overall rises in nearly all of these constituents in an environment of generally rising pH.

An elevated cadmium level was measured at MP-15 after ash placement. Other trace elements including nickel, barium, copper, and silver at MP-15 and nickel, barium, copper, silver, chromium and zinc at MP-19 were measured at higher levels during the ash placement period than before this period. At both of these monitoring points, nickel was below the old DWS of 0.10 mg/L before ash placement but found in multiple samplings at concentrations of concern – more than 1 to more than 10 times the old DWS - during ash placement with higher levels occurring in the latter duration of monitoring. In the case of MP-19, high levels of nickel are presumably flowing out of this seep uncontrolled into a ravine and exiting the northern boundary of the property in surface water.

At MP-20, the data indicate that very high acidity, extremely high levels of sulfate and iron and most other major pollutants levels in leachate from the older portion of the pile are coming down with time. Exceptions are slightly rising manganese levels and moderately rising aluminum levels both of which were already many times over the DWS and AWQC in Pennsylvania when ash placement started on the pile.

In addition, trace element concentrations at MP-20 that were below levels of concern during the baseline period such as those for chromium, nickel and silver have reached and/or surpassed levels of concern (DWS) after the issuance of the permit revision authorizing ash placement at the site in September, 1996. Silver levels reached the secondary DWS once and remained above baseline levels throughout most samplings during ash placement. The highest nickel, zinc and copper readings were all concentrated from 1999 onward indicating growing degradation from these trace elements over time. However high arsenic, selenium and cadmium levels during baseline sampling were measured at lower concentrations after ash placement started. Thus the results of data from MP-20 suggest good and bad impacts to water quality over the 8 years of monitoring that has occurred since ash was first placed on this refuse pile.

In addition to sampling for Module 25 metals and trace elements at more of the established monitoring points, analyzing on a regular basis for these constituents directly in the ash and ash/gob mixtures in the refuse pile would provide a better idea of the degree to which toxic trace metals are being mobilized at the source of any potential problem. Additional monitoring for signature ash parameters, not currently monitored under Module 25, such as antimony, boron and molybdenum would also help differentiate the sources of pollution between gob and ash. In all sampling for trace elements, detection levels used in the analysis and accepted by the PADEP in the results should be low enough to document whether any analytes are occurring at levels of concern.

The EME Refuse Disposal Site is unique among the permits studied in this report in that there was a long period of monitoring when gob was actively disposed on this refuse pile before ash placement occurred. The oldest permit in the public file for this site was dated 1989, although PADEP staff maintains that the refuse disposal at this site started well before then. Thus there is a baseline of data delineating the impacts of active gob placement on water quality that can be compared with and clearly differentiated from data measuring the impacts of subsequent ash placement on that water quality. The resulting comparison suggests that ash at the EME site is contributing significantly more sulfates to downstream waters than the gob was contributing and is also contributing higher levels of trace elements such as nickel, zinc, copper, barium, silver and chromium to leachate and shallow groundwater draining the site.

Permit Review 9

LAWRENCE COAL COMPANY, HARTLEY STRIP MINE
(PERMIT # 30713008)

Site Summary

The Lawrence Coal Company, Inc. Hartley Strip mine operation is located in Monongahela Township, Greene County, Pennsylvania, in the Lower Monongahela Priority Watershed 19D. Over 300,000 tons of conventional PC fly and bottom ash from the Hatfield's Ferry Power Plant were placed on 30.3 acres of the site. The purpose of the operation is not clear from permit materials. It may have been simple "placement" to fill a pit on the site or as alkaline addition to remediate AMD problems. Information in the permit indicates the ash had been placed in the mine previous to this permitted operation but do not provide the locations for that placement.

Four monitoring wells were installed at the Hartley Strip ash placement area, two downgradient wells (MW-1 and MW1-A) and two upgradient wells (MW-2 and MW2-A). Operations started in 1988, and monitoring continued until 1998.

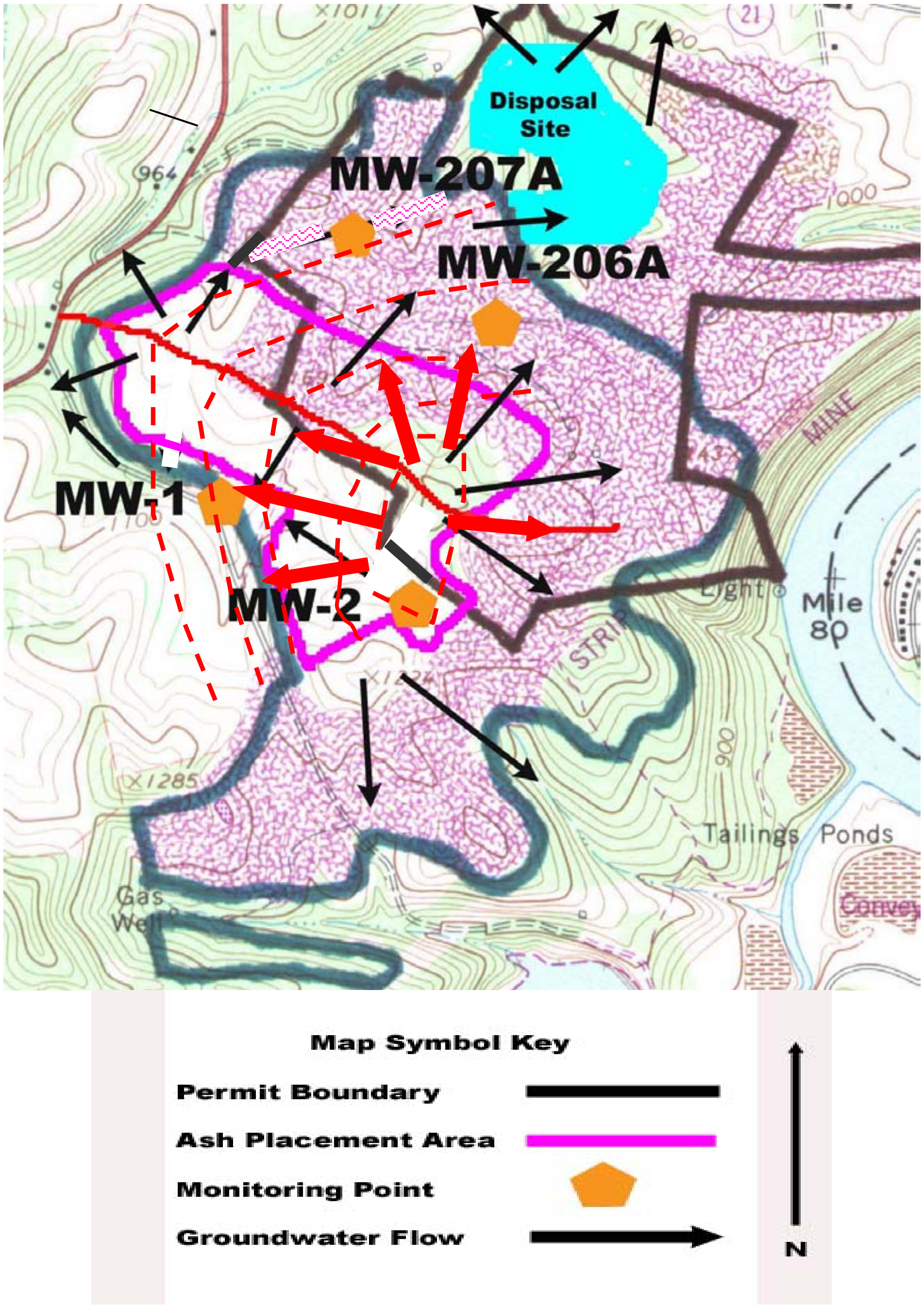
The northeastern half of the Hartley Site has become a coal ash landfill utilized for disposal of ash generated by the Hatfield's Ferry Power Plant. The mining operation has ceased but the landfill is still operating. Two monitoring wells installed as upgradient wells for the landfill, MW-206A and MW-207A (not operated under Surface Mine Permit 30713008) are probably affected by earlier ash placement from the Hartley Strip operation. These additional landfill wells provide insight into the impacts occurring from the Hartley Strip operation because of their location and the greater range of parameters measured at these wells under PADEP's residual solid waste program, including ash indicator parameters boron and molybdenum. The map below shows the original Hartley permit boundary in dark green, and the present Hatfield ash landfill disposal area shaded in light blue. The portion surrounded by the pink line was the ash placement area for the Hartley permit.

Geology

The two coal beds mined at the Hartley Strip operation were the Waynesburg Coal and the Waynesburg "A" Coal which is about 70 feet above the Waynesburg Coal. The Pittsburgh Coal is about 350 feet below the Waynesburg Coal. . The Pittsburgh seam was deep mined underneath this site, below the water level of the nearby Monongahela River although there is enough separation hydraulically that flow between the River and the deep mine is unlikely to affect shallow groundwater flow in the spoil and ash from the ridge at the Hartley site.

A structural syncline (the “trough” between two anticlines) runs across the center of the Hartley site. The structural attitude of the sedimentary beds is a dip (or inclination direction) towards the centerline (axis) of the syncline. This structure also probably does not significantly affect relevant surface and shallow groundwater flow directions.

<u>Site Map: Hartley</u>



Lawrence Coal Company, Hartley Strip Operation (Permit # 30713008)
Scale: 1” = Approximately 1000’

Topography

The regional topography is typical of the Pittsburgh Low Plateau section of Pennsylvania. The Hartley mine occupies the top of a hill (see map) with valleys trending down southeastward and northeastward towards the Monongahela River. A ridge, represented by the solid red line on the map above, that trends northwest/southeast divides the site into two roughly equal portions.

Groundwater

According to the permit, MW-1 and MW-2 are monitoring shallow groundwater in the spoil aquifer created from previous mining on the site. Permit information indicate that MW1-A and MW2-A are monitoring water at deeper depth. Monitoring reports for 1988 document an average static water elevation (elevation above seal level) in three measurements at MW-1 of 1049 feet and a average static water elevation in three measurements at MW-2 of 1078 feet. The dashed red lines on the map above are a conceptualized potentiometric surface depicting a radial flow pattern of shallow groundwater through the site based on these static water elevations and the flow directions described in the permit, depicted by the black arrows.

This map indicates groundwater is flowing through the disturbed portions of soil, rock and ash from MW-2, the upgradient well, to MW-1, the downgradient well. However as MW-2 is within the ash placement area and screened in the spoil aquifer, it might also measure impacts associated with ash contamination should ash be placed upgradient to the well. Unfortunately the authors of this review could not find information on specific ash placement configurations or the actual locations of ash deposits within the ash placement area.

Wells 206A and 207A for the Hatfield landfill are downgradient of flow moving north from the divide. Unlike the mine wells, the "A" in their label signifies their depth in the shallow spoil aquifer of the Hartley Mine, as opposed to being screened in the Uniontown Sandstone and Benwood Limestone underneath the mine and landfill as other landfill wells are. Hereafter this review will identify them simply as MW-206 and MW-207. On the north side of this ridge, groundwater flows mostly north and northeast from the Hartley ash placement area toward these two wells making them downgradient of the Hartley ash site but upgradient of the ash disposed in the Hatfield landfill. On the south side of this ridge, groundwater flows mostly to the southwest and the southeast into valleys bordering these portions of the site.

Components of shallow groundwater at the site also flow west and northwest into a valley and tributary draining to the northeast and then into the Monongahela River, via Little Whitely Creek. Little Whitely Creek is contaminated with high levels of boron, sulfate and molybdenum according to surface water monitoring data collected for the adjacent Hatfield coal ash landfill.

Groundwater monitoring data: Discussion

MW-1

Monitoring wells MW-1 and MW-2 were selected for analysis within this report. The monitoring reports for these wells do not indicate whether concentrations reported are for dissolved or total concentrations of analytes. The data collected for the Hatfield wells (discussed later) do differentiate, and in such instances, only dissolved values are assessed in the discussion of data from MW-206 and MW-207.

The first four graphs (figures 9.1 through 9.4) plot the concentrations of iron, manganese, sulfates, acidity, and trace elements for downgradient MW-1.

Initially, iron and manganese (figure 9.1) and sulfates (figure 9.2) were monitored only for a 1-year period in 1988. The next monitoring data for the major elements found in the permit are dated from mid 1995 onward, with a resulting 6-year data gap. No baseline data were found in the permit files. Review of the graphed data for iron and manganese suggest that there is a general upward trend in concentrations for iron but a less clear trend for manganese, with the highest value, 4.74 mg/L in September 1997, occurring in more recent monitoring but all other recent concentrations of manganese below levels reported in 1988. Sulfate concentrations generally appear to decrease over time, suggesting some remediation of AMD from reclamation activities and possibly from the placed ash. Acidity is increasing (figure 9.3) towards the end of the monitoring period even though it is only reaching levels one-tenth the peak in acidity that occurred in November 1988 (420 mg/L). Nonetheless the rise in acidity and peaks of iron and manganese from 1995 onward probably reflect mining operation disturbances.

Figures 9.3A and 9.3B are plots of lab pH and alkalinity, respectively at MW-1. Field pH data, which are generally considered to be more reflective of actual groundwater pH, were not recorded in the monitoring sheets within the permit files. The large data gap makes interpretation difficult. An extremely low lab pH of 2.9 units measured in November 1988 may have been an outlier, but is corroborated by a very high acidity and low alkalinity recorded in the November 1988 sampling. Notwithstanding the low November 1988 pH reading which produces a slightly upward trend line for pH, these data appear to reflect slightly declining alklanity and increasing acidity over time at MW-1.

Trace element data (figure 9.4; antimony, cadmium, lead, and mercury) were collected over the life of the site, on a yearly basis, for MW-1. Data for 1994, 1995 and 1996 are missing however. In addition, the extremely variable detection limits make it very difficult to interpret the data, and on several occasions, the detection limits were well above the DWS. For example values reported as less than a detection limit for antimony in July 1992 and July 1993 samplings (<.10 mg/L) are more than 16 times higher than the DWS for antimony, and values reported as less than detection for cadmium in those samplings as well as in the April 1988 sampling (<0.010 mg/L) are below a limit twice its DWS. The value recorded as less than the detection limit for mercury in September 1998, 0.004 mg/L, is twice the DWS for mercury.

There were a number of actual concentrations measured for these trace elements at MW-1 however, and in several instances these concentrations exceeded the DWS. An actual concentration of antimony at 0.03 mg/L, exceeding the DWS (0.006 mg/L) by five times, was measured in August 1991. A cadmium concentration of 0.01 mg/L, twice the DWS, was measured in September 1998. Lead concentrations of 0.04 mg/L, 0.02 mg/L, and 0.06 mg/L were measured in April 1988, July 1992 and July 1993 respectively. The DWS (federal Action Level) for lead is 0.015 mg/L.

Molybdenum (ungraphed) was also measured in the last two samplings at MW-1 at 0.0040 mg/L in September 1997 and 0.19 mg/L in September 1998. The EPA Removal Action Level (clean up standard under Superfund, 42 U.S.C. 9601) for molybdenum is 0.010 mg/L. The EPA short term health children's health advisory for ingestion of this metal is 0.02 mg/L, longer term children's health advisory is 0.01 mg/L and longer term adult health advisory is 0.05 mg/L (Drinking Water Regulations and Health Advisories, US EPA, Office of Water, EPA 822-B-96-002, Oct. 1996). Thus the latter measurement clearly presents a level of concern.

These measurements suggest mobilization of trace elements although more measurements are needed before a meaningful analysis can be accomplished of the impacts of ash on trace elements in waters monitored by MW-1.

It should be noted nonetheless that antimony and molybdenum have been found to leach readily in the SPLP tests on many ashes placed in the minefills studied in this report although the Hartley permit was the only one researchers found in which water quality monitoring was undertaken for these two trace elements albeit with only two samplings at one monitoring well for molybdenum. Notwithstanding this fact, the Hartley permit failed to require any monitoring for arsenic, another trace element that has been found to leach from many ashes placed in the coal mines studied in this report.

Figure 9.1 30713008 MW-1 Hartley Major Elements

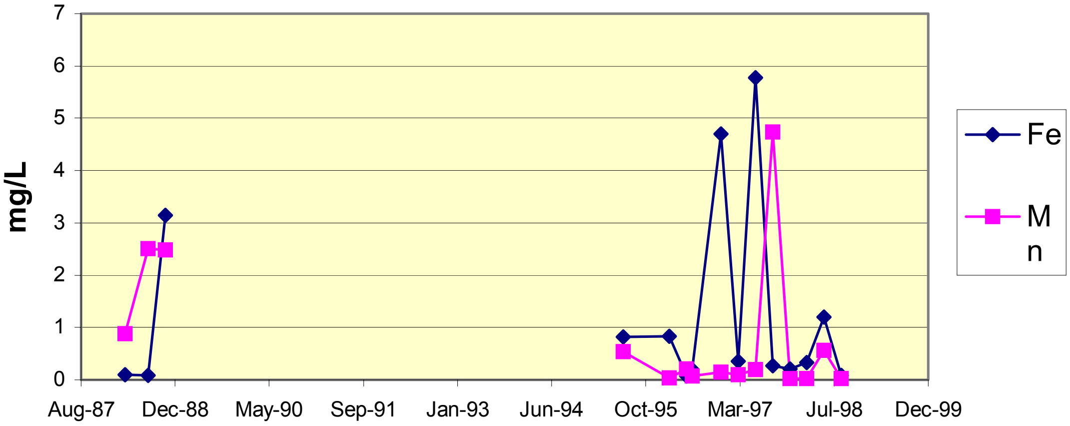
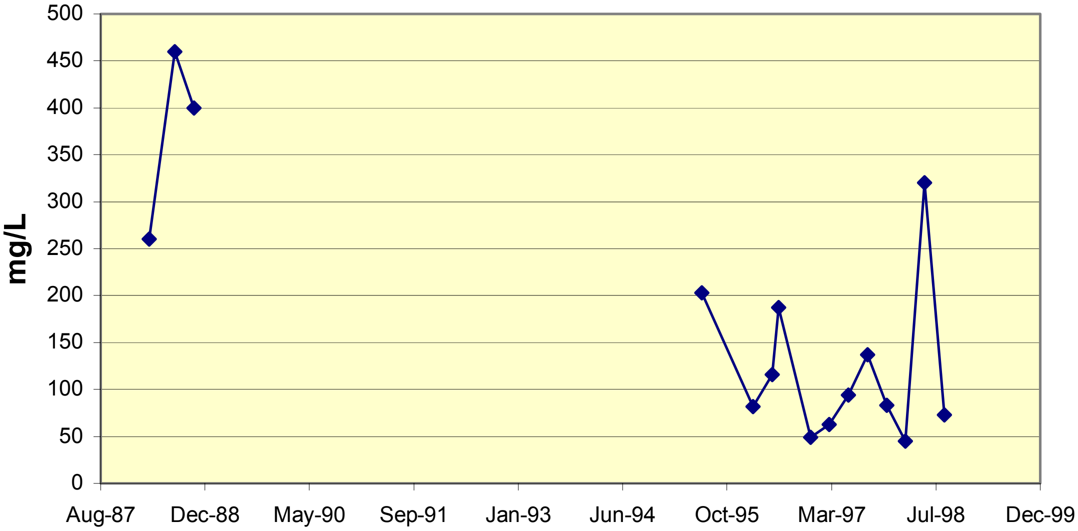


Figure 9.2 3073008 MW-1 Hartley Sulfates



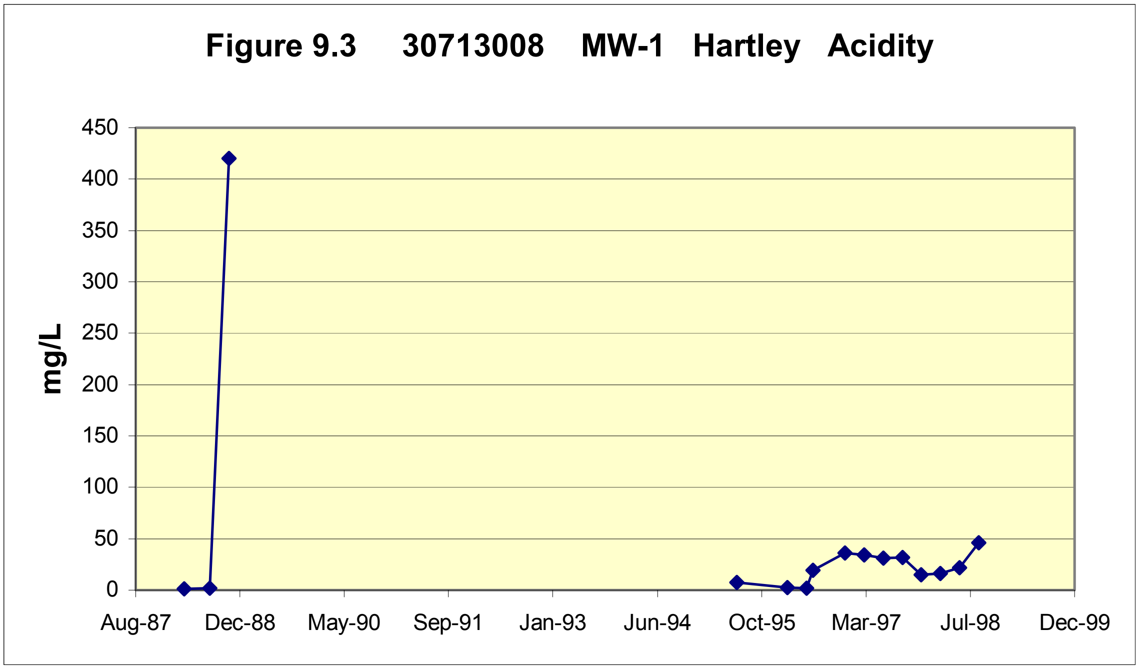


Figure 9.3 30713008 MW-1 Hartley Acidity
mg/L
450
400
350
300
250
200
150
100
50
0
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99

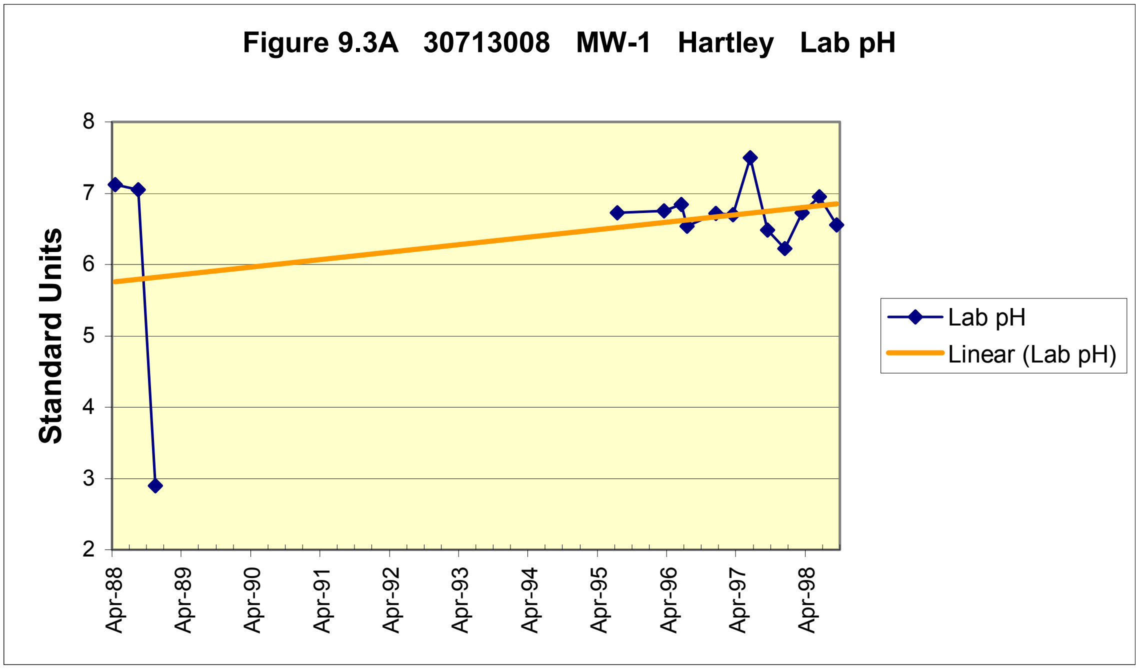


Figure 9.3A 30713008 MW-1 Hartley Lab pH
Standard Units
8
7
6
5
4
3
2
Apr-88
Apr-89
Apr-90
Apr-91
Apr-92
Apr-93
Apr-94
Apr-95
Apr-96
Apr-97
Apr-98
Lab pH
Linear (Lab pH)

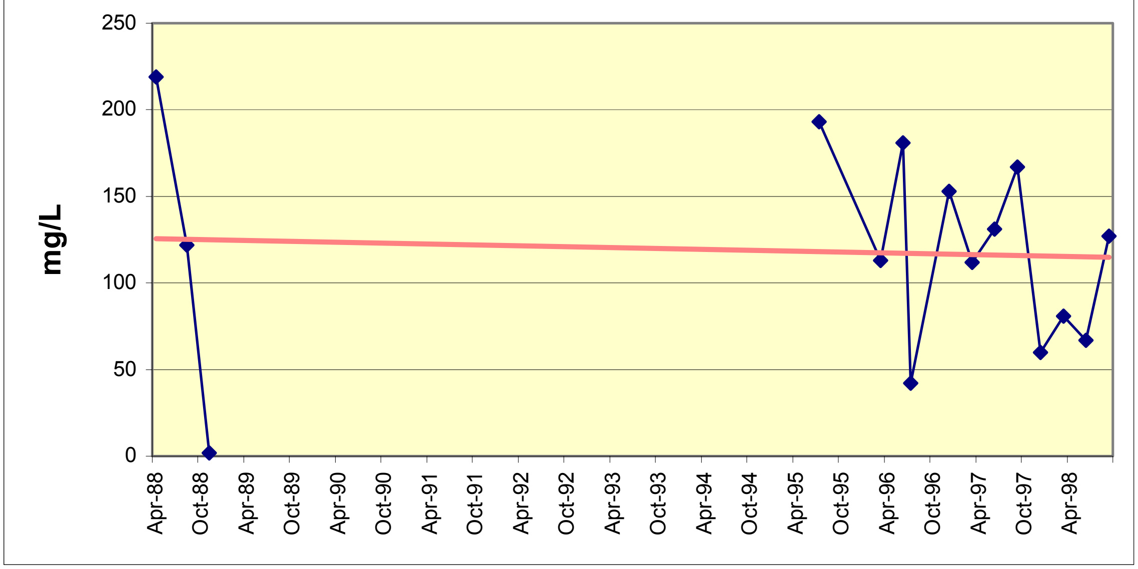


Figure 9.3B 30713008 Hartley MW-1 Alkalinity

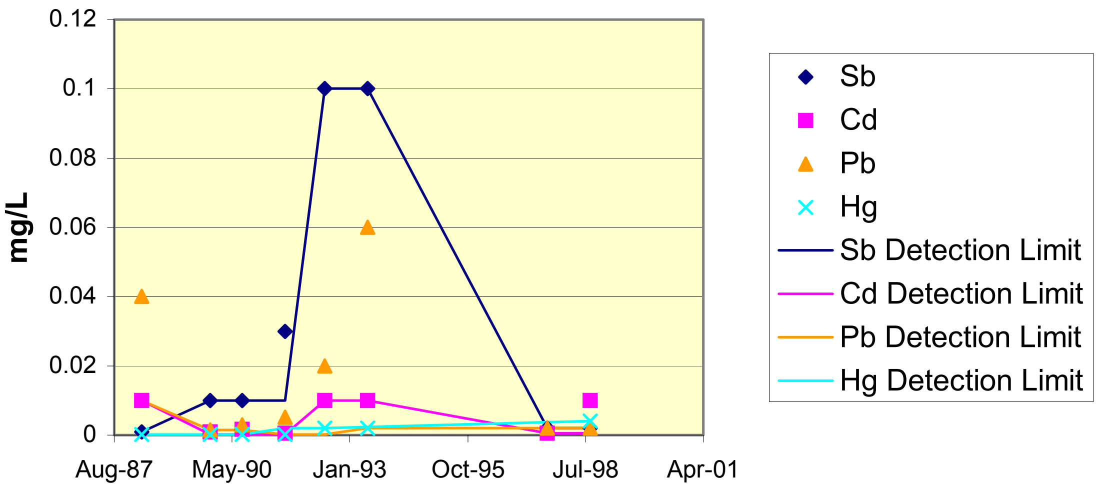


Figure 9.4 30713008 MW-1 Hartley Trace Elements

MW-2

Major element data for upgradient MW-2 (figure 9.5, iron and manganese and figure 9.6, sulfates) was reported for 1988, with three samples, as was the case with MW-1. As MW-2 is an upgradient well, the concentrations of the major elements and sulfate are considerably less than that of downgradient MW-1. As was the case for MW-1, monitoring data for the six and a half years from 1989 until July 1995 were not found in the permit files for MW-2, and subsequent written and in-person inquiries to the PADEP Greensburg Office were to no avail.

The data obtained shows different levels but a similar erratic behavior of these elements at the two wells; iron and manganese concentrations at MW-2 are usually less than one tenth their concentrations at MW-1. Both decrease at MW-1 (figure 9.1) in 1995; then iron rises in December 1996, followed by manganese in September 1997 both peaking at concentrations 5-15 times higher than their 1995 and 1996 levels. After another rise in June 1998, they drop in the last sample, in September 1998 to levels below the 1995-96 concentrations and within the DWS (0.30 mg/L for iron and 0.05 mg/L for manganese). However, the higher concentrations at MW 1 are many times over the DWS. At MW-2, (figure 9.5) all iron and manganese concentrations are under 1 mg/L. Both elements decrease in 1995 and 1996, then increase in1997 to levels 5-10 times higher and then decrease in 1998 back to the 1995-96 levels which are under the DWS. The higher concentrations of iron are except for one instance, barely over the DWS at MW-2, while at least 5 higher concentrations of manganese range from nearly 4 to 10 times over the DWS. High and low levels of these constituents occur in all seasons, and don't appear to be driven by precipitation events or seasonal fluctuations.

Average sulfate concentrations are around half of those at MW-1, except for one peak of 1180 mg/L on June 1998. However, this peak appears to be an outlier and is not consistent with the other data for this site. Overall, excluding this high value, it appears that sulfate concentrations have remained relatively stable over time at concentrations less than half the DWS (250 mg/L).

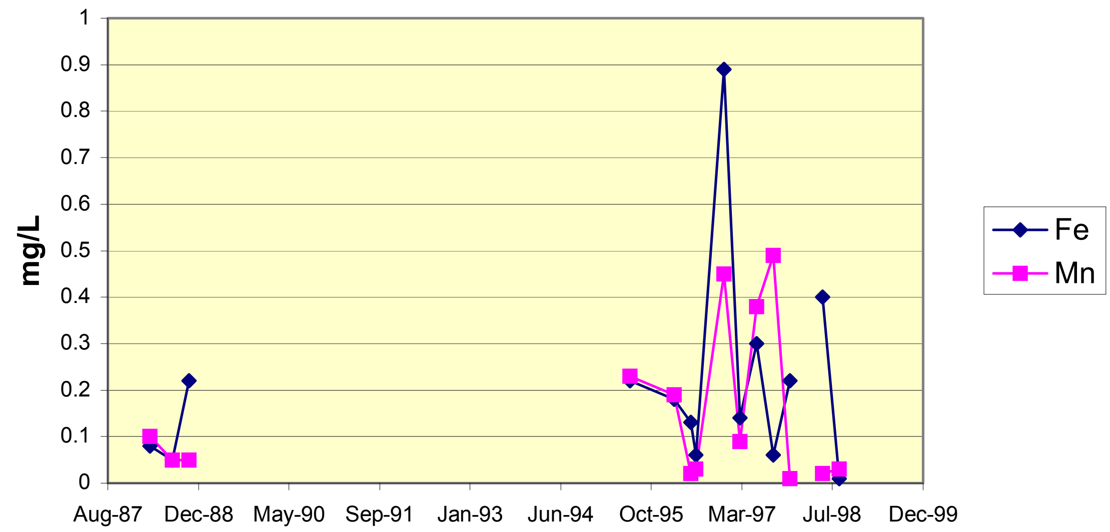
Acidity concentrations (figure 9.7) significantly increase from the 1988 levels of between 0 and 2 mg/L starting in the summer of 1996 to a maximum concentration of 39 mg/L in June 1998. Figures 9.7A and 9.7B are graphs of the lab pH and alkalinity over time. As with MW-1, field pH data was not included in the monitoring reports available to this report's authors. Consistent with other data for this site, the large data gap for MW-2 makes interpretation difficult. What is clear is that after 1995 the alkaline buffering capacity of the waters at MW-2 was being taxed; there is a declining average alkalinity with drops in actual values of 99-210 mg/L and a declining pH from values in the range of 7-7.5 units to values in the range of 6.5 to 7 units. This indicates the effects of mining were reaching this well, raising the question of its validity as an "upgradient" monitoring point.

The trace element data for MW-2 (figure 9.8) are more complete than that of MW-1 with no data points missing except for any measurements in 1990. The plot pattern is similar to MW-1. The same high detection limits erode the usefulness of much of the data for antimony and cadmium. The antimony values for 1992, 1993, 1994 and 1996 were <0.1 mg/L, 16.7 times the DWS for antimony. And cadmium values for 1988, 1992, 1995 and 1996 were <0.01 mg/L, twice the DWS for cadmium. All mercury values were recorded at below detection limits, although from 1992 through 1996 that detection limit was <0.002 mg/L which is the DWS.

There were several actual concentrations exceeding the DWS at MW-2 and to somewhat greater degrees in a couple of instances than exceedances measured at MW-1. Antimony exceeded its DWS by 6.7 times in August 1991 at 0.04 mg/L. A measurement of 0.11 mg/L for antimony in July 1995 exceeded the DWS by 18.3 times. Unfortunately there is no measurement in 1995 at MW-1 with which to compare this value. Cadmium concentrations exceeded the DWS by 2 times in the July 1993, August 1994, and September 1998 measurements. And lead concentrations exceeded the DWS in four of the ten total measurements for trace elements at MW-2. The July 1993 lead measurement of 0.10 mg/L was the highest at 6.7 times the DWS.

There were no measurements for molybdenum at MW-2. Of some note however were actual concentrations for silver which ranged as high as 0.02 mg/L at MW-1 in July 1993 and 0.05 mg/L at MW-2 in July 1996. Although the federal secondary DWS for silver is 0.1 mg/L, the authors did not usually see silver detected at these levels in waters at the sites studied in this report.

Figure 9.5 30713008 MW-2 Hartley Major Elements



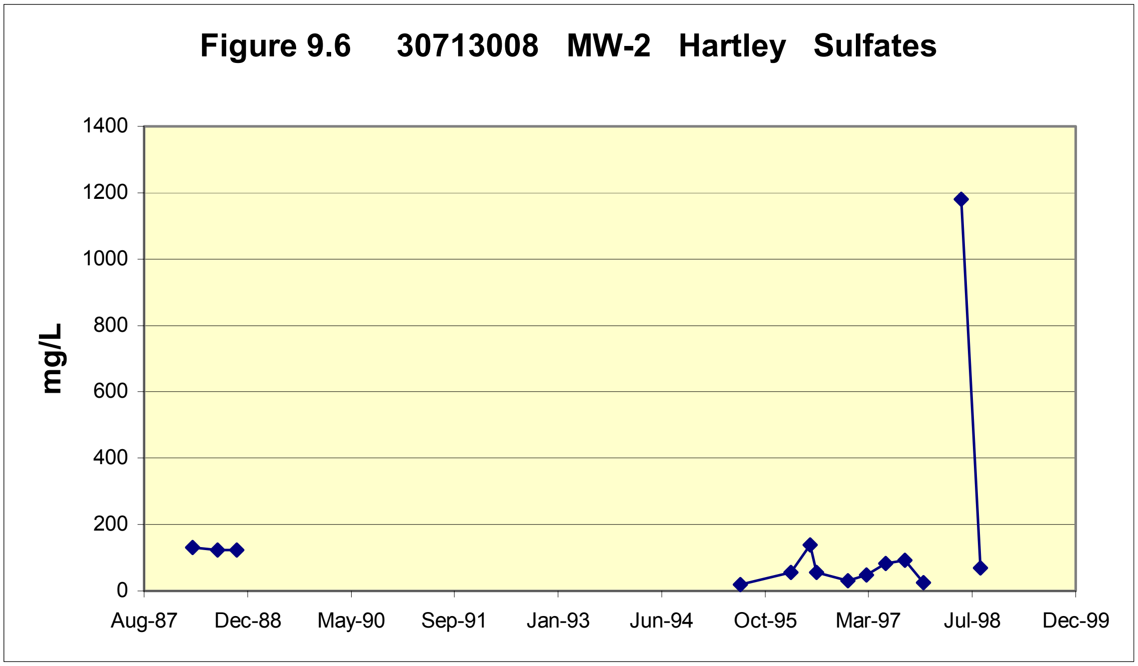


Figure 9.6 30713008 MW-2 Hartley Sulfates
mg/L
1400
1200
1000
800
600
400
200
0
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99

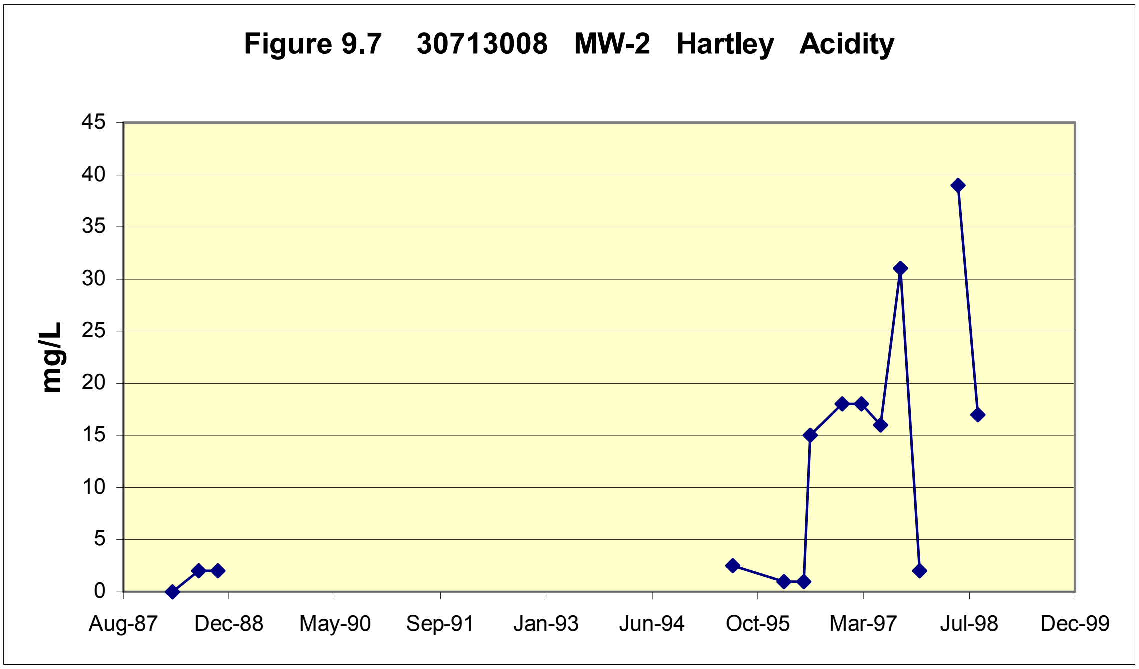


Figure 9.7 30713008 MW-2 Hartley Acidity
mg/L
45
40
35
30
25
20
15
10
5
0
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99

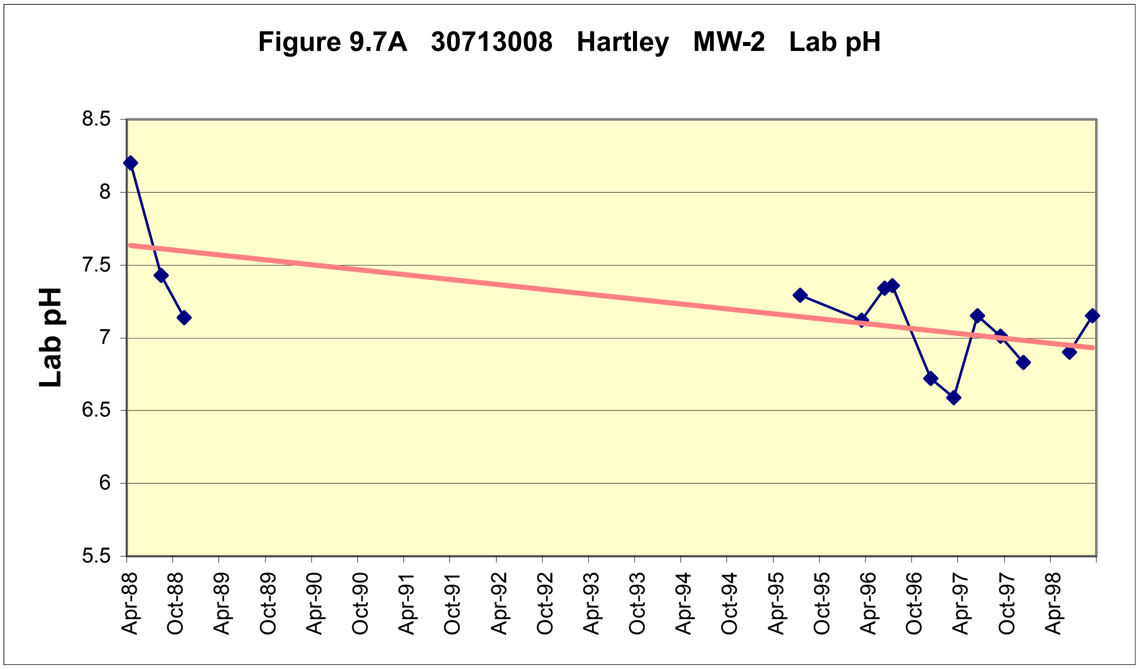


Figure 9.7A 30713008 Hartley MW-2 Lab pH
Lab pH
8.5
8
7.5
7
6.5
6
5.5
Apr-88
Oct-88
Apr-89
Oct-89
Apr-90
Oct-90
Apr-91
Oct-91
Apr-92
Oct-92
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Oct-96
Apr-97
Oct-97
Apr-98

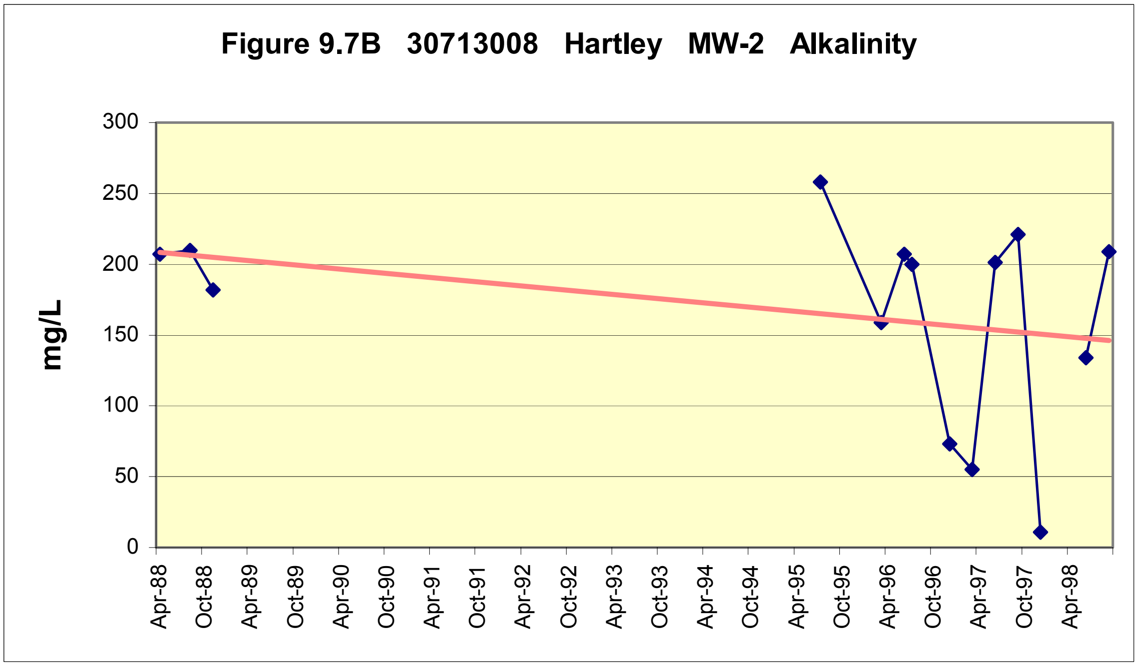
Figure 9.7B 30713008 Hartley MW-2 Alkalinity
mg/L
300
250
200
150
100
50
0
Apr-88
Oct-88
Apr-89
Oct-89
Apr-90
Oct-90
Apr-91
Oct-91
Apr-92
Oct-92
Apr-93
Oct-93
Apr-94
Oct-94
Apr-95
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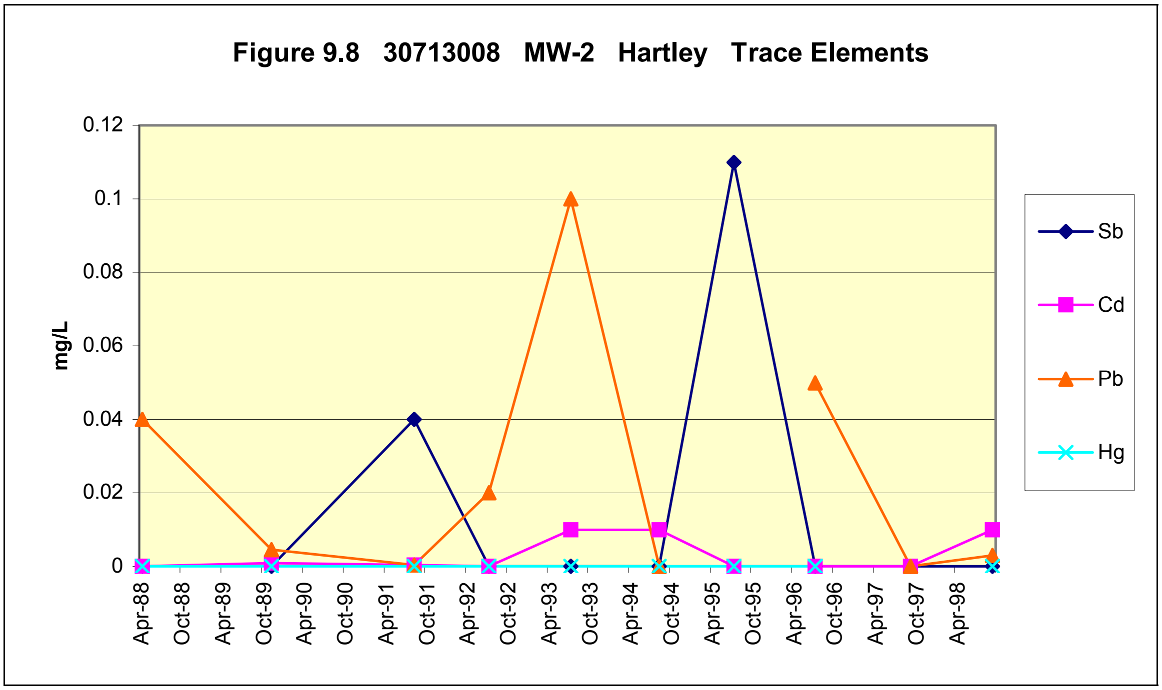
Oct-96
Apr-97
Oct-97
Apr-98



Hatfield Coal Ash Landfill

The Hatfield coal ash landfill is adjacent to and partially overlaps the Hartley Strip ash placement site. The ash was transported from the nearby Hatfield's Ferry Power Plant to this landfill for disposal purposes, with no intent to remediate AMD problems associated with mining activity. See the map above for the relationship between the Hatfield landfill and the Hartley site. The original Hartley site is outlined in dark green, and the more recent Hatfield ash disposal area is outlined in dark brown.

Data from two monitoring wells are discussed below: MW-206, and MW-207. While the exact timing, sequence, and location of ash placement in the Hartley mine is not clear, it should be noted that the data reflected in the figures for these wells presumably should reflect impacts from ash from the first measurements forward as ash placement presumably was well underway for as many as six years at Hartley before the first data discussed below was collected.

MW-206

Cross sections and elevation information in the Hatfield permit file indicate that MW-206 is upgradient of the ash disposed in the Hatfield landfill but downgradient of the ash in the northern half of the Hartley Strip site. Groundwater sampled at this well will be affected to some degree by ash at the Hartley operation.

Two ash indicator element concentrations are graphed in figures 9.9 and 9.10, boron and molybdenum. Boron was not monitored at the Hartley wells and only two measurements of molybdenum were taken at MW-1. After a short decline in 1994 and 1995 from 7.225 mg/L to 2.616 mg/L, the boron concentrations rise steadily at MW-206 up to 13.466 mg/L in February 1998 and later, after some data gaps, to a high of 14.052 mg/L in June 2000. These concentrations are well beyond levels of concern for boron which has a Removal Action Level of 0.900 mg/L and health advisories ranging from 0.6 mg/L for an adult's lifetime exposure to 4 mg/L for the child's one day exposure to boron in drinking water (Drinking Water Regulations and Health Advisories, US EPA, Office of Water, EPA 822-B-96-002, Oct. 1996). Molybdenum concentrations at MW-206 are under 0.01 mg/L and their average level is slightly dropping over time (figure 9.10).

Manganese and sulfate trends are shown in figures 9.9 and 9.12, respectively. Manganese values at MW-206 are 1.5 to 2 times higher than at MW-1, and 15-20 times higher than at MW-2. However the graphs for manganese at all three of these monitoring points show sharp rises during the middle of 1997, indicating the Hartley wells and MW-206 could possibly be connected hydrologically. The sulfate concentrations at MW-206 are about 10 times the values from MW-1 and almost 20 times the values from MW-2. The sulfate trend at MW-206 starts from average levels already more than six times over the DWS in 1994 but clearly increases to average levels just under 2500 mg/L, ten times the DWS, compared with trends at MW-1 and MW-2 that are less clear.

Figure 9.12A graphs alkalinity over time, showing a steady rise from an average of 300 mg/L to approximately 540 mg/L over the six years of monitoring data presented, that could be due to alkaline ash leachate reactions. The field pH (figure 9.12B) has a corresponding gradual rise from an average of 6.23 to 6.50 units, probably from alkaline ash leachate . There are no data for acidity in the database for Hatfield monitoring points in the Hatfield Landfill permit files available for this assessment. Calcium, potassium, and magnesium, all of which are ash indicator elements, have clearly rising trends at MW-206 (figures 9.12C, 9.12D, and 9.12E, respectively); over the six year monitoring period, average calcium rises from 340 mg/L to 560 mg/L, average magnesium more than doubles from 150 mg/L to 360 mg/L and average potassium also more than doubles from 10 to 21 mg/L. All of the evidence from these five graphs points to water quality effects from ash.

There is a small rise in chloride over the monitoring period at MW-206 (not graphed) punctuated with a spike in the November 25, 1996 sampling to 43.7 mg/l, 5-8 times over the other concentrations recorded at this point. This spike was measured from a sample taken on the same date that a sample from MW-207 was collected from which a spike in chloride to 37.99 mg/L was measured, also 5 times over the other concentrations for chloride at MW-207. This could have resulted from a sampling problem(s) or reveal a potential hydrologic linkage between these two points.

Figure 9.9 Hatfield MW-206 Boron

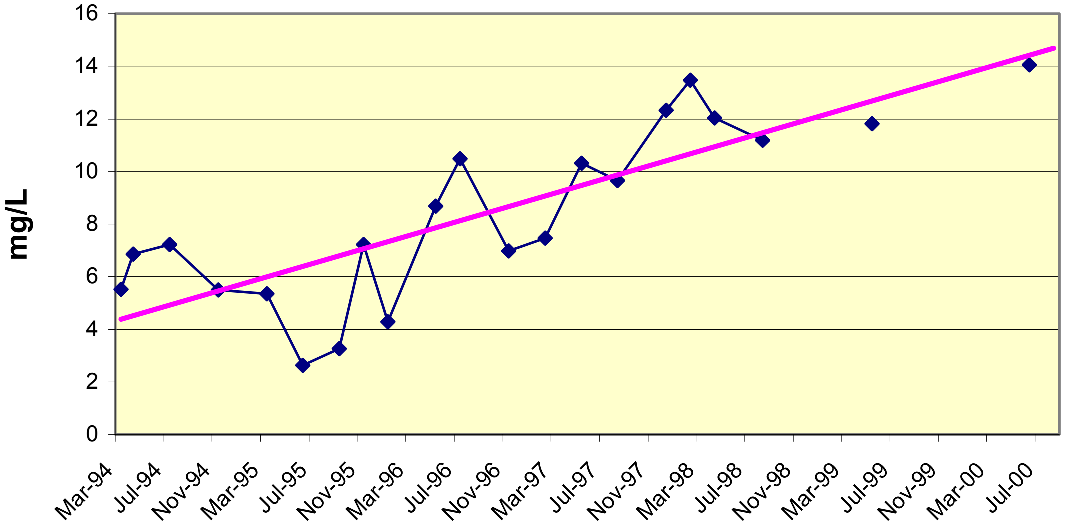


Figure 9.10 Hatfield MW-206 Molybdenum

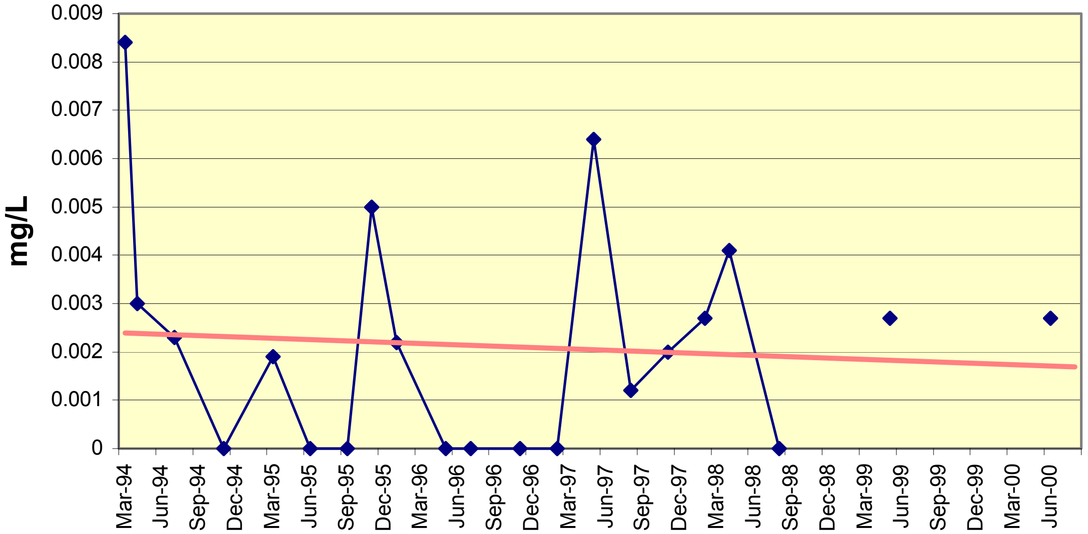


Figure 9.11 Hatfield MW-206 Manganese

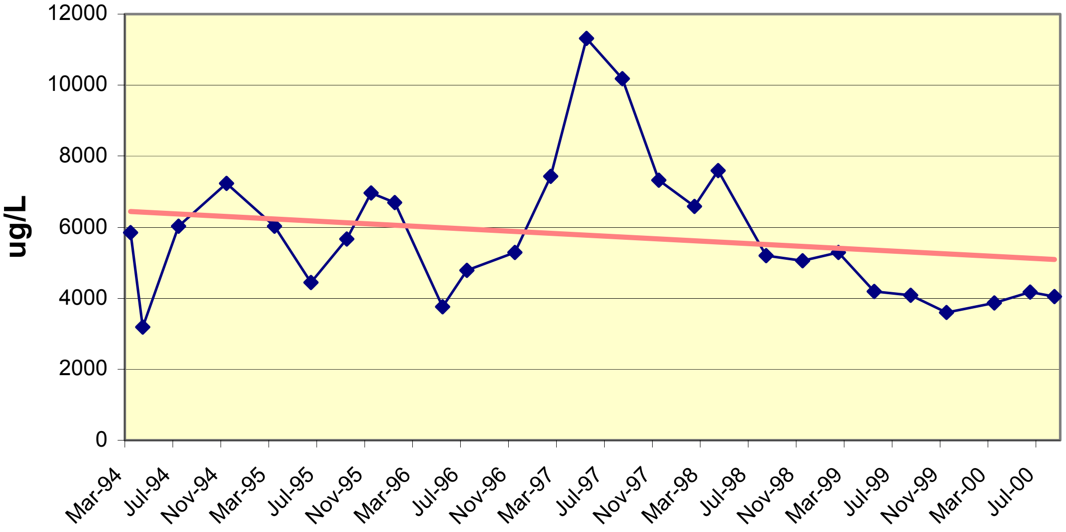
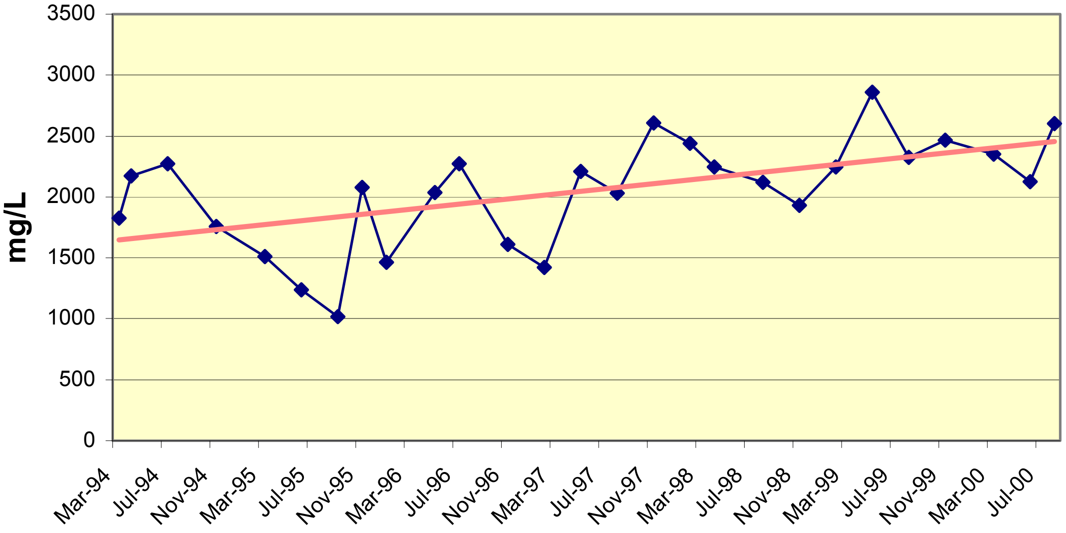


Figure 9.12 Hatfield MW-206 Sulfates



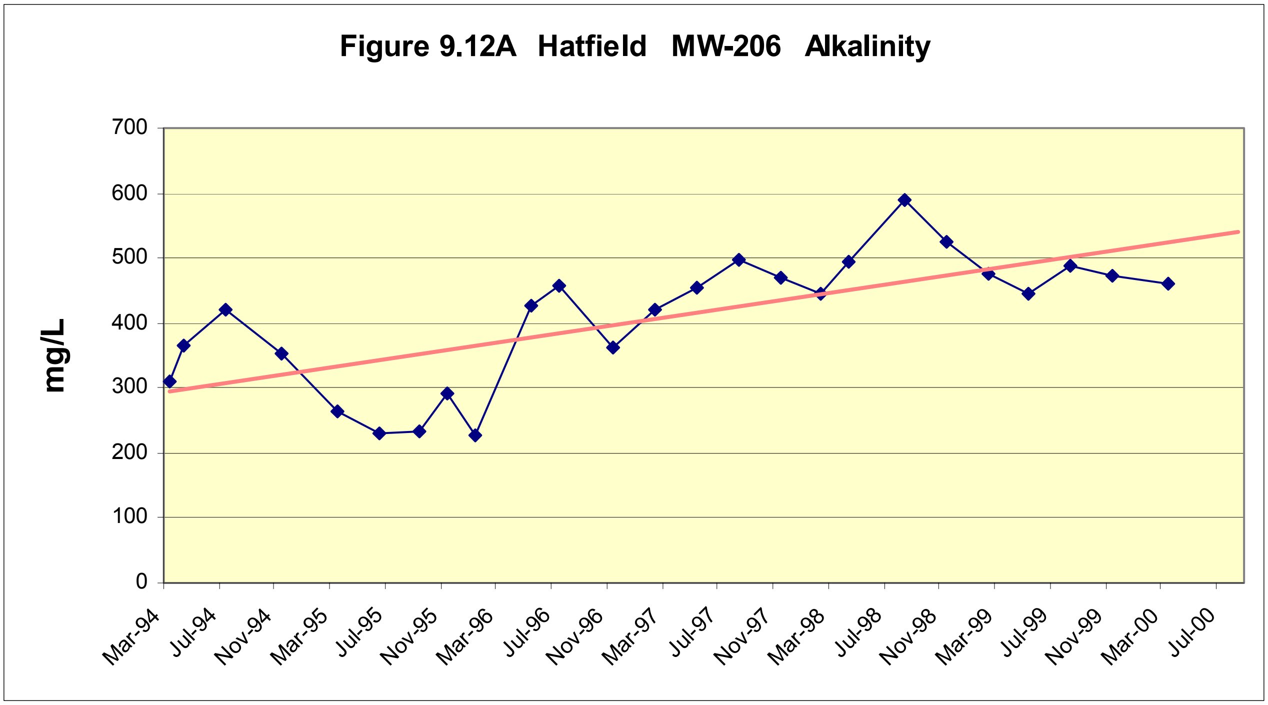


Figure 9.12A Hatfield MW-206 Alkalinity
mg/L
700
600
500
400
300
200
100
0
Mar-94
Jul-94
Nov-94
Mar-95
Jul-95
Nov-95
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
Mar-98
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Jul-99
Nov-99
Mar-00
Jul-00

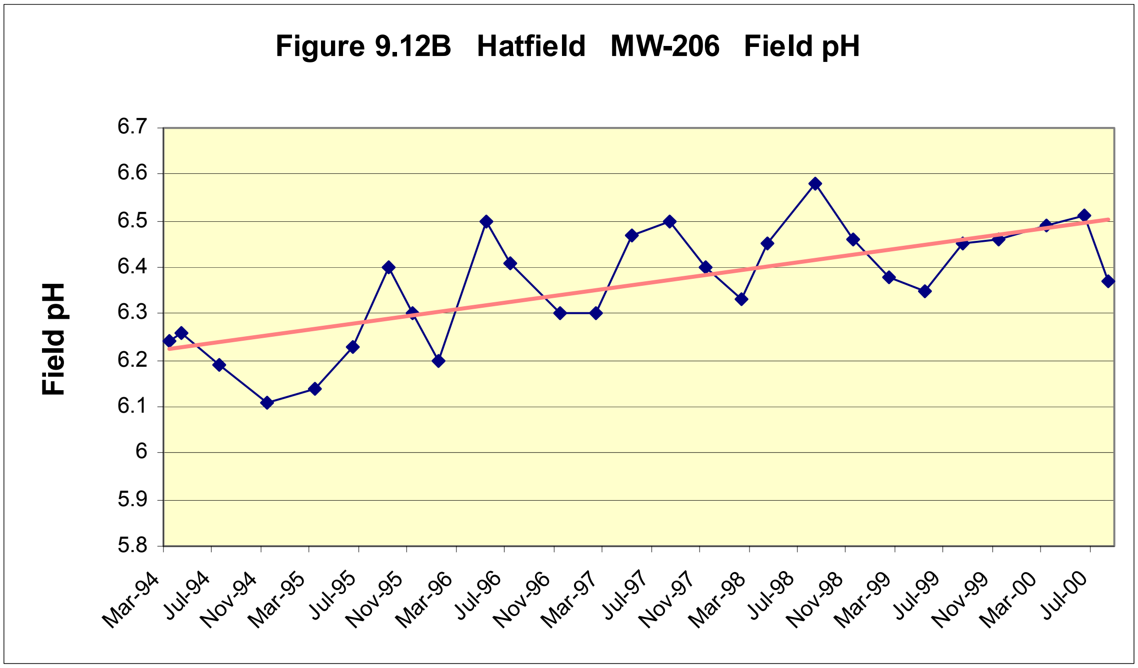
Figure 9.12B Hatfield MW-206 Field pH
Field pH
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
Mar-94
Jul-94
Nov-94
Mar-95
Jul-95
Nov-95
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
Mar-98
Jul-98
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Mar-99
Jul-99
Nov-99
Mar-00
Jul-00

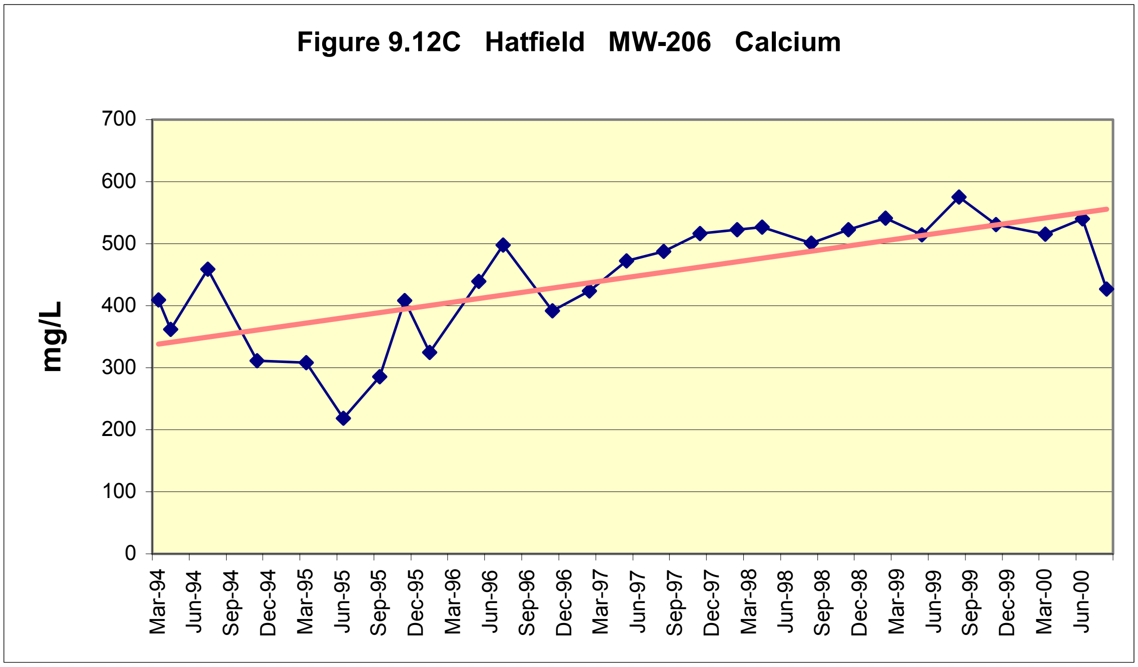
Figure 9.12C Hatfield MW-206 Calcium
mg/L
700
600
500
400
300
200
100
0
Mar-94
Jun-94
Sep-94
Dec-94
Mar-95
Jun-95
Sep-95
Dec-95
Mar-96
Jun-96
Sep-96
Dec-96
Mar-97
Jun-97
Sep-97
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Sep-99
Dec-99
Mar-00
Jun-00

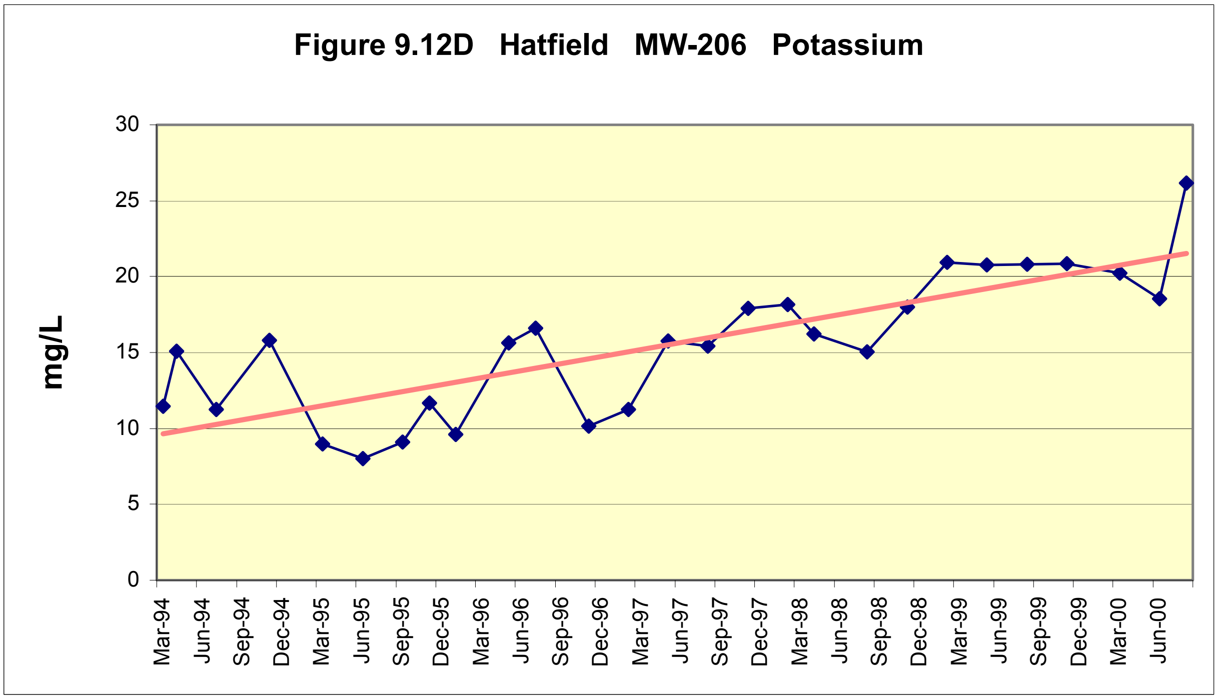
Figure 9.12D Hatfield MW-206 Potassium
mg/L
30
25
20
15
10
5
0
Mar-94
Jun-94
Sep-94
Dec-94
Mar-95
Jun-95
Sep-95
Dec-95
Mar-96
Jun-96
Sep-96
Dec-96
Mar-97
Jun-97
Sep-97
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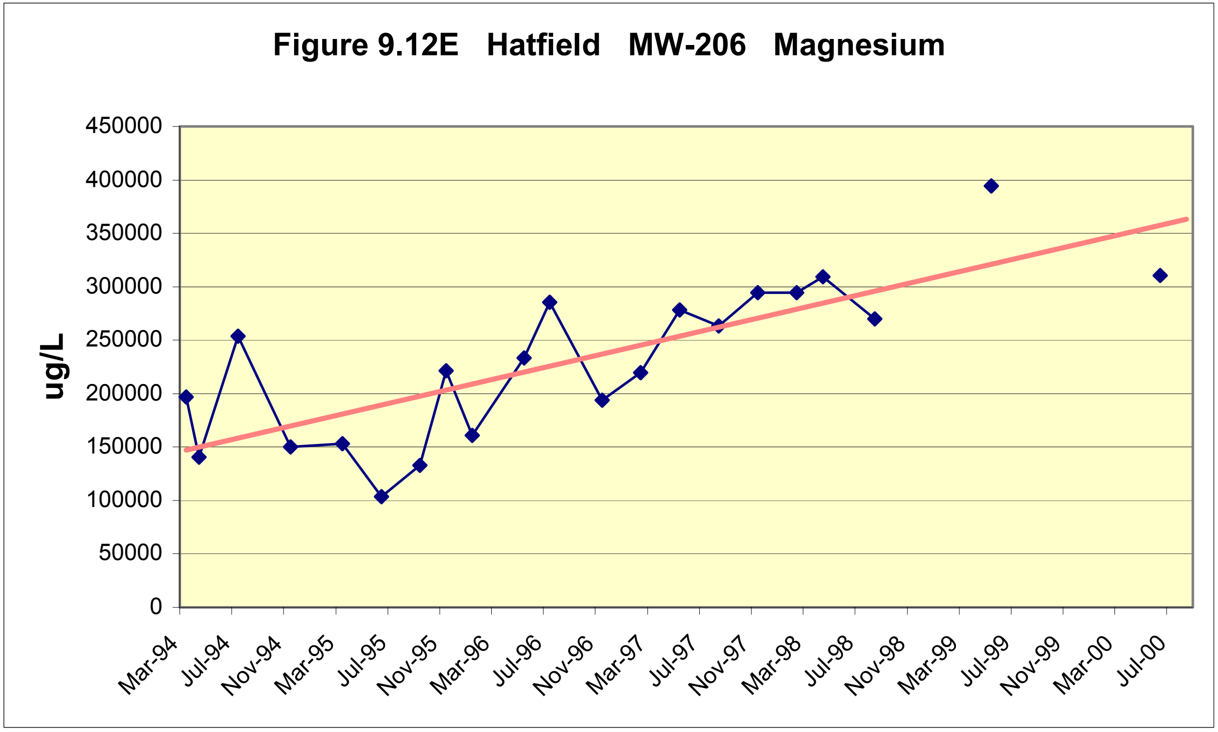
Sep-99
Dec-99
Mar-00
Jun-00



MW-207

MW-207 is also identified as upgradient of the Hatfield ash disposal operation and downgradient of the Hartley strip ash. The trends for boron and molybdenum (figures 9.13 and 9.14) are both increasing with time. The rise in average boron concentrations at MW-207 is nearly identical to the rise at MW-206 from around 4 mg/L in 1994 to around 14 mg/L in 2000. However, molybdenum concentrations at MW-207 vary but with an average rising from 0.003 mg/L in 1994 to 0.010 mg/L in 2000. This latest average level is equivalent to the EPA's Removal Action Level and longer term child health advisory for molybdenum and differs with the very gradual downward trend for average molybdenum levels at MW 206 from above 0.002 mg/L to below 0.002 mg/L although the concentrations are within the same order of magnitude.

Manganese concentrations are falling over time at MW-207 (figures 9.15) from an average of approximately 4.7 mg/L to an average of 1.8 mg/L. They are less than half the concentrations at MW-206 but still noticeably higher than manganese levels at MW-1 and MW-2. There is no general rise in concentration in 1997 as seen in the graphs of data from MW-206 and the Hartley wells, suggesting MW-207 is hydrologically independent of MW-206 and the wells at Hartley.

The average sulfate concentration at MW-207 (figure 9.16) is about 3600 mg/L, about 1500 mg/L higher than the average concentration at MW-206 (figure 9.12). However the MW 207 trend is not rising like the MW-206 trend.

Alkalinity and field pH are both rising at MW-207 (figures 9.16A and 9.16B). Their trends are similar to those at MW-206 except that pH values at MW-207 are around one fourth of a unit higher than at MW-206 while the rise in average alkalinity at MW-206 is more steep than at MW-207 (240 mg/L increase at MW-206 vs 70 mg/L increase at MW-207). The trends for concentrations of calcium, potassium, and magnesium (figures 9.16C, 9.16D, 9.16E respectively) are all rising at MW-207 and in the same general ranges as at MW-206, although there are some differences of note. At MW-206, calcium concentrations on average are about 200 mg/L higher than magnesium concentrations, while at MW-207 magnesium concentrations on average range from 95 to 140 mg/L higher than calcium concentrations. Nonetheless the steady rises of these known ash indicator parameters provide strong evidence that Hartley ash is a source for the groundwater degradation observed at the upgradient Hatfield monitoring points.

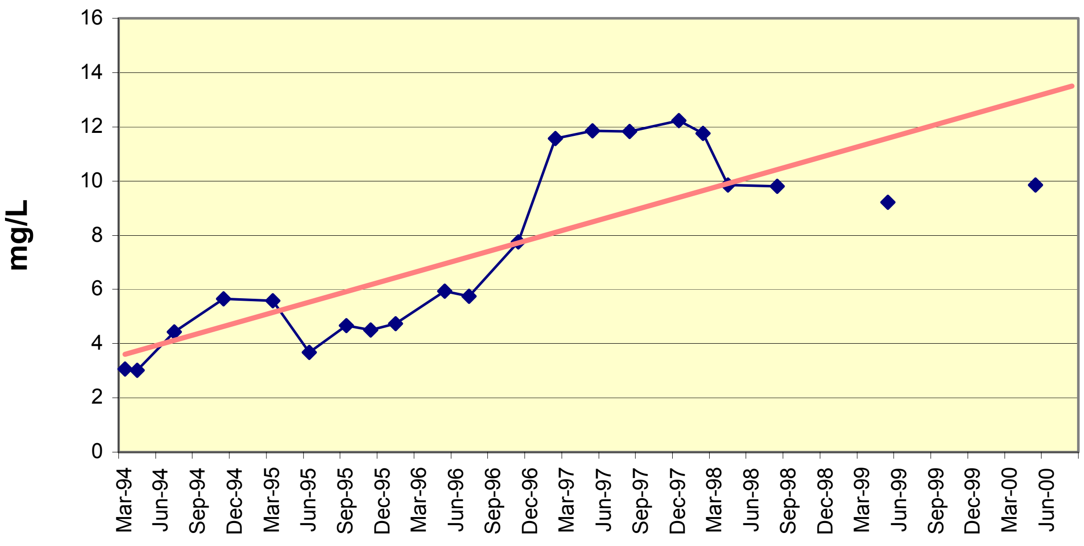


Figure 9.14 Hatfield MW-207 Molybdenum

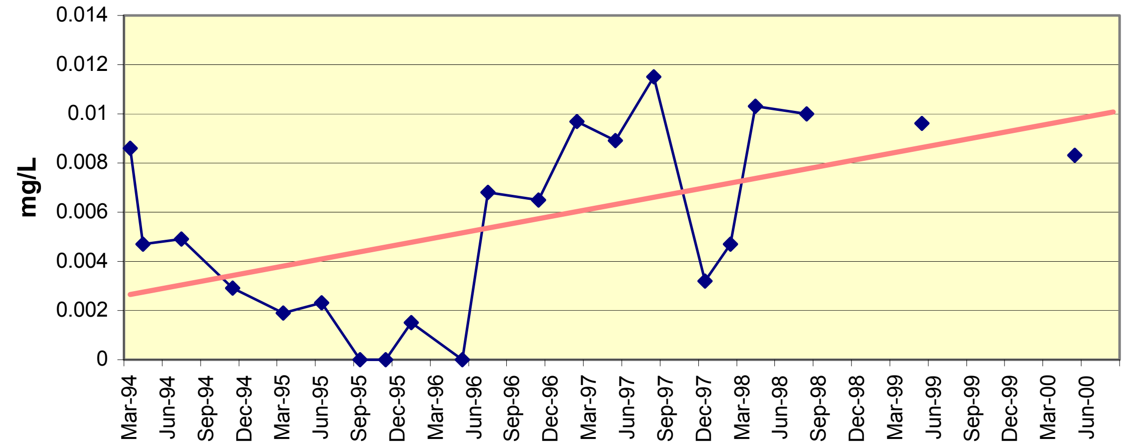


Figure 9.15 Hatfield MW-207 Manganese

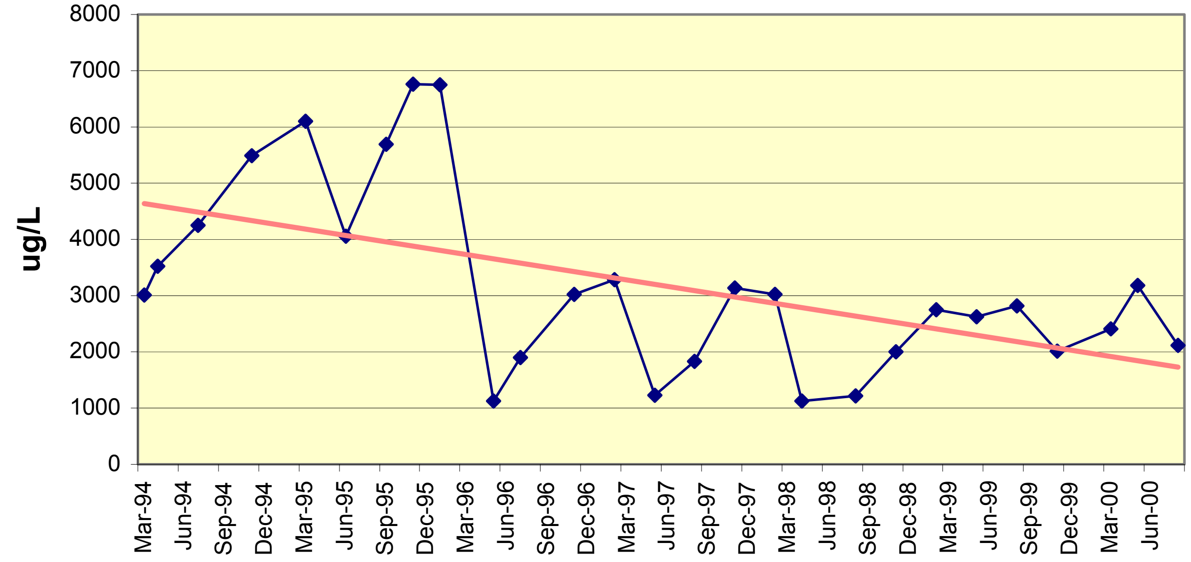


Figure 9.16 Hatfield MW-207 Sulfates

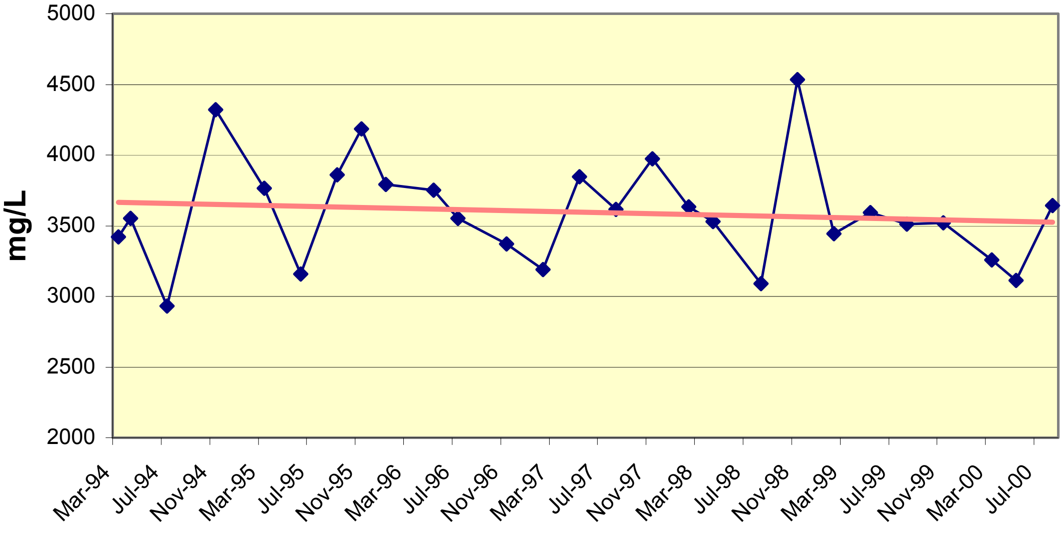
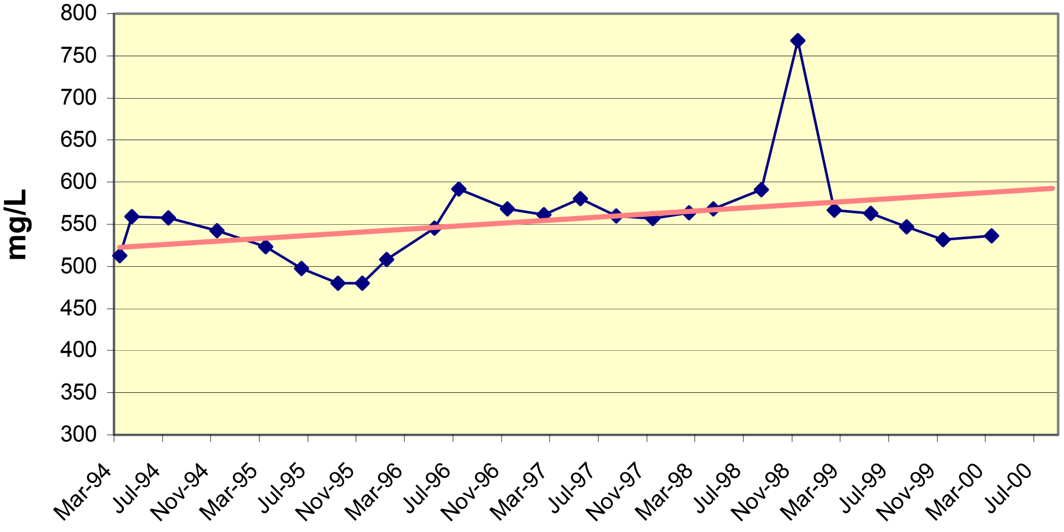


Figure 9.16A Hatfield MW-207 Alkalinity



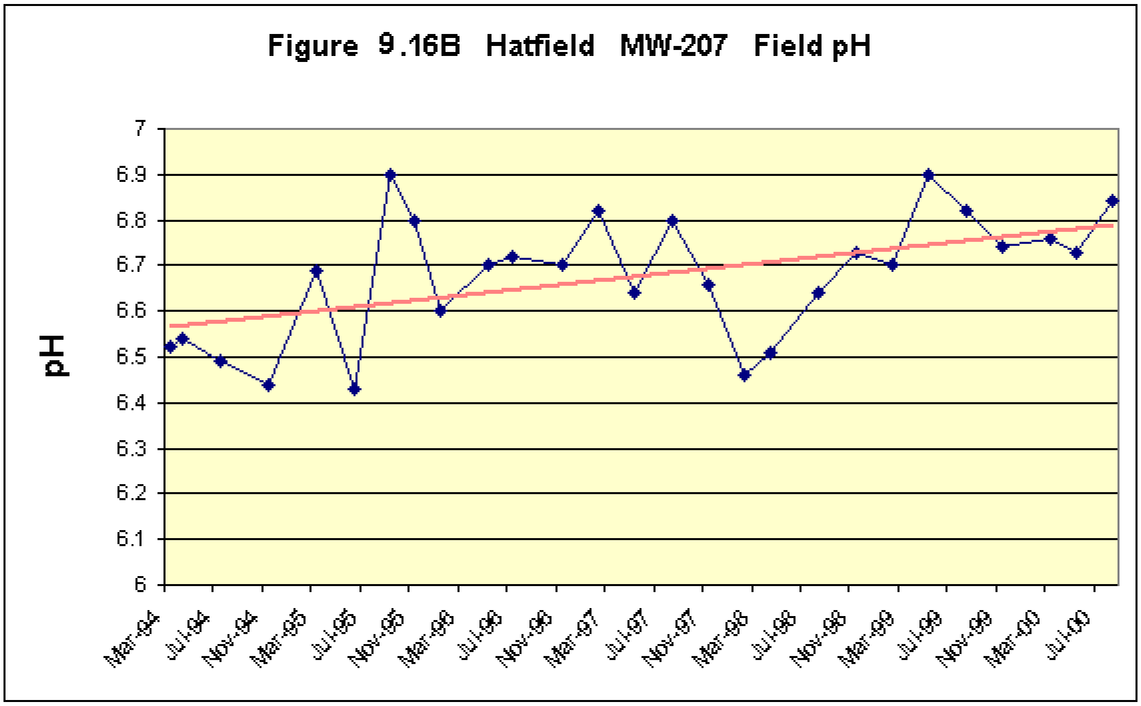


Figure 9.16B Hatfield MW-207 Field pH
pH
7
6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
Mar-94
Jul-94
Nov-94
Mar-95
Jul-95
Nov-95
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
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Jul-99
Nov-99
Mar-00
Jul-00

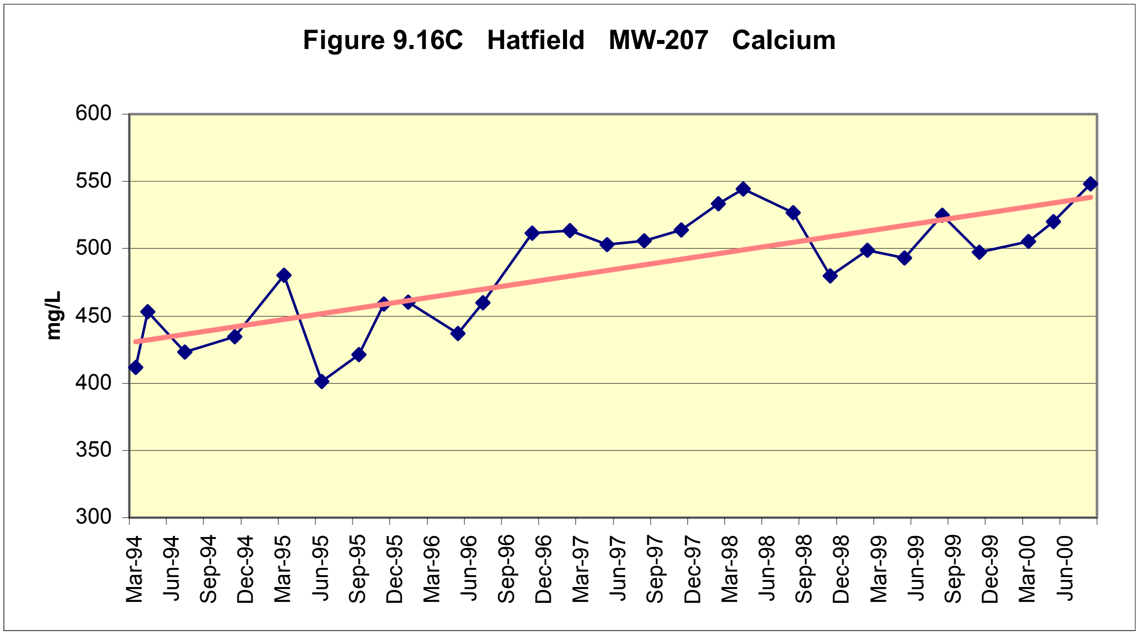


Figure 9.16C Hatfield MW-207 Calcium
mg/L
600
550
500
450
400
350
300
Mar-94
Jun-94
Sep-94
Dec-94
Mar-95
Jun-95
Sep-95
Dec-95
Mar-96
Jun-96
Sep-96
Dec-96
Mar-97
Jun-97
Sep-97
Dec-97
Mar-98
Jun-98
Sep-98
Dec-98
Mar-99
Jun-99
Sep-99
Dec-99
Mar-00
Jun-00

Figure 9.16D Hatfield MW-207 Potassium

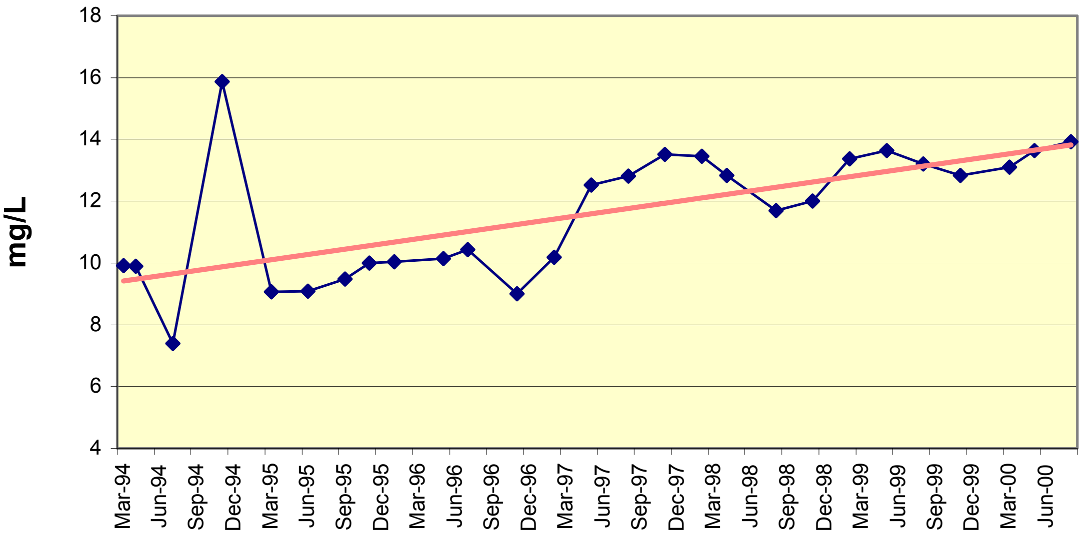
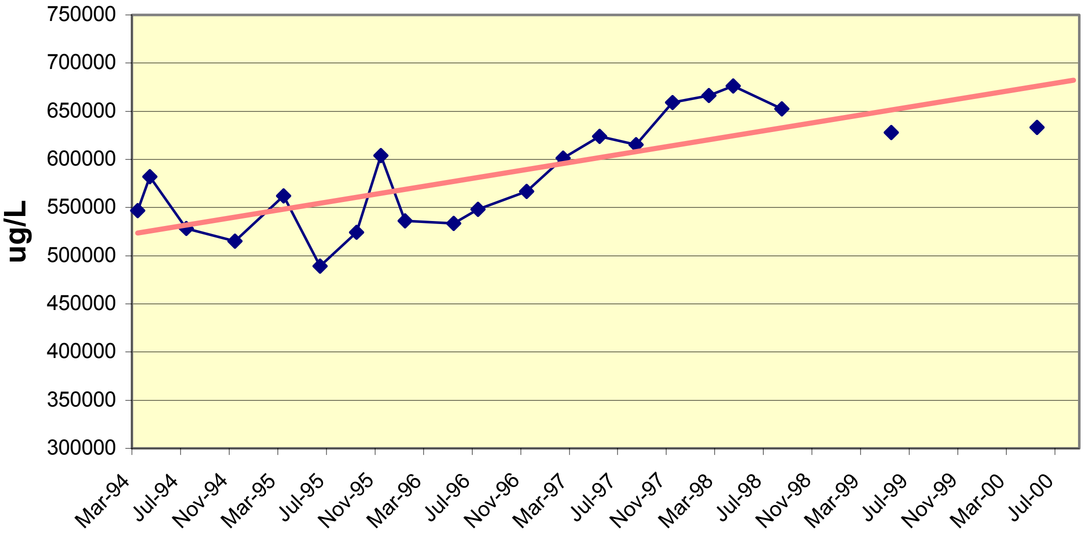


Figure 9.16E Hatfield MW-207 Magnesium



Conclusion

Missing information and data gaps make analysis of this site difficult. There is no baseline data, a six -year data gap exists for most elements in the middle of the mining and ash placement operation, and apparently there was no monitoring of the Hartley Strip wells after ash placement ended although specific dates of when ash placement and monitoring ceased were not found in the Hartley permit file.

At downgradient MW-1, trace element concentrations were measured only eight times during an 11-year time period. Upgradient MW-2 had 11 concentration measurements for trace elements over this 11-year period. Variable detection limits make it very difficult to interpret the data however. In a number of occasions, the detection limits were well above the DWS. Nonetheless actual concentrations of dissolved cadmium and lead were measured at two to six times above the DWS at both of these wells. Antimony was measured at a concentration of 0.03 mg/L, six times the DWS in the downgradient MW-1 and at concentrations of 0.04 mg/L and 0.11 mg/L, more than 18 times the DWS in the upgradient MW-2. Antimony regularly leaches in the tests on coal ashes deposited in the mines studied in this report although only at this site could the report's authors find water quality monitoring data for antimony. The authors also found two measurements of molybdenum at MW-1, with the latest one in September 1998 being 0.190 mg/L. This is 19 times the EPA Superfund Removal Action Level and several 4-8 times most health advisory levels for molybdenum. High levels of antimony, molybdenum and other trace metals revealed by this data suggest a mobilization from the ash. While a number of the high levels were measured at MW-2 labeled as an upgradient well, its location inside the area authorized for ash placement as well as other data indicating AMD and alkalinity impacts on this well warrant further examination of whether this well was actually "upgradient" of ash placed at this site. Nonetheless the amount of information collected was not enough to effectively characterize the impacts of ash on trace elements at this site.

However, there are relationships between the Hartley Strip ash placement operation and the upgradient monitoring wells at the Hatfield coal ash landfill that provide clues to the impact of the ash placement at Hartley. The patterns for concentrations of constituents such as manganese suggest that MW-206 may have a hydrological connection to MW-1 and MW-2. A more in-depth study of these relationships would be possible if boron and molybdenum were regularly analyzed for in the Hartley operation monitoring wells.

Nonetheless, rising levels of boron, a classic indicator parameter for coal ash, in both MW-206 and MW-207 indicate that ash in the Hartley strip operation is degrading downgradient groundwater with concentrations 3-15 times EPA health advisory levels for ingestion of boron in drinking water. Allegheny Energy, the operator of the Hatfield landfill and generator of the ash placed in the Hartley strip, stated in an August 20, 1997 revision to an application to modify the permit for the landfill that the elevated boron in these upgradient wells was "due to the fact that fly ash has been codisposed with mine spoil in the upgradient area, in addition to the permitted disposal area." This observation of degradation of water quality from the Hartley ash is corroborated by the rising field pH and concentrations of alkalinity, calcium, magnesium, and potassium, additional indicators of ash leachate, at both of these monitoring points which are upgradient of the ash placed in the Hatfield landfill.

Based on this data as well as additional data revealing very high levels of boron, sulfate and molybdenum in Little Whitely Creek which is fed by the tributary draining north and east from the Hartley ash site, there is a need to reinstate a monitoring program for the ash in the Hartley Strip. Such a monitoring program must be an enhanced program with sufficient parameters, monitoring points and frequency of sampling to ensure that CCW-contaminated drainages from this mine are located and remediated.

Permit Review 10

SKY HAVEN COAL COMPANY, BLOOM #1 MINE (PERMIT # 17950111)

Site Summary

The Sky Haven Coal Company Bloom #1 Mine is located in Bigler Township in Clearfield County, Pennsylvania. This site covers 51.7 acres in the Clearfield Creek Priority Watershed 8C. Bloom #1 was a subchapter F active surface mining operation. Mining started in December, 1996 and ended in 2003. The permit authorized placement of approximately 80,200 tons of FBC ash as an alkaline addition, starting in December 1996. According to PADEP, just 45,000 to 50,000 tons was deposited at the site as of June 2005 with the ash coming from the Piney Creek and Scrubgrass (also FBC) Power Plants in the Clarion Pennsylvania area. The ash was deposited in the backfilling phases as alkaline addition for the remediation of AMD. During mining operations, an abandoned surface mine (6 acres) and portions of a deep mine (2 acres) were daylighted and treated with FBC ash which was also mixed with spoils and used to plug holes created from auger mining under the permit. Data from two groundwater monitoring wells (MW-1 and MW-3) and four downgradient subchapter F monitoring points (FA-19, FA-30, FA-32 and FA-20) were assessed in this review.

Geology

The rocks exposed during mining at the Bloom #1 Mine belong to the middle Pennsylvanian System of geological time. The coals on the site include the Clarion, Lower Kittanning, Middle Kittanning, and Lower Freeport, but only the Middle Kittanning seam was actively mined for this permit. This coal was mined by open pit and auger methods. The structure of the sedimentary beds is essentially flat lying, with a gentle dip (inclination) to the southeast.

Because the Middle Kittanning seam was deposited in nearshore brackish and marine conditions, the amount of sulfur in this coal is higher than in younger coals. This high sulfur content enhances the potential for AMD to result from mining at this site.

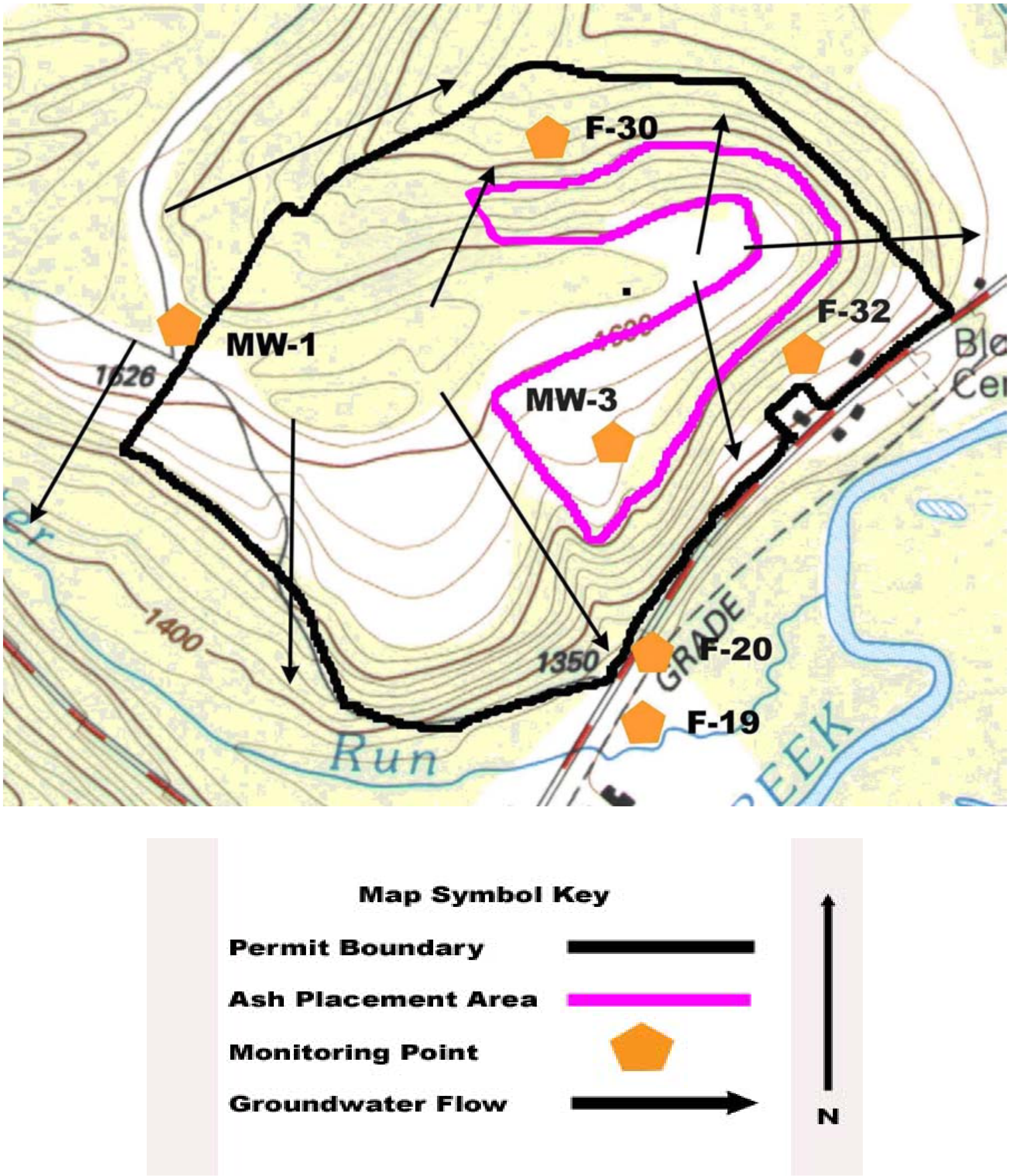
Topography

The Bloom #1 Mine is in the Allegheny Mountain physiographic province (figure 1) and is situated near the top of the eastern end of an east-west trending hill (see map below). The mine is on the north, east, and south slopes of this hill and is shaped like a horseshoe, with the open end pointing west. The top of the hill was not removed during mining; the coal under the hilltop was auger mined.

Groundwater

The groundwater at the Bloom #1 site follows the topographic trends closely, even though they have been disturbed by mining. The water moves from the top of the hill, and flows north, east, or south, depending on what part of the “horseshoe” it is above. The water travels through the spoil and ash and down to the horizon of the Middle Kittanning Coal, which has become the local base level for groundwater movement that eventually exits the site. The underclay below the coal acts as a water trap, or aquitard.

Site Map: Bloom



Sky Haven Coal Co., Bloom #1 Operation (Permit # 17950111)
Scale: 1” = Approximately 800’

Water monitoring data: Discussion

Concentration data was examined from five monitoring points: (1) MW-1, an upgradient monitoring well on the top of the hill which was dug into previously mined ground and is screened in spoil; (2) MW-3, a well in the mined area backfilled with ash and spoil; (3) subchapter F point FA-19, monitoring discharges of a seep flowing from the mining and ash placement area downhill to the south of the "horseshoe;" (4) subchapter F point FA-30, monitoring a seep discharging from the mining and ash placement area downhill to the north; and (5) FA-32, a well monitoring shallow groundwater flowing east from the "horseshoe." Monitoring points FA-19, FA-30 and FA-32 can be expected to see different degrees of impacts, because the extent of mining and ash placement is greater on the south side of the horseshoe than on the north side. All five monitoring points have concentration data, and the two subchapter F points (FA-19 and FA-30) also have loading data that was examined. Thus these points were selected to include an upgradient point (MW-1, not always possible at the sites examined in this report), a monitoring point inside the ash (MW-3, also rarely provided in the examined monitoring systems) and monitoring points on different downgradient sides of the horseshoe that have the most complete sets of data for assessing impacts at the site both from a concentration and a loading standpoint. In addition, the review will briefly discuss loadings from a sixth monitoring point, FA-20 that have increased significantly in the last year for manganese and acidity resulting in an increased frequency of monitoring required by PADEP. FA-20 is a subchapter F monitoring point located close to FA-19.

MW-1

Figures 10.1, 10.2, and 10.3 are graphs of concentrations for iron, manganese, and sulfates for upgradient MW-1. The baseline monitoring period ended by June 1996. All of the MW-1 data have a gap in the sampling on December 27, 2000, due to "inaccessible" conditions. The baseline data for iron has a "spike" of 19 mg/L in December 1995, and then the trend for the rest of the monitoring period is relatively flat, with a gradual decrease in concentration. The average value for iron after baseline monitoring is about 1.7 mg/L, nearly 6 times the drinking water standard (DWS) of 0.30 mg/L. The concentrations for manganese are all under 1.3 mg/L. Although they fluctuate widely and follow a seasonal trend of increases in the fall and winter, they nonetheless undergo a slightly decreasing average trend during the permit operation. The DWS for manganese is 0.05 mg/L, so the maximum value for manganese at MW-1 is 24 times the DWS. The sulfate (figure 10.3) has an increasing trend although values are less than 25 mg/L. The average concentration for sulfate during baseline monitoring is about 10 mg/L, which increases to about 17 mg/L at the end of monitoring with actual values all well under the DWS of 250 mg/L. These values and trends represent groundwater that is not badly degraded.

Figure 10.1 17950111 MW-1 Bloom #1 Iron

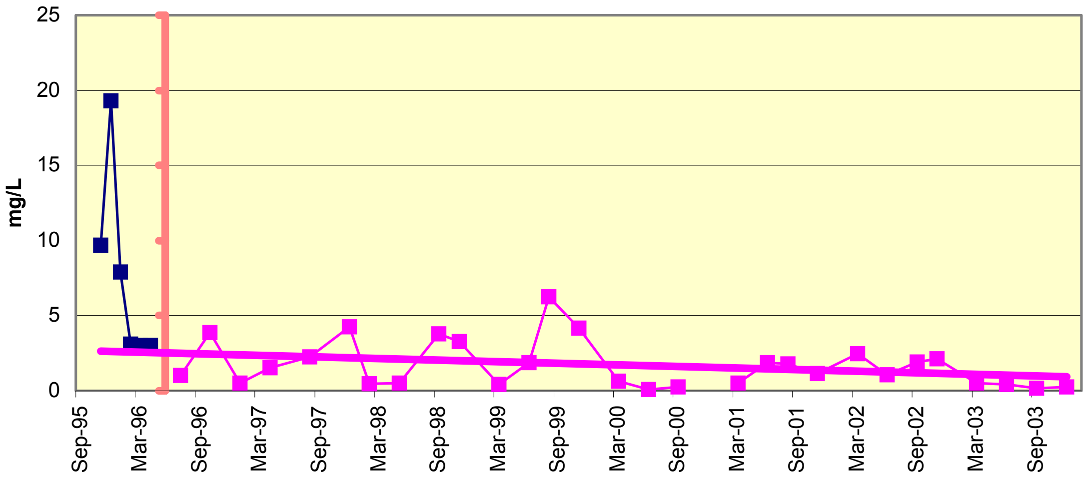
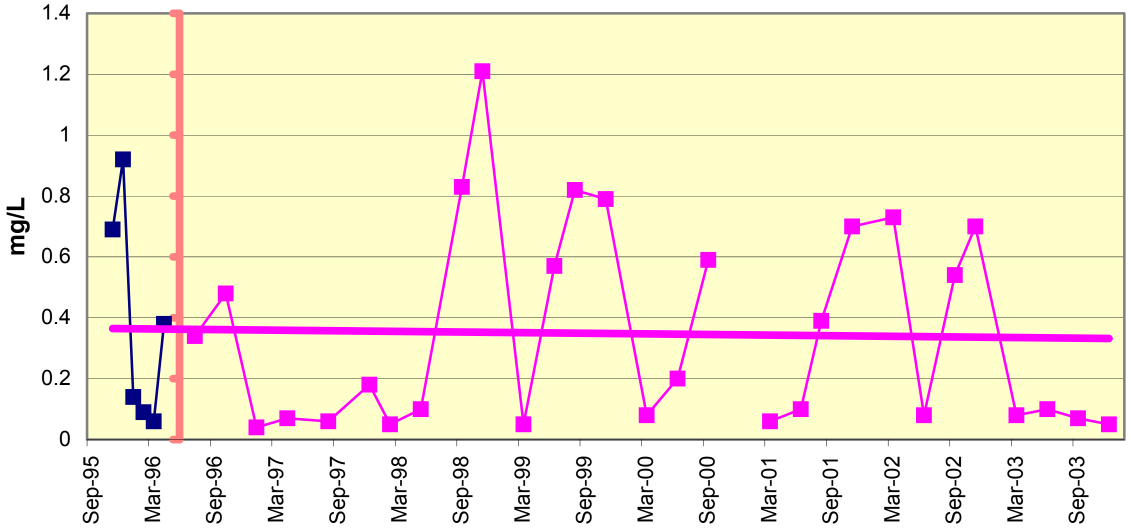


Figure 10.2 17950111 MW-1 Bloom #1 Manganese



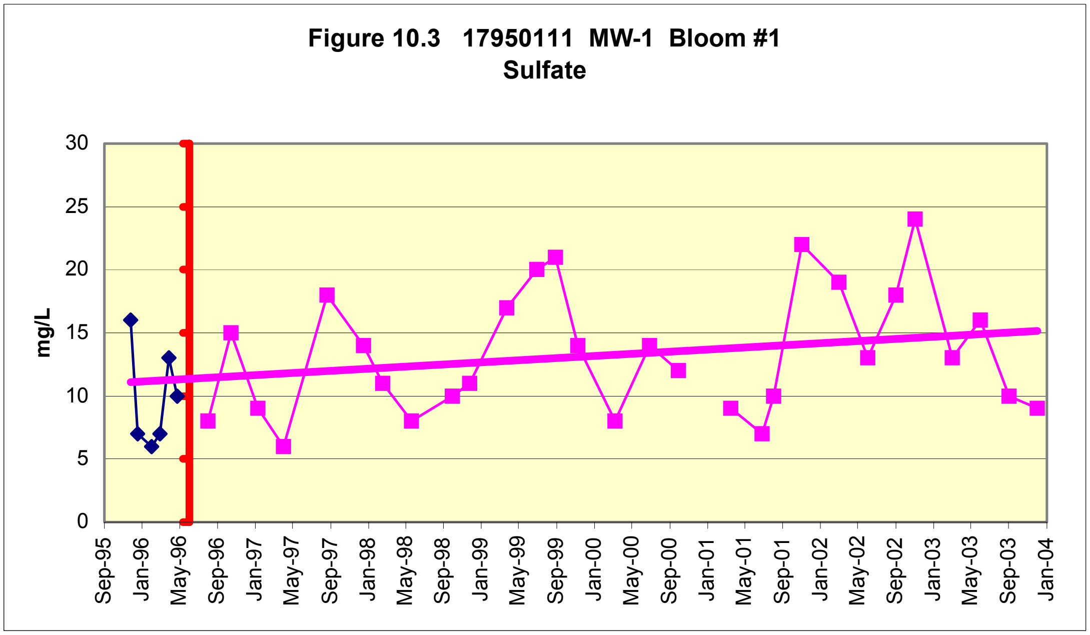


Figure 10.4 charts the field pH at MW-1. Field instead of laboratory pH data is used in this report because it should best represent natural groundwater conditions. The pH is slowly falling over time, along with a gradually increasing acidity (figure 10.6), both indicating activity producing AMD. The alkalinity (figure 10.5) also rises slightly over time after baseline monitoring. The position of this well, upgradient from the ash but screened in mined ground reveals low levels of residual degradation from previous mining athough these levels of gradually increasing alkalinity and AMD may indicate a some hydrologic connection or flow path from the permitted operation that is not characterized by the permit.

Figure 10.4 17950111 MW-1 Bloom #1 pH

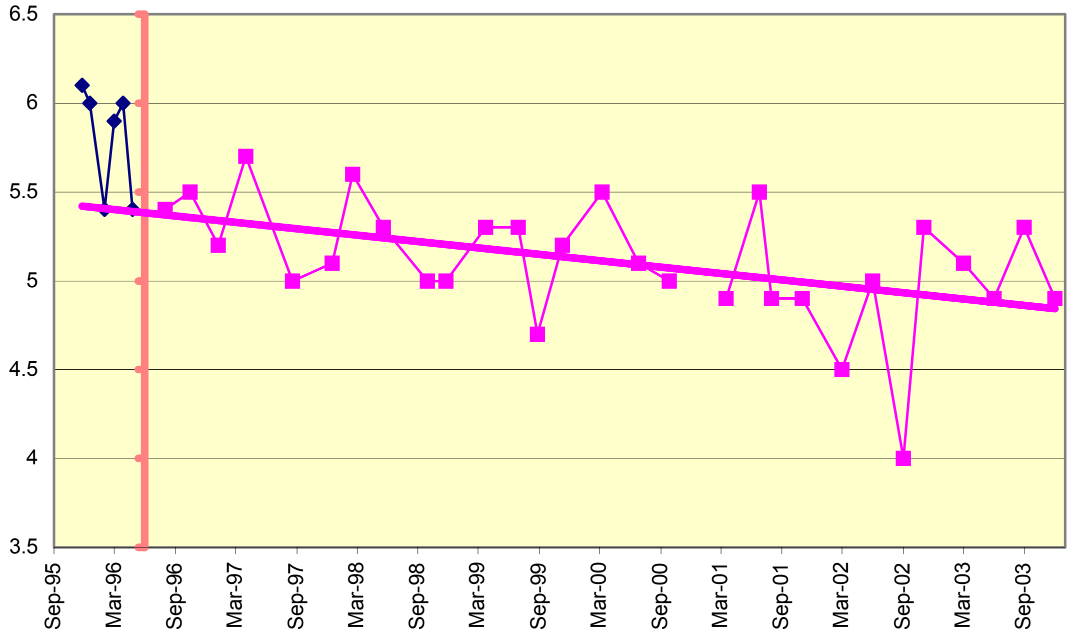
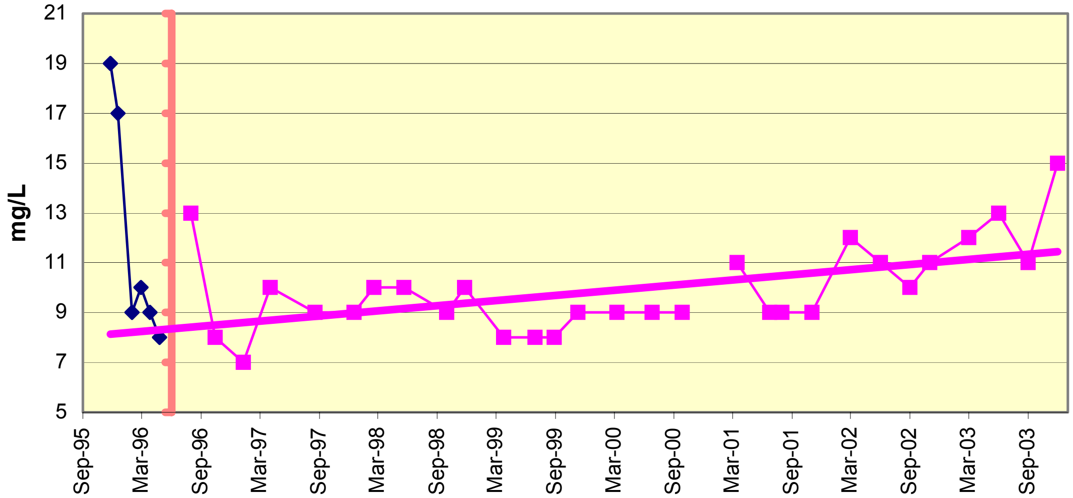
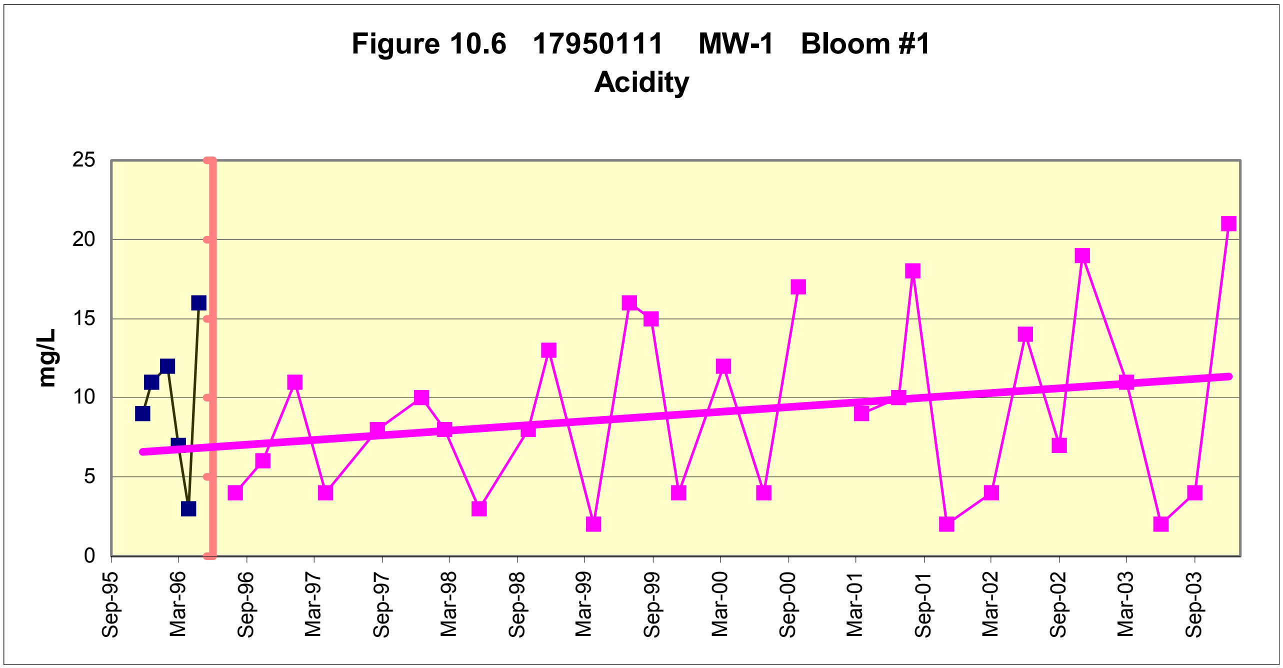
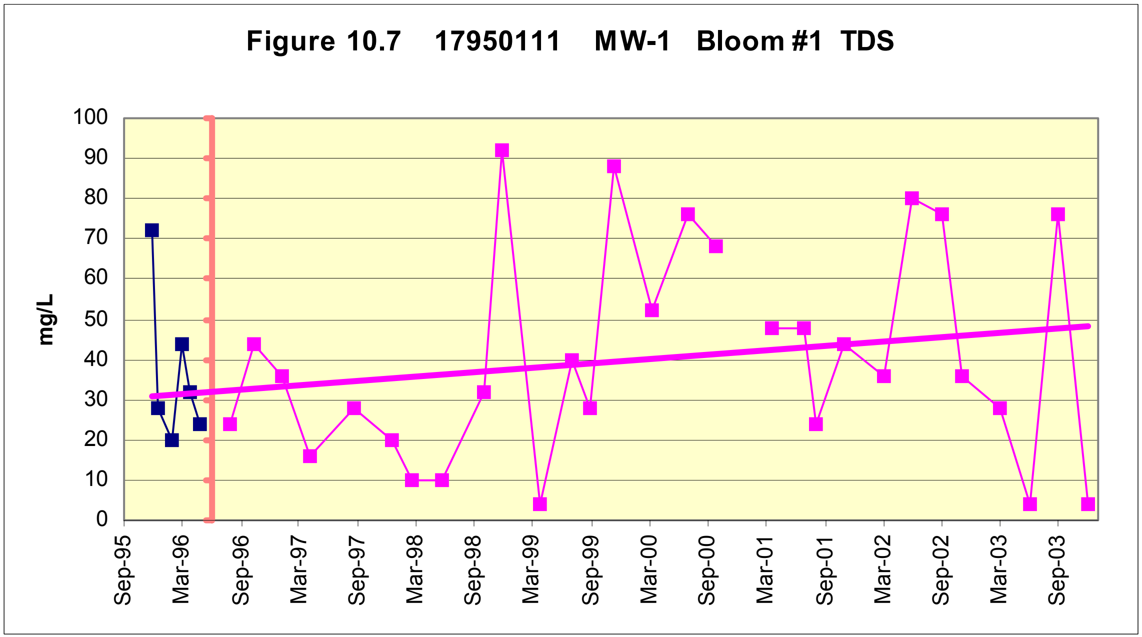


Figure 10.5 17950111 MW-1 Bloom #1 Alkalinity



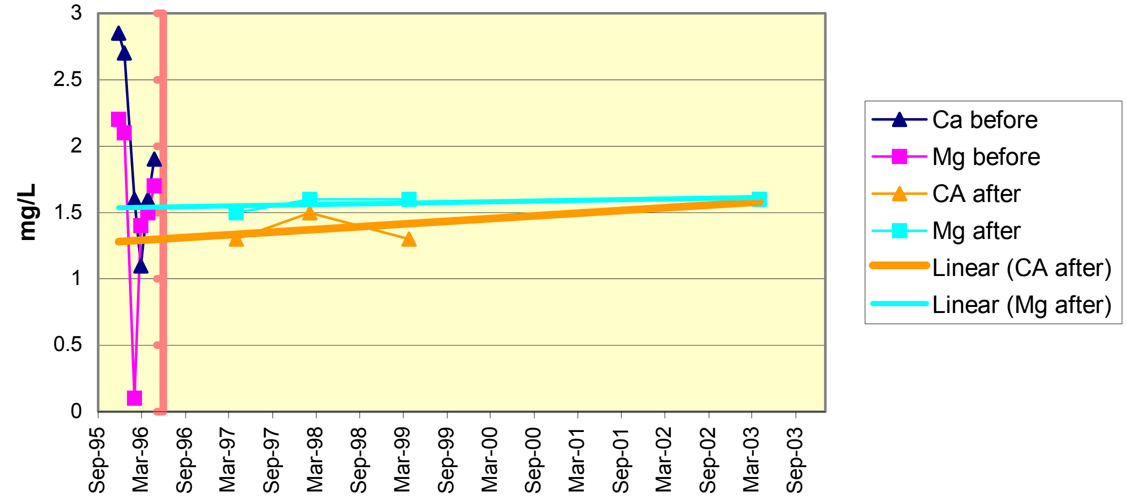


The TDS trends are illustrated in figure 10.7. The concentrations are not that high, (all under one fifth the secondary DWS). Nonetheless they fluctuate greatly with an average overall rising trend possibly due to both AMD and ash placement leachates.

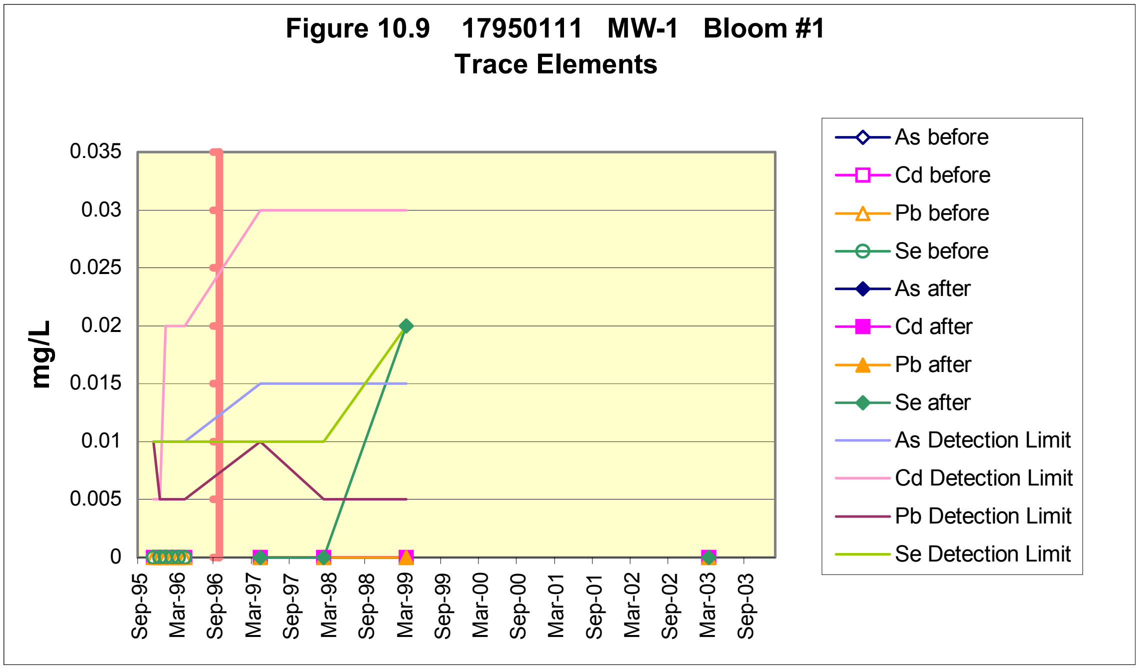


Calcium and magnesium concentrations are both plotted on figure 10.8. No data were found for concentrations of these constituents in 2000, 2001, or 2002. There is one data point for magnesium in 2003. Given this paucity of data, general trends cannot be established after 1999. After the baseline period, both calcium and magnesium have fairly flat trends from the beginning of 1997 through early 1999. If the 2003 magnesium data point represents the continuation of this trend, then the average concentrations for both elements have not changed by more than 0.5 mg/L over the entire ash placement period, but the gap in measurements leaves that to speculation.

Figure 10.8 17950111 MW-1 Bloom #1
Calcium & Magnesium

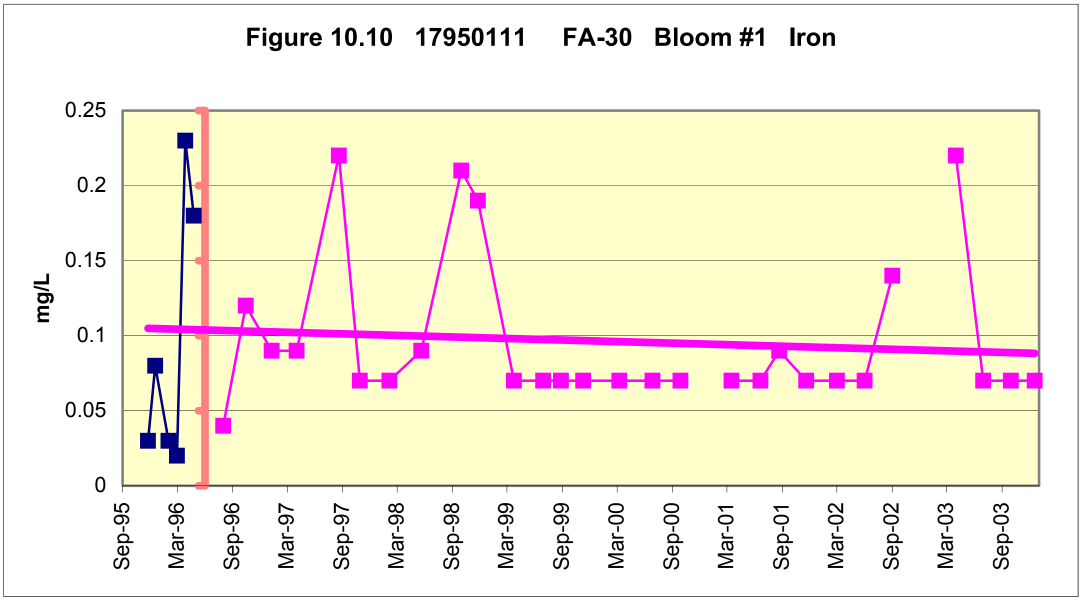


Trace element values measured at MW-1 (figure 10.9) portray increases in detection limits for arsenic, cadmium, and selenium concentrations and unchanging detection limits for lead concentrations from baseline levels. All of the values in figure 10.9 are listed in the monitoring reports as detection limits or levels, except for the March 1999 selenium value which is an actual concentration measured of 0.02 mg/L. In other words, with the exception of this single selenium value, rather than an actual concentration, the laboratory analysis indicates the trace element was not present at a concentration at or above the detection limit used in the analysis. Curiously, the higher detection limits recorded after mining and ash placement started indicate that PADEP accepted results from analyses with even greater limitations such as matrix interferences than occurred in baseline samples. This is the opposite of what reviewers of this data might expect, i.e., that the agency would have at least requested that the laboratory reduce detection limits from those used in the baseline analyses to determine the impacts of ash placement more accurately if not required new baseline samples with lower, more accurate detection limits to begin with. The last reading for selenium in March 2003 was <0.05 mg/L, a detection limit five times higher than detection limit values recorded during baseline monitoring. Detection limits for arsenic and cadmium also increased from the baseline detection levels. Similar to calcium and magnesium, there is a four-year gap in sampling data for these trace elements from 1999 to 2003.

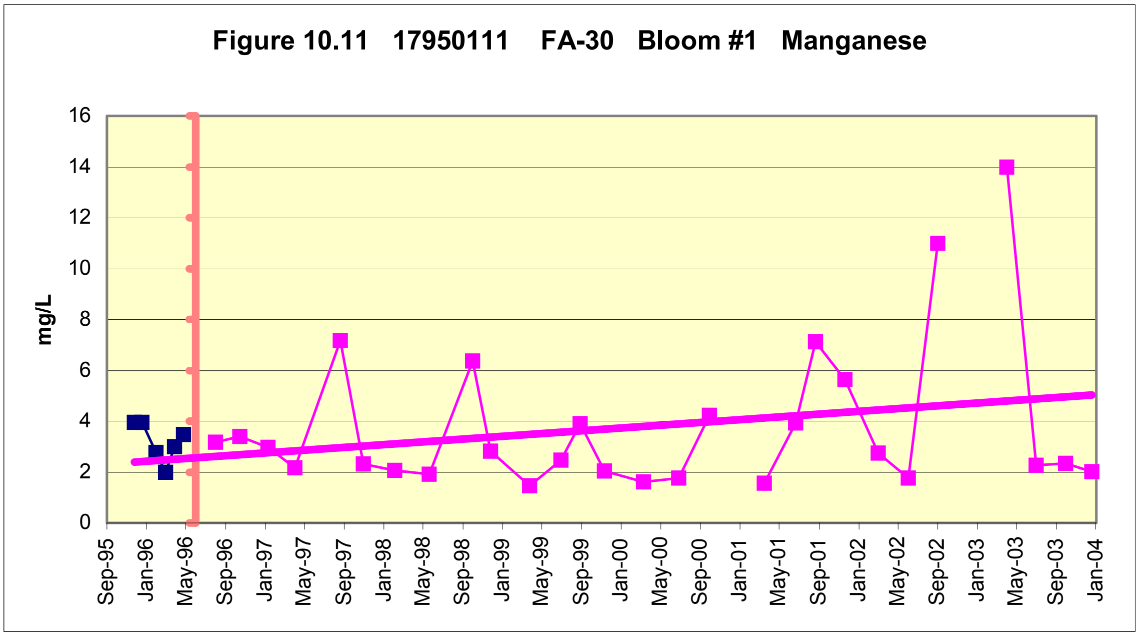


FA-30

Figures 10.10, 10.11 and 10.12 are graphs that plot iron, manganese and sulfate concentrations from the subchapter F monitoring point, FA-30, a surface discharge that is downgradient below the northern arm of the horseshoe. The values for iron are very low (figure 10.10), fluctuate widely until December 1998, and then flatten until a spike in early 2003. Iron values for this well are lower than those for upgradient MW-1 and are all below the DWS of 0.3 mg/L. The flat-lined portion of the graph represents points whose values were below the detection limit of the analysis,at 0.07 mg/L.

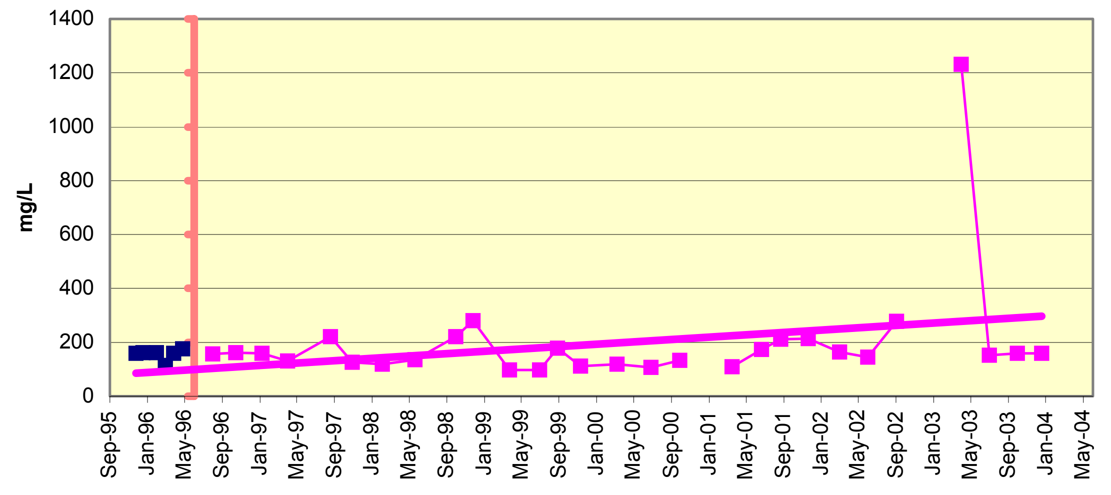


Manganese values (figure 10.11) are about 4 times the MW-1 concentrations and fluctuate widely, with a slow average increase. While this plot shows manganese concentrations no higher than 3.96 mg/L during the baseline period, some six measurements of manganese exceed 5 mg/L after ash placement starts, and a spike in manganese concentrations reaches 11 mg/L, 220 times the DWS in September 2002 and 14 mg/L in March 2003, 280 times the DWS. However, low manganese values also occur after ash placement, resulting in an average measured concentration for manganese after ash placement of 3.8 mg/L, 76 times the DWS. This can be compared to an average manganese concentration before ash placement of 3.2 mg/L, 64 times the DWS. These levels indicate degraded water that is gradually becoming more degraded with manganese after mining and ash placement.



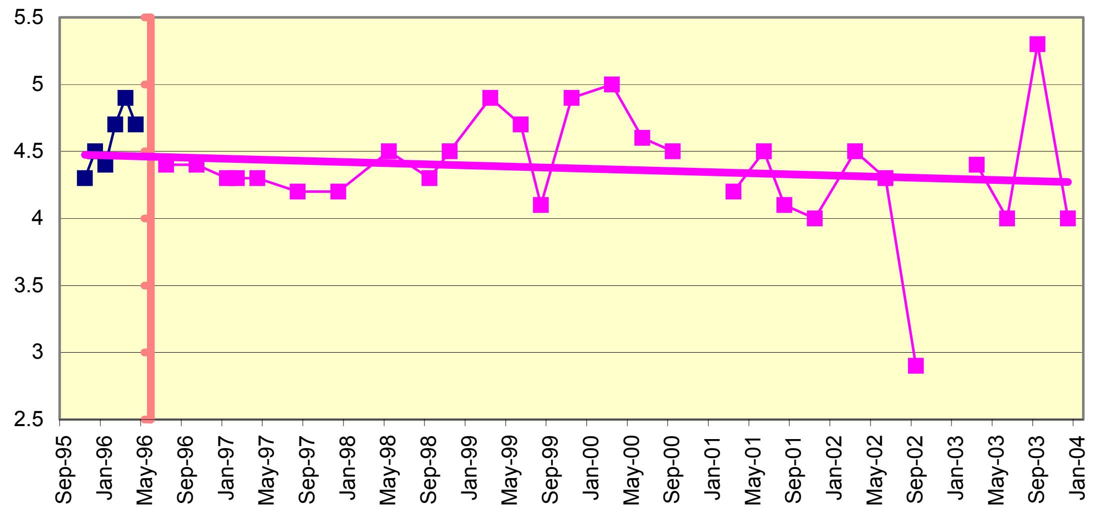
Sulfate concentrations at FA-30 (figure 10.12) are on average 10 times higher than sulfate concentrations at MW-1, although the levels rise above the DWS of 250 mg/L only three times, in all instances after ash placement started. A spike in sulfate concentrations to 1,231 mg/L, occurred in March, 2003. Nonetheless an average sulfate concentration of 155 mg/L before ash placement rises to about 300 mg/L after ash placement indicating that while the trend in sulfate concentrations is increasing after ash placement, the water is not yet badly degraded by this constituent.

Figure 10.12 17950111 FA-30 Bloom #1 Sulfates



The field pH, alkalinity and acidity at FA-30 are plotted on figures 10.13, 10.14, and 10.15, respectively. Each component has a fairly flat trend line. The pH values have a slightly declining trend during the period of mining and ash placement from an average of 4.4 standard units to 4.3 standard units, and average acidity is increasing slightly. The range of acidity values from 10 to 40 mg/L of CaCO3 equivalence and range of alkalinity from 1 to 12 mg/L of CaCO3 equivalence indicates a weaker level of AMD compared to more degraded mine sites in Pennsylvania. Yet it also suggests that the FBC ash placed in this mine is not having a significant buffering effect on the acidity at this monitoring point despite the relative weakness of the AMD.

Figure 10.13 17950111 FA-30 Bloom #1 pH



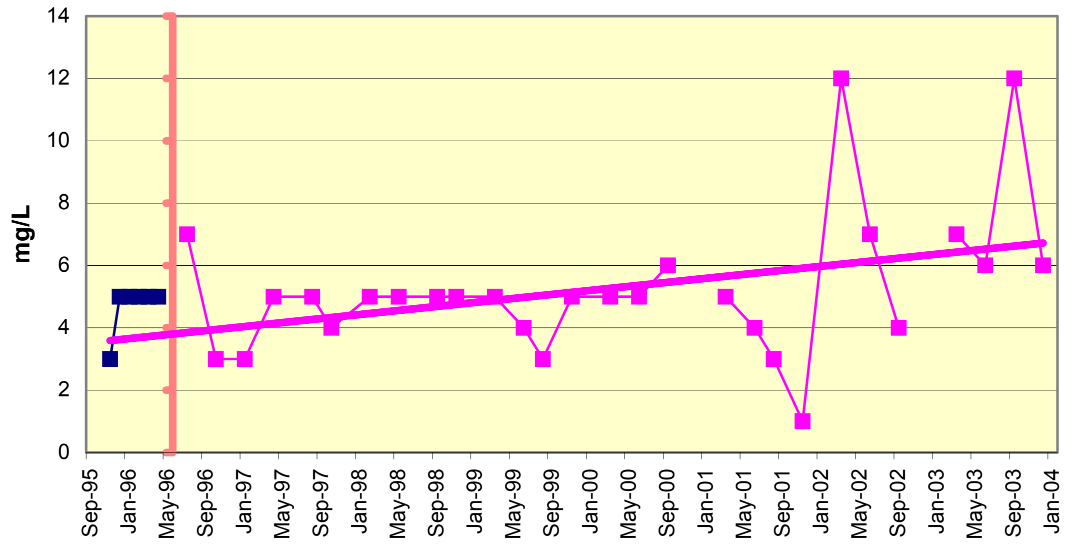


Figure 10.14 17950111 FA-30 Bloom #1
Alkalinity

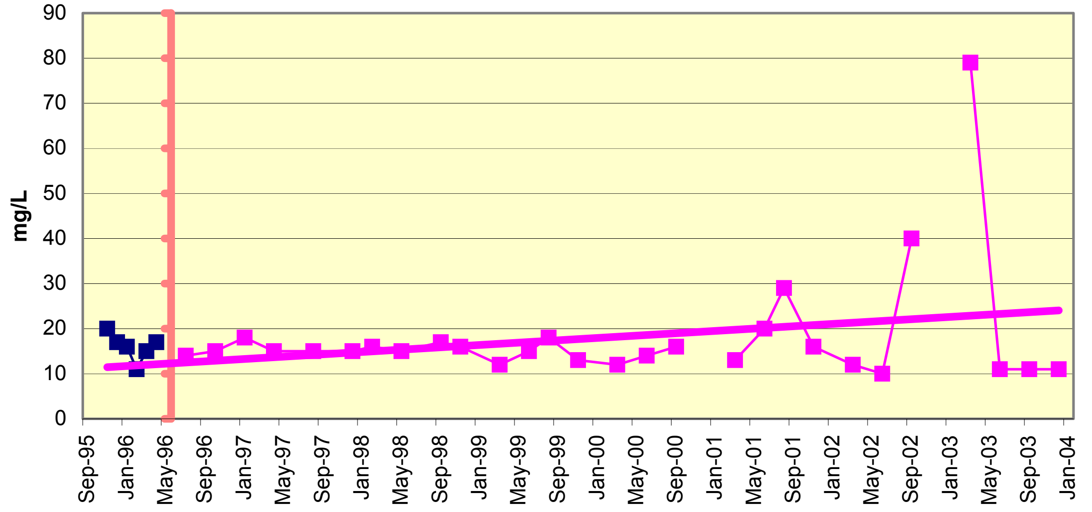
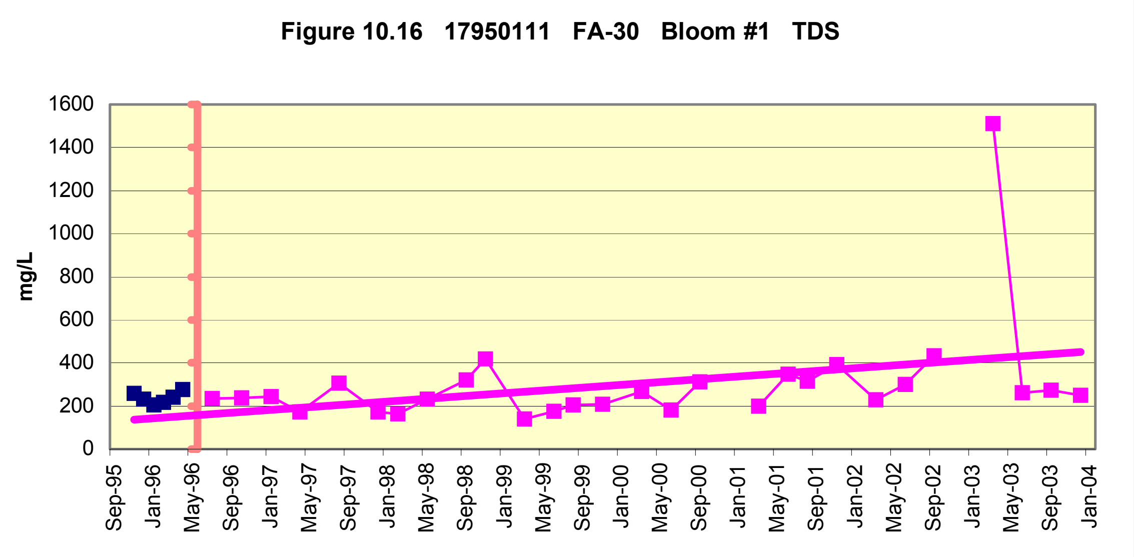


Figure 10.15 17950111 FA-30 Bloom #1 Acidity

TDS concentrations at FA-30 are shown in figure 10.16. There is a definitive upward trend after ash placement starts. The average concentration increase is about 300 mg/L during the ash placement period with a peak of 1512 mg/L in March 2003, coinciding with the peak in sulfate and exceeding the DWS for TDS of 500 mg/L by over 3 times.



Calcium and magnesium values (figure 10.17) initially decrease slightly or appear static. However, after a three-year gap in data the concentrations in March 2003 of calcium (182 mg/L) and magnesium (129 mg/L) were 6 and 11 times greater than their highest earlier measurements respectively suggesting an impact from burnt limestone in the FBC ash. Nonetheless the gap in data collection prevents further substantiation of any trend pointing to placed ash.

The trace elements, arsenic, cadmium, lead, and selenium, are shown in figure 10.18 for FA-30. All of the concentrations shown are below instrument detection limits. As with MW-1, the detection levels reported for cadmium, arsenic, and selenium increase at FA-30 beyond baseline detection levels once ash placement is underway. This leaves reviewers only with questions, unable to discern whether metals are present much less increasing to levels exceeding the DWS or decreasing, only that concentrations are not higher than the detection values reported. After ash placement, arsenic detection levels rise from 0.010 mg/L (the level of the new DWS) to 0.015 mg/L. Cadmium detection values rise from a range of 0.005 mg/L (the DWS) to 0.020 mg/L before ash placement to 0.030 mg/L after ash placement, exceeding the DWS by 6 times. Selenium reaches its highest detection level, 0.050 mg/L, equal to the DWS, in March 2003.

Figure 10.17 17950111 FA-30 Bloom #1 FA-30
Calcium & Magnesium

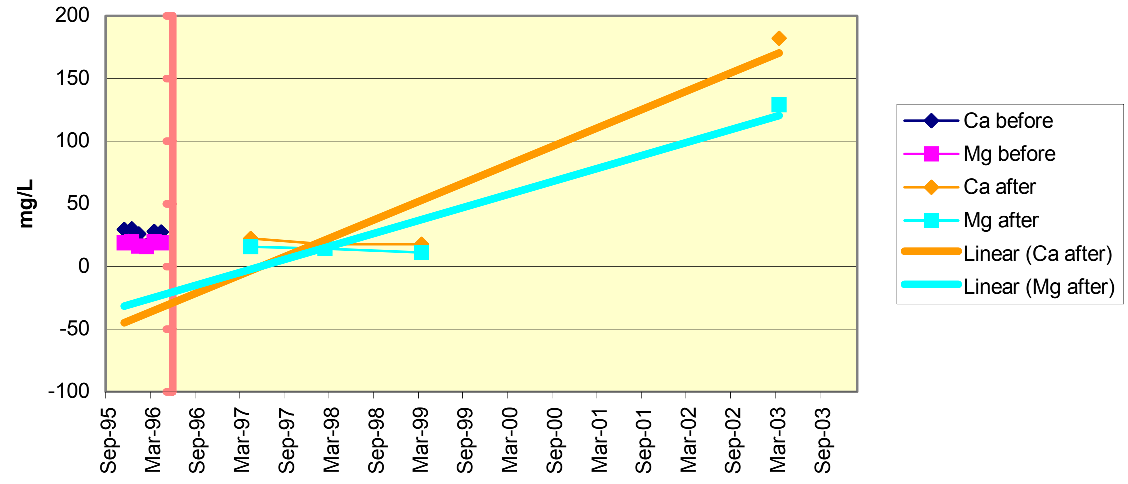
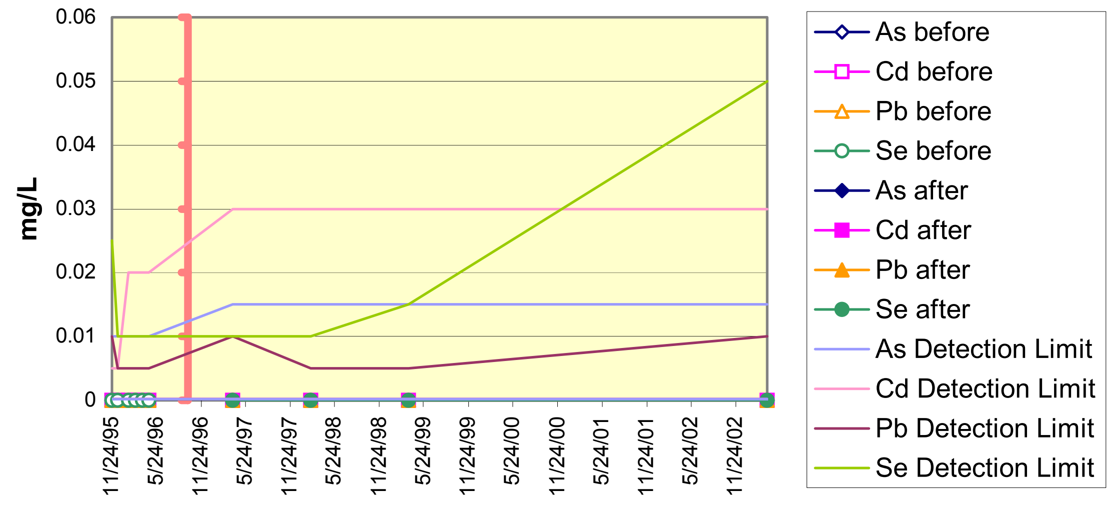


Figure 10.18 17950111 FA30 Bloom #1
Trace Elements

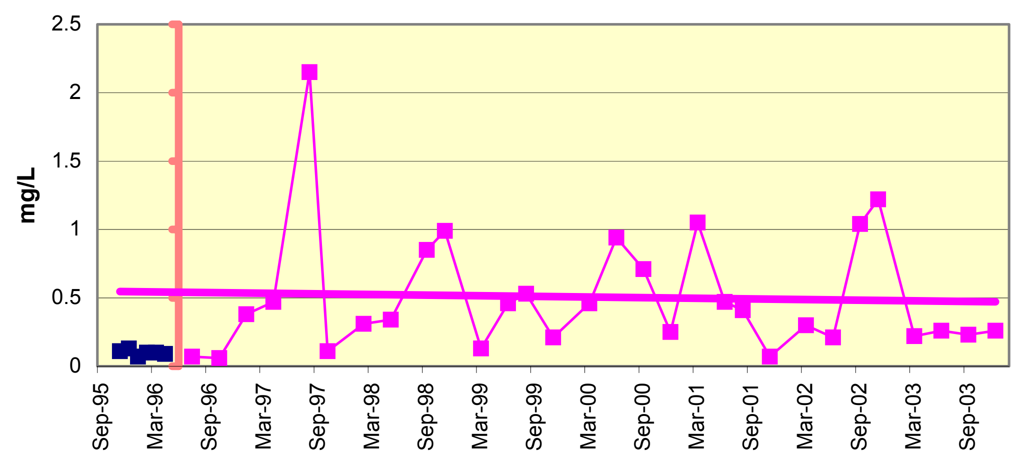


The substantial rises at FA-30 in concentrations of manganese, sulfates and TDS above baseline levels and DWS, combined with relatively static and weak pH and acidity throughout the monitoring period, suggest that the FBC ash is contributing to the degradation of water seen at this point.

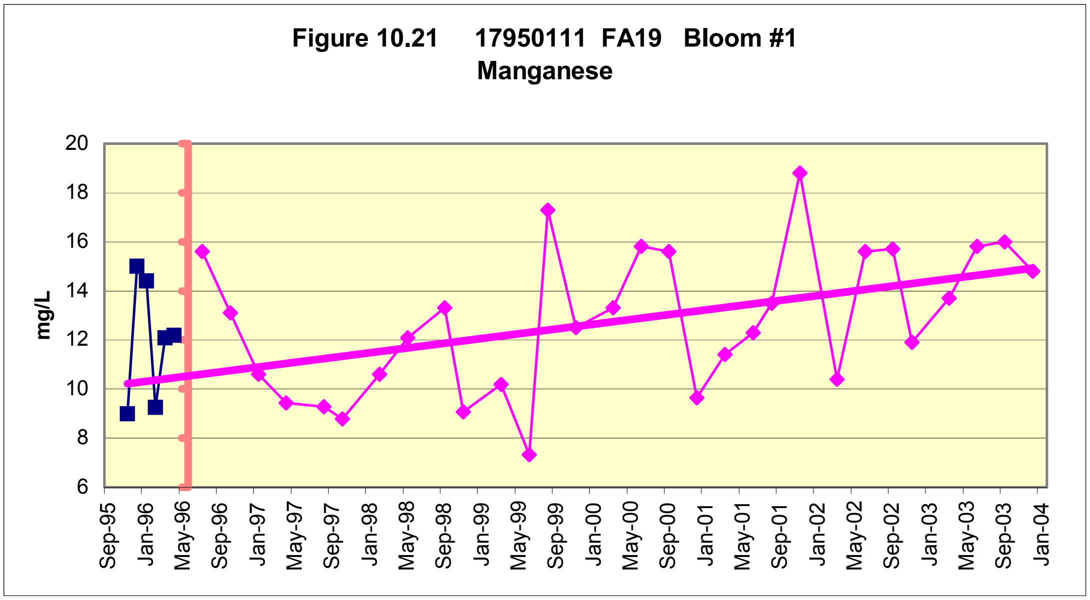
.FA-19

Figures 10.20, 10.21, and 10.22 are plots for iron, manganese, and sulfates for the subchapter F monitoring point FA-19, which is located on a downgradient surface discharge south of the horseshoe. Iron fluctuates considerably, jumping after mining and ash placement begin to levels several times to more than 16 times over the highest baseline concentration and more than 7 times the DWS. These levels slowly decline to levels about twice baseline concentrations in the latest data available in the permit file, resulting in an overall average of 0.4 mg/L, not far above the DWS of 0.3 mg/L.

Figure 10.20 17950111 FA-19 Bloom #1
Iron

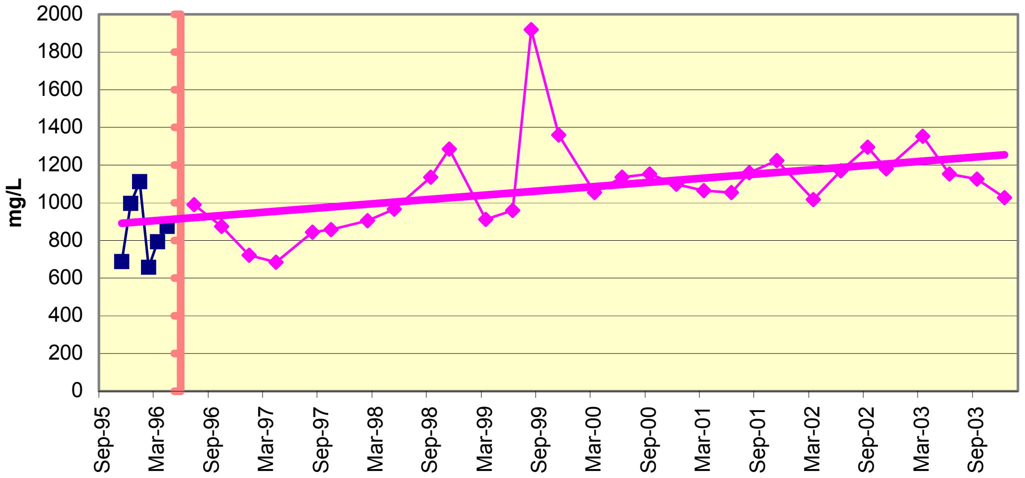


Manganese levels (figure 10.21) fluctuate with average concentrations rising over time. Nine of the 30 concentrations measured for manganese after ash placement exceeded the highest baseline concentration, and 17 of these measurements were between 250 and 376 times the DWS. This illustrates degraded water that has become more degraded as a result of mining and ash placement.



Sulfates are high with an upward trend (figure 10.22). Fifteen of 30 concentrations measured after the start of mining and ash placement exceeded the highest baseline concentration of 1113 mg/L and these values peak at 1900 mg/L, 7.6 times the DWS. Thus degraded groundwater is becoming badly degraded. All but two of the sulfate concentrations after the baseline period were at least 3 times the DWS. The sources for these rising levels of manganese and sulfate are some combination of coal mine spoil drainage, ash leachate, and leachate generated from the reactions of ash, spoils and other host materials at the Bloom site.

Figure 10.22 1795011 FA19 Bloom #1
Sulfates



The field pH and alkalinity at FA-19 (figures 10.23 and 10.24) show an overall downward trend in the monitoring period. However these parameters both rise initially after baseline monitoring, with six pH measurements and five alkalinity measurements exceeding their highest baseline measurements during the first three years after mining and ash placement began in July 1996. The pH rose from a maximum of 5.3 during baseline monitoring to a maximum of 6.7 in this period, before dropping eventually to a low of 4.2 by the end of 2003 (the last monitoring data available in the permit file). The acidity (figure 10.25) drops after baseline monitoring, reflecting the higher alkalinity. After 1998, however, the acidity rose to levels usually about 20 mg/L above baseline values, with a drop to baseline levels in November 2001 and March 2002. These graphs suggest a scenario in which ash was placed shortly after baseline monitoring, resulting in some buffering of acidity before the ash lost its neutralization potential and was overridden by AMD or was cut off from water.

The TDS (figure 10.26) rises after baseline monitoring but then falls after 1999. The TDS drops again after the middle of 2002.

Figure 10.23 17950111 FA-19 Bloom #1 pH

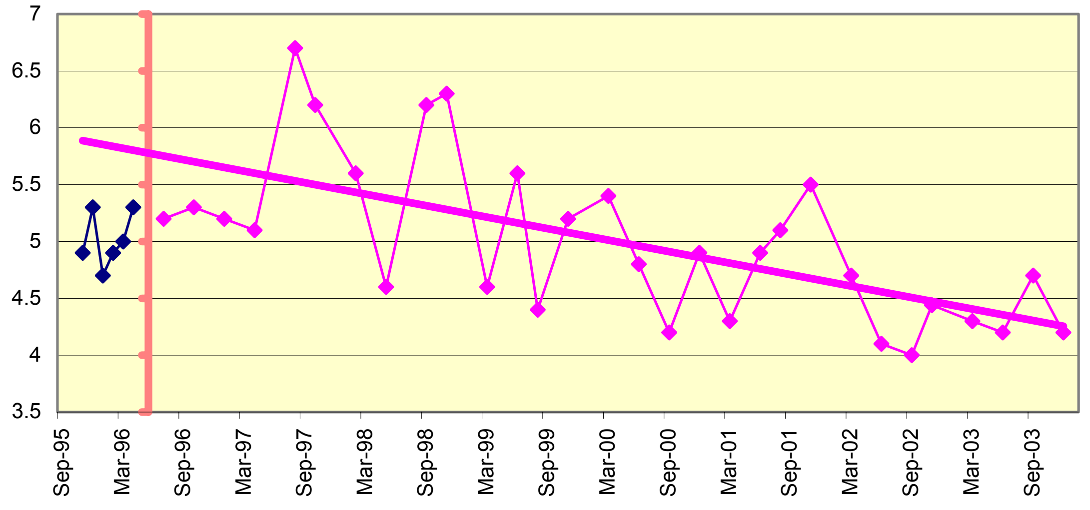
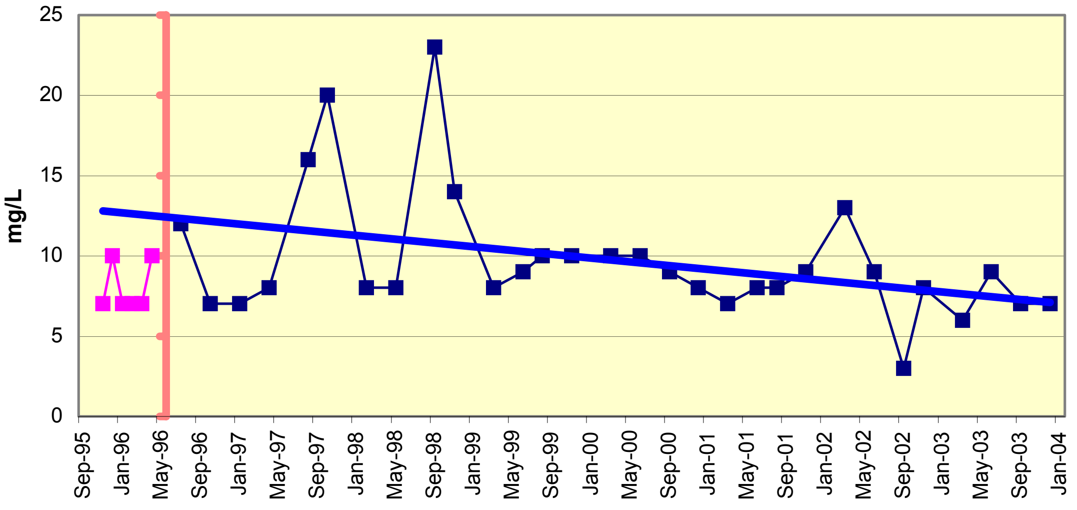


Figure 10.24 17950111 FA-19 Bloom #1 Alkalinity



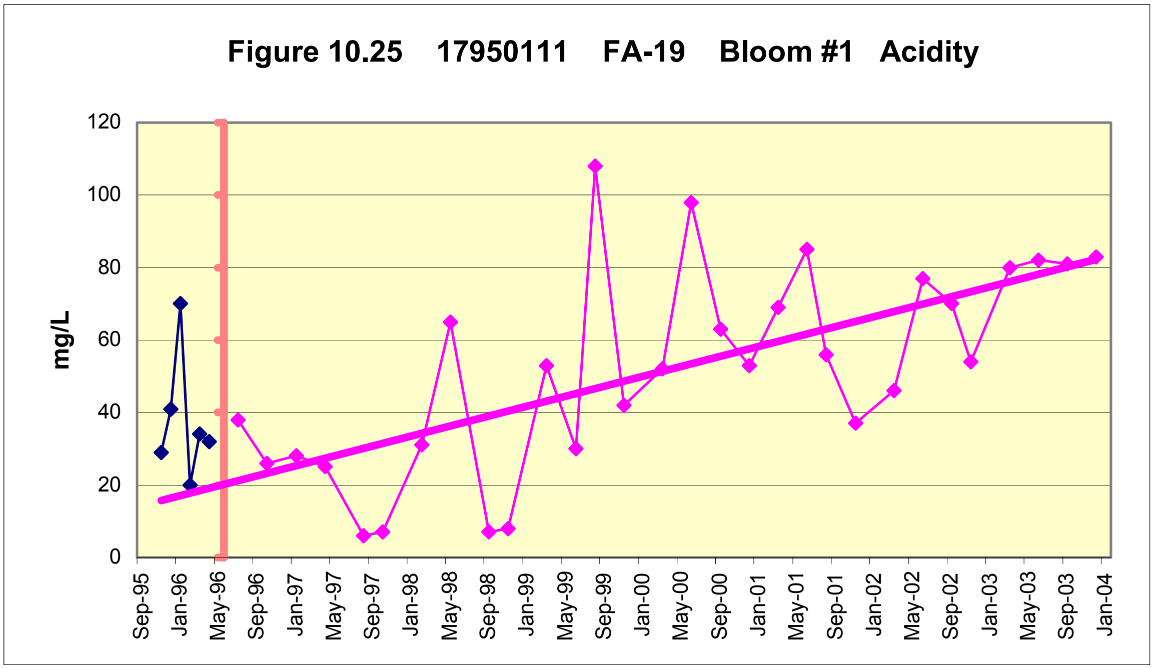


Figure 10.25 17950111 FA-19 Bloom #1 Acidity

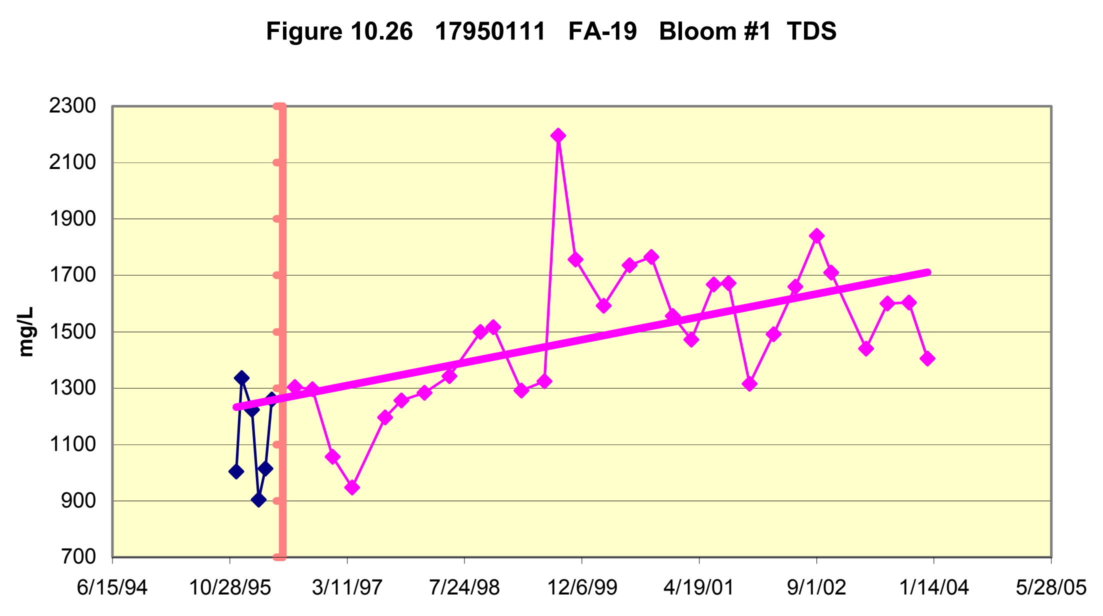
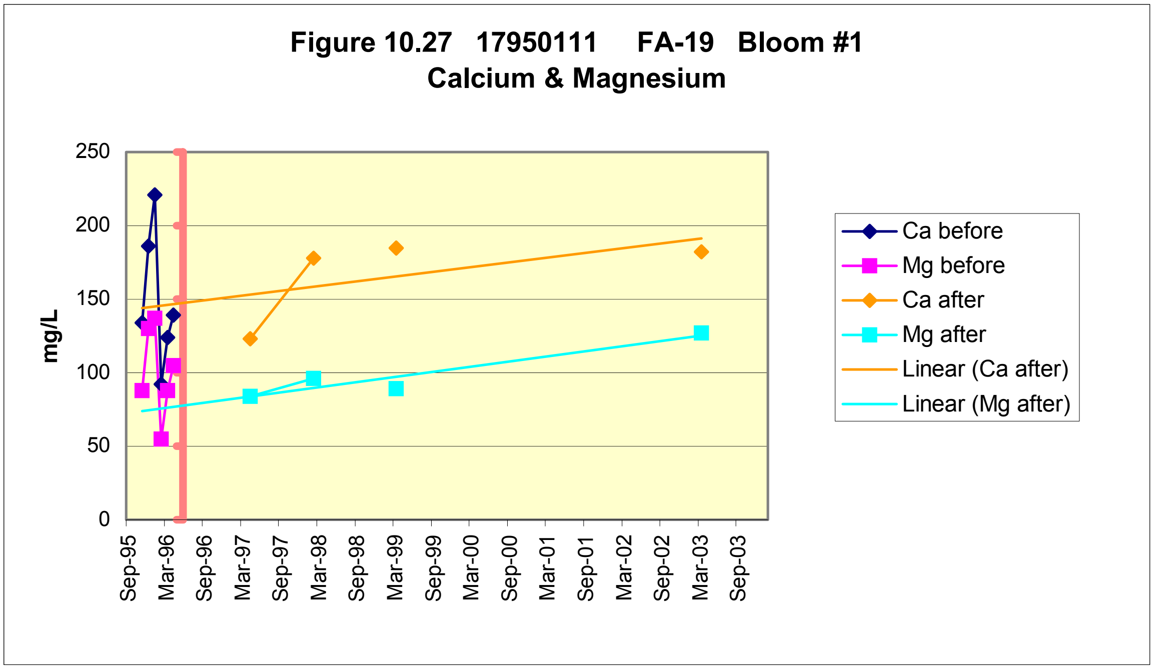
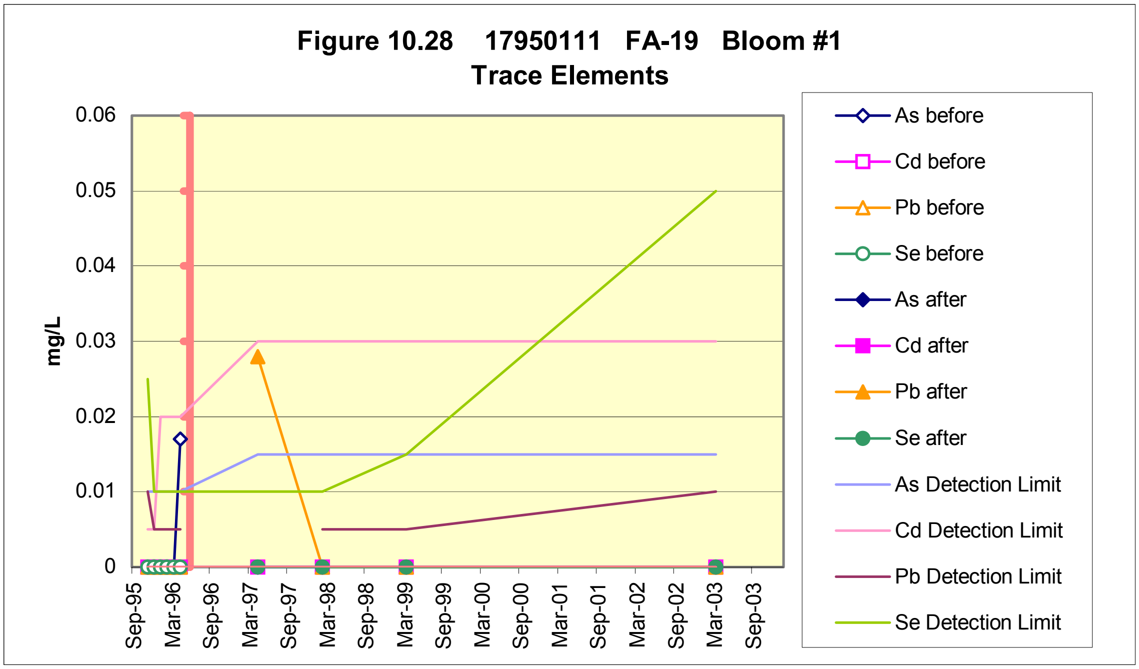


Figure 10.26 17950111 FA-19 Bloom #1 TDS

Figure 10.27 is a plot of calcium and magnesium at FA-19 through mid-1999. After baseline monitoring, these constituents rise but do not surpass baseline levels which are high to begin with. The baseline concentrations, the existence of only four data points after mining and ash placement started, and the absence of chloride data prevents a suggestion that these constituents are coming from the ash but does suggest that a previous source of alkalinity such as lime or lime kiln dust may have been placed at this site.



As is the case at other monitoring points, values for trace elements in figure 10.28 are detection levels rather than actual concentrations except for arsenic in April 1996 during baseline monitoring (of 0.017 mg/L) and lead in April 1997. While detection limits for arsenic, cadmium, and selenium, are lower at FA-19 than at MW-1 (figure 10.28), the dissolved concentration of lead actually measured at FA-19 of 0.028 mg/L in April, 1997 is higher than any measurement or detection limit recorded at MW-1, the upgradient monitoring point. The existence of only 4 data points after the baseline period representing only detection limits in nearly every instance greatly limits the ability to assess trace elements at this monitoring point.



FA-32

The subchapter F monitoring point FA-32 is a well dug on the eastern side of the "horseshoe," slightly below the elevation of the Middle Kittanning coal bed.

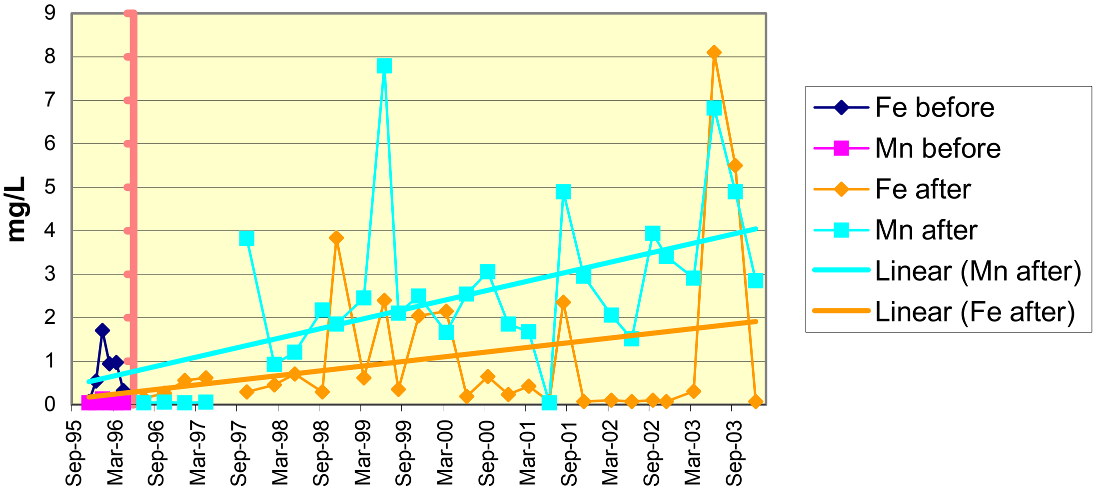
Figure 10.29 is a plot of the iron and manganese concentrations over time. There are a couple of instances in which these constituents drop below detection levels (.04 to .07 mg/L), but for the most part both show an increasing trend from levels relatively close to the DWS during the baseline period, to levels many times over the DWS after mining and ash placement. Manganese is rising more precipitously to levels up to 200 times the DWS by the latest monitoring data available.

The sulfate and TDS values are plotted in figure 10.29A, and both also increase rapidly after mining and ash deposition from below DWS to average concentrations reaching three times higher than the DWS for sulfates and two times higher than the DWS for TDS by the most recent data available in the monitoring period.

Figure 10.29B shows the trends for alkalinity and acidity; while alkalinity is initially significantly higher than acidity, alkalinity is falling, while acidity is increasing, suggesting that the driving source of contamination is rising AMD, instead of ash placement even if some of the pollution could be coming from dissolution of the ash. Both the field and lab pH are also falling during this period, from an average of almost 7 down to nearly 5 (figure 10.29C), which is further evidence of AMD. Calcium and magnesium values rise steadily over time (figure 10.29D) beyond baseline levels, suggesting input from placed ash, though not enough to neutralize the AMD.

Values for selenium, cadmium, lead, and arsenic are shown in figure 10.29E. There were no actual concentrations of these trace elements measured at FA-32. As at other monitoring points, the detection limits, particularly those for selenium have a rising trend, increasing by 5 times to 0.05 mg/L, equal to the federal DWS in the latest sampling. For arsenic, cadmium, and selenium, detection levels after mining and ash placement started were raised to levels at or above their respective DWS. Without lower detection limits, reviewers are unable to discern whether actual concentrations of trace elements are rising, declining or remaining the same as before mining and ash placement started.

Figure 10.29 17950111 Bloom #1 FA-32 Iron & Manganese



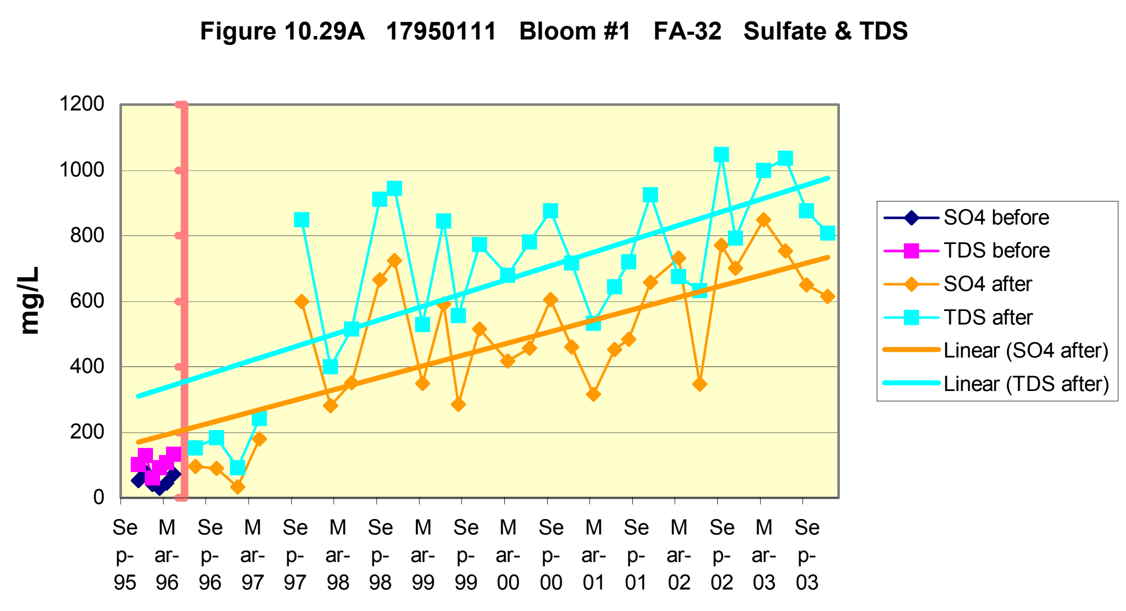


Figure 10.29A 17950111 Bloom #1 FA-32 Sulfate & TDS
mg/L
1200
1000
800
600
400
200
0
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
SO4 before
TDS before
SO4 after
TDS after
Linear (SO4 after)
Linear (TDS after)

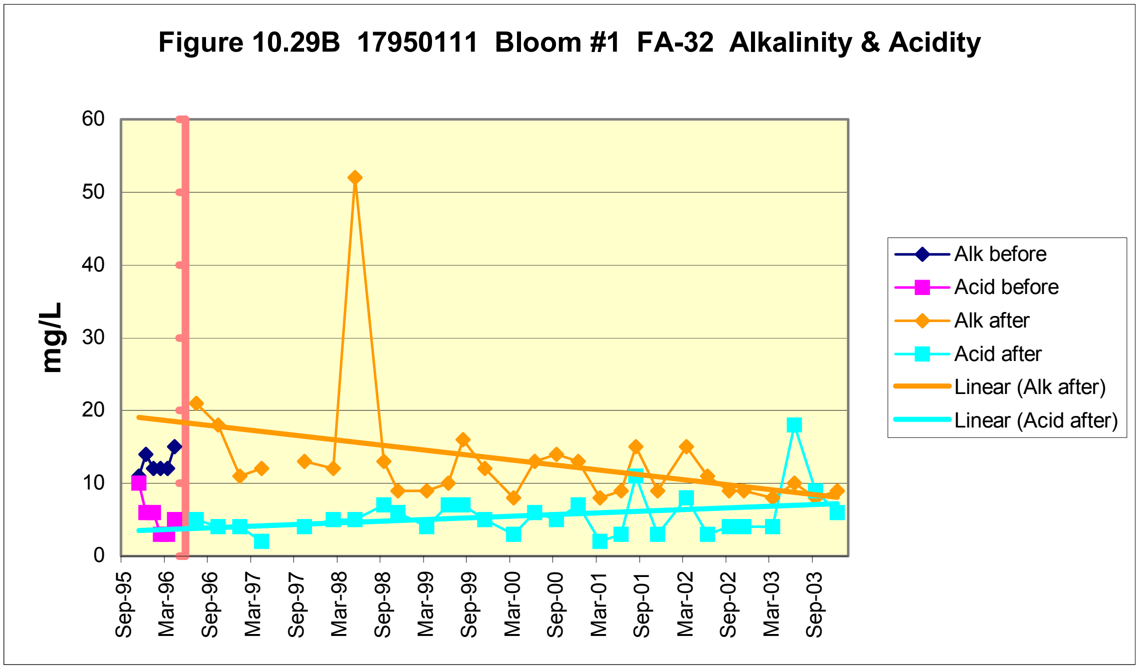


Figure 10.29B 17950111 Bloom #1 FA-32 Alkalinity & Acidity
mg/L
60
50
40
30
20
10
0
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Alk before
Acid before
Alk after
Acid after
Linear (Alk after)
Linear (Acid after)

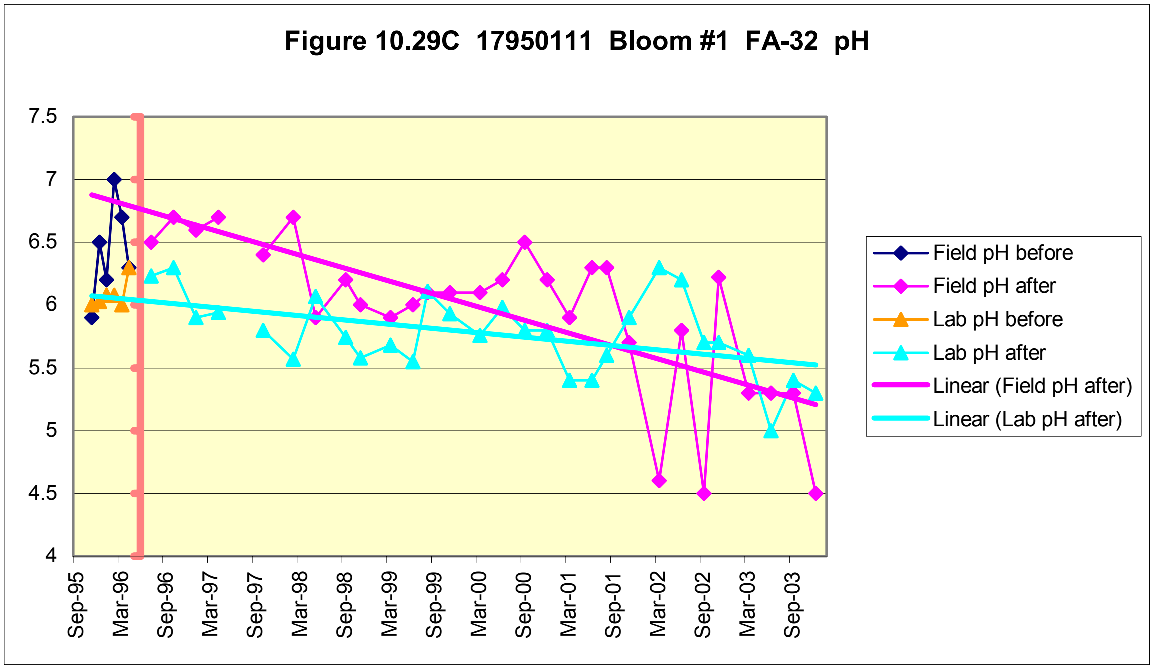


Figure 10.29C 17950111 Bloom #1 FA-32 pH
7.5
7
6.5
6
5.5
5
4.5
4
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Field pH before
Field pH after
Lab pH before
Lab pH after
Linear (Field pH after)
Linear (Lab pH after)

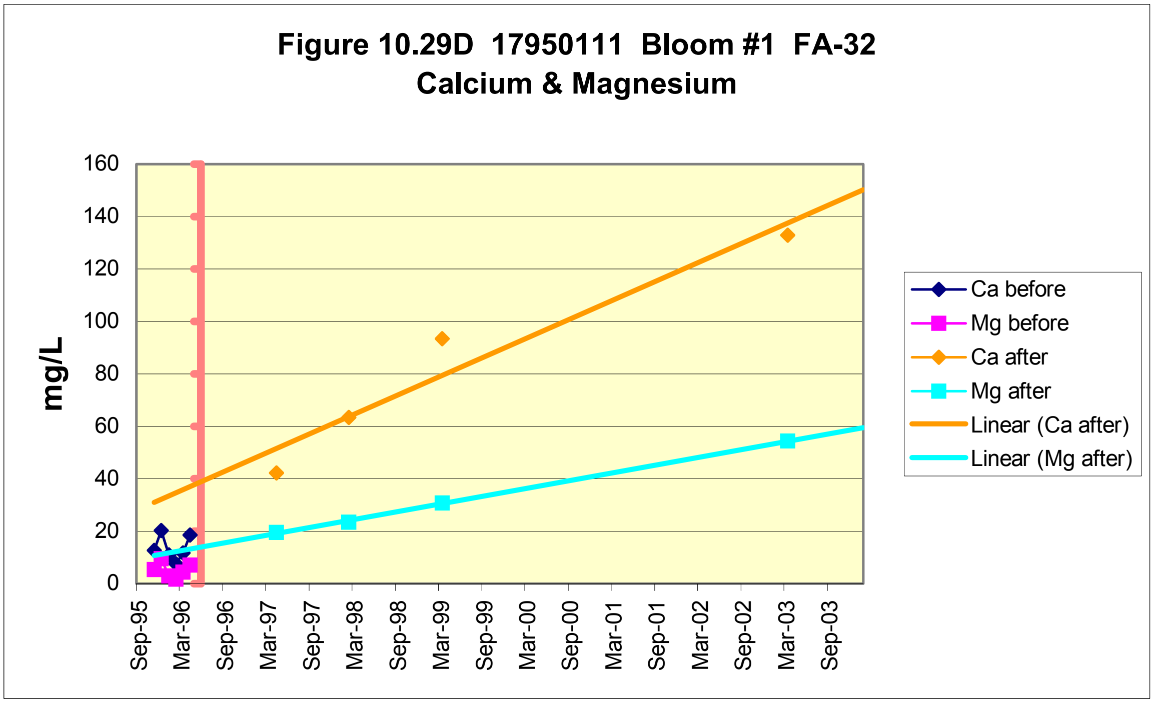
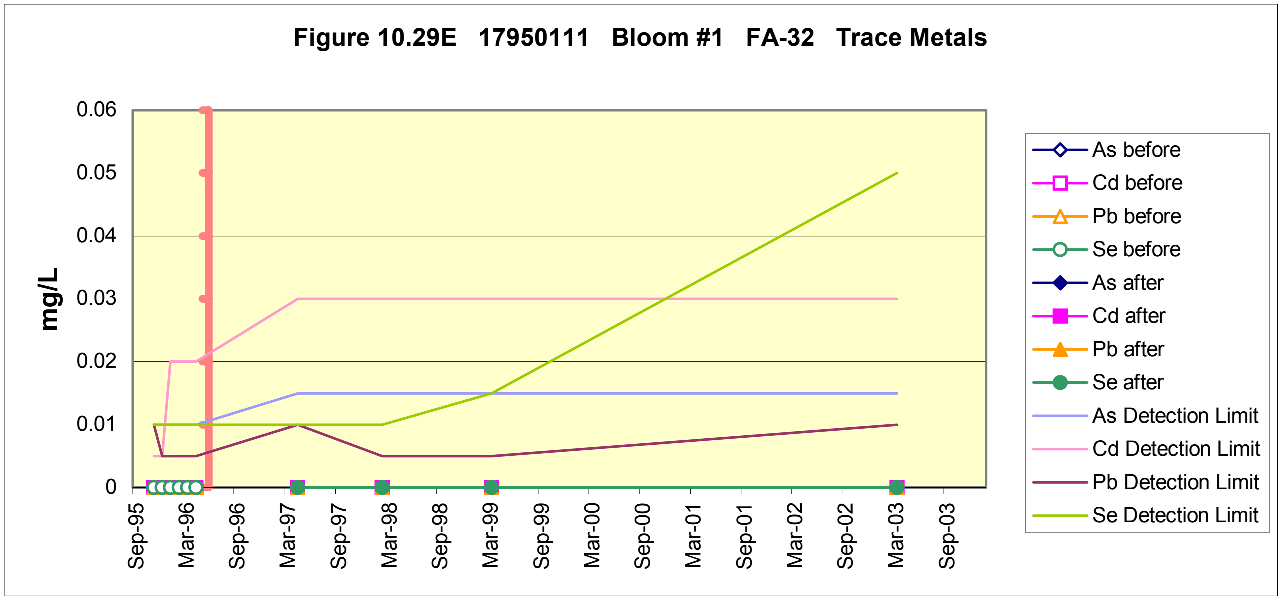


Figure 10.29D 17950111 Bloom #1 FA-32
Calcium & Magnesium
mg/L
160
140
120
100
80
60
40
20
0
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Ca before
Mg before
Ca after
Mg after
Linear (Ca after)
Linear (Mg after)



MW-3

Monitoring well MW-3 is located inside the southern end of the "horseshoe," and was placed in the ash-spoil backfill after the permitted operation had been underway for five years to sample water affected by ash placement at the coal seam elevation, explicitly to measure alkalinity effects of the ash placement. Most of the trends in the following figures indicate the ash is imparting significant alkalinity to the water but also significantly contaminating the water with other constituents.

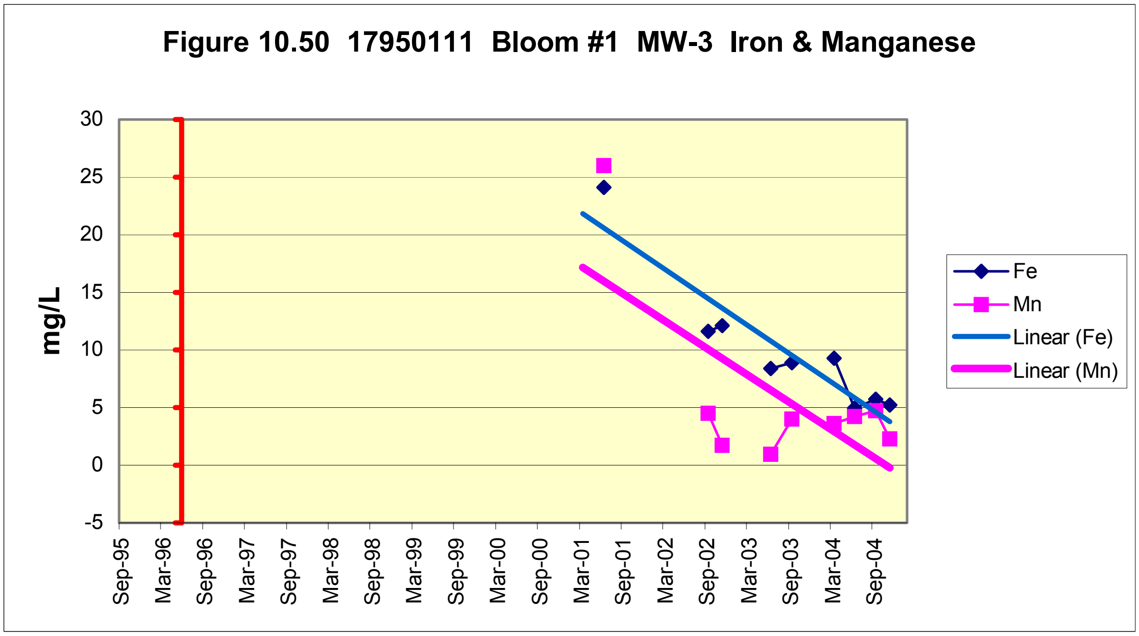


Figure 10.51 17950111 Bloom #1 MW-3 Sulfate, TDS, & Specific Conductance

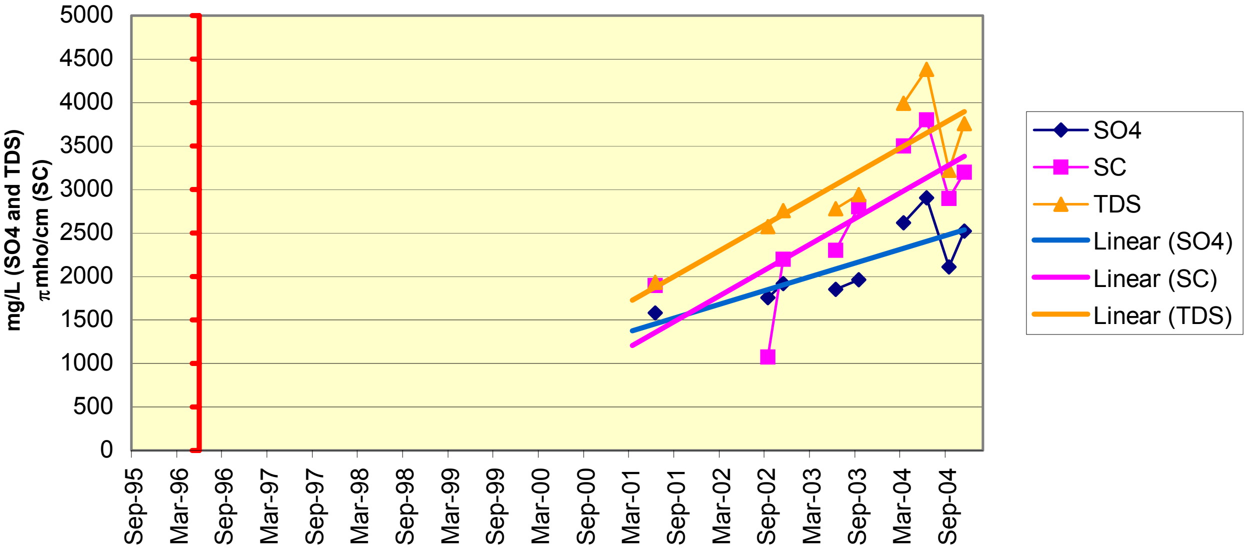


Figure 10.52 17950111 Bloom #1 MW-3 pH

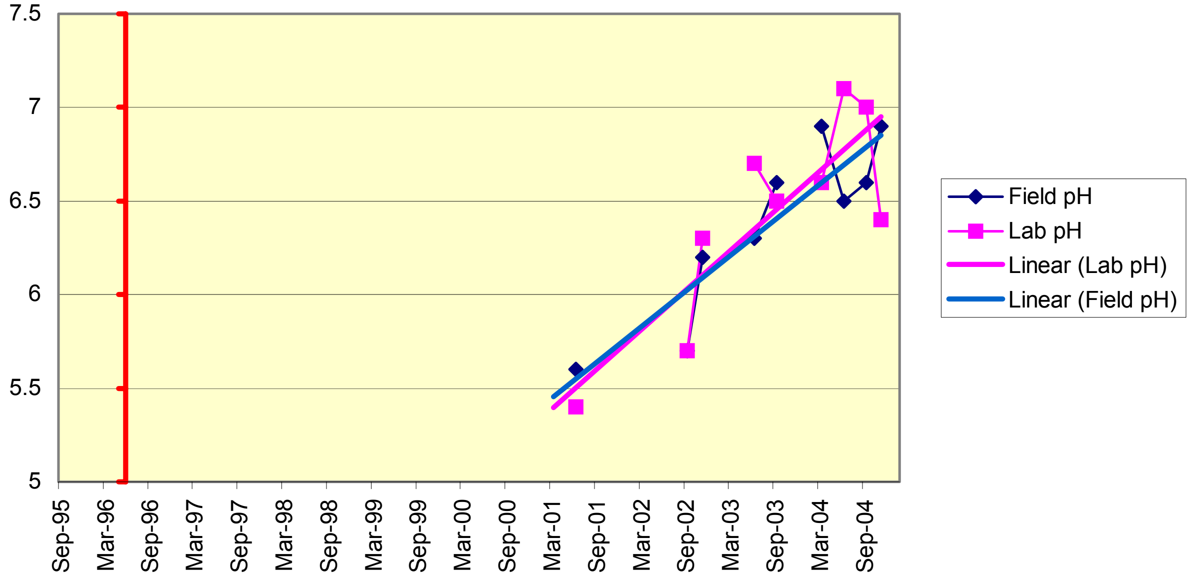


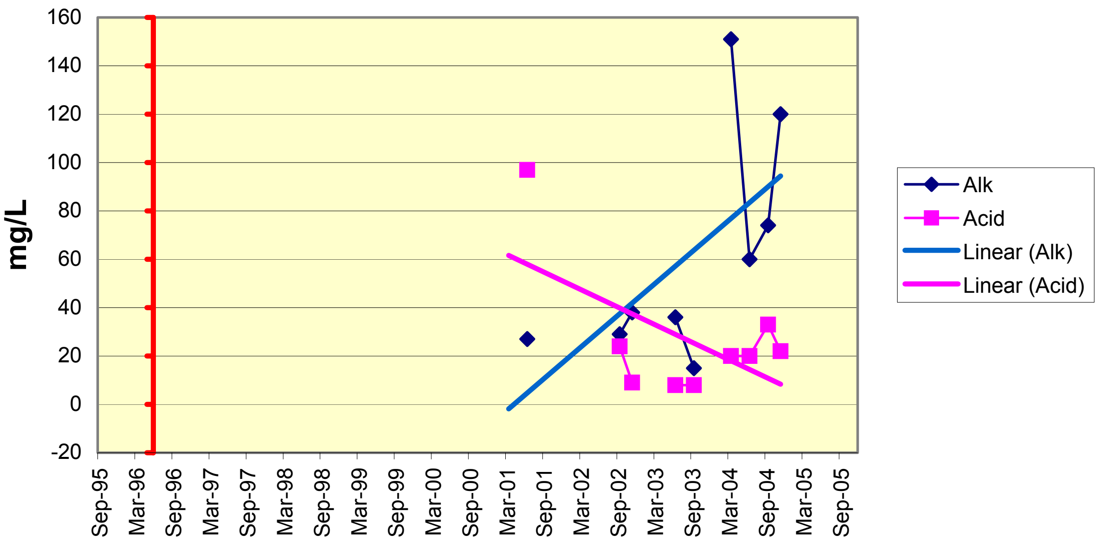
Figure 10.50 shows iron and manganese at MW-3 dropping from levels initially found in June 2001 of 26 mg/L for manganese and 24.1 mg/L for iron, the highest concentrations measured on the site from any monitoring point. Both constituents are declining decisively at the same rates although there are multiple gaps in the data due to the well being dry or inaccessible.

In contrast to the trends for iron and manganese, figure 10.51 shows concentrations of sulfate rising steadily to levels between six and 12 times the DWS, TDS rising to between seven and nine times its DWS and specific conductance rising in unison with TDS. The sulfate and these broader parameters more reflective of all pollution in the water are rising to their highest levels seen at any of the monitoring points, showing a large amount of material being mobilized in the groundwater at MW-3.

Figure 10.52 graphs the lab and field pH, whose trends are both increasing noticeably and at about the same rate, i.e., by nearly 1.5 units from around 5.5 to 6.9 units in the three years of monitoring at this point. The acidity drops, and the alkalinity rises sharply. The marked dominance of alkalinity over acidity at this monitoring point is not seen at any of the other monitoring points and gives the clearest evidence of water contamination from ash placement (figure 10.53).

There are no graphs for trace metals because only one measurement of concentrations at MW-3 for trace elements and other ash parameters such as calcium, magnesium, and chloride that are normally measured with them was found in the permit file from March 2004. However, this sampling reveals very high levels of certain elements that point to ash contamination. Calcium is 632 mg/L, magnesium is 254 mg/L, potassium is 70.30 mg/L, chloride is 153.0 mg/L, sodium is 23.80 mg/L and arsenic is 21.5 mg/L. This level of arsenic is 430 times the old DWS and 2,150 times the new DWS (0.010 mg/L). Data from sites studied in this report indicate that arsenic is more likely to leach from placed ash and the more neutral pHs generated by alkaline ash placement than from coal mine spoils or gob in an environment dominated by AMD. High levels of Total Suspended Solids (TSS) have been measured at MW-3, and the highest of those levels, 418 mg/L, was measured in the March 2004 sampling raising a question of how much of this arsenic is actually dissolved in the water versus undissolved arsenic bound to sediments. If all of the arsenic is undissolved, it would comprise more than 5% of the TSS. The dominance of alkalinity over acidity, rising pH levels and levels of calcium, magnesium, potassium, chloride, and sodium all indicator parameters for FBC ash leachate, that were substantially higher in this sampling of MW-3 than found at any other monitoring point at the site, suggest that the arsenic whether dissolved or not, is in fact coming from the ash or at least from the effects of the ashes placement on mine materials at the site.

Figure 10.53 17950111 Bloom #1 MW-3 Alkalinity & Acidity



Loads

Figure 10.30 is a plot of the rate of water flow in gallons per minute (GPM) at subchapter F monitoring point FA-30. The same pattern is seen in all of the load graphs for this point; the acidity load is almost identical (figure 10.31) to the flow graph, indicating the trends are controlled more by flow rate than concentration values. Coinciding with the sharp decrease in flow, the sulfate load (figure 10.34) shows a precipitous drop in the first half of 1998 from 58 lbs/day to a level below detection limits throughout the fall of 1998. Sulfate levels then start a slow and steady increase back to levels mostly between 5-20 lbs/day in 2003. The manganese load is similar (figure 10.33) to that for sulfate, but the seasonal variations are not quite as pronounced as in the previous graphs indicating more of a concentration control than flow over the graph trends. The iron load (figure 10.32) drops down to instrument detection limits.

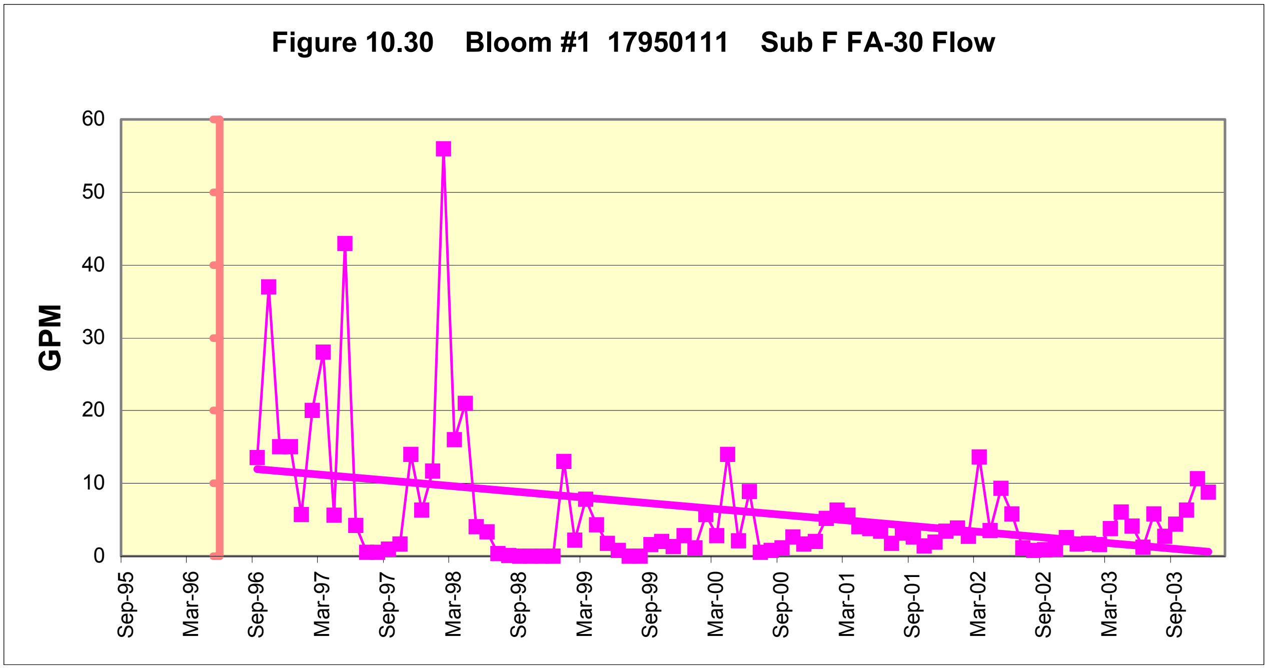


Figure 10.30 Bloom #1 17950111 Sub F FA-30 Flow
GPM
60
50
40
30
20
10
0
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03

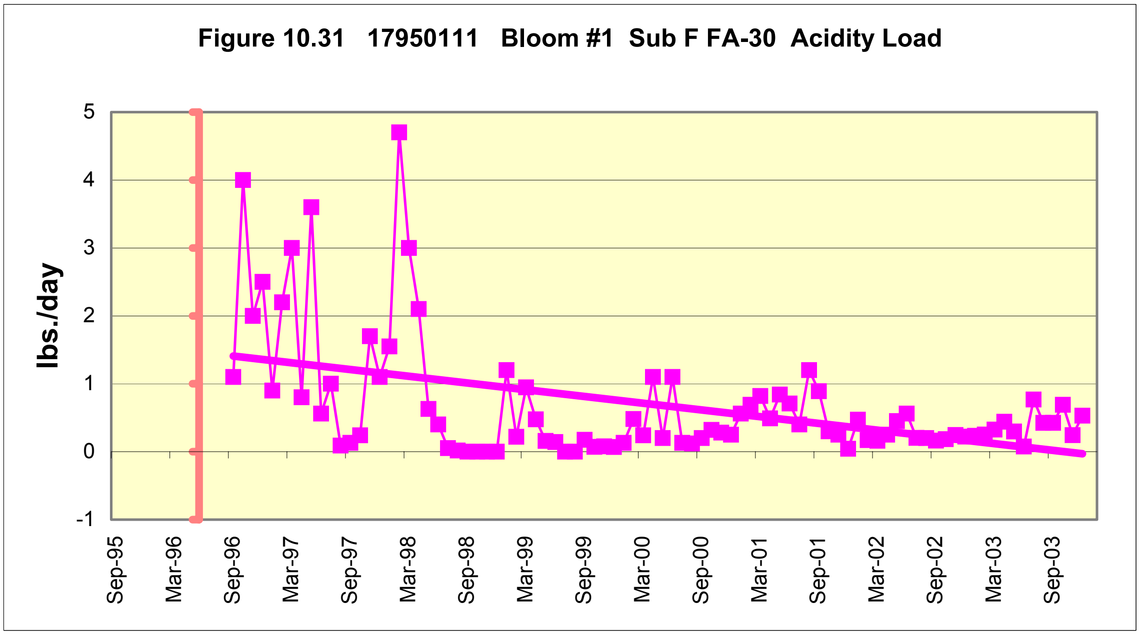


Figure 10.31 17950111 Bloom #1 Sub F FA-30 Acidity Load
lbs./day
5
4
3
2
1
0
-1
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03

Figure 10.32 17950111 Bloom #1 Sub F FA-30 Iron Load

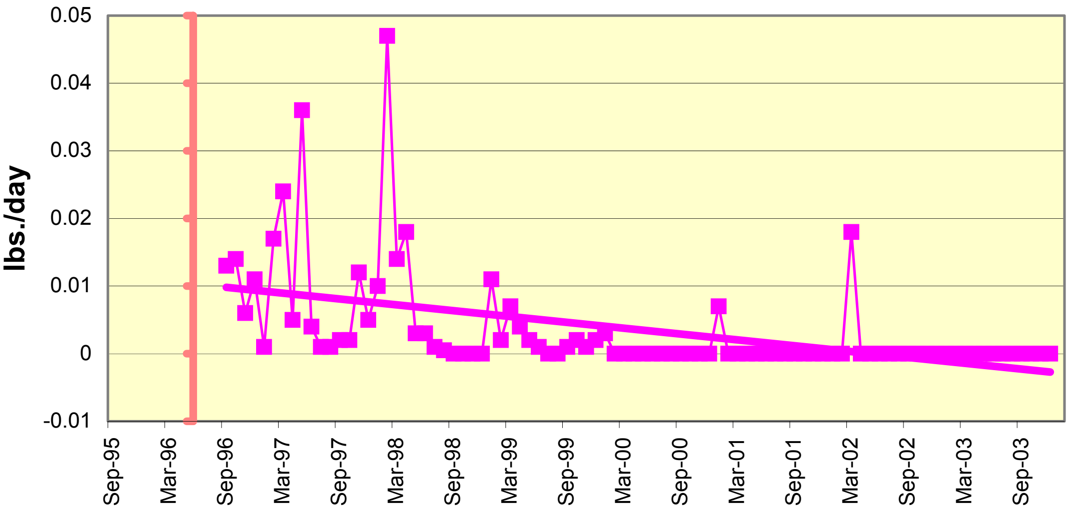


Figure 10.33 17950111 Bloom #1 Sub F FA-30 Manganese Load

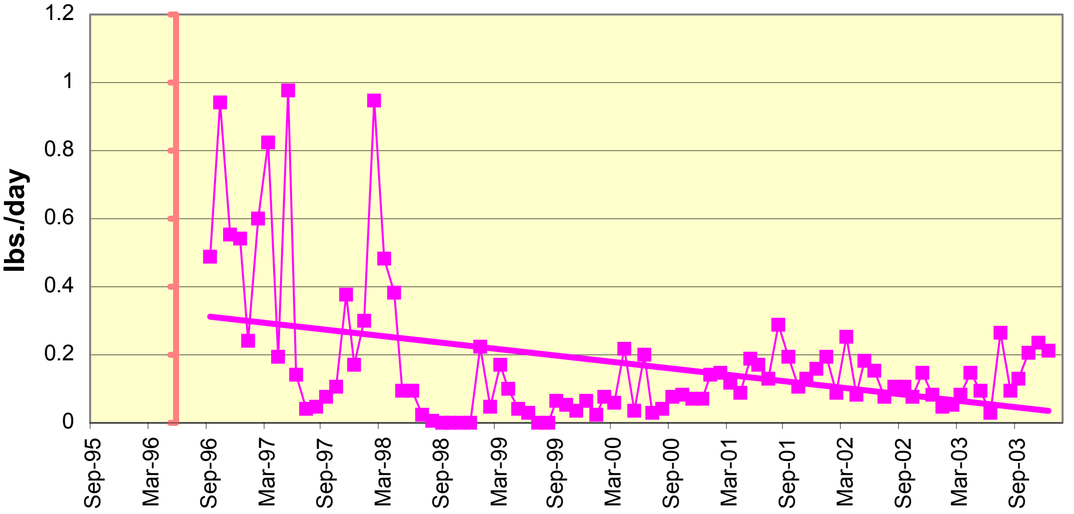
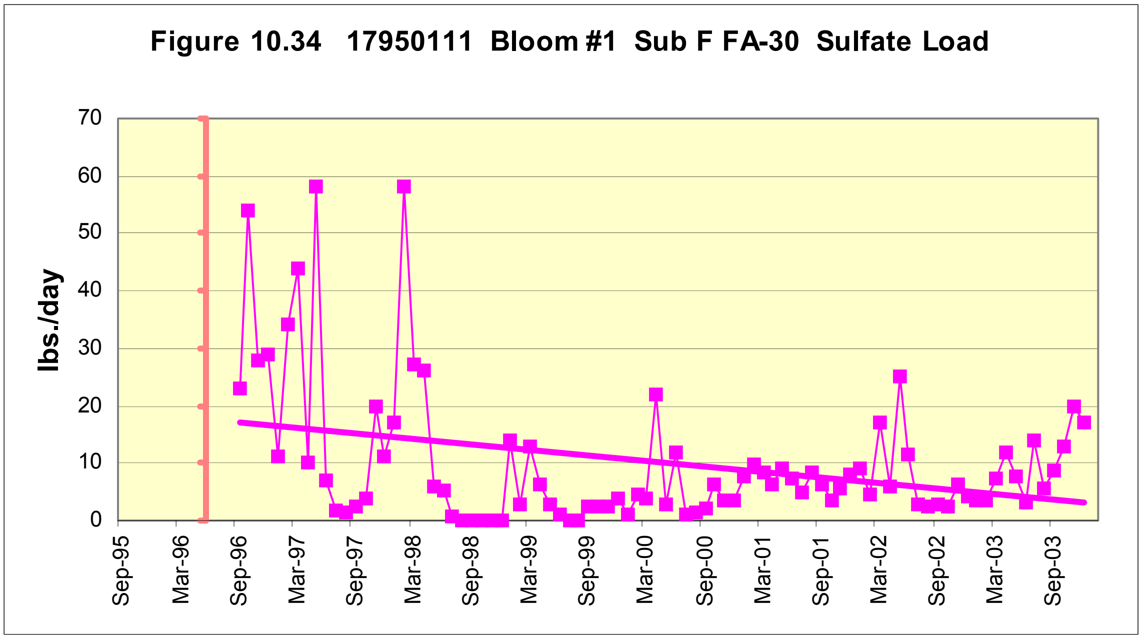


Figure 10.34 17950111 Bloom #1 Sub F FA-30 Sulfate Load



The average water flow at subchapter F monitoring point FA-19 (figure 10.35) is four to ten times the flow of FA-30 (figure 10.30), with high values reaching over 90 GPM at least four times in the first two years of mining and ash placement and the highest flow in the perod of ash placement,113 GPM, measured in April 2000. There are peaks in loads of acidity, manganese and sulfate that coincide with this measurement. The large majority of flows afer 1998 however are well under half these levels with average values declining. The acidity load has a bimodal shape (figure 10.36), declining until the beginning of 2000 and then rising slightly to the end of monitoring. This suggests more evidence of a placed ash that lost its neutralizing powers. The iron load (figure 10.37) rises with ocillating values after the baseline period to a peak in February, 2000 of 1.7 lbs/day before dropping to values generally less than one tenth this load for the rest of the monitoring period. The manganese load (figure 10.38) has a similar curve shape to the acidity load with higher peaks accentuated by higher manganese concentrations. The sulfate load (figure 10.39) generally decreases over the life of the permit, although, many sulfate values remained high, with measurements of over 500 lbs/day of sulfate leaving the site at FA-19 recorded 8 times from 2000 to the end of the monitoring in 2004 and an average sulfate load more than 40 times the average amount of this pollutant leaving the site at FA-30 attesting to the impact that higher flows and somewhat higher concentrations of sulfates are having at FA-19.

These declining loading values indicate an overall improvement from the baseline period in the total amounts of iron, manganese and sulfate leaving the Bloom #1 mine at these monitoring points. This improvement starts during a sharp reduction in flow that begins in the spring of 1998 at both monitoring points and continues through 2002. There is not enough information in the permit materials to determine the extent of any less permeable conditions that may have developed in the deposited ash much less what impact such conditions could have had on flows and pollutant loads exiting the site. There is also no data base of site precipitation measurements in the permit files that would enable reviewers to assess if changing precipitation patterns at the site may has played a role in this decline in flow and loads.

Climate data maintained by Penn State University (at http://climate.met.psu.edu/data/state.php) indicates that average annual precipitation in Climate Region 7 of western Pennsylvania which appears from a general map to include the Bloom site, dropped from 54.41 inches in 1996 to 38.96 inches in 1997 and 37.03 inches in 1998. Reduced annual precipitation levels continued through 2001 when the average annual precipitation in Region 7 dropped to 33.41 inches, some 21 inches below the precipitation in this Region in 1996. A similar drop occurred in Climate Region 10, just west (within 20 miles approximately) of the Bloom site where average annual precipitation in 1996 was more than 19 inches greater than the average annual precipitation in 2001.

A comparison of the average monthly precipitation in Climate Region 7 to the flow volumes recorded at FA-19 (figure 10.35) and FA-30 (figure 10.30) shows that during the years of lower annual precipitation, the highest gallon per minute flows nearly always occurred in the spring months of March, April and May when higher monthly average rainfalls generally occurred in Region 7. Presumably the greatest period of snow melt would also have occurred in these months adding to the flows at these points. Not surprisingly, loads of sulfate, iron, manganese and acidity, particularly at FA-19 are usually highest in these spring months, what one would expect if loads at the Bloom site are being driven by the amount of rain and snow melt occurring there.

An exception to the overall decline in loads is the gradually rising acidity load at FA-19 from an average of 15 lbs/day to 20 lbs/day over the mining and ash placement period.

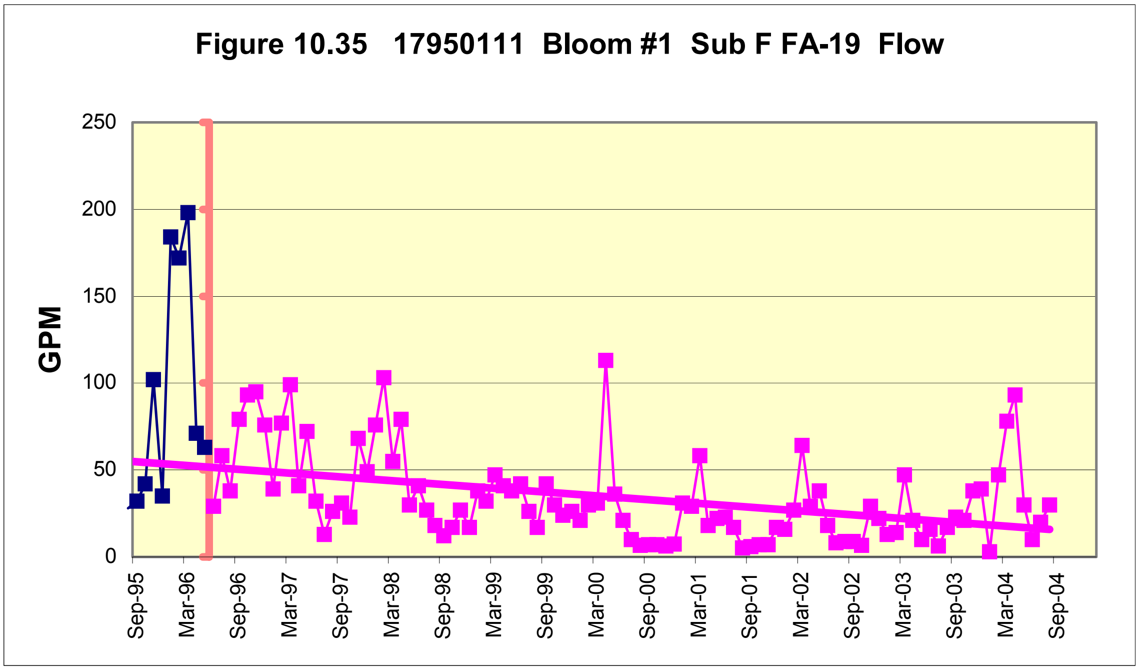


Figure 10.35 17950111 Bloom #1 Sub F FA-19 Flow
GPM
250
200
150
100
50
0
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
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Sep-02
Mar-03
Sep-03
Mar-04
Sep-04

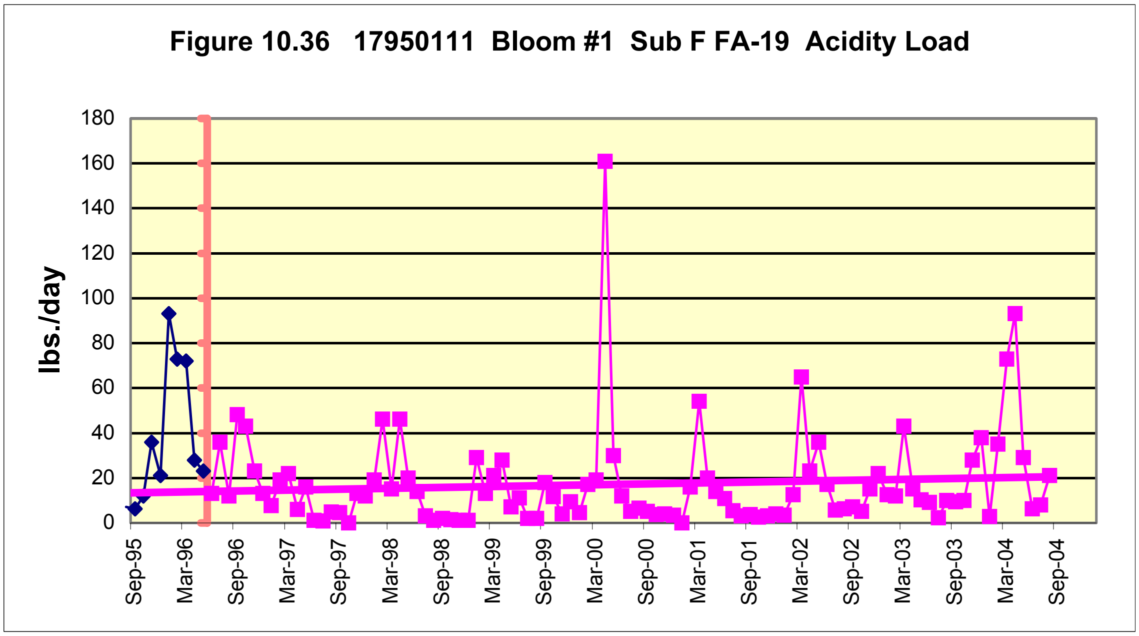
Figure 10.36 17950111 Bloom #1 Sub F FA-19 Acidity Load
lbs./day
180
160
140
120
100
80
60
40
20
0
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
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Mar-03
Sep-03
Mar-04
Sep-04

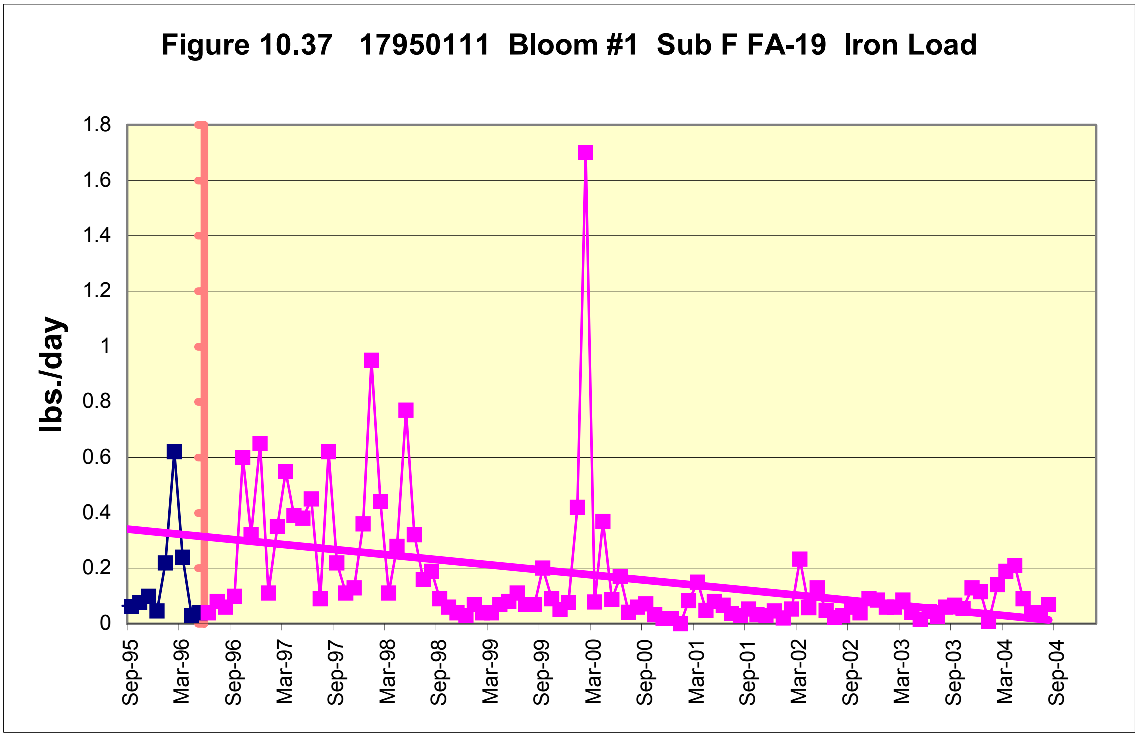


Figure 10.37 17950111 Bloom #1 Sub F FA-19 Iron Load
lbs./day
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04

Figure 10.38 17950111 Bloom #1 Sub F FA-19 Manganese Load

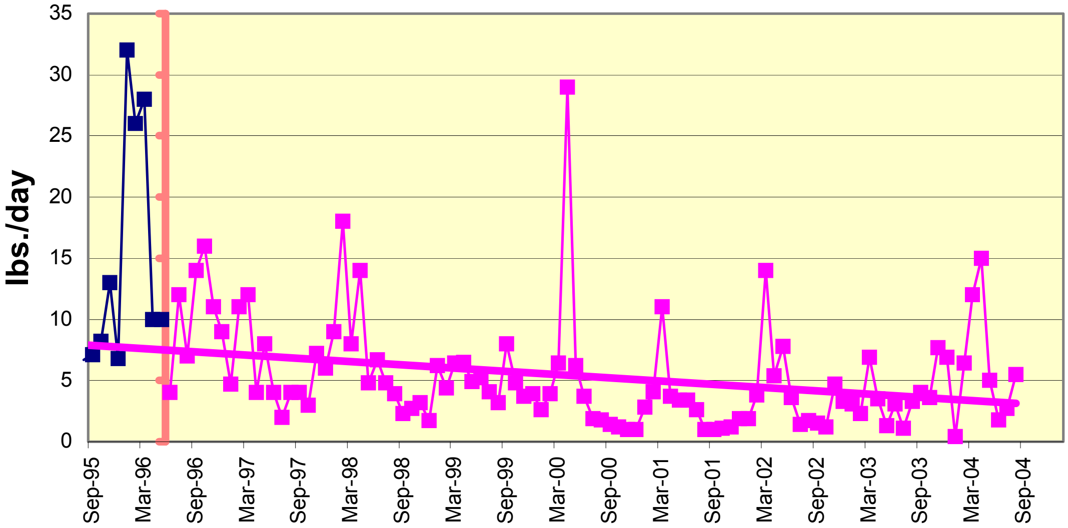
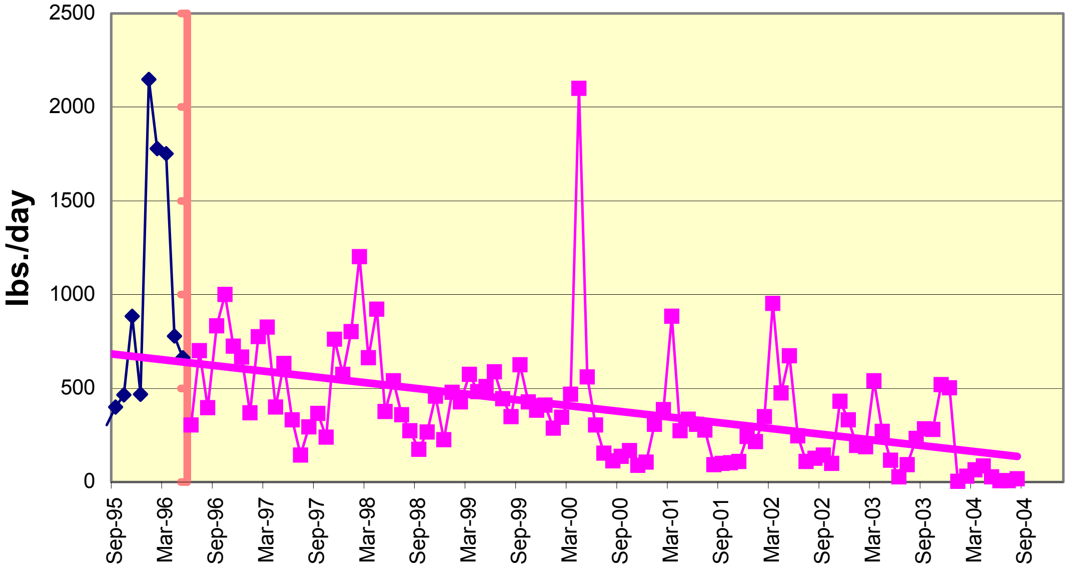


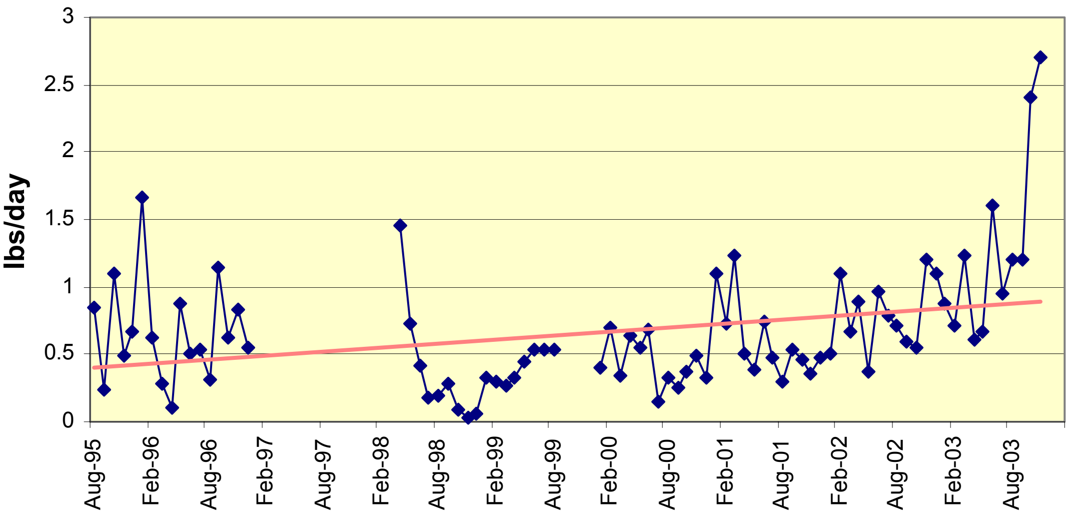
Figure 10.39 17950111 Bloom #1 Sub F FA-19 Sulfate Load



FA-20

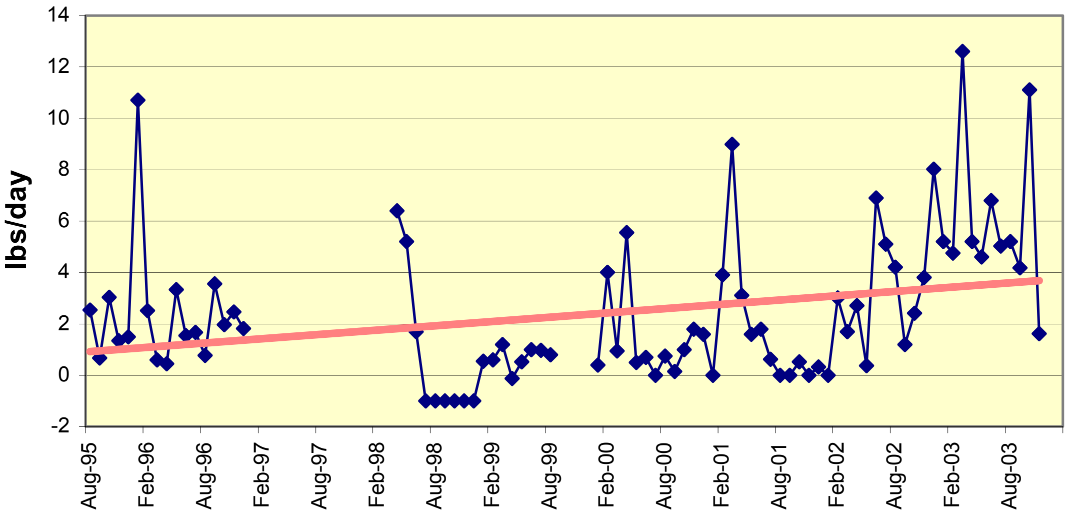
Loading data for acidity and manganese were plotted for subchapter F point FA-20, which is a downgradient seep on the southeastern side of the "horseshoe" near FA-19. (see map). Inspection reports indicate that PADEP is concerned about rising loads of these parameters at this monitoring point.

Figure 10.40 17950111 Bloom #1 FA-20 Manganese Loading



The average manganese loading stays below 1 lbs./day for most of the site life (figure 10.40) and then jumps steeply in the middle of 2003.

Figure 10.41 17950111 Bloom #1 FA-20 Acidity Loading



The graph of loads for net acidity (figure 10.41) shows the same general behavior as the manganese loading; a fairly consistent, slight rise over the life of the site, until 2003, when consistently higher measurements are recorded. This large load increase induced the PADEP to require weekly sampling for these parameters (not shown in graphs) at FA-20 in the fall of 2003.

Conclusion

Assessment of the data generated by the monitoring points at this site reveals a high potential for ash to degrade site waters and the complexity of the relationship between ash and AMD. Rising concentrations of ash indicator parameters in or downgradient from the ash suggest this impact is already occurring to some extent. This is best shown by the data from monitoring well FA-32 east of the mining and ash placement area. The data from MW-3 located in the FBC ash and spoil shows a clear impact from the ash with average pH rising from 5.5 to 7 units in less than 4 years, alkalinity dominating acidity, and sulfate, TDS and specific conductance rising to the highest concentrations measured at the site. An extremely high level of arsenic (21.5 mg/L) measured in March, 2004 at MW-3 is not dismissed as a sampling or laboratory anomaly in the monitoring reports and was also found with the highest levels documented at this site of other ash parameters such as calcium, magnesium, chloride, potassium and sodium. This suggests a very harmful potential in the leachate being generated in the ash-spoil mixtures at this site and underscores why more than annual monitoring of ash leachate parameters at only a few monitoring points is needed at these sites.

However, monitoring at the subchapter F points reveals that in a relatively short period of time, as water moves outward from the ash placement area, the ash's alkalinity is overrun by the site's acidity. To the south of the mining and ash placement area at FA-19 where monitoring reveals the most polluted water prior to mining, rising alkalinity and pH from 1996 through 1998 is followed by a steady decrease in alkalinity, increase in acidity, and a decline in average pH of 1.5 units through 2004. Although acidity is weaker at FA-30 north of the mining area and at FA-32 southeast of the mining area, by the latest data reviewed in this report, average acidity had overtaken alkalinity and average pH levels had declined by .5 units at FA-30 and 1.5 units at FA-32. Either the alkalinity of the ash is being exhausted or the ash becomes hydrologically isolated from groundwater and thus its full potential alkalinity is not being utilized. In the overall picture, despite levels of acidity that were not that high throughout the monitoring period, (generally below 100 mg/L), the ash does not appear to have had a significant buffering effect on acidity for more than temporary periods at any of the downgradient subchapter F monitoring points assessed in this report.

From a concentration standpoint the effect of the mining and ash placement on manganese and sulfates has not been good. These constituents were already at or exceeding the DWS in baseline monitoring but their average concentrations have risen substantially further and by roughly the same amounts after mining and ash placement at all three subchapter F monitoring points. This trend is also reflected in rising TDS levels. On the other hand, iron is rising at FA-32 to levels as high as 8.1 mg/L in June 2003, 27 times over the DWS, yet declining at FA-30 and after an initial increase, also declining at FA-19 to levels near or below the DWS. And the highest iron levels at the site were measured in baseline monitoring at the upgradient MW-1 (up to 19.5 mg/L) and in the initial measurements at MW-3 in the ash and spoil of the site (up to 24.1 mg/L). In both of these cases, field pH was 6-7 and alkalinity was exceeding acidity.

Concentrations of calcium and magnesium did rise substantially as a result of the operation at FA-30 and FA-32, although the high levels of these constituents in the baseline monitoring at FA-19 indicate a source of alkalinity was already placed at least on the south side of the site prior to this ash placement operation. Still, the near absence of calcium and magnesium at upgradient MW-1 (whose concentrations are all under 3 mg/L) compared to the highest levels measured for these constituents at the site in the ash-spoil mixture surrounding MW-3 (calcium at 632 mg/L and magnesium at 254 mg/L in March, 2004) indicates not surprisingly that the FBC ash at this site is a source for rising levels of these constituents.

Dissolved concentrations of trace elements, arsenic, cadmium, lead, and selenium, are below detection limits of the lab analysis in the large majority of results reported from the monitoring points assessed in this report. In addition the detection limits reported for cadmium, arsenic, and selenium increase beyond baseline detection values to levels equal to or exceeding the DWS once ash placement is underway. This leaves reviewers unable to discern if these trace heavy metals are even present much less increasing to levels exceeding the DWS or decreasing, only that their concentrations are not higher than the detection limits reported. The worst examples of this are the detection limits used for cadmium which rise from the DWS before ash placement to 0.030 mg/L after ash placement, six times the DWS.

Despite MW-1's designation as an upgradient monitoring well in the permit, water quality at MW-1 appears to reflect some impacts from the activities in this operation. Manganese, sulfates, and TDS were a tenth or less their concentrations at all other monitoring points, yet sulfates and TDS rise slightly during the mining and ash placement. These rising concentrations along with gradual rises in alkalinity and acidity and an average pH decline of a half unit during mining suggest the existence of a flow pathway between the mining and ash placement area and MW-1 that is not identified or characterized by the permit.

There have been reductions in loadings in pounds per day of iron, sulfate and manganese over the monitoring period at FA-19 and FA-30 that appear to have been driven by a substantial decline in flow in the permit area starting in 1998. While average acidity loads have also declined at FA-30, they are gradually increasing at FA-19. There is not enough information in the permit materials to determine the whether the ashes physical characteristics, i.e., any less permeable conditions the ash is creating in its deposited state, are having any impact on flows or loads at this site. Reviewers also could not locate rain gauge data or other site precipitation data. However regional climate data at Penn State University reveals that the reduced loads have been occurring in years with significantly less precipitation in the climatic region in which the Bloom site is located. Furthermore within those years of reduced rainfall, the highest loads of iron, sulfate, manganese and acidity have nearly all occurred during the spring when the greatest precipitation and snow melt also occurs, suggesting that reduced loads at this site are primarily a function of weather and changing climatic conditions. While these reductions in loads are normally an important sign of reduced impact to the watershed, the significant increases in concentrations of manganese and sulfates at these and other monitoring points and the potential connection to ash placed at the site should not be discounted. If the reduced load is a function of reduced precipitation, flow in the receiving stream would be similarly reduced and the higher concentration would have a proportionately greater impact. Loading data from FA-20, near FA-19, also shows a marked rise in the manganese and net acidity leaving the site in 2003. The reasons for these higher inputs into the water should be investigated as the data show worsening conditions at a time when reclamation should be resulting in improved water quality.

Given the rises in loadings and in concentrations of ash parameters in the water flowing from this site, the need for an enhanced post-placement monitoring program is apparent. In addition to continued sampling of the existing monitoring points, efforts should be made to improve the understanding of flow pathways at the site and establish more monitoring points closer to the ash, in the ash and upgradient of the ash. Monitoring for trace elements and other ash indicator parameters such as calcium, magnesium, chloride and potassium should be conducted on at least a quarterly rather than annual basis, and boron, antimony and molybdenum should be added to the list of monitored constituents. Detection limits used in the lab analysis should be reduced to levels that enable reviewers and regulators to tell if trace metals are increasing and posing a problem in waters exiting the site. These steps will help pinpoint the timing of ash-generated leachate flow and thus greatly contribute to the understanding of the influence of ash and other potential sources of pollution at the site and any responses needed.

CAPTION - Sulfate increased to higher concentrations in downstream drainages after ash placement started at the EME Generation Site than had occurred during at least 8 years of prior active gob disposal at this site. Iron and aluminum also increased. Nickel, chromium, zinc, copper, silver and barium increased and exceeded drinking water standards in several instances in downgradient waters after ash placement started at this site, a.k.a. the Homer City Coal Refuse Disposal site in Indiana County, PA. These trends took place amidst a decline in acidity and increase in alkalinity and pH at all but one monitoring point. The ash at this site is from the conventional Homer City Power plant in the picture and thus gray to black rather than tan or reddish brown, the color of FBC ash. Photo by Jeff Stant, August 2007.

Chapter 4 – Mine Sites Degraded, Evidence Inconclusive

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Permit Review 11

TDK MINING, SANDY HOLLOW MINE (PERMIT # 16910104)

Site Summary

The Sandy Hollow Mine is located in Madison Township, Clarion County, Pennsylvania, in the Mahoning Creek Priority Watershed 17D. The coal seam mined was the Upper Freeport, and 342,000 tons of FBC and conventional (PC) fly and bottom ash were placed at this site. The placement started in August 1996 and finished in September 2000 according to inspection reports and confirmed by personnel at the PA DEP Knox District Office.

The FBC ash was from the Piney Creek Limited Partnership in Pennsylvania, and the conventional ash source is the Jamestown Board of Public Utilities, S.A. Carlson Generating Station, Jamestown, New York. The ash was placed incrementally as strip-mining operations proceeded to prevent acid mine drainage through alkaline addition. The acreage covered by ash placement was not specified in the permit.

Geology

The geology of the site consists of the Upper Freeport Coal and its overburden rocks. Many of the overburden beds at this site are naturally cemented with calcite, increasing the neutralization potential (NP) and decreasing the potential for acid mine drainage. The sedimentary beds at the Sandy Hollow Mine are nearly flat-lying, except for a very slight dip to the south, which reflects the geometry of the original depositional basin.

Topography

The topography of the site is typical for the Pittsburgh Plateau province in Pennsylvania; steep valleys with relatively flat-topped hills that represent the old plateau surface before uplift and erosion. The surface water drainage is a radial pattern, with small streams running off the site in many different directions due to the mine being placed at the tops of the hills where the coal outcrops. (See map below.)

Groundwater

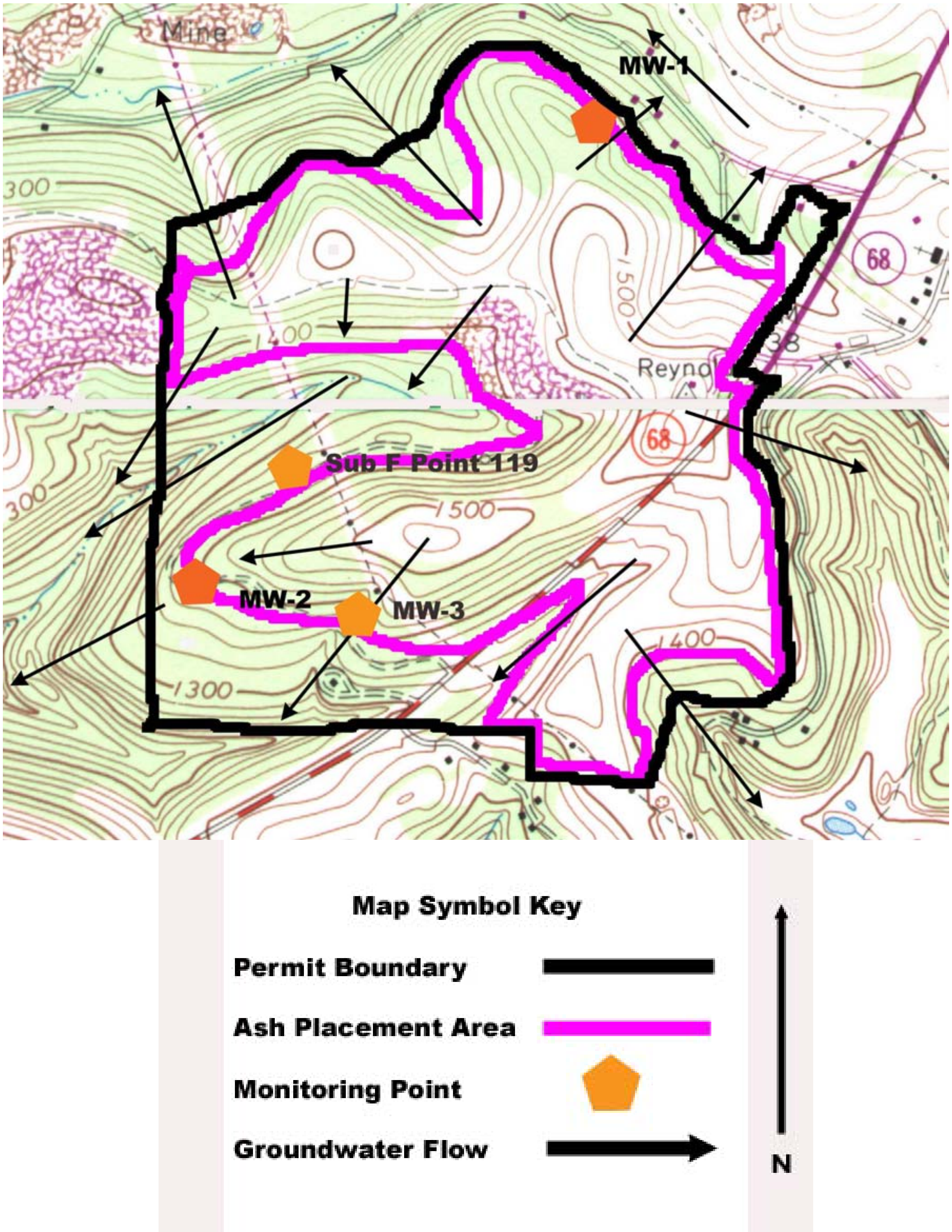
Groundwater flow follows topography closely except where the land has been disturbed by mining. In mined areas like Sandy Hollow, surface water and groundwater will tend to run through the spoil, due to its higher secondary porosity, down to the level of the Upper Freeport Coal and exit at this elevation on the downgradient side of the hill in question.

Monitoring data: Discussion

Four ash groundwater monitoring wells were installed on this site, one upgradient well, MW-1 and three downgradient wells, MW2, MW3 and MW-4. MW-1 and MW-3 were selected for study, to include one upgradient point and the downgradient sampling point with the most complete data set. Water level elevations from five measurements taken on identical dates from May 1999 to May 2000 place the water at MW-1 about 71 feet above the water at MW-3. Both wells were drilled down to the first aquifer below the coal seam to be mined. Nonetheless there is some question as to whether MW1 is actually upgradient of the influence of mining and ash placement given its placement inside the mining and ash placement areas. The elevation of its screen according to CONSTRUCTION DETAILS on pages 25-27 and 25-29 in the permit's Module 25 Section B-2 is at 1337 feet above sea level, about 140 feet below the land surface at the well. The elevation of the screen for MW3 is 1294.7 feet above sea level, about 53.3 feet below the surface of the ground. The depth of the mining above these levels, the slope of the ground from the ridge going downhill to the northeast past MW-1 and the incremental placement of ash authorized throughout the area to be mined leaves some question about whether flows from mined ground containing AMD and ash leachate could not reach the screen of MW1. Thus the placement of the arrow by MW1 on the map below indicating this possibility.

There were four Subchapter F monitoring points at this site and of these, Point 119 has been selected for loading discussions because it is the most downgradient and has a relatively complete data set. This point is monitoring a seep in the southwest portion of the site about a thousand feet northeast of MW-2 (see map). MW-1 and MW-3 were monitored from 1996 to 2001 with a baseline monitoring period from January 1996 to June 1996. Point 119 was monitored from April 1994 to December 2003. This monitoring point was not designated in the permit as an ash monitoring point, and thus has no data for more exclusive ash parameters monitored under Module 25 such as trace RCRA elements, calcium and magnesium making its data more useful for looking at general trends from the mining operation as a whole rather than measuring ash impacts specifically.

Site Map: Sandy Hollow



TDK Coal Company, Sandy Hollow Operation (Permit # 16910104)
Scale: 1" = Approximately 1000'

MW-1

MW-1, the only upgradient monitoring well, showed little sign of degradation with the exception of minimal impacts possibly due to coal mining and/or coal wastes (gob). Figure 11.1 is a graph of iron concentrations; a rising trend was evident from an average concentration increasing from 2.5 to 4.0 mg/L with an anomously high value of 28.40 mg/L in late December 1998. The manganese concentrations (figure 11.2) had a flat, or very slightly rising trend, averaging between 0.3 and 0.4 mg/L with an anomously high value of 3.90 mg/L also in the late December 1998 sampling. The sulfate values rose after ash placement (figure 11.3) from an average of 25 up to 40 mg/L. All of the sulfate values are well below the PA MCL (DWS) standard of 250 mg/L and do not reflect badly degraded water.

Figure 11.1 16910104 MW-1 Sandy Hollow Iron

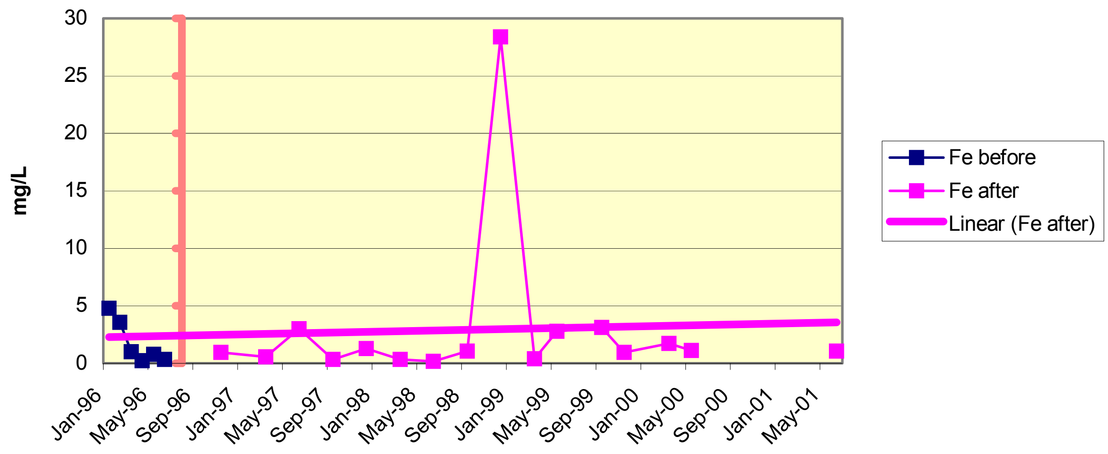
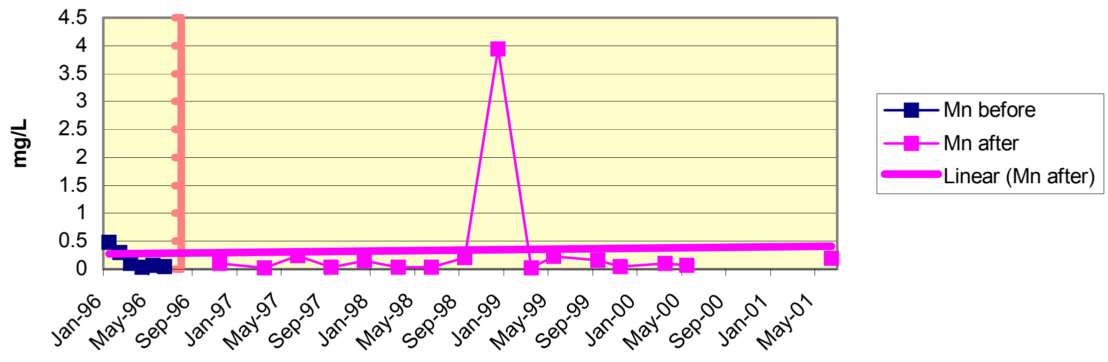
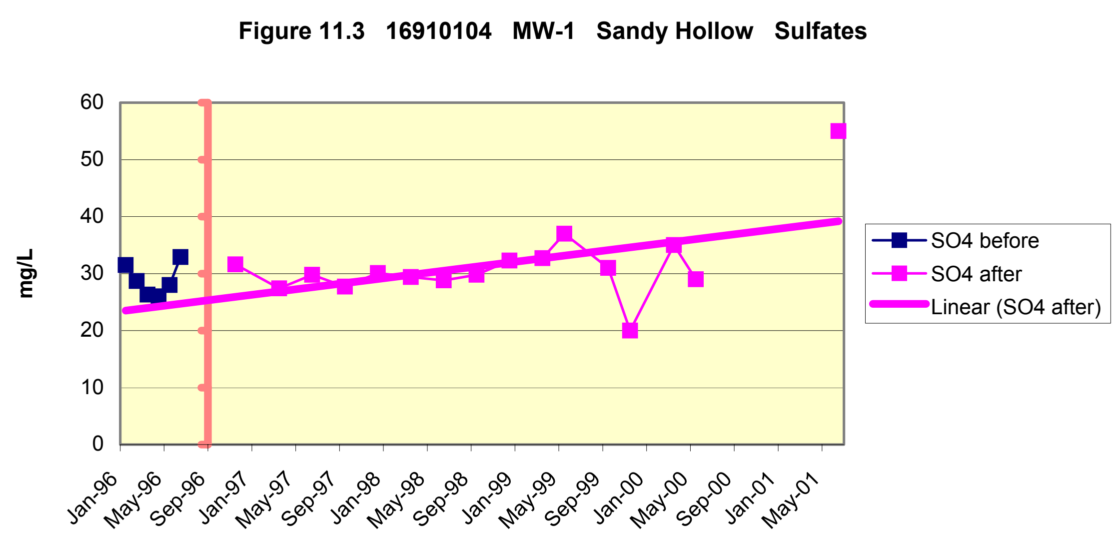


Figure 11.2 16910104 MW-1 Sandy Hollow Manganese





The pH rose slightly after ash placement and then fell toward the end of the monitoring period (figure 11.4). Field pH values are used in this report, as they more accurately reflect field conditions, even though the instrumentation that generates field pH values can be slightly less accurate than laboratory pH measurements. At MW-1, the field pH and the laboratory pH have similar overall trends, and there is usually not more than 0.2 pH units difference between the two. The average trend is downward from baseline values, but levels fluctuated greatly from 6.4 s.u. in May 1999 to 7.8 s.u. in September 1999 (above all baseline values) before falling to 6.0 s.u. in March 2000. This indicates a temporary neutralizing of AMD from some source of alkalinity. The alkalinity could have been coming from the coal ash through an unknown groundwater pathway to this upgradient monitoring point, from placement of ash very close to the monitoring point, or from calcium sources in the surrounding rock and spoil activated by the mining.

The TDS (figure 11.5) fell during ash placement below levels measured in the baseline monitoring period. Even though the sulfate concentrations were rising at MW-1 (figure 11.3), the values of the remaining dissolved material were falling, except for a large spike to 877 mg/L in June, 2001 at the end of the monitoring period.

Figure 11.4 16910104 MW-1 Sandy Hollow pH

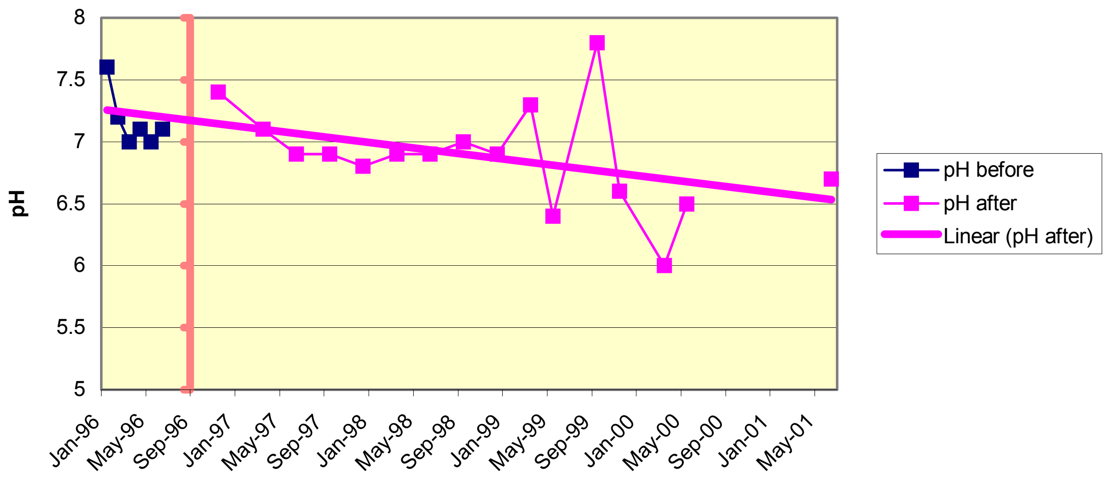


Figure 11.5 16910104 MW-1 Sandy Hollow TDS

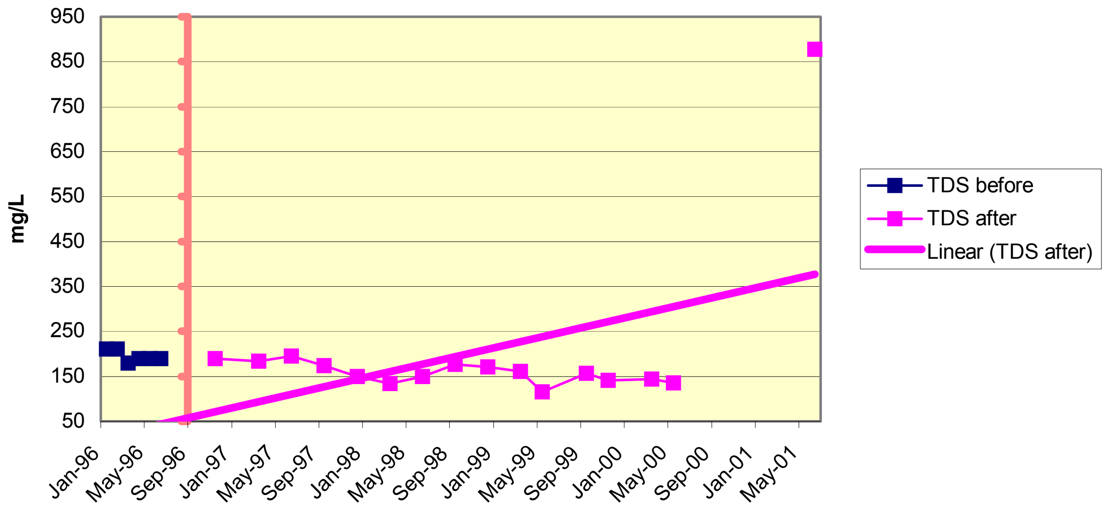
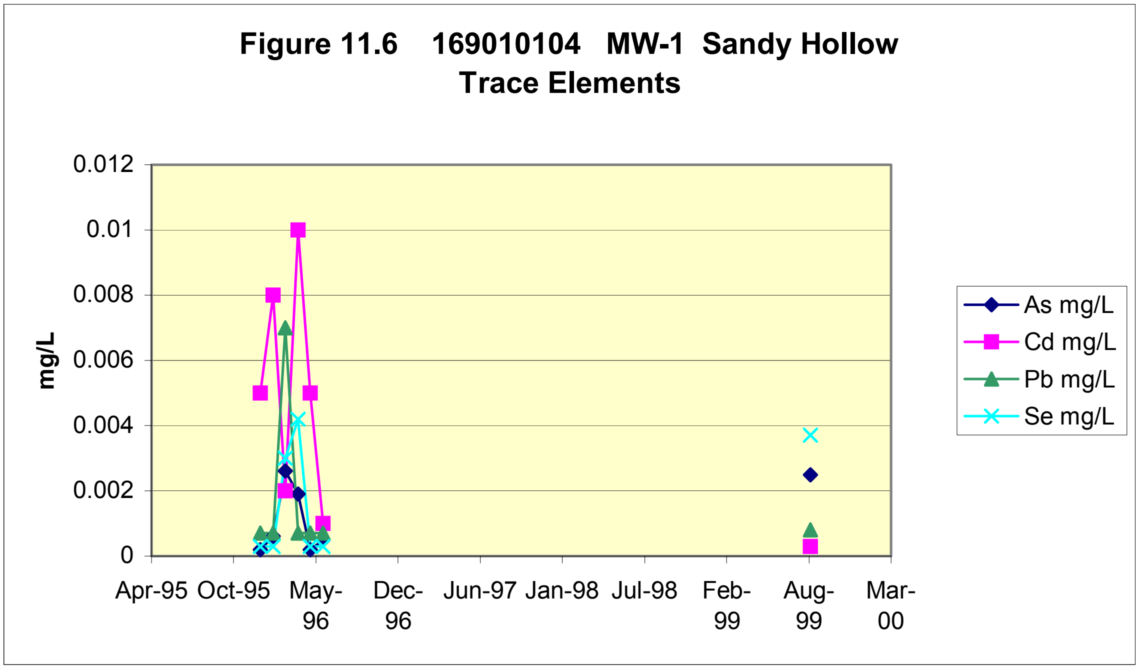


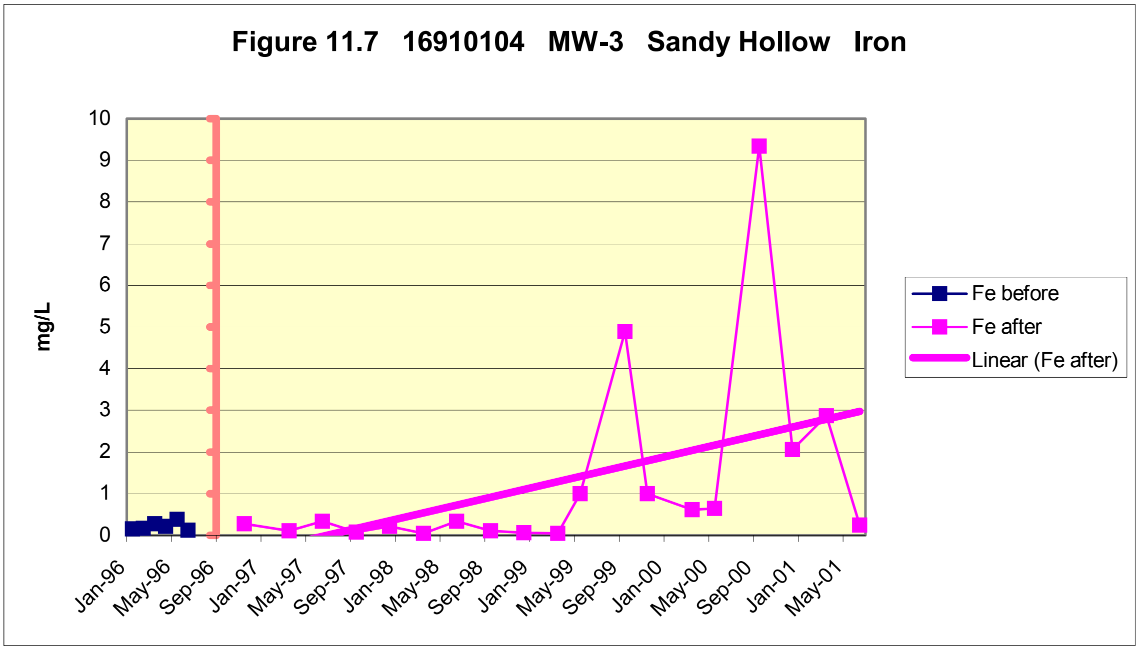
Figure 11.6 shows a plot of dissolved concentrations for four trace elements at MW-1 revealing that only one measurement from September 1999 could be found in the monitoring reports during the entire mining and ash placement period. Four of the six cadmium concentrations in the baseline period equaled or exceeded the DWS with the highest being twice the DWS, 0.01 mg/L in April 1996 while the cadmium measured in September 1999 was less than a tenth the DWS. There was a high concentration of total arsenic (0.023 mg/L) in the first sampling of the baseline period (Jan. 1996) but dissolved arsenic values stayed well below the DWS in baseline measurements, and the September 1999 measurement was below the limit of detection at <0.0025 mg/L for both total and

dissolved arsenic. Most lead and selenium measurements were below the limit of detection in the analyses and all levels were well below the DWS. Only one measurement during the ash placement period at this upgradient monitoring point greatly hinders a meaningful assessment of impacts from ash by eliminating the ability to compare downgradient concentrations of trace elements that could be coming from ash to upgradient concentrations that would not be.



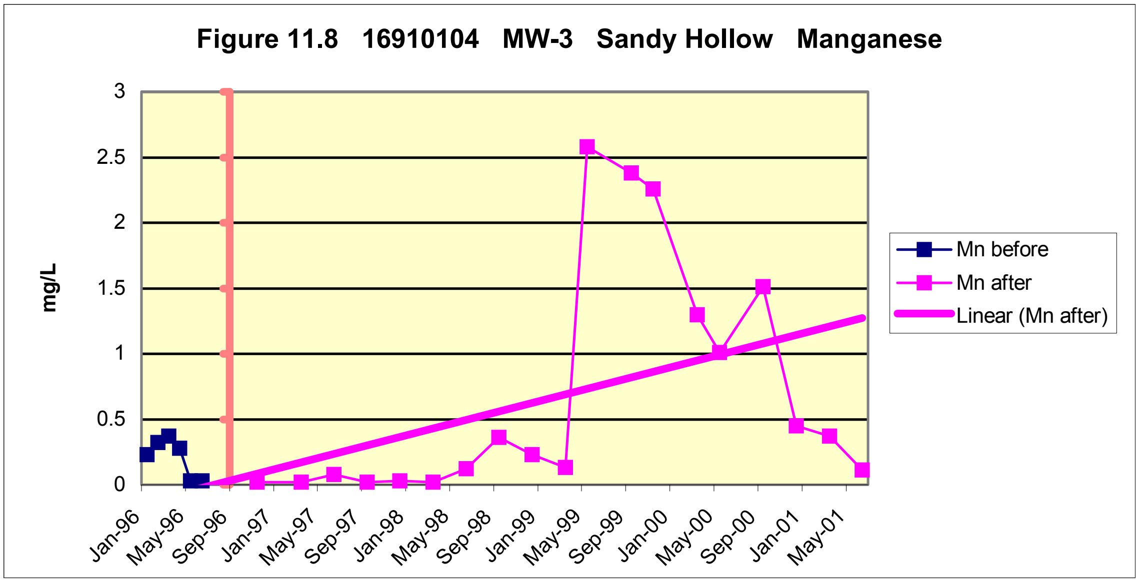
MW-3

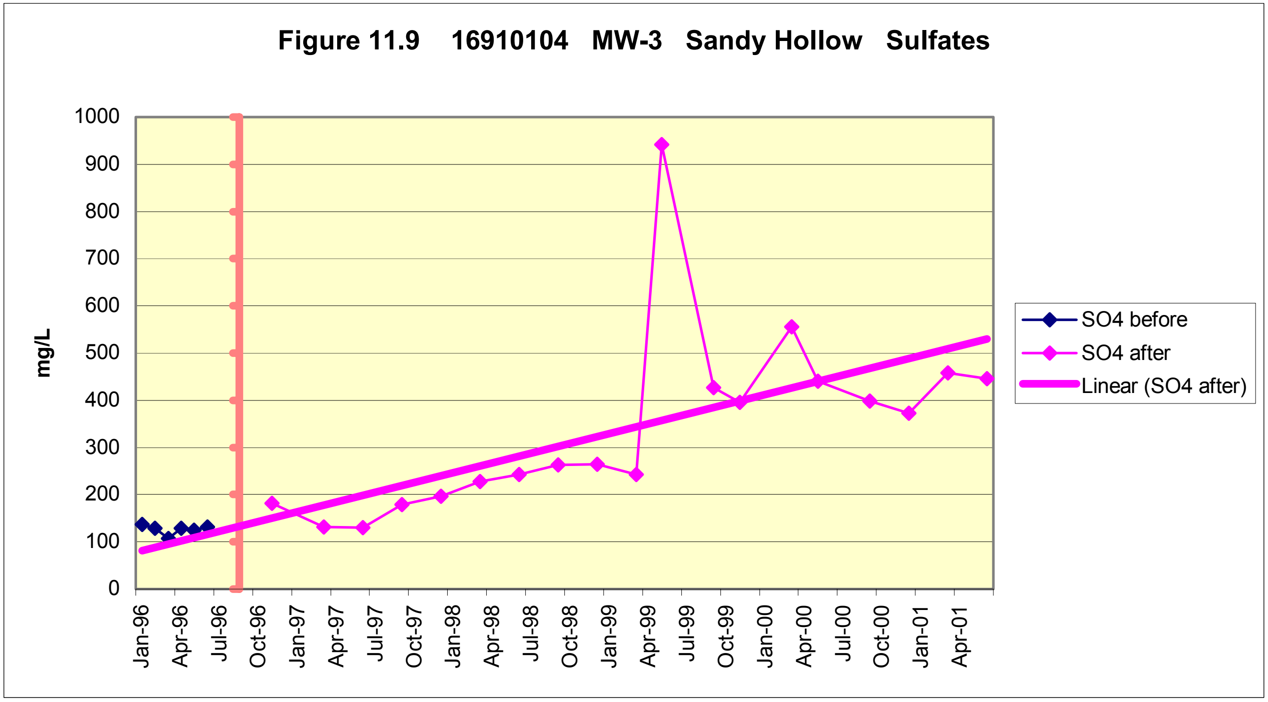
The downgradient monitoring well, MW-3, showed an increasing concentration of iron with time suggesting some mobilization from the ash and/or the disturbance of material during mining operations (figure 11.7). These iron values were slightly higher than those at MW-1, with average concentrations about 3.0 mg/L at the end of monitoring. Unlike MW-1, however, the highest iron values occurred after mining and ash placement at MW-3, although the concentrations did not rise above baseline values until the spring of 1999. The upward trend in those values was somewhat steeper than the trend at MW-1, however. The result shows more apparent degradation at MW-3 as iron rose from concentrations roughly equal to or below the DWS during baseline monitoring to levels as high as 9.34 mg/L, 31 times the DWS, in September 2000, before declining ultimately to baseline levels in the last data collected in June 2001.



Manganese concentrations (figure 11.8) had a trend similar to iron. Subsequent to the beginning of mining and ash placement, manganese levels remained at or below the DWS and baseline concentrations for a year and a half before starting to rise in June 1998. Levels increased sharply to 2.58 mg/L in May 1999, 7 times the highest baseline concentration (0.37 mg/L) and 52 times the DWS (0.050 mg/L). For the next two and a half years, manganese remained above 1.00 mg/L before dropping down to baseline levels in the last six months of monitoring.

The sulfate trend at MW-3 was upward and similar to the sulfate trend at MW-1, but with concentrations that were 10 times higher (figure 11.9). Degradation of groundwater was occurring at MW-3 as sulfates rose from baseline levels around half the DWS in 1996 to levels substantially exceeding the standard from March 1999 to the end of monitoring in June 2001. This was unlike the degradation from manganese and iron whose concentrations declined to baseline levels in the last six months of monitoring.





The data shows a spike in sulfate that occurred simultaneously with the jump in the manganese concentration at MW-3 in May 1999, when the sulfate level reached 942 mg/L, nearly 4 times the DWS. This "spike" in sulfate and manganese was measured during a period of sustained, declining flow at the site and thus did not appear to have resulted from heavy precipitation. A major site disturbance or input from ash leachate could have caused this rise.

The trend of pH at MW-3 decreased from an average of 6.8 units to about 5.8 units (figure 11.10). Alkaline buffering from ash placement was not visible through any overall rising pH trend during ash placement although there was a rise of 1.2 to 1.8 units in pH values in the last four measurements at MW-3 .

TDS rose at MW-3 (figure 11.11), in contrast to their declining trend at MW-1, and followed a concentration pattern very similar to the pattern for sulfates, inferring that sulfates are the major contributors to TDS at MW-3. TDS levels rose from around 400 mg/L, below the DWS (500 mg/L), during baseline monitoring and the first two years of ash placement to 1377 mg/L in May 1999 and then remained above 600 mg/L until the end of monitoring, reflecting the spike in sulfate and higher levels of sulfate that persisted through the end of monitoring.

Figure 11.10 16910104 MW-3 Sandy Hollow pH

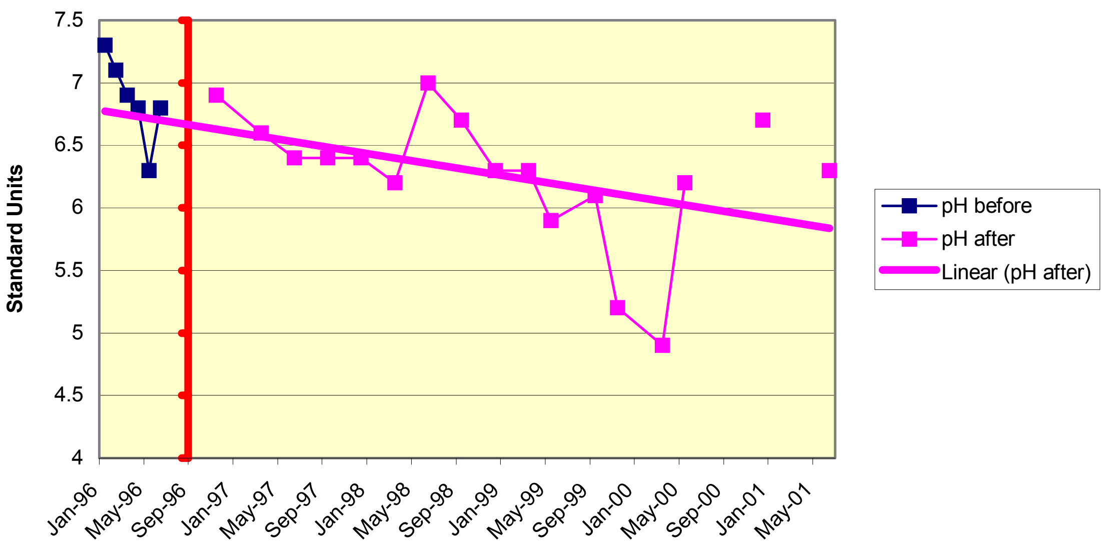
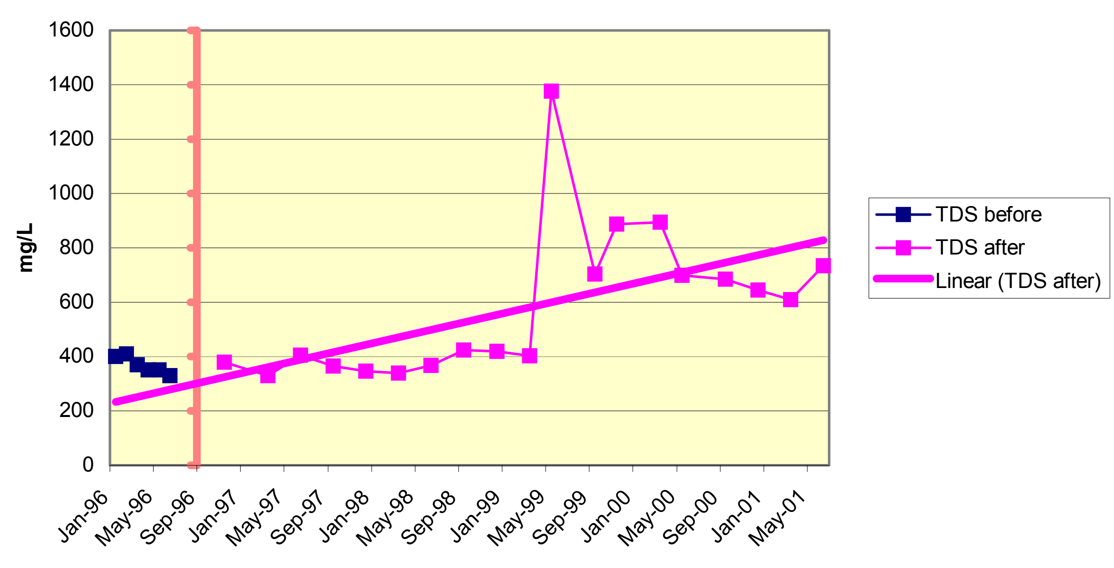


Figure 11.11 16910104 MW-3 Sandy Hollow TDS



Calcium and magnesium (unplotted) both rise after ash placement at MW-3 although the scant amount of data collected for these constituents that are good signatures of the alkalinity from FBC ashes prevents a more clear picture from emerging that would implicate the ash in the rises of sulfate and manganese occurring at the same time. The data set has only 1996 baseline values, and concentrations from one sampling in 1999, and another in 2001. Nonetheless, the baseline concentrations for calcium (dissolved values) at MW-3 average 50.41 mg/L compared to 114.14 mg/L in September 1999, and 128 mg/L in September 2001 at MW-3. Magnesium has similar behavior, with a baseline average value of 11.57 mg/L at MW-3, increasing to measured concentrations of 30.56 mg/L in September 1999, and 32.58 mg/L in September 2001. Large increases in these elements in the absence of major limestone deposits would suggest contamination of groundwater from ash placement.

On the other hand concentrations of chloride and sodium which are also often seen as ash indicator parameters are plotted in figure 11.11A and their trends at MW-3 do not corroborate what the higher calcium and magnesium concentrations might suggest. The chloride concentrations stay below baseline values, even though they increase slightly over the monitoring period. Sodium values stay in the general baseline range after ash placement, and then decrease over time. *If* chloride and sodium are ash indicator parameters at MW-3, then ash placement has had little effect on groundwater.

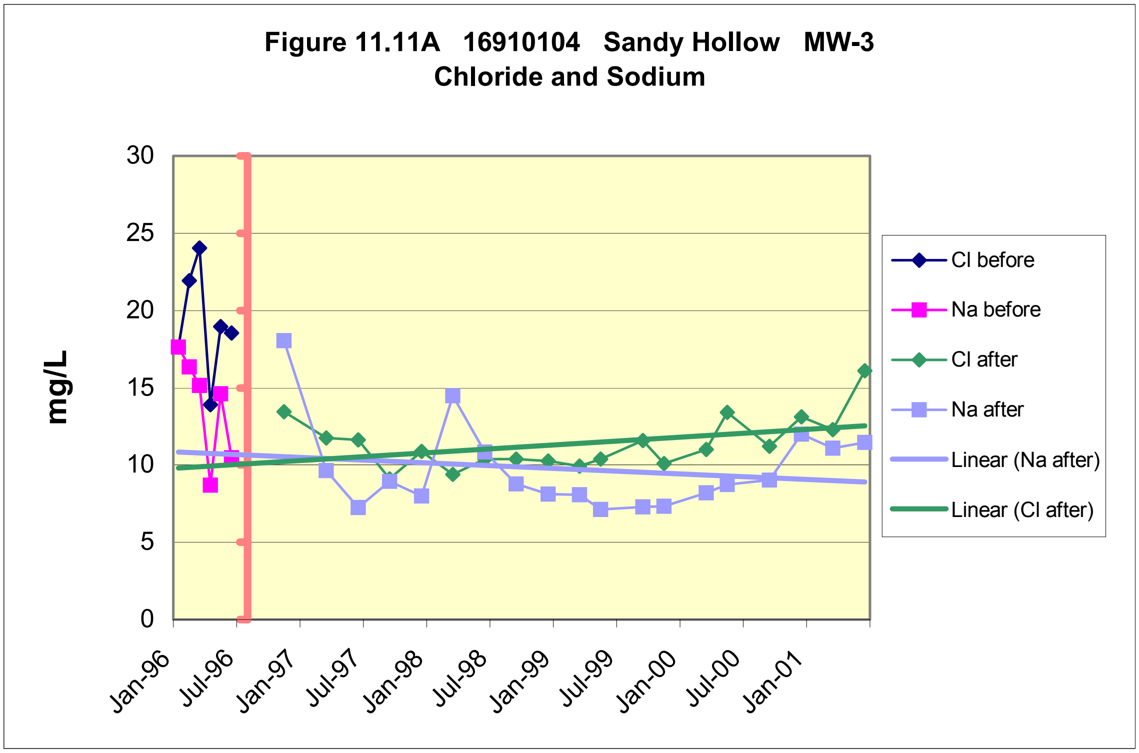
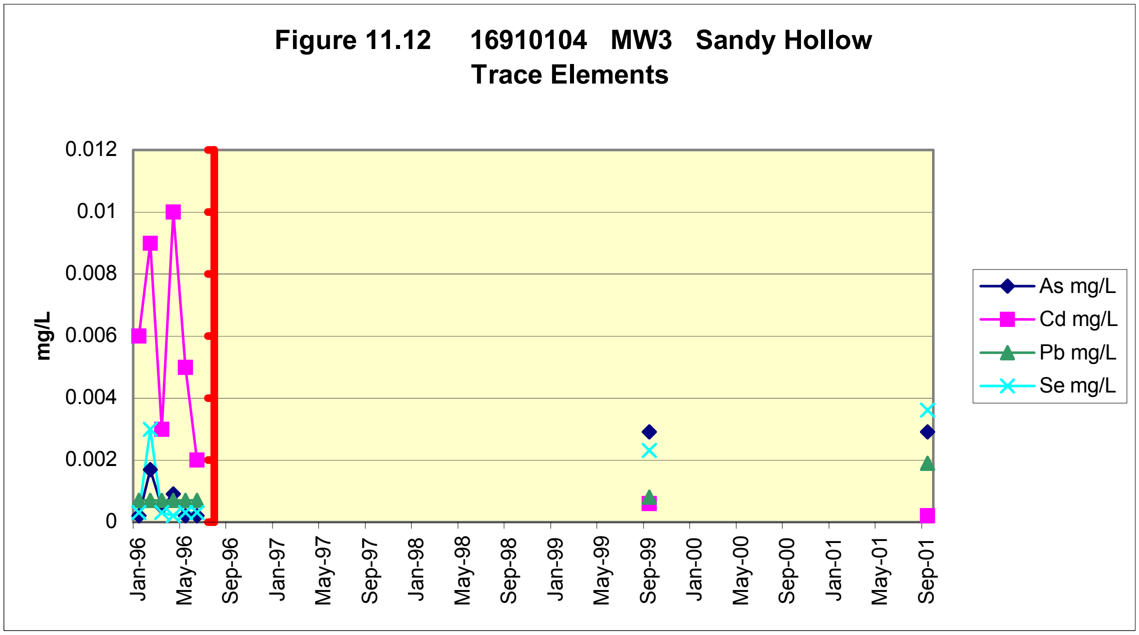


Figure 11.11A 16910104 Sandy Hollow MW-3
Chloride and Sodium

Figure 11.12 shows the MW-3 trace element concentrations for selenium, lead, cadmium, and arsenic. As is the case for calcium and magnesium, the monitoring reports contain trace element data for only the six-month baseline monitoring period in 1996 and two samplings in September 1999 and September 2001. Dissolved values are usually below detection limits of analyses, except for cadmium concentrations which are above detection limits during the baseline period and equal to or above the DWS in 4 of the 6 baseline samplings. The highest arsenic measurement occurs during mining and ash placement in September 1999 at 0.0029 mg/L. Lead and selenium concentrations are below detection limits in all measurements except for one of selenium during the baseline period, but this measurement (0.0030 mg/L in February 1996) and all detection limit values for these trace elements are well below the DWS.

Very little data for the period in which ash was placed could be found in the permit file. Monitoring reports indicate there was insufficient water to sample at MW-3 for the September 2000 sampling for annual ash parameters.

Given that PADEP apparently did not require that sampling results be submitted in monitoring reports for trace elements between 1996 and September 1999 or that any monitoring results be recorded for trace elements after the September 2001 sampling, it is not possible to determine the ash's effect on trace element concentrations in downgradient waters.



Subchapter F Point 119

The major element concentrations (iron, manganese, and aluminum) are graphed in figure 11.13 at Subchapter F Point 119, the previously described seep that drains part of the southwestern portion of the site. Data for elemental concentration and load monitoring were available from February 1999, until May 2001. Data for alkalinity extends from April 1994 to December 2003.

The trend for iron concentrations dropped, and average manganese concentrations were static with a horizontal trendline. The average values were between 1.0 mg/L and 2.0 mg/L for both of these elements. The aluminum had a flat average trend at 5.0 mg/L. There is fairly close correlation between rising and falling concentrations of these constituents (iron, aluminum, and manganese) suggesting a seasonal influence on their concentrations. The sulfate values at Point 119 were lower than those at MW-3 and showed a slightly falling trend (figure 11.14). The acidity trend was the opposite of sulfates (figure 11.15) and was rising. The pH was dropping (figure 11.16) in agreement with the rising acidity.

Alkalinity data was found for Point 119 starting in April 1994 and extending to December 2003, and sampled on a monthly basis (figure 11.15A). Much of the data was zero, or below the detection capability of the analyses. There are also many data gaps, further complicating interpretation. The trendline shows a slowly falling alkalinity at Point 119, and the highest concentrations in a “spike” to 66 mg/L in October 1999 and 92 mg/L in November 1999. This is the same period in which the highest values were recorded for pH at Point 119 (4.4-4.6 units). None of the concentration data sets for other parameters at this monitoring point included any data for the pre-ash baseline monitoring period or the first two and a half years of ash placement. While the distance and hydrologic connection between this subchapter F Point and ash at the site is not clear, the water quality appears to be neither improving nor deteriorating to any significant degree for these parameters in surface waters at this point.

Figure 11.13 16910104 Point 119 Sandy Hollow Major Elements

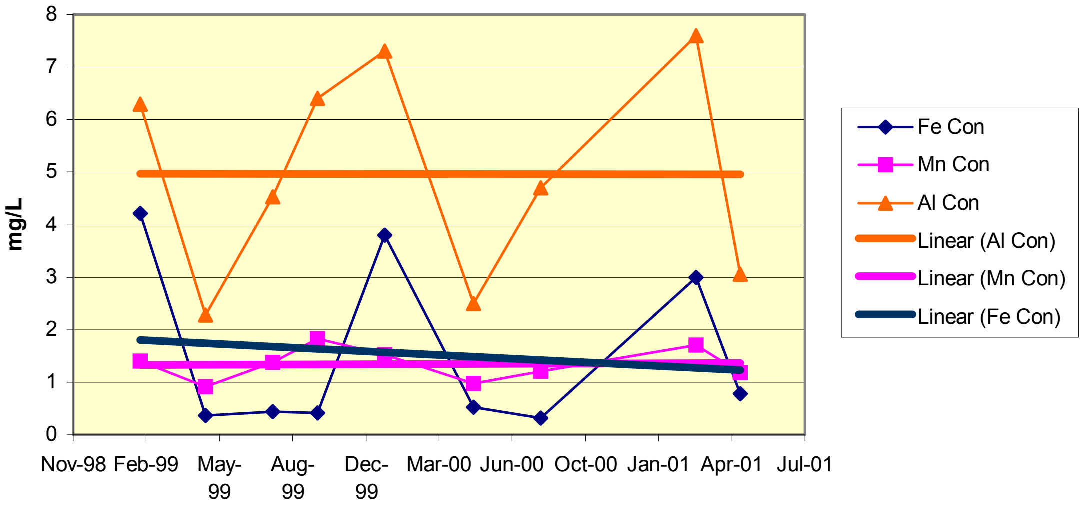
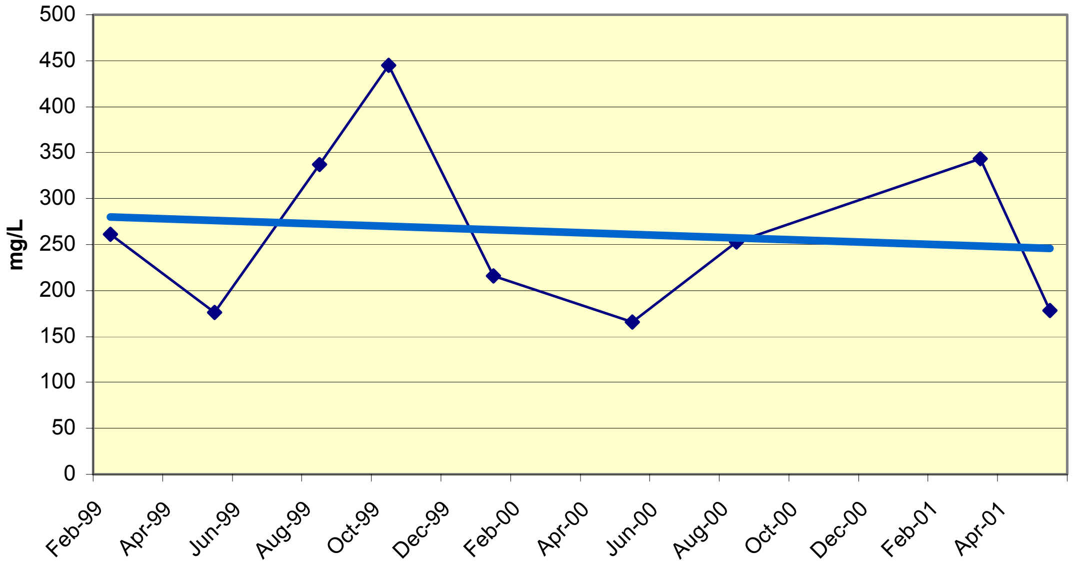


Figure 11.14 16910104 Point 119 Sandy Hollow Sulfates



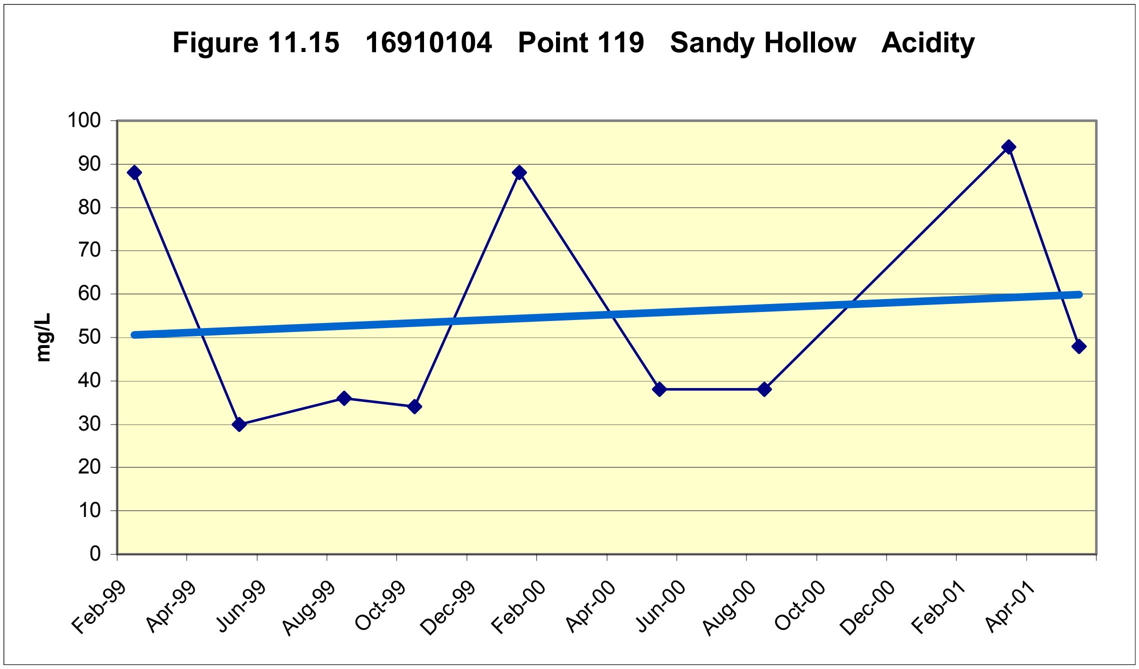


Figure 11.15 16910104 Point 119 Sandy Hollow Acidity
mg/L
0
10
20
30
40
50
60
70
80
90
100
Feb-99
Apr-99
Jun-99
Aug-99
Oct-99
Dec-99
Feb-00
Apr-00
Jun-00
Aug-00
Oct-00
Dec-00
Feb-01
Apr-01

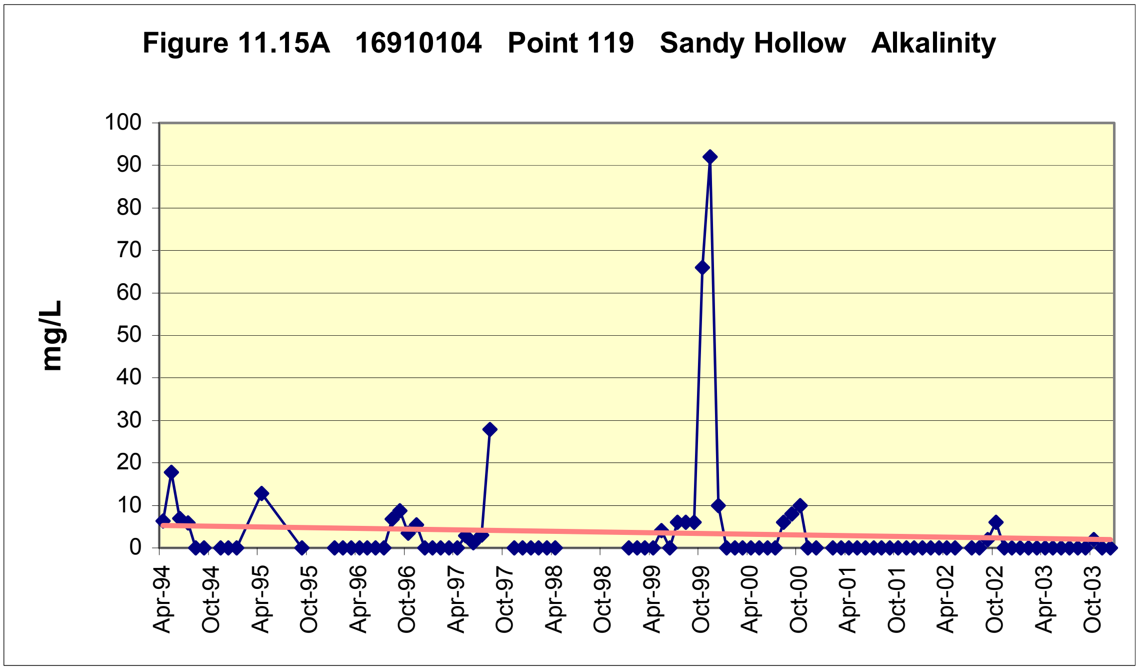


Figure 11.15A 16910104 Point 119 Sandy Hollow Alkalinity
mg/L
0
10
20
30
40
50
60
70
80
90
100
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
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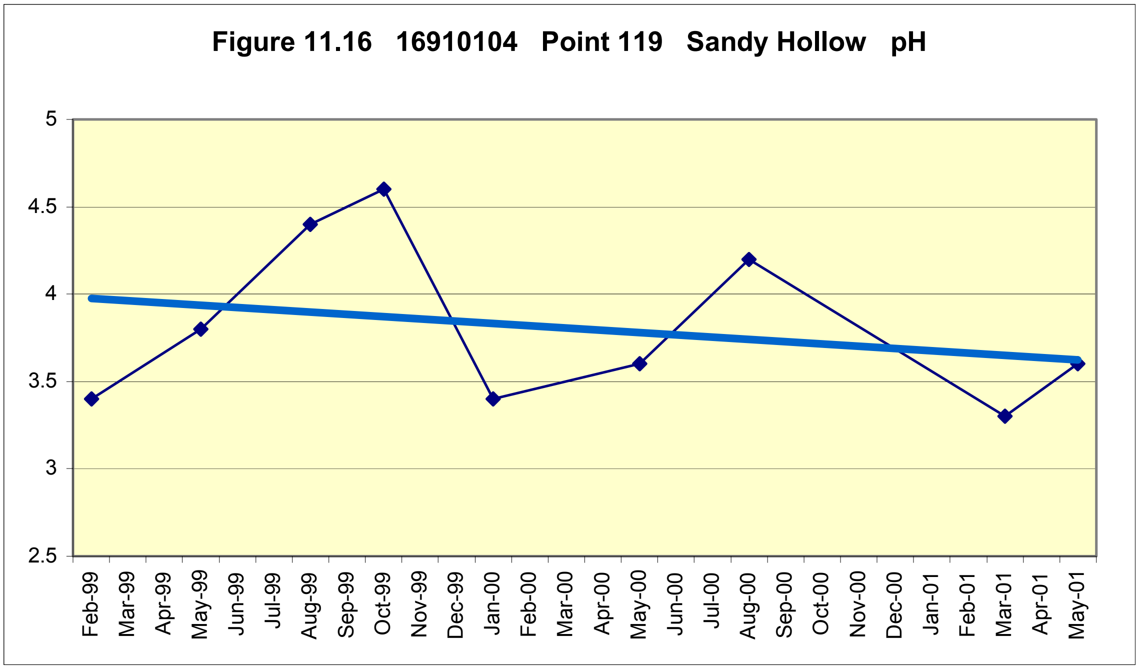
Oct-03



Subchapter F Point 119 – Loading

Figure 11.17 is a graph of flow volume from Point 119. Figure 11.18 is a graph of loading values for iron, manganese, and aluminum at Point 119. The range of loads was greatest for aluminum, followed by iron and then manganese, but all three elements had downward average trend lines, indicating less flow, lower concentrations, or a combination of these occurring at Point 119. The major variant appeared to be seasonal flow with concentration having a secondary effect. Figure 11.19 graphs both sulfate concentration and loading; both average trends fell, and there was an inverse relationship between the two, i.e. the load increasing while the concentration was declining, until August 2000 when their trends became parallel. This relationship therefore is probably controlled by precipitation amounts that have seasonal variation. Given many samples were apparently assessed for acidity with flow alone at Point 119, the acidity loading data (figure 11.20) have more data points than the sulfate, iron, manganese, and aluminum data. The acidity data was recorded monthly, but all data from year 2000 were missing from the permit file. The overall average trend was flat, and the variations were controlled more by seasonal water flow rates than changing acidity concentrations, i.e., loads were higher generally when flow was higher.

Figure 11.17 16910104 Sub F Point 119 TDK Sandy Hollow Flow

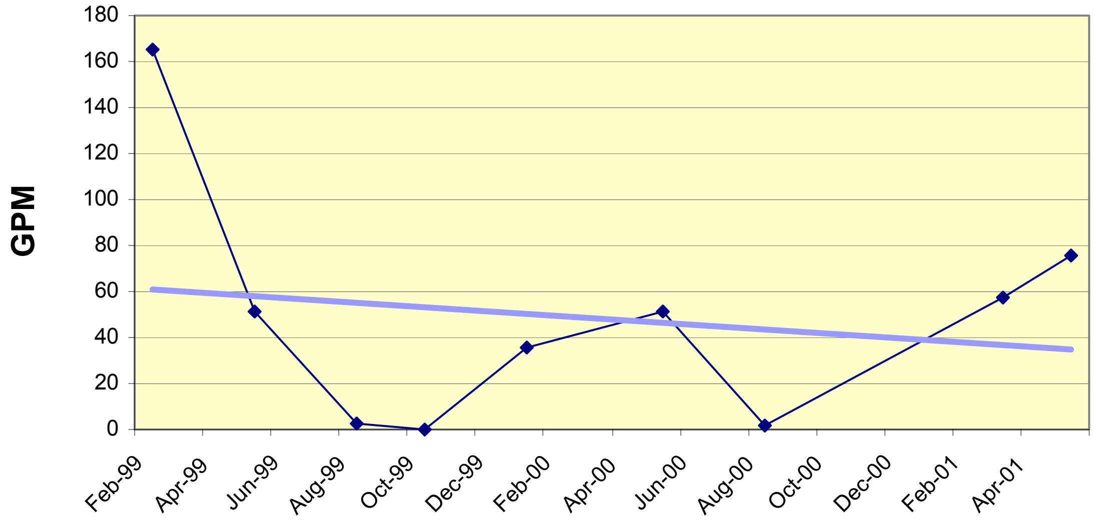


Figure 11.18 16910104 Sub F Point 119 TDK Sandy Hollow Iron, Manganese, and Aluminum Loading

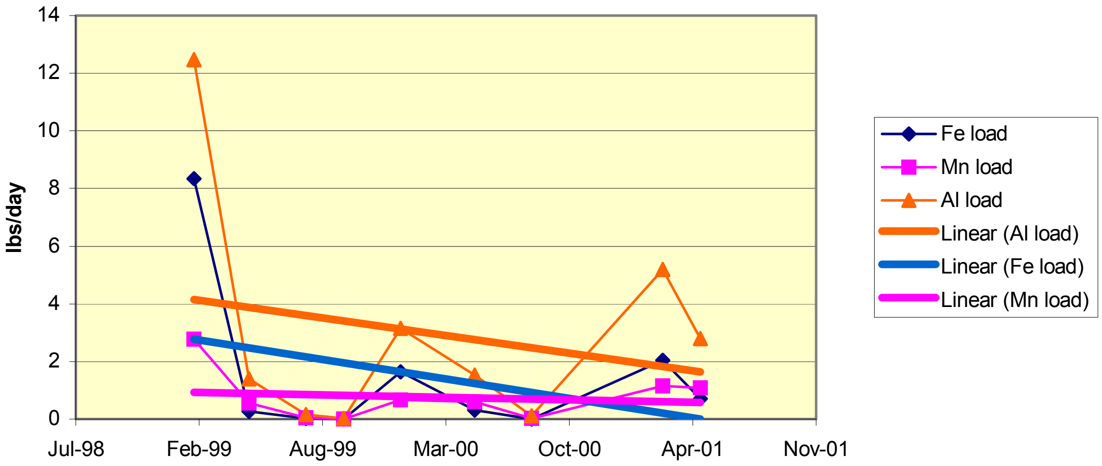


Figure 11.19 16910104 Sub F Point 119 TDK Sandy Hollow
Sulfate Loading (lbs./day) and Concentrations (mg/L)

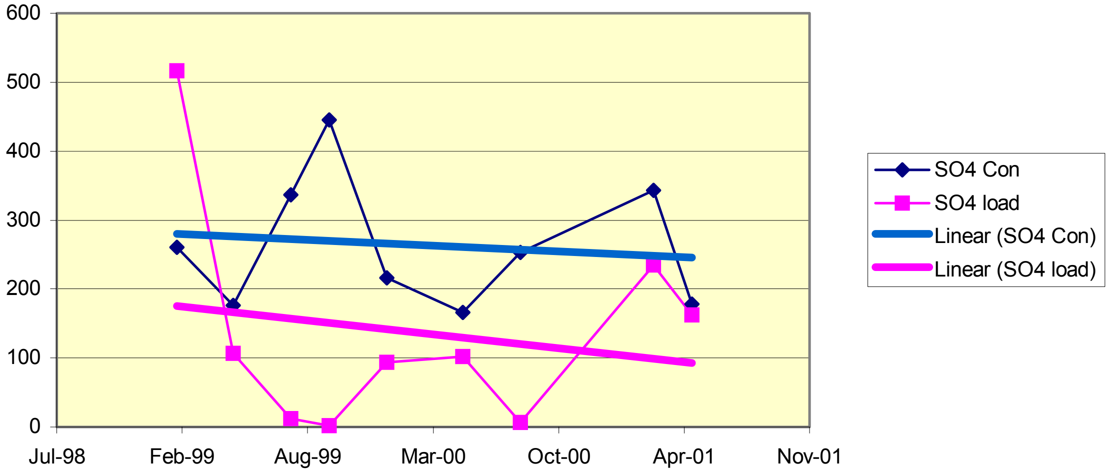
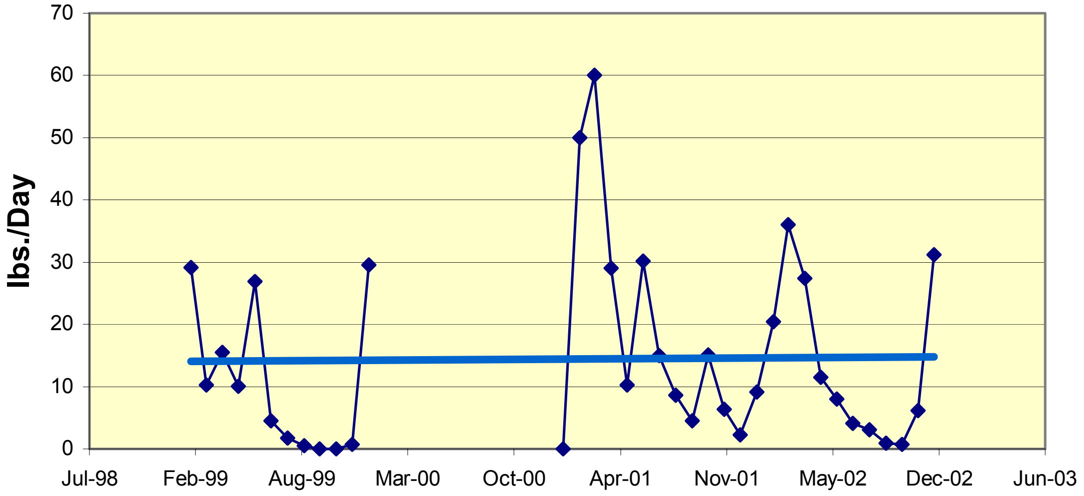


Figure 11.20 16910104 Sub F Point 119 TDK Sandy Hollow
Acidity Loading



Conclusion

The flat trends associated with MW-1 versus the general rise in contaminants at MW-3 show a definite degradation of groundwater at the Sandy Hollow Mine downgradient of the mining and ash placement operations. Groundwater was degraded to levels substantially above baseline concentrations and several to many times over secondary drinking water standards for iron, manganese, sulfates, and TDS. Concentrations of manganese, sulfates and TDS rose sharply in the spring of 1999 at downgradient MW-3 when flows were declining precipitously at Subchapter F Monitoring Point 119 in the southwest quadrant of the mine where MW-3 is located. However, it is difficult to determine the degree to which ash placement or AMD from mining activity is contributing to this increasing degradation with the information at hand. Loading data suggests the amount of material leaving the Sandy Hollow site in surface waters during most of the monitoring period has been controlled more by the volume of water flow than by concentration trends.

The source of groundwater contamination could be better pinpointed if more than one or two samplings for trace elements and other ash parameters such as calcium and magnesium had been reported in permit monitoring reports during and after the ash placement period. Rechecking of monitoring reports reveals slightly more data for these parameters from three samplings at MW-2 and MW-4, although three samplings over five years is still too deficient to identify trends definitively. Monitoring for certain trace elements such as boron, molybdenum, and antimony, known to be markers for ashes generated from Pennsylvania coals and waste coals and which are analyzed in PADEP's permit leach tests, would have also enhanced the understanding of the contribution ash may be making to the water quality degradation. As at other sites in this report, a post-ash placement monitoring program that analyzes for ash-specific parameters including boron, molybdenum and antimony at appropriate (at least quarterly) frequencies and at adequate upgradient and downgradient locations as well as in the ash itself would explain some of these earlier trends and show which constituents in the ash and mine materials are stable or mobile over a longer period of time than the five years for which monitoring data was collected from ash monitoring points. The volume of ash placed along with the degradation seen at MW-3 appear to warrant such expansion of the monitoring at this site.

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Permit Review 12

C & K COAL COMPANY (PERMIT # 16703006)

Site Summary

The C & K Coal Company mine is located in Perry Township, Clarion County Pennsylvania in the Redbank Creek Priority Watershed 17C. This mine covers approximately 1200 acres, with 135 acres devoted to ash placement. The coal seams (Lower Kittanning and Middle Kittanning) were contour-mined around the hillsides, following the contours at the base of the Lower Kittanning and Lower Clarion Coal, which was also mined in parts of this site under an earlier permit. About 200,000 tons of FBC and conventional coal ash were placed as mining operations proceeded at the site, and an additional small amount of ash was used as a soil amendment.

According to permit materials and PADEP Knox District Mining staff (from phone discussions on September 30 and October 13, 2005), the ash came from six generators, two of which were FBC plants and four were conventional pulverized coal plants. A breakdown of actual quantities sent by each source could not be obtained from the permit files and was not known by PADEP staff. Nonetheless, the FBC generators, Piney Power Plant in Clarion County, Pennsylvania and United Development Corporation's Power Plant in Niagara Falls, New York, reportedly sent the largest quantities of ash. The four conventional sources were the Carlson Generating Station in Jamestown, New York, Petrowax Plant in Emlenton, Pennsylvania, Witco Corporation's Plant in Bradford, Pennsylvania and Niagara Mohawk Power Plant in Dunkirk New York. The Carlson Plant's ash is acidic and its pH was adjusted with lime before being sent to the site.

Ash placement operations commenced in May 1995 and were completed by early 1999. The sited "beneficial purpose" for putting ash at the site was "placement." The ash was dumped on pods roughly the size of football fields, mixed with small amounts of coal refuse (approximately one third of a truckload of coal refuse to 20 truckloads of ash) and covered with mine spoil. There was a small amount of CCW, roughly 2500 to 3000 tons, then applied as a soil amendment over the ash placement area (reportedly in addition to the 200,000 tons "placed" under the reclaimed surface).

Coal refuse was also placed elsewhere in the permit area. The authors, however, were unable to determine the amount of coal refuse or the location of its placement from permit information or discussions with PADEP staff.

Geology

The Lower and Middle Kittanning coals and Lower and Upper Clarion coals occur in the middle portion of the Pennsylvanian Period of geological time. The sedimentary bed structural attitude is nearly flat lying, with a very gentle dip to the south, formed by the original depositional basin geometry.

Topography

The topography of the site is typical for the Pittsburgh Plateau province in Pennsylvania; steep valleys, with relatively flat-topped hills that represent the old plateau surface before uplift and erosion. The surface water drainage is in a radial pattern, with small streams running off the site in many different directions due to the mine's location near the tops of the hills where the coal outcrops (see map below). Most of the surface water flows from the site via an unnamed tributary to the Clarion River.

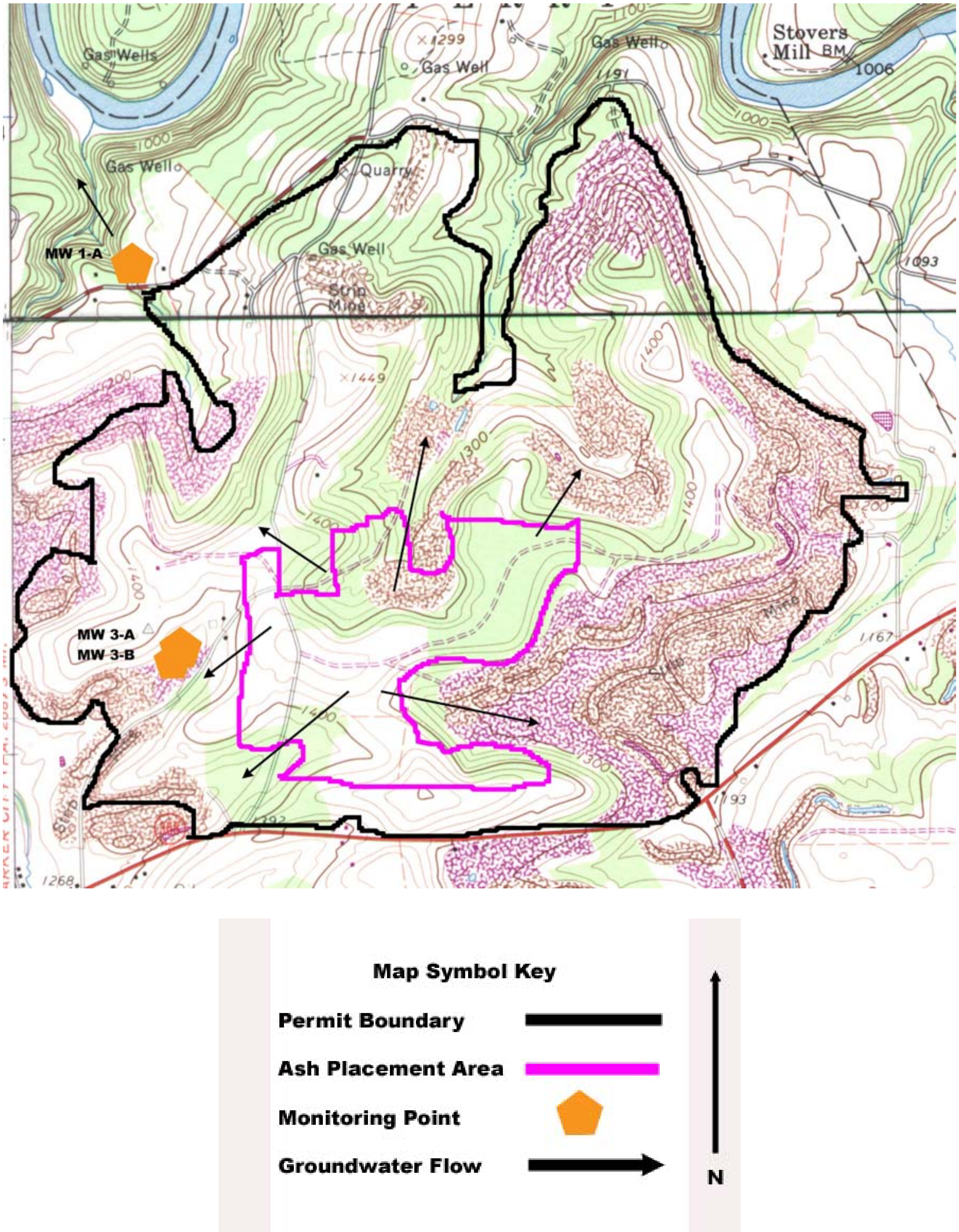
Groundwater

Groundwater flow follows topography closely, except where the land has been disturbed by mining. In the mined areas, groundwater tends to run through the mine waste and spoils, (due to higher secondary porosity) down to the level of the Lower Clarion Coal and exit at this elevation on the downgradient side of the hill in question.

Groundwater monitoring data: Discussion

Eight ash groundwater monitoring wells were installed at the C & K Coal Company site; four of them sampled water down to the Vanport Limestone (below the Lower Kittanning Coal) and the other four stopped at the bottom of the Lower Kittanning Coal. MW-1A (an upgradient well) and MW-3A and MW-3B (both downgradient wells) were selected for analysis; MW-1A and MW-3A well bottoms stop at the base of the Lower Kittanning Coal horizon. MW-3B was drilled deeper down to the Vanport Limestone.

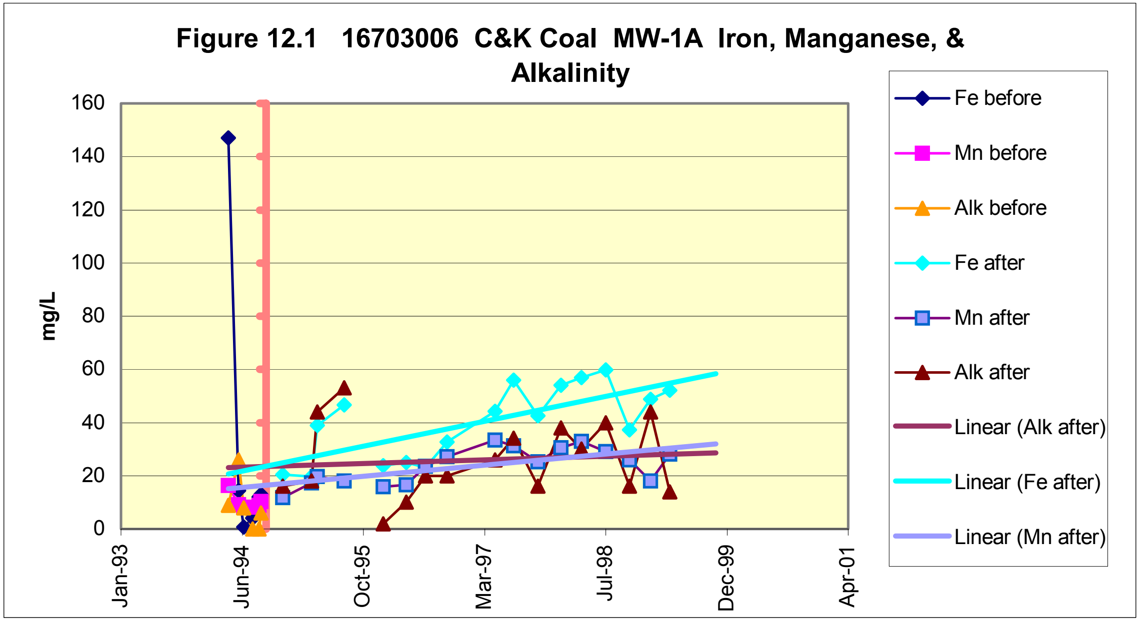
Site Map: CK Coal



C & K Coal Company (Permit # 16703006)
Scale: 1" = Approximately 2000'

MW-1A

While PADEP Knox Mining Office staff believe that MW-1A may not be entirely upgradient from the ash placement area from the standpoint of the elevation of the groundwater it is monitoring, they assert that this monitoring point is far enough away from the ash to not be affected by ash impacted drainages. It average static water elevation in 14 measurements from April 1994 through July 1996 was 12.8 feet above the static water elevation of MW-3A in that period. Despite this difference and the fact MW-1A is approximately 4000 feet away from the ash placement area, the data from this well appears to show some effects of mining and ash placement. The concentration trends for major elements iron, manganese and sulfates at MW-1A are graphed in figures 12.1 and 12.2. The baseline monitoring period in these graphs concludes in the fall of 1994. Ash placement did not commence for at least six more months, until May 1995. The data gap for October 1995 reflects a dry hole with no data; this is seen in all the graphs for all wells in this report. There is a general increase in iron, manganese, and sulfate concentrations at MW-1A. Notwithstanding a high peak in the first baseline sample, iron averaged about 12 mg/L during baseline monitoring, which is 40 times the drinking water standard (DWS which is the PA MCL and federal secondary MCL of 0.3 mg/L). After mining and ash placement started, the iron increased to a high of 60 mg/L, 200 times the DWS. Manganese averaged about 11 mg/L during the baseline monitoring, which is 220 times the DWS of 0.05 mg/L, before rising to average levels almost three times this high during mining and ash placement. Alkalinity is also plotted on figure 12.1 and has a gradual upward trend.



The sulfate and TDS concentrations are shown in figure 12.2. Baseline sulfate levels averaged 500 mg/L, twice the DWS of 250 mg/L. After mining and ash placement began, sulfates rose to a high of about 1200 mg/L, 4.8 times the DWS. The TDS trends are very similar to those of sulfate, and sulfate comprises more than half the TDS.

Figure 12.3 shows that chloride rose from baseline values to an anomalous high of 71.9 mg/L, an order of magnitude above all previous concentrations in April 1997, and then dropped sharply to levels below baseline numbers in 1998.

Figure 12.4a plots the field pH values for MW-1A. Field pH data is used in this report, as best characterizing natural groundwater. The pH has an average drop over time from around 6.0 to 5.0 units, with the highest values during the baseline monitoring period. From 1997 to 1999, the pH rose slightly. The acidity trends are graphed in figure 12.4b for MW-1A. After an initial drop, the values for acidity increased to a high of 180 mg/L in July 1997, surpassing the highest acidity measured during the baseline period of 161 mg/L and then leveled off at between 100 and 120 mg/L after mid-1997. Aside from a steep drop (a possible outlier) to 0 mg/L in January 1999, the pattern of the acidity trend is roughly similar to the sulfate trend.

Figure 12.5 shows the concentration of calcium and magnesium over time; both increased markedly after baseline monitoring, and after mid 1997, dropped in value although remaining well above baseline concentrations.

Figure 12.2 16703006 C&K Coal MW-1A Sulfates & TDS

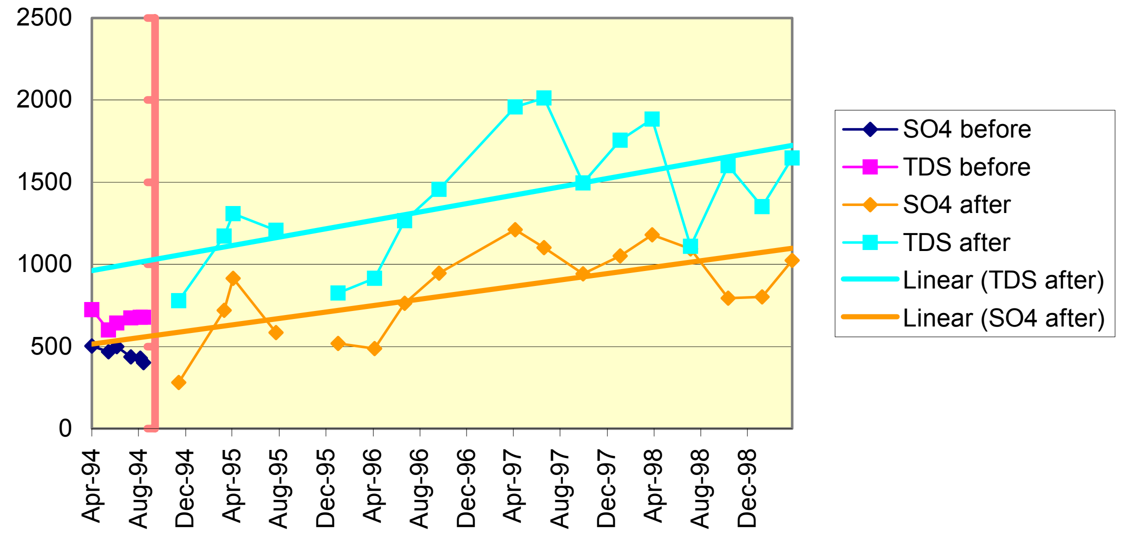


Figure 12.3 16703006 C&K Coal MW-1A pH & Chloride

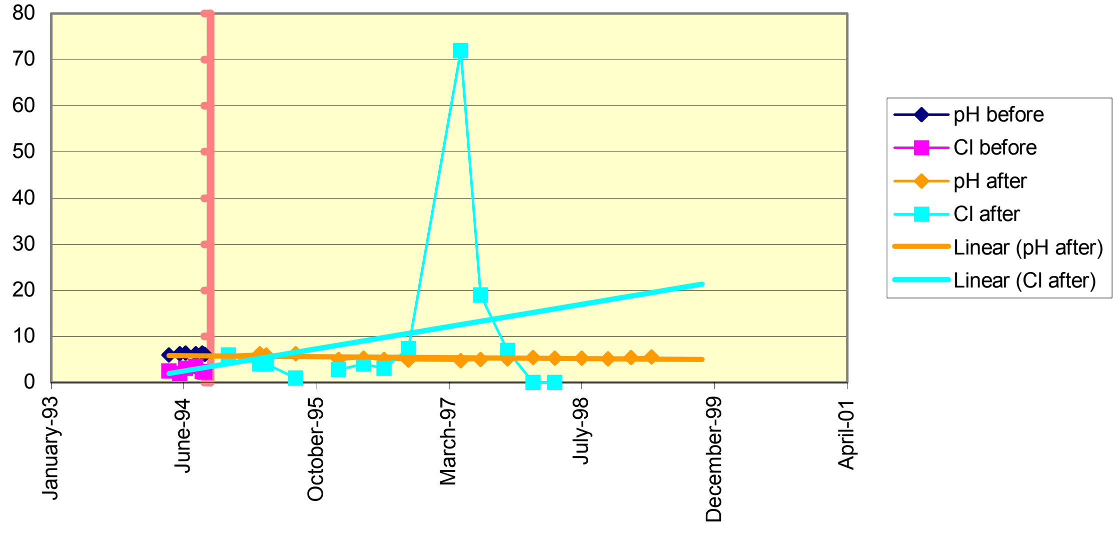
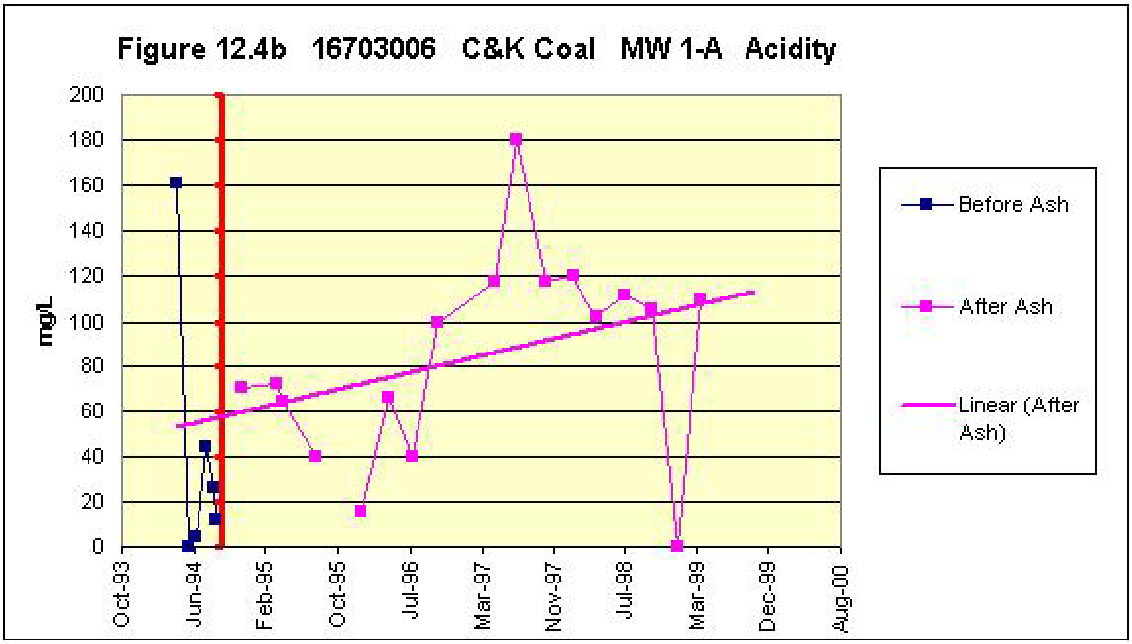
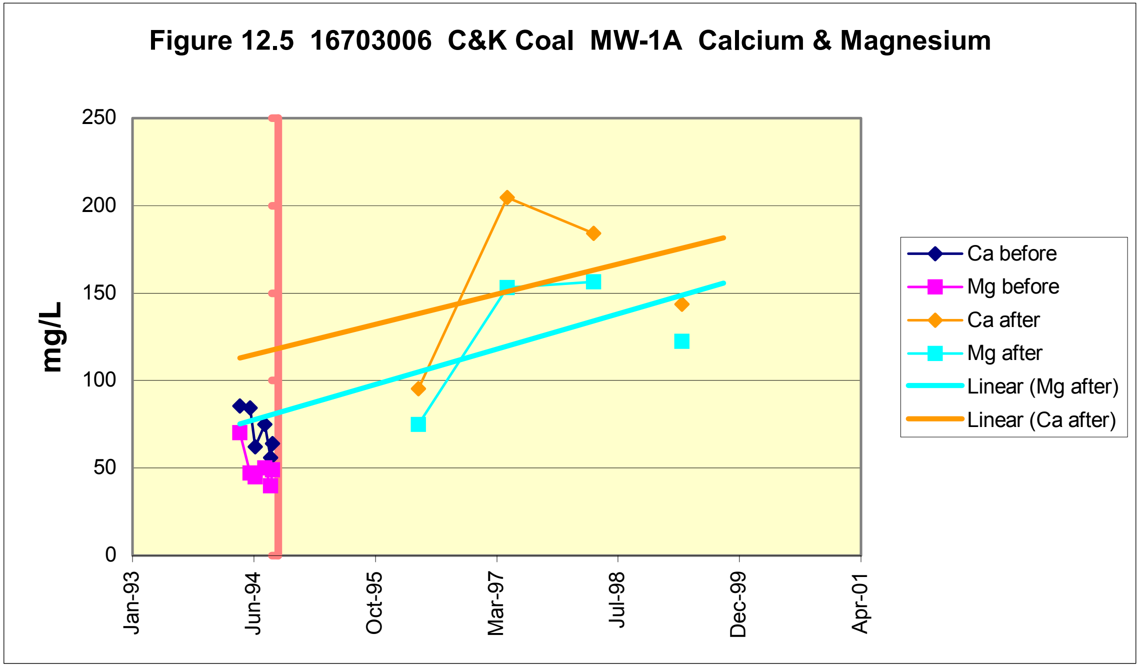


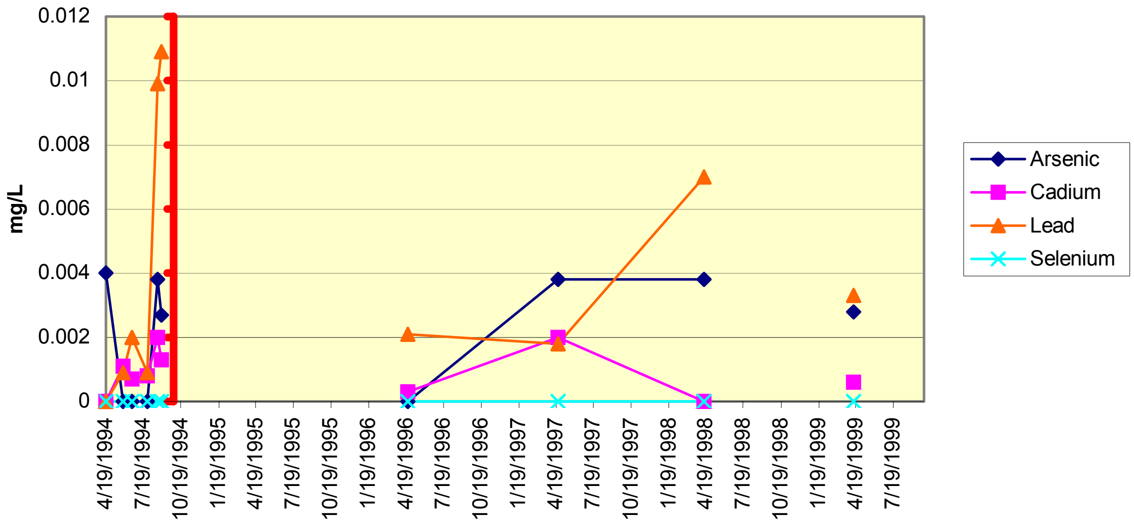
Figure 12.4a 16703006 C&K Coal MW-1A Field pH





Dissolved concentrations for trace elements at MW-1A are presented in figure 12.6 for April 1994 through April 1999. There are no data for 1995, as MW-1A was dry during the April sampling for trace elements that year. Figure 12.6 also does not include data from an undated sampling in the permit's Module 25B monitoring report recorded between the last baseline sampling on September 22, 1994 and the first sampling in the graph during ash placement on April 22, 1996. That data shows arsenic at .0040 mg/L, cadmium at 0.0020 mg/L, lead at 0.0109 mg/L, and selenium at <0.0023 mg/L, levels below the DWS and close to the values for these elements in figure 12.6. The concentrations of total lead during the baseline period at MW-1A were as high as 0.190 mg/L, substantially greater than the highest total lead of 0.0075 measured from 1996 through 1999 during mining and ash placement. Nonetheless dissolved concentrations of lead were fairly similar from the baseline to mining/ash placement periods in the .001 to .011 mg/L range. Selenium has low detection limit values of <0.001 to <0.0023 mg/L during baseline monitoring which then rise to detection limits of <0.023, <0.031, and <0.027 mg/L in 1996, 1997, and 1998 respectively. The 1999 selenium value falls back to baseline detection levels at < .0027 mg/L. Arsenic and cadmium concentrations remain below their DWS and do not rise from baseline levels. A total of just four data points after ash placement begins limits meaningful trend analysis for these elements. More data points beyond those generated by annual sampling are needed to enable an accurate assessment of groundwater impacts from trace elements and other ash parameters such as calcium and magnesium.

Figure 12.6 16703006 MW-1A - C&K Coal Trace Elements



The patterns at MW-1A suggest contributions from both AMD and ash placement. The concentrations for iron, manganese, and sulfates, which could represent an AMD contamination signature, first rose and then fell somewhat as if some neutralization was taking place although not enough to prevent further AMD and possible mobilization of these constituents in the ash. Chloride levels rose and then fell back to baseline levels in 1998. The calcium and magnesium concentrations also both rose and later fell somewhat in 1998 and 1999 although their levels stayed approximately twice average baseline levels. These two elements are probably ash placement contamination signatures. The ratios between these elements stayed fairly constant. As calcium and magnesium concentrations started to fall, the pH started to rise although its overall trend was flat throughout the monitoring period. There was a gradual increase in average alkalinity but a sharper increase in average acidity during mining and ash placement. It appears that some major change in the chemical relationships between the AMD-producing material and the ash took place after mid-1997.

MW-3A

The graphs in figures 12.7 through 12.12 represent elemental concentrations in groundwater at MW-3A, which is a downgradient well drilled to the level of the bottom of the Lower Kittanning Coal. The data gaps in these graphs are the same as those for MW-1A, except for 1995, as this well was not dry then.

The major element concentrations (figures 12.7 and 12.8) (iron, manganese, and sulfate) show a general rise after baseline monitoring. The sulfates fluctuated greatly after baseline data were collected and in 1996 flattened with a very slight decreasing trend. Iron had a large “spike” during October 1995 that is also seen in the sulfate graph and may reflect a period of intense site disturbance.

Despite their increasing trends, in general, the concentrations of iron, manganese, and sulfates are less than those at MW-1A, even though MW-3A is labeled as the downgradient monitoring well between the two. Nonetheless the highest baseline iron concentration at MW-3A was 11.96 mg/L, which is about 40 times the DWS (figure 12.7). However at the end of mining and ash placement, the average iron value at MW-3A is about 18 mg/L, 60 times the DWS. The highest baseline concentration for manganese at MW-3A was 4.16 mg/L, 83.2 times the DWS, and average manganese concentrations rose gradually to about 8.0 mg/L, 160 times the DWS, at the end of mining and ash placement. Although they were higher than baseline concentrations until the last few measurements, sulfate levels except for three spikes (figure 12.8) remained at or below the DWS after mining and ash placement began.

Figure 12.7 16703006 - MW3A - C & K Coal Major Elements

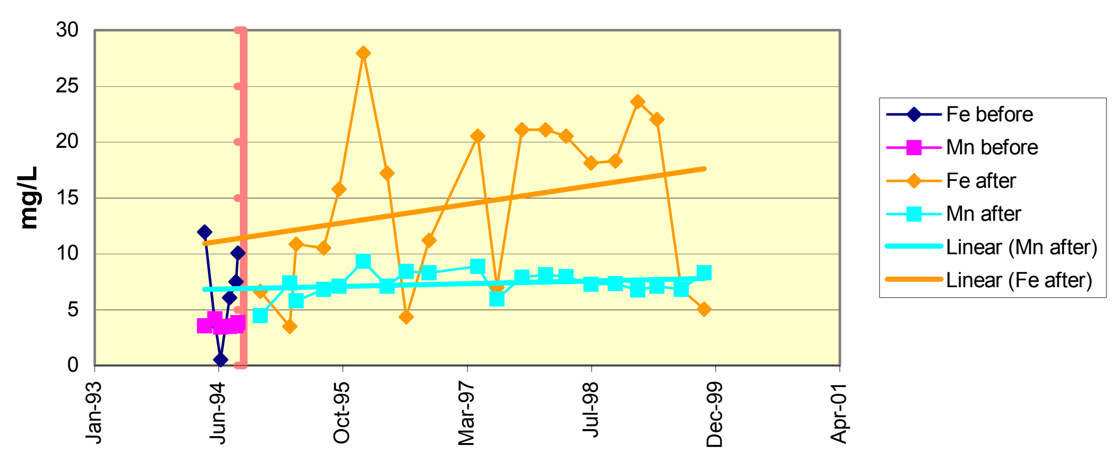
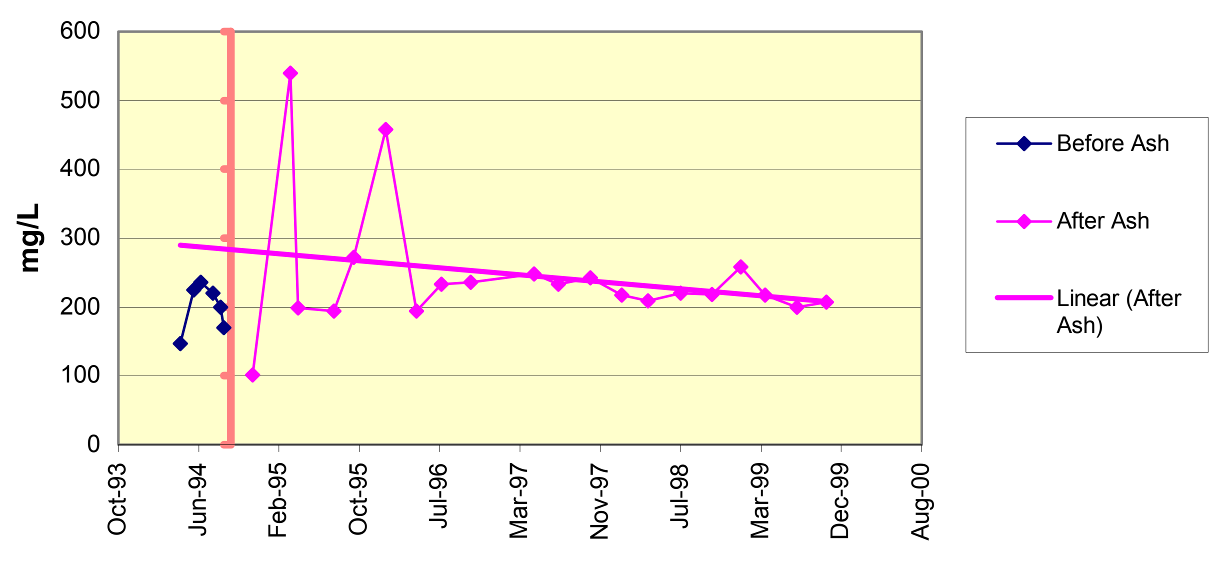


Figure 12.8 16703006 C&K Coal MW-3A Sulfates



Both the pH and chloride have rising trends (figures 12.9a and 12.9b) and probably reflect a contribution from ash placement. Actual field pH values dropped after the baseline monitoring below 6 units initially, but average pH then slowly rose to about 6.3 units by the end of the monitoring period. Although its values are small, chloride has an increasing trend; after dropping from baseline values averaging 1.7 mg/L, it rose to an average of about 4 mg/L. No chloride data were recorded after April 1999.

TDS (figure 12.10) increased steadily from baseline values, and then dropped off after July 1998, similar to data from MW-1A. Average alkalinity (figure 12.10A) more than doubled during mining and ash placement from approximately 35 to 80 mg/L, a likely contribution from ash, although the last two measurements of alkalinity in 1999 were at baseline levels between 30 and 40 mg/L. In contrast, except for one reading of 30 mg/L in the beginning of the baseline period (April 19,1994 sample), all recorded acidity numbers are zero. Rising pH and alkalinity coupled with falling (or zero, in this case) acidity points to an alkaline addition to the groundwater, probably from ash placement.

Average calcium and magnesium (figure 12.11) concentrations doubled approximately from baseline levels but dropped slightly after July 1998. This also appears to reflect mobilization of ash constituents.

With the exception of arsenic, trace elements (figure 12.12) at MW-3A were monitored in the same concentration ranges as at MW-1A. Dissolved arsenic increased however during mining and ash placement to 0.0110 mg/L, exceeding the new federal DWS of 0.010 mg/L, in April 1997 and increased further to 0.0370 mg/L in April 1998, nearly 4 times the new DWS. As seen at other ash placement sites in this report, these higher arsenic concentrations were accompanied by rising alkalinity and pH in the 6-7 unit range at this monitoring point. Selenium values were the same detection limit values as those recorded for MW-1A samples which were ten times higher during the mining and ash placement period than during baseline sampling. Lead and cadmium concentrations declined slightly from baseline measurements. As at MW-1A, monitoring reports are missing the 1995 data, and the existence of four data points limits the ability to assess impacts to groundwater from these trace elements and other ash parameter such as calcium and magnesium.

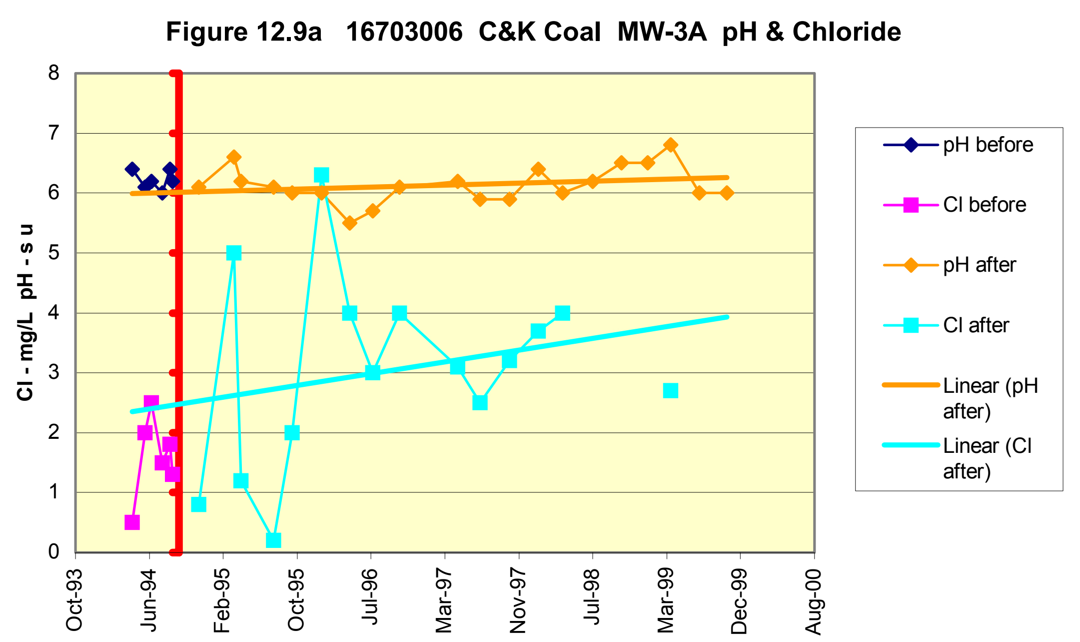


Figure 12.9b 16703006 C&K Coal MW-3A Field pH

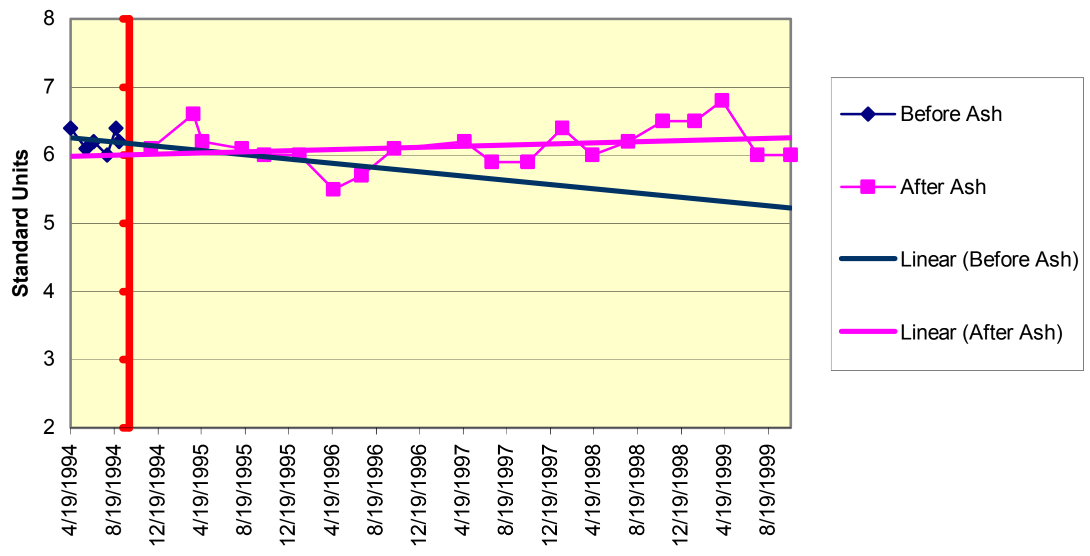
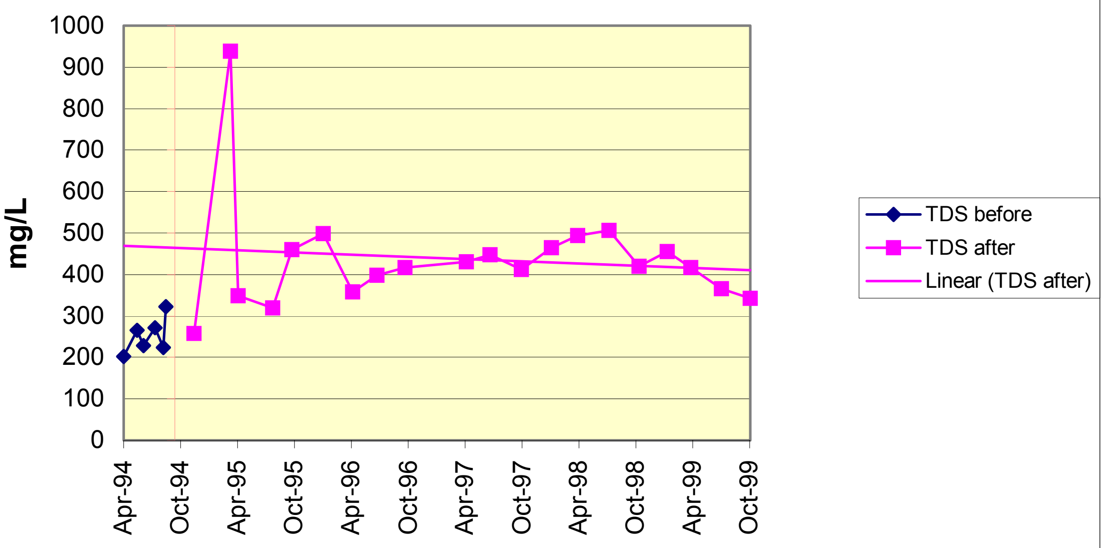


Figure 12.10 16703006 C&K Coal MW-3A TDS



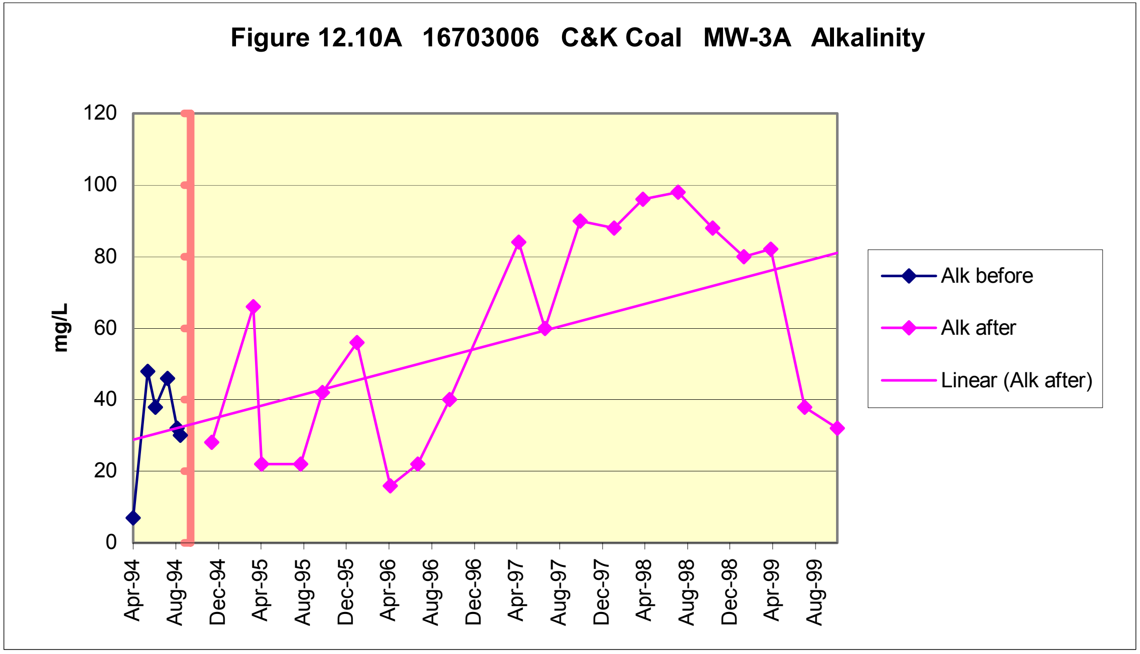


Figure 12.10A 16703006 C&K Coal MW-3A Alkalinity
mg/L
0
20
40
60
80
100
120
Apr-94
Aug-94
Dec-94
Apr-95
Aug-95
Dec-95
Apr-96
Aug-96
Dec-96
Apr-97
Aug-97
Dec-97
Apr-98
Aug-98
Dec-98
Apr-99
Aug-99
Alk before
Alk after
Linear (Alk after)

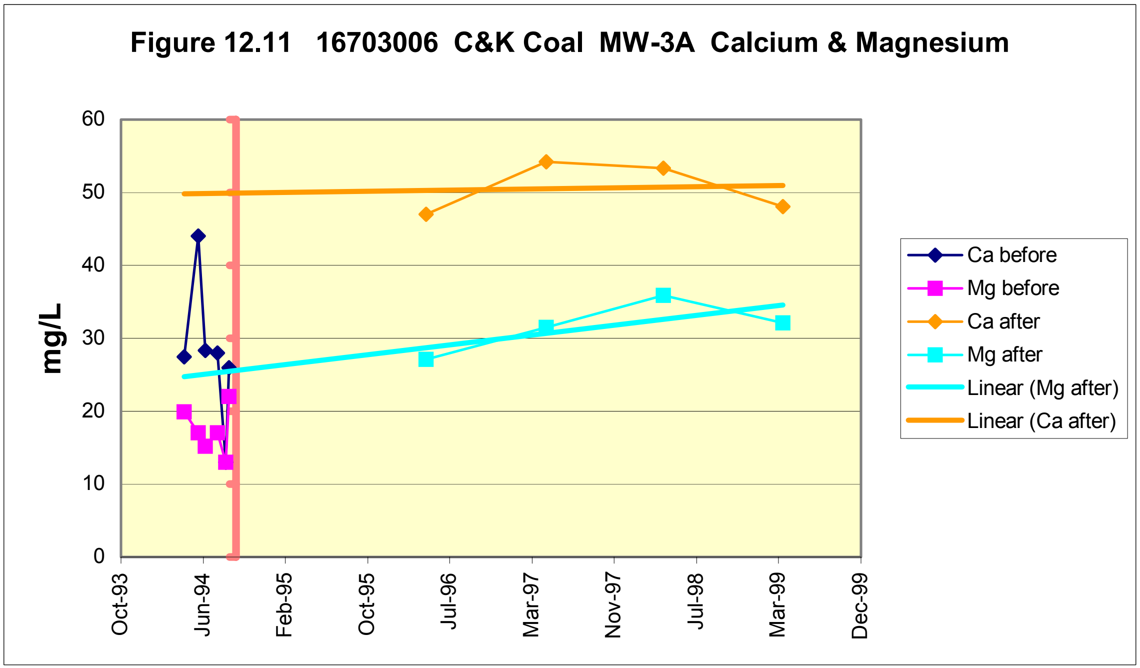
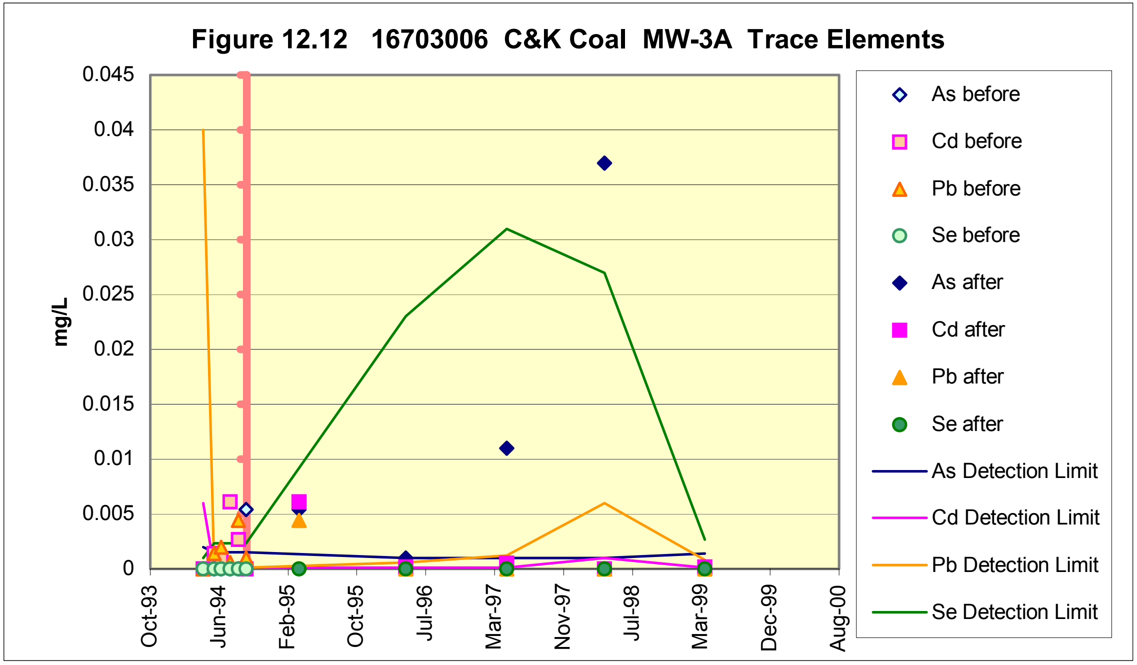


Figure 12.11 16703006 C&K Coal MW-3A Calcium & Magnesium
mg/L
0
10
20
30
40
50
60
Oct-93
Jun-94
Feb-95
Oct-95
Jul-96
Mar-97
Nov-97
Jul-98
Mar-99
Dec-99
Ca before
Mg before
Ca after
Mg after
Linear (Mg after)
Linear (Ca after)



The dominance of alkalinity over acidity, gradually rising pH during mining, rising levels of major constituents including ash parameters such as calcium and magnesium and high measurements of arsenic suggest an impact to groundwater from ash placement at MW-3A.

MW-3B

MW-3B is a downgradient monitoring well that was drilled down to the Vanport Limestone and is deeper then MW-1A and MW-3A. MW-3B is located 75 feet from MW-3A. There is a 1.5 year gap in data for major elements, pH and TDS in the monitoring reports for this well that extended throughout 1997 and the first half of 1998. Reviewers also could not locate annual data for 1999 for trace elements and other coal ash parameters at MW-3B.

Figure 12.13 16703006 C&K Coal MW-3B Iron

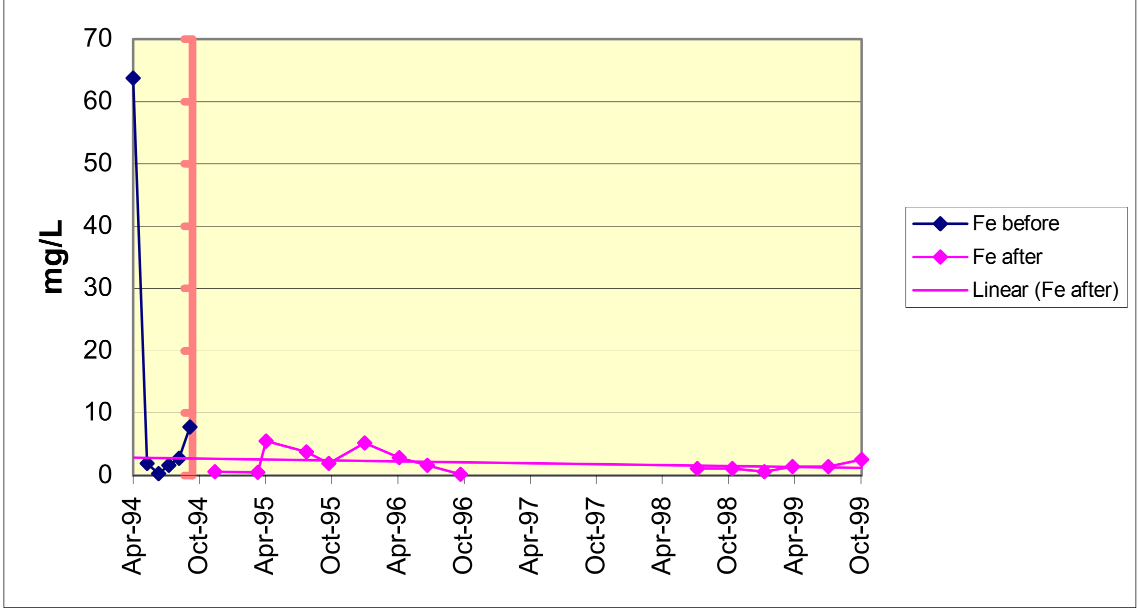
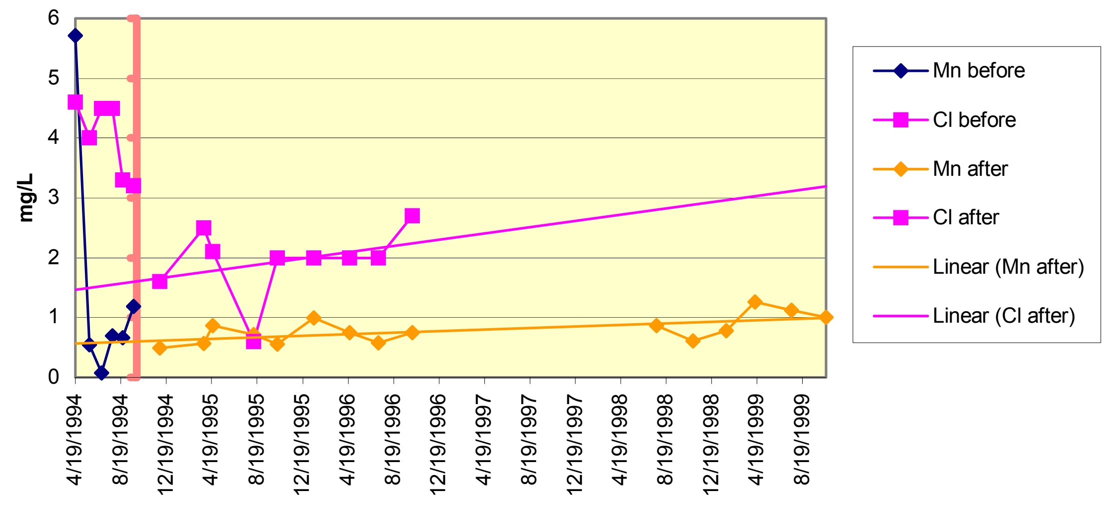
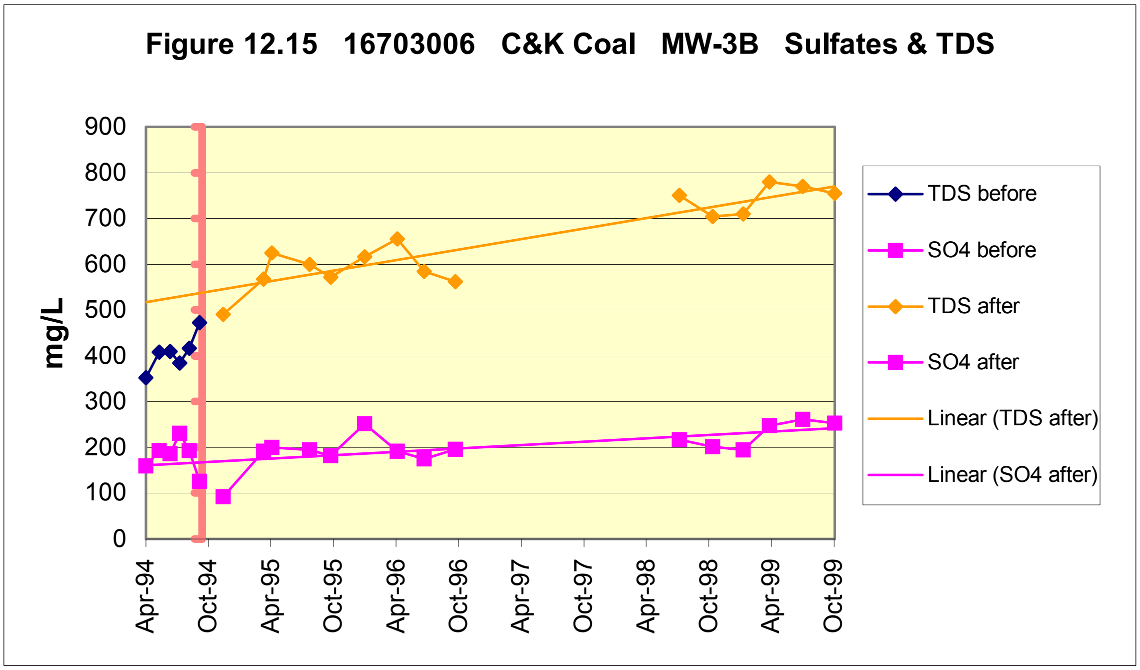


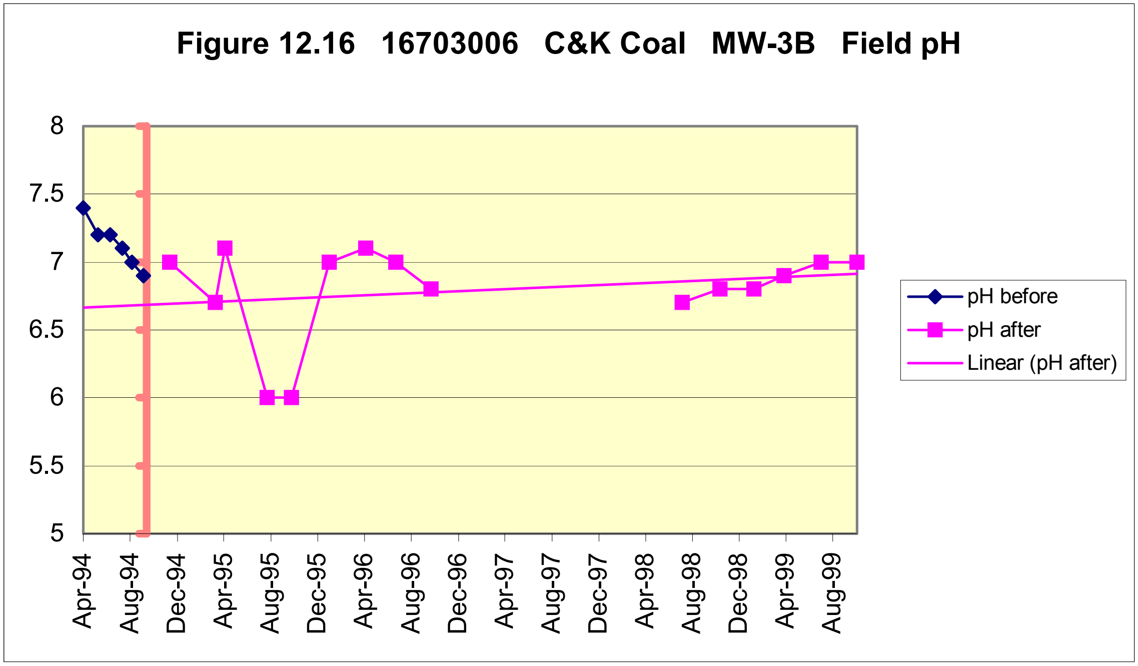
Figure 12.14 16703006 C&K Coal MW-3B Manganese and Chloride





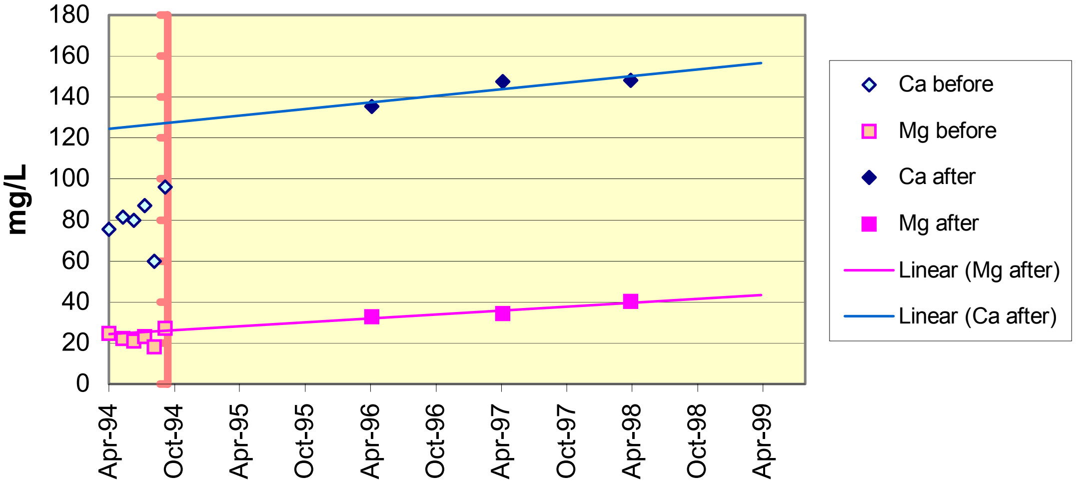
The iron concentrations at MW-3B (figure 12.13) start with a high single value of 63.75 mg/L on April 19, 1994 at the beginning of baseline monitoring. The remainder of baseline and all of post ash placement monitoring show iron well under 10 mg/L, and the trend is slowly decreasing. Iron levels vary far more and reach substantially higher levels during mining and ash placement at MW-3A, with an average value rising to 18 mg/L. Manganese, like iron at MW-3B (figure 12.14) has a high initial baseline “spike” of 5.71 mg/L, and decreases to less than 1.5 mg/L in all subsequent measurements. The trend shows a slight increase after ash placement, although the concentrations are less than a fifth the manganese concentrations after ash placement at MW-3A. Chloride drops after the baseline period, and then shows an increasing trend, averaging from about 1.6 to 2.8 mg/L, approximately half the chloride levels at MW-3A. Chloride data is missing after October 1996. The sulfates and TDS (Total Dissolved Solids) at MW-3B have increasing trends during the ash monitoring time period (figure 12.15). The sulfate values are well under those at MW-3A in the first year of mining and ash placement, but the trend is opposite; at MW-3B the sulfates increase, and at MW-3A the sulfates decrease with levels in both monitoring wells roughly equal to the DWS at the end of monitoring. Except for the spike in TDS to more than 900 mg/L at MW-3A at the beginning of the mining and ash placement, the TDS at MW-3B is higher than TDS at MW-3A. The trends are also opposite, with TDS rising at MW-3B, and falling at MW-3A.

Acidity at MW-3B (ungraphed) has an initial concentration of <0.2 mg/L in April 1994, and is zero for the rest of the baseline and ash placement monitoring period. Alkalinity at MW-3B (ungraphed) is very high in the April, 1994 measurement at 1799 mg/L (of calcium carbonate equivalent), then drops to measurements of 200-300 mg/L during the rest of the baseline period before rising to 300-400 mg/L during the mining and ash placement period.

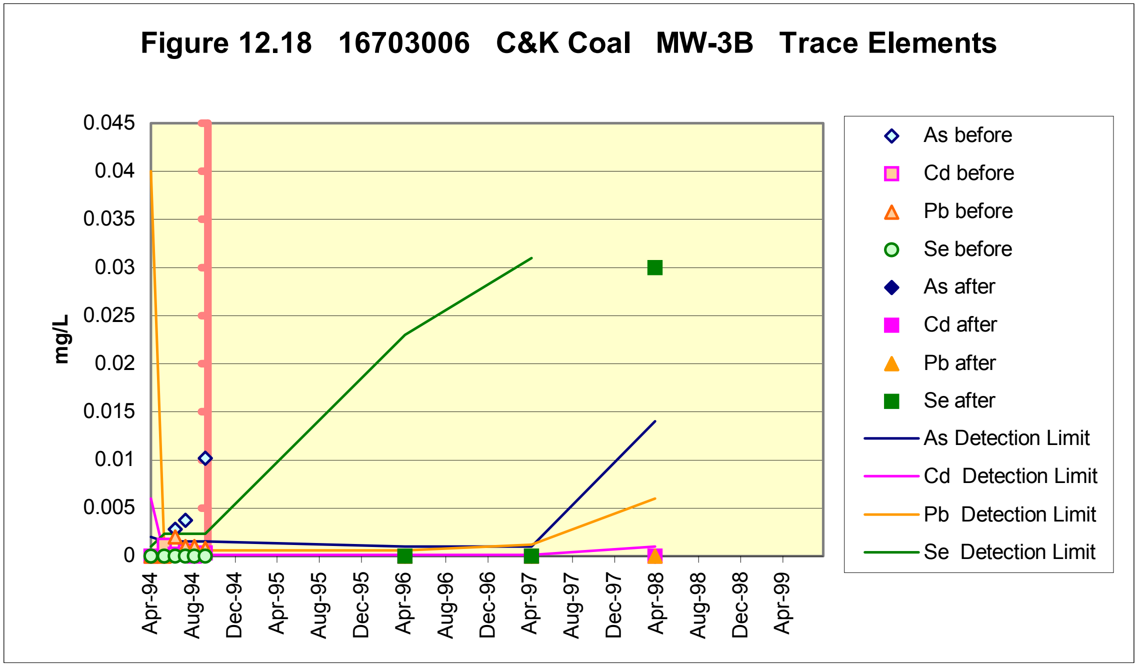


The field pH at MW-3B (figure 12.16) has a slowly increasing upward trend during the post ash placement monitoring period, even though the average values are at or below the baseline concentrations. Except for a sharp drop to 6 in the fall of 1995, the post placement numbers are between 6.6 and 7.2, indicating buffering of mining impacts from the surrounding Vanport Limestone and/or possibly alkaline ash leachate.

Figure 12.17 16703006 C&K Coal MW-3B Calcium & Magnesium



Calcium and magnesium values are plotted in figure 12.17, and both show higher concentrations after mining and ash placement as occurred in the shallower monitoring wells. However, while magnesium concentrations are about the same as found at MW-3A, the calcium concentrations at MW-3B are over twice the concentrations at MW-3A. This is probably due to the proximity of the Vanport Limestone.



The graph of trace elements at MW-3B in figure 12.18 shows only one actual concentration that rises above trace element concentrations at MW-3A, that of selenium to 0.030 mg/L in April 1998. All other selenium measurements were the same detection level values measured at MW-3A. Dissolved lead concentrations were also at the same detection level values as at MW-3A after ash placement and at roughly the same low actual values measured during the baseline period although the concentrations of total lead measured at MW-3B during the baseline period were higher and included a first measurement taken of 0.3000 mg/L for total lead in April 1994. Cadmium concentrations are slightly below those of MW-3A and are below detection limits and the DWS after ash placement. Arsenic concentrations are slightly above those of MW-3A during the baseline period but at detection limits that are below actual arsenic concentrations measured at MW-3A after ash placement.

This well (MW-3B) appears to have been affected by leachate from mining and ash placement, but not to the degree MW-3A has been affected. The data reflects lower concentrations of major constituents at MW-3B except for calcium and TDS and concentrations less prone to the oscillations seen at MW-3A. The greater depth and screening in bedrock isolate this monitoring point somewhat from the mining and ash placement and are probably the causes of lower and more stable contaminant levels. Without a sampling for1999, there are only three data points for trace elements, calcium and magnesium at MW-3B after the baseline period limiting trend analysis even further than at MW-3A and MW-1A for these more exclusive ash parameters.

Conclusion

The chemical behavior of monitoring wells MW-1A and MW-3A do not support the upgradient label given to MW-1A as the major element concentrations were higher at MW-1A than at MW-3A. Both monitoring wells have elevated and rising levels of constituents that can result from mining, AMD, ash placement or any combination of these activities.

Rising concentrations of calcium, magnesium, chloride, alkalinity, and pH in these wells after mining and ash placement began at this site appear to indicate an impact from the ash on groundwater quality assuming there is no chemical contribution from the Vanport Limestone. Such a contribution appears unlikely since this limestone bed is well below the bottoms of MW-1A and MW-3A.

The concentrations of iron, manganese, sulfates and TDS increased sharply in the first two years of mining and ash placement but then leveled off in 1998 or declined in some cases (sulfate for example) suggesting some neutralization of AMD by ash placement or reclamation activity. The gradually rising pH values and dominance of alkalinity over acidity throughout the monitoring period support the explanation of increasing buffering and neutralization from ash over time. The higher concentrations of arsenic at this monitoring point and the higher concentration of selenium measured at the same time at MW-3B (in April 1998) nearby but at a deeper depth are also consistent with this effect.

Monitoring well MW-3B shows some effects from ash placement, but to a lesser degree than MW-3A. A dramatic increase at MW-3A for TDS takes longer to occur at MW-3B and sulfate and manganese levels have only started to rise above baseline concentrations at the end of the monitoring period. As these two wells are close together laterally, the chief differences are their depth and the material they are screened in. MW-3A is in looser spoil material that is a good conductor of groundwater while the lower portion of MW-3B is in undisturbed bedrock, with resulting poorer water conductivity, a good example of a hard rock aquifer. The Vanport Limestone directly adjacent to MW-3B appears to impart a significant alkalinity to the waters sampled by this well and is a likely source for the high calcium measured at this monitoring point. Nonetheless higher major and trace element concentrations in the spoil aquifer can result from mining activity and the placement of the ash and coal waste directly into the spoil water. Some of this contamination can reach a deeper aquifer in undisturbed rock within a relatively short period of time. This assumes the bedrock has been extensively fractured by blasting activity on the mine surface, has significant natural jointing or is exposed to groundwater movement downward from the mining surface.

As is the case for other sites in this report, the low annual frequency of monitoring for trace elements and other Module 25 ash parameters, the absence of any monitoring for boron, molybdenum, and other signature ash constituents, and absence of post-ash placement monitoring makes it impossible to evaluate the longer-term effects of ash placement on groundwater at this site.

Permit Review 13

FORCEY COAL COMPANY, BUTERBAUGH MINE (PERMIT # 17990112)

Site Summary

The Forcey Coal Company Buterbaugh Mine is located in Bigler Township, Clearfield County, Pennsylvania, in the Clearfield Creek Priority Watershed 8C. About 24,538 tons of ash from Westvaco's Tyrone Paper Mill pulverized coal-fired power plant have been placed at this site in a mixture that is cited by PADEP to be approximately 10% fly ash and 90% bottom ash. Although the entire area of mining was about 72 acres, the ash was only placed over approximately 20 acres according to a 2005 Final Ash Placement Map in the permit file. Ash placement commenced during January 2001 and finished in August 2004. No ash was delivered to the site from October 2001 to November 2003. Ash was placed as active mining progressed, and mixed with spoil rather than being deposited in mined out benches at the coal seam levels as done at many other sites reviewed in this project. The purpose for placement was vaguely defined as "beneficial use" (Module 25.4, p.25-1-2) which is presumed to mean "placement" for the purpose of achieving final reclamation.

Some lime (and possibly lime kiln dust) was also mixed with the spoil, and placed on the pit floor. The authors can find no source information or chemical analysis for the lime in the permit files. The areas and amounts of lime addition are summarized in Exhibit 10.9, Special Handling Map. The actual tonnage of this lime placement is difficult to calculate, as the areas of placement are not clearly delineated on the Special Handling Map. However, as specified on the map, an "area of influence" was to receive 100 tons of lime per acre on the pit floor, and up to 840 tons per acre mixed with the mine spoils. Other areas were to receive 20 tons per acre on the pit floor, and up to 100 tons per acre mixed with the spoil at the discretion of the operator if there was less than 40 feet of cover (overburden depth down to the coal being mined). If one assumes the maximum addition rates for the whole 72 acre active mining area, the amount of lime placed on the site would have been well over twice the tonnage of ash. While this undoubtedly overstates the amount of lime placed at the site, its potential significance in effecting water quality at this site should be recognized. Two monitoring points (BC-3 and BC-14, both downgradient) were selected for analysis as the monitoring points with the most complete data sets. There are no upgradient ash monitoring points at this site.

Geology

The Forcey Coal Company Buterbaugh Mine worked the Upper Kittanning and Middle Kittanning Coals that occur in the middle of the Allegheny Group sedimentary rocks of the Pennsylvanian Period. The overburden rocks and coal seams are flat lying, with a very gentle dip (down slope) geological structure to the southeast. The Upper Kittanning Coal slopes 1.1 degrees and the Middle Kittanning 1.9 degrees. These slopes are very slight structure dip numbers and reflect the geometry of the depositional basin.

In between the Upper Kittanning and Lower Kittanning coals is a bed of limestone that varies in thickness from 2 to 5 feet. This limestone was encountered in many of the test bores, including BR-8, BR-7, DH-5A, OB-1, OB-2, and OB-13. The logs for these test holes were found in Module 7.1(B).

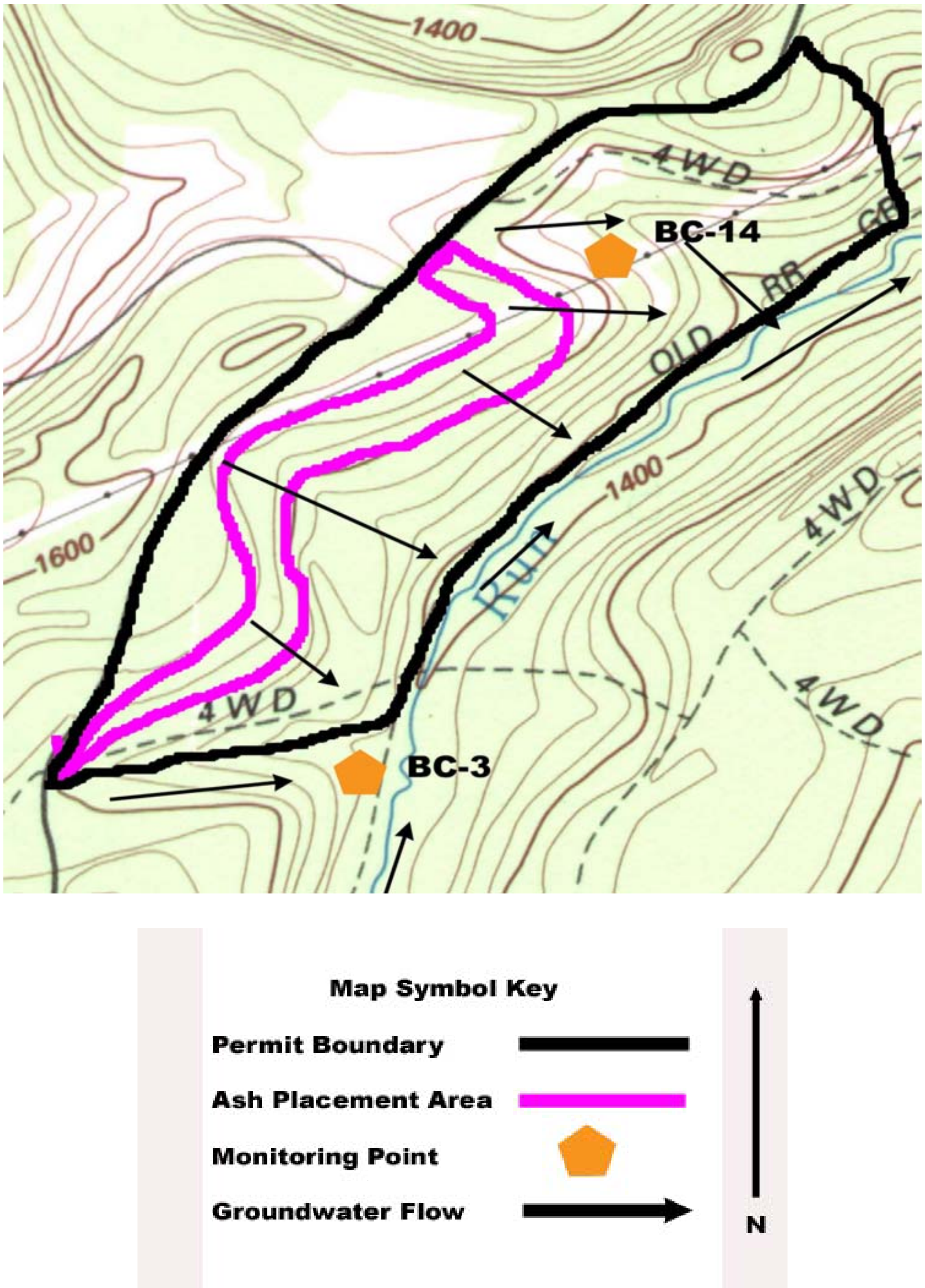
Topography

The Buterbaugh Mine occupies the northwest side of a northeast/southwest trending valley, (see map below) with Banian Run at the bottom. The elevation of the mine ranges from 1350 feet (above sea level, at the downstream water level of Banian Run) to about 1600 feet at the top of the highest hill on the property. The Middle Kittanning Coal outcrops at about 1400 feet and the Upper Kittanning at about 1480 feet. The mine is in the Allegheny Mountain Physiographic province (figure 1).

Groundwater

The groundwater at the Buterbaugh site flows generally from the northwest to the southeast, following topography and geological structure. The shallow groundwater and surface water flows into Banion Run, which flows northeast out of the site. All water exiting the property eventually runs into the West Branch of the Susquehanna River. Most of the shallow groundwater probably percolates down to where the permeable mine spoils and ash meet the much less permeable underclay that underlies the Middle Kittanning Coal mined in the permit, and exits the site where this coal outcropped at the surface. As with the large majority of permits in this report, there is not enough detailed information to discern more site-specific groundwater flow paths at this mine relative to the ash placement area.

Site Map Buterbaugh



Forcey Coal Co., Buterbaugh Operation (Permit # 17990112)
Scale: 1" = Approximately 750'

Groundwater Monitoring Data: Discussion

Two monitoring points are discussed in this report: BC-3 and BC-14. BC-3 is a small spring that discharges from the toe of the mine spoil pile. The water from this discharge flows into a small tributary of Banion Run. Surface water and shallow groundwater flow from the southern end of the ash placement area downhill to point BC-3. BC-14 is a discharge downhill from the ash placement area that flows into an unnamed tributary of Banion Run downstream and to the northeast of the ash placement area and BC-3. Both sampling points are downgradient from the spoil pile and areas of ash placement.

In comment on an earlier draft of this report, PADEP stated that data from two other ash monitoring points, BC12A and BC10, "are reflective of downgradient groundwater conditions" and should have been considered in this report. However, the authors of this report can find only one measurement collected from a monitoring point "BC12" (nothing for a "BC12A") for the entire monitoring period and data from BC10 only for December 1999 through July 2001, a few months into the ash placement period. The rest of monitoring at this point (from November 2001 to November 2003) recorded an insufficient amount of water to sample. The monitoring reports in the permit file also do not have any trace element measurements for these monitoring points. There are however several trace element measurements collected from a D-12-A from September 1999 through November 2002 including two measurements during the period of mining and ash placement that do not show elevated trace element levels from the baseline period. Nonetheless, the paucity of data from BC-12 and BC10 does not warrant its graphing and discussion at this time.

BC-3

BC-3 was monitored from January 2000 to July 2004. Baseline monitoring data was recorded from September 11, 2000 to December 26, 2000 in six samplings. There are four other data points also recorded before this baseline data was collected. Figures 13.1, 13.2, and 13.3 are graphs of iron, manganese, and sulfates plotted against time. The iron values in figure 13.1 range from about 0.3 mg/L (equal to the federal secondary MCL (DWS)) to 5.09 mg/L. This high value was measured during baseline data collection. During ash placement, iron rose from a low value of about 0.26 mg/L to a high of 2.7 mg/L, 9 times the DWS. The last three sampling points in 2003 show a short decline in iron values to below 1.0 mg/L. Some data are missing during 2002, as the spring monitored by this sampling point was dry.

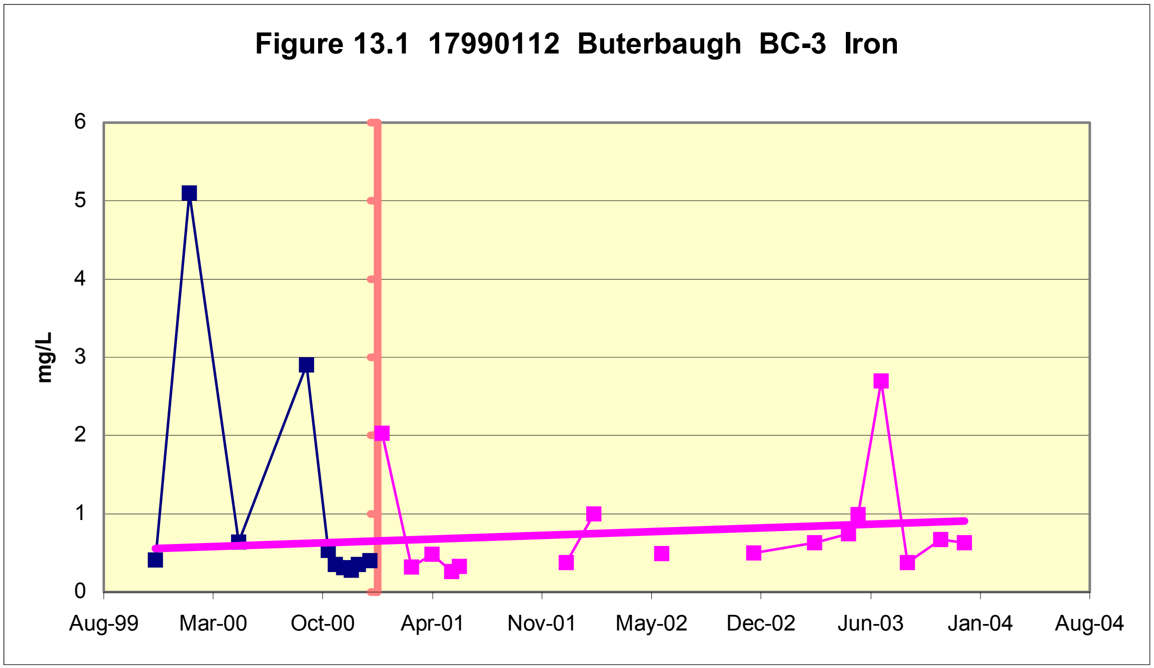


Figure 13.1 17990112 Buterbaugh BC-3 Iron
mg/L
0
1
2
3
4
5
6
Aug-99
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Aug-04

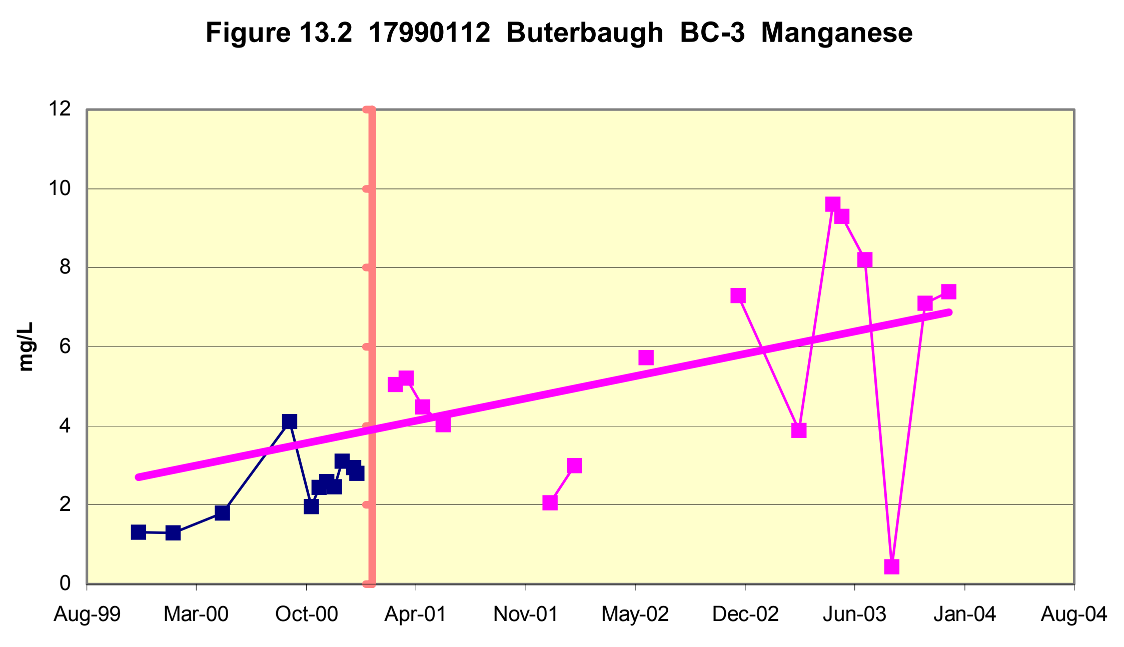
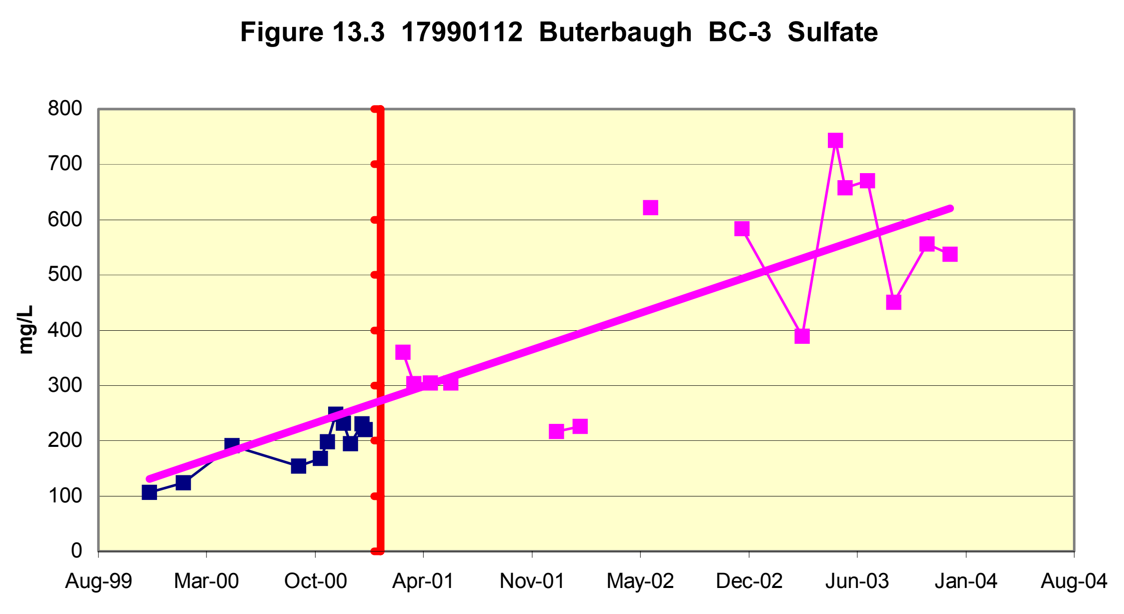
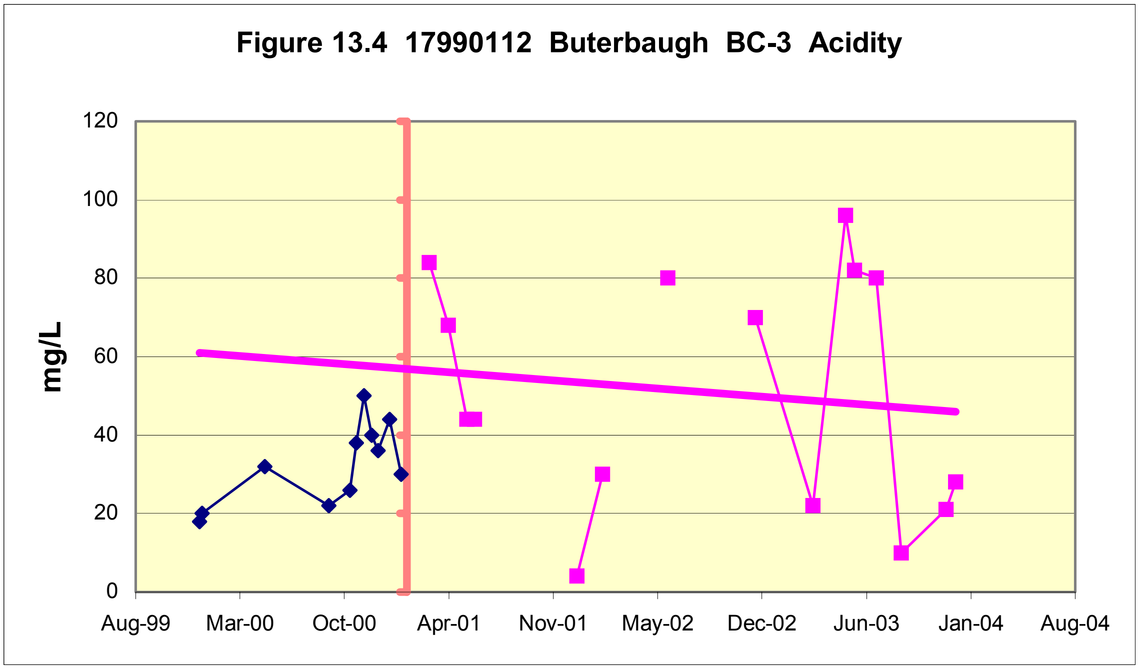
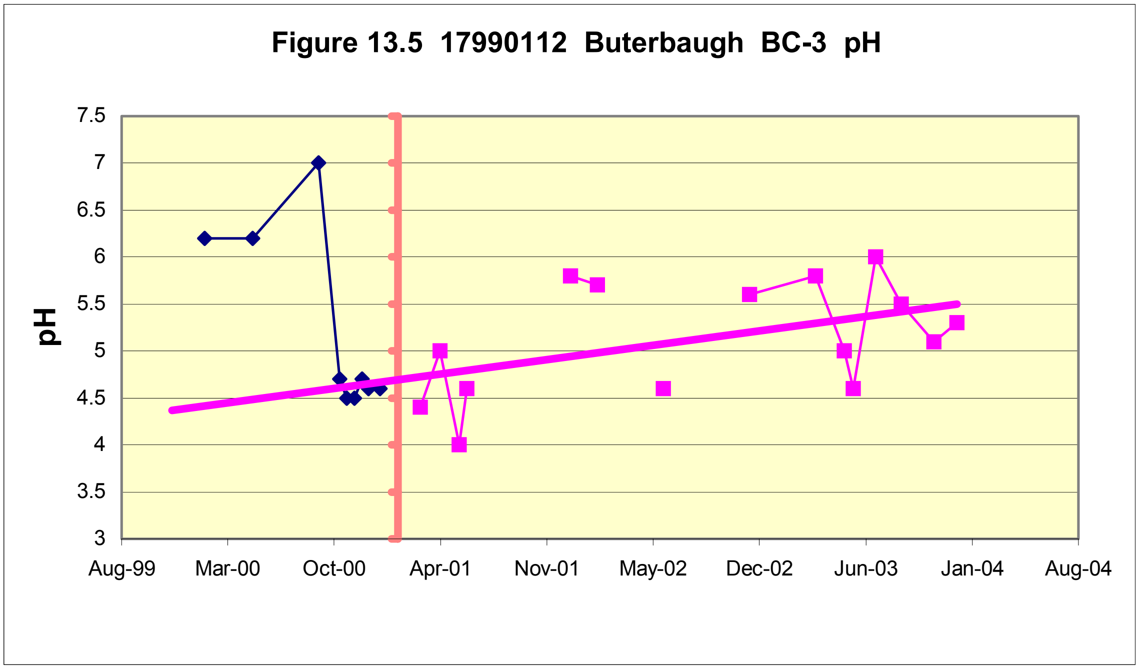


Figure 13.2 17990112 Buterbaugh BC-3 Manganese
mg/L
0
2
4
6
8
10
12
Aug-99
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Aug-04



Manganese concentrations (figure 13.2) fluctuated widely, but had a general increasing trend from a peak of 4.1 mg/L during the baseline period, 82 times the DWS of 0.05 mg/L, to a high of 9.6 mg/L on May 19, 2003. This level is 192 times the drinking water standard and reveals a trend from degraded water prior to mining and ash placement to badly degraded water two and a half years after these activities started. The sulfate concentration trends (figure 13.3) roughly mirror those of manganese, rising from maximum levels equal to the DWS of 250 mg/L before ash placement, to a high value of 743 mg/L in May 2003 which represents degraded water. These trends have resulted from ash placement, and/or mining activity. Acidity at BC-3 rises significantly after mining and ash and lime placement start but then begins to decline. Acidity concentrations vary somewhat from a low of 4 mg/L to a high of 96 mg/l yet experience an overall decreasing trend throughout the mining and ash placement period (figure 13.4). The pH at BC-3 (figure 13.5) mirrors the acidity. PHs as high as 7 during the baseline period drop abruptly just before the mining operation starts to values around 4.5 and then drop further after mining starts to as low as 4 units. However as the mining and ash/lime placement proceeds the average pH values increase from 4.7 to 5.5 units with a range from 4 to 6 units over the life of the operation. The rising pH and rising alkalinity (figure 13.7) suggest an impact to water quality from ash as well as lime.





The TDS (figure 13.6) rose from less than 200 mg/L in December 1999 to nearly 900 mg/L in early 2004 with seven out of the nine measurements exceeding the DWS (500 mg/L) after permit operations started. All but one of these higher measurements occurred from the spring of 2002 onward. This indicates that the total amount of material carried in the dissolved state in the groundwater was increasing from that point onward due to the availability of easily dissolved mineral phases; this could have resulted from mining disturbance, ash and lime placement, or both activities. Alkalinity concentrations (figure 13.7) undergo a modest rise from an average of approximately 3.1 mg/L to 7.1 mg/L after falling initially somewhat from baseline measurements. The alkalinity, acidity and pH data at BC-3 show an initial impact from mining that increased acidity which was overtaken by alkalinity as the operation progressed.

The concentrations of the elements calcium, magnesium, and chloride at BC-3 are graphed in figure 13.7A. Concentrations of calcium and magnesium rise noticeably above baseline values after mining and ash placement begin. Calcium concentrations increase from an average baseline value of about 35 mg/L up to an average value during mining and ash/lime placement of 107 mg/L and a high of 138 mg/L in June, 2004. Magnesium has a similar pattern, with concentrations more than doubling from an average of 22 mg/L during the baseline period to 56 mg/L during mining and ash/lime placement and a high of 85 mg/L in June 2004. The fact that each of the four measurements for these two constituents during mining and ash/lime placement was successively higher than the previous one with the highest concentrations measured in the most recent sample suggests mobilization of alkalinity from ash and lime being added to the site more than a source already in the spoils such as any limestone mined at the site. Nevertheless as chemical analyses for calcium and magnesium are not available for the placed lime or site limestones, it is impossible to differentiate the contributions of these constituents between ash, lime and limestone at BC-3.

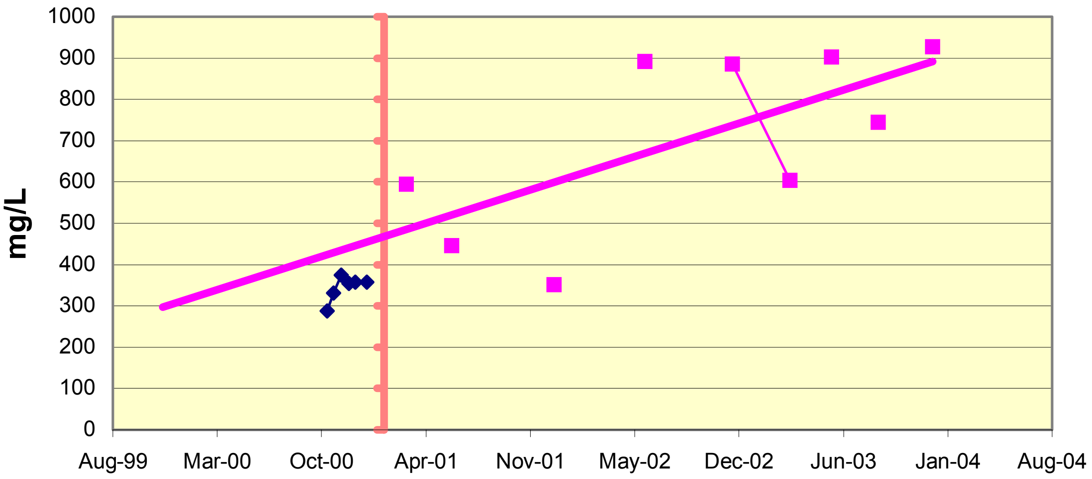
The chloride values of between 1 and 2 mg/L in the baseline period rise during mining and ash placement to 4.8 mg/L in November 2002 and 37.6 mg/L in June, 2003 with an average of 11.45 mg/L due to that measurement. The permit leach tests on the ash placed at this site indicate an average value of 2.5 mg/L of chloride leaching in the 24 hour tests, suggesting there may be an additional source of chloride along with the ash leachate at this site as the test concentrations are much less than November 2002 field value. Still the accuracy of this test beyond its ability as a benchmark indicator of solubility under fixed laboratory conditions has been repeatedly questioned, and there are too few field measurements to conclude that the chloride would or would not be coming from the ash.

Figure 13.7B shows the concentrations for sodium and potassium at BC-3. Baseline concentrations for sodium range from 0.80 mg/L to 1.93 mg/L while the range in baseline concentrations for potassium is from <.02 mg/L to 2.23 mg/L. Potassium rises to between 3.13 and 3.27 mg/L after ash placement, showing only a slight change from baseline to ash placement values. Sodium concentrations rise to 14 mg/L in June 2001, six months after ash placement began and then drop down to values similar to those of potassium. The permit's ash leach tests produce an average value of 25.75 mg/L for sodium, and 50.3 mg/L for potassium from the ash placed at this site. As sodium and potassium are very mobile elements in groundwater, the placed ash could be a source of these constituents since the leach test concentrations are well above the reported concentrations at BC-3 suggesting the dilution of these constituents as they migrate from ash deposits in site water.

Figure 13.8 shows trace element concentrations. Selenium increased from baseline levels below an analysis detection limit (<0.0023 mg/L) to actual levels as high as 0.0168 mg/L in June 2001, while initial baseline concentrations of lead exceeding the DWS by up to four times decreased to below 0.01 mg/L during mining and ash placement. Concentrations of arsenic during and after the baseline period were below detection limits that were also below the DWS. Cadmium levels were actually measured although well below the DWS until the last measurement in June 2004 when cadmium reached 0.007 mg/L (DWS is 0.005 mg/L). November 2000 measurements of 0.05 mg/L for cadmium and 0.01 mg/L for arsenic were actually below the detection limits of the analysis at those levels. The higher selenium concentrations are consistent with rising alkalinity and pH and could have come from the ash or lime or have been mobilized from site materials under those conditions.

The baseline monitoring time period for Module 25 ash parameters was October 11, 2000 to December 26, 2000. As in the previous major element graphs, data from 2002 are missing. The existence of only four data points from the three year period of mining and ash placement and changing levels of detection used in the laboratory analysis limits the ability to assess trends in trace elements at BC-3.

Figure 13.6 17990112 Buterbaugh BC-3 TDS



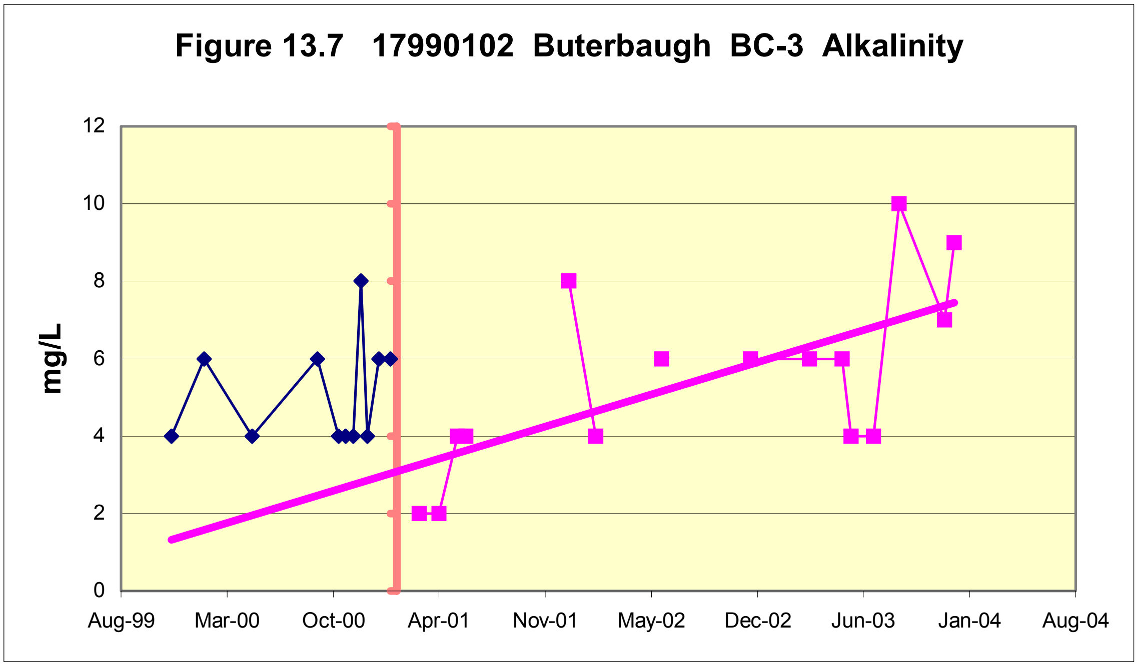


Figure 13.7 17990102 Buterbaugh BC-3 Alkalinity
mg/L
0
2
4
6
8
10
12
Aug-99
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Aug-04

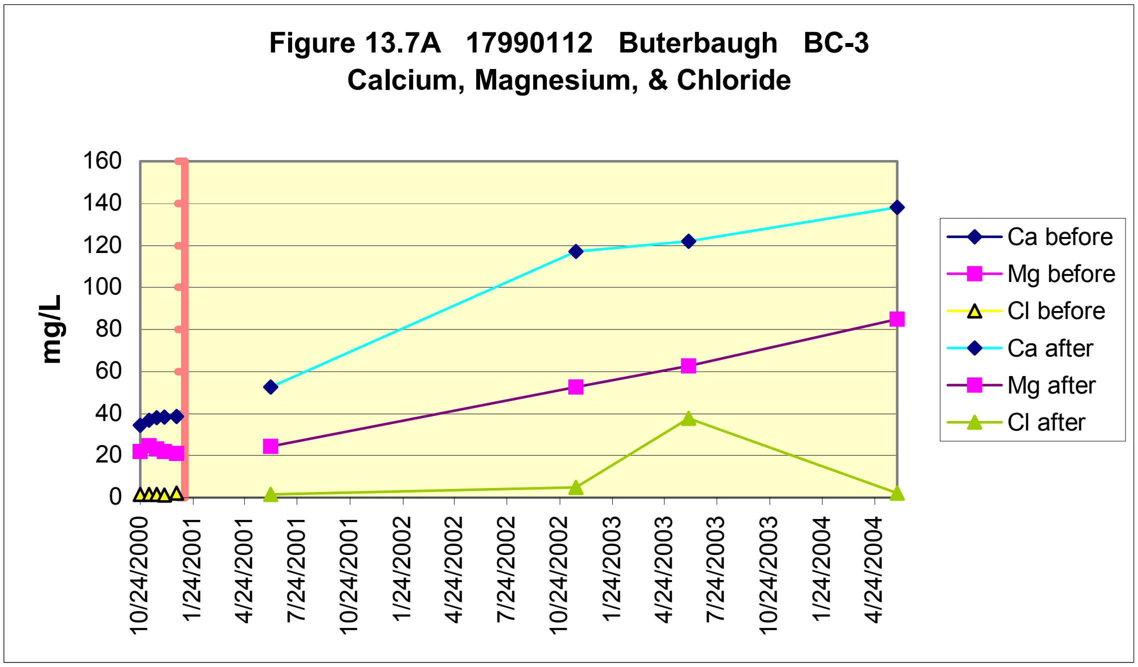


Figure 13.7A 17990112 Buterbaugh BC-3
Calcium, Magnesium, & Chloride
mg/L
0
20
40
60
80
100
120
140
160
10/24/2000
1/24/2001
4/24/2001
7/24/2001
10/24/2001
1/24/2002
4/24/2002
7/24/2002
10/24/2002
1/24/2003
4/24/2003
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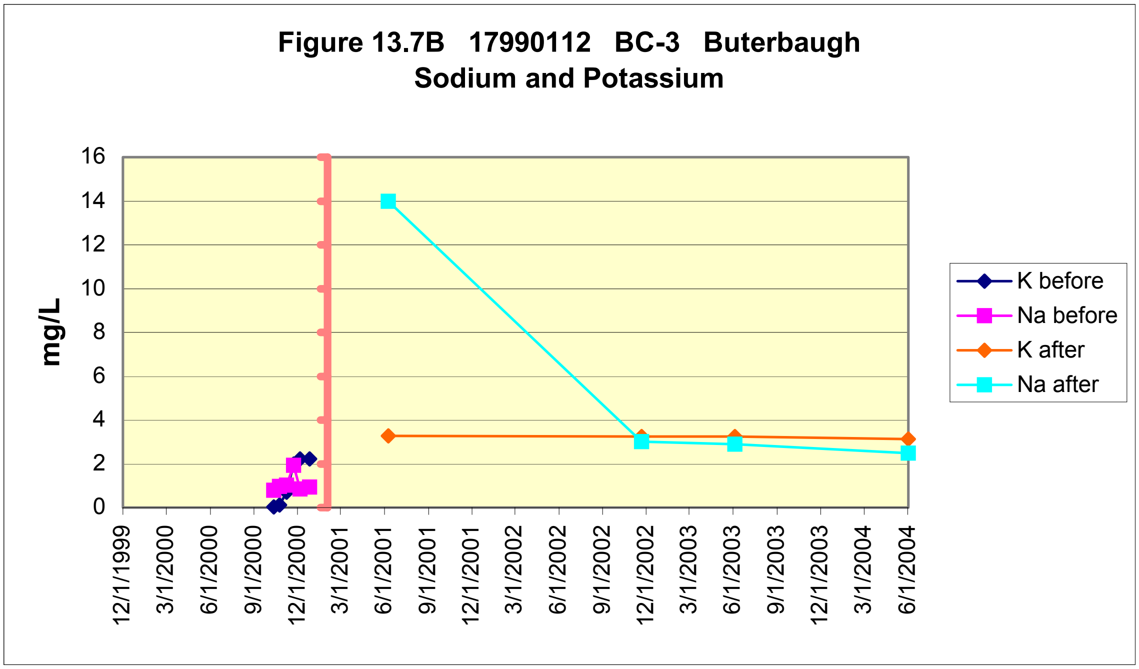
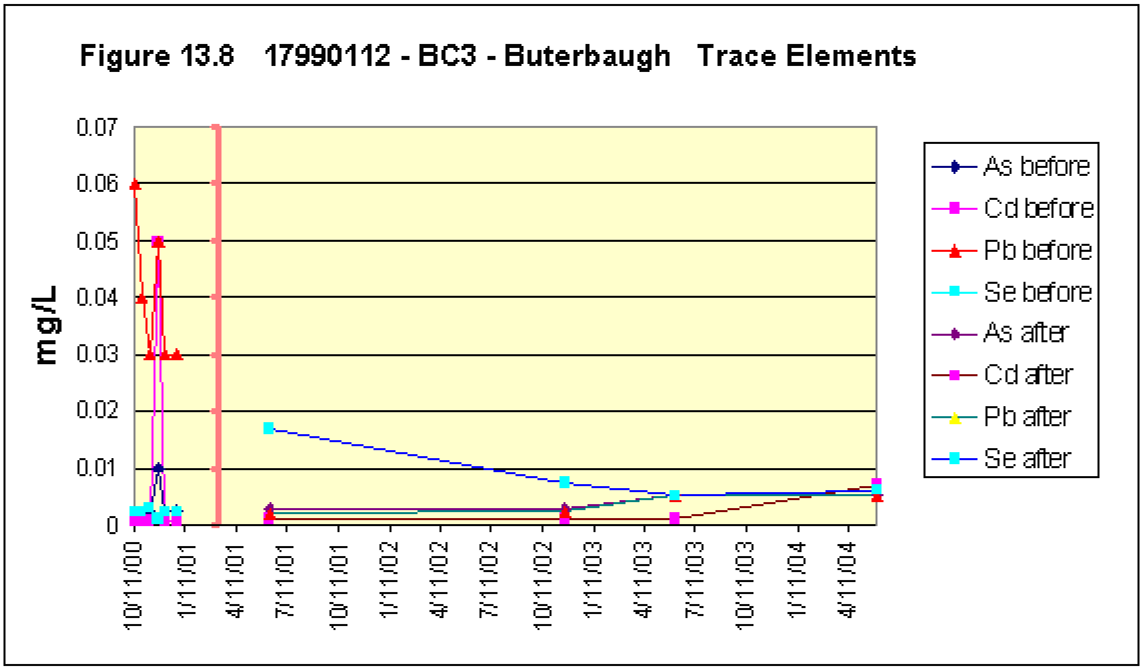
10/24/2003
1/24/2004
4/24/2004
Ca before
Mg before
Cl before
Ca after
Mg after
Cl after



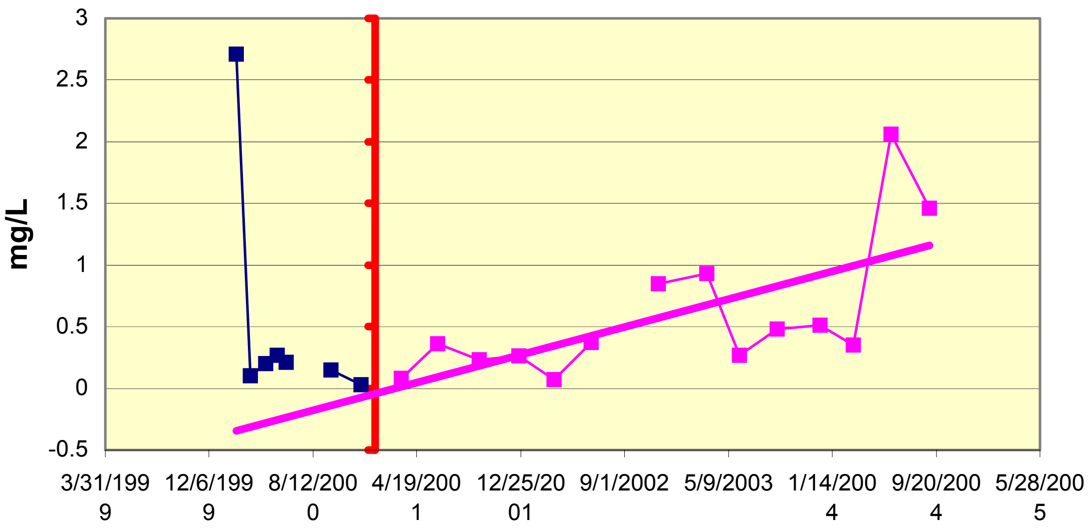


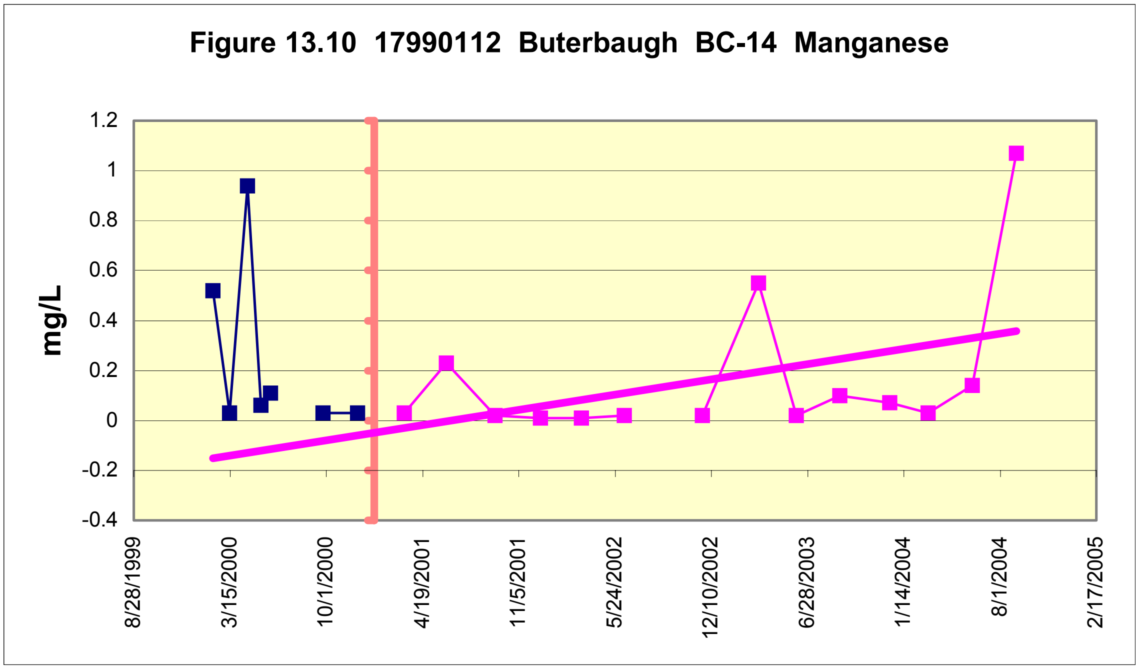
BC-14

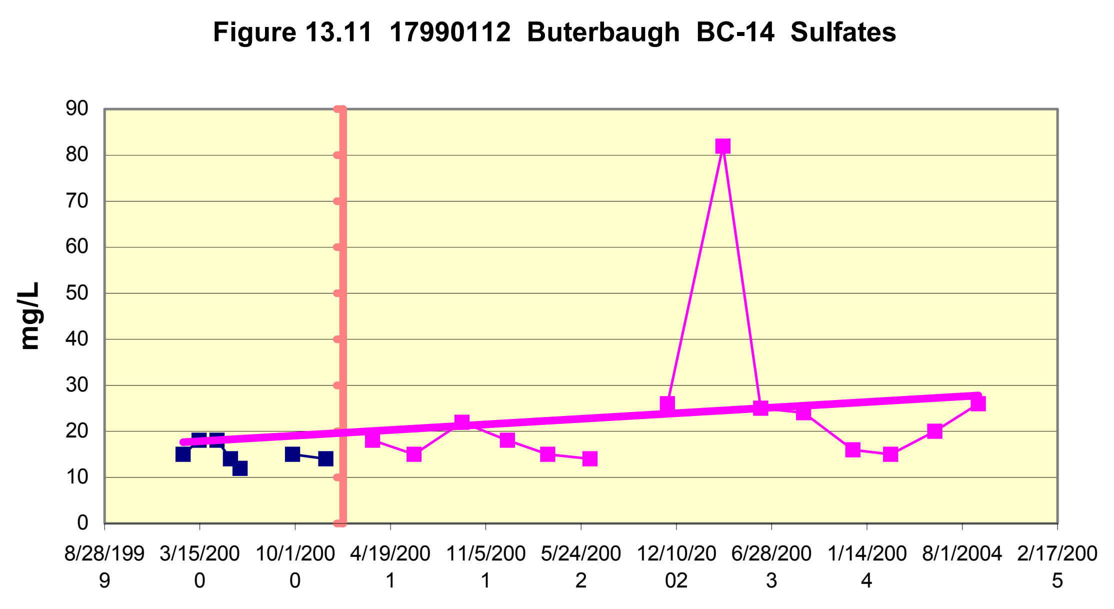
The ash monitoring point BC-14 is a discharge that drains into Banion Run northeast of the mining area and well downstream from where the BC-3 discharge enters this stream. This discharge is slightly below the level of where the Middle Kittanning Coal was mined out, at an old deep mine working exit that was mined through by the surface mining operations. The water quality at BC-14 appears to be less affected by the permit activities than at BC-3. Figures 13.9, 13.10, and 13.11 are graphs of iron, manganese, and sulfate concentrations, respectively. Data were recorded from February 2000 to September 2004, with baseline monitoring starting in February 2000 and ending in September 2000. There are some data missing in 2000 and 2002, as the sampling points were dry for these times. Iron (figure 13.9) had an increasing trend from baseline values, although after operations started, its highest level reached in the second to last measurement (2.06 mg/L in June 2004), was less than the highest baseline value of 2.71 mg/L. These concentrations are similar to those from sampling point BC-3.

The manganese (figure 13.10) fluctuates with a high initial baseline reading, two spikes and the highest concentration 1.07 mg/L reached in the last measurement, September 2004. However these values are barely one tenth of the manganese concentrations at BC-3. Sulfates at this point (figure 13.11) are also much lower than at BC-3; the highest concentration reached only 82 mg/L in March 2003, compared with a high of 743 mg/L at BC-3 in May 2003. Average sulfate levels at BC-14 slowly rose above baseline values to only 28.4 mg/L.

Figure 13.9 17990102 Buterbaugh BC-14 Iron







The acidity values at BC-14 (figure 13.12) were lower than at BC-3 and had a very slight increasing trend while alkalinity values at BC-14 (figure 13.15) rose from an average of approximately 4 mg/L at the start of mining to an average of 21 mg/L when monitoring stopped at BC-14. This rise in average alkalinity however does not reflect actual alkalinity measurements which remained at or below baseline levels until the last two measurements when alkalinity jumped to 26 mg/L in June 2004 and 48 mg/L in September 2004, indicating a delayed influence from broken limestone, lime, or ash at

BC-14. Average field pH (figure 13.13) at BC-14 appeared to reflect mining impact and not much alkalinity from these trends, dropping from approximately 6.25 to 5.3 units. The laboratory pH (ungraphed) had no general trend down or up and ranges from 4.6 to 6.3 units.

Figure 13.14 shows that TDS values increased over time. The high value of 142.9 mg/L in March 2003 correlates to the highest sulfate value (82 mg/L) and a peak in specific conductance to 236 micromhos also measured in this sampling at BC-14. The latest TDS values between 70-100 mg/L indicate a continuation of this rising trend from baseline values (31-59 mg/L).

Figure 13.12 17990112 Buterbaugh BC-14 Acidity

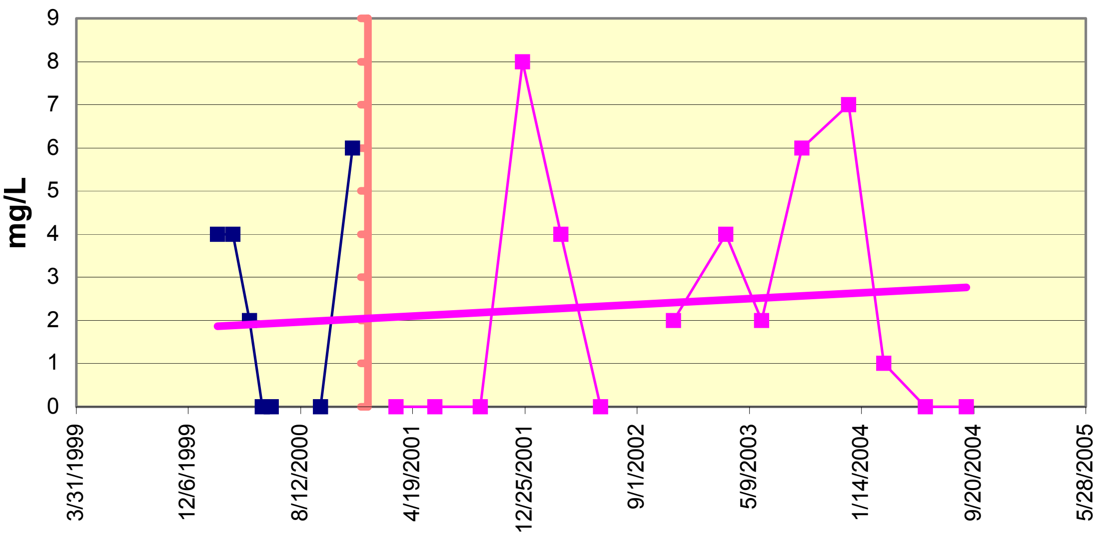


Figure 13.13 17990112 Buterbaugh BC-14 Field pH

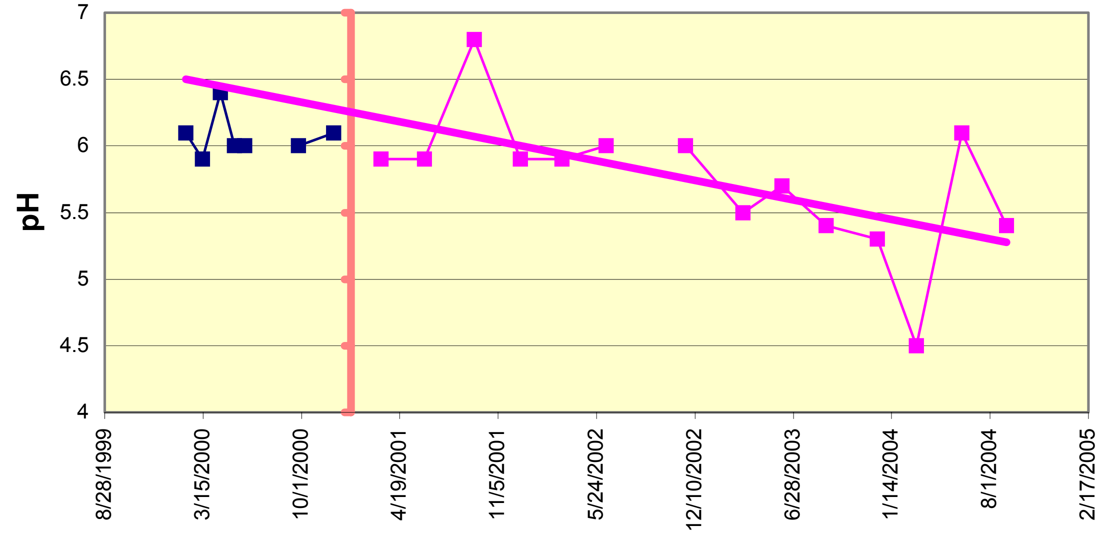
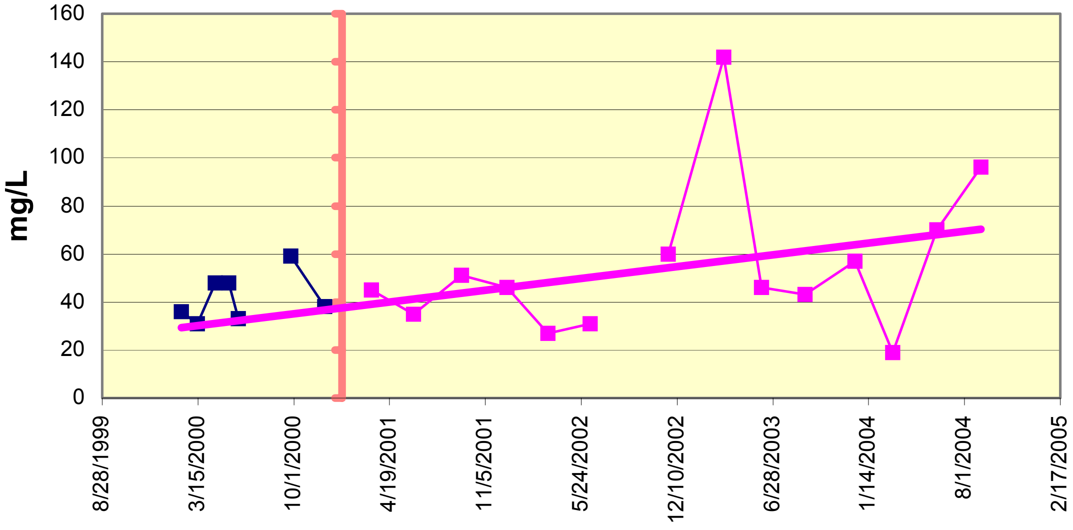
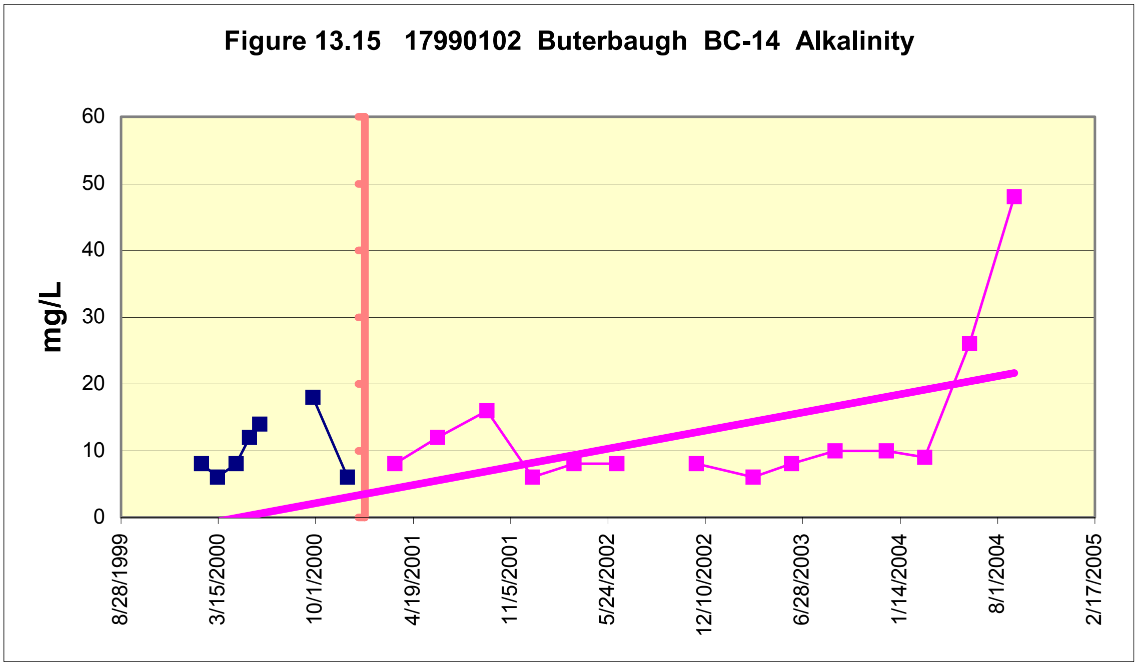


Figure 13.14 17990112 Buterbaugh BC-14 TDS





Concentrations for ash parameters measured annually showed no elevated levels at BC-14 and were therefore not graphed. However, data for calcium, magnesium, and chloride indicated slightly rising values for all three of these parameters after the mining and ash and lime placement got underway although their concentrations remained a tenth or less concentrations for these parameters at BC-3. The values for sodium were well below sodium concentrations at BC-3 and all under 1.0 mg/L in the baseline period and after mining started, showing no discernable trends. Potassium values are also low, ranging from 1.22 mg/L during the baseline period to 2.58 mg/L in the last sampling, with no apparent trend. Trace element data from BC-14 for arsenic, cadmium, selenium, and lead usually remained at analysis detection levels, (below 0.010 mg/L) and did not rise notably above baseline concentrations. While the levels of these ash parameters were not elevated, the annual frequency of sampling for them prevents a definitive conclusion that the ash is not contributing these constituents to waters at BC-14. This permit is not a subchapter F permit and contained no loading data.

Conclusion

The data available for this review shows degradation is occurring to shallow groundwater from the Buterbaugh operation, but the source or sources of the pollution cannot be effectively differentiated from the information available. The general upward contaminant trends from the major element graphs indicate waters are being degraded at sampling point BC-3 and to a lesser extent, at BC-14. Sulfate rose at BC-3 from levels below the DWS to nearly three times the DWS in recent samplings. Manganese concentrations in BC-3 that exceeded the DWS by 28 to 82 times prior to ash placement increased to levels 142 to 192 times the standard in the latest samplings. Iron concentrations in BC-3, however, declined from values that were 10 to 20 times over the DWS to levels closer to the standard during ash placement. This decline did not follow the total concentration of pollution measured by TDS that rose steadily beyond baseline levels from around 288 mg/L just after mining and placement of ash and lime started to nearly 900 mg/L in recent measurements, almost twice the DWS.

Amidst these rises, acidity declined at BC-3, while alkalinity rose and field pH rose after the subsiding of initial impacts from mining that had increased acidity and reduced alkalinity. Values for calcium and magnesium also rose steadily over the monitoring period, while chloride, sodium and potassium rose but to lesser extents at BC-3. These trends present a distinct possibility of contamination from the ash. However placed lime and broken overburden limestone could also be contributing these parameters at this site.

Higher selenium values that occurred at BC-3 during the rises of these constituents suggests ash as a source of the degradation, but the lack of information characterizing the chemistry of the lime or limestone at this site prevents these sources from being ruled out also as possible sources of selenium. Nonetheless increasing concentrations of several different ash parameters suggests in turn that markedly increasing concentrations of sulfates, manganese and TDS at BC-3 amidst a decline in acidity could be coming at least partially from the ash. It should be noted that sulfate leaches prolifically from most coal ashes placed in Pennsylvania coal mines, and manganese is also concentrated in conventional eastern Type F coal ashes and can readily leach from them under acidic pHs (see "The Influence of Fly Ash Additions on Acid Mine Drainage Production from Coarse Coal Refuse," Stewart *et al*., Virginia Tech, 1996).

Pollutant concentrations at BC-14 do not yet reflect degraded groundwater, but are increasing. TDS levels have increased from typically less than one tenth to between one fifth and one fourth the DWS. Sulfates from BC-14 were well below the DWS, but rose from around 15 mg/L before ash placement to a peak of 82 mg/L in 2003 before declining again to just over 20 mg/L. Concentrations for manganese exceeded its DWS 6 times at BC-14, although the levels usually remained less than a tenth of those at BC-3. Before ash placement, iron concentrations measured at BC-14 started with a spike of 2.71 mg/L, but then fell to levels below the DWS. After ash placement began, the iron concentrations hovered at or slightly above the standard, and in June 2003, iron rose to 2.06 mg/L.

Although pH values decreased, acidity did not increase and alkalinity eventually increased at BC-14. These trends suggest an impact from mining which could have disrupted limestone on the site that, in concert with lime and ash, eventually produced an increase in alkalinity at BC-14 just as monitoring ended at this point. The higher sulfate trend could also reflect some contamination from the ash. The sources for these trends at BC-14 could be better differentiated if there were chemical analysis of the ash, lime, site limestone and spoils for trace elements, calcium, magnesium, chloride, sodium and potassium. A decreasing pH at BC-14 results from acid mine water, but the shallow slope of the pH trend and rising alkalinity suggests some buffering by ash and/or lime placement and/or overburden limestone.

The gaps in monitoring data, short duration of monitoring – none occurred at most monitoring points after mining and ash placement were completed, low frequency of monitoring for trace elements and other ash parameters, deficient chemical analysis of ash and other alkaline materials at the site and absence of an upgradient monitoring point prevent a definitive analysis of the contribution of pollution from ash placement at this site. Although the permit's Operations Map shows a proposed monitoring well MW-2, uphill from the mining and ash placement operations, which would have functioned as an upgradient monitoring well, there was no data in the permit for this well. Most PADEP permits clearly label which monitoring points are upgradient or downgradient; this was not the case with this permit.

The data from this site suggests ash could be contributing to the contamination of water in this mining operation. Continuation of monitoring at this site after the completion of mining and ash placement which occurred in late 2004 is necessary to allow a fuller interpretation of the data. The impact of degradation at this site on the intermittent stream, Banion Run, is unknown as there are no monitoring data from this stream for annual ash parameters in the permit file. Monitoring for these parameters should be expanded to points on this stream downstream and upstream from the Buterbaugh Mine and additional points should be established monitoring waters directly in the ash/spoil configurations at the site. Additional chemical analysis of the ash, lime and limestone at this site should be undertaken. Monitoring parameters should then be expanded to include more constituents' exclusive to the leachate of the ash placed at this site to differentiate its impacts from the effects of lime additions, overburden limestone, and the mining itself. Additional parameters would likely include boron and molybdenum. Monitoring for ash parameters should be increased from an annual to at least a quarterly basis.

Chapter 5 – Mine Sites with Improvement

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Permit Review 14

ALLEGHENY VALLEY RESOURCES, INC., RUSSELTON MINE (PERMIT # 02930201)

Site Summary

The Russelton refuse reprocessing operation is located in West Deer Township, Allegheny County, Pennsylvania, in the Lower Allegheny River Priority Watershed 18A. About 1,500,000 tons of FBC ash from the Scrubgrass Power Plant were placed at this 56- acre site as Russelton's coal mine refuse was mined, shipped, and burned at the Scrubgrass facility. One thousand tons of coal refuse was burned each day, generating 650 tons of FBC ash for each 1000 tons of refuse, which was eventually returned and placed at the Russelton site. Ash placement commenced in 1997 and finished in 2002 or 2003. Monitoring started with sampling for background data in 1992 and continued from 1994 to 2004.

Russelton's coal mine waste pile resulted from deep mining the Upper Freeport coal seam. This coal seam is more than 200 feet below the permitted waste pile and has no effect on monitoring data. In addition, there are no pit floors or deep mine discharges at the site that could affect groundwater quality.

All of the data were collected from surface water monitoring points; no groundwater monitoring wells were drilled at Russelton. Data from three monitoring points were assessed in this analysis: an upstream point on Little Deer Creek, a downstream point on Little Deer Creek (below the waste pile site), and a direct discharge from a waste pile. These points are labeled S-1u, S-1d, and D-8, respectively. The discharge point D-8 is also a subchapter F monitoring point.

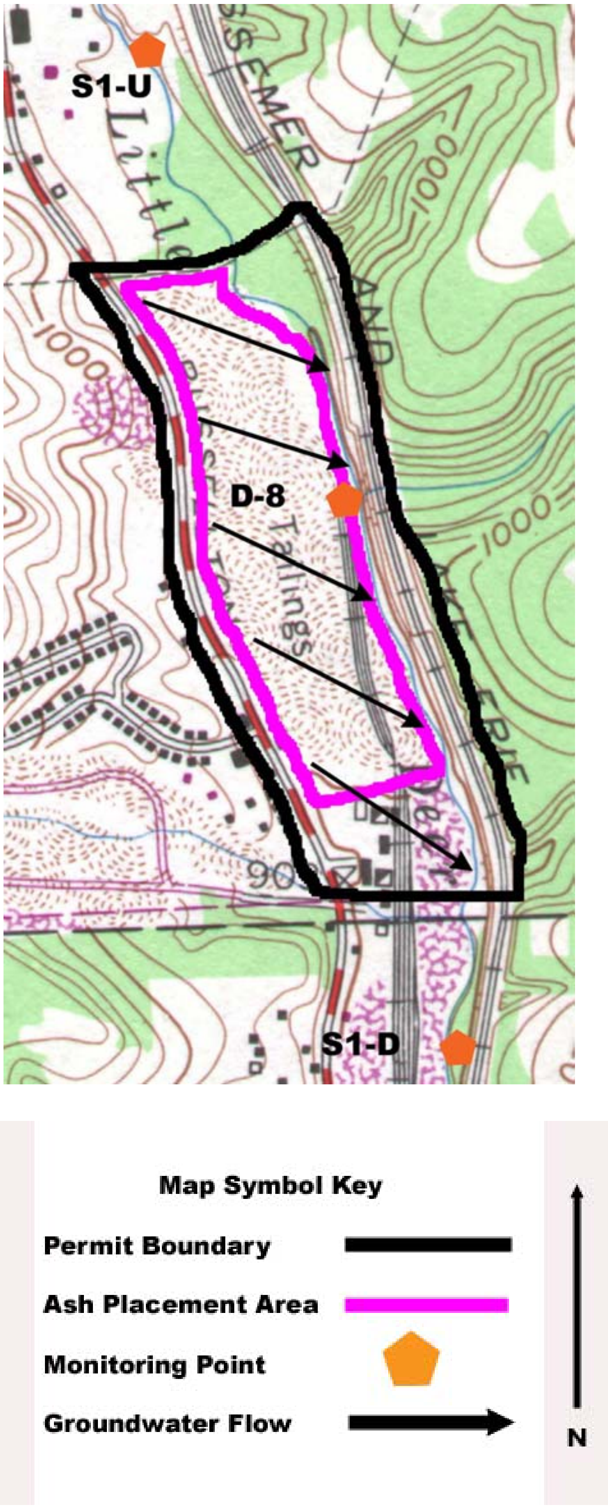
Geology

The bedrock at the Russelton site is in the Glenshaw Formation of the Casselman Group, Pennsylvanian geological time period. The sedimentary strata are barren of coal, except at the very bottom where the Upper Freeport seam is located. Any geological structure in the bedrock does not affect water flow relevant to the analysis of ash impacts.

Topography

The Russelton coal waste pile lies in a north-south trending valley in which Little Deer Creek flows (see map). The pile covers the floodplain of Little Deer Creek on the west side of the valley. The physiographic section is part of the Pittsburgh Low Plateau region. The pile elevation ranges from 890 feet above sea level (the surface of the creek on the downstream or south end of the site) to 960 feet above sea level.

Site Map: Russelton



Russelton Waste Coal Operation Map (Permit # 02930201)
Scale: 1" = Approximately 800'

Groundwater

It is assumed that most of the groundwater flow through the coal waste pile is to the east toward Little Deer Creek. All of the discharge monitoring points, including D-8, are on the east side of the pile where it borders the creek. Since the surface of the original floodplain also has a slight southerly slope, some of the groundwater is expected to flow to the southeast.

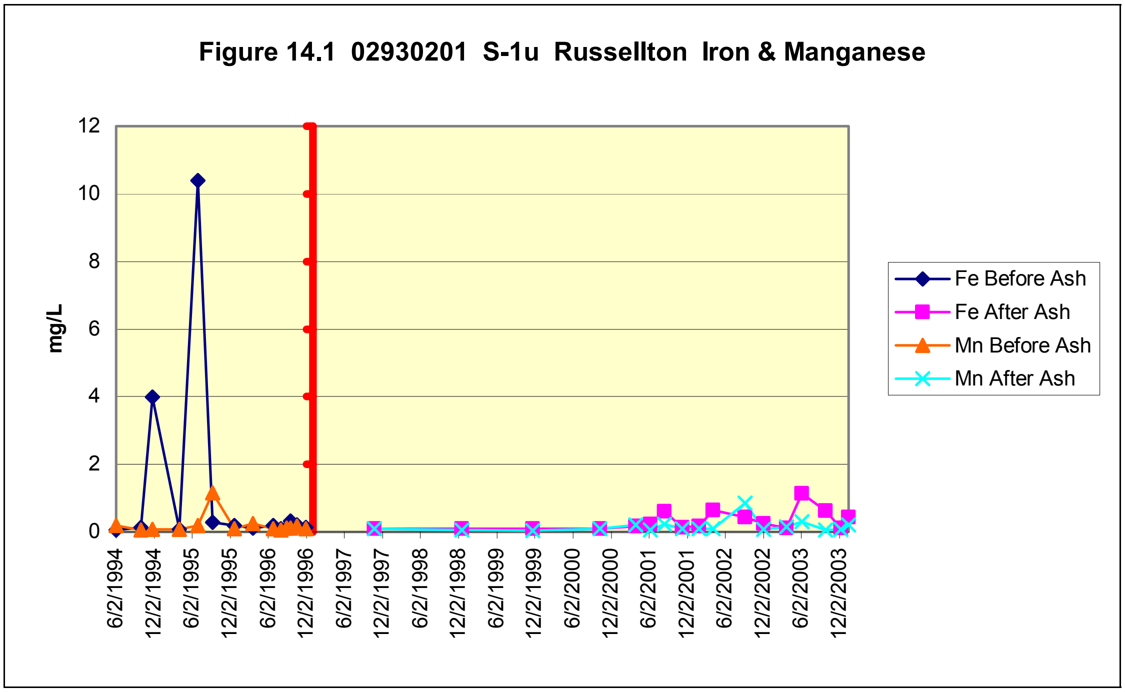
Groundwater monitoring data: Discussion

The water monitoring program and data set for this permit are comprehensive in comparison to the other permits reviewed in this report. This site has over 15 discharge sampling points, plus many in the surrounding watershed. The three selected monitoring points with the most complete data sets that best represent the entire site are upstream and downstream surface water data collecting points, S-1u and S-1d, and the waste pile discharge point, D-8, which also has with the the most complete flow data. D-8 is also a subchapter F monitoring point. For purposes of measuring impacts from ash placement, the baseline monitoring period extends to the end of 1996.

S-1u

Elemental concentration plot graphs for the upstream sampling point, S-1u, are shown in figures 14.1, 14.2, and 14.4. The data for iron (figure 14.1) show a high value of 3.99 mg/L in November 1994 and an anomoulously high value of 10.4 mg/L in June 1995 before the Russellton permit's replacement of gob with ash began. The highest iron value after the operation started was 1.14 mg/L in June 2003. The highest manganese value before ash placement was 1.16 mg/L in September 1995 while the highest manganese at S-1u after ash placement was 0.85 mg/L in September 2002. There were modest rises in the upstream surface waters in both iron and manganese from 2001 onward. The iron spike in June 1995 may be an outlier resulting from sampling difficulties or could have resulted from disturbance at an upstream site or from another event(s) not connected with the activities at the Russellton site. There were peaks in sulfate and acidity in this sampling and a much higher peak in iron at S-1d (to be discussed) also in the same sampling.

As stated, a spike in sulfate (figure 14.2) also occurred in June 1995 at 1890 mg/L. Sulfate concentrations rose until May 1999, fell until March 2001, and then rose again to a high of 182 mg/L in December 2002 before falling again in 2004. The overall concentrations of sulfate slowly increased during the life of this operation but did not surpass the water quality standard of 250 mg/L that applies in surface waters used for public drinking water supply.



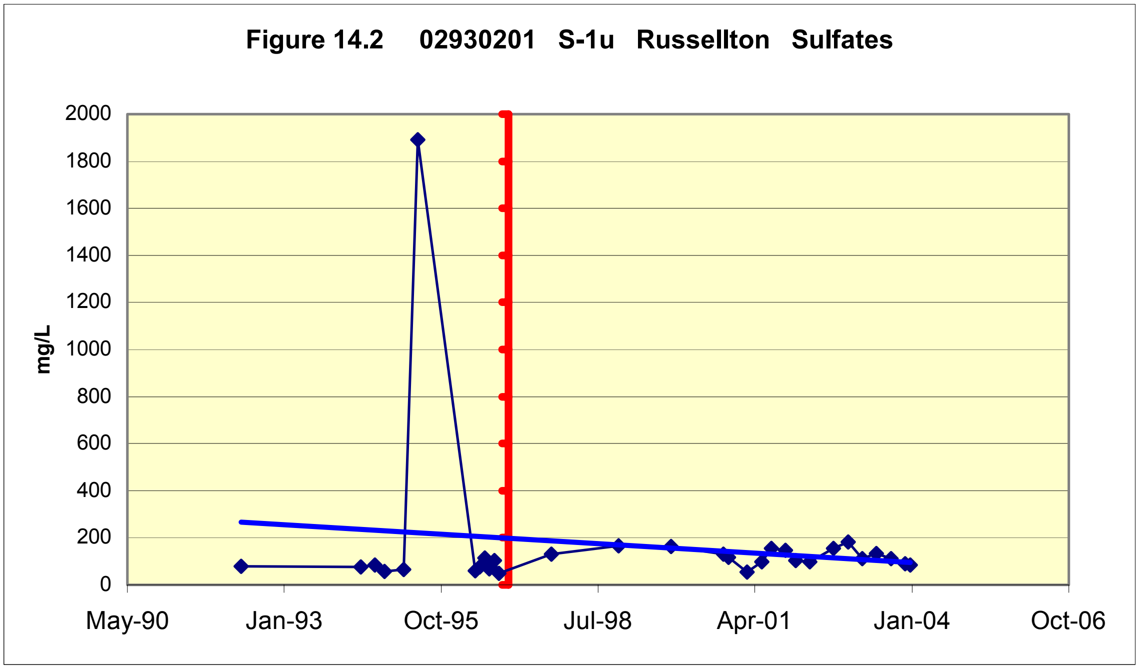
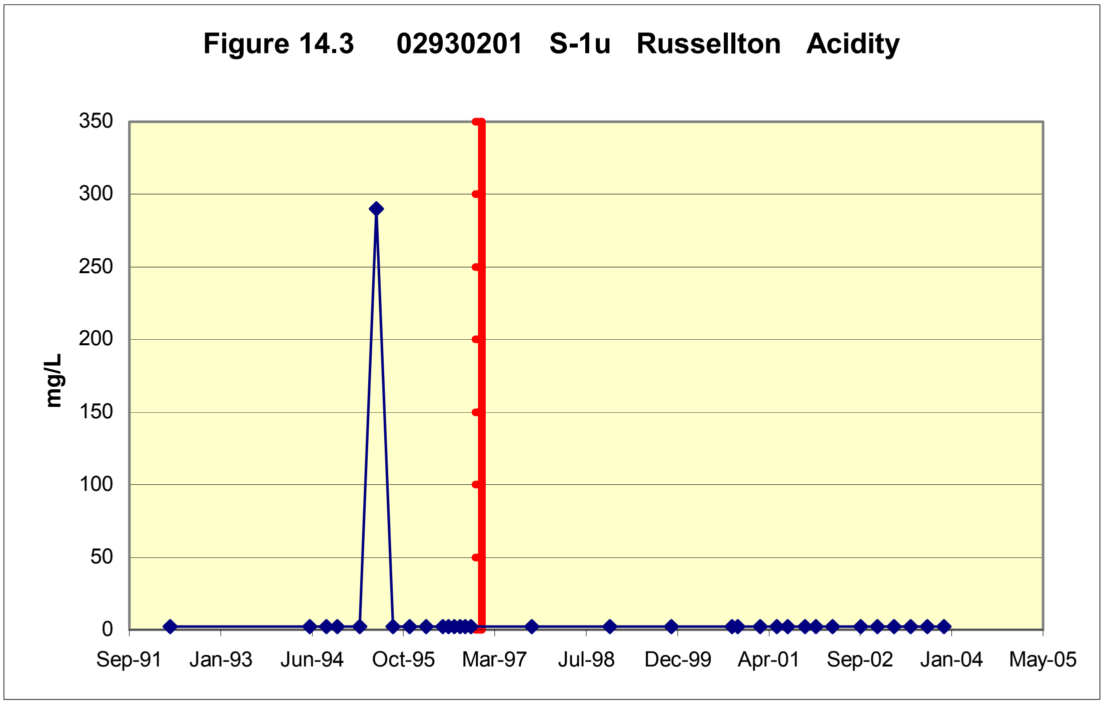
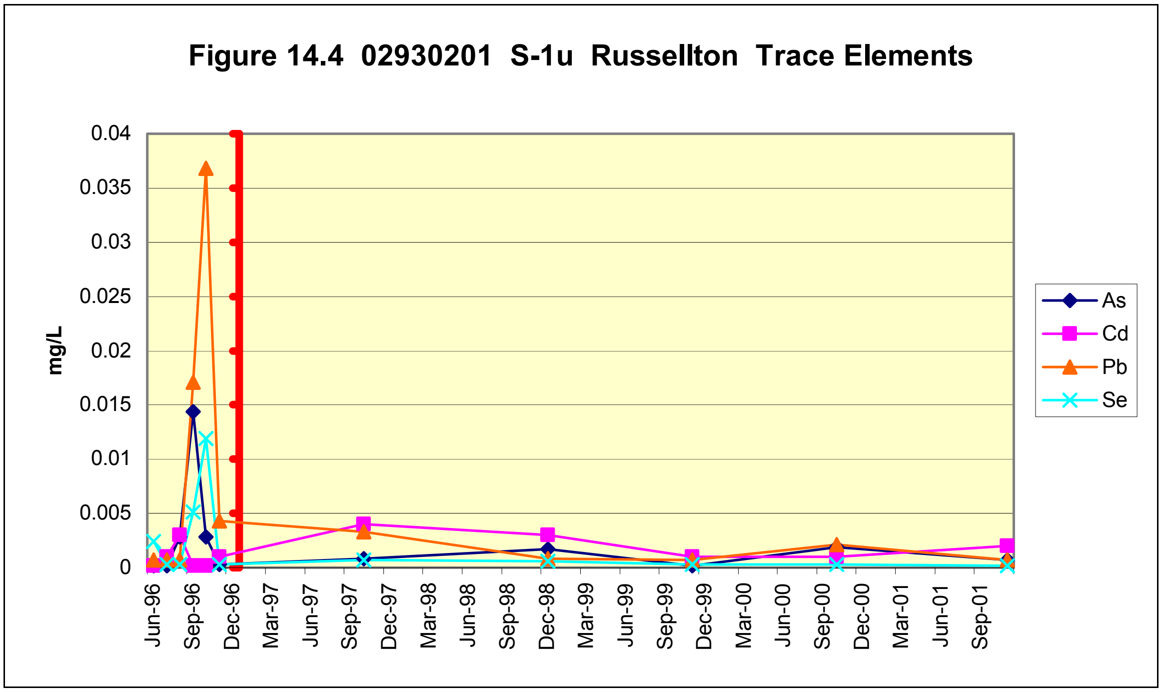


Figure 14.3 illustrates the acidity trends at point S-1u. Other than a spike to 290 mg/L in the same June 1995 sampling from which high iron and sulfate were measured, acidity remained under a detection limit of 2 mg/L.



The trace elements, arsenic, lead, and selenium (figure 14.4) at S-1u peaked during the baseline measurement period in September and October 1996 although the highest value for cadmium, 0.004 mg/L, was measured in October 1997. Otherwise, concentrations for these trace elements were relatively flat and about half of the measurements at detection limits below 0.001 mg/L.

The data from S-1u depicts stream water not impacted by the Russelton operation.



S-1d

The concentrations for iron, manganese, and sulfates (figures 14.5 and 14.6) for the downstream surface sampling point S-1d were much greater than those for S-1u, reflecting pollution from the Russelton site. The iron concentrations (figure 14.5) included a spike in the same June 29, 1995 sampling in which a spike occurred at S-1u, but the S-1d measurement was about 40 times as high as occurred at the upstream point, (450 mg/L vs. 11 mg/L). Unlike the spike at S-1u, the spike at S-1d was not accompanied by spikes in sulfate or acidity (although peak concentrations of both of these parameters were measured in the subsequent September 1995 sampling at S-1d). There were also concentration peaks of iron in October 1997 (17.85 mg/L), December 1998 (23.4 mg/L), November 1999 (15 mg/L) and September 2002 (45.9 mg/L) at S-1d that were absent at S-1u. Manganese (figure 14.5) rose to 6.7 mg/L in June 1995 and 12.8 mg/L in September 1995 before falling back to levels below 1 mg/L for the rest of the baseline period and two thirds of the measurements during the gob remining and ash placement at Russellton. After these activities started, there were seven measurements of manganese over 1 mg/L at S-1d compared to none over 1 mg/L at S-1u. However the highest measurement at S-1d, 6.2 mg/L in September 2002, occurred when the highest manganese after the baseline period at S-1u was measured (0.85 mg/L).

Although the highest concentration of sulfate at S-1d, 790 mg/L, occurred before ash placement on the pile in September 1995, sulfate concentrations were generally higher after gob remining and ash placement began, with an average concentration before ash placement of 233 mg/L compared to an average concentration of 256 mg/L after ash placement (figure 14.6). Nonetheless there was overall declining trend for sulfate during ash placement. Exceptions included a notable rise from 1997 through 1999 peaking at

735 mg/L in December 1998 and a peak again in September 2002 to 699 mg/L. Three out of 16 measurements before ash placement were above the PA water quality standard for public water supply intake waters of 250 mg/L, while 7 of 20 measurements after ash placement were above this standard. The two peaks in sulfate during the baseline period could have occurred from disturbance of the pile, while the peaks during the replacement of the gob with ash could have resulted from pile disturbance and/or a from a large amount of FBC ash placement.

The acidity at S-1d (figure 14.7) had a similar pattern to the sulfates with the highest value occurring in September 1995, prior to ash placement followed by a notable rise from 1997 through 1999 although acidity concentrations stayed low during higher sulfate measurements in 2001 and 2002. Sampling frequencies for the downstream major elements varied with quarterly sampling in Module 8 reports from 1994 through 1997 for parameters such as iron, manganese, and sulfate considered to be both mining and ash parameters, annual sampling for these parameters under Module 25 reports from 1998 through 2000 and quarterly sampling again from 2001 through 2003.

The highest concentrations for trace elements at S-1d (figure 14.8) were measured during the baseline period, with a peak in lead (0.0536 mg/L), arsenic (0.0262 mg/L), and selenium (0.0113 mg/L) concentrations in October 1996 and the highest cadmium in August 1996 at 0.008 mg/L. After ash placement operations were underway there was a rise in December 1998 to 0.0099 mg/L for arsenic, 0.0095 mg/L for selenium and 0.005 mg/L for cadmium and a lead measurement in October 1997 of 0.0032 mg/L, but otherwise concentrations for these trace elements stayed lower than most baseline values and below detection limits in half of the measurements. Nonetheless the highest selenium and cadmium concentrations both before and after ash placement were well over the USEPA recommended water quality standard (Fresh Water Chronic Criteria) for these elements. And the high baseline measurement for lead exceeded this water quality standard by 17 times, while the lead measurement in October 1997 was equal to this standard. The December 1998 rise in these trace element concentrations did not occur at S-1u. Nevertheless the existence of only 5 samplings over 8 years of monitoring after ash placement began limits meaningful assessment of trace elements at these monitoring points.

Figure 14.5 02930201 S-1d Russellton Iron & Manganese

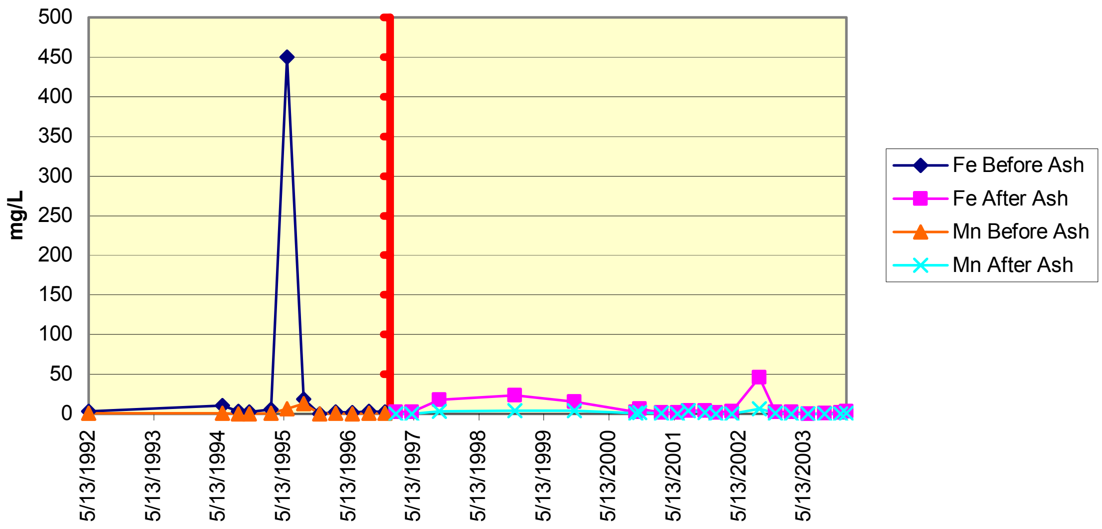
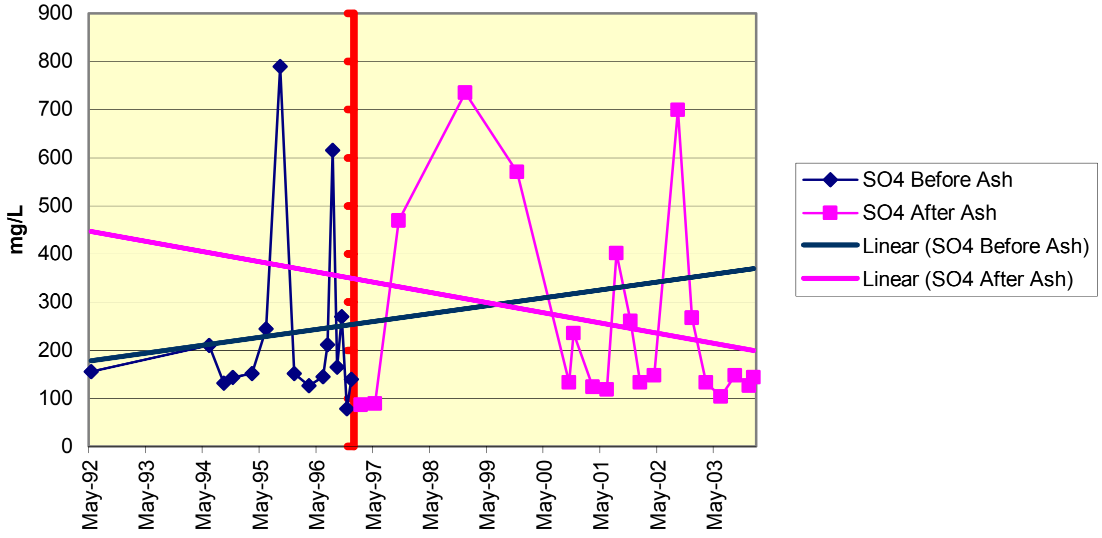


Figure 14.6 02930201 S-1d Russellton Sulfate



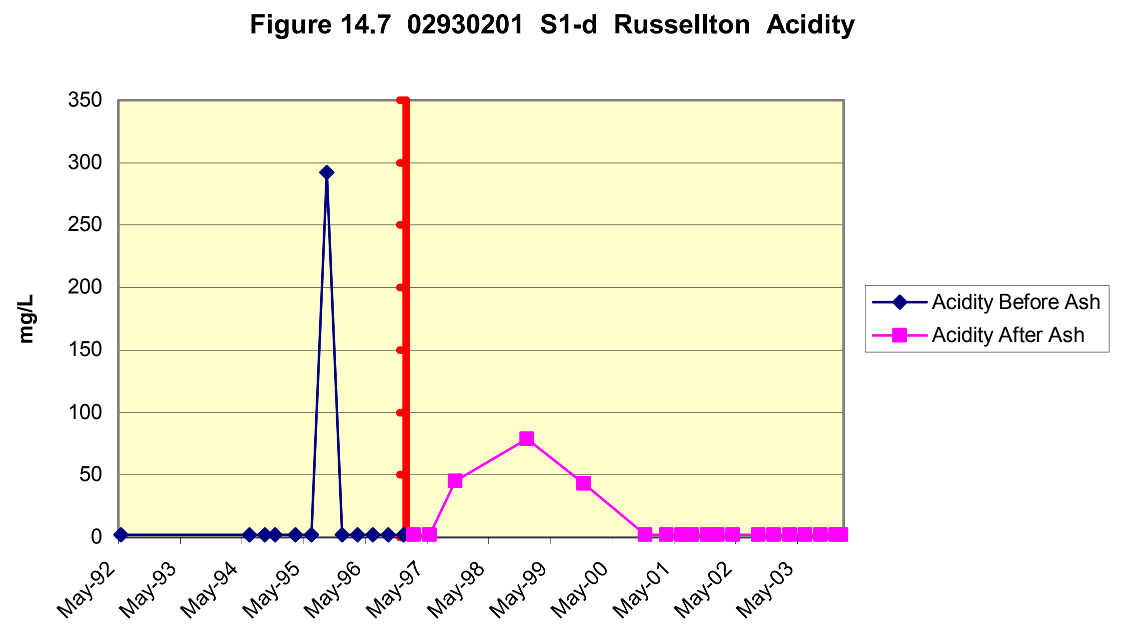


Figure 14.7 02930201 S1-d Russellton Acidity
mg/L
350
300
250
200
150
100
50
0
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
Acidity Before Ash
Acidity After Ash

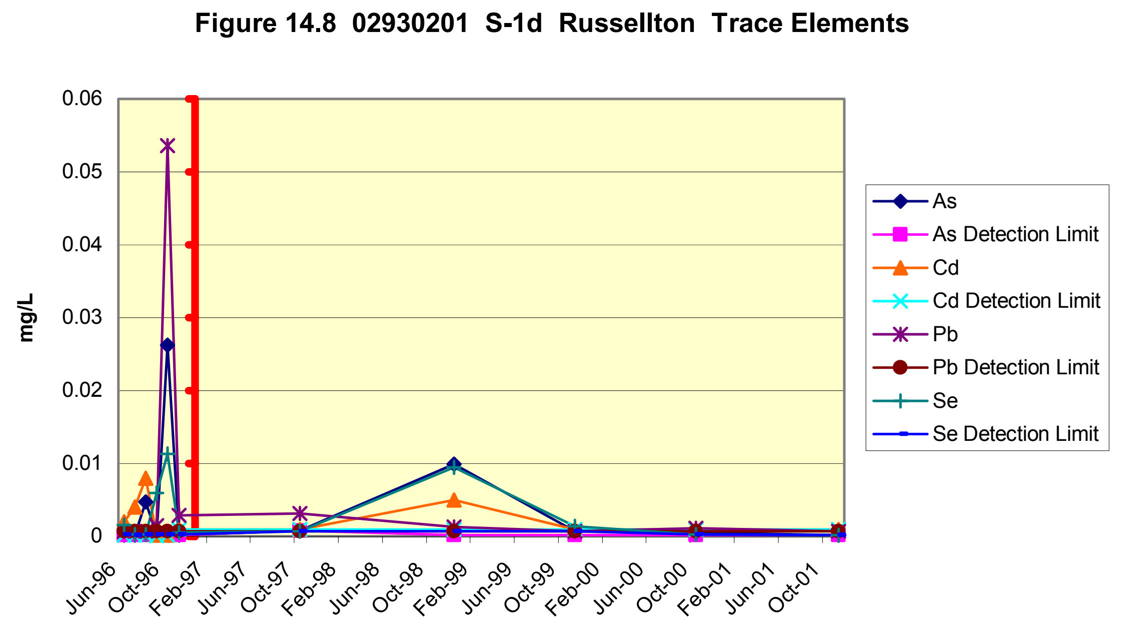


Figure 14.8 02930201 S-1d Russellton Trace Elements
mg/L
0.06
0.05
0.04
0.03
0.02
0.01
0
Jun-96
Oct-96
Feb-97
Jun-97
Oct-97
Feb-98
Jun-98
Oct-98
Feb-99
Jun-99
Oct-99
Feb-00
Jun-00
Oct-00
Feb-01
Jun-01
Oct-01
As
As Detection Limit
Cd
Cd Detection Limit
Pb
Pb Detection Limit
Se
Se Detection Limit

Point D-8

Figure 14.9 shows iron, manganese and aluminum concentrations at Subchapter F point D-8, a discharge from the waste pile into Little Deer Creek. The data sets for these major elements are comprehensive, as samples were taken monthly over the active time span of the site. There are two gaps, one from June 1993 to April 1994 and one from March 1997 to February 1998. The concentrations at D-8 were higher than iron, manganese and aluminum concentrations at either stream point (with the exception of the June 1995 peak in iron at S-1d) but fluctuated to a large degree. High peaks in the latter half of 1995 and in 1998 and 1999 dominated the trends depicting a bimodal distribution. All three elements have very similar patterns often peaking and dropping at the same time. Each peak may reflect an ash placement event or greater disturbance of the waste coal pile. While the highest concentrations for iron, manganese and aluminum all occurred after ash placement started, after June 2000, concentrations of these pollutants decrease notably and flatten, probably due to the end of the remining disturbance. This suggests that the remining may have been more responsible for the rises in these elements than the ash placed at the site.

The sulfates (figure 14.10) have a trend similar to these three elements but with much higher concentrations. The correlation of the high sulfate values with high aluminum concentrations, implies the source of the leachate could be FBC ash. The sulfate numbers are higher than those of the downstream samples. The acidity at D-8 has a higher average value than points S-1d and S-1u (figure 14.11). The acidity pattern is somewhat similar to the sulfates, except acidity drops more decisively and levels off in the fall of 1999. Higher sulfate measurements in January 2001, March 2002, and November 2003, exceeding the 250 mg/L secondary DWS and water quality standard, occur when acidity stays below a 2 mg/L detection limit.

Trace elements, arsenic, cadmium, lead, and selenium (figure 14.12), reach peak concentrations at D-8 before and after ash placement starts with lead and selenium peaking at 0.037 mg/L and 0.0752 mg/L respectively in October 1996 and arsenic and cadmium reaching 0.0876 mg/L and 0.053 mg/L respectively in October 1997. These are the highest levels of arsenic, cadmium and selenium recorded at any of the three monitoring points examined in this review. In addition, the D-8 concentrations are more than several times the water quality standards for lead, cadmium, and selenium and more than 8 times the drinking water standard for arsenic. There are no other levels exceeding standards after the October 1997 measurement. However D-8 was recorded as "DRY" in the annual sampling for trace elements in 1999, and there are no data for 2002. Thus four measurements for trace elements from the beginning of 1997 until 2004 does not allow those assessing this site to know how mobile these elements are at D-8 with much degree of confidence.

Figure 14.9 02930201 D-8 Russellton Iron, Manganese and Aluminum

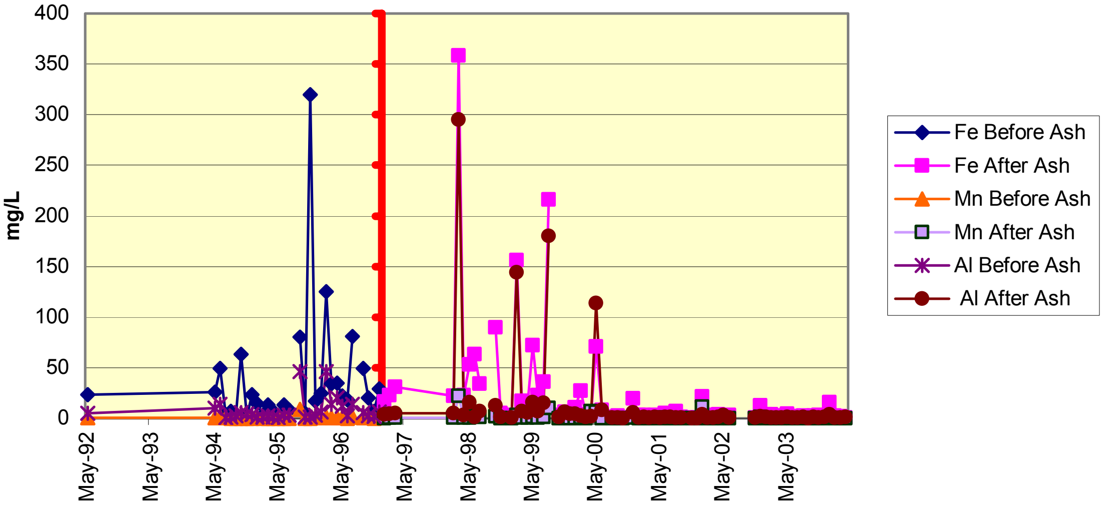
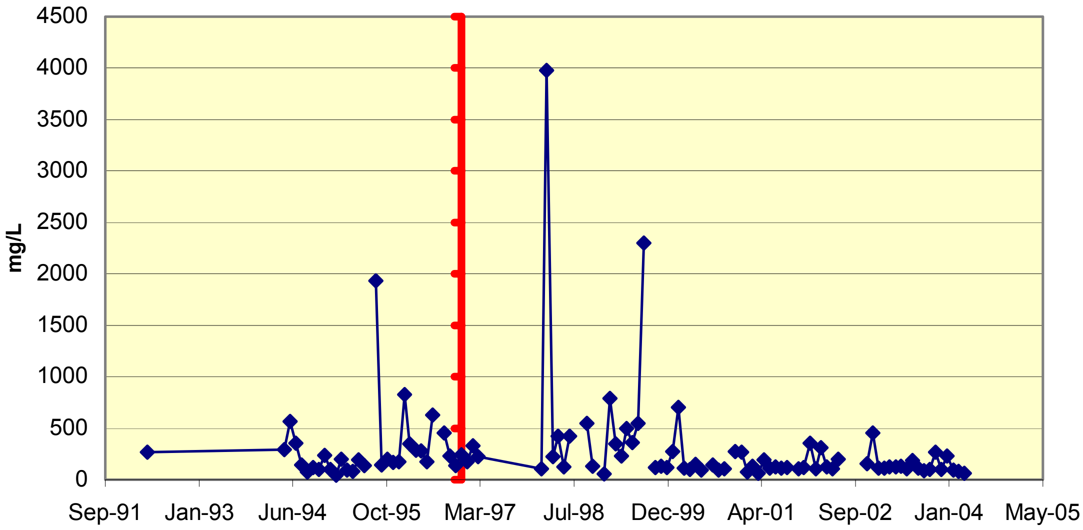


Figure 14.10 02930201 D-8 Russellton Sulfates



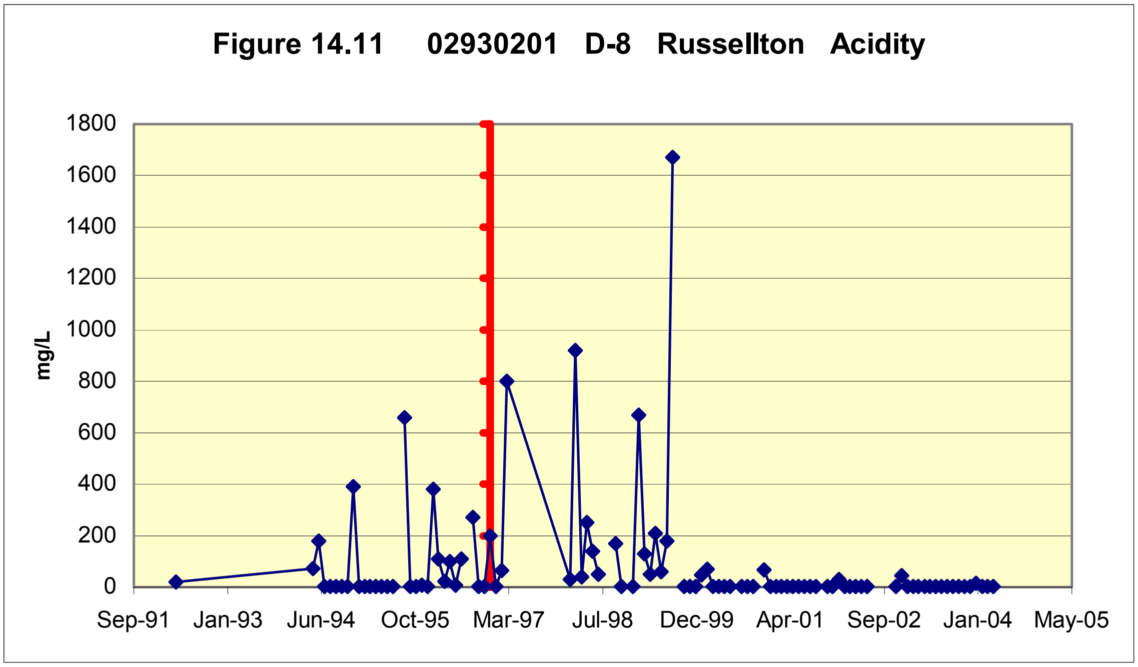


Figure 14.11 02930201 D-8 Russellton Acidity
mg/L
1800
1600
1400
1200
1000
800
600
400
200
0
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05

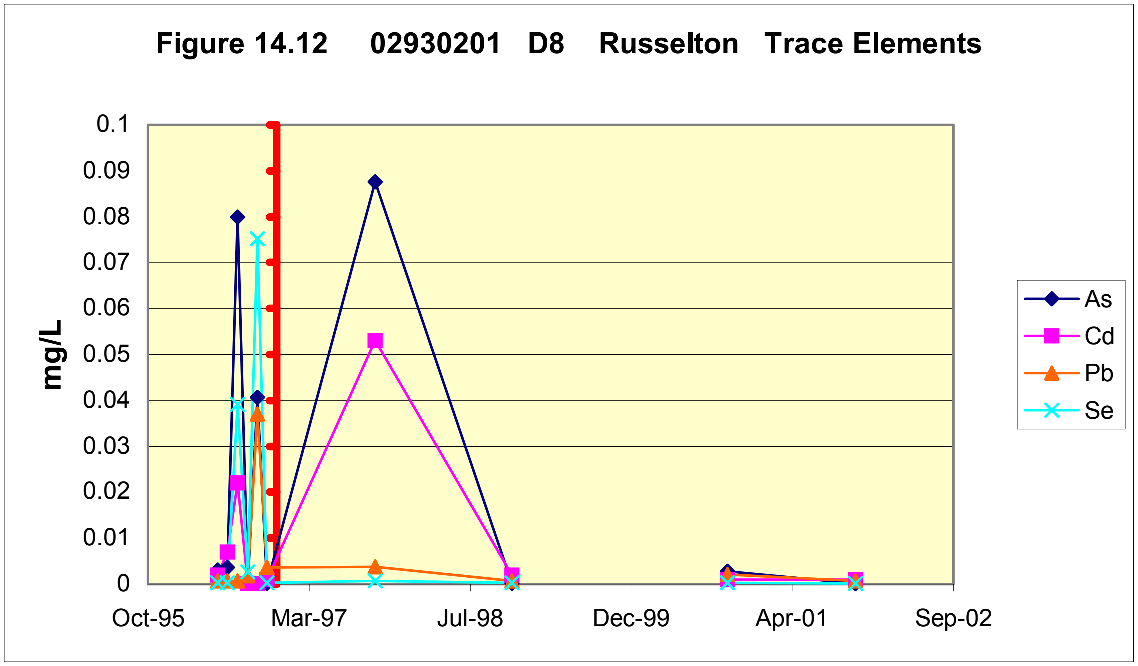


Figure 14.12 02930201 D8 Russelton Trace Elements
mg/L
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
As
Cd
Pb
Se

Loading Data

Loading data, expressed in pounds of contaminant per day, were recorded for subchapter F monitoring point D-8. The total loading, which is the sum of all the discharge points at the site, was also recorded.

Figure 14.13 illustrates loading at D-8 for iron, manganese, and aluminum. The patterns for these three elements are similar, with iron having the highest average concentration, followed by aluminum and manganese. Although the highest loading levels occurred after remining and ash placement were underway for more than a year, the amount of iron, manganese and aluminum released into the environment decreased slightly over time at D-8. Figure 14.14 shows the sulfate loading data for D-8; by far the highest loading value occurred in March 1998 at 1674 lbs of sulfate exiting D-8 per day when a peak also occurred in loading for iron, manganese and aluminum, but the average loading of sulfate also decreased gradually over time. Of note however is that one of the last loading measurements available (in October 2004) found 159 lbs of sulfate leaving the site per day at D-8, a larger amount than any loading measured during the baseline period, which was occurring after reclamation would have been in its advanced stages at the site.

The total loading data for these parameters from all subchapter F discharge points at the Russellton site are almost complete and span monthly measurements from April 1995 to April 2004. Only the data from July 2001 to December 2001 is missing. Figure 14.15 is a graph of total iron loading for the whole Russellton site; the average starting value was about 55 lbs/day and dropped to fewer than 10 lbs/day. The manganese loading data (figure 14.16) shows a less dramatic decrease, averaging 1.5 lbs/day decreasing to about 0.75 lbs/day. The variations in the graph curve pattern are regular and repeating and suggest seasonal water flow variations. The aluminum loading graph (figure 14.17) is similar to that of iron although with a more gradual average decrease from about 18 lbs/day to 5 lbs/day. The total acidity loading for the site (figure 14.18) shows a noticeable decrease of nearly 200 lbs/day in the average amount of acidity leaving the site over the entire period of monitoring at the Russellton site. However it should be noted that total acidity loadings increased from under 5 lbs/day in the fall of 2003 to values between 112- 225 lbs/day from December 2004 through April 2004 in the last five measurements available for this report.

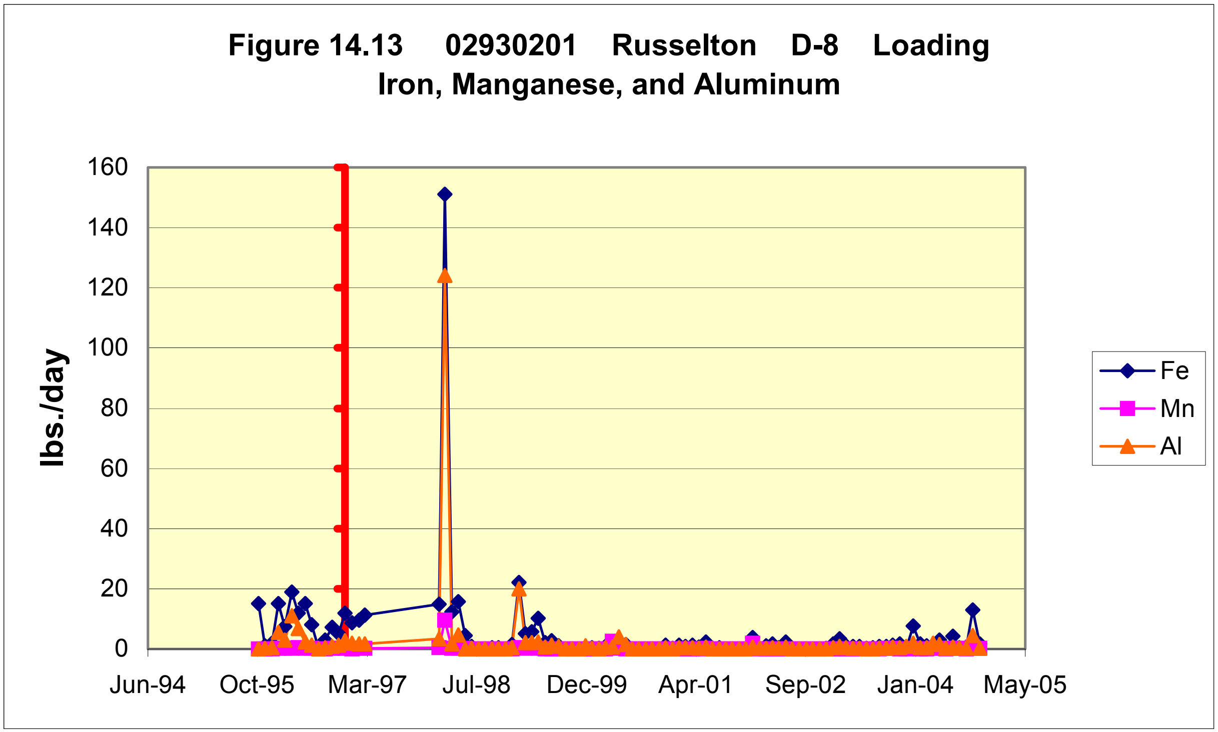


Figure 14.13 02930201 Russelton D-8 Loading
Iron, Manganese, and Aluminum
lbs./day
160
140
120
100
80
60
40
20
0
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Fe
Mn
Al

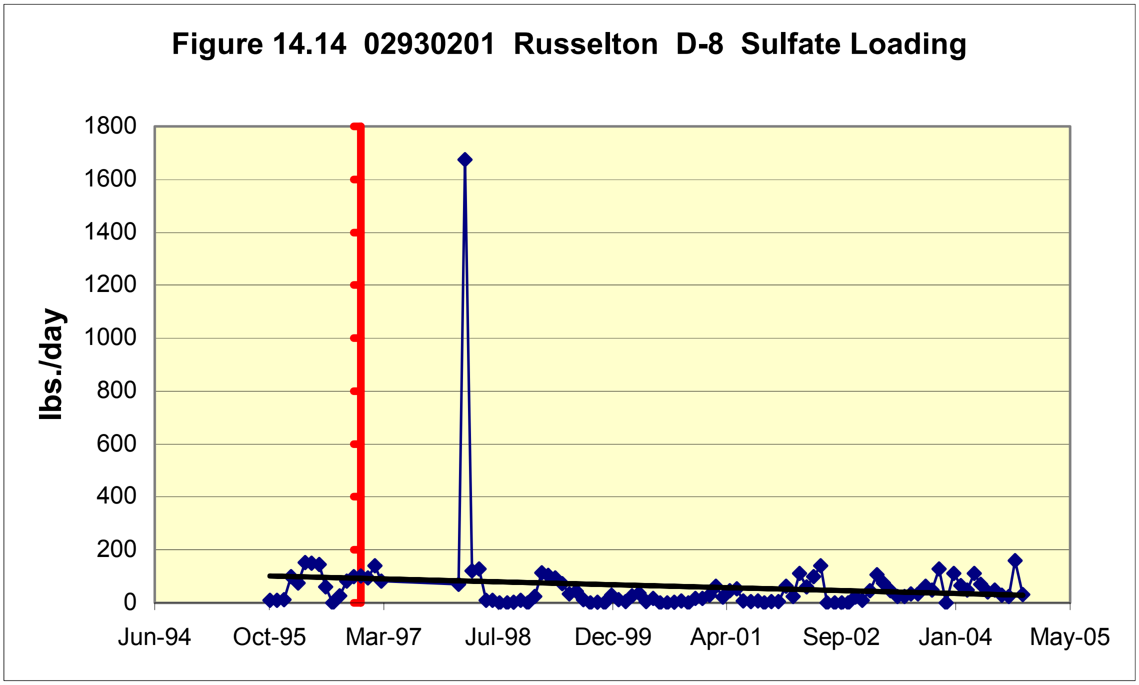


Figure 14.14 02930201 Russelton D-8 Sulfate Loading
lbs./day
1800
1600
1400
1200
1000
800
600
400
200
0
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05

Figure 14.15 02930201 Russelton All Points
Total Iron Loading

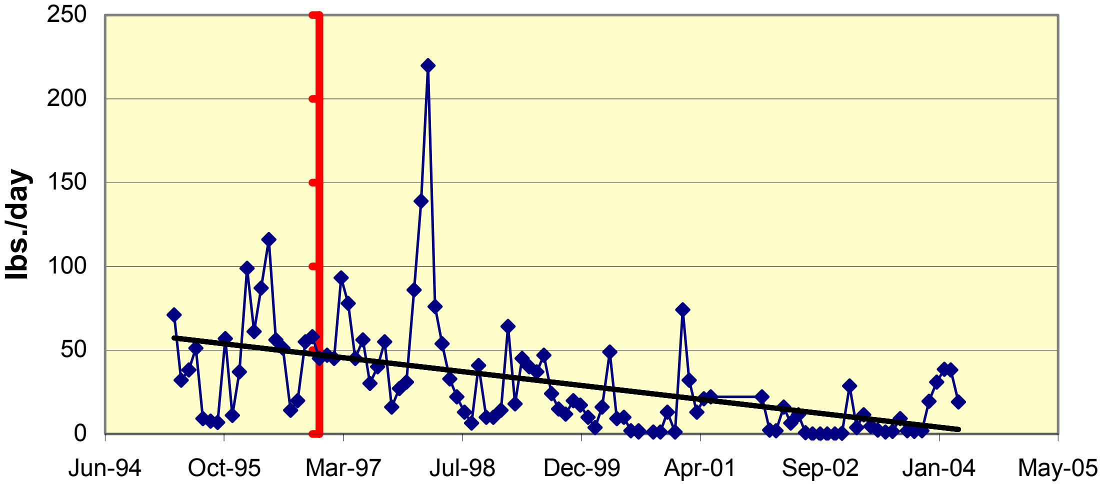


Figure 14.16 02930201 Russelton All Points
Total Manganese Loading

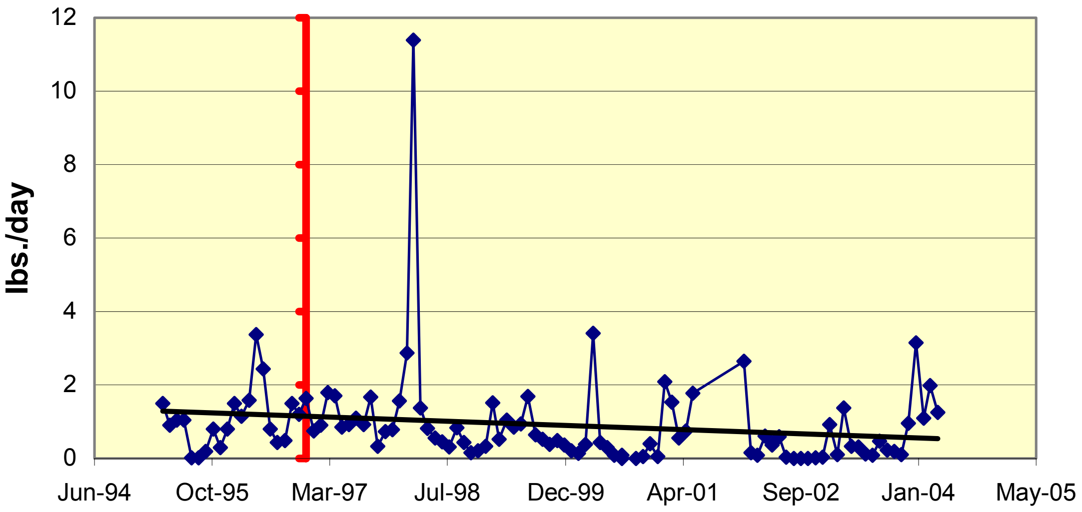


Figure 14.17 02930201 Russelton All Points
Total Aluminum Loading

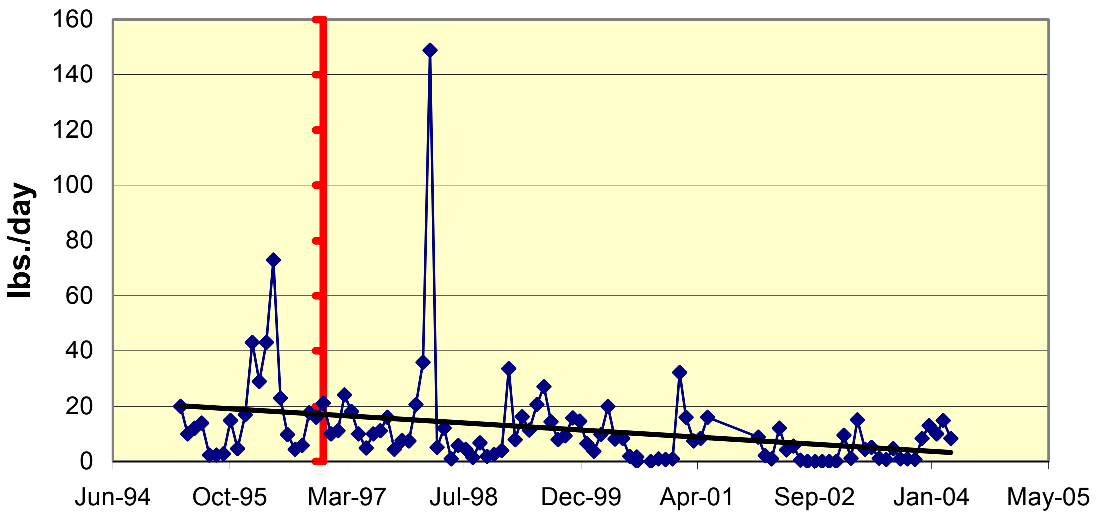
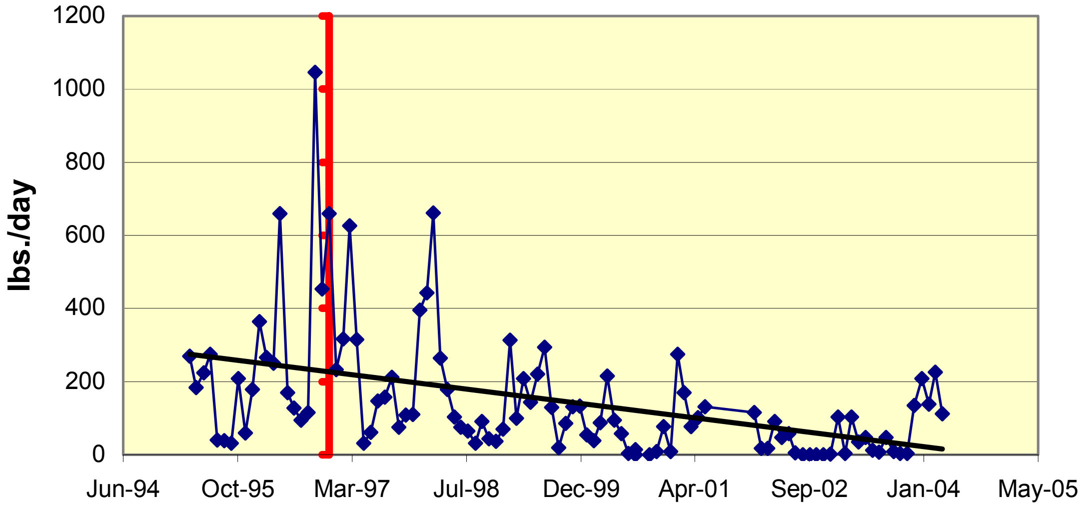


Figure 14.18 02930201 Russelton All Points
Total Acidity Loading



Conclusion

The Russelton site has a relatively complete data set compared to other permits, but there are still significant gaps, particularly in trace element values. Despite the measurement in December 1998 of dissolved arsenic and cadmium in the discharge at the base of the gob pile (D-8) that were higher than any baseline concentrations and substantially above federal water quality and drinking water standards, only two more sampling events for trace elements were taken from this discharge in 2000 and 2001

It appears that the stream (Little Deer Creek) has been suffering water quality degradation from major elements due to the Russelton waste coal mining operation, and possibly FBC ash placement, and other sources of contamination upstream but that this degradation has been abating over the past four years. Notwithstanding this improvement, all of the major elements graphed at D-8 and at downstream monitoring point S-1d have readily exceeded federal and state safe drinking water standards and ambient water quality criteria for iron, manganese, aluminum and sulfate on numerous occasions. The increases in concentrations from the upstream to the downstream data are considerable, even though the contaminants flowing from the site were presumably diluted by the increasing volume of stream flow. Concentrations of iron, manganese, aluminum, sulfate and acidity also underwent slight increases after remining and ash placement started at S-1d and D-8. However significant decreases in concentrations of these constituents in the last four years of monitoring (2000-2004) are what is most noticeable in the data.

Loading data trends also indicate an improvement in discharge contaminant levels over the life of the site. The amount of iron, manganese, aluminum, and acidity leaving the site in pounds per day over the life span of the operation has been clearly decreasing, indicating an improvement with regard to AMD pollutants. Thus, remining and reclamation with FBC ash appears to have been successful in addressing AMD.

The trace element data showed declines in concentrations of trace elements (lead and selenium) from baseline measurements at the monitoring points. The measurement of dissolved arsenic at 0.0876 mg/L (more than 8 times the DWS) and dissolved cadmium at 0.053 mg/L (more than 10 times the DWS) at D-8 in October 1997, after ash placement was underway at the site, were notable exceptions. The latter concentration is 212 times the federal freshwater chronic water quality standard, "the Criterion Continuous Concentration" for cadmium, which is a more relevant standard given the D-8 point is a discharge to Little Deer Creek. However a paucity of data for trace elements (only five measurements after the baseline period at S1-d and S1-u and four measurements after the baseline period at D-8 over an eight year period) prevents definitive conclusions about trends in their concentrations. As there is no trace element loading data, it was also not possible to assess the actual amount of trace element material carried by Little Deer Creek from the Russelton Site. Given the volume of FBC ash placed at Russellton (approximately 1,500,000 tons), monitoring should continue at this site, and additional monitoring for trace elements and other constituents that would be reliable indicator parameters for ash contamination (based on an adequate characterization of the ash placed here) such as boron, molybdenum, calcium and magnesium should be undertaken.

Permit Review 15

WILDWOOD WASTE COAL OPERATION (ACV POWER CORPORATION)
PERMIT # 02940201

Site Summary

The Wildwood waste coal operation is located in Hampton Township, Allegheny County, Pennsylvania, in the Lower Allegheny River Priority Watershed 18A. The site covers 32 acres and contained about 2,000,000 tons of coal waste or "gob" spread over 29 of those acres in large, steep piles. Much of this gob was removed and burned at the Scrubgrass Power Plant in Venango County, using fluidized bed combustion technology. The resulting waste coal ash (about 454,000 tons) was placed back in the site.

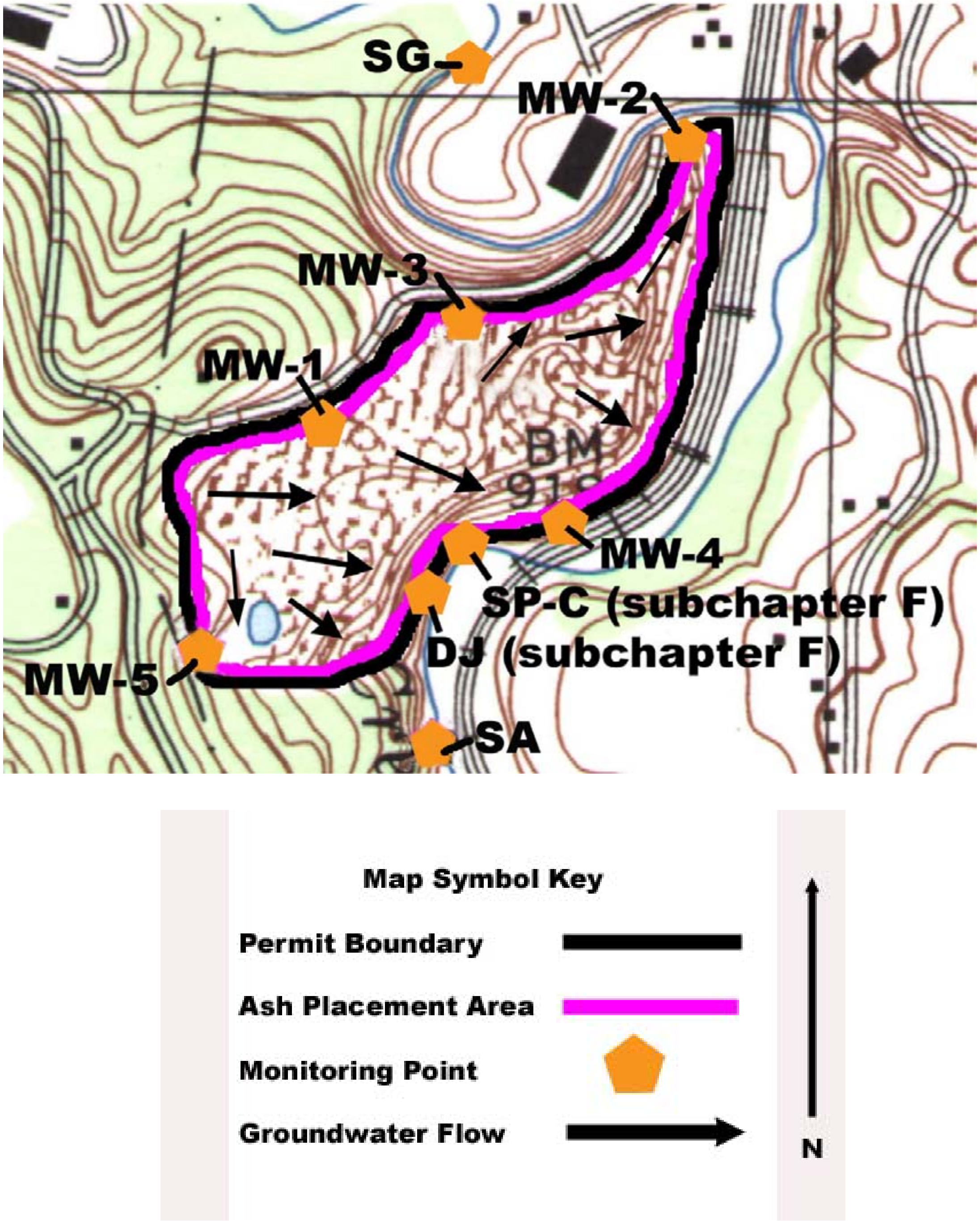
The original deep mine (Wildwood Mine) has been abandoned for several years. No coal seams were exposed in this operation; the Upper Freeport Coal is about 200 feet below the lowest portion of the site. No ash was placed in an abandoned shaft mine underneath the site.

Most of the operation was conducted under a subchapter F remining permit although Pine Creek, a stocked trout stream adjacent to the site, was not being appreciably degraded by AMD from the site. Ash placement was authorized with a permit revision issued on March 24, 1995. According to the permit the ash was to serve two purposes: (1) neutralize residual AMD flowing from the waste piles after most of the gob was removed, and (2) help control fires in and on the waste piles. Remining of the gob pile and return of ash to the site began at an unspecified date after the first quarter in 1995 and ended by August 1999 when the permit was renewed for "reclamation only." During the remining, ash was placed and compacted in wetted layers on top of the remaining "red dog" and waste pile materials to set up in a cementitious form before being covered by one foot of top soil. Ash configurations reportedly would have been up to four feet thick if the operator's plans were followed. Gob mining moved in "blocks" from the north to the south and southwest across the piles with ash placement and final surface revegetation following two blocks behind the mining. Monitoring by the operator stopped in 2002, and PADEP had apparently stopped monitoring the site by 2004, although the latest data available for this report extends only through the second quarter of 2002.

Geology

The geology of this site has little bearing on the operations, as the mined coal seams are far below the surface. Any regional or local structure would have had little effect on water flow in the coal waste piles at this site.

Siate Map: Wildwood



Wildwood Waste Coal Operation Map (Permit # 02940201)
Scale: 1" = Approximately 500'

Groundwater and topography

The relevant groundwater flows mainly at the contact of the relatively porous waste pile material and the less porous, underlying soil and bedrock. This contact provides a conduit for water flow, and the direction is determined by the topography of the surface before the waste was placed. Groundwater flow is primarily through the gob to the east (see map below) according to the PADEP permit maps, water level elevation data in well logs and monitoring reports and discussion in the Module 25. All of the surface water and shallow groundwater flows into Pine Creek which flows to the south into the Allegheny River.

Groundwater monitoring data: Discussion

There were five monitoring wells installed to monitor impacts of the coal ash on groundwater although only one of those, MW-4, based on the description of site hydrology in Modules 8 and 25 of the permit, appears to be in a solid downgradient position from the ash placement operation. MW-4 was identified in the permit as a shallow downgradient well near where groundwater flows into Pine Creek. MW-4 was approximately 26 feet deep and opened to groundwater 8 feet below the surface. MW-1 was approximately 175 feet uphill of MW-4, along the western border of the gob piles. MW-1 was dug 110 feet deep into the aquifer underlying the site, encountering water water at 54 feet, six inches of depth and identified in the permit as an upgradient well. Initially data from MW-4, MW-1 and two subchapter "F" monitoring points, D-J, and SP-C, were analyzed as the best data sets for assessing impacts from ash placement. After PADEP examination of this review, suggested data from additional monitoring wells should be assessed, the review was expanded to examine data at ash monitoring wells MW-5, MW-3, and MW-2.

Data from these latter monitoring wells was less complete and/or from wells screened in positions not as likely to discern impacts from ash at the site. According to a November 3, 1994 PADEP letter advising the mine operator on revisions to the then-proposed Module 25, "Monitoring wells 1, 3 and 5 represent the first aquifer beneath the refuse pile. Their samples show water quality high in sulfate, metals, and alkalinity." According to cross sections and well logs in the Module 25, MW-1, MW-3 and MW-5 are screened in a sandstone layer separated from the refuse by 66-81 feet of shale and sandy shale layers although the thichness of this cover disappears quickly in the steep terrain of the site. There is also a three feet layer of limestone in the MW-3 well bore although MW-3 is not open to this layer. The PADEP letter states, "Therefore, acidic water which is generated in the pile percolates downward and is neutralized by the time it reaches the aquifer represented by wells 1, 3, and 5. This neutralization is likely provided by calcareous strata in the interval intercepted by the well bores." Thus the waters in these wells was fairly isolated from the waters likely to be most effected by the project and at a minimum should have reflected different, more alkaline chemistry than the shallow water moving through the gob pile.

Discussion and a geologic cross section in the Module 25 and water level data confirm that MW-1 and MW-5 were upgradient points with groundwater elevations when drilled of 1047.27 feet above mean sea level (MSL) for MW-1 and 1040.36 feet MSL for MW-5. This compared to a groundwater elevation of 925.78 feet MSL at MW-3 making it downgradient of MW-1 (the surface location of which is located almost exactly between MW-3 and MW-5 in a straight line) in this underlying aquifer. The data from MW-1 and MW-5 was spotty. MW-1 went dry approximately one year into the start of the remining. Data from MW-5 was available from less than half of the samplings after remining began and then extending only through April, 2000 before MW-5 went dry. Reports indicate that MW-1 and MW-5 were "destroyed by skidder" as of the February 2002 sampling. MW-3, located on the northern perimeter of the waste pile, was dry from July 2000 onward and was "caved in" as of the February, 2002 sampling. The fact that these wells in the deeper aquifer underlying the site went dry during or after the conclusion of mining and ash placement indicates a hydrologic connection of the refuse pile to the underlying aquifer.

MW-2 was 28 feet deep, screened in the refuse and had an average static water elevation during baseline monitoring of 914.95 feet MSL, very close to the 914.79 feet average water elevation measured at MW-4. However MW-2 was located on the far northeastern corner of the site making it more sidegradient to most of the mining activities and ash placed in this operation. Shallow groundwater flowing through the preponderance of the excavated pile areas being covered with ash was likely to be flowing more directly east or southeast into Pine Creek. There was no monitoring data available in the permit file from 1996 for MW-2. The following assessment of data from the ash monitoring wells focuses on data and trends from MW-1 and MW-4 but also discusses data from MW-5, MW-3, and MW-2 and includes graphs of data from these latter points primarily where they differ noticeably from those at MW-1 and MW-4.

Every monitoring point at the Wildwood site had missing data. In addition to the gaps at MW-2, MW-3 and MW-5, there are few data available from MW-1 during the ash placement period as it was dry after 1996. There is a gap in the MW-4 data for most of 1997. The two subchapter F monitoring points (DJ and SP-C) are both missing 1998 data and did not monitor for any Module 25 coal ash parameters aside from the constituents also associated with mining impacts – acidity, iron, manganese, aluminum and sulfate. Although remining and ash placement could have begun as early as April 1995, for purposes of safely demarcating the baseline period, the authors of this report have assumed in the following figures that the period for measuring impacts from the operation did not start until July 1, 1995.

Ash Monitoring Wells – Primarily Upgradient Data from Aquifer Below the Pile

Figure 15.1a shows that concentrations of iron and manganese had a decisive downward trend at MW-1, an "upgradient" ash monitoring well. These downward trends should not have occurred from any decrease in water entering the western section of the waste piles, as the sealing of any of the piles by soil, ash or other cover material would not have occurred by late 1994. Neither would the decrease have resulted from the removal of much of the waste coal which could not have occurred by late 1994. Extremely high peaks of iron to 503 mg/L in March 1994 and 344.50 mg/L in June 1994 contrast with all but 2 readings of iron well below 1 mg/L in ten subsequent samplings before MW-1 went dry sometime in the summer or fall of 1996. While PADEP dismissed as suspect several of the baseline samples of ash monitoring wells that had high Total Suspended Solids (TSS) levels, neither of the high iron readings occurred when TSS levels were high.

Data from the other upgradient ash monitoring point in the underlying aquifer, MW-5, shows that a similar decline from high baseline levels of manganese and iron stopped once water came back into this well toward the end of mining and ash placement. From the beginning of 1996 until the second quarter of 1998 data from MW-5 was either unavailable or MW-5 was listed as "DRY" and unavailable for sampling "due to mining" through all but one sampling in April 1997. Starting in May 1998, manganese concentrations (figure 15.1b) returned to levels higher than all but the one of the baseline measurements in three samplings. It should be noted that the two highest baseline concentrations of manganese during the baseline period and highest concentration during mining and ash placement at MW-5 were apparently viewed by PADEP as suspect given they were measured in samples with TSS far beyond 100 mg/L including one sample in May 1998 in which TSS was measured at 2812 mg/L. PADEP staff would not accept baseline samples with TSS exceeding 100 mg/L as valid, according to the November 3, 1994 letter from PADEP to the operator. Rejecting the samples with TSS exceeding 100 mg/L would leave the highest manganese concentration occurring in February 2000 at 1.99 mg/L, more than a year after mining and ash placement had been completed at the Wildwood site. Iron concentrations at MW-5 went through the same increase from May 1998 on to levels similar to the high baseline concentrations. The highest concentrations of iron at MW-5 before and after operations started also occurred in the samples with high TSS. Rejecting these samples leaves the highest iron concentration at MW-5 at 10.80 mg/L in March 1994, more than a year before mining and ash placement started.

Sulfate concentrations at MW-1 (figure 15.2a) were also declining but still nearly twice the DWS for sulfate (federal Secondary Maximum Contaminant Level of 250 mg/L) in the last samples taken in July 1996. Baseline sulfate concentrations at MW-5 were approximately one fifth those at MW-1. However similar to manganese and iron, after an initial decline from baseline levels, a sharp rise in sulfate concentrations occurred at MW-5 (figure 15.2b) once water returned to this well. In May 1998, sulfates at MW-5 jumped to 641.4 mg/L two and half times the DWS. Subsequent sulfate levels declined before rising again to a peak of 824.9 mg/L three and a half times the DWS in April 2000, the last sample collected from MW-5 before it went dry. Thus, despite its "upgradient" designation, sulfates increased at MW-5 from an average of 125.03 mg/L and a median of 138 mg/L during baseline monitoring to an average of 265 mg/L and a median of 192.5 mg/L when water was found in this well as mining and ash placement were concluding. This increase in sulfates along with the loss of water at MW-5 indicates that the remining and ash placement was having some impact on the aquifer underlying the southern-most portion of the gob piles. The impact was different from that measured at MW-1 under the western portion of the gob piles where sulfate concentrations were declining. However, the delayed timing of increases in sulfates, manganese and iron at MW-5 might be explained by the sequence of mining and ash placement starting in the northern and ending in the southern end of the Wildwood site where MW-5 is located.

Sulfate concentrations were declining at MW-3, the third well in the underlying aquifer downgradient of both MW-5 and MW-1 and along the north central perimeter of the gob piles. At MW-3, sulfates were usually about twice as high as the sulfates at MW-1 but declined from between 1500-2000 mg/L before ash placement to around 1,000 mg/L in the last year of monitoring (1999-2000).

Field pH values indicate a mildly alkaline environment at both upgradient wells. Field (rather than laboratory) pH data were used for this report, as field pH characterizes the natural groundwater system more accurately. The trends for field and lab pH were closely parallel. Figure 15.3a is a plot of the field pH at MW-1, the average of which dropped from 7.27 units during the baseline period to 7.22 units during the first year of mining and ash placement even though pH levels were rising in that year. Field pH at MW-5 (figure 15.3b) dropped more substantively from an average of 7.83 units before mining and ash placement to an average of 7.14 units after these operations got underway. The acidity values for MW-1 (figure 15.4a) were uniformly detected at 0 mg/l ("N.D." was the actual result in the monitoring reports) except for the initial sampling event in February 1994 where a result of <0.2 mg/l was recorded. The same absence of acidity was measured at MW-5 with the exception that the February 1994 value was recorded as <0.02 mg/L. Alkalinity averaged 265 mg/L at MW-1 with a slight, 20-30 mg/L rise throughout the two and a half years of monitoring at this point. Alkalinity at MW-5 (figure 15.4b) rose steadily in every successive measurement during baseline monitoring more than doubling from 165.75 mg/L in February 1994 to 369.88 mg/L in May 1995. This upward trend continued during mining and ash placement with the first three samples measuring 439.85 mg/L, 465.81 mg/L and 487.11 mg/L in August and November 1995 and April 1997 respectively. Then after water was continuously found again in MW-5, alkalinity declined and remained at levels between 230 and 295 mg/L to the last sample in April 2000. This data indicates acidity was not an appreciable problem underneath the western and southern portions of the gob piles before or after the advent of the project. Nonetheless project operations appeared to consume some alkalinity or at least reduce alkaline inputs to the underlying aquifer that were occurring during the baseline period and early part of the project at MW-5.

TDS (figure 15.5a) at MW-1 has a decreasing trend although its levels in the final year (1995-96) remained well above the secondary DWS of 500 mg/L. Although MW-1 was dug through the gob pile into underlying strata, the fact that MW-1 was dry when sampled from October of 1996 until it was destroyed in February 2002, suggests a definite impact on the underlying hydrologic system from this operation. Water levels in monitoring reports indicate that for two and half years prior to the fall of 1996, MW-1 contained water in sufficient quantities to sample with more than 60 feet of elevation or "head" between its static water level and that measured at MW-3 screened downgradient of MW-1 in the same underlying sandstone aquifer.

The highest TDS at MW-5 (figure 15.5b), 1064 mg/L in May 1998, was measured nearly three years into the operation. Nevertheless an increasing trend during the baseline period changed to an overall decreasing trend during and after the site operation as TDS fell below 600 mg/L in the final year of monitoring before MW-5 went dry. The TDS measured in the final sample in April 2000 of 564 mg/L was below the sulfate in that sample, which was the highest sulfate measured at MW-5. The peak of TDS in May 1998 may also be viewed by PADEP as suspect given it was measured in the sample with 2812 mg/L of TSS.

Figure 15.1a 02940201 Wildwood MW-1 Iron & Manganese

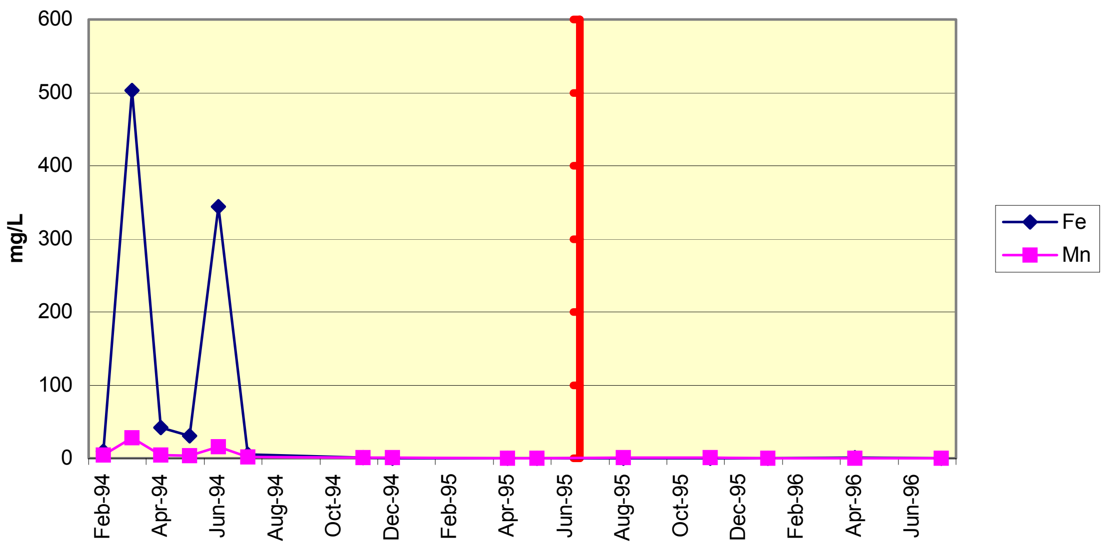


Figure 15.1b 02940201 Wildwood MW-5 Manganese

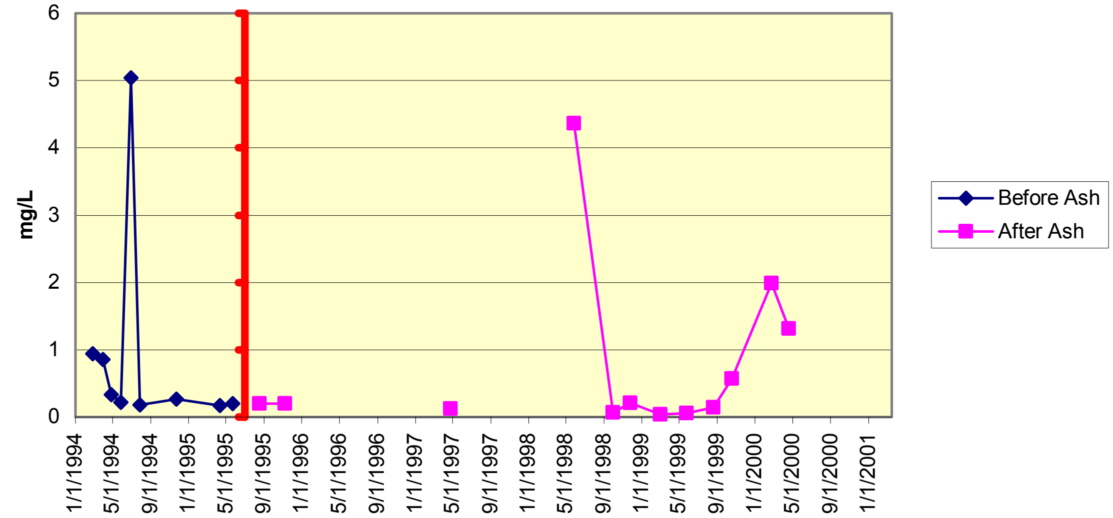
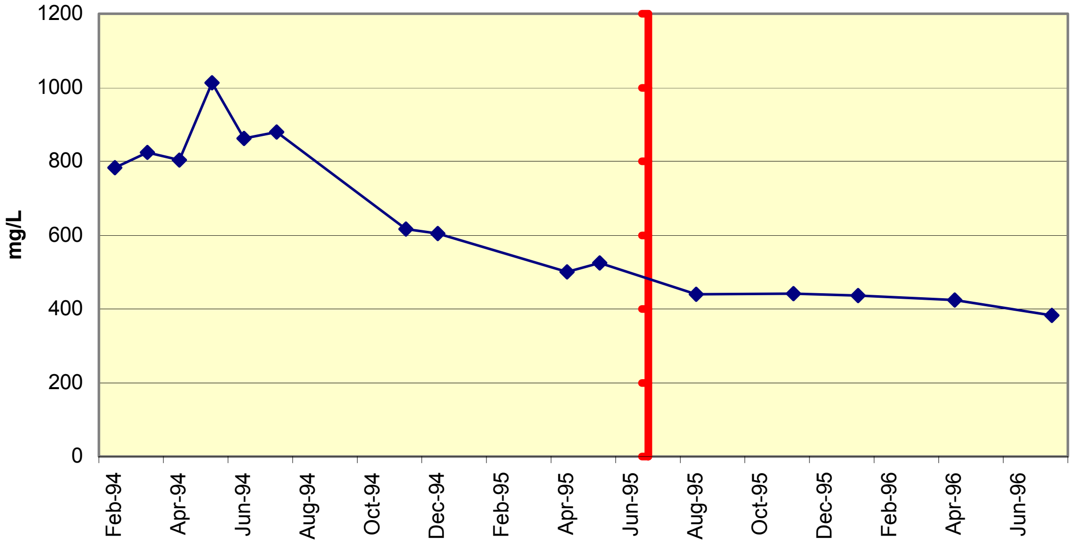


Figure 15.2a 02940201 Wildwood MW-1 Sulfates



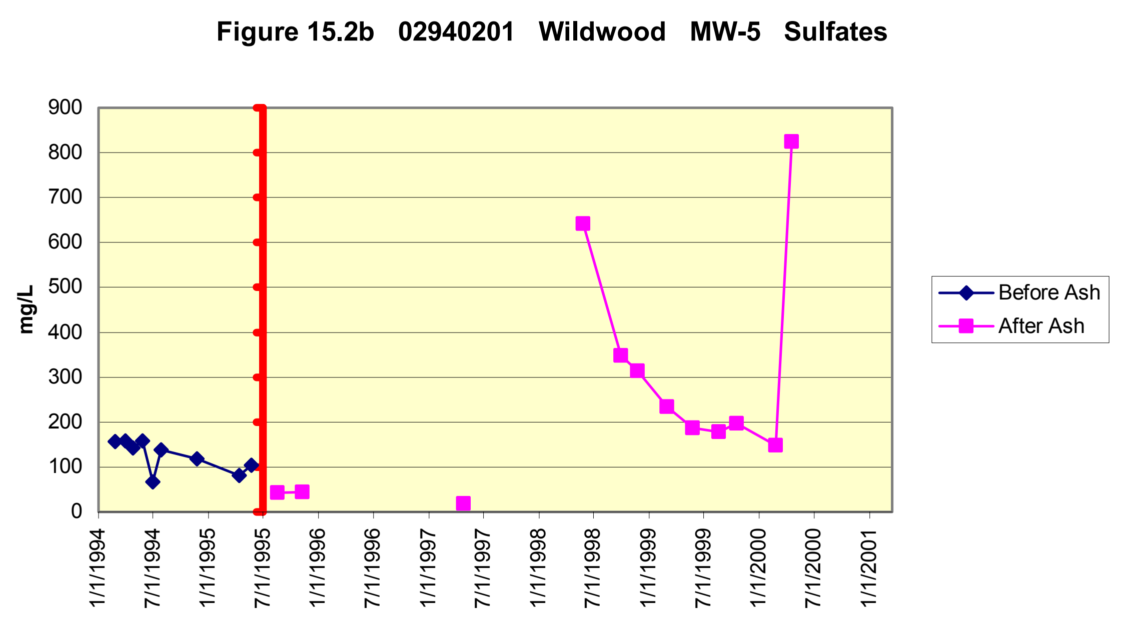


Figure 15.2b 02940201 Wildwood MW-5 Sulfates
mg/L
900
800
700
600
500
400
300
200
100
0
1/1/1994
7/1/1994
1/1/1995
7/1/1995
1/1/1996
7/1/1996
1/1/1997
7/1/1997
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7/1/2000
1/1/2001
Before Ash
After Ash

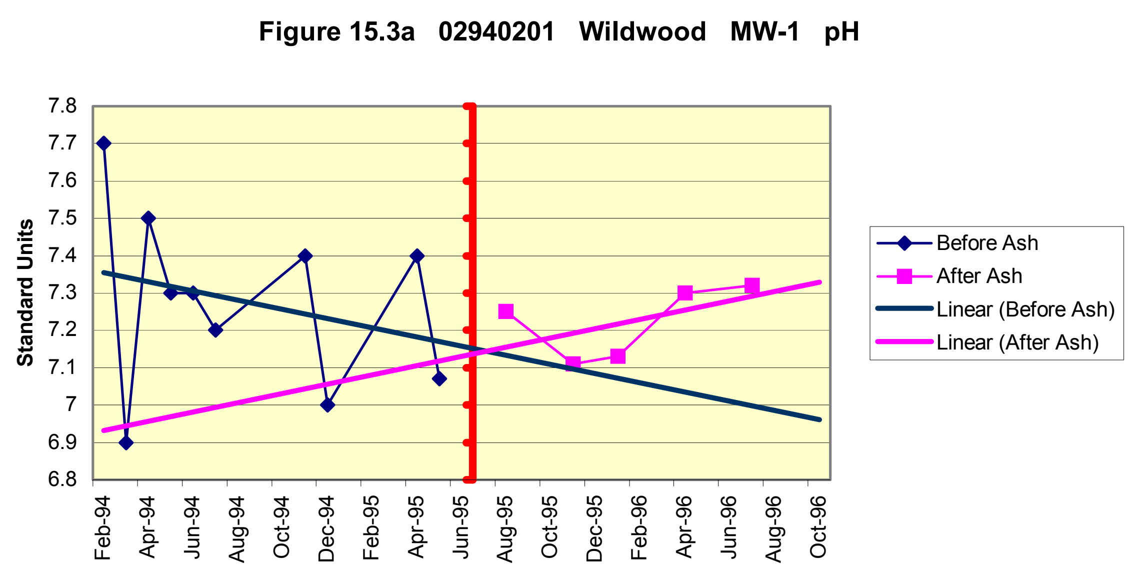
Figure 15.3a 02940201 Wildwood MW-1 pH
Standard Units
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7
6.9
6.8
Feb-94
Apr-94
Jun-94
Aug-94
Oct-94
Dec-94
Feb-95
Apr-95
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

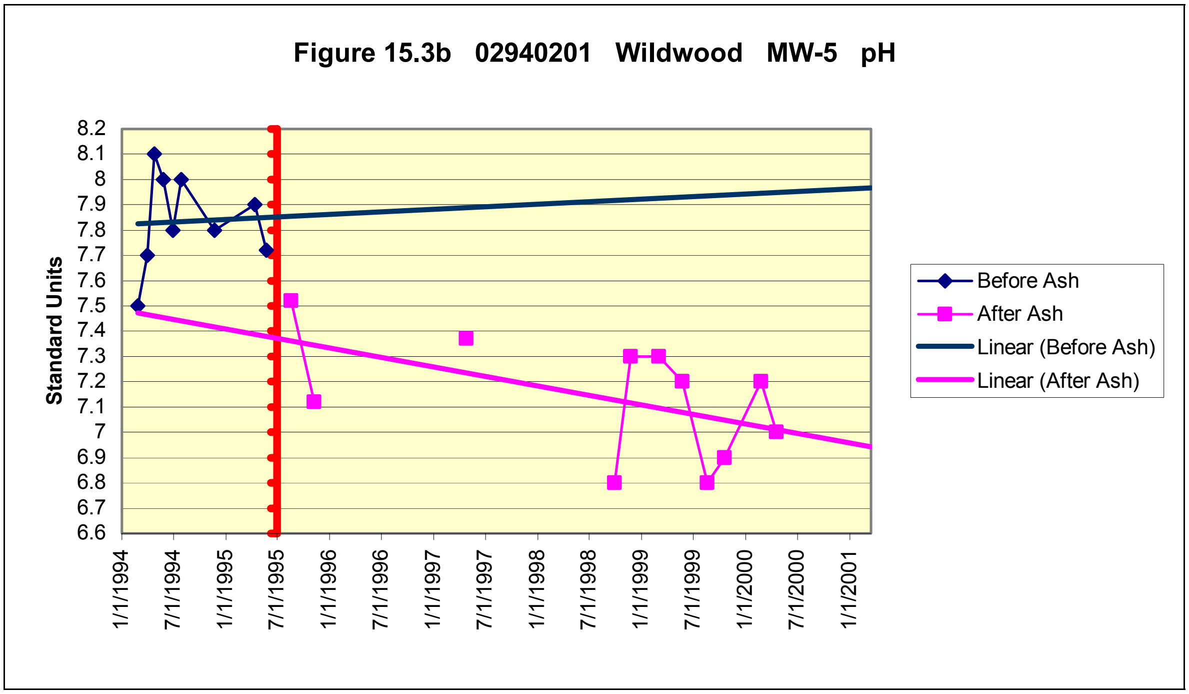
Figure 15.3b 02940201 Wildwood MW-5 pH
Standard Units
8.2
8.1
8
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7
6.9
6.8
6.7
6.6
1/1/1994
7/1/1994
1/1/1995
7/1/1995
1/1/1996
7/1/1996
1/1/1997
7/1/1997
1/1/1998
7/1/1998
1/1/1999
7/1/1999
1/1/2000
7/1/2000
1/1/2001
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

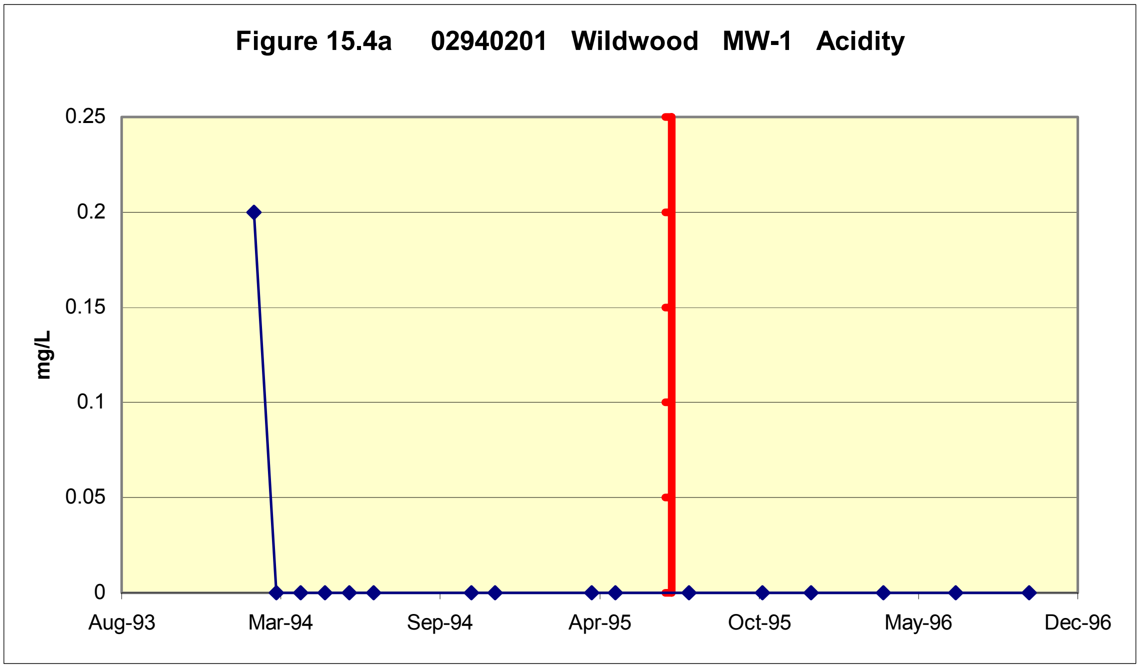
Figure 15.4a 02940201 Wildwood MW-1 Acidity
mg/L
0.25
0.2
0.15
0.1
0.05
0
Aug-93
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96

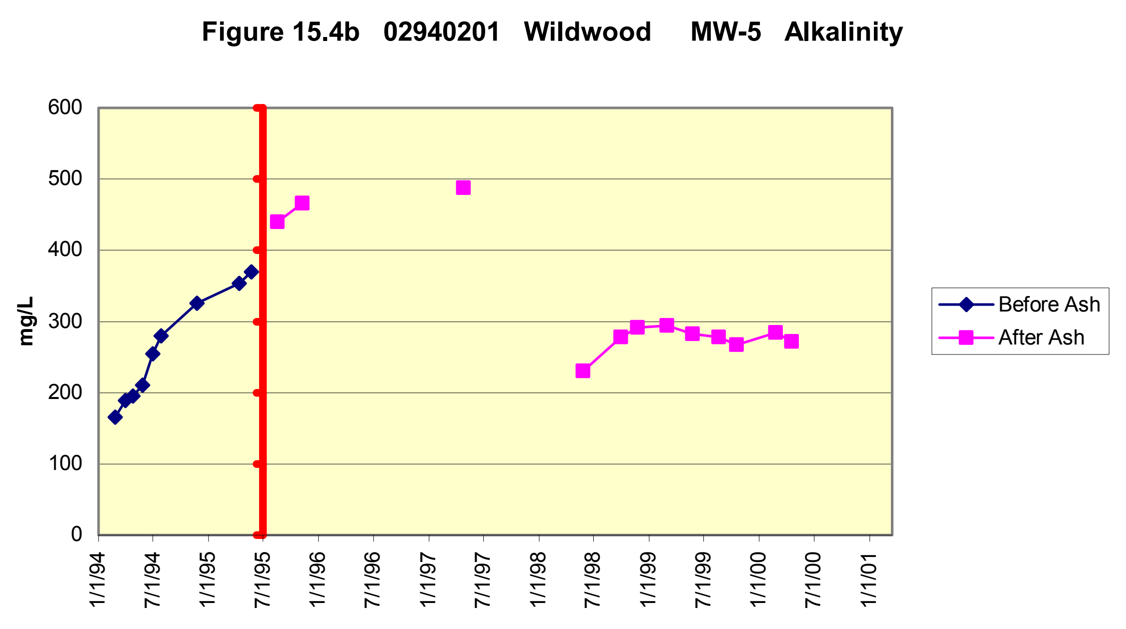
Figure 15.4b 02940201 Wildwood MW-5 Alkalinity
mg/L
0
100
200
300
400
500
600
1/1/94
7/1/94
1/1/95
7/1/95
1/1/96
7/1/96
1/1/97
7/1/97
1/1/98
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1/1/99
7/1/99
1/1/00
7/1/00
1/1/01
Before Ash
After Ash

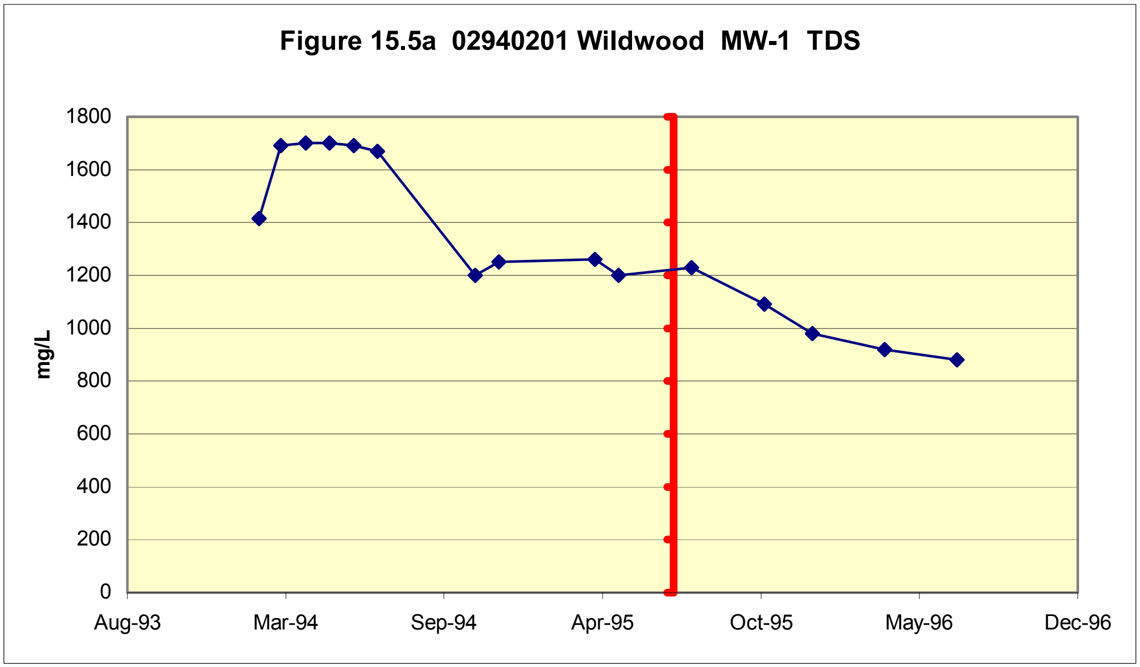
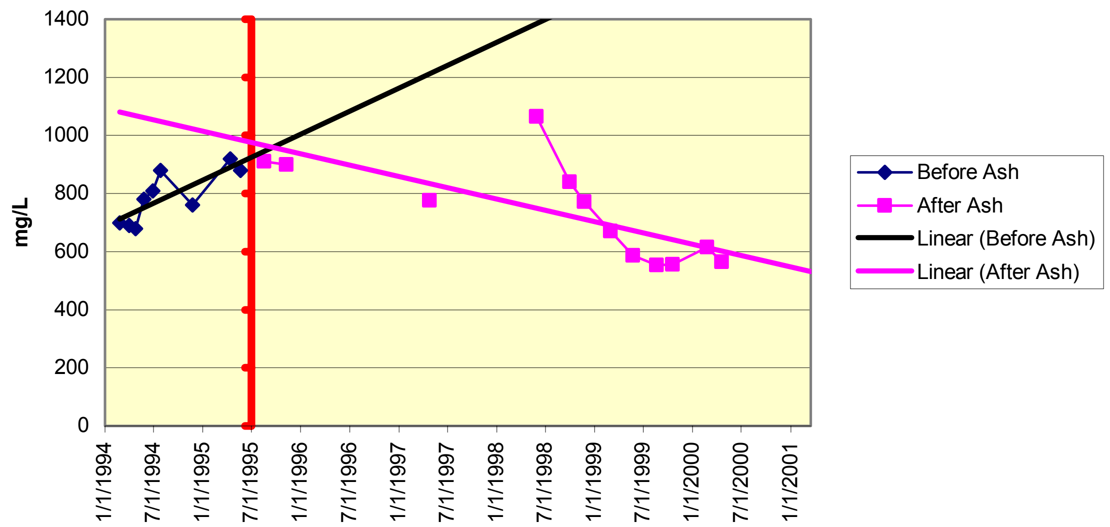


Figure 15.5a 02940201 Wildwood MW-1 TDS
mg/L
0
200
400
600
800
1000
1200
1400
1600
1800
Aug-93
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96

Figure 15.5b 02940201 Wildwood MW-5 TDS



Available trace element concentrations for MW-1 (figure 15.6a) are plotted for selenium, arsenic, lead, and cadmium. These concentrations are total rather than dissolved values. In 12 of the 32 sample results (four constituents times 8 samples each), total concentrations were substantially greater (6-264 times higher) than the dissolved concentrations. The high total values cannot be the result of ash placement or other project operations affecting water quality as this data is entirely from within the reported baseline period. Of course, assuming MW-1's position as an upgradient well was actually correct, any ash leachate should not have had a great effect on groundwater chemistry at this monitoring point even if it was hydrologically connected to the shallow groundwater in the gob pile. The peaks of the trace elements at MW-1 did not occur in the same samplings; the highest cadmium was measured in March, the highest arsenic in May and the highest lead and selenium are in June of 1994. The high values of 0.1034 mg/L for arsenic, 0.2900 mg/L for lead, and 0.061 mg/L for cadmium found at MW-1 were the highest concentrations for these trace elements found at any of the ash wells. The highest selenium concentration at MW-1, 0.0532 mg/L was below selenium levels found at MW-4. As occurred at the other ash wells, there were a couple of high values of trace elements occurring in samples with suspect levels of TSS (e.g., the May, 0.1034 mg/L arsenic value occurs with TSS at 232 mg/L). Nonetheless, even without those samples, the data reflects elevated concentrations (over the DWS) in the baseline water quality for trace elements in all the ash wells both in the underlying aquifer as well as in the gob.

There were four measurements of trace elements at MW-5 (figure 15.6b) taken after mining and ash placement started that could be located in the permit file. The highest trace element concentrations at MW-5 were measured during the baseline period, although they were not as high as those at MW-1. The highest selenium at MW-5 was

0.0491 mg/L in an April 1994 sample. However, the highest concentrations for arsenic (0.074 mg/L), lead (0.112 mg/L) and cadmium (0.006 mg/L) at MW-5 were measured in a June 1994 sample in which TSS was 830 mg/L, well beyond the 100 mg/L level of TSS that resulted in the PADEP's rejection of baseline samples. If the June 1994 sample is disregarded, the highest arsenic at MW-5 was measured in January 1996 at 0.0445 mg/L, and second highest arsenic was 0.0303 mg/L in January 1997, both after mining and ash placement started although presumably well before operations were in the southern portion of the site near this monitoring point.

The dissolved concentrations of arsenic in these samples (0.0422 mg/L in January 1996 and 0.0261 mg/L in January 1997) and other samples taken at MW-5 after mining and ash placement started were fairly close to total concentrations, unlike many samples during the baseline monitoring in which total concentrations were markedly higher than dissolved concentrations (as discussed above at MW-1). For example although the two highest lead concentrations at MW-5, 0.1120 mg/L in June 1994 and 0.0342 mg/L in March 1994, were measured during the baseline period, dissolved lead concentrations were 0.0034 mg/L in the June sample and 0.0008 mg/L in the March sample. The highest dissolved concentration of lead was measured after mining and ash placement were underway in January 1996 at 0.0059 mg/L. Total cadmium concentrations were consistently in the 0.003-0.006 mg/L range including in the first sample during mining and ash placement which measured cadmium at 0.005 mg/L (the DWS).

As occurred with sulfate, there were increases in concentrations of other more soluble ash parameters from before to after mining and ash placement at MW-5. Chloride (figure 15.6b) rose beyond the highest baseline concentrations to 40.80 mg/L in April 1997, then declined to baseline levels (just over 20 mg/L) before rising to 116.86 mg/L in April 2000. This was nearly four times the highest chloride measured during the baseline period. These high spring values suggest road salts perhaps applied to mine haul roads or other nearby roads as a possible source of the chloride in addition to FBC ash. The highest sodium at MW-5, 220 mg/L, was measured nearly two years into mining and ash placement but implicates road salts further as it occurred in April 1997. Subsequent sodium measurements at MW-5 were below higher sodium levels during the baseline period. At MW-1 most sodium levels in the year after mining and ash placement started were higher than most sodium levels during the baseline period, with the exception of a sharp peak of sodium to 475.63 mg/L (5-210 times higher than all other sodium measurements) in December 1994.

Fluoride concentrations increased at both monitoring points suggesting further that neither point was fully upgradient of project operations. At MW-1, the average fluoride concentration more than doubled from 0.213 mg/L in the baseline period to 0.496 mg/L in the first year of mining and ash placement. At MW-5 there was an increase in fluoride levels from a high of 0.96 mg/L during the baseline period to 1.50 mg/L in April 1997 and 1.19 mg/L in May 1998. However these measurements were followed by a considerable decrease in fluoride levels in subsequent samples resulting in average fluoride concentrations declining from 0.628 mg/L in the baseline period to 0.508 mg/L during and after mining and ash placement. Although there were only four samples from MW-5 measuring calcium after the baseline period, the highest calcium in those samples, 161.86 mg/L in March 1999, was 2.4 times higher than the highest calcium measured during the baseline period at MW-5 (figure 15.6c). There was no notable increase measured in magnesium at MW-5 from before to after mining and ash placement. Nevertheless as with calcium and the trace elements, the existence of only four measurements for magnesium during and after operations, provides an inadequate basis for assessing magnesium impacts.

There were no measurements of calcium or magnesium concentrations at MW-1 after the baseline period although calcium declined in each successive baseline sample at MW-1. Calcium and magnesium concentrations were considerably higher at MW-1 than at MW-5 in baseline measurements. The range of calcium at MW-1 was 168.75 to 394.50 mg/L compared to a range of 17.37 to 67.50 mg/L at MW-5. The range of magnesium at MW-1 was 62.25 to 123.50 mg/L compared to a range of 4.22 to 23.93 mg/L at MW-5.

Figure 15.6a 02940201 Wildwood MW-1 Trace Elements

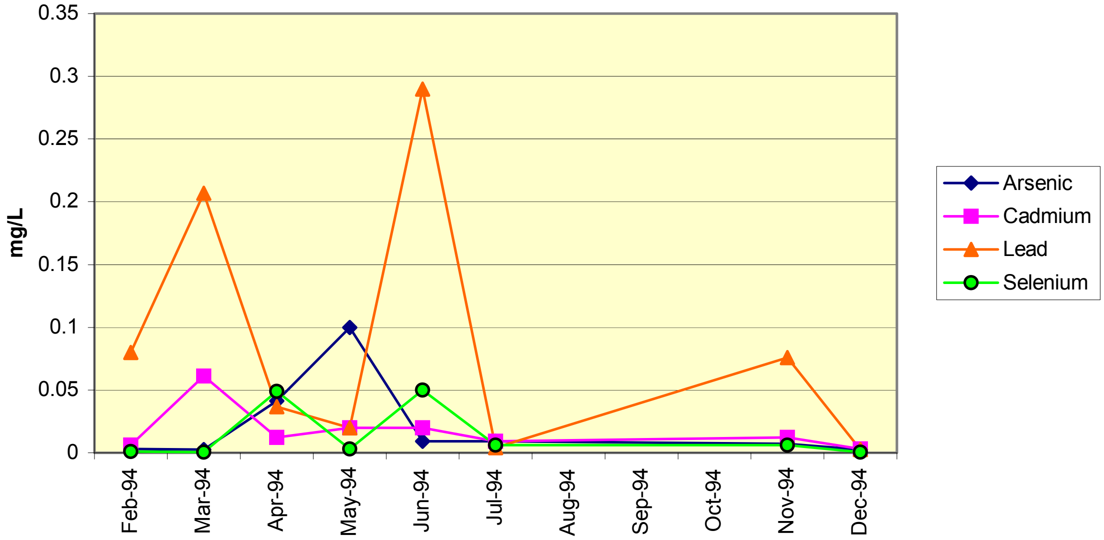


Figure 15.6b 02940201 Wildwood MW-5 Trace Elements

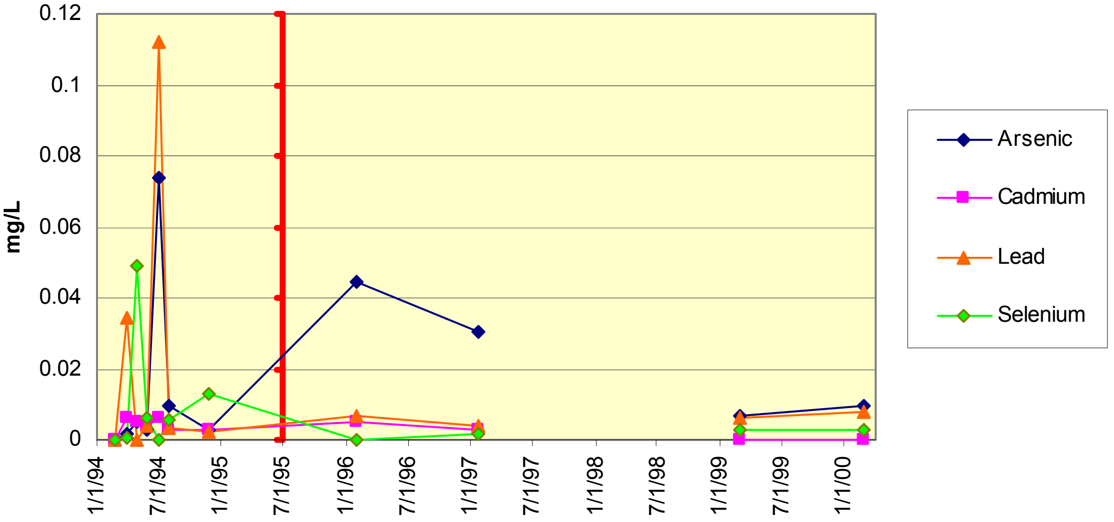


Figure 15.6c 02940201 Wildwood MW-5 Chloride

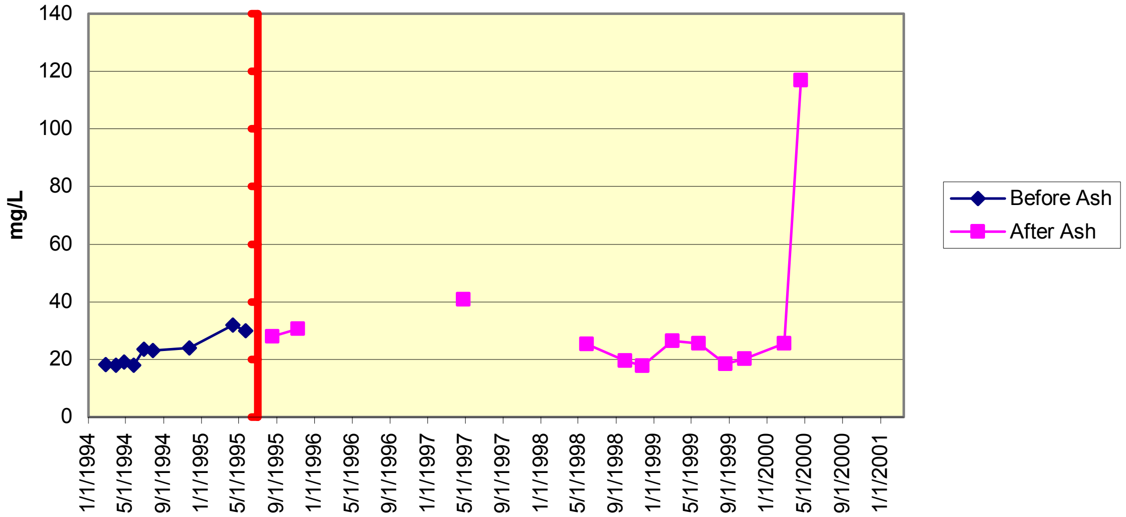
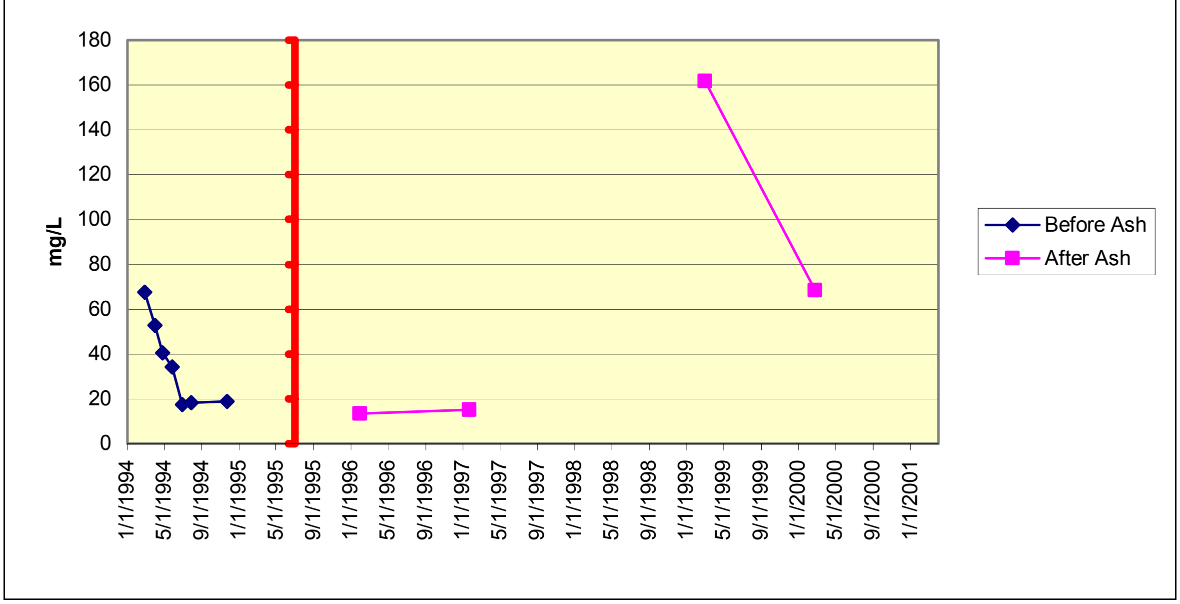


Figure 15.6d 02940201 Wildwood MW-5 Calcium



Ash Monitoring Wells -Downgradient Data

The data set from downgradient MW-4 is more complete than the data sets for other ash wells, particularly the uprgadient ones. Nonetheless the graphs for iron, manganese and sulfates (figures 15.7a and 15.8a) reveal a data gap from October 1996 to September 1997 at MW-4. Data gathered indicates that these constituents had a downward trend at MW-4 during the height of mining until September 1998 with the downward trend for sulfate continuing beyond that date.

The iron values at MW-4 were highest during the first half of the 15 month baseline period although well below the extremely high iron values at MW1. On the other hand high manganese values during baseline monitoring at MW-4 were almost twice as high as the highest manganese values measured during the same time at MW-1.

At the other well monitoring downgradient gob pile water, MW-2, despite a gap in 1996 data, the remainder of data appeared to follow the more typical impacts from mining with concentrations rising initially but then falling back to baseline levels as mining concluded. There was also less difference between most baseline values and values after mining and ash placement started than at MW-4. In fact several iron and manganese concentrations after operations started were actually higher than all but the one or two highest baseline concentrations for these constituents. Given the start of mining near the northeastern corner of the Wildwood site where MW-2 is located, data from this point would have reflected nearby mining impacts as well as the cessation of those impacts followed by ash placement sooner than the other ash monitoring points.

Figure 15.7b reflects this impact for manganese at MW-2 and reveals that manganese levels did decline predominantly to typical baseline concentrations from

March 1999 onward. Thanks to two very high initial baseline values, the average manganese concentration during baseline monitoring was 4.1 mg/L while the average after the baseline period was 1.25 mg/L. However the median manganese baseline value was 0.49 mg/L while the median manganese value for monitoring after the baseline period was 0.59 mg/L.

Figure 15.7c shows an increasing trend for iron concentrations at MW-2 after operations started and ended at the site. The highest iron concentration depicted in this figure, 1.64 mg/L, occurred in November 2000 more than a year after mining and ash placement had finished (by mid 1999), and three other iron concentrations were higher than all but the highest depicted baseline iron level. It should be understood however that a very high iron concentration of 50.75 mg/L measured in the first baseline sample in February 1994 is not depicted in Figure 15.7c to enable the differences between other iron concentrations to be effectively shown. The TSS in that sample was 200 mg/L causing PADEP to reject its use as a valid baseline sample. To be consistent, the highest iron measured during mining and ash placement, 2.81 mg/L in May 1998 was also deleted from this figure as the TSS reported in that sample was 180 mg/L. Without these two higher values, the average iron concentration during baseline period was 0.569 mg/L while the average after the baseline period was 0.464 mg/L. Including all data, the median value during the baseline period was 0.68 mg/L compared to a median value after operations started of 0.145 mg/L.

The downgradient data from the underlying aquifer at MW-3 was more limited but it shows declining iron and manganese concentrations from the baseline period onward. Not counting three samples during the baseline period and one sample afterwards that all had high TSS levels, average iron concentrations declined from 1.95 mg/L during baseline monitoring to 0.81 mg/L after the baseline period and 0.70 mg/L in the last two years of data from MW-3 (May 1998-April 2000). Average manganese levels declined sharply from 2.34 mg/L during baseline monitoring to 0.15 mg/L after the baseline period at MW-3 (also not counting the four samples collected with high TSS).

The concentrations of sulfates at MW-4 (figure 15.8a) were the highest measured at any of the ash monitoring wells, but declined from an average of 4072 mg/L during the baseline period to 2182 mg/L after the operation started. The range of decline in actual values after the mining and ash placement started was from a high of 4183 in October 1995 to a low of 1053 mg/L in April 2002 the last sample collected at MW-4. Sulfates at MW-3 in the underlying aquifer declined more moderately from an average of 1646 mg/L during the baseline period to averages of 1196 mg/L throughout monitoring after the baseline period and 1056 mg/L in the final two years of data from this point. Thus sulfates at MW-3 declined to levels very close to those measured at MW-4 two years later.

Sulfate concentrations did not undergo much of a decline at MW-2 (figure 15.8b). The average sulfate concentration during the baseline period of 720 mg/L slipped to an average during mining and ash placement of 680 mg/L. Indeed the average sulfate concentration at MW-2 during the baseline period was only 267 mg/L if three high measurements are not counted which reflects most concentrations measured during the baseline period being considerably below concentrations measured after mining and ash placement began and concluded at MW-2. The median concentration at MW-2 during the baseline period was 294.5 mg/L compared to a median concentration after the permit was issued of 629 mg/L.

Concentrations of TDS at MW-4 (figure 15.9) showed a strong downward trend, mirroring the declining sulfates and indicating improving groundwater conditions. However the lowest TDS levels still ranged between 3 and 5 times the secondary DWS, and TDS levels at MW-4 from March 1999 to the latest monitoring in April 2002 rose by 600-900 mg/L.

There were three samples (Oct. 1997, Oct. 1999, and July 2000) in which the sulfate concentration reported from MW-4 exceeded the TDS concentration by 52-272 mg/L. The TDS concentrations should represent the sum of *all* the dissolved elements for a given water sample. There are no total versus dissolved values provided for sulfates although TSS levels that were 30 mg/L or below indicate there were not much undissolved sulfates in these samples, which is usually the case for sulfates. There was higher turbidity, another indication of floating sediment, in the July 2000 sample. Nonetheless, the low TSS coupled with noticeably higher sulfates than TDS, raises a question about the sampling methods and/or laboratory procedures that produced these results. Although sampling of all five monitoring wells was done on the same dates, there were only two instances in which this discrepancy occurred at other monitoring wells. Those were the November 1994 baseline sample at MW-3 which measured 1,700.2 mg/L of sulfates and 1,485.0 mg/L of TDS and the April 2000 sample at MW-5 which measured 824.9 mg/L of sulfates and 564 mg/L of TDS.

TDS concentrations at MW-2 and MW-3 also declined from baseline levels. Average TDS declined from 1861 mg/L during baseline monitoring to 1309 mg/L in the last two years of monitoring at MW-2. Average TDS declined from 2630 mg/L during baseline monitoring to 1,558 mg/L in the last two years of monitoring at MW-3. While the last concentrations at ash monitoring wells showed degraded water with TDS substantially exceeding the secondary DWS (500 mg/L), this data still indicates an overall improvement in water quality in the shallow and underlying aquifers at the Wildwood site.

Figure 15.7a 02940201 Wildwood MW-4 Iron & Manganese

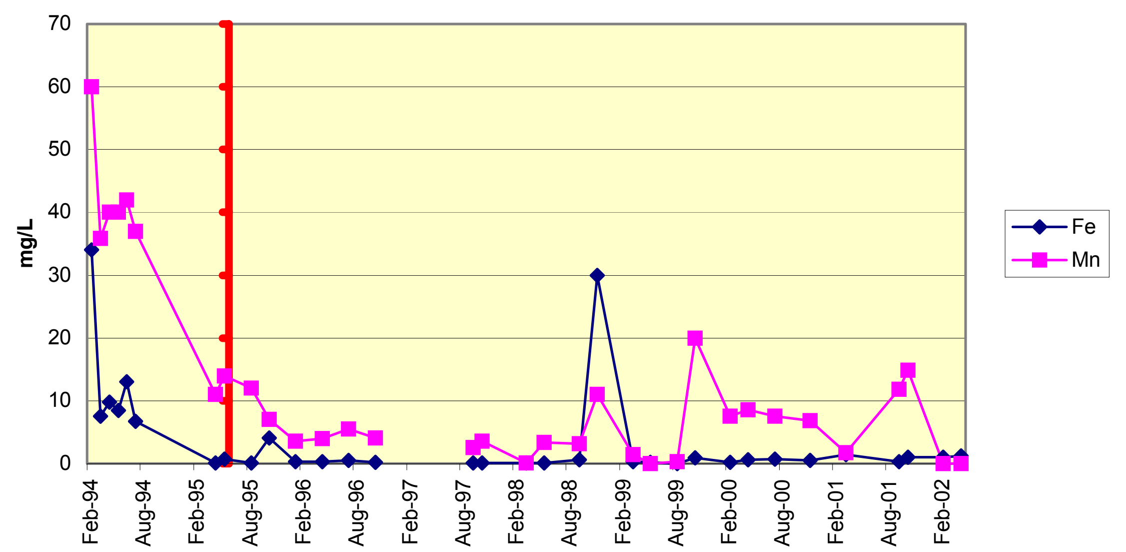


Figure 15.7b 02940201 Wildwood MW-2 Manganese

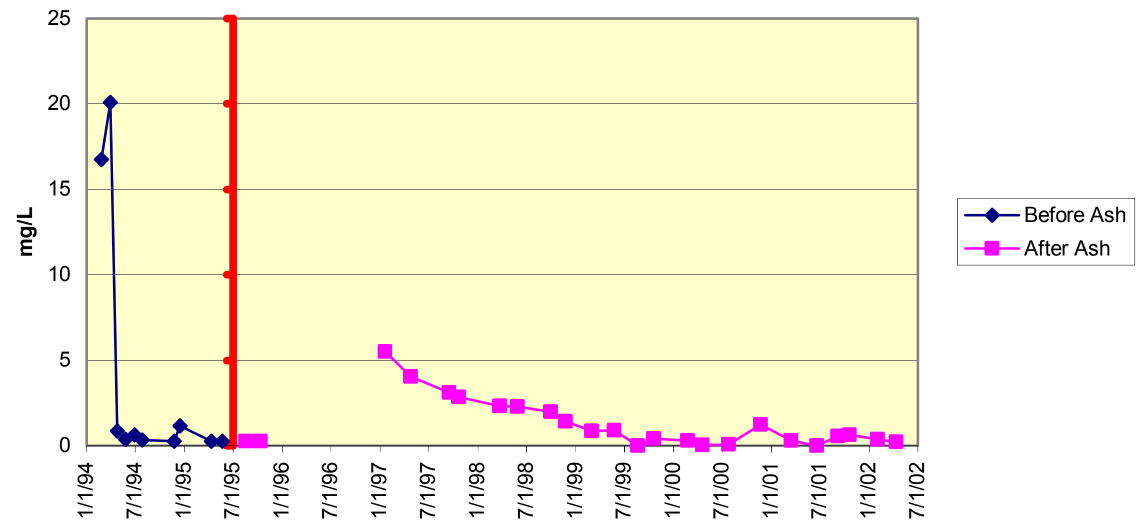


Figure 15.7c 02940201 Wildwood MW-2 Iron

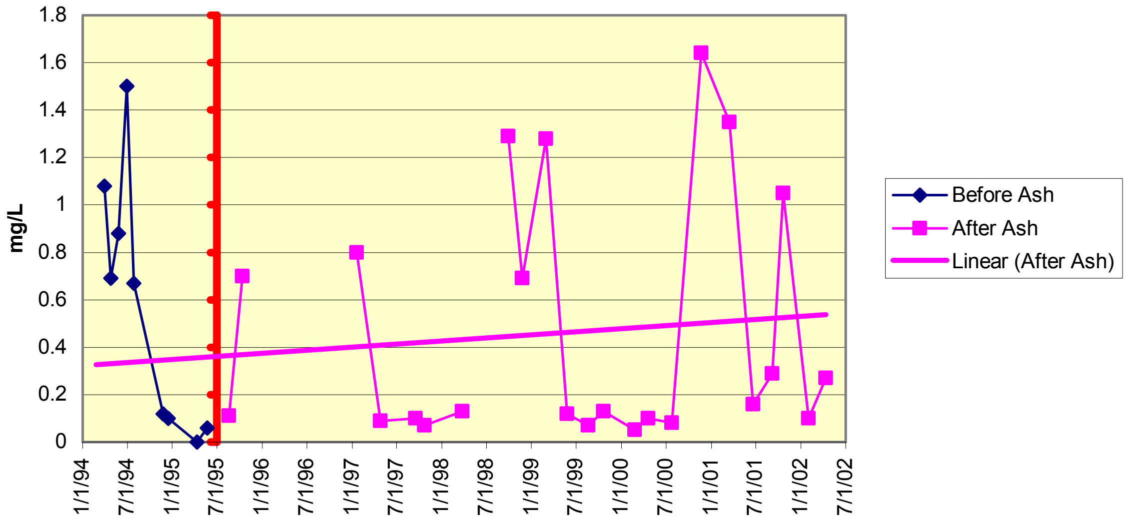


Figure 15.8a 02940201 Wildwood MW-4 Sulfates

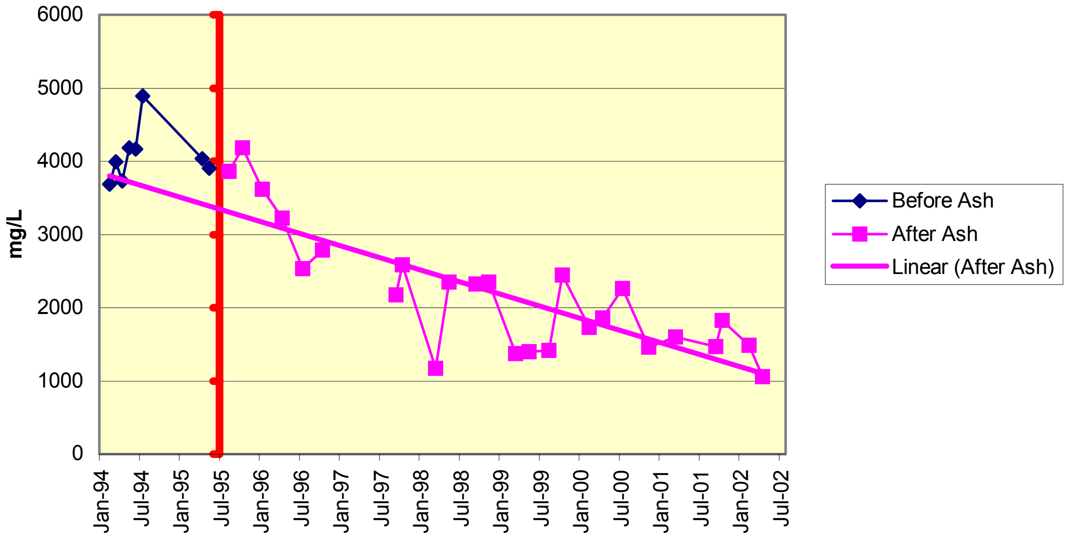


Figure 15.8b 02940201 Wildwood MW-2 Sulfates

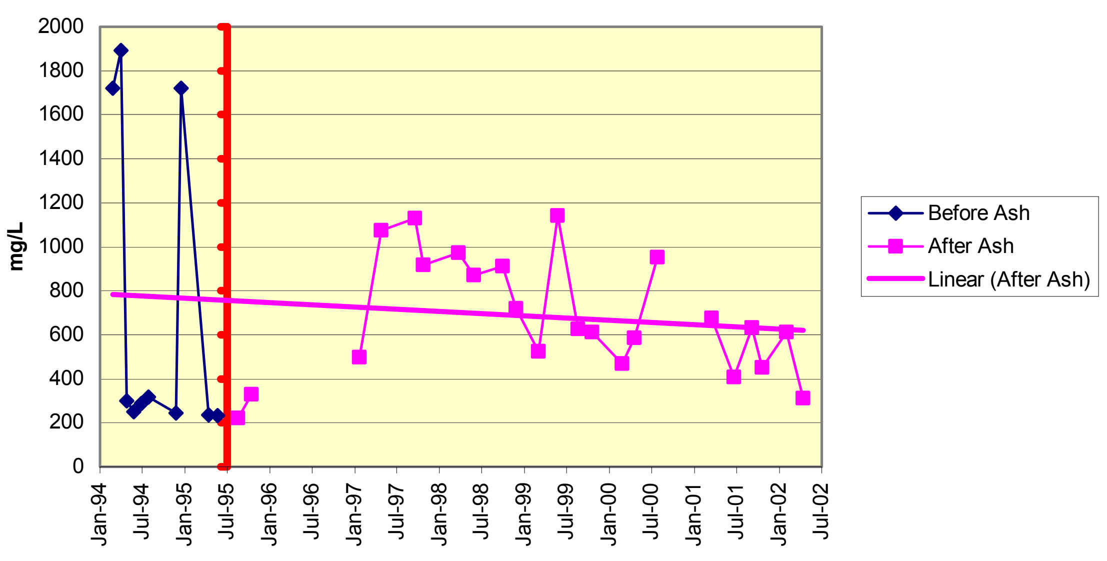


Figure 15.9 02940201 Wildwood MW-4 TDS

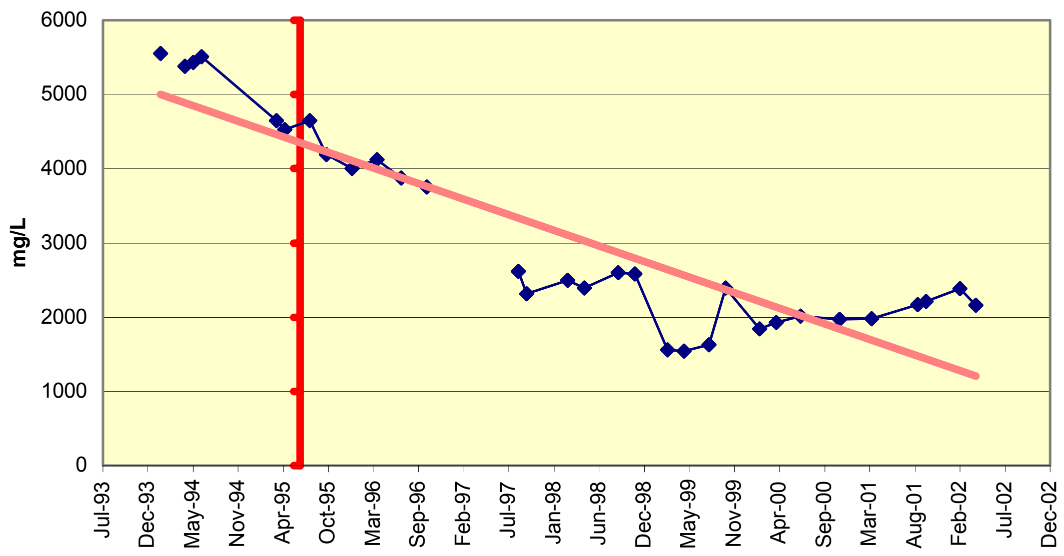


Figure 15.10a illustrates the field pH for MW-4, which had a clearly rising trend from a low of 4.0 s.u. during the baseline period to a high after ash placement reaching 8.5 s.u. in March 2001, indicating decreasing AMD. Average values increased from 7 units to 8 units during mining and ash placement. Similar to MW-4, field pH at MW-2 was measured at 4.0 and 4.2 units respectively in its first two samples before rising to

levels between 6.51 and 8.2 units for the rest of monitoring. Figure 15.10b indicates that at the downgradient well (MW-3) in the underlying aquifer, field pH was rising during mining and ash placement although not as sharply as the pH rise in the gob aquifer. This rise is in concert with the rise in pH at upgradient MW-1 but contrasts with the declining pH at upgradient MW-5 in the underlying aquifer (see figures 15.3a and 15.3b).

After slipping from 179.6 mg/L to 92.2 mg/L over the first six samples in the baseline period, acidity fell to zero ("N.D." in the monitoring reports) for the duration of monitoring at MW-4 (figure 15.11a). A similar result was monitored at MW-2, where acidity was measured at 614.9 mg/L in February 1994 and 593.42 mg/L in March 1994, the highest acidity measured at any of the ash monitoring wells, before plummeting to zero for the duration of monitoring. Acidity was essentially never existent at MW-3 in the underlying aquifer. Like the upgradient monitoring wells in this deeper aquifer, only the first measurement at this monitoring point in February 1994 indicated any possible acidity at <0.20 mg/L while the rest were listed as N.D. in monitoring reports.

A sizeable increase in alkalinity (figure 15.11b) from baseline levels below 100 mg/L to levels exceeding 400 mg/L at the end of monitoring corroborates the increase in field pH at MW-4. Alkalinity had already risen markedly in the baseline period at MW-2 (figure 15.11c) and then declined as decisively about a year into site operations in 1997 until rising again in 1998-99 to levels eventually in the same range as the highest alkalinity at MW-4. The timing of the alkalinity increases after the baseline period at these monitoring points would be expected as the acid-producing impact of remining would be felt before the acid buffering and alkaline impact of subsequent ash placement and reclamation activities. The causes for the sharp declines of acidity to zero at both monitoring points during the year and a half baseline period are not clear. Virtually all of the alkalinity was reflected in an overall rise in bicarbonate levels from an average of 6 mg/L in the first year of baseline monitoring (1994) to an average of 378 mg/L in the last year of data available from the permit files (2001-2002). At MW-2, alkalinity measurements were identical to the bicarbonate measurements.

Average alkalinity declined downgradient in the underlying aquifer at MW-3 (figure 15.11d) from 261 mg/L during the baseline period to 242 mg/L during mining and ash placement (before MW-3 went dry). This was in accord with alkalinity at upgradient MW-5 in the underlying aquifer which declined from initial levels between 400-500 mg/L during mining and ash placement to levels just under 300 mg/L in 1998-2000.

Figure 15.10a 02940201 Wildwood MW-4 pH

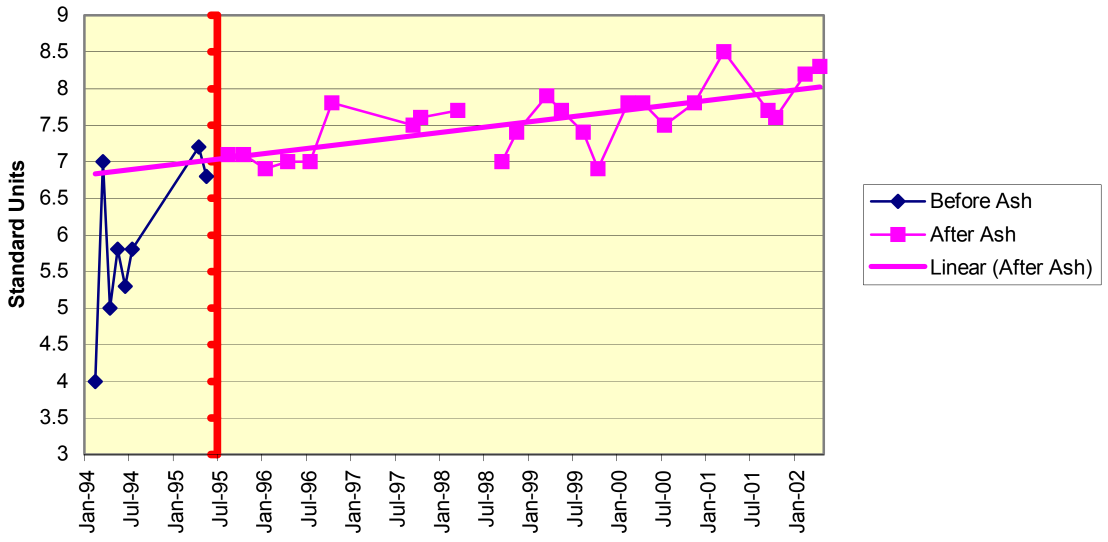
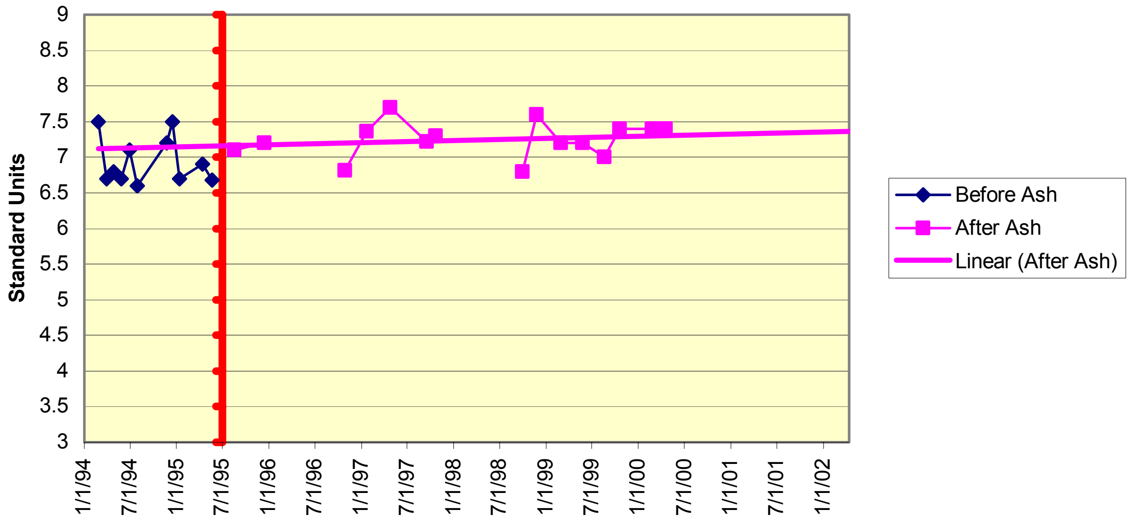


Figure 15.10b 02940201 Wildwood MW-3 pH



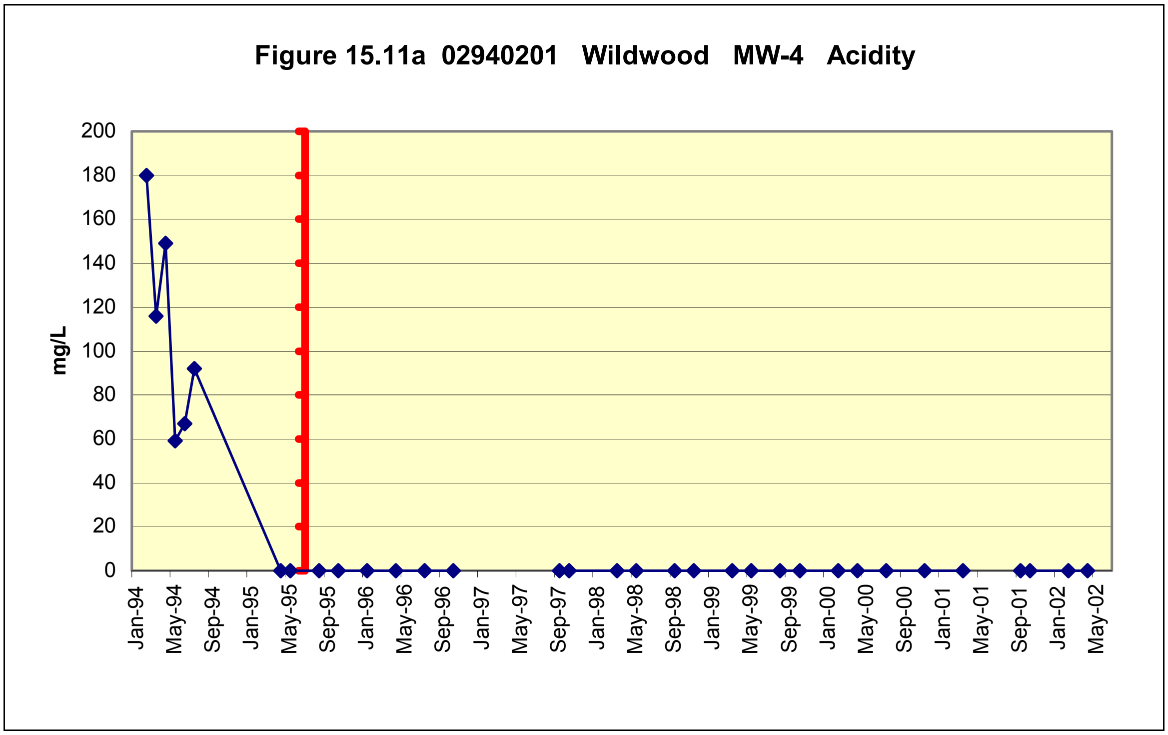


Figure 15.11a 02940201 Wildwood MW-4 Acidity
mg/L
200
180
160
140
120
100
80
60
40
20
0
Jan-94
May-94
Sep-94
Jan-95
May-95
Sep-95
Jan-96
May-96
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May-98
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Sep-01
Jan-02
May-02

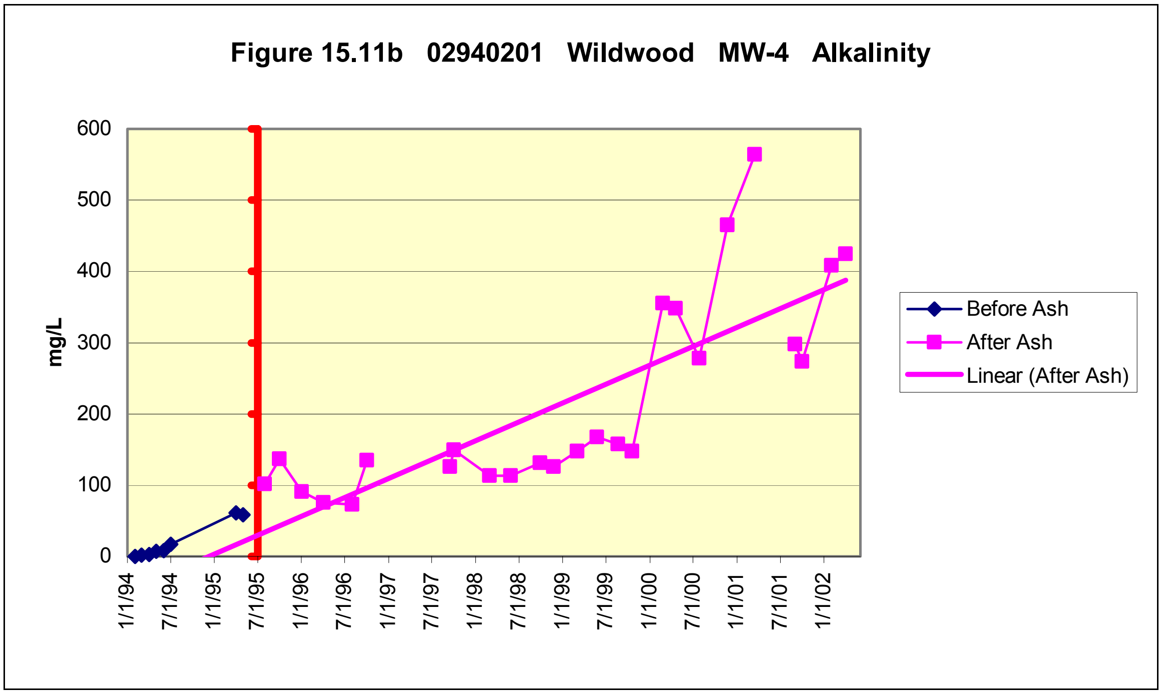


Figure 15.11b 02940201 Wildwood MW-4 Alkalinity
mg/L
600
500
400
300
200
100
0
1/1/94
7/1/94
1/1/95
7/1/95
1/1/96
7/1/96
1/1/97
7/1/97
1/1/98
7/1/98
1/1/99
7/1/99
1/1/00
7/1/00
1/1/01
7/1/01
1/1/02
Before Ash
After Ash
Linear (After Ash)

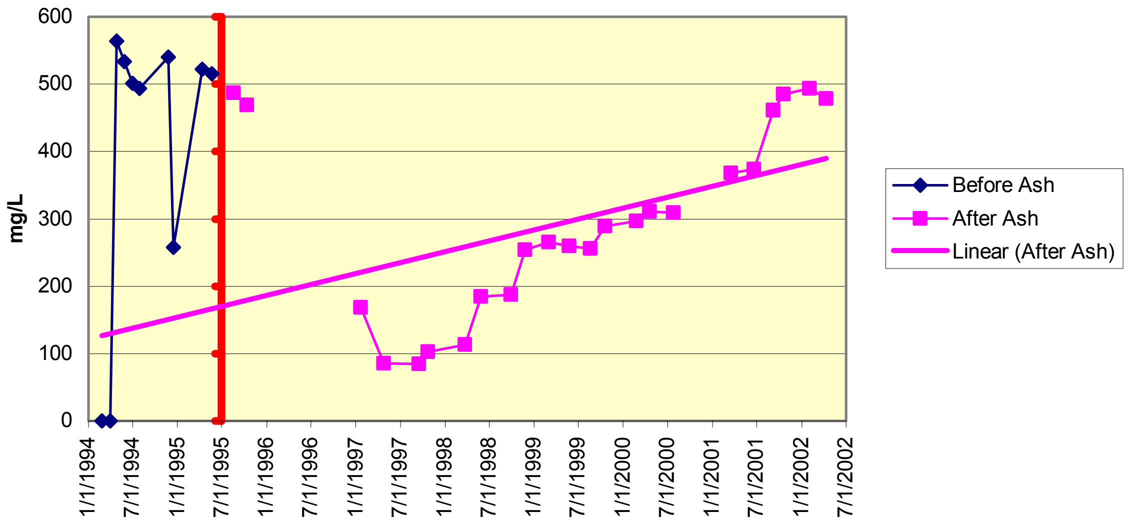


Figure 15.11c 02940201 Wildwood MW-2 Alkalinity

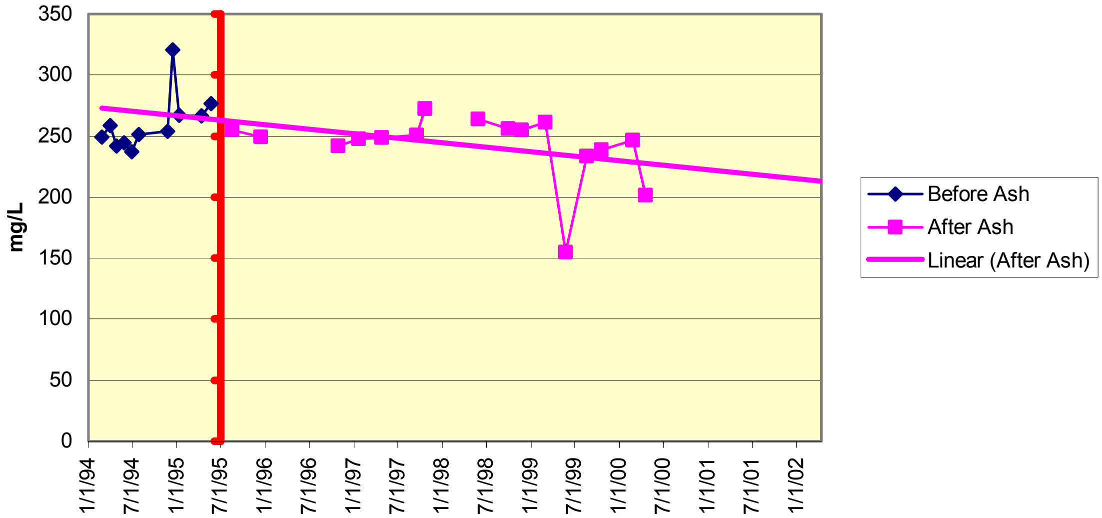


Figure 15.11d 02940201 Wildwood MW-3 Alkalinity

Trace element data available from MW-4 through February 2002 (figure 15.12a) report higher levels of arsenic, cadmium, lead and selenium in baseline monitoring than during remining and ash placement. The peak values for MW-4 were similar to those for MW-1 during the baseline period exceeding the DWS for arsenic, lead, cadmium and selenium by 2 to more than several times.

The concentrations in figure 15.12a are total rather than dissolved values. Unlike baseline concentrations at MW-1 and MW-5, there was little difference between total and dissolved concentrations in most baseline samples at MW-4. An odd exception was a sample in April 1994 where dissolved arsenic was 0.357 mg/L (36 times the DWS) while total arsenic was only 0.0561 mg/L. These were the highest values recorded for arsenic at MW-4 and the highest dissolved arsenic reported at any of the points. Four of six arsenic measurements during the baseline period exceeded the DWS (0.01 mg/L). This compares to the highest arsenic during mining and ash placement of 0.0088 mg/L in March 2001, the second to last measurement reported for trace elements.

There was a very high initial value of 0.23 mg/L for lead reported at MW-4 in February 1994 although all subsequent lead measurements including those during mining and ash placement were below the DWS (0.015 mg/L). Every one of six cadmium measurements during the baseline period exceeded the DWS by two to almost eight times, and the first two cadmium measurements during mining and ash placement also exceeded the DWS by four times, although subsequent measurements were below the DWS. The highest selenium measurement was 0.1279 mg/L, more than twice the DWS (0.050 mg/L) also reported during baseline monitoring (April 1994). Subsequent selenium measurements were all well below the DWS until March 2001 when selenium was measured over the DWS at 0.086 mg/L. Aside from the April 1994 measurement, this was the highest selenium concentration measured at any of the monitoring wells.

The burning of gob that was reportedly ongoing at this site for years may have contributed to the higher dissolved concentrations in the baseline measurements by leaving them in a more soluble state from the burned rock and residual gob ash.

At MW-2, the other downgradient well in the gob pile, the highest selenium was measured on the same sample dates as the selenium peaks at MW-4, with 0.0374 mg/L in April 1994 and 0.0143 mg/L in March 2001 (figure 15.12b). The highest arsenic, cadmium and lead levels at MW-2 were also recorded during the baseline period. However high concentrations in the first baseline sample in February 1994 were measured in a sample with 200 mg/L of TSS, making the validity of their results suspect to PADEP. There was an elevated level of cadmium, 0.015 mg/L measured at MW-2 during mining and ash placement in the January 1997 sample although this value was below the second highest cadmium measured during the baseline period at MW-2, 0.030 mg/L in March 1994. The highest lead at MW-2 after the suspect February 1994 sample was during mining and ash placement, 0.0094 mg/L in January 1996. The differences between total and dissolved values at MW-2 were not substantive (< 2-3 times) unlike larger differences seen at MW-1 and MW-5.

While data from MW3, the downgradient monitoring point in the underlying aquifer, would have been useful for assessing whether trace elements were leaching to this aquifer as a result of the operation, repeated searches of the permit file for trace element data turned up only two results from MW-3 after the operation started, in March 1999 and February 2000. MW-3 was dry from July 2000 on and “caved in” as of the February 2002 sampling. Concentrations of arsenic, cadmium, lead and selenium from the March 1999 and February 2000 samples did not exceed their DWS and were not as high as the high concentrations for these elements during the baseline period which did exceed the DWS. However, 7 of the 15 highest concentrations of arsenic, lead, and cadmium in the baseline period, including the highest concentrations of arsenic and lead, occurred in samples with TSS levels ranging from 114 mg/L to 380 mg/L making their validity suspect to the PADEP.

As the only point monitoring groundwater moving through the gob pile that is solidly downgradient of ash in the center of the site, MW-4 appears to present the best data available for measuring trace element impacts from ash for the Wildwood operation. The data set for MW-4 includes six samples of trace elements over a six month period during baseline monitoring and only seven samples of trace elements over seven years after the mining and ash placement started. Thus there is far too little data to assess impacts from trace elements due to the nearly half million tons of FBC ash placed at this site.

There were rises in other ash-parameters (monitored under Module 25) at downgradient ash monitoring wells. Fluoride levels (figure 15.12b) jumped immediately from around 1 mg/L measured consistently during the baseline period to a high of 5.95 mg/L in October of 1995. There were a total of eight exceedances of the primary DWS for fluoride (4.0 mg/L) and 20 exceedances of the secondary DWS (2.0 mg/L) out of 25 total measurements for fluoride after mining and ash placement got underway. Fluoride actually increased at all ash monitoring wells whether identified as up or downgradient, after ash placement started but the most decisive increase was at MW-4. Figure 15.12c shows a sharp increase also in fluoride concentrations at MW-3 in the underlying aquifer which was notably higher than the increases at upgradient MW-1 and MW-5 in the underlying aquifer. There were eight exceedances of the secondary DWS for fluoride at MW-3.

There was also a noticeable rise in sodium at MW-4 (figure 15.12d). Relative to other sites studied in this report, sodium levels were already high during the baseline period at MW-4 with a peak value of 258 mg/L in March 1994 and all other values between 102 and 146 mg/L. For nearly five years after mining and ash placement started, sodium levels stayed in this range or slipped below it occasionally with one exception being an anomalously high spike to 2,584 mg/L in October 1997. This concentration could not be depicted in Figure 15.12c with the vertical scale necessary to discern the differences more readily between other sodium values. In particular, in April 2000 sodium rose beyond the earlier range to values thereafter averaging 228 mg/L and was measured at 357 mg/L in April 2002, the last sample collected at MW-4. While there is no DWS for sodium, the Drinking Water Equivalent Level (DWEL) for sodium established by USEPA is 20 mg/L, making the water at MW-4 very unsuitable for human ingestion (see Drinking Water Regulations and Health Advisories, USEPA, Office of Water, October 1996).

The sodium concentrations at MW-2 ranged from 28.50 to 998.13 mg/L during the baseline period. The range of values narrowed after mining and ash placement started to 93.53 to 467.50 mg/L and the average declined from 342.18 mg/L during the baseline period to 233.90 mg/L during and after mining and ash placement. The location of MW-2 adjacent to the main haul road entering the site and its baseline groundwater elevations found just below the surface of the gob pile (11 feet down) suggests this well would have readily seen impacts from any road salting in the Wildwood operation. Impacts from sodium appeared to lesson somewhat in the underlying aquifer at MW-3. While the highest concentrations before and after ash placement were approximately the same, the lowest concentrations dropped from 101.50 mg/L to 21.75 mg/L. Thus average sodium concentrations declined from 150.36 mg/L to 110.93 mg/L from before to after ash placement started.

Unlike sodium, a substantive decline was measured at MW-4 for chloride. The average concentration of 120 mg/L for chloride in the first year of monitoring (1994) declined to an average of 40 mg/L in the last year of monitoring (2001-02).

This contrasts with a rise in chloride at MW-2 from an average of 105.72 mg/L during baseline monitoring to an average of 130.43 mg/L after mining and ash placement started (figure 15.12e). Twelve of 23 chloride concentrations measured during mining and ash placement were higher than all but the highest baseline value for chloride at MW-2. At MW-3, chloride jumped to a peak concentration of 635.20 mg/L in December 1995, nearly three times the highest baseline chloride about a half year into mining and ash placement (figure 15.12f). Then after a gap in monitoring for the first three quarters of 1996, chloride was measured above the highest baseline concentrations at MW-3 three times in 1996/97 before falling back to baseline levels.

There were also substantive declines at MW-4 also for calcium, and magnesium from high baseline concentrations. These as well as chloride, sodium and sulfate are highly soluble constituents usually considered indicator parameters for fluidized bed combustion coal ashes. An average concentration of 465 mg/L for calcium in the first year of monitoring fell to 84 mg/L in the last year of monitoring, and an average of 446 mg/L for magnesium in the first year of monitoring fell to 167 mg/L in the last year. The latter year averages for calcium and magnesium are derived from just two annual measurements in March 2001 and February 2002. Still the sharply lower values for these constituents (except for sodium) suggests that the geochemistry occurring in the ash at the site was reducing their solubility during the duration of monitoring at MW-4.

At MW-3, there were only two samples measuring calcium and magnesium after mining and ash placement started. The results were below the large majority of baseline concentrations for these constituents.

However, such a picture is not clearly presented for calcium and magnesium at MW-2. There was a large range of values for calcium measured at MW-2 (figure 15.12g) during baseline monitoring (52.10-320.25 mg/L). While the highest calcium value after mining and ash placement started was barely half the highest calcium during baseline monitoring, most values during and after the operations were higher than most baseline values. Thus the median value increased from 65.72 mg/L to 105.25 mg/L from before to after mining and ash placement started, and the average calcium concentration increased from 109 to 119 mg/L. The range in magnesium concentrations was also much greater during baseline monitoring (23.85-170.30 mg/L) at MW-2 than after operations started (37.03-63.94 mg/L). Although average magnesium fell from 74 to 47 mg/L from before to after operations started, the median baseline magnesium of 33.23 mg/L was below the median magnesium of 41.54 mg/L after mining and ash placement started.

Major differences reported between total and dissolved values for magnesium and calcium in most samples from MW-4 are not reflected by the TSS and turbidity values reported from those samples. For example, in the March 31, 1994 baseline sample, dissolved calcium was measured at 355.50 mg/L while total calcium was 431.50 mg/L, indicating that 76 mg/L of calcium was undissolved floating in the water. Total magnesium in this sample was 467.00 mg/L while dissolved magnesium was 118.25 mg/L indicating that 348.75 mg/L of magnesium was undissolved in the water. Yet the TSS reported in this sample was only 9 mg/L and the turbidity measurement was 4.85 turbidity units, low measurements indicating clear water with little suspended, undissolved material. Of the thirteen samples analyzed for calcium and magnesium at MW-4, nine had this discrepancy for TSS (low TSS despite a large difference between total and dissolved Ca and Mg) and seven had the discrepancy for turbidity. This suggests more evidence of a problem with sampling methods and/or analysis of the samples in the laboratory. Documentation of concern about such results from the PADEP was not found in the permit files.

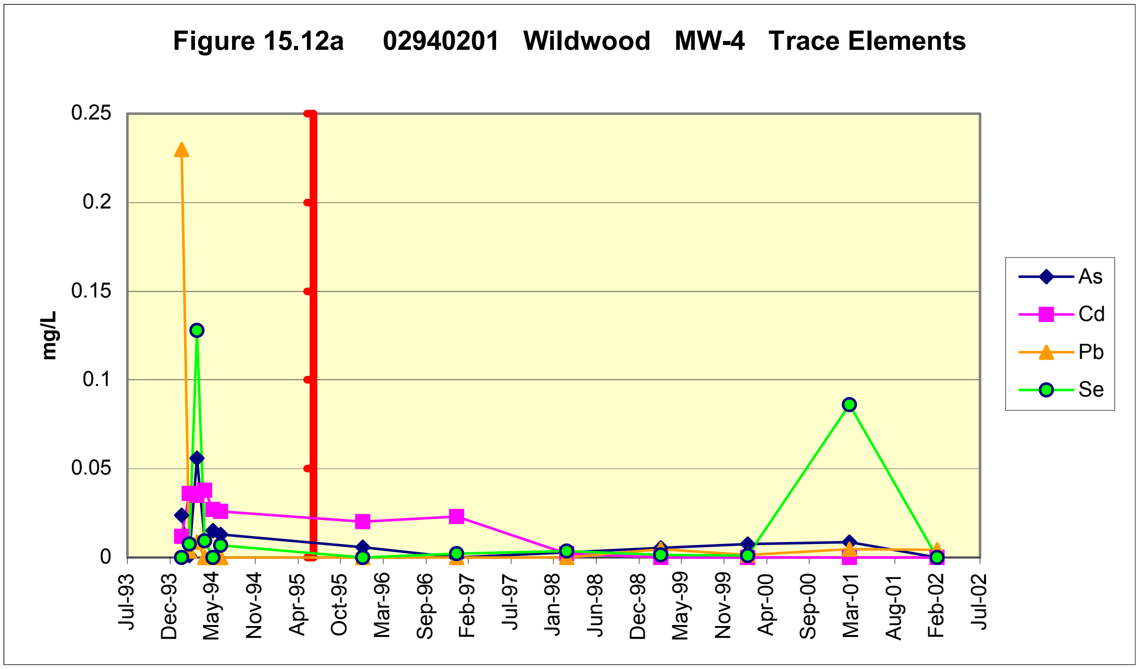


Figure 15.12a 02940201 Wildwood MW-4 Trace Elements
mg/L
0.25
0.2
0.15
0.1
0.05
0
Jul-93
Dec-93
May-94
Nov-94
Apr-95
Oct-95
Mar-96
Sep-96
Feb-97
Jul-97
Jan-98
Jun-98
Dec-98
May-99
Nov-99
Apr-00
Sep-00
Mar-01
Aug-01
Feb-02
Jul-02
As
Cd
Pb
Se

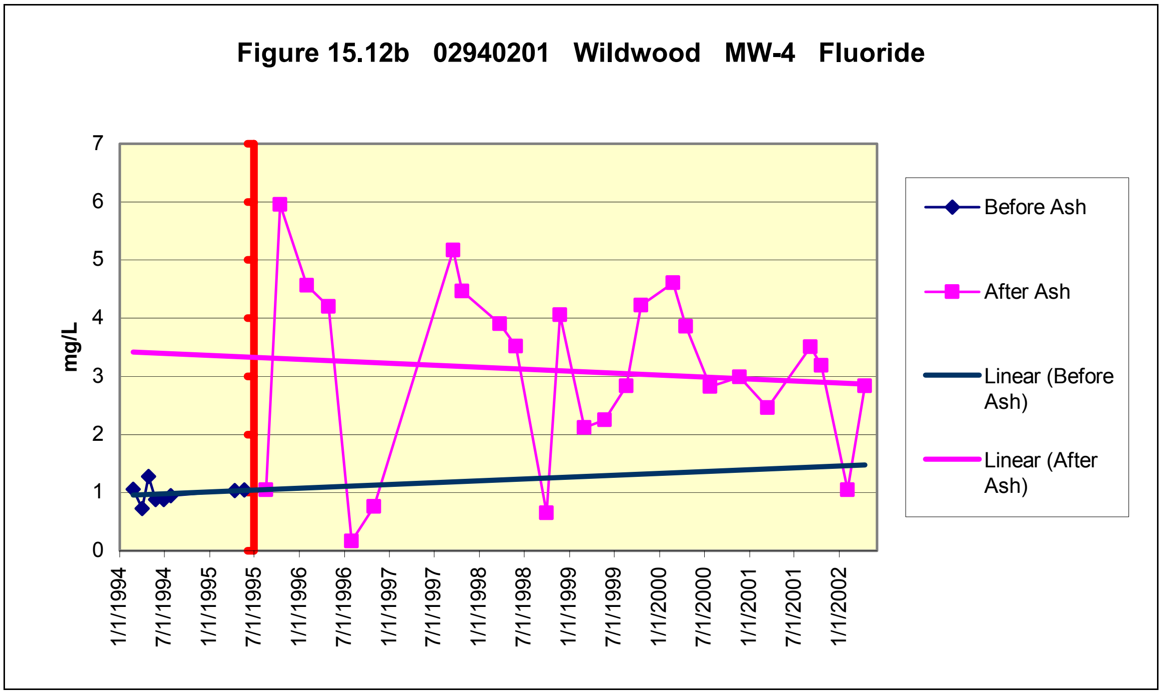


Figure 15.12b 02940201 Wildwood MW-4 Fluoride
mg/L
7
6
5
4
3
2
1
0
1/1/1994
7/1/1994
1/1/1995
7/1/1995
1/1/1996
7/1/1996
1/1/1997
7/1/1997
1/1/1998
7/1/1998
1/1/1999
7/1/1999
1/1/2000
7/1/2000
1/1/2001
7/1/2001
1/1/2002
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

Figure 15.12c 02940201 Wildwood MW-3 Fluoride

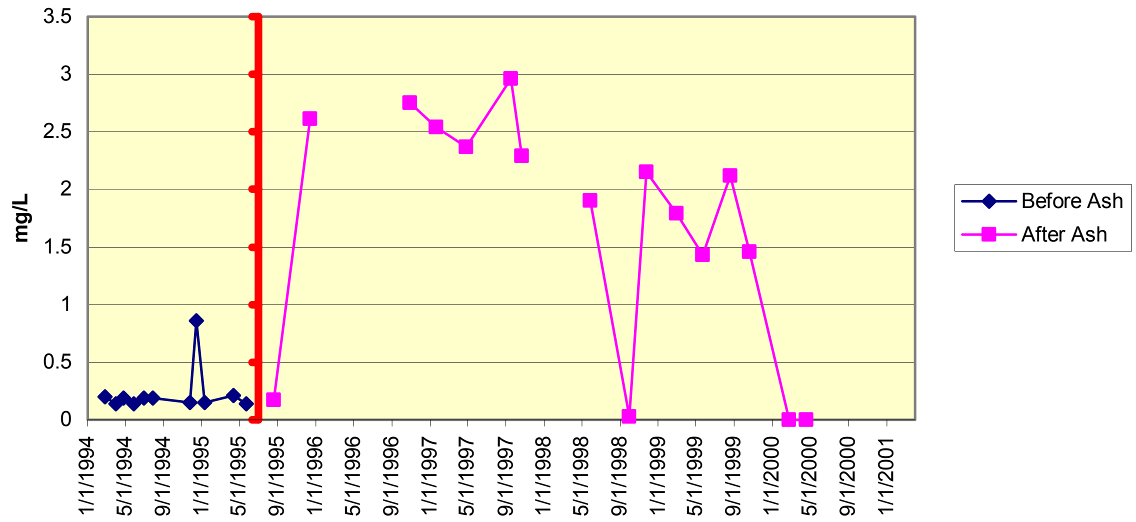


Figure 15.12d 02940201 Wildwood MW-4 Sodium

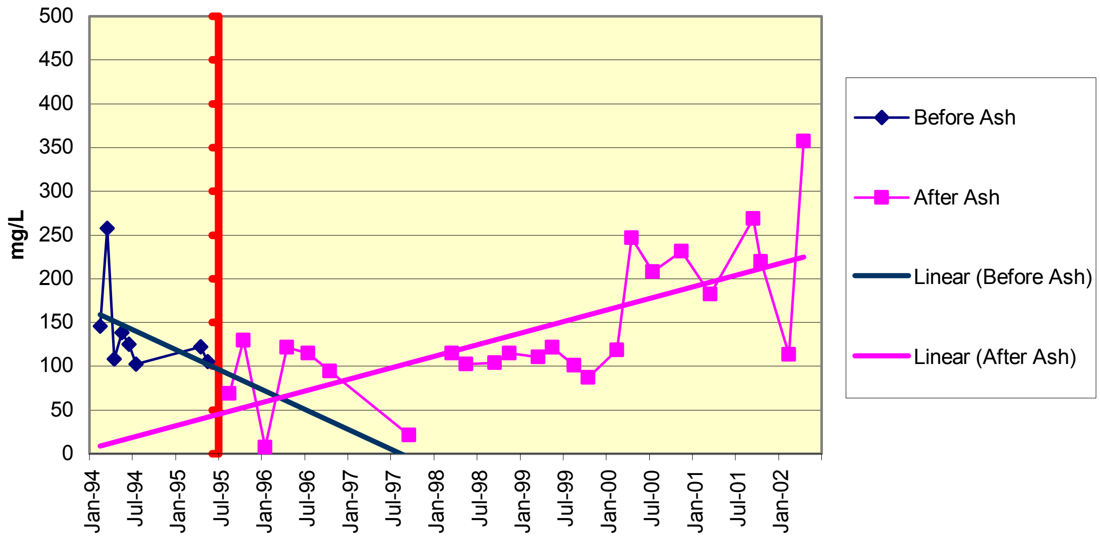


Figure 15.12e 02940201 Wildwood MW-2 Chloride

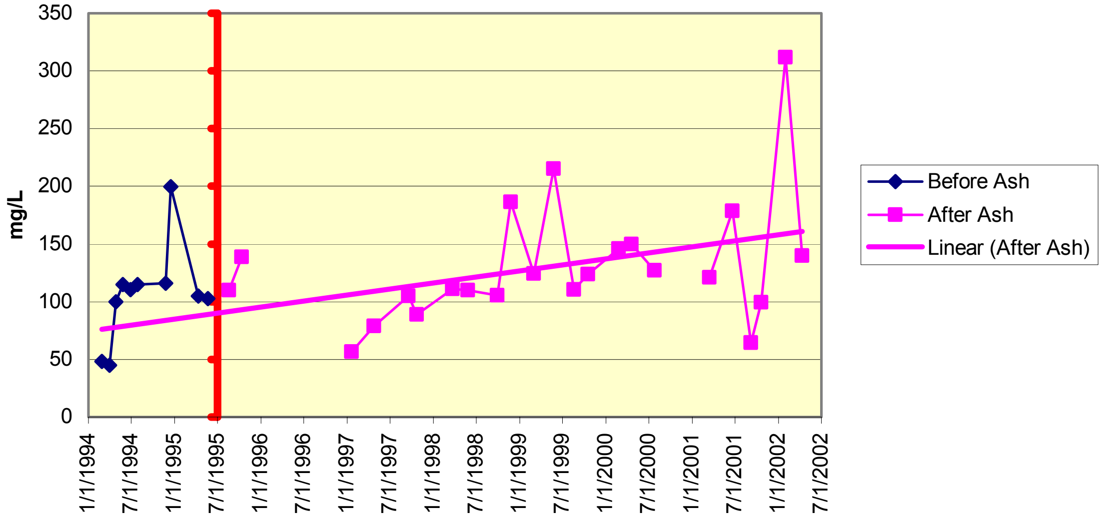
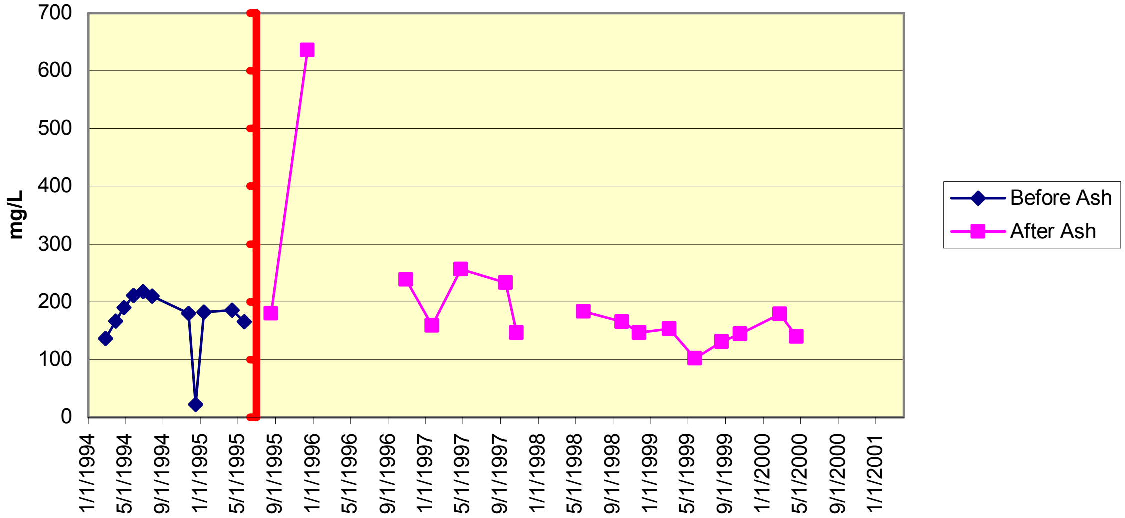
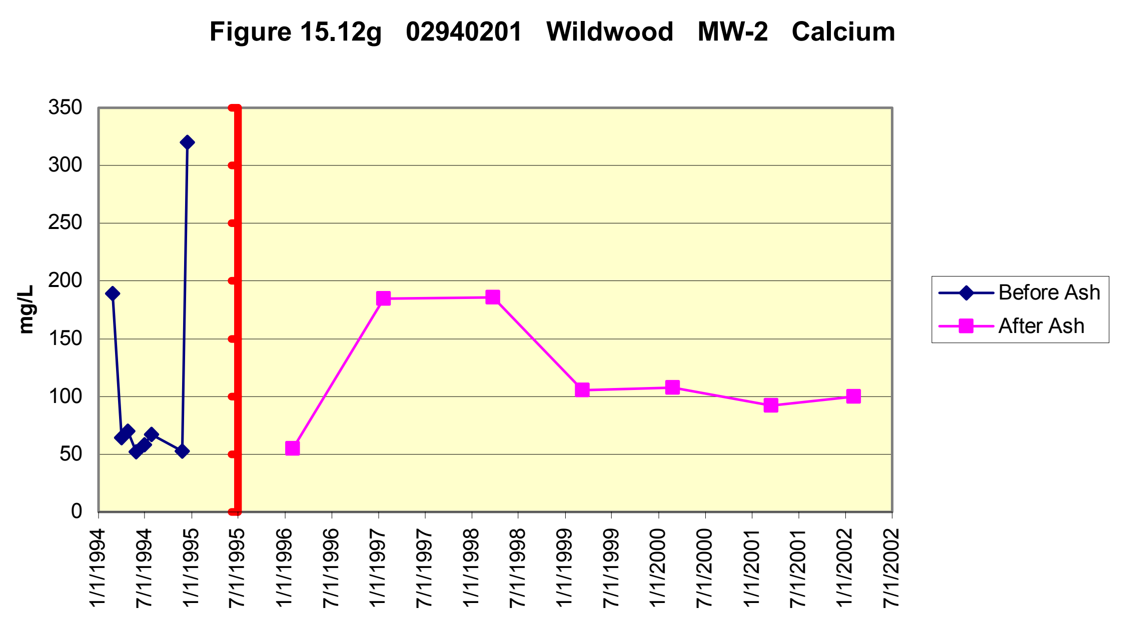


Figure 15.12f 02940201 Wildwood MW-3 Chloride





Subchapter F Points

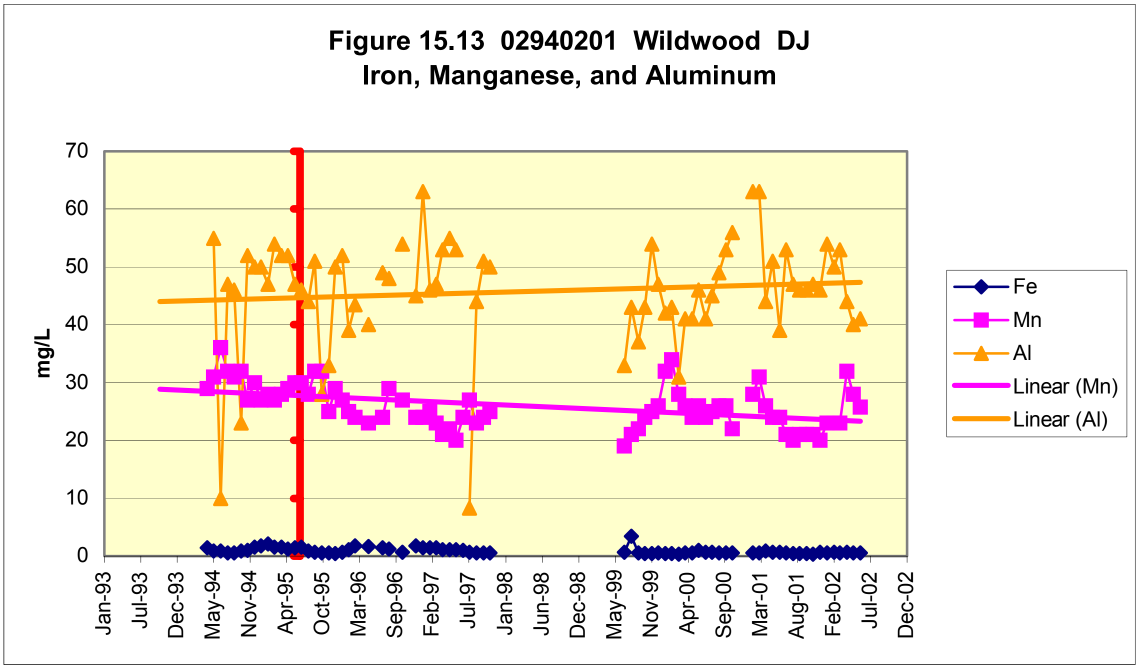
The two subchapter F monitoring points (DJ and SP-C) are both downgradient of the remining and ash placement operation. Point DJ is a discharge pipe from the pile, and SP-C is a spring near the bottom of the pile. These points are both missing 1998 concentration data and were monitored for Module 8 mining parameters only. Thus aside from the constituents associated with mining impacts -- iron, manganese, aluminum, sulfate, TDS, acidity and pH -- which are also ash parameters, there were no concentrations for the trace elements or calcium, magnesium, chloride, fluoride, sodium or other ash parameters monitored under Module 25 reported from DJ or SP-C.

It should be noted that Permit 02940201 was revised to incorporate Subchapter F provisions subsequent to the March 1995 revision that authorized ash placement at this site, and thus samples collected from May 27, 1994 through November 27, 1996 were designated as "baseline" samples for DJ and SP-C by PADEP. For purposes of comparing and assessing impacts from mining and ash placement consistently with those observed at ash monitoring points, however, the following figures and discussion are assessing the baseline period as remaining before July 1, 1995.

Figure 15.13 is a graph of the iron, manganese, and aluminum concentrations over time at DJ. The overall trends for iron and manganese were slightly downward although the highest iron concentration, 3.4 mg/L, occurred in August 1999 after remining and associated ash placement operations were finished. The overall trend for aluminum was slightly upward.

Sulfate concentrations (figure 15.14) were very high (up to 6800 mg/L) but trend downward over time, suggesting that gob removal and possibly AMD treatment from ash are having a positive impact. Figure 15.14 also illustrates the downward trend of TDS. The discrepancy of higher sulfate than TDS was more evident at DJ than at MW-4. While there was just one baseline sample where this occurred, after mining and ash placement were underway, sulfate concentrations exceeded TDS concentrations in 30 of the 56 samples in which both values were measured at DJ. From July 1999 on at DJ, nearly all sulfate values were higher than the TDS values until the final four samples collected from March through June of 2002. TSS values at DJ from July 1999 on were consistently low (the highest being 14 mg/L in July 1999) indicating little of the sulfate was undissolved in the water.

The acidity dropped over time (figure 15.15), correlating well with the drop in sulfate concentrations. The field pH had a gradually rising trend, but at a low level, increasing to an average of about 3.3 s.u.(figure 15.16), entirely different than the alkaline pH at the ash monitoring wells.



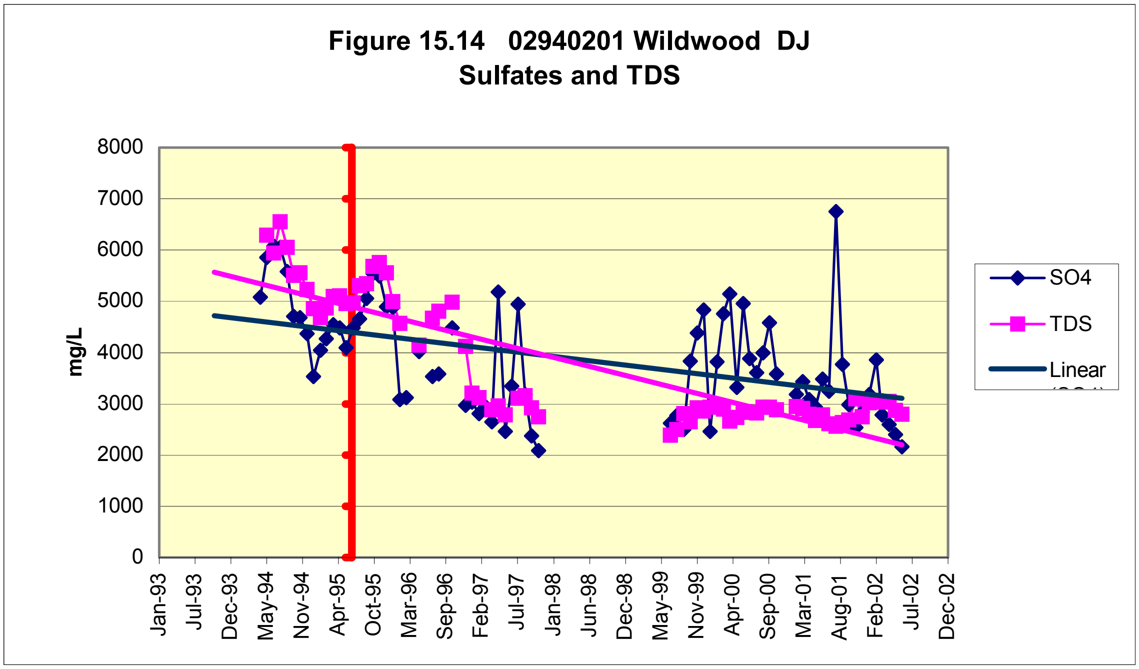


Figure 15.14 02940201 Wildwood DJ
Sulfates and TDS
mg/L
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan-93
Jul-93
Dec-93
May-94
Nov-94
Apr-95
Oct-95
Mar-96
Sep-96
Feb-97
Jul-97
Jan-98
Jun-98
Dec-98
May-99
Nov-99
Apr-00
Sep-00
Mar-01
Aug-01
Feb-02
Jul-02
Dec-02
SO4
TDS
Linear

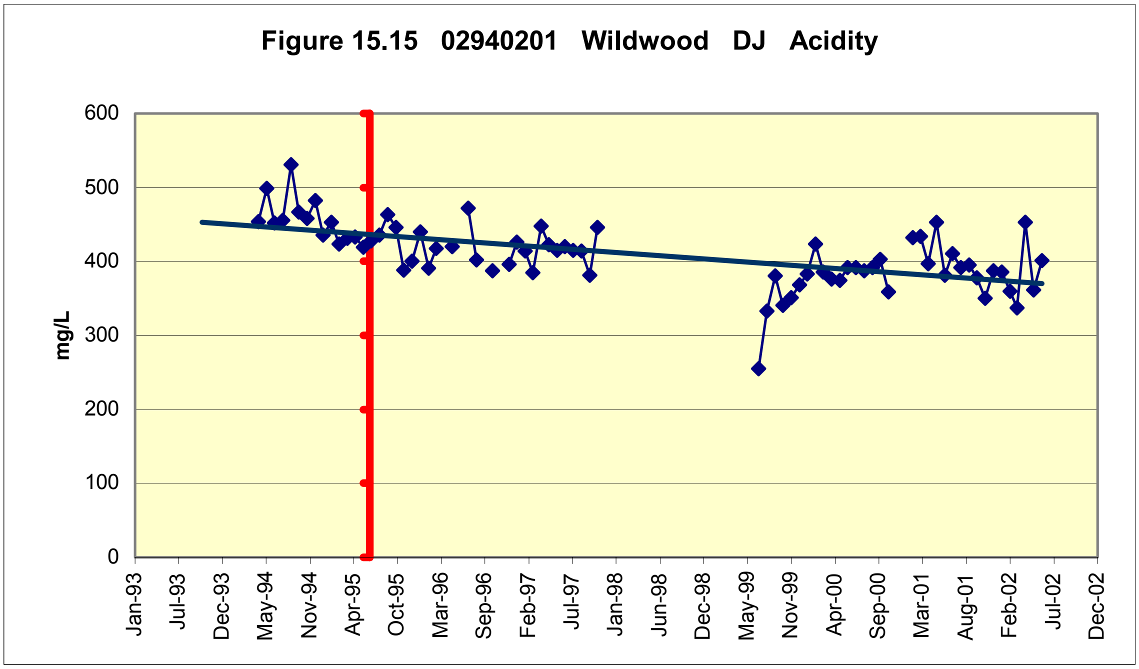
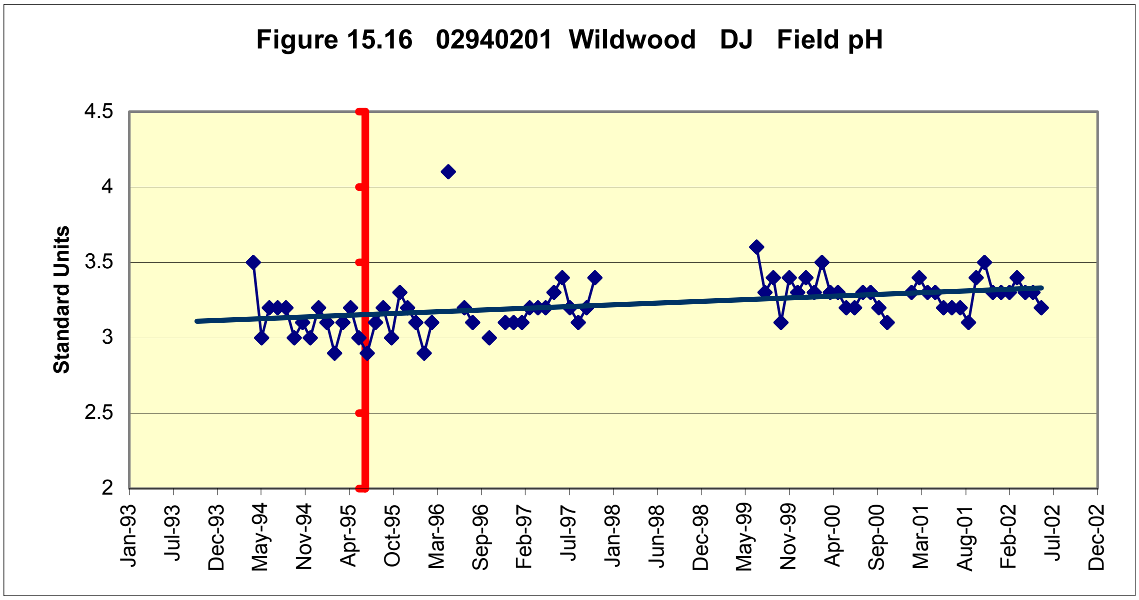


Figure 15.15 02940201 Wildwood DJ Acidity
mg/L
600
500
400
300
200
100
0
Jan-93
Jul-93
Dec-93
May-94
Nov-94
Apr-95
Oct-95
Mar-96
Sep-96
Feb-97
Jul-97
Jan-98
Jun-98
Dec-98
May-99
Nov-99
Apr-00
Sep-00
Mar-01
Aug-01
Feb-02
Jul-02
Dec-02



The data sets for loading at DJ reveal sharp increases in loads of iron, manganese, aluminum (figures 15.17a-c) and sulfates (figure 15.18) in the last quarter of 1996 and first quarter of 1997. These high values are reflective of higher concentrations during mining but even more so of flow volumes from this discharge pipe that were five to ten times greater during this time. The amounts of these pollutants leaving the site at DJ also peaked subsequently in spring samplings (June 16, 2000, April 23, 2001, and May 20, 2002). The April 2001 sample produced the highest loads beyond the mining period for iron, manganese, aluminum and sulfate. With the exception of iron, these peaks surpassed the highest loads measured during the baseline period. The last three loading values for manganese (April-June, 2002) and the May 2002 loading value for sulfate also surpassed all but one or two of the loadings measured for these constituents during the baseline period even though the flow volumes in gallons per minute were not appreciably greater than baseline flow volumes. Thus while loads declined dramatically from those during the peak of mining, as of the latest measurements in 2002, they had not declined below baseline loading levels. In addition to the absence of any 1998 values, there were nine sampling events in 1996, 1997, and 1999 in which monitoring reports indicate DJ was “INACCESSIBLE DUE TO HIGH WATER.”

Figure 15.17a 02940201 Wildwood DJ Iron Loading

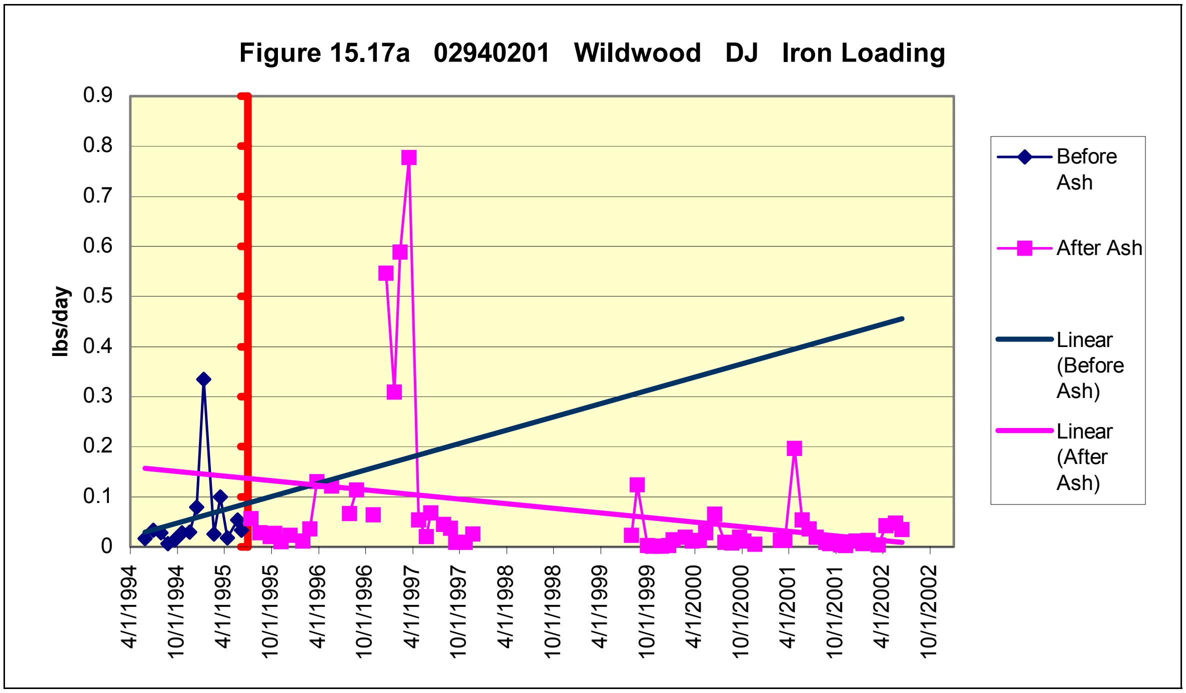
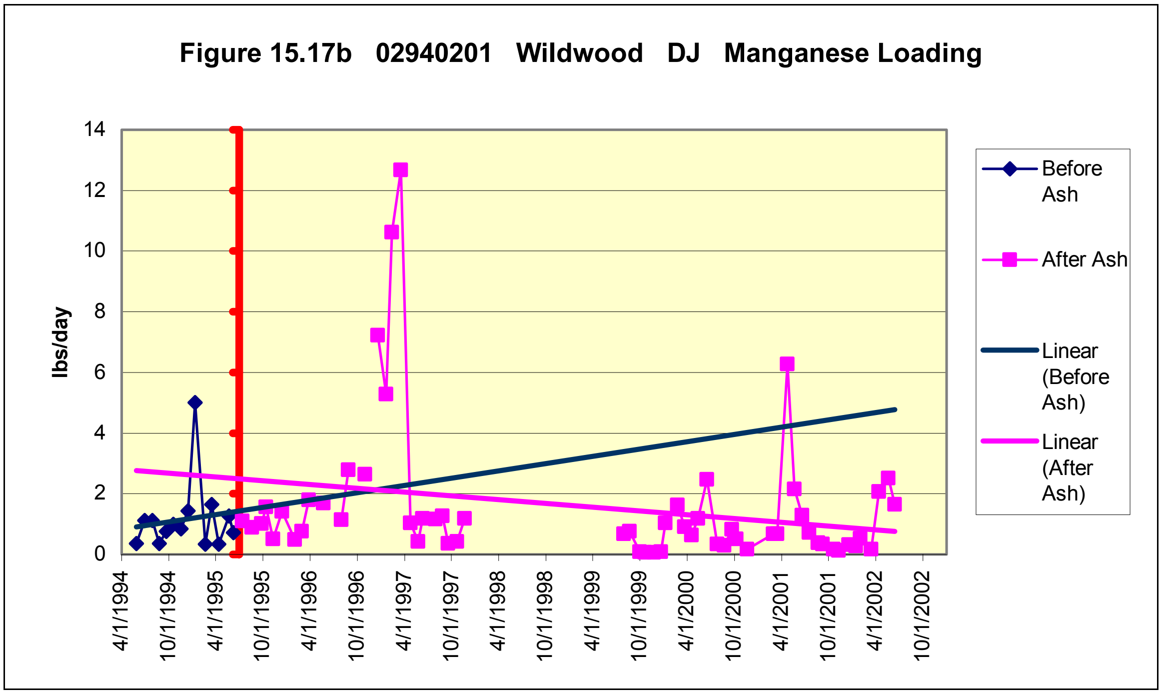
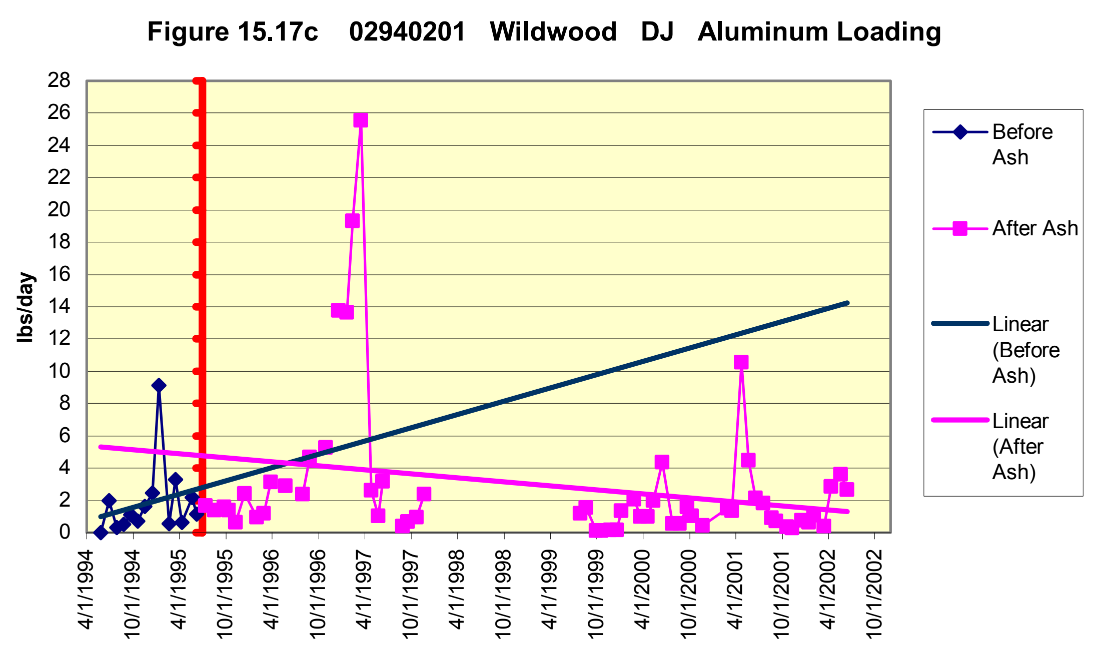
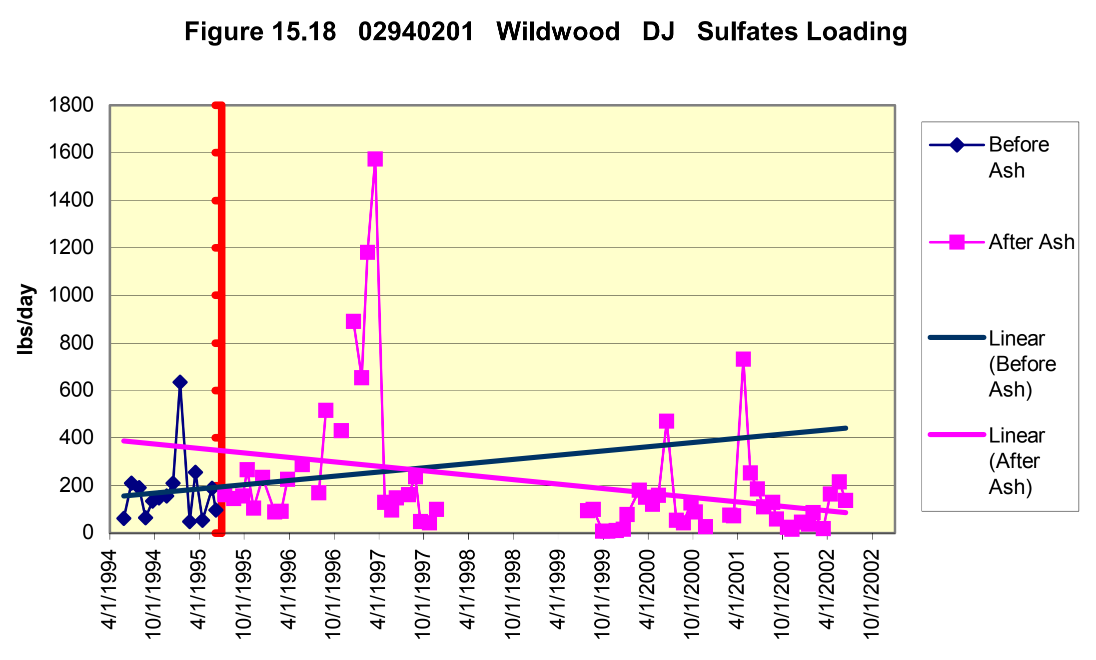


Figure 15.17b 02940201 Wildwood DJ Manganese Loading







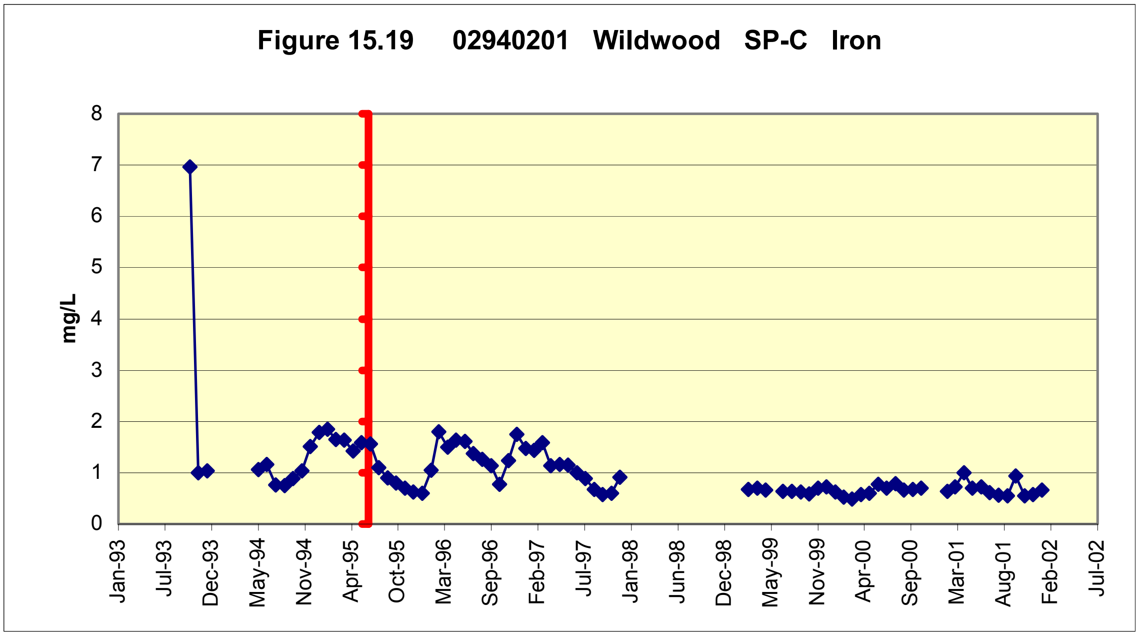
The subchapter F point SP-C had trends after mining and ash placement began that were similar to the trends observed at DJ. The iron concentrations were low (figure 15.19), with only one value, the first measurement during the baseline period, exceeding 2.0 mg/L. The trend was decreasing over time. Manganese dropped from an average concentration of 38 mg/L in the first year of monitoring to an average concentration of 22 mg/L in the last year of monitoring data available (figure 15.20). Unlike results at DJ, aluminum concentrations also dropped at SP-C from an average of 68 mg/L in the first year of monitoring to an average of 52 mg/L in the last year of monitoring data available (figure 15.21). Sulfate concentrations (figure 15.22) averaging 5,380 mg/L in the first year of baseline monitoring declined to an average of 3092 mg/L in the last year of monitoring data available.

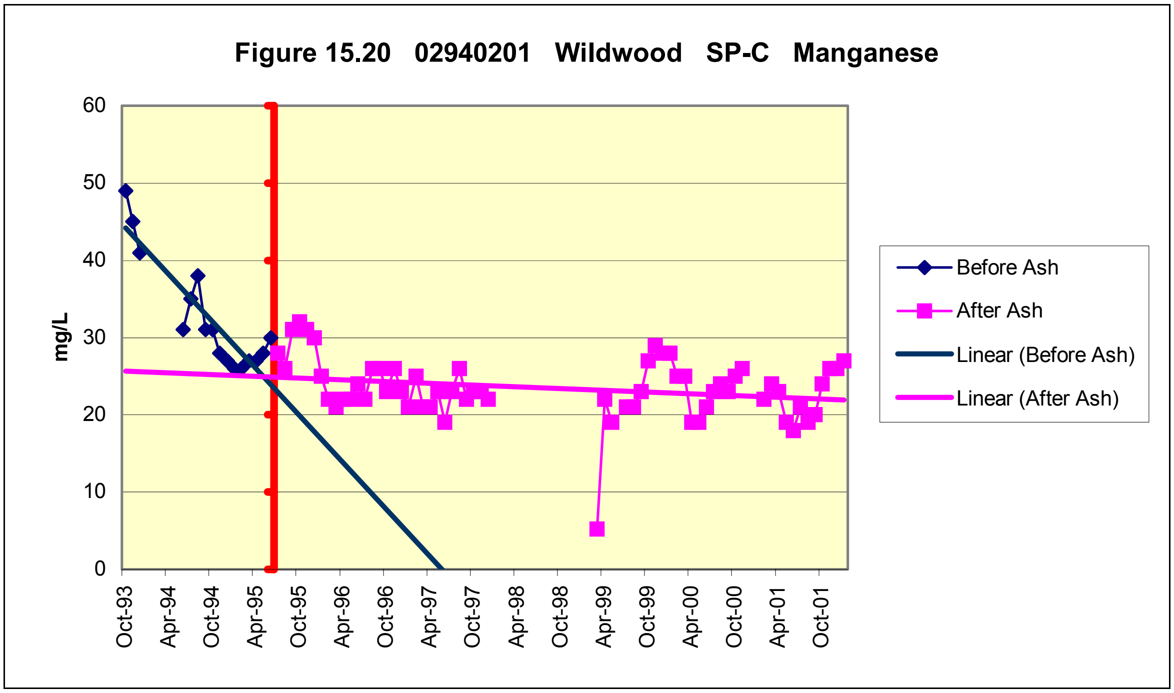
The field pH values reflect acidified waters at SP-C but had a slightly increasing trend during the remining and ash placement, averaging about 3.2 s.u. (figure 15.23) at the end of monitoring. The acidity also dropped from an average of 608 mg/L in the first year of monitoring to an average of 434 mg/L in the last year of monitoring data (figure 15.24). This trend is consistent with the significant drop in sulfate values over time to levels that nonetheless are still elevated. The acidity at SP-C and DJ were substantially higher than the acidity at ash monitoring wells underneath and in the gob reflecting the AMD that strengthens in the site as water migrates through the materials affected by the remining from subsurface to surface environments. The latest values of acidity and pH at these subchapter F points indicate that the project had improved upon but definitely not eliminated AMD at this site.

The TDS at SP-C (figure 15.25a) dropped substantially from an average of 5,580 mg/L in the first year of monitoring to an average of 2,658 mg/L in the last year of monitoring. As occurred at DJ, Figure 15.25b shows that while TDS concentrations were above sulfate throughout the baseline period, during mining and ash placement, sulfate concentrations exceeded TDS concentrations in 34 of the 59 samples collected from SP-C in which values for both analytes were reported. After a gap in data from January 1998 through February 1999, sulfate remained higher than TDS from March 1999 to the last two samples reported in 2002. In many of these samples, sulfate concentrations were 500 mg/L to more than 1,000 mg/L higher than TDS concentrations. Yet as occurred at DJ, TSS levels during this latter monitoring were consistently low at SP-C -- the highest being 12 mg/L in July 2001 and most being below 5 mg/L -- demonstrating there would have been little undissolved sulfate in the water. Again this indicates a problem with the sampling or laboratory analysis procedures.

Of note is that precipitous declines in concentrations of manganese, aluminum, sulfate, acidity and TDS that were occurring at SP-C during the baseline period abated to slower rates of decline during the remining and ash placement. In the case of aluminum, there appeared to be no declining trend after operations commenced at the site. This suggests that poor water quality at this point was abating before remining and ash placement started although the baseline monitoring period was not long enough to establish this definitively. At DJ, the trends do not change as noticeably from the baseline period to the period of remining and ash placement.

Nevertheless despite clear improvement from initial baseline conditions (with the exception of aluminum at DJ as shown in figure 15.13), the data indicates there was still substantive sulfate, manganese, aluminum and acidity leaching from site materials and/or the placed ash at the conclusion of the project at both of these subchapter F points.





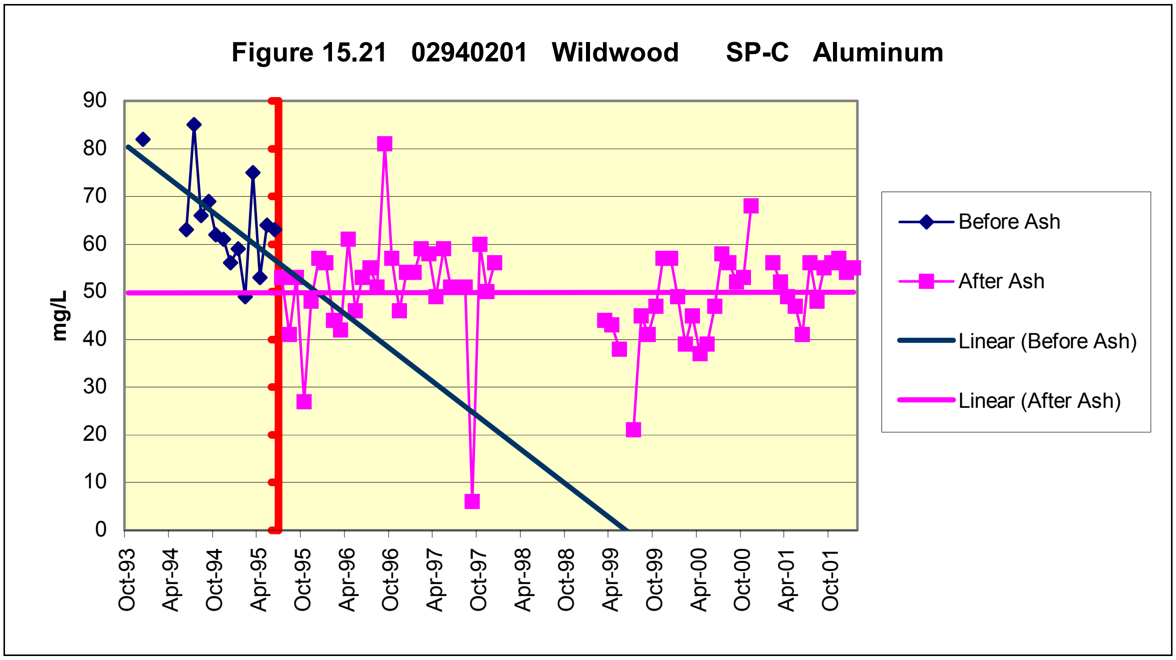


Figure 15.21 02940201 Wildwood SP-C Aluminum
mg/L
0
10
20
30
40
50
60
70
80
90
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

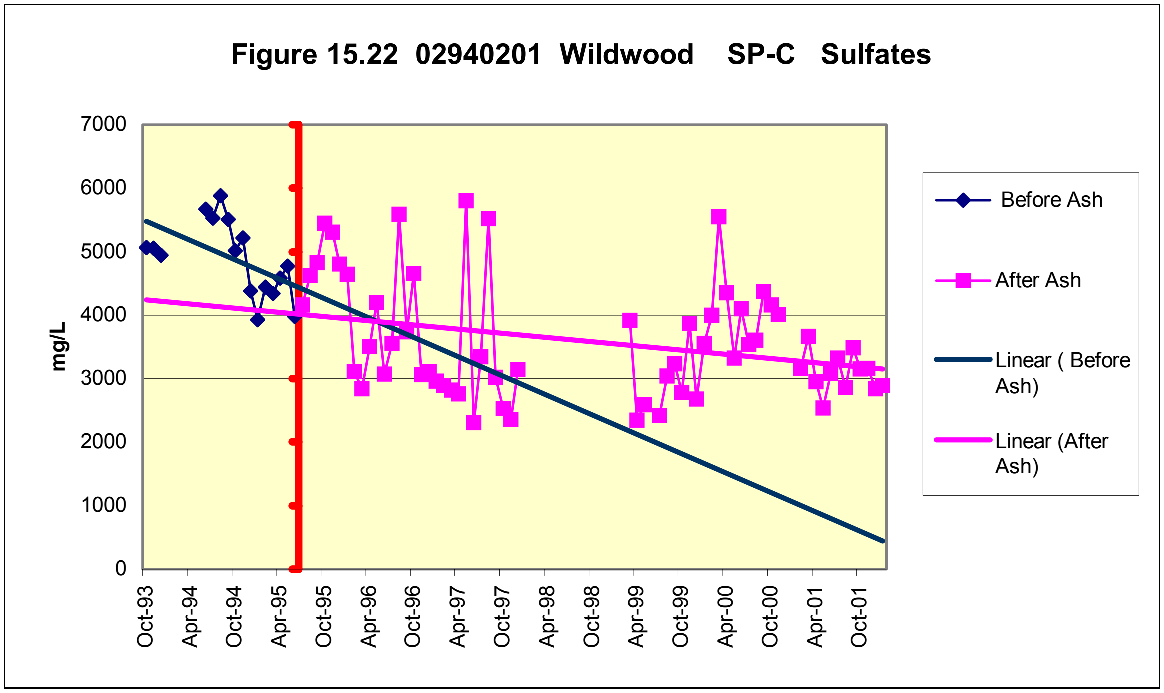


Figure 15.22 02940201 Wildwood SP-C Sulfates
mg/L
0
1000
2000
3000
4000
5000
6000
7000
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

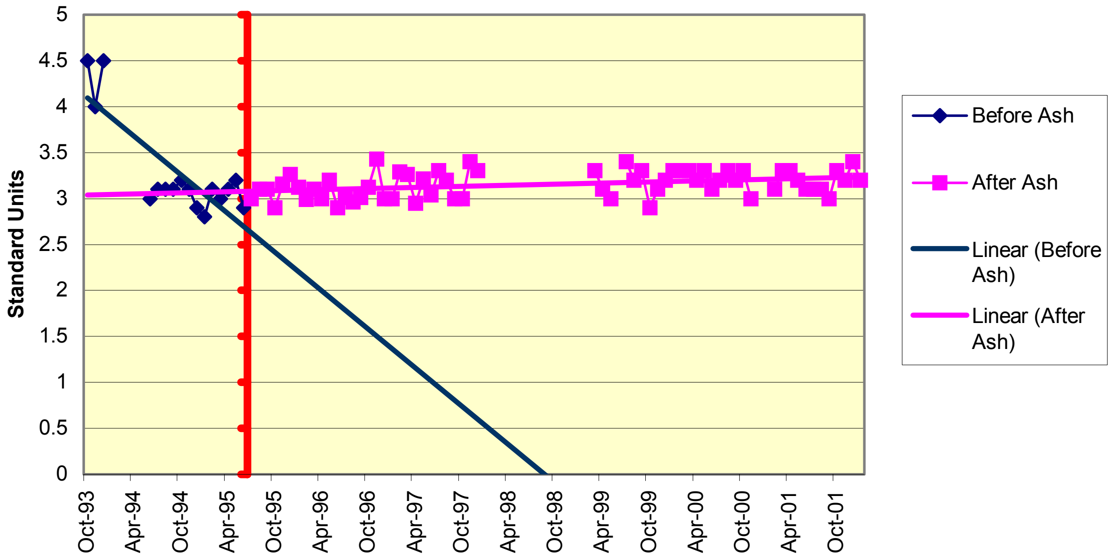


Figure 15.23 02940201 SP-C pH
Standard Units
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

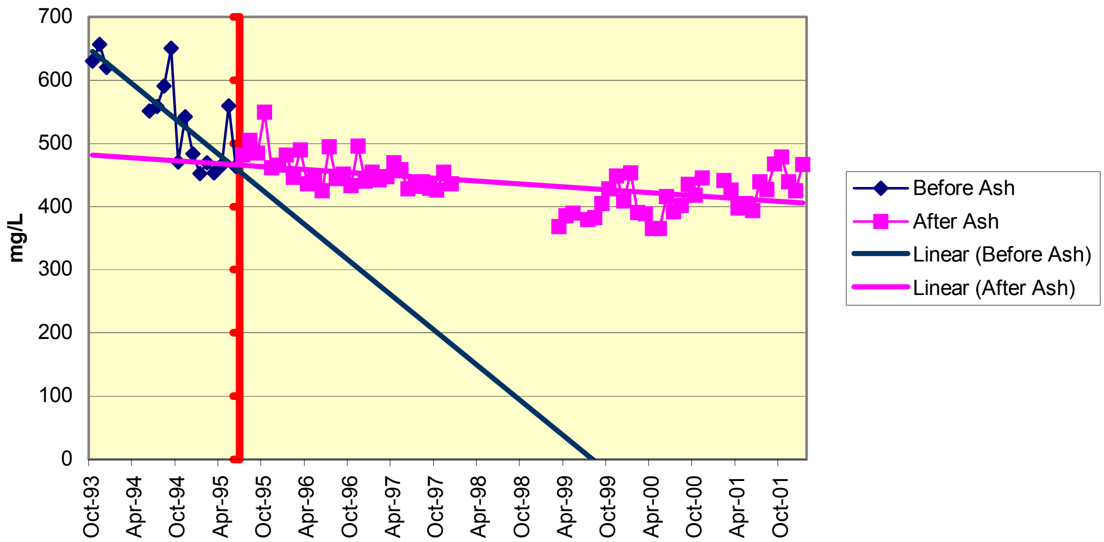


Figure 15.24 02940201 Wildwood SP-C Acidity
mg/L
700
600
500
400
300
200
100
0
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

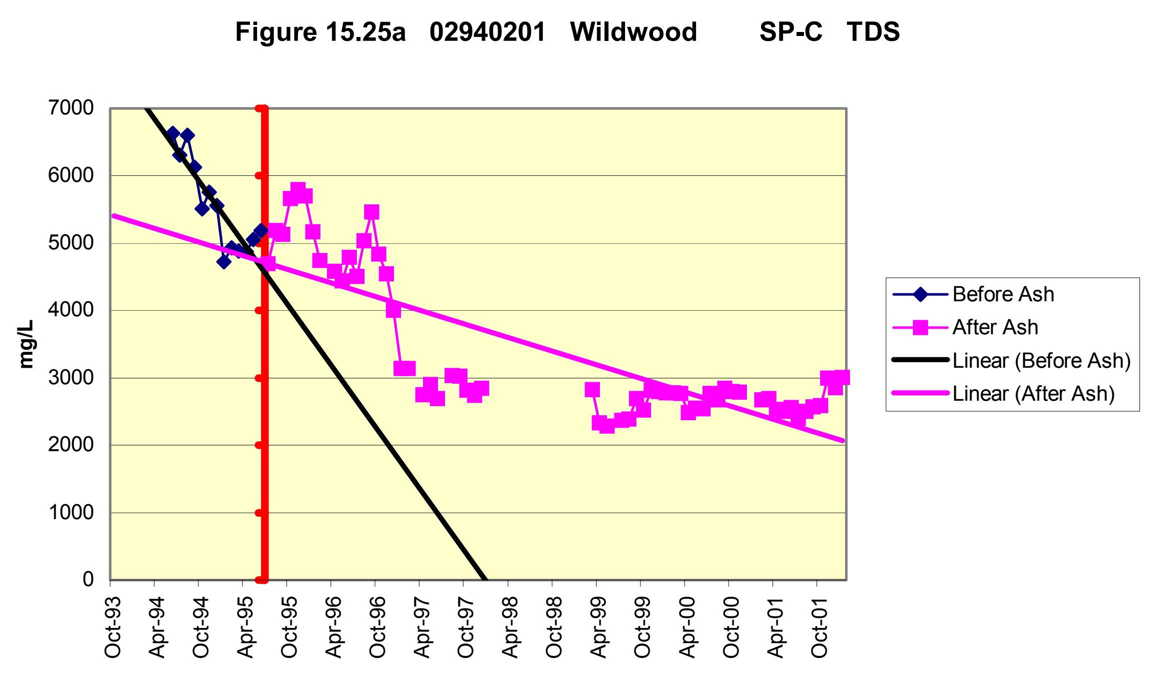


Figure 15.25a 02940201 Wildwood SP-C TDS
mg/L
7000
6000
5000
4000
3000
2000
1000
0
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
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Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Before Ash
After Ash
Linear (Before Ash)
Linear (After Ash)

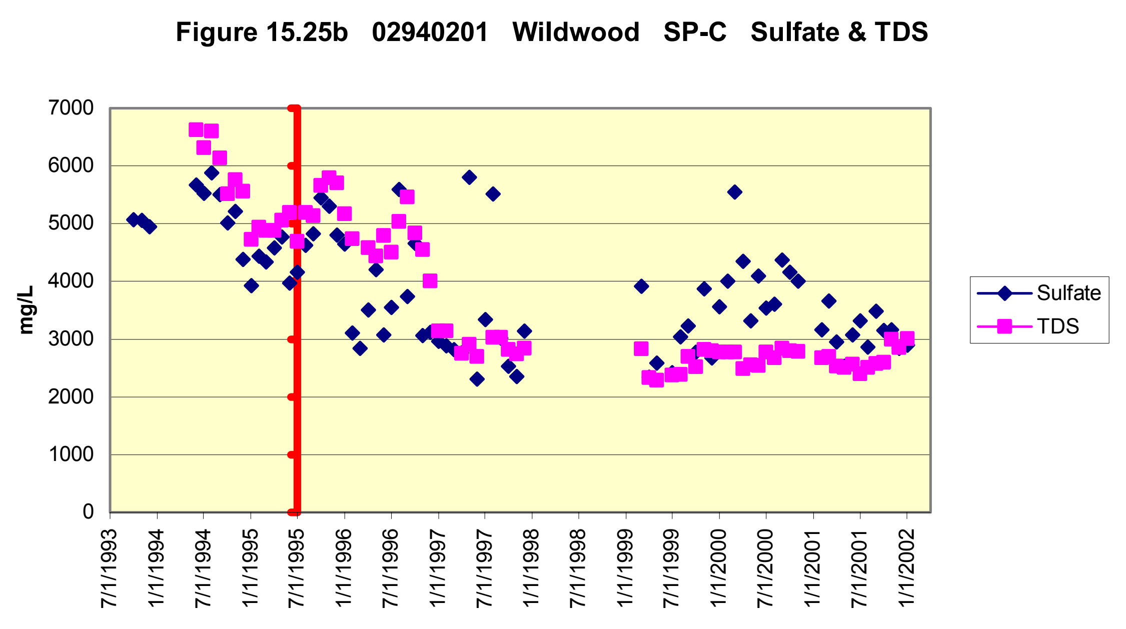
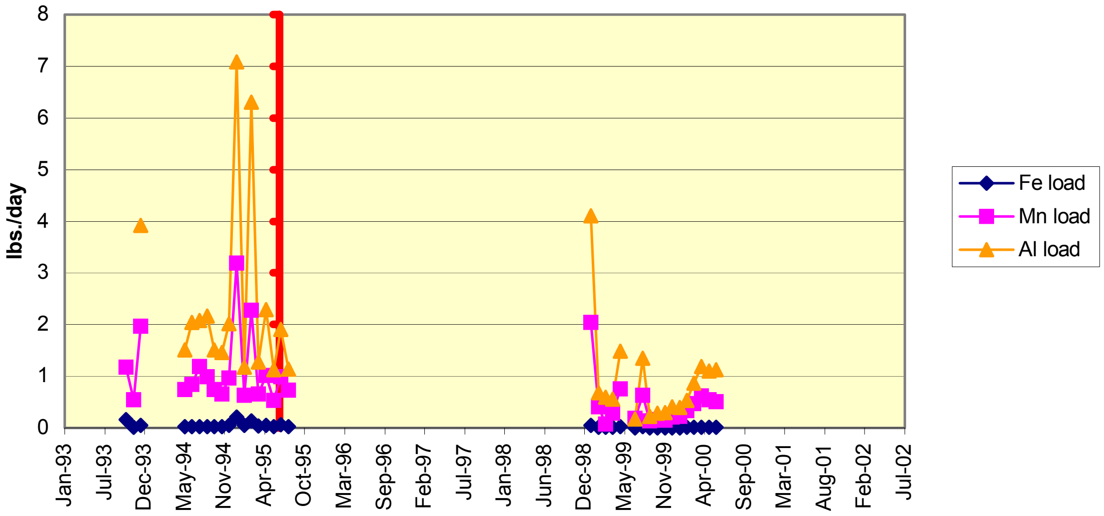
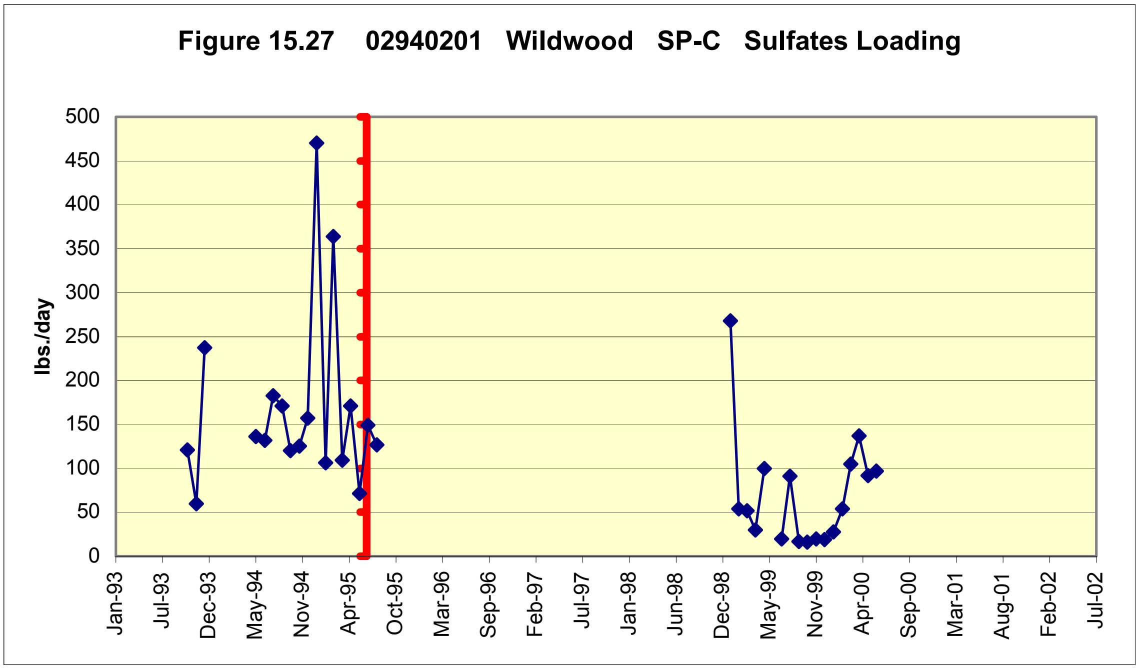


Figure 15.25b 02940201 Wildwood SP-C Sulfate & TDS
mg/L
7000
6000
5000
4000
3000
2000
1000
0
7/1/1993
1/1/1994
7/1/1994
1/1/1995
7/1/1995
1/1/1996
7/1/1996
1/1/1997
7/1/1997
1/1/1998
7/1/1998
1/1/1999
7/1/1999
1/1/2000
7/1/2000
1/1/2001
7/1/2001
1/1/2002
Sulfate
TDS

Figures 15.26 and 15.27 reflect the loadings for iron, manganese, aluminum and sulfate at SP-C. The trends for these constituents followed each other closely and reflect concentration trends to a small degree showing lower values over time. While there was no data in the permit files for 1998, these graphs also do not reflect data that was available from 1996 and 1997 and from June, 2000 through January, 2002. Discharge volumes at SP-C which otherwise ranged from 0.21 to 10 gallons per minute (GPM), peaked to 30-45 GPM from October 1996 through January 1997, presumably during the height of mining. These much higher volumes produced loading values ranging from 9.486 to 11.205 lbs/day for manganese, 16.632 to 28.944 lbs/day for aluminum and 1,103 to 1,956 lbs/day for sulfate that substantially surpass the vertical scales in Figures 15.26 and 15.27. In contrast, loading values in the final year of data (February 2001 to January 2002) were below those in these figures as the discharge volumes at SP-C declined to their lowest levels, between 0.21 and 2.0 GPM. The highest loadings then, measured in the April 2001 sample, were 0.5374 lbs/day for manganese, 1.1892 lbs/day for aluminum and 71 lbs/day for sulfate. From both a concentration and loading standpoint, water quality for these parameters has been improving at SP-C although with high residual concentrations remaining in the most recent monitoring data available.

Figure 15.26 02940201 Wildwood SP-C Loading
Iron, Manganese, and Aluminum





Conclusion

Monitoring suggests an overall improvement in water quality as a result of the remining and ash placement operation at the Wildwood site although there are several exceptions to this trend. There were also gaps in monitoring, insufficient monitoring for trace elements and discrepancies in sample results. Furthermore the operator of the site, ACV Power Corporation, ceased monitoring in 2002 and did not respond to two subsequent compliance orders issued by PADEP in August 2003 and January 2004 to sample and produce monitoring data from subchapter F monitoring points and pay some $23,550 in penalty assessments for this failure to monitor. Thus there is a basic question about whether bond release or the cessation of monitoring should have been allowed at this site.

Despite the failure of the operator to produce monitoring data or respond otherwise, PADEP apparently released the bond for the site in the latter half of 2004, terminated monitoring and wrote off the penalties in February 2006 stating, "The entity against whom the civil penalties were issued is no longer in business. Consequently these civil penalty assessments are not collectible."

Yet the basis for terminating monitoring much less releasing the bonds at this site does not appear to have been definitively established. An internal memorandum dated June 16, 2004, by a PADEP geologist reviewing data to determine whether final release of bonds was appropriate, states:

> In my attempt to review the monitoring and loading data for each point--I found that the operator hasn't submitted monitoring data

> since 2002. The Mine Conservation Inspectors for the site have been gathering samples of several of the Subchapter F monitoring points in addition to upstream and downstream points.
>
> The last set of samples for HU-2 was taken by the MCI in August, 2003.
>
> The loadings were below the short-term triggers for the relevant parameters. No samples were found for HU-1 points for a period well-before August, 2003. A comparison of upstream versus downstream samples (as submitted by the MCI's from late 2003 to early 2004) shows no degradation of the receiving stream during that timeframe.

Conclusions

> I am unable to provide you with any definitive analysis of the current Subchapter-F data since none apparently exists. A cursory examination of the receiving stream reveals no major degradation. If the operation was a "complete haul-out" of coal refuse as you have indicated and the field staff believes that no adverse hydrologic impacts have occurred—such as to the receiving stream, the Department may consider releasing the remaining bond.

The HU-1 (Hydrologic Unit One) points referred to in this memorandum include Subchapter F monitoring points D-J and SP-C. This memo does not discuss data from these points. The data available reveals lower concentrations and loadings of pollutants in the final year of monitoring than occurred during baseline monitoring at SP-C. This data also suggests that water quality at this monitoring point was improving during the baseline period, with concentrations of manganese, aluminum, sulfate, TDS and acidity declining significantly in 1993-1995 before mining and ash placement began.

However the data also reveals loadings of manganese, aluminum and sulfate in the final two years of monitoring that were higher than any loadings measured during baseline monitoring at DJ and concentrations of aluminum and sulfate in the final two years that were higher than any concentrations measured during baseline monitoring at DJ. In addition the overall trend for aluminum concentrations was gradually increasing at DJ over the duration of the project. If indeed, this project resulted in the "complete haul out of coal refuse," the high concentrations of manganese, aluminum, sulfate, TDS, alkalinity and acidity measured at site monitoring points in 2000-2002 demonstrates that waste coal ash from the Scrubgrass Plant and/or remaining site materials were leaching significant levels of these parameters after the remining and ash placement was finished, and the surface of the site was reclaimed.

Furthermore notwithstanding the assertion in the memo that no degradation was occurring to Pine Creek in 2003-2004, a comparison of water quality at upstream monitoring point S-G to a downstream monitoring point S-A (from five quarterly samples taken at each point on the same dates) in the last year of data available for these points in this report (2001-2002) reveals an average sulfate upstream of 64 mg/L compared to average sulfate downstream of 198 mg/L and average manganese upstream of 0.154 mg/L compared to average manganese downstream of 0.25 mg/L. This data is from 2-3 years after remining had concluded at the Wildwood site. The average sulfate at the same upstream point in the first year of baseline monitoring of 65.62 mg/L compared to average sulfate at the same downstream point in that year of 96.62 mg/L. Average manganese in the first year of baseline monitoring was 0.212 mg/L at the upstream point versus 0.312 mg/L at the downstream point. There was negligible difference between average upstream and downstream iron concentrations (0.312 vs. 0.316 mg/L respectively) in the final year of available data for these points, and aluminum data was not available. Acidity at both points was N.D. (presumed to mean Not Detected). However, average alkalinity in the final year was slightly lower upstream (62.70 mg/L) than downstream (82.23 mg/L), and average pH also slightly lower upstream (7.13 field and 7.13 lab) than downstream (7.3 field and 7.32 lab). Beyond suggesting that the site was contributing manganese and sulfate to Pine Creek after the conclusion of the project, in the case of sulfate, this data suggests the site was contributing more sulfate to Pine Creek as a result of the remining and ash placement, opposite of the intended result of a Subchapter F permit.

Although there were five monitoring wells installed at the Wildwood site to monitor for ash contaminants, only one, MW-4, appeared to be in a solidly downgradient position relative to the ash placement area. Data for upgradient MW-1 were examined but are baseline values only until the last year of samples (1996) and thus were not to useful for comparing to downgradient data from MW-4 to assess impacts of the project on site groundwater. MW-1 was also screened in a different aquifer, well below the water in the gob pile being monitored by MW-4. Data from monitoring wells MW-3 and MW-5 was also less complete and like MW-1, these wells were measuring impacts to the underlying aquifer that should have been more isolated from near-term impacts to the water moving through the gob piles from ash placement. MW-2 was measuring gob pile water on the far northeast perimeter of the site and thus also not likely to be seeing the effects of ash as readily as MW-4.

There were steady downward trends of iron, manganese, sulfate and TDS and strong increases in alkalinity and bicarbonates at MW-4. Lower concentrations of highly soluble ash parameters such as sulfate, calcium, magnesium and chloride in the final year of monitoring than in the first year of baseline monitoring at MW-4 as well as sharply reduced flow volumes at SP-C and moderately reduced volumes at DJ suggest that the reclamation activities including the placement of ash may have reduced the amount of water infiltration at the site.

Indeed laboratory leach tests on the Scrubgrass Generating Station ash indicate that constituents such as calcium and sulfate leached readily from the FBC ash being produced at the station in 1993 and 1994 although whether the tested ashes were from gob mined from the Wildwood site is not clear from the permit materials. Wildwood permit tests did not normally analyze for calcium in ash leachate, but an April 1993 TCLP test on Scrubgrass ash extracted 3688 mg/L of calcium in the leachate. While other test results for calcium were not located in the permit file, sulfate concentrations in extracts from 7 permit leach tests from January through July 1994 (using the Synthetic Precipitation Leaching Procedure instead of the TCLP) ranged from 509 to 2001 mg/L and sulfate leached from the April 1993 TCLP test at 2345 mg/L.

Aside from recontouring and revegetating the surface to promote better drainage and less infiltration of surface water into acidic material, the operator's assertion in the application to place ash at the site, that, "the high CaO content reacts with insitu sulfate compounds to produce insoluble CaSO4 (gypsum)" may have been born out by monitoring data at MW-4. However the sharply increasing alkalinity indicates the ash was being somewhat reactive in site groundwaters.

Despite smaller flow volumes at the Subchapter F points and MW-1 remaining dry during most of the mining and ash placement at the site, static water level elevations in MW-4 were higher in the final two years of monitoring (915 to 925 feet above sea level) than water elevations during the baseline period in (913-916 feet above sea level). Also relevant were higher concentrations of calcium and sulfate at MW-2 and MW-5 and increases in chloride at MW-2, MW-3 and MW-5 after remining and ash placement were underway if not completed entirely at the site. These data suggests soluble constituents in the ash were being mobilized at the site.

The burning of coal refuse on the site prior to the remining and ash placement in this operation may have released trace elements (and other constituents) and therefore contributed to high concentrations of lead, arsenic, cadmium and selenium measured in the baseline period at MW-1 and MW-4 including peaks of dissolved metals that were substantially exceeding the DWS. Trace element concentrations declined after the baseline period, with one exception being a measurement of 0.086 in total selenium in March 2001 at MW-4. Researchers for this report could find only one other measurement of selenium at any of the ash monitoring wells, (0.1279 in April 1994 at MW-4), higher than this value. However, there was no data for trace elements collected from the Subchapter F points and other monitoring wells were not in effective downgradient positions relative to ash placement. Thus the data for trace elements from MW-4 (just six samples during the baseline and only seven samples over a seven year period during mining and ash placement) comprise the best data for effectively assessing the impacts of trace metals from ash on water quality at this site, clearly an inadequate body of information.

Fluoride concentrations rose sharply at MW-4 after mining and ash placement started to levels exceeding the primary DWS of 4.0 mg/L, in eight samples and the secondary DWS of 2.0 mg/L in twenty samples. Although they were not as decisive as at MW-4, rises in fluoride were clearly discernable at MW-2 and MW-3 from the baseline to ash placement periods, i.e., rising from below 1 mg/L to between 1 and 3 mg/L, sometimes surpassing the secondary DWS of 2.0 mg/L. These results indicate an adverse impact on water quality from high fluoride levels leaching from the ash. Although fluoride is a listed Module 25 ash parameter, the ash leaching tests in the permit for the Wildwood site did not analyze for fluoride in the leachate which would have allowed for this effect to be further linked to the ash.

Sodium levels that were high to begin with at MW-4, rose even further after mining and ash placement had concluded, averaging 228 mg/L from April 2000 on. This is more than eleven times the level of sodium in water considered suitable for human ingestion by EPA. High sodium levels were measured at MW-2 and MW-3 although they existed during baseline period also and tended to occur during the spring, implicating the possible use of salt on nearby or haul roads as the source.

There are also discrepancies in many of the sample results. TDS concentrations in the large majority of samples from DJ and SP-C after mining and ash placement started were lower than sulfate concentrations, and in many cases, 500-1,000 mg/L lower. In nearly all of these samples, low reported levels of Total Suspended Solids (TSS) and turbidity rule out the possibility that such amounts of sulfate were undissolved in the water. There were large differences between total and dissolved calcium and magnesium that also were not reflected by the low TSS and turbidity values from the same samples. These discrepancies raise questions about the validity of sampling methods or analysis procedures and place doubt over the results. The authors could find no documentation of concern about these discrepancies from PADEP in the file for this permit.

The water quality improvement that occurred for major and minor elements could be due to removal of AMD-producing coal refuse, ash placement, surface reclamation measures or most likely a combination of these activities. Indeed PADEP staff believed the removal of gob would be the most decisive reason for water quality improvement, stating in a November 3, 1994 letter to ACV Power Corporation, "Alkalinity provided by ash placement on site will help neutralize acid generated in the shallow groundwater zone described above. However, the largest improvement to water quality will come from removal of the acid producing refuse and minimizing infiltration by establishing positive drainage and adequate vegetation."

Notwithstanding improvements in water quality, the following facts from the data warrant the reestablishment of monitoring at this site:

- higher aluminum concentrations found at Subchapter F point DJ than during the baseline period;
- high sulfate and manganese concentrations found in latter monitoring at MW-5;
- high sulfate, manganese, TDS and acidity concentrations at DJ and SP-C at the end of monitoring;
- higher sodium concentrations at MW-4;
- higher fluoride concentrations at all ash monitoring points after operations started;
- a high concentration of selenium at MW-4 in 2001;

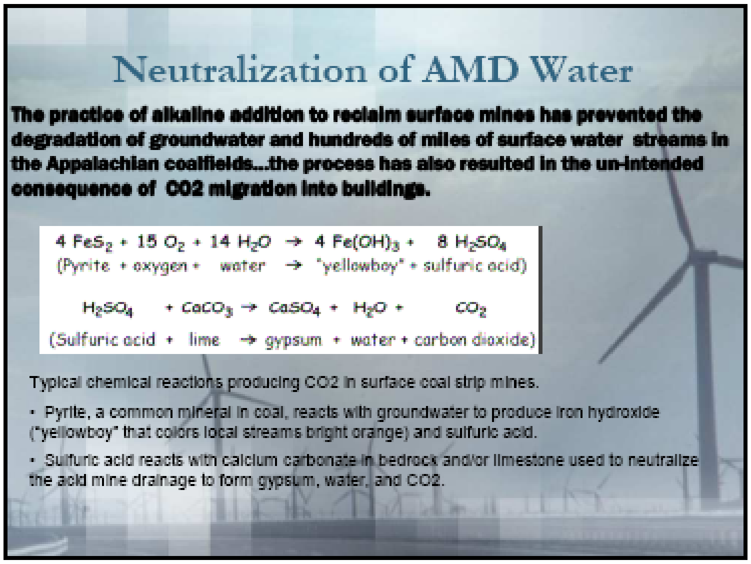
- higher chloride concentrations after operations had started and/or concluded at MW-5, MW-2 and MW-3;
- higher concentrations of sulfate and manganese in Pine Creek downstream of the site than upstream of the site 2-3 years after the completion of remining and ash placement, and the difference in sulfate concentrations between upstream and downstream points increasing by four times from before to after site operations;
- gaps in monitoring; and
- discrepancies in sulfate/TDS, total versus dissolved calcium and magnesium and TSS results that cast doubt over the validity of data.

Even without these concerns, the volume of waste alone at this site, more than 400,000 tons of FBC ash, as well as well-known research documenting the exhaustion of buffering capacity in CCW over time in acidic refuse environments clearly warrants continued monitoring to assure that contamination from the ash is detected and addressed. The collection of substantially more relevant trace element data from greater numbers of monitoring points, upgradient, downgradient and in the placed ash could provide trends of ash "signature" element concentrations that would more conclusively demonstrate the impacts at this site. Constituents such as boron, molybdenum, antimony and potassium are known indicator parameters at Pennsylvania ash sites and have been found at elevated levels at downgradient monitoring points at other coal mine ash sites in Pennsylvania. Molybdenum and potassium have been notably detected in the leachate from permit leach tests for the Scrubgrass ash. These four constituents should be added to the list of constituents analyzed for at monitoring points at this site. Continued monitoring for major and minor constituents would also reveal whether the improvements in water quality reflected in the data from 1994-2000 were temporary or long term.

On a bright note, the permitted operations apparently did extinguish the fires that had been burning on the waste coal piles at this site since the late 1970s.

EDITOR'S NOTE: The following insight from Robert Gadinski, PG was provided as another note of caution to consider regarding the beneficial chemical reactions asserted between alkaline additions and acidic material at these sites.

Based on PADEP and OSM reports this same reaction also produces CO_2 and contradicts the assertion about the inertness of the fill. Additionally, CO_2 produced from the reaction between AMD and carbonate materials used in mine reclamation has been shown to be the cause of gas intrusion problems in homes built above sites reclaimed with "carbonate rocks and acid reducing materials." Furthermore, the CO_2 has the propensity to replace O_2 and create O_2 deficient environments that are potentially deadly; this reaction further contradicts the supposed inert nature of CCW wastes (Etschlager, Harris and Baldassare. Fugitive Carbon Based Gases Blasting Related Or Not. 30th Explosives and Blasting Technique Conference, New Orleans, Louisiana (February 2004)



Neutralization of AMD Water

The practice of alkaline addition to reclaim surface mines has prevented the degradation of groundwater and hundreds of miles of surface water streams in the Appalachian coalfields…the process has also resulted in the un-intended consequence of CO2 migration into buildings.

$4\ FeS_2 + 15\ O_2 + 14\ H_2O \rightarrow 4\ Fe(OH)_3 + 8\ H_2SO_4$

(Pyrite + oxygen + water → "yellowboy" + sulfuric acid)

$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$

(Sulfuric acid + lime → gypsum + water + carbon dioxide)

Typical chemical reactions producing CO2 in surface coal strip mines.

- Pyrite, a common mineral in coal, reacts with groundwater to produce iron hydroxide ("yellowboy" that colors local streams bright orange) and sulfuric acid.
- Sulfuric acid reacts with calcium carbonate in bedrock and/or limestone used to neutralize the acid mine drainage to form gypsum, water, and CO2.

Baldassare, Fred. Stray CO_2 An Emerging Vapor Phase Intrusion Hazard In Some Areas of the Appalachian Coal Fields. (PADEP).
http://www.eswp.com/brownfields/program.htm

A –

B –

CAPTIONS - Photo A- Waste anthracite coal, i.e. "culm," remined at the Silverbrook Refuse Reprocessing site is piled at the Northeastern Power Company's FBC Cogen Station where it will be burned to produce the piles of FBC culm ash in Photo B which are dumped back in the Silverbrook site as part of reclamation. While this process avoids use of limited public funds available for reclamation of abandoned sites, the volume of material for reclamation is usually reduced, and monitoring data in this Report suggests the impacts on water quality are more often adverse than positive. Photos provided by Steven Dreyer, McAdoo, PA.

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CHAPTER 6: FAILURES OF THE PENNSYLVANIA CCW MINE PLACEMENT PROGRAM

6.1 INTRODUCTION

This report reaches two important conclusions. The first is that coal ash placement in Pennsylvania mines has degraded water quality. The second is that Pennsylvania's regulatory program itself is deficient in many critical respects and that *these deficiencies will lead not only to degradation of water quality at many more sites, but they will also ensure that such degradation is not detected in most cases.* The deficiencies in Pennsylvania's program include problems with both the regulations establishing the program and the enforcement of existing requirements.

Before discussing those problems, however, it is important to recognize the potential for harm that large-scale placement of coal ash poses to the mine environment and that of surrounding lands. Therefore, just as the Committee on Mine Placement of Coal Combustion Wastes of the National Research Council concluded was needed on a national level,[1] a program is needed in Pennsylvania to encourage options for reusing coal ash and other coal combustion wastes that reduce the threat of environmental contamination from this waste before placement in mines is pursued. These would include use of CCW components as additives in concrete and road pavements (placed above the water table) and in the manufacture of wall board or other similar uses. The failure to appreciate the threat that lax management of coal ash in mines is posing to water supplies, human health and the environment will undercut the expeditious development of such a program in Pennsylvania. Conversely, the development and enforcement of sensible safeguards in mine placement permits will encourage safer uses.

This chapter identifies and documents the many critical deficiencies of Pennsylvania's Coal Ash Beneficial Use Program and provides examples of the impact of these deficiencies in the permits for the placement of coal ash examined in this report.

6.2 INADEQUATE GROUNDWATER AND SURFACE WATER MONITORING

6.2.1 The duration of monitoring at coal ash mine placement sites is fundamentally deficient

PADEP approves requests by mine operators to stop groundwater monitoring at coal ash placement sites after the operator has backfilled and contoured the placement area and reestablished vegetation.[2] At minefills involving a few hundred thousand tons or less of coal ash this can occur one to three years after mining and ash placement has started and

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[1] NRC, Managing Coal Combustion Residues in Mines, 2006, page 178.

[2] At the Phase II release of the mine bonds, water monitoring by the operator is waived unless there is an indication of groundwater degradation of the baseline pollution load, defined by the iron and acid loadings, and other parameters at the Department's discretion. 25 Pa Code 87.205.

concluded. This is a far shorter monitoring period than required at coal ash landfills and is clearly insufficient to determine whether degradation of water quality will occur, much less whether impacts, if occurring, are starting to subside. The temporary water quality degradation that occurs during most active mining or remining operations magnifies the need for longer term monitoring at ash minefills to distinguish impacts caused by the ash from temporary changes in water quality caused by the mining itself.

Long term monitoring is essential because coal ash includes a host of materials of highly varying chemical and mineralogical composition. One common characteristic of almost all of these materials is that they react with water and they continue to react as time goes on. The ash that forms in the burner is not the material that exists when it initially comes into contact with water, and that is not the material that will exist 5, 10, or 50 years later in the mine. Contamination at a given site may not even be detected for many years after placement occurs. And even when detected early contamination may still be worsening 30 years later. There are ash disposal sites in the U.S. where contamination has increased with age. Yet there are sites in Pennsylvania coal mines where monitoring ceases within three years of the beginning of ash placement. A lack of identifiable degradation after this length of time offers absolutely *no* guarantee that degradation will not occur in the future.[3]

PADEP has acknowledged the importance of monitoring coal ash placement, particularly at alkaline addition sites. In their guidance document entitled *Alkaline Addition for Surface Coal Mines*, PADEP states,

> Monitoring of mine sites is necessary, not just to determine the success of mining, but for refinement of the science. There is still much to learn as to acceptable application rates, the effectiveness of various types of materials, the most advantageous placement(s) of alkaline materials, and so forth. *Without good water monitoring, success cannot be determined.*[4]

This report's examination of PADEP minefill permits reveals that the agency is not requiring the type of monitoring that their guidance asserts is necessary regardless of the size or purpose of the ash placement involved. For example, at the Buterbaugh Mine (Permit #17990112), ash placement commenced during January 2001 and finished in August 2004. Some 24,539 tons of pulverized coal (PC) ash was put on approximately 20 acres for the beneficial purpose of "placement." The latest data that could be located from any ash monitoring points in repeated trips to the permit file extends only through September 2004. At the Bloom #1 Mine (Permit #17950111), 45,000-50,000 tons of FBC ash was placed as an alkaline addition in an area substantially less than 50 acres from December 1996 up to an undisclosed date before mid 2005. Yet the latest

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[3] Norris, Charles H. Minefill *Practices for Power Plant Wastes: An Initial Review and Assessment of the Pennsylvania System*, August 29, 2003. Examples include the 3 years of monitoring at the Jacksonville minefill, (SMP #102360-32980108) and the less than 2 years of monitoring at Lucerne No. 2 minefill (SMP # 1387-32940105-05).

[4] PADEP, *Alkaline Addition for Surface Coal Mines*, Document Number 563-2112-217, BMR PGM Section II, Part 2, Subpart 17. Emphasis added.

monitoring data for trace elements and other more exclusive ash parameters (such as calcium and magnesium) that could be located in the permit file from examinations through 2005 extended only through March 2004 for one ash monitoring point and through December 2003 for all of the other ash monitoring points.

At the C&K Coal Mine (Permit # 16703006), ash placement started in May 1995 and ended in early 1999. Yet, data for trace elements and other ash parameters were collected for only a three year period from April 1996 through April 1999 and data for major and minor elements (sulfate, iron, manganese, pH, acidity, alkalinity, TDS, etc,) extended only through October 1999. This despite some 200,000 tons of FBC and PC ash being placed over 135 acres at the site. The placement purposes were ostensibly for "placement" and a small amount (few thousand tons) for soil amendment.

At the Swamp Poodle Mine (Permit # 17950115), after mining and ash placement started in February 1996, the data in the permit file indicate that monitoring extended through April 1999 for trace elements and other more exclusive ash parameters and September 1999 for major and minor elements. Yet mining and ash placement had only ceased in April 1999. Some 214,000 tons of FBC ash was placed on approximately 50 acres at the Swamp Poodle Mine primarily as an alkaline addition.

At the Sandy Hollow Mine (Permit # 16910104), 342,000 tons of FBC and PC ash were placed on the site as an alkaline addition. Mining and ash placement occurred from August 1996 through September 2000. Researchers could find only up to three measurements for trace elements and more exclusive ash parameters at any monitoring points after operations started, taken from September 1999 through September 2001. The latest data for major element concentrations at ash monitoring points extended to June 2001, nine months after mining and ash placement ended.

At the Wildwood waste coal remining operation (Permit #02940201) approximately 450,000 tons of FBC ash were placed over a 32 acre site from April 1995 to August 1999, serving as a barrier to infiltration for abating AMD and to stop persistent fires. Monitoring at three of five ash monitoring wells had stopped by the spring of 2000 (as they had gone dry and were then destroyed) and the last data from the other two wells was collected in April 2002.

At the Russelton waste coal remining operation (Permit #02930201) approximately 1,500,000 tons of FBC ash were placed in a 56-acre site to abate AMD. Ash placement started in early 1997 and finished in late 2002/early 2003. The latest monitoring for trace elements and other ash parameters in the permit file extended through November 2001, not even through the completion of ash placement, while monitoring for subchapter F mining parameters extended only through the summer of 2005.

Thus at seven of the 15 sites studied in this report the length of monitoring after ash placement was completed ranged from barely one month to approximately two and a half years. Indeed, for trace elements and other ash parameters at ash monitoring points monitoring apparently stopped at the Bloom #1 and Russelton sites before ash placement was even finished. While there may be more data, project researchers made repeated attempts in every case to verify that they had obtained all monitoring data from these sites. These consisted of written requests for missing data, multiple visits to the permit files at PADEP offices, meetings with PADEP staff and follow up phone calls to verify that they had obtained all data for the sites. To complete the project, researchers eventually had to assume that the data retrieved from these efforts represented all data available.

6.2.2 Monitoring is stopped even when data indicates degradation is occurring

In several cases, monitoring stopped not only before success was determined, but when the most recent data revealed water quality had worsened at ash monitoring points. For example, at the Swamp Poodle Mine, arsenic, cadmium, lead and selenium were measured at their highest concentrations and very toxic levels in the last sample collected at downgradient monitoring well, MW-2D in March 1999. The concentration of dissolved arsenic in this sample was 3.89 mg/L, 389 times the federal drinking water standard and by far the highest arsenic measured before or after ash placement. Likewise, the dissolved cadmium concentration was the highest measured before or after ash placement at 0.230 mg/L, 46 times the DWS. Lead was measured at its highest concentration at 0.069 mg/L, more than four times the DWS, and selenium was measured at its second highest concentration at 0.177 mg/L, more than three times the DWS. These trace elements were also measured at toxic levels and, in the case of arsenic, again at its highest dissolved concentration, 0.415 mg/L, at another downgradient monitoring well, MW-3D in the final March 1999 sample. And while major parameters such as acidity, sulfate and TDS had declined sharply in this final sample at MW-2D, they were rising to their highest levels ever at MW-3D and were well beyond baseline concentrations at another downgradient ash monitoring well, MW-4D.

At the Sandy Hollow and Buterbaugh Mines, the highest sulfates and TDS have occurred at downgradient monitoring points during ash placement (not before it during baseline monitoring) and overall trends in average concentrations during the permit operations were rising when monitoring stopped. At downgradient ash well MW-3 in Sandy Hollow the highest sulfate concentration during ash placement was 942 mg/L compared to the highest sulfate concentration during baseline monitoring of 137 mg/L. The highest TDS during ash placement was 1377 mg/L, compared to highest TDS during baseline monitoring of 410 mg/L. In three measurements during the final six months of monitoring at MW-3 the average sulfate concentration was 426 mg/L and average TDS was 662 mg/L, compared to average sulfates of 126 mg/L and average TDS of 368 mg/L from the six baseline measurements (over six months) at MW-3. Thus sulfate and TDS concentrations had risen from below secondary DWS (250 mg/L for sulfate and 500 mg/L for TDS) during baseline monitoring to levels substantively exceeding these DWS when monitoring stopped.

At downgradient ash well BC-3 in the Buterbaugh Mine, the highest sulfate during baseline monitoring was 248 mg/L. The highest TDS during baseline monitoring was 374 mg/L. The highest sulfate after mining and ash placement started was 743 mg/L in

May 2003 seven months before monitoring ended and the highest TDS was the last measurement taken, 927 mg/L in December 2003. Average sulfate of 188 mg/L and average TDS of 344 mg/L in baseline measurements rose to 573 mg/L (more than twice the DWS) and 794 mg/L (more than 1.5 times the DWS) respectively in the last year of measurements at BC-3.

Manganese concentrations were also notably higher in the Buterbaugh Mine in the last monitoring at BC-3. Average manganese during baseline monitoring of 2.43 mg/L (48.6 times the DWS) compared to an average concentration in the last 13 months of monitoring of 6.65 mg/L (133 times the DWS). The highest manganese during baseline monitoring was 4.1 mg/L, whereas the highest, second highest, and third highest manganese concentrations after mining and ash placement occurred in the summer of 2003 when manganese ranged from 8.2 to 9.6 mg/L, more than twice the highest baseline level and only five months before the end of monitoring at BC-3.

Sulfate, TDS, and manganese levels were higher in the latter monitoring data at the C&K mine although the most notable increases were at MW-1A, the well that PADEP staff asserted was placed to measure shallow groundwater not effected by the mining and ash placement operation. Here average sulfate increased from 456 mg/L during baseline monitoring to 930 mg/L in the last year of monitoring. Average TDS also more than doubled from 665 mg/L to 1427 mg/L as did average manganese, increasing from 10.18 mg/L during baseline monitoring to 25.25 mg/L in the last year of monitoring. Acidity increased by almost five times, from an average concentration of 17.2 mg/L during baseline monitoring to 82 mg/L in the last year of monitoring and alkalinity increased by more than three times from 8.2 to 28.5 mg/L. While there were only 4 annual measurements for calcium and magnesium during mining and ash placement, average calcium doubled from a baseline level of 71.2 mg/L to 157 mg/L during mining and ash placement and average magnesium increased from 50.2 mg/L to 127 mg/L.

Although their increases were not as sharp, these constituents were found in higher concentrations after mining and ash placement started at C&K at the monitoring well designated as downgradient of the ash by PADEP, MW-3A and in a well dug deeper at this location to the Vanport Limestone, MW-3B. Furthermore, even though the frequency of measurements dropped significantly for trace elements at MW-1A, MW-3A and MW-3B after mining and ash placement began, the two highest arsenic concentrations were measured at MW-3A and the highest selenium concentration was measured at MW-3B after these operations were underway. In the case of arsenic at MW-3A, both measurements exceeded the new DWS, at 0.011 mg/L in April 1997 and 0.037 mg/L (nearly four times the DWS) in April 1998. The selenium measured at MW-3B of 0.030 mg/L in April 1998, while not exceeding the DWS, was still the highest measurement found at any time at any monitoring point and was the last measurement taken from this point.

While this report's researchers do not know when mining and ash placement stopped at the Hartley Strip Mine (Permit #30713008), the last data they could locate for this permit extended through September 1998 for the mine's ash monitoring points. In addition, they were able to locate data extending through August 2000 for two other monitoring points inside the mine that are part of the monitoring system for the Hatfield Coal Ash Landfill. When assessed collectively, the latest concentrations and trends from this data warrant concern that monitoring should have been continuing at the Hartley mine's monitoring wells. There was little if any baseline data available for review from the permit file but levels of antimony, cadmium, and lead measured have been substantially higher than their concentrations in 1988, the first year of data available, when operations also began at Hartley. Antimony has reached several concentrations at ash monitoring points exceeding the DWS, including a concentration of 0.11 mg/L at MW-2 in July 1995, more than 18 times the DWS. While MW-2 is designated an "upgradient well" in the permit, it is located well inside the ash placement area and trends such as spikes in acidity and oscillating alkalinity in MW-2's data suggest it is picking up impacts of mining and ash placement. Antimony was also measured in August 1991 at downgradient MW-1 at 0.03 mg/L, six times the DWS. Lead has been measured in at least five samples exceeding the DWS (0.015 mg/L). Three of those were above the highest lead concentration measured in 1988. These included 0.06 mg/L at MW-1 in July 1993, and 0.10 mg/L and 0.050 mg/L at MW-2 in July 1993 and July 1996 respectively. Cadmium was measured at 0.10 mg/L, twice the DWS in the final measurements in September 1998 at both MW-1 and MW-2. It should be noted that researchers could only find seven measurements at MW-1 and nine measurements at MW-2 for trace elements during the nine years between the permit issuance in 1988 and final monitoring in 1998.

Although researchers did not find regulator monitoring results for molybdenum at the mine ash monitoring wells, they did find this trace metal measured at MW-1 at 0.004 mg/L in September 1997 and 0.19 mg/L in September 1998, the last available data from this well. This latter concentration is 19 times the Superfund Removal Action Level for molybdenum and 9.5 times EPA's short term child health advisory for ingestion of this metal. Both molybdenum and antimony leach in elevated levels in tests from many Pennsylvania coal ashes, and ample monitoring data documents their leaching from ash deposits at many ash disposal sites. In addition, molybdenum has been found in high levels at downgradient ash monitoring points in the neighboring Hatfield coal ash landfill and has been monitored at very harmful levels in Little Whitely Creek, which drains the watershed that shallow groundwaters at MW-1 flow to [5].

Data from upgradient wells MW206 and MW207 in the Hatfield coal ash landfill that are downgradient to the ash in the Hartley mine indicate further that degradation was occurring as mine monitoring stopped and has worsened since. The average concentration of dissolved boron, a well known ash indicator parameter more than doubled at MW206 from 5.32 mg/L in 1994-1996 to 12.27 mg/L in 1998-2000 and doubled at MW207 from 4.37 mg/L in 1994-1996 to 9.68 mg/L in 1998-2000. These concentrations are well beyond levels of concern for boron which has a Removal Action Level of 0.900 mg/L and health advisories ranging from 0.6 mg/L for an adult's lifetime exposure to 4 mg/L for the child's one day exposure to boron in drinking water (Drinking Water Regulations

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[5] PADEP Quarterly Monitoring Reports in 1999 and 2000 document molybdenum concentrations from over 0.500 mg/L to levels as high as 23.3 mg/L, 81.3 mg/L, 352 mg/L and 419 mg/L in the surface waters of this stream, levels thousands of times over the adult and child health advisories for this trace element.

and Health Advisories, US EPA, Office of Water, EPA 822-B-96-002, Oct. 1996). Thus boron has been rising from levels already of concern to levels far higher at these monitoring points in 1998-2000. Allegheny Energy, the operator of the Hatfield landfill and generator of the ash placed in the Hartley strip, stated in an August 20, 1997 revision to an application to modify the permit for the landfill that the elevated boron in these upgradient wells was "due to the fact that fly ash has been codisposed with mine spoil in the upgradient area, in addition to the permitted disposal area."

The sulfate trend at MW-206 increased from average levels already more than six times over the DWS in 1994 to average levels just under 2500 mg/L, ten times the DWS, in 2000. Sulfate levels were even higher at MW-207 averaging 3500-3700 mg/L, although declining slightly from 1994 to 2000. Average molybdenum concentrations rose at MW-207 from 0.003 mg/L in 1994 to 0.010 mg/L in 2000 equal to EPA's Removal Action Level and long-term child health advisory. This evidence that Hartley ash has been degrading water quality is corroborated further by rising field pH, alkalinity, calcium, magnesium, and potassium, additional indicators of ash leachate, at MW-206 and MW-207.

Clearly, even if PADEP does not believe that CCW placement poses a risk to water supplies in coal mines, these data do not suggest the time to stop monitoring had arrived at these sites. In every case, DWS that weren't being exceeded during baseline monitoring were being exceeded in the last year of monitoring at these sites or DWS that were being exceeded during baseline monitoring were being exceeded by a greater degree in the final year of monitoring. Yet researchers could not find a single report or other document in the mine permit files indicating that such increases in concentrations or exceedances of DWS at ash monitoring points in the latest monitoring at these sites had any bearing on decisions to stop monitoring or relinquish bonds. The cessation of monitoring that occurred suggests that monitoring at ash monitoring points is merely a proforma exercise in this program.

For projects involving placement of significant quantities of ash, (i.e., all permits involving alkaline addition or reclamation to original contour), the authors of this report conclude that monitoring should be required until evidence establishes definitively that the following conditions are met: (1) post-mine flow directions and seasonal levels of groundwaters are restored to premine directions and levels underneath ash placement sites; (2) monitoring of those groundwaters and surface waters indicates that the specific goal of improvement has been achieved and is being sustained; and (3) adverse impacts such as exceedances of drinking water standards or water quality standards are not resulting from contamination by the ash. In addition, these conditions should include monitoring of CCW constituent concentrations within the CCW itself and throughout the placement area to demonstrate that the placement has achieved its goal and the environmental liability posed by generation of leachate in the CCW is negligible.

6.2.3 No groundwater monitoring is required when CCW is placed in abandoned mines

Pennsylvania regulations do not require groundwater monitoring when coal ash is placed in an abandoned mine.[6] Monitoring at such sites is at the discretion of PADEP. Groundwater monitoring should be required at *all* CCW placement sites, regardless of whether the mine is active or abandoned. Determining the safety and success of ash placement at abandoned mines is no less important than evaluating impacts at active mine sites. Such findings were voiced repeatedly in the NRC Report which recommended the following in Chapter 8, Synthesis of Issues for Planning and Regulation of CCR Mine Placement:

> ***Abandoned Mine Lands and Remining Sites.*** A special consideration is the use of CCRs in reclaiming AML and remining sites and in mining coal refuse piles. As noted in Chapter 5, any regulatory standards for CCR use adopted under SMCRA for active coal mining would most likely apply to remining activities but would not apply directly to CCR use in the reclamation of abandoned mine lands. To ensure adequate protection of public health and the environment, **the committee recommends that placement of CCRs in abandoned and remining sites be subject to the same CCR characterization, site characterization, and management planning standards recommended for active coal mines.** However, when developing performance standards, adequate consideration should be given to the significant differences between active mines, abandoned mines, and the remining of previously abandoned mine sites. At such abandoned sites the CCR placement process begins with a degraded site and the same management options available in an active mine site may not always be feasible. The plans should consider the benefits of CCR use for reclamation at these degraded sites but should also factor in the potential adverse impacts of CCRs, accommodating these concerns in the overall plan.[7] (emphasis in original)

6.2.4 No water quality or other monitoring is required when CCW is used as a soil amendment or additive

According to PADEP regulations and guidance, there is no water quality monitoring required for coal ash used as a soil amendment or additive in coal mines.[8] Researchers for this project attempted to examine one permit authorizing as much as 10,000 tons of coal

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[6] See 25 PA Code 287.664(c)(2).

[7] NRC, Managing Coal Combustion Residues in Mines, 2006, page 183.

[8] See 25 PA Code 287.662 and PADEP, *Technical Guidance Document for Beneficial Uses of Coal Ash,* Doc. No. 563-2112-225, April 30, 1998 at page 3 and 6.

ash as a soil amendment at the RFI Energy Mine 208 site (Permit #16940103) for water quality impacts from monitoring points near soils where this ash was placed. The only monitoring well within a close enough distance to assess for impacts was drilled to a 35 foot depth and screened in the spoil. Sewage sludge was also being applied to soils at the site. While small trace element rises were measured in this well, (MW4A), there was not enough information to effectively assess whether the ash from the soil amendment was a source for these rises. There were no data from surface water monitoring points or other information on other potential impacts from the ash such as whether trace element uptake by plants was occurring. Thus further assessment of the site was discontinued. Given more than 300 feet of relief from the highest to lowest elevations at the site, which covers several hill tops intersected by small ravines, the authors are concerned about the possibility for surface drainages contaminated with trace elements and other constituents from ash and sewage sludge to flow offsite without being monitored and for uptake of trace elements by plants and plant eaters.

It appears that PADEP policy allows relatively large amounts of ash to be placed close to or on the ground surface in Pennsylvania coal mines as soil amendment where the ash is exposed continually to precipitation without monitoring of drainages from that ash into surface waters or underlying groundwater or plant uptake of ash constituents. The NRC emphasized repeatedly the need to monitor soil applications of ash:

> ***Topsoil Replacement.*** . … In some cases, CCR is used as a soil additive to neutralize acidic soil. However, as discussed in Chapter 4 and in the following section, the uptake by vegetation of metals and other contaminants that may be present in CCRs is a concern.
>
> ***Revegetation.*** … Many post-mining land uses, such as prime farmland, commercial forestry, and wildlife habitat, have specific revegetation requirements with very specialized planting practices. The uptake by vegetation of metals and other contaminants that may be present in CCRs is a concern, especially when the reclaimed land will be used as farmland. Sufficient soil cover, which is appropriate for the type of vegetation, is necessary to minimize plant uptake (see Chapter 4).
>
> **Reclamation of Abandoned Mine Lands**
>
> . . . Finally, CCRs are used as either a soil amendment or a soil replacement, particularly at abandoned mine sites where topsoil may be totally lacking (see Chapter 2). However, plant uptake of contaminants must be considered when CCRs are used as a soil replacement. [9]

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[9] NRC, Managing Coal Combustion Residues in Mines, 2006, pages 161 & 162.

6.2.5 Overview of deficiencies regarding number and location of monitoring points

One of the principal deficiencies of the Pennsylvania monitoring program is the failure of regulators to require an adequate number of well-placed monitoring points. PADEP often accepts the use of the monitoring points associated with the active mine, such as existing seeps, springs, mine discharges and abandoned mine shafts for monitoring of ash placement areas.[10] The points are generally accepted as appropriate based on their prior use for monitoring mining impacts. PADEP has great discretion in this area; mining regulations require only one downgradient point and do not require an upgradient monitoring point.

The reason for the gross deficiencies in number and location of monitoring points is likely PADEP's failure to acknowledge that CCW placement sites require monitoring consistent with the goals and requirements of RCRA solid waste management programs. By accepting monitoring schemes whose genesis is the guidance and regulations of the state surface mining program developed pursuant to SMCRA, much is lost. The Surface Mining Control and Reclamation Act was enacted to protect society from the adverse effects of strip mining and to ensure proper reclamation of active and abandoned strip mine lands. SMCRA was never intended to be used as a law for managing large quantities of nonmine waste. While SMCRA's framers tried to make the law as proactive as possible by designing it to minimize harm to the neighbors of strip mines, they accepted some harm from the mining process as inevitable and wrote provisions into the law to require compensation for water supplies lost or degraded by mining. The monitoring systems in surface coal mines have evolved to serve this objective. They are designed to measure major changes in water levels that can be attributed to the pumping, dewatering, and excavation that take place during active mining. They collect baseline information for a few common mine drainage parameters (e.g., iron, sulfate, manganese) from neighboring property owners' wells and mine monitoring points and monitor the changes that occur in those parameters in these wells during the mining.

Monitoring systems for SMCRA permits in Pennsylvania and elsewhere are *not* designed to provide the level of detail provided by the monitoring systems at solid waste disposal facilities permitted under federal RCRA and its state counterparts. Mine monitoring systems are based on site characterizations that typically do not include the level of information provided by the standard hydrogeologic investigations required for most solid waste landfill permits. Information such as the potentiometric contour for water in each aquifer layer in, under, and adjacent to the disposal area; the rates of water flow in each of those layers; and detailed knowledge of the interconnections between the aquifers and between those aquifers and surface waters is not assembled in the Module 8 addressing hydrology or in the Module 25 addressing coal ash in PADEP mining permits involving ash placement. Mining permits require monitoring for fewer constituents in the baseline monitoring than are typically required in landfill permits. The frequency of

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[10] PADEP, *Technical Guidance Document for Beneficial Use of Coal Ash*. Document Number 563-2112-225,

monitoring for ash parameters (usually annually) after mining and ash placement is typically less than required for those same parameters at coal ash landfills (usually at least quarterly). The end result is a monitoring system in most Pennsylvania minefill permits that is based on more rudimentary information and is not designed to detect problems and prevent harm to water supplies, as is the goal for RCRA permitted landfills.

Coal ash is a nonmine-generated industrial solid waste that is chemically different from coal or other mine material. Unlike acid-producing spoils and coal refuse, which generally become less active when taken out of contact with air and placed in reduced environments such as under the post-mining water table in a coal mine, coal ash often becomes chemically more active when placed in water. Most cases of contamination from CCW involved its placement close to or below the water table. RCRA was enacted to ensure that any solid waste that could pose harm if mismanaged is treated, stored, and disposed in a manner that *prevents* that harm from occurring. Thus monitoring systems at RCRA permitted landfills are designed to detect contamination before it becomes a problem and to abate its source to prevent environmental degradation. To accomplish this, RCRA requires extensive site information and effective early warning monitoring systems.

6.2.5.a. Failure to require a sufficient number of monitoring wells

If RCRA's goal is not to be contravened by the minefilling of industrial wastes like CCW, one downgradient ash monitoring point will not suffice as a minimum requirement for the typical mine fills (placing more than 10,000 tons of ash) studied in this report, particularly given the poor site-specific characterizations of the hydrologic systems surrounding these mine fills.

Although all of the permits reviewed in this report had more than one downgradient monitoring point, there is a major difference between the number of monitoring points at large coal ash mine fills and coal ash landfills in Pennsylvania. For example, there are three downgradient ash monitoring points (two monitoring wells and a seep) and no upgradient ash monitoring points at the Ernest Mine to monitor 7-8 million tons of CCW. There are two ash monitoring points (one upgradient and one downgradient well) at the Ellengowan Mine to monitor 9 million tons of CCW. There are two ash monitoring points (both downgradient wells) and no upgradient points at the BD Mine to monitor nearly 4 million tons. There are seven monitoring points, including two upgradient wells, at the Big Gorilla Pit-Silverbrook Refuse Reprocessing site to monitor 4-5 million tons of CCW. This compares to 15 monitoring wells at the Hatfield's Ferry Power Plant Coal Ash Landfill (Greene County) monitoring approximately 2.2 million tons of CCW and approximately 15 points at the Fern Valley Coal Ash Landfill (Jefferson Hills, PA) monitoring 4.8 million tons.

Even if minefill sites of this size are well-characterized hydrologically, two to three monitoring points is not an adequate number given the varied flow paths of groundwater through fractures, faults, underground mines and mine pools; varying flow gradients from steep to shallow; varying materials through which water is flowing from spoil to gob to coal to less permeable rock layers; frequent disposal below water tables; no requirement for liners; minimal requirements for covers; and the significant size of ash placement areas. Inadequate site characterization plagued the monitoring programs at several sites examined in this report. For example, PADEP concedes that it has not identified any specific groundwater pathways through which groundwater in the water tables in the ash are migrating from the Big Gorilla Pit.[11] Also, PADEP does not know the volume of the water in the mine pool monitored at the Ellengowan and BD Mines, although that water has become contaminated with high levels of lead.[12] Lastly, PADEP asserts that the water in the ash at the Ernest Mine has not reached downgradient monitoring points, even though after eight years of site operation PADEP readily admits that they have never collected information documenting the rate at which groundwater flows from the ash through the site's refuse pile to the monitoring points.[13]

Good characterization of the hydrology and geology at a disposal site gives operators and regulators the knowledge to put monitoring points more reliably in effective locations, thereby establishing cost-effective monitoring systems that can rely on fewer monitoring points to protect water resources. Lack of knowledge about the basic hydrology and geology at a large ash placement or disposal site creates the need to install greater numbers of monitoring wells at the site. The disparity between monitoring at coal ash landfills and mine fills in Pennsylvania turns this basic logic on its head. Landfill operators who have a detailed understanding of the hydrogeologic systems surrounding their facilities are monitoring their ash from many more points than minefill operators who have a very poor understanding of the hydrogeologic systems. The resulting level of protection afforded to water resources by monitoring at mine fills is substantially weaker than at coal ash landfills.

6.2.5.b. Failure to Monitor Leachate or Pore Water

PADEP does not usually require that leachate from coal ash in the mine placement site or pore water within the coal ash or within the mixtures of ash with refuse or spoil at these sites be monitored. The authors found such monitoring in only five of the 18 permits examined in this report.[14] Collecting data on the concentrations of constituents in site leachate or from the pore spaces within saturated ash, or mixtures of mine material with ash, is one of the most effective ways to ensure that metals and other constituents are mobilizing in safe concentrations predicted by the characterization of the ash and site in the permit. If high levels of metals or other constituents are detected in groundwater near ash placement areas, pore water wells may be able to confirm or rule out ash as the source. Such wells could have determined the degree to which ash was contributing to

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[11] See Permit Review 6.
[12] See Permit Reviews 5 and 7.
[13] See Permit Review 1.
[14] Those sites are the McDermott site (Permit # 11950102, Per. Rev. 2) at monitoring point MD-22, the Big Gorilla Pit (Permit # 54920201, Per. Rev. 6) at MW-5, the McCloskey site (Permit # 17793044) at a number of cores drilled in the ash (although the data for these cores was not in the permit file), the Bloom #1 site (Permit # 17950111, Per. Rev. 10) at MW-3, and the EME Generation site (Permit # 32753702, Per. Rev. 8) .

the increased degradation seen at the majority of sites reviewed in this report. The NRC Report spoke to the need for pore water monitoring with this statement among others:

> At least one well (or a suction or pan lysimeter for unsaturated conditions), and preferably two wells, should be placed directly in the CCR to monitor local porewater chemistry and assess the field leaching behavior. These data should then be compared to the predicted flux rates in the site conceptual model.[15]

6.2.5.c. Failure to require upgradient monitoring points

PADEP guidance does not require a monitoring point upgradient from the area where coal ash is placed in a mine.[16] Without an upgradient well, PADEP cannot compare the effects of mining and ash disposal with water quality in an area of the site where those activities did not occur. In addition, the absence of upgradient monitoring points means PADEP cannot compare the effects of mining and ash on water quality detected at one monitoring point with the effects of mining (without ash addition) that might be observed at another point. The authors found that rather than correct this inability, PADEP regulators repeatedly appeared to use this inability to differentiate degradation based on the absence of effective upgradient monitoring points to dismiss ash as the source of any increases in concentrations found at downgradient ash monitoring wells.

At two of the fifteen sites assessed in this report (Buterbaugh and BD Mining), permit materials simply stated that no monitoring points were designated as upgradient to the ash. At three others (Ernest, McDermott and Wildwood), monitoring reports indicate the upgradient wells became dry before or within one year of the start of ash placement. Thus, there was no upgradient monitoring capability openly conceded in five of these sites.

Of the nine other sites studied, permit materials, historical information, and monitoring data at four of the sites explicitly indicate or suggest that ash had been placed upgradient to the "upgradient" monitoring points prior to the start of ash placement under the permit or was allowed to be placed upgradient to those points during ash placement, thus compromising the ability of those points to generate upgradient data. These are the Ellengowan, EP Bender, Hartley, and Sandy Hollow sites. This possibility may also be the case with the upgradient well MW-2 at the Silverbrook site. At the C&K site, the doubling of manganese concentrations and jumps in iron, acidity, and alkalinity from the baseline to mining and ash placement periods, a jump in sulfate from around 500 mg/L to 1,000-1,200 mg/L, an increase in TDS from an average around 700 mg/L to an average of 1700 mg/L, and the doubling to tripling of chloride, calcium and magnesium levels from before to after mining and ash placement started strongly indicate that "upgradient" MW-1A was in fact downgradient of these operations and was seeing their impacts within 2-3 years despite being 4,000 feet from the mining and ash placement area. These are the only upgradient points we found at these sites. Thus only at the Swamp Poodle, EME

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[15] NRC, Managing Coal Combustion Residues in Mines, 2006, page 170

[16] PADEP Technical Guidance No 563-2112-225.

Generation, Bloom #1, and Russelton sites (four of the fifteen sites studied) did researchers find upgradient, or, in the case of Russelton, upstream monitoring points that they considered reliably isolated from the influence of ash throughout the duration of monitoring.

At the largest ash placement site studied in this report, the Ellengowan Mine, deep mine fires resulted in many dozens of truckloads of burning coal, culm, and associated rock and the ash from that material being dumped directly into the mine pool at the bottom of the ShennPenn Pit in the 1970s. That minepool for the Indian Ridge deep mine flows east where some of it is sampled by MW-1, the most "upgradient" monitoring point at the Ellengowan site. From this monitoring point, waters flow through the Knickerbocker deep mine under 3 million tons of FBC ash slurried into the Knickerbocker Pit before turning westward into the mine pool in the Maple Hill deep mine where they are eventually sampled by the other designated "upgradient" monitoring point in the Ellengowan Permit, the Maple Hill Shaft. But not before being joined by potentially large amounts of ash leachate entering the Maple Hill minepool through the bottom of the Conveyor Ash pit which has received nearly 3 million tons of FBC ash. Deep mine maps and minepool elevations measured from boreholes by the PADEP's Wilkesbarre District staff also document that waters under the BD Mining ash pit where nearly 4 million tons of FBC ash have been placed also flow north on occasion into the Maple Hill mine pool. In addition, deep mine water has been withdrawn from the Maple Hill deep mine by pumps at the Maple Hill Shaft for decades to control mine pools in the area and more recently to provide water for the Schuylkill Energy Resources power plant and the Knickerbocker Pit Demonstration Project. Water withdrawal rates at the Maple Hill Shaft can be considerable, exceeding 1100 gallons per minute, meaning that this monitoring point pulls water from many directions. Thus both of the "upgradient" monitoring points for the Ellengowan permit, MW-1 and Maple Hill Shaft, were not even upgradient to coal ash prior to the issuance of the Ellengowan permit in 1986. Furthermore the Maple Hill Shaft has in fact been downgradient to the placement of nearly 10 million tons of FBC ash in three pits starting 19 years ago with the dumping of ash into the BD Mining pit.

The continued pumping of mine pools from the Maple Hill Shaft and at least two other withdrawal points, combined with the absence of data on water elevation data at Ellengowan monitoring points for up to 15 years while most of this ash placement has occurred makes any assumptions about water flow directions problematic at monitoring points. These include the "upgradient" Maple Hill Shaft or the only other point established to monitor three fourths of the ash dumped at the Ellengowan site, the "downgradient" Monitoring Holes South, which also samples the minepool. There are no well logs or diagrams that provide details on the construction and screening, or sample collection depths for these two monitoring points in the permit files. The absence of this information was confirmed at a May 19, 2005 meeting with staff of the PADEP's Pottsville District Mining Office. However, water elevations from 1989 in the Module 25 and water elevations reported from sampling in 2005 and 2006 at these points and monitoring wells at the Knickerbocker pit document a direction of flow from minepools under the Knickerbocker and Conveyor ash pits past the Maple Hill Shaft to the west, confirming that Maple Hill Shaft is a downgradient ash monitoring point. Why the PADEP continues to identify Maple Hill Shaft as an "upgradient" ash monitoring point is not clear. Doing so can cause those who examine the monitoring data to falsely conclude that water at the Ellengowan site is not being contaminated by ash given the high pollutant concentrations found at this "upgradient" monitoring point.

6.2.5.d. Monitoring of hydrologic units and large volumes of water

Subchapter F of Chapter 87 (Pennsylvania's surface mining law) allows and, in fact, encourages the monitoring of hydrologic units rather than individual monitoring points.[17] The goal of the hydrologic unit is to measure significant impacts to surface waters draining an entire permit area or portion of a permit area. The system does not focus on and often cannot determine impacts at any particular monitoring point. Consequently, there can be no response to degradation of water quality from one or two monitoring points. Substantial groundwater contamination is not detected until those waters reach the surface. Agency responses to rising concentrations of ash contaminants measured at surface monitoring points such as springs, seeps, or other mine discharges are not likely to occur until those rises have been substantial and sustained for a long enough period to cause significant degradation to larger volumes of surface waters outside the mine environment.

The monitoring systems at large anthracite minefills studied in this report rely in significant part on downgradient points that are monitoring large quantities of water in underground mine pools. While information on the actual volumes of water in these mine pools is not usually provided, they are characterized as draining large areas. For example, the mine pool underlying the Ellengowan and BD sites is reportedly draining a series of connected underground mines spanning an area of 8,000 to 10,000 acres. Monitoring Hole South, the sole downgradient ash monitoring point inside the permit area for approximately 9 million tons of coal ash placed at the Ellengowan Mine (aside from the ash in the Knickerbocker Pit), is monitoring this mine pool.[18]

Any detection of high levels of pollution at Monitoring Hole South measures this pollution in a very large quantity of water. Whether this pollution comes from ash in the Ellengowan permit or the more than three million tons of ash placed to date in the neighboring BD permit, monitoring it from one point in the mine pool allows the ash potentially to cause very large amounts of pollution at levels threatening human health and the environment, without any opportunity for early detection and abatement. This approach to managing pollution is the opposite of the preventive approach prescribed by RCRA. Indeed the high levels of lead and cadmium, far over DWS, and high levels of other trace elements measured repeatedly at Monitoring Hole South as well as the downgradient monitoring points in the BD mine raise a distinct possibility that the

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[17] 25 PA Code 87.201 through 87.209. See *Alkaline Addition for Surface Coal Mines* (Document No. 53-2112-217), BMR PGM Section II, Part 2, Subpart 17 and *Permitting Pre-existing Pollutional Discharges under Subchapter F of 25 PA Code Chapter 87, Subchapter G of 25 PA Code Chapter 88* (Document No.

[18] See Ellengowan Surface Mine/Knickerbocker Pit (Permit Review 5) and BD Mining (Permit Review 7).

approximately 16 million tons of ash placed in these two mines is seriously contaminating very large quantities of water in the mine pool underlying these sites.

6.2.6 Insufficiency of baseline monitoring

It is essential to determine adequate baseline water quality prior to placement of coal ash. Without such a determination, it is difficult to identify and quantify the impact of ash placement. Baseline values for both concentration and loading are needed. Legally, enough baseline data to characterize seasonal variations in water quality and quantity (meaning baseline loading values must also to be determined) is required by SMCRA. This applies to any pollutant that might cause a material damage to the hydrologic balance beyond the permit boundaries. If mine permits are modified to allow for the importation of coal ash to sites, the baseline seasonal variation in the quality and quantity of parameters in the coal ash must be as equally characterized in waters at those sites as are the quality and quantity of mining parameters. We know of no provision in SMCRA that implies otherwise. According to a US DOI study of Pennsylvania remining sites, a full 12-month baseline sampling program is recommended to accurately characterize any preexisting discharges.[19] The DOI recommendations apply as fully to remining operations that include ash disposal as those that do not, extending the need for the baseline characterization that applies to traditional mining parameters to coal ash parameters.

No loading values for ash parameters were presented for baseline characterization at any of the sites studied in this report. While there are baseline loading values for aluminum, iron, manganese, and sulfate which are significant ash parameters, loadings were calculated for those constituents as mining parameters from subchapter F monitoring points, not as ash parameters from ash monitoring points.

While there were several permits examined in this report that had more than six months of baseline concentration data for Module 25 ash parameters, there were none that used more than six months of data to characterize baseline quality for those parameters. Those permits with the most data prior to ash placement were for the EME Generation site and Big Gorilla site.[20] The expanded pre-ash placement monitoring data in the EME case come from having at least three years of monitoring data from active gob disposal operations from which to measure the added impact of the ash placement. At the Big Gorilla site, there are water quality data from the Silver Brook discharge and other points monitoring effects of the refuse remining and ash placement occurring for eight years prior to the commencement of ash disposal into the Big Gorilla Pit. However, much of these data at both sites did not include values for many trace elements monitored under the Module 25 provisions for PADEP mine fill permits.

The large majority of sites had only 3 to 6 months of concentration data (monthly samples) collected at ash monitoring points for Module 25 parameters with two

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[19] Hawkins, Jay W. *Characterization and Effectiveness of Remining Abandoned Coal Mines in Pennsylvania*, U.S. Bureau of Mines, U.S. Department of the Interior, 1995.

[20] EME Generation - Permit Review 8, Big Gorilla - Permit Review 6.

exceptions noted for having even less baseline data. One of these is the BD Mining site and the other is the Hartley Strip site.

At the BD Mining site, downgradient monitoring point MP006 (the Gilberton Shaft) had only one measurement for trace elements and other ash parameters. There were no baseline measurements for these or any other Module 25 parameters at the other downgradient well, MP007, which is much closer to the pit where ash was placed.[21] This despite the fact that some 4 million tons of ash have been placed in this first disposal pit at the BD site and another 4 million tons of ash placement are now underway at a second pit. The Hartley Strip had no baseline data for any constituents at the ash monitoring wells that the authors could find in the permit files.[22] Incredibly at the BD Mining site, PADEP also did not require an upgradient monitoring point to be established, and at the Hartley site, designated upgradient well MW-2 was within the ash placement area, calling into question its subsequent performance monitoring results as reliable upgradient data. The failure to collect adequate baseline data seriously hinders assessment of the impact of coal ash at these sites. The NRC report specifically mentioned Pennsylvania when discussing the lack of good upgradient monitoring points as well as the failure to gather sufficient baseline data:

> **Number and Placement of Wells and Length of Monitoring**
>
> The committee is concerned about the number and placement of monitoring wells at CCR mine placement sites. . . .
>
> Additionally, the committee observed sites at which background or upgradient wells were not situated in appropriate locations to achieve long-term baseline data for comparison. Monitoring well data from mine placement of CCRs is often difficult to interpret due to the influences of the mining process itself and the large volumes of spoil, which can impact water quality in ways similar to CCR. Nearly all sites face the difficulty of siting wells in locations where the background influences of mining operations can be separated from the influence of CCRs, even somewhat simple sites. Substantial pre-CCR-placement monitoring data (or background data) are needed to discern the contributions of CCR from other influences. The problem is particularly severe in densely mined regions, such as the anthracite region of Pennsylvania, where several active or abandoned mines may contribute flow to a single monitoring point.[23]

This discussion reflects two kinds of "baseline" or "background" data used to gauge impacts from ash placement, data from upgradient monitoring points compared to that from downgradient points and data from before to after ash placement starts at

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[21] BD Mining, Permit Review 7.

[22] Hartley Strip Mine, Permit Review 9.

[23] NRC, Managing Coal Combustion Residues in Mines, 2006, pages 167 & 168.

downgradient points. The fact that PADEP failed to require the operator to establish any upgradient monitoring point at the BD Mining ash site makes its failure to require more than one baseline measurement of trace metals and other ash parameters from downgradient monitoring points that much more egregious. The Department approved this permit knowing it was authorizing a massive ash minefilling operation with a monitoring system that lacked either kind of background data assessment capability from which to gauge impacts of the ash.

6.2.7 Frequency of monitoring for trace metals and other ash parameters is inadequate

After ash placement at active coal mine sites, groundwater monitoring must be performed annually for the following parameters: aluminum, arsenic, cadmium, calcium, chloride, chromium, copper, lead, magnesium, mercury, nickel, potassium, selenium, sodium, and zinc.[24] Yet annual monitoring is clearly insufficient. It fails to account for different seasons in the hydrologic cycle when aquifers are recharging or discharging and when water tables are fluctuating and greater precipitation may dilute contaminant concentrations. Depending on when the sampling occurs, the results can understate or overstate trends in concentrations or miss detection of a contaminant entirely. Thus the fundamental requirement of SMCRA for performance monitoring to ensure that material damage to the offsite hydrologic balance is avoided has been simply abrogated in this instance by PADEP guidance for coal ash parameters.

Not all permits studied were requiring only annual monitoring for these parameters. Several of the larger ash application sites were requiring more frequent monitoring although sometimes the frequency of monitoring at these sites was erratic. For example, at the Ernest Mine (Permit # 32950201), monitoring for trace elements and other ash parameters during ash placement has ranged from once every quarter to once every 15 months. At the NEPCO Silverbrook site (Permit # 54920201), monitoring has been similarly erratic. While it has extended for more than 20 years, prior to 2000, there were several gaps including two gaps of three to four years each in which no data for trace elements or other ash parameters can be found. Since 2000, monitoring for ash parameters has varied from quarterly to semi-annual. At the McDermott Mine (Permit # 11950102), monitoring for trace elements and other ash parameters was quarterly on a fairly consistent basis. This has also been the case at the EME Generation site (Permit #32753702) and at the BD Mining site (Permit #54850202). At the EP Bender Mine (Permit # 11930102), a smaller site involving 65 thousand tons of FBC ash, there was also quarterly monitoring for trace metals and other ash parameters.

However, at the other nine sites assessed in the report (Swamp Poodle, Ellengowan, Bloom #1, Hartley, Sandy Hollow, Buterbaugh, C&K, Russelton, and Wildwood), monitoring for trace elements and other readily soluble ash parameters such as calcium and magnesium was performed on the minimal annual basis prescribed in PADEP

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[24] PADEP, *Technical Guidance Document for Beneficial Uses of Coal Ash,* Doc. No. 563-2112-225, April 30, 1998 at page 4.

guidance. This has produced just nine measurements of concentrations of these constituents over nine years at Hartley (after ash placement started), five measurements of these constituents over four and half years at C&K, four measurements over three and a half years at Buterbaugh, four measurements over 6 years at Bloom #1, three measurements over three years at Swamp Poodle, and three measurements over five years at Sandy Hollow at individual monitoring points. There were other ash monitoring points at these sites, but even less measurements of ash parameters were taken at them. While there are other trends that add to evidence that ash is the source of high trace element concentrations at the Hartley, Swamp Poodle, and Bloom #1 sites, clearly too little data on trace elements, calcium and magnesium has been produced at any of these sites to give a definitive picture of the impacts that are occurring from these constituents.

6.2.8 No monitoring for obvious indicator parameters

The absence of antimony, boron, and molybdenum from PADEP's list of monitoring parameters is a critical deficiency. These three trace metals are not commonly seen in AMD but leach from Eastern and Midwestern coal ash in alkaline pH environments making them useful markers for distinguishing coal ash contamination in the disturbed coal mine setting, particularly when alkaline ashes are being used to abate acidity. PADEP's SPLP leach test has repeatedly documented these three metals leaching above other trace element concentrations from ashes of bituminous and anthracite coals and waste coals authorized for mine placement in the permits studied in this report.

Frequent monitoring for antimony, boron, and molybdenum would provide timely information about adverse impacts from coal ash placement that could be differentiated from mining impacts at the same site. Yet only one of the 19 permits studied in this report monitors for any of these constituents on a regular basis. That permit for the Hartley Strip site monitored for antimony and found it in levels exceeding the DWS in both mine monitoring wells assessed and in one case by more than 18 times.[25] There was sporadic monitoring for molybdenum at those wells that found this trace metal at a level 19 times higher than EPA's Removal Action Level and long-term child health advisory. As discussed in Section 6.2.1, boron and molybdenum were also found in two other wells in the Hartley mine that are part of the monitoring system for the Hatfield's Ferry Power Plant's coal ash landfill and found in harmful concentrations in the waters of Little Whitely Creek that drain from the mine and the landfill.

Additional field data demonstrating the leachability of boron and molybdenum are readily available. At the Montour PPL coal ash landfill in Pennsylvania, a study found boron, molybdenum, and selenium to be consistently above detection limits in the generally alkaline pore water in a test cell.[26] Molybdenum and selenium have been repeatedly found in levels well beyond detection (exceeding DWS and health advisories by several times) and boron has been detected, albeit in levels below health advisories, in

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[25] See Permit Review 9.

[26] Fruchter et al. (Fruchter, J.S., D. Rai, J.M. Zachara, and R.L. Schmidt. 1988. *Leachate Chemistry at the Montour Fly Ash Test Cell, Interim Report.* EPRI EA-5922. Electric Power Research Institute, Palo Alto, CA.)

pore water measurements on the waste anthracite coal ash in the Big Gorilla Pit studied in this report.[27]

Additional research confirms the leachability of boron and molybdenum from coal ash. Dressen et al. (1977) found that molybdenum was highly leachable from coal fly ash under alkaline conditions, and Wu and Chen (1987) found that very high percentages of boron (58-88%) were leachable from Illinois Basin bituminous coal ashes under alkaline conditions. Ainsworth and Rai (1987) found molybdenum to be strikingly more concentrated in fly ash from eastern bituminous coal compared to western subbituminous coal and lignite. The inexplicable failure of PADEP mining regulators to monitor for well known signature parameters of contamination from eastern and midwestern CCW such as antimony, boron, and molybdenum raises a basic question about whether the PADEP appreciates the need for its mine monitoring programs to differentiate sources of contamination between mining, coal refuse, and coal ash (a waste that has nothing to do with mining or cleaning coal) and thus whether the agency is genuinely committed to protecting the mine environment from the adverse effects of coal ash.

In addition, PADEP also fails to analyze for hexavalent chromium in leach tests or monitor for it at ash placement sites. There is, nevertheless, research from within Pennsylvania showing that much, if not most, of the chromium in coal ash is the more toxic and water-soluble chromium (VI).[28] PADEP should require monitoring for all of these trace metals at coal ash mine placement sites.

Lastly, it should be noted that despite the requirement to monitor for potassium annually (at a minimum) at coal ash placement sites, the authors did not find consistent monitoring for this parameter in the permits examined in this report. This is a significant omission because potassium is another important indicator parameter often found in large quantities in the eastern coal ashes and waste coal ashes being placed in the mines studied in this report and is readily soluble in the SPLP tests performed on those ashes.

6.2.9 Monitoring at detection limits that are too high

PADEP is allowing mine operators to routinely submit monitoring reports that analyze for trace metals only down to detection limits that are above DWS and water quality standards as well as the highest baseline concentrations reported for those metals, sometimes by many times. As a result, researchers found many instances, in at least eight of the fifteen permits studied in this report, in which regulators and the public are left not knowing from monitoring reports whether harmful levels of these metals are leaching from deposits past monitoring points. For example, some 56 of 174 samples, nearly one third of all samples from monitoring points in the adjoining Ellengowan and BD Mining sites (Permit Review 5 and Permit Review 7 respectively), that were analyzed for lead

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[27] See Permit Review 6.

[28] Cain, Randy D. Dengwei Huo, and H.M. “Skip” Kingston. *Treating Hexavalent Chromium In Fly Ash Leachate Using Acid Mine Drainage*, 1999, Allegheny Energy, Generation Division, 800 Cabin Hill Drive, Greensburg, PA 15601, Department of Chemistry and Biochemistry and Environmental Science and Management Program. Duquesne University, Pittsburgh, PA 15282-15230.

from 1994 to 2006, reported results as being less than a detection limit that exceeded the DWS for lead (0.015 mg/L). The operators reported one sample with a result of <0.50 mg/L, more than 33 times the DWS and 26 other samples with a result of <0.10 mg/L, 6.7 times the DWS. Thus at these adjoining sites where 16 million tons of FBC culm ash has been dumped and there have been many actual concentrations of lead exceeding the DWS at downgradient ash monitoring points, this constant use of high detection levels has hampered understanding of what appears to be a very serious lead problem in large mine pools downgradient from the ash. It is worth noting that the permit-required SPLP tests on both sources of the FBC culm ash dumped here have revealed to PADEP for many years that both ashes readily leach high levels of lead in the laboratory (10-32 times the DWS).

At the EME Generation site (a.k.a. Homer City Coal Refuse Disposal site, Permit # 32753702), every one of 113 samples analyzed for lead at the three designated ash monitoring points reported a result of <0.05 mg/L, more than 3 times the DWS. Thus in nine years of monitoring, PADEP failed to establish whether there was a harmful concentration of lead in the water before this permit was issued or whether lead was rising from below the DWS to up to up to 3.3 times beyond the DWS after the permit was issued.

At the Hartley site, high detection limits crippled analysis of trace elements at the mine's ash monitoring wells because there were so few results reported to begin with, given the annual frequency of monitoring. For example, of seven samples analyzed for antimony at MW-1 from 1989 to 1998, four reported results at detection limits exceeding the DWS (0.006 mg/L). Two of those results were <0.10 mg/L, 16.67 times the DWS. Two of the seven results for cadmium at MW-1 were reported less than a detection limit that was twice as high as the DWS (0.005 mg/L) and one of the seven results for mercury was less than a detection limit twice the DWS (0.002 mg/L). At MW-2, five of nine samples analyzed for antimony reported results less than detection limits that were greater than the DWS and four of those were below detection limits 16.67 times the DWS. Three of nine samples reported cadmium at less than a detection limit twice the DWS.

At the Bloom #1 site, detection limits for arsenic and cadmium were raised in monitoring from before to after the commencement of operations, leaving observers less able to tell if problems were occurring once ash placement started. Virtually all values reported for these two trace elements were below detection limits throughout monitoring. Furthermore, at all ash monitoring points, cadmium concentrations were recorded in monitoring reports in the first two samples in the baseline period at <0.005 mg/L, (equal to the DWS). In the subsequent four samples to the end of the baseline period, cadmium was reported at <0.020 mg/L, four times the DWS at all monitoring points. Then, after ash placement started, cadmium was reported at <0.030 mg/L, six times the DWS through the duration of monitoring at all monitoring points. Arsenic was reported at <0.010 mg/L (equal to the DWS) during the baseline period and then at <0.015 mg/L throughout the duration of monitoring after ash placement started at all monitoring points[29]. At monitoring well FA-32, this problem occurred for selenium as well, with values reported at detection limits that rose from <0.010 throughout baseline monitoring to a limit eventually five times as high, <0.050 mg/L, equal to the DWS during ash placement.

The same problem occurred in results from both of the shallow ash monitoring wells assessed at the C&K site, with selenium values reported below detection limits that rose by more than thirteen times from baseline monitoring (at <0.0023 mg/L) to ash placement monitoring (up to <0.031 mg/L). While these higher detection limits are not exceeding the DWS for selenium, they are well beyond the federal recommended water quality standard that prevents chronic toxicity to aquatic life in surface waters of 0.005 mg/L (Continuous Chronic Criterion), and thus are not protective analytical levels for monitoring shallow groundwater whose discharges to surface waters can often increase through the broken earth of reclaimed surface mines.

High detection limits have been frequently allowed in monitoring for trace elements in the Ernest Mine (Permit # 32950201). Some 37 results for arsenic, cadmium, lead, and selenium have been reported at less than detection limits that exceeded DWS. The worse examples were results of <0.4 mg/L for lead, 26.7 times the DWS, reported in September 1999 and June 2000 at all three downgradient ash monitoring points. These two results preceded actual lead concentrations at MW1 of 0.170 mg/L in September 2000 and 0.131 mg/L in June 2001 that exceeded the highest baseline (before ash placement) concentration (0.012 mg/L) by more than 10 times and the DWS (federal action level) by more than 8.7 times. Similar high lead levels exceeding all baseline concentrations and the DWS were measured at the other two downgradient ash points in the two samplings after those two with the results at <0.4 mg/L. PADEP's acceptance of such high detection limits in this instance may have presented a picture substantially more benign than it actually was, given the high actual values subsequently reported at all points. Cadmium values were reported at <0.04 mg/L, eight times the DWS in those samples with the high lead detection limits. Selenium values were reported at less than detection limits up to <0.2 mg/L, four times the DWS at all three monitoring points. These detection limit values were much farther above water quality standards particularly for cadmium (CCC of 0.00025 mg/L) and selenium (CCC of 0.005 mg/L) which are the more relevant standards of concern at one of those ash monitoring points, E-5 a surface seep into McKee Run, a major stream draining the area.

Similar high detection limits may have masked cadmium, arsenic, and selenium exceedances of DWS and WQS at ash monitoring points in the McDermott Mine (Permit #11950102). Detection limits for cadmium, set at <0.010 mg/L were reported for the large majority of results at all monitoring points and thus kept reviewers of data from knowing how many exceedances of the DWS took place for this element. This hindered understanding of the scope of a problem that is documented by multiple measurements of actual cadmium above twice the DWS in latter samples at several of the monitoring

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[29] An exception was an actual concentration of 0.017 mg/L of arsenic reported in the last baseline sample (April, 1996) at monitoring point FA-19. See Permit Review 10, Figure 10.28.

points, while not a single result was reported above <0.010 mg/L before ash placement started at any monitoring point.

6.2.10 Lapses in data collection

The authors of this report encountered gaps in monitoring data in every permit examined. Sometimes the gaps occurred because monitoring points were dry or disabled but other times there was no documentation explaining why the gaps occurred. In several cases, these gaps were filled by asking PADEP staff for data not found in the permit files.

The most notable gaps in data occurred for trace elements and other more exclusive readily soluble ash parameters such as calcium, magnesium, potassium, sodium, and chloride. Ironically, trace elements, particularly the heavy metals, are the constituents that generate the greatest concerns in controversies concerning coal ash management. In several cases these gaps exacerbated an existing paucity of data for trace elements given that only annual monitoring was required for them to begin with. The gaps also occurred at times after high trace element concentrations had been recently reported or when major operations began. Thus regulators are left with no data, precisely when they need more data to look for the source of any potential problem suggested by the high concentration, or whether adverse impacts are readily occurring from the advent of the operation.

An example of the first situation occurred at the Bloom #1 site, where there were only four measurements for trace elements (and calcium, magnesium, and other annual ash parameters) over a six year period of monitoring at four ash monitoring points. Worse, however, is that three of the measurements were grouped in a two year period from April 1997 to March 1999 which was then followed by a four year gap of any data before the last measurement occurred in March 2003. Adding to the concern over this gap was the fact that the sole measurement for trace elements obtained a year later from a fifth ash monitoring point, MW-3 installed directly in the ash/spoil backfill, recorded arsenic at 21.5 mg/L, 2150 times the DWS.

Another example of this situation occurred at the Russelton site (Permit # 02930201), where there were just four measurements of trace metals taken at what PADEP considered the best downgradient ash monitoring point, D-8, in five years of monitoring (from beginning of 1997 through end of 2001). Adding to this paucity of data and short duration of monitoring was a one year and ten month gap between the December 1998 and October 2000 measurements. This level of monitoring occurred at a site where 1.5 million tons of ash had been placed. Of further note is that the highest arsenic (0.0876 mg/L nearly nine times the DWS) and highest cadmium (0.053 mg/L, more than 10 times the DWS) concentrations found at Russelton were measured at D-8 in October 1997, nearly a year after ash placement was underway.

An example of the second situation occurred at the Silverbrook Mine (Permit # 54920201). After high levels of selenium were reported in the May 1994 sampling at upgradient MW-2 (0.0960 mg/L) and the downgradient Silverbrook Discharge (0.260 mg/L), there were no data for selenium, other trace elements, or other ash parameters such as calcium, magnesium, aluminum, and sodium for more than a three year period (from June 1995 to August 1998) at either MW-2 or the Silverbrook Discharge in the PADEP monitoring records. This absence of data reporting occurred during ongoing placement of ash over a 250 acre area at the site. Many of these other parameters had also been rising gradually at both monitoring points previous to June 1995. Furthermore in the middle of this gap, in July/August of 1997, ash placement started in the Big Gorilla Pit making the data from the Silverbrook Discharge, the primary monitoring point downgradient of this Pit, that much more important.

At the Swamp Poodle site there were only three measurements of trace elements and other ash parameters at ash monitoring points and the first measurement did not take place until a year and one month after ash placement had been underway. Chloride measurements stopped in March 1998 even though ash placement continued for another year.

At the Hartley site, assessment of data from two mine ash monitoring wells was seriously hampered by the lack of baseline data in the permit files. There was a six and half year gap in data for major and minor elements from both of the mine ash monitoring wells examined, a four year gap in trace element data at the downgradient well and a nearly two year gap in trace element data at the upgradient well. These gaps occurred amidst measurements of antimony and lead several times over the DWS. Rising levels of boron and molybdenum at two additional wells installed in this mine, as part of a monitoring network for an adjacent coal ash landfill, document that ash in the Hartley Mine is contaminating water as even the generator of the ash has conceded, making these gaps in data from the mine monitoring wells that much more egregious.

At the McDermott site, assessment of high levels of lead, cadmium, and selenium revealed from quarterly monitoring for trace elements was hampered by a gap in data ranging from one year and three months to one year and ten months in 2000 and 2001 at all monitoring points.

Data gaps hindered our assessment of the impacts of ash at all sites and made any effective assessment at a number of other sites impossible, resulting in their removal from this study. These data gaps, on top of the standard termination of monitoring within a few years if not months of the completion of ash placement, the small numbers of monitoring points, annual frequency of monitoring for trace elements and other ash parameters, failure to monitor for well-known ash indicator parameters such as boron and molybdenum, inadequate collection of baseline data and frequent use of high detection limits in analysis of samples leave those seeking to definitively assess impacts at most Pennsylvania mine fills with more questions than answers. Indeed it would seem difficult to design monitoring programs less capable of characterizing impacts than the ones accepted by PADEP for several of the sites studied in this report.

6.2.11 No monitoring of ecological impacts

Given the numerous basic deficiencies in monitoring, it is not surprising that researchers for this report found no evidence that PADEP is attempting to monitor let alone assess the ecological impacts of mine placement of coal ash. In numerous cases, the operations sanctioned in permits issued by the PADEP suggest the Department is oblivious to the ecological threats posed by large volumes of coal ash in the open environment. The temporary placement of CCW in large mine sites left uncovered for long periods (as is occurring at all large minefilling operations examined in the report), the construction of wetlands partially from coal ash or evaporation ponds and impoundments where ash leachate is directed and its constituents left to concentrate in sediments to be taken up in microorganisms, plants, benthic life, fish and higher organisms (as is occurring at the EME and Ernest sites) or the filling of end-cut lakes, silt ponds or water filled pits with ash (as was done in the Big Gorilla Demonstration project and the BD Mining site) are examples of this lax regard for the potential harm that CCW poses to ecosytems. In many instances the deficiencies in basic monitoring reduce the likelihood that mine operators or the Department would discern problems that may be developing. With only annual monitoring at many sites for trace elements that have toxic repercussions in extremely small amounts, regular detection limits accepted in monitoring results that are hundreds of times over those amounts, small numbers of monitoring points, and short durations of monitoring, the failure to detect ecological problems should be an expected result. Researchers note that when mine placement permits had concentration “triggers” for trace elements in ash, they were usually set at drinking water standards and in some cases 25 times the DWS, which levels are hundreds of times over the levels of selenium, cadmium, silver, copper, mercury and other trace elements that cause adverse impacts to aquatic life. Unfortunately the exceedance of even those concentrations did not “trigger” actions by the Department to investigate or remediate contamination from ash. The examination of these permits provided much data of trace element concentrations well above the federal recommended water quality standards (more often the chronic Criterion Continuous Concentrations and but even the higher acute Criterion Maximum Concentrations) being discharged from springs, seeps and other surface discharges from coal ash sites into low flow streams in comparatively large flow volumes. The selenium and cadmium discharges from the MD3 mine discharge and other seeps at the McDermott Site into tributaries of Hinckton Run at McDermott site, cadmium, chromium, lead, and nickel discharges from the Ernest E5 seep into McKee Run at the Ernest site, and silver, nickel, and zinc discharges from MP-19 down downhill to Cherry Run at the EME Generation site are examples.

The NRC summarized the need for better surface water and ecological monitoring in the following statement:

> Surface-water and ecological monitoring are key components of any monitoring program to protect the ecosystem from potential adverse impacts. It is important to note that chemical levels adequate to protect environmental health can be significantly lower than those prescribed to protect human health. For surface-water, the frequency of sampling should adequately capture

> temporal variations in the background conditions as well as variations in any point- and/or non-point-source loading. Tissue residue monitoring provides valuable insights into the bioavailability of certain contaminants that can be present at low concentrations in water but accumulate in living organisms (e.g., selenium). The duration of surface-water monitoring should be consistent with the duration of groundwater monitoring. In the event that surface water quality impacts are detected, appropriate ecological monitoring may need to be implemented.[30]

6.3 FAILURE TO ADEQUATELY CHARACTERIZE COAL ASH PRIOR TO PLACEMENT

6.3.1 The PADEP certification criteria for coal ash is clearly inadequate

PADEP's certification criteria for coal ash, as set forth in the Certification Guidelines,[31] fails to require a waste characterization that predicts the potential of the ash to leach harmful constituents after placement. Certification of coal ash for mine placement requires the use of the Synthetic Precipitation Leaching Procedure (SPLP)[32] to determine the mobility of trace heavy metals and other metal oxides, as well as more prevalent inorganic constituents such as sulfate, chloride, and sodium. For a coal ash to be certified for placement in a Pennsylvania coal mine, the concentrations of constituents in the leachate cannot exceed maximum acceptable leachate concentrations set by PADEP. Those concentrations are normally 25 times the "groundwater parameter," equivalent to Pennsylvania's drinking water standard, for metals and 10 times the groundwater parameter for nonmetals.

While this test determines the quantity of inorganic constituents that readily leach out of a coal ash sample under controlled laboratory conditions for short periods, it is *not* designed to simulate actual conditions in the coal mines where CCW is placed. The actual conditions in mines are more geochemically complex. Placements usually involve large volumes of coal ash in much more concentrated environments for leaching, a variety of overburden materials, and changing chemistries of groundwaters and leachates moving through the coal ash. Also missing from the SPLP is the ability to predict coal ash leaching behavior over time. Coal ash placements will produce leachate over decades, not hours. Different constituents in CCW and the surrounding overburden will become more or less soluble as these factors change. Not surprisingly, researchers at US EPA, US DOE, and at numerous universities have found standard leaching tests, such as the SPLP, in and of themselves, should simply not be relied upon to predict the leaching

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[30] NRC, Managing Coal Combustion Residues in Mines, page 175, 2006.

[31] PADEP, *Certification Guidelines for Beneficial Uses of Coal Ash*, 563-2112-224, BMR PGM Section II, Part 2, Subpart 24.

[32] A description of the SPLP can be found in Chapter 1, Section 1.4.3.

behavior of numerous contaminants in coal ash at CCW disposal sites.[33] Concentrations of metals and other constituents in groundwater affected by CCW are often markedly different from concentrations generated in tests such as the SPLP.

A study of a bituminous fly ash disposal site revealed that several different leaching tests, both column and shake extraction, failed to predict the contaminants found in the monitoring wells.[34] The study found that leaching tests both over predict and under predict concentrations of pollutants and that results should be field tested until the leaching characteristics of the particular ash in the site in question are fully known. The study found that leach tests are unreliable field indicators "primarily because these tests are not designed, and should not be used, to predict exactly the concentrations of leachate components that will be found in the field."[35]

6.3.2. Why waste characterization of coal ash is essential

Prior to the “beneficial use” of any CCW, the waste must be characterized to determine if it is an appropriate material for the specific use and site in question. This means that both its elemental and its mineralogical composition (different oxidation states of elements and the compounds in which they are found) must be determined. It means that the probable reactions of the ash with water and minerals at the site must be predicted to understand how the waste and the water leaching through it will evolve chemically over time. The fate of mineral phases of major and minor constituents of the ash such as iron, manganese, calcium, aluminum, and sulfate and the constituents of site materials must be calculated to understand when potentially harmful metals might leach from the ash or from site materials as a result of chemical reactions with the ash.

This degree of characterization is analogous to the characterization routinely required for overburden spoils and coal wastes in mining permits. It is as fundamental to the safety and success of beneficial use of CCW at a mine as the overburden analysis is to preventing AMD in contemporary mining. Nothing close to this degree of characterization is required in PADEP’s Certification Guidelines. PADEP’s limited waste characterization for the placement of coal ash is indefensible. In Pennsylvania, it would be unacceptable for a mine operator to submit a mining permit application with a random index leaching test of overburden for each 20 acres to be mined, along with a paste pH. Such tests are grossly inadequate to characterize natural materials for their toxic forming potential. Yet, in spite of PADEP’s need to understand the complexity of

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[33] From testimony of Greg Helms, USEPA Office of Solid Waste and Emergency Response, Washington D.C.; Ann Kim, US Department of Energy, National Energy Technology Laboratory, Pittsburgh PA; David Kosson, Ph.D., Chairman, Department of Civil and Environmental Engineering, Vanderbilt University, Nashville TN; and Rick Holbrook, US Office of Surface Mining, Western Region, at the December 6, 2004 Meeting of the National Research Council’s Committee on Mine Placement of Coal Combustion Wastes in Farmington, New Mexico.

[34] Dodd, D.J.R., A. Golomb, H.T.Chan and D. Chartier. “A Comparative Field and Laboratory Study of Fly Ash Leaching Characteristics,” Ontario Hydro Research Division, Toronto, Ontario, Canada, in *Hazardous Solid Waste Testing: First Conference, ASTM STP 760*, American Society for Testing and Materials, 1981, pp. 164-185.

[35] *Ibid*.

spoil chemistry and its reactions during mining, PADEP shows no similar intent to understand the complexity of CCW chemistry and its reactions at mine sites.

The National Research Council discussed the shortcomings of leach tests used by states in minefill permits like the TCLP and the SPLP extensively and among other points, concluded the following:

> These tests do not use leaching solutions that are representative of the large range of geochemical conditions likely to be encountered in mines, and they may greatly underestimate the actual leaching that will occur. It is recommended that leaching procedures be continually improved to encompass the range of pH and oxidation-reduction conditions that might be encountered in pore-water close to the CCR placement area over an extended time (many decades to centuries). Leaching tests should also assess slower dissolution reactions.
>
> Until some recently proposed leaching protocols are evaluated more thoroughly, some simple improvements to currently applied leaching protocols can be made. As a first step, a wider range of leaching conditions should be applied in static leach tests. These leaching conditions should include low-pH leaching solutions to represent the aggressive leaching that may occur in the most reactive areas of the unsaturated zone. The composition of the leaching solution should be monitored both before and after leaching is complete to ensure that the final leaching solution is representative of expected conditions at the mine site. Leaching tests should be conducted over longer periods (e.g. several weeks) and a few solid-to-solution ratios should be evaluated to assess whether precipitation controls are limiting leaching characteristics. Samples that do not pass a predetermined criterion should be rejected for mine placement. Samples that do pass the criterion may still have to be evaluated in greater detail, depending on the potential risks of CCR placement determined from site characterization, including column leaching tests and longer-term evaluations of leaching as CCR materials age.[36]

The authors of this report found that none of these steps are being considered, let alone employed, at the sites studied. There is no range of leaching conditions being applied in the SPLP test. There is always only one pH of the leaching solution, 4.2 standard units, which may be more acidic than some mine environments and is definitely not as acidic as the low-pH of acid mine drainage found in the most aggressive leaching environments of mines. The composition of the leaching solution is not monitored at the end of the test to ensure that the final leaching solution is representative of expected conditions at the mine site. Usually the pH of the final test leachate is several units higher than the field pH

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[36] NRC, Managing Coal Combustion Residues in Mines, pages 151 & 152, 2006.

measured at downgradient points close to the ash deposits. Leaching tests are only conducted for 18 hours and only with one solid to solution ratio that is typically far more dilute (with much more solution to solid) than that found in the mine disposal environment. Whether “precipitation controls are limiting leaching characteristics” is not assessed. Even samples whose metals concentrations pass the limit on leaching allowed under PADEP’s guidance, are sometimes disposed in the mines without explanation as will be discussed. Samples that do pass the test are never “evaluated in greater detail, depending on the potential risks of CCR placement determined from site characterization.”

6.3.3 Acid base accounting is insufficient at coal ash placement mine sites

In fact, unlike the overburden analysis required by SMCRA, PADEP only requires acid base accounting procedures for CCW at a mine site when it is used officially as an “alkaline addition” to address acid mine drainage. And those procedures fail to take into account the impact of the kinetic potential for the alkalinity in the ash to buffer acidity. For example, much of the alkalinity in FBC ash is not available to react with acidity, because it is bound up inside cementaceous clumps of the ash. Concerns have also been raised that PADEP’s standard acid base accounting procedure fails to analyze for the different oxidation states of major elements in the ash such as iron, manganese, and sulfur. This can result in the failure to account for the acid-generating potential of an ash and the resulting overestimation of the net neutralization potential or buffering capacity.

Given that alkaline addition is one of the primary “beneficial purposes” claimed for ash placement in the sites studied in this report, the authors were surprised to find that a sustained decline in acidity and increase in pH appeared to occur at only three out of the 12 sites where ash was used for this purpose. At the other nine sites, the abatement of AMD was at best temporary and was never uniformly achieved. Indeed, at six alkaline addition ash sites in western Pennsylvania, the McDermott, Ernest, EP Bender, Bloom #1, Swamp Poodle and Hartley Mines,[37] average acidity at most downgradient ash monitoring points steadily increased and the average pH decreased as a result of the mining operation, without readily apparent sustained buffering effects from large quantities of ash. This occurred despite the fact that the ash placed in five of the six mines was the more alkaline FBC ash rather than the less alkaline Type F bituminous coal ash from conventional pulverized coal plants.

Thus, it appears that PADEP’s procedures for acid base accounting and estimating the neutralization potential of coal ash for AMD treatment need to be reexamined. Without an effective acid base accounting procedure for a given coal ash that can be used to determine the quantity of the ash needed to address AMD in a given mine, the ash’s buffering capacity can be exhausted. As a result, the ash can acidify and be stripped of that portion of its metals that mobilize in lower pH conditions. (Stewart, 1996) The

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[37] See McDermott Mine (Permit Review 2), Ernest Mine (Permit Review 1), EP Bender Mine (Permit Review 3), Bloom #1 Mine (Permit Review 10), Swamp Poodle Mine (Permit Review 4), and Hartley Mine (Permit Review 9).

concentrations of those metals in the mine waters can then increase to levels higher than their levels in the AMD before the ash was put in the mine.

6.3.4 Failure to recognize the leaching potential of metals in an alkaline environment

In addition, PADEP's focus on lowering acidity in coal mines overlooks the increased leaching potential of metals such as arsenic and selenium when acidity is decisively buffered at these mines by alkaline ashes. Monitoring at the Ernest, McDermott, C&K Coal, Swamp Poodle, Bloom #1, Penn State, and Big Gorilla operations, detected arsenic and/or selenium during periods of reduced acidity, elevated alkalinity and/or rising pH.

In several cases, very high levels of these metals were detected. For example, at the Swamp Poodle Mine, while arsenic was found at high levels in a downgradient monitoring well located in strongly acidic drainages, the level skyrocketed from 0.180 mg/L to 3.890 mg/L as acidity (which was as high as 18,500 mg/L) dropped from 4,000 mg/L to 0.0 mg/L at this monitoring point.[38] Likewise at the Ernest Mine, when acidity dropped by approximately 4,000 mg/L at a downgradient ash monitoring point four years after ash placement began, arsenic climbed to 0.513 mg/L, its highest recorded level at this monitoring point.[39]

Similarly at the Bloom #1 Mine, when a well was installed in the area of the mine where spoils were mixed with FBC ash to measure alkalinity effects, the concentration of arsenic measured in the only sample taken from the well in which trace elements were measured was 21.5 mg/L, 430 times the current DWS, and 2150 times the new DWS for arsenic (effective January 23, 2006).[40] The pH (field-6.9, lab-6.6) in this sampling, as with other samplings from this well, was also higher than at the other monitoring points in the mine, and alkalinity (151 mg/L) was dominating acidity (20 mg/L).[41]

Metals often exist in solution as cations. Some metals can also complex with oxygen to form oxyanions. In other words, they can mobilize as positively charged cations or negatively charged anions and migrate in water under a wide range of different pH and

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[38] See Swamp Poodle Mine, Permit Review 4.

[39] See Ernest Mine, Permit Review 1.

[40] See Bloom #1 Mine, Permit Review 10.

[41] PADEP stated (phone conversation June 15, 2005 with John Varner, Phillipsburg Office, PADEP) that the high level of total suspended solids in this sample, 418 mg/L, indicates the sample probably was not handled correctly resulting in high levels of arsenic being acidified into the sample. Levels of total versus dissolved arsenic were not provided in the monitoring report. However, even if PADEP believes virtually all of the 21.5 mg/L of arsenic was an undissolved portion of the 418 mg/L of TSS that was measured in this sample, that would mean approximately 5 percent of those solids were arsenic, a matter that should be of concern. Furthermore, the much higher levels of other ash indicator parameters in this sample such as calcium (632 mg/L), chloride (153 mg/L), magnesium (254 mg/L) and potassium (70.30 mg/L) than were found in most waters measured at other monitoring points, along with the higher alkalinity and pH and lower acidity in this sample, all suggest that the arsenic if not mostly solubilized, is moving with the groundwater in this ash-influenced environment.

oxidizing/reducing conditions. Metals having this characteristic include arsenic, antimony, boron, chromium (VI), molybdenum, selenium, and vanadium.[42]

The tendency for oxyanions to leach in oxidized and reduced environments or when acidic pHs are elevated raises questions about whether the objective of improving water quality is being served by remining permits that place large volumes of FBC ash into acid mine environments. Does the disruption of gob piles in abandoned mine sites and their replacement with large volumes of alkaline FBC ash, with the objective to rapidly raise pH, create more problems by mobilizing high levels of oxyanionic toxic metals that would otherwise remain immobile if these sites were not excavated and the acidity was allowed to abate gradually? There is a growing body of data indicating that over time acidity levels decline significantly in abandoned surface and underground mines as the pyrites near the surface of gob piles and acid-producing rock and spoils are oxidized, the piles settle and their inner geochemical environments become less exposed to the atmosphere and oxygen. (See Chapter 1, Section1.5.1.)

6.3.5 Failure to adhere to standards in the Certification Guidelines for acceptable coal ash

In the course of this report's permit reviews, the authors found that PADEP failed numerous times to enforce the requirement in the Certification Guidelines that prohibits an ash from being placed in a mine if one of the heavy metals in the ash leaches more than 25 times the state drinking water standard in the leach test.

For example, SPLP leach test results indicated that antimony regularly leached at levels more than 25 times the drinking water standard from FBC ashes disposed in several mines examined in this report. The drinking water standard for antimony, a potently toxic heavy metal, is 0.006 mg/L. Thus the "Maximum Acceptable Leachate Concentration" for antimony in the leachate is 0.150 mg/L.[43] Nevertheless, PADEP approved large volumes of ash for placement that leached higher levels:

- The concentration of antimony that leached from "fly/bottom ash" in a January 1994 test reported to PADEP in the February 1994 biannual analysis of FBC ash (from waste anthracite coal) placed at the Ellengowan Mine was 0.71 mg/L, almost 5 times the acceptable level
- Permit-approved test results show the antimony that leached from a sample of FBC bottom ash (from waste bituminous coal) approved for disposal at the Ernest Mine in August 1994 was 0.250 mg/L.
- Permit-approved test results show that antimony leached from an April 1995 composite sample of bottom ash and fly ash at 0.200 mg/L, but was approved for disposal at the McDermott Mine.
- The above test result was used to approve the ash for disposal at the E.P.Bender Mine in 1996.

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[42] PADEP, Report, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania at pg 284, December 2004.
[43] PADEP, Certification Guidelines.

- Antimony leached at 0.260 mg/L in March 1997 from another composite sample of ash from the same source, and this resulted in approval to dispose of that ash at the Colver #2 Mine "Rail Yard Site" (Permit # 11970201 – initially examined but not studied in this report).

This low level of concern for adhering to the standards was not exclusive to antimony. A detailed examination of the Penn State site is illustrative.[44] Ash from the Carlson Generating Station in Jamestown, New York was placed at the Penn State site apparently without interruption even though the ash surpassed several Maximum Acceptable Leachate Concentrations in the first two quarters of 2004. A fly ash sample collected in February 2004 leached an arsenic concentration of 5.0075 mg/L in the required SPLP test, 4 times the acceptable limit. The sample also leached 0.2141 mg/L of antimony exceeding the previously stated acceptable limit, 7.98 mg/L of aluminum exceeding the acceptable limit for this element (5.00 mg/L), and 0.192 mg/L of cadmium exceeding the acceptable limit for this element (0.130 mg/L).

We found no documentation in the permit files of a PADEP response to these leaching levels, much less any indication of a temporary halting of ash shipments. Instead there were only test results for a second sample of fly ash collected in mid March 2004. Aside from pH, this sample was tested and apparently only analyzed for arsenic, antimony, aluminum, and cadmium. It leached 2.90 mg/L of arsenic, over twice the acceptable limit, but leached within acceptable limits for antimony, aluminum and cadmium, although both antimony and aluminum levels were elevated (0.032 mg/L and 2.28 mg/L, respectively).

There is no documentation of concern over this second test in the permit file, only documentation of a test result for a third sample of fly ash collected in mid April 2004. Leachate from this test was analyzed only for arsenic, which measured 1.132 mg/L, a high level but within "acceptable limits."

Selenium and molybdenum leached at high levels, 0.1864 and 0.520 mg/L from the first sample in the test. The pH of the first sample's leachate climbed in 18 hours to 10.19 units from 4.20 units in the extraction fluid at the start of this test and the second sample's leachate climbed from 4.20 units to 8.15 units over the same short duration, indicating that substantial chemical changes were occurring. This raises questions of whether the trace metals, which were not tested in the second and third tests, would have been elevated and why PADEP would not want to determine their concentrations.

Indeed it appears that PADEP accords little priority to checking the toxic potential of ashes placed in Pennsylvania coal mines from the information available in permit files. In this case, there was no indication that the PADEP knew about unacceptable levels of arsenic, aluminum, antimony, and cadmium leaching from the Carlson ash until it received the "Six-Month Submittal For Coal Ash Beneficial Use Certification" on June 26, 2004 from Geotech Engineering, Inc., who managed the collection and testing of ash

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[44] The Penn State Site, Permit # 17820104, was one of four sites in the study for which final work could not be completed.

on behalf of the mine operator. This report was the only document in the permit file that informed PADEP that the Carlson ash violated these leaching limits. Absent another document dated before this report indicating otherwise, it is reasonable to assume that much of this ash was placed in the mine for at least several months before PADEP even became aware of the unacceptable levels of arsenic, aluminum, antimony and cadmium that readily leached from it.

Perhaps even more troubling is the absence of any indication that PADEP was concerned about those levels after it received the information. The next communication between Geotech Engineering and PADEP available in the permit file was a January 19, 2005, "Six-Month Submittal For Coal Ash Beneficial Use" which included test results for an August 2004 sample of Carlson ash to cover ash placed in the Penn State #1 Mine during the second half of 2004. The measured arsenic was again high at 0.865 mg/L. But there was no comment from Geotech to the agency about the unacceptable leaching levels of the previous report's samples and no comments from the agency in the file indicating any concern about these levels, much less any evidence of a PADEP response action.

Based on letters in the permit file from PADEP to the operator for the Penn State #1 Mine approving continued use of different ashes at this mine that met "the Department's guidelines," it is clear that PADEP was not even aware of the leaching results of these tests until long after they occurred. The following statement from a letter dated October 8, 1997 from PADEP to the mine operator concerning use of BUA (Beneficial Use Ash) from the Scrubbgrass Power Plant represents a typical timeframe for PADEP approval of leach test results submitted by the mine operator:

> We have reviewed Synthetic Precipitate Leaching Procedure (SPLP) analytical data submitted for the month of **February 1997** which we received on **September 29, 1997**. We have found the quality of the BUA to be in compliance with the Department's guidelines. Based on the **SPLP** analysis the project may continue in accordance with the approved permit. (From file for Surface Mining Permit # 17820104 – emphasis in original document)

The guidelines emphasize that the SPLP test be on ash in the exact condition it will be in when it is placed in the mine. This letter is to the mine operator, not the generator. It is approving leach test data produced eight months earlier for coal ash that is generally not to be stockpiled in large quantities at the mine site. Regarding the ashes from the Carlson Station placed in the first half of 2004, the report from the laboratory to the operator of Carlson Station, for the first sample stated, "SAMPLE MARKED: Fly Ash / 2-5-04 / 2:00PM/SAMPLE FROM FRONT, MIDDLE, AND BACK OF ASH TRUCK" on the page giving the results of the bulk analysis of the ash. The reports for the second and third sample were also labeled "from the ash truck." This suggests that the ash was sampled enroute from the power station to the mine. Clearly it appears that, regardless of the quality of the ashes involved, PADEP's approval of their use at the Penn State #1 Mine was largely an after-the-fact exercise that often occurs many months after the ash has actually been placed in the mine and after large volumes have accumulated and are interacting with the environment.

This failure to enforce the restriction on placing ash at mine sites that exceed the PADEP standard for acceptable leaching is particularly of concern given the high level of leaching that must occur quickly from the ash in a dilute leaching test to surpass this standard and the lax requirements for isolating the ash from water in the state's mines. This concern is exacerbated by PADEP's failure to require that metals such as antimony be monitored at mine ash placement sites. The bottom line is that even if the SPLP were a reliable indicator of what trace metals in ash will do in placement environments, there is ample opportunity in the permits examined in this report for large volumes of coal ash that readily leach metals in toxic amounts to be placed into Pennsylvania coal mines and cause considerable water quality degradation before PADEP would even know that there was a problem. What is needed are regulatory requirements that PADEP adhere to certification guidelines, evaluate leach test results and respond to exceedances of leach tests in a timely matter before large amounts of the ash are deposited in the mines.

6.4 FAILURE TO ADEQUATELY CHARACTERIZE THE MINE SITE PRIOR TO PLACEMENT

6.4.1 Failure to determine pre-placement water flow

In general, Pennsylvania permits show little in the way of detailed pre-placement site characterization. Most remining sites presume that the pre-existing mining characterization is still adequate. However, the characterization deemed adequate for mining purposes often does not contain the detail needed to effectively abate AMD, much less establish monitoring systems to measure adequately the impacts of coal ash placement at previously mined sites.

Pre-placement characterization of mine sites is absolutely critical to preventing degradation from coal ash placement. One important aspect of site characterization is understanding pre-placement groundwater and surface water flow. One scientist explained:

> An understanding of the groundwater flow regime is essential to the design of site-specific monitoring plans to determine the impact of mining on groundwater quality and the hydrologic balance. The more thorough the understanding of this system, the more efficient this plan can be, maximizing the information which can be obtained and minimizing the cost of monitoring. This knowledge also gives the groundwater chemistry of the site meaning by providing a frame of reference regarding a given monitoring point's location and relative importance within the groundwater flow system. Absent this understanding, considerable time and money can be wasted by the poor placement of groundwater monitoring wells and the subsequent collection of meaningless water quality data. Although groundwater chemistry can be used to help

> characterize the flow system, it must be integrated within a broader effort intended to define groundwater potential and hydraulic gradient.[45]

Placement of CCW in mines will change the pre-placement hydrology. Such changes may be deliberate, such as the plugging of holes to stop or divert mine drainage, or the changes may be inadvertent. Pre-placement monitoring locations may become meaningless because of mining operations. Points unnecessary to monitor before placement may become important in evaluating the post-placement conditions. For all site elements, the pre-placement conditions should be described, and the conditions post-operations should be projected. The post-operations conditions should be measured against projections, and the site characterization should be updated as needed. Then, the performance should again be projected into the future. Because coal ash placement creates an inherently transient system, site characterization is a dynamic process that should continue indefinitely.[46]

Examples of the need for ongoing effort to update the characterization of these sites occurred at the Ernest and McDermott sites when the sole upgradient wells designated by these permits became dry before and right after operations started, and at the Wildwood site where the sole upgradient well became dry one year into mining and ash placement. A fourth example already described would be that at the C&K Site where the data from upgradient monitoring well M-1A showed decisive deterioration in water quality after mining and ash placement started. Yet in none of these cases was there any record of any effort by PADEP to require the operators to install functional upgradient wells or update the characterizations of these sites. While PADEP did respond to sharp increases in AMD and related mining parameters controlled by NPDES permits and subchapter F limits, we could find no effort to actually gain any updated understanding of the hydrogeology at sites that would explain how the unforeseen pollution was occurring to effectively address it. An example of a PADEP response occurred at the McDermott site, where the operator was ordered to double the volume of ash placement to provide more acid buffering capability, which effort completely failed to stop the sharp increase in acidity at the site.

The National Research Council voiced a fairly strong, unambiguous, and detailed opinion in support of the need for adequate pre- and post-site characterization that involved continuing efforts to reevaluate and update understanding of sites as mining and ash operations proceed and to integrate information from waste characterization measures with information from site characterization to improve monitoring and better protect site waters from contamination.

> **SITE CHARACTERIZATION**
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> Site characterization is a dynamic process of developing and continually refining a site conceptual model, which captures

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[45] Norris, Charles H. *Minefill Practices for Power Plant Wastes: An Initial Review and Assessment of the Pennsylvania System*, August 29, 2003 at page 16.

[46] *Ibid*.

relevant aspects of the site that affect the behavior and potential impacts of CCRs in the mine environment. According to the National Research Council (NRC, 2001), a site conceptual model is "an evolving hypothesis identifying the important features, processes, and events controlling fluid flow and contaminant transport of consequence at a specific field site in the context of a recognized problem." It can also serve as a valuable tool to link potential sources to receptors through environmental fate and transport pathways and exposure routes (ASTM, 2003) The site conceptual model supports CCR management decisions, such as whether to place CCRs at a particular mine site. ….

A site conceptual model can only represent an approximation of the real world because of the complexity of the mine setting and the inherent scarcity of field data. Nevertheless, the conceptual model serves as the basis for identifying critical information gaps, so that additional characterization data can be gathered to evaluate risk. This additional characterization data is then used to further refine, or, if necessary, to completely revise the site conceptual model (Bredehoeft, 2005) to capture site-specific complexities in groundwater flow, CCR leaching, and contaminant transport. Although site characterization and CCR characterization are initially discussed separately in this chapter, CCR characterization information is an integral part of the site conceptual model because the total mass and leachability of contaminants in the CCRs affect the extent of natural (or engineered) isolation necessary to prevent downgradient ecological or human health impacts.

The extent of pre-placement site characterization needed will depend on the aforementioned assessment of the risk of CCR mine placement as well as a consideration of the uncertainty in the site conceptual model. As uncertainty in the site characteristics and behavior of CCR increases, more effort should be placed on characterization. As discussed in Chapter 5, although the potential benefits of CCR mine placement are important to consider in CCR management decisions, these benefits do not reduce the need to characterize potential risks. Managers and regulators cannot make sound decisions about CCR placement unless both the benefits and the potential risks are well understood. Inadequate investment in the site characterization up front may lead to an erroneous assessment of potential CCR impacts and improper placement or engineering design. The costs of adequate site characterization are likely to be far lower than the costs of remediating groundwater and surface water contamination from a mine site with improperly sited CCRs.

Information Needed for CCR Placement

> The Surface Mining Control and Reclamation Act (SMCRA) outlines general site characterization requirements to obtain a mining permit and to develop the reclamation and operation plan (30 CFR 779.25, 780.22 (2004) (see Sidebar 6.1). However, these site characterization requirements were intended to assess the potential impacts from coal mining and do not specifically consider the impacts of CCR placement. In most cases, additional site characterization data are needed to guide CCR placement, both to evaluate the potential for contaminant transport and to support the engineering plan for the placement and design of an effective groundwater monitoring network (see Chapter 7). [47] (emphasis in original)

Beyond the drying up of a few wells, research of the sites in this Report found that pre-permit characterizations of large ash placement sites in remining operations have had more fundamental deficiencies because they have been based on the limited level of information necessary for mining permits. But rather than putting more effort into characterization to address the uncertainties confronting them, the PADEP's response has been to ignore the deficiencies. For example, at the Ernest remining operation in Indiana County, PADEP asserted, four years after the initiation of ash placement after more than a million tons had been placed at the site and toxic concentrations of lead, arsenic, chromium, and cadmium were showing up at the downgradient ash monitoring points, that NONE of the designated downgradient ash monitoring points were capable of seeing impacts from the ash because the waste was still 2400 feet away from the ash monitoring points. [48] Yet it appears that PADEP never measured the permeability or hydraulic conductivity of the 94-acre waste coal pile separating the ash from the monitoring points.[49] Furthermore, the single upgradient point required to be installed in the permit went dry and was never replaced. Thus, despite the substantial degradation of groundwater and surface water that has occurred at this site since ash placement began, PADEP maintains that its monitoring system is not capable of measuring impacts from the ash on the shallow groundwater moving through the refuse pile. Since this is the only water being monitored for ash placement impacts, it is unfathomable that analysis of water flow in this critical area of the site was not required.

Another example of the failure to perform adequate site characterization involves the Big Gorilla Pit Demonstration Permit.[50] In this case, beyond ignoring the obvious

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[47] NRC Managing Coal Combustion Residues in Mines, pages 129-130 & 132, 2006.

[48] See Ernest Mine, Permit Review 1.

[49] PADEP Ebensberg Office staff stated to this report's authors in a February 2005 meeting that they never collected such data and did not know how fast water was moving from the uncovered ash through the refuse and downhill to these monitoring points although they believed the pile had the consistency of sand and gravel.

[50] Solid Waste Management Permit #301304. The site is within the Silverbrook Refuse Project (Permit #54920201, see Permit Review 6).

deficiencies in the site characterization, PADEP has chosen to promote the site nationally as a success story involving the elimination of an acid lake. This Demonstration Project deposited 3 million tons of highly alkaline FBC ash into the 17-acre "Big Gorilla" acidic pit lake, in part to reduce AMD by eliminating the flow of water from the pit lake into the underlying deep mine pool. The pit lake is recharged by precipitation, and it discharges as groundwater. Yet according to the permit and PADEP, the specific groundwater flow path from the pit was never determined. PADEP acknowledges that the underlying earth has interconnected deep mines and is crossed with several faults and fractures, but the extent or direction of water movement through these conduits was not ascertained. Furthermore, the PADEP report on beneficial use of coal ash in mines stated that neither the groundwater monitoring wells in the most likely positions to be downgradient from the pit nor the monitoring of mine pool water discharging from the nearby Silverbrook outfall saw noticeable influence from the ash.[51] And while PADEP maintained that the ash blocked the flow of water from the pit into the mine pool, PADEP also asserted that water levels in nearby monitoring wells and in the mine pool continued to fluctuate seasonally at the same levels as before the filling of the pit (indicating that a hydraulic connection remains between the pit and the mine pool). A monitoring well and two cores installed in the ash in the Big Gorilla Pit also ran readily into water and sampling of these points always found a water table. Thus the effectiveness of the ash in preventing water movement and infiltration has not been demonstrated.

Furthermore levels of selenium and molybdenum in the Big Gorilla ash pore water have measured at several times drinking water standards and health advisories (in multiple samples in the case of selenium) and lead levels have also started to rise over the DWS. And once ash placement started in the lake, selenium, chromium, arsenic, and copper climbed to levels never before seen in the acid lake before the ash was dumped into it. Thus PADEP is unable to measure the effect the project is having on acidity in the underlying hydrologic system or to determine where high metal concentrations from the ash may be draining. Yet the Department continues to promote the Big Gorilla Demonstration Project as a success, making no apparent effort to fill obvious gaps in its understanding of what is occurring with the underlying hydrogeologic system.

The degree of information needed for effective site characterization was outlined in great detail by the NRC. The following are details relating to some of the information needed to characterize groundwater flow and its pathways to surface waters.

> ***Subsurface Water Flow***. To understand the potential for contaminant transport from CCR placement sites, three dimensional flow processes should be included in the site conceptual model based on current theories of unsaturated and saturated flow in heterogeneous systems. The placement of CCR calls for thorough characterization of pre-mining groundwater flow and predictions of post-reclamation flow through the entire mine area, including disturbed area such as the mine spoil and the emplaced CCR. Site data to characterize groundwater flow would include seasonal fluctuations of the water table with respect to the CCR

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[51] PADEP, Report, Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania. Chapter 9, December 2004

> placement zone and hydraulic conductivities, rates, and directions of groundwater flow in all aquifers potentially influenced by the CCR. Predictions of post-reclamation groundwater flow would require an understanding of the material properties of the spoil and CCR, including the hydraulic conductivities of the material upon emplacement, and an approximation of the placement geometry. As described in Chapter 3, water flow paths can change dramatically because of CCR emplacement. Groundwater flow through fractured rock, including coal, is difficult to quantify, and adequate site characterization information about fractures is costly to obtain, because prediction of flow requires knowledge of the number, size and thickness, and continuity of the fractures (NRC, 1990, 1996; Domenico and Schwartz, 1998). Similarly, groundwater flow through heterogeneous coal spoils, which may contain both matrix and conduit (or pseudokarstic) flow (Hawkins and Aljoe, 1991; Smith and Beckie, 2003) is difficult to quantify.
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> Information on unsaturated flow characteristics is required to define the rate of contaminant migration into the groundwater zone, especially when CCRs are placed above but in close proximity to the water table. Prediction of water movement in the unsaturated zone requires information on values of hydraulic conductivity for CCR, spoil, and other materials as a function of water content and wetting and drying histories. Information on surficial topography relative to hydraulic conductivity variations may provide additional information about local infiltration at the land surface.
>
> Sufficient data should be collected to estimate travel times for contaminants to the habitats of sensitive receptors and to the nearest monitoring wells. A thorough groundwater flow characterization will also inform the design of an effective groundwater monitoring network that will intercept any contaminant plume from the CCR placement site.
>
> ***Surface water flow.*** Large amounts of surface water flow data are typically collected in the standard mine permit application. However, the addition of CCR placement at a mine site necessitates that there be a clear understanding of the interconnections between groundwater and surface water flow under pre-mining, mining, and post-reclamation conditions.[52] (emphasis in original)

Not a single one of the permits studied in this report came close to providing this level of information about groundwater or its interconnections to surface water at the sites. The NRC report also stressed the importance of integrating the characterizations of the ash with the characterizations of the mine sites into which the ash was proposed to be placed to make intelligent decisions about the suitability of ash for sites and the safeguards, including monitoring systems, needed at those sites.

INTEGRATION OF CCR AND SITE CHARACTERIZATION DATA

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[52] NRC., Managing Coal Combustion Residues in Mines, pages 134 & 135, 2006

> Current site characterization is usually conducted independently of CCR characterization. In practice, site characterization and CCR characterization should be carried out in an integrated fashion to provide the information needed to develop a site conceptual model that adequately informs CCR management decision making in a way that is protective of the environment. For example, site characterization data are needed to inform the design of relevant leaching tests, by providing the range of geochemical conditions that might be encountered over long periods of time (decades to centuries) at the mine site. Likewise, an understanding of the total mass and leach ability of the contaminants in CCRs to be disposed at a mine site is needed to evaluate the potential for attenuation through reaction with geological materials. Given the complex hydrology and geochemistry of mine sites, the site conceptual model should reevaluated as additional site data are obtained (at least annually during active placement).[53] (emphasis in original)

There are no annual reevaluations of site conceptual models at any of the ash placement sites studied in this report. And there is no attempt to integrate waste characterizations with site characterizations at the sites, even though the need for such integration became obvious to the authors of this report in a number of cases. An example of the failure to integrate these characterizations occurred at the McDermott site, where high levels of lead (exceeding the DWS by up to 9 times) were documented to be a problem in baseline water quality at the site at many of the monitoring points. Despite this fact, the McDermott permit was amended in 1997 to allow for a different ash to be brought to this site. The new ash, FBC ash from the Cambria Power Plant, had leached lead at 0.180 mg/L, 12 times the DWS in the SPLP test performed on it for its disposal at the Ernest site in August 1994. More recent samples of Cambria ash have leached even higher concentrations of lead in the SPLP test including one sample of bottom ash that leached 0.350 mg/L, 23 times the DWS. Lead concentrations have continued to be a problem throughout mining and ash placement at the McDermott site. Some 90 percent of the 316,000 tons of ash dumped there is from the Cambria cogen plant. Yet rather than concern over the prospect of exacerbating what appeared to already be a "natural" problem of high lead at this site, PADEP has repeatedly asserted that the high lead in the baseline proves that the ash dumped at this site could not have been the source of the problem. The concept that ash known for leaching high lead levels might not be a good ash to dump at McDermott does not appear to have entered the Department's thinking.

6.4.2 Failure to predict post-placement conditions

As a rule, there is no attempt to predict post-placement site conditions. Under Subchapter F, which is intended to remediate the pre-existing water pollution from mine sites through remining and various acidity abatement measures such as alkaline addition in mining permits, the only required projection by the permit is for the type and success of post-mining vegetative cover. Without performance projections, there is no way to measure performance and determine the need for additional, new characterization. There is also no process institutionalized to account for the success or failure of mining and

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[53] *Ibid.*at page 152.

reclamation and acid abatement methods such as alkaline addition through ash placement so that any needed changes in these activities are more assuredly made.

6.5 FAILURE OF THE PENNSYLVANIA PROGRAM TO IMPROVE WATER QUALITY OR PREVENT DEGRADATION OF SURFACE WATER AND GROUNDWATER

6.5.1. No requirement for the "beneficial use of ash" to improve water quality

There is no requirement in Pennsylvania law that ash placement projects actually improve water quality, only a requirement that they not cause deterioration in water quality.[54] Regardless of whether coal ash is being used ostensibly to clean up water pollution in a mine, Pennsylvania surface mining regulations allow the release of reclamation bonds to a mine operator upon a demonstration that surface and ground water quality simply has not been degraded.[55] This is in sharp contrast to the original intent of Pennsylvania's coal ash beneficial use program as set forth in the state's 1992 regulations. Those regulations required that "placement of coal ash as part of a mining or reclamation activity shall achieve an overall improvement in water quality." [56] Although Pennsylvania regulations require that ash placement projects in active mines where acid mine drainage is evident be *designed* to improve overall water quality, there is no requirement that this be accomplished prior to bond release.[57] Given that monitoring of groundwater and surface water ceases upon bond release, the legal and practical ability of PADEP to assure that the operator achieves the overall improvement intended by the permit's design is questionable.

In the case of CCW placement in abandoned mines, the requirement is the same, only that the ash not degrade water quality. No specific or overall improvement in water quality is required.[58] Nor is post-project monitoring to assure that degradation does not occur later from the ash.

Indeed, there were no specific goals of improvement in water quality set in any of the 18 ash minefill permits examined in this report. For example, there were no objectives to reduce high aluminum, iron, or manganese in acid-degraded waters to levels complying with water quality standards or at least to levels in nearby streams less impacted by AMD. There were no objectives to raise pH specifically to levels in compliance with water quality standards. There were no objectives to reduce pollution to any specific degree.

6.5.2. Subchapter F regulatory prohibition against "degradation" does not address contamination from most coal ash parameters

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[54] 25 PA Code 287.663 and 664.

[55] See 25 Pa Code 87.209(b)(3)(ii).

[56] See 25 PA Code 287.664(a) in Pennsylvania Bulletin, Vol. 22, No. 27, July 4, 1992.

[57] See 25 Pa Code 287.663(d)(5)(iv).

[58] See 25 Pa Code 287.644(c).

While regulations require that coal ash placement at Subchapter F remining sites not "degrade water quality, " this nondegradation specifically applies only to four major constituents: acidity, iron, manganese, and aluminum.[59] Nondegradation also applies only to surface water discharges and not to site groundwater, and only to contaminant loadings (the total amount of contaminant flowing into a surface water in units of pounds per day) not contaminant concentrations (the amount of contaminants in a given volume of water or milligrams per liter). Finally contaminant loadings can be noticeably increasing at ash monitoring points that are surface discharges, but PADEP does not consider this to be a problem unless those increased loadings are great enough to cause a significant increase in loadings over a "hydrologic unit," which can often include many discharge points.[60]

It is concentration that determines toxicity to biota, not load. Furthermore, there are many constituents concentrated in ash, from sulfates to chlorides, fluorides, sodium, and a myriad of trace elements and metals that leach in concentrations harmful to life beyond just acidity, iron, manganese and aluminum. When groundwater polluted with high concentrations of those constituents reaches small streams as baseflow, the effects can be devastating on aquatic life regardless of whether the loadings are rising significantly further downstream. The result of confining the "nondegradation" requirement to just loadings of four pollutants in surface waters with large volumes of flow (often greater than 1000 gallons per minute) is that under state laws and regulations, actions to place coal ash in coal mines to "clean up acid mine drainage" can legally contaminate groundwater to an unpalatable, toxic quality or pollute surface waters in seeps, springs and small streams to concentrations that are fatal to aquatic life, while PADEP maintains that no degradation or harm is occurring.

PADEP agreed with the importance of monitoring in-stream concentrations of contaminants in its Final Project Agreement (FPA) for a joint US EPA/PADEP project that was to evaluate the environmental impacts of remining in Pennsylvania. In the FPA describing the proposed 2000 study, PADEP wrote:

> In certain circumstances, in-stream water quality monitoring is the most effective way to measure the performance of AMD remediation activities within the watershed, as the water quality impact of all remining, reclamation, and abatement activities are manifest there. The XL Project will use concentration, rather than loading data, because: 1) in-stream concentration data are more stable than load data; 2) concentration data are much easier and less costly to collect than load data (however for this test load data will also be collected); 3) pollution loads from individual discharges are manifested in the in-stream concentration; and 4) loading data, particularly in large streams, tend to be dominated by flow, which makes it difficult and impractical to monitor actual changes in in-stream quality. Accordingly, when using in-stream monitoring as a measure of environmental performance, concentration data are much more practical and sensitive than loading data. This would not be an appropriate method of

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[59] See 25 PA Code 87.201-209.

[60] See, for example, hydrologic units for the Ernest Permit, Permit Review 1.

> monitoring if a stream were so large that massive dilution was taking place that would mask the effect of the remining. As stated previously, the testing required by the project will provide for the collection of both in-stream concentration and individual discharge loading data in order to assess the BMP approach to remining permits.[61]

Yet PADEP routinely relies solely on loading data for a few mining parameters to assess environmental impact at mine sites where ash has been placed. Concentrations of ash parameters at ash monitoring points appear to have no bearing on whether the agency considers water quality problems to be occurring.

6.5.3 Absence of corrective action requirements and failure to address rising concentrations

Trigger levels are essential to the detection and timely remediation of water quality degradation. Such "triggers" are concentrations of pollution that, if exceeded, generate a requirement to undertake a response action so that the source of the contamination is found and further contamination is avoided. Monitoring groundwater in the absence of trigger levels or similar enforceable corrective action standards confers no protection. Environmental protection only exists if the regulations define an unacceptable condition, and agencies require by law corrective action when that unacceptable condition occurs. While there are trigger levels established at Subchapter F mines for loads of the aforementioned four mining parameters,[62] there are no trigger levels similar to those used in solid waste disposal programs for ash parameters at monitoring points around Pennsylvania's minefills. The NRC recognized that triggers for ash parameters are needed at ash monitoring points in coal mines:

> **Performance Standards for Monitoring**
>
> Performance standards should be established for the aforementioned groundwater and surface water monitoring points to ensure adequate protection of groundwater and surface water quality. . . . These performance standards could be based on best available data, model predictions, and relevant water quality standards (including tissue-based standards developed for elements such as selenium), considering pre-placement water quality conditions. Indications that the established performance standards have not been met, should trigger more intensive monitoring and, if warranted, the development of a remediation plan.[63]
> (emphasis in original)

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[61] PADEP. Coal Mining and Reclamation XL Project, Final Project Agreement, September 22, 2000. www.dep.state.pa.us/dep/deputate/minres/districts/ProjectXL/FPA-Final-9-22-00.htm.

[62] These triggers have been exceeded and prompted corrective responses from PADEP at the McDermott, Bloom #1 and EP Bender Mines.

[63] NRC., Managing Coal Combustion Residues in Mines, page 173, 2006

And in the final chapter of its Report, the NRC recommended the following:

> **Disposal of CCR's in coal mines should be subject to reasonable site specific performance standards that are tailored to address potential environmental problems associated with CCR disposal.** These requirements may be in addition to any permitting requirements associated with mine-site and CCR characterization. For example, the maximum contaminent levels established under the Safe Drinking Water Act might be used as a benchmark for determining unacceptable contamination levels for groundwater at some appropriate, designated monitoring site. In some mined areas, however, the natural groundwater is of poor quality, and some relative non-degradation approach may be needed. In areas where CCR leachate may interact with surface water (directly or through groundwater interactions) more stringent requirements may be necessary to protect aquatic life (see Chapter 4, Sidebar 4.5). Where violations of permit requirements or performance standards occur, authority for appropriate penalties or corrective actions must be available to mitigate the damage and prevent future violations.[64] (emphasis in original)

Regulations promulgated in Pennsylvania in 1992 did require minefill permits to incorporate corrective action triggers at ash monitoring points.[65] *Operators placing coal ash in mines were required to conduct groundwater monitoring and abide by the corrective action requirements set forth for the state's residual waste landfills.*[66] Accordingly, before 1997, PADEP's mining permits authorizing ash placement incorporated trigger levels at ash monitoring points for concentrations of trace metals and several major constituents. These triggers were equal to the state drinking water standard or the highest background concentration measured during the baseline period (prior to ash placement), whichever was higher.[67] In April 1998, however, Pennsylvania amended these regulations to remove these requirements for permits involving ash placement in coal mines.

Thus explicit corrective action standards for ash placement do not exist in the Pennsylvania mine ash placement program. This means that contamination, even when detected, does not necessarily trigger a response let alone any effort to abate damage that may be occurring. In fact, when monitoring data documented significant increases in contaminant concentrations in the permits examined in this report, the contamination was almost never acknowledged officially, or even informally, by PADEP.

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[64] *Ibid.*, page 181, 2006

[65] See Pennsylvania Bulletin, Vol. 22, No. 27, July 4, 1992.

[66] See 25 PA Code 288.251-258 (Water Quality Monitoring).

[67] See 25 PA Code 288.257.

As a result serious pollution at downgradient ash monitoring points is occurring and is not being recognized, let alone addressed. For example, at the Ernest Mine, triggers at monitoring points for ash contaminants (approved in the original 1995 permit) were exceeded some 370 times by June 2003.[68] Triggers for the trace metals, arsenic, cadmium, chromium, lead, nickel, and zinc, were exceeded cumulatively 94 times. Aluminum triggers were exceeded 62 times, and the exceedances occurred at all three downgradient ash monitoring points. Triggers for other major/minor constituents such as iron, manganese, sulfate, fluoride, chloride, and TDS were exceeded 214 times. Many of these exceedances involved concentrations that were several times to hundreds of times higher than the highest concentrations measured before ash placement and, in some cases, the exceedances were thousands of times drinking water standards. Many exceedances did not start until ash placement had been underway for at least one year and in the case of sulfate, aluminum, cadmium, nickel, and zinc, the exceedances had worsened with time through the period studied in this report. Many of these exceedances occurred as ash indicator parameters such as calcium and chloride were rising and as acidity was dropping significantly from 1999-2001, further implicating ash as the source.

Regardless of any debate about its cause, substantial water quality degradation beyond trigger levels set in the permit occurred at the Ernest Mine and is continuing to occur at all three downgradient ash monitoring points. Yet this report's researchers could find no documentation of any response from PADEP to these exceedances during the 8-year period in which they occurred. The only recognition of the rising pollution at these monitoring points appeared to be a report issued by PADEP in June 2002 that responded to concerns voiced by the Clean Air Task Force about this water quality degradation by dismissing it as the inevitable result of mine drainage. As of the end of 2005, there were no inspection reports, hydrologic investigations, or other evidence in the permit file that indicated PADEP has ever discussed mitigating steps with the operator. These could have included increasing the frequency of monitoring, installing additional monitoring points, monitoring for additional ash constituents, isolating or diverting ash and refuse leachate, capping the ash and removing ash or at least halting ash placement temporarily. Yet there was no evidence that PADEP staff even asked the operator about the exceedances during the near decade of monitoring examined in this report.

The exceedances of concentration triggers were also documented at several other permit sites in this report.[69] The following exceedances of pre-1998 triggers at ash monitoring points were found:

	Major/Minor Elements	Trace Elements
McDermott	543	37
Buterbaugh	41	3
Swamp Poodle	51	20
C&K Coal	68	3
EME Generation	231	6
Bloom #1	20	

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[68] See Permit Review 1.

[69] See McDermott, Permit Review 2; Buterbaugh, Permit Review 13; Swamp Poodle, Permit Review 4; C&K Coal, Permit Review 12; EME Generation, Permit Review 8; Bloom #1, Permit Review 10.

Researchers could find no information indicating the degradation of water quality at ash monitoring points at the sites above had abated as of the end of 2005. Yet with the exception of the McDermott site, project researchers could find no recognition of these exceedances of concentration triggers or any evidence of PADEP actions to address the pollutant concentrations involved.

Despite PADEP's failure to address the exceedances of these triggers, the agency continued to issue permits that established triggers, although in at least one case at far higher concentrations. For example, rather than using drinking water standards or baseline concentrations (as was required in the 1992 regulations), PADEP in July 1998 set trigger levels at ash monitoring points in the Maple Coal Company's "Rail Yard Site" at concentrations generally equal to the Maximum Acceptable Leachate Concentrations for metals under the Coal Ash Certification Guidelines.[70] For some constituents, the triggers were set at even higher levels. In other words, most triggers were 25 times the drinking water standard for metals and 10 times the standard for nonmetals. Because baseline levels at the two downgradient monitoring points for most ash parameters were well below DWS, these trigger levels allowed concentrations of pollutants in the water from ash to reach levels many times higher than concentrations in the water prior to ash placement before any response would be expected of the operator or PADEP. For example, the trigger for arsenic of 1.25 mg/L at ash monitoring point SW-23 was 962 times higher than the highest level of baseline arsenic measured in the water at that point. The trigger for barium at 50.00 mg/L was 1000 times higher than the highest baseline barium. The trigger for selenium at 1.25 mg/L was 1250 times higher than the highest baseline selenium. The trigger for fluoride at 100 mg/L was 1000 times higher than the highest baseline fluoride, and the trigger for chloride at 6250 mg/L was 255 times higher than the highest baseline chloride.

The discussion in the Module 25 of this permit stated that concentrations of chromium, cadmium, and lead were one to two orders of magnitude higher in the leachate generated from the leach test on the ash to be placed at the Rail Yard Site than in the mine drainage, making these three metals "good indicators of groundwater degradation (from the ash) if it occurs." Yet the triggers for these metals were twice the highest baseline concentration for chromium, 72 times the highest baseline concentration for lead and 260 times the highest baseline concentration for cadmium at this monitoring point (SW-23).

The same discrepancies were found at the other downgradient ash monitoring point at the Rail Yard Site, with trigger levels several times to several thousand times over the highest baseline concentrations measured for the ash trace elements at SW-4A. The most egregious difference was in the trigger established for mercury, which at 4.38 mg/L was 3,982 times higher than the highest baseline level for mercury at SW-23 and 4,380 times higher than the highest baseline level for mercury at SW-4A.

The failure to enforce corrective action triggers at ash monitoring points in coal mines when the regulations required such enforcement, the removal of these triggers from the

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[70] Permit # 11970201.

regulations in 1998, and the extremely lax setting of triggers by administrative discretion in the Rail Yard permit suggest that PADEP discounts the potential for pollution to occur from ash at minefill sites. More importantly, monitoring without standards for responding to contamination or without the consistent intention to respond if it occurs defeats the purpose of monitoring and confers none of the protection that the public assumes is being afforded to water supplies by PADEP's minefilling program.

6.5.4 No control of pollution from coal ash in mine NPDES Permits

The National Pollution Discharge Elimination System (NPDES) Permits issued as Part A of the mining permits studied in this report do not attempt to control point or nonpoint sources of water pollution that could occur from the coal ash in these mines. Researchers found virtually identical technology-based limits for average monthly, maximum daily and instantaneous maximum concentrations of iron, manganese, and Total Suspended Solids for NPDES permits outfalls at all mines examined in this report.[71] Additionally alkalinity must always exceed acidity and pH must stay within the 6-9 units range.

Notwithstanding the fact that iron, manganese and TSS can come from ash, there are no limits or monitoring requirements in these NPDES permits for any of the myriad other potentially dangerous parameters in Pennsylvania coal ashes. These include Total Dissolved Solids, sulfate, chloride, sodium or trace elements such as lead, cadmium, arsenic, selenium, chromium, antimony, boron, molybdenum, nickel, copper, zinc, and other constituents. Most of these are concentrated in the ashes being placed in these mines, have regularly leached at toxic levels from those ashes in 18 hour leach tests and have the potential to leach in more unpredictable and lethal concentrations from large ash deposits in mines than indicated by those tests. Aside from bulk analysis and leach test data, there is baseline data gathered for most of these constituents as part of the Module 25 in these permits. Monitoring has shown sustained rises in concentrations of at least several of these constituents after ash placement commenced at the large majority of sites examined in the report. Research documents the propensity of trace elements in Pennsylvania coal ash such as arsenic, selenium and antimony to leach in alkaline drainages and neutral to higher pHes [72] that are the objectives of "alkaline additions" to mine sites and the purpose of the pH and alkalinity standards in these NPDES permits. On the other hand, acidic conditions which may prevail at these mines are ideal for the leaching of other cations and trace elements concentrated in Pennsylvania coal ash, such as aluminum, cobalt, chromium, copper, manganese, nickel and zinc due to the enhanced dissolution of the ash particles.[73] Yet there is no attempt to use any of this information to set water quality-based effluent limits or monitoring requirements at permit outfalls for potentially dangerous parameters in ash. Thus the following statement in these NPDES permits boiler-plated from permit to permit presents a false premise,

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[71] There were some differences noted. For example total iron allowed in the monthly average concentration limit in the Ernest NPDES Permit No. PA0213004, Mine Drainage Treatment Facilities was 2.8 mg/L while other permits were uniformly enforcing 3.0 mg/L as this limit.

[72] NRC 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.

[73] *Ibid.*

> Based on the hydrologic data and anticipated characteristics and flows described in the permit application and its supporting documents and/or revisions, the following effluent limitations and monitoring requirements apply to the above listed outfall numbers.

The uniform limits in these NPDES permits infers a single characterization for all coal mines in the state that is oblivious to any drainage that might be produced by ash being placed in the mines regardless of the ash's location, amount or toxicity.

Indeed there is long-established precedent in other state mining regulatory programs for conducting effluent characterization and monitoring, if not setting additional limits to address ash constituents in NPDES permits for coal mines being used as dumping grounds or placement sites for coal ash. For example, the Guidance Policy Memorandum for the West Virginia Office of Mining and Reclamation concerning "Disposal and Utilization of Coal Ash on Surface Mining Operations," dated January 3, 1994, states:

> <u>Permits, Revisions, and Modifications</u>
>
> The OMR may approve the utilization of coal ash in a beneficial use application as described in an application for a surface mining permit, an NPDES permit, and revisions or modifications to existing permits. . . . .
>
> Coal ash utilization as a beneficial use on surface mining operations will be evaluated by OMR in accordance with plans, design specifications, testing procedures, and monitoring requirements as set forth and submitted on the attached form (MR-36). The attached form will serve as an element to both the surface mining and NPDES permit application or application for a revision or modification of an existing permit.
>
> <u>Water Quality</u>
>
> Surface and ground water monitoring stations for the purpose of monitoring coal ash leachates shall be established at appropriate locations so as to satisfy the requirements of both the Surface Mining Act and the NPDES program. Likewise, the analysis of water samples shall include the same chemical parameters for both permits. In the event that discharge points are established at different locations than the designated monitoring stations, analysis of water at the discharge point will include the same chemical parameters as for the monitoring station.

The absence of provisions in NPDES permits for coal ash parameters combined with the failure of the Subchapter F program to address ash parameters and the elimination of corrective action triggers leaves those living next to Pennsylvania coal mines unprotected by any discernable regulatory limits on contamination coming from coal ash placed in those mines.

6.6 INADEQUACY OF BONDING TO GUARANTEE ENVIRONMENTAL REMEDIATION

Coal mine bonds are fundamentally inadequate in amount and duration to serve as financial assurance for correcting adverse impacts to surface water or groundwater and other problems created by coal ash placement. Bonds at coal ash placement sites must be set at levels that include costs for maintaining ash disposal sites and for long term water quality monitoring to ensure that failures will be detected and adverse impacts remediated. However, according to PADEP's 1998 guidance document, *Beneficial Use of Coal Ash at Active Coal Mine Sites*, "The beneficial use of coal ash will require no additional bonding associated with the mining of the site."[74] Given that bonds are the primary means for assuring that natural resources are restored and post-mine land uses achieved, it is critical that this inadequacy be addressed.

A comparison of the bonds required for coal ash residual waste landfills and those required for coal ash minefills in Pennsylvania illustrates the inadequacy of the bonds required for minefills. According to 25 PA Code 287.331(a), the total bond liability for a coal ash landfill must be based on the total estimated cost to the Commonwealth for the following: (1) To complete final closure of the facility according to all the regulatory and permit requirements; and (2) To take measures necessary to prevent adverse effects upon public health and safety, public welfare and the environment, during operation and after closure, until the bond is released. Accordingly, Section 287.331(c) requires that the amount of the landfill bond be based on the following factors:

> 1) The costs to the Commonwealth to conduct closure and post closure care activities, as well as costs of monitoring, sampling and analysis, and soil and leachate analysis, facility security measures, remedial abatement measures, and postclosure restoration and maintenance measures.
> (2) The nature and size of the facility and type of operation.
> (3) The quantity, type and nature of the waste to be managed at the facility.
> (4) The costs related to size of the surface area, the topography and geology of the area and the land uses around the facility.
> (5) The additional estimated costs to PADEP that may arise from applicable public contracting requirements or the need to bring personnel and equipment to the permit area after its abandonment by the operator to perform restoration and abatement work.
> (6) The additional estimated costs incident to or necessary and proper for the satisfactory completion of the requirements of the state environmental protection acts, title 25 of the PA code, the terms and conditions of the landfill permit and orders of PADEP.
> (7) The additional estimated cost for at least the next three years which is anticipated to be caused by inflation, determined by averaging the annual Implicit Price Deflator for Gross National Product published by the United States Commerce Department, or a superseding standard, for at least the prior 3 years.

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[74] PADEP, *Beneficial Use of Coal Ash at Active Mine Sites,* Document No. 563-2112-206 at page 6.

> (8) The compliance history of the operator, applicant, permittee and related parties.

Consideration of the above factors can raise significantly the amount of a residual waste landfill bond. For example, the surety bond posted for the Montour Coal Ash Disposal Area at the PPL Montour Power Station in Washingtonville, PA is $20,741,700. The total permitted capacity of this residual waste landfill is 4,992,221 tons and the size of the landfill is 64 acres. For the Fern Valley Residual Waste Landfill in Jefferson Hills, PA, the surety bond was $3,150,865. At the time of closure of this facility in 2003, 4,850,152 tons of coal ash were placed in the landfill. At the Hatfield's Ferry coal ash landfill, the surety bond is $3,463,000. The capacity of this landfill is 2.2 million tons, and it covers 187 acres.

In comparison, bonds required at surface mines are woefully inadequate. Unlike the substantial surety bonds required by PADEP at coal ash residual waste landfills, mining bonds in Pennsylvania are calculated only to cover the costs of reclaiming the original contour of a surface mine and revegetating its ground to certain standards and do not include resources for monitoring or remediating contamination of groundwaters or surface waters resulting from coal ash placed at the surface mine. Consider the following bonds for several surface mines where ash has been placed. The total bond value for the Knickerbocker-Ellengowan site is $932,698. This site has 12 million tons of coal ash placed on 144 acres. The total bond value for the Silverbrook-Big Gorilla surface mine is $465,982. That site now contains over 4.1 million tons of ash and is slated to receive more ash. The total value of the bond for the BD Mining surface mine is $1,402,953, and the mine has 3.7 million tons of coal ash placed over 125 acres. This site is also slated to receive significantly more ash. The EME Generation Refuse Disposal Site is authorized to accept 2-2.8 million tons of coal ash, and the total value of its bond is $1,040,713. Lastly, the total value of the bond for the Ernest surface mine is $511,109, and the amount of coal ash expected to be placed on that site is 7-9 million tons.

Based on this small sample of surface mines and landfills, the amount of the bond per ton of coal ash at a residual waste landfill is more than 15 times the amount per ton of coal ash at a surface mine. While millions of dollars are routinely required as financial assurance at coal ash landfills, the addition of millions of tons of ash to a surface mine engenders no responsibility on the mine operator to set aside any funds to address potential adverse impacts from the waste. Yet at all of the aforementioned surface mines, this report found evidence of substantial water quality degradation from the coal ash.

Bonds for coal ash residual waste landfills and for coal ash minefills also differ in their duration. Pursuant to 25 PA Code 287.314, the duration of bond liability for a residual waste landfill is 10 years after final closure certification. In contrast, the period of liability for bonds posted for a coal surface mining activity extends only five additional years after completion of permanent revegetation of the permit area, and PADEP routinely uses its discretion to release the majority of the bond amount much earlier.[75] At

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[75] See 25 PA Code Sec. 86.151.

surface mining sites, Phase I bond release (60% of the total bond) is permitted when backfilling is complete. Phase II bond release (85% of the total bond) occurs upon revegetation. Thus only 15% of the bond is retained during Phase III, which terminates when vegetation has been established for five years.

In fact, PADEP usually releases the mine operator from the requirement to monitor water quality at the Phase II release of the bond (when revegetation is initially established), frequently 2-3 years after mining and ash placement occurs, far too short a period for monitoring to ascertain with any assurance that contamination of groundwater and/or surface water will not occur from the ash at the mine site. In fact, while the criteria for bond release for surface mining permits includes the consideration of environmental factors, the authors of this report found at several sites that PADEP released the Phase II portion of the bond and the operator from the monitoring requirement despite the fact that the latest publicly available monitoring data indicated that water quality degradation was continuing if not worsening at the relevant ash monitoring point(s).

For example, at the Sandy Hollow Mine, monitoring for ash monitoring wells was terminated even before the Phase II bond was released, despite rising sulfates and TDS levels above DWS at the downgradient ash monitoring well that were well under DWS during the baseline monitoring period. At the Swamp Poodle Mine, PADEP released all bonds and terminated the monitoring requirement despite the latest publicly available data for trace elements at a downgradient well that revealed by far the highest levels measured for arsenic (78 times the 2005 DWS) and cadmium (46 times the DWS) observed at that well. The latest data for manganese, sulfates, and TDS at another downgradient well also revealed contamination at 320 times, 8.8 times, and over 6 times DWS respectively, and 2 to 3 times higher than the highest baseline levels for these constituents.

6.7 ISOLATION REQUIREMENTS INADEQUATE FOR COAL ASH PLACEMENT IN MINES

Placement of coal ash directly in contact with groundwater at mine sites heightens the risk of contamination of groundwater by ash. The guiding principle of solid waste disposal under RCRA is isolation from water. The National Research Council also placed great emphasis on the need to isolate coal ash from water in mines:

> Given the known impacts that can occur when CCRs react with water in surface impoundments and landfills, CCR placement in mines should be designed to minimize reactions with water and the flow of water through CCRs. Regardless of whether the CCR is placed in an active or an abandoned coal mine, the issue of limiting the interactions of CCRs with groundwater should be a priority.[76]

In the case of coal ash placement in Pennsylvania's mines, however, contact with groundwater is frequently tolerated and, in some cases, intentional. Pennsylvania regulations do prohibit placement of coal ash within 8 feet of the regional water table for

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[76] NRC., Managing Coal Combustion Residues in Mines, page 162, 2006

some beneficial uses. This prohibition applies to the use of coal ash at coal refuse disposal sites (25 PA Code 287.663(f)(1)(v)), use of coal ash as a soil substitute or additive (25 PA Code 287.662(d)(7)), and use of coal ash in abandoned mines (25 PA Code 287.664(c)(3)). According to 25 PA Code 287.663(d)(6), however, the prohibition against placement in groundwater does *not* apply when PADEP approves the use of coal ash "as part of a mine drainage project" at active mine sites and coal refuse reprocessing sites. It is arguable that this vaguely drafted exemption would not be applicable to any placement project at an active mine or coal refuse reprocessing site whose purpose was to address AMD. Furthermore, PADEP's regulations, as well as its technical guidance, indicates that PADEP has the discretion to approve placement within 8 feet of the regional water table at all sites "upon a demonstration that groundwater contamination will not occur."[77] The technical guidance requires a study demonstrating there will be improvement or at least no degradation to water quality prior to placement within 8 feet of the regional groundwater table.[78]

The problem with Pennsylvania's regulatory prohibition is not only in the loopholes mentioned above, but in the narrow definition of its terms. Section 25 PA Code 287.1 defines the regional groundwater table as "the fluctuating upper water level surface of an unconfined or confined aquifer, where the hydrostatic pressure is equal to the ambient atmospheric pressure. *The term does not include the perched water table or the seasonal high water table*." (Emphasis added.) The seasonal high water table is defined as the minimum depth from the soil surface at which redoximorphic features are present in the soil.

Thus the prohibition against deposition in the water table explicitly fails to include the perched and seasonal high water tables. This was not always the case. When PADEP enacted its coal ash beneficial use program in 1992, the regulations originally included a prohibition against placement in the perched and seasonal high water tables. The requirement found at 25 PA Code 287.664(c)(12), (13) and in the Module 25, Table 25-1 (1993) stated: "Ash placement shall be at least 4 feet above the premining seasonal high water table or perched water table, and at least 8 feet above the regional groundwater table. The regional groundwater table may not be artificially manipulated to achieve the above." PADEP removed this requirement in 1997 when the department amended its coal ash beneficial use regulations. One major problem with allowing placement of ash in contact with a perched zone is that perched water does not mean isolated water; in most cases perched water is in fact an integral part of the regional groundwater and surface water system.

The impact of relaxing the isolation requirement is significant. Of the 15 permits examined thus far, the eight that authorized the mining of coal seams all authorized placement of coal ash into the elevations of perched water tables that existed at these sites prior to mining and thus presumably also authorized ash placement under the water tables of the spoil aquifers that will emerge at these sites in the post-mining environment. Essentially, the permits allowed operators to place large quantities of coal ash into the

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[77] See 25 PA Code 287.663(d)(6) and (f)(1)(v). See also PADEP, Technical Guidance Document for Beneficial Uses of Coal Ash, Doc. No. 563-2112-225 at page 4.

[78] *Ibid*.

space originally occupied by the coal seams, which were aquifers and any limestone, sandstone, or other aquifer layers above or in between those seams.

Furthermore, the permits in this report did not identify the location of the relevant "regional groundwater table." Thus it was very difficult if not impossible for the reviewers to determine whether the mine operator was even in compliance with the current less stringent requirement.

Lastly, PADEP authorizes placement of coal ash in groundwater at selected "demonstration projects" pursuant to the residual waste regulations.[79] These sites are permitted on the basis that they demonstrate a "new or unique technology for the processing or disposal of residual waste."[80] Ash can be placed within 8 feet of the regional groundwater table if a study is submitted to the Department that demonstrates that there will be an improvement to water quality or at least demonstrates that there will be no groundwater pollution. In the Big Gorilla demonstration project that placed dry ash into a wet environment, the authors of this report can find no such study even though the ash in this project was placed into the mine pool at the bottom of the Big Gorilla Pit, which is presumed to be part of the regional water table. However, from information in PADEP's permit files, they also cannot conclude definitively whether this mine pool is considered to be groundwater or surface water. Assuming mine pools are considered to be groundwater, there is no indication in the permit materials of what elevations in this mine pool are considered to be "the fluctuating upper water level surface," which would define the upper limit of the "regional water table" on which a study of impacts to water quality in this case presumably would be required. The absence of water elevation data from groundwater and mine pool monitoring points at several of the sites in this report marginalizes considerations about protecting the regional water table. The characterizations of most mine sites and monitoring systems studied in this report do not readily identify the location of the regional water table.

6.8 SUMMARY

The water quality problems identified at numerous mine sites in this report can be traced directly to the above-described deficiencies in the guidance, regulations, and implementation of the Pennsylvania coal ash minefill program. In its zeal to reclaim mines and provide an affordable means of ash disposal, PADEP has created a program that lacks many critically important and basic safeguards. Among the most critical deficiencies are the lack of long term monitoring, monitoring from too few points, failure to characterize waste and waste sites, failure to isolate the waste from water and the absence of corrective action standards. Also critical is the failure to enforce program requirements such as responding to the exceedance of concentration triggers at monitoring points and the placement of ash that exceeds prohibited leaching levels for toxic metals, the inadequacy of bonds and their release before protection of water supplies is assured, indeed even when monitoring indicates harm to those supplies is occurring, and the illusory protection afforded to groundwater aquifers. These

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[79] 25 PA Code 287.501-506.

[80] See 25 PA code 287.501 The Big Gorilla Pit Site, Permit Review 6, was permitted as a residual waste demonstration project.

deficiencies can be cured by several means. These include programs to establish safer uses for ash before minefilling it, regulatory reform, amendment of guidance documents, and effective enforcement by PADEP of program requirements. Regulations should establish common sense safeguards regarding the characterization of wastes and sites, and monitoring and corrective action requirements. These regulations should be enforceable by those who live in the vicinity of ash placement sites should PADEP fail to enforce them. Without such changes, it is certain that significant water degradation from ash placement in coal mines will continue.

CAPTION - AC Fuels Co Site, SMP # 54980201 in Schuylkill County, a mile west of McAdoo, is the site for major refuse remining and disposal of FBC ash from the Panther Creek Cogen Plant. PADEP staff says the ash put in the site equals 50 % of the volume of coal refuse taken out (Aug. 2007 communication). Photo by Steven Dreyer, McAdoo, PA.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

This report provides an in depth analysis of impacts to groundwater and surface water at 15 coal ash placement sites in mines in the bituminous and anthracite coalfields of Pennsylvania. The goal of this report is to test the assertion of the Pennsylvania Department of Environmental Protection that the use of CCW in coal mine reclamation, as permitted under this Agency's Coal Ash Beneficial Use Program, does not result in the pollution of groundwater or surface water. *This report concludes that degradation has occurred from coal ash placement at the majority (two-thirds) of the permit sites examined, based on rising trends in concentrations of CCW contaminants at relevant ash monitoring points.* In addition, our analysis reveals serious deficiencies in the PADEP beneficial use program that could potentially lead to degradation and the contamination of water supplies at many more ash placement sites. Below is a summary of the findings of this report and a list of recommendations that addresses these findings.

Findings:

• ***At 10 of the 15 coal ash minefills examined, monitoring data indicate CCW degraded water quality***. Increased levels of contaminants including sulfate, total dissolved solids, manganese, iron, aluminum, calcium, magnesium, potassium, sodium, chloride, fluoride, and trace elements such as arsenic, cadmium, lead, selenium, chromium, nickel, zinc and copper were detected in monitoring wells and/or surface water downgradient of CCW placement areas after ash placement occurred at levels substantially exceeding concentrations of any of these constituents before ash placement. Often the level of these contaminants greatly exceeded safe drinking water standards and water quality standards. The following conclusions were reached for the other five sites:

- For three of the minefills, degradation occurred but data do not provide compelling evidence to differentiate ash from mining or coal refuse as a source contributing to the deterioration of water quality.
- At one of the minefills, data indicate that water quality improvement appeared to have occurred as a result of remining and reclamation with ash placement for some parameters, but degradation has occurred in other water quality parameters that appears to be from the ash. Serious gaps in monitoring for trace metals and the absence of monitoring data after the conclusion of ash placement render it impossible to determine long-term impacts from the ash.
- At one of the minefills, water quality improvement appeared to have occurred as a result of remining and reclamation with ash placement. However, the absence of monitoring after the conclusion of ash placement renders it impossible to determine long-term impacts from the ash.

• ***At sites where monitoring data indicated ash degraded water quality, the increases in contaminants commonly found in ash leachate (such as arsenic, selenium, lead, cadmium, chromium, nickel, calcium, magnesium, potassium, sodium and chloride and antimony, boron and molybdenum at the one site in which these three contaminants were monitored) often corresponded with drops in acidity and rises in***

alkalinity and/or pH. Thus a correlation was usually found between the decline in acidity and rise in alkalinity during active mining caused by the coal ash and the level of coal ash contaminants in the water.

- ***At all 15 coal ash minefill sites, serious deficiencies in monitoring occurred****.* These deficiencies included: (1) inadequate number of groundwater and surface water monitoring points including no monitoring points located in the ash and no upgradient monitoring points in at least half the placement sites; (2) insufficient frequency of data collection including only annual sampling for trace elements at most sites; (3) significant lapses in data collection particularly for trace elements after ash placement; (4) absence of monitoring for key ash indicator parameters including antimony, boron, and molybdenum; (5) analyzing samples at detection limits above or far above drinking water standards; (6) inadequate records indicating water elevations at groundwater monitoring points and dates, quantities, and locations of ash placement; and (7) the termination of monitoring after the completion of ash placement, even when the most recent monitoring data indicated worsening degradation of water quality. A standard release of the mine operator from water monitoring usually at the completion of Phase II of reclamation, when ground surfaces have been recontoured and revegetated, occurs in most cases one to three years after coal ash placement and backfilling at mine sites is completed. This is far shorter than the time normally required at coal ash landfills for post closure monitoring (one to three decades) and not enough time to ascertain that adverse impacts to water quality from coal ash placement will not occur.

- ***Water quality is threatened by the systematic failure to require adequate site characterization, particularly for groundwater systems prior to approval of permits for ash placement.*** Such characterizations would provide substantive site-specific information identifying the natural and man-made groundwater flow paths at ash placement sites and locate the connections of shallow groundwater flow in mine placement sites to deeper groundwater aquifers and minepools underneath sites. It would document the directions and rates of flow of groundwater in shallow systems directly affected by ash placement and the flow rates and directions in aquifers underneath ash placement areas. It would identify flow directions, rates and volumes of water being sampled in minepools underneath ash sites. Thus regulators would understand when monitoring points should see the effects of ash placement with a reasonable degree of confidence. The failure to assemble this site information, integrate it with information about the waste, and update the characterizations of sites as new information becomes available results in the placement of ash at sites where monitoring systems allow contamination of groundwater and surface water from the ash without knowledge or response from mining operators or PADEP.

- ***The failure to require adequate waste characterization is a systemic deficiency of the PADEP Coal Ash Beneficial Use Program****.* There is no attempt in the PADEP program to field validate the results of the SPLP test on ashes at mine sites or otherwise predict what particular ashes may do at particular sites given the specific geochemistries of those sites. The reliance on the SPLP test as the sole safeguard for protecting groundwater and surface water in coal mines results in the placement of CCW that is capable of leaching dangerous quantities of hazardous constituents without understanding that potential toxicity and without engineered safeguards in place to prevent the contamination of groundwater and surface water.

- ***PADEP's failure to require corrective action standards in CCW placement permits is a critical program-wide deficiency***. Because of PADEP's failure to establish these standards at ash monitoring points for ash parameters in permits, contamination of water from ash at a mine site fails to trigger a response from PADEP in most instances. Thus the operator makes no attempt to assess the contamination, much less engage in steps to stop further contamination or remediate damages. Dangerous degradation of water quality from ash is not being recognized or addressed.

- ***NPDES permits at coal ash placement minesites fail to regulate constituents of concern for coal ash.*** The Clean Water Act water pollution discharge permits granted for Pennsylvania coal mines accepting coal ash make no attempt to limit or even monitor coal ash contaminants in those discharges to surface waters. Leachate from ash should be characterized and monitoring requirements and limits for ash contaminants set in these permits. Combined with the absence of corrective action standards, this deficiency means there are no limits on the concentrations of coal ash contaminants that can migrate from minefills into groundwater or surface water.

- ***Coal mine bonds are grossly insufficient in amount and duration to serve as financial assurance for correcting adverse impacts to surface water or groundwater caused by coal ash placement.*** Unlike the substantial financial assurance required by PADEP at coal ash residual waste landfills, mining bonds in Pennsylvania are calculated only to cover the costs of reclaiming the original contour of a surface mine and revegetating its ground to certain standards and do not include resources for monitoring or remediating contamination of groundwaters or surface waters resulting from coal ash placed at the surface mine. As a result, mine bonds typically cover substantially smaller expenditures of resources. One surface mine examined in this report had 12 million tons of coal ash placed on 144-acres with a bond of $930,000, while PADEP required a 64-acre coal ash landfill holding 4.9 million tons of ash to post a surety bond of $20 million.

- ***PADEP regulations do not require sufficient isolation of the coal ash placed in coal mines from groundwater.*** For some beneficial applications, Pennsylvania regulations prohibit placement of coal ash within 8 feet of the "regional water table." However, this prohibition does not apply to all coal ash placement projects nor does it afford sufficient protection when it does apply. A narrow definition of "regional water table" exempts the perched and seasonal high water tables from this prohibition. Consequently, the researchers of this report found that of the permits that authorized the mining of coal seams, all authorized placement of coal ash into the elevations of perched water tables that existed at these sites prior to mining and thus also authorized ash placement under the water tables of the spoil aquifers that will emerge at these sites in the post-mining environment. Because this report also finds that PADEP is lax in enforcement of its Certification Guidelines (allowing ash that leached harmful amounts of contaminants to be placed in coal mines) and is lax in its groundwater monitoring and corrective action requirements, the failure to isolate large quantities of waste from groundwater creates a significant potential hazard at ash placement sites.

- ***Poor organization of PADEP permit files and inaccurate information in the files hampers evaluation of ash placement sites.*** The hallmarks of a modern and efficient information system are transparency, accuracy, and accessibility. The permits lacked transparency because information was not well organized or consistently assembled. The permits lacked a general information section explaining where pertinent data, such as the date operations commenced and ceased, could be found. Information was also often missing, including inspection reports, monitoring data and maps. Researchers of this report also found inaccurate information, including the location and characterization of wells. Lastly, the permits were difficult to access because information was not available electronically.

- ***A major program deficiency is the failure of PADEP to require that ash placement projects improve water quality, which is ostensibly asserted as their purpose.*** The operative standard in PADEP laws and regulations of "no degradation" from projects using ash in coal mines is not even protecting, much less cleaning up, Pennsylvania's waters. One of the most publicized objectives of placing coal ash in coal mines is to clean up acid mine drainage from past mining practices. Yet there are no general or specific levels of reduction in acidity, increase in pH, or reduction in other mine drainage parameters from baseline concentrations set as objectives in permits that use coal ash for "alkaline addition" to treat AMD, only a calculation of the amount of ash that should be applied to avoid generating AMD from new mining or remining. Thus there is no standard against which to measure the results of these permits and make needed improvements when permits are not successful in meeting the standard. Indeed, in 6 of the nine of permits examined for which ash was specifically used as an "alkaline addition" to treat acid mine drainage, acidity increased and pH decreased at all or the majority of downgradient monitoring points. The adage of 'the best defense is a strong offense' applies here. Without regulatory requirements for ash placement permits to set and achieve specific goals of improvement in water quality, this program is in essence permitting disposal sites without the basic safeguards imposed by the state's solid waste regulations such as long term monitoring for ash parameters, and corrective action standards. The result is contamination of water.

- ***PADEP's permitting program fails to require ecological monitoring of streams or other surface waters in the vicinity of ash disposal sites.*** PADEP does not require ecological monitoring of streams or other surface waters or terrestrial life that may be affected by ash disposal sites.

- ***PADEP fails to promote the safe reuse of coal ash in Pennsylvania.*** Rather than promoting safer beneficial reuses of coal ash in lieu of mine placement as recommended in the NRC report, PADEP actively promotes mine placement which maximizes the potential for future harm from CCW.

Recommendations

It is essential that Pennsylvania's coal ash beneficial use program require sufficient safeguards in the following areas to address the above findings of deficiencies. These recommendations are consistent with the recommendations of the National Research Council of the National Academies of Science set forth in their March 2006 report:

1. *Waste Characterization*: Sufficient testing of CCW must better determine the propensity of the ash to leach constituents in harmful amounts at mine placement sites. PADEP must use effective field validation techniques such as monitoring of water quality directly within the placed ash to ascertain the actual behavior of the ash in the mines and adjust leach tests accordingly. PADEP must end its total reliance on one short-term laboratory leaching test, that uses the same conditions on every coal ash to be placed in every mine regardless of the differences between ashes and mines. Most experts agree that this test does not reflect how CCW actually behaves in the mine.

2. *Site Characterization*: Baseline water quality, rates and directions of flow, and interconnections between all surface water and groundwater potentially affected by ash placement must be identified and documented with site specific data at every ash placement site before decisions are made to approve ash placement permits. The locations of all connections to deeper groundwater systems and minepools underneath ash placement sites must be identified with site specific detail. Efforts must be made to identify volumes of water in minepools underneath ash placement sites so that monitoring systems can be calibrated to detect changes in the water quality in those minepools before ash has contaminated substantial volumes of water. Site characterization must be integrated with waste characterization and updated regularly as new information from sites and the wastes becomes available so that placement of CCW with clearly dangerous leaching potentials in specific sites is avoided, evolving hydrology at sites is understood and monitoring systems are adjusted to account for changes in water movement.

3. *Water Quality Monitoring*: At all sites, monitoring for ash parameters should occur on no less than a quarterly frequency and from sufficient points based on competent site specific characterization of placement areas to assure that contaminant plumes are not migrating from ash. Monitoring results must be analyzed by laboratories and reported at concentrations low enough to assure that exceedances of Drinking Water Standards and other relevant standards are documented. Monitoring should never stop if contaminant concentrations are increasing. Decisions to terminate monitoring should be supported by ample data revealing safe and stable concentrations of ash parameters in pore water within the ash on the site, rates and directions of water movement from ash placement areas and concentrations at downgradient and downstream points that demonstrate consistent attenuation and dispersion of contaminants to levels well below safe standards. The duration of the monitoring period should be no less protective than for nonmine coal ash landfills using RCRA based standards. The required monitoring must include ash indicator parameters such as boron, molybdenum and other indicators and baseline monitoring for those parameters at ash and nonash monitoring points in order to differentiate contamination caused by coal ash from mining impacts.

4. ***Corrective Action*****:** Permits must contain enforceable corrective action standards that provide "trigger levels" for all coal ash parameters being monitored. To ensure that water quality is not degraded to conditions worse than existed prior to ash disposal, these trigger levels should not be set above levels measured for coal ash parameters during baseline monitoring periods. Exceedance of these standards must "trigger" enhanced monitoring at greater frequencies and at additional monitoring points to verify the existence of the contamination, locate its sources and implement any remedial steps necessary to clean up the contamination.

5. ***NPDES permits*****:** The federal Clean Water Act water pollution discharge permits granted for Pennsylvania coal mines accepting coal ash (Part A of the mining permits) must regularly characterize leachate from the ash, monitor for ash contaminants and set limits for ash contaminants that pose the potential for harm in surface discharges from ash placement areas.

6. ***Financial Assurance*****:** Just as PADEP requires for operators of coal ash landfills, PADEP must establish a program to require operators of coal mines that serve as ash placement sites to calculate the costs to monitor water quality and address potential long term water quality problems at coal ash placement sites. PADEP must require operators to purchase financial assurance instruments sufficient to accomplish these steps should the operator become unable to do so.

7. ***Isolation of Coal Ash from Groundwater:*** PADEP must include a prohibition against placement of coal ash in the perched and seasonal high water tables. Placement of coal ash directly in contact with groundwater at mine sites significantly heightens the risk of contamination of the groundwater by the waste.

8. ***Permit Organization:*** Information pertaining to coal ash placement at mine sites must be better organized, more accurate and much more accessible. The present system essentially precludes anyone but the most tenacious researcher from understanding the impacts of an ash placement operation. Consistent organization, closing of information gaps, and review of permits for accuracy is needed. Ultimately, the permits should be updated with the use of a modern database system that could be readily accessible by the public via the internet.

9. ***Requiring a Beneficial Result from the Coal Ash Beneficial Use Program*****:** Coal ash is a nonmine-generated industrial solid waste. If Pennsylvania's "beneficial use" of coal ash in coal mines is not a disposal program, there must be a measurable benefit achieved by placement of coal ash in Pennsylvania coal mines. Accordingly at coal mine sites with water quality degraded from past mining practices, PADEP should require permits authorizing the "beneficial use" of ash to meet specific demonstrable improvements in water quality within the effective dates of the permits. These permits should outline the specific changes in parameters of degraded water quality to be addressed and the timeframes for achieving the changes. Examples could include specific, sustained decreases in acidity, increases in pH, and decreases in mine drainage parameters at downgradient or downstream ash monitoring points. At regular intervals, progress in achieving the improvements in water quality should be assessed so that modifications can be made to ensure the improvements are achieved. Permits that propose to use coal ash for another beneficial purpose, such as for a soil amendment or cap, should also include specific performance objectives to which they are held accountable. The overall performance of PADEP's programs for the beneficial use of coal ash in mines should be periodically assessed as well.

10. ***Ecological monitoring:*** As a condition of permitting, PADEP should require ecological monitoring of streams or other surface waters that may be affected by ash disposal sites. PADEP should require monitoring to determine ash impacts on aquatic biota (i.e., studying aquatic biota's uptake of ash contaminants). Such monitoring must include collection of baseline data as well as long-term monitoring after ash placement has ceased to determine impacts to water quality and aquatic biota. Plant uptake of CCW contaminants and the effects of CCW on plant life at CCW sites should also be monitored.

11. ***Enforceable Regulations:*** Central to the failures of the Pennsylvania program discussed throughout this report is the absence of explicit, enforceable regulations requiring minimum safeguards at coal ash placement sites. Enforceable safeguards, required by regulations and explicit permit conditions, are necessary elements of any program permitting the deposition of industrial solid waste in mines. When PADEP amended its coal ash beneficial use program in 1998, most of the requirements for groundwater monitoring, corrective action, waste characterization, and other safeguards were removed from regulations and placed in several guidance documents. Consequently, PADEP gained great discretion in these critical areas, while the public has no standards to enforce. For example, PADEP can and does accept ash for placement that exceeds maximum allowable leachate concentrations. However, the certification standards are set forth in unenforceable guidance. Clearly PADEP has the discretion to certify ash that exceeds these guidelines, is doing so without establishing that the ash will not harm water and the public has no recourse. Similarly, monitoring results indicate at many ash placement sites that contamination is occurring, but since there are no longer any "trigger" levels in the regulations or permits, a response is wholly within the discretion of PADEP. In most instances PADEP fails to take any response action and makes no attempt to document or explain its inaction. This degree of discretion is entirely inappropriate in view of the millions of tons of coal ash placed each year in mines in Pennsylvania and in view of the known toxicity of this waste. Considering the rapidly increasing generation of waste coal ash in Pennsylvania, which is primarily disposed in mines, the absence of regulatory standards becomes even more problematic.

12. ***Statewide Programmatic Review of Pennsylvania Coal Ash Placement Sites:*** PADEP should conduct a statewide review of all ash placement in mines conducted under its beneficial use program given (1) the failure of permitted ash minefills, as documented in this report, to achieve their intended purpose; (2) the propensity of permitted ash minefills, as documented in this report, to contaminate groundwater and surface water; (2) the increasing public concern about minefilling in Pennsylvania; (3)

the National Academies of Science's recommendations that call into question many critical aspects of the Pennsylvania Coal Ash Beneficial Use Program; and (4) the pending national rulemaking on mine placement. This review should include the imposition of long-term monitoring at older, finished mine placement sites where such monitoring is not currently underway. This monitoring must be designed to determine whether adverse impacts from coal ash disposal are occurring.

13. ***Promotion of Safe Reuse of Coal Ash*****:** PADEP must heed the primary recommendation of the NRC Report to promote safe and beneficial reuse of CCW in lieu of mine disposal. PADEP should approve CCW disposal in mines only when safer reuse alternatives are not feasible. PADEP should require all applicants, prior to receiving permits or the renewal of permits for ash placement in mines, to demonstrate that reasonable efforts have been made by the CCW generators to market the CCW for beneficial reuses, such as in the manufacture of concrete, pavement or other aggregates. PADEP should encourage CCW generators to continue these efforts to divert the CCW from mine placement after minefill permits for their CCW are issued.

In summary, the Pennsylvania Coal Ash Beneficial Use Program in mines is far from a model program. In principle, the safe and beneficial reuse of an abundant industrial waste is a sound goal. However, the authors of this report have observed practices that defeat this laudable goal by damaging water supplies and leaving large unmonitored waste deposits not isolated and posing longterm potential risks to local communities. The authors look forward to working with the Commonwealth of Pennsylvania to create a safer coal ash placement program and to conducting additional research to better define the risks and benefits of coal ash placement in mines.

CAPTION - AC Fuels Co Minefill in Schuylkill County where FBC ash from Panther Creek Cogen Station is used for reclamation according to PADEP and dumped without standards according to nearby residents. Photo by Steven Dreyer, McAdoo, PA.

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APPENDIX 1: PENNSYLVANIA LAW GOVERNING THE PLACEMENT OF COAL COMBUSTION WASTE IN ACTIVE AND ABANDONED MINES

1.1 Introduction

Pennsylvania law permits the beneficial use of coal ash in active and abandoned mines. Mine sites where coal ash is beneficially used have to comply with the provisions of four Pennsylvania laws: the Solid Waste Management Act (P.L. 380, No. 97, 35 P.S. § 6018.101 et seq.), the Surface Mining Conservation and Reclamation Act (P.L. 1198, 52 P.S. § 1396.1 et seq.), the Clean Streams Law (P.L. 1987, 35 P.S. § 691.1 et seq.) and the Coal Refuse Disposal Act (P.L. 1040, 52 P.S. §30.51 et seq).

Pursuant to these laws, the Pennsylvania Environmental Quality Board promulgated numerous chapters of regulations contained in Title 25 of the Pennsylvania Code. The regulations most relevant to the use of coal ash in mines are in 25 PA Code Chapter 287 (specifically, Subchapter H, Beneficial Use, 25 PA Code 287.661 through 287.666). Subchapter H gives the Pennsylvania Bureau of Mining and Reclamation (BMR) authority to approve beneficial uses of coal ash in four categories: ash placement, ash placement as an alkaline addition, as low permeability material, as a soil amendment or soil substitute.[1] In addition, sections of the coal mining regulations in 25 PA Code, Chapters 86 to 90, are applicable. Two mining permit modules are specifically applicable to mine placement, Module 25 for the placement of coal ash at surface mine sites (including placement, alkaline addition and use of ash as low-permeability material) and Module 27 for coal ash is used as a soil substitute or additive. In addition, Subchapter F of 25 PA Code Chapter 87 (25 PA Code 87.201 to 209) applies to coal ash placement at remined sites. Lastly, sections of PADEP's water quality and air quality regulations apply to ash placement, as well.

In 1997, Pennsylvania made significant revisions to the residual waste regulations applying to coal ash placement (25 PA Code 287.661-666). These revisions relaxed the standards applicable to coal ash placement and removed from the regulations many important requirements concerning waste analysis, groundwater monitoring, isolation and corrective action. The more stringent regulatory requirements had been in place only five years, from 1992 to 1997.[2] In place of these regulatory requirements, PADEP issued numerous guidance documents, described below, pertaining to the placement of coal ash. The 1997amendments to the regulations and the accompanying guidance documents give PADEP much more discretion in the operation of coal ash placement/disposal projects.

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[1] The Pennsylvania Solid Waste Management Act (SWMA) defines coal ash as fly ash, bottom ash, or boiler slag resulting from the combustion of coal. Waste from emission control devises, such as flue gas desulfurization sludge is excluded from the definition of coal ash. Waste from the burning of waste coal, however, is included.

[2] See Pennsylvania Bulletin, Vol. 22, No. 27, July 4, 1992.

1.2 Technical Guidance Documents Applicable to Coal Ash Mine Placement

PADEP developed in 1997 four guidance documents that attempt to define and clarify the overlapping requirements of the regulations and permits noted above. These guidance documents are (1) *Certification Guidelines for Beneficial Uses of Coal Ash,* 563-2112-224, BMR PGM Section II, Part 2, Subpart 24; (2) *Beneficial Use of Coal Ash at Active Coal Mine Sites,* 563-2112-206, BMR PGM Section II, Part 2, Subpart 6; (3) *Technical Guidance Document for Beneficial Uses of Coal Ash,* 563-2112-225 BMR/PGM Section II, Part 2, Subpart 25;' and (4) *Alkaline Addition for Surface Coal Mines*, 563-2112-217, BMR PGM Section II, Part 2, Subpart 17.[3]

Two of the guidance documents, *Certification Guidelines for Beneficial Uses of Coal Ash* and *Technical Guidance Document for Beneficial Uses of Coal Ash,* were required by the coal ash regulations (25 PA Code 287.663- 287.664) when they were promulgated in 1997. These two guidances are central to PADEP's implementation of the beneficial use program. They guide PADEP's review of proposals for coal ash use at active coal mine sites, abandoned coal mine sites and abandoned noncoal mine sites. For active mine sites, one has to also consult an additional guidance document entitled *Beneficial Use of Coal Ash at Active Coal Mine Sites,* as well as Modules 25 and/or 27 of the coal surface mine applications.

The purpose and contents of each guidance document is briefly summarized.

(1) *Beneficial Use of Coal Ash at Active Coal Mine Sites*
The purpose of this guidance is to describe the procedure that the District Mining Offices should use to review requests for the use of coal ash at active mine sites. The guidance covers issues such as permitting (major or minor), public notice, contents of applications for use, and review of groundwater monitoring plans.

(2) *Certification Guidelines for Beneficial Uses of Coal Ash*
The purpose of this document is to set out the guidelines for certifying coal ash for beneficial uses. The guidance provides detailed instructions for certification by PADEP for the four different beneficial uses of coal ash at mine sites (coal ash placement, alkaline addition, soil additive or substitute and coal ash as low permeability material). The document contains the standards set for maximum acceptable leachate concentrations as well as additional requirements.

(3) *Technical Guidance Document for Beneficial Uses of Coal Ash*
The purpose of this guidance is to set parameters for the four beneficial uses of coal ash that can be approved in active mine permits, as part of PADEP's mine reclamation contracts, or as PA DEP-approved mine reclamation projects. The guidance describes requirements for groundwater monitoring, isolation distance from groundwater, coal ash placement method, application method for coal ash alkaline addition, and method of installation of low-permeability material.

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[3] These guidance documents can be found on the PA DEP website at www.dep.state.pa.us.

(4) *Alkaline Addition for Surface Coal Mines*
This guidance defines where PADEP will consider the use of alkaline addition and "assists mine operators in maintaining and achieving compliance with environmental protection standards." It is applicable to mine operators who wish to use alkaline addition as a mine drainage pollution prevention method. The guidance also provides guidance to PADEP staff who review such proposals. It contains information on how to calculate alkaline addition rates, determine placement and design a groundwater monitoring program.

1.3 Placement of Coal Ash in Active Mines

Coal ash may be beneficially used in four mine settings relevant to this report: (1) in an active mine; (2) in an abandoned mine; (3) for alkaline addition in a mine permitted for remining; and (4) at a coal refuse reprocessing site. Different requirements apply to each type of mine site, as well as to each of the four approved uses. It is beyond the scope of this report to describe in detail the regulatory requirements applicable to ash placement at each mine setting. For ease of explanation, this chapter explains first the general requirements applicable to all four beneficial uses at all active mine sites.[4] Second, the chapter separately addresses the specific requirements applying to coal ash placement at remining sites with preexisting pollutional discharges.

1.3.1 Required certification of ash

According to 25 Pa Code 287.663, coal ash placed in mines must comply with PADEP's *Certification Guidelines for Beneficial Uses of Coal Ash* ("Certificate Guidelines"). (25 PA Code 287.663(a)(1)) The generator of coal ash must demonstrate that the coal ash meets the chemical and physical characteristics set out in the Certification Guidelines before placement in a mine. PADEP must review and approve the demonstration prior to use of the ash. (25 PA Code 287.663(a)(2))

The Certification Guidelines set out the criteria for certifying coal ash for beneficial use. The guidance contains the standards set for maximum acceptable leachate concentrations for all uses of ash as well as specific requirements for the four different beneficial uses of coal ash at mines. If the coal ash of a generator is certified for one or more beneficial uses by PADEP, the ash can be used for those purposes on a statewide basis. The generator must submit constituent results of ash and leachate analyses every six months to maintain certification for the ash.

The following specifications apply to all four beneficial uses:

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[4] Pennsylvania regulates the placement of ash into active mines slightly differently than the placement of ash into abandoned mines. 25 Pa Code 287.663 governs "beneficial use" of ash in active mines while 25 Pa Code 287.664 controls use of ash in abandoned mines. Since all minesites examined in this report were active mines. This chapter primarily focuses on guidance and regulations applicable to active mines.

(1) PADEP set "maximum acceptable leachate concentrations" for ash at 25 times the groundwater parameters (MCLs) for metals and other catons and at 10 times the groundwater parameters for nonmetals. Ash exceeding these limits cannot be certified for beneficial use.

(2) The above restriction applies *only* to constituents that have primary MCLs. For constituents whose groundwater parameter is based on a secondary MCL (e.g., iron, zinc, boron, manganese, aluminum, chloride, sulfate, sodium) and whose leachate exceeds the "maximum acceptable leachate concentrations" noted above, PADEP has the discretion to grant a "contingent certificate" for use, if the applicant can demonstrate that the use of the ash will not impact surface or groundwater quality.

In addition, for most beneficial uses of ash, the pH of the ash must be in the range of 7.0 to 12.5, measured at the coal ash generator's site. For use of coal ash as an alkaline addition or liming agent, the equivalent calcium carbonate equivalent must be at least 100 parts per thousand or 10% by dry weight.

For certification purposes, the Guidelines require that the ash be tested using an index leaching test, the Synthetic Precipitation Leaching Procedure (SPLP). This test runs water, simulating natural rainfall, through a small sample of ash in a laboratory for 18 hours to determine what elements of the ash dissolve into the water during the 18-hour test.

1.3.2 Submission of plan for coal ash use

The request to use coal ash at an active mine site requires a new permit application or a major permit revision. Module 25, *Coal Ash Beneficial Use*, is used for proposals involving coal ash placement, coal ash alkaline addition and coal ash as low-permeability material. Module 27, *Sewage Sludge/Coal Ash Beneficial Use*, is used for proposals involving coal ash as a soil substitute.

Pursuant to 25 PA Code 287.663, a mine operator wanting to use coal ash must formally request the use of coal ash in the reclamation plan of the mining activities permit, and this request must be approved by PADEP before placement. The request shall contain a narrative description including: (1) an explanation of how coal ash will be placed; (2) where and how coal ash will be stored; (3) identification of the sources of coal ash and an estimate of the quantity to be used; (4) for the beneficial use of coal ash as a soil substitute or additive, the proposed application rate and justification for the rate; and (5) proof that the coal ash meets the certification guidelines.

1.3.3 Operating requirements

1.3.3.i. Performance standards and design requirements

According to 25 PA Code 287.663(c), the use of coal ash at active mines shall be designed to achieve an overall improvement in water quality *or* shall be designed to prevent the degradation of water quality. Thus an operator need not design coal ash placement to improve water quality, the use must simply be designed to prevent degradation. The only exception is for multiple refuse pile reprocessing projects at which AMD is evident where there is a requirement to design the integrated project (involving the coordinated use of multiple coal refuse sites) to achieve an overall improvement of surface water or groundwater. 25 PA Code 287.663(d)(5) However, if AMD is not evident at the site, the project is to be designed to achieve no degradation.

1.3.3.ii. Placement criteria- location

Generally, PADEP guidance indicates that coal ash must not be placed within eight feet of the regional water table, unless PADEP approves placement within eight feet based upon a demonstration that groundwater contamination will not occur. This prohibition, however, is not applied uniformly for all coal ash placement. A regulatory prohibition against placement in groundwater applies to use of coal ash at coal refuse disposal sites (25 PA Code 287.663(f)(1)(v), use of coal ash as a soil substitute or additive (25 PA Code 287.662(d)(7) and use of coal ash in abandoned mines (25 PA Code 287.664(c)(3)). Yet the regulations also provide a widely applicable exception to this prohibition. According to 25 PA Code 287.663(d)(6), the prohibition against placement in groundwater does *not* apply when PADEP approves the use of coal ash "as part of a mine drainage project" at active mine sites and coal refuse reprocessing sites.

In addition, Section 25 PA Code 287.1 defines *regional groundwater table* as "the fluctuating upper water level surface of an unconfined or confined aquifer, where the hydrostatic pressure is equal to the ambient atmospheric pressure. The term does not include the perched water table or the seasonal high water table." The s*easonal high water table* is defined as the minimum depth from the soil surface at which redoximorphic features are present in the soil.

Lastly, PADEP does permit placement of coal ash in groundwater at selected "demonstration projects" permitted pursuant the residual waste regulations. See 25 PA Code 287.501-506. These sites are permitted on the basis that they demonstrate a "new or unique technology for the processing or disposal of residual waste." 25 PA Code 287.501.[5] If the ash is to be placed within eight feet of the regional groundwater table, a study must be submitted to the Department that demonstrates that there will be an improvement to water quality or at least demonstrates that there will be no groundwater pollution.

1.3.3.iii. Groundwater monitoring requirements

Groundwater monitoring is required for coal ash placement, coal ash alkaline addition and coal ash as low permeability material at active mines and coal ash refuse reprocessing sites in accordance with the applicable provisions of 25 PA Code Chapters

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[5] The Big Gorilla Pit Site, described in this report, was permitted as a residual waste demonstration project.

86-90. The regulations do *not* require groundwater monitoring when coal ash is placed in abandoned mines, although PADEP can use its discretion to request it.[6]

Guidance, and not regulations, sets forth the parameters for conducting groundwater monitoring at ash placement sites. The guidance indicates that monitoring points at placement sites can be wells, springs, seeps or mine discharges. A monitoring point upgradient from the area where coal ash is being used is *not* required.[7] The set number of monitoring points downgradient is not specified, although guidance states that it is to be "the minimum needed to assess the coal ash impact on groundwater."[8]

According to the technical guidance pertaining to coal ash placement at active mine sites, background groundwater quality monitoring should characterize the groundwater quality before ash placement. Six samples, taken at monthly or six-week intervals, is generally recommended, but can be reduced at the discretion of PADEP. Operators must test for the constituents identified in Module 25B, *Coal Ash Groundwater Quality Parameters, Background and Quarterly Report*[9] and in Module 25B, *Coal Ash Groundwater Quality Parameters, Background and Annual Report*.[10]

After coal ash placement begins, quarterly monitoring is required for the constituents identified in the Module 25B, *Coal Ash Groundwater Quality Parameter, Quarterly Report* and annually for those constituents identified in Module 25B, *Coal Ash Groundwater Quality Parameters, Background and Annual Report*. Coal ash as a soil substitute or additive does not require groundwater monitoring. Coal ash alkaline addition may require additional groundwater monitoring (see below, section 1.4).

1.3.3.iv. Bonding Requirements at Coal Ash Placement sites

The beneficial use of coal ash requires no additional bonding associated with the placement of the ash. The standard procedures for release of bonds, 25 PA Code 86.172, applies to active coal mine sites using coal ash beneficially. Pursuant to 26 PA Code 86.174 and 86.175, the majority of the bond is released when revegetation of the site is completed (Stage 2 bond release). This release occurs at a time (often 1-3 years after ash

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[6] The water quality monitoring may be required by PADEP where information is needed to evaluate the success of the reclamation project. 25 PA Code 287.644(c)(2).

[7] Upgradient groundwater monitoring points are not required unless there is a need to characterize the groundwater coming onto the placement sites because of concerns unrelated to the mine sites being monitored. *Beneficial Use of Coal Ash at Active Coal Mine Sites*, Document Number 563-2112-206, BMR PGM Section II, Part 2, Subpart 6.

[8] Ibid.

[9] Module 25B, *Coal Ash Groundwater Quality Parameters, Background and Quarterly Report* requires monitoring for static water elevation (for monitoring wells), flow (for springs, seeps or mine discharges), pH (field and laboratory), specific conductance, alkalinity, acidity, iron, manganese, sulfate, total dissolved solids, and total suspended solids.

[10] Module 25B, *Coal Ash Groundwater Quality Parameters, Background and Annual Report* requires monitoring for aluminum, arsenic, cadmium, calcium, chloride, chromium, copper, lead, magnesium, mercury, nickel, potassium, selenium, sodium and zinc.

placement) when the impacts on water quality from coal ash placement water quality may not yet be detected by the monitoring program.

1.3.3.v. Closure

Closure for coal ash used as placement, alkaline addition and low-permeability material is considered to occur upon the completion of backfilling and establishment of vegetation. Groundwater monitoring is discontinued at this time, although PADEP has the ability to extend groundwater monitoring, if there is an indication of groundwater degradation. The decision to terminate groundwater monitoring is often made soon after ash placement (1-3 years), an insufficient amount of time in which to determine whether degradation will occur.

1.3.3.vi Permit Special Conditions

According to PADEP guidance, all permits issued for coal ash placement at active mine sites should contain special conditions requiring the identification of the facility or facilities that generated the coal ash, an annual estimate of the volume of ash placed, and a map of the location of coal ash placement.

1.4 Regulations pertaining to coal ash used as alkaline addition at remining sites

1.4.1. Purpose of Title 25, Chapter 87, Subchapter F permits

Pennsylvania encourages remining through Subchapter F permits. Subchapter F permits apply to operations where ash is placed in surface mines where remining is taking place and where previous mining has resulted in continuing water pollution. The purpose of the program is enhanced coal recovery, reclamation of abandoned mine lands, and the reduction of (or no net increase in) degraded mine drainage. Mine operators are more inclined to enter into a remining project when the potential of incurring liability for long-term treatment of mine waters from prior mining activities is low. Under a Subchapter F permit, an operator can legally mine sites that created and continue to discharge effluent water that fails to meet applicable standards for acidity and iron. Operators can legally mine such sites without assuming responsibility for treatment of the previously degraded water, as long as the discharged waters are not further degraded by the operation. If the water is additionally degraded because of the remining operation, the level of treatment required is based on pre-remining contaminant load levels and not on the legislatively promulgated effluent standards applicable to non-Subchapter F mine sites.[11]

In Pennsylvania, coal ash is frequently used at remining sites as an alkaline addition. Subchapter F of Chapter 87 (25 PA Code 87.201 through 87.209) sets forth the requirements for these sites. Several PADEP guidance documents also apply, including *Alkaline Addition for Surface Coal Mines,* (Document No. 563-2112-217), BMR PGM Section II, Part 2, Subpart 17; *Permitting Pre-existing Pollutional Discharges under Subchapter F of 25 PA Code Chapter 87, Subchapter G of 25 PA Code Chapter 88*

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[11] Set forth in 25 PA Code 87.102.

(Document No. 563-2112-611; *Determining Eligibility of Pre-existing Pollutional Discharges under Subchapter F of 25 PA Code Chapter 87, Subchapter G of 25 PA Code 88,* (Document No. 563-2112-610).

1.4.2. Subchapter F authorization

Receipt of authorization under Subchapter F to remine entitles an operator to later request bond release for areas that continue to discharge pollutional material. According to 87.205, authorization under Subchapter F may not be granted unless the operator seeking the authorization demonstrates to the satisfaction of PADEP that, among other requirements: (1) the operator's proposed abatement plan will result in significant reduction of the baseline pollution load and represents best technology and (2) the surface mining operation on the proposed pollution abatement area will not cause additional ground water degradation. 25 PA Code 87.205(a)(2) and (6). *Baseline pollution load* is defined as "the characterization of the pollution material being discharged from or on the pollution abatement area, described in terms of mass discharge for each parameter, including seasonal variations and variations in response to precipitation events. The Department will establish in each authorization the specific parameters, including, at a minimum, iron and acid loadings, it deems relevant for the baseline pollution load." 87 PA Code 87.202.

1.4.3 Water quality standards

The effluent standards for preexisting mine discharges on remining sites are based on the pre-remining water quality and flow rates. Remining effluent standards are set as baseline contaminant loading rates calculated by multiplying contaminant concentration by flow rate, which are reported in units of pounds of contaminant per day. This is in contrast to the contaminant effluent limits applicable to mine sites that are not remining sites, which are in units of contaminant concentration (e.g., mg/L) as set by EPA regulation in 40 CFR part 432.30 and by state regulation in 25 PA Code 87.102. At a minimum the samples must be analyzed for alkalinity, total manganese, total iron, aluminum, sulfate, total suspended solids and pH.

There are also no explicit objectives for water quality improvement that AMD abatement projects using alkaline coal ashes must achieve at Subchapter F sites. A remining project justified by on the basis of abatement of acid mine drainage does not have to abate any acid drainage, it is enough that it not cause additional degradation. See 25 Pa Code 87.209(b)(3)(ii). Yet the non-degradation requirement applies only to four major constituents; acidity, iron, manganese and aluminum, and the measurement is based on contaminant loading and not contaminant concentration. Also non-degradation applies only to surface water discharges and not to site groundwater.

Accordingly, Subchapter F permits usually do not set any numerical or descriptive objective for improving water quality by placing coal ash in the mines. Examples of such objectives could include the lowering of average acidity over five years by a certain number of milligrams per liter in waters draining the placement sites, the sustained raising of pH by a certain number of units in those waters, a reduction in aluminum, iron or manganese in those waters to the average level for these constituents measured in nearby waters that are not affected by acid mine drainage, the avoidance of any new pollutants not detected in baseline monitoring, and the strict avoidance of increases in any pollutant levels beyond levels detected in baseline monitoring.

1.4.4 Bond release at Subchapter F sites

Section 87.209 sets forth the criteria and schedule for the release of bonds where coal ash has been placed on remined sites. PADEP will release up to 60% of the amount of the bond for the authorized pollution abatement area if the applicant has complied with the permit, completed backfilling and drainage control under the approved reclamation plan and the Department finds that, among other requirements: (1) the operator has not caused degradation of the baseline pollution load at any time during the 6 months prior to the submittal of the request for bond release and until the bond release is approved as shown by all ground and surface water monitoring conducted by the permittee and (2) the operator has not caused or contributed to surface water pollution or groundwater degradation by reaffecting or mining the pollution abatement area. 25 PA Code 87.209(a)(4) and (5) Despite the general requirement above that the operation not cause pollution of groundwater and surface water, PADEP routinely permits the release of bonds considering only the assessment of the more narrowly defined baseline pollution load.

PADEP will release the remainder of the bond, save an amount sufficient to cover the cost of revegetating the site, if the Department finds, again among other requirements, that (1) the operator has not caused or contributed to surface water pollution or groundwater degradation by reaffecting or mining the pollution abatement area, and (2) the operator has either achieved the actual improvement of the baseline pollution load *or* has not caused degradation of the baseline pollution load and has caused aesthetic or other environmental improvements or the elimination of public health and safety problems. In other words, bond release will occur when the operator can show that there is no degradation of the baseline pollution load and that there is either an aesthetic, environmental or safety improvement at the site. Improvement of the baseline load (i.e., successful treatment of AMD) is not required for bond release. The absence of degradation (as defined by the loads of acid, aluminum, iron and manganese) and physical site improvements are generally sufficient. 25 Pa Code 87.209(b).

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Appendix 2 – Monitoring Data

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Ernest Mine
Fig 1.1 pH

Date	Before Ash Field	After Ash Field	Before Ash Lab	After Ash Lab
11/21/94	5		4.1	
12/19/1994	4.1		4.1	
01/09/95	4.2		4.1	
02/09/95	4.3		4.1	
3/10/1995	4.1		4	
04/19/95	4.1		4	
05/22/95	4		3.9	
6/21/1995	3.7		3	
07/12/95	3.7		3.8	
8/18/1995	3.6		3.7	
09/14/95	3.7		3.9	
10/19/1995	3.8		4	
3/12/1996	4.6		3.7	
6/12/1996	4.6		3.9	
8/14/1996	4.6		3.49	
11/25/1996		4.5		3.9
3/24/1997		4.2		3.8
6/10/1997		4.6		3.8
8/15/1997		4.5		3.6
12/18/1997		4.5		3.9
3/24/1998		4.5		3.8
6/24/1998		4.6		3.9
9/25/1998		4		3.9
12/17/1998		4.5		3.8
3/25/1999		4		3.6
6/21/1999		4.5		3.6
9/23/1999		4.3		3.6
12/8/1999		4		3.6
3/23/2000		4.3		3.7
6/16/2000		4.5		3.4
9/13/2000		4.1		3.6
12/19/2000		4		2.7
3/5/2001		4		3.4
6/2/2001		4.7		3.4
9/19/2001		4.5		3.5
12/12/2001		4.3		3.7
3/19/2002		4.5		3.6
3/19/2002				3.8
6/20/2002		4.5		3.5
9/18/2002		4.5		3.7
12/13/2002		4		3.8
3/24/2003		4		3.7

6/13/2003		3.9		3.7
9/30/2003		4		3.7
12/23/2003		3.9		3.9
3/29/2004		4		3.7
6/29/2004		3.8		3.6
9/27/2004		4		3.7

Ernest Mine
Acidity

Date	Before Ash	After Ash
11/21/94	1646	
12/19/1994	1736	
01/09/95	1696	
02/09/95	2280	
3/10/1995	2220	
04/19/95	2080	
05/22/95	2060	
6/21/1995	1882	
07/12/95	2168	
8/18/1995	2200	
09/14/95	2160	
10/19/1995	1780	
3/12/1996	3810	
6/12/1996	3660	
8/14/1996		4000
11/25/1996		2800
3/24/1997		3160
6/10/1997		3160
8/15/1997		3000
12/18/1997		3620
3/24/1998		3540
6/24/1998		4000
9/25/1998		3800
12/17/1998		3620
3/25/1999		4050
6/21/1999		3660
9/23/1999		4690
12/8/1999		5410
3/23/2000		3490
6/16/2000		2232
9/13/2000		1415
12/19/2000		3966
3/5/2001		3980
6/2/2001		4310
9/19/2001		4500
12/12/2001		4300
3/19/2002		4590
6/20/2002		4800
9/18/2002		4600
12/13/2002		4700
3/24/2003		4600
6/13/2003		4400

9/30/2003		4250
12/23/2003		4550
3/29/2003		4400
6/29/2004		4600
9/27/2004		3952

Ernest Mine
Fig 1.3 Iron

Date	Before Ash	After Ash
11/21/94	490.2	
12/19/1994	502	
01/09/95	433.3	
02/09/95	558.2	
3/10/1995	458.6	
04/19/95	466	
05/22/95	521.8	
6/21/1995	527	
07/12/95	583.3	
8/18/1995	593	
09/14/95	539.8	
10/19/1995	579	
3/12/1996	710	
6/12/1996	948	
8/14/1996	705	
11/25/1996		749
3/24/1997		747
6/10/1997		741
8/15/1997		782
12/18/1997		773
3/24/1998		808.7
6/24/1998		820.5
9/25/1998		819.3
12/17/1998		917.5
3/25/1999		668
6/21/1999		916
9/23/1999		1056
12/8/1999		932
3/23/2000		950
6/16/2000		1192
9/13/2000		1156
12/19/2000		825
3/5/2001		730
6/2/2001		531
9/19/2001		290
12/12/2001		260
3/19/2002		532
3/19/2002		1030
6/20/2002		568
9/18/2002		351
12/13/2002		330
3/24/2003		330

6/13/2003		326
9/30/2003		751
12/23/2003		354
3/29/2003		790
6/29/2004		807
9/27/2004		772

Ernest Mine
Fig 1.4 Manganese

Date	
11/21/94	33.42
12/19/1994	33.22
01/09/95	34.14
02/09/95	37.5
3/10/1995	36.3
04/19/95	36.8
05/22/95	36.46
6/21/1995	36.5
07/12/95	33.35
8/18/1995	41
09/14/95	36.73
10/19/1995	39
3/12/1996	44.5
6/12/1996	51.8
8/14/1996	46.8
11/25/1996	39.1
3/24/1997	44.3
6/10/1997	40.3
8/15/1997	41.9
12/18/1997	40.9
3/24/1998	40
6/24/1998	40
9/25/1998	38.5
12/17/1998	38.2
3/25/1999	39.3
6/21/1999	40.6
9/23/1999	48
12/8/1999	25.1
3/23/2000	42.7
6/16/2000	45.3
9/13/2000	58.7
12/19/2000	41
3/5/2001	40.9
6/2/2001	33.7
9/19/2001	28
12/12/2001	24
3/19/2002	45.5
6/20/2002	27
9/18/2002	21.6
12/13/2002	19.5
3/24/2003	19.8
6/13/2003	19.8

9/30/2003	44.5
12/23/2003	20.8
3/29/2003	41.4
6/29/2004	41.3
9/27/2004	40.2

Ernest Mine
Fig 1.5 Sulfates

Date	Before Ash	After Ash
11/21/94	3440	
12/19/94	3000	
01/09/95	2300	
02/09/95	3600	
3/10/1995	3500	
04/19/95	4000	
05/22/95	3363	
6/21/1995	5717	
07/12/95	5834	
8/18/1995	5084	
09/14/95	4035	
10/19/1995	3439	
3/12/1996	4472.2	
6/12/1996	5335.3	
8/14/1996	5744.6	
11/25/1996		5312
3/24/1997		4898
6/10/1997		4219
8/15/1997		4224
12/18/1997		4963
3/24/1998		4661
6/24/1998		5322
9/25/1998		5905
12/17/1998		4972
3/25/1999		6400
6/21/1999		5400
9/23/1999		5300
12/8/1999		7750
3/23/2000		5000
6/16/2000		4100
9/13/2000		5025
12/19/2000		4775
3/5/2001		6850
6/2/2001		8624
9/19/2001		7240
12/12/2001		4400
3/19/2002		5466
6/20/2002		6900
9/18/2002		6348
12/13/2002		7498
3/24/2003		7285
6/13/2003		5716

9/30/2003		5815
12/23/2003		4895
3/29/2003		4574
6/29/2004		4896
9/27/2004		5022

Ernest Mine
Fig 1.6 Chloride

Date	Before Ash	After Ash
Date		
11/21/1994	20	
12/19/1994	9	
1/9/1995	9	
2/9/1995	9	
3/10/1995	9	
4/19/1995	9	
5/22/1995	7	
6/21/1995	6	
7/12/1995	2	
8/18/1995	1	
9/14/1995	1	
10/19/1995	1	
3/12/1996	12.72	
6/12/1996	14.8	
8/14/1996	8.4	
11/25/1996		7.3
3/24/1997		8
6/10/1997		1
8/15/1997		0.1
12/18/1997		1
3/24/1998		1
6/24/1998		0.2
9/25/1998		0.2
12/17/1998		47
3/25/1999		14
6/21/1999		8
9/23/1999		150
12/8/1999		20
3/23/2000		10
6/16/2000		50
9/13/2000		297
12/19/2000		10
3/15/2001		6
6/21/2001		20
9/19/2001		4
12/12/2001		20
3/19/2002		6
6/20/2002		9
9/18/2002		15
12/13/2002		22
3/24/2003		10.4

6/13/2003		28.4
9/30/2003		2
12/23/2003		2
3/29/2003		2
6/29/2004		7.9
9/27/2004		44.2

Ernest Mine

Fig 1.7 Calcium

Date	Before Ash	After Ash
11/21/94	426.5	
12/19/1994	329	
01/09/95	496	
02/09/95	362	
3/10/1995	441	
04/19/95	446.5	
05/22/95	424.5	
6/21/1995	417	
07/12/95	435.2	
8/18/1995	408.5	
09/14/95	343.2	
10/19/1995	415.7	
3/12/1996		
6/12/1996	420	
8/14/1996		
11/25/1996		
3/24/1997		
6/10/1997		465
8/15/1997		451
12/18/1997		
3/24/1998		
6/24/1998		478
9/25/1998		
12/17/1998		
3/25/1999		
6/21/1999		
9/23/1999		880
12/8/1999		
3/23/2000		
6/16/2000		364
9/13/2000		534
12/19/2000		
3/5/2001		
6/2/2001		383
9/19/2001		
12/12/2001		
3/19/2002		504
6/20/2002		299
9/18/2002		
12/13/2002		
3/24/2003		
6/13/2003		433

9/30/2003		422
12/23/2003		
3/29/2003		
6/29/2004		396
9/27/2004		

Ernest Mine
Fig 1.8 Trace Elements

Date					
Date	Arsenic	Arsenic Detection Limits	Cadmium	Cadmium Detection Limits	Lead
11/21/94	0.0543	0.015	0.0096	0.001	<0.0006
12/19/94	0.0515	0.015	0.0014	0.001	0.0044
01/09/95	<0.015	0.015	0.0022	0.001	0.008
02/09/95	0.017	0.015	<0.001	0.001	0.009
03/10/95	0.0931	0.015	<0.001	0.001	0.012
04/19/95	0.017	0.015	0.001	0.001	<0.006
05/22/95	0.057	0.015	0.0017	0.001	<0.01
6/21/1995	<0.015	0.015	<0.0006	0.0006	<0.01
07/12/95	<0.015	0.015	0.0012	0.001	<0.01
08/18/95	0.089	0.015	0.0014	0.001	<0.01
09/14/95	0.05	0.015	0.0035	0.001	<0.01
10/19/95	0.068	0.015	<0.001	0.001	<0.01
6/12/1996	0.77	0.04	<0.002	0.002	<0.05
6/10/1997	0.093	0.04	<0.001	0.001	0.009
08/15/97	0.186	0.04	<0.001	0.001	0.007
6/24/1998	0.103	0.04	<0.001	0.001	<0.006
9/23/1999	<0.040	0.04	<0.04	0.04	<0.4
6/16/2000	0.076	0.04	<0.04	0.04	<0.4
09/13/00	0.2	0.04	0.02	0.01	0.16
6/21/2001	0.082	0.04	<0.002	0.002	0.131
6/20/2002	0.132	0.02	<0.004	0.004	<0.004
6/13/2003	0.014	0.004	0.043	0.004	0.018
9/30/2003	0.004	0.004	<0.0002	0.0002	<0.001
12/23/2003					
3/29/2003					
6/29/2004	<0.05	0.05	0.066	0.05	<0.05
9/27/2004					

Lead Detection Limits	Selenium	Selenium Detection Limits
0.0006	<0.023	0.023
0.004	<0.023	0.023
0.006	<0.023	0.023
0.006	<0.023	0.023
0.006	<0.023	0.023
0.006	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.05	<0.0002	0.0002
0.006	<0.031	0.031
0.006	<0.031	0.032
0.006	<0.027	0.027
0.4	<0.04	0.04
0.4	<0.002	0.002
0.004	<0.2	0.3
0.004	<0.004	0.004
0.004	<0.008	0.008
0.004	<0.005	0.005
0.001	<0.007	0.007
0.05	<0.05	0.05

Ernest Mine

Fig 1.9 Aluminum

Date	Before Ash	After Ash
11/21/94	106.1	
12/19/1994	59.7	
01/09/95	53.46	
02/09/95	126	
03/10/95	119.1	
04/19/95	96.8	
05/22/95	169.7	
6/21/1995	176.2	
07/12/95	176.4	
08/18/95	161.2	
09/14/95	154.1	
10/19/95	172.5	
6/12/1996	295	
6/10/1997		292
08/15/97		289.3
6/24/1998		270.6
6/21/1999		340
6/16/2000		600
6/21/2001		440
6/20/2002		398
6/13/2003		244
9/30/2003		436
12/23/2003		244
3/29/2003		467
6/29/2004		481
9/27/2004		452

Ernest Mine

Fig 1.10 Nickel

Date	Before Ash	After Ash
11/21/1994	0.71	
12/19/1994	0.7	
01/09/95	0.79	
02/09/95	0.8	
03/10/95	0.78	
04/19/95	0.79	
05/22/95	0.93	
6/21/1995	0.9	
07/12/95	0.88	
08/18/95	0.87	
09/14/95	0.86	
10/19/95	0.86	
6/12/1996	0.93	
6/10/1997		1.1
08/15/97		1.14
6/24/1998		1.2
6/21/1999		1.2
09/23/99		1.8
6/16/2000		1.71
09/13/00		2.2
6/21/2001		1.78
6/20/2002		1.44
6/13/2003		1.9
9/30/2003		1.8
12/23/2003		
3/29/2003		
6/29/2004		1.8
9/27/2004		

Ernest Mine
Fig 1.11 Zinc

Date	Monitoring Point	Monitoring Point
11/21/94	1.537	
12/19/1994	1.5	
01/09/95	1.53	
02/09/95	1.62	
03/10/95	1.641	
04/19/95	1.515	
05/22/95	1.789	
6/21/1995	1.8	
07/12/95	1.95	
08/18/95	1.84	
09/14/95	1.8	
10/19/95	1.75	
6/12/1996	0.09	
6/10/1997		2.25
08/15/97		2.6
6/24/1998		2.56
6/21/1999		3.6
09/23/99		3.6
6/16/2000		2.88
09/13/00		3.1
6/21/2001		3.25
6/20/2002		2.7
6/13/2003		4.16
9/30/2003		3.72
12/23/2003		
3/29/2003		3.86
6/29/2004		
9/27/2004		

Ernest Mine
Fig 1.11a pH

Date	Before Ash Field	After Ash Field	Before Ash Lab	After Ash Lab
11/21/1994	2		2.3	
12/19/1994	2		2.4	
1/9/1995	2.2		2.3	
2/9/1995	2.3		2.5	
3/10/1995	2.5		2.5	
4/19/1995	2.6		2.6	
5/22/1995	2.3		2.5	
6/21/1995	1.8		2.6	
7/12/1995	2.3		2.4	
8/18/1995	2.3		2.4	
9/14/1995	2		2.4	
10/19/1995	2		2.4	
3/12/1996	4.3		2.5	
6/12/1996	4.5		2.6	
8/14/1996	4.4		2.3	
11/25/1996		4.5		2.6
3/24/1997		4.5		2.6
6/10/1997		4.5		2.5
8/15/1997		4.5		2.4
12/18/1997		4.5		2.5
3/24/1998		4.5		2.6
6/24/1998		4.6		2.6
9/25/1998		4.6		2.4
12/17/1998		4.5		2.5
3/25/1999		4.3		2.4
6/21/1999		4.2		2.4
9/23/1999		4.4		2.4
12/8/1999		4.5		2.3
3/23/2000		4.3		2.5
6/16/2000		4.3		2.4
9/13/2000		4.5		2.3
12/19/2000		4.4		2.4
3/5/2001		4.5		2.3
6/2/2001		4.7		2.3
9/19/2001		4.7		2.3
12/12/2001		4.5		2.4
3/19/2002		4.5		2.3
3/19/2002				2.4
6/20/2002		4.5		2.5
9/18/2002		4.5		2.3
12/13/2002		4		2.2
3/24/2003		4		2.5

6/13/2003		2.6		2.4
9/30/2003		4		3.7
12/23/2003		3.9		3.9
3/29/2004		4		3.7
6/29/2004		3.8		3.6
9/27/2004		4		3.7

Ernest Mine
Fig 1.12 Acidity

Date	Before Ash	After Ash
11/21/1994	4020	
12/19/1994	3718	
1/9/1995	3654	
2/9/1995	2220	
4/19/1995	3460	
5/22/1995	2900	
3/10/1995	2480	
7/12/1995	3452	
6/21/1995	3495	
9/14/1995	4220	
8/12/1995	3920	
10/19/1995	4080	
3/12/1996	4960	
6/12/1996	5100	
8/14/1996	4275	
11/25/1996		3900
3/24/1997		3680
6/10/1997		3800
8/15/1997		4420
12/18/1997		5660
3/24/1998		3940
6/24/1998		4680
9/25/1998		5140
12/17/1998		3440
3/25/1999		3900
6/21/1999		4370
9/23/1999		3860
12/8/1999		4690
3/23/2000		2550
6/16/2000		1238
9/13/2000		955
12/19/2000		2982
3/5/2001		2770
6/21/2001		5310
9/19/2001		7100
12/12/2001		6400
3/19/2002		4000
6/20/2002		4166
9/18/2002		5400
12/13/2002		7000
3/24/2003		6100
6/13/2003		5400

9/30/2003		5250
12/23/2003		5200
3/29/2004		3800
6/29/2004		4200
6/29/2004		4297
9/27/2004		4000

Ernest Mine
Fig 1.13 Sulfates

Date	Before Ash	After Ash
11/21/1994	5130	
12/19/1994	4390	
1/9/1995	3800	
2/9/1995	5600	
3/10/1995	4200	
4/19/1995	5100	
5/22/1995	3561	
6/21/1995	4654	
7/12/1995	7415	
8/12/1995	6292	
9/14/1995	5194	
10/19/1995	5482	
3/12/1996	5028	
6/12/1996	4556.5	
8/14/1996	5666.6	
11/25/1996		5163
3/24/1997		4227
6/10/1997		4139
8/15/1997		4931
12/18/1997		4652
3/24/1998		4413
6/24/1998		5860
9/25/1998		6515
12/17/1998		3922
3/25/1999		5400
6/21/1999		4520
9/23/1999		6620
12/8/1999		7450
3/23/2000		2810
6/16/2000		3425
9/13/2000		5200
12/19/2000		3033
3/5/2001		3700
6/21/2001		6520
9/19/2001		8900
12/12/2001		8500
3/19/2002		5300
6/20/2002		6900
9/18/2002		8009
12/13/2002		7022
3/24/2003		7330
6/13/2003		5257

9/30/2003		5914
12/23/2003		5026
3/29/2003		3514
6/29/2004		4417
9/27/2004		4551

Ernest Mine
Fig 1.14 Manganese

Date	Before Ash	After Ash
11/21/1994	6.18	
12/19/1994	7.16	
1/9/1995	5.97	
2/9/1995	7.51	
3/10/1995	6.92	
4/19/1995	7.4	
5/22/1995	6.21	
6/21/1995	6.43	
7/12/1995	4.56	
8/18/1995	7.6	
9/14/1995	6.79	
10/19/1995	7.49	
3/12/1996	8.3	
6/12/1996	8.7	
8/14/1996	9	
11/25/1996		8.1
3/24/1997		8.2
6/10/1997		9.1
8/15/1997		8
12/18/1997		8.2
3/24/1998		8.4
6/24/1998		8.6
9/25/1998		7.4
12/17/1998		5.5
3/25/1999		9
6/21/1999		8.9
9/23/1999		8.2
12/8/1999		8.3
3/23/2000		7
6/16/2000		12.6
9/13/2000		13.8
12/19/2000		4.6
3/5/2001		4.6
6/21/2001		9.26
9/19/2001		9.1
12/12/2001		8.2
3/19/2002		6.42
6/20/2002		7.07
9/18/2002		6.41
12/13/2002		5.9
3/24/2003		5.89
6/13/2003		5.84

9/30/2003		11.2
12/23/2003		6.6
3/29/2004		9.5
6/29/2004		12.1
6/29/2004		10.9
9/27/2004		16

Ernest Mine

Fig 1.15 Calcium

Date	Before Ash	After Ash
11/21/1994	354	
12/19/1994	209.5	
1/9/1995	390	
2/9/1995	279	
3/10/1995	313.6	
4/19/1995	306.1	
5/22/1995	278.3	
6/21/1995	261.5	
7/12/1995	279.8	
8/18/1995	300.8	
9/14/1995	306.9	
10/19/1995	338.5	
6/12/1996	280	
6/10/1997		252
8/15/1997		346
6/24/1998		348
9/23/1999		510
6/16/2000		279
9/13/2000		536
6/21/2001		296
3/19/2002		272
6/20/2002		270
9/18/2002		
12/13/2002		
3/24/2003		
6/13/2003		274
9/30/2003		371
12/23/2003		
3/29/2004		
6/29/2004		390
6/29/2004		394
9/27/2004		

Ernest Mine
Fig 1.16 Chloride

Date	Before Ash	After Ash
11/21/1994	10	
12/19/1994	6	
1/9/1995	4	
2/9/1995	7	
3/10/1995	8	
4/19/1995	5	
5/22/1995	5	
6/21/1995	4	
7/12/1995	2	
8/18/1995	1	
9/14/1995	1	
10/19/1995	1	
3/12/1996	10.6	
6/12/1996	7.4	
8/14/1996	7.4	
11/25/1996		6
3/24/1997		6.5
6/10/1997		1
8/15/1997		0.1
12/18/1997		1
3/24/1998		1
6/24/1998		0.2
9/25/1998		0.2
12/17/1998		49.5
3/25/1999		15
6/21/1999		5
9/23/1999		10
12/8/1999		10
3/23/2000		10
6/16/2000		30
9/13/2000		11
12/19/2000		8
3/5/2001		8
6/21/2001		10
9/19/2001		5
12/12/2001		4
3/19/2002		5
6/20/2002		15
9/18/2002		16
12/13/2002		9.4
3/24/2003		15.5
6/13/2003		26.3

9/30/2003		13.9
12/23/2003		2
3/29/2004		2
6/29/2004		12.7
6/29/2004		16.7
9/27/2004		46.5

Ernest Mine
Fig 1.17 Trace Elements

Date	Arsenic	Arsenic Detection Limit	Cadmium	Cadmium Detection Limit	Lead
11/21/1994	0.083	0.015	0.007	0.0006	<0.0006
12/19/1994	0.191	0.015	0.0097	0.0006	<0.0006
1/9/1995	0.226	0.015	0.0062	0.0006	0.0006
2/9/1995	0.117	0.015	0.0066	0.0006	<0.0006
3/10/1995	0.153	0.015	0.0054	0.0006	<0.0006
4/19/1995	0.102	0.015	0.0047	0.0006	<0.0006
5/22/1995	0.205	0.015	0.0037	0.0006	<0.001
6/21/1995	<0.015	0.015	0.0003	0.0006	<0.01
7/12/1995	<0.015	0.015	<0.0006	0.0006	<0.01
8/18/1995	0.223	0.015	0.0062	0.0006	<0.01
9/14/1995	0.272	0.015	0.0111	0.0006	<0.01
10/19/1995	0.256	0.015	0.0077	0.0006	<0.01
6/12/1996	0.48	0.04	<0.002	0.002	<0.05
9/1/1996					
6/10/1997	0.179	0.04	0.005	0.002	<0.006
8/15/1997	0.347	0.04	0.0079	0.002	<0.006
6/24/1998	0.497	0.04	0.0085	0.002	<0.006
9/23/1999	<0.04	0.04	<0.04	0.04	<0.4
6/16/2000	0.535	0.04	<0.04	0.04	<0.4
9/13/2000	0.513	0.04	0.03	0.002	0.13
6/21/2001	0.075	0.04	<0.002	0.002	0.146
3/19/2002	<0.004	0.04	<0.01	0.01	0.0016
6/20/2002	0.2	0.04	0.006	0.002	0.004
9/18/2002					
12/13/2002					
3/24/2003					
6/13/2003	0.019	0.004	0.024	0.0002	0.005
9/30/2003	<0.004	0.004	0.0045	0.0002	0.0002
12/23/2003					
3/29/2003					
6/29/2004	<0.05	0.05	0.074	0.0002	<0.05
9/27/2004					

Lead Detection Limit	Selenium	Selenium Detection Limit
0.0006	<0.023	0.023
0.0006	<0.023	0.023
0.0006	<0.023	0.023
0.0006	<0.023	0.023
0.0006	<0.023	0.023
0.0006	<0.023	0.023
0.001	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.05	<0.002	0.002
0.006	<0.031	0.031
0.006	<0.031	0.031
0.006	<0.027	0.027
0.4	<0.04	0.04
0.4	<0.002	0.002
0.01	<0.2	0.2
0.01	<0.004	0.004
0.001	<0.007	0.007
0.001	<0.008	0.008
0.001	<0.005	0.005
0.001	<0.07	0.07
0.05	<0.05	0.05

Ernest Mine
Fig 1.18 Chromium

Date	
11/21/1994	0.14
12/19/1994	0.14
1/9/1995	0.14
2/9/1995	0.11
3/10/1995	0.1
4/19/1995	0.09
5/22/1995	0.08
6/21/1995	0.08
7/12/1995	0.07
8/18/1995	0.14
9/14/1995	0.14
10/19/1995	0.16
6/12/1996	0.09
6/12/1996	0.09
6/10/1997	0.08
6/10/1997	0.08
8/15/1997	0.13
8/15/1997	0.13
6/24/1998	0.11
9/23/1999	0.24
9/23/1999	0.24
6/16/2000	0.22
6/16/2000	0.22
9/13/2000	0.24
9/13/2000	0.24
6/21/2001	0.118
6/21/2001	0.118
3/19/2002	0.14
3/19/2002	0.14
6/20/2002	0.032
6/20/2002	0.032
9/18/2002	
9/18/2002	
12/13/2002	
12/13/2002	
3/24/2003	
3/24/2003	
6/13/2003	0.167
6/13/2003	0.17
9/30/2003	0.083
9/30/2003	0.083
12/23/2003	

12/23/2003	
3/29/2004	
3/29/2004	
6/29/2004	0.1
6/29/2004	0.08
6/29/2004	0.1
6/29/2004	0.08
9/27/2004	

Ernest Mine
Fig 1.19 Cadmium

Date	Before Ash	After Ash	Cadmium Detection Limit
11/21/1994	0.007		0.0006
12/19/1994	0.0097		0.0006
1/9/1995	0.0062		0.0006
2/9/1995	0.0066		0.0006
3/10/1995	0.0054		0.0006
4/19/1995	0.0047		0.0006
5/22/1995	0.0037		0.0006
6/21/1995	0.0003		0.0006
7/12/1995	<0.0006		0.0006
8/18/1995	0.0062		0.0006
9/14/1995	0.0111		0.0006
10/19/1995	0.0077		0.0006
6/12/1996	<0.002		0.002
6/10/1997		0.005	0.002
8/15/1997		0.0079	0.002
6/24/1998		0.0085	0.002
9/23/1999		<0.04	0.04
6/16/2000		<0.04	0.04
9/13/2000		0.03	0.002
6/21/2001		<0.002	0.002
9/19/2001			
12/12/2001			
3/19/2002		<0.01	0.01
6/20/2002		0.006	0.002
9/18/2002			
12/13/2002			
3/24/2003			
6/13/2003		0.024	0.0002
9/30/2003		0.0045	0.0002
12/23/2003			
3/29/2004			
6/29/2004		0.074	0.0002
9/27/2004			

Ernest Mine
Fig 1.20 Copper

Date	Before Ash	After Ash
11/21/1994	0.49	
12/19/1994	0.52	
1/9/1995	0.52	
2/9/1995	0.42	
3/10/1995	0.29	
4/19/1995	0.23	
5/22/1995	0.25	
6/21/1995	0.29	
7/12/1995	0.32	
8/18/1995	0.46	
9/14/1995	0.49	
10/19/1995	0.49	
6/12/1996	0.31	
6/10/1997	0.29	0.29
8/15/1997		0.51
6/24/1998		0.35
9/23/1999		0.55
6/16/2000		0.46
9/13/2000		0.75
5/21/2001		0.595
9/19/2001		
12/12/2001		
3/19/2002		0.62
6/20/2002		0.11
9/18/2002		
12/13/2002		
3/24/2003		
6/13/2003		0.45
9/30/2003		0.29
12/23/2003		
3/29/2004		0.239
6/29/2004		0.256
9/27/2004		

Ernest Mine

Fig 1.21 Aluminum

Date	Before Ash	After Ash
11/21/1994	382	
12/19/1994	312	
1/9/1995	247	
2/9/1995	267	
3/10/1995	290	
4/19/1995	253	
5/22/1995	354	
6/21/1995	433.5	
7/12/1995	481	
8/18/1995	482	
9/14/1995	575	
10/19/1995	564	
6/12/1996	384	
6/10/1997		407
8/15/1997		560
6/24/1998		509
9/23/1999		575
6/16/2000		610
9/13/2000		783
5/21/2001		644
9/19/2001		
12/12/2001		
3/19/2002		672
6/20/2002		349
9/18/2002		499
12/13/2002		484
3/24/2003		290
6/13/2003		390
9/30/2003		497
12/23/2003		273
3/29/2004		317
6/29/2004		412
9/27/2004		326

Ernest Mine
Fig 1.22 Nickel

Date	Before Ash	After Ash
11/21/1994	1.23	
12/19/1994	1.24	
1/9/1995	1.28	
2/9/1995	1.27	
3/10/1995	1.01	
4/19/1995	0.99	
5/22/1995	1.03	
6/21/1995	1.07	
7/12/1995	1.08	
8/18/1995	1.4	
9/14/1995	1.49	
10/19/1995	1.47	
6/12/1996		0.77
6/10/1997		1.02
8/15/1997		1.59
6/24/1998		1.43
9/23/1999		2
6/16/2000		1.69
9/13/2000		3.4
5/21/2001		1.78
3/19/2002		1.7
6/20/2002		1.1
9/18/2002		
12/13/2002		
3/24/2003		
6/13/2003		1.1
9/30/2003		1.5
12/23/2003		
3/29/2004		
6/29/2004		1.4
9/27/2004		

Ernest Mine
Fig 1.23 Zinc

Date	Before Ash	After Ash
11/21/1994	2.3	
12/19/1994	2.1	
1/9/1995	2.03	
2/9/1995	2.3	
3/10/1995	1.96	
4/19/1995	1.75	
5/22/1995	1.9	
6/21/1995	2.15	
7/12/1995	1.94	
8/18/1995	2.5	
9/14/1995	2.52	
10/19/1995	2.69	
6/12/1996	0.36	
6/10/1997		1.9
8/15/1997		2.8
6/24/1998		3.1
9/23/1999		4.4
6/16/2000		4.05
9/13/2000		5.4
5/21/2001		3.8
9/19/2001		
12/12/2001		
3/19/2002		3.9
6/20/2002		2.4
9/18/2002		
12/13/2002		
3/24/2003		
6/13/2003		2.3
9/30/2003		3.3
12/23/2003		
3/29/2004		
6/29/2004		2.9
9/27/2004		

Ernest Mine

Fig 1.23a pH

Date	Before Ash Field	After Ash Field	Before Ash Lab	After Ash Lab
11/21/1994	3.7		5.8	
12/19/1994	4.5		3.9	
1/9/1995	3.7		3.8	
2/9/1995	4		3.9	
3/10/1995	3.8		3.9	
4/19/1995	3.7		3.8	
5/22/1995	3.6		3.7	
6/21/1995	3.2		3.2	
7/12/1995	3.4		3.5	
8/18/1995	3.4		3.5	
9/14/1995	3.3		3.5	
10/19/1995	3.5		3.5	
3/12/1996	4.6		3.7	
6/12/1996	4.5		3.7	
8/14/1996	4.6		3.46	
11/25/1996		4.5		3.2
3/24/1997		4.2		3.8
6/10/1997		4.6		3.6
8/15/1997		4.5		3.7
12/18/1997		4.5		3.8
3/24/1998		4		3.6
6/24/1998		4.2		3.6
9/25/1998		4		3.7
12/17/1998		4.5		3.8
3/25/1999		4		3.4
6/21/1999		4.5		3.6
9/23/1999		4.3		3.5
12/8/1999		4		3.4
3/23/2000		4.3		3.5
6/16/2000		4.5		3.4
9/13/2000		4.1		3.4
12/19/2000		4		2.7
3/5/2001		4		3.4
6/2/2001		4.7		3.4
9/19/2001		4.5		3.3
12/12/2001		4.3		3.5
3/19/2002		4.5		3.4
3/19/2002				3.7
6/20/2002		4.5		3.5
9/18/2002		4.5		3.7
12/13/2002		4		3.7
3/24/2003		4		3.8

6/13/2003		3.9		3.8
6/13/2003		3.9		3.8
9/30/2003		4.7		3.8
12/23/2003		4		3.9
3/29/2004		4		3.8
6/29/2004		3.8		3.8
9/27/2004		4		3.8

Ernest Mine
Fig 1.24 Sulfates

Date	Before Ash	After Ash
11/21/1994	922	
12/19/1994	1130	
1/9/1995	710	
2/9/1995	910	
3/10/1995	840	
4/19/1995	1040	
5/22/1995	994	
6/21/1995	768	
9/14/1995	577	
7/12/1995	887	
8/12/1995	730	
10/19/1995	385	
3/12/1996	1333.19	
6/12/1996	2435	
8/14/1996	2319	
11/25/1996		960
3/24/1997		1637
6/10/1997		1522
8/15/1997		1892
12/18/1997		1523
3/24/1998		1488
6/24/1998		1815
9/25/1998		1830
12/17/1998		1592
3/25/1999		1480
6/21/1999		1920
9/23/1999		1333
12/8/1999		1280
3/23/2000		1600
6/16/2000		1160
9/13/2000		1880
12/19/2000		1460
3/5/2001		1260
6/2/2001		1574
9/19/2001		1640
12/12/2001		1500
3/19/2002		1076
6/20/2002		1200
9/18/2002		1495
12/13/2002		1423
3/24/2003		1348

6/13/2003		1331.9
9/30/2003		1198
12/23/2003		926
3/29/2003		1094
6/29/2004		1390.5
9/27/2004		1238

Ernest Mine

Fig 1.25 Total Dissolved Solids

Date	Before Ash	After Ash
11/21/1994	2064	
12/19/1994	1902	
1/9/1995	1758	
2/9/1995	1632	
3/10/1995	1640	
4/19/1995	1640	
5/22/1995	1892	
6/21/1995	1	
7/12/1995	1098	
8/12/1995	1134	
9/14/1995	938	
10/19/1995	736	
3/12/1996	2261	
6/12/1996	2895	
8/14/1996	2976	
11/25/1996		1476
3/24/1997		2668
6/10/1997		2676
8/15/1997		3186
12/18/1997		2425
3/24/1998		2284
6/24/1998		2584
9/25/1998		2748
12/17/1998		1228
3/25/1999		2042
6/21/1999		3190
9/23/1999		3068
12/8/1999		2434
3/23/2000		2423
6/16/2000		2368
9/13/2000		2721
12/19/2000		2309
3/5/2001		2083
6/21/2001		2335
9/19/2001		2800
12/12/2001		2400
3/19/2002		2000
6/20/2002		1850
9/18/2002		2211
12/13/2002		2002
3/24/2003		1961
6/13/2003		1920

9/30/2003		1811
12/23/2003		1554
3/29/2004		2143
6/29/2004		1780
9/27/2004		2170

Ernest Mine

Fig 1.26 Acidity

Date	Before Ash	After Ash
11/21/1994	622	
12/19/1994	742	
1/9/1995	546	
2/9/1995	482	
3/10/1995	400	
4/19/1995	422	
5/22/1995	528	
6/21/1995	374	
7/12/1995	370	
8/12/1995	362	
9/14/1995	254	
10/19/1995	192	
3/12/1996	955	
6/12/1996	3350	
8/14/1996	2200	
11/25/1996		460
3/24/1997		750
6/10/1997		768
8/15/1997		1204
12/18/1997		780
3/24/1998		752
6/24/1998		1000
9/25/1998		962
12/17/1998		812
3/25/1999		660
6/21/1999		620
9/23/1999		910
12/8/1999		785
3/23/2000		640
6/16/2000		282
9/13/2000		270
12/19/2000		966
3/5/2001		760
6/21/2001		910
9/19/2001		1300
12/12/2001		1000
3/19/2002		800
6/20/2002		720
9/18/2002		882
12/13/2002		800
3/24/2003		690
6/13/2003		648

9/30/2003		586
12/23/2003		600
3/29/2004		612
6/29/2004		718
6/29/2004		717.6
9/27/2004		736

Ernest Mine
Fig 1.27 Calcium

Date	Before Ash	After Ash
11/21/1994	233	
12/19/1994	161.6	
1/9/1995	240	
2/9/1995	145	
3/10/1995	164	
4/19/1995	169.8	
5/22/1995	180.9	
6/21/1995	114.4	
7/12/1995	104.9	
8/18/1995	102.1	
9/14/1995	84.3	
10/19/1995	77.8	
1/1/1996		
6/12/1996	270	
6/10/1997		224.9
8/15/1997		270
6/24/1998		243.4
9/23/1999		330
6/16/2000		170
9/13/2000		342
6/21/2001		194
3/19/2002		181
6/20/2002		169
9/18/2002		
12/13/2002		
3/24/2003		
6/13/2003		166
9/30/2003		158
12/23/2003		
3/29/2003		
6/29/2004		192
9/27/2004		

Ernest Mine
Fig 1.28 Chloride

Date	Before Ash	After Ash
11/21/1994	6	
12/19/1994	6	
1/9/1995	6	
2/9/1995	8	
3/10/1995	7	
4/19/1995	7	
5/22/1995	6	
6/21/1995	5	
7/12/1995	5	
8/18/1995	2	
9/14/1995	1	
10/19/1995	0.1	
3/12/1996	11.66	
6/12/1996	7.4	
8/14/1996	6.4	
11/25/1996		5.9
3/24/1997		6.4
6/10/1997		72
8/15/1997		7
12/18/1997		114
3/24/1998		81
6/24/1998		7.1
9/25/1998		0.2
12/17/1998		10.8
3/25/1999		14
6/21/1999		10
9/23/1999		10
12/8/1999		15
3/23/2000		9
6/16/2000		75
9/13/2000		9
12/19/2000		9
3/15/2001		76
6/21/2001		8
9/19/2001		70
12/12/2001		2
3/19/2002		8
6/20/2002		8
9/18/2002		8.8
12/13/2002		12.5
3/24/2003		10.8
6/13/2003		8

9/30/2003		44.6
12/23/2003		2
3/29/2003		2
6/29/2004		9.3
9/27/2004		8.6

Ernest Mine
Fig 1.29 Iron

Date	Before Ash	After Ash
11/21/1994	74.9	
12/19/1994	66.84	
1/9/1995	81.33	
2/9/1995	64.08	
3/10/1995	52.7	
4/19/1995	58.97	
5/22/1995	64.28	
6/21/1995	24.5	
7/12/1995	8.09	
8/12/1995	7.6	
9/14/1995	6.38	
10/19/1995	8.9	
3/12/1996	138	
6/12/1996	214	
8/14/1996	204	
11/25/1996		13.5
3/24/1997		171.2
6/10/1997		148.9
8/15/1997		200.8
12/18/1997		163.8
3/24/1998		161
6/24/1998		165
9/25/1998		173.2
12/17/1998		167.8
3/25/1999		156
6/21/1999		172
9/23/1999		186
12/8/1999		137
3/23/2000		143
6/16/2000		164
9/13/2000		167
12/19/2000		139
3/5/2001		82.6
6/2/2001		128
9/19/2001		110
12/12/2001		92
3/19/2002		120
6/20/2002		119
9/18/2002		111
12/13/2002		95
3/24/2003		90.4
6/13/2003		122

9/30/2003		125
12/23/2003		91.3
3/29/2004		114
6/29/2004		144
9/27/2004		156

Ernest Mine
Fig 1.20 Manganese

Date	Before Ash	After Ash
11/21/1994	8.9	
12/19/1994	9.58	
1/9/1995	8.54	
2/9/1995	8.24	
3/10/1995	7.9	
4/19/1995	7.93	
5/22/1995	8.86	
6/21/1995	5.5	
7/12/1995	4.6	
8/12/1995	5.2	
9/14/1995	4.25	
10/19/1995	3.5	
3/12/1996	10.7	
6/12/1996	15.6	
8/14/1996	15.9	
11/25/1996		7.39
3/24/1997		12.93
6/10/1997		11.01
8/15/1997		13.93
12/18/1997		11.85
3/24/1998		10.89
6/24/1998		12.7
9/25/1998		12.3
12/17/1998		10.25
3/25/1999		10.2
6/21/1999		11.5
9/23/1999		13
12/8/1999		9.8
3/23/2000		10.7
6/16/2000		9.8
9/13/2000		12.9
12/19/2000		10.8
3/5/2001		7.9
6/2/2001		9.69
9/19/2001		9.4
12/12/2001		7.6
3/19/2002		9.11
6/20/2002		8.72
9/18/2002		8.27
12/13/2002		7.72
3/24/2003		7.15
6/13/2003		7.32

9/30/2003		6.64
12/23/2003		7.18
3/29/2003		8.15
6/29/2004		12.1
9/27/2004		10.5

Ernest Mine
Fig 1.31 Aluminum

Date	Before Ash	After Ash
11/21/1994	63.38	
12/19/1994	42.7	
1/9/1995	30.55	
2/9/1995	26.8	
3/10/1995	48.1	
4/19/1995	38.1	
5/22/1995	64.5	
6/21/1995	51.9	
7/12/1995	55.7	
8/18/1995	56.4	
9/14/1995	34.5	
10/19/1995	22	
6/12/1996	116	
6/10/1997		78.2
8/15/1997		114
6/24/1998		105.7
6/23/1999		108
6/16/2000		120
9/13/2000		125
6/21/2001		101
3/19/2002		99.2
6/20/2002		84
9/18/2002		92.6
12/13/2002		76.8
3/24/2003		67.8
6/13/2003		69.1
9/30/2003		55.2
12/23/2003		51.8
3/29/2003		55.2
6/29/2004		64.4
9/27/2004		67.6

Ernest Mine

Fig 1.32 Trace Elements

Date	Arsenic	Arsenic Detection Limit	Cadmium	Cadmium Detection Limit	Lead
11/21/1994	0.0398	0.015	0.0178	0.0006	0.007
12/19/1994	0.0246	0.015	0.002	0.0006	0.0466
1/9/1995	<0.015	0.015	0.0021	0.0006	0.019
2/9/1995	0.025	0.015	0.0013	0.0006	<0.006
3/10/1995	0.0303	0.015	0.0016	0.0006	<0.006
4/19/1995	0.041	0.015	0.0011	0.0006	<0.006
5/22/1995	0.049	0.015	0.0051	0.0006	<0.01
6/21/1995	<0.015	0.015	0.0001	0.0006	<0.01
7/12/1995	<0.015	0.015	0.0012	0.0006	<0.01
8/18/1995	<0.015	0.015	0.0123	0.0006	<0.01
9/14/1995	<0.015	0.015	0.0056	0.0006	<0.01
10/19/1995	<0.015	0.015	0.0019	0.0006	<0.01
6/12/1996	0.1		<0.002	0.002	<0.05
6/10/1997	0.056	0.01	<0.001	0.001	<0.006
8/15/1997	0.086	0.01	0.0013	0.001	<0.006
6/24/1998	0.041	0.01	0.0025	0.001	<0.006
9/23/1999	<0.04	0.04	<0.04	0.04	<0.4
6/16/2000	0.032	0.002	<0.04	0.04	<0.4
9/13/2000	0.038	0.002	<0.01	0.01	<0.1
6/21/2001	0.02		<0.002	0.002	0.052
3/19/2002	<0.004	0.0041	<0.01	0.01	0.007
6/20/2002	0.032		<0.004	0.004	<0.004
9/18/2002					
12/13/2002					
3/24/2003					
6/13/2003	0.007		0.01	0.01	<0.005
9/30/2003	<0.004	0.004	0.0004	0.0004	0.0036
12/23/2003					
3/29/2003					
6/29/2004	<0.01	0.01	0.012		<0.01

Lead Detection Limit	**Selenium**	**Selenium Detection Limit**
0.006	<0.023	0.023
0.006	<0.023	0.023
0.006	<0.023	0.023
0.006	<0.023	0.023
0.006	<0.023	0.023
0.006	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	0.223	0.223
0.01	<0.023	0.023
0.01	<0.023	0.023
0.01	<0.023	0.023
0.05	<0.02	0.02
0.006	<0.03	0.03
0.006	<0.03	0.03
0.006	<0.027	0.027
0.4	<0.04	0.04
0.4	<0.002	0.002
0.1	0.2	0.2
0.05	<0.004	0.004
0.007	<0.007	0.007
0.004	<0.007	0.007
0.005	<0.005	0.005
0.003	<0.007	0.007
0.01	<0.01	0.01

Ernest Mine
Fig 1.33 Nickel

Date	Before Ash	After Ash
11/21/1994	0.4	
12/19/1994	0.36	
1/9/1995	0.4	
2/9/1995	0.28	
3/10/1995	0.31	
4/19/1995	0.28	
5/22/1995	0.34	
6/21/1995	0.23	
7/12/1995	0.23	
8/18/1995	0.29	
9/14/1995	0.19	
10/19/1995	0.17	
6/12/1996	0.33	
8/10/1997		0.4
8/15/1997		0.52
6/24/1998		0.54
9/23/1999		0.56
6/16/2000		0.47
9/13/2000		0.69
6/21/2001		0.47
3/19/2002		0.44
6/20/2002		0.4
9/18/2002		
12/13/2002		
3/24/2003		
6/13/2003		0.361
9/30/2003		0.331
12/23/2003		
3/29/2003		
6/29/2004		0.325
9/27/2004		

Ernest Mine

Fig 1.34 Total Dissolved Solids

Date	Before Ash	After Ash
11/21/94	5002	
12/19/1994	4352	
01/09/95	5180	
02/09/95	5530	
3/10/1995	5586	
04/19/95	5738	
05/22/95	5926	
6/21/1995	5388	
07/12/95	6026	
8/18/1995	5804	
09/14/95	5480	
10/19/1995	5596	
3/12/1996	7461	
6/12/1996	7731	
8/14/1996	7273	
11/25/1996		7692
3/24/1997		7934
6/10/1997		7919
8/15/1997		7712
12/18/1997		7822
3/24/1998		7992
6/24/1998		7192
9/25/1998		7856
12/17/1998		8426
3/25/1999		8055
6/21/1999		9103
9/23/1999		8979
12/8/1999		8430
3/23/2000		8156
6/16/2000		8728
9/13/2000		7934
12/19/2000		7472
3/5/2001		8974
6/2/2001		9515
9/19/2001		9700
12/12/2001		9700
3/19/2002		11358
6/20/2002		9020
9/18/2002		9547
12/13/2002		9747
3/24/2003		10033
6/13/2003		8660

6/13/2003		592
9/30/2003		4617
12/23/2003		3454
3/29/2003		9489
6/29/2004		7620
9/27/2004		9330

Ernest Mine
Fig 1.35 Total Dissolved Solids

Date	Before Ash	After Ash
11/21/1994	2064	
12/19/1994	1902	
1/9/1995	1758	
2/9/1995	1632	
3/10/1995	1640	
4/19/1995	1640	
5/22/1995	1892	
6/21/1995	1154	
7/12/1995	1098	
8/12/1995	1134	
9/14/1995	938	
10/19/1995	736	
3/12/1996	2261	
6/12/1996	2895	
8/14/1996	2976	
11/25/1996		1476
3/24/1997		2668
6/10/1997		2676
8/15/1997		3186
12/18/1997		2425
3/24/1998		2284
6/24/1998		2584
9/25/1998		2748
12/17/1998		1228
3/25/1999		2042
6/21/1999		3190
9/23/1999		3068
12/8/1999		2434
3/23/2000		2423
6/16/2000		2368
9/13/2000		2721
12/19/2000		2309
3/5/2001		2083
6/21/2001		2335
9/19/2001		2880
12/12/2001		2440
3/19/2002		2000
6/20/2002		1850
9/18/2002		2211
12/13/2002		2002
3/24/2003		1961
6/13/2003		1920

9/30/2003		1811
12/23/2003		1554
3/29/2004		2143
6/29/2004		1780
9/27/2004		2170

Ernest Mine

Fig 1.36 Total Dissolved Solids

Date	Before Ash	After Ash
11/21/1994	7828	
12/19/1994	7022	
1/9/1995	6642	
2/9/1995	8024	
3/10/1995	7058	
4/19/1995	6902	
5/22/1995	1690	
6/21/1995	6928	
7/12/1995	6780	
8/18/1995	6292	
9/14/1995	5794	
10/19/1995	8138	
3/12/1996	8313	
6/12/1996	5893	
8/14/1996	6663	
11/25/1996		8034
3/24/1997		7002
6/10/1997		7412
8/15/1997		8306
12/18/1997		8610
3/24/1998		7154
6/24/1998		8164
9/25/1998		8406
12/17/1998		6066
3/25/1999		7893
6/21/1999		9619
9/23/1999		8816
12/8/1999		9002
3/23/2000		5123
6/16/2000		8230
9/13/2000		9503
12/19/2000		4490
3/5/2001		4583
6/2/2001		9500
9/19/2001		12000
12/12/2001		11000
3/19/2002		6400
6/20/2002		9370
9/18/2002		11818
12/13/2002		9804
3/24/2003		9997
6/13/2003		7400

9/30/2003		3856
12/23/2003		4871
3/29/2004		7411
6/29/2004		7060

Ernest Mine
Fig 1.37 Aluminum Load

Date	Before Ash	After Ash
4/5/1994	65.91	
4/19/1994	72.13	
5/4/1994	52.45	
5/24/1994	44.74	
6/8/1994	16.75	
6/22/1994	7.06	
7/8/1994	3.48	
7/27/1994	9.86	
8/11/1994	5.11	
8/25/1994	22.29	
9/7/1994	11.5	
9/22/1994	7.37	
10/7/1994	6.86	
10/21/1994	3.32	
11/7/1994	5.37	
11/21/1994	13.07	
12/9/1994	24.54	
12/20/1994	15.02	
1/9/1995	7.39	
1/20/1995	7.1	
2/3/1995	5.61	
2/17/1995	15.15	
3/8/1995	37.66	
3/23/1995	14.02	
4/11/1995	12.51	
4/26/1995	9.34	
5/9/1995	7.53	
5/22/1995	7.08	
6/8/1995	22.39	
6/28/1995	5.78	
7/13/1995	6.6	
7/28/1995	8.33	
8/11/1995	7.35	
8/29/1995	5.11	
9/13/1995	5.85	
9/22/1995	4.449	
10/3/1995	9.77	
10/24/1995	7.99	
4/11/1997		22.59
5/7/1997		14.28
6/10/1997		26.45

7/21/1997		8.24
8/15/1997		5.43
9/23/1997		7.37
10/14/1997		8.17
11/27/1997		20.8
12/18/1997		22.72
1/19/1998		30.87
2/19/1998		61.62
3/24/1998		28.19
4/24/1998		53.33
5/14/1998		56.46
6/24/1998		52.13
7/22/1998		13.65
8/14/1998		8.55
9/25/1998		7.82
10/22/1998		6.94
11/13/1998		5.3
12/17/1998		10.14
1/26/1999		31.85
2/23/1999		14.02
3/25/1999		25.34
4/22/1999		49.23
5/24/1999		19.38
6/21/1999		12.87
7/12/1999		11.25
8/17/1999		19.86
9/23/1999		31.97
10/15/1999		17.98
11/15/1999		25.24
12/8/1999		52.17
1/19/2000		0
2/22/2000		81.28
3/23/2000		42.42
4/14/2000		83.39
5/8/2000		29.87
6/16/2000		45.46
7/12/2000		21.68
8/15/2000		36.7
9/13/2000		17.57
10/17/2000		44.9
11/15/2000		24.5
12/19/2000		35.8
1/17/2001		23.3
2/15/2001		68.93
3/15/2001		43.16
4/19/2001		53.33
5/23/2001		25

6/21/2001		40.99
7/25/2001		23.4
8/28/2001		15.6
9/19/2001		19.3
10/23/2001		10.45
11/19/2001		9.12
12/12/2001		13
1/17/2002		13.7
2/14/2002		33.45
3/19/2002		73.39
4/22/2002		40.25
5/20/2002		82.85
6/20/2002		98.49
7/23/2002		33.02
7/29/2002		15.01
8/7/2002		18.8
9/18/2002		7.89
10/23/2002		14.9
11/14/2002		22.9
12/13/2002		21.19
1/16/2003		36.27
2/20/2003		2.12
3/24/2003		44.56
4/21/2003		39.76
5/15/2003		18.6

Ernest Mine
Fig 1.38 Aluminum Load Before Ash

Date	
4/5/1994	65.91
4/19/1994	72.13
5/4/1994	52.45
5/24/1994	44.74
6/8/1994	16.75
6/22/1994	7.06
7/8/1994	3.48
7/27/1994	9.86
8/11/1994	5.11
8/25/1994	22.29
9/7/1994	11.5
9/22/1994	7.37
10/7/1994	6.86
10/21/1994	3.32
11/7/1994	5.37
11/21/1994	13.07
12/9/1994	24.54
12/20/1994	15.02
1/9/1995	7.39
1/20/1995	7.1
2/3/1995	5.61
2/17/1995	15.15
3/8/1995	37.66
3/23/1995	14.02
4/11/1995	12.51
4/26/1995	9.34
5/9/1995	7.53
5/22/1995	7.08
6/8/1995	22.39
6/28/1995	5.78
7/13/1995	6.6
7/28/1995	8.33
8/11/1995	7.35
8/29/1995	5.11
9/13/1995	5.85
9/22/1995	4.449
10/3/1995	9.77
10/24/1995	7.99

Ernest Mine

Fig 1.39 Aluminum After Ash

Date	
4/11/1997	22.59
5/7/1997	14.28
6/10/1997	26.45
7/21/1997	8.24
8/15/1997	5.43
9/23/1997	7.37
10/14/1997	8.17
11/27/1997	20.8
12/18/1997	22.72
1/19/1998	30.87
2/19/1998	61.62
3/24/1998	28.19
4/24/1998	53.33
5/14/1998	56.46
6/24/1998	52.13
7/22/1998	13.65
8/14/1998	8.55
9/25/1998	7.82
10/22/1998	6.94
11/13/1998	5.3
12/17/1998	10.14
1/26/1999	31.85
2/23/1999	14.02
3/25/1999	25.34
4/22/1999	49.23
5/24/1999	19.38
6/21/1999	12.87
7/12/1999	11.25
8/17/1999	19.86
9/23/1999	31.97
10/15/1999	17.98
11/15/1999	25.24
12/8/1999	52.17
1/19/2000	0
2/22/2000	81.28
3/23/2000	42.42
4/14/2000	83.39
5/8/2000	29.87
6/16/2000	45.46
7/12/2000	21.68
8/15/2000	36.7
9/13/2000	17.57

10/17/2000	44.9
11/15/2000	24.5
12/19/2000	35.8
1/17/2001	23.3
2/15/2001	68.93
3/15/2001	43.16
4/19/2001	53.33
5/23/2001	25
6/21/2001	40.99
7/25/2001	23.4
8/28/2001	15.6
9/19/2001	19.3
10/23/2001	10.45
11/19/2001	9.12
12/12/2001	13
1/17/2002	13.7
2/14/2002	33.45
3/19/2002	73.39
4/22/2002	40.25
5/20/2002	82.85
6/20/2002	98.49
7/23/2002	33.02
7/29/2002	15.01
8/7/2002	18.8
9/18/2002	7.89
10/23/2002	14.9
11/14/2002	22.9
12/13/2002	21.19
1/16/2003	36.27
2/20/2003	2.12
3/24/2003	44.56
4/21/2003	39.76
5/15/2003	18.6

Ernest Mine
Fig 1.40 Aluminum Load

Date	
4/5/1994	925
4/19/1994	894.6
5/4/1994	523.7
5/24/1994	135.5
6/8/1994	38.27
6/22/1994	21.5
7/8/1994	10.7
7/27/1994	14.37
8/11/1994	18.52
8/25/1994	41.55
9/7/1994	32.33
9/22/1994	23.5
10/7/1994	24.5
10/21/1994	12
11/7/1994	18.7
11/21/1994	48.5
12/9/1994	52.3
12/20/1994	41
1/9/1995	31
1/20/1995	35
2/3/1995	67.3
2/17/1995	45.1
3/8/1995	71
3/23/1995	33.6
4/11/1995	17.9
4/26/1995	38.7
5/9/1995	20.5
5/22/1995	30.2
6/8/1995	128.5
6/28/1995	54.1
7/13/1995	38.6
7/28/1995	33.6
8/11/1995	30.1
8/29/1995	25
9/13/1995	17
9/22/1995	19
10/3/1995	12
10/24/1995	20.1
1/1/1996	
4/11/1997	65
5/7/1997	29.5
6/10/1997	134.8

7/21/1997	54.6
8/15/1997	11.6
9/23/1997	13.2
10/14/1997	20.8
11/27/1997	96.5
12/18/1997	138
1/19/1998	188
2/19/1998	75
3/24/1998	73
4/24/1998	287.3
5/14/1998	307
6/24/1998	293
7/22/1998	36.4
8/14/1998	20.6
9/25/1998	27.3
10/22/1998	18.17
11/13/1998	7.18
12/17/1998	10
1/26/1999	335.1
2/23/1999	304
3/25/1999	141
4/22/1999	180
5/24/1999	41.4
6/21/1999	12.3
7/12/1999	15.3
8/17/1999	33.5
9/23/1999	6.35
10/15/1999	3.45
11/15/1999	3.33
12/8/1999	37.4
1/19/2000	22.2
2/22/2000	89.2
3/23/2000	65.3
4/14/2000	229.5
5/8/2000	71.65
6/16/2000	85.6
7/12/2000	23.68
8/15/2000	30.7
9/13/2000	6.4
10/17/2000	16.22
11/15/2000	11.14
12/19/2000	14.8
1/17/2001	4
2/15/2001	54.1
3/15/2001	18.9
4/19/2001	112.5
5/23/2001	27.5

6/21/2001	47.8
7/25/2001	2
8/28/2001	1.58
9/19/2001	2.5
10/23/2001	0.85
11/19/2001	0.81
12/12/2001	15.7
1/17/2002	9.78
2/14/2002	32.1
3/19/2002	19.9
4/22/2002	110.8
5/20/2002	346.7
6/20/2002	374.36
7/23/2002	43
8/7/2002	21.2
9/18/2002	2.8
10/23/2002	5.1
11/14/2002	17.89
12/13/2002	17.2
1/16/2003	85.9
2/20/2003	38.2
3/24/2003	183
4/21/2003	134
5/15/2003	27.8

Ernest Mine
Fig 1.41 Aluminum Load

Date	
11/21/1994	382
12/19/1994	312
1/9/1995	247
2/9/1995	267
3/10/1995	290
4/19/1995	253
5/22/1995	354
6/21/1995	433.5
7/12/1995	481
8/18/1995	482
9/14/1995	575
10/19/1995	564
6/12/1996	384
8/10/1997	407
8/15/1997	560
6/24/1996	509
9/23/1999	575
6/16/2000	610
9/13/2000	783
5/21/2001	644
6/20/2002	349
6/13/2003	390
9/30/2003	497
6/29/2004	412
	59.1
	4.3
	20.1
	63.4

Ernest Mine
Fig 1.42a Arsenic Load

Date	Before Ash	After Ash
11/21/1994	0.003890874	
12/19/1994	0.014234084	
1/9/1995	0.005976344	
2/9/1995	0.010688184	
3/10/1995	0.023356062	
4/19/1995	0.013241232	
5/22/1995	0.01527742	
6/21/1995	0	
7/12/1995	0	
8/18/1995	0.001072184	
9/14/1995	0.000326944	
10/19/1995	0.000615424	
6/12/1996	0.06461952	
6/10/1997		0.03872844
8/15/1997		0.003753846
6/24/1998		0.209685294
9/23/1999		0
6/16/2000		0.03987034
9/13/2000		0.000616626
6/21/2001		0.00387645
3/19/2002		0
6/20/2002		0.1420764
6/13/2003		0.000982034
9/30/2003		0
6/29/2004		0

Ernest Mine

Fig 1.42b Lead Load

Date	Pb Before Ash	Pb After Ash
11/21/1994	0	
12/19/1994	0	
1/9/1995	0.000158664	
2/9/1995	0	
3/10/1995	0	
4/19/1995	0	
5/22/1995	0	
6/21/1995	0	
7/12/1995	0	
8/18/1995	0	
9/14/1995	0	
10/19/1995	0	
6/12/1996	0	
6/10/1997		0
8/15/1997		0
6/24/1998		0
9/23/1999		0
6/16/2000		0
9/13/2000		0.00015626
6/21/2001		0.007546156
3/19/2002		0.000040868
6/20/2002		0
6/13/2003		0.00025843
9/30/2003		4.83204E-05
6/29/2004		0

Ernest Mine

Fig 1.43 Barium Load

Date	Monitoring Point	Monitoring Point
11/21/1994	0.83946291	
12/19/1994	1.73279389	
1/9/1995	0.17272343	
2/9/1995	2.22816517	
3/10/1995	6.75794068	
4/19/1995	4.26360505	
5/22/1995	1.96605461	
6/21/1995	0.01002116	
7/12/1995	0.17790739	
8/18/1995	0.01114233	
9/14/1995	0.00083076	
10/19/1995	0.00325948	
6/12/1996	6.95947061	
8/10/1997		19.05234139
8/15/1997		0.065536309
6/24/1998		90.60266048
9/23/1999		0.000830762
6/16/2000		3.387834211
9/13/2000		0.001131282
6/21/2001		1.720409032
3/19/2002		
6/20/2002		0
6/13/2003		0
9/30/2003		
6/29/2004		0

Ernest Mine
Fig 1.44 Cadmium Load

Date	Before Ash	After Ash
11/21/1994	0.000328146	
12/19/1994	0.000722883	
1/9/1995	0.000163953	
2/9/1995	0.000602923	
3/10/1995	0.000824332	
4/19/1995	0.000610135	
5/22/1995	0.000275739	
6/21/1995	1.44E-06	
7/12/1995	0	
8/18/1995	2.98E-05	
9/14/1995	1.33E-05	
10/19/1995	1.85E-05	
6/12/1996	0	
6/10/1997		0.0010818
8/15/1997		8.55E-05
6/24/1998		0.003586167
9/23/1999		0
6/16/2000		0
9/13/2000		0.00003606
6/21/2001		0
6/20/2002		0.004262292
6/13/2003		0.001240464
9/30/2003		0.001087209
6/29/2004		0.056393032

Ernest Mine

Fig 1.45 Calcium Load

Date	Before Ash	After Ash
11/21/1994	16.594812	
12/19/1994	15.612778	
1/9/1995	10.31316	
2/9/1995	25.487208	
3/10/1995	47.8722944	
4/19/1995	39.7366776	
5/22/1995	20.7400292	
6/21/1995	1.257292	
7/12/1995	5.3811136	
8/18/1995	1.4462464	
9/14/1995	0.3688938	
10/19/1995	0.813754	
6/12/1996	37.69472	
8/10/1997		54.609264
8/15/1997		3.743028
6/24/1998		146.821896
9/23/1999		0.61302
6/16/2000		20.792196
9/13/2000		0.644272
6/21/2001		15.299056
3/19/2002		5.558048
6/20/2002		191.80314
6/13/2003		8.01133
9/30/2003		89.634342
6/29/2004		297.20652
9/27/2004		

Ernest Mine

Fig 1.46 Chromium Load

Date	Before Ash	After Ash
11/21/1994	0.00656292	
12/19/1994	0.01043336	
1/9/1995	0.00370216	
2/9/1995	0.01004872	
3/10/1995	0.0152654	
4/19/1995	0.01168344	
5/22/1995	0.00596192	
6/21/1995	0.00038464	
7/12/1995	0.00134624	
8/18/1995	0.00067312	
9/14/1995	0.00016828	
10/19/1995	0.00038464	
6/12/1996	0.01211616	
8/10/1997		0.0173088
8/15/1997		0.00140634
6/24/1998		0.04640922
9/23/1999		0.00028848
6/16/2000		0.01639528
9/13/2000		0.00028848
6/21/2001		0.006098948
3/19/2002		0.00286076
6/20/2002		0.022732224
6/13/2003		0.005323658
9/30/2003		0.020052966
6/29/2004		0.0762068

Ernest Mine
Fig 1.47 Zinc Load

Date	Before Ash	After Ash
11/21/1994	0.1078194	
12/19/1994	0.1565004	
1/9/1995	0.05368132	
2/9/1995	0.2101096	
3/10/1995	0.29920184	
4/19/1995	0.227178	
5/22/1995	0.1415956	
6/21/1995	0.0103372	
7/12/1995	0.03731008	
8/18/1995	0.01202	
9/14/1995	0.00302904	
10/19/1995	0.00646676	
6/12/1996	0.04846464	
8/10/1997		0.411084
8/15/1997		0.0302904
6/24/1998		1.3078962
9/23/1999		0.0052888
6/16/2000		0.3018222
9/13/2000		0.0064908
6/21/2001		0.1964068
3/19/2002		0.08132732
6/20/2002		1.71202062
6/13/2003		0.11732722
9/30/2003		0.80453466
6/29/2004		2.25572128
9/27/2004		

Ernest Mine
Fig 1.48a Acidity

Date	Before Ash	After Ash
5/4/1994	2660	
6/8/1994	2840	
7/8/1994	4580	
8/11/1994	4540	
9/7/1994	4240	
10/071994	4560	
11/7/1994	4700	
12/9/1994	1068	
1/9/1995	3304	
1/20/1995		
2/3/1995	3136	
3/8/1995	1274	
4/11/1995	402	
4/26/1995		
5/9/1995	3620	
6/8/1995	0.254	
7/13/1995	3440	
8/11/1995	3420	
9/13/1995	4120	
10/3/1995	3840	
11/8/1995	3460	
12/7/1995	3460	
3/12/1996	4050	
6/12/1996	4000	
7/23/1996	1800	
8/14/1996	3650	
11/25/1996		1330
12/16/1996		1098
1/15/1997		1600
2/18/1997		1242
3/24/1997		1120
6/10/1997		1270
9/23/1997		2740
11/27/1997		2620
12/18/1997		2860
1/19/1998		1720
3/24/1998		1204
6/24/1998		2500
9/25/1998		2760
12/17/1998		1820
3/25/1999		1430
6/21/1999		2490

9/23/1999		2570
12/8/1999		2450
3/23/2000		310
6/16/2000		456
9/13/2000		650
12/19/2000		470
3/15/2001		2700
6/21/2001		2510
9/19/2001		3200
12/12/2001		3300
3/19/2002		2300
6/20/2002		2500
9/18/2002		3800
12/13/2002		3400
3/24/2003		1900
6/13/2003		1240
9/30/2003		2300
12/23/2003		1650
3/29/2004		1400
6/29/2004		1650
9/27/2004		2150

Ernest Mine

Fig 1.48b Acidity Load

Date	Before Ash	After Ash
5/4/1994	8236.3	
6/8/1994	1502.02	
7/8/1994	275.26	
8/11/1994	693.05	
9/7/1994	438.3	
10/071994	202.8	
11/7/1994	28.25	
12/9/1994	680.38	
1/9/1995	516.28	
1/20/1995		
2/3/1995	1455.02	
3/8/1995	967.81	
4/11/1995	518.96	
4/26/1995		
5/9/1995	1170.48	
6/8/1995	0.16	
7/13/1995	1025.45	
8/11/1995	184.99	
9/13/1995	138.66	
10/3/1995	32.31	
11/8/1995	91.5	
12/7/1995	374.3	
3/12/1996	8562.99	
6/12/1996	3706.97	
7/23/1996	694.52	
8/14/1996	372.92	
11/25/1996		605.89
12/16/1996		1138.98
1/15/1997		1219.31
2/18/1997		825.56
3/24/1997		910.06
6/10/1997		630.46
9/23/1997		98.8
11/27/1997		453.49
12/18/1997		928.18
1/19/1998		725.67
3/24/1998		644.01
6/24/1998		2253.75
9/25/1998		72.99
12/17/1998		37.19
3/25/1999		603.32
6/21/1999		65.85

9/23/1999		67.96
12/8/1999		126.63
3/23/2000		231.02
6/16/2000		53.71
9/13/2000		13.28
12/19/2000		12.43
3/15/2001		71.4
6/21/2001		117.66
9/19/2001		23.08
12/12/2001		87.27
3/19/2002		118.88
6/20/2002		2587.31
9/18/2002		77.65
12/13/2002		175.73
3/24/2003		1349.73
6/13/2003		268.29
9/30/2003		1141.78
12/23/2003		1828.6
3/29/2004		2024.41
6/29/2004		2268.9
9/27/2004		5150.51

Ernest Mine

Fig 1.49 Manganese Load

Date	Monitoring Point	Monitoring Point					
	Flow	Acidity			Iron		
5/4/1994	257	2660	**5/4/1994**	**8217.112**	10	257	**5/4/1994**
6/8/1994	44	2840	**6/8/1994**	**1502.019**	473.3	44	**6/8/1994**
7/8/1994	5	4580	**7/8/1994**	**275.258**	399.2	5	**7/8/1994**
8/11/1994	12.7	4540	**8/11/1994**	**693.0492**	339.2	12.7	**8/11/1994**
9/7/1994	8.6	4240	**9/7/1994**	**438.2973**	366.2	8.6	**9/7/1994**
10/7/1994	3.7	4560	**10/7/1994**	**202.8014**	359.9	3.7	**10/7/1994**
11/7/1994	0.5	4700	**11/7/1994**	**28.247**	352.2	0.5	**11/7/1994**
12/9/1994	53	1068	**12/9/1994**	**680.3801**	0.08	53	**12/9/1994**
1/9/1995	13	3304	**1/9/1995**	**516.283**	285	13	**1/9/1995**
2/3/1995			**2/3/1995**	**0**			**2/3/1995**
3/8/1995	38.6	3136	**3/8/1995**	**1455.016**	457	38.6	**3/8/1995**
4/11/1995	107	402	**4/11/1995**	**517.0283**	143.6	107	**4/11/1995**
4/26/1995	27.4		**4/26/1995**			27.4	**4/26/1995**
5/9/1995	26.9	3620	**5/9/1995**	**1170.484**	413.1	26.9	**5/9/1995**
6/8/1995	51	254	**6/8/1995**	**155.7071**	373.1	51	**6/8/1995**
7/13/1995	24.8	3440	**7/13/1995**	**1025.45**	406	24.8	**7/13/1995**
8/11/1995	4.5	3420	**8/11/1995**	**184.9878**	254.7	4.5	**8/11/1995**
9/22/1995	2.8	4120	**9/22/1995**	**138.6627**	229	2.8	**9/22/1995**
10/3/1995	0.7	3840	**10/3/1995**	**32.30976**	296.8	0.7	**10/3/1995**
11/8/1995	2.2	3460	**11/8/1995**	**91.49624**	245.4	2.2	**11/8/1995**
12/7/1995	9	3460	**12/7/1995**	**374.3028**	248.5	9	**12/7/1995**
3/12/1996	175.9	4050	**3/12/1996**	**8562.988**	960	175.9	**3/12/1996**
6/12/1996	77.1	4000	**6/12/1996**	**3706.968**	376	77.1	**6/12/1996**
8/14/1996	8.5	3650	**8/14/1996**	**372.9205**	445	8.5	**8/14/1996**
11/25/1996	37.9	1330	**11/25/1996**	**605.8921**	220	37.9	**########**
12/16/1996	86.3	1098	**12/16/1996**	**1138.984**	160.4	86.3	**########**
1/15/1997	63.4	1600	**1/15/1997**	**1219.309**	303.1	63.4	**1/15/1997**
2/18/1997	55.3	1242	**2/18/1997**	**825.5649**	137.7	55.3	**2/18/1997**
3/24/1997	67	1120	**3/24/1997**	**901.9808**	155.9	67	**3/24/1997**
6/10/1997	41.3	1270	**6/10/1997**	**630.461**	109.6	41.3	**6/10/1997**
9/23/1997	3	2740	**9/23/1997**	**98.8044**	609.1	3	**9/23/1997**
11/27/1997	14.4	2620	**11/27/1997**	**453.4906**	239.9	14.4	**########**
12/18/1997	27	2860	**12/18/1997**	**928.1844**	216.5	27	**########**
1/19/1998	35.1	1720	**1/19/1998**	**725.6714**	190.4	35.1	**1/19/1998**
3/24/1998	44.5	1204	**3/24/1998**	**644.0076**	172.1	44.5	**3/24/1998**
6/14/1998	75	2500	**6/14/1998**	**2253.75**	234	75	**6/14/1998**
9/26/1998	2.2	2760	**9/26/1998**	**72.98544**	465.8	2.2	**9/26/1998**
12/17/1998	1.7	1820	**12/17/1998**	**37.18988**	654.6	1.7	**########**
3/25/1999	35	1430	**3/25/1999**	**601.601**	212	35	**3/25/1999**
6/21/1999	2.2	2490	**6/21/1999**	**65.84556**	706	2.2	**6/21/1999**

9/23/1999	2.2	2570	**9/23/1999**	**67.96108**	836	2.2	**9/23/1999**
12/8/1999	4.3	2450	**12/8/1999**	**126.6307**	172	4.3	**12/8/1999**
3/23/2000	62	310	**3/23/2000**	**231.0244**	23.5	62	**3/23/2000**
6/16/2000	9.8	456	**6/16/2000**	**53.71498**	270	9.8	**6/16/2000**
9/13/2000	1.7	650	**9/13/2000**	**13.2821**	670	1.7	**9/13/2000**
12/19/2000	2.2	470	**12/19/2000**	**12.42868**	620	2.2	**########**
3/15/2001	2.2	2700	**3/15/2001**	**71.3988**	447	2.2	**3/15/2001**
6/21/2001	3.9	2510	**6/21/2001**	**117.6638**	198	3.9	**6/21/2001**
9/19/2001	0.6	3200	**9/19/2001**	**23.0784**	260	0.6	**9/19/2001**
12/12/2001	2.2	3300	**12/12/2001**	**87.2652**	250	2.2	**########**
3/19/2002	4.3	2300	**3/19/2002**	**118.8778**	290	4.3	**3/19/2002**
6/20/2002	86.1	2500	**6/20/2002**	**2587.305**	490	86.1	**6/20/2002**
9/18/2002	1.7	3800	**9/18/2002**	**77.6492**	332	1.7	**9/18/2002**
12/13/2002	4.3	3400	**12/13/2002**	**175.7324**	301	4.3	**########**
3/24/2003	59.1	1900	**3/24/2003**	**1349.726**	185	59.1	**3/24/2003**
6/13/2003	18	1240	**6/13/2003**	**268.2864**	148	18	**6/13/2003**
9/30/2003	41	2300	**9/30/2003**	**1133.486**	500	41	**9/30/2003**
12/23/2003	92.2	1650	**12/23/2003**	**1828.603**	238	92.2	**########**
3/29/2004	120	1400	**3/29/2004**	**2019.36**	235	120	**3/29/2004**
6/29/2004	114.4	1650	**6/29/2004**	**2268.895**	226	114.4	**6/29/2004**
9/27/2004	199.3	2150	**9/27/2004**	**5150.51**	452	199.3	**9/27/2004**

	Manganese				
30.8914	5	257	**5/4/1994**	**15.4457**	
250.3189	6.4	44	**6/8/1994**	**3.384832**	
23.99192	9.59	5	**7/8/1994**	**0.576359**	
51.78024	11.6	12.7	**8/11/1994**	**1.770786**	
37.85483	11.9	8.6	**9/7/1994**	**1.230127**	
16.00619	13	3.7	**10/7/1994**	**0.578162**	
2.116722	131.1	0.5	**11/7/1994**	**0.787911**	
0.050965	0.01	53	**12/9/1994**	**0.006371**	
44.5341	10.15	13	**1/9/1995**	**1.586039**	
	11.5		**2/3/1995**	**0**	
212.0352	4.38	38.6	**3/8/1995**	**2.032197**	
184.6897	1.17	107	**4/11/1995**	**1.504784**	
		27.4	**4/26/1995**	**0**	
133.5709	10	26.9	**5/9/1995**	**3.23338**	
228.7178	7.6	51	**6/8/1995**	**4.658952**	
121.027	10.4	24.8	**7/13/1995**	**3.100198**	
13.77672	13.6	4.5	**8/11/1995**	**0.735624**	
7.707224	12.57	2.8	**9/22/1995**	**0.423056**	
2.497275	16.7	0.7	**10/3/1995**	**0.140514**	
6.489358	14	2.2	**11/8/1995**	**0.370216**	
26.88273	10.52	9	**12/7/1995**	**1.138054**	
2029.745	7	175.9	**3/12/1996**	**14.80023**	
348.455	5.9	77.1	**6/12/1996**	**5.467778**	
45.46565	14.8	8.5	**8/14/1996**	**1.512116**	
100.2228	5.37	37.9	**########**		**2.446346**
166.3871	3.8	86.3	**########**		**3.941839**
230.9828	5.03	63.4	**1/15/1997**		**3.833202**
91.53002	3.81	55.3	**2/18/1997**		**2.53253**
125.5525	3.24	67	**3/24/1997**		**2.609302**
54.40829	3.9	41.3	**6/10/1997**		**1.936061**
21.96415	33.1	3	**9/23/1997**		**1.193586**
41.52381	10.3	14.4	**########**		**1.782806**
70.26291	6.3	27	**########**		**2.044602**
80.33014	3.7	35.1	**1/19/1998**		**1.561037**
92.05457	3.6	44.5	**3/24/1998**		**1.925604**
210.951	5.06	75	**6/14/1998**		**4.56159**
12.31762	20.7	2.2	**9/26/1998**		**0.547391**
13.3761	29.78	1.7	**########**		**0.608525**
89.1884	4.8	35	**3/25/1999**		**2.01936**
18.66946	31	2.2	**6/21/1999**		**0.819764**

22.10718	40	2.2	**9/23/1999**	**1.05776**
8.889992	24	4.3	**12/8/1999**	**1.240464**
17.51314	2.1	62	**3/23/2000**	**1.565004**
31.80492	8.6	9.8	**6/16/2000**	**1.013046**
13.69078	0.71	1.7	**9/13/2000**	**0.014508**
16.39528	27.8	2.2	**########**	**0.735143**
11.82047	27.5	2.2	**3/15/2001**	**0.72721**
9.281844	12.9	3.9	**6/21/2001**	**0.604726**
1.87512	23	0.6	**9/19/2001**	**0.165876**
6.611	20	2.2	**########**	**0.52888**
14.98894	16.6	4.3	**3/19/2002**	**0.857988**
507.1118	5.35	86.1	**6/20/2002**	**5.536833**
6.784088	16.7	1.7	**9/18/2002**	**0.341248**
15.55749	16.4	4.3	**########**	**0.84765**
131.4207	3.8	59.1	**3/24/2003**	**2.699452**
32.02128	5.38	18	**6/13/2003**	**1.164017**
246.41	5.6	41	**9/30/2003**	**2.759792**
263.7621	3.35	92.2	**########**	**3.712617**
338.964	2.88	120	**3/29/2004**	**4.154112**
310.7699	3.4	114.4	**6/29/2004**	**4.675299**
1082.805	7.02	199.3	**9/27/2004**	**16.81701**

Ernest Mine

Fig 1.50 Sulfate Load

Date	Monitoring Point	Monitoring Point					
	Flow	**Acidity**			**Iron**		
5/4/1994	257	2660	**5/4/1994**	**8217.112**	10	257	**5/4/1994**
6/8/1994	44	2840	**6/8/1994**	**1502.019**	473.3	44	**6/8/1994**
7/8/1994	5	4580	**7/8/1994**	**275.258**	399.2	5	**7/8/1994**
8/11/1994	12.7	4540	**8/11/1994**	**693.0492**	339.2	12.7	**8/11/1994**
9/7/1994	8.6	4240	**9/7/1994**	**438.2973**	366.2	8.6	**9/7/1994**
10/7/1994	3.7	4560	**10/7/1994**	**202.8014**	359.9	3.7	**10/7/1994**
11/7/1994	0.5	4700	**11/7/1994**	**28.247**	352.2	0.5	**11/7/1994**
12/9/1994	53	1068	**12/9/1994**	**680.3801**	0.08	53	**12/9/1994**
1/9/1995	13	3304	**1/9/1995**	**516.283**	285	13	**1/9/1995**
2/3/1995			**2/3/1995**	**0**			**2/3/1995**
3/8/1995	38.6	3136	**3/8/1995**	**1455.016**	457	38.6	**3/8/1995**
4/11/1995	107	402	**4/11/1995**	**517.0283**	143.6	107	**4/11/1995**
4/26/1995	27.4		**4/26/1995**			27.4	**4/26/1995**
5/9/1995	26.9	3620	**5/9/1995**	**1170.484**	413.1	26.9	**5/9/1995**
6/8/1995	51	254	**6/8/1995**	**155.7071**	373.1	51	**6/8/1995**
7/13/1995	24.8	3440	**7/13/1995**	**1025.45**	406	24.8	**7/13/1995**
8/11/1995	4.5	3420	**8/11/1995**	**184.9878**	254.7	4.5	**8/11/1995**
9/22/1995	2.8	4120	**9/22/1995**	**138.6627**	229	2.8	**9/22/1995**
10/3/1995	0.7	3840	**10/3/1995**	**32.30976**	296.8	0.7	**10/3/1995**
11/8/1995	2.2	3460	**11/8/1995**	**91.49624**	245.4	2.2	**11/8/1995**
12/7/1995	9	3460	**12/7/1995**	**374.3028**	248.5	9	**12/7/1995**
3/12/1996	175.9	4050	**3/12/1996**	**8562.988**	960	175.9	**3/12/1996**
6/12/1996	77.1	4000	**6/12/1996**	**3706.968**	376	77.1	**6/12/1996**
8/14/1996	8.5	3650	**8/14/1996**	**372.9205**	445	8.5	**8/14/1996**
11/25/1996	37.9	1330	**11/25/1996**	**605.8921**	220	37.9	**########**
12/16/1996	86.3	1098	**12/16/1996**	**1138.984**	160.4	86.3	**########**
1/15/1997	63.4	1600	**1/15/1997**	**1219.309**	303.1	63.4	**1/15/1997**
2/18/1997	55.3	1242	**2/18/1997**	**825.5649**	137.7	55.3	**2/18/1997**
3/24/1997	67	1120	**3/24/1997**	**901.9808**	155.9	67	**3/24/1997**
6/10/1997	41.3	1270	**6/10/1997**	**630.461**	109.6	41.3	**6/10/1997**
9/23/1997	3	2740	**9/23/1997**	**98.8044**	609.1	3	**9/23/1997**
11/27/1997	14.4	2620	**11/27/1997**	**453.4906**	239.9	14.4	**########**
12/18/1997	27	2860	**12/18/1997**	**928.1844**	216.5	27	**########**
1/19/1998	35.1	1720	**1/19/1998**	**725.6714**	190.4	35.1	**1/19/1998**
3/24/1998	44.5	1204	**3/24/1998**	**644.0076**	172.1	44.5	**3/24/1998**
6/14/1998	75	2500	**6/14/1998**	**2253.75**	234	75	**6/14/1998**
9/26/1998	2.2	2760	**9/26/1998**	**72.98544**	465.8	2.2	**9/26/1998**
12/17/1998	1.7	1820	**12/17/1998**	**37.18988**	654.6	1.7	**########**
3/25/1999	35	1430	**3/25/1999**	**601.601**	212	35	**3/25/1999**
6/21/1999	2.2	2490	**6/21/1999**	**65.84556**	706	2.2	**6/21/1999**

9/23/1999	2.2	2570	**9/23/1999**	**67.96108**	836	2.2	**9/23/1999**
12/8/1999	4.3	2450	**12/8/1999**	**126.6307**	172	4.3	**12/8/1999**
3/23/2000	62	310	**3/23/2000**	**231.0244**	23.5	62	**3/23/2000**
6/16/2000	9.8	456	**6/16/2000**	**53.71498**	270	9.8	**6/16/2000**
9/13/2000	1.7	650	**9/13/2000**	**13.2821**	670	1.7	**9/13/2000**
12/19/2000	2.2	470	**12/19/2000**	**12.42868**	620	2.2	**########**
3/15/2001	2.2	2700	**3/15/2001**	**71.3988**	447	2.2	**3/15/2001**
6/21/2001	3.9	2510	**6/21/2001**	**117.6638**	198	3.9	**6/21/2001**
9/19/2001	0.6	3200	**9/19/2001**	**23.0784**	260	0.6	**9/19/2001**
12/12/2001	2.2	3300	**12/12/2001**	**87.2652**	250	2.2	**########**
3/19/2002	4.3	2300	**3/19/2002**	**118.8778**	290	4.3	**3/19/2002**
6/20/2002	86.1	2500	**6/20/2002**	**2587.305**	490	86.1	**6/20/2002**
9/18/2002	1.7	3800	**9/18/2002**	**77.6492**	332	1.7	**9/18/2002**
12/13/2002	4.3	3400	**12/13/2002**	**175.7324**	301	4.3	**########**
3/24/2003	59.1	1900	**3/24/2003**	**1349.726**	185	59.1	**3/24/2003**
6/13/2003	18	1240	**6/13/2003**	**268.2864**	148	18	**6/13/2003**
9/30/2003	41	2300	**9/30/2003**	**1133.486**	500	41	**9/30/2003**
12/23/2003	92.2	1650	**12/23/2003**	**1828.603**	238	92.2	**########**
3/29/2004	120	1400	**3/29/2004**	**2019.36**	235	120	**3/29/2004**
6/29/2004	114.4	1650	**6/29/2004**	**2268.895**	226	114.4	**6/29/2004**
9/27/2004	199.3	2150	**9/27/2004**	**5150.51**	452	199.3	**9/27/2004**

	Manganese				Aluminum				
30.8914	5	257	5/4/1994	15.4457	7	257	5/4/1994	21.62398	5/4/1994
250.3189	6.4	44	6/8/1994	3.384832	171.6	44	6/8/1994	90.75581	6/8/1994
23.99192	9.59	5	7/8/1994	0.576359		5	7/8/1994	0	7/8/1994
51.78024	11.6	12.7	8/11/1994	1.770786	321	12.7	8/11/1994	49.00193	8/11/1994
37.85483	11.9	8.6	9/7/1994	1.230127	366.2	8.6	9/7/1994	37.85483	9/7/1994
16.00619	13	3.7	10/7/1994	0.578162	427.8	3.7	10/7/1994	19.02598	10/7/1994
2.116722	131.1	0.5	11/7/1994	0.787911	307.9	0.5	11/7/1994	1.850479	11/7/1994
0.050965	0.01	53	12/9/1994	0.006371	0.49	53	12/9/1994	0.312159	12/9/1994
44.5341	10.15	13	1/9/1995	1.586039	295.2	13	1/9/1995	46.12795	1/9/1995
	11.5		2/3/1995	0	328.3	38.6	2/3/1995	152.322	2/3/1995
212.0352	4.38	38.6	3/8/1995	2.032197	129.4	38.6	3/8/1995	60.03798	3/8/1995
184.6897	1.17	107	4/11/1995	1.504784	26.5	107	4/11/1995	34.08271	4/11/1995
		27.4	4/26/1995	0		27.4	4/26/1995		4/26/1995
133.5709	10	26.9	5/9/1995	3.23338	300.5	26.9	5/9/1995	97.16307	5/9/1995
228.7178	7.6	51	6/8/1995	4.658952	245	51	6/8/1995	150.1899	6/8/1995
121.027	10.4	24.8	7/13/1995	3.100198	328.6	24.8	7/13/1995	97.95435	7/13/1995
13.77672	13.6	4.5	8/11/1995	0.735624	381.4	4.5	8/11/1995	20.62993	8/11/1995
7.707224	12.57	2.8	9/22/1995	0.423056	371.3	2.8	9/22/1995	12.49647	9/22/1995
2.497275	16.7	0.7	10/3/1995	0.140514	482.2	0.7	10/3/1995	4.057231	10/3/1995
6.489358	14	2.2	11/8/1995	0.370216	369.2	2.2	11/8/1995	9.763125	11/8/1995
26.88273	10.52	9	12/7/1995	1.138054	458.9	9	12/7/1995	49.6438	12/7/1995
2029.745	7	175.9	3/12/1996	14.80023	304	175.9	3/12/1996	642.7527	3/12/1996
348.455	5.9	77.1	6/12/1996	5.467778	232	77.1	6/12/1996	215.0041	6/12/1996
45.46565	14.8	8.5	8/14/1996	1.512116	196	8.5	8/14/1996	20.02532	8/14/1996
100.2228	5.37	37.9	########	2.446346	150	37.9	########	68.3337	########
166.3871	3.8	86.3	########	3.941839	119	86.3	########	123.4418	########
230.9828	5.03	63.4	1/15/1997	3.833202	154.1	63.4	1/15/1997	117.4347	1/15/1997
91.53002	3.81	55.3	2/18/1997	2.53253	142	55.3	2/18/1997	94.38825	2/18/1997
125.5525	3.24	67	3/24/1997	2.609302	99.3	67	3/24/1997	79.97026	3/24/1997
54.40829	3.9	41.3	6/10/1997	1.936061	148.3	41.3	6/10/1997	73.61998	6/10/1997
21.96415	33.1	3	9/23/1997	1.193586	227.1	3	9/23/1997	8.189226	9/23/1997
41.52381	10.3	14.4	########	1.782806	341.3	14.4	########	59.07493	########
70.26291	6.3	27	########	2.044602	226.3	27	########	73.4434	########
80.33014	3.7	35.1	1/19/1998	1.561037	172	35.1	1/19/1998	72.56714	1/19/1998
92.05457	3.6	44.5	3/24/1998	1.925604	131	44.5	3/24/1998	70.07059	3/24/1998
210.951	5.06	75	6/14/1998	4.56159	202	75	6/14/1998	182.103	6/14/1998
12.31762	20.7	2.2	9/26/1998	0.547391	171.3	2.2	9/26/1998	4.529857	9/26/1998
13.3761	29.78	1.7	########	0.608525	29.7	1.7	########	0.60689	########
89.1884	4.8	35	3/25/1999	2.01936	4.8	35	3/25/1999	2.01936	3/25/1999
18.66946	31	2.2	6/21/1999	0.819764	31	2.2	6/21/1999	0.819764	6/21/1999

22.10718	40	2.2	9/23/1999	1.05776	40	2.2	9/23/1999	1.05776	9/23/1999
8.889992	24	4.3	12/8/1999	1.240464	24	4.3	12/8/1999	1.240464	12/8/1999
17.51314	2.1	62	3/23/2000	1.565004	2.1	62	3/23/2000	1.565004	3/23/2000
31.80492	8.6	9.8	6/16/2000	1.013046	8.6	9.8	6/16/2000	1.013046	6/16/2000
13.69078	0.71	1.7	9/13/2000	0.014508	0.7	1.7	9/13/2000	0.014304	9/13/2000
16.39528	27.8	2.2	########	0.735143	27.8	2.2	########	0.735143	########
11.82047	27.5	2.2	3/15/2001	0.72721	27.5	2.2	3/15/2001	0.72721	3/15/2001
9.281844	12.9	3.9	6/21/2001	0.604726	12.9	3.9	6/21/2001	0.604726	6/21/2001
1.87512	23	0.6	9/19/2001	0.165876	23	0.6	9/19/2001	0.165876	9/19/2001
6.611	20	2.2	########	0.52888	20	2.2	########	0.52888	########
14.98894	16.6	4.3	3/19/2002	0.857988	16.6	4.3	3/19/2002	0.857988	3/19/2002
507.1118	5.35	86.1	6/20/2002	5.536833	5.3	86.1	6/20/2002	5.485087	6/20/2002
6.784088	16.7	1.7	9/18/2002	0.341248	211	1.7	9/18/2002	4.311574	9/18/2002
15.55749	16.4	4.3	########	0.84765	214	4.3	########	11.0608	########
131.4207	3.8	59.1	3/24/2003	2.699452	168	59.1	3/24/2003	119.3442	3/24/2003
32.02128	5.38	18	6/13/2003	1.164017	113	18	6/13/2003	24.44868	6/13/2003
246.41	5.6	41	9/30/2003	2.759792	194	41	9/30/2003	95.60708	9/30/2003
263.7621	3.35	92.2	########	3.712617	136	92.2	########	150.7212	########
338.964	2.88	120	3/29/2004	4.154112	104	120	3/29/2004	150.0096	3/29/2004
310.7699	3.4	114.4	6/29/2004	4.675299	140	114.4	6/29/2004	192.5123	6/29/2004
1082.805	7.02	199.3	9/27/2004	16.81701	216	199.3	9/27/2004	517.4466	9/27/2004

	Sulfate			
257	3070	**5/4/1994**	**9483.66**	
44	1716	**6/8/1994**	**907.5581**	
5	5970	**7/8/1994**	**358.797**	
12.7	7340	**8/11/1994**	**1120.48**	
8.6	5080	**9/7/1994**	**525.1298**	
3.7	3490	**10/7/1994**	**155.2143**	
0.5	4060	**11/7/1994**	**24.4006**	
53	1290	**12/9/1994**	**821.8074**	
13	3900	**1/9/1995**	**609.414**	
38.6	4300	**2/3/1995**	**1995.08**	
38.6	1850	**3/8/1995**	**858.3482**	
107	550	**4/11/1995**	**707.377**	
27.4		**4/26/1995**		
26.9	5354	**5/9/1995**	**1731.152**	
51	4036	**6/8/1995**	**2474.149**	
24.8	5614	**7/13/1995**	**1673.511**	
4.5	4597	**8/11/1995**	**248.6517**	
2.8	5840	**9/22/1995**	**196.551**	
0.7	3993	**10/3/1995**	**33.5971**	
2.2	5255	**11/8/1995**	**138.9632**	
9	5828	**12/7/1995**	**630.473**	
175.9	4833	**3/12/1996**	**10218.5**	
77.1	2638	**6/12/1996**	**2444.745**	
8.5	3051	**8/14/1996**	**311.7207**	
37.9	1801	**########**		**820.46**
86.3	1207	**########**		**1252.052**
63.4	1916	**1/15/1997**		**1460.122**
55.3	1658	**2/18/1997**		**1102.083**
67	1388	**3/24/1997**		**1117.812**
41.3	1605	**6/10/1997**		**796.7637**
3	3769	**9/23/1997**		**135.9101**
14.4	3583	**########**		**620.1743**
27	2550	**########**		**827.577**
35.1	2156	**1/19/1998**		**909.6207**
44.5	1591	**3/24/1998**		**851.01**
75	2418	**6/14/1998**		**2179.827**
2.2	4397	**9/26/1998**		**116.2743**
1.7	3861	**########**		**78.89567**
35	2100	**3/25/1999**		**883.47**
2.2	3840	**6/21/1999**		**101.545**

2.2	3500	**9/23/1999**	**92.554**
4.3	3040	**12/8/1999**	**157.1254**
62	560	**3/23/2000**	**417.3344**
9.8	1925	**6/16/2000**	**226.7573**
1.7	3275	**9/13/2000**	**66.92135**
2.2	3975	**########**	**105.1149**
2.2	4175	**3/15/2001**	**110.4037**
3.9	3320	**6/21/2001**	**155.635**
0.6	4000	**9/19/2001**	**28.848**
2.2	4600	**########**	**121.6424**
4.3	3300	**3/19/2002**	**170.5638**
86.1	3000	**6/20/2002**	**3104.766**
1.7	5710	**9/18/2002**	**116.6781**
4.3	4167	**########**	**215.3756**
59.1	3083	**3/24/2003**	**2190.108**
18	1910	**6/13/2003**	**413.2476**
41	3033	**9/30/2003**	**1494.723**
92.2	1934	**########**	**2143.344**
120	1542	**3/29/2004**	**2224.181**
114.4	2136	**6/29/2004**	**2937.188**
199.3	2914	**9/27/2004**	**6980.738**

Ernest Mine
Fig 1.51 Aluminum Load

Date	Monitoring Point	Monitoring Point					
	Flow	Acidity			Iron		
5/4/1994	257	2660	**5/4/1994**	**8217.112**	10	257	**5/4/1994**
6/8/1994	44	2840	**6/8/1994**	**1502.019**	473.3	44	**6/8/1994**
7/8/1994	5	4580	**7/8/1994**	**275.258**	399.2	5	**7/8/1994**
8/11/1994	12.7	4540	**8/11/1994**	**693.0492**	339.2	12.7	**8/11/1994**
9/7/1994	8.6	4240	**9/7/1994**	**438.2973**	366.2	8.6	**9/7/1994**
10/7/1994	3.7	4560	**10/7/1994**	**202.8014**	359.9	3.7	**10/7/1994**
11/7/1994	0.5	4700	**11/7/1994**	**28.247**	352.2	0.5	**11/7/1994**
12/9/1994	53	1068	**12/9/1994**	**680.3801**	0.08	53	**12/9/1994**
1/9/1995	13	3304	**1/9/1995**	**516.283**	285	13	**1/9/1995**
2/3/1995			**2/3/1995**	**0**			**2/3/1995**
3/8/1995	38.6	3136	**3/8/1995**	**1455.016**	457	38.6	**3/8/1995**
4/11/1995	107	402	**4/11/1995**	**517.0283**	143.6	107	**4/11/1995**
4/26/1995	27.4		**4/26/1995**			27.4	**4/26/1995**
5/9/1995	26.9	3620	**5/9/1995**	**1170.484**	413.1	26.9	**5/9/1995**
6/8/1995	51	254	**6/8/1995**	**155.7071**	373.1	51	**6/8/1995**
7/13/1995	24.8	3440	**7/13/1995**	**1025.45**	406	24.8	**7/13/1995**
8/11/1995	4.5	3420	**8/11/1995**	**184.9878**	254.7	4.5	**8/11/1995**
9/22/1995	2.8	4120	**9/22/1995**	**138.6627**	229	2.8	**9/22/1995**
10/3/1995	0.7	3840	**10/3/1995**	**32.30976**	296.8	0.7	**10/3/1995**
11/8/1995	2.2	3460	**11/8/1995**	**91.49624**	245.4	2.2	**11/8/1995**
12/7/1995	9	3460	**12/7/1995**	**374.3028**	248.5	9	**12/7/1995**
3/12/1996	175.9	4050	**3/12/1996**	**8562.988**	960	175.9	**3/12/1996**
6/12/1996	77.1	4000	**6/12/1996**	**3706.968**	376	77.1	**6/12/1996**
8/14/1996	8.5	3650	**8/14/1996**	**372.9205**	445	8.5	**8/14/1996**
11/25/1996	37.9	1330	**11/25/1996**	**605.8921**	220	37.9	**########**
12/16/1996	86.3	1098	**12/16/1996**	**1138.984**	160.4	86.3	**########**
1/15/1997	63.4	1600	**1/15/1997**	**1219.309**	303.1	63.4	**1/15/1997**
2/18/1997	55.3	1242	**2/18/1997**	**825.5649**	137.7	55.3	**2/18/1997**
3/24/1997	67	1120	**3/24/1997**	**901.9808**	155.9	67	**3/24/1997**
6/10/1997	41.3	1270	**6/10/1997**	**630.461**	109.6	41.3	**6/10/1997**
9/23/1997	3	2740	**9/23/1997**	**98.8044**	609.1	3	**9/23/1997**
11/27/1997	14.4	2620	**11/27/1997**	**453.4906**	239.9	14.4	**########**
12/18/1997	27	2860	**12/18/1997**	**928.1844**	216.5	27	**########**
1/19/1998	35.1	1720	**1/19/1998**	**725.6714**	190.4	35.1	**1/19/1998**
3/24/1998	44.5	1204	**3/24/1998**	**644.0076**	172.1	44.5	**3/24/1998**
6/14/1998	75	2500	**6/14/1998**	**2253.75**	234	75	**6/14/1998**
9/26/1998	2.2	2760	**9/26/1998**	**72.98544**	465.8	2.2	**9/26/1998**
12/17/1998	1.7	1820	**12/17/1998**	**37.18988**	654.6	1.7	**########**
3/25/1999	35	1430	**3/25/1999**	**601.601**	212	35	**3/25/1999**
6/21/1999	2.2	2490	**6/21/1999**	**65.84556**	706	2.2	**6/21/1999**

9/23/1999	2.2	2570	**9/23/1999**	**67.96108**	836	2.2	**9/23/1999**
12/8/1999	4.3	2450	**12/8/1999**	**126.6307**	172	4.3	**12/8/1999**
3/23/2000	62	310	**3/23/2000**	**231.0244**	23.5	62	**3/23/2000**
6/16/2000	9.8	456	**6/16/2000**	**53.71498**	270	9.8	**6/16/2000**
9/13/2000	1.7	650	**9/13/2000**	**13.2821**	670	1.7	**9/13/2000**
12/19/2000	2.2	470	**12/19/2000**	**12.42868**	620	2.2	**########**
3/15/2001	2.2	2700	**3/15/2001**	**71.3988**	447	2.2	**3/15/2001**
6/21/2001	3.9	2510	**6/21/2001**	**117.6638**	198	3.9	**6/21/2001**
9/19/2001	0.6	3200	**9/19/2001**	**23.0784**	260	0.6	**9/19/2001**
12/12/2001	2.2	3300	**12/12/2001**	**87.2652**	250	2.2	**########**
3/19/2002	4.3	2300	**3/19/2002**	**118.8778**	290	4.3	**3/19/2002**
6/20/2002	86.1	2500	**6/20/2002**	**2587.305**	490	86.1	**6/20/2002**
9/18/2002	1.7	3800	**9/18/2002**	**77.6492**	332	1.7	**9/18/2002**
12/13/2002	4.3	3400	**12/13/2002**	**175.7324**	301	4.3	**########**
3/24/2003	59.1	1900	**3/24/2003**	**1349.726**	185	59.1	**3/24/2003**
6/13/2003	18	1240	**6/13/2003**	**268.2864**	148	18	**6/13/2003**
9/30/2003	41	2300	**9/30/2003**	**1133.486**	500	41	**9/30/2003**
12/23/2003	92.2	1650	**12/23/2003**	**1828.603**	238	92.2	**########**
3/29/2004	120	1400	**3/29/2004**	**2019.36**	235	120	**3/29/2004**
6/29/2004	114.4	1650	**6/29/2004**	**2268.895**	226	114.4	**6/29/2004**
9/27/2004	199.3	2150	**9/27/2004**	**5150.51**	452	199.3	**9/27/2004**

	Manganese				Aluminum				Sulfate
30.8914	5	257	**5/4/1994**	**15.4457**	7	257	**5/4/1994**	**21.62398**	
250.3189	6.4	44	**6/8/1994**	**3.384832**	171.6	44	**6/8/1994**	**90.75581**	
23.99192	9.59	5	**7/8/1994**	**0.576359**		5	**7/8/1994**		
51.78024	11.6	12.7	**8/11/1994**	**1.770786**	321	12.7	**8/11/1994**	**49.00193**	
37.85483	11.9	8.6	**9/7/1994**	**1.230127**	366.2	8.6	**9/7/1994**	**37.85483**	
16.00619	13	3.7	**10/7/1994**	**0.578162**	427.8	3.7	**10/7/1994**	**19.02598**	
2.116722	131.1	0.5	**11/7/1994**	**0.787911**	307.9	0.5	**11/7/1994**	**1.850479**	
0.050965	0.01	53	**12/9/1994**	**0.006371**	0.49	53	**12/9/1994**	**0.312159**	
44.5341	10.15	13	**1/9/1995**	**1.586039**	295.2	13	**1/9/1995**	**46.12795**	
	11.5		**2/3/1995**	**0**	328.3		**2/3/1995**		
212.0352	4.38	38.6	**3/8/1995**	**2.032197**	129.4	38.6	**3/8/1995**	**60.03798**	
184.6897	1.17	107	**4/11/1995**	**1.504784**	26.5	107	**4/11/1995**	**34.08271**	
		27.4	**4/26/1995**	**0**		27.4	**4/26/1995**		
133.5709	10	26.9	**5/9/1995**	**3.23338**	300.5	26.9	**5/9/1995**	**97.16307**	
228.7178	7.6	51	**6/8/1995**	**4.658952**	245	51	**6/8/1995**	**150.1899**	
121.027	10.4	24.8	**7/13/1995**	**3.100198**	328.6	24.8	**7/13/1995**	**97.95435**	
13.77672	13.6	4.5	**8/11/1995**	**0.735624**	381.4	4.5	**8/11/1995**	**20.62993**	
7.707224	12.57	2.8	**9/22/1995**	**0.423056**	371.3	2.8	**9/22/1995**	**12.49647**	
2.497275	16.7	0.7	**10/3/1995**	**0.140514**	482.2	0.7	**10/3/1995**	**4.057231**	
6.489358	14	2.2	**11/8/1995**	**0.370216**	369.2	2.2	**11/8/1995**	**9.763125**	
26.88273	10.52	9	**12/7/1995**	**1.138054**	458.9	9	**12/7/1995**	**49.6438**	
2029.745	7	175.9	**3/12/1996**	**14.80023**	304	175.9	**3/12/1996**	**642.7527**	
348.455	5.9	77.1	**6/12/1996**	**5.467778**	232	77.1	**6/12/1996**	**215.0041**	
45.46565	14.8	8.5	**8/14/1996**	**1.512116**	196	8.5	**8/14/1996**	**20.02532**	
100.2228	5.37	37.9	**########**	**2.446346**	150	37.9	**########**		**68.3337**
166.3871	3.8	86.3	**########**	**3.941839**	119	86.3	**########**		**123.4418**
230.9828	5.03	63.4	**1/15/1997**	**3.833202**	154.1	63.4	**1/15/1997**		**117.4347**
91.53002	3.81	55.3	**2/18/1997**	**2.53253**	142	55.3	**2/18/1997**		**94.38825**
125.5525	3.24	67	**3/24/1997**	**2.609302**	99.3	67	**3/24/1997**		**79.97026**
54.40829	3.9	41.3	**6/10/1997**	**1.936061**	148.3	41.3	**6/10/1997**		**73.61998**
21.96415	33.1	3	**9/23/1997**	**1.193586**	227.1	3	**9/23/1997**		**8.189226**
41.52381	10.3	14.4	**########**	**1.782806**	341.3	14.4	**########**		**59.07493**
70.26291	6.3	27	**########**	**2.044602**	226.3	27	**########**		**73.4434**
80.33014	3.7	35.1	**1/19/1998**	**1.561037**	172	35.1	**1/19/1998**		**72.56714**
92.05457	3.6	44.5	**3/24/1998**	**1.925604**	131	44.5	**3/24/1998**		**70.07059**
210.951	5.06	75	**6/14/1998**	**4.56159**	202	75	**6/14/1998**		**182.103**
12.31762	20.7	2.2	**9/26/1998**	**0.547391**	171.3	2.2	**9/26/1998**		**4.529857**
13.3761	29.78	1.7	**########**	**0.608525**	29.7	1.7	**########**		**0.60689**
89.1884	4.8	35	**3/25/1999**	**2.01936**	4.8	35	**3/25/1999**		**2.01936**
18.66946	31	2.2	**6/21/1999**	**0.819764**	31	2.2	**6/21/1999**		**0.819764**

22.10718	40	2.2	**9/23/1999**	**1.05776**	40	2.2	**9/23/1999**	**1.05776**
8.889992	24	4.3	**12/8/1999**	**1.240464**	24	4.3	**12/8/1999**	**1.240464**
17.51314	2.1	62	**3/23/2000**	**1.565004**	2.1	62	**3/23/2000**	**1.565004**
31.80492	8.6	9.8	**6/16/2000**	**1.013046**	8.6	9.8	**6/16/2000**	**1.013046**
13.69078	0.71	1.7	**9/13/2000**	**0.014508**	0.7	1.7	**9/13/2000**	**0.014304**
16.39528	27.8	2.2	**########**	**0.735143**	27.8	2.2	**########**	**0.735143**
11.82047	27.5	2.2	**3/15/2001**	**0.72721**	27.5	2.2	**3/15/2001**	**0.72721**
9.281844	12.9	3.9	**6/21/2001**	**0.604726**	12.9	3.9	**6/21/2001**	**0.604726**
1.87512	23	0.6	**9/19/2001**	**0.165876**	23	0.6	**9/19/2001**	**0.165876**
6.611	20	2.2	**########**	**0.52888**	20	2.2	**########**	**0.52888**
14.98894	16.6	4.3	**3/19/2002**	**0.857988**	16.6	4.3	**3/19/2002**	**0.857988**
507.1118	5.35	86.1	**6/20/2002**	**5.536833**	5.3	86.1	**6/20/2002**	**5.485087**
6.784088	16.7	1.7	**9/18/2002**	**0.341248**	211	1.7	**9/18/2002**	**4.311574**
15.55749	16.4	4.3	**########**	**0.84765**	214	4.3	**########**	**11.0608**
131.4207	3.8	59.1	**3/24/2003**	**2.699452**	168	59.1	**3/24/2003**	**119.3442**
32.02128	5.38	18	**6/13/2003**	**1.164017**	113	18	**6/13/2003**	**24.44868**
246.41	5.6	41	**9/30/2003**	**2.759792**	194	41	**9/30/2003**	**95.60708**
263.7621	3.35	92.2	**########**	**3.712617**	136	92.2	**########**	**150.7212**
338.964	2.88	120	**3/29/2004**	**4.154112**	104	120	**3/29/2004**	**150.0096**
310.7699	3.4	114.4	**6/29/2004**	**4.675299**	140	114.4	**6/29/2004**	**192.5123**
1082.805	7.02	199.3	**9/27/2004**	**16.81701**	216	199.3	**9/27/2004**	**517.4466**

Ernest Mine

Fig 1.52 Iron Load

Date	**Monitoring Point**	**Monitoring Point**					
	Flow	**Acidity**			**Iron**		
5/4/1994	257	2660	**5/4/1994**	**8217.112**	10	257	**5/4/1994**
6/8/1994	44	2840	**6/8/1994**	**1502.019**	473.3	44	**6/8/1994**
7/8/1994	5	4580	**7/8/1994**	**275.258**	399.2	5	**7/8/1994**
8/11/1994	12.7	4540	**8/11/1994**	**693.0492**	339.2	12.7	**8/11/1994**
9/7/1994	8.6	4240	**9/7/1994**	**438.2973**	366.2	8.6	**9/7/1994**
10/7/1994	3.7	4560	**10/7/1994**	**202.8014**	359.9	3.7	**10/7/1994**
11/7/1994	0.5	4700	**11/7/1994**	**28.247**	352.2	0.5	**11/7/1994**
12/9/1994	53	1068	**12/9/1994**	**680.3801**	0.08	53	**12/9/1994**
1/9/1995	13	3304	**1/9/1995**	**516.283**	285	13	**1/9/1995**
2/3/1995			**2/3/1995**	**0**			**2/3/1995**
3/8/1995	38.6	3136	**3/8/1995**	**1455.016**	457	38.6	**3/8/1995**
4/11/1995	107	402	**4/11/1995**	**517.0283**	143.6	107	**4/11/1995**
4/26/1995	27.4		**4/26/1995**			27.4	**4/26/1995**
5/9/1995	26.9	3620	**5/9/1995**	**1170.484**	413.1	26.9	**5/9/1995**
6/8/1995	51	254	**6/8/1995**	**155.7071**	373.1	51	**6/8/1995**
7/13/1995	24.8	3440	**7/13/1995**	**1025.45**	406	24.8	**7/13/1995**
8/11/1995	4.5	3420	**8/11/1995**	**184.9878**	254.7	4.5	**8/11/1995**
9/22/1995	2.8	4120	**9/22/1995**	**138.6627**	229	2.8	**9/22/1995**
10/3/1995	0.7	3840	**10/3/1995**	**32.30976**	296.8	0.7	**10/3/1995**
11/8/1995	2.2	3460	**11/8/1995**	**91.49624**	245.4	2.2	**11/8/1995**
12/7/1995	9	3460	**12/7/1995**	**374.3028**	248.5	9	**12/7/1995**
3/12/1996	175.9	4050	**3/12/1996**	**8562.988**	960	175.9	**3/12/1996**
6/12/1996	77.1	4000	**6/12/1996**	**3706.968**	376	77.1	**6/12/1996**
8/14/1996	8.5	3650	**8/14/1996**	**372.9205**	445	8.5	**8/14/1996**
11/25/1996	37.9	1330	**11/25/1996**	**605.8921**	220	37.9	**########**
12/16/1996	86.3	1098	**12/16/1996**	**1138.984**	160.4	86.3	**########**
1/15/1997	63.4	1600	**1/15/1997**	**1219.309**	303.1	63.4	**1/15/1997**
2/18/1997	55.3	1242	**2/18/1997**	**825.5649**	137.7	55.3	**2/18/1997**
3/24/1997	67	1120	**3/24/1997**	**901.9808**	155.9	67	**3/24/1997**
6/10/1997	41.3	1270	**6/10/1997**	**630.461**	109.6	41.3	**6/10/1997**
9/23/1997	3	2740	**9/23/1997**	**98.8044**	609.1	3	**9/23/1997**
11/27/1997	14.4	2620	**11/27/1997**	**453.4906**	239.9	14.4	**########**
12/18/1997	27	2860	**12/18/1997**	**928.1844**	216.5	27	**########**
1/19/1998	35.1	1720	**1/19/1998**	**725.6714**	190.4	35.1	**1/19/1998**
3/24/1998	44.5	1204	**3/24/1998**	**644.0076**	172.1	44.5	**3/24/1998**
6/14/1998	75	2500	**6/14/1998**	**2253.75**	234	75	**6/14/1998**
9/26/1998	2.2	2760	**9/26/1998**	**72.98544**	465.8	2.2	**9/26/1998**
12/17/1998	1.7	1820	**12/17/1998**	**37.18988**	654.6	1.7	**########**
3/25/1999	35	1430	**3/25/1999**	**601.601**	212	35	**3/25/1999**
6/21/1999	2.2	2490	**6/21/1999**	**65.84556**	706	2.2	**6/21/1999**

9/23/1999	2.2	2570	**9/23/1999**	**67.96108**	836	2.2	**9/23/1999**
12/8/1999	4.3	2450	**12/8/1999**	**126.6307**	172	4.3	**12/8/1999**
3/23/2000	62	310	**3/23/2000**	**231.0244**	23.5	62	**3/23/2000**
6/16/2000	9.8	456	**6/16/2000**	**53.71498**	270	9.8	**6/16/2000**
9/13/2000	1.7	650	**9/13/2000**	**13.2821**	670	1.7	**9/13/2000**
12/19/2000	2.2	470	**12/19/2000**	**12.42868**	620	2.2	**########**
3/15/2001	2.2	2700	**3/15/2001**	**71.3988**	447	2.2	**3/15/2001**
6/21/2001	3.9	2510	**6/21/2001**	**117.6638**	198	3.9	**6/21/2001**
9/19/2001	0.6	3200	**9/19/2001**	**23.0784**	260	0.6	**9/19/2001**
12/12/2001	2.2	3300	**12/12/2001**	**87.2652**	250	2.2	**########**
3/19/2002	4.3	2300	**3/19/2002**	**118.8778**	290	4.3	**3/19/2002**
6/20/2002	86.1	2500	**6/20/2002**	**2587.305**	490	86.1	**6/20/2002**
9/18/2002	1.7	3800	**9/18/2002**	**77.6492**	332	1.7	**9/18/2002**
12/13/2002	4.3	3400	**12/13/2002**	**175.7324**	301	4.3	**########**
3/24/2003	59.1	1900	**3/24/2003**	**1349.726**	185	59.1	**3/24/2003**
6/13/2003	18	1240	**6/13/2003**	**268.2864**	148	18	**6/13/2003**
9/30/2003	41	2300	**9/30/2003**	**1133.486**	500	41	**9/30/2003**
12/23/2003	92.2	1650	**12/23/2003**	**1828.603**	238	92.2	**########**
3/29/2004	120	1400	**3/29/2004**	**2019.36**	235	120	**3/29/2004**
6/29/2004	114.4	1650	**6/29/2004**	**2268.895**	226	114.4	**6/29/2004**
9/27/2004	199.3	2150	**9/27/2004**	**5150.51**	452	199.3	**9/27/2004**

		Manganese			Load	Concentrat	**Aluminum**
30.8914		5	257	**5/4/1994**	**15.4457**	5	7
250.3189		6.4	44	**6/8/1994**	**3.384832**	6.4	171.6
23.99192		9.59	5	**7/8/1994**	**0.576359**	9.59	
51.78024		11.6	12.7	**8/11/1994**	**1.770786**	11.6	321
37.85483		11.9	8.6	**9/7/1994**	**1.230127**	11.9	366
16.00619		13	3.7	**10/7/1994**	**0.578162**	13	427.8
2.116722		131.1	0.5	**11/7/1994**	**0.787911**	131.1	307.9
0.050965		0.01	53	**12/9/1994**	**0.006371**	0.01	0.49
44.5341		10.15	13	**1/9/1995**	**1.586039**	10.15	295.2
		11.5		**2/3/1995**		11.5	
212.0352		4.38	38.6	**3/8/1995**	**2.032197**	4.38	
184.6897		1.17	107	**4/11/1995**	**1.504784**	1.17	
			27.4	**4/26/1995**			
133.5709		10	26.9	**5/9/1995**	**3.23338**	10	
228.7178		7.6	51	**6/8/1995**	**4.658952**	7.6	
121.027		10.4	24.8	**7/13/1995**	**3.100198**	10.4	
13.77672		13.6	4.5	**8/11/1995**	**0.735624**	13.6	
7.707224		12.57	2.8	**9/22/1995**	**0.423056**	12.57	
2.497275		16.7	0.7	**10/3/1995**	**0.140514**	16.7	
6.489358		14	2.2	**11/8/1995**	**0.370216**	14	
26.88273		10.52	9	**12/7/1995**	**1.138054**	10.52	
2029.745		7	175.9	**3/12/1996**	**14.80023**	7	
348.455		5.9	77.1	**6/12/1996**	**5.467778**	5.9	
45.46565		14.8	8.5	**8/14/1996**	**1.512116**	14.8	
	100.2228	5.37	37.9	**########**	**2.446346**	5.37	
	166.3871	3.8	86.3	**########**	**3.941839**	3.8	
	230.9828	5.03	63.4	**1/15/1997**	**3.833202**	5.03	
	91.53002	3.81	55.3	**2/18/1997**	**2.53253**	3.81	
	125.5525	3.24	67	**3/24/1997**	**2.609302**	3.24	
	54.40829	3.9	41.3	**6/10/1997**	**1.936061**	3.9	
	21.96415	33.1	3	**9/23/1997**	**1.193586**	33.1	
	41.52381	10.3	14.4	**########**	**1.782806**	10.3	
	70.26291	6.3	27	**########**	**2.044602**	6.3	
	80.33014	3.7	35.1	**1/19/1998**	**1.561037**	3.7	
	92.05457	3.6	44.5	**3/24/1998**	**1.925604**	3.6	
	210.951	5.06	75	**6/14/1998**	**4.56159**	5.06	
	12.31762	20.7	2.2	**9/26/1998**	**0.547391**	20.7	
	13.3761	29.78	1.7	**########**	**0.608525**	29.78	
	89.1884	4.8	35	**3/25/1999**	**2.01936**	4.8	
	18.66946	31	2.2	**6/21/1999**	**0.819764**	31	

22.10718	40	2.2	**9/23/1999**	**1.05776**	40
8.889992	24	4.3	**12/8/1999**	**1.240464**	24
17.51314	2.1	62	**3/23/2000**	**1.565004**	2.1
31.80492	8.6	9.8	**6/16/2000**	**1.013046**	8.6
13.69078	0.71	1.7	**9/13/2000**	**0.014508**	0.71
16.39528	27.8	2.2	**########**	**0.735143**	27.8
11.82047	27.5	2.2	**3/15/2001**	**0.72721**	27.5
9.281844	12.9	3.9	**6/21/2001**	**0.604726**	12.9
1.87512	23	0.6	**9/19/2001**	**0.165876**	23
6.611	20	2.2	**########**	**0.52888**	20
14.98894	16.6	4.3	**3/19/2002**	**0.857988**	16.6
507.1118	5.35	86.1	**6/20/2002**	**5.536833**	5.35
6.784088	16.7	1.7	**9/18/2002**	**0.341248**	16.7
15.55749	16.4	4.3	**########**	**0.84765**	16.4
131.4207	3.8	59.1	**3/24/2003**	**2.699452**	3.8
32.02128	5.38	18	**6/13/2003**	**1.164017**	5.38
246.41	5.6	41	**9/30/2003**	**2.759792**	5.6
263.7621	3.35	92.2	**########**	**3.712617**	3.35
338.964	2.88	120	**3/29/2004**	**4.154112**	2.88
310.7699	3.4	114.4	**6/29/2004**	**4.675299**	3.4
1082.805	7.02	199.3	**9/27/2004**	**16.81701**	7.02

Ernest Mine
Fig 1.53 Alkalinity Load

Date	
11/25/1996	68
3/24/1997	68
6/10/1997	72
9/23/1997	
12/18/1997	38
3/24/1998	28
6/14/1998	56
9/26/1998	
12/17/1998	
3/25/1999	34
6/21/1999	
9/23/1999	
12/8/1999	
3/23/2000	28
6/16/2000	68
9/13/2000	
12/19/2000	28
3/15/2001	32
6/21/2001	76
9/19/2001	
12/12/2001	
3/19/2002	60
6/20/2002	68
9/18/2002	
12/13/2002	
3/24/2003	48
6/13/2003	60
9/30/2003	75
12/23/2003	59

Ernest Mine
Fig 1.54 Sulfate Load

Date	Monitoring Point	Monitoring Point			
	Sulfate			Load	Concentration
4/5/1994	4.2	45	4/5/1994	2.27178	45
5/4/1994	11.8	26	5/4/1994	3.687736	26
6/8/1994			6/8/1994		
7/8/1994			7/8/1994		
8/11/1994			8/11/1994		
9/7/1994			9/7/1994		
10/7/1994			10/7/1994		
11/7/1994			11/7/1994		
12/9/1994	12	26	12/9/1994	3.75024	26
1/9/1995	0.5	18	1/9/1995	0.10818	18
2/3/1995			2/3/1995		
3/8/1995	20.9	20	3/8/1995	5.02436	20
4/11/1995	25.5	22	4/11/1995	6.74322	22
4/26/1995			4/26/1995		
5/9/1995			5/9/1995		
6/8/1995	9.1	25	6/8/1995	2.73455	25
7/13/1995			7/13/1995		
8/11/1995			8/11/1995		
9/22/1995			9/22/1995		
10/3/1995			10/3/1995		
11/8/1995			11/8/1995		
12/7/1995			12/7/1995		
3/12/1996	7.2	37.52	3/12/1996	3.247131	37.52
6/12/1996			6/12/1996		
8/14/1996			8/14/1996		
11/25/1996	1	47	11/25/1996	0.56494	47
3/24/1997	3.5	49	3/24/1997	2.06143	49
6/10/1997	3.5	31	6/10/1997	1.30417	31
9/23/1997			9/23/1997		
12/18/1997	1.1	33	12/18/1997	0.436326	33
3/24/1998	6.2	35	3/24/1998	2.60834	35
6/14/1998	0.4	25	6/14/1998	0.1202	25
9/26/1998			9/26/1998		
12/17/1998			12/17/1998		
3/25/1999	6.2	28	3/25/1999	2.086672	28
6/21/1999			6/21/1999		
9/23/1999			9/23/1999		
12/8/1999			12/8/1999		
3/23/2000	28.3	24.3	3/23/2000	8.266034	24.3
6/16/2000	1	30.5	6/16/2000	0.36661	30.5

9/13/2000			9/13/2000		
12/19/2000	8.5	20.5	12/19/2000	2.094485	20.5
3/15/2001	11.1	20.5	3/15/2001	2.735151	20.5
6/21/2001	0.5	30	6/21/2001	0.1803	30
9/19/2001			9/19/2001		
12/12/2001			12/12/2001		
3/19/2002	8.5	22	3/19/2002	2.24774	22
6/20/2002	5	32	6/20/2002	1.9232	32
9/18/2002			9/18/2002		
12/13/2002			12/13/2002		
3/24/2003	5.2	30	3/24/2003	1.87512	30
6/13/2003	5.2	26	6/13/2003	1.625104	26
9/30/2003	3.5	31	9/30/2003	1.30417	31
12/23/2003	9.2	28	12/23/2003	3.096352	28

Ernest Mine
Fig 1.55 Aluminum Load

Date	Monitoring Point	Monitoring Point					
	Sulfate			Load	Concentrat	Aluminum	
4/5/1994	4.2	45	4/5/1994	2.27178	4.2	0.07	4.2
5/4/1994	11.8	26	5/4/1994	3.687736	11.8	0.03	11.8
6/8/1994			6/8/1994				
7/8/1994			7/8/1994				
8/11/1994			8/11/1994				
9/7/1994			9/7/1994				
10/7/1994			10/7/1994				
11/7/1994			11/7/1994				
12/9/1994	12	26	12/9/1994	3.75024	12	0.08	12
1/9/1995	0.5	18	1/9/1995	0.10818	0.5	0.1	0.5
2/3/1995			2/3/1995				
3/8/1995	20.9	20	3/8/1995	5.02436	20.9	0.03	20.9
4/11/1995	25.5	22	4/11/1995	6.74322	25.5	0.12	25.5
4/26/1995			4/26/1995				
5/9/1995			5/9/1995				
6/8/1995	9.1	25	6/8/1995	2.73455	9.1	0.13	9.1
7/13/1995			7/13/1995				
8/11/1995			8/11/1995				
9/22/1995			9/22/1995				
10/3/1995			10/3/1995				
11/8/1995			11/8/1995				
12/7/1995			12/7/1995				
3/12/1996	7.2	37.52	3/12/1996	3.247131	7.2	0.27	7.2
6/12/1996			6/12/1996				
8/14/1996			8/14/1996				
11/25/1996	1	47	11/25/1996	0.56494	1	0.23	1
3/24/1997	3.5	49	3/24/1997	2.06143	3.5	0.04	3.5
6/10/1997	3.5	31	6/10/1997	1.30417	3.5	0.04	3.5
9/23/1997			9/23/1997				
12/18/1997	1.1	33	12/18/1997	0.436326	1.1	0.04	1.1
3/24/1998	6.2	35	3/24/1998	2.60834	6.2	0.04	6.2
6/14/1998	0.4	25	6/14/1998	0.1202	0.4	0.04	0.4
9/26/1998			9/26/1998				
12/17/1998			12/17/1998				
3/25/1999	6.2	28	3/25/1999	2.086672	6.2	0.32	6.2
6/21/1999			6/21/1999				
9/23/1999			9/23/1999				
12/8/1999			12/8/1999				
3/23/2000	28.3	24.3	3/23/2000	8.266034	28.3	0.1	28.3
6/16/2000	1	30.5	6/16/2000	0.36661	1	0.6	1

9/13/2000			9/13/2000				
12/19/2000	8.5	20.5	12/19/2000	2.094485	8.5	0.32	8.5
3/15/2001	11.1	20.5	3/15/2001	2.735151	11.1	0.05	11.1
6/21/2001	0.5	30	6/21/2001	0.1803	0.5	0.4	0.5
9/19/2001			9/19/2001				
12/12/2001			12/12/2001				
3/19/2002	8.5	22	3/19/2002	2.24774	8.5	0.1	8.5
6/20/2002	5	32	6/20/2002	1.9232	5	0.51	5
9/18/2002			9/18/2002				
12/13/2002			12/13/2002				
3/24/2003	5.2	30	3/24/2003	1.87512	5.2	0.13	5.2
6/13/2003	5.2	26	6/13/2003	1.625104	5.2	0.21	5.2
9/30/2003	3.5	31	9/30/2003	1.30417	3.5	0.07	3.5
12/23/2003	9.2	28	12/23/2003	3.096352	9.2	0.07	9.2
3/29/2004	5.3	27	3/29/2004	1.720062	5.3	0.1	5.3
6/29/2004	2.8	34	6/29/2004	1.144304	2.8	0.24	2.8
9/27/2004	2	34	9/27/2004	0.81736	2	0.44	2

4/5/1994	0.003534
5/4/1994	0.004255
6/8/1994	
7/8/1994	
8/11/1994	
9/7/1994	
10/7/1994	
11/7/1994	
12/9/1994	0.011539
1/9/1995	0.000601
2/3/1995	
3/8/1995	0.007537
4/11/1995	0.036781
4/26/1995	
5/9/1995	
6/8/1995	0.01422
7/13/1995	
8/11/1995	
9/22/1995	
10/3/1995	
11/8/1995	
12/7/1995	
3/12/1996	0.023367
6/12/1996	
8/14/1996	
11/25/1996	0.002765
3/24/1997	0.001683
6/10/1997	0.001683
9/23/1997	
12/18/1997	0.000529
3/24/1998	0.002981
6/14/1998	0.000192
9/26/1998	
12/17/1998	
3/25/1999	0.023848
6/21/1999	
9/23/1999	
12/8/1999	
3/23/2000	0.034017
6/16/2000	0.007212

9/13/2000	
12/19/2000	0.032694
3/15/2001	0.006671
6/21/2001	0.002404
9/19/2001	
12/12/2001	
3/19/2002	0.010217
6/20/2002	0.030651
9/18/2002	
12/13/2002	
3/24/2003	0.008126
6/13/2003	0.013126
9/30/2003	0.002945
12/23/2003	0.007741
3/29/2004	0.006371
6/29/2004	0.008077
9/27/2004	0.010578

Ernest Mine
Fig 1.56 pH

Date	Monitoring Point	Monitoring Point
4/5/1994	5.6	
5/4/1994	6	
6/8/1994	6	
7/8/1994	5.6	
8/11/1994	5.9	
9/7/1994	6.3	
10/7/1994	5.8	
11/7/1994	4.5	
12/9/1994	6.4	
1/9/1995	6	
2/3/1995	6.2	
3/8/1995	6.5	
4/11/1995	6.5	
4/26/1995	6.3	
5/9/1995	6.5	
6/8/1995	5.5	
7/13/1995	5	
8/11/1995	4.5	
9/22/1995	5	
10/3/1995	5.8	
11/8/1995	5.8	
12/7/1995	5.2	
3/12/1996	6.5	
6/12/1996		
8/14/1996	5.8	
11/25/1996		5.8
3/24/1997		5.9
6/10/1997		6
9/23/1997		6
12/18/1997		6
3/24/1998		6.6
6/14/1998		6.1
9/26/1998		5.9
12/17/1998		5.9
3/25/1999		5
6/21/1999		5.9
9/23/1999		6.4
12/8/1999		6.4
3/23/2000		6.4
6/16/2000		6.3
9/13/2000		6.5

12/19/2000	6.4
3/15/2001	5.9
6/21/2001	6.4
9/19/2001	4.7
12/12/2001	6.5
3/19/2002	6.8
6/20/2002	5
9/18/2002	4.5
12/13/2002	6.7
3/24/2003	5.5
6/13/2003	5.2
9/30/2003	6
12/23/2003	5.6
3/29/2004	5.7
6/29/2004	5.8
9/27/2004	5.3
	5.909375

Ernest Mine
Fig 1.56a Alkalinity

Date	Before Ash	After Ash
4/5/1994	10	
5/4/1994	18	
6/8/1994	34	
7/8/1994	14	
8/11/1994	12	
9/7/1994	28	
10/7/1994	20	
11/7/1994	10	
12/9/1994	26	
1/9/1995	30	
2/3/1995	18	
3/8/1995	22	
4/11/1995	30	
4/26/1995		
5/9/1995	24	
6/8/1995	16	
7/13/1995	8	
8/11/1995	12	
9/22/1995	0	
10/3/1995	6	
11/8/1995	38	
12/7/1995	26	
3/12/1996	8	
6/12/1996	42	
8/14/1996	4	
11/25/1996		10
3/24/1997		20
6/10/1997		0
9/23/1997		10
12/18/1997		24
3/24/1998		30
6/14/1998		12
9/26/1998		14
12/17/1998		24
3/25/1999		14
6/21/1999		0
9/23/1999		4
12/8/1999		18
3/23/2000		12
6/16/2000		26
9/13/2000		52
12/19/2000		20

3/15/2001		22
6/21/2001		14
9/19/2001		0
12/12/2001		44
3/19/2002		20
6/20/2002		0
9/18/2002		0
12/13/2002		36
3/24/2003		18
6/13/2003		40
9/30/2003		44
12/23/2003		32
3/29/2004		27
6/29/2004		40
9/27/2004		13

Ernest Mine

Fig 1.57 Specific Conductance

Date	Monitoring Point E4	Monitoring Point E34
4/5/1994	285	225
5/4/1994	222	200
6/8/1994	447	400
7/8/1994	251	235
8/11/1994	499	494
9/7/1994	455	460
10/7/1994	348	312
11/7/1994	506	492
12/9/1994	195	180
1/9/1995	350	325
2/3/1995	318	398
3/8/1995	236	224
4/11/1995	200	185
4/26/1995		
5/9/1995	330	312
6/8/1995	214	206
7/13/1995	454	397
8/11/1995	519	447
9/22/1995	729	576
10/3/1995	679	642
11/8/1995	348	316
12/7/1995	279	259
3/12/1996	280	215
6/12/1996	270	250
8/14/1996	530	470
11/25/1996	289	269
3/24/1997	285	245
6/10/1997	307	248
9/23/1997	567	502
12/18/1997	276	228
3/24/1998	251	211
6/14/1998	267	233
9/26/1998	440	429
12/17/1998	542	490
3/25/1999	280	270
6/21/1999	488	428
9/23/1999	526	491
12/8/1999	295	281
3/23/2000	196	169
6/16/2000	169	161
9/13/2000	357	354

12/19/2000	243	231
3/15/2001	243	238
6/21/2001	383	357
9/19/2001	783	599
12/12/2001	525	342
3/19/2002	378	224
6/20/2002	457	263
9/18/2002	969	487
12/13/2002	526	481
3/24/2003	276	253
6/13/2003	189	193
9/30/2003	295	271
12/23/2003	289	295
3/29/2004	281	265
6/29/2004	273	249
9/27/2004	324	283

Ernest Mine
Fig 1.58 pH

	E34pH Before ash	E34pH After Ash	E4 Before Ash	E4 After Ash	E34 pH
4/5/1994	6.8		5.6		6.8
5/4/1994	7		6		7
6/8/1994	7.1		6		7.1
7/8/1994	7.1		5.6		7.1
8/11/1994	6.8		5.9		6.8
9/7/1994	6.6		6.3		6.6
10/7/1994	6.7		5.8		6.7
11/7/1994	6.4		4.5		6.4
12/9/1994	6.6		6.4		6.6
1/9/1995	6.9		6		6.9
2/3/1995	6.3		6.2		6.3
3/8/1995	7.3		6.5		7.3
4/11/1995	6.6		6.5		6.6
4/26/1995			6.3		
5/9/1995	6.8		6.5		6.8
6/8/1995	7.3		5.5		7.3
7/13/1995	6.3		5		6.3
8/11/1995	6.7		4.5		6.7
9/22/1995	5.2		5		5.2
10/3/1995	6.1		5.8		6.1
11/8/1995	7		5.8		7
12/7/1995	6.6		5.2		6.6
3/12/1996	6.78		6.5		6.78
6/12/1996	7				7
8/14/1996	6		5.8		6
11/25/1996		6.9		5.8	6.9
3/24/1997		6.8		5.9	6.8
6/10/1997		7.2		6	7.2
9/23/1997		6.7		6	6.7
12/18/1997		7.2		6	7.2
3/24/1998		6.9		6.6	6.9
6/14/1998		6.9		6.1	6.9
9/26/1998		6.9		5.9	6.9
12/17/1998		6.9		5.9	6.9
3/25/1999		5.7		5	5.7
6/21/1999		6.1		5.9	6.1
9/23/1999		6.3		6.4	6.3
12/8/1999		6.4		6.4	6.4
3/23/2000		6		6.4	6
6/16/2000		6.5		6.3	6.5

9/13/2000		7		6.5	7
12/19/2000		6.8		6.4	6.8
3/15/2001		6.6		5.9	6.6
6/21/2001		6.5		6.4	6.5
9/19/2001		5.6		4.7	5.6
12/12/2001		7		6.5	7
3/19/2002		6.7		6.8	6.7
6/20/2002		6.4		5	6.4
9/18/2002		7		4.5	7
12/13/2002		7.4		6.7	7.4
3/24/2003		7		5.5	7
6/13/2003		7.4		5.2	7.4
9/30/2003		6.1		6	6.1
12/23/2003		6.4		5.6	6.4
3/29/2004		6.7		5.7	6.7
6/29/2004		7.2		5.8	7.2
9/27/2004		7		5.3	7

Ernest Mine
Fig 1.59 Aluminum

Date	Monitoring Point E4	Monitoring Point E34
4/5/1994	1.01	0.47
5/4/1994	1.31	0.22
6/8/1994	0.47	0.22
7/8/1994		
8/11/1994	1.16	0.01
9/7/1994	0.41	0.13
10/7/1994	0.32	0.13
11/7/1994	0.92	0.16
12/9/1994	0.24	0.06
1/9/1995	0.46	0.25
2/3/1995	1.3	0.48
3/8/1995	0.18	0.14
4/11/1995	0.45	0.3
4/26/1995		
5/9/1995	0.57	0.31
6/8/1995	0.59	0.33
7/13/1995	1.06	0.11
8/11/1995	4.44	0.27
9/22/1995	6.27	0.16
10/3/1995	3.72	0.75
11/8/1995	0.12	0.11
12/7/1995	0.37	0.07
3/12/1996	3.1	0.94
6/12/1996	10.17	0.6
8/14/1996	4.35	0.79
11/25/1996	2	0.76
3/24/1997	1.22	0.23
6/10/1997	0.12	0.1
9/23/1997	3.3	0.31
12/18/1997	0.15	0.05
3/24/1998	1	0.34
6/14/1998	2.65	0.37
9/26/1998	2.37	0.22
12/17/1998	3.75	1.11
3/25/1999	1.4	0.32
6/21/1999	3.7	0.9
9/23/1999	4.5	0.32
12/8/1999	2.2	1.3
3/23/2000	0.9	0.62
6/16/2000	2.4	1.5
9/13/2000	1.9	1.6

12/19/2000	1.2	0.32
3/15/2001	1.1	0.2
6/21/2001	3	0.42
9/19/2001	8.3	0.1
12/12/2001	2.1	0.14
3/19/2002	1.12	0.1
6/20/2002	5.95	0.56
9/18/2002		0.62
12/13/2002	1.63	0.26
3/24/2003	2.39	0.52
6/13/2003	5.55	1.46
9/30/2003	1.7	0.14
12/23/2003	1.28	0.05
3/29/2004	1.5	0.22
6/29/2004	2.57	0.89
9/27/2004	4.1	0.54

Ernest Mine
Fig 1.60 Sulfate

Date	Monitoring Point E4	Monitoring Point E34
4/5/1994	231	59
5/4/1994	47	37
6/8/1994	247	96
7/8/1994	62	41
8/11/1994	258	231
9/7/1994	129	107
10/7/1994	153	132
11/7/1994	155	126
12/9/1994	44	37
1/9/1995	33	31
2/3/1995	67	82
3/8/1995	36	32
4/11/1995	32	27
4/26/1995	76	
5/9/1995	37	38
6/8/1995	158	34
7/13/1995	118	129
8/11/1995	229	85
9/22/1995	233	201
10/3/1995	79	214
11/8/1995	56	61
12/7/1995	82	52
3/12/1996	65	54
6/12/1996		46
8/14/1996	215	166
11/25/1996	84	68
3/24/1997	66	76
6/10/1997	33	52
9/23/1997	207	147
12/18/1997	65	50
3/24/1998	51	44
6/14/1998	76	43
9/26/1998	115	70
12/17/1998	175	132
3/25/1999	42	42
6/21/1999	172	144
9/23/1999	163	26
12/8/1999	55	51
3/23/2000	39	32
6/16/2000	60	44
9/13/2000	68.5	52

12/19/2000	34	31
3/15/2001	36.5	26
6/21/2001	100	83
9/19/2001	309	208
12/12/2001	82	35
3/19/2002	41	29
6/20/2002	110	46
9/18/2002	403	68
12/13/2002	50	36
3/24/2003	64	43
6/13/2003	21	19
9/30/2003	50	36
12/23/2003	35	28
3/29/2004	37	31
6/29/2004	47	33
9/27/2004	98	61

Ernest Mine
Fig 1.61 Acidity

Date	Monitoring Point	Monitoring Point	Monitoring Point
	E7	E35	E70
8/14/1996	580	41	780
11/25/1996	288	0	
3/24/1997	272	0	
6/10/1997	90	0	
9/23/1997	198	0	
12/18/1997	366	0	1026
3/24/1998	258	0	
6/24/1998	320	0	2240
9/25/1998	344	0	290
12/11/1998	234	0	
3/25/1999	300	-18	930
6/21/1999	248	-38	1330
9/23/1999	356	-26	450
12/8/1999	535	-48	1670
3/23/2000	184	-28	860
6/16/2000	344	-30	352
9/13/2000	298	-38	175
12/19/2000	340	-50	146
3/15/2001	250	-66	740
6/21/2001	302	-48	1730
9/19/2001	500	-44	
12/12/2001	380	-52	210
3/19/2002	340	-34	910
6/20/2002	530	-32	1900
9/18/2002	438	0	1800
12/13/2002	314	0	440
3/24/2003	398	0	1400
6/13/2003	224	0	880
9/30/2003	576	0	1900
12/23/2003	381	0	1100
3/29/2004	328	0	975
6/29/2004	382	0	1825
9/27/2004	426	0	2500

Ernest Mine
Fig 1.62 pH

Date	Monitoring Point	Monitoring Point	Monitoring Point
	E7	E35	E70
8/14/1996	4.8	6.3	
11/25/1996	4.7	6	
3/24/1997	4.7	5.9	
6/10/1997	4.9	6	4.5
9/23/1997	4.8	6.4	
12/18/1997	4.5	6	4
3/24/1998	4.8	5.8	4.4
6/24/1998	4.8	5.9	4.3
9/25/1998	4.9	6	4.6
12/11/1998	4.7	6	
3/25/1999	4.8	5.7	4
6/21/1999	4.8	5.9	4.5
9/23/1999	4.7	5.8	4.7
12/8/1999	4.7	6	4
3/23/2000	4.8	5.9	4
6/16/2000	4.2	5.7	4
9/13/2000	4.7	6	4.3
12/19/2000	5	6.1	4
3/15/2001	5	6	4.5
6/21/2001	5	5.9	4.5
9/19/2001	4.8	6	
12/12/2001	4.8	6	4.5
3/19/2002	5	5.8	4.5
6/20/2002	4.9	5.9	4.5
9/18/2002	4.5	6.1	4.5
12/13/2002	5	6.2	4
3/24/2003	5.5	6	4
6/13/2003	4.8	6	2.8
9/30/2003	4.6	6	2.9
12/23/2003	4.4	5.1	2.7
3/29/2004	5	6	2.8
6/29/2004	4.5	5.8	2.7
9/27/2004	4.7	5.7	4

Ernest Mine
Fig 1.63 Iron

Date	Monitoring Point	Monitoring Point	Monitoring Point
	E7	E-35	E-70
8/14/1996	101.5	26.2	
11/25/1996	96.39	14.96	
3/24/1997	77.13	3.16	
6/10/1997	47.01	3.29	16.24
9/23/1997	80.38	20.91	12.8
12/18/1997	93.02	5.3	24.8
3/24/1998	81.79	3.13	37.12
6/24/1998	101.4	4.39	90.25
9/25/1998	88.92	13.48	9.93
12/11/1998	77.79	20.88	
3/25/1999	114	2.6	29
6/21/1999	97.3	10.6	172
9/23/1999	144	25	30
12/8/1999	87.5	6.5	20.5
3/23/2000	77.8	1.1	22
6/16/2000	104	3.2	114
9/13/2000	123	18.9	75
12/19/2000	79	20.2	2.6
3/15/2001	70.8	3.7	10.9
6/21/2001	97.9	7.39	126
9/19/2001	150	24	
12/12/2001	100	28	3.1
3/19/2002	122	11.2	44.4
6/20/2002	151	0.41	254
9/18/2002	143	36.2	259
12/13/2002	98.1	26.7	10.1
3/24/2003	101	2.72	75.2
6/13/2003	83.9	1.06	65.5
9/30/2003	159	26.5	427
12/23/2003	114	16.6	110
3/29/2004	120	7.69	138
6/29/2004	104	13.5	274
9/27/2004	141	9.23	488

Ernest Mine

Fig 1.64 Manganese

Date	Monitoring Point	Monitoring Point	
	E7	E35	E70
8/14/1996	2.8	1.8	
11/25/1996	2.12	1.39	
3/24/1997	2.22	0.77	
6/10/1997	2.08	1.01	1.74
9/23/1997	2.45	1.73	
12/18/1997	2.75	1.21	2.67
3/24/1998	2.03	1	1.67
6/24/1998	2.32	0.95	3.3
9/25/1998	2.35	1.26	5.55
12/11/1998	2.53	1.57	
3/25/1999	2.4	0.78	2.2
6/21/1999	2.2	1.2	3.7
9/23/1999	3.5		6
12/8/1999	3.5	1.1	4.4
3/23/2000	2.4	0.5	2.4
6/16/2000	2.8	1.1	3.7
9/13/2000	3.2	1.7	6
12/19/2000	2.5	1.4	5
3/15/2001	2.3	0.89	3.9
6/21/2001	2.43	1.01	3.84
9/19/2001	4	1.7	
12/12/2001	3	2.1	5.5
3/19/2002	2.88	1.7	4.13
6/20/2002	2.53	0.38	3.22
9/18/2002	3.21	2.03	5.63
12/13/2002	2.83	2.53	6.19
3/24/2003	2.55	1.48	2.18
6/13/2003	2.46	1.56	2.39
9/30/2003	2.49	2.09	3.56
12/23/2003	2.2	2.09	1.86
3/29/2004	2.51	1.79	1.82
6/29/2004	2.47	2.29	3.24
9/27/2004	3.12	1.85	4.15

Ernest Mine
Fig 1.65 Aluminum

Date	Monitoring Point	Monitoring Point	Monitoring Point
	E7	E35	E70
8/14/1996	28.5	0.18	
11/25/1996	24.65	0.24	
3/24/1997	20.79	0.08	
6/10/1997	13.16	0.04	101.4
9/23/1997	21.7	0.1	
12/18/1997	32.87	0.04	136.1
3/24/1998	22.84	0.06	98.5
6/24/1998	30.59	0.06	215.6
9/25/1998	20.59	0.04	23.01
12/11/1998	29.88	0.2	
3/25/1999	30	0.32	102
6/21/1999	32	0.32	225
9/23/1999	35	0.32	29.2
12/8/1999	87.5	0.32	240
3/23/2000	23.6	0.22	90.5
6/16/2000	27.3	0.6	180
9/13/2000	36	0.92	77.5
12/19/2000	15	0.32	14
3/15/2001	22.8	0.05	85.2
6/21/2001	23.6	0.05	164
9/19/2001	40	0.1	
12/12/2001	28	0.1	15
3/19/2002	27.8	0.1	88.1
6/20/2002	32.5	0.1	154
9/18/2002	36.4	0.57	149
12/13/2002	26.5	0.1	50.3
3/24/2003	31.8	0.15	147
6/13/2003	20.2	0.12	97.3
9/30/2003	42.2	0.09	165
12/23/2003	31.7	0.11	102
3/29/2004	28.3	0.26	81.3
6/29/2004	32.9	0.44	169
9/27/2004	40.3	0.12	218

Ernest Mine
Fig 1.66 Sulfate

Date	Monitoring Point	Monitoring Point	Monitoring Point
	E7	E35	E70
8/14/1996	873	278.3	975
11/25/1996	766	240	
3/24/1997	675	294	
6/10/1997	557	163	
9/23/1997	712	226	
12/18/1997	786	196	1170
3/24/1998	649	172	926
6/24/1998	773	154	2168
9/25/1998	812	141	505
12/11/1998	722	223	
3/25/1999	800	136	1080
6/21/1999	700	132	1160
9/23/1999	855	266	288
12/8/1999	860	114	1760
3/23/2000	657	105	1015
6/16/2000	705	137	1210
9/13/2000	920	204	770
12/19/2000	725	189	212
3/15/2001	600	129	815
6/21/2001	834	156	1876
9/19/2001	995	186	
12/12/2001	920	220	210
3/19/2002	1100	160	1100
6/20/2002	1100	94	1900
9/18/2002	1151	204	2287
12/13/2002	881	220	653
3/24/2003	966	161	1899
6/13/2003	729	155	1087
9/30/2003	1048	275	2594
12/23/2003	760	266	1419
3/29/2004	648	237	1051
6/29/2004	751	262	2144
9/27/2004	747	244	3101

Ernest Mine
Fig 1.67 Specific Conductance

Date	Monitoring Point	Monitoring Point	Monitoring Point
	E7	E35	E70
8/14/1996	1420	680	
11/25/1996	1350	522	
3/24/1997	1370	490	
6/10/1997	1290	498	2070
9/23/1997	1500	678	
12/18/1997	1450	566	2660
3/24/1998	1370	446	1980
6/24/1998	1530	503	4670
9/25/1998	1560	565	1090
12/11/1998	1590	679	
3/25/1999	1212	456	1173
6/21/1999	1446	445	2220
9/23/1999	1613	658	1119
12/8/1999	2110	449	2910
3/23/2000	1283	312	1944
6/16/2000	1404	310	2880
9/13/2000	1571	585	1565
12/19/2000	1479	526	604
3/15/2001	1355	480	1803
6/21/2001	1503	482	2650
9/19/2001	1860	607	
12/12/2001	1820	596	735
3/19/2002	1460	492	2080
6/20/2002	1640	301	2890
9/18/2002	1750	624	5670
12/13/2002	1520	636	1410
3/24/2003	1560	452	4780
6/13/2003	1270	440	2210
9/30/2003	1880	770	4290
12/23/2003	1550	756	3010
3/29/2004	1570	703	2720
6/29/2004	1500	730	3620
9/27/2004	1760	657	5280

McDermott
Fig 2.1 Manganese

Date	Before Ash	After Ash
7/18/1995	3.2	
8/8/1995	3.5	
10/17/1995	6.6	
11/29/1995	3.5	
2/23/1996	2.28	
5/17/1996	3.96	
8/28/1996		5
12/12/1996		6.18
3/5/1997		5.73
6/26/1997		8.8
9/29/1997		11.8
12/17/1997		13.8
3/16/1998		17.9
6/25/1998		14.6
8/21/1998		17.1
12/14/1998		15.7
3/29/1999		15.5
6/23/1999		16.8
9/30/1999		15.7
12/6/1999		12.5
3/6/2000		12
6/13/2000		14.5
9/28/2000		13.4
12/14/2000		14.1
3/16/2001		
6/14/2001		15.9
9/18/2001		19.3
12/27/2001		11.5
3/23/2002		12.5
6/11/2002		20.3
9/24/2002		21.8
12/18/2002		18.9
3/25/2003		18.6
6/9/2003		20.3
9/10/2003		24.2

McDermott
Fig 2.2 Sulfates

Date	Before Ash	After Ash
7/18/1995	152	
8/8/1995	188	
10/17/1995	354	
11/29/1995	260	
2/23/1996	210	
5/17/1996	178	
8/28/1996		271
12/12/1996		295
3/5/1997		339
6/26/1997		546
9/29/1997		380
12/17/1997		625
3/16/1998		776
6/25/1998		833
8/21/1998		825
12/14/1998		1088
3/29/1999		836
6/23/1999		1221
9/30/1999		633
12/6/1999		685
3/6/2000		746
6/13/2000		957
9/28/2000		881
12/14/2000		889
3/16/2001		
6/14/2001		866
9/18/2001		681
12/27/2001		904
3/23/2002		804
6/11/2002		1194
9/24/2002		1145
12/18/2002		1226
3/25/2003		1230
6/9/2003		1110.8
9/10/2003		1161

McDermott

Fig 2.3 Calcium

Date	Before Ash	After Ash
7/18/1995	17.9	
8/8/1995	20.9	
10/17/1995	33.7	
11/29/1995	16.9	
2/23/1996		
5/17/1996	30.5	
8/28/1996		36.5
12/12/1996		69
3/5/1997		75.6
6/26/1997		115
9/29/1997		118
12/17/1997		146
3/16/1998		193
6/25/1998		180
8/21/1998		179
12/14/1998		143
3/29/1999		170
6/23/1999		186
9/30/1999		154
12/6/1999		147
3/6/2000		173
6/13/2000		211
9/28/2000		177
12/14/2000		
3/16/2001		
6/14/2001		205
9/18/2001		236
12/27/2001		161
3/23/2002		193
6/11/2002		291
9/24/2002		245
12/18/2002		242
3/25/2003		218
6/9/2003		250
9/10/2003		291

McDermott
Fig 2.4 Magnesium

Date	Before Ash	After Ash
7/18/1995	15.6	
8/8/1995	16.8	
10/17/1995	33.2	
11/29/1995	15.5	
2/23/1996		
5/17/1996	22	
8/28/1996		30.6
12/12/1996		30
3/5/1997		36.8
6/26/1997		54.8
9/29/1997		50
12/17/1997		60.1
3/16/1998		86.7
6/25/1998		81.5
8/21/1998		96.5
12/14/1998		78
3/29/1999		60.5
6/23/1999		84.5
9/30/1999		72.5
12/6/1999		65.9
3/6/2000		75.1
6/13/2000		82.4
9/28/2000		8.3
12/14/2000		
6/14/2001		87.9
9/18/2001		108
12/27/2001		71.5
3/23/2002		74
6/11/2002		117
9/24/2002		105
12/18/2002		104
3/25/2003		89.8
6/9/2003		98.9
9/10/2003		115

McDermott
Fig 2.5 Chloride

Date	Before Ash	After Ash
7/18/1995	2	
8/8/1995	1	
10/17/1995	2	
11/29/1995	2	
2/23/1996	2	
5/17/1996	2	
8/28/1996		4
12/12/1996		7
3/5/1997		9
6/26/1997		11
9/29/1997		9
12/17/1997		12
3/16/1998		14
6/25/1998		11
8/21/1998		13
12/14/1998		12
3/29/1999		9
6/23/1999		10
9/30/1999		7
12/6/1999		7
3/6/2000		7
6/13/2000		8
9/28/2000		7
12/14/2000		
3/16/2001		
6/14/2001		7
9/18/2001		7
12/27/2001		5
3/23/2002		5
6/11/2002		6
9/24/2002		7
12/18/2002		6.7
3/25/2003		5.6
6/9/2003		5.1
9/10/2003		5.7

McDermott
Fig 2.6 Sodium

Date	Before Ash	After Ash
7/18/1995	0.858	
8/8/1995	0.71	
10/17/1995	0.904	
11/29/1995	0.894	
2/23/1996	0.81	
5/17/1996	1.26	
8/28/1996		2.42
12/12/1996		3.7
3/5/1997		6.5
6/26/1997		7.2
9/29/1997		19.4
12/17/1997		9.62
3/16/1998		9.5
6/25/1998		7.98
8/21/1998		9.3
12/14/1998		6.46
3/29/1999		6.73
6/1/1999		8.4
9/1/1999		6
12/1/1999		7.8
3/6/2000		7
6/13/2000		7.5
9/28/2000		6.6
12/14/2000		
3/16/2001		
6/14/2001		7.23
9/18/2001		8.38
12/27/2001		6
3/23/2002		5.98
6/11/2002		8.35
9/24/2002		8
12/18/2002		8.5
3/25/2003		7.33
6/9/2003		7.26
9/10/2003		7.4

McDermott
Fig 2.7 Iron

Date	Before Ash	After Ash
7/18/1995	8.5	
8/8/1995	9.1	
10/17/1995	18.7	
11/29/1995	6.4	
2/23/1996	2.2	
5/17/1996	5.26	
8/28/1996		12.1
12/12/1996		5.6
3/5/1997		3.89
6/26/1997		12.5
9/29/1997		5.38
12/17/1997		9.75
3/16/1998		7.57
6/25/1998		6.7
8/21/1998		37.1
12/14/1998		29.7
3/29/1999		4.6
6/23/1999		18.1
9/30/1999		25.3
12/6/1999		13.2
3/6/2000		3.8
6/13/2000		8.4
9/28/2000		20.9
12/14/2000		8.8
3/16/2001		
6/14/2001		8.9
9/18/2001		33.5
12/27/2001		5.6
3/23/2002		3.3
6/11/2002		6.2
9/24/2002		32.3
12/18/2002		7.5
3/25/2003		3.2
6/9/2003		3.59
9/10/2003		4.2

McDermott

Fig 2.8 Total Dissolved Solids

Date	Before Ash	After Ash
7/18/1995	718	
8/8/1995	770	
10/17/1995	1276	
11/29/1995	696	
2/23/1996		
5/17/1996	480	
8/28/1996		1020
12/12/1996		1516
3/5/1997		828
6/26/1997		1644
9/29/1997		1212
12/17/1997		1490
3/16/1998		1722
6/25/1998		1686
8/21/1998		1984
12/14/1998		1626
3/29/1999		1308
6/1/1999		2090
9/1/1999		1336
12/1/1999		1470
3/6/2000		1548
6/13/2000		1962
9/28/2000		2132
12/14/2000		1610
3/16/2001		
6/14/2001		1974
9/18/2001		2348
12/27/2001		1674
3/23/2002		1740
6/11/2002		2198
9/24/2002		2458
12/18/2002		2202
3/25/2003		2086
6/9/2003		2240
9/10/2003		2546

McDermott

Fig 2.9 Acidity

Date	Before Ash	After Ash
7/18/1995	232	
8/8/1995	246	
10/17/1995	408	
11/29/1995	232	
2/23/1996	144	
5/17/1996	244	
8/28/1996		264
12/12/1996		242
3/5/1997		254
6/26/1997		330
9/29/1997		336
12/17/1997		328
3/16/1998		322
6/25/1998		296
8/21/1998		390
12/14/1998		396
3/29/1999		240
6/1/1999		336
9/1/1999		256
12/1/1999		302
3/6/2000		246
6/13/2000		284
9/28/2000		268
12/14/2000		278
3/16/2001		
6/14/2001		260
9/18/2001		359
12/27/2001		210
3/23/2002		238
6/11/2002		269
9/24/2002		366
12/18/2002		245
3/25/2003		251
6/9/2003		220
9/10/2003		234.6

McDermott
Fig 2.9a pH

Date	Field Before Ash	Field After Ash	Lab Before Ash	Lab After Ash
7/18/1995			3	
8/8/1995			3	
10/17/1995	4.6		2.9	
11/29/1995	4.6		3	
2/23/1996			3.2	
5/17/1996	4.7		3.1	
8/28/1996		4.6		3
12/12/1996		4.5		3.1
3/5/1997		4.6		3
6/26/1997		4.6		3.2
9/29/1997		4.7		3
12/17/1997		4		3.1
3/16/1998		4.6		3
6/25/1998		4.2		3
8/21/1998		4.5		3.2
12/14/1998		4.2		3.1
3/29/1999		4.2		3.1
6/23/1999		4.3		3.1
9/30/1999		4.5		3
12/6/1999		4.2		3
3/6/2000		4		3.1
6/13/2000		4.5		3.1
9/28/2000		4.5		3.1
12/14/2000		4.3		3.1
3/16/2001		4		
6/14/2001		4		3
9/18/2001		4		3.1
12/27/2001		4.5		3.1
3/23/2002		4.5		3.1
6/11/2002		4.5		3.1
9/24/2002		4.3		3.1
12/18/2002		4		3
3/25/2003		4		3.2
6/9/2003		3.3		3.2
9/10/2003		3.3		3.1

McDermott
Fig 2.10 Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
7/18/1995	<0.004	<0.01	0.0593	<0.007
8/8/1995	<0.004	<0.01	0.015	<0.007
10/17/1995	<0.004	<0.01	0.0228	<0.007
11/29/1995	<0.004	<0.01	0.0186	<0.007
2/23/1996				
5/17/1996	<0.004	<0.01	0.0116	<0.007
8/28/1996	<0.004	<0.01	0.0349	<0.007
12/12/1996	<0.004	<0.01	0.0232	<0.007
3/5/1997	<0.004	<0.01	0.011	<0.007
6/26/1997	<0.004	<0.01	0.016	<0.007
9/29/1997	<0.004	<0.01	0.0207	<0.007
12/17/1997	<0.004	<0.01	0.0184	<0.007
3/16/1998	<0.004	<0.01	0.0211	<0.007
6/25/1998	<0.004	<0.01	0.0164	<0.007
8/21/1998	<0.004	<0.01	0.021	<0.007
12/14/1998	<0.04	<0.01	<0.01	<0.007
3/29/1999	<0.04	<0.01	0.0176	<0.007
6/23/1999	<0.004	<0.01	0.0194	<0.007
9/30/1999	<0.004	<0.01	0.0167	<0.007
12/6/1999	<0.004	<0.01	0.0169	<0.007
3/6/2000	<0.004	<0.01	0.0148	<0.007
6/13/2000				
9/28/2000				
12/14/2000				
3/16/2001				
6/14/2001	<0.004	<0.01	0.0199	<0.007
9/18/2001	<0.004	<0.01	0.0239	<0.007
12/27/2001	<0.004	<0.01	0.0134	<0.007
3/23/2002	<0.004	<0.01	0.0197	<0.007
6/11/2002	<0.004	<0.01	0.02	0.0075
9/24/2002	<0.004	<0.01	0.0221	<0.007
12/18/2002	<0.004	<0.01	0.0166	0.012
3/25/2003	<0.004	0.01	0.0165	<0.007

McDermott
Fig 2.11 Acidity

Date	Before Ash	After Ash
7/18/1995	120	
8/8/1995	6.6	
10/17/1995	32	
11/29/1995	10.4	
2/23/1996		
5/17/1996	10.4	
8/28/1996		40
12/12/1996		150
3/5/1997		210
6/26/1997		458
9/29/1997		344
12/17/1997		392
3/16/1998		310
6/25/1998		402
8/21/1998		384
12/14/1998		310
3/29/1999		196
6/23/1999		350
9/30/1999		290
12/6/1999		326
3/6/2000		306
6/13/2000		384
9/28/2000		338
12/14/2000		336
3/16/2001		280
6/14/2001		344
9/18/2001		419.2
12/27/2001		294
3/23/2002		325.4
6/11/2002		364
9/24/2002		380
12/18/2002		330.4
3/25/2003		262.4
6/9/2003		275.8
9/10/2003		264.4

McDermott
Fig 2.11a pH

Date	Field Before Ash	Field After Ash	Lab Before Ash	Lab After Ash
7/18/1995			5.6	
8/8/1995			5.3	
10/17/1995	5.9		5.3	
11/29/1995	5		5	
2/23/1996				
5/17/1996	5		4.9	
8/28/1996		4.7		4.5
12/12/1996		4.6		3.5
3/5/1997		4.6		3.3
6/26/1997		4.5		3.4
9/29/1997		4.7		3.4
12/17/1997		4		3.5
3/16/1998		4.4		3.3
6/25/1998		4.2		3.3
8/21/1998		4.7		3.6
12/14/1998		4		3.5
3/29/1999		4.2		3.2
6/23/1999		4.2		3.5
9/30/1999		4.2		3.4
12/6/1999		4		3.4
3/6/2000		4		3.4
6/13/2000		4.6		3.4
9/28/2000		4		3.7
12/14/2000		4		3.6
3/16/2001		4.3		3.4
6/14/2001		4.7		3.5
9/18/2001		4		3.7
12/27/2001		4.5		3.7
3/23/2002		4.5		3.5
6/11/2002		4.7		3.7
9/24/2002		4.5		3.6
12/18/2002		4		3.7
3/25/2003		4		3.4
6/9/2003		3.5		3.5
9/10/2003		3.7		3.5

McDermott

Fig 2.12 Iron & Manganese

Date	Fe	Mn
7/18/1995	2.12	0.218
8/8/1995	2	2.6
10/17/1995	3.7	0.527
11/29/1995	0.185	0.251
5/17/1996	0.36	0.59
8/28/1996	2.27	7.2
12/12/1996	16.8	14.4
3/5/1997	40.8	29.7
6/26/1997	119	44.6
9/29/1997	81	34.8
12/17/1997	99.2	42.8
3/16/1998	120	43
6/25/1998	164	50.5
12/14/1998	121	38.9
3/29/1999	51	22.3
6/23/1999	158	42.6
9/30/1999	130	33.7
12/6/1999	117	30
3/6/2000	113	38
6/13/2000	147	40.3
9/28/2000	177	36.9
12/14/2000	143	33.4
3/16/2001	112	31.2
6/14/2001	164	37.4
9/18/2001	164	37.8
12/27/2001	116	24.6
3/23/2002	112	25.7
6/11/2002	151	31.8
9/24/2002	143	37.4
12/18/2002	147	32.3
3/25/2003	78	21
6/9/2003	92	23.6
9/10/2003	102	29

McDermott
Fig 2.13 Sulfate

Date	Before Ash	After Ash
7/18/1995	28	
8/8/1995	65	
10/17/1995	32	
11/29/1995	68	
2/23/1996		
5/17/1996	105	
8/28/1996		252
12/12/1996		427
3/5/1997		538
6/26/1997		1080
9/29/1997		656
12/17/1997		1420
3/16/1998		1440
6/25/1998		1500
8/21/1998		1300
12/14/1998		1506
3/29/1999		1150
6/23/1999		1814
9/30/1999		1280
12/6/1999		1380
3/6/2000		1370
6/13/2000		1930
9/28/2000		1520
12/14/2000		1360
3/16/2001		970
6/14/2001		1547
9/18/2001		1590
12/27/2001		1610
3/23/2002		1192
6/11/2002		1548
9/24/2002		1950
12/18/2002		1689
3/25/2003		1130
6/9/2003		1243
9/10/2003		1331

McDermott

Fig 2.13a Total Dissolved Solids

Date	Before Ash	After Ash
7/18/1995	74	
8/8/1995	40	
10/17/1995	94	
11/29/1995	72	
2/23/1996		
5/17/1996	130	
8/28/1996		582
12/12/1996		1100
3/5/1997		1178
6/26/1997		2460
9/29/1997		2202
12/17/1997		2802
3/16/1998		2606
6/25/1998		3042
8/21/1998		3163
12/14/1998		2280
3/29/1999		1808
6/23/1999		3090
9/30/1999		2502
12/6/1999		2114
3/6/2000		2628
6/13/2000		2982
9/28/2000		2836
12/14/2000		2344
3/16/2001		2224
6/14/2001		2796
9/18/2001		3188
12/27/2001		2484
3/23/2002		2034
6/11/2002		2696
9/24/2002		3478
12/18/2002		3066
3/25/2003		1824
6/9/2003		2432
9/10/2003		2714

McDermott
Fig 2.14 Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
7/18/1995	<0.004	<0.01	0.0129	<0.007
8/8/1995	<0.004	<0.01	0.0082	<0.007
10/17/1995	<0.004	<0.01	0.0081	<0.007
11/29/1995	<0.004	<0.01	0.0045	<0.007
2/23/1996				
5/17/1996	<0.004	<0.01	0.0014	<0.007
8/28/1996	<0.004	<0.01	0.0043	<0.007
12/12/1996	<0.004	<0.01	0.0376	0.008
3/5/1997	<0.004	<0.01	0.0394	<0.007
6/26/1997	<0.004	<0.01	0.0841	<0.007
9/29/1997	<0.004	<0.01	0.0663	<0.007
12/17/1997	<0.004	<0.01	0.0701	0.008
3/16/1998	<0.004	<0.01	0.0646	<0.007
6/25/1998	<0.004	0.011	0.0587	<0.007
8/21/1998	<0.004	0.018	0.039	<0.007
12/14/1998	<0.040	<0.01	0.048	<0.070
3/29/1999	<0.004	0.013	0.0424	<0.007
6/23/1999	<0.004	<0.01	0.0387	<0.007
9/30/1999	<0.004	0.016	0.0346	<0.007
12/6/1999	<0.004	<0.01	0.0325	<0.007
3/6/2000	<0.004	<0.01	0.03	<0.007
6/13/2000				
9/28/2000				
12/14/2000				
3/16/2001				
6/14/2001	<0.004	<0.010	0.0331	<0.007
9/18/2001	<0.004	<0.010	0.0316	<0.007
12/27/2001	<0.004	<0.010	0.0275	<0.007
3/23/2002				
6/11/2002	<0.004	<0.01	0.0385	<0.007
9/24/2002	<0.004	<0.01	0.0321	<0.007
12/18/2002	<0.004	<0.01	0.0243	0.0109
3/25/2003	<0.004	<0.010	0.022	<0.007

McDermott

Fig 2.14a Calcium & Magnesium

Date	Ca Before Ash	Ca After Ash	Mg Before Ash	Mg After Ash
7/18/1995	7.48		2.41	
8/8/1995	5.76		2.5	
10/17/1995	5.21		3.87	
11/29/1995	9.62		2.55	
2/23/1996				
5/17/1996	19		6	
8/28/1996		62.6		29.2
12/12/1996		104		41.6
3/5/1997		110		52.4
6/26/1997		205		111
9/29/1997		289		102
12/17/1997		315		98.7
3/16/1998		304		146
6/25/1998		362		173
8/21/1998		294		128
12/14/1998		254		108
3/29/1999		196		82.5
6/23/1999		286		151
9/30/1999		231		118
12/6/1999		265		103
3/6/2000		316		112
6/13/2000		301		140
9/28/2000		282		153
12/14/2000				
3/16/2001				
6/14/2001		272		150
9/18/2001		344		165
12/27/2001		235		117
3/23/2002		226		119
6/11/2002		261		143
9/24/2002		379		177
12/18/2002		253		146
3/25/2003		201		107
6/9/2003		223		116
9/10/2003		272		136

McDermott

Fig 2.15 Manganese

Date	Before Ash	After Ash
5/22/1995	0.362	
6/16/1995	0.588	
7/18/1995	0.342	
10/17/1995	2.43	
11/29/1995	0.3	
8/28/1996		25.6
12/12/1996		6.35
3/5/1997		12.7
6/25/1997		32.7
9/24/1997		47.3
12/17/1997		31.7
3/16/1998		22.5
6/25/1998		25.2
8/21/1998		46.4
12/14/1998		44.2
3/29/1999		8.42
6/23/1999		29.4
9/30/1999		39.9
12/6/1999		33.1
3/6/2000		18
6/13/2000		21.1
9/28/2000		54.1
12/14/2000		35.2
3/15/2001		20.7
6/14/2001		32.4
9/18/2001		68.4
12/27/2001		28.5
3/23/2002		17.5
6/11/2002		17.4
9/24/2002		51.6
12/18/2002		32.9
3/25/2003		12
6/9/2003		10.198
9/10/2003		14.7

McDermott
Fig 2.16 Sulfate

Date	Before Ash	After Ash
5/22/1995	22	
6/16/1995	68	
7/18/1995	34	
10/17/1995	110	
11/29/1995	23	
8/28/1996		407
12/12/1996		159
3/5/1997		316
6/26/1997		803
9/29/1997		850
12/17/1997		675
3/16/1998		649
6/25/1998		646
8/21/1998		952
12/14/1998		1118
3/29/1999		393
6/23/1999		1267
9/30/1999		1000
12/6/1999		984
3/6/2000		528
6/13/2000		582
9/28/2000		1260
12/14/2000		726
3/16/2001		591
6/14/2001		1018
9/18/2001		1341
12/27/2001		871
3/23/2002		484
6/11/2002		490
9/24/2002		1118
12/18/2002		846
3/25/2003		440
6/9/2003		379
9/10/2003		437

McDermott
Fig 2.16a Acidity

Date	Before Ash	After Ash
5/22/1995	11.6	
6/16/1995	24	
7/18/1995	9.6	
10/17/1995	72	
11/29/1995	8.6	
8/28/1996		172
12/12/1996		52
3/5/1997		116
6/25/1997		292
9/24/1997		330
12/17/1997		240
3/16/1998		134
6/25/1998		150
8/21/1998		264
12/14/1998		226
3/29/1999		38
6/23/1999		174
9/30/1999		148
12/6/1999		156
3/6/2000		62
6/13/2000		106
9/28/2000		238
12/14/2000		150
3/15/2001		84
6/14/2001		162
9/18/2001		367.4
12/27/2001		145.2
3/23/2002		109.4
6/11/2002		96.4
9/24/2002		276.6
12/18/2002		143.8
3/25/2003		68.2
6/9/2003		52.6
9/10/2003		66.8

McDermott
Fig 2.16b pH

Date	Field Before Ash	Field After Ash	Lab Before Ash	Lab After Ash
5/22/1995			4.5	
6/16/1995			4.4	
7/18/1995			4.6	
10/17/1995	4.4		4.1	
11/29/1995	5.1		5.2	
8/28/1996		4.2		3.3
12/12/1996		4.5		4
3/5/1997		4.6		3.6
6/25/1997		4.5		3.4
9/24/1997		4.3		3.2
12/17/1997		4.6		3.4
3/16/1998		4.6		3.5
6/25/1998		4.6		3.3
8/21/1998		4.5		3.3
12/14/1998		4.8		3.4
3/29/1999		4.2		3.9
6/23/1999		4.5		3.7
9/30/1999		4.7		4.2
12/6/1999		4.5		4.3
3/6/2000		4.4		4.4
6/13/2000		4.7		4.2
9/28/2000		4.7		4.1
12/14/2000		4.5		4.3
3/15/2001		4.6		4.4
6/14/2001		4.7		4.1
9/18/2001		4.5		4.1
12/27/2001		4.5		4.3
3/23/2002		4.5		4.2
6/11/2002		4.5		4
9/24/2002		4.4		3.9
12/18/2002		4		4.1
3/25/2003		4.7		4.3
6/9/2003		4.4		4.4
9/10/2003		4.4		4.3

McDermott
Fig 2.17 Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
5/22/1995	<0.004	<0.01	<0.001	<0.007
6/16/1995	<0.004	<0.01	0.0138	<0.007
7/18/1995	<0.004	<0.01	<0.001	<0.007
10/17/1995	<0.004	<0.01	<0.001	<0.007
11/29/1995	<0.004	<0.01	<0.001	<0.007
3/1/1996				
6/1/1996				
8/28/1996	<0.004	<0.01	0.0201	<0.007
12/12/1996	<0.004	<0.01	0.007	<0.007
3/5/1997	<0.004	<0.01	0.0167	<0.007
6/26/1997	<0.004	<0.01	0.0412	<0.007
9/29/1997	<0.004	<0.01	0.0629	<0.007
12/17/1997	<0.004	<0.01	0.0289	<0.007
3/16/1998	<0.004	<0.01	0.0225	<0.007
6/25/1998	<0.004	<0.01	0.0223	<0.007
8/21/1998	<0.004	<0.01	0.024	<0.007
12/14/1998	<0.040	<0.01	0.023	<0.07
3/29/1999	<0.040	<0.01	<0.01	<0.07
6/23/1999	<0.004	<0.01	0.0093	<0.007
9/30/1999	<0.004	<0.01	0.0053	<0.007
12/6/1999	<0.004	<0.01	0.0036	<0.007
3/6/2000	<0.004	<0.01	0.0023	<0.007
6/13/2000				
9/28/2000				
12/14/2000				
3/16/2001				
6/14/2001	<0.004	<0.010	0.0058	<0.007
9/18/2001	<0.004	<0.010	0.0077	<0.007
12/27/2001	<0.004	<0.010	0.0032	<0.007
3/23/2002	<0.004	<0.010	0.0028	<0.007
6/11/2002	<0.004	<0.010	0.0049	<0.007
9/24/2002	<0.004	<0.01	0.0136	<0.007
12/18/2002	<0.004	<0.01	0.0034	<0.007
3/25/2003	<0.004	<0.01	0.0022	<0.007

McDermott
Fig 2.17a Calcium & Magnesium

Date	Ca Before Ash	Ca After Ash	Mg Before Ash	Mg After Ash
5/22/1995	7.71		3.05	
6/16/1995	8.7		3.72	
7/18/1995	8.01		3.13	
10/17/1995	20.2		2.43	
11/29/1995	9.87		3.16	
2/23/1996				
5/17/1996				
8/28/1996		64.3		40.8
12/12/1996		40.6		18
3/5/1997		65.9		35.1
6/25/1997		150		67.9
9/24/1997		212		91.8
12/17/1997		176		68.9
3/16/1998		158		77.3
6/25/1998		186		87.2
8/21/1998		271		115
12/14/1998		240		107
3/29/1999		95.1		40
6/23/1999		184		94.1
9/30/1999		223		107
12/6/1999		179		84.4
3/6/2000		114		49.8
6/13/2000		135		60.8
9/28/2000		259		153
12/14/2000				
3/16/2001				
6/14/2001		201		92.2
9/18/2001		328		165
12/27/2001		146		73.1
3/23/2002		114		52
6/11/2002		104		48.5
9/24/2002		250		126
12/18/2002		173		82.4
3/25/2003		83		37.1
6/9/2003		73.7		32.6
9/10/2003		87.3		41.9

McDermott
Fig 2.18 Manganese

Date	
8/21/1998	29.3
12/14/1998	22.4
3/29/1999	51.3
6/23/1999	22.8
9/30/1999	18.5
12/6/1999	21.1
3/6/2000	59.4
6/13/2000	41.2
9/28/2000	26.3
12/14/2000	28.3
3/16/2001	33.7
6/14/2001	35.9
9/18/2001	30.1
12/27/2001	46.8
3/23/2002	46.9
6/11/2002	43.5
9/24/2002	31
12/18/2002	36.8
3/25/2003	46.4
6/9/2003	42.1
9/10/2003	45.2

McDermott
Fig 2.19 Sulfates

Date	
8/21/1998	1400
12/14/1998	2212
3/29/1999	2750
6/23/1999	2115
9/30/1999	1950
12/6/1999	1950
3/6/2000	2430
6/13/2000	2090
9/28/2000	1710
12/14/2000	1850
3/16/2001	1240
6/14/2001	2635
9/18/2001	1699
12/27/2001	2480
3/23/2002	2346
6/11/2002	2435
9/24/2002	2260
12/18/2002	2500
3/25/2003	2502
6/9/2003	2746
9/10/2003	2493

McDermott

Fig 2.20 Total Dissolved Solids

Date	
8/21/1998	3778
12/14/1998	3300
3/29/1999	3866
6/23/1999	3172
9/30/1999	3092
12/6/1999	3104
3/6/2000	3800
6/13/2000	3782
9/28/2000	3658
12/14/2000	3150
3/16/2001	3098
6/14/2001	4116
9/18/2001	3850
12/27/2001	4264
3/23/2002	4206
6/11/2002	4268
9/24/2002	4118
12/18/2002	4300
3/25/2003	4044
6/9/2003	4438
9/10/2003	4700

McDermott
Fig 2.21 Iron

Date	
8/21/1998	29.5
12/14/1998	3.31
3/29/1999	84.7
6/23/1999	21.8
9/30/1999	25
12/6/1999	15.3
3/6/2000	76.6
6/13/2000	102
9/28/2000	46.2
12/14/2000	34.1
3/16/2001	43.7
6/14/2001	90.4
9/18/2001	64.4
12/27/2001	67.4
3/23/2002	83
6/11/2002	109
9/24/2002	52
12/18/2002	42.1
3/25/2003	65.2
6/9/2003	79
9/10/2003	79

McDermott
Fig 2.22 Chloride

Date	
8/21/1998	43
12/14/1998	58
3/29/1999	38
6/23/1999	62
9/30/1999	56
12/6/1999	48
3/6/2000	41
6/13/2000	51
9/28/2000	52
12/14/2000	
3/16/2001	
6/14/2001	80
9/18/2001	92
12/27/2001	57
3/23/2002	47
6/11/2002	92
9/24/2002	138
12/18/2002	88.9
3/25/2003	48.4
6/9/2003	41.6
9/10/2003	48.3

McDermott
Fig 2.23 Sodium

Date	
8/21/1998	21.9
12/14/1998	31
3/29/1999	20.1
6/23/1999	23.9
9/30/1999	32.1
12/6/1999	31.8
3/6/2000	23.9
6/13/2000	26.5
9/28/2000	29.7
12/14/2000	
3/16/2001	
6/14/2001	35.6
9/18/2001	43.4
12/27/2001	23.5
3/23/2002	25.3
6/11/2002	45.7
9/24/2002	62
12/18/2002	47.5
3/25/2003	31
6/9/2003	27.3
9/10/2003	31.7

McDermott
Fig 2.23a Calcium & Magnesium

Date	Calcium	Magnesium
8/21/1998	637	140
12/14/1998	590	97
3/29/1999	478	195
6/23/1999	464	106
9/30/1999	614	115
12/6/1999	568	109
3/6/2000	595	275
6/13/2000	506	160
9/28/2000	630	142
12/14/2000		
3/16/2001		
6/14/2001	571	183
9/18/2001	676	161
12/27/2001	526	236
3/23/2002	492	224
6/11/2002	570	247
9/24/2002	589	191
12/18/2002	488	208
3/25/2003	493	259
6/9/2003	466	247
9/10/2003	494	264

McDermott
Fig 2.23b Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
8/21/1998	<0.004	<0.010	<0.001	<0.007
12/14/1998	<0.040	<0.010	<0.010	<0.070
3/29/1999	<0.040	0.018	<0.010	<0.070
6/23/1999	<0.004	<0.010	<0.001	<0.007
9/30/1999	<0.004	<0.010	<0.001	0.008
12/6/1999	<0.004	<0.010	<0.001	0.009
3/6/2000	<0.004	<0.010	0.004	0.008
6/13/2000				
9/28/2000				
12/14/2000				
3/16/2001				
6/14/2001	<0.004	<0.010	<0.0010	<0.007
9/18/2001	0.0053	<0.010	<0.0010	0.0099
12/27/2001	<0.004	<0.010	0.0015	0.0095
3/23/2002	<0.004	<0.010	0.0015	<0.007
6/11/2002	0.0043	<0.010	0.0015	0.014
9/24/2002	<0.004	<0.010	<0.001	<0.007
12/18/2002	0.0062	<0.010	0.003	0.0234
3/25/2003	<0.004	<0.010	0.0022	<0.007

McDermott
Fig 2.24 Acidity & Alkalinity

Date	Acidity	Alkalinity
8/21/1998	0	188
12/14/1998	0	100
3/29/1999	274	10.8
6/23/1999	0	170
9/30/1999	0	170
12/6/1999	0	142
3/6/2000	296	3.4
6/13/2000	226	58
9/28/2000	0	158
12/14/2000	0	106
3/16/2001	146	5.6
6/14/2001	175.4	50
9/18/2001	40	136
12/27/2001	187.4	24
3/23/2002	337.4	6
6/11/2002	277.2	8.2
9/24/2002	77.4	116
12/18/2002	205.4	3.4
3/25/2003	338.2	3.2
6/9/2003	310.8	7.2
9/10/2003	280.6	5

McDermott
Fig 2.25 pH

Date	Field	Lab
8/21/1998	5.9	6.3
12/14/1998	7.5	6.9
3/29/1999	4.7	4.4
6/23/1999	5.8	6.2
9/30/1999	6.3	6.4
12/6/1999	6.8	6.7
3/6/2000	4.5	4
6/13/2000	5.7	5.6
9/28/2000	6	6.2
12/14/2000	6.6	6.5
3/16/2001	5	4.9
6/14/2001	6	5.7
9/18/2001	6.1	6.4
12/27/2001	5.8	5.5
3/23/2002		
6/11/2002		
9/24/2002	6	6.3
12/18/2002	4.6	4.7
3/25/2003	4.8	4.6
6/9/2003	5	4.8
9/10/2003	5	4.7

McDermott

Fig 2.26 Manganese

Date	Before Ash	After Ash
5/22/1995	0.01	
6/16/1995	0.01	
8/8/1995	0.01	
10/17/1995		
11/29/1995	0.01	
2/23/1996		
5/17/1996		
8/28/1996		
12/12/1996		0.031
3/5/1997		0.033
6/25/1997		
9/24/1997		
12/17/1997		
3/16/1998		
6/25/1998		
8/21/1998		
12/14/1998		
3/29/1999		5.59
6/23/1999		
9/30/1999		3.22
12/6/1999		4.64
3/6/2000		30.8
6/13/2000		24.9
9/28/2000		5.55
12/14/2000		4.82
3/16/2001		5.47
6/14/2001		
9/18/2001		
12/27/2001		3.86
3/23/2002		2.46
6/11/2002		24.4
9/24/2002		
12/18/2002		11.7
3/25/2003		25.7
6/9/2003		14.4
9/10/2003		

McDermott
Fig 2.27
Sulfates &
TDS

Date	Sulfates Before Ash	Sulfates After Ash	TDS Before Ash	TDS After Ash
5/22/1995	107		56	
6/16/1995	10		40	
8/8/1995	16		26	
10/17/1995				
11/29/1995	11		74	
2/23/1996				
5/17/1996				
8/28/1996				
12/12/1996		20		54
3/5/1997		20		226
6/25/1997				
9/24/1997				
12/17/1997				
3/16/1998				
6/25/1998				
8/21/1998				
12/14/1998				
3/29/1999		1230		1710
6/23/1999				
9/30/1999		500		896
12/6/1999		899		1660
3/6/2000		1220		2884
6/13/2000		1480		2512
9/28/2000		968		1422
12/14/2000		830		1424
3/16/2001		816		1402
6/14/2001				
9/18/2001				
12/27/2001		963		1624
3/23/2002		686		1262
6/11/2002		1747		3046
9/24/2002				
12/18/2002		1319		2332
3/25/2003		2196.6		3496
6/9/2003		1352.2		2652
9/10/2003				

McDermott
Fig 2.28 Acidity & Alkalinity

Date	Acidity Before Ash	Acidity After Ash	Alkalinity Before Ash	Alkalinity After Ash
5/22/1995	5.4		12.6	
6/16/1995	8.6		13.8	
8/8/1995	1.2		11	
10/17/1995				
11/29/1995	4.6		10.4	
2/23/1996				
5/17/1996				
8/28/1996				
12/12/1996		4.6		13.4
3/5/1997		3		10.6
6/25/1997				
9/24/1997				
12/17/1997				
3/16/1998				
6/25/1998				
8/21/1998				
12/14/1998				
3/29/1999		16.8		9
6/23/1999				
9/30/1999		11.2		8.4
12/6/1999		20		11.4
3/6/2000		80		10.8
6/13/2000		72		10.2
9/28/2000		4.2		12.4
12/14/2000		7.6		12.2
3/16/2001		7.2		3.4
6/14/2001				
9/18/2001				
12/27/2001		13		3.6
3/23/2002		24.6		2.6
6/11/2002		81.8		2
9/24/2002				
12/18/2002		33.8		2.2
3/25/2003		128.2		2
6/9/2003		57.4		4.8
9/10/2003				

McDermott
Fig 2.29 pH

Date	Field Before Ash	Field After Ash	Lab Before Ash	Lab After Ash
5/22/1995			6	
6/16/1995			6.1	
8/8/1995			6.1	
10/17/1995				
11/29/1995	5.9		5.9	
2/23/1996				
5/17/1996				
8/28/1996				
12/12/1996		6		6.1
3/5/1997		5.9		5.7
6/25/1997				
9/24/1997				
12/17/1997				
3/16/1998				
6/25/1998				
8/21/1998				
12/14/1998				
3/29/1999		5		4.8
6/23/1999				
9/30/1999		4.9		4.7
12/6/1999		5		5
3/6/2000		4.8		4.6
6/13/2000		4.7		4.6
9/28/2000		5.7		5.5
12/14/2000		5.8		5.7
3/16/2001		4.5		5.2
6/14/2001				
9/18/2001				
12/27/2001		5.8		5.2
3/23/2002		5.5		5.4
6/11/2002		5		4.7
9/24/2002				
12/18/2002		4.9		4.8
3/25/2003		4.8		4.6
6/9/2003		5		4.8
9/10/2003				

McDermott
Fig 2.30 Calcium & Magnesium

Date	Calcium Before Ash	Calcium After Ash	Magnesium Before Ash	Magnesium After Ash
5/22/1995	5.02		1.71	
6/16/1995	6.22		1.77	
8/8/1995	5.09		1.65	
10/17/1995				
11/29/1995	8.79		1.59	
2/23/1996				
5/17/1996				
8/28/1996				
12/12/1996		7.78		1.35
3/5/1997		6.39		1.08
6/25/1997				
9/24/1997				
12/17/1997				
3/16/1998				
6/25/1998				
8/21/1998				
12/14/1998				
3/29/1999		310		62.9
6/23/1999				
9/30/1999		157		30.3
12/6/1999		330		65.6
3/6/2000		513		156
6/13/2000		390		97.9
9/28/2000		278		55.8
12/14/2000				
3/16/2001				
6/14/2001				
9/18/2001				
12/27/2001		260		47.7
3/23/2002		226		37.1
6/11/2002		486		156
9/24/2002				
12/18/2002		353		91.5
3/25/2003		527		187
6/9/2003		375		118
9/10/2003				

McDermott
Fig 2.31 Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
5/22/1995	<0.004	<0.010	<0.001	<0.007
6/16/1995	<0.004	<0.010	0.0025	<0.007
8/8/1995	<0.004	<0.010	<0.001	<0.007
10/17/1995				
11/29/1995	<0.004	<0.010	<0.001	<0.007
2/23/1996				
5/17/1996				
8/28/1996				
12/12/1996	<0.004	<0.010	<0.001	<0.007
3/5/1997	<0.004	<0.010	<0.001	<0.007
6/25/1997				
9/24/1997				
12/17/1997				
3/16/1998				
6/25/1998				
8/21/1998				
12/14/1998				
3/29/1999	<0.040	<0.010	<0.010	<0.070
6/23/1999				
9/30/1999	<0.004	0.012	0.0028	<0.007
12/6/1999	<0.004	<0.010	<0.001	0.009
3/6/2000	<0.040	<0.010	<0.010	<0.070
6/13/2000				
9/28/2000				
12/14/2000				
3/16/2001				
6/14/2001				
9/18/2001				
12/27/2001	<0.004	<0.010	<0.0010	0.0138
3/23/2002	<0.004	<0.010	<0.0010	0.0118
6/11/2002	<0.004	<0.010	0.0028	0.183
9/24/2002				
12/18/2002	<0.004	<0.010	0.0021	0.0125
3/25/2003	<0.004	<0.010	0.0032	<0.007
6/9/2003				
9/10/2003				

McDermott
Fig 2.32 Acidity

Date	Before Ash	After Ash
7/18/1995	36	
8/8/1995	6.8	
10/17/1995	210	
11/29/1995	15.6	
5/17/1996	3.2	
8/28/1996		9.4
12/12/1996		9.4
3/5/1997		8.6
6/26/1997		13.6
9/29/1997		76
12/17/1997		11.6
3/16/1998		264
6/25/1998		330
8/21/1998		322
12/14/1998		412
3/29/1999		426
6/23/1999		498
9/30/1999		530
12/6/1999		656
3/6/2000		606
6/13/2000		552
9/28/2000		454
12/14/2000		560
3/16/2001		560
6/14/2001		486
9/18/2001		558.6
12/27/2001		532.4
3/23/2002		615.2
6/11/2002		553
9/24/2002		607.4
12/18/2002		460.6
3/25/2003		587.8
6/9/2003		558.6
9/10/2003		542.4

McDermott
Fig 2.32 Alkalinity

Date	Before Ash	After Ash
7/18/1995	6.8	
8/8/1995	9.2	
10/17/1995	8.4	
11/29/1995	9.2	
5/17/1996	8.8	
8/28/1996		9.2
12/12/1996		11.6
3/5/1997		4.2
6/26/1997		11.4
9/29/1997		6.8
12/17/1997		13.6
3/16/1998		4.2
6/25/1998		8.8
8/21/1998		11.2
12/14/1998		13.4
3/29/1999		11.8
6/23/1999		13.2
9/30/1999		12.8
12/6/1999		16.2
3/6/2000		16.2
6/13/2000		13.2
9/28/2000		15.2
12/14/2000		15.8
3/16/2001		4.2
6/14/2001		5.2
9/18/2001		5.6
12/27/2001		7.6
3/23/2002		4.8
6/11/2002		4.4
9/24/2002		5
12/18/2002		0
3/25/2003		5.4
6/9/2003		8.2
9/10/2003		6.2

McDermott
Fig 2.33 pH

Date	Field pH Baseline	Field pH After Ash	Lab pH Baseline	Lab pH After Ash
7/18/1995			4.5	
8/8/1995			5.1	
10/17/1995	5		4.8	
11/29/1995	4.8		4.9	
5/17/1996	5.4		5.2	
8/28/1996		5.3		5.1
12/12/1996		5.5		5.4
3/5/1997		5.8		4.2
6/26/1997		5.4		5.2
9/29/1997		5		4.5
12/17/1997		5		5.2
3/16/1998		4.9		4.2
6/25/1998		4.9		4.5
8/21/1998		4.7		4.7
12/14/1998		4.8		4.9
3/29/1999		5.3		5
6/23/1999		4.8		4.9
9/30/1999		4.9		4.9
12/6/1999		4.9		5.2
3/6/2000		5.2		5.2
6/13/2000		5.3		5
9/28/2000		5.3		5.2
12/14/2000		5.2		5.2
3/16/2001		5		5
6/14/2001		5.1		5
9/18/2001		5.3		5.1
12/27/2001		5		5.2
3/23/2002		4.5		5
6/11/2002		5		4.9
9/24/2002		5.3		5
12/18/2002		4.7		2.8
3/25/2003		5		5.1
6/9/2003		5.4		5
9/10/2003		5.1		5.2

McDermott
Fig 2.34 Manganese

Date	Before Ash	After Ash
7/18/1995	0.92	
8/8/1995	0.092	
10/17/1995	3.72	
11/29/1995	0.175	
5/17/1996	0.107	
8/28/1996		0.089
12/12/1996		0.059
3/5/1997		0.1
6/26/1997		0.061
9/29/1997		2.3
12/17/1997		0.222
3/16/1998		7.65
6/25/1998		7.43
8/21/1998		8.13
12/14/1998		13
3/29/1999		12.4
6/23/1999		14.1
9/30/1999		
12/6/1999		18.1
3/6/2000		16.8
6/13/2000		14.4
9/28/2000		14.9
12/14/2000		16.6
3/16/2001		18.8
6/14/2001		19.1
9/18/2001		18.5
12/27/2001		16.3
3/23/2002		16.6
6/11/2002		16.7
9/24/2002		19.7
12/18/2002		18.1
3/25/2003		18.7
6/9/2003		17.737
9/10/2003		18.7

McDermott
Fig 2.35 Iron

Date	Before Ash	After Ash
7/18/1995	16.3	
8/8/1995	0.547	
10/17/1995	92.2	
11/29/1995	1.25	
5/17/1996	6.49	
8/28/1996		6.91
12/12/1996		5.45
3/5/1997		9.58
6/26/1997		7.01
9/29/1997		30.3
12/17/1997		11.3
3/16/1998		186
6/25/1998		221
8/21/1998		212
12/14/1998		249
3/29/1999		253
6/23/1999		237
9/30/1999		353
12/6/1999		396
3/6/2000		373
6/13/2000		299
9/28/2000		276
12/14/2000		302
3/16/2001		352
6/14/2001		336
9/18/2001		337
12/27/2001		316
3/23/2002		304
6/11/2002		340
9/24/2002		329
12/18/2002		157
3/25/2003		312
6/9/2003		304
9/10/2003		310

McDermott

Fig 2.36 Sulfate & Total Dissolved Solids

Date	Sulfate Before Ash	Sulfate After Ash	TDS Before Ash	TDS After Ash
7/18/1995	55		132	
8/8/1995	55		54	
10/17/1995	29		648	
11/29/1995	16		62	
5/17/1996	20		328	
8/28/1996		<20.0		48
12/12/1996		<20.0		26
3/5/1997		43		38
6/26/1997		<20.0		32
9/29/1997		117		232
12/17/1997		<20.0		100
3/16/1998		478		1030
6/25/1998		635		1300
8/21/1998		549		1352
12/14/1998		957		1256
3/29/1999		1070		1954
6/23/1999		1354.6		2502
9/30/1999				2230
12/6/1999		1330		2226
3/6/2000		1220		2534
6/13/2000		1250		2172
9/28/2000		1280		2318
12/14/2000		918		2094
3/16/2001		1090		2190
6/14/2001		1250		1994
9/18/2001		1162		2248
12/27/2001		1520		2454
3/23/2002		1290		2242
6/11/2002		1346		2328
9/24/2002		1528.7		2678
12/18/2002		1324		2210
3/25/2003		1456.9		2620
6/9/2003		1446.6		2818
9/10/2003		1346.4		1812

McDermott

Fig 2.37 Calcium & Magnesium

Date	Calcium Before Ash	Calcium After Ash	Magnesium Before Ash	Magnesium After Ash
7/18/1995	9.25		5.47	
8/8/1995	3.93		1.65	
10/17/1995	29		20.2	
11/29/1995	3.26		1.42	
5/17/1996	4.31		1.49	
8/28/1996		4.79		1.72
12/12/1996		4.47		1.08
3/5/1997		4.29		1.34
6/26/1997		4.22		1.62
9/29/1997		22.2		14.4
12/17/1997		5.63		2.12
3/16/1998		53.6		40.3
6/25/1998		114		67.6
8/21/1998		95.1		52.5
12/14/1998		96.8		62.5
3/29/1999		125		66.5
6/23/1999		117		75
9/30/1999		183		94.7
12/6/1999		165		81.3
3/6/2000		139		80.8
6/13/2000		135		72.5
9/28/2000		171		87.5
12/14/2000				
3/16/2001				
6/14/2001		177		88.1
9/18/2001		188		91.6
12/27/2001		162		81.8
3/23/2002		167		80.9
6/11/2002		165		92.5
9/24/2002		207		101
12/18/2002		182		91.1
3/25/2003		212		101
6/9/2003		185		98.3
9/10/2003		205		100

McDermott
Fig 2.38 Sodium & Chloride

Date	Sodium Baseline	Sodium After ash	Chloride Baseline	Chloride After ash
7/18/1995	0.595		2	
8/8/1995	0.543		1	
10/17/1995	0.659		2	
11/29/1995	0.699		2	
5/17/1996	0.591		2	
8/28/1996		0.61		2
12/12/1996		0.504		1
3/5/1997		0.828		2
6/26/1997		0.799		1
9/29/1997		8.55		2
12/17/1997		0.775		1
3/16/1998		0.842		<1.0
6/25/1998		3.54		7
8/21/1998		3.02		5
12/14/1998		3.02		8
3/29/1999		4.98		14
6/23/1999		5.18		12
9/30/1999		9.7		18
12/6/1999		9.39		13
3/6/2000		6.94		10
6/13/2000		6.45		11
9/28/2000		8.39		14
12/14/2000				
3/16/2001				
6/14/2001		12.4		24
9/18/2001		10.8		15
12/27/2001		11.9		20
3/23/2002		10.7		21
6/11/2002		11		19
9/24/2002		16.5		33
12/18/2002		14		26.2
3/25/2003		16.5		30.9
6/9/2003		14.2		28.6
9/10/2003		15.4		28.4

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Fig 2.39 Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
7/18/1995	<0.004	<0.010	0.138	<0.007
8/8/1995	<0.004	<0.010	<0.001	<0.007
10/17/1995	<0.004	<0.010	0.0122	<0.007
11/29/1995	<0.004	<0.010	0.0035	<0.007
5/17/1996	<0.004	<0.010	<0.001	<0.007
7/1/1996				
8/28/1996	<0.004	<0.010	0.002	<0.007
12/12/1996	<0.004	<0.010	0.0011	<0.007
3/5/1997	<0.004	<0.010	<0.0010	<0.007
6/26/1997	<0.004	<0.010	<0.0010	<0.007
9/29/1997	<0.004	<0.010	0.0043	<0.007
12/17/1997	<0.004	<0.010	0.01	<0.007
3/16/1998	<0.004	<0.010	<0.001	<0.007
6/25/1998	<0.004	0.018	<0.001	<0.007
8/21/1998	<0.004	0.015	<0.001	<0.007
12/14/1998	<0.040	<0.010	<0.010	<0.070
3/29/1999	<0.040	0.026	<0.010	<0.070
6/23/1999	<0.004	<0.010	0.0017	<0.007
9/30/1999	<0.004	0.05	0.0014	<0.007
12/6/1999	<0.004	<0.010	<0.001	<0.007
3/6/2000	<0.004	0.012	<0.001	<0.007
6/13/2000				
9/28/2000				
12/14/2000				
3/16/2001				
6/14/2001	<0.004	<0.010	0.0014	<0.007
9/18/2001	<0.004	<0.010	0.0012	<0.007
12/27/2001	<0.004	<0.010	<0.0001	<0.007
3/23/2002	0.005	<0.010	0.001	<0.007
6/11/2002	0.0044	<0.010	0.0011	<0.007
9/24/2002	<0.004	<0.010	<0.001	<0.007
12/18/2002	<0.004	<0.010	0.0085	<0.007
3/25/2003	<0.004	0.068	0.0014	<0.007
6/9/2003				
9/10/2003				

McDermott
Fig 2.40 Acidity

Date	Before Ash	After Ash
5/22/1995	404	
6/16/1995	518	
8/14/1995	614	
10/17/1995	900	
11/29/1995	288	
8/28/1996		540
12/12/1996		216
3/5/1997		474
6/25/1997		520
9/24/1997		644
12/17/1997		398
3/16/1998		310
6/25/1998		316
8/21/1998		570
12/14/1998		
3/29/1999		454
6/23/1999		748
9/30/1999		758
12/6/1999		942
3/6/2000		664
6/13/2000		596
9/28/2000		712
12/14/2000		
10/16/2001		692
12/27/2001		612.6
3/23/2002		611.8
6/11/2002		558.8
9/24/2002		715.4
12/18/2002		588
3/25/2003		527.8
6/9/2003		157.6
9/10/2003		436

McDermott
Fig 2.41 pH

Date	Field Before Ash	Field After Ash	Lab Before Ash	Lab After Ash
5/22/1995			2.8	
6/16/1995			2.7	
8/14/1995			2.6	
10/17/1995	4.6		2.5	
11/29/1995	4.6		2.9	
8/28/1996		4.6		2.7
12/12/1996		4.5		3
3/5/1997		4.5		2.9
6/25/1997		4.5		2.8
9/24/1997		4.5		2.6
12/17/1997		4.3		2.8
3/16/1998		4.4		2.9
6/25/1998		4.6		2.8
8/21/1998		4.6		2.7
12/14/1998				
3/29/1999		4.2		2.7
6/23/1999		4.6		2.6
9/30/1999		4.5		2.6
12/6/1999		4.4		2.6
3/6/2000		4.5		2.7
6/13/2000		4.6		2.8
9/28/2000		4.5		2.7
12/14/2000				
3/15/2001				
6/14/2001				
10/31/2001		4.5		2.7
12/27/2001		4.5		2.8
3/23/2002		5		2.8
6/11/2002		4.5		2.9
9/24/2002		4.3		2.7
12/18/2002		4		2.8
3/25/2003		4		2.9
6/9/2003		3.1		2.9
9/10/2003		3.3		2.9

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Fig 2.42 Manganese

Date	Before Ash	After Ash
5/22/1995	8.43	
6/16/1995	10.9	
7/18/1995	12.4	
10/17/1995	16.4	
11/29/1995	7.9	
8/28/1996		11.4
12/12/1996		5.2
3/5/1997		5
6/26/1997		9.9
9/29/1997		12
12/17/1997		10.2
3/16/1998		8.1
6/25/1998		7.5
8/21/1998		9.45
12/14/1998		
3/29/1999		11.2
6/23/1999		8.9
9/30/1999		16.9
12/6/1999		19.5
3/6/2000		19.4
6/13/2000		19.5
9/28/2000		20
12/14/2000		
10/16/2001		15.4
12/27/2001		31.3
3/23/2002		41.3
6/11/2002		46
9/24/2002		27.4
12/18/2002		35.3
3/25/2003		44.3
6/9/2003		45.3
9/10/2003		40.8

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Fig 2.43 Sulfates

Date	Before Ash	After Ash
5/22/1995	185	
6/16/1995	314	
8/14/1995	667	
10/17/1995	734	
11/29/1995	332	
8/28/1996		557
12/12/1996		142
3/5/1997		118
6/25/1997		493
9/24/1997		504
12/17/1997		325
3/16/1998		253
6/25/1998		421
8/21/1998		441
12/14/1998		
3/29/1999		717
6/23/1999		1110
9/30/1999		870
12/6/1999		942
3/6/2000		786
6/13/2000		719
9/28/2000		1050
12/14/2000		
10/31/2001		1354
12/27/2001		1770
3/23/2002		1541
6/11/2002		1999
9/24/2002		1288
12/18/2002		1813
3/25/2003		1893
6/9/2003		1740
9/10/2003		1728

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Fig 2.44 Total Dissolved Solids

Date	Before Ash	After Ash
5/22/1995	1344	
6/16/1995	1432	
8/14/1995	2362	
10/17/1995	2698	
11/29/1995	752	
8/28/1996		1872
12/12/1996		538
3/5/1997		474
6/25/1997		1706
9/24/1997		1588
12/17/1997		882
3/16/1998		782
6/25/1998		1136
8/21/1998		1597
12/14/1998		
3/29/1999		1364
6/23/1999		1836
9/30/1999		2144
12/6/1999		2668
3/6/2000		2156
6/13/2000		2056
9/28/2000		2866
12/14/2000		
3/16/2001		
6/14/2001		
10/31/2001		1787
12/27/2001		3104
3/23/2002		2956
6/11/2002		3250
9/24/2002		2842
12/18/2002		3250
3/25/2003		3392
6/9/2003		3654
9/10/2003		3626

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Fig 2.45 Chloride & Sodium

Date	Chloride Before Ash	Chloride After Ash	Sodium Before Ash	Sodium After Ash
5/22/1995	35		20.5	
6/16/1995	28		16.6	
8/14/1995	20		13	
10/17/1995	15		10.7	
11/29/1995	79		46.1	
8/28/1996		18		11.8
12/12/1996		51		32
3/5/1997		48		30.4
6/25/1997		16		11.8
9/24/1997		12		8.7
12/17/1997		81		46.5
3/16/1998		50		32.2
6/25/1998		27		20.6
8/21/1998		24		15.3
12/14/1998				
3/29/1999		133		72
6/23/1999		44		18.3
9/30/1999		37		26.4
12/6/1999		50		33.7
3/6/2000		120		74.3
6/13/2000		53		38.8
9/28/2000		48		39.4
12/14/2000				
3/16/2001				
6/14/2001				
10/31/2001		35		29.1
12/27/2001		52		33.2
3/23/2002		106		63.4
6/11/2002		51		37.2
9/24/2002		37.4		27.5
12/18/2002		67.9		42.5
3/25/2003		89.1		60.6
6/9/2003		57.6		39.4
9/10/2003		40.8		33.9

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Fig 2.46 Calcium & Magnesium

Date	Calcium Before Ash	Calcium After Ash	Magnesium Before Ash	Magnesium After Ash
5/22/1995	20.7		31.8	
6/16/1995	25.2		37.3	
8/14/1995	30.3		45.8	
10/17/1995	39.8		16.4	
11/29/1995	22.8		31.5	
2/23/1996				
5/17/1996				
8/28/1996		30.3		47.8
12/12/1996		19.6		24.9
3/5/1997		17.6		26.5
6/25/1997		27		43
9/24/1997		33.7		53.2
12/17/1997		31.4		39
3/16/1998		27.9		37.3
6/25/1998		57.8		38.1
8/21/1998		48.5		40.5
12/14/1998				
3/29/1999		74.5		44.2
6/23/1999		54.6		32.8
9/30/1999		125		66.4
12/6/1999		127		70.5
3/6/2000		128		74.2
6/13/2000		153		80.1
9/28/2000		161		97
12/14/2000				
3/15/2001				
6/14/2001				
10/31/2001		125		72.2
12/27/2001		197		126
3/23/2002		248		153
6/11/2002		289		192
9/24/2002				
12/18/2002				
3/25/2003		288		220
6/9/2003		293		233
9/10/2003		289		209

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Fig 2.47 Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
5/22/1995	<0.004	<0.010	0.0015	<0.007
6/16/1995	<0.004	<0.010	0.0037	<0.007
8/14/1995	<0.004	<0.010	0.0024	<0.007
10/17/1995	<0.004	<0.010	0.0028	<0.007
11/29/1995	<0.004	<0.010	0.0011	<0.007
2/23/1996				
5/17/1996				
8/28/1996	<0.004	<0.010	0.0025	<0.007
12/12/1996	<0.004	<0.010	0.0017	<0.007
3/5/1997	<0.004	<0.010	0.0026	<0.007
6/25/1997	<0.004	<0.010	0.002	<0.007
9/24/1997	<0.004	<0.010	0.0038	<0.007
12/17/1997	<0.004	<0.010	0.0025	<0.007
3/16/1998	<0.004	<0.010	<0.001	<0.007
6/25/1998	<0.004	<0.010	<0.001	<0.007
8/21/1998	<0.004	<0.010	<0.001	<0.007
12/14/1998				
3/29/1999	<0.004	0.012	0.0078	<0.007
6/23/1999	<0.004	<0.010	0.0038	<0.007
9/30/1999	<0.004	0.019	0.0032	<0.007
12/6/1999	<0.004	<0.010	0.0031	<0.007
3/6/2000	<0.004	0.012	0.0042	0.0095
6/13/2000				
9/28/2000				
12/14/2000				
3/15/2001				
6/14/2001				
10/31/2001				
12/27/2001	<0.004	<0.010	0.0022	0.0089
3/23/2002	<0.004	<0.010	0.0028	0.0097
6/11/2002	0.0053	<0.010	0.0026	0.025
9/24/2002				
12/18/2002				
3/25/2003	<0.004	<0.010	0.0026	<0.007
6/9/2003				
9/10/2003				

EP Bender
Fig 3.1 Acidity

Date	
2/24/1992	14
3/23/1992	8
4/14/1992	15
5/28/1992	10
6/24/1992	10
7/28/1992	16
8/19/1992	10
9/24/1992	12
10/28/1992	6
11/24/1992	18
12/30/1992	8
1/18/1993	6
2/11/1993	13
3/12/1993	12
4/27/1993	12
5/14/1993	10
6/3/1993	14
7/15/1993	0
8/13/1993	8
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	64
12/10/1996	40
2/26/1997	64
6/24/1997	16
9/8/1997	60
11/6/1997	48
3/23/1998	70
6/17/1998	64
9/23/1998	3.2
12/3/1998	40
3/24/1999	74
6/29/1999	60
9/22/1999	36
12/15/1999	72
3/8/2000	96
6/20/2000	94
9/27/2000	60
12/21/2000	52
3/13/2001	72
6/22/2001	99

9/24/2001	86
12/28/2001	86
3/18/2002	6
6/13/2002	115
9/16/2002	106
12/12/2002	17
3/19/2003	123
6/10/2003	214
9/29/2003	125

EP Bender
Fig 3.2 Acidity Load

Date	
12/10/1996	78
12/19/1996	68
12/27/1996	89
1/2/1997	58
1/10/1997	85
1/15/1997	51
1/23/1997	54.7
1/30/1997	28
2/5/1997	33
2/14/1997	13
2/19/1997	24
2/26/1997	210
3/4/1997	141
3/12/1997	206
3/20/1997	167
3/26/1997	94
4/2/1997	100
4/11/1997	64
4/16/1997	44
4/25/1997	46
4/30/1997	43
5/7/1997	30
5/13/1997	33
5/23/1997	50.7
5/28/1997	188.9
6/6/1997	111.9
6/13/1997	87.3
6/20/1997	71
6/27/1997	68
7/2/1997	46
7/10/1997	27
7/18/1997	37.3
7/24/1997	48.5
7/31/1997	27.2
8/8/1997	22.2
8/15/1997	28.7
8/21/1997	92.5
8/27/1997	54.2
9/5/1997	44
9/8/1997	31
9/22/1997	38
10/9/1997	68

10/24/1997	43
11/6/1997	
2/19/1997	
1/15/1998	
2/23/1998	
3/23/1998	
4/23/1998	
5/21/1998	
6/17/1998	133
7/28/1998	40
8/24/1998	42
9/23/1998	
10/23/1998	74
11/20/1998	30
12/3/1998	30
12/29/1998	22
1/28/1999	660
2/25/1999	121
3/24/1999	304
4/20/1999	197
5/19/1999	77
6/29/1999	
7/28/1999	
8/21/1999	
9/22/1999	
10/20/1999	
11/18/1999	
12/2/1999	71
12/29/1999	74
1/27/2000	57
2/25/2000	175
3/24/2000	314
4/20/2000	193
5/25/2000	125
6/20/2000	123
7/20/2000	62
8/21/2000	42
9/27/2000	40
12/1/2000	
3/1/2001	
6/8/2001	110
7/6/2001	98
8/14/2001	98
9/24/2001	41
10/26/2001	48
11/29/2001	47
12/28/2001	81

1/30/2001	107
2/26/2002	117
3/18/2002	128
4/22/2002	415
5/23/2002	744
6/13/2002	259
7/24/2002	119
8/9/2002	90
9/16/2002	112
10/17/2002	42
11/21/2002	201
12/12/2002	121
1/6/2003	1406

EP Bender
Fig 3.3 Acidity

Date		
2/24/1992	16	
3/23/1992	14	
4/14/1992	20	
5/28/1992	14	
6/24/1992	26	
7/28/1992	22	
8/19/1992	22	
9/24/1992	18	
10/28/1992	17	
11/24/1992	28	
12/30/1992	14	
1/18/1993	8	
2/11/1993	22	
3/12/1993	22	
4/27/1993	0	
5/14/1993	12	
6/3/1993	26	
7/15/1993	28	
8/13/1993	52	
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996		15
12/10/1996		3.2
2/26/1997		1.6
6/24/1997		6.4
9/8/1997		24
11/6/1997		22
3/23/1998		0
6/17/1998		12.2
9/23/1998		10
12/3/1998		9.6
3/24/1999		0
6/29/1999		8.2
9/22/1999		12.8
12/15/1999		8
3/8/2000		0
6/20/2000		6.8
9/27/2000		12.6
12/21/2000		5.8
3/13/2001		6.2
6/22/2001		32.2

9/24/2001		28
12/28/2001		17.2
3/18/2002		14.2
6/13/2002		0
9/16/2002		76.6
12/12/2002		
3/19/2003		14.8
6/10/2003		25.8
9/29/2003		5.2

EP Bender
Fig 3.4 Acidity Load

Date	
1/17/1996	0.73
3/11/1996	0
5/13/1996	0
7/18/1996	0.22
9/27/1996	0
11/26/1996	0
1/23/1997	0
3/26/1997	0
5/28/1997	0
7/24/1997	0.15
9/8/1997	0.16
1/15/1998	0
3/23/1998	0
5/21/1998	0
7/28/1998	0.06
9/23/1998	0.42
11/20/1998	0.04
1/28/1999	0
3/24/1999	0
5/19/1999	0.2
6/29/1999	0.13
8/31/1999	0.16
10/20/1999	0.41
12/15/1999	0.31
2/25/2000	0
4/20/2000	0
6/20/2000	0.35
8/21/2000	0.04
11/22/2000	0.44
1/19/2001	0.1
3/13/2001	0.89
5/21/2001	0.27
7/18/2001	0
9/24/2001	0.16
11/29/2001	0.1
1/30/2002	0.94
3/18/2002	0.89
5/23/2002	0
7/24/2002	0
9/16/2002	0.06
11/21/2002	

1/6/2003	

EP Bender
Fig 3.5 Acidity

Date	
2/24/1992	0
3/23/1992	0
4/14/1992	0
5/28/1992	0
6/24/1992	0
7/28/1992	0
8/19/1992	0
9/24/1992	0
10/28/1992	0
11/24/1992	0
12/30/1992	0
1/18/1993	0
2/11/1993	0
3/12/1993	0
4/27/1993	0
5/14/1993	0
6/3/1993	0
7/15/1993	0
8/13/1993	0
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	26
12/10/1996	40
2/26/1997	50
6/24/1997	15
9/8/1997	28
11/6/1997	32
3/23/1998	38
6/17/1998	40
9/23/1998	3.6
12/3/1998	7.4
3/24/1999	52
6/29/1999	2.4
9/22/1999	0
12/15/1999	0
3/8/2000	72
6/20/2000	64
9/27/2000	50
12/21/2000	54
3/13/2001	40
6/22/2001	127

9/24/2001	80
12/28/2001	85
3/18/2002	
6/13/2002	0
9/16/2002	
12/12/2002	
3/19/2003	
6/10/2003	80
9/29/2003	33

EP Bender
Fig 3.6 Alkalinity

Date	
2/24/1992	4
3/23/1992	4
4/14/1992	3
5/28/1992	4
6/24/1992	4
7/28/1992	4
8/19/1992	6
9/24/1992	4
10/28/1992	8
11/24/1992	6
12/30/1992	6
1/18/1993	6
2/11/1993	1
3/12/1993	2
4/27/1993	2
5/14/1993	6
6/3/1993	8
7/15/1993	8
8/13/1993	6
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	2.4
12/10/1996	4.6
2/26/1997	0
6/24/1997	5
9/8/1997	5
11/6/1997	3.2
3/23/1998	0
6/17/1998	0
9/23/1998	22
12/3/1998	0
3/24/1999	0
6/29/1999	0
9/22/1999	2.2
12/15/1999	0
3/8/2000	0
6/20/2000	0
9/27/2000	0
12/21/2000	0
3/13/2001	0
6/22/2001	0

9/24/2001	0
12/28/2001	0
3/18/2002	0
6/13/2002	0
9/16/2002	0
12/12/2002	0
3/19/2003	0
6/10/2003	0
9/29/2003	0

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Fig 3.7 Alkalinity

Date	
2/24/1992	0
3/23/1992	2
4/14/1992	2
5/28/1992	6
6/24/1992	0
7/28/1992	0
8/19/1992	0
9/24/1992	0
10/28/1992	3
11/24/1992	0
12/30/1992	2
1/18/1993	4
2/11/1993	0
3/12/1993	0
4/27/1993	6
5/14/1993	4
6/3/1993	0
7/15/1993	0
8/13/1993	0
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	7.6
12/10/1996	18.2
2/26/1997	22
6/24/1997	11
9/8/1997	9.6
11/6/1997	7.6
3/23/1998	19.6
6/17/1998	10.4
9/23/1998	9.6
12/3/1998	8.8
3/24/1999	16
6/29/1999	10
9/22/1999	9
12/15/1999	8
3/8/2000	14.8
6/20/2000	11.6
9/27/2000	8.6
12/21/2000	10
3/13/2001	3
6/22/2001	4.4

9/24/2001	2.8
12/28/2001	3
3/18/2002	3.2
6/13/2002	28
9/16/2002	2.8
12/12/2002	13.2
3/19/2003	7
6/10/2003	8.4
9/29/2003	8.8

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Fig 3.8 Alkalinity

Date	
2/24/1992	11
3/23/1992	12
4/14/1992	12
5/28/1992	22
6/24/1992	32
7/28/1992	24
8/19/1992	44
9/24/1992	24
10/28/1992	38
11/24/1992	16
12/30/1992	10
1/18/1993	12
2/11/1993	16
3/12/1993	8
4/27/1993	8
5/14/1993	14
6/3/1993	26
7/15/1993	62
8/13/1993	50
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	30
12/10/1996	30
2/26/1997	24
6/24/1997	18.2
9/8/1997	17
11/6/1997	18.2
3/23/1998	11.8
6/17/1998	15.4
9/23/1998	42
12/3/1998	22
3/24/1999	9
6/29/1999	26
9/22/1999	58
12/15/1999	346
3/8/2000	10
6/20/2000	16
9/27/2000	7.6
12/21/2000	13
3/13/2001	3.8
6/22/2001	0

9/24/2001	6.2
12/28/2001	2
3/18/2002	
6/13/2002	274
9/16/2002	
12/12/2002	
3/19/2003	88
6/10/2003	6
9/29/2003	7.8

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Fig 3.9 Alkalinity

Date	
2/24/1992	4.3
3/23/1992	4.7
4/14/1992	4.7
5/28/1992	5.1
6/24/1992	5.7
7/28/1992	4.7
8/19/1992	5.7
9/24/1992	5.4
10/28/1992	3.6
11/24/1992	5.8
12/30/1992	4.7
1/18/1993	4.6
2/11/1993	4.3
3/12/1993	4.5
4/27/1993	4.6
5/14/1993	4.9
6/3/1993	5.2
7/15/1993	5.1
8/13/1993	5.5
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	4.7
12/10/1996	4.5
2/26/1997	4.5
6/24/1997	4.6
9/8/1997	4.6
11/6/1997	4.5
3/23/1998	4.2
6/17/1998	4.5
9/23/1998	5.8
12/3/1998	4.5
3/24/1999	4.3
6/29/1999	4.6
9/22/1999	4.5
12/15/1999	4.6
3/8/2000	4.3
6/20/2000	4.3
9/27/2000	4.5
12/21/2000	4.4
3/13/2001	4.3
6/22/2001	4.5

9/24/2001	4.6
12/28/2001	4.4
3/18/2002	4.5
6/13/2002	4.5
9/16/2002	4.5
12/12/2002	4.5
3/19/2003	4.5
6/10/2003	3.6
9/29/2003	3.6

EP Bender
Fig 3.10 pH

Date	
2/24/1992	4.4
3/23/1992	4.4
4/14/1992	4.7
5/28/1992	4.7
6/24/1992	4.9
7/28/1992	4.3
8/19/1992	5
9/24/1992	5.3
10/28/1992	4.4
11/24/1992	5.8
12/30/1992	4.6
1/18/1993	4.6
2/11/1993	4
3/12/1993	4.2
4/27/1993	5.5
5/14/1993	4.6
6/3/1993	4.8
7/15/1993	4.9
8/13/1993	4.9
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	5.1
12/10/1996	5.9
2/26/1997	5.9
6/24/1997	5.5
9/8/1997	4.9
11/6/1997	4.9
3/23/1998	5.9
6/17/1998	5
9/23/1998	4.9
12/3/1998	4.8
3/24/1999	5.7
6/29/1999	4.9
9/22/1999	4.8
12/15/1999	5.4
3/8/2000	5.8
6/20/2000	4.9
9/27/2000	5
12/21/2000	5.3
3/13/2001	5.8
6/22/2001	5

9/24/2001	5
12/28/2001	5.3
3/18/2002	5.5
6/13/2002	6
9/16/2002	4.9
12/12/2002	6.8
3/19/2003	6
6/10/2003	4.7
9/29/2003	5.6

EP Bender
Fig 3.11 pH

Date	
2/24/1992	6.1
3/23/1992	6.3
4/14/1992	7.2
5/28/1992	6.7
6/24/1992	7
7/28/1992	6.5
8/19/1992	7.1
9/24/1992	7.1
10/28/1992	6.2
11/24/1992	5.9
12/30/1992	5.9
1/18/1993	6.5
2/11/1993	6.5
3/12/1993	6.3
4/27/1993	5.5
5/14/1993	6.4
6/3/1993	6.8
7/15/1993	7
8/13/1993	7
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	6.4
12/10/1996	6.3
2/26/1997	5.8
6/24/1997	6.1
9/8/1997	6.3
11/6/1997	6.3
3/23/1998	5.5
6/17/1998	6
9/23/1998	6.8
12/3/1998	6.3
3/24/1999	5
6/29/1999	6.6
9/22/1999	6.9
12/15/1999	10
3/8/2000	5
6/20/2000	6
9/27/2000	4.9
12/21/2000	5.8
3/13/2001	5.5
6/22/2001	4.5

9/24/2001	5.8
12/28/2001	6
3/18/2002	
6/13/2002	6.7
9/16/2002	
12/12/2002	
3/19/2003	6.6
6/10/2003	5.2
9/29/2003	5.2

EP Bender
Fig 3.12 Sulfates

Date	
2/24/1992	74
3/23/1992	68
4/14/1992	64
5/28/1992	74
6/24/1992	205
7/28/1992	116
8/19/1992	210
9/24/1992	123
10/28/1992	123
11/24/1992	62
12/30/1992	45
1/18/1993	43
2/11/1993	88
3/12/1993	56
4/27/1993	40
5/14/1993	76
6/3/1993	105
7/15/1993	123
8/13/1993	116
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	294
12/10/1996	244
2/26/1997	261
6/24/1997	286
9/8/1997	360
11/6/1997	311
3/23/1998	467
6/17/1998	426
9/23/1998	391.9
12/3/1998	587.2
3/24/1999	595
6/29/1999	572
9/22/1999	542
12/15/1999	580
3/8/2000	672
6/20/2000	698
9/27/2000	578
12/21/2000	651
3/13/2001	702
6/22/2001	657.6

9/24/2001	386
12/28/2001	616
3/18/2002	684
6/13/2002	847
9/16/2002	692
12/12/2002	900
3/19/2003	878
6/10/2003	883
9/29/2003	932

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Fig 3.13 Sulfates

Date	
2/24/1992	66
3/23/1992	44
4/14/1992	43
5/28/1992	64
6/24/1992	78
7/28/1992	53
8/19/1992	64
9/24/1992	66
10/28/1992	68
11/24/1992	50
12/30/1992	36
1/18/1993	30
2/11/1993	48
3/12/1993	50
4/27/1993	24
5/14/1993	51
6/3/1993	48
7/15/1993	70
8/13/1993	55
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	124
12/10/1996	141
2/26/1997	142
6/24/1997	118
9/8/1997	138
11/6/1997	164
3/23/1998	252
6/17/1998	132
9/23/1998	210
12/3/1998	165
3/24/1999	343
6/29/1999	142
9/22/1999	107
12/15/1999	286
3/8/2000	287
6/20/2000	273
9/27/2000	104
12/21/2000	461
3/13/2001	216
6/22/2001	180

9/24/2001	74
12/28/2001	463
3/18/2002	326
6/13/2002	336
9/16/2002	11
12/12/2002	410
3/19/2003	333
6/10/2003	327
9/29/2003	420

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Fig 3.14 Sulfates

Date	
2/24/1992	49
3/23/1992	39
4/14/1992	40
5/28/1992	38
6/24/1992	41
7/28/1992	39
8/19/1992	31
9/24/1992	34
10/28/1992	40
11/24/1992	35
12/30/1992	37
1/18/1993	30
2/11/1993	32
3/12/1993	32
4/27/1993	28
5/14/1993	34
6/3/1993	33
7/15/1993	31
8/13/1993	26
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	260
12/10/1996	286
2/26/1997	303
6/24/1997	280
9/8/1997	332
11/6/1997	297
3/23/1998	420
6/17/1998	276
9/23/1998	340
12/3/1998	426
3/24/1999	532
6/29/1999	464
9/22/1999	460
12/15/1999	526
3/8/2000	670
6/20/2000	554
9/27/2000	622
12/21/2000	543
3/13/2001	549
6/22/2001	692

9/24/2001	505
12/28/2001	626
3/18/2002	
6/13/2002	444
9/16/2002	
12/12/2002	
3/19/2003	398
6/10/2003	564
9/29/2003	497

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Fig 3.15 Manganese

Date	
8/1/1996	0.72
12/10/1996	0.66
2/26/1997	0.7
6/24/1997	1.1
9/8/1997	1.2
11/6/1997	1.7
3/23/1998	1.5
6/17/1998	1.3
9/23/1998	1.5
12/3/1998	1.3
3/24/1999	1.3
6/29/1999	1.4
9/22/1999	1.5
12/15/1999	1.2
3/8/2000	1.3
6/20/2000	1.2
9/27/2000	1.2
12/21/2000	1.4
3/13/2001	1.2
6/22/2001	1.3
9/24/2001	1.6
12/29/2001	1
3/8/2002	2.2
6/13/2002	1.3
9/16/2002	2.8
12/12/2002	1.6
3/19/2003	2.8

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Fig 3.16 Manganese

Date	
2/24/1992	0.53
3/23/1992	0.47
4/14/1992	0.42
5/28/1992	0.57
6/24/1992	0.81
7/28/1992	0.9
8/19/1992	1.02
9/24/1992	0.94
10/28/1992	1
11/24/1992	0.59
12/30/1992	0.4
1/18/1993	0.41
2/11/1993	0.63
3/12/1993	0.54
4/27/1993	0.18
5/14/1993	
6/3/1993	
7/15/1993	
8/13/1993	
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	7
12/10/1996	4.8
2/26/1997	8.8
6/24/1997	5.8
9/8/1997	6.86
11/6/1997	6
3/23/1998	12.6
6/17/1998	8.8
9/23/1998	6.9
12/3/1998	16.2
3/24/1999	11.6
6/29/1999	11
9/22/1999	11.7
12/15/1999	15.9
3/8/2000	18.9
6/20/2000	
9/27/2000	17
12/21/2000	15.4
3/13/2001	17.4
6/22/2001	17.1

9/24/2001	14.9
12/28/2001	14.5
3/18/2002	15.7
6/13/2002	25.3
9/16/2002	18.9
12/12/2002	18.5
3/19/2003	30
6/10/2003	32.5
9/29/2003	32.1

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Fig 3.17 Manganese

Date	
12/10/1996	14.27976
12/19/1996	16.12531
12/27/1996	14.6162
1/2/1997	10.97498
1/10/1997	5.489053
1/15/1997	9.677422
1/23/1997	7.543752
1/30/1997	7.082184
2/5/1997	7.457208
2/14/1997	9.575733
2/19/1997	6.800435
2/26/1997	39.7237
3/4/1997	19.58491
3/12/1997	28.55952
3/20/1997	19.28309
3/26/1997	14.86586
4/2/1997	14.15091
4/11/1997	10.61847
4/16/1997	9.639559
4/25/1997	7.909761
4/30/1997	7.845454
5/7/1997	5.906628
5/13/1997	5.840999
5/23/1997	7.942816
5/28/1997	15.28463
6/6/1997	11.76277
6/13/1997	10.25546
6/20/1997	8.07744
6/27/1997	7.835838
7/2/1997	6.344156
7/10/1997	4.988661
7/18/1997	4.886851
7/24/1997	4.13464
7/31/1997	0.333194
8/8/1997	4.997916
8/15/1997	3.937752
8/21/1997	10.72785
8/27/1997	8.35991
9/5/1997	6.47878
9/8/1997	6.386226
9/22/1997	4.912574
10/9/1997	8.20365

10/24/1997	4.79598
11/6/1997	
2/19/1997	
1/15/1998	
2/23/1998	
3/23/1998	
4/23/1998	
5/21/1998	
6/17/1998	13.09916
7/28/1998	8.052198
8/24/1998	6.110968
9/23/1998	9.59196
10/23/1998	10.06314
11/20/1998	6.483588
12/3/1998	6.512436
12/29/1998	5.351304
1/28/1999	71.94691
2/25/1999	19.85704
3/24/1999	50.23879
4/20/1999	35.56958
5/19/1999	16.33398
6/29/1999	
7/28/1999	
8/21/1999	
9/22/1999	
10/20/1999	
11/18/1999	
12/2/1999	16.05391
12/29/1999	15.57516
1/27/2000	13.3446
2/25/2000	31.46836
3/24/2000	66.56676
4/20/2000	41.02186
5/25/2000	30.95631
6/20/2000	30.30963
7/20/2000	15.64163
8/21/2000	9.613596
9/27/2000	12.03202
12/1/2000	0
3/1/2001	
6/8/2001	23.25149
7/6/2001	23.06398
8/14/2001	19.82939
9/24/2001	10.28431
10/26/2001	12.53686
11/29/2001	10.0968
12/28/2001	15.15722

1/30/2001	19.22719
2/26/2002	20.21764
3/18/2002	17.74873
4/22/2002	64.64837
5/23/2002	130.0901
6/13/2002	57.37867
7/24/2002	23.84768
8/9/2002	19.2921
9/16/2002	15.54907
10/17/2002	12.36858
11/21/2002	34.1368
12/12/2002	22.97022
1/6/2003	221.769

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Fig 3.18 Manganese

Date	
2/24/1992	0.21
3/23/1992	0.13
4/14/1992	0.15
5/28/1992	0.21
6/24/1992	0.21
7/28/1992	0.21
8/19/1992	0.27
9/24/1992	0.29
10/28/1992	0.29
11/24/1992	0.24
12/30/1992	0.13
1/18/1993	0.12
2/11/1993	0.2
3/12/1993	0.25
4/27/1993	0.31
5/14/1993	0.2
6/3/1993	0.01
7/15/1993	0.24
8/13/1993	0.34
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	0.9
12/10/1996	1.5
2/26/1997	2.1
6/24/1997	1.3
9/8/1997	1.5
11/6/1997	1.5
3/23/1998	3.3
6/17/1998	1.5
9/23/1998	1.7
12/3/1998	1.03
3/24/1999	3
6/29/1999	1.6
9/22/1999	1.3
12/15/1999	1.6
3/8/2000	2.1
6/20/2000	1.6
9/27/2000	1.5
12/21/2000	2.87
3/13/2001	1.2
6/22/2001	1.1

9/24/2001	2.4
12/28/2001	2.7
3/18/2002	1.8
6/13/2002	2.1
9/16/2002	4.7
12/12/2002	0.7
3/19/2003	1.5
6/10/2003	2.2
9/29/2003	2.8

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Fig 3.19 Manganese Load

Date	
1/17/1996	0.009231
3/11/1996	0.239535
5/13/1996	0.464861
7/18/1996	0.005625
9/27/1996	0.210783
11/26/1996	0.115452
1/23/1997	0.04207
3/26/1997	0.273816
5/28/1997	0.049102
7/24/1997	0.009195
9/8/1997	0.030038
11/6/1997	0.063574
1/15/1998	1.960654
3/23/1998	1.588623
5/21/1998	0.47354
7/28/1998	0.013955
9/23/1998	0.040195
11/20/1998	0.011395
1/28/1999	0.004808
5/19/1999	0.044089
6/29/1999	0.022742
8/31/1999	0.010746
10/20/1999	0.021456
12/15/1999	0.093552
2/25/2000	0.948174
4/20/2000	0.898531
6/20/2000	0.070762
8/21/2000	0.00351
11/22/2000	0.022814
1/19/2001	0.011683
3/13/2001	0.136379
5/21/2001	0.049474
7/18/2001	0.012657
9/24/2001	0.017309
10/26/2001	0.065233
1/30/2002	0.279177
3/18/2002	0.125946
5/23/2002	1.752756
7/24/2002	0.002308
9/16/2002	0.010505
11/21/2002	0.698122
1/6/2003	2.931053

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Fig 3.20 Manganese

Date	
2/24/1992	0.51
3/23/1992	0.41
4/14/1992	0.57
5/28/1992	0.32
6/24/1992	0.57
7/28/1992	0.57
8/19/1992	0.93
9/24/1992	0.82
10/28/1992	0.34
11/24/1992	0.26
12/30/1992	0.54
1/18/1993	0.49
2/11/1993	0.61
3/12/1993	0.45
4/27/1993	0.04
5/14/1993	0.59
6/3/1993	0.01
7/15/1993	2.5
8/13/1993	0.43
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	11
12/10/1996	10.5
2/26/1997	16
6/24/1997	9
9/8/1997	13
11/6/1997	9.9
3/23/1998	13.1
6/17/1998	14.4
9/23/1998	9.3
12/3/1998	8.3
3/24/1999	16.7
6/29/1999	9.7
9/22/1999	10.5
12/15/1999	13.3
3/8/2000	21.6
6/20/2000	18.2
9/27/2000	20.2
12/21/2000	23
3/13/2001	15.9
6/22/2001	24.3

9/24/2001	20.2
12/28/2001	18.4
3/18/2002	
6/13/2002	7.55
9/16/2002	
12/12/2002	
3/19/2003	10.2
6/10/2003	15.1
9/29/2003	14.7

EP Bender

Fig 3.21 Manganese Load

Date	
12/10/1996	1.597061
12/19/1996	1.822977
12/27/1996	1.497019
1/2/1997	1.467642
1/10/1997	0.869334
1/15/1997	1.038528
1/23/1997	1.331095
1/30/1997	1.277125
2/5/1997	2.126098
2/14/1997	1.708042
2/19/1997	1.248638
2/26/1997	2.319379
3/4/1997	2.02513
3/12/1997	4.0868
3/20/1997	2.457729
3/26/1997	2.206872
4/2/1997	1.627748
4/11/1997	1.401772
4/16/1997	1.225078
4/25/1997	0.983897
4/30/1997	0.770242
5/7/1997	0.582273
5/13/1997	0.700526
5/23/1997	1.187456
5/28/1997	1.307776
6/6/1997	1.389488
6/13/1997	1.297006
6/20/1997	0.71519
6/27/1997	0.562536
7/2/1997	0.719782
7/10/1997	1.43038
7/18/1997	0.521668
7/24/1997	0.540299
7/31/1997	0.458683
8/8/1997	0.387645
8/15/1997	0.71519
8/21/1997	0.87169
8/27/1997	0.581287
9/5/1997	0.624319
9/8/1997	0.605207
9/22/1997	0.791878
10/9/1997	1.076655

10/24/1997	0.077529
11/6/1997	
2/19/1997	
1/15/1998	
2/23/1998	
3/23/1998	
4/23/1998	
5/21/1998	3.158856
6/17/1998	1.605391
7/28/1998	0.864575
8/24/1998	0.804859
9/23/1998	0.733893
10/23/1998	0.655811
11/20/1998	0.413488
12/3/1998	0.33656
12/29/1998	0.407839
1/28/1999	4.835646
2/25/1999	0.980832
3/24/1999	3.768991
4/20/1999	2.206151
5/19/1999	1.76117
6/29/1999	
7/28/1999	
8/21/1999	
9/22/1999	
10/20/1999	
11/18/1999	0.488012
12/2/1999	1.154521
12/29/1999	0.804234
1/27/2000	0.936478
2/25/2000	7.9332
3/24/2000	1.931854
4/20/2000	2.786717
5/25/2000	1.951447
6/20/2000	2.01561
7/20/2000	1.288135
8/21/2000	0.857988
9/27/2000	0.813153
12/1/2000	
3/1/2001	
6/8/2001	2.000897
7/6/2001	2.333322
8/14/2001	0.900298
9/24/2001	0.971697
10/26/2001	0.790916
11/29/2001	0.840919
12/28/2001	1.266908

1/30/2001	1.453939
2/26/2002	1.497211
3/18/2002	
4/22/2002	0.110584
5/23/2002	0.38464
6/13/2002	0.100968
7/24/2002	
8/9/2002	
9/16/2002	
10/17/2002	
11/21/2002	
12/12/2002	
1/6/2003	1.0818

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Fig 3.22 Iron

Date	
8/1/1996	1.6
12/10/1996	5.4
2/26/1997	6.64
6/24/1997	2.7
9/8/1997	3.5
11/6/1997	10.3
3/23/1998	4.3
6/17/1998	4.2
9/23/1998	10.6
12/3/1998	2.9
3/24/1999	5.5
6/29/1999	3.1
9/22/1999	6.8
12/15/1999	6.1
3/8/2000	7.8
6/20/2000	1.3
9/27/2000	1.5
12/21/2000	4.3
3/13/2001	5.8
6/22/2001	1.2
9/24/2001	2.5
12/29/2001	2.3
3/8/2002	7.6
6/13/2002	1.1
9/16/2002	9.3
12/12/2002	3.5
3/19/2003	23.7

EP Bender
Fig 3.23 Iron

Date	
2/24/1992	0.14
3/23/1992	0.16
4/14/1992	0.08
5/28/1992	0.18
6/24/1992	0.26
7/28/1992	0.37
8/19/1992	0.3
9/24/1992	0.3
10/28/1992	0.34
11/24/1992	0.21
12/30/1992	0.14
1/18/1993	0.19
2/11/1993	0.21
3/12/1993	0.47
4/27/1993	0.12
5/14/1993	0.49
6/3/1993	0.39
7/15/1993	0.66
8/13/1993	
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	1.3
12/10/1996	0.92
2/26/1997	1.3
6/24/1997	1.27
9/8/1997	1.4
11/6/1997	1.4
3/23/1998	1.8
6/17/1998	2.5
9/23/1998	2.7
12/3/1998	2.7
3/24/1999	1.6
6/29/1999	4.6
9/22/1999	4.3
12/15/1999	2.8
3/8/2000	3.5
6/20/2000	6
9/27/2000	6.9
12/21/2000	5.2
3/13/2001	5.1
6/22/2001	5.8

9/24/2001	7.1
12/28/2001	4.3
3/18/2002	4.8
6/13/2002	3.4
9/16/2002	8.3
12/12/2002	7
3/19/2003	3.4
6/10/2003	2.9
9/29/2003	2.9

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Fig 3.24 Iron Load

Date	
12/10/1996	2.128982
12/19/1996	1.266547
12/27/1996	2.042438
1/2/1997	1.60443
1/10/1997	0.872291
1/15/1997	1.830406
1/23/1997	1.65876
1/30/1997	1.687608
2/5/1997	1.982939
2/14/1997	1.593131
2/19/1997	1.025066
2/26/1997	4.011314
3/4/1997	2.246899
3/12/1997	2.617956
3/20/1997	1.844469
3/26/1997	2.120328
4/2/1997	1.850118
4/11/1997	1.413552
4/16/1997	1.47846
4/25/1997	1.28614
4/30/1997	1.183249
5/7/1997	1.09382
5/13/1997	1.09382
5/23/1997	2.69248
5/28/1997	2.15783
6/6/1997	1.876442
6/13/1997	1.633278
6/20/1997	1.649144
6/27/1997	1.448891
7/2/1997	1.312584
7/10/1997	1.184691
7/18/1997	0.277662
7/24/1997	0.901139
7/31/1997	0.711824
8/8/1997	0.92554
8/15/1997	0.954148
8/21/1997	2.86076
8/27/1997	1.10608
9/5/1997	1.119903
9/8/1997	1.230968
9/22/1997	0.982515
10/9/1997	1.236017

10/24/1997	0.269248
11/6/1997	
2/19/1997	
1/15/1998	
2/23/1998	
3/23/1998	
4/23/1998	
5/21/1998	
6/17/1998	3.163904
7/28/1998	2.230551
8/24/1998	1.602266
9/23/1998	3.567536
10/23/1998	2.537662
11/20/1998	1.907814
12/3/1998	1.968876
12/29/1998	0.872772
1/28/1999	8.784216
2/25/1999	3.70216
3/24/1999	5.84172
4/20/1999	6.153278
5/19/1999	4.115648
6/29/1999	
7/28/1999	
8/21/1999	
9/22/1999	
10/20/1999	
11/18/1999	
12/2/1999	3.53388
12/29/1999	3.729806
1/27/2000	7.831751
2/25/2000	13.23919
3/24/2000	15.70293
4/20/2000	21.9353
5/25/2000	11.39496
6/20/2000	10.92378
7/20/2000	7.40432
8/21/2000	4.903679
9/27/2000	5.864558
12/1/2000	
3/1/2001	
6/8/2001	9.68812
7/6/2001	8.719308
8/14/2001	9.14121
9/24/2001	4.993108
10/26/2001	6.3105
11/29/2001	4.71184
12/28/2001	4.815332

1/30/2001	8.316878
2/26/2002	6.27444
3/18/2002	5.916244
4/22/2002	9.606384
5/23/2002	12.96718
6/13/2002	8.645746
7/24/2002	10.2545
8/9/2002	8.874366
9/16/2002	7.700493
10/17/2002	6.083322
11/21/2002	8.704884
12/12/2002	7.65674
1/6/2003	24.8814

EP Bender
Fig 3.25 Iron

Date	
2/24/1992	0.29
3/23/1992	0.28
4/14/1992	0.01
5/28/1992	0.02
6/24/1992	0.08
7/28/1992	0.05
8/19/1992	0.13
9/24/1992	0.42
10/28/1992	0.03
11/24/1992	0.06
12/30/1992	0.28
1/18/1993	0.48
2/11/1993	0.44
3/12/1993	0.23
4/27/1993	0.17
5/14/1993	0.05
6/3/1993	0.12
7/15/1993	0.15
8/13/1993	0.43
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	14.3
12/10/1996	15.8
2/26/1997	19.2
6/24/1997	3.3
9/8/1997	4.5
11/6/1997	4.4
3/23/1998	11.8
6/17/1998	14.6
9/23/1998	17.2
12/3/1998	7.2
3/24/1999	14.8
6/29/1999	16
9/22/1999	21.8
12/15/1999	17.5
3/8/2000	15.2
6/20/2000	27.4
9/27/2000	18.4
12/21/2000	28.4
3/13/2001	19.1
6/22/2001	27.9

9/24/2001	20.9
12/28/2001	20.4
3/18/2002	
6/13/2002	
9/16/2002	
12/12/2002	
3/19/2003	
6/10/2003	
9/29/2003	

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Fig 3.26 Iron Load

Date	
12/10/1996	1.631751
12/19/1996	1.451415
12/27/1996	2.038207
1/2/1997	1.694459
1/10/1997	0.87169
1/15/1997	1.254888
1/23/1997	1.448891
1/30/1997	1.144304
2/5/1997	1.691214
2/14/1997	1.088435
2/19/1997	0.911741
2/26/1997	2.042438
3/4/1997	1.852042
3/12/1997	2.104702
3/20/1997	2.151965
3/26/1997	1.211616
4/2/1997	1.062039
4/11/1997	0.444091
4/16/1997	0.77981
4/25/1997	0.214557
4/30/1997	0.159241
5/7/1997	0.116582
5/13/1997	0.17215
5/23/1997	0.356237
5/28/1997	0.324636
6/6/1997	1.213383
6/13/1997	0.692352
6/20/1997	0.459765
6/27/1997	0.328867
7/2/1997	0.29437
7/10/1997	1.22604
7/18/1997	0.027574
7/24/1997	0.178858
7/31/1997	0.1083
8/8/1997	0.134384
8/15/1997	0.245208
8/21/1997	0.176694
8/27/1997	0.172896
9/5/1997	0.235712
9/8/1997	0.21023
9/22/1997	0.289922
10/9/1997	0.400506

10/24/1997	0.004508
11/6/1997	
2/19/1997	
1/15/1998	
2/23/1998	
3/23/1998	
4/23/1998	
5/21/1998	0.932512
6/17/1998	1.554426
7/28/1998	1.332778
8/24/1998	0.686366
9/23/1998	1.019488
10/23/1998	0.812312
11/20/1998	0.439331
12/3/1998	0.308794
12/29/1998	0.158448
1/28/1999	1.366313
2/25/1999	1.624503
3/24/1999	3.177066
4/20/1999	2.980239
5/19/1999	3.308866
6/29/1999	
7/28/1999	
8/21/1999	
9/22/1999	
10/20/1999	
11/18/1999	0.647878
12/2/1999	1.757324
12/29/1999	1.137092
1/27/2000	1.536589
2/25/2000	2.8848
3/24/2000	2.04965
4/20/2000	2.86219
5/25/2000	1.808409
6/20/2000	2.752099
7/20/2000	1.545508
8/21/2000	0.904505
9/27/2000	0.758943
12/1/2000	
3/1/2001	
6/8/2001	3.003077
7/6/2001	4.019728
8/14/2001	1.005473
9/24/2001	1.03372
10/26/2001	0.37863
11/29/2001	0.554242
12/28/2001	1.415956

1/30/2001	1.540483
2/26/2002	3.833899
3/18/2002	0
4/22/2002	0.21636
5/23/2002	0.01779
6/13/2002	0.001202
7/24/2002	
8/9/2002	
9/16/2002	
10/17/2002	
11/21/2002	
12/12/2002	
1/6/2003	0.100968

EP Bender
Fig 3.27 Iron Load

Date	
1/17/1996	0.01327
3/11/1996	0.045195
5/13/1996	0.030483
7/18/1996	0.000433
9/27/1996	0.012308
11/26/1996	0.01226
1/23/1997	0.004628
3/26/1997	0.024521
5/28/1997	0.111425
7/24/1997	0.003678
9/8/1997	0.003269
11/6/1997	0.053237
1/15/1998	
3/23/1998	
5/21/1998	
7/28/1998	0.000649
9/23/1998	0.011106
11/20/1998	0.000288
1/28/1999	0
3/24/1999	0.086304
5/19/1999	0.002356
6/29/1999	0.001587
8/31/1999	0.002164
10/20/1999	0.002248
12/15/1999	0.00827
2/25/2000	0.084392
4/20/2000	0.054607
6/20/2000	0.006972
8/21/2000	0.000337
11/22/2000	0.000781
1/19/2001	0.000216
3/13/2001	0.011179
5/21/2001	0.005722
7/18/2001	0.000865
9/24/2001	0.00137
11/29/2001	0.000288
1/30/2002	0.00589
3/18/2002	0.003726
5/23/2002	0.038103
7/24/2002	0.000481
9/16/2002	0.002332
11/21/2002	0.028848

1/6/2003	0.107892

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Fig 3.28 Chloride

Date	
8/1/1996	7
12/10/1996	8
2/26/1997	9
6/24/1997	10
9/8/1997	8
11/6/1997	7
3/23/1998	9
6/17/1998	8
9/23/1998	6
12/3/1998	8
3/24/1999	8
6/29/1999	10
9/22/1999	8
12/15/1999	8
3/8/2000	12
6/20/2000	13
9/27/2000	12
12/21/2000	
3/13/2001	
6/22/2001	14
9/24/2001	13
12/28/2001	10
3/18/2002	
6/13/2002	11
9/16/2002	12.6
12/12/2002	
3/19/2003	
6/10/2003	17.9
9/29/2003	11.9

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Fig 3.28a Calcium

Date	
8/1/1996	72
12/10/1996	83.8
2/26/1997	102
6/24/1997	70.8
9/8/1997	109
11/6/1997	83.2
3/23/1998	104
6/17/1998	99.1
9/23/1998	97.1
12/3/1998	114
3/24/1999	118
6/29/1999	112
9/22/1999	111
12/15/1999	108
3/8/2000	144
6/20/2000	159
9/27/2000	160
12/21/2000	
3/13/2001	
6/22/2001	
9/24/2001	
12/28/2001	
3/18/2002	
6/13/2002	
9/16/2002	
6/10/2003	96
9/29/2003	89
12/9/2003	104
3/19/2004	93.5
6/18/2004	87.5
9/21/2004	69.7

EP Bender
Fig 3.29 Aluminum

Date	
2/24/1992	1.22
3/23/1992	1.05
4/14/1992	0.88
5/28/1992	0.91
6/24/1992	0.91
7/28/1992	1.2
8/19/1992	1.11
9/24/1992	1.42
10/28/1992	1.07
11/24/1992	1.14
12/30/1992	0.74
1/18/1993	0.96
2/11/1993	0.92
3/12/1993	1.15
4/27/1993	0.43
5/14/1993	0.8
6/3/1993	1
7/15/1993	0.59
8/13/1993	0.85
1/1/1994	
1/1/1995	
1/1/1996	
1/1/1997	
1/1/1998	
9/23/1998	2.9
12/3/1998	3.5
3/24/1999	8.3
6/29/1999	3.6
9/22/1999	3.2
12/15/1999	4.2
3/8/2000	9.4
6/20/2000	7.5
1/1/2001	
9/16/2002	3.2
6/10/2003	12.5
9/29/2003	12.7

EP Bender
Fig 3.29a Aluminum

Date	
2/24/1992	1.75
3/23/1992	1.02
4/14/1992	0.8
5/28/1992	1.32
6/24/1992	1.76
7/28/1992	1.1
8/19/1992	1.37
9/24/1992	1.37
10/28/1992	1.38
11/24/1992	1.58
12/30/1992	0.88
1/18/1993	0.88
2/11/1993	1.47
3/12/1993	1.85
4/27/1993	0.68
5/14/1993	0.75
6/3/1993	1.33
7/15/1993	1.19
8/13/1993	1.34
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	0.775
12/10/1996	0.162
2/26/1997	0.21
6/24/1997	0.61
9/8/1997	2.5
11/6/1997	1.8
3/23/1998	0.3
6/17/1998	1.25
9/23/1998	1.49
12/3/1998	1.5
3/24/1999	0.3
6/29/1999	1.3
9/22/1999	1
12/15/1999	0.679
3/8/2000	0.2
6/20/2000	1.3
9/27/2000	1.4
12/21/2000	
3/13/2001	
6/22/2001	

9/24/2001	
12/28/2001	
3/18/2002	
6/13/2002	
9/16/2002	
12/12/2002	
3/19/2003	
6/10/2003	
9/29/2003	

EP Bender
Fig 3.29b Aluminum

Date	
8/1/1996	0.264
12/10/1996	0.739
2/26/1997	2.1
6/24/1997	
9/8/1997	0.5
11/6/1997	
3/23/1998	1.38
6/17/1998	0.292
9/23/1998	
12/3/1998	
3/24/1999	4.1
6/29/1999	
9/22/1999	0.235
12/15/1999	0.789
3/8/2000	4.5
6/20/2000	0.74
9/27/2000	
12/21/2000	
3/13/2001	
6/22/2001	
9/24/2001	
12/28/2001	
3/18/2002	
6/13/2002	
9/16/2002	
6/10/2003	1.88
9/29/2003	1.3
12/9/2003	1.33
3/19/2004	
6/18/2004	
9/21/2004	1.7

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Fig 3.30 Specific Conductance

Date	
2/24/1992	300
3/23/1992	190
4/14/1992	178
5/28/1992	180
6/24/1992	275
7/28/1992	250
8/19/1992	260
9/24/1992	274
10/28/1992	312
11/24/1992	229
12/30/1992	187
1/18/1993	191
2/11/1993	216
3/12/1993	205
4/27/1993	158
5/14/1993	195
6/3/1993	254
7/15/1993	325
8/13/1993	331
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	711
12/10/1996	660
2/26/1997	805
6/24/1997	748
9/8/1997	850
11/6/1997	747
3/23/1998	1011
6/17/1998	951
9/23/1998	889
12/3/1998	1087
3/24/1999	1223
6/29/1999	1176
9/22/1999	1131
12/15/1999	1149
3/8/2000	1354
6/20/2000	1427
9/27/2000	1333
12/21/2000	1331
3/13/2001	1486
6/22/2001	1334

9/24/2001	1347
12/28/2001	1278
3/18/2002	1377
6/13/2002	1547
9/16/2002	1452
12/12/2002	1640
3/19/2003	1579
6/10/2003	1690
9/29/2003	1706

EP Bender
Fig 3.31 Aluminum

Date	#11	#18
2/24/1992	0.81	1.22
3/23/1992	0.76	1.05
4/14/1992	0.57	0.88
5/28/1992	0.77	0.91
6/24/1992	0.85	0.91
7/28/1992	1.17	1.2
8/19/1992	1.13	1.11
9/24/1992	1.18	1.42
10/28/1992	1.27	1.07
11/24/1992	0.99	1.14
12/30/1992	0.53	0.74
1/18/1993	0.46	0.96
2/11/1993	0.73	0.92
3/12/1993	0.73	1.15
4/27/1993	0.28	0.43
5/14/1993	0.36	0.8
6/3/1993	0.59	1
7/15/1993	0.56	0.59
8/13/1993	0.89	0.85
1/1/1994		
1/1/1995		
1/1/1996		
1/1/1997		
1/1/1998		
9/23/1998	1.2	2.9
12/3/1998	1	3.5
3/24/1999	0.4	8.3
6/29/1999	0.8	3.6
9/22/1999	1.2	3.2
12/15/1999	0.7	4.2
3/8/2000	0.63	9.4
6/20/2000	0.72	7.5
1/1/2001		
9/16/2002		3.2
6/10/2003	0.66	12.5
9/29/2003	0.64	12.7

EP Bender
Fig 3.32 Nickel

Date	#11	#18
8/1/1996	0.05	0.323
12/10/1996	0.039	0.241
2/26/1997	0.025	0.362
6/24/1997		0.225
9/8/1997	0.1	0.246
11/6/1997	0.06	0.245
3/23/1998	0.05	0.431
6/17/1998	0.05	0.318
9/23/1998	0.085	0.235
12/3/1998	0.072	0.29
3/24/1999	0.05	0.543
6/29/1999	0.059	0.326
9/22/1999	0.088	0.309
12/15/1999	0.058	0.326
3/8/2000	0.055	0.543
6/20/2000	0.051	0.509
9/27/2000	0.05	0.332
12/21/2000		
3/13/2001		
6/22/2001		
9/24/2001		
12/28/2001		
3/18/2002		
6/13/2002		
9/16/2002		0.375
6/10/2003	0.143	0.826
9/29/2003	0.137	0.8
12/9/2003	0.192	0.684
3/19/2004	0.137	0.676
6/18/2004	0.154	0.512
9/21/2004	0.125	1.1

EP Bender
Fig 3.32a Nickel

Date	#11	#19
8/1/1996	0.05	0.05
12/10/1996	0.039	0.058
2/26/1997	0.025	0.061
6/24/1997		0.052
9/8/1997	0.1	0.086
11/6/1997	0.06	0.058
3/23/1998	0.05	0.097
6/17/1998	0.05	0.071
9/23/1998	0.085	0.082
12/3/1998	0.072	0.07
3/24/1999	0.05	0.1
6/29/1999	0.059	0.085
9/22/1999	0.088	0.077
12/15/1999	0.058	0.074
3/8/2000	0.055	0.088
6/20/2000	0.051	0.088
9/27/2000	0.05	
12/21/2000		
3/13/2001		
6/22/2001		
9/24/2001		
12/28/2001		
3/18/2002		
6/13/2002		
9/16/2002		0.066
6/10/2003	0.143	0.114
9/29/2003	0.137	0.132
12/9/2003	0.192	0.105
3/19/2004	0.137	0.085
6/18/2004	0.154	0.1
9/21/2004	0.125	0.138

EP Bender

Fig 3.32b Nickel

Date	#11	#24
8/1/1996	0.05	0.09
12/10/1996	0.039	0.159
2/26/1997	0.025	0.217
6/24/1997		0.08
9/8/1997	0.1	0.067
11/6/1997	0.06	0.06
3/23/1998	0.05	0.172
6/17/1998	0.05	0.113
9/23/1998	0.085	0.062
12/3/1998	0.072	0.062
3/24/1999	0.05	0.288
6/29/1999	0.059	0.077
9/22/1999	0.088	0.098
12/15/1999	0.058	0.133
3/8/2000	0.055	0.326
6/20/2000	0.051	0.194
9/27/2000	0.05	0.12
12/21/2000		
3/13/2001		
6/22/2001		
9/24/2001		
12/28/2001		
3/18/2002		
6/13/2002		
9/16/2002		
6/10/2003	0.143	0.31
9/29/2003	0.137	0.278
12/9/2003	0.192	0.32
3/19/2004	0.137	0.193
6/18/2004	0.154	0.15
9/21/2004	0.125	0.231

EP Bender

Fig 3.33 Total Dissolved Solids

Date	#11	#18
8/1/1996	118	304
12/10/1996	106	520
2/26/1997	108	610
6/24/1997		642
9/8/1997	196	856
11/6/1997	130	578
3/23/1998	112	876
6/17/1998		
9/23/1998	178	790
12/3/1998	204	882
3/24/1999	90	564
6/29/1999	122	1118
9/22/1999	226	968
12/15/1999	160	924
3/8/2000	172	1150
6/20/2000	172	1298
9/27/2000	138	1146
12/21/2000	220	1164
3/13/2001	170	1422
6/22/2001	238	1274
9/24/2001		236
12/28/2001	298	1080
3/18/2002	358	1334
6/13/2002	622	1844
9/16/2002		1322
12/12/2002	1708	1708
3/19/2003	90	226
6/10/2003	498	1840
9/29/2003	326	534

EP Bender

Fig 3.33a Total Dissolved Solids

Date	#11	#19
8/1/1996	118	726
12/10/1996	106	414
2/26/1997	108	372
6/24/1997		334
9/8/1997	196	378
11/6/1997	130	300
3/23/1998	112	398
6/17/1998		408
9/23/1998	178	348
12/3/1998	204	290
3/24/1999	90	127
6/29/1999	122	300
9/22/1999	226	258
12/15/1999	160	442
3/8/2000	172	450
6/20/2000	172	476
9/27/2000	138	204
12/21/2000	220	432
3/13/2001	170	368
6/22/2001	238	330
9/24/2001		1432
12/28/2001	298	798
3/18/2002	358	598
6/13/2002	622	786
9/16/2002		182
12/12/2002	1708	682
3/19/2003	90	228
6/10/2003	498	544
9/29/2003	326	782
12/9/2003	598	504
3/19/2004	358	454
6/18/2004	544	468
9/21/2004	414	814

EP Bender

Fig 3.33b Total Dissolved Solids

Date	#11	#24
8/1/1996	118	670
12/10/1996	106	614
2/26/1997	108	694
6/24/1997		718
9/8/1997	196	716
11/6/1997	130	610
3/23/1998	112	778
6/17/1998		849
9/23/1998	178	658
12/3/1998	204	1840
3/24/1999	90	928
6/29/1999	122	730
9/22/1999	226	790
12/15/1999	160	894
3/8/2000	172	1080
6/20/2000	172	1186
9/27/2000	138	1092
12/21/2000	220	1110
3/13/2001	170	894
6/22/2001	238	1228
9/24/2001		478
12/28/2001	298	110
3/18/2002	358	
6/13/2002	622	1298
9/16/2002		
12/12/2002	1708	
3/19/2003	90	614
6/10/2003	498	1042
9/29/2003	326	680
12/9/2003	598	980
3/19/2004	358	710
6/18/2004	544	792
9/21/2004	414	730

EP Bender
Fig 3.33c Total Dissolved Solids

Date	
8/1/1996	726
12/10/1996	414
2/26/1997	372
6/24/1997	334
9/8/1997	378
11/6/1997	300
3/23/1998	398
6/17/1998	408
9/23/1998	348
12/3/1998	290
3/24/1999	127
6/29/1999	300
9/22/1999	258
12/15/1999	442
3/8/2000	450
6/20/2000	476
9/27/2000	204
12/21/2000	432
3/13/2001	368
6/22/2001	330
9/24/2001	1432
12/28/2001	798
3/18/2002	598
6/13/2002	786
9/16/2002	182
12/12/2002	682
3/19/2003	228
6/10/2003	544
9/29/2003	782
12/9/2003	504
3/19/2004	454
6/18/2004	468
9/21/2004	814

EP Bender

Fig 3.34 Zinc

Date	#11	#18
9/3/1998	0.145	0.32
12/3/1998	0.133	0.39
3/24/1999	0.08	0.86
6/29/1999	0.112	0.45
9/22/1999	0.152	0.42
12/15/1999	0.11	0.46
3/8/2000	0.099	0.84
6/20/2000	0.09	0.67
9/27/2000	0.092	0.41

EP Bender

Fig 3.35 Acidity

Date	#11	#18
2/24/1992	8	14
3/23/1992	2	8
4/14/1992	18	15
5/28/1992	8	10
6/24/1992	12	10
7/28/1992	14	16
8/19/1992	8	10
9/24/1992	14	12
10/28/1992	10	6
11/24/1992	26	18
12/30/1992	6	8
1/18/1993	6	6
2/11/1993	14	13
3/12/1993	12	12
4/27/1993	2	12
5/14/1993	8	10
6/3/1993	8	14
7/15/1993	4	0
8/13/1993	16	8
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	12.4	64
12/10/1996	8.6	40
2/26/1997	8	64
6/24/1997		16
9/8/1997	13.4	60
11/6/1997	17.4	48
3/23/1998	6.6	70
6/17/1998	11.4	64
9/23/1998	9.4	3.2
12/3/1998	11.4	40
3/24/1999	5	74
6/29/1999	11.2	60
9/22/1999	9.4	36
12/15/1999	11.8	72
3/8/2000	9.6	96
6/20/2000	8.2	94
9/27/2000	10.4	60
12/21/2000	9.6	52
3/13/2001	5.6	72
6/22/2001	30.6	99

9/24/2001		86
12/28/2001	17.2	86
3/18/2002	19.8	6
6/13/2002	23	115
9/16/2002		106
12/12/2002	18.6	17
3/19/2003	12.2	123
6/10/2003	40	214
9/29/2003	15	125

EP Bender
Fig 3.35a Acidity

Date	#11	#19
2/24/1992	8	0
3/23/1992	2	2
4/14/1992	18	2
5/28/1992	8	6
6/24/1992	12	0
7/28/1992	14	0
8/19/1992	8	0
9/24/1992	14	0
10/28/1992	10	3
11/24/1992	26	0
12/30/1992	6	2
1/18/1993	6	4
2/11/1993	14	0
3/12/1993	12	0
4/27/1993	2	6
5/14/1993	8	12
6/3/1993	8	12
7/15/1993	4	16
8/13/1993	16	16
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	12.4	15
12/10/1996	8.6	3.2
2/26/1997	8	1.6
6/24/1997		
9/8/1997	13.4	24
11/6/1997	17.4	22
3/23/1998	6.6	0
6/17/1998	11.4	12.2
9/23/1998	9.4	10
12/3/1998	11.4	9.6
3/24/1999	5	0
6/29/1999	11.2	8.2
9/22/1999	9.4	12.8
12/15/1999	11.8	8
3/8/2000	9.6	0
6/20/2000	8.2	6.8
9/27/2000	10.4	12.6
12/21/2000	9.6	5.8
3/13/2001	5.6	6.2
6/22/2001	30.6	32.6

9/24/2001		
12/28/2001	17.2	17.2
3/18/2002	19.8	14.2
6/13/2002	23	0
9/16/2002		
12/12/2002	18.6	0
3/19/2003	12.2	14.8
6/10/2003	40	25.2
9/29/2003	15	5.2

EP Bender

Fig 3.36 Calcium

Date	#11	#18
8/1/1996	6.9	70
12/10/1996	5.6	72.9
2/26/1997	6	85.2
6/24/1997		82.2
9/8/1997	10	111
11/6/1997	10.6	82
3/23/1998	6	127
6/17/1998	6.5	106
9/23/1998	12	130
12/3/1998	10.6	148
3/24/1999	7	132
6/29/1999	9.3	141
9/22/1999	11.4	136
12/15/1999	9.2	138
3/8/2000	9	153
6/20/2000	9.5	182
9/27/2000	9.5	178
12/21/2000		
3/13/2001		
6/22/2001		
9/24/2001		
12/28/2001		
3/18/2002		
6/13/2002		
9/16/2002		179
6/10/2003	36	160
9/29/2003	36	155
12/9/2003	48.7	171
3/19/2004	36	158
6/18/2004	40	149
9/21/2004	33	180

EP Bender

Fig 3.36a Calcium

Date	#11	#19
8/1/1996	6.9	25.6
12/10/1996	5.6	34.7
2/26/1997	6	50.7
6/24/1997		30.6
9/8/1997	10	37
11/6/1997	10.6	34.3
3/23/1998	6	63
6/17/1998	6.5	36.8
9/23/1998	12	43.5
12/3/1998	10.6	34.9
3/24/1999	7	69.6
6/29/1999	9.3	31.1
9/22/1999	11.4	22
12/15/1999	9.2	53
3/8/2000	9	54
6/20/2000	9.5	56.1
9/27/2000	9.5	21.2
12/21/2000		
3/13/2001		
6/22/2001		
9/24/2001		
12/28/2001		
3/18/2002		
6/13/2002		
9/16/2002		24
6/10/2003	36	58.5
9/29/2003	36	79
12/9/2003	48.7	52
3/19/2004	36	48.2
6/18/2004	40	46
9/21/2004	33	76

EP Bender

Fig 3.36b Calcium

Date	#11	#24
8/1/1996	6.9	72
12/10/1996	5.6	83.8
2/26/1997	6	102
6/24/1997		70.8
9/8/1997	10	109
11/6/1997	10.6	83.2
3/23/1998	6	104
6/17/1998	6.5	99.1
9/23/1998	12	97.1
12/3/1998	10.6	114
3/24/1999	7	118
6/29/1999	9.3	112
9/22/1999	11.4	111
12/15/1999	9.2	108
3/8/2000	9	144
6/20/2000	9.5	159
9/27/2000	9.5	160
12/21/2000		
3/13/2001		
6/22/2001		
9/24/2001		
12/28/2001		
3/18/2002		
6/13/2002		
9/16/2002		
6/10/2003	36	96
9/29/2003	36	89
12/9/2003	48.7	104
3/19/2004	36	93.5
6/18/2004	40	87.5
9/21/2004	33	69.7

EP Bender

Fig 3.36c Calcium

Date	
8/1/1996	25.6
12/10/1996	34.7
2/26/1997	50.7
6/24/1997	30.6
9/8/1997	37
11/6/1997	34.3
3/23/1998	63
6/17/1998	36.8
9/23/1998	43.5
12/3/1998	34.9
3/24/1999	69.6
6/29/1999	31.1
9/22/1999	22
12/15/1999	53
3/8/2000	54
6/20/2000	56.1
9/27/2000	21.2
12/21/2000	
3/13/2001	
6/22/2001	
9/24/2001	
12/28/2001	
3/18/2002	
6/13/2002	
9/16/2002	24
6/10/2003	58.5
9/29/2003	79
12/9/2003	52
3/19/2004	48.2
6/18/2004	46
9/21/2004	76

EP Bender
Fig 3.37 Iron

Date	
2/24/1992	0.01
3/23/1992	0.01
4/14/1992	0.01
5/28/1992	0.01
6/24/1992	0.01
7/28/1992	0.01
8/19/1992	0.01
9/24/1992	0.01
10/28/1992	0.01
11/24/1992	0.01
12/30/1992	0.04
1/18/1993	0.01
2/11/1993	0.01
3/12/1993	0.03
4/27/1993	0.01
5/14/1993	0.01
6/3/1993	0.01
7/15/1993	0.22
8/13/1993	
1/1/1994	
1/1/1995	
1/1/1996	
8/1/1996	0.029
12/10/1996	0.03
2/26/1997	0.02
6/24/1997	
9/8/1997	0.029
11/6/1997	0.034
3/23/1998	0.024
6/17/1998	0.032
9/23/1998	0.187
12/3/1998	0.03
3/24/1999	0.02
6/29/1999	0.02
9/22/1999	0.095
12/15/1999	0.02
3/8/2000	0.02
6/20/2000	0.022
9/27/2000	0.094
12/21/2000	0.044
3/13/2001	0.163
6/22/2001	0.2

9/24/2001	
12/28/2001	0.03
3/18/2002	0.07
6/13/2002	0.03
9/16/2002	
12/12/2002	1.1
3/19/2003	0.18
6/10/2003	0.02
9/29/2003	0.04

EP Bender

Fig 3.37a Iron

Date	11	18
2/24/1992	0.01	0.29
3/23/1992	0.01	0.28
4/14/1992	0.01	0.01
5/28/1992	0.01	0.02
6/24/1992	0.01	0.08
7/28/1992	0.01	0.05
8/19/1992	0.01	0.13
9/24/1992	0.01	0.42
10/28/1992	0.01	0.03
11/24/1992	0.01	0.06
12/30/1992	0.04	0.28
1/18/1993	0.01	0.48
2/11/1993	0.01	0.44
3/12/1993	0.03	0.23
4/27/1993	0.01	0.17
5/14/1993	0.01	0.05
6/3/1993	0.01	0.12
7/15/1993	0.22	0.15
8/13/1993		0.43
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	0.029	14.3
12/10/1996	0.03	15.8
2/26/1997	0.02	19.2
6/24/1997		3.3
9/8/1997	0.029	4.5
11/6/1997	0.034	4.4
3/23/1998	0.024	11.8
6/17/1998	0.032	14.6
9/23/1998	0.187	17.2
12/3/1998	0.03	7.2
3/24/1999	0.02	14.8
6/29/1999	0.02	16
9/22/1999	0.095	21.8
12/15/1999	0.02	17.5
3/8/2000	0.02	15.2
6/20/2000	0.022	27.4
9/27/2000	0.094	18.4
12/21/2000	0.044	28.4
3/13/2001	0.163	19.1
6/22/2001	0.2	27.9

9/24/2001		20.9
12/28/2001	0.03	20.4
3/18/2002	0.07	
6/13/2002	0.03	
9/16/2002		
12/12/2002	1.1	
3/19/2003	0.18	
6/10/2003	0.02	
9/29/2003	0.04	

EP Bender
Fig 3.37b Iron

Date	MP#11	MP#19
2/24/1992	0.01	0.15
3/23/1992	0.01	0.14
4/14/1992	0.01	0.03
5/28/1992	0.01	0.17
6/24/1992	0.01	0.24
7/28/1992	0.01	0.28
8/19/1992	0.01	0.39
9/24/1992	0.01	0.33
10/28/1992	0.01	0.42
11/24/1992	0.01	0.3
12/30/1992	0.04	0.19
1/18/1993	0.01	0.16
2/11/1993	0.01	0.12
3/12/1993	0.03	0.18
4/27/1993	0.01	0.12
5/14/1993	0.01	0.03
6/3/1993	0.01	0.14
7/15/1993	0.22	0.67
8/13/1993		0.73
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	0.029	0.064
12/10/1996	0.03	0.15
2/26/1997	0.02	0.123
6/24/1997		0.033
9/8/1997	0.029	0.067
11/6/1997	0.034	0.11
3/23/1998	0.024	0.233
6/17/1998	0.032	0.051
9/23/1998	0.187	0.075
12/3/1998	0.03	0.02
3/24/1999	0.02	0.193
6/29/1999	0.02	0.047
9/22/1999	0.095	0.075
12/15/1999	0.02	0.02
3/8/2000	0.02	0.02
6/20/2000	0.022	0.02
9/27/2000	0.094	0.02
12/21/2000	0.044	0.02
3/13/2001	0.163	0.05
6/22/2001	0.2	0.03

9/24/2001		0.123
12/28/2001	0.03	0.06
3/18/2002	0.07	0.06
6/13/2002	0.03	0.08
9/16/2002		0.353
12/12/2002	1.1	0.02
3/19/2003	0.18	0.342
6/10/2003	0.02	0.054
9/29/2003	0.04	0.054
9/29/2003		0.298

EP Bender
Fig 3.38 Manganese

Date	#11	#18
2/24/1992	0.71	0.53
3/23/1992	0.65	0.47
4/14/1992	0.47	0.42
5/28/1992	0.66	0.57
6/24/1992	0.72	0.81
7/28/1992	0.85	0.9
8/19/1992	1.05	1.02
9/24/1992	1.05	0.94
10/28/1992	1.2	1.03
11/24/1992	0.86	0.59
12/30/1992	0.58	0.4
1/18/1993	0.49	0.41
2/11/1993	0.64	0.63
3/12/1993	0.55	0.54
4/27/1993	0.16	0.18
5/14/1993	0.36	0.55
6/3/1993	0.16	0.02
7/15/1993	0.76	1.05
8/13/1993	0.94	1.24
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	0.46	7
12/10/1996	0.35	5
2/26/1997	0.33	8.8
6/24/1997		5.8
9/8/1997	0.89	6.86
11/6/1997	0.75	6
3/23/1998	0.3	12.6
6/17/1998	0.46	8.8
9/23/1998	1.1	6.9
12/3/1998	0.97	9
3/24/1999	0.39	16.2
6/29/1999	0.8	11.6
9/22/1999	1.2	11.1
12/15/1999	0.7	11.7
3/8/2000	0.7	15.9
6/20/2000	0.9	18.9
9/27/2000	0.97	17
12/21/2000	1.7	15.4
3/13/2001	1	17.4
6/22/2001	2	17.1

9/24/2001		14.9
12/28/2001	2.3	14.5
3/18/2002	2.9	15.7
6/13/2002	5.7	25.3
9/16/2002		18.9
12/12/2002	3.7	18.5
3/19/2003	2	30
6/10/2003	4.7	32.5
9/29/2003	5.3	32.1

EP Bender
Fig 3.38a Manganese

Date	#11	#19
2/24/1992	0.71	0.21
3/23/1992	0.65	0.13
4/14/1992	0.47	0.15
5/28/1992	0.66	0.21
6/24/1992	0.72	0.21
7/28/1992	0.85	0.21
8/19/1992	1.05	0.27
9/24/1992	1.05	0.29
10/28/1992	1.2	0.29
11/24/1992	0.86	0.24
12/30/1992	0.58	0.13
1/18/1993	0.49	0.12
2/11/1993	0.64	0.2
3/12/1993	0.55	0.25
4/27/1993	0.16	0.31
5/14/1993	0.36	0.2
6/3/1993	0.16	0.01
7/15/1993	0.76	0.24
8/13/1993	0.94	0.34
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	0.46	0.9
12/10/1996	0.35	1.5
2/26/1997	0.33	2.1
6/24/1997		1.3
9/8/1997	0.89	1.5
11/6/1997	0.75	1.5
3/23/1998	0.3	3.3
6/17/1998	0.46	1.5
9/23/1998	1.1	1.7
12/3/1998	0.97	1.03
3/24/1999	0.39	3
6/29/1999	0.8	1.6
9/22/1999	1.2	1.3
12/15/1999	0.7	1.6
3/8/2000	0.7	2.1
6/20/2000	0.9	1.6
9/27/2000	0.97	1.5
12/21/2000	1.7	2.87
3/13/2001	1	1.2
6/22/2001	2	1.1

9/24/2001		2.4
12/28/2001	2.3	2.7
3/18/2002	2.9	1.8
6/13/2002	5.7	2.1
9/16/2002		4.7
12/12/2002	3.7	0.7
3/19/2003	2	1.5
6/10/2003	4.7	2.2
9/29/2003	5.3	2.8

EP Bender
Fig 3.38b Manganese

Date	MP11	MP24
2/24/1992	0.71	0.51
3/23/1992	0.65	0.41
4/14/1992	0.47	0.57
5/28/1992	0.66	0.32
6/24/1992	0.72	0.57
7/28/1992	0.85	0.57
8/19/1992	1.05	0.93
9/24/1992	1.05	0.82
10/28/1992	1.2	0.34
11/24/1992	0.86	0.26
12/30/1992	0.58	0.54
1/18/1993	0.49	0.49
2/11/1993	0.64	0.61
3/12/1993	0.55	0.45
4/27/1993	0.16	0.04
5/14/1993	0.36	0.59
6/3/1993	0.16	0.01
7/15/1993	0.76	2.5
8/13/1993	0.94	0.43
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	0.46	11
12/10/1996	0.35	10.5
2/26/1997	0.33	16
6/24/1997		9
9/8/1997	0.89	13
11/6/1997	0.75	9.9
3/23/1998	0.3	13.1
6/17/1998	0.46	14.4
9/23/1998	1.1	9.3
12/3/1998	0.97	8.3
3/24/1999	0.39	16.7
6/29/1999	0.8	9.7
9/22/1999	1.2	10.5
12/15/1999	0.7	13.3
3/8/2000	0.7	21.6
6/20/2000	0.9	18.2
9/27/2000	0.97	20.2
12/21/2000	1.7	23
3/13/2001	1	15.9
6/22/2001	2	24.3

9/24/2001		20.2
12/28/2001	2.3	18.4
3/18/2002	2.9	
6/13/2002	5.7	7.55
9/16/2002		
12/12/2002	3.7	
3/19/2003	2	10.2
6/10/2003	4.7	15.1
9/29/2003	5.3	14.7

EP Bender
Fig 3.39 Sulfate

Date	MP#11	MP#18
2/24/1992	58	74
3/23/1992	48	68
4/14/1992	44	64
5/28/1992	50	74
6/24/1992	145	205
7/28/1992	68	116
8/19/1992	83	210
9/24/1992	78	123
10/28/1992	83	123
11/24/1992	53	62
12/30/1992	36	45
1/18/1993	32	43
2/11/1993	44	88
3/12/1993	35	56
4/27/1993	28	40
5/14/1993	40	76
6/3/1993	42	105
7/15/1993	63	123
8/13/1993	52	116
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	42	294
12/10/1996	36	244
2/26/1997	64	261
6/24/1997		286
9/8/1997	47	360
11/6/1997	43	311
3/23/1998	20	467
6/17/1998	24	426
9/23/1998	67.7	391.9
12/3/1998	63.4	587.2
3/24/1999	30	595
6/29/1999	43	572
9/22/1999	69	542
12/15/1999	48	580
3/8/2000	35	672
6/20/2000	44	698
9/27/2000	47	578
12/21/2000	60	651
3/13/2001	46	702
6/22/2001	97	657.6

9/24/2001		386
12/28/2001	144	616
3/18/2002	163	684
6/13/2002	249	847
9/16/2002		692
12/12/2002	224	900
3/19/2003	105	878
6/10/2003	216	883
9/29/2003	308	932

EP Bender
Fig 3.39a Sulfate

Date	MP#11	MP#19
2/24/1992	58	66
3/23/1992	48	44
4/14/1992	44	43
5/28/1992	50	64
6/24/1992	145	78
7/28/1992	68	53
8/19/1992	83	64
9/24/1992	78	66
10/28/1992	83	68
11/24/1992	53	50
12/30/1992	36	36
1/18/1993	32	30
2/11/1993	44	48
3/12/1993	35	50
4/27/1993	28	24
5/14/1993	40	51
6/3/1993	42	48
7/15/1993	63	70
8/13/1993	52	55
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	42	124
12/10/1996	36	141
2/26/1997	64	142
6/24/1997		118
9/8/1997	47	138
11/6/1997	43	164
3/23/1998	20	252
6/17/1998	24	132
9/23/1998	67.7	210
12/3/1998	63.4	165
3/24/1999	30	343
6/29/1999	43	142
9/22/1999	69	107
12/15/1999	48	286
3/8/2000	35	287
6/20/2000	44	273
9/27/2000	47	104
12/21/2000	60	461
3/13/2001	46	216
6/22/2001	97	180

9/24/2001		74
12/28/2001	144	463
3/18/2002	163	326
6/13/2002	249	336
9/16/2002		11
12/12/2002	224	410
3/19/2003	105	333
6/10/2003	216	327
9/29/2003	308	420

EP Bender

Fig 3.39b Sulfate

Date	MP11	MP24
2/24/1992	58	49
3/23/1992	48	39
4/14/1992	44	40
5/28/1992	50	38
6/24/1992	145	41
7/28/1992	68	39
8/19/1992	83	31
9/24/1992	78	34
10/28/1992	83	40
11/24/1992	53	35
12/30/1992	36	37
1/18/1993	32	30
2/11/1993	44	32
3/12/1993	35	32
4/27/1993	28	28
5/14/1993	40	34
6/3/1993	42	33
7/15/1993	63	31
8/13/1993	52	26
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	42	260
12/10/1996	36	286
2/26/1997	64	303
6/24/1997		280
9/8/1997	47	332
11/6/1997	43	297
3/23/1998	20	420
6/17/1998	24	276
9/23/1998	67.7	340
12/3/1998	63.4	426
3/24/1999	30	532
6/29/1999	43	464
9/22/1999	69	460
12/15/1999	48	526
3/8/2000	35	670
6/20/2000	44	554
9/27/2000	47	622
12/21/2000	60	543
3/13/2001	46	549
6/22/2001	97	692

9/24/2001		505
12/28/2001	144	626
3/18/2002	163	
6/13/2002	249	444
9/16/2002		
12/12/2002	224	
3/19/2003	105	398
6/10/2003	216	564
9/29/2003	308	497

EP Bender
Fig 3.40 pH

Date	#11	#19
2/24/1992	4.5	4.4
3/23/1992	4.7	4.4
4/14/1992	5	4.7
5/28/1992	5.2	4.7
6/24/1992	5.2	4.9
7/28/1992	5.1	4.3
8/19/1992	5.1	5
9/24/1992	5.3	5.3
10/28/1992	4.3	4.4
11/24/1992	5.8	5.8
12/30/1992	4.6	4.6
1/18/1993	4.5	4.6
2/11/1993	4.6	4
3/12/1993	4.5	4.2
4/27/1993	5	5.5
5/14/1993	4.8	4.6
6/3/1993	5	4.8
7/15/1993	4.6	4.9
8/13/1993	4.9	4.9
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	4.7	4.8
12/10/1996	4.7	6.2
2/26/1997	4.7	5.7
6/24/1997		5.2
9/8/1997	4.7	4.8
11/6/1997	4.7	4.6
3/23/1998	4.7	6
6/17/1998	4.7	4.8
9/23/1998	4.6	4.8
12/3/1998	4.7	4.8
3/24/1999	4.7	5.8
6/29/1999	4.7	4.9
9/22/1999	4.6	4.8
12/15/1999	4.6	4.9
3/8/2000	4.7	5.8
6/20/2000	4.5	5
9/27/2000	4.7	5
12/21/2000	4.5	5.3
3/13/2001	4.7	5.8
6/22/2001	5	5

9/24/2001		5
12/28/2001	5	5.3
3/18/2002	5	5.5
6/13/2002	4.7	6
9/16/2002		4.9
12/12/2002	5	6.8
3/19/2003	4.9	6
6/10/2003	5	4.7
9/29/2003	3.8	5.6

EP Bender
Fig 3.40a Alkalinity

Date	#11	#19
2/24/1992	2	0
3/23/1992	4	2
4/14/1992	4	2
5/28/1992	4	6
6/24/1992	2	0
7/28/1992	2	0
8/19/1992	6	0
9/24/1992	2	0
10/28/1992	8	3
11/24/1992	4	0
12/30/1992	6	2
1/18/1993	4	4
2/11/1993	0	0
3/12/1993	2	0
4/27/1993	6	6
5/14/1993	6	4
6/3/1993	6	0
7/15/1993	4	0
8/13/1993	4	0
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	4.6	7.6
12/10/1996	6.2	18.2
2/26/1997	6.8	22
6/24/1997		11
9/8/1997	6.6	9.6
11/6/1997	6.8	7.6
3/23/1998	7.4	19.6
6/17/1998	5.6	10.4
9/23/1998	5.8	9.6
12/3/1998	5.6	8.8
3/24/1999	6	16.2
6/29/1999	5	10.2
9/22/1999	8	9.4
12/15/1999	4.8	8
3/8/2000	6	14.8
6/20/2000	6	11.6
9/27/2000	7	8.6
12/21/2000	7	10
3/13/2001	2.2	3
6/22/2001	2	4.4

9/24/2001		2.8
12/28/2001	2.4	3
3/18/2002	2.6	3.2
6/13/2002	1.4	28
9/16/2002		2.8
12/12/2002	1.6	13.2
3/19/2003	4.2	7.2
6/10/2003	2.8	8.4
9/29/2003	3.4	8.8

EP Bender

Fig 3.40b pH

Date	#11	#24
2/24/1992	4.5	6.5
3/23/1992	4.7	6.4
4/14/1992	5	7.2
5/28/1992	5.2	6.7
6/24/1992	5.2	7
7/28/1992	5.1	6.5
8/19/1992	5.1	7.1
9/24/1992	5.3	7.1
10/28/1992	4.3	6.2
11/24/1992	5.8	5.9
12/30/1992	4.6	5.9
1/18/1993	4.5	6.5
2/11/1993	4.6	6.5
3/12/1993	4.5	6.3
4/27/1993	5	5.5
5/14/1993	4.8	6.4
6/3/1993	5	6.8
7/15/1993	4.6	7
8/13/1993	4.9	7
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	4.7	6.4
12/10/1996	4.7	6.3
2/26/1997	4.7	5.8
6/24/1997		6.1
9/8/1997	4.7	6.3
11/6/1997	4.7	6.3
3/23/1998	4.7	5.5
6/17/1998	4.7	6
9/23/1998	4.6	6.8
12/3/1998	4.7	6.3
3/24/1999	4.7	5
6/29/1999	4.7	6.6
9/22/1999	4.6	6.9
12/15/1999	4.6	10
3/8/2000	4.7	5.4
6/20/2000	4.5	6
9/27/2000	4.7	4.9
12/21/2000	4.5	5.8
3/13/2001	4.7	5.5
6/22/2001	5	4.5

9/24/2001		5.8
12/28/2001	5	6
3/18/2002	5	
6/13/2002	4.7	6.7
9/16/2002		
12/12/2002	5	
3/19/2003	4.9	6.5
6/10/2003	5	5.2
9/29/2003	3.8	5.2
12/9/2003	3.8	4.7
3/19/2004	4.8	5.9
6/18/2004	5	5.9
9/21/2004	4.7	5

EP Bender

Fig 3.40c Alkalinity

Date	MP24	MP11
2/24/1992	11	2
3/23/1992	12	4
4/14/1992	12	4
5/28/1992	22	4
6/24/1992	32	2
7/28/1992	24	2
8/19/1992	44	6
9/24/1992	24	2
10/28/1992	38	8
11/24/1992	16	4
12/30/1992	10	6
1/18/1993	12	4
2/11/1993	16	0
3/12/1993	8	2
4/27/1993	8	6
5/14/1993	14	6
6/3/1993	26	6
7/15/1993	62	4
8/13/1993	50	4
1/1/1994		
1/1/1995		
1/1/1996		
8/1/1996	30	4.6
12/10/1996	30	6.2
2/26/1997	24	6.8
6/24/1997	18.2	
9/8/1997	17	6.6
11/6/1997	18.2	6.8
3/23/1998	11.8	7.4
6/17/1998	15.4	5.6
9/23/1998	42	5.8
12/3/1998	22	5.6
3/24/1999	9	6
6/29/1999	26	5
9/22/1999	58	8
12/15/1999	346	4.8
3/8/2000	10	6
6/20/2000	16	6
9/27/2000	7.6	7
12/21/2000	13	7
3/13/2001	3.8	2.2
6/22/2001	0	2

9/24/2001	6.2	
12/28/2001	2	2.4
3/18/2002		2.6
6/13/2002	274	1.4
9/16/2002		
12/12/2002		1.6
3/19/2003	88	4.2
6/10/2003	6	2.8
9/29/2003	7.8	3.4

Swamp Poodle

Fig 4.1 Iron

DATE	
8/30/1995	17.05
9/22/1995	
10/25/1995	229.3
11/15/1995	42.83
12/16/1995	13.82
1/18/1996	53.01
5/21/1996	178
7/11/1996	181
10/21/1996	109
3/27/1997	9.93
4/22/1997	28.6
9/23/1997	75.2
10/23/1997	44.5
3/24/1998	6.42
4/21/1998	4.23
9/1/1998	
10/6/1998	
3/16/1999	27.1
9/15/1999	144

Swamp Poodle
Fig 4.2 Manganese

DATE	
8/30/1995	1.04
9/22/1995	
10/25/1995	1.78
11/15/1995	0.72
12/16/1995	0.49
1/18/1996	1.22
5/21/1996	5.73
7/11/1996	1.74
10/21/1996	1.95
3/27/1997	1.66
4/22/1997	3.42
9/23/1997	1.53
10/23/1997	0.9
3/24/1998	0.28
4/21/1998	0.21
9/1/1998	
10/6/1998	
3/16/1999	0.63
9/15/1999	2.25

Swamp Poodle
Fig 4.3 Sulfates

DATE	
8/30/1995	320
9/22/1995	
10/25/1995	899
11/15/1995	378
12/16/1995	161
1/18/1996	325
5/21/1996	1037
7/11/1996	898
10/21/1996	559
3/27/1997	103
4/22/1997	205
9/23/1997	533
10/23/1997	408
3/24/1998	91
4/21/1998	132
9/1/1998	
10/6/1998	
3/16/1999	415
9/15/1999	775

Swamp Poodle
Fig 4. Acidity

DATE	
DATE	Acidity
8/30/1995	0
9/22/1995	
10/25/1995	840
11/15/1995	220
12/16/1995	104
1/18/1996	262
5/21/1996	744
7/11/1996	831
10/21/1996	466
3/27/1997	162
4/22/1997	203
9/23/1997	402
10/23/1997	271
3/24/1998	85
4/21/1998	93
9/1/1998	
10/6/1998	
3/16/1999	451
9/15/1999	529

Swamp Poodle
Fig 4.5 pH

DATE	
8/30/1995	6.1
9/22/1995	
10/25/1995	2.4
11/15/1995	2.9
12/16/1995	3.2
1/18/1996	3
5/21/1996	4.1
7/11/1996	2.8
10/21/1996	2.8
3/27/1997	3.4
4/22/1997	3
9/23/1997	2.6
10/23/1997	3.2
3/24/1998	3.5
4/21/1998	3.6
9/1/1998	
10/6/1998	
3/16/1999	3.2
9/15/1999	3

Swamp Poodle

Fig 4.6 Total Dissolved Solids

DATE	
8/30/1995	928
9/22/1995	
10/25/1995	2066
11/15/1995	684
12/16/1995	618
1/18/1996	866
5/21/1996	1250
7/11/1996	1140
10/21/1996	875
3/27/1997	704
4/22/1997	616
9/23/1997	103.5
10/23/1997	836
3/24/1998	1040
4/21/1998	884
9/1/1998	
10/6/1998	
3/16/1999	1480
9/15/1999	1420

Swamp Poodle

Fig 4.6a Chloride

DATE	
8/30/1995	52
9/22/1995	
10/25/1995	80
11/15/1995	160
12/16/1995	230
1/18/1996	215
5/21/1996	101
7/11/1996	197
10/21/1996	155
3/27/1997	432
4/22/1997	263
9/23/1997	230
10/23/1997	215
3/24/1998	427
4/21/1998	
9/1/1998	
10/6/1998	
3/16/1999	
9/15/1999	

Swamp Poodle

Fig 4.7 Calcium & Magnesium

DATE	Ca	Mg
8/30/1995	112.5	14.2
9/22/1995		
10/25/1995	135	16
11/15/1995	44	12
12/16/1995	34	10
1/18/1996	48	17
5/21/1996		
7/11/1996		
10/21/1996		
3/27/1997	46.2	22.9
4/22/1997		
9/23/1997		
10/23/1997		
3/24/1998	48.2	17.5
4/21/1998		
9/1/1998		
10/6/1998		
3/16/1999	66.2	20.5
9/15/1999		

Swamp Poodle
Fig 4.8 Trace Elements

Date	As	Cd	Pb	Se
8/30/1995	<0.015	0.0031	<0.01	0.023
9/22/1995				
10/25/1995	0.025	0.0039	0.02	<0.023
11/15/1995	0.039	0.0017	0.014	<0.023
12/16/1995	0.083	0.0008	<0.01	<0.023
1/18/1996	<0.015	0.0014	<0.01	<0.023
5/21/1996				
7/11/1996				
10/21/1996				
3/27/1997	<0.05	<0.03	0.038	<0.05
4/22/1997				
9/23/1997				
10/23/1997				
3/24/1998	<0.015	<0.03	0.005	<0.01
4/21/1998				
9/1/1998				
10/6/1998				
3/16/1999	0.018	<0.03	0.014	0.016
9/15/1999				

Swamp Poodle

Fig 4.10 Iron

DATE	
8/31/1995	10594
9/22/1995	3019
10/25/1995	2058
11/15/1995	1108
12/16/1995	1748
1/18/1996	3193
5/21/1996	1733
7/11/1996	1150
10/22/1996	864
3/27/1997	1091
4/22/1997	1469
9/23/1997	2000
10/23/1997	1591
3/24/1998	1217
4/21/1998	1020
9/1/1998	1280
10/6/1998	1064
3/16/1999	1111
9/15/1999	9320

Swamp Poodle
Fig 4.11 Manganese

DATE	
8/31/1995	95.4
9/22/1995	25.7
10/25/1995	23.61
11/15/1995	14.2
12/16/1995	19.53
1/18/1996	11.3
5/21/1996	19.3
7/11/1996	6.91
10/22/1996	6.57
3/27/1997	9.66
4/22/1997	13.7
9/23/1997	19
10/23/1997	13.3
3/24/1998	21.1
4/21/1998	17.9
9/1/1998	17.5
10/6/1998	17.9
3/16/1999	34.2
9/15/1999	50.7

Swamp Poodle
Fig 4.12 Sulfates

DATE	
8/31/1995	15,192
9/22/1995	8583
10/25/1995	4819
11/15/1995	4171
12/16/1995	5054
1/18/1996	9294
5/21/1996	4741
7/11/1996	4016
10/22/1996	3593
3/27/1997	4185
4/22/1997	5346
9/23/1997	6076
10/23/1997	6471
3/24/1998	5946
4/21/1998	4447
9/1/1998	5053
10/6/1998	3862
3/16/1999	99
9/15/1999	

Swamp Poodle
Fig 4.13 Acidity

DATE	
8/31/1995	18480
9/22/1995	6582
10/25/1995	5400
11/15/1995	3960
12/16/1995	4520
1/18/1996	8800
5/21/1996	4614
7/11/1996	3648
10/22/1996	3564
3/27/1997	3712
4/22/1997	4561
9/23/1997	5470
10/23/1997	5281
3/24/1998	4590
4/21/1998	3142
9/1/1998	4051
10/6/1998	2604
3/16/1999	1111
9/15/1999	

Swamp Poodle
Fig 4.14 pH

DATE	
8/31/1995	2.9
9/22/1995	3.1
10/25/1995	2.8
11/15/1995	2.7
12/16/1995	2.6
1/18/1996	7.8
5/21/1996	3.7
7/11/1996	2.9
10/22/1996	2.8
3/27/1997	2.8
4/22/1997	2.6
9/23/1997	2.3
10/23/1997	2.8
3/24/1998	2.5
4/21/1998	2.5
9/1/1998	2.7
10/6/1998	2.8
3/16/1999	2.1
9/15/1999	2.6

Swamp Poodle

Fig 4.15 Total Dissolved Solids

DATE	
8/31/1995	26798
9/22/1995	12890
10/25/1995	10388
11/15/1995	6500
12/16/1995	8590
1/18/1996	15152
5/21/1996	6688
7/11/1996	5180
10/22/1996	6000
3/27/1997	5000
4/22/1997	7590
9/23/1997	7680
10/23/1997	9650
3/24/1998	8830
4/21/1998	6480
9/1/1998	7050
10/6/1998	5870
3/16/1999	1111
9/15/1999	

Swamp Poodle

Fig 4.16 Chloride

DATE	
8/31/1995	1
9/22/1995	91.6
10/25/1995	50
11/15/1995	119
12/16/1995	2400
1/18/1996	116
5/21/1996	219
7/11/1996	173
10/22/1996	214
3/27/1997	114
4/22/1997	129
9/23/1997	217
10/23/1997	248
3/24/1998	236
4/21/1998	
9/1/1998	
10/6/1998	
3/16/1999	
9/15/1999	

Swamp Poodle

Fig 4.17 Calcium & Magnesium

Date	Ca	Mg
8/31/1995	252	148
9/22/1995	175	69
10/25/1995	302	113
11/15/1995	181	70
12/16/1995	139	57
1/18/1996	139	81
5/21/1996		
7/11/1996		
10/22/1996		
3/27/1997	159	66
4/22/1997		
9/23/1997		
10/23/1997		
3/24/1998	269	102
4/21/1998		
9/1/1998		
10/6/1998		
3/16/1999	128	298
9/15/1999		

Swamp Poodle
Fig 4.18 Trace Elements

Date	As	Cd	Pb	Se
8/31/1995	0.153	0.0169	<0.01	<0.023
9/22/1995	0.11	0.0081	<0.01	<0.023
10/25/1995	0.02	0.0092	<0.01	<0.023
11/15/1995	0.206	0.0106	<0.01	<0.023
12/16/1995	0.238	0.0133	<0.01	<0.023
1/18/1996	0.918	0.0173	<0.01	<0.023
5/21/1996				
7/11/1996				
10/22/1996				
3/27/1997	1.095	0.03	0.063	0.334
4/22/1997				
9/23/1997				
10/23/1997				
3/24/1998	0.119	0.04	0.005	0.024
4/21/1998				
9/1/1998				
10/6/1998				
3/16/1999	3.89	0.23	0.069	0.177
9/15/1999				

Swamp Poodle

Fig 4.20 Iron

DATE	
8/30/1995	196
9/22/1995	98
10/25/1995	64
11/15/1995	106
12/16/1995	168.6
1/18/1996	104.8
5/21/1996	117
7/11/1996	163
10/21/1996	167
3/27/1997	250
4/22/1997	235
9/23/1997	174
10/23/1997	165
3/24/1998	253
4/21/1998	286
9/1/1998	205
10/6/1998	242
3/16/1999	250
9/15/1999	182

Swamp Poodle
Fig 4.21 Manganese

DATE	
8/30/1995	8
9/22/1995	5.6
10/25/1995	5.7
11/15/1995	4.9
12/16/1995	4.7
1/18/1996	4.4
5/21/1996	3.8
7/11/1996	4.5
10/21/1996	6.3
3/27/1997	8.9
4/22/1997	8.8
9/23/1997	9.4
10/23/1997	8.8
3/24/1998	9.9
4/21/1998	11.2
9/1/1998	11.2
10/6/1998	13.2
3/16/1999	18.2
9/15/1999	16.1

Swamp Poodle
Fig 4.22 Sulfate

DATE	
8/30/1995	532
9/22/1995	462
10/25/1995	368
11/15/1995	638
12/16/1995	834
1/18/1996	686
5/21/1996	673
7/11/1996	845
10/21/1996	965
3/27/1997	1326
4/22/1997	1339
9/23/1997	1130
10/23/1997	1001
3/24/1998	1679
4/21/1998	1704
9/1/1998	1444
10/6/1998	1638
3/16/1999	1758
9/15/1999	2220

Swamp Poodle

Fig 4.23 Acidity

DATE	
8/30/1995	362
9/22/1995	402
10/25/1995	482
11/15/1995	290
12/16/1995	578
1/18/1996	540
5/21/1996	525
7/11/1996	71
10/21/1996	670
3/27/1997	1034
4/22/1997	942
9/23/1997	623
10/23/1997	544
3/24/1998	1098
4/21/1998	1084
9/1/1998	861
10/6/1998	1014
3/16/1999	1093
9/15/1999	1217

Swamp Poodle
Fig 4.24 pH

DATE	
8/30/1995	4.4
9/22/1995	3.4
10/25/1995	3.1
11/15/1995	3
12/16/1995	3
1/18/1996	7.8
5/21/1996	3.9
7/11/1996	3.2
10/21/1996	3.2
3/27/1997	3.2
4/22/1997	3
9/23/1997	3
10/23/1997	3.5
3/24/1998	2.7
4/21/1998	2.9
9/1/1998	3.1
10/6/1998	3.1
3/16/1999	2.8
9/15/1999	3.1

Swamp Poodle

Fig 4.25 Total Dissolved Solids

DATE	
8/30/1995	1060
9/22/1995	942
10/25/1995	1132
11/15/1995	1010
12/16/1995	1242
1/18/1996	1200
5/21/1996	945
7/11/1996	1172
10/21/1996	1555
3/27/1997	190.3
4/22/1997	2030
9/23/1997	1775
10/23/1997	1668
3/24/1998	2435
4/21/1998	2535
9/1/1998	2035
10/6/1998	2395
3/16/1999	2610
9/15/1999	3435

Swamp Poodle
Fig 4.26 Chloride

DATE	
8/30/1995	11
9/22/1995	66.7
10/25/1995	70
11/15/1995	58
12/16/1995	50
1/18/1996	51
5/21/1996	183
7/11/1996	113
10/21/1996	121
3/27/1997	116
4/22/1997	112
9/23/1997	149
10/23/1997	138
3/24/1998	123
4/21/1998	
9/1/1998	
10/6/1998	
3/16/1999	
9/15/1999	

Swamp Poodle
Fig 4.27 Calcium & Magnesium

DATE	Ca	Mg
8/30/1995	51	32
9/22/1995	39	28
10/25/1995	39	28
11/15/1995	42	34
12/16/1995	41	31
1/18/1996	41	33
5/21/1996		
7/11/1996		
10/21/1996		
3/27/1997	102	47
4/22/1997		
9/23/1997		
10/23/1997		
3/24/1998	125	56
4/21/1998		
9/1/1998		
10/6/1998		
3/16/1999	175	81
9/15/1999		

Swamp Poodle

Fig 4.28 Trace Elements

Date	As	Cd	Pb	Se
8/30/1995	0.055	0.0034	<0.01	<0.023
9/22/1995	0.064	0.001	<0.01	<0.023
10/25/1995	0.024	0.0017	<0.01	<0.023
11/15/1995	0.059	0.0038	<0.01	<0.023
12/16/1995	0.032	0.0027	<0.01	<0.023
1/18/1996	0.063	0.0054	<0.01	<0.023
5/21/1996				
7/11/1996				
10/21/1996				
3/27/1997	0.391	<0.03	0.065	0.169
4/22/1997				
9/23/1997				
10/23/1997				
3/24/1998	0.053	<0.03	0.022	0.01
4/21/1998				
9/1/1998				
10/6/1998				
3/16/1999	0.415	<0.03	0.031	0.024
9/15/1999				

Swamp Poodle
Fig 4.29 Iron

DATE	
8/30/1995	68.2
9/22/1995	84.7
10/24/1995	74.2
11/14/1995	78.6
12/15/1995	74.3
1/17/1996	87.1
5/20/1996	76.5
7/11/1996	175
10/21/1996	103
3/27/1997	91
4/22/1997	29.1
9/23/1997	93.5
10/23/1997	90.1
3/24/1998	18.3
4/21/1998	107
9/1/1998	216
10/6/1998	188
3/16/1999	132
9/15/1999	125

Swamp Poodle
Fig 4.30 Manganese

DATE	
8/30/1995	3.36
9/22/1995	4.48
10/24/1995	4.67
11/14/1995	4
12/15/1995	2.58
1/17/1996	2.55
5/20/1996	1.1
7/11/1996	8.96
10/21/1996	6.83
3/27/1997	10.1
4/22/1997	11.1
9/23/1997	11.4
10/23/1997	9.95
3/24/1998	11.6
4/21/1998	11.3
9/1/1998	19.2
10/6/1998	15.9
3/16/1999	5.7
9/15/1999	9.96

Swamp Poodle
Fig 4.31 Sulfate

DATE	
8/30/1995	366
9/22/1995	407
10/24/1995	328
11/14/1995	520
12/15/1995	518
1/17/1996	607
5/20/1996	318
7/11/1996	1148
10/21/1996	701
3/27/1997	903
4/22/1997	846
9/23/1997	1032
10/23/1997	940
3/24/1998	959
4/21/1998	1088
9/1/1998	1553
10/6/1998	1359
3/16/1999	917
9/15/1999	1064

Swamp Poodle
Fig 4.32 Acidity

DATE	
8/30/1995	330
9/22/1995	360
10/24/1995	364
11/14/1995	424
12/15/1995	444
1/17/1996	472
5/20/1996	185
7/11/1996	574
10/21/1996	496
3/27/1997	540
4/22/1997	409
9/23/1997	479
10/23/1997	467
3/24/1998	441
4/21/1998	657
9/1/1998	885
10/6/1998	783
3/16/1999	725
9/15/1999	487

Swamp Poodle
Fig 4.33 pH

DATE	
8/30/1995	2.8
9/22/1995	2.7
10/24/1995	4.8
11/14/1995	2.6
12/15/1995	2.6
1/17/1996	2.8
5/20/1996	4.2
7/11/1996	3
10/21/1996	3
3/27/1997	3.2
4/22/1997	3
9/23/1997	2.7
10/23/1997	3.2
3/24/1998	2.8
4/21/1998	2.8
9/1/1998	3
10/6/1998	3
3/16/1999	2.7
9/15/1999	3.1

Swamp Poodle

Fig 4.34 Total Dissolved Solids

DATE	
8/30/1995	844
9/22/1995	918
10/24/1995	996
11/14/1995	1084
12/15/1995	1192
1/17/1996	1244
5/20/1996	865
7/11/1996	1560
10/21/1996	1192
3/27/1997	1250
4/22/1997	1316
9/23/1997	1560
10/23/1997	1455
3/24/1998	1492
4/21/1998	1680
9/1/1998	2245
10/6/1998	2045
3/16/1999	1510
9/15/1999	1535

Swamp Poodle
Fig 4.35 Chloride

DATE	
8/30/1995	57
9/22/1995	95.5
10/24/1995	110
11/14/1995	250
12/15/1995	280
1/17/1996	234
5/20/1996	307
7/11/1996	95.2
10/21/1996	192
3/27/1997	119
4/22/1997	141
9/23/1997	167
10/23/1997	156
3/24/1998	196
4/21/1998	
9/1/1998	
10/6/1998	
3/16/1999	
9/15/1999	

Swamp Poodle
Fig 4.36 Calcium & Magnesium

DATE	Ca	Mg
8/30/1995	50.1	26.8
9/22/1995	42.1	30.5
10/24/1995	43.6	28.9
11/14/1995	48.3	31.7
12/15/1995	46.5	24.5
1/17/1996	49.4	28.3
5/20/1996		
7/11/1996		
10/21/1996		
3/27/1997	121	53.2
4/22/1997		
9/23/1997		
10/23/1997		
3/24/1998	143	51.5
4/21/1998		
9/1/1998		
10/6/1998		
3/16/1999	116	34
9/15/1999		

Swamp Poodle

Fig 4.37 Trace Elements

DATE	As	Cd	Pb	Se
8/30/1995	0.02	0.0027	<0.01	<0.023
9/22/1995	<0.015	0.0005	<0.01	<0.023
10/24/1995	<0.015	0.0012	<0.01	<0.023
11/14/1995	0.053	0.0026	0.011	<0.023
12/15/1995	0.077	0.0025	<0.01	<0.023
1/17/1996	<0.015	0.0013	<0.01	<0.023
5/20/1996				
7/11/1996				
10/21/1996				
3/27/1997	0.137	<0.03	0.038	0.214
4/22/1997				
9/23/1997				
10/23/1997				
3/24/1998	<0.015	<0.03	0.005	<0.01
4/21/1998				
9/1/1998				
10/6/1998				
3/16/1999	0.077	<0.03	0.008	0.029
9/15/1999				

Ellengowan
Fig 5.1 Iron

Date	MW2	MW1
10/24/1994	50.14	48.09
12/19/1994	83.95	74.00
2/2/1995	43.84	63.40
2/23/1995		52.23
3/15/1995	95.50	85.20
4/20/1995	118.00	40.90
6/1/1995	138.00	32.90
10/26/1995		41.25
12/13/1995	172.00	
2/21/1996	42.90	42.10
6/4/1996	22.40	
6/18/1996	33.60	32.50
7/2/1996	33.90	
7/16/1996	44.10	
8/13/1996	27.80	
8/27/1996		12.00
12/17/1996	51.80	7.92
1/8/1997	38.60	
1/21/1997	40.60	
2/6/1997	40.23	
2/27/1997	20.90	2.66
3/5/1997	3.51	
3/18/1997	4.49	
4/3/1997	9.45	
4/15/1997	7.22	
4/29/1997	8.66	
5/27/1997	9.35	27.70
6/24/1997	54.40	
7/29/1997	161.00	
8/26/1997	167.50	23.80
10/28/1997		46.80
11/25/1997		19.10
1/27/1998		13.60
3/30/1998	29.68	
6/22/1998	49.90	8.24
7/15/1998	51.00	8.31
8/26/1998	8.39	11.18
9/28/1998	113.70	11.90
10/19/1998		4.14
12/17/1998		19.80
1/28/1999	31.40	12.10
2/26/1999	107.00	7.49

3/29/1999	79.50	15.30
4/27/1999	73.00	6.74
6/9/1999	92.70	10.90
7/1/1999		8.63
7/27/1999		81.20
8/20/1999	37.70	28.90
9/16/1999	31.00	19.90
10/28/1999		22.10
11/19/1999		17.20
12/20/1999		29.40
3/16/2000	65.50	71.30
4/28/2000	60.50	16.50
5/25/2000	43.30	22.20
6/21/2000	52.10	65.90
7/27/2000	47.40	
8/28/2000	54.70	
9/26/2000	96.00	75.00
10/23/2000	94.00	36.40
12/26/2000	158.00	13.20
3/20/2001	153.00	46.70
5/21/2001	94.80	
6/15/2001	104.30	40.08
7/9/2001	61.00	31.00
8/10/2001	26.80	40.30
9/26/2001		40.00
10/26/2001		45.00
11/21/2001		64.00
12/26/2001		25.90
1/23/2002		19.30
2/25/2002		12.10
3/26/2002		14.50
4/12/2002		22.00
5/16/2002	5.26	2.98
6/13/2002	14.30	6.92
7/25/2002	9.50	2.84
8/15/2002	19.90	27.10
9/28/2002	11.70	11.30
10/18/2002	9.93	1.17
11/29/2002	17.40	27.50
1/9/2003	14.90	17.20
3/18/2003	4.76	9.27
5/14/2003	4.97	1.68
8/21/2003		7.65
11/11/2003	13.10	8.73
2/17/2004	8.49	5.79
5/11/2004	16.40	3.86
8/11/2004	19.80	6.30

Ellengowan
Fig 5.2 Manganese

Date	MW1	MW2
10/24/1994	1.93	4.02
12/19/1994	2.62	2.80
2/2/1995	3.69	1.22
2/23/1995	2.36	
3/15/1995	2.59	2.37
4/20/1995	2.37	2.53
6/1/1995	2.38	4.93
10/26/1995	0.59	
12/13/1995		6.06
2/21/1996	0.82	2.25
6/4/1996		2.14
6/18/1996	0.51	2.27
7/2/1996		3.20
7/16/1996		2.77
8/13/1996		2.58
8/27/1996	0.48	
12/17/1996	0.21	3.62
1/8/1997		3.87
1/21/1997		4.16
2/6/1997		3.76
2/27/1997	0.20	4.81
3/5/1997		3.28
3/18/1997		3.38
4/3/1997		45.80
4/15/1997		33.20
4/29/1997		41.00
5/27/1997	0.57	4.96
6/24/1997		36.70
7/29/1997		4.35
8/26/1997	0.46	1.23
10/28/1997	7.38	
11/25/1997	0.42	
1/27/1998	0.34	
3/30/1998		1.11
6/22/1998	0.19	1.17
7/15/1998	0.20	1.30
8/26/1998	0.15	0.60
9/28/1998	0.13	2.27
10/19/1998	0.10	
12/17/1998	0.28	
1/28/1999	0.20	2.70
2/26/1999	0.12	3.80

3/29/1999	0.26	4.90
4/27/1999	0.07	2.51
6/9/1999	0.23	2.73
7/1/1999	0.17	
7/27/1999	1.01	
8/20/1999	0.46	2.56
9/16/1999	0.31	2.40
10/28/1999	0.34	
11/19/1999	0.29	
12/20/1999	0.32	
3/16/2000	0.57	3.41
4/28/2000	0.21	1.82
5/25/2000	0.25	0.84
6/21/2000	0.53	0.74
7/27/2000		0.72
8/28/2000		0.83
9/26/2000	0.54	1.22
10/23/2000	0.64	1.75
12/26/2000	0.18	5.84
3/20/2001	0.88	5.50
5/21/2001		2.53
6/15/2001	0.67	2.29
7/9/2001	0.59	2.33
8/10/2001	0.62	2.45
9/26/2001	0.77	
10/26/2001	1.00	
11/21/2001	1.20	
12/26/2001	1.10	
1/23/2002	0.20	
2/25/2002	0.14	
3/26/2002	0.20	
4/12/2002	0.78	
5/16/2002	0.20	0.41
6/13/2002	0.09	0.50
7/25/2002	0.05	0.23
8/15/2002	0.70	0.39
9/28/2002	0.16	0.68
10/18/2002	0.02	0.81
11/29/2002	0.72	0.58
1/9/2003	0.19	0.61
3/18/2003	0.11	0.32
5/14/2003	0.03	0.38
8/21/2003	0.12	
11/11/2003	0.14	0.52
2/17/2004	0.11	0.64
5/11/2004	0.06	0.70
8/11/2004	0.13	0.73

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Fig 5.3 Sulfate

Date	MW2	MW1
10/24/1994	401.90	103.30
12/19/1994	379.90	92.60
2/2/1995	296.20	96.08
2/23/1995		95.80
3/15/1995	309.40	91.03
4/20/1995	394.00	90.60
6/1/1995	627.00	80.40
10/26/1995		27.90
12/13/1995	1270.00	
2/21/1996	136.95	24.35
6/4/1996	258.00	
6/18/1996	132.00	25.87
7/2/1996	233.00	
7/16/1996	96.00	
8/13/1996	227.00	
8/27/1996		15.10
12/17/1996	164.00	0.02
1/8/1997	156.00	
1/21/1997	191.00	
2/6/1997	272.00	
2/27/1997	299.00	0.00
3/5/1997	172.00	
3/18/1997	167.00	
4/3/1997	205.00	
4/15/1997	189.00	
4/29/1997	61.00	
5/27/1997	179.00	0.00
6/24/1997	186.00	
7/29/1997	367.00	
8/26/1997	553.00	0.00
10/28/1997		448.00
11/25/1997		12.30
1/27/1998		16.30
3/30/1998	309.00	
6/22/1998	256.00	19.80
7/15/1998	339.00	35.60
8/26/1998	429.00	12.80
9/28/1998	746.00	13.60
10/19/1998		13.80
12/17/1998		9.48
1/28/1999	867.00	12.50
2/26/1999	1266.00	13.40

3/29/1999	1217.00	16.20
4/27/1999	1020.00	24.00
6/9/1999	1215.00	28.80
7/1/1999		27.00
7/27/1999		56.40
8/20/1999	1180.00	27.10
9/16/1999	1205.00	22.30
10/28/1999		25.60
11/19/1999		26.20
12/20/1999		32.20
3/16/2000	1210.00	25.00
4/28/2000	699.00	20.40
5/25/2000	660.00	20.80
6/21/2000	580.00	25.20
7/27/2000	581.00	
8/28/2000	604.00	
9/26/2000	596.00	29.80
10/23/2000	735.00	41.90
12/26/2000	1260.00	17.10
3/20/2001	1510.00	54.00
5/21/2001	938.00	
6/15/2001	886.00	36.40
7/9/2001	912.00	41.00
8/10/2001	1242.00	39.60
9/26/2001		45.40
10/26/2001		33.60
11/21/2001		27.20
12/26/2001		74.50
1/23/2002		35.00
2/25/2002		11.30
3/26/2002		26.00
4/12/2002		55.90
5/16/2002	280.00	8.92
6/13/2002	204.00	8.10
7/25/2002	186.00	8.22
8/15/2002	155.00	48.80
9/28/2002	303.00	8.95
10/18/2002	329.00	16.60
11/29/2002	273.00	54.00
1/9/2003	288.00	6.33
3/18/2003	92.00	4.34
5/14/2003	284.00	25.70
8/21/2003		4.04
11/11/2003	226.00	*0.50*
2/17/2004	222.00	0.55
5/11/2004	238.00	1.45
8/11/2004	362.00	1.20

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Fig 5.4 Alkalinity

Date	MW2	MW1
10/24/1994	77.88	2.92
12/19/1994	127.64	2.01
2/2/1995	169.51	2.03
2/23/1995		2.03
3/15/1995	189.41	0.00
4/20/1995	164.00	1.50
6/1/1995	47.04	0.98
10/26/1995		10.90
12/13/1995	6.50	
2/21/1996	42.00	12.70
6/4/1996	74.00	
6/18/1996	62.00	16.90
7/2/1996	86.00	
7/16/1996	130.00	
8/13/1996	134.00	
8/27/1996		20.70
12/17/1996	98.00	19.50
1/8/1997	114.00	
1/21/1997	118.00	
2/6/1997	120.00	
2/27/1997	130.00	19.40
3/5/1997	100.00	
3/18/1997	118.00	
4/3/1997	166.00	
4/15/1997	100.00	
4/29/1997	140.00	
5/27/1997	128.00	18.40
6/24/1997	140.00	
7/29/1997	88.00	
8/26/1997	564.00	15.50
10/28/1997		1.96
11/25/1997		14.90
1/27/1998		14.90
3/30/1998	306.90	
6/22/1998	98.00	22.00
7/15/1998	68.70	23.90
8/26/1998	65.00	45.50
9/28/1998	12.90	14.60
10/19/1998		27.60
12/17/1998		26.80
1/28/1999	136.40	30.80
2/26/1999	37.40	30.80

3/29/1999	3.18	29.68
4/27/1999	31.80	28.60
6/9/1999	10.10	27.10
7/1/1999		28.10
7/27/1999		20.10
8/20/1999	33.00	44.00
9/16/1999	35.40	38.00
10/28/1999		35.00
11/19/1999		31.00
12/20/1999		14.90
3/16/2000	54.25	23.87
4/28/2000	219.20	21.60
5/25/2000	239.00	17.00
6/21/2000	370.00	20.00
7/27/2000	235.00	
8/28/2000	173.87	
9/26/2000	110.30	36.10
10/23/2000	54.30	15.10
12/26/2000	94.30	28.70
3/20/2001	36.50	9.85
5/21/2001	89.10	
6/15/2001	122.50	14.70
7/9/2001	87.00	12.30
8/10/2001	51.00	15.00
9/26/2001		13.20
10/26/2001		15.20
11/21/2001		22.20
12/26/2001		12.00
1/23/2002		15.60
2/25/2002		28.40
3/26/2002		21.30
4/12/2002		19.70
5/16/2002	365.40	24.40
6/13/2002	366.00	23.00
7/25/2002	320.00	29.40
8/15/2002	342.00	16.20
9/28/2002	261.00	27.30
10/18/2002	225.00	32.30
11/29/2002	178.00	21.80
1/9/2003	159.00	25.60
3/18/2003	95.30	24.10
5/14/2003	87.70	22.40
8/21/2003		24.40
11/11/2003	88.90	28.30
2/17/2004	88.80	25.50
5/11/2004	84.10	22.60
8/11/2004	28.40	24.40

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Fig 5.4 Acidity

Date	MW1	MW2
10/24/1994	50.74	0.00
12/14/1994	37.09	0.00
2/2/1995	35.62	
2/7/1995		0.00
2/23/1995	48.95	
3/15/1995	37.79	0.00
4/20/1995	39.00	0.00
6/1/1995	18.20	0.00
10/26/1995	0.00	
12/13/1995		124.00
2/21/1996	0.00	0.00
6/4/1996		2.00
6/18/1996	0.00	0.00
7/2/1996		0.00
7/16/1996		0.00
8/13/1996		0.00
8/27/1996	0.00	
12/17/1996	0.40	0.00
2/27/1997	11.90	
1/8/1997		0.00
1/21/1997		0.00
2/4/1997		0.00
2/28/1997		0.00
3/6/1997		0.00
3/18/1997		0.00
4/3/1997		0.00
4/15/1997		0.00
4/29/1997		0.00
5/27/1997	0.00	0.00
6/24/1997		0.00
7/29/1997		0.00
8/26/1997	0.00	0.00
10/28/1997	118.00	
11/25/1997	0.00	
1/27/1998	0.00	
3/30/1998		0.00
6/22/1998	0.00	0.00
7/14/1998	0.00	0.00
8/26/1998	0.00	0.00
9/28/1998	0.00	17.80
10/19/1998	0.00	
11/10/1998		

12/17/1998	0.00	
1/28/1999	0.00	0.00
2/26/1999	0.00	37.30
3/29/1999	0.00	56.80
4/27/1999	0.00	0.00
6/9/1999		32.10
6/10/1999	0.00	
7/2/1999	0.00	
7/27/1999	0.00	
8/19/1999		22.75
8/20/1999	0.00	
9/16/1999	0.00	18.70
10/28/1999	0.00	
11/19/1999	0.00	
12/20/1999	0.00	
1/12/2000		
2/1/2000		
3/16/2000	0.40	0.40
4/28/2000	0.40	0.40
5/25/2000	0.40	0.40
6/21/2000	0.40	0.40
7/27/2000		0.40
8/28/2000		0.40
9/26/2000	4.87	0.40
10/23/2000	0.40	0.40
12/26/2000	0.40	0.40
3/20/2001	5.12	89.40
5/21/2001		0.40
6/15/2001	9.10	0.40
7/9/2001	4.20	0.40
8/10/2001	3.33	0.40
9/26/2001	0.40	
10/26/2001	0.40	
11/21/2001	0.40	
12/26/2001	3.10	
1/23/2002	0.40	
2/25/2002	0.40	
3/26/2002	0.40	
4/12/2002	0.40	
5/16/2002	0.40	0.40
6/13/2002	0.40	0.40
7/25/2002	0.40	0.40
8/15/2002	0.40	0.40
9/28/2002	0.40	0.40
10/18/2002	0.40	0.40
11/29/2002	0.40	0.40
1/9/2003	0.40	0.40

3/18/2003	0.40	0.40
5/14/2003	0.40	0.40
8/21/2003	0.40	
11/11/2003	0.40	0.40
2/18/2004	0.40	0.40
5/11/2004	36.70	0.40
8/11/2004	0.40	0.40

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Fig 5.5 Total Dissolved Solids

Date	MW1	MW2
10/24/1994	134.00	552.00
12/19/1994	138.00	626.00
2/2/1995	218.00	594.00
2/23/1995	180.00	
3/15/1995	180.00	716.00
4/20/1995	136.00	704.00
6/1/1995	131.00	950.00
10/26/1995	40.00	
12/13/1995		2020.00
2/21/1996	21.00	242.00
6/4/1996		388.00
6/18/1996	12.00	434.00
7/2/1996		400.00
7/16/1996		622.00
8/13/1996		564.00
8/27/1996	21.00	
12/17/1996	70.00	328.00
1/8/1997		720.00
1/21/1997		292.00
2/6/1997		374.00
2/27/1997	30.00	396.00
3/5/1997		304.00
3/18/1997		432.00
4/3/1997		514.00
4/15/1997		388.00
4/29/1997		512.00
5/27/1997	23.00	584.00
6/24/1997		542.00
7/29/1997		802.00
8/26/1997	11.00	
10/28/1997	684.00	
11/25/1997	78.00	
1/27/1998	34.00	
3/30/1998		0.00
6/22/1998	44.00	374.00
7/15/1998	39.00	467.00
8/26/1998	56.00	548.00
9/28/1998	66.00	1284.00
10/19/1998	58.00	
11/18/1998		
12/17/1998	74.00	
1/28/1999	92.00	1410.00

2/26/1999	28.00	1834.00
3/29/1999	56.00	1652.00
4/27/1999	20.00	1510.00
5/12/1999		
6/9/1999	136.00	1722.00
7/1/1999	96.00	
7/27/1999	106.00	
8/20/1999	62.00	1555.00
9/16/1999	66.00	1540.00
10/28/1999	64.00	
11/19/1999	58.00	
12/20/1999	86.00	
3/16/2000	169.00	1782.00
4/28/2000	49.00	1121.00
5/25/2000	79.00	1163.00
6/21/2000	59.00	1060.00
7/27/2000		1098.00
8/28/2000		1062.00
9/26/2000	15.00	995.00
10/23/2000	118.00	1224.00
12/26/2000	15.00	1834.00
1/31/2001		
3/20/2001	150.00	1912.00
5/21/2001		1452.00
6/15/2001	60.00	281.00
7/9/2001	66.00	1444.00
8/10/2001	78.00	1597.00
9/26/2001	119.00	
10/26/2001	88.00	
11/21/2001	68.00	
12/26/2001	144.00	
1/23/2002	92.00	
2/25/2002	82.00	
3/26/2002	87.00	
4/12/2002	126.00	
5/16/2002	39.00	647.00
6/13/2002	55.00	555.00
7/25/2002	56.00	559.00
8/15/2002	106.00	552.00
9/28/2002	62.00	739.00
10/18/2002	52.00	662.00
11/29/2002	128.00	594.00
1/9/2003	27.00	541.00
3/18/2003	87.00	572.00
5/14/2003	88.00	538.00
8/21/2003	64.00	
11/11/2003	7.00	404.00

2/17/2004	31.00	388.00
5/11/2004	60.00	451.00
8/11/2004	45.00	622.00

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Fig 5.6 Iron

Date	MW3	MW1
10/24/1994	24.77	48.09
12/19/1994	18.54	74.00
2/2/1995	32.34	63.40
2/23/1995	17.28	52.23
3/15/1995	32.33	85.20
4/20/1995	12.30	40.90
6/1/1995	34.20	32.90
10/26/1995	54.09	41.25
2/21/1996	29.20	42.10
5/21/1996	43.90	
6/4/1996	11.60	
6/18/1996	1.79	32.50
7/2/1996	3.72	
7/16/1996	43.70	
8/13/1996	4.32	
8/27/1996		12.00
12/17/1996	25.40	7.92
1/8/1997	10.30	
1/21/1997	6.67	
2/6/1997	4.57	
2/27/1997	7.84	2.66
3/5/1997	4.43	
3/18/1997	4.65	
4/3/1997	5.02	
4/15/1997	4.59	
4/29/1997	88.50	
5/27/1997	1.27	27.70
6/24/1997	1.50	
7/29/1997	31.70	
8/26/1997	6.89	23.80
10/28/1997		46.80
11/25/1997		19.10
1/27/1998	32.09	13.60
3/30/1998		
6/22/1998	13.40	8.24
7/15/1998	10.30	8.31
8/26/1998	73.60	11.18
9/28/1998	14.20	11.90
10/19/1998	5.38	4.14
12/17/1998	64.50	19.80
1/28/1999	11.90	12.10
2/26/1999	14.40	7.49

3/29/1999	5.84	15.30
4/27/1999	6.79	6.74
6/9/1999	14.30	10.90
7/1/1999	14.90	8.63
7/27/1999	24.60	81.20
8/20/1999	20.00	28.90
9/16/1999	23.00	19.90
10/28/1999	18.00	22.10
11/19/1999	21.00	17.20
12/20/1999	17.40	29.40
3/16/2000	16.50	71.30
4/28/2000	7.62	16.50
5/25/2000	12.10	22.20
6/21/2000	31.40	65.90
7/27/2000	27.40	
8/28/2000	20.90	
9/26/2000	28.80	75.00
10/23/2000	20.70	36.40
12/26/2000	31.60	13.20
3/20/2001	27.30	46.70
5/21/2001	28.40	
6/15/2001	29.98	40.08
7/9/2001	27.22	31.00
8/10/2001	21.46	40.30
9/26/2001	24.80	40.00
10/26/2001		45.00
11/21/2001		64.00
12/26/2001		25.90
1/23/2002	36.70	19.30
2/25/2002	35.10	12.10
3/26/2002	31.40	14.50
4/12/2002	13.80	22.00
5/16/2002	37.50	2.98
6/13/2002	92.20	6.92
7/25/2002	86.10	2.84
8/15/2002		27.10
9/28/2002		11.30
10/18/2002		1.17
11/29/2002	335.00	27.50
1/9/2003	86.00	17.20
3/18/2003	91.30	9.27
5/14/2003	40.20	1.68
8/21/2003	108.00	7.65
11/11/2003	76.80	8.73
2/17/2004	54.80	5.79
5/11/2004	48.00	3.86
8/11/2004	48.30	6.30

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Fig 5.7 Manganese

Date	MW1	MW3
10/24/1994	1.93	0.99
12/19/1994	2.62	0.63
2/2/1995	3.69	0.80
2/23/1995	2.36	1.04
3/15/1995	2.59	0.80
4/20/1995	2.37	0.30
6/1/1995	2.38	0.56
10/26/1995	0.59	0.95
2/21/1996	0.82	1.11
5/21/1996		1.76
6/4/1996		1.49
6/18/1996	0.51	1.13
7/2/1996		1.17
7/16/1996		1.58
8/13/1996		0.63
8/27/1996	0.48	
12/17/1996	0.21	1.40
1/8/1997		1.71
1/21/1997		1.55
2/6/1997		1.36
2/27/1997	0.20	1.51
3/5/1997		1.37
3/18/1997		1.38
4/3/1997		77.60
4/15/1997		44.10
4/29/1997		1.85
5/27/1997	0.57	0.48
6/24/1997		0.29
7/29/1997		0.57
8/26/1997	0.46	3.41
10/28/1997	7.38	
11/25/1997	0.42	
1/27/1998	0.34	1.98
6/22/1998	0.19	0.64
7/15/1998	0.20	0.75
8/26/1998	0.15	1.95
9/28/1998	0.13	1.31
10/19/1998	0.10	0.46
12/17/1998	0.28	1.58
1/28/1999	0.20	1.66
2/26/1999	0.12	1.20
3/29/1999	0.26	1.37

4/27/1999	0.07	0.65
6/9/1999	0.23	0.91
7/1/1999	0.17	0.75
7/27/1999	1.01	0.27
8/20/1999	0.46	1.49
9/16/1999	0.31	1.15
10/28/1999	0.34	0.98
11/19/1999	0.29	1.01
12/20/1999	0.32	0.86
3/16/2000	0.57	0.97
4/28/2000	0.21	0.41
5/25/2000	0.25	0.64
6/21/2000	0.53	1.18
7/27/2000		1.21
8/28/2000		0.94
9/26/2000	0.54	0.76
10/23/2000	0.64	0.80
12/26/2000	0.18	1.53
3/20/2001	0.88	0.96
5/21/2001		0.88
6/15/2001	0.67	0.65
7/9/2001	0.59	0.71
8/10/2001	0.62	0.89
9/26/2001	0.77	1.17
10/26/2001	1.00	
11/21/2001	1.20	
12/26/2001	1.10	
1/23/2002	0.20	0.65
2/25/2002	0.14	0.74
3/26/2002	0.20	0.07
4/12/2002	0.78	0.54
5/16/2002	0.20	0.52
6/13/2002	0.09	3.84
7/25/2002	0.05	3.62
8/15/2002	0.70	
9/28/2002	0.16	
10/18/2002	0.02	
11/29/2002	0.72	11.90
1/9/2003	0.19	3.73
3/18/2003	0.11	3.03
5/14/2003	0.03	1.69
8/21/2003	0.12	3.52
11/11/2003	0.14	4.80
2/17/2004	0.11	4.49
5/11/2004	0.06	5.78
8/11/2004	0.13	6.07

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Fig 5.8 Sulfate

Date	MW3	MW1
10/24/1994	438.50	103.30
12/19/1994	319.40	92.60
2/2/1995	363.50	96.08
2/23/1995	463.40	95.80
3/15/1995	472.11	91.03
4/20/1995	492.00	90.60
6/1/1995	462.00	80.40
10/26/1995	450.00	27.90
2/21/1996	435.29	24.35
5/21/1996	463.00	
6/4/1996	431.00	
6/18/1996	480.00	25.87
7/2/1996	418.00	
7/16/1996	394.00	
8/13/1996	403.00	
8/27/1996		15.10
12/17/1996	317.00	0.02
1/8/1997	311.00	
1/21/1997	333.00	
2/6/1997	429.00	
2/27/1997	306.00	0.00
3/5/1997	276.00	
3/18/1997	287.00	
4/3/1997	300.00	
4/15/1997	297.00	
4/29/1997	298.00	
5/27/1997	292.00	0.00
6/24/1997	304.00	
7/29/1997	330.00	
8/26/1997	292.00	0.00
10/28/1997		448.00
11/25/1997		12.30
1/27/1998	515.00	16.30
6/22/1998	407.00	19.80
7/15/1998	468.00	35.60
8/26/1998	524.00	12.80
9/28/1998	358.00	13.60
10/19/1998	340.00	13.80
12/17/1998	300.00	9.48
1/28/1999	284.00	12.50
2/26/1999	298.00	13.40
3/29/1999	324.00	16.20

4/27/1999	362.00	24.00
6/9/1999	360.00	28.80
7/1/1999	331.00	27.00
7/27/1999	306.00	56.40
8/20/1999	411.00	27.10
9/16/1999	388.00	22.30
10/28/1999	359.00	25.60
11/19/1999	324.00	26.20
12/20/1999	297.00	32.20
3/16/2000	318.00	25.00
4/28/2000	18.00	20.40
5/25/2000	288.00	20.80
6/21/2000	307.00	25.20
7/27/2000	280.00	
8/28/2000	325.00	
9/26/2000	294.00	29.80
10/23/2000	324.00	41.90
12/26/2000	231.00	17.10
3/20/2001	336.00	54.00
5/21/2001	361.00	
6/15/2001	339.00	36.40
7/9/2001	344.00	41.00
8/10/2001	357.00	39.60
9/26/2001	379.00	45.40
10/26/2001		33.60
11/21/2001		27.20
12/26/2001		74.50
1/23/2002	316.00	35.00
2/25/2002	283.00	11.30
3/26/2002	310.00	26.00
4/12/2002	248.00	55.90
5/16/2002	353.00	8.92
6/13/2002	114.00	8.10
7/25/2002	1200.00	8.22
8/15/2002		48.80
9/28/2002		8.95
10/18/2002		16.60
11/29/2002	1790.00	54.00
1/9/2003	1080.00	6.33
3/18/2003	990.00	4.34
5/14/2003	620.00	25.70
8/21/2003	449.00	4.04
11/11/2003	504.00	*0.50*
2/18/2004	437.00	0.55
5/11/2004	567.00	1.45
8/16/2004	476.00	1.20

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Fig 5.8a Total Dissolved Solids

Date	MW3
10/24/1994	606.00
12/19/1994	916.00
2/2/1995	508.00
2/23/1995	652.00
3/15/1995	788.00
4/20/1995	818.00
6/1/1995	715.00
10/26/1995	770.00
2/21/1996	675.00
5/21/1996	838.00
6/4/1996	766.00
6/18/1996	1058.00
7/2/1996	864.00
7/16/1996	912.00
8/13/1996	910.00
12/17/1996	532.00
1/8/1997	462.00
1/21/1997	488.00
2/6/1997	510.00
2/27/1997	502.00
3/5/1997	512.00
3/18/1997	570.00
4/3/1997	556.00
4/15/1997	560.00
4/29/1997	1632.00
5/27/1997	632.00
6/24/1997	734.00
7/29/1997	710.00
8/26/1997	722.00
1/27/1998	1120.00
6/22/1998	486.00
7/15/1998	456.00
8/26/1998	630.00
9/28/1998	610.00
10/19/1998	474.00
12/17/1998	504.00
1/28/1999	538.00
2/26/1999	550.00
3/29/1999	632.00
4/27/1999	594.00
6/9/1999	0.00

7/1/1999	524.00
7/27/1999	486.00
8/20/1999	596.00
9/16/1999	574.00
10/28/1999	535.00
11/19/1999	530.00
12/20/1999	496.00
3/16/2000	602.00
4/28/2000	34.00
5/25/2000	482.00
6/21/2000	443.00
7/27/2000	379.00
8/28/2000	464.00
9/26/2000	443.00
10/23/2000	439.00
12/26/2000	436.00
3/20/2001	569.00
5/21/2001	512.00
6/15/2001	489.00
7/9/2001	512.00
8/10/2001	587.00
9/26/2001	672.00
1/23/2002	611.00
2/25/2002	582.00
3/26/2002	595.00
4/12/2002	726.00
5/16/2002	820.00
6/13/2002	1775.00
7/25/2002	1692.00
11/29/2002	2571.00
1/9/2003	1575.00
3/18/2003	1482.00
5/14/2003	966.00
8/21/2003	697.00
11/11/2003	798.00
2/17/2004	776.00
5/11/2004	1065.00
8/11/2004	796.00

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Fig 5.9 Alkalinity

Date	MW1	MW3
10/24/1994	2.92	14.61
12/19/1994	2.01	29.15
2/2/1995	2.03	11.17
2/23/1995	2.03	25.38
3/15/1995	0.00	23.81
4/20/1995	1.50	17.00
6/1/1995	0.98	13.72
10/26/1995	10.90	24.60
2/21/1996	12.70	22.00
5/21/1996		28.00
6/4/1996		32.00
6/18/1996	16.90	36.00
7/2/1996		36.00
7/16/1996		36.00
8/13/1996		36.00
8/27/1996	20.70	
12/17/1996	19.50	88.00
1/8/1997		82.00
1/21/1997		88.00
2/6/1997		82.00
2/27/1997	19.40	84.00
3/5/1997		74.00
3/18/1997		72.00
4/3/1997		68.00
4/15/1997		62.00
4/29/1997		68.00
5/27/1997	18.40	48.00
6/24/1997		34.00
7/29/1997		26.00
8/26/1997	15.50	74.00
10/28/1997	1.96	
11/25/1997	14.90	
1/27/1998	14.90	141.00
3/30/1998		
6/22/1998	22.00	78.00
7/15/1998	23.90	59.70
8/26/1998	45.50	68.30
9/28/1998	14.60	35.60
10/19/1998	27.60	22.80
11/18/1998		
12/17/1998	26.80	55.30
1/28/1999	30.80	99.00

2/26/1999	30.80	83.60
3/29/1999	29.68	53.00
4/27/1999	28.60	31.80
6/9/1999	27.10	44.20
7/1/1999	28.10	44.20
7/27/1999	20.10	52.30
8/20/1999	44.00	51.90
9/16/1999	38.00	58.20
10/28/1999	35.00	47.30
11/19/1999	31.00	52.60
12/20/1999	14.90	47.80
3/16/2000	23.87	48.83
4/28/2000	21.60	12.00
5/25/2000	17.00	37.00
6/21/2000	20.00	34.00
7/27/2000		35.00
8/28/2000		27.14
9/26/2000	36.10	20.10
10/23/2000	15.10	17.10
12/26/2000	28.70	89.20
3/20/2001	9.85	52.20
5/21/2001		33.50
6/15/2001	14.70	19.60
7/9/2001	12.30	34.00
8/10/2001	15.00	52.05
9/26/2001	13.20	102.50
10/26/2001	15.20	
11/21/2001	22.20	
12/26/2001	12.00	
1/23/2002	15.60	138.00
2/25/2002	28.40	203.00
3/26/2002	21.30	145.00
4/12/2002	19.70	279.20
5/16/2002	24.40	132.50
6/13/2002	23.00	120.00
7/25/2002	29.40	68.30
8/15/2002	16.20	
9/28/2002	27.30	
10/18/2002	32.30	
11/29/2002	21.80	163.00
1/9/2003	25.60	172.00
3/18/2003	24.10	45.00
5/14/2003	22.40	97.50
8/21/2003	24.40	12.20
11/11/2003	28.30	66.70
2/17/2004	25.50	48.90
5/11/2004	22.60	90.20

8/11/2004	24.40	72.10

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Fig 5.9a Acidity

Date	MW1	MW3
10/24/1994	50.74	0.00
12/14/1994	37.09	0.00
2/2/1995	35.62	0.89
2/23/1995	48.95	0.00
3/15/1995	37.79	0.00
4/20/1995	39.00	0.00
6/1/1995	18.20	0.00
10/26/1995	0.00	0.00
2/21/1996	0.00	
2/26/1996		0.00
5/21/1996		8.80
6/4/1996		0.00
6/18/1996	0.00	0.00
7/2/1996		0.00
7/16/1996		0.00
8/13/1996		0.00
8/27/1996	0.00	
12/17/1996	0.40	0.00
1/8/1997		0.00
1/21/1997		0.00
2/6/1997		0.00
2/27/1997	11.90	0.00
3/5/1997		0.00
3/18/1997		0.00
4/3/1997		0.00
4/15/1997		0.00
4/29/1997		0.00
5/27/1997	0.00	0.00
6/24/1997		0.00
7/29/1997		0.00
8/26/1997	0.00	0.00
10/28/1997	118.00	
11/25/1997	0.00	
1/27/1998	0.00	0.00
6/22/1998	0.00	0.00
7/14/1998	0.00	0.00
8/26/1998	0.00	0.00
9/28/1998	0.00	0.00
10/19/1998	0.00	0.00
12/17/1998	0.00	0.00
1/28/1999	0.00	0.00
2/26/1999	0.00	0.00

3/29/1999	0.00	0.00
4/27/1999	0.00	0.00
6/9/1999		0.00
6/10/1999	0.00	
7/2/1999	0.00	0.00
7/27/1999	0.00	0.00
8/20/1999	0.00	0.00
9/16/1999	0.00	0.00
10/28/1999	0.00	0.00
11/19/1999	0.00	0.00
12/20/1999	0.00	0.00
1/12/2000		
2/1/2000		
3/16/2000	0.40	0.40
4/28/2000	0.40	0.40
5/25/2000	0.40	1.03
6/21/2000	0.40	0.40
7/27/2000		0.40
8/28/2000		0.40
9/26/2000	4.87	0.40
10/23/2000	0.40	0.40
12/26/2000	0.40	0.40
3/20/2001	5.12	0.40
5/21/2001		0.40
6/15/2001	9.10	24.20
7/9/2001	4.20	0.40
8/10/2001	3.33	0.40
9/26/2001	0.40	0.40
10/26/2001	0.40	
11/21/2001	0.40	
12/26/2001	3.10	
1/23/2002	0.40	0.40
2/25/2002	0.40	0.40
3/26/2002	0.40	0.40
4/12/2002	0.40	0.40
5/16/2002	0.40	0.40
6/13/2002	0.40	0.40
7/25/2002	0.40	0.40
8/15/2002	0.40	
9/28/2002	0.40	
9/30/2002		
10/18/2002	0.40	
11/29/2002	0.40	0.40
1/9/2003	0.40	0.40
3/18/2003	0.40	0.40
5/14/2003	0.40	0.40
8/21/2003	0.40	12.20

11/11/2003	0.40	0.40
2/18/2004	0.40	0.40
5/11/2004	36.70	0.40
8/11/2004	0.40	
8/16/2004		0.40

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Fig 5.10 Lab pH

Date	
10/24/1994	5.87
12/14/1995	5.92
2/2/1995	5.50
2/7/1995	
2/23/1995	5.76
3/15/1995	5.22
4/20/1995	5.43
6/1/1995	5.23
10/26/1995	8.43
12/13/1995	
2/21/1996	6.62
6/4/1996	
6/18/1996	6.12
7/2/1996	
7/16/1996	
8/13/1996	
8/27/1996	6.40
12/17/1996	7.52
1/8/1997	
1/21/1997	
2/4/1997	
2/27/1997	7.49
2/28/1997	
3/6/1997	
3/18/1997	
4/3/1997	
4/15/1997	
4/29/1997	
5/27/1997	7.47
6/24/1997	
7/29/1997	
8/26/1997	7.50
10/28/1997	5.14
11/25/1997	7.71
1/27/1998	7.80
3/30/1998	
6/22/1998	9.02
7/14/1998	8.95
8/26/1998	7.81
9/28/1998	9.02
10/19/1998	7.51
11/10/1998	

12/17/1998	8.98
1/28/1999	8.91
2/26/1999	9.09
3/29/1999	8.72
4/27/1999	9.53
6/9/1999	
6/10/1999	8.67
7/2/1999	8.7
7/27/1999	6.41
8/19/1999	
8/20/1999	7.93
9/16/1999	6.89
10/28/1999	6.43
11/19/1999	6.55
12/20/1999	6.61
1/12/2000	
2/1/2000	
3/16/2000	9.17
4/28/2000	9.38
5/25/2000	8.75
6/21/2000	8.28
7/27/2000	
8/28/2000	
9/26/2000	6.89
10/23/2000	6.55
12/26/2000	9.12
3/20/2001	6.44
5/21/2001	
6/15/2001	6.91
7/9/2001	6.77
8/10/2001	6.25
9/26/2001	6.76
10/26/2001	6.82
11/21/2001	7.78
12/26/2001	6.26
1/23/2002	6.60
2/25/2002	6.40
3/26/2002	6.50
4/12/2002	7.45
5/16/2002	9.25
6/13/2002	9.18
7/25/2002	9.47
8/15/2002	7.43
9/28/2002	9.47
10/18/2002	9.75
11/29/2002	7.83
1/9/2003	9.59

3/18/2003	9.54
5/14/2003	9.56
8/21/2003	9.43
11/11/2003	9.06
2/18/2004	8.76
5/11/2004	8.70
8/11/2004	8.38

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Fig 5.11 Lab pH

Date	
10/24/1994	6.31
12/14/1995	6.49
2/2/1995	
2/7/1995	6.89
2/23/1995	
3/15/1995	6.34
4/20/1995	6.48
6/1/1995	6.10
10/26/1995	
12/13/1995	5.91
2/21/1996	6.39
6/4/1996	6.40
6/18/1996	6.30
7/2/1996	6.50
7/16/1996	6.40
8/13/1996	6.40
8/27/1996	
12/17/1996	6.30
1/8/1997	6.40
1/21/1997	6.50
2/4/1997	6.40
2/27/1997	
2/28/1997	6.40
3/6/1997	6.30
3/18/1997	6.50
4/3/1997	6.60
4/15/1997	6.40
4/29/1997	6.60
5/27/1997	6.60
6/24/1997	6.50
7/29/1997	6.20
8/26/1997	6.50
10/28/1997	
11/25/1997	
1/27/1998	
3/30/1998	6.70
6/22/1998	6.61
7/14/1998	6.51
8/26/1998	7.52
9/28/1998	6.35
10/19/1998	
11/10/1998	

12/17/1998	
1/28/1999	6.54
2/26/1999	6.22
3/29/1999	6.28
4/27/1999	6.78
6/9/1999	5.79
6/10/1999	
7/2/1999	
7/27/1999	
8/19/1999	6.81
8/20/1999	
9/16/1999	6.56
10/28/1999	
11/19/1999	
12/20/1999	
1/12/2000	
2/1/2000	
3/16/2000	6.31
4/28/2000	6.86
5/25/2000	6.46
6/21/2000	6.70
7/27/2000	7.02
8/28/2000	6.36
9/26/2000	6.47
10/23/2000	6.29
12/26/2000	6.16
3/20/2001	6.14
5/21/2001	6.41
6/15/2001	6.49
7/9/2001	6.11
8/10/2001	5.93
9/26/2001	
10/26/2001	
11/21/2001	
12/26/2001	
1/23/2002	
2/25/2002	
3/26/2002	
4/12/2002	
5/16/2002	8.01
6/13/2002	8.24
7/25/2002	8.79
8/15/2002	8.48
9/28/2002	7.61
10/18/2002	8.02
11/29/2002	8.02
1/9/2003	8.08

3/18/2003	8.43
5/14/2003	8.40
8/21/2003	
11/11/2003	8.16
2/18/2004	8.13
5/11/2004	8.40
8/11/2004	8.77

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Fig 5.12 Lab pH

Date	
10/24/1994	6.53
12/14/1994	8.98
2/2/1995	6.36
2/23/1995	7.55
3/15/1995	8.65
4/20/1995	9.31
6/1/1995	8.96
10/26/1995	9.49
2/26/1996	6.85
5/21/1996	6.30
6/4/1996	6.60
6/18/1996	6.50
7/2/1996	7.00
7/16/1996	7.40
8/13/1996	7.50
12/17/1996	6.50
1/8/1997	6.60
1/21/1997	7.10
2/6/1997	7.00
2/27/1997	6.80
3/5/1997	6.60
3/18/1997	6.70
4/3/1997	6.80
4/15/1997	6.80
4/29/1997	7.30
5/27/1997	8.20
6/24/1997	8.10
7/29/1997	7.80
8/26/1997	7.20
1/27/1998	7.31
6/22/1998	8.20
7/14/1998	8.46
8/26/1998	6.42
9/28/1998	7.51
10/19/1998	7.18
12/17/1998	7.84
1/28/1999	7.17
2/26/1999	7.80
3/29/1999	7.06
4/27/1999	8.77
6/9/1999	7.83
7/2/1999	8.18

7/27/1999	7.75
8/20/1999	7.43
9/16/1999	7.51
10/28/1999	7.32
11/19/1999	7.45
12/20/1999	7.41
1/12/2000	
2/1/2000	
3/16/2000	7.39
4/28/2000	7.66
5/25/2000	6.88
6/21/2000	7.52
7/27/2000	7.44
8/28/2000	7.30
9/26/2000	7.60
10/23/2000	7.92
12/26/2000	7.09
3/20/2001	7.51
5/21/2001	7.63
6/15/2001	8.10
7/9/2001	7.95
8/10/2001	8.00
9/26/2001	7.27
1/23/2002	7.72
2/25/2002	8.07
3/26/2002	7.89
4/12/2002	8.05
5/16/2002	5.80
6/13/2002	6.36
7/25/2002	6.46
8/15/2002	
9/30/2002	
10/18/2002	
11/29/2002	6.64
1/9/2003	6.53
3/18/2003	6.38
5/14/2003	6.49
8/21/2003	6.22
11/11/2003	6.51
2/18/2004	6.41
5/11/2004	6.50
8/16/2004	6.57

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Fig 5.13 Magnesium

Date	MW1	MW2	MW3
06/01/95	6.70	105.00	43.20
07/16/96		50.90	75.70
10/22/96		64.00	69.60
12/17/96	1.60		61.50
10/28/97		40.70	
12/20/99	5.45		49.20
01/31/01	4.44	250.00	47.80
11/21/01			84.10
01/09/03	2.62	93.40	189.00
11/10/03	1.95	66.70	40.50

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Fig 5.14 Calcium

Date	MW1	MW2	MW3
06/01/95	9.26	138.3	105.8
07/16/96		70.8	87.2
10/22/96		97	70
12/17/96	6.8		
10/28/97		53	
12/17/98			81
12/20/99	42.7		55.5
12/26/00	9	33	15
11/21/01			31.7
01/09/03	6.58	31.9	134
11/11/03	4.63	19.7	104

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Fig 5.15 Chloride

Date	MW1	MW2	MW3
10/24/1994	0.00	6.24	11.68
12/14/1994	2.22	8.85	2.72
2/2/1995	2.84	3.14	5.07
2/23/1995	0.00		5.22
3/15/1995	5.48	6.72	9.58
4/20/1995	3.94	6.57	7.61
6/1/1995	6.05	8.11	11.10
10/26/1995	0.00		3.53
12/13/1995		4.06	
2/21/1996	4.71	3.03	1.29
5/21/1996			2.00
6/4/1996		2.00	2.00
6/18/1996	0.00	2.00	2.00
7/2/1996		3.00	2.00
7/16/1996		2.00	1.00
8/13/1996		2.00	0.00
8/27/1996	2.39		
12/17/1996	1.58	2.00	1.00
1/8/1997		2.00	0.00
1/21/1997		3.00	1.00
2/6/1997		2.00	1.00
2/27/1997	1.91	2.00	1.00
3/5/1997		1.00	1.00
3/18/1997		1.00	1.00
4/3/1997		1.00	0.00
4/15/1997		1.00	0.00
4/29/1997		2.00	0.00
5/27/1997	2.23	1.00	0.00
6/24/1997		1.00	0.00
7/29/1997		1.00	0.00
8/26/1997	0.00	2.00	0.00
10/28/1997	4.02		
11/25/1997	1.76		
1/27/1998	1.77		1.98
3/30/1998		1.44	
6/22/1998	0.57	1.14	0.00
7/15/1998	4.38	1.42	7.20
8/26/1998	2.45	0.00	5.91
9/28/1998	0.00	1.57	1.45
10/19/1998	5.22		0.00
12/20/99	0.46		0.67
01/31/01	*<0.02*	5.73	2.91

11/21/01			20.90
01/09/03	2.60	9.51	3.62
11/11/03	*<0.02*	*<0.02*	15.50

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Fig 5.16 Arsenic

Date	Maple Hill	Holes South
10/22/86	0.00	
12/05/86	0.00	
01/20/87	0.00	
02/04/87	0.00	
03/05/87	0.00	
03/31/87	0.00	
09/03/87		0.00
10/05/87	0.00	0.00
11/02/87	0.00	0.00
11/27/87	0.02	0.00
12/31/87	0.00	0.00
02/01/88	0.00	0.00
02/29/88	0.00	0.01
03/31/88	0.00	0.00
05/02/88	0.00	0.00
06/01/88	0.00	0.00
06/30/88	0.00	0.00
08/01/88	0.01	0.00
09/01/88	0.06	0.03
09/30/88	0.00	0.00
01/03/89	0.06	0.00
04/12/89	0.24	
04/25/89		0.00
06/29/89	0.00	0.00
09/28/89		0.00
10/25/89	0.22	
12/22/89	0.00	0.04
03/23/90	0.03	0.00
06/27/90	0.03	0.00
12/27/90	0.10	0.00
12/17/91	0.00	0.00
12/22/92	0.00	0.00
12/20/93	0.02	
12/22/93		0.01
12/19/94	0.01	0.01
11/07/95	0.00	0.00
06/18/96	0.00	0.00
07/02/96	0.00	0.00
07/16/96	0.00	0.00
08/13/96	0.00	0.00
10/22/96	0.03	0.00

10/28/97	0.00	0.02
11/18/98	0.00	0.00
12/20/99	0.00	0.00
12/26/00		<0.01
01/31/01	<0.01	
11/21/01	<0.01	<0.01
01/09/03	<0.01	<0.01

Ellengowan
Fig 5.17 Cadmium

Date	Maple Hill	Holes South
10/22/86	0.00	
12/05/86	0.00	
01/20/87	0.00	
02/04/87	0.00	
03/05/87	0.00	
03/31/87	0.00	
09/03/87		0.00
10/05/87	0.00	0.00
11/02/87	0.00	0.00
11/27/87	0.00	0.00
12/31/87	0.00	0.01
02/01/88	0.00	0.00
02/29/88	0.00	0.01
03/31/88	0.00	0.00
05/02/88	0.00	0.01
06/01/88	0.16	0.00
06/30/88	0.00	0.01
08/01/88	0.00	0.00
09/01/88	0.00	0.03
09/30/88	0.00	0.02
01/03/89	0.00	0.00
04/12/89	0.00	
04/25/89		0.00
06/29/89	0.00	0.00
09/28/89		0.00
10/25/89	0.01	
12/22/89	0.00	0.00
03/23/90	0.00	0.00
06/27/90	0.00	0.00
12/27/90	0.00	0.00
12/17/91	0.00	0.00
12/22/92	0.00	0.01
12/20/93	0.01	
12/22/93		0.01
12/19/94	0.00	0.00
06/01/95		
11/07/95	0.00	0.00
06/18/96	0.00	0.00
07/02/96	0.00	0.00
07/16/96	0.00	0.00
08/13/96	0.00	0.00

10/22/96	0.00	0.00
12/17/96		
10/28/97		
11/18/98	0.00	0.01
12/20/99	0.01	0.01
12/26/00		0.01
01/31/01	<0.01	
11/21/01	<0.01	0.07
01/09/03	<0.01	<0.01

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Fig 5.18 Chromium

Date	Maple Hill	Holes South
10/22/86	0.00	
12/05/86	0.00	
01/20/87	0.00	
02/04/87	0.06	
03/05/87	0.00	
03/31/87	0.00	
09/03/87		0.34
10/05/87	0.00	0.26
11/02/87	0.00	0.23
11/27/87	0.00	0.35
12/31/87	0.00	0.38
02/01/88	0.00	0.48
02/29/88	0.00	0.50
03/31/88	0.00	0.34
05/02/88	0.00	0.32
06/01/88	0.00	0.38
06/30/88	0.00	0.56
08/01/88	0.05	0.38
09/01/88	0.06	0.44
09/30/88	0.00	0.33
01/03/89	0.09	0.32
04/12/89	0.32	
04/25/89		0.58
06/29/89	0.06	
06/30/89		0.25
09/28/89		0.25
10/25/89	0.25	
12/22/89	0.12	0.13
03/23/90	0.00	0.00
06/27/90	0.06	0.00
12/27/90	0.13	0.00
12/17/91	0.00	0.00
12/22/92	0.10	0.07
12/20/93	0.15	
12/22/93		0.05
12/19/94	0.00	0.00
11/07/95	0.00	
11/08/95		0.00
06/18/96	0.00	0.00
07/02/96	0.00	0.00
07/16/96	0.00	0.00

08/13/96	0.00	0.00
10/22/96	0.00	0.00
10/28/97	0.00	0.00
11/18/98	0.00	0.00
12/20/99	0.00	0.00
12/26/00		<0.05
01/31/01	<0.06	
11/21/01	<0.05	<0.05
01/09/03	<0.005	<0.005

Ellengowan
Fig 5.19 Lead

Date	Maple Hill	Holes South
10/22/86	0.00	
12/05/86	0.00	
01/20/87	0.00	
02/04/87	0.10	
03/05/87	0.00	
03/31/87	0.00	
09/03/87		0.20
10/05/87	0.00	0.00
11/02/87	0.00	0.00
11/27/87	0.00	0.00
12/31/87	0.00	0.00
02/01/88	0.00	0.00
02/29/88	0.00	0.10
03/31/88	0.00	0.00
05/02/88	0.00	0.00
06/01/88	0.00	0.00
06/30/88	0.00	0.10
08/01/88	0.00	0.00
09/01/88	0.00	0.30
09/30/88	0.00	0.00
01/03/89	0.00	0.00
04/12/89	0.00	
04/25/89		0.70
06/29/89	0.00	
06/30/89		0.00
09/28/89		0.00
10/25/89	0.00	
12/22/89	0.10	0.00
03/23/90	0.00	0.00
06/27/90	0.00	0.00
12/27/90	0.00	0.00
12/17/91	0.13	0.18
12/22/92	0.00	0.00
12/20/93	0.12	
12/22/93		0.10
12/19/94	0.00	0.33
11/07/95	0.00	0.00
06/18/96	0.00	0.02
07/02/96	0.00	0.01
07/16/96	0.00	0.00
08/13/96	0.01	0.01

10/22/96	0.00	0.00
10/28/97	0.00	0.00
11/18/98	0.18	0.13
12/20/99	0.00	0.00
12/26/00		<0.1
01/31/01	<0.1	
11/21/01	<0.1	0.40
01/09/03	<0.025	<0.025

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Fig 5.20 Calcium

Date	Maple Hill	Holes South
10/22/86		
12/05/86		
01/20/87		
02/04/87		
03/05/87		
03/31/87		
09/03/87		
10/05/87		
11/02/87		
11/27/87		
12/31/87		
02/01/88		
02/29/88		
03/31/88		
05/02/88		
06/01/88		
06/30/88		
08/01/88		
09/01/88		
09/30/88		
01/03/89		
04/12/89		
06/29/89		
09/28/89		
10/25/89		
12/22/89		
03/23/90		
06/27/90		
12/27/90		
12/17/91		
12/22/92		
12/20/93		
12/19/94	181.56	95.19
06/01/95		
11/07/95	180.00	
11/08/95		260.00
06/18/96	197.00	134.00
07/02/96	226.00	108.00
07/16/96	244.00	127.00
08/13/96	230.00	119.00
10/22/96	160.00	120.00

12/17/96		
10/28/97	205.00	148.00
11/18/98	200.00	99.00
12/20/99	29.90	81.10
12/26/00		49.00
01/31/01	6.40	
11/21/01	3.65	27.00
01/09/03	89.00	90.60
11/10/03		

Ellengowan
Fig 5.21 Magnesium

Date	Maple Hill	Holes South
10/22/86	21.10	
12/05/86	17.50	
01/20/87	36.60	
02/04/87	23.00	
03/05/87	24.00	
03/31/87	28.10	
09/03/87		122.00
10/05/87	25.90	165.00
11/02/87	29.20	107.00
11/27/87	26.90	152.00
12/31/87	22.40	82.00
02/01/88	27.80	112.00
02/29/88	25.10	124.00
03/31/88	23.00	90.00
05/02/88	18.80	134.00
06/01/88	31.20	130.00
06/30/88	28.00	107.00
08/01/88	23.30	146.00
09/01/88	26.40	118.00
09/30/88	35.20	118.00
01/03/89	64.60	114.00
04/12/89	41.00	85.00
06/29/89	82.60	
06/30/89		70.00
09/28/89		110.00
10/25/89	46.30	
12/22/89	70.00	18.00
03/23/90	23.80	80.30
06/27/90	19.40	84.00
12/27/90	25.96	59.98
12/17/91	101.60	1.14
12/22/92	87.20	10.45
12/20/93	20.94	
12/22/93		20.93
12/19/94	95.40	70.80
11/07/95	54.00	73.30
06/18/96	85.90	37.50
07/02/96	90.30	29.30
07/16/96	114.00	34.30
08/13/96	88.50	31.60
10/22/96	68.80	24.90

10/28/97	83.30	78.20
11/18/98	127.00	24.40
12/20/99	1.12	27.10
12/26/00		12.50
01/31/01	0.73	
11/21/01	0.78	4.73
01/09/03	38.80	38.80

Ellengowan
Fig 5.22a Chloride

Date	Maple Hill	Holes South
10/22/1986	7.30	
12/5/1986	3.40	
1/20/1987	5.20	
2/4/1987	6.40	
3/5/1987	7.70	
3/31/1987	6.00	
9/3/1987		7.50
10/5/1987	9.21	9.21
11/2/1987	4.00	0.00
11/27/1987	5.00	0.00
12/31/1987	5.90	5.40
2/1/1988	12.00	7.00
2/29/1988	7.80	2.00
3/31/1988	4.90	5.90
5/2/1988	16.60	1.90
6/1/1988	10.30	7.80
6/30/1988	4.80	0.00
8/1/1988	8.20	0.00
9/1/1988	8.10	0.00
9/30/1988	7.40	4.80
1/3/1989	1.90	0.00
4/12/1989	10.70	
4/25/1989		0.00
6/29/1989	7.20	
6/30/1989		18.40
9/28/1989		11.50
12/22/1989	7.70	8.80
3/23/1990	7.60	5.20
6/27/1990	9.00	8.00
12/27/1990	9.80	7.90
3/14/1991		
6/20/1991		
9/19/1991		
12/17/1991	2.60	7.30
3/11/1992		
4/13/1992		
5/20/1992		
6/19/1992		
1/26/1993		
3/5/1993		
4/6/1993		

4/19/1993		
5/14/1993		
6/14/1993		
10/22/1993		
11/17/1993		
12/20/1993	8.30	4.42
2/17/1994		
3/9/1994		
4/27/1994		
5/24/1994		
6/8/1994		
6/21/1994		
7/21/1994	5.52	3.42
10/24/1994		
12/19/1994	4.58	2.98
2/2/1995		
2/23/1995		
3/15/1995		
4/20/1995	5.14	4.28
6/1/1995		
7/21/1995		
8/17/1995	3.90	1.64
10/26/1995		
11/7/1995	6.14	7.81
12/13/1995		
1/24/1996	4.90	
2/8/1996		5.84
2/21/1996		
5/21/1996	4.00	8.00
6/4/1996	5.00	9.00
6/18/1996	5.00	9.00
7/2/1996	5.00	8.00
7/16/1996	5.00	8.00
8/13/1996	4.00	8.00
8/27/1996		
12/17/1996	3.00	8.00
1/8/1997	3.00	9.00
1/21/1997	3.00	9.00
2/6/1997	4.00	8.00
2/27/1997	6.00	8.00
3/5/1997	6.00	8.00
3/18/1997	7.00	8.00
4/3/1997	7.00	8.00
4/15/1997	8.00	9.00
4/29/1997	8.00	7.00
5/27/1997	10.00	9.00
6/24/1997	10.00	8.00

7/29/1997	10.00	8.00
8/26/1997	6.00	8.00
10/28/1997		
11/25/1997		
1/27/1998		
3/30/1998		
6/22/1998		
7/15/1998	15.70	11.00
12/20/99	6.48	11.80
01/31/01	4.86	10.30
11/21/01	10.10	13.70
01/09/03	22.70	11.80

Ellengowan
Fig 5.22b Fluoride

Date	Maple Hill	Holes South
10/22/1986	0.15	
12/5/1986	0.13	
1/20/1987	0.09	
2/4/1987	0.10	
3/5/1987	0.15	
3/31/1987	0.11	
9/3/1987		0.12
10/5/1987	0.09	
10/5/1987		0.14
11/2/1987	0.12	
11/2/1987		0.13
11/27/1987	0.15	
11/27/1987		0.20
12/31/1987	0.14	
12/31/1987		0.17
2/1/1988	0.15	
2/1/1988		0.12
2/29/1988	0.13	
2/29/1988		0.11
3/31/1988	0.08	
3/31/1988		0.10
5/2/1988	0.09	
5/2/1988		0.10
6/1/1988	0.12	
6/1/1988		0.16
6/30/1988	0.10	
6/30/1988		0.13
8/1/1988	0.12	
8/1/1988		0.14
9/1/1988	0.08	
9/1/1988		0.09
9/30/1988	0.09	
9/30/1988		0.09
1/3/1989	0.15	
1/3/1989		0.14
4/12/1989	0.10	
4/25/1989		0.06
6/29/1989	0.34	
6/30/1989		0.14
9/28/1989		
9/28/1989		0.11

12/22/1989	0.17	
12/22/1989		0.11
3/23/1990	0.09	
3/23/1990		0.12
6/27/1990	0.24	
6/27/1990		0.20
12/27/1990	0.11	
12/27/1990		0.21
3/14/1991		
3/14/1991		
6/20/1991		
6/20/1991		
9/19/1991		
9/19/1991		
12/17/1991	0.00	
12/17/1991		0.00
3/11/1992		
3/11/1992		
4/13/1992		
4/13/1992		
5/20/1992		
5/20/1992		
6/19/1992		
6/19/1992		
1/26/1993		
1/26/1993		
3/5/1993		
3/5/1993		
4/6/1993		
4/6/1993		
4/19/1993		
5/14/1993		
5/14/1993		
6/14/1993		
6/14/1993		
10/22/1993		
10/22/1993		
11/17/1993		
11/17/1993		
12/20/1993	1.00	
12/20/1993		1.00
2/17/1994		
3/9/1994		
4/27/1994		
4/27/1994		
5/24/1994		
6/8/1994		

6/21/1994		
6/21/1994		
7/21/1994	0.00	
7/21/1994		0.00
12/19/1994	0.15	
12/19/1994		0.12
2/2/1995		
4/20/1995	0.00	
4/20/1995		0.00
7/21/1995		
8/17/1995	0.00	
8/17/1995		0.00
11/7/1995	0.00	
11/8/1995		0.00
1/24/1996	0.00	
2/8/1996		0.00
5/21/1996	0.00	
5/21/1996		0.36
6/4/1996	0.20	
6/4/1996		0.36
6/18/1996	0.00	
6/18/1996		0.32
7/2/1996	0.24	
7/2/1996		0.42
7/16/1996	0.33	
7/16/1996		0.34
8/13/1996	0.40	
8/13/1996		0.20
12/17/1996	0.00	
12/17/1996		0.00
1/7/1997		0.00
1/8/1997	0.00	
1/21/1997	0.00	
1/21/1997		0.00
2/4/1997		0.26
2/6/1997	0.00	
2/18/1997		0.21
2/27/1997	0.00	
3/5/1997	0.00	
3/5/1997		0.25
3/18/1997	0.00	
3/18/1997		0.25
4/3/1997	0.00	
4/3/1997		0.32
4/15/1997	0.00	
4/15/1997		0.33
4/29/1997	0.00	

4/29/1997		0.00
5/27/1997	0.00	
5/27/1997		0.24
6/24/1997	0.00	
6/24/1997		0.27
7/29/1997	0.00	
7/29/1997		0.00
8/26/1997	0.00	
8/26/1997		0.24
7/15/1998	0.00	
7/15/1998		0.00
11/18/1998		
11/18/1998		
2/26/1999		
2/26/1999		
5/12/1999		
5/12/1999		
7/1/1999		
7/1/1999		
8/20/1999		
8/20/1999		
12/20/1999		
12/20/1999		
2/1/2000		
5/25/2000		
5/25/2000		
7/27/2000		
7/27/2000		
9/26/2000		
12/26/2000		
1/31/2001		
3/20/2001		
3/20/2001		
6/15/2001		
6/15/2001		
8/10/2001		
8/10/2001		
11/21/2001		
11/21/2001		
1/23/2002		
1/23/2002		
2/25/2002		
2/25/2002		
4/12/2002		
4/12/2002		
5/16/2002		
5/16/2002		

6/13/2002		
6/13/2002		
7/25/2002		
7/25/2002		
8/15/2002		
8/15/2002		
11/29/2002		
11/29/2002		
1/9/2003		
1/9/2003		
3/18/2003		
3/18/2003		
5/14/2003		
5/14/2003		
8/21/2003		
8/21/2003		
11/11/2003		
11/11/2003		
2/17/2004		
2/17/2004		
5/11/2004		
5/11/2004		
8/11/2004		
8/11/2004		

Ellengowan
Fig 5.23 Aluminum

Date	Maple Hill	Holes South
10/22/86	0.00	
12/05/86	0.00	
01/20/87	0.00	
02/04/87	0.00	
03/05/87	0.00	
03/31/87	0.00	
09/03/87		1.60
10/05/87	0.00	0.00
11/02/87	0.00	0.00
11/27/87	0.00	0.00
12/31/87	0.00	0.00
02/01/88	0.00	0.00
02/29/88	0.00	0.00
03/31/88	0.00	0.00
05/02/88	0.00	0.00
06/01/88	0.00	0.80
06/30/88	1.10	1.20
08/01/88	0.90	1.20
09/01/88	0.00	6.80
09/30/88	0.00	1.40
01/03/89	0.00	2.00
04/12/89	1.40	
04/25/89		1.40
06/29/89	1.30	0.00
09/28/89		0.80
12/22/89	3.80	1.20
03/23/90	0.00	0.00
06/27/90	0.00	0.18
12/27/90	0.18	0.10
12/17/91	2.63	0.46
12/19/94	4.14	4.57
11/07/95	1.07	
11/08/95		3.82
06/18/96	1.05	1.32
07/02/96	5.27	0.20
07/16/96	5.87	0.00
08/13/96	6.97	0.00
10/22/96	7.29	0.26
10/28/97	7.30	34.90
11/18/98	3.66	0.19
12/20/99	0.62	1.34

01/31/01	0.47	0.26
11/21/01	0.14	0.56
01/09/03	1.73	1.73

Ellengowan
Fig 5.24 Copper

Date	Maple Hill	Holes South
10/22/86	0.00	
12/05/86	0.00	
01/20/87	0.13	
02/04/87	0.00	
03/05/87	0.00	
03/31/87	0.00	
09/03/87		0.00
10/05/87	0.00	0.00
11/02/87	0.00	0.00
11/27/87	0.00	0.00
12/31/87	0.00	0.00
02/01/88	0.00	0.00
02/29/88	0.00	0.00
03/31/88	0.00	0.00
05/02/88	0.00	0.00
06/01/88	0.00	0.00
06/30/88	0.00	0.17
08/01/88	0.00	0.00
09/01/88	0.00	0.10
09/30/88	0.00	0.00
01/03/89	0.00	0.00
04/12/89	0.10	0.00
06/29/89	0.08	0.00
09/28/89		0.00
10/25/89	0.06	
12/22/89	0.00	0.00
03/23/90	0.00	0.00
06/27/90	0.00	0.00
12/27/90	0.07	0.00
12/17/91	0.00	0.04
12/22/92	0.02	0.09
12/20/93	0.61	0.03
12/19/94	0.03	0.25
11/07/95	0.03	0.07
06/18/96	0.01	0.02
07/02/96	0.03	0.00
07/16/96	0.01	0.00
08/13/96	0.06	0.01
10/22/96	0.03	0.02
10/28/97	0.05	1.72
11/18/98	0.00	0.00

12/20/99	0.02	0.04
01/31/01	<*0.02*	0.03
11/21/01	<*0.02*	0.02
01/09/03	0.01	0.01

Ellengowan

Fig 5.25 Nickel

Date	Maple Hill	Holes South
12/19/94	0.51	0.41
11/07/95	0.17	0.23
06/18/96	0.12	0.42
07/02/96	0.25	0.00
07/16/96	0.33	0.00
08/13/96	0.32	0.03
10/22/96	0.14	0.00
10/28/97	0.21	2.79
11/18/98	0.21	0.00
12/20/99	0.00	0.33
01/31/01	0.06	*0.02*
11/21/01	*0.02*	*0.03*
01/09/03	0.10	0.10

Ellengowan
Fig 5.26 Zinc

Date	Maple Hill	Holes South
10/22/86	0.15	
12/05/86	0.15	
01/20/87	0.20	
02/04/87	0.13	
03/05/87	0.17	
03/31/87	0.15	
09/03/87		1.09
10/05/87	0.15	0.20
11/02/87	0.12	0.20
11/27/87	0.12	0.20
12/31/87	0.13	0.17
02/01/88	0.18	0.59
02/29/88	0.20	0.32
03/31/88	0.12	0.15
05/02/88	0.10	0.42
06/01/88	0.15	0.12
06/30/88	0.60	0.44
08/01/88	0.21	0.50
09/01/88	0.25	11.50
09/30/88	0.39	0.97
01/03/89	0.14	0.47
04/12/89	0.39	
04/25/89		0.54
06/29/89	0.54	0.10
09/28/89		1.15
10/25/89	1.60	
12/22/89	1.20	1.30
03/23/90	0.60	0.30
06/27/90	0.20	0.59
12/27/90	0.35	0.02
12/17/91	0.29	0.10
12/22/92	0.71	2.73
12/20/93	10.11	
12/22/93		0.38
12/19/94	0.46	3.16
11/07/95	0.64	
11/08/95		1.85
06/18/96	0.46	1.12
07/02/96	0.50	0.15
07/16/96	1.11	0.12
08/13/96	1.36	0.33

10/22/96	0.24	0.32
10/28/97	0.50	52.00
11/18/98	0.31	0.13
12/20/99	1.57	1.17
12/26/00		0.20
01/31/01	0.63	
11/21/01	0.84	0.81
01/09/03	0.63	0.65

Ellengowan
Fig 5.27 Lab pH

Date	Maple Hill	Holes South
10/22/1986	5.96	
12/5/1986	6.10	
1/20/1987	6.00	
2/4/1987	5.95	
3/5/1987	6.36	
3/31/1987	5.98	
9/3/1987		6.33
10/5/1987	5.96	6.19
11/2/1987	5.83	6.10
11/27/1987	5.84	6.09
12/31/1987	5.89	6.58
2/1/1988	5.77	6.30
2/29/1988	5.96	6.29
3/31/1988	6.14	6.27
5/2/1988	6.03	6.35
6/1/1988	6.04	6.12
6/30/1988	6.15	6.14
8/1/1988	5.93	6.19
9/1/1988	6.05	6.21
9/30/1988	6.02	5.96
1/3/1989	6.39	6.20
4/12/1989	6.84	
4/25/1989		6.35
6/29/1989	4.94	
6/30/1989		5.95
9/28/1989	6.33	6.36
12/22/1989	6.73	6.74
3/23/1990	6.02	7.40
6/27/1990	6.03	6.76
12/27/1990	6.33	6.68
3/14/1991	6.73	5.90
6/20/1991	5.97	5.63
9/19/1991	5.81	5.71
12/17/1991	5.72	6.52
3/11/1992	5.84	5.31
4/13/1992	5.57	5.67
5/20/1992	5.29	4.42
6/19/1992	5.70	5.69
1/26/1993	4.78	5.43
3/5/1993	5.30	5.12
4/6/1993	5.00	5.55

4/19/1993		4.95
5/14/1993	6.48	5.90
6/14/1993	5.05	6.15
10/22/1993	5.67	5.53
11/17/1993	5.65	5.78
12/20/1993	6.25	5.72
2/17/1994	5.61	
3/9/1994	5.68	
4/27/1994	4.73	6.21
5/24/1994		6.10
6/8/1994	5.17	
6/21/1994	5.23	5.89
7/21/1994	5.89	6.08
12/19/1994	5.41	5.17
2/2/1995		6.07
4/20/1995	5.55	4.97
7/21/1995		5.05
8/17/1995	5.63	6.03
11/7/1995	4.22	
11/8/1995		5.40
1/24/1996	6.10	
2/8/1996		6.03
5/21/1996	6.40	6.10
6/4/1996	6.00	6.20
6/18/1996	5.80	6.20
7/2/1996	5.70	6.10
7/16/1996	5.60	6.00
8/13/1996	5.50	5.90
12/17/1996	6.00	6.10
1/7/1997		6.40
1/8/1997	5.30	
1/21/1997	5.30	7.10
2/4/1997		6.40
2/6/1997	5.40	
2/18/1997		6.20
2/27/1997	5.60	
3/5/1997	5.40	5.90
3/18/1997	5.70	6.30
4/3/1997	5.70	6.30
4/15/1997	5.80	6.40
4/29/1997	5.90	6.30
5/27/1997	5.80	6.80
6/24/1997	5.80	6.00
7/29/1997	5.80	6.30
8/26/1997	4.90	6.80
7/15/1998	5.60	8.87
11/18/1998	6.67	7.99

2/26/1999	6.36	9.31
5/12/1999	6.11	8.12
7/1/1999	6.14	8.84
8/20/1999	7.49	8.15
12/20/1999	6.87	7.88
2/1/2000	5.14	
5/25/2000	6.88	7.52
7/27/2000	7.12	7.98
12/26/2000		9.08
1/31/2001	6.69	
3/20/2001	6.62	
6/15/2001	6.95	7.48
8/10/2001	7.63	8.72
11/21/2001	7.55	9.23
1/23/2002	7.44	9.06
2/25/2002	7.35	9.32
4/12/2002	7.11	9.19
5/16/2002	6.00	9.24
6/13/2002	5.99	9.16
7/25/2002	8.46	6.14
8/15/2002	6.50	8.21
11/29/2002	5.52	9.01
1/9/2003	6.34	8.93
3/18/2003	6.20	9.58
5/14/2003		8.38
8/21/2003	6.18	
11/11/2003	6.37	8.00
2/17/2004	6.21	
5/11/2004	6.20	6.00
8/11/2004	6.39	6.25

Ellengowan
Fig 5.28 Alkalinity

Date	Maple Hill Before	Holes South Before
10/22/1986	22.50	
12/5/1986	22.00	
1/20/1987	20.80	
2/4/1987	19.60	
3/5/1987	19.80	
3/31/1987	19.80	
9/3/1987		101.00
10/5/1987	22.00	70.40
11/2/1987	21.60	85.80
11/27/1987	22.00	132.00
12/31/1987	22.00	171.00
2/1/1988	21.60	155.00
2/29/1988	21.20	162.00
3/31/1988	24.40	104.00
5/2/1988	22.50	77.20
6/1/1988	25.20	92.00
6/30/1988	28.00	111.00
8/1/1988	28.20	148.00
9/1/1988	25.20	143.00
9/30/1988	32.70	86.00
1/3/1989	78.50	108.00
4/12/1989	75.60	138.00
6/29/1989	14.00	39.00
9/28/1989	33.40	44.90
12/22/1989	34.40	35.20
3/23/1990	22.00	31.00
6/27/1990	22.50	17.10
12/27/1990	19.00	10.00
3/14/1991	17.00	7.00
6/20/1991	17.20	10.20
9/19/1991	15.20	9.10
12/17/1991	72.00	8.00
3/11/1992	71.00	24.00
4/13/1992	29.00	16.00
5/20/1992	28.00	0.00
6/19/1992	3.00	16.00
1/26/1993	7.00	12.00
3/5/1993	8.00	5.00
4/6/1993	8.00	14.00
4/19/1993		6.00

5/14/1993	21.00	22.00
6/14/1993	5.00	23.00
10/22/1993	97.00	15.00
11/17/1993	45.00	43.00
12/20/1993	31.00	28.00
2/17/1994	50.00	
3/9/1994	35.00	
4/27/1994	6.00	26.00
5/24/1994		17.00
6/8/1994	5.00	
6/21/1994	3.00	7.00
7/21/1994	20.00	9.00
10/24/1994		
12/19/1994	16.08	5.03
2/2/1995		35.53
4/20/1995	2.49	1.50
7/21/1995		3.30
8/17/1995	29.30	17.10
11/7/1995	0.00	0.00
1/24/1996	88.00	
2/8/1996		27.40
5/21/1996	52.00	12.60
6/4/1996	46.00	13.20
6/18/1996	46.00	13.80
7/2/1996	44.00	12.60
7/16/1996	42.00	11.80
8/13/1996	34.00	10.60
12/17/1996	62.00	30.00
1/8/1997	16.60	17.80
1/21/1997	16.80	19.20
2/6/1997	15.20	20.00
2/27/1997	15.80	17.00
3/5/1997	14.60	14.80
3/18/1997	17.20	17.60
4/3/1997	18.20	15.60
4/15/1997	18.00	19.40
4/29/1997	22.00	102.00
5/27/1997	22.00	15.80
6/24/1997	20.00	15.80
7/29/1997	24.00	16.00
8/26/1997	16.80	17.00
7/15/1998	7.00	10.00
11/18/1998	25.60	9.60
2/26/1999	55.00	15.40
5/12/1999	15.00	22.30
7/1/1999	8.04	28.50
8/20/1999	27.50	22.70

12/20/1999	7.96	39.80
2/1/2000	5.38	
5/25/2000	5.00	19.00
7/27/2000	8.00	20.00
12/26/2000		6.15
1/31/2001	13.80	
3/20/2001	7.88	
6/15/2001	4.90	11.00
8/10/2001	8.16	13.30
11/21/2001	5.05	15.20
1/23/2002	12.50	15.20
2/25/2002	10.20	20.30
4/12/2002	6.50	16.40
5/16/2002	48.70	14.20
6/13/2002	13.00	13.00
7/25/2002	21.00	26.30
8/15/2002	32.50	20.30
11/29/2002	78.40	16.30
1/9/2003	55.40	16.40
3/18/2003	38.40	17.50
5/14/2003		19.50
8/21/2003	5.10	
11/11/2003	28.30	44.50
2/17/2004	16.30	
5/11/2004	34.90	20.50
8/11/2004	11.20	8.10

Ellengowan
Fig 5.29 Acidity

Date	Maple Hill Before	Holes South Before
10/22/1986	0.00	
12/5/1986	0.00	
1/20/1987	5.70	
2/4/1987	1.10	
3/5/1987	1.90	
3/31/1987	0.00	
9/3/1987		163.00
10/5/1987	84.60	218.00
11/2/1987	18.00	219.00
11/27/1987	52.00	226.00
12/31/1987	66.00	401.00
2/1/1988	35.70	318.00
2/29/1988	27.30	163.00
3/31/1988	0.00	89.40
5/2/1988	0.00	129.00
6/1/1988	0.00	79.00
6/30/1988	0.00	105.00
8/1/1988	10.40	159.00
9/1/1988	0.00	131.00
9/30/1988	0.00	120.00
1/3/1989	129.00	50.50
4/12/1989	0.00	106.00
6/29/1989	49.30	47.00
9/28/1989	0.00	3.80
12/22/1989	0.00	1.50
3/23/1990	0.00	0.00
6/27/1990	2.20	3.90
12/27/1990	0.00	0.00
3/14/1991	0.00	11.00
6/20/1991	21.00	23.00
9/19/1991	24.00	26.00
12/17/1991	62.00	6.00
3/11/1992	56.00	78.00
4/13/1992	92.00	42.00
5/20/1992	96.00	46.00
6/19/1992	10.00	8.00
1/26/1993	109.00	44.00
3/5/1993	41.00	58.00
4/6/1993	65.00	48.00
4/19/1993		28.00

5/14/1993	0.00	35.00
6/14/1993	117.00	42.00
10/22/1993	115.00	143.00
11/17/1993	91.00	126.00
12/20/1993	46.00	56.00
2/17/1994	90.00	
3/9/1994	74.00	
4/27/1994	81.00	0.00
5/24/1994		27.00
6/8/1994	74.00	
6/21/1994	87.00	14.00
7/21/1994	57.00	26.00
12/19/1994	71.90	25.68
2/2/1995		0.00
4/20/1995	36.70	36.70
7/21/1995		19.70
8/17/1995	57.00	10.50
11/7/1995	17.00	71.50
1/24/1996	0.00	
2/8/1996		0.00
5/21/1996	7.20	7.40
6/4/1996	34.00	1.20
6/18/1996	50.00	8.00
7/2/1996	112.00	4.00
7/16/1996	94.00	6.20
8/13/1996	100.00	6.40
12/17/1996	24.00	34.00
1/8/1997	22.00	4.20
1/21/1997	54.00	0.00
2/6/1997	15.40	7.20
2/27/1997	14.20	5.80
3/5/1997	13.40	2.60
3/18/1997	15.00	3.00
4/3/1997	4.80	0.80
4/15/1997	6.40	1.00
4/29/1997	12.60	100.00
5/27/1997	26.00	0.00
6/24/1997	3.40	0.60
7/29/1997	14.60	7.60
8/26/1997	112.00	0.00
7/15/1998	110.40	0.00
11/18/1998	48.20	0.00
2/26/1999	38.60	0.00
5/12/1999	25.30	1.20
7/1/1999	56.90	8.90
8/20/1999	0.00	1.50
12/20/1999	3.33	26.80

2/1/2000	1.94	
5/25/2000	0.73	0.40
7/27/2000	0.40	0.40
12/26/2000		0.40
1/31/2001	0.40	
3/20/2001	0.40	
6/15/2001	26.20	0.40
8/10/2001	0.40	0.40
11/21/2001	0.40	0.40
1/23/2002	0.40	0.40
2/25/2002	0.40	0.40
4/12/2002	0.40	0.40
5/16/2002	1.75	0.40
6/13/2002	1.30	0.40
7/25/2002	0.40	0.54
8/15/2002	0.49	2.41
11/29/2002	0.40	0.40
1/9/2003	21.40	0.40
3/18/2003	46.40	0.40
5/14/2003		0.40
8/21/2003	33.60	
11/11/2003	37.70	0.40
2/17/2004	32.10	
5/11/2004	17.40	20.90
8/11/2004	13.00	19.80

Ellengowan

Fig 5.30 Specific Conductance

Date	Maple Hill	Holes South
12/27/1990	4.93	1098.00
3/14/1991	422.00	798.00
12/17/1991	1609.00	915.00
3/11/1992	1844.00	864.00
4/13/1992	1995.00	912.00
5/20/1992	1868.00	969.00
6/19/1992	315.00	672.00
1/26/1993	1915.00	859.00
3/5/1993	2136.00	1014.00
4/6/1993	2010.00	1112.00
4/19/1993		1100.00
5/14/1993	470.00	1151.00
6/14/1993	1901.00	901.00
10/22/1993	1980.00	1447.00
11/17/1993	1976.00	1445.00
12/20/1993	1322.00	1849.00
2/17/1994	1904.00	
3/9/1994	1920.00	
4/27/1994	1909.00	1062.00
5/24/1994		1176.00
6/8/1994	2184.00	
6/21/1994	2020.00	1071.00
7/21/1994	1778.00	1097.00
12/19/1994	2207.00	1194.00
2/2/1995		1103.00
4/20/1995	2106.00	896.00
7/21/1995		928.00
8/17/1995	2413.00	1086.00
11/7/1995	1361.00	1415.00
12/13/1995		
1/24/1996	1378.00	
2/8/1996		1055.00
5/21/1996	1030.00	745.00
6/4/1996	1342.00	753.00
6/18/1996	1353.00	782.00
7/2/1996	1608.00	720.00
7/16/1996	1771.00	734.00
8/13/1996	1775.00	743.00
12/17/1996	1072.00	893.00
1/8/1997	884.00	733.00
1/21/1997	852.00	703.00

2/6/1997	759.00	737.00
2/27/1997	505.00	704.00
3/5/1997	674.00	700.00
3/18/1997	515.00	726.00
4/3/1997	482.00	727.00
4/15/1997	480.00	733.00
4/29/1997	507.00	1243.00
5/27/1997	490.00	754.00
6/24/1997	435.00	749.00
7/29/1997	436.00	725.00
8/26/1997	1780.00	725.00
7/15/1998	2015.00	689.00
11/18/1998	1776.00	657.00
2/26/1999	1696.00	692.00
5/12/1999	1710.00	669.00
7/1/1999	1544.00	657.00
8/20/1999	82.00	652.00
12/20/1999	55.00	666.00
2/1/2000	61.00	
5/25/2000	46.40	573.00
7/27/2000	38.39	533.00
12/26/2000		445.20
1/31/2001	46.86	
3/20/2001	49.15	
6/15/2001	36.87	476.00
8/10/2001	41.03	315.00
11/21/2001	67.20	275.60
1/23/2002	48.30	246.00
2/25/2002	41.53	218.90
4/12/2002	38.62	204.40
5/16/2002	37.00	186.40
6/13/2002	1699.00	178.00
7/25/2002	193.00	1920.00
8/15/2002	1803.00	181.50
11/29/2002	1917.00	144.00
1/9/2003	1569.00	129.00
3/18/2003	1394.00	122.00
5/14/2003		145.00
8/21/2003	1589.00	
11/11/2003	1587.00	150.00
2/17/2004	2296.00	
5/11/2004	1474.00	884.00
8/11/2004	1317.00	723.00

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Fig 5.31 Iron

Date		
Date	Maple Hill	Holes South
10/22/1986	1.31	
12/5/1986	1.50	
1/20/1987	1.12	
2/4/1987	1.26	
3/5/1987	1.20	
3/31/1987	1.50	
9/3/1987		174.00
10/5/1987	1.45	99.00
11/2/1987	0.95	140.00
11/27/1987	3.16	157.00
12/31/1987	2.40	167.00
2/1/1988	2.30	180.00
2/29/1988	2.60	169.00
3/31/1988	3.70	145.00
5/2/1988	1.18	180.00
6/1/1988	2.90	163.00
6/30/1988	6.50	172.00
8/1/1988	3.45	168.00
9/1/1988	2.40	175.00
9/30/1988	4.60	190.00
1/3/1989	16.90	185.00
4/12/1989	22.90	172.00
6/29/1989	11.60	75.50
9/28/1989	18.20	59.50
12/22/1989	47.10	21.90
3/23/1990	3.50	20.40
6/27/1990	0.50	17.30
12/27/1990	2.11	8.53
3/14/1991	0.95	59.10
6/20/1991	0.43	11.00
9/19/1991	0.95	12.00
12/17/1991	68.90	34.33
3/11/1992	53.53	85.60
4/13/1992	47.98	53.21
5/20/1992	52.11	35.31
6/19/1992	24.05	32.49
1/26/1993	31.12	15.23
3/5/1993	32.67	24.24
4/6/1993	31.50	30.20
4/19/1993		37.18

5/14/1993	13.60	87.14
6/14/1993	37.22	92.60
10/22/1993	63.30	94.20
11/17/1993	65.15	128.40
12/20/1993	86.30	52.27
2/17/1994	52.01	
3/9/1994	45.73	
4/27/1994	31.41	8.50
5/24/1994		138.90
6/8/1994	35.76	
6/21/1994	43.85	70.20
7/21/1994	51.62	51.10
12/19/1994	4.43	2.94
2/2/1995		35.56
4/20/1995	34.10	16.80
7/21/1995		36.40
8/17/1995	45.85	28.62
11/7/1995	2.80	52.00
1/24/1996	43.56	
2/8/1996		118.00
5/21/1996	25.60	18.70
6/4/1996	1.14	0.81
6/18/1996	3.78	40.90
7/2/1996	33.90	1.27
7/16/1996	41.80	2.95
8/13/1996	36.80	5.09
12/17/1996	11.90	23.90
1/8/1997	2.91	43.50
1/21/1997	2.59	15.30
2/6/1997	1.65	39.50
2/27/1997	3.98	9.74
3/5/1997	5.49	7.93
3/18/1997	2.53	6.43
4/3/1997	3.08	4.70
4/15/1997	8.52	11.50
4/29/1997	2.45	18.40
5/27/1997	5.68	6.10
6/24/1997	15.10	3.73
7/29/1997	9.83	19.30
8/26/1997	25.00	21.10
7/15/1998	25.70	23.40
11/18/1998	48.80	11.70
2/26/1999	39.80	5.52
5/12/1999	41.10	7.60
7/1/1999	42.50	8.10
8/20/1999	3.99	8.30
12/20/1999	0.76	6.90

2/1/2000	1.51	
5/25/2000	36.80	36.70
7/27/2000	0.34	42.80
12/26/2000		21.70
1/31/2001	0.98	
3/20/2001	0.19	
6/15/2001	0.75	3.00
8/10/2001	0.35	32.50
11/21/2001	0.70	37.00
1/23/2002	1.31	28.00
2/25/2002	1.64	32.00
4/12/2002	1.22	23.30
5/16/2002	3.21	13.90
6/13/2002	36.80	13.00
7/25/2002	7.42	40.70
8/15/2002	39.50	9.32
11/29/2002	28.50	11.10
1/9/2003	24.80	24.80
3/18/2003	46.40	7.55
5/14/2003		2.78
8/21/2003	31.30	
11/11/2003	27.80	9.22
2/17/2004	29.60	
5/11/2004	28.40	51.40
8/11/2004	26.80	30.40

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Fig 5.32a Manganese

Date	Maple Hill	Holes South
10/22/1986	0.98	
12/5/1986	0.86	
1/20/1987	0.85	
2/4/1987	0.93	
3/5/1987	1.70	
3/31/1987	1.28	
9/3/1987		15.40
10/5/1987	0.93	7.30
11/2/1987	0.97	11.20
11/27/1987	1.10	14.00
12/31/1987	1.29	13.50
2/1/1988	1.44	13.70
2/29/1988	1.20	13.50
3/31/1988	1.02	12.20
5/2/1988	0.79	14.20
6/1/1988	0.82	13.60
6/30/1988	1.00	14.20
8/1/1988	1.55	13.30
9/1/1988	1.81	14.30
9/30/1988	4.10	13.90
1/3/1989	15.30	13.30
4/12/1989	16.70	12.40
6/29/1989	10.60	6.60
9/28/1989	5.90	5.70
12/22/1989	2.25	5.90
3/23/1990	2.38	0.55
6/27/1990	2.34	0.60
12/27/1990	2.38	0.39
3/14/1991	2.72	0.60
6/20/1991	2.80	1.60
9/19/1991	3.20	1.85
12/17/1991	15.09	58.20
3/11/1992	17.91	7.92
4/13/1992	19.93	10.46
5/20/1992	16.80	7.74
6/19/1992	1.24	5.15
1/26/1993	15.91	6.01
3/5/1993	16.93	10.57
4/6/1993	16.98	12.20
4/19/1993		12.85
5/14/1993	1.82	13.04

6/14/1993	17.95	12.14
10/22/1993	18.71	13.63
11/17/1993	17.33	12.88
12/20/1993	13.03	14.46
2/17/1994	1.37	
3/9/1994	13.89	
4/27/1994	13.59	4.87
5/24/1994		9.59
6/8/1994	15.47	
6/21/1994	15.32	0.85
7/21/1994	15.56	8.78
12/19/1994	1.44	1.18
2/2/1995		11.69
4/20/1995	17.00	9.83
7/21/1995		8.64
8/17/1995	17.10	8.79
11/7/1995	5.61	7.80
1/24/1996	8.77	
2/8/1996		7.76
5/21/1996	7.20	0.38
6/4/1996	7.77	0.19
6/18/1996	7.61	0.93
7/2/1996	16.30	0.32
7/16/1996	17.90	0.37
8/13/1996	16.50	0.33
12/17/1996	7.30	0.43
1/8/1997	6.02	0.36
1/21/1997	6.02	0.21
2/6/1997	5.38	0.43
2/27/1997	3.98	0.19
3/5/1997	5.15	0.34
3/18/1997	3.62	0.25
4/3/1997	30.40	32.90
4/15/1997	26.50	254.00
4/29/1997	31.20	387.00
5/27/1997	4.00	0.18
6/24/1997	3.58	0.14
7/29/1997	3.17	0.25
8/26/1997	104.00	0.26
7/15/1998	13.50	0.34
11/18/1998	13.70	0.22
2/26/1999	11.50	0.10
5/12/1999	11.60	0.20
7/1/1999	11.90	0.18
8/20/1999	0.86	0.25
12/20/1999	0.10	0.87
2/1/2000	0.23	

5/25/2000	0.59	0.59
7/27/2000	0.02	0.59
12/26/2000		0.21
1/31/2001	0.30	
3/20/2001	0.09	
6/15/2001	0.34	0.34
8/10/2001	0.50	0.31
11/21/2001	0.30	0.40
1/23/2002	0.74	0.38
2/25/2002	1.03	0.41
4/12/2002	0.74	0.31
5/16/2002	8.69	0.20
6/13/2002	11.60	0.11
7/25/2002	0.18	0.11
8/15/2002	11.40	0.18
11/29/2002	9.68	0.20
1/9/2003	4.91	4.93
3/18/2003	8.75	0.08
5/14/2003		0.18
8/21/2003	9.93	
11/11/2003	9.71	0.23
2/17/2004	10.20	
5/11/2004	9.16	7.82
8/11/2004	8.18	3.15

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Fig 5.32b Managanese

Date	Maple Hill	Holes South
10/22/1986	0.98	
12/5/1986	0.86	
1/20/1987	0.85	
2/4/1987	0.93	
3/5/1987	1.70	
3/31/1987	1.28	
9/3/1987		15.40
10/5/1987	0.93	7.30
11/2/1987	0.97	11.20
11/27/1987	1.10	14.00
12/31/1987	1.29	13.50
2/1/1988	1.44	13.70
2/29/1988	1.20	13.50
3/31/1988	1.02	12.20
5/2/1988	0.79	14.20
6/1/1988	0.82	13.60
6/30/1988	1.00	14.20
8/1/1988	1.55	13.30
9/1/1988	1.81	14.30
9/30/1988	4.10	13.90
1/3/1989	15.30	13.30
4/12/1989	16.70	12.40
6/29/1989	10.60	6.60
9/28/1989	5.90	5.70
12/22/1989	2.25	5.90
3/23/1990	2.38	0.55
6/27/1990	2.34	0.60
12/27/1990	2.38	0.39
3/14/1991	2.72	0.60
6/20/1991	2.80	1.60
9/19/1991	3.20	1.85
12/17/1991	15.09	58.20
3/11/1992	17.91	7.92
4/13/1992	19.93	10.46
5/20/1992	16.80	7.74
6/19/1992	1.24	5.15
1/26/1993	15.91	6.01
3/5/1993	16.93	10.57
4/6/1993	16.98	12.20
4/19/1993		12.85
5/14/1993	1.82	13.04

6/14/1993	17.95	12.14
10/22/1993	18.71	13.63
11/17/1993	17.33	12.88
12/20/1993	13.03	14.46
2/17/1994	1.37	
3/9/1994	13.89	
4/27/1994	13.59	4.87
5/24/1994		9.59
6/8/1994	15.47	
6/21/1994	15.32	0.85
7/21/1994	15.56	8.78
12/19/1994	1.44	1.18
2/2/1995		11.69
4/20/1995	17.00	9.83
7/21/1995		8.64
8/17/1995	17.10	8.79
11/7/1995	5.61	7.80
1/24/1996	8.77	
2/8/1996		7.76
5/21/1996	7.20	0.38
6/4/1996	7.77	0.19
6/18/1996	7.61	0.93
7/2/1996	16.30	0.32
7/16/1996	17.90	0.37
8/13/1996	16.50	0.33
12/17/1996	7.30	0.43
1/8/1997	6.02	0.36
1/21/1997	6.02	0.21
2/6/1997	5.38	0.43
2/27/1997	3.98	0.19
3/5/1997	5.15	0.34
3/18/1997	3.62	0.25
4/3/1997	30.40	32.90
4/15/1997	26.50	254.00
4/29/1997	31.20	387.00
5/27/1997	4.00	0.18
6/24/1997	3.58	0.14
7/29/1997	3.17	0.25
8/26/1997	104.00	0.26
7/15/1998	13.50	0.34
11/18/1998	13.70	0.22
2/26/1999	11.50	0.10
5/12/1999	11.60	0.20
7/1/1999	11.90	0.18
8/20/1999	0.86	0.25
12/20/1999	0.10	0.87
2/1/2000	0.23	

5/25/2000	0.59	0.59
7/27/2000	0.02	0.59
12/26/2000		0.21
1/31/2001	0.30	
3/20/2001	0.09	
6/15/2001	0.34	0.34
8/10/2001	0.50	0.31
11/21/2001	0.30	0.40
1/23/2002	0.74	0.38
2/25/2002	1.03	0.41
4/12/2002	0.74	0.31
5/16/2002	8.69	0.20
6/13/2002	11.60	0.11
7/25/2002	0.18	0.11
8/15/2002	11.40	0.18
11/29/2002	9.68	0.20
1/9/2003	4.91	4.93
3/18/2003	8.75	0.08
5/14/2003		0.18
8/21/2003	9.93	
11/11/2003	9.71	0.23
2/17/2004	10.20	
5/11/2004	9.16	7.82
8/11/2004	8.18	3.15

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Fig 5.33 Sulfate

Date	Maple Hill	Holes South
10/22/1986	105.00	
12/5/1986	130.00	
1/20/1987	144.00	
2/4/1987	130.00	
3/5/1987	240.00	
3/31/1987	145.00	
9/3/1987		546
10/5/1987	129.00	448.00
11/2/1987	119.00	546.00
11/27/1987	119.00	796.00
12/31/1987	213.00	992.00
2/1/1988	192.00	910.00
2/29/1988	150.00	896.00
3/31/1988	109.00	796.00
5/2/1988	149.00	909.00
6/1/1988	129.00	824.00
6/30/1988	160.00	1068.00
8/1/1988	160.00	850.00
9/1/1988	149.00	908.00
9/30/1988	139.00	824.00
1/3/1989	248.00	851.00
4/12/1989	140.00	690.00
6/29/1989	645.00	747.00
9/28/1989	170.00	520.00
12/22/1989	448.00	214.00
3/23/1990	139.00	454.00
6/27/1990	107.00	320.00
12/27/1990	119.10	495.70
3/14/1991	229.20	479.80
6/20/1991	415.00	427.00
9/19/1991	351.00	340.00
12/17/1991	1046.90	528.20
3/11/1992	964.30	378.80
4/13/1992	1000.50	382.40
5/20/1992	1062.90	407.00
6/19/1992	77.00	173.00
1/26/1993	1096.30	435.40
3/5/1993	1113.50	445.40
4/6/1993	1112.30	449.10
4/19/1993		535.00
5/14/1993	167.50	472.90

6/14/1993	656.90	326.10
10/22/1993	1065.20	792.10
11/17/1993	1034.60	711.40
12/20/1993	720.00	1010.00
2/17/1994	1056.20	
3/9/1994	949.30	
4/27/1994	1066.10	439.00
5/24/1994		294.21
6/8/1994	235.95	
6/21/1994	1156.50	500.00
7/21/1994	1049.00	555.00
12/19/1994	19.70	536.61
4/20/1995	1191.00	492.00
8/17/1995	1143.00	457.70
11/7/1995	508.00	672.00
1/24/1996	607.00	574.18
5/21/1996	513.00	357.00
6/4/1996	976.00	369.00
6/18/1996	701.00	375.00
7/2/1996	983.00	359.00
7/16/1996	659.00	317.00
8/13/1996	1050.00	334.00
12/17/1996	505.00	421.00
1/8/1997	414.00	300.00
1/21/1997	411.00	317.00
2/6/1997	501.00	310.00
2/27/1997	196.00	299.00
3/5/1997	284.00	296.00
3/18/1997	243.00	302.00
4/3/1997	193.00	329.00
4/15/1997	197.00	308.00
4/29/1997	195.00	579.00
5/27/1997	166.00	317.00
6/24/1997	151.00	343.00
7/29/1997	40.00	372.00
8/26/1997	697.00	286.00
7/15/1998	1313.00	337.00
11/18/1998	960.00	302.00
2/26/1999	942.00	384.00
5/12/1999	952.00	335.00
7/1/1999	939.00	303.00
8/20/1999	5.03	356.00
12/20/1999	6.83	310.00
2/1/2000	5.38	271.00
5/25/2000	6.04	225.00
7/27/2000	5.34	
1/31/2001	6.30	216.00

3/20/2001	4.94	
6/15/2001	4.59	233.00
8/10/2001	4.84	113.00
11/21/2001	7.62	84.50
1/23/2002	6.24	88.00
2/25/2002	5.73	60.70
4/12/2002	10.30	52.60
5/16/2002	10.20	48.50
6/13/2002	9.65	40.00
7/25/2002	49.30	103.00
8/15/2002	1175.00	41.90
11/29/2002	1340.00	28.00
1/9/2003	925.00	25.50
3/18/2003	910.00	12.90
5/14/2003		56.20
8/21/2003	904.00	
11/11/2003	840.00	9.03
2/17/2004	860.00	
5/11/2004	375.00	431.00
8/11/2004	598.00	334.00

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Fig 5.34 TDS

Date	Maple Hill	Holes South
10/22/1986	440.00	
12/5/1986	248.00	
1/20/1987	237.00	
2/4/1987	240.00	
3/5/1987	340.00	
3/31/1987	262.00	
9/3/1987		1466.00
10/5/1987	236.00	1445.00
11/2/1987	247.00	1360.00
11/27/1987	254.00	1420.00
12/31/1987	321.00	1384.00
2/1/1988	367.00	1531.00
2/29/1988	225.00	1381.00
3/31/1988	292.00	1526.00
5/2/1988	168.00	1740.00
6/1/1988	263.00	1519.00
6/30/1988	346.00	1462.00
8/1/1988	368.00	1759.00
9/1/1988	351.00	1555.00
9/30/1988	360.00	1595.00
1/3/1989	443.00	1438.00
4/12/1989	499.00	1503.00
6/29/1989	1129.00	982.00
9/28/1989	396.00	990.00
12/22/1989	1138.00	487.00
3/23/1990	269.00	880.00
6/27/1990	327.00	896.00
12/27/1990	384.00	936.00
3/14/1991	341.00	720.00
6/20/1991		
9/19/1991		
12/17/1991	1548.00	839.00
3/11/1992	1469.00	569.00
4/13/1992		
5/20/1992		
6/19/1992		
1/26/1993		
3/5/1993		
4/6/1993		
4/19/1993		
5/14/1993		

6/14/1993		
10/22/1993		
11/17/1993		
12/20/1993		
2/17/1994		
3/9/1994		
4/27/1994		
5/24/1994		
6/8/1994		
6/21/1994		
7/21/1994	1522.00	804.00
12/19/1994	1673.00	802.00
2/2/1995		
4/20/1995	1709.00	657.00
7/21/1995		
8/17/1995	1570.00	642.00
11/7/1995	890.00	1060.00
1/24/1996	931.00	
2/8/1996		777.00
5/21/1996	1028.00	646.00
6/4/1996	1260.00	658.00
6/18/1996	1432.00	806.00
7/2/1996	1714.00	640.00
7/16/1996	2064.00	676.00
8/13/1996	2218.00	698.00
12/17/1996	920.00	734.00
1/8/1997	720.00	642.00
1/21/1997	668.00	528.00
2/6/1997	468.00	630.00
2/27/1997	368.00	516.00
3/5/1997	704.00	550.00
3/18/1997	418.00	616.00
4/3/1997	394.00	570.00
4/15/1997	394.00	548.00
4/29/1997	436.00	1244.00
5/27/1997	454.00	688.00
6/24/1997	420.00	704.00
7/29/1997	378.00	646.00
8/26/1997	1798.00	710.00
7/15/1998	1736.00	540.00
11/18/1998	1528.00	528.00
2/26/1999	1556.00	516.00
5/12/1999	1328.00	529.00
7/1/1999	1274.00	572.00
8/20/1999	48.00	519.00
12/20/1999	20.00	396.00
2/1/2000	43.00	

5/25/2000	40.00	420.00
7/27/2000	16.00	365.00
12/26/2000		292.00
1/31/2001	6.00	
3/20/2001	49.00	
6/15/2001	15.00	305.00
8/10/2001	31.00	202.00
11/21/2001	31.00	157.00
1/23/2002	26.00	116.00
2/25/2002	*1.00*	85.00
4/12/2002	11.00	104.00
5/16/2002	12.70	116.00
6/13/2002	14.60	125.00
7/25/2002	17.00	160.90
8/15/2002	1620.00	129.00
11/29/2002	1670.00	107.00
1/9/2003	1273.00	75.00
3/18/2003	1254.00	86.00
5/14/2003		90.00
8/21/2003	1350.00	
11/11/2003	1278.00	64.00
2/17/2004	1392.00	
5/11/2004	1131.00	723.00
8/11/2004	1058.00	537.00

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Fig 5.35 Sulfate

Date	MW1
10/24/1994	103.30
10/24/1994	
10/24/1994	
12/8/1994	
12/19/1994	92.60
12/19/1994	
2/2/1995	96.08
2/2/1995	
2/7/1995	
2/23/1995	95.80
3/14/1995	
3/15/1995	91.03
3/15/1995	
3/15/1995	
4/20/1995	90.60
4/20/1995	
4/20/1995	
6/1/1995	80.40
6/1/1995	
6/1/1995	
6/5/1995	
7/21/1995	
7/24/1995	
8/17/1995	
9/19/1995	
10/26/1995	27.90
11/7/1995	
12/5/1995	
12/13/1995	
12/13/1995	
12/14/1995	
1/16/1996	
1/24/1996	
1/31/1996	
2/8/1996	
2/19/1996	
2/21/1996	24.35
2/21/1996	
3/4/1996	
3/13/1996	
3/25/1996	
4/24/1996	

5/21/1996	
6/4/1996	
6/4/1996	
6/18/1996	25.87
6/18/1996	
6/24/1996	
6/26/1996	
7/2/1996	
7/2/1996	
7/16/1996	
7/16/1996	
7/17/1996	
8/13/1996	
8/13/1996	
8/27/1996	15.10
9/12/1996	
12/17/1996	0.02
12/17/1996	
12/17/1996	
12/18/1996	
1/7/1997	
1/8/1997	
1/8/1997	
1/21/1997	
1/21/1997	
2/6/1997	
2/6/1997	
2/27/1997	0.00
2/27/1997	
2/27/1997	
3/5/1997	
3/5/1997	
3/18/1997	
3/18/1997	
4/3/1997	
4/3/1997	
4/15/1997	
4/15/1997	
4/29/1997	
4/29/1997	
5/27/1997	0.00
5/27/1997	
6/19/1997	
6/24/1997	
6/24/1997	
6/24/1997	
7/29/1997	

7/29/1997	
8/26/1997	0.00
8/26/1997	
9/4/1997	
10/28/1997	448.00
11/17/1997	
11/25/1997	12.30
1/27/1998	16.30
3/5/1998	
3/30/1998	
3/30/1998	
5/18/1998	
6/22/1998	19.80
6/22/1998	
6/22/1998	
7/14/1998	
7/15/1998	35.60
7/15/1998	
8/26/1998	12.80
8/26/1998	
9/18/1998	
9/28/1998	13.60
9/28/1998	
10/19/1998	13.80
11/5/1998	
11/18/1998	
12/17/1998	9.48
1/28/1999	12.50
1/28/1999	
2/26/1999	13.40
2/26/1999	
3/3/1999	
3/29/1999	16.20
3/29/1999	
4/27/1999	24.00
4/27/1999	
5/12/1999	
6/9/1999	28.80
6/9/1999	
6/23/1999	
7/1/1999	27.00
7/27/1999	56.40
8/20/1999	27.10
8/20/1999	
9/16/1999	22.30
9/16/1999	
9/23/1999	

10/28/1999	25.60
11/19/1999	26.20
12/20/1999	32.20
2/1/2000	
3/3/2000	
3/16/2000	25.00
3/16/2000	
4/28/2000	20.40
4/28/2000	
4/28/2000	
5/25/2000	20.80
5/25/2000	
5/25/2000	
6/6/2000	
6/21/2000	25.20
6/21/2000	
6/21/2000	
7/27/2000	
7/27/2000	
7/27/2000	
8/17/2000	
8/28/2000	
8/28/2000	
8/28/2000	
9/26/2000	29.80
9/26/2000	
10/23/2000	41.90
10/23/2000	
12/11/2000	
12/26/2000	17.10
12/26/2000	
1/31/2001	
3/7/2001	
3/20/2001	54.00
3/20/2001	
5/21/2001	
5/21/2001	
5/21/2001	
6/15/2001	36.40
6/15/2001	
6/19/2001	
7/9/2001	41.00
7/9/2001	
8/10/2001	39.60
8/10/2001	
9/4/2001	
9/26/2001	45.40

10/26/2001	33.60
11/21/2001	27.20
12/19/2001	
12/26/2001	74.50
1/23/2002	35.00
2/25/2002	11.30
3/14/2002	
3/26/2002	26.00
4/12/2002	55.90
5/16/2002	8.92
5/16/2002	
5/16/2002	
6/13/2002	8.10
6/13/2002	
7/3/2002	
7/25/2002	8.22
7/25/2002	
8/15/2002	48.80
8/15/2002	
9/28/2002	8.95
9/28/2002	
9/30/2002	
10/18/2002	16.60
10/18/2002	
11/29/2002	54.00
11/29/2002	
12/13/2002	
1/9/2003	6.33
1/9/2003	
2/25/2003	
3/18/2003	4.34
3/18/2003	
4/30/2003	
5/14/2003	25.70
5/14/2003	
7/21/2003	
8/21/2003	4.04
10/10/2003	
11/11/2003	*0.50*
11/11/2003	
2/2/2004	
2/17/2004	0.55
2/17/2004	
2/18/2004	
5/11/2004	1.45
5/11/2004	
5/12/2004	

5/25/2004	
7/22/2004	
8/11/2004	
8/11/2004	1.2
8/11/2004	
8/16/2004	
11/2/2004	2.89
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/18/2004	
11/18/2004	
2/18/2005	2.87
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/25/2005	
2/28/2005	
2/28/2005	
5/6/2005	1.12
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	
7/6/2005	
7/25/2005	1.15
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
9/28/2005	
9/28/2005	
11/30/2005	
11/30/2005	
12/27/2005	
12/27/2005	
12/30/2005	1.13

12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	
3/1/2006	
3/20/2006	
3/20/2006	
3/27/2006	<20.0
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	
6/21/2006	<20.0
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/22/2006	
6/23/2006	
7/6/2006	
7/6/2006	
9/12/2006	
9/12/2006	
9/26/2006	
9/26/2006	
9/28/2006	<0.20
9/28/2006	
9/28/2006	
9/28/2006	
10/4/2006	

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Fig 5.35 Sulfate

Date	
Date	MW2
10/24/1994	
10/24/1994	401.90
10/24/1994	
12/8/1994	
12/19/1994	
12/19/1994	379.90
2/2/1995	
2/2/1995	296.20
2/7/1995	
2/23/1995	
3/14/1995	
3/15/1995	
3/15/1995	309.40
3/15/1995	
4/20/1995	
4/20/1995	394.00
4/20/1995	
6/1/1995	
6/1/1995	627.00
6/1/1995	
6/5/1995	
7/21/1995	
7/24/1995	
8/17/1995	
9/19/1995	
10/26/1995	
11/7/1995	
12/5/1995	
12/13/1995	
12/13/1995	1270.00
12/14/1995	
1/16/1996	
1/24/1996	
1/31/1996	
2/8/1996	
2/19/1996	
2/21/1996	
2/21/1996	136.95
3/4/1996	
3/13/1996	
3/25/1996	

4/24/1996	
5/21/1996	
6/4/1996	
6/4/1996	258.00
6/18/1996	
6/18/1996	132.00
6/24/1996	
6/26/1996	
7/2/1996	
7/2/1996	233.00
7/16/1996	
7/16/1996	96.00
7/17/1996	
8/13/1996	
8/13/1996	227.00
8/27/1996	
9/12/1996	
12/17/1996	
12/17/1996	164.00
12/17/1996	
12/18/1996	
1/7/1997	
1/8/1997	
1/8/1997	156.00
1/21/1997	
1/21/1997	191.00
2/6/1997	
2/6/1997	272.00
2/27/1997	
2/27/1997	299.00
2/27/1997	
3/5/1997	
3/5/1997	172.00
3/18/1997	
3/18/1997	167.00
4/3/1997	
4/3/1997	205.00
4/15/1997	
4/15/1997	189.00
4/29/1997	
4/29/1997	61.00
5/27/1997	
5/27/1997	179.00
6/19/1997	
6/24/1997	
6/24/1997	186.00
6/24/1997	

7/29/1997	
7/29/1997	367.00
8/26/1997	
8/26/1997	553.00
9/4/1997	
10/28/1997	
11/17/1997	
11/25/1997	
1/27/1998	
3/5/1998	
3/30/1998	309.00
3/30/1998	
5/18/1998	
6/22/1998	
6/22/1998	256.00
6/22/1998	
7/14/1998	
7/15/1998	
7/15/1998	339.00
8/26/1998	
8/26/1998	429.00
9/18/1998	
9/28/1998	
9/28/1998	746.00
10/19/1998	
11/5/1998	
11/18/1998	
12/17/1998	
1/28/1999	
1/28/1999	867.00
2/26/1999	
2/26/1999	1266.00
3/3/1999	
3/29/1999	
3/29/1999	1217.00
4/27/1999	
4/27/1999	1020.00
5/12/1999	
6/9/1999	
6/9/1999	1215.00
6/23/1999	
7/1/1999	
7/27/1999	
8/20/1999	
8/20/1999	1180.00
9/16/1999	
9/16/1999	1205.00

9/23/1999	
10/28/1999	
11/19/1999	
12/20/1999	
2/1/2000	
3/3/2000	
3/16/2000	
3/16/2000	1210.00
4/28/2000	
4/28/2000	699.00
4/28/2000	
5/25/2000	
5/25/2000	660.00
5/25/2000	
6/6/2000	
6/21/2000	
6/21/2000	580.00
6/21/2000	
7/27/2000	
7/27/2000	581.00
7/27/2000	
8/17/2000	
8/28/2000	
8/28/2000	604.00
8/28/2000	
9/26/2000	
9/26/2000	596.00
10/23/2000	
10/23/2000	735.00
12/11/2000	
12/26/2000	
12/26/2000	1260.00
1/31/2001	
3/7/2001	
3/20/2001	
3/20/2001	1510.00
5/21/2001	
5/21/2001	938.00
5/21/2001	
6/15/2001	
6/15/2001	886.00
6/19/2001	
7/9/2001	
7/9/2001	912.00
8/10/2001	
8/10/2001	1242.00
9/4/2001	

9/26/2001	
10/26/2001	
11/21/2001	
12/19/2001	
12/26/2001	
1/23/2002	
2/25/2002	
3/14/2002	
3/26/2002	
4/12/2002	
5/16/2002	
5/16/2002	280.00
5/16/2002	
6/13/2002	
6/13/2002	204.00
7/3/2002	
7/25/2002	
7/25/2002	186.00
8/15/2002	
8/15/2002	155.00
9/28/2002	
9/28/2002	303.00
9/30/2002	
10/18/2002	
10/18/2002	329.00
11/29/2002	
11/29/2002	273.00
12/13/2002	
1/9/2003	
1/9/2003	288.00
2/25/2003	
3/18/2003	
3/18/2003	92.00
4/30/2003	
5/14/2003	
5/14/2003	284.00
7/21/2003	
8/21/2003	
10/10/2003	
11/11/2003	
11/11/2003	226.00
2/2/2004	
2/17/2004	
2/17/2004	222.00
2/18/2004	
5/11/2004	
5/11/2004	238.00

5/12/2004	
5/25/2004	
7/22/2004	
8/11/2004	
8/11/2004	362.00
8/11/2004	
8/16/2004	
11/2/2004	
11/2/2004	247
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/18/2004	
11/18/2004	
2/18/2005	
2/18/2005	351
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/25/2005	
2/28/2005	
2/28/2005	
5/6/2005	
5/6/2005	290
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	
7/6/2005	
7/25/2005	
7/25/2005	416
7/25/2005	
7/25/2005	
7/25/2005	
9/28/2005	
9/28/2005	
11/30/2005	
11/30/2005	
12/27/2005	
12/27/2005	

12/30/2005	
12/30/2005	780.2
12/30/2005	
12/30/2005	
12/30/2005	
3/1/2006	
3/20/2006	
3/20/2006	
3/27/2006	
3/27/2006	249.1
3/27/2006	
3/27/2006	
3/27/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/22/2006	
6/23/2006	
7/6/2006	48
7/6/2006	
9/12/2006	
9/12/2006	
9/26/2006	
9/26/2006	
9/28/2006	
9/28/2006	141
9/28/2006	
9/28/2006	
10/4/2006	

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Fig 5.35c Sulfate

Date	MW3
10/24/1994	438.5
10/24/1994	
10/24/1994	
12/8/1994	
12/19/1994	319.4
12/19/1994	
2/2/1995	363.5
2/2/1995	
2/7/1995	
2/23/1995	463.4
3/14/1995	
3/15/1995	472.11
3/15/1995	
3/15/1995	
4/20/1995	492
4/20/1995	
4/20/1995	
6/1/1995	462
6/1/1995	
6/1/1995	
6/5/1995	
7/21/1995	
7/24/1995	
8/17/1995	
9/19/1995	
10/26/1995	450
11/7/1995	
12/5/1995	
12/13/1995	
12/13/1995	
12/14/1995	
1/16/1996	
1/24/1996	
1/31/1996	
2/8/1996	
2/19/1996	
2/21/1996	435.29
2/21/1996	
3/4/1996	
3/13/1996	
3/25/1996	
4/24/1996	

5/21/1996	463
6/4/1996	431
6/4/1996	
6/18/1996	480
6/18/1996	
6/24/1996	
6/26/1996	
7/2/1996	418
7/2/1996	
7/16/1996	394
7/16/1996	
7/17/1996	
8/13/1996	403
8/13/1996	
8/27/1996	
9/12/1996	
12/17/1996	317
12/17/1996	
12/17/1996	
12/18/1996	
1/7/1997	
1/8/1997	311
1/8/1997	
1/21/1997	333
1/21/1997	
2/6/1997	429
2/6/1997	
2/27/1997	306
2/27/1997	
2/27/1997	
3/5/1997	276
3/5/1997	
3/18/1997	287
3/18/1997	
4/3/1997	300
4/3/1997	
4/15/1997	297
4/15/1997	
4/29/1997	298
4/29/1997	
5/27/1997	292
5/27/1997	
6/19/1997	
6/24/1997	304
6/24/1997	
6/24/1997	
7/29/1997	330

7/29/1997	
8/26/1997	292
8/26/1997	
9/4/1997	
10/28/1997	
11/17/1997	
11/25/1997	
1/27/1998	515
3/5/1998	
3/30/1998	
3/30/1998	
5/18/1998	
6/22/1998	407
6/22/1998	
6/22/1998	
7/14/1998	
7/15/1998	468
7/15/1998	
8/26/1998	524
8/26/1998	
9/18/1998	
9/28/1998	358
9/28/1998	
10/19/1998	340
11/5/1998	
11/18/1998	
12/17/1998	300.00
1/28/1999	284.00
1/28/1999	
2/26/1999	298.00
2/26/1999	
3/3/1999	
3/29/1999	324.00
3/29/1999	
4/27/1999	362.00
4/27/1999	
5/12/1999	
6/9/1999	360.00
6/9/1999	
6/23/1999	
7/1/1999	331.00
7/27/1999	306.00
8/20/1999	411.00
8/20/1999	
9/16/1999	388.00
9/16/1999	
9/23/1999	

10/28/1999	359.00
11/19/1999	324.00
12/20/1999	297.00
2/1/2000	
3/3/2000	
3/16/2000	318.00
3/16/2000	
4/28/2000	18.00
4/28/2000	
4/28/2000	
5/25/2000	288.00
5/25/2000	
5/25/2000	
6/6/2000	
6/21/2000	307.00
6/21/2000	
6/21/2000	
7/27/2000	280.00
7/27/2000	
7/27/2000	
8/17/2000	
8/28/2000	325.00
8/28/2000	
8/28/2000	
9/26/2000	294.00
9/26/2000	
10/23/2000	324.00
10/23/2000	
12/11/2000	
12/26/2000	231.00
12/26/2000	
1/31/2001	
3/7/2001	
3/20/2001	336.00
3/20/2001	
5/21/2001	361.00
5/21/2001	
5/21/2001	
6/15/2001	339.00
6/15/2001	
6/19/2001	
7/9/2001	344.00
7/9/2001	
8/10/2001	357.00
8/10/2001	
9/4/2001	
9/26/2001	379.00

10/26/2001	
11/21/2001	
12/19/2001	
12/26/2001	
1/23/2002	316.00
2/25/2002	283.00
3/14/2002	
3/26/2002	310.00
4/12/2002	248.00
5/16/2002	353.00
5/16/2002	
5/16/2002	
6/13/2002	114.00
6/13/2002	
7/3/2002	
7/25/2002	1200.00
7/25/2002	
8/15/2002	
8/15/2002	
9/28/2002	
9/28/2002	
9/30/2002	
10/18/2002	
10/18/2002	
11/29/2002	1790.00
11/29/2002	
12/13/2002	
1/9/2003	1080.00
1/9/2003	
2/25/2003	
3/18/2003	990.00
3/18/2003	
4/30/2003	
5/14/2003	620.00
5/14/2003	
7/21/2003	
8/21/2003	449.00
10/10/2003	
11/11/2003	504.00
11/11/2003	
2/2/2004	
2/17/2004	
2/17/2004	
2/18/2004	437.00
5/11/2004	567.00
5/11/2004	
5/12/2004	

5/25/2004	
7/22/2004	
8/11/2004	
8/11/2004	
8/11/2004	
8/16/2004	476.00
11/2/2004	
11/2/2004	
11/2/2004	522
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/18/2004	
11/18/2004	
2/18/2005	
2/18/2005	
2/18/2005	441
2/18/2005	
2/18/2005	
2/18/2005	
2/25/2005	
2/28/2005	
2/28/2005	
5/6/2005	
5/6/2005	
5/6/2005	417
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	
7/6/2005	
7/25/2005	
7/25/2005	
7/25/2005	485
7/25/2005	
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9/28/2005	
9/28/2005	
11/30/2005	
11/30/2005	
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12/30/2005	
12/30/2005	568.1
12/30/2005	
12/30/2005	
3/1/2006	
3/20/2006	
3/20/2006	
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3/27/2006	
3/27/2006	522.8
3/27/2006	
3/27/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/22/2006	
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7/6/2006	
7/6/2006	472
9/12/2006	
9/12/2006	
9/26/2006	453
9/26/2006	
9/28/2006	
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9/28/2006	
9/28/2006	
10/4/2006	

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Fig 5.35d Sulfate

Date	MW4
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10/24/1994	149.60
12/8/1994	
12/19/1994	
12/19/1994	
2/2/1995	
2/2/1995	
2/7/1995	142.10
2/23/1995	
3/14/1995	
3/15/1995	
3/15/1995	
3/15/1995	141.39
4/20/1995	
4/20/1995	
4/20/1995	157.00
6/1/1995	
6/1/1995	
6/1/1995	145.10
6/5/1995	
7/21/1995	
7/24/1995	
8/17/1995	
9/19/1995	
10/26/1995	
11/7/1995	
12/5/1995	
12/13/1995	
12/13/1995	
12/14/1995	149.40
1/16/1996	
1/24/1996	
1/31/1996	
2/8/1996	
2/19/1996	
2/21/1996	
2/21/1996	
3/4/1996	
3/13/1996	
3/25/1996	
4/24/1996	

5/21/1996	
6/4/1996	
6/4/1996	
6/18/1996	
6/18/1996	
6/24/1996	
6/26/1996	
7/2/1996	
7/2/1996	
7/16/1996	
7/16/1996	
7/17/1996	53.40
8/13/1996	
8/13/1996	
8/27/1996	
9/12/1996	
12/17/1996	
12/17/1996	
12/17/1996	16.90
12/18/1996	
1/7/1997	
1/8/1997	
1/8/1997	
1/21/1997	
1/21/1997	
2/6/1997	
2/6/1997	
2/27/1997	
2/27/1997	
2/27/1997	32.60
3/5/1997	
3/5/1997	
3/18/1997	
3/18/1997	
4/3/1997	
4/3/1997	
4/15/1997	
4/15/1997	
4/29/1997	
4/29/1997	
5/27/1997	
5/27/1997	
6/19/1997	
6/24/1997	
6/24/1997	
6/24/1997	0.00
7/29/1997	

7/29/1997	
8/26/1997	
8/26/1997	
9/4/1997	
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11/17/1997	
11/25/1997	
1/27/1998	
3/5/1998	
3/30/1998	
3/30/1998	65.50
5/18/1998	
6/22/1998	
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6/22/1998	106.00
7/14/1998	67.50
7/15/1998	
7/15/1998	
8/26/1998	
8/26/1998	
9/18/1998	
9/28/1998	
9/28/1998	
10/19/1998	
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1/28/1999	
1/28/1999	
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3/3/1999	
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9/16/1999	
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3/16/2000	
3/16/2000	
4/28/2000	
4/28/2000	
4/28/2000	18.00
5/25/2000	
5/25/2000	
5/25/2000	12.70
6/6/2000	
6/21/2000	
6/21/2000	
6/21/2000	13.10
7/27/2000	
7/27/2000	
7/27/2000	10.20
8/17/2000	
8/28/2000	
8/28/2000	
8/28/2000	10.50
9/26/2000	
9/26/2000	
10/23/2000	
10/23/2000	
12/11/2000	
12/26/2000	
12/26/2000	
1/31/2001	
3/7/2001	
3/20/2001	
3/20/2001	
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5/21/2001	
5/21/2001	5.18
6/15/2001	
6/15/2001	
6/19/2001	
7/9/2001	
7/9/2001	
8/10/2001	
8/10/2001	
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10/26/2001	
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1/23/2002	
2/25/2002	
3/14/2002	
3/26/2002	
4/12/2002	
5/16/2002	
5/16/2002	
5/16/2002	28.10
6/13/2002	
6/13/2002	
7/3/2002	
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11/29/2002	
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2/18/2004	
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5/11/2004	
5/12/2004	

5/25/2004	
7/22/2004	
8/11/2004	
8/11/2004	
8/11/2004	2.19
8/16/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	1.98
11/18/2004	
11/18/2004	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	1.58
2/25/2005	
2/28/2005	
2/28/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	1.57
5/12/2005	
5/13/2005	
7/6/2005	
7/6/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	1.44
9/28/2005	
9/28/2005	
11/30/2005	
11/30/2005	
12/27/2005	
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12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	285.00
3/1/2006	
3/20/2006	
3/20/2006	
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	<0.20
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6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	<0.20
6/22/2006	
6/23/2006	
7/6/2006	
7/6/2006	
9/12/2006	
9/12/2006	
9/26/2006	
9/26/2006	<0.20
9/28/2006	
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9/28/2006	
10/4/2006	

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Fig 5.35e Sulfate

Date	Packer V
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2/2/1995	
2/7/1995	
2/23/1995	
3/14/1995	
3/15/1995	651.72
3/15/1995	
3/15/1995	
4/20/1995	671.00
4/20/1995	
4/20/1995	
6/1/1995	
6/1/1995	
6/1/1995	
6/5/1995	
7/21/1995	
7/24/1995	679.00
8/17/1995	
9/19/1995	
10/26/1995	
11/7/1995	625.00
12/5/1995	
12/13/1995	
12/13/1995	
12/14/1995	
1/16/1996	
1/24/1996	619.00
1/31/1996	
2/8/1996	
2/19/1996	
2/21/1996	
2/21/1996	
3/4/1996	
3/13/1996	
3/25/1996	
4/24/1996	

5/21/1996	606.00
6/4/1996	657.00
6/4/1996	
6/18/1996	595.00
6/18/1996	
6/24/1996	
6/26/1996	
7/2/1996	680.00
7/2/1996	
7/16/1996	391.00
7/16/1996	
7/17/1996	
8/13/1996	587.00
8/13/1996	
8/27/1996	
9/12/1996	
12/17/1996	605.00
12/17/1996	
12/17/1996	
12/18/1996	
1/7/1997	137.00
1/8/1997	
1/8/1997	
1/21/1997	540.00
1/21/1997	
2/6/1997	577.00
2/6/1997	
2/27/1997	558.00
2/27/1997	
2/27/1997	
3/5/1997	567.00
3/5/1997	
3/18/1997	587.00
3/18/1997	
4/3/1997	562.00
4/3/1997	
4/15/1997	52.00
4/15/1997	
4/29/1997	469.00
4/29/1997	
5/27/1997	476.00
5/27/1997	
6/19/1997	
6/24/1997	597.00
6/24/1997	
6/24/1997	
7/29/1997	536.00

7/29/1997	
8/26/1997	491.00
8/26/1997	
9/4/1997	
10/28/1997	
11/17/1997	
11/25/1997	
1/27/1998	
3/5/1998	
3/30/1998	
3/30/1998	
5/18/1998	
6/22/1998	634.00
6/22/1998	
6/22/1998	
7/14/1998	
7/15/1998	617.00
7/15/1998	
8/26/1998	
8/26/1998	
9/18/1998	
9/28/1998	648.00
9/28/1998	
10/19/1998	647.00
11/5/1998	
11/18/1998	
12/17/1998	586.00
1/28/1999	569.00
1/28/1999	
2/26/1999	596.00
2/26/1999	
3/3/1999	
3/29/1999	578.00
3/29/1999	
4/27/1999	596.00
4/27/1999	
5/12/1999	
6/9/1999	620.00
6/9/1999	
6/23/1999	
7/1/1999	604.00
7/27/1999	638.00
8/20/1999	693.00
8/20/1999	
9/16/1999	631.00
9/16/1999	
9/23/1999	

10/28/1999	535.00
11/19/1999	588.00
12/20/1999	506.00
2/1/2000	471.00
3/3/2000	
3/16/2000	510.00
3/16/2000	
4/28/2000	498.00
4/28/2000	
4/28/2000	
5/25/2000	439.00
5/25/2000	
5/25/2000	
6/6/2000	
6/21/2000	513.00
6/21/2000	
6/21/2000	
7/27/2000	515.00
7/27/2000	
7/27/2000	
8/17/2000	
8/28/2000	516.00
8/28/2000	
8/28/2000	
9/26/2000	505.00
9/26/2000	
10/23/2000	529.00
10/23/2000	
12/11/2000	
12/26/2000	568.00
12/26/2000	
1/31/2001	
3/7/2001	
3/20/2001	598.00
3/20/2001	
5/21/2001	593.00
5/21/2001	
5/21/2001	
6/15/2001	608.00
6/15/2001	
6/19/2001	
7/9/2001	592.00
7/9/2001	
8/10/2001	577.00
8/10/2001	
9/4/2001	
9/26/2001	630.00

10/26/2001	625.00
11/21/2001	623.00
12/19/2001	
12/26/2001	581.00
1/23/2002	566.00
2/25/2002	582.00
3/14/2002	
3/26/2002	602.00
4/12/2002	601.00
5/16/2002	661.00
5/16/2002	
5/16/2002	
6/13/2002	537.00
6/13/2002	
7/3/2002	
7/25/2002	603.00
7/25/2002	
8/15/2002	608.00
8/15/2002	
9/28/2002	528.00
9/28/2002	
9/30/2002	
10/18/2002	632.00
10/18/2002	
11/29/2002	687.00
11/29/2002	
12/13/2002	
1/9/2003	567.00
1/9/2003	
2/25/2003	
3/18/2003	580.00
3/18/2003	
4/30/2003	
5/14/2003	690.00
5/14/2003	
7/21/2003	
8/21/2003	582.00
10/10/2003	
11/11/2003	523.00
11/11/2003	
2/2/2004	
2/17/2004	586.00
2/17/2004	
2/18/2004	
5/11/2004	
5/11/2004	
5/12/2004	559

5/25/2004	
7/22/2004	
8/11/2004	
8/11/2004	
8/11/2004	
8/16/2004	449.00
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	549
11/2/2004	
11/2/2004	
11/2/2004	
11/18/2004	
11/18/2004	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/25/2005	516
2/28/2005	
2/28/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	527
5/6/2005	
5/6/2005	
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	580
7/6/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
9/28/2005	
9/28/2005	
11/30/2005	412
11/30/2005	
12/27/2005	
12/27/2005	
12/30/2005	

12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	
3/1/2006	565
3/20/2006	
3/20/2006	
3/27/2006	
3/27/2006	
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3/27/2006	
3/27/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/22/2006	586
6/23/2006	
7/6/2006	
7/6/2006	
9/12/2006	
9/12/2006	
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9/28/2006	
9/28/2006	
9/28/2006	
9/28/2006	
10/4/2006	672

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Fig 5.35 Sulfate

Date	Maple Hill
10/24/1994	
10/24/1994	
10/24/1994	
12/8/1994	
12/19/1994	19.7
12/19/1994	
2/2/1995	
2/2/1995	
2/7/1995	
2/23/1995	
3/14/1995	
3/15/1995	
3/15/1995	
3/15/1995	
4/20/1995	1191
4/20/1995	
4/20/1995	
6/1/1995	
6/1/1995	
6/1/1995	
6/5/1995	
7/21/1995	
7/24/1995	
8/17/1995	1143
9/19/1995	
10/26/1995	
11/7/1995	508
12/5/1995	
12/13/1995	
12/13/1995	
12/14/1995	
1/16/1996	
1/24/1996	607
1/31/1996	
2/8/1996	
2/19/1996	
2/21/1996	
2/21/1996	
3/4/1996	
3/13/1996	
3/25/1996	

4/24/1996	
5/21/1996	513
6/4/1996	976.00
6/4/1996	
6/18/1996	701.00
6/18/1996	
6/24/1996	
6/26/1996	
7/2/1996	983.00
7/2/1996	
7/16/1996	659.00
7/16/1996	
7/17/1996	
8/13/1996	1050.00
8/13/1996	
8/27/1996	
9/12/1996	
12/17/1996	505.00
12/17/1996	
12/17/1996	
12/18/1996	
1/7/1997	
1/8/1997	414.00
1/8/1997	
1/21/1997	411.00
1/21/1997	
2/6/1997	501.00
2/6/1997	
2/27/1997	196.00
2/27/1997	
2/27/1997	
3/5/1997	284.00
3/5/1997	
3/18/1997	243.00
3/18/1997	
4/3/1997	193.00
4/3/1997	
4/15/1997	197.00
4/15/1997	
4/29/1997	195.00
4/29/1997	
5/27/1997	166.00
5/27/1997	
6/19/1997	
6/24/1997	151.00
6/24/1997	
6/24/1997	

7/29/1997	40.00
7/29/1997	
8/26/1997	697.00
8/26/1997	
9/4/1997	
10/28/1997	
11/17/1997	
11/25/1997	
1/27/1998	
3/5/1998	
3/30/1998	
3/30/1998	
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6/22/1998	
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7/14/1998	
7/15/1998	1313.00
7/15/1998	
8/26/1998	
8/26/1998	
9/18/1998	
9/28/1998	
9/28/1998	
10/19/1998	
11/5/1998	
11/18/1998	960
12/17/1998	
1/28/1999	
1/28/1999	
2/26/1999	942.00
2/26/1999	
3/3/1999	
3/29/1999	
3/29/1999	
4/27/1999	
4/27/1999	
5/12/1999	952.00
6/9/1999	
6/9/1999	
6/23/1999	
7/1/1999	939.00
7/27/1999	
8/20/1999	5.03
8/20/1999	
9/16/1999	
9/16/1999	

9/23/1999	
10/28/1999	
11/19/1999	
12/20/1999	6.83
2/1/2000	5.38
3/3/2000	
3/16/2000	
3/16/2000	
4/28/2000	
4/28/2000	
4/28/2000	
5/25/2000	6.04
5/25/2000	
5/25/2000	
6/6/2000	
6/21/2000	
6/21/2000	
6/21/2000	
7/27/2000	5.34
7/27/2000	
7/27/2000	
8/17/2000	
8/28/2000	
8/28/2000	
8/28/2000	
9/26/2000	
9/26/2000	
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10/23/2000	
12/11/2000	
12/26/2000	
12/26/2000	
1/31/2001	6.30
3/7/2001	
3/20/2001	4.94
3/20/2001	
5/21/2001	
5/21/2001	
5/21/2001	
6/15/2001	4.59
6/15/2001	
6/19/2001	
7/9/2001	
7/9/2001	
8/10/2001	4.84
8/10/2001	
9/4/2001	

9/26/2001	
10/26/2001	
11/21/2001	7.62
12/19/2001	
12/26/2001	
1/23/2002	6.24
2/25/2002	5.73
3/14/2002	
3/26/2002	
4/12/2002	10.30
5/16/2002	10.20
5/16/2002	
5/16/2002	
6/13/2002	9.65
6/13/2002	
7/3/2002	
7/25/2002	49.30
7/25/2002	
8/15/2002	1175.00
8/15/2002	
9/28/2002	
9/28/2002	
9/30/2002	
10/18/2002	
10/18/2002	
11/29/2002	1340.00
11/29/2002	
12/13/2002	
1/9/2003	925.00
1/9/2003	
2/25/2003	
3/18/2003	910.00
3/18/2003	
4/30/2003	
5/14/2003	
5/14/2003	
7/21/2003	
8/21/2003	904.00
10/10/2003	
11/11/2003	840.00
11/11/2003	
2/2/2004	
2/17/2004	860.00
2/17/2004	
2/18/2004	
5/11/2004	375.00
5/11/2004	

5/12/2004	
5/25/2004	
7/22/2004	
8/11/2004	598.00
8/11/2004	
8/11/2004	
8/16/2004	
11/2/2004	
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11/2/2004	
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2/18/2005	450
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5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	893
5/6/2005	
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	
7/6/2005	833
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
9/28/2005	
9/28/2005	
11/30/2005	
11/30/2005	863
12/27/2005	
12/27/2005	

12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	
3/1/2006	
3/20/2006	
3/20/2006	
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/22/2006	
6/23/2006	951
7/6/2006	
7/6/2006	
9/12/2006	
9/12/2006	
9/26/2006	
9/26/2006	
9/28/2006	
9/28/2006	
9/28/2006	<0.20
9/28/2006	
10/4/2006	

Ellengowan
Fig 5.36 TDS

Date	Holes South
10/24/1994	
10/24/1994	
10/24/1994	
12/08/94	
12/19/1994	
12/19/1994	
12/19/1994	802.00
2/2/1995	
2/2/1995	
2/7/1995	
2/23/1995	
2/23/1995	
03/14/95	
3/15/1995	
3/15/1995	
3/15/1995	
4/20/1995	
4/20/1995	
4/20/1995	
4/20/1995	657.00
4/20/1995	
6/1/1995	
6/1/1995	
6/1/1995	
06/05/95	
7/24/1995	
8/17/1995	642.00
09/19/95	
10/26/1995	
10/26/1995	
11/7/1995	
11/7/1995	1060.00
12/05/95	
12/13/1995	
12/14/1995	
01/16/96	
1/24/1996	
1/24/1996	
01/31/96	
2/8/1996	777.00
02/19/96	

2/21/1996	
2/21/1996	
03/04/96	
03/13/96	
03/25/96	
04/24/96	
5/21/1996	
5/21/1996	
5/21/1996	646.00
6/4/1996	
6/4/1996	
6/4/1996	
6/4/1996	658.00
6/18/1996	
6/18/1996	
6/18/1996	
6/18/1996	806.00
06/24/96	
7/2/1996	
7/2/1996	
7/2/1996	
7/2/1996	640.00
7/16/1996	
7/16/1996	
7/16/1996	
7/16/1996	676.00
7/17/1996	
8/13/1996	
8/13/1996	
8/13/1996	
8/13/1996	698.00
8/27/1996	
09/12/96	
12/17/1996	
12/17/1996	
12/17/1996	
12/17/1996	734.00
12/17/1996	
12/18/96	
1/7/1997	
1/8/1997	
1/8/1997	
1/8/1997	642.00
1/21/1997	
1/21/1997	
1/21/1997	
1/21/1997	528.00

2/4/1997	
2/6/1997	
2/6/1997	
2/6/1997	630.00
2/18/1997	
2/27/1997	
2/27/1997	
2/27/1997	516.00
2/27/1997	
3/5/1997	
3/5/1997	
3/5/1997	
3/5/1997	550.00
03/05/97	
3/18/1997	
3/18/1997	
3/18/1997	
3/18/1997	616.00
4/3/1997	
4/3/1997	
4/3/1997	
4/3/1997	570.00
4/15/1997	
4/15/1997	
4/15/1997	
4/15/1997	548.00
4/29/1997	
4/29/1997	
4/29/1997	
4/29/1997	1244.00
5/27/1997	
5/27/1997	
5/27/1997	
5/27/1997	688.00
06/19/97	
6/24/1997	
6/24/1997	
6/24/1997	
6/24/1997	704.00
6/24/1997	
7/29/1997	
7/29/1997	
7/29/1997	
7/29/1997	646.00
8/26/1997	
8/26/1997	
8/26/1997	

8/26/1997	710.00
09/04/97	
10/28/1997	
11/17/97	
11/25/1997	
1/27/1998	
1/27/1998	
03/05/98	
3/30/1998	
3/30/1998	
05/18/98	
6/22/1998	
6/22/1998	
6/22/1998	
6/22/1998	
7/14/1998	
7/14/1998	
7/15/1998	
7/15/1998	
7/15/1998	540.00
8/26/1998	
8/26/1998	
09/18/98	
9/28/1998	
9/28/1998	
9/28/1998	
10/19/1998	
10/19/1998	
10/19/1998	
11/05/98	
11/18/1998	528.00
12/17/1998	
12/17/1998	
12/17/1998	
1/28/1999	
1/28/1999	
1/28/1999	
2/26/1999	
2/26/1999	
2/26/1999	
2/26/1999	516.00
03/03/99	
3/29/1999	
3/29/1999	
3/29/1999	
4/27/1999	
4/27/1999	

4/27/1999	
5/12/1999	529.00
6/9/1999	
6/9/1999	
6/9/1999	
06/23/99	
7/1/1999	
7/1/1999	
7/1/1999	
7/1/1999	572.00
7/27/1999	
7/27/1999	
7/27/1999	
8/20/1999	
8/20/1999	
8/20/1999	
8/20/1999	519.00
9/16/1999	
9/16/1999	
9/16/1999	
09/23/99	
10/28/1999	
10/28/1999	
10/28/1999	
11/19/1999	
11/19/1999	
11/19/1999	
11/19/99	
12/20/1999	
12/20/1999	
12/20/1999	
12/20/1999	396.00
2/1/2000	
2/1/2000	
03/03/00	
3/16/2000	
3/16/2000	
3/16/2000	
4/28/2000	
4/28/2000	
4/28/2000	
4/28/2000	
5/25/2000	
5/25/2000	
5/25/2000	
5/25/2000	420.00
5/25/2000	

06/06/00	
6/21/2000	
6/21/2000	
6/21/2000	
6/21/2000	
7/27/2000	
7/27/2000	
7/27/2000	
7/27/2000	365.00
7/27/2000	
08/17/00	
8/28/2000	
8/28/2000	
8/28/2000	
8/28/2000	
9/26/2000	
9/26/2000	
9/26/2000	
10/23/2000	
10/23/2000	
10/23/2000	
12/11/00	
12/26/2000	
12/26/2000	
12/26/2000	
12/26/2000	292.00
1/31/2001	
03/07/01	
3/20/2001	
3/20/2001	
3/20/2001	
3/20/2001	
5/21/2001	
5/21/2001	
5/21/2001	
5/21/2001	
6/15/2001	
6/15/2001	
6/15/2001	
6/15/2001	305.00
06/19/01	
7/9/2001	
7/9/2001	
7/9/2001	
8/10/2001	
8/10/2001	
8/10/2001	

8/10/2001	202.00
09/04/01	
9/26/2001	
9/26/2001	
9/26/2001	
10/26/2001	
10/26/2001	
11/21/2001	
11/21/2001	
11/21/2001	157.00
12/19/01	
12/26/2001	
12/26/2001	
1/23/2002	
1/23/2002	
1/23/2002	
1/23/2002	116.00
2/25/2002	
2/25/2002	
2/25/2002	
2/25/2002	85.00
03/14/02	
3/26/2002	
3/26/2002	
3/26/2002	
4/12/2002	
4/12/2002	
4/12/2002	
4/12/2002	104.00
5/16/2002	
5/16/2002	
5/16/2002	
5/16/2002	116.00
5/16/2002	
6/13/2002	
6/13/2002	
6/13/2002	
6/13/2002	125.00
07/03/02	
7/25/2002	
7/25/2002	
7/25/2002	
7/25/2002	160.90
8/15/2002	
8/15/2002	
8/15/2002	129.00
9/28/2002	

9/28/2002	
09/30/02	
10/18/2002	
10/18/2002	
11/29/2002	
11/29/2002	
11/29/2002	
11/29/2002	107.00
12/13/02	
1/9/2003	
1/9/2003	
1/9/2003	
1/9/2003	75.00
02/25/03	
3/18/2003	
3/18/2003	
3/18/2003	
3/18/2003	86.00
04/30/03	
5/14/2003	
5/14/2003	
5/14/2003	
5/14/2003	90.00
07/21/03	
8/20/2003	
8/21/2003	
8/21/2003	
8/21/2003	
10/10/03	
11/10/2003	
11/11/2003	
11/11/2003	
11/11/2003	64.00
02/02/04	
2/17/2004	
2/17/2004	
2/17/2004	
2/17/2004	
5/11/2004	
5/11/2004	
5/11/2004	723.00
5/12/2004	
05/25/04	
07/22/04	
8/11/2004	
8/11/2004	537.00
8/11/2004	

8/16/2004	
8/16/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	696
11/2/2004	
11/18/2004	
11/18/2004	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	663
2/18/2005	
2/25/2005	
2/28/2005	
2/28/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	704
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	
7/6/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	826
7/25/2005	
9/28/2005	
9/28/2005	
11/30/2005	
11/30/2005	
11/30/2005	
12/27/2005	
12/27/2005	
12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	718

12/30/2005	
3/1/2006	
3/20/2006	
3/20/2006	
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	443
3/27/2006	
6/21/2006	
6/21/2006	704
6/21/2006	
6/21/2006	
6/21/2006	
6/22/2006	
6/23/2006	
7/6/2006	
7/6/2006	
9/12/2006	
9/12/2006	
9/26/2006	
9/26/2006	
9/28/2006	
9/28/2006	
9/28/2006	
9/28/2006	801
10/4/2006	

Ellengowan
Fig 5.37a Iron

Date	MW1
10/24/1994	48.09
10/24/1994	
10/24/1994	
12/19/1994	74.00
12/19/1994	
12/19/1994	
2/2/1995	63.40
2/2/1995	
2/2/1995	
2/7/1995	
2/23/1995	52.23
3/15/1995	85.20
3/15/1995	
3/15/1995	
3/15/1995	
4/20/1995	40.90
4/20/1995	
4/20/1995	
4/20/1995	
4/20/1995	
6/1/1995	32.90
6/1/1995	
6/1/1995	
7/21/1995	
7/24/1995	
8/17/1995	
10/26/1995	41.25
11/7/1995	
11/7/1995	
12/13/1995	
12/14/1995	
01/16/96	
1/24/1996	
1/24/1996	
01/31/96	
2/8/1996	
02/19/96	
2/21/1996	42.10
2/21/1996	
03/04/96	
03/13/96	
03/25/96	

04/24/96	
5/21/1996	
5/21/1996	
5/21/1996	
6/4/1996	
6/4/1996	
6/4/1996	
6/4/1996	
6/18/1996	32.50
6/18/1996	
6/18/1996	
6/18/1996	
06/24/96	
7/2/1996	
7/2/1996	
7/2/1996	
7/2/1996	
7/16/1996	
7/16/1996	
7/16/1996	
7/16/1996	
7/17/1996	
8/13/1996	
8/13/1996	
8/13/1996	
8/13/1996	
8/27/1996	12.00
09/12/96	
12/17/1996	7.92
12/17/1996	
12/17/1996	
12/17/1996	
12/17/1996	
12/18/96	
1/7/1997	
1/8/1997	
1/8/1997	
1/8/1997	
1/21/1997	
1/21/1997	
1/21/1997	
1/21/1997	
2/4/1997	
2/6/1997	
2/6/1997	
2/6/1997	
2/18/1997	

2/27/1997	2.66
2/27/1997	
2/27/1997	
2/27/1997	
3/5/1997	
3/5/1997	
3/5/1997	
03/05/97	
3/5/1997	
3/18/1997	
3/18/1997	
3/18/1997	
3/18/1997	
4/3/1997	
4/3/1997	
4/3/1997	
4/3/1997	
4/15/1997	
4/15/1997	
4/15/1997	
4/15/1997	
4/29/1997	
4/29/1997	
4/29/1997	
4/29/1997	
5/27/1997	27.70
5/27/1997	
5/27/1997	
5/27/1997	
06/19/97	
6/24/1997	
6/24/1997	
6/24/1997	
6/24/1997	
6/24/1997	
7/29/1997	
7/29/1997	
7/29/1997	
7/29/1997	
8/26/1997	23.80
8/26/1997	
8/26/1997	
8/26/1997	
09/04/97	
10/28/1997	46.80
11/17/97	
11/25/1997	19.10

1/27/1998	13.60
03/05/98	
3/30/1998	
3/30/1998	
3/30/1998	
05/18/98	
6/22/1998	8.24
6/22/1998	
6/22/1998	
6/22/1998	
7/14/1998	
7/14/1998	
7/15/1998	8.31
7/15/1998	
7/15/1998	
8/26/1998	11.18
8/26/1998	
09/18/98	
9/28/1998	11.90
9/28/1998	
9/28/1998	
10/19/1998	4.14
10/19/1998	
11/05/98	
11/18/1998	
12/17/1998	19.80
12/17/1998	
1/28/1999	12.10
1/28/1999	
1/28/1999	
2/26/1999	7.49
2/26/1999	
2/26/1999	
2/26/1999	
03/03/99	
3/29/1999	15.30
3/29/1999	
3/29/1999	
4/27/1999	6.74
4/27/1999	
4/27/1999	
5/12/1999	
6/9/1999	10.90
6/9/1999	
6/9/1999	
06/23/99	
7/1/1999	8.63

7/1/1999	
7/1/1999	
7/27/1999	81.20
7/27/1999	
8/20/1999	28.90
8/20/1999	
8/20/1999	
8/20/1999	
9/16/1999	19.90
9/16/1999	
9/16/1999	
09/23/99	
10/28/1999	22.10
10/28/1999	
11/19/1999	17.20
11/19/1999	
11/19/99	
12/20/1999	29.40
12/20/1999	
12/20/1999	
1/12/2000	
2/1/2000	
2/1/2000	
03/03/00	
3/16/2000	71.30
3/16/2000	
3/16/2000	
4/28/2000	16.50
4/28/2000	
4/28/2000	
4/28/2000	
5/25/2000	22.20
5/25/2000	
5/25/2000	
5/25/2000	
5/25/2000	
06/06/00	
6/21/2000	65.90
6/21/2000	
6/21/2000	
6/21/2000	
7/27/2000	
7/27/2000	
7/27/2000	
7/27/2000	
7/27/2000	
08/17/00	

8/28/2000	
8/28/2000	
8/28/2000	
8/28/2000	
9/26/2000	75.00
9/26/2000	
9/26/2000	
10/23/2000	36.40
10/23/2000	
10/23/2000	
12/11/00	
12/26/2000	13.20
12/26/2000	
12/26/2000	
12/26/2000	
1/31/2001	
03/07/01	
3/20/2001	46.70
3/20/2001	
3/20/2001	
3/20/2001	
5/21/2001	
5/21/2001	
5/21/2001	
5/21/2001	
6/15/2001	40.08
6/15/2001	
6/15/2001	
6/15/2001	
06/19/01	
7/9/2001	31.00
7/9/2001	
7/9/2001	
8/10/2001	40.30
8/10/2001	
8/10/2001	
8/10/2001	
09/04/01	
9/26/2001	40.00
9/26/2001	
10/26/2001	45.00
10/26/2001	
11/21/2001	64.00
11/21/2001	
11/21/2001	
12/19/01	
12/26/2001	25.90

12/26/2001	
1/23/2002	19.30
1/23/2002	
1/23/2002	
02/07/02	
2/25/2002	12.10
2/25/2002	
2/25/2002	
03/14/02	
3/26/2002	14.50
3/26/2002	
4/12/2002	22.00
4/12/2002	
4/12/2002	
5/16/2002	2.98
5/16/2002	
5/16/2002	
5/16/2002	
5/16/2002	
6/13/2002	6.92
6/13/2002	
6/13/2002	
6/13/2002	
07/03/02	
7/25/2002	2.84
7/25/2002	
7/25/2002	
7/25/2002	
8/15/2002	27.10
8/15/2002	
8/15/2002	
8/15/2002	
9/28/2002	11.30
9/28/2002	
9/28/2002	
09/30/02	
10/18/2002	1.17
10/18/2002	
10/18/2002	
11/29/2002	27.50
11/29/2002	
11/29/2002	
11/29/2002	
12/13/02	
1/9/2003	17.20
1/9/2003	
1/9/2003	

1/9/2003	
02/25/03	
3/18/2003	9.27
3/18/2003	
3/18/2003	
3/18/2003	
04/30/03	
5/14/2003	1.68
5/14/2003	
5/14/2003	
5/14/2003	
07/21/03	
8/20/2003	
8/21/2003	7.65
8/21/2003	
10/10/03	
11/10/2003	
11/11/2003	8.73
11/11/2003	
11/11/2003	
02/02/04	
2/17/2004	5.79
2/17/2004	
2/17/2004	
2/17/2004	
5/11/2004	3.86
5/11/2004	
5/11/2004	
5/12/2004	
05/25/04	
07/22/04	
8/11/2004	6.30
8/11/2004	
8/11/2004	
8/11/2004	
8/16/2004	
11/2/2004	
11/2/2004	
11/2/2004	22.6
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	
11/18/2004	
11/18/2004	
2/18/2005	
2/18/2005	

2/18/2005	12.2
2/18/2005	
2/18/2005	
2/18/2005	
2/25/2005	
2/28/2005	
2/28/2005	
5/6/2005	
5/6/2005	
5/6/2005	12.13
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	
7/6/2005	
7/25/2005	
7/25/2005	
7/25/2005	6.23
7/25/2005	
7/25/2005	
9/28/2005	
9/28/2005	
11/30/2005	
11/30/2005	
12/27/2005	
12/27/2005	
12/30/2005	
12/30/2005	
12/30/2005	7.82
12/30/2005	
12/30/2005	
3/1/2006	
3/20/2006	
3/20/2006	
3/27/2006	
3/27/2006	
3/27/2006	17.4
3/27/2006	
3/27/2006	
6/21/2006	9.29
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	

6/22/2006	
6/23/2006	
7/6/2006	
7/6/2006	
9/12/2006	
9/21/2006	
9/26/2006	
9/26/2006	
9/28/2006	
9/28/2006	14.4
9/28/2006	
9/28/2006	
10/4/2006	

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Fig 5.37b Iron

Date	MW2
10/24/1994	
10/24/1994	50.14
10/24/1994	
12/19/1994	
12/19/1994	
12/19/1994	83.95
2/2/1995	
2/2/1995	
2/2/1995	43.84
2/7/1995	
2/23/1995	
3/15/1995	
3/15/1995	
3/15/1995	95.50
3/15/1995	
4/20/1995	
4/20/1995	
4/20/1995	
4/20/1995	118.00
4/20/1995	
6/1/1995	
6/1/1995	138.00
6/1/1995	
7/21/1995	
7/24/1995	
8/17/1995	
10/26/1995	
11/7/1995	
11/7/1995	
12/13/1995	172.00
12/14/1995	
01/16/96	
1/24/1996	
1/24/1996	
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6/4/1996	22.40
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6/18/1996	33.60
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7/16/1996	44.10
7/17/1996	
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8/13/1996	27.80
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4/3/1997	9.45
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6/24/1997	54.40
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8/26/1997	
8/26/1997	167.50
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1/27/1998	
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3/30/1998	
3/30/1998	29.68
3/30/1998	
05/18/98	
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6/22/1998	49.90
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7/15/1998	51.00
8/26/1998	
8/26/1998	8.39
09/18/98	
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9/28/1998	113.70
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11/05/98	
11/18/1998	
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1/28/1999	
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06/23/99	
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9/16/1999	
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5/25/2000	43.30
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8/28/2000	
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8/28/2000	54.70
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5/21/2001	
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06/19/01	
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7/9/2001	
7/9/2001	61.00
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8/10/2001	26.80
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5/16/2002	5.26
5/16/2002	
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6/13/2002	
6/13/2002	
6/13/2002	14.30
07/03/02	
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7/25/2002	
7/25/2002	9.50
8/15/2002	
8/15/2002	
8/15/2002	
8/15/2002	19.90
9/28/2002	
9/28/2002	
9/28/2002	11.70
09/30/02	
10/18/2002	
10/18/2002	
10/18/2002	9.93
11/29/2002	
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11/29/2002	
11/29/2002	17.40
12/13/02	
1/9/2003	
1/9/2003	
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1/9/2003	14.90
02/25/03	
3/18/2003	
3/18/2003	
3/18/2003	
3/18/2003	4.76
04/30/03	
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5/14/2003	4.97
07/21/03	
8/20/2003	
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11/11/2003	13.10
02/02/04	
2/17/2004	
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2/17/2004	8.49
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5/11/2004	16.40
5/12/2004	
05/25/04	
07/22/04	
8/11/2004	
8/11/2004	
8/11/2004	19.80
8/11/2004	
8/16/2004	
11/2/2004	
11/2/2004	2.59
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11/2/2004	
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2/18/2005	
2/18/2005	10.7

2/18/2005	
2/18/2005	
2/18/2005	
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2/25/2005	
2/28/2005	
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3/27/2006	7.57
3/27/2006	
3/27/2006	
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9/28/2006	30.2
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10/4/2006	

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Fig 5.37c Iron

Date	MW3
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12/19/1994	
12/19/1994	
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2/7/1995	
2/23/1995	17.28
3/15/1995	32.33
3/15/1995	
3/15/1995	
3/15/1995	
4/20/1995	12.30
4/20/1995	
4/20/1995	
4/20/1995	
4/20/1995	
6/1/1995	34.20
6/1/1995	
6/1/1995	
7/21/1995	
7/24/1995	
8/17/1995	
10/26/1995	54.09
11/7/1995	
11/7/1995	
12/13/1995	
12/14/1995	
01/16/96	
1/24/1996	
1/24/1996	
01/31/96	
2/8/1996	
02/19/96	
2/21/1996	29.20
2/21/1996	
03/04/96	
03/13/96	
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04/24/96	
5/21/1996	43.90
5/21/1996	
5/21/1996	
6/4/1996	11.60
6/4/1996	
6/4/1996	
6/4/1996	
6/18/1996	1.79
6/18/1996	
6/18/1996	
6/18/1996	
06/24/96	
7/2/1996	3.72
7/2/1996	
7/2/1996	
7/2/1996	
7/16/1996	43.70
7/16/1996	
7/16/1996	
7/16/1996	
7/17/1996	
8/13/1996	4.32
8/13/1996	
8/13/1996	
8/13/1996	
8/27/1996	
09/12/96	
12/17/1996	25.40
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2/6/1997	4.57
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2/27/1997	
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2/27/1997	
3/5/1997	4.43
3/5/1997	
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03/05/97	
3/5/1997	
3/18/1997	4.65
3/18/1997	
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3/18/1997	
4/3/1997	5.02
4/3/1997	
4/3/1997	
4/3/1997	
4/15/1997	4.59
4/15/1997	
4/15/1997	
4/15/1997	
4/29/1997	88.50
4/29/1997	
4/29/1997	
4/29/1997	
5/27/1997	1.27
5/27/1997	
5/27/1997	
5/27/1997	
06/19/97	
6/24/1997	1.50
6/24/1997	
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6/24/1997	
6/24/1997	
7/29/1997	31.70
7/29/1997	
7/29/1997	
7/29/1997	
8/26/1997	6.89
8/26/1997	
8/26/1997	
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09/04/97	
10/28/1997	
11/17/97	
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1/27/1998	32.09
03/05/98	
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3/30/1998	
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05/18/98	
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6/22/1998	
6/22/1998	
6/22/1998	
7/14/1998	
7/14/1998	
7/15/1998	10.30
7/15/1998	
7/15/1998	
8/26/1998	73.60
8/26/1998	
09/18/98	
9/28/1998	14.20
9/28/1998	
9/28/1998	
10/19/1998	5.38
10/19/1998	
11/05/98	
11/18/1998	
12/17/1998	64.50
12/17/1998	
1/28/1999	11.90
1/28/1999	
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2/26/1999	14.40
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7/27/1999	
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8/20/1999	
8/20/1999	
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9/16/1999	
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10/28/1999	18.00
10/28/1999	
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11/19/1999	
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4/28/2000	7.62
4/28/2000	
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8/28/2000	20.90
8/28/2000	
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12/26/2000	
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03/07/01	
3/20/2001	27.30
3/20/2001	
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06/19/01	
7/9/2001	27.22
7/9/2001	
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09/04/01	
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9/26/2001	
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12/26/2001	
1/23/2002	36.70
1/23/2002	
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02/07/02	
2/25/2002	35.10
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03/14/02	
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5/16/2002	37.50
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6/13/2002	92.20
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12/13/02	
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11/10/2003	
11/11/2003	76.80
11/11/2003	
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02/02/04	
2/17/2004	54.80
2/17/2004	
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7/25/2005	
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12/30/2005	
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3/1/2006	
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3/27/2006	
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7/6/2006	11.3
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9/26/2006	204.1
9/26/2006	
9/28/2006	
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Fig 5.37e Iron

Date

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Fig 5.37e Iron

Date	
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3/15/1995	
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11/7/1995	20.28
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12/13/1995	
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01/16/96	
1/24/1996	20.60
1/24/1996	
01/31/96	
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2/4/1997	75.00
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2/27/1997	
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4/29/1997	
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5/27/1997	17.20
5/27/1997	
5/27/1997	
06/19/97	
6/24/1997	
6/24/1997	20.90
6/24/1997	
6/24/1997	
6/24/1997	
7/29/1997	
7/29/1997	17.30
7/29/1997	
7/29/1997	
8/26/1997	
8/26/1997	18.50
8/26/1997	
8/26/1997	
09/04/97	
10/28/1997	
11/17/97	
11/25/1997	

1/27/1998	
03/05/98	
3/30/1998	
3/30/1998	
3/30/1998	
05/18/98	
6/22/1998	
6/22/1998	18.00
6/22/1998	
6/22/1998	
7/14/1998	16.50
7/14/1998	
7/15/1998	
7/15/1998	
7/15/1998	
8/26/1998	
8/26/1998	
09/18/98	
9/28/1998	
9/28/1998	19.40
9/28/1998	
10/19/1998	
10/19/1998	17.70
11/05/98	
11/18/1998	
12/17/1998	
12/17/1998	23.60
1/28/1999	
1/28/1999	18.10
1/28/1999	
2/26/1999	
2/26/1999	17.60
2/26/1999	
2/26/1999	
03/03/99	
3/29/1999	
3/29/1999	17.00
3/29/1999	
4/27/1999	
4/27/1999	17.30
4/27/1999	
5/12/1999	
6/9/1999	
6/9/1999	15.70
6/9/1999	
06/23/99	
7/1/1999	

7/1/1999	18.40
7/1/1999	
7/27/1999	
7/27/1999	4.49
8/20/1999	
8/20/1999	2.82
8/20/1999	
8/20/1999	
9/16/1999	
9/16/1999	6.87
9/16/1999	
09/23/99	
10/28/1999	
10/28/1999	7.12
11/19/1999	
11/19/1999	5.23
11/19/99	
12/20/1999	
12/20/1999	4.31
12/20/1999	
1/12/2000	
2/1/2000	4.50
2/1/2000	
03/03/00	
3/16/2000	
3/16/2000	6.77
3/16/2000	
4/28/2000	
4/28/2000	4.75
4/28/2000	
4/28/2000	
5/25/2000	
5/25/2000	5.63
5/25/2000	
5/25/2000	
5/25/2000	
06/06/00	
6/21/2000	
6/21/2000	8.24
6/21/2000	
6/21/2000	
7/27/2000	
7/27/2000	3.03
7/27/2000	
7/27/2000	
7/27/2000	
08/17/00	

8/28/2000	
8/28/2000	3.82
8/28/2000	
8/28/2000	
9/26/2000	
9/26/2000	3.44
9/26/2000	
10/23/2000	
10/23/2000	2.07
10/23/2000	
12/11/00	
12/26/2000	
12/26/2000	19.10
12/26/2000	
12/26/2000	
1/31/2001	
03/07/01	
3/20/2001	
3/20/2001	21.60
3/20/2001	
3/20/2001	
5/21/2001	
5/21/2001	18.90
5/21/2001	
5/21/2001	
6/15/2001	
6/15/2001	19.27
6/15/2001	
6/15/2001	
06/19/01	
7/9/2001	
7/9/2001	20.20
7/9/2001	
8/10/2001	
8/10/2001	21.50
8/10/2001	
8/10/2001	
09/04/01	
9/26/2001	
9/26/2001	19.90
10/26/2001	
10/26/2001	20.00
11/21/2001	
11/21/2001	21.00
11/21/2001	
12/19/01	
12/26/2001	

12/26/2001	18.20
1/23/2002	
1/23/2002	19.80
1/23/2002	
02/07/02	
2/25/2002	
2/25/2002	19.20
2/25/2002	
03/14/02	
3/26/2002	
3/26/2002	18.80
4/12/2002	
4/12/2002	17.40
4/12/2002	
5/16/2002	
5/16/2002	17.00
5/16/2002	
5/16/2002	
5/16/2002	
6/13/2002	
6/13/2002	23.00
6/13/2002	
6/13/2002	
07/03/02	
7/25/2002	
7/25/2002	19.70
7/25/2002	
7/25/2002	
8/15/2002	
8/15/2002	17.00
8/15/2002	
8/15/2002	
9/28/2002	
9/28/2002	20.30
9/28/2002	
09/30/02	
10/18/2002	
10/18/2002	18.40
10/18/2002	
11/29/2002	
11/29/2002	19.00
11/29/2002	
11/29/2002	
12/13/02	
1/9/2003	
1/9/2003	19.90
1/9/2003	

1/9/2003	
02/25/03	
3/18/2003	
3/18/2003	19.50
3/18/2003	
3/18/2003	
04/30/03	
5/14/2003	
5/14/2003	18.70
5/14/2003	
5/14/2003	
07/21/03	
8/20/2003	18.50
8/21/2003	
8/21/2003	
10/10/03	
11/10/2003	17.70
11/11/2003	
11/11/2003	
11/11/2003	
02/02/04	
2/17/2004	
2/17/2004	17.50
2/17/2004	
2/17/2004	
5/11/2004	
5/11/2004	
5/11/2004	
5/12/2004	17.70
05/25/04	
07/22/04	
8/11/2004	
8/11/2004	
8/11/2004	
8/11/2004	
8/16/2004	17.00
11/2/2004	
11/2/2004	
11/2/2004	
11/2/2004	17.3
11/2/2004	
11/2/2004	
11/2/2004	
11/18/2004	
11/18/2004	
2/18/2005	
2/18/2005	

2/18/2005	
2/18/2005	
2/18/2005	
2/18/2005	
2/25/2005	13.6
2/28/2005	
2/28/2005	
5/6/2005	
5/6/2005	
5/6/2005	
5/6/2005	17.4
5/6/2005	
5/6/2005	
5/6/2005	
5/12/2005	
5/13/2005	
7/6/2005	16.9
7/6/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
7/25/2005	
9/28/2005	
9/28/2005	
11/30/2005	18.7
11/30/2005	
12/27/2005	
12/27/2005	
12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	
12/30/2005	
3/1/2006	18.3
3/20/2006	
3/20/2006	
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	
3/27/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	
6/21/2006	

6/22/2006	16.9
6/23/2006	
7/6/2006	
7/6/2006	
9/12/2006	
9/21/2006	
9/26/2006	
9/26/2006	
9/28/2006	
9/28/2006	
9/28/2006	
9/28/2006	
10/4/2006	17.3

Ellengowan
Fig 5.37f Iron

Date	Maple Hill	Holes South
10/24/1994		
10/24/1994		
10/24/1994		
12/19/1994		
12/19/1994	4.43	2.94
12/19/1994		
2/2/1995		
2/2/1995		35.56
2/2/1995		
2/7/1995		
2/23/1995		
3/15/1995		
3/15/1995		
3/15/1995		
3/15/1995		
4/20/1995		
4/20/1995		
4/20/1995	34.10	16.80
4/20/1995		
4/20/1995		
6/1/1995		
6/1/1995		
6/1/1995		
7/21/1995		36.40
7/24/1995		
8/17/1995	45.85	28.62
10/26/1995		
11/7/1995		
11/7/1995	2.80	52.00
12/13/1995		
12/14/1995		
01/16/96		
1/24/1996		
1/24/1996	43.56	
01/31/96		
2/8/1996		118.00
02/19/96		
2/21/1996		
2/21/1996		
03/04/96		
03/13/96		

03/25/96		
04/24/96		
5/21/1996		
5/21/1996		
5/21/1996	25.60	18.70
6/4/1996		
6/4/1996		
6/4/1996	1.14	0.81
6/4/1996		
6/18/1996		
6/18/1996		
6/18/1996	3.78	40.90
6/18/1996		
06/24/96		
7/2/1996		
7/2/1996		
7/2/1996	33.90	1.27
7/2/1996		
7/16/1996		
7/16/1996		
7/16/1996	41.80	2.95
7/16/1996		
7/17/1996		
8/13/1996		
8/13/1996		
8/13/1996	36.80	5.09
8/13/1996		
8/27/1996		
09/12/96		
12/17/1996		
12/17/1996		
12/17/1996	11.90	23.90
12/17/1996		
12/17/1996		
12/18/96		
1/7/1997		
1/8/1997		
1/8/1997	2.91	43.50
1/8/1997		
1/21/1997		
1/21/1997		
1/21/1997	2.59	15.30
1/21/1997		
2/4/1997		
2/6/1997		
2/6/1997	1.65	39.50
2/6/1997		

2/18/1997		
2/27/1997		
2/27/1997	3.98	9.74
2/27/1997		
2/27/1997		
3/5/1997		
3/5/1997		
3/5/1997	5.49	7.93
03/05/97		
3/5/1997		
3/18/1997		
3/18/1997		
3/18/1997	2.53	6.43
3/18/1997		
4/3/1997		
4/3/1997		
4/3/1997	3.08	4.70
4/3/1997		
4/15/1997		
4/15/1997		
4/15/1997	8.52	11.50
4/15/1997		
4/29/1997		
4/29/1997		
4/29/1997	2.45	18.40
4/29/1997		
5/27/1997		
5/27/1997		
5/27/1997	5.68	6.10
5/27/1997		
06/19/97		
6/24/1997		
6/24/1997		
6/24/1997	15.10	3.73
6/24/1997		
6/24/1997		
7/29/1997		
7/29/1997		
7/29/1997	9.83	19.30
7/29/1997		
8/26/1997		
8/26/1997		
8/26/1997	25.00	21.10
8/26/1997		
09/04/97		
10/28/1997		
11/17/97		

11/25/1997		
1/27/1998		
03/05/98		
3/30/1998		
3/30/1998		
3/30/1998		
05/18/98		
6/22/1998		
6/22/1998		
6/22/1998		
6/22/1998		
7/14/1998		
7/14/1998		
7/15/1998		
7/15/1998	25.70	23.40
7/15/1998		
8/26/1998		
8/26/1998		
09/18/98		
9/28/1998		
9/28/1998		
9/28/1998		
10/19/1998		
10/19/1998		
11/05/98		
11/18/1998	48.80	11.70
12/17/1998		
12/17/1998		
1/28/1999		
1/28/1999		
1/28/1999		
2/26/1999		
2/26/1999		
2/26/1999	39.80	5.52
2/26/1999		
03/03/99		
3/29/1999		
3/29/1999		
3/29/1999		
4/27/1999		
4/27/1999		
4/27/1999		
5/12/1999	41.10	7.60
6/9/1999		
6/9/1999		
6/9/1999		
06/23/99		

7/1/1999		
7/1/1999		
7/1/1999	42.50	8.10
7/27/1999		
7/27/1999		
8/20/1999		
8/20/1999		
8/20/1999	3.99	8.30
8/20/1999		
9/16/1999		
9/16/1999		
9/16/1999		
09/23/99		
10/28/1999		
10/28/1999		
11/19/1999		
11/19/1999		
11/19/99		
12/20/1999		
12/20/1999		
12/20/1999	0.76	6.90
1/12/2000		
2/1/2000		
2/1/2000	1.51	
03/03/00		
3/16/2000		
3/16/2000		
3/16/2000		
4/28/2000		
4/28/2000		
4/28/2000		
4/28/2000		
5/25/2000		
5/25/2000		
5/25/2000	36.80	36.70
5/25/2000		
5/25/2000		
06/06/00		
6/21/2000		
6/21/2000		
6/21/2000		
6/21/2000		
7/27/2000		
7/27/2000		
7/27/2000	0.34	42.80
7/27/2000		
7/27/2000		

08/17/00		
8/28/2000		
8/28/2000		
8/28/2000		
8/28/2000		
9/26/2000		
9/26/2000		
9/26/2000		
10/23/2000		
10/23/2000		
10/23/2000		
12/11/00		
12/26/2000		
12/26/2000		
12/26/2000		21.70
12/26/2000		
1/31/2001	0.98	
03/07/01		
3/20/2001		
3/20/2001		
3/20/2001	0.19	
3/20/2001		
5/21/2001		
5/21/2001		
5/21/2001		
5/21/2001		
6/15/2001		
6/15/2001		
6/15/2001	0.75	3.00
6/15/2001		
06/19/01		
7/9/2001		
7/9/2001		
7/9/2001		
8/10/2001		
8/10/2001		
8/10/2001	0.35	32.50
8/10/2001		
09/04/01		
9/26/2001		
9/26/2001		
10/26/2001		
10/26/2001		
11/21/2001		
11/21/2001		
11/21/2001	0.70	37.00
12/19/01		

12/26/2001		
12/26/2001		
1/23/2002		
1/23/2002		
1/23/2002	1.31	28.00
02/07/02		
2/25/2002		
2/25/2002		
2/25/2002	1.64	32.00
03/14/02		
3/26/2002		
3/26/2002		
4/12/2002		
4/12/2002		
4/12/2002	1.22	23.30
5/16/2002		
5/16/2002		
5/16/2002	3.21	13.90
5/16/2002		
5/16/2002		
6/13/2002		
6/13/2002		
6/13/2002	36.80	13.00
6/13/2002		
07/03/02		
7/25/2002		
7/25/2002		
7/25/2002	7.42	40.70
7/25/2002		
8/15/2002		
8/15/2002		
8/15/2002	39.50	9.32
8/15/2002		
9/28/2002		
9/28/2002		
9/28/2002		
09/30/02		
10/18/2002		
10/18/2002		
10/18/2002		
11/29/2002		
11/29/2002		
11/29/2002	28.50	11.10
11/29/2002		
12/13/02		
1/9/2003		
1/9/2003		

1/9/2003	24.80	24.80
1/9/2003		
02/25/03		
3/18/2003		
3/18/2003		
3/18/2003	46.40	7.55
3/18/2003		
04/30/03		
5/14/2003		
5/14/2003		
5/14/2003		2.78
5/14/2003		
07/21/03		
8/20/2003		
8/21/2003		
8/21/2003	31.30	
10/10/03		
11/10/2003		
11/11/2003		
11/11/2003	27.80	9.22
11/11/2003		
02/02/04		
2/17/2004		
2/17/2004		
2/17/2004	29.60	
2/17/2004		
5/11/2004		
5/11/2004	28.40	51.40
5/11/2004		
5/12/2004		
05/25/04		
07/22/04		
8/11/2004		
8/11/2004	26.80	30.40
8/11/2004		
8/11/2004		
8/16/2004		
11/2/2004		
11/2/2004		
11/2/2004		
11/2/2004		
11/2/2004	30.1	
11/2/2004		48.2
11/2/2004		
11/18/2004		
11/18/2004		
2/18/2005		

2/18/2005		
2/18/2005		
2/18/2005	22.3	
2/18/2005		24.9
2/18/2005		
2/25/2005		
2/28/2005		
2/28/2005		
5/6/2005		
5/6/2005		
5/6/2005		
5/6/2005		
5/6/2005	28.5	
5/6/2005		64.1
5/6/2005		
5/12/2005		
5/13/2005		
7/6/2005		
7/6/2005	31.1	
7/25/2005		
7/25/2005		
7/25/2005		
7/25/2005		74.5
7/25/2005		
9/28/2005		
9/28/2005		
11/30/2005		
11/30/2005	38.4	
12/27/2005		
12/27/2005		
12/30/2005		
12/30/2005		
12/30/2005		
12/30/2005		47.1
12/30/2005		
3/1/2006		
3/20/2006		
3/20/2006		
3/27/2006		
3/27/2006		
3/27/2006		
3/27/2006		18.4
3/27/2006		
6/21/2006		
6/21/2006		48.9
6/21/2006		
6/21/2006		

6/21/2006		
6/22/2006		
6/23/2006	30.2	
7/6/2006		
7/6/2006		
9/12/2006		
9/21/2006		
9/26/2006		
9/26/2006		
9/28/2006		
9/28/2006		
9/28/2006	<0.10	
9/28/2006		89.8
10/4/2006		

Ellengowan
Fig 5.37g Iron

Date	MW3	MW4	MW2	MW1	Packer V	Maple Hill	Holes South	Gilberton
10/24/1994	24.77			48.09				
10/24/1994			50.14					
10/24/1994		40.35						
12/19/1994	18.54			74.00				
12/19/1994						4.43	2.94	
12/19/1994			83.95					
2/2/1995	32.34			63.40				
2/2/1995							35.56	
2/2/1995			43.84					
2/7/1995		40.16						
2/23/1995	17.28			52.23				
3/15/1995	32.33			85.20				
3/15/1995					19.01			
3/15/1995			95.50					
3/15/1995		41.86						
4/20/1995	12.30			40.90				
4/20/1995					19.00			
4/20/1995						34.10	16.80	
4/20/1995			118.00					
4/20/1995		102.00						
6/1/1995	34.20			32.90				
6/1/1995			138.00					
6/1/1995		61.20						
7/21/1995							36.40	
7/24/1995					18.50			
8/17/1995						45.85	28.62	
10/26/1995	54.09			41.25				
11/7/1995					20.28			
11/7/1995						2.80	52.00	
12/13/1995			172.00					
12/14/1995		72.60						
01/16/96								
1/24/1996					20.60			
1/24/1996						43.56		
01/31/96								
2/8/1996							118.00	
02/19/96								
2/21/1996	29.20			42.10				
2/21/1996			42.90					
03/04/96								
03/13/96								

03/25/96								42.60
04/24/96								
5/21/1996	43.90							
5/21/1996					16.30			
5/21/1996						25.60	18.70	
6/4/1996	11.60							
6/4/1996					17.80			
6/4/1996						1.14	0.81	
6/4/1996			22.40					
6/18/1996	1.79			32.50				
6/18/1996					19.50			
6/18/1996						3.78	40.90	
6/18/1996			33.60					
06/24/96								39.50
7/2/1996	3.72							
7/2/1996					20.60			
7/2/1996						33.90	1.27	
7/2/1996			33.90					
7/16/1996	43.70							
7/16/1996					20.80			
7/16/1996						41.80	2.95	
7/16/1996			44.10					
7/17/1996		23.47						
8/13/1996	4.32							
8/13/1996					16.30			
8/13/1996						36.80	5.09	
8/13/1996			27.80					
8/27/1996				12.00				
09/12/96								36.80
12/17/1996	25.40			7.92				
12/17/1996					20.90			
12/17/1996						11.90	23.90	
12/17/1996			51.80					
12/17/1996		9.02						
12/18/96								24.60
1/7/1997					23.20			
1/8/1997	10.30							
1/8/1997						2.91	43.50	
1/8/1997			38.60					
1/21/1997	6.67							
1/21/1997					19.80			
1/21/1997						2.59	15.30	
1/21/1997			40.60					
2/4/1997					75.00			
2/6/1997	4.57							
2/6/1997						1.65	39.50	
2/6/1997			40.23					

2/18/1997					19.30			
2/27/1997	7.84			2.66				
2/27/1997						3.98	9.74	
2/27/1997			20.90					
2/27/1997		4.15						
3/5/1997	4.43							
3/5/1997					18.10			
3/5/1997						5.49	7.93	
03/05/97								27.80
3/5/1997			3.51					
3/18/1997	4.65							
3/18/1997					24.80			
3/18/1997						2.53	6.43	
3/18/1997			4.49					
4/3/1997	5.02							
4/3/1997					19.50			
4/3/1997						3.08	4.70	
4/3/1997			9.45					
4/15/1997	4.59							
4/15/1997					23.20			
4/15/1997						8.52	11.50	
4/15/1997			7.22					
4/29/1997	88.50							
4/29/1997					16.00			
4/29/1997						2.45	18.40	
4/29/1997			8.66					
5/27/1997	1.27			27.70				
5/27/1997					17.20			
5/27/1997						5.68	6.10	
5/27/1997			9.35					
06/19/97								38.10
6/24/1997	1.50							
6/24/1997					20.90			
6/24/1997						15.10	3.73	
6/24/1997			54.40					
6/24/1997		37.30						
7/29/1997	31.70							
7/29/1997					17.30			
7/29/1997						9.83	19.30	
7/29/1997			161.00					
8/26/1997	6.89			23.80				
8/26/1997					18.50			
8/26/1997						25.00	21.10	
8/26/1997			167.50					
09/04/97								36.20
10/28/1997				46.80				
11/17/97								43.00

11/25/1997				19.10				
1/27/1998	32.09			13.60				
03/05/98								36.00
3/30/1998								
3/30/1998			29.68					
3/30/1998		25.35						
05/18/98								45.20
6/22/1998	13.40			8.24				
6/22/1998					18.00			
6/22/1998			49.90					
6/22/1998		22.80						
7/14/1998					16.50			
7/14/1998		17.10						
7/15/1998	10.30			8.31				
7/15/1998						25.70	23.40	
7/15/1998			51.00					
8/26/1998	73.60			11.18				
8/26/1998			8.39					
09/18/98								42.40
9/28/1998	14.20			11.90				
9/28/1998					19.40			
9/28/1998			113.70					
10/19/1998	5.38			4.14				
10/19/1998					17.70			
11/05/98								44.10
11/18/1998						48.80	11.70	
12/17/1998	64.50			19.80				
12/17/1998					23.60			
1/28/1999	11.90			12.10				
1/28/1999					18.10			
1/28/1999			31.40					
2/26/1999	14.40			7.49				
2/26/1999					17.60			
2/26/1999						39.80	5.52	
2/26/1999			107.00					
03/03/99								47.00
3/29/1999	5.84			15.30				
3/29/1999					17.00			
3/29/1999			79.50					
4/27/1999	6.79			6.74				
4/27/1999					17.30			
4/27/1999			73.00					
5/12/1999						41.10	7.60	
6/9/1999	14.30			10.90				
6/9/1999					15.70			
6/9/1999			92.70					
06/23/99								42.30

7/1/1999	14.90			8.63				
7/1/1999					18.40			
7/1/1999						42.50	8.10	
7/27/1999	24.60			81.20				
7/27/1999					4.49			
8/20/1999	20.00			28.90				
8/20/1999					2.82			
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8/20/1999			37.70					
9/16/1999	23.00			19.90				
9/16/1999					6.87			
9/16/1999			31.00					
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10/28/1999	18.00			22.10				
10/28/1999					7.12			
11/19/1999	21.00			17.20				
11/19/1999					5.23			
11/19/99								42.70
12/20/1999	17.40			29.40				
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12/20/1999						0.76	6.90	
1/12/2000								
2/1/2000					4.50			
2/1/2000						1.51		
03/03/00								38.60
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4/28/2000	7.62			16.50				
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5/25/2000	12.10			22.20				
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5/25/2000						36.80	36.70	
5/25/2000			43.30					
5/25/2000		12.80						
06/06/00								36.50
6/21/2000	31.40			65.90				
6/21/2000					8.24			
6/21/2000			52.10					
6/21/2000		15.70						
7/27/2000	27.40							
7/27/2000					3.03			
7/27/2000						0.34	42.80	
7/27/2000			47.40					
7/27/2000		11.20						

08/17/00								37.30
8/28/2000	20.90							
8/28/2000					3.82			
8/28/2000			54.70					
8/28/2000		5.17						
9/26/2000	28.80			75.00				
9/26/2000					3.44			
9/26/2000			96.00					
10/23/2000	20.70			36.40				
10/23/2000					2.07			
10/23/2000			94.00					
12/11/00								44.10
12/26/2000	31.60			13.20				
12/26/2000					19.10			
12/26/2000							21.70	
12/26/2000			158.00					
1/31/2001						0.98		
03/07/01								50.50
3/20/2001	27.30			46.70				
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3/20/2001			153.00					
5/21/2001	28.40							
5/21/2001					18.90			
5/21/2001			94.80					
5/21/2001		4.15						
6/15/2001	29.98			40.08				
6/15/2001					19.27			
6/15/2001						0.75	3.00	
6/15/2001			104.30					
06/19/01								36.98
7/9/2001	27.22			31.00				
7/9/2001					20.20			
7/9/2001			61.00					
8/10/2001	21.46			40.30				
8/10/2001					21.50			
8/10/2001						0.35	32.50	
8/10/2001			26.80					
09/04/01								46.80
9/26/2001	24.80			40.00				
9/26/2001					19.90			
10/26/2001				45.00				
10/26/2001					20.00			
11/21/2001				64.00				
11/21/2001					21.00			
11/21/2001						0.70	37.00	
12/19/01								38.80

12/26/2001				25.90				
12/26/2001					18.20			
1/23/2002	36.70			19.30				
1/23/2002					19.80			
1/23/2002						1.31	28.00	
02/07/02								
2/25/2002	35.10			12.10				
2/25/2002					19.20			
2/25/2002						1.64	32.00	
03/14/02								44.80
3/26/2002	31.40			14.50				
3/26/2002					18.80			
4/12/2002	13.80			22.00				
4/12/2002					17.40			
4/12/2002						1.22	23.30	
5/16/2002	37.50			2.98				
5/16/2002					17.00			
5/16/2002						3.21	13.90	
5/16/2002			5.26					
5/16/2002		0.66						
6/13/2002	92.20			6.92				
6/13/2002					23.00			
6/13/2002						36.80	13.00	
6/13/2002			14.30					
07/03/02								41.70
7/25/2002	86.10			2.84				
7/25/2002					19.70			
7/25/2002						7.42	40.70	
7/25/2002			9.50					
8/15/2002				27.10				
8/15/2002					17.00			
8/15/2002						39.50	9.32	
8/15/2002			19.90					
9/28/2002				11.30				
9/28/2002					20.30			
9/28/2002			11.70					
09/30/02								44.60
10/18/2002				1.17				
10/18/2002					18.40			
10/18/2002			9.93					
11/29/2002	335.00			27.50				
11/29/2002					19.00			
11/29/2002						28.50	11.10	
11/29/2002			17.40					
12/13/02								49.60
1/9/2003	86.00			17.20				
1/9/2003					19.90			

1/9/2003						24.80	24.80	
1/9/2003			14.90					
02/25/03								42.10
3/18/2003	91.30			9.27				
3/18/2003					19.50			
3/18/2003						46.40	7.55	
3/18/2003			4.76					
04/30/03								39.00
5/14/2003	40.20			1.68				
5/14/2003					18.70			
5/14/2003							2.78	
5/14/2003			4.97					
07/21/03								42.80
8/20/2003					18.50			
8/21/2003	108.00			7.65				
8/21/2003						31.30		
10/10/03								41.60
11/10/2003					17.70			
11/11/2003	76.80			8.73				
11/11/2003						27.80	9.22	
11/11/2003			13.10					
02/02/04								41.20
2/17/2004	54.80			5.79				
2/17/2004					17.50			
2/17/2004						29.60		
2/17/2004			8.49					
5/11/2004	48.00			3.86				
5/11/2004						28.40	51.40	
5/11/2004			16.40					
5/12/2004					17.70			
05/25/04								37.70
07/22/04								34.50
8/11/2004				6.30				
8/11/2004						26.80	30.40	
8/11/2004			19.80					
8/11/2004		13.40						
8/16/2004	48.3				17.00			
11/2/2004	45.3							
11/2/2004			2.59					
11/2/2004				22.6				
11/2/2004					17.3			
11/2/2004						30.1		
11/2/2004							48.2	
11/2/2004		12.50						
11/18/2004								37.14
11/18/2004								
2/18/2005	44.7							

2/18/2005			10.7					
2/18/2005				12.2				
2/18/2005						22.3		
2/18/2005							24.9	
2/18/2005		15.40						
2/25/2005					13.6			
2/28/2005								36.9
2/28/2005								
5/6/2005	28.31							
5/6/2005			5.34					
5/6/2005				12.13				
5/6/2005					17.4			
5/6/2005						28.5		
5/6/2005							64.1	
5/6/2005		5.75						
5/12/2005								
5/13/2005								33.34
7/6/2005					16.9			
7/6/2005						31.1		
7/25/2005	43.9							
7/25/2005			20.7					
7/25/2005				6.23				
7/25/2005							74.5	
7/25/2005		18.50						
9/28/2005								37.5
9/28/2005								
11/30/2005					18.7			
11/30/2005						38.4		
12/27/2005								48.8
12/27/2005								
12/30/2005	160.4							
12/30/2005			125					
12/30/2005				7.82				
12/30/2005							47.1	
12/30/2005		41.60						
3/1/2006					18.3			
3/20/2006								43.6
3/20/2006								
3/27/2006	65.2							
3/27/2006			7.57					
3/27/2006				17.4				
3/27/2006							18.4	
3/27/2006		12.70						
6/21/2006				9.29				
6/21/2006							48.9	
6/21/2006								33.6
6/21/2006								

6/21/2006		77.10						
6/22/2006					16.9			
6/23/2006						30.2		
7/6/2006	11.3							
7/6/2006			45.3					
9/12/2006								
9/21/2006								31
9/26/2006	204.1							
9/26/2006		136.00						
9/28/2006			30.2					
9/28/2006				14.4				
9/28/2006						<0.10		
9/28/2006							89.8	
10/4/2006					17.3			

MP008
108.00
125.00
166.00
172.00
121.00

128.00
89.60
114.00
126.00

67.40
133.00
12.70
11.80

0.66
26.10
39.20
5.65
1.70
9.65

0.88
33.20
0.65
5.29

13.80
5.08
6.80
6.35
14.40

32.20
5.23
31.10
41.60
38.70

50.90
48.30
41.40
54.00
56.00
50.90
51.30
46.4

43.1
47.68
45.9
48
47.1
43.2

36.2

Ellengowan
Fig 5.38 Manganese

Date		
Date	MW4	Packer
10/24/1994		
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10/24/1994	3.45	
12/08/94		
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2/23/1995		
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4/20/1995		8.42
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6/1/1995		
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6/1/1995	3.82	
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7/21/1995		
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09/19/95		
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11/7/1995		
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6/24/1997		7.81
6/24/1997		
6/24/1997		
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8/26/1997		
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3/16/2000		
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5/25/2000		4.60
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08/17/00		
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2/18/2005		
2/18/2005		
2/18/2005	1.50	
2/25/2005		5.76
2/28/2005		
2/28/2005		
5/6/2005		
5/6/2005		
5/6/2005		
5/6/2005		6.629
5/6/2005		
5/6/2005		
5/6/2005	1.12	
5/12/2005		
5/13/2005		
7/6/2005		6.74
7/6/2005		
7/25/2005		
7/25/2005		
7/25/2005		
7/25/2005		
7/25/2005	1.21	
9/28/2005		
9/28/2005		
11/30/2005		7.24
11/30/2005		
12/27/2005		
12/27/2005		
12/30/2005		
12/30/2005		
12/30/2005		
12/30/2005		
12/30/2005	1.49	
3/1/2006		6.68
3/20/2006		
3/20/2006		
3/27/2006		
3/27/2006		
3/27/2006		
3/27/2006		

3/27/2006	1.36	
6/21/2006		
6/21/2006		
6/21/2006		
6/21/2006		
6/21/2006	1.81	
6/22/2006		6.99
6/23/2006		
7/6/2006		
7/6/2006		
9/12/2006		
9/12/2006		
9/26/2006		
9/26/2006	2.97	
9/28/2006		
9/28/2006		
9/28/2006		
9/28/2006		
10/4/2006		6.52

Ellengowan

Fig 5.39 Lab pH

Date	MW1	MW2	MW3	MW4	Packer V	Holes South	Maple Hill	Gilberton
10/24/1994	5.87							
10/24/1994			6.53					
10/24/1994		6.31						
10/24/1994				6.55				
12/08/94								6.06
12/14/1994			8.98					
12/19/1994						5.17		
12/19/1994							5.41	
2/2/1995	5.50							
2/2/1995			6.36					
2/2/1995						6.07		
2/7/1995								
2/7/1995		6.89						
2/7/1995				6.78				
2/23/1995	5.76							
2/23/1995			7.55					
03/14/95								6.13
3/15/1995	5.22							
3/15/1995			8.65					
3/15/1995					6.17			
3/15/1995		6.34						
3/15/1995				6.28				
4/20/1995	5.43							
4/20/1995			9.31					
4/20/1995					6.50			
4/20/1995						4.97		
4/20/1995							5.55	
4/20/1995		6.48						
4/20/1995				6.48				
6/1/1995	5.23							
6/1/1995			8.96					
6/1/1995		6.10						
6/1/1995				6.55				
06/05/95								6.15
7/21/1995						5.05		
7/24/1995					6.18			
8/17/1995						6.03		
8/17/1995							5.63	
09/19/95								5.88
10/26/1995	8.43							
10/26/1995			9.49					

11/7/1995					6.50			
11/7/1995							4.22	
11/8/1995						5.40		
12/05/95								6.03
12/13/1995								
12/13/1995		5.91						
12/14/1995	5.92							
12/14/1995		6.49						
12/14/1995				6.69				
01/16/96								
1/24/1996					6.12			
1/24/1996							6.10	
01/31/96								
2/8/1996						6.03		
02/19/96								
2/21/1996	6.62							
2/21/1996		6.39						
2/26/1996			6.85					
03/04/96								
03/13/96								
03/25/96								6.32
04/24/96								
5/21/1996			6.30					
5/21/1996					6.30			
5/21/1996						6.10		
5/21/1996							6.40	
6/4/1996								
6/4/1996			6.60					
6/4/1996					6.50			
6/4/1996						6.20		
6/4/1996							6.00	
6/4/1996		6.40						
6/18/1996	6.12							
6/18/1996			6.50					
6/18/1996					6.30			
6/18/1996						6.20		
6/18/1996							5.80	
6/18/1996		6.30						
06/24/96								6.09
06/26/96								
7/2/1996								
7/2/1996			7.00					
7/2/1996					6.50			
7/2/1996						6.10		
7/2/1996							5.70	
7/2/1996		6.50						
7/16/1996								

7/16/1996			7.40					
7/16/1996					6.30			
7/16/1996						6.00		
7/16/1996							5.60	
7/16/1996		6.40						
7/17/1996				7.33				
8/13/1996								
8/13/1996			7.50					
8/13/1996					6.30			
8/13/1996						5.90		
8/13/1996							5.50	
8/13/1996		6.40						
8/27/1996	6.40							
09/12/96								6.02
09/12/96								
12/17/1996	7.52							
12/17/1996			6.50					
12/17/1996					6.30			
12/17/1996						6.10		
12/17/1996							6.00	
12/17/1996		6.30						
12/17/1996				6.75				
12/18/96								6.26
12/18/96								
1/7/1997					6.40			
1/7/1997						6.40		
1/8/1997								
1/8/1997			6.60					
1/8/1997							5.30	
1/8/1997		6.40						
1/21/1997								
1/21/1997			7.10					
1/21/1997					6.40			
1/21/1997						7.10		
1/21/1997							5.30	
1/21/1997		6.50						
2/4/1997								
2/4/1997					6.40			
2/4/1997						6.40		
2/4/1997		6.40						
2/6/1997			7.00					
2/6/1997							5.40	
2/18/1997					6.40			
2/18/1997						6.20		
2/27/1997	7.49							
2/27/1997			6.80					
2/27/1997							5.60	

2/27/1997				7.93				
2/28/1997								
2/28/1997		6.40						
3/5/1997			6.60					
3/5/1997					6.30			
3/5/1997						5.90		
3/5/1997							5.40	
03/05/97								6.99
03/05/97								
3/6/1997								
3/6/1997		6.30						
3/18/1997								
3/18/1997			6.70					
3/18/1997					6.50			
3/18/1997						6.30		
3/18/1997							5.70	
3/18/1997		6.50						
4/3/1997								
4/3/1997			6.80					
4/3/1997					6.40			
4/3/1997						6.30		
4/3/1997							5.70	
4/3/1997		6.60						
4/15/1997								
4/15/1997			6.80					
4/15/1997					6.50			
4/15/1997						6.40		
4/15/1997							5.80	
4/15/1997		6.40						
4/29/1997								
4/29/1997			7.30					
4/29/1997					6.40			
4/29/1997						6.30		
4/29/1997							5.90	
4/29/1997		6.60						
5/27/1997	7.47							
5/27/1997			8.20					
5/27/1997					6.40			
5/27/1997						6.80		
5/27/1997							5.80	
5/27/1997		6.60						
06/19/97								6.00
06/19/97								
6/24/1997								
6/24/1997			8.10					
6/24/1997					6.40			
6/24/1997						6.00		

6/24/1997							5.80	
6/24/1997		6.50						
6/24/1997				8.66				
7/29/1997								
7/29/1997			7.80					
7/29/1997					6.30			
7/29/1997						6.30		
7/29/1997							5.80	
7/29/1997		6.20						
8/26/1997	7.50							
8/26/1997			7.20					
8/26/1997					6.30			
8/26/1997						6.80		
8/26/1997							4.90	
8/26/1997		6.50						
09/04/97								6.13
09/04/97								
10/28/1997	5.14							
11/17/97								5.82
11/17/97								
11/25/1997	7.71							
1/27/1998	7.80							
1/27/1998			7.31					
03/05/98								5.95
03/05/98								
3/30/1998								
3/30/1998		6.70						
3/30/1998				7.24				
05/18/98								6.06
05/18/98								
6/22/1998	9.02							
6/22/1998			8.20					
6/22/1998					6.40			
6/22/1998		6.61						
6/22/1998				6.72				
7/14/1998	8.95							
7/14/1998			8.46					
7/14/1998					6.37			
7/14/1998		6.51						
7/14/1998				7.19				
7/15/1998						8.87		
7/15/1998							5.60	
8/26/1998	7.81							
8/26/1998			6.42					
8/26/1998		7.52						
09/18/98								6.11
09/18/98								

9/28/1998	9.02							
9/28/1998			7.51					
9/28/1998					6.37			
9/28/1998		6.35						
10/19/1998	7.51							
10/19/1998			7.18					
10/19/1998					6.31			
11/05/98								6.03
11/05/98								
11/10/1998								
11/18/1998						7.99		
11/18/1998							6.67	
12/17/1998	8.98							
12/17/1998			7.84					
12/17/1998					6.46			
1/28/1999	8.91							
1/28/1999			7.17					
1/28/1999					6.41			
1/28/1999		6.54						
2/26/1999	9.09							
2/26/1999			7.80					
2/26/1999					6.36			
2/26/1999						9.31		
2/26/1999							6.36	
2/26/1999		6.22						
03/03/99								6.02
03/03/99								
3/29/1999	8.72							
3/29/1999			7.06					
3/29/1999					6.52			
3/29/1999		6.28						
4/27/1999	9.53							
4/27/1999			8.77					
4/27/1999					6.94			
4/27/1999		6.78						
5/12/1999						8.12		
5/12/1999							6.11	
6/9/1999								
6/9/1999			7.83					
6/9/1999					6.73			
6/9/1999		5.79						
6/10/1999	8.67							
06/23/99								6.03
06/23/99								
7/1/1999					6.30			
7/1/1999						8.84		
7/1/1999							6.14	

7/2/1999	8.7							
7/2/1999			8.18					
7/27/1999	6.41							
7/27/1999			7.75					
7/27/1999					6.87			
8/19/1999								
8/19/1999		6.81						
8/20/1999	7.93							
8/20/1999			7.43					
8/20/1999					6.83			
8/20/1999						8.15		
8/20/1999							7.49	
9/16/1999	6.89							
9/16/1999			7.51					
9/16/1999					6.76			
9/16/1999		6.56						
09/23/99								6.24
09/23/99								
10/28/1999	6.43							
10/28/1999			7.32					
10/28/1999					6.85			
11/19/1999	6.55							
11/19/1999			7.45					
11/19/1999					6.81			
11/19/99								5.82
11/19/99								
12/20/1999	6.61							
12/20/1999			7.41					
12/20/1999					6.96			
12/20/1999						7.88		
12/20/1999							6.87	
1/12/2000								
1/12/2000								
1/12/2000								
2/1/2000								
2/1/2000								
2/1/2000					5.68			
2/1/2000							5.14	
03/03/00								6.14
03/03/00								
3/16/2000	9.17							
3/16/2000			7.39					
3/16/2000					6.94			
3/16/2000		6.31						
4/28/2000	9.38							
4/28/2000			7.66					
4/28/2000					6.92			

4/28/2000		6.86						
4/28/2000				7.66				
5/25/2000	8.75							
5/25/2000			6.88					
5/25/2000					6.75			
5/25/2000						7.52		
5/25/2000							6.88	
5/25/2000		6.46						
5/25/2000				7.52				
06/06/00								6.46
06/06/00								
6/21/2000	8.28							
6/21/2000			7.52					
6/21/2000					6.88			
6/21/2000		6.70						
6/21/2000				7.82				
7/27/2000								
7/27/2000			7.44					
7/27/2000					7.24			
7/27/2000						7.98		
7/27/2000							7.12	
7/27/2000		7.02						
7/27/2000				7.51				
08/17/00								6.23
08/17/00								
8/28/2000								
8/28/2000			7.30					
8/28/2000					6.67			
8/28/2000		6.36						
8/28/2000				8.12				
9/26/2000	6.89							
9/26/2000			7.60					
9/26/2000					6.82			
9/26/2000								
9/26/2000		6.47						
10/23/2000	6.55							
10/23/2000			7.92					
10/23/2000					6.88			
10/23/2000		6.29						
12/11/00								6.09
12/11/00								
12/26/2000	9.12							
12/26/2000			7.09					
12/26/2000					6.39			
12/26/2000						9.08		
12/26/2000		6.16						
1/31/2001							6.69	

03/07/01								6.12
03/07/01								
3/20/2001	6.44							
3/20/2001			7.51					
3/20/2001					6.35			
3/20/2001								
3/20/2001							6.62	
3/20/2001		6.14						
5/21/2001								
5/21/2001			7.63					
5/21/2001					6.31			
5/21/2001		6.41						
5/21/2001				7.83				
6/15/2001	6.91							
6/15/2001			8.10					
6/15/2001					6.33			
6/15/2001						7.48		
6/15/2001							6.95	
6/15/2001		6.49						
06/19/01								5.96
06/19/01								
7/9/2001	6.77							
7/9/2001			7.95					
7/9/2001					6.28			
7/9/2001		6.11						
8/10/2001	6.25							
8/10/2001			8.00					
8/10/2001					6.20			
8/10/2001						8.72		
8/10/2001							7.63	
8/10/2001		5.93						
09/04/01								6.04
09/04/01								
9/26/2001	6.76							
9/26/2001			7.27					
9/26/2001					6.48			
10/26/2001	6.82							
10/26/2001					6.41			
11/21/2001	7.78							
11/21/2001					6.39			
11/21/2001						9.23		
11/21/2001							7.55	
12/19/01								6.04
12/26/2001	6.26							
12/26/2001					6.40			
1/23/2002	6.60							
1/23/2002			7.72					

1/23/2002					6.52			
1/23/2002						9.06		
1/23/2002							7.44	
02/07/02								
2/25/2002	6.40							
2/25/2002			8.07					
2/25/2002					6.36			
2/25/2002						9.32		
2/25/2002							7.35	
03/14/02								6.07
03/14/02								
3/26/2002	6.50							
3/26/2002			7.89					
3/26/2002					6.41			
4/12/2002	7.45							
4/12/2002			8.05					
4/12/2002					6.35			
4/12/2002						9.19		
4/12/2002							7.11	
5/16/2002	9.25							
5/16/2002			5.80					
5/16/2002					6.33			
5/16/2002						9.24		
5/16/2002							6.00	
5/16/2002		8.01						
5/16/2002				7.32				
6/13/2002	9.18							
6/13/2002			6.36					
6/13/2002					6.34			
6/13/2002						9.16		
6/13/2002							5.99	
6/13/2002		8.24						
07/03/02								5.79
07/03/02								
7/25/2002	9.47							
7/25/2002			6.46					
7/25/2002					6.43			
7/25/2002						6.14		
7/25/2002							8.46	
7/25/2002		8.79						
8/15/2002	7.43							
8/15/2002								
8/15/2002					6.45			
8/15/2002						8.21		
8/15/2002							6.50	
8/15/2002		8.48						
9/28/2002	9.47							

9/28/2002					6.17			
9/28/2002		7.61						
9/30/2002								
09/30/02								5.96
09/30/02								
10/18/2002	9.75							
10/18/2002								
10/18/2002					6.53			
10/18/2002		8.02						
11/29/2002	7.83							
11/29/2002			6.64					
11/29/2002					6.56			
11/29/2002						9.01		
11/29/2002							5.52	
11/29/2002		8.02						
12/13/02								6.26
12/13/02								
1/9/2003	9.59							
1/9/2003			6.53					
1/9/2003					6.21			
1/9/2003						8.93		
1/9/2003							6.34	
1/9/2003		8.08						
02/25/03								5.87
02/25/03								
3/18/2003	9.54							
3/18/2003			6.38					
3/18/2003					6.31			
3/18/2003						9.58		
3/18/2003							6.20	
3/18/2003		8.43						
04/30/03								5.93
04/30/03								
5/14/2003	9.56							
5/14/2003			6.49					
5/14/2003					6.28			
5/14/2003						8.38		
5/14/2003								
5/14/2003		8.40						
07/21/03								6.15
07/21/03								
8/20/2003					6.51			
8/21/2003	9.43							
8/21/2003			6.22					
8/21/2003								
8/21/2003							6.18	
10/10/03								6.06

10/13/03								
11/10/2003					6.40			
11/11/2003	9.06							
11/11/2003			6.51					
11/11/2003						8.00		
11/11/2003							6.37	
11/11/2003		8.16						
02/02/04								5.87
02/02/04								
2/17/2004					6.54			
2/17/2004								
2/17/2004							6.21	
2/18/2004	8.76							
2/18/2004			6.41					
2/18/2004		8.13						
5/11/2004	8.70							
5/11/2004			6.50					
5/11/2004						6.00		
5/11/2004		8.40						
5/12/2004							6.20	
5/12/2004					6.50			
05/25/04								5.94
05/25/04								
07/22/04								5.91
07/22/04								
8/11/2004	8.38							
8/11/2004						6.25		
8/11/2004							6.39	
8/11/2004		8.77						
8/11/2004				6.62				
8/16/2004			6.57					
8/16/2004					6.30			
11/2/2004	6.58							
11/2/2004		7.72						
11/2/2004			6.43					
11/2/2004					6.36			
11/2/2004						6.28		
11/2/2004							6.33	
11/2/2004				6.48				
11/18/2004								6.1
11/18/2004								
2/18/2005	7.67							
2/18/2005		7.33						
2/18/2005			6.39					
2/18/2005						6.4		
2/18/2005							6.4	
2/18/2005				6.55				

2/25/2005					6.42			
2/28/2005								6.2
2/28/2005								
5/6/2005	7.57							
5/6/2005		7.5						
5/6/2005			6.66					
5/6/2005					6.35			
5/6/2005						8.43		
5/6/2005							5.98	
5/6/2005				6.96				
5/12/2005								
5/13/2005								5.78
7/6/2005					6.29			
7/6/2005							6.37	
7/25/2005	8.02							
7/25/2005		8.23						
7/25/2005			6.37					
7/25/2005						6.21		
7/25/2005				6.62				
9/28/2005								6.3
9/28/2005								
11/30/2005					6.3			
11/30/2005							6.5	
12/27/2005								6.5
12/27/2005								
12/30/2005	8.29							
12/30/2005		6.19						
12/30/2005			8.95					
12/30/2005						6.69		
12/30/2005				6.05				
3/1/2006					6.4			
3/20/2006								6.2
3/20/2006								
3/27/2006	8.55							
3/27/2006		7.17						
3/27/2006			6.11					
3/27/2006						6.7		
3/27/2006				6.50				
6/21/2006	8.6							
6/21/2006						5.8		
6/21/2006								6.06
6/21/2006								
6/21/2006				6.80				
6/22/2006					6.3			
6/23/2006							5.83	
7/6/2006		6.1						
7/6/2006			6.6					

9/12/2006								5.9
9/12/2006								
9/26/2006			6.4					
9/26/2006				6.30				
9/28/2006	7.5							
9/28/2006		6.6						
9/28/2006						5.9		
9/28/2006							5.9	
10/4/2006					6.3			

MP008

6.42
5.64
6.24
6.05
6.25
6.40
6.20

5.96
6.31

6.41
6.01

4.34
3.59
3.93
6.30
6.39

5.58
5.70
6.18

5.77
5.92
5.49

6.08
4.16
4.70

5.07
4.85
4.97

6.42
5.52
5.63

5.98
6.32
6.10
6.05
5.70

4.98
5.08
5.07
4.99
5.6

4.8
5.04
6.4
5.2
5.3
5.74

5.4

Ellengowan

Fig 5.40 Alkalinity

Date	Packer V	MW4
10/24/1994		
10/24/1994		
10/24/1994		
10/24/1994		68.15
12/08/94		
12/14/1994		
12/14/1994		
12/19/1994		
12/19/1994		
2/2/1995		
2/2/1995		
2/2/1995		
2/7/1995		
2/7/1995		102.52
2/23/1995		
2/23/1995		
03/14/95		
3/15/1995	122.13	
3/15/1995		
3/15/1995		
3/15/1995		
3/15/1995		52.27
4/20/1995		
4/20/1995		
4/20/1995	127.00	
4/20/1995		
4/20/1995		
4/20/1995		
4/20/1995		79.00
6/1/1995		
6/1/1995		
6/1/1995		
6/1/1995		76.87
06/05/95		
7/21/1995		
7/24/1995	118.00	
8/17/1995		
8/17/1995		
09/19/95		
10/26/1995		
10/26/1995		
11/7/1995		

11/7/1995	117.00	
11/8/1995		
12/05/95		
12/13/1995		
12/14/1995		
12/14/1995		82.41
01/16/96		
1/24/1996		
1/24/1996	129.00	
01/31/96		
2/8/1996		
02/19/96		
2/21/1996		
2/21/1996		
2/26/1996		
03/04/96		
03/13/96		
03/25/96		
04/24/96		
5/21/1996		
5/21/1996		
5/21/1996	162.00	
5/21/1996		
6/4/1996		
6/4/1996		
6/4/1996	162.00	
6/4/1996		
6/4/1996		
6/18/1996		
6/18/1996		
6/18/1996	162.00	
6/18/1996		
6/18/1996		
6/18/1996		
06/24/96		
06/26/96		
7/2/1996		
7/2/1996		
7/2/1996	160.00	
7/2/1996		
7/2/1996		
7/16/1996		
7/16/1996		
7/16/1996	162.00	
7/16/1996		
7/16/1996		
7/17/1996		12.60

8/13/1996		
8/13/1996		
8/13/1996	160.00	
8/13/1996		
8/13/1996		
8/27/1996		
09/12/96		
09/12/96		
12/17/1996		
12/17/1996		
12/17/1996	162.00	
12/17/1996		
12/17/1996		
12/17/1996		
12/17/1996		24.40
12/18/96		
12/18/96		
1/7/1997		
1/7/1997	166.00	
1/8/1997		
1/8/1997		
1/8/1997		
1/21/1997		
1/21/1997		
1/21/1997	166.00	
1/21/1997		
1/21/1997		
2/4/1997		
2/4/1997	166.00	
2/4/1997		
2/6/1997		
2/6/1997		
2/18/1997		
2/18/1997	170.00	
2/27/1997		
2/27/1997		
2/27/1997		
2/27/1997		24.20
2/28/1997		
3/5/1997		
3/5/1997		
3/5/1997	162.00	
3/5/1997		
03/05/97		
03/05/97		
3/6/1997		
3/18/1997		

3/18/1997		
3/18/1997	166.00	
3/18/1997		
3/18/1997		
4/3/1997		
4/3/1997		
4/3/1997	160.00	
4/3/1997		
4/3/1997		
4/15/1997		
4/15/1997		
4/15/1997	168.00	
4/15/1997		
4/15/1997		
4/29/1997		
4/29/1997		
4/29/1997	168.00	
4/29/1997		
4/29/1997		
5/27/1997		
5/27/1997		
5/27/1997	126.00	
5/27/1997		
5/27/1997		
5/27/1997		
06/19/97		
06/19/97		
6/24/1997		
6/24/1997		
6/24/1997	160.00	
6/24/1997		
6/24/1997		
6/24/1997		31.36
7/29/1997		
7/29/1997		
7/29/1997	154.00	
7/29/1997		
7/29/1997		
8/26/1997		
8/26/1997		
8/26/1997	160.00	
8/26/1997		
8/26/1997		
8/26/1997		
09/04/97		
09/04/97		
10/28/1997		

11/17/97		
11/17/97		
11/25/1997		
1/27/1998		
1/27/1998		
03/05/98		
03/05/98		
3/30/1998		
3/30/1998		36.63
05/18/98		
05/18/98		
6/22/1998	144.00	
6/22/1998		
6/22/1998		
6/22/1998		
6/22/1998		52.00
7/14/1998	135.30	
7/14/1998		
7/14/1998		
7/14/1998		
7/14/1998		53.70
7/15/1998		
7/15/1998		
8/26/1998		
8/26/1998		
8/26/1998		
09/18/98		
09/18/98		
9/28/1998	121.30	
9/28/1998		
9/28/1998		
9/28/1998		
9/28/1998		
10/19/1998	130.00	
10/19/1998		
10/19/1998		
10/19/1998		
10/19/1998		
11/05/98		
11/05/98		
11/10/1998		
11/10/1998		
11/18/1998		
11/18/1998		
12/17/1998	139.10	
12/17/1998		
12/17/1998		

12/17/1998		
12/17/1998		
1/28/1999	151.80	
1/28/1999		
1/28/1999		
1/28/1999		
1/29/1999		
2/26/1999		
2/26/1999		
2/26/1999	140.80	
2/26/1999		
2/26/1999		
2/26/1999		
2/26/1999		
03/03/99		
03/03/99		
3/29/1999	122.96	
3/29/1999		
3/29/1999		
3/29/1999		
3/29/1999		
4/27/1999	130.00	
4/27/1999		
4/27/1999		
4/27/1999		
4/27/1999		
5/12/1999		
5/12/1999		
6/9/1999	126.00	
6/9/1999		
6/9/1999		
6/9/1999		
6/10/1999		
06/23/99		
06/23/99		
7/1/1999		
7/1/1999		
7/1/1999	121.00	
7/2/1999		
7/2/1999		
7/27/1999	80.40	
7/27/1999		
7/27/1999		
8/19/1999		
8/20/1999		
8/20/1999		
8/20/1999	99.00	

8/20/1999		
8/20/1999		
9/16/1999	112.00	
9/16/1999		
9/16/1999		
9/16/1999		
09/23/99		
09/23/99		
10/28/1999	94.00	
10/28/1999		
10/28/1999		
10/28/1999		
11/19/1999	88.40	
11/19/1999		
11/19/1999		
11/19/1999		
11/19/99		
11/19/99		
12/20/1999		
12/20/1999		
12/20/1999	104.70	
12/20/1999		
12/20/1999		
12/20/1999		
1/12/2000		
1/12/2000		
1/12/2000		
1/12/2000		
2/1/2000		
2/1/2000	76.33	
2/1/2000		
2/1/2000		
2/1/2000		
03/03/00		
03/03/00		
3/16/2000	74.87	
3/16/2000		
3/16/2000		
3/16/2000		
4/28/2000	68.00	
4/28/2000		
4/28/2000		
4/28/2000		
4/28/2000		12.00
5/25/2000		
5/25/2000		
5/25/2000	66.00	

5/25/2000		
5/25/2000		
5/25/2000		
5/25/2000		15.00
06/06/00		
06/06/00		
6/21/2000	68.00	
6/21/2000		
6/21/2000		
6/21/2000		
6/21/2000		16.00
7/27/2000		
7/27/2000		
7/27/2000	63.00	
7/27/2000		
7/27/2000		
7/27/2000		22.00
08/17/00		
08/17/00		
8/28/2000	65.33	
8/28/2000		
8/28/2000		
8/28/2000		18.09
9/26/2000		
9/26/2000	61.30	
9/26/2000		
9/26/2000		
9/26/2000		
9/26/2000		
10/23/2000	66.30	
10/23/2000		
10/23/2000		
10/23/2000		
10/23/2000		
12/11/00		
12/11/00		
12/26/2000		
12/26/2000	144.00	
12/26/2000		
12/26/2000		
12/26/2000		
12/26/2000		
1/31/2001		
03/07/01		
03/07/01		
3/20/2001		
3/20/2001		

3/20/2001	142.00	
3/20/2001		
3/20/2001		
3/20/2001		
3/20/2001		
5/21/2001	156.00	
5/21/2001		
5/21/2001		
5/21/2001		27.70
6/15/2001		
6/15/2001		
6/15/2001	126.40	
6/15/2001		
6/15/2001		
6/15/2001		
6/15/2001		
06/19/01		
06/19/01		
7/9/2001	136.00	
7/9/2001		
7/9/2001		
7/9/2001		
7/9/2001		
8/10/2001		
8/10/2001		
8/10/2001	137.70	
8/10/2001		
8/10/2001		
8/10/2001		
8/10/2001		
09/04/01		
09/04/01		
9/26/2001	137.00	
9/26/2001		
9/26/2001		
9/26/2001		
9/26/2001		
10/26/2001	135.00	
10/26/2001		
11/21/2001		
11/21/2001		
11/21/2001	136.40	
11/21/2001		
11/21/2001		
11/21/2001		
12/19/01		
12/26/2001	140.70	

12/26/2001		
12/26/2001		
1/23/2002		
1/23/2002		
1/23/2002	102.00	
1/23/2002		
1/23/2002		
02/07/02		
2/25/2002		
2/25/2002		
2/25/2002	147.20	
2/25/2002		
2/25/2002		
03/14/02		
03/14/02		
3/26/2002	112.00	
3/26/2002		
3/26/2002		
4/12/2002		
4/12/2002		
4/12/2002	145.60	
4/12/2002		
4/12/2002		
5/16/2002		
5/16/2002		
5/16/2002	149.20	
5/16/2002		
5/16/2002		
5/16/2002		
5/16/2002		36.50
6/13/2002		
6/13/2002		
6/13/2002	125.00	
6/13/2002		
6/13/2002		
6/13/2002		
07/03/02		
07/03/02		
7/25/2002		
7/25/2002		
7/25/2002	146.00	
7/25/2002		
7/25/2002		
7/25/2002		
8/15/2002		
8/15/2002		
8/15/2002	130.00	

8/15/2002		
8/15/2002		
8/15/2002		
9/28/2002	146.00	
9/28/2002		
9/28/2002		
9/30/2002		
09/30/02		
09/30/02		
10/18/2002	128.00	
10/18/2002		
10/18/2002		
10/18/2002		
11/29/2002		
11/29/2002		
11/29/2002	147.00	
11/29/2002		
11/29/2002		
11/29/2002		
12/13/02		
12/13/02		
1/9/2003		
1/9/2003		
1/9/2003	147.00	
1/9/2003		
1/9/2003		
1/9/2003		
1/9/2003		
02/25/03		
02/25/03		
3/18/2003		
3/18/2003		
3/18/2003	134.70	
3/18/2003		
3/18/2003		
3/18/2003		
3/18/2003		
04/30/03		
04/30/03		
5/14/2003		
5/14/2003		
5/14/2003	115.00	
5/14/2003		
5/14/2003		
5/14/2003		
5/14/2003		
07/21/03		

07/21/03		
8/20/2003	111.00	
8/21/2003		
8/21/2003		
8/21/2003		
8/21/2003		
8/21/2003		
8/21/2003		
10/10/03		
10/13/03		
11/10/2003	123.00	
11/11/2003		
11/11/2003		
11/11/2003		
11/11/2003		
11/11/2003		
11/11/2003		
02/02/04		
02/02/04		
2/17/2004		
2/17/2004		
2/17/2004	134.00	
2/17/2004		
2/18/2004		
2/18/2004		
2/18/2004		
5/11/2004		
5/11/2004		
5/11/2004		
5/11/2004		
5/11/2004		
5/11/2004		
5/12/2004	113.00	
05/25/04		
05/25/04		
07/22/04		
07/22/04		
8/11/2004		
8/11/2004		
8/11/2004		
8/11/2004		
8/11/2004		33.50
8/16/2004	109.00	
8/16/2004		
11/2/2004		
11/2/2004		
11/2/2004	110.00	

11/2/2004		
11/2/2004		
11/2/2004		
11/2/2004		30.5
11/18/04		
11/18/04		
2/18/2005		
2/18/2005		
2/18/2005		
2/18/2005		
2/18/2005		
2/18/2005		35.6
2/25/2005	105.00	
02/28/05		
02/28/05		
5/6/2005		
5/6/2005		
5/6/2005	136.60	
5/6/2005		
5/6/2005		
5/6/2005		
5/6/2005		36.70
05/12/05		
05/13/05		
7/6/2005		
7/6/2005	109.00	
7/25/2005		
7/25/2005		
7/25/2005		
7/25/2005		
7/25/2005		34.20
09/28/05		
09/28/05		
11/30/2005		
11/30/2005	111.00	
12/27/05		
12/27/05		
12/30/2005		
12/30/2005		
12/30/2005		
12/30/2005		
12/30/2005		36.30
3/1/2006	109.00	
03/20/06		
03/20/06		
3/27/2006		
3/27/2006		

3/27/2006		
3/27/2006		
3/27/2006		36.00
6/21/2006		
6/21/2006		
06/21/06		
06/21/06		
6/21/2006		38.80
6/22/2006	126.70	
6/23/2006		
7/6/2006		
7/6/2006		
09/12/06		
09/12/06		
9/26/2006		
9/26/2006		41.80
9/28/2006		
9/28/2006		
9/28/2006		
9/28/2006		
10/4/2006	108.70	

Ellengowan
Fig 5.41 Aluminum

Date	Packer V	MW1	MW2	MW3	MW4	Gilberton	MP008
12/08/94						0.73	
12/19/94							
12/19/94							
03/14/95						0.81	
06/01/95		0.00					
06/01/95			7.58				
06/01/95				7.28			
06/01/95					7.35		
06/05/95						16.12	
09/19/95						0.81	
11/07/95							
11/07/95	0.23						
11/08/95							
12/05/95						1.26	
01/16/96							0.28
01/31/96							0.17
02/19/96							0.20
03/04/96							0.00
03/13/96							0.22
03/25/96						0.57	
04/24/96							0.10
06/18/96							
06/18/96							
06/18/96	0.00						
06/24/96						1.60	
06/26/96							0.20
07/02/96							
07/02/96							
07/02/96	0.00						
07/16/96							
07/16/96							
07/16/96	0.00						
07/16/96			1.04				
07/16/96				3.41			
08/13/96							
08/13/96							
08/13/96	0.29						
09/12/96						0.47	
09/12/96							0.00
10/22/96							
10/22/96							
10/22/96	0.16						

10/22/96			1.74				
10/22/96				7.38			
12/17/96		0.12					
12/17/96					0.13		
12/18/96						0.97	
12/18/96							0.97
03/05/97						0.23	
03/05/97							12.80
06/19/97						0.60	
06/19/97							7.84
09/04/97						0.78	
09/04/97							11.00
10/28/97							
10/28/97							
10/28/97			0.00				
10/29/97	0.00						
11/17/97						0.80	
11/17/97							11.30
11/05/98						0.72	
11/05/98							0.26
11/18/98							
11/18/98							
11/19/98	0.00						
12/17/98				3.91			
03/03/99						0.63	
03/03/99							0.22
06/23/99						0.00	
06/23/99							0.00
09/23/99						1.02	
09/23/99							0.11
11/19/99						0.82	
11/19/99							0.40
12/20/99							
12/20/99							
12/20/99	0.34						
12/20/99		6.39					
12/20/99							
12/20/99				1.10			
03/03/00						0.95	
03/03/00							0.50
06/06/00						0.64	
06/06/00							0.20
08/17/00						1.23	
08/17/00							0.88
12/11/00						0.52	
12/11/00							0.11
12/26/00							

12/26/00	0.12						
12/26/00		0.22					
12/26/00			0.54				
12/26/00				0.67			
01/31/01							
03/07/01						0.40	
03/07/01							0.10
06/19/01						0.73	
06/19/01							<0.1
09/04/01						0.58	
09/04/01							<0.26
11/21/01							
11/21/01							
11/21/01	<0.1						
11/21/01				1.09			
12/19/01						0.30	
02/07/02							0.22
03/14/02						0.42	
03/14/02							0.05
07/03/02						0.67	
07/03/02							0.40
09/30/02						1.70	
09/30/02							1.61
12/13/02						4.53	
12/13/02							0.44
01/09/03							
01/09/03							
01/09/03	<0.02						
01/09/03		0.22					
01/09/03			0.47				
01/09/03				0.22			
02/25/03						0.83	
02/25/03							1.85
04/30/03						0.51	
04/30/03							0.77
07/21/03						0.60	
07/21/03							0.95
10/10/03						0.57	
10/13/03							7.69
11/10/03	<0.02						
11/11/03		0.06					
11/11/03			0.05				
11/11/03				0.07			
02/02/04						0.46	
02/02/04							7.94
05/25/04						0.45	
05/25/04							5.43

07/22/04						0.45	
07/22/04							3.50
11/02/04							
11/02/04							
11/02/04	<0.020						
11/02/04		0.38					
11/02/04			0.05				
11/02/04				0.25			
11/02/04					0.03		
11/18/04						3.12	
11/18/04							4.07
02/28/05						0.61	
02/28/05							4.58
05/12/05							1.94
05/13/05						0.63	
09/28/05						0.59	
09/28/05							0.54
11/30/05							
11/30/05	0.05						
12/27/05						0.08	
12/27/05							2.16
03/20/06						0.57	
03/20/06							1.16
06/21/06							
06/21/06		<0.050					
06/21/06					0.46		
06/21/06						0.43	
06/21/06							0.22
06/22/06	0.36						
06/23/06							
07/06/06			0.29				
07/06/06				0.16			
09/12/06						0.52	
09/12/06							0.47
09/26/06				6.04			
09/26/06					0.80		
09/28/06							
09/28/06							
09/28/06		0.34					
09/28/06			0.36				

Ellengowan
Fig 5.42 Zinc

Date	Maple Hill	Holes South	Packer V	MW1	MW2	MW3	MW4	Gilberton
12/08/94								0.19
12/19/94	0.46							
12/19/94		3.16						
03/14/95								0.23
06/01/95				0.02				
06/01/95					0.20			
06/01/95						0.24		
06/01/95							0.21	
06/05/95								1.82
09/19/95								0.23
11/07/95	0.64							
11/07/95			0.01					
11/08/95		1.85						
12/05/95								0.24
01/16/96								
01/31/96								
02/19/96								
03/04/96								
03/13/96								
03/25/96								0.24
04/24/96								
06/18/96	0.46							
06/18/96		1.12						
06/18/96			0.02					
06/24/96								0.39
06/26/96								
07/02/96	0.50							
07/02/96		0.15						
07/02/96			0.06					
07/16/96	1.11							
07/16/96		0.12						
07/16/96			0.30					
07/16/96					0.47			
07/16/96						0.67		
08/13/96	1.36							
08/13/96		0.33						
08/13/96			0.13					
09/12/96								0.28
09/12/96								
10/22/96	0.24							
10/22/96		0.32						

10/22/96			0.00					
10/22/96					0.51			
10/22/96						0.34		
12/17/96				0.03				
12/17/96							0.03	
12/18/96								0.20
12/18/96								
03/05/97								0.22
03/05/97								
06/19/97								0.22
06/19/97								
09/04/97								0.20
09/04/97								
10/28/97	0.50							
10/28/97		52.00						
10/28/97					0.12			
10/29/97			0.00					
11/17/97								0.22
11/17/97								
11/05/98								0.17
11/05/98								
11/18/98	0.31							
11/18/98		0.13						
11/19/98			0.00					
12/17/98						0.23		
03/03/99								0.18
03/03/99								
06/23/99								0.29
06/23/99								
09/23/99								0.23
09/23/99								
11/19/99								0.20
11/19/99								
12/20/99	1.57							
12/20/99		1.17						
12/20/99			0.02					
12/20/99				0.64				
12/20/99								
12/20/99						0.09		
03/03/00								0.21
03/03/00								
06/06/00								0.20
06/06/00								
08/17/00								0.19
08/17/00								
12/11/00								0.18
12/11/00								

12/26/00		0.20						
12/26/00			<0.005					
12/26/00				0.12				
12/26/00					0.53			
12/26/00						0.13		
01/31/01	0.63							
03/07/01								0.25
03/07/01								
06/19/01								0.36
06/19/01								
09/04/01								0.11
09/04/01								
11/21/01	0.84							
11/21/01		0.81						
11/21/01			<0.005					
11/21/01						0.29		
12/19/01								0.17
02/07/02								
03/14/02								0.17
03/14/02								
07/03/02								0.20
07/03/02								
09/30/02								0.46
09/30/02								
12/13/02								0.01
12/13/02								
01/09/03	0.63							
01/09/03		0.65						
01/09/03			0.01					
01/09/03				0.32				
01/09/03					0.05			
01/09/03						0.13		
02/25/03								0.30
02/25/03								
04/30/03								0.15
04/30/03								
07/21/03								0.19
07/21/03								
10/10/03								0.20
10/13/03								
11/10/03			< 0.005					
11/11/03				0.14				
11/11/03					0.15			
11/11/03						0.26		
02/02/04								0.20
02/02/04								
05/25/04								0.18

05/25/04								
07/22/04								0.18
07/22/04								
11/02/04	0.26							
11/02/04		5.56						
11/02/04			0.01					
11/02/04				0.45				
11/02/04					0.12			
11/02/04						0.62		
11/02/04							0.18	
11/18/04								0.46
11/18/04								
02/28/05								0.118
02/28/05								
05/12/05								
05/13/05								0.153
09/28/05								0.235
09/28/05								
11/30/05	0.24							
11/30/05			<0.005					
12/27/05								0.128
12/27/05								
03/20/06								0.138
03/20/06								
03/27/06		0.77						
06/21/06				<0.050				
06/21/06							0.77	
06/21/06								0.111
06/21/06								
06/23/06	0.26							
07/06/06					0.12			
07/06/06						<0.050		
09/12/06								0.21
09/12/06								
09/26/06						2.62		
09/26/06							1.29	
09/28/06	0.41							
09/28/06		30.90						
09/28/06				0.08				
09/28/06					0.06			

MP008
0.12
0.04
0.07
0.04
0.05
0.03
0.09
0.07

0.09
0.56
0.43
0.25
0.27
0.00
0.06
0.13
0.06
0.09
0.29
0.09
0.08
0.13

0.21
0.12
0.04
0.05
0.05
0.03
0.10
0.07
0.10
0.09
0.10
0.27
0.18

0.19
0.16
0.15
0.24
0.13
0.09
0.15
0.14
<0.050
0.10

Ellengowan
Fig 5.43 Nickel

Date	Gilberton	MP008	Holes South	Maple Hill	Packer V	MW1	MW2	MW3
12/08/94	0.11							
12/19/94			0.41					
12/19/94				0.51				
03/14/95	0.19							
06/01/95						0.00		
06/01/95							0.00	
06/01/95								0.00
06/01/95								
06/05/95	0.18							
09/19/95	0.11							
11/07/95				0.17				
11/07/95					0.08			
11/08/95			0.23					
12/05/95	0.15							
01/16/96		0.05						
01/31/96		0.06						
02/19/96		0.00						
03/04/96		0.00						
03/13/96		0.00						
03/25/96	0.11							
04/24/96		0.00						
06/18/96			0.42					
06/18/96				0.12				
06/18/96					0.07			
06/24/96	0.16							
06/26/96		0.07						
07/02/96			0.00					
07/02/96				0.25				
07/02/96					0.07			
07/16/96			0.00					
07/16/96				0.33				
07/16/96					0.09			
07/16/96							0.07	
07/16/96								0.07
08/13/96			0.03					
08/13/96				0.32				
08/13/96					0.06			
09/12/96	0.13							
09/12/96		0.04						
10/22/96			0.00					
10/22/96				0.14				

10/22/96					0.00			
10/22/96							0.00	
10/22/96								0.00
12/17/96						0.00		
12/17/96								
12/18/96	0.11							
12/18/96		0.00						
03/05/97	0.10							
03/05/97		0.06						
06/19/97	0.14							
06/19/97		0.14						
09/04/97	0.10							
09/04/97		0.06						
10/28/97			2.79					
10/28/97				0.21				
10/28/97							0.00	
10/29/97					0.04			
11/17/97	0.13							
11/17/97		0.08						
11/05/98	0.08							
11/05/98		0.00						
11/18/98			0.00					
11/18/98				0.21				
11/19/98					0.04			
12/17/98								0.09
03/03/99	0.12							
03/03/99		<0.04						
06/23/99	0.18							
06/23/99		<0.04						
09/23/99	0.16							
09/23/99		<0.04						
11/19/99	0.16							
11/19/99		<0.04						
12/20/99			0.33					
12/20/99				0.00				
12/20/99					0.11			
12/20/99						0.10		
12/20/99								
12/20/99								0.06
03/03/00	0.15							
03/03/00		<0.04						
06/06/00	0.10							
06/06/00		<0.04						
08/17/00	0.10							
08/17/00		<0.04						
12/11/00	0.15							
12/11/00		<0.04						

12/26/00			<0.04					
12/26/00					0.06			
12/26/00						<0.04		
12/26/00							0.08	
12/26/00								<0.04
01/31/01				0.06				
03/07/01	0.21							
03/07/01		0.04						
06/19/01	0.13							
06/19/01		<0.04						
09/04/01	0.15							
09/04/01		0.04						
11/21/01			<0.05					
11/21/01				<0.04				
11/21/01					<0.04			
11/21/01								<0.04
12/19/01	0.10							
02/07/02		0.01						
03/14/02	0.10							
03/14/02		0.01						
07/03/02	0.11							
07/03/02		<0.01						
09/30/02	0.11							
09/30/02		0.04						
12/13/02	0.11							
12/13/02		0.01						
01/09/03			0.10					
01/09/03				0.10				
01/09/03					0.04			
01/09/03						0.02		
01/09/03							<0.010	
01/09/03								0.01
02/25/03	0.10							
02/25/03		0.03						
04/30/03	0.09							
04/30/03		0.03						
07/21/03	0.10							
07/21/03		0.04						
10/10/03	0.15							
10/13/03		0.11						
11/10/03					0.05			
11/11/03						0.01		
11/11/03							0.02	
11/11/03								0.05
02/02/04	0.19							
02/02/04		0.07						
05/25/04	0.10							

05/25/04		0.05						
07/22/04	0.10							
07/22/04		0.08						
11/2/2004			0.20					
11/2/2004				0.19				
11/2/2004					0.08			
11/2/2004						0.06		
11/2/2004							0.04	
11/2/2004								0.06
11/2/2004								
11/18/2004	0.13							
11/18/2004		0.08						
2/28/2005	0.07							
2/28/2005		0.04						
5/12/2005		0.09						
5/13/2005	0.12							
9/28/2005	0.10							
9/28/2005		0.03						
11/30/2005				0.14				
11/30/2005					0.04			
12/27/2005	0.09							
12/27/2005		0.06						
3/20/2006	0.06							
3/20/2006		0.03						
3/27/2006			0.07					
6/21/2006	0.06							
6/21/2006		<0.020						
6/21/2006			0.08					
6/21/2006						<0.020		
6/21/2006								
6/23/2006				0.14				
7/6/2006							0.02	
7/6/2006								<0.020
9/12/2006	0.08							
9/12/2006		0.04						
9/26/2006								0.10
9/26/2006								
9/28/2006			1.02					
9/28/2006				<0.020				
9/28/2006						<0.020		
9/28/2006							<0.020	

MW4
0.00

0.00

0.039
<0.020
0.022

Ellengowan
Fig 5.44 Lead

Date	MW1	MW2	MW3	MW4	Packer V	Maple Hill	Holes South	Gilberton
12/08/94								0.00
12/19/94						0.00	0.33	
03/14/95								0.00
06/01/95	0.00							
06/01/95		0.00						
06/01/95			0.00					
06/01/95				0.00				
06/05/95								0.00
09/19/95								0.00
11/07/95						0.00	0.00	
11/07/95					0.00			
12/05/95								0.00
01/16/96								
01/31/96								
02/19/96								
03/04/96								
03/13/96								
03/25/96								0.00
04/24/96								
06/18/96						0.00	0.02	
06/18/96					0.00			
06/24/96								0.00
06/26/96								
07/02/96						0.00	0.01	
07/02/96					0.00			
07/16/96						0.00	0.00	
07/16/96					0.00			
07/16/96		0.00						
07/16/96			0.01					
08/13/96						0.01	0.01	
08/13/96					0.00			
09/12/96								0.00
09/12/96								
10/22/96						0.00	0.00	
10/22/96					0.00			
10/22/96		0.00						
10/22/96			0.00					
12/17/96	0.00							
12/17/96				0.00				
12/18/96								0.00
12/18/96								

03/05/97								0.00
03/05/97								
06/19/97								0.00
06/19/97								
09/04/97								0.00
09/04/97								
10/28/97						0.00	0.00	
10/28/97		0.00						
10/29/97					0.00			
11/17/97								0.00
11/17/97								
11/05/98								0.00
11/05/98								
11/18/98						0.18	0.13	
11/19/98					0.12			
12/17/98			0.00					
03/03/99								0.12
03/03/99								
06/23/99								0.16
06/23/99								
09/23/99								<0.1
09/23/99								
11/19/99								<0.1
11/19/99								
12/20/99						0.00	0.00	
12/20/99					0.00			
12/20/99	0.00							
12/20/99								
12/20/99			0.00					
03/03/00								<0.1
03/03/00								
06/06/00								<0.1
06/06/00								
08/17/00								<0.1
08/17/00								
12/11/00								<0.1
12/11/00								
12/26/00							<0.1	
12/26/00					<0.1			
12/26/00	<0.1							
12/26/00		<0.1						
12/26/00			<0.1					
01/31/01						<0.1		
03/07/01								<0.1
03/07/01								
06/19/01								<0.1
06/19/01								

09/04/01								0.15
09/04/01								
11/21/01						<0.1	0.40	
11/21/01					<0.1			
11/21/01			<0.1					
12/19/01								<0.05
02/07/02								
03/14/02								<0.05
03/14/02								
07/03/02								<0.05
07/03/02								
09/30/02								<0.05
09/30/02								
12/13/02								<0.025
12/13/02								
01/09/03						<0.025	<0.025	
01/09/03					<0.025			
01/09/03	<0.025							
01/09/03		<0.025						
01/09/03			<0.025					
02/25/03								<0.025
02/25/03								
04/30/03								<0.025
04/30/03								
07/21/03								0.01
07/21/03								
10/10/03								0.01
10/13/03								
11/10/03					<0.001			
11/11/03	0.03							
11/11/03		0.06						
11/11/03			0.00					
02/02/04								<0.05
02/02/04								
05/25/04								<0.05
05/25/04								
07/22/04								<0.05
07/22/04								
11/02/04						<0.05	<0.05	
11/02/04					<0.05			
11/02/04	<0.05							
11/02/04		<0.05						
11/02/04			<0.05					
11/02/04				<0.05				
11/18/04								0.07
11/18/04								
02/28/05								<0.05

02/28/05								
05/12/05								
05/13/05								<0.05
09/28/05								<0.05
09/28/05								
11/30/05						0.09		
11/30/05					0.06			
12/27/05								<0.009
12/27/05								
03/20/06								<0.009
03/20/06								
06/21/06							<0.050	
06/21/06	<0.050							
06/21/06				<0.050				
06/21/06								0.08
06/21/06								
06/23/06						<0.05		
07/06/06		<0.050						
07/06/06			<0.050					
09/12/06								<0.050
09/12/06								
09/26/06			0.53					
09/26/06				0.43				
09/28/06						<0.050	0.21	
09/28/06	0.05							
09/28/06		0.08						

MP008
0.00
0.00
0.00
0.00
0.00
0.10
0.00
0.00
0.00

0.00
0.00
0.00
0.00
0.00
<0.1
0.18
<0.1
<0.1
<0.1
<0.1
<0.1
<0.1
<0.1
<0.1

0.58
<0.5
<0.05
<0.05
<0.05
<0.025
<0.025
<0.025
0.01
0.01
<0.05
<0.05
<0.05
<0.05

<0.05
<0.05
<0.05
<0.009
<0.009
0.08
<0.050

Ellengowan
Fig 5.45 Cadmium

Date	MW1	MW2	MW3	MW4	Packer V	Maple Hill	Holes South	Gilberton
12/08/94								0.00
12/19/94						0.00	0.00	
03/14/95								0.00
06/01/95								
06/01/95	0.00							
06/01/95		0.00						
06/01/95			0.00					
06/01/95				0.00				
06/05/95								0.00
09/19/95								0.00
11/07/95						0.00	0.00	
11/07/95					0.00			
12/05/95								0.00
01/16/96								
01/31/96								
02/19/96								
03/04/96								
03/13/96								
03/25/96								0.00
04/24/96								
06/18/96						0.00	0.00	
06/18/96					0.00			
06/24/96								0.00
06/26/96								
07/02/96						0.00	0.00	
07/02/96					0.00			
07/16/96						0.00	0.00	
07/16/96		0.00						
07/16/96			0.00					
07/16/96					0.00			
08/13/96						0.00	0.00	
08/13/96					0.00			
09/12/96								0.01
09/12/96								
10/22/96						0.00	0.00	
10/22/96		0.00						
10/22/96			0.05					
10/22/96					0.00			
12/17/96								
12/17/96	0.00							
12/17/96				0.00				

12/18/96								0.00
12/18/96								
03/05/97								0.00
03/05/97								
06/19/97								0.00
06/19/97								
09/04/97								0.01
09/04/97								
10/28/97								
10/29/97								
11/17/97								0.00
11/17/97								
11/05/98								0.00
11/05/98								
11/18/98						0.00	0.01	
11/19/98					0.00			
12/17/98			0.00					
03/03/99								<0.005
03/03/99								
06/23/99								0.02
06/23/99								
09/23/99								<0.005
09/23/99								
11/19/99								0.02
11/19/99								
12/20/99						0.01	0.01	
12/20/99	0.03							
12/20/99			0.01					
12/20/99					0.01			
03/03/00								<0.005
03/03/00								
06/06/00								<0.005
06/06/00								
08/17/00								<0.005
08/17/00								
12/11/00								<0.005
12/11/00								
12/26/00							0.01	
12/26/00	0.01							
12/26/00		0.01						
12/26/00			0.01					
12/26/00					0.01			
01/31/01						<0.01		
03/07/01								<0.005
03/07/01								
06/19/01								<0.005
06/19/01								

09/04/01								<0.005
09/04/01								
11/21/01						<0.01	0.07	
11/21/01			0.01					
11/21/01					<0.005			
12/19/01								<0.005
02/07/02								
03/14/02								0.01
03/14/02								
07/03/02								0.01
07/03/02								
09/30/02								0.01
09/30/02								
12/13/02								<0.005
12/13/02								
01/09/03						<0.01	<0.01	
01/09/03	<0.005							
01/09/03		<0.005						
01/09/03			0.01					
01/09/03					<0.005			
02/25/03								<0.005
02/25/03								
04/30/03								<0.01
04/30/03								
07/21/03								<0.01
07/21/03								
10/10/03								<0.01
10/13/03								
11/10/03					<0.005			
11/11/03	<0.005							
11/11/03		<0.005						
11/11/03			<0.005					
02/02/04								<0.005
02/02/04								
05/25/04								<0.005
05/25/04								
07/22/04								<0.005
07/22/04								
11/02/04						<0.005	0.01	
11/02/04	<0.005							
11/02/04		<0.005						
11/02/04			0.01					
11/02/04				<0.005				
11/02/04					<0.005			
11/18/2004								<0.005
11/18/2004								
2/28/2005								<0.005

2/28/2005								
5/12/2005								
5/13/2005								<0.005
9/28/2005								<0.005
9/28/2005								
11/30/05						<0.005		
11/30/05					<0.005			
12/27/2005								<0.005
12/27/2005								
3/20/2006								<0.005
3/20/2006								
06/21/06							<0.005	
06/21/06	<0.005							
06/21/06				0.01				
6/21/2006								<0.005
6/21/2006								
06/23/06						<0.005		
07/06/06		<0.005						
07/06/06			<0.005					
9/12/2006								<0.005
9/12/2006								
09/26/06			0.03					
09/26/06				0.02				
09/28/06						<0.005	0.03	
09/28/06	<0.005							
09/28/06		<0.005						

MP008
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00

0.00
0.00
0.00
0.01
0.00
0.00
0.02
0.03
0.01
0.02
<0.005
<0.005
<0.005
<0.005
<0.005
<0.005

<0.005
<0.005
<0.005
<0.005
0.01
<0.005
<0.005
<0.005
<0.01
0.01
<0.005
<0.005
<0.005
<0.005

<0.005
<0.005
<0.005
<0.005
<0.005
<0.005
<0.005

Ellengowan
Fig 5.46 Calcium

Date	Maple Hill	Holes South	Packer V	MW1	MW2	MW3	MW4	Gilberton
12/08/94								126.25
12/19/94	181.56	95.19						
03/14/95								138.68
06/01/95								
06/01/95				9.26	138.3	105.8		
06/01/95							112.70	
06/05/95								154.51
09/19/95								150.00
11/07/95	180.00							
11/07/95			190.00					
11/08/95		260.00						
12/05/95								130.00
01/16/96								
01/31/96								
02/19/96								
03/04/96								
03/13/96								
03/25/96								160.00
04/24/96								
06/18/96	197.00	134.00						
06/18/96			232.00					
06/24/96								140.00
07/02/96	226.00	108.00						
07/02/96			179.00					
07/16/96	244.00	127.00						
07/16/96			182.00					
07/16/96					70.8	87.2		
08/13/96	230.00	119.00						
08/13/96			172.00					
09/12/96								140.00
10/22/96	160.00	120.00						
10/22/96			170.00					
10/22/96					97	70		
12/17/96								
12/17/96				6.8				
12/17/96							14.00	
12/18/96								125.20
03/05/97								122.00
06/19/97								118.00
09/04/97								122.00
10/28/97	205.00	148.00						

10/28/97					53			
10/29/97			0.00					
11/17/97								141.00
11/05/98								143.00
11/18/98	200.00	99.00						
11/19/98			146.00					
12/17/98						81		
03/03/99								137.00
06/23/99								129.00
09/23/99								130.50
11/19/99								120.00
12/20/99	29.90	81.10						
12/20/99			137.00					
12/20/99				42.7		55.5		
03/03/00								126.70
06/06/00								119.00
08/17/00								120.00
12/11/00								143.00
12/26/00		49.00						
12/26/00			160.00					
12/26/00				9	33	15		
01/31/01	6.40							
03/07/01								100.00
06/19/01								146.00
09/04/01								134.00
11/21/01	3.65	27.00						
11/21/01			125.00					
11/21/01						31.7		
12/19/01								111.00
02/07/02								
03/14/02								96.30
07/03/02								127.00
09/30/02								126.00
12/13/02								116.00
01/09/03	89.00	90.60						
01/09/03			142.00					
01/09/03				6.58	31.9	134		
02/25/03								102.00
04/30/03								107.00
07/21/03								118.00
10/10/03								111.00
10/13/03								
11/10/03			123.00					
11/11/03				4.63	19.7	104		
02/02/04								117.00
05/25/04								114.00
07/22/04								134.00

11/02/04	165.30	85.60						
11/2/2004			138.40					
11/2/2004				7.01	26.1	133.7		
11/2/2004							7.49	
11/18/2004								120.40
2/28/2005								109.00
5/12/2005								
5/13/2005								106.60
9/28/2005								122.20
11/30/05	166.50							
11/30/2005			130.30					
12/27/2005								110.00
3/20/2006								108.90
06/21/06		73.90						
6/21/2006				5.16				
6/21/2006							6.24	
6/21/2006								151.60
06/23/06	156.60							
7/6/2006					113.8	90.3		
9/12/2006								109.80
9/26/2006						102.2		
9/26/2006							7.38	
09/28/06	4.08	68.10						
9/28/2006				4.91	43.9			

MP008
70.00
26.00
33.00
57.00
26.00
26.50
30.00
20.00
39.30
40.00
37.00
37.00

40.00
8.70
11.00
7.00
8.70
7.00
11.30
12.00
14.00
0.50
6.06
12.50
5.24
7.79
6.65
10.60
41.80
25.00
31.70
36.20
41.40
60.60
69.80
68.10
74.20

72.20
66.50
65.08
31.00
71.90
70.20
21.90
66.00

Ellengowan
Fig 5.47 Magnesium

Date	Maple Hill	Holes South	Packer V	MW1	MW2	MW3	MW4	Gilberton
12/08/94								67.00
12/19/94	95.40							
12/19/94		70.80						
03/14/95								68.20
06/01/95				6.70				
06/01/95					105.00			
06/01/95						43.20		
06/01/95							77.90	
06/05/95								78.10
09/19/95								61.30
11/07/95	54.00							
11/07/95			78.00					
11/08/95		73.30						
12/05/95								67.40
01/16/96								
01/31/96								
02/19/96								
03/04/96								
03/13/96								
03/25/96								79.00
04/24/96								
06/18/96	85.90							
06/18/96		37.50						
06/18/96			115.00					
06/24/96								72.10
06/26/96								
07/02/96	90.30							
07/02/96		29.30						
07/02/96			85.50					
07/16/96	114.00							
07/16/96		34.30						
07/16/96			103.00					
07/16/96					50.90			
07/16/96						75.70		
08/13/96	88.50							
08/13/96		31.60						
08/13/96			80.10					
09/12/96								69.00
09/12/96								
10/22/96	68.80							
10/22/96		24.90						

10/22/96			76.30					
10/22/96					64.00			
10/22/96						69.60		
12/17/96				1.60				
12/17/96							3.70	
12/18/96								60.00
12/18/96								
03/05/97								67.80
03/05/97								
06/19/97								67.00
06/19/97								
09/04/97								66.00
09/04/97								
10/28/97	83.30							
10/28/97		78.20						
10/28/97					40.70			
10/29/97			79.50					
11/17/97								68.90
11/17/97								
11/05/98								74.00
11/05/98								
11/18/98	127.00							
11/18/98		24.40						
11/19/98			97.20					
12/17/98						61.50		
03/03/99								66.60
03/03/99								
06/23/99								64.30
06/23/99								
09/23/99								63.20
09/23/99								
11/19/99								75.00
11/19/99								
12/20/99	1.12							
12/20/99		27.10						
12/20/99			61.10					
12/20/99				5.45				
12/20/99								
12/20/99						49.20		
03/03/00								72.60
03/03/00								
06/06/00								80.70
06/06/00								
08/17/00								69.50
08/17/00								
12/11/00								77.00
12/11/00								

12/26/00		12.50						
12/26/00			82.60					
12/26/00				4.44				
12/26/00					250.00			
12/26/00						47.80		
01/31/01	0.73							
03/07/01								43.00
03/07/01								
06/19/01								67.70
06/19/01								
09/04/01								94.00
09/04/01								
11/21/01	0.78							
11/21/01		4.73						
11/21/01			75.80					
11/21/01						84.10		
12/19/01								62.30
02/07/02								
03/14/02								63.40
03/14/02								
07/03/02								110.00
07/03/02								
09/30/02								67.50
09/30/02								
12/13/02								63.50
12/13/02								
01/09/03	38.80							
01/09/03		38.80						
01/09/03			75.80					
01/09/03				2.62				
01/09/03					93.40			
01/09/03						189.00		
02/25/03								61.60
02/25/03								
04/30/03								59.50
04/30/03								
07/21/03								66.50
07/21/03								
10/10/03								60.30
10/13/03								
11/10/03			81.50					
11/11/03				1.95				
11/11/03					66.70			
11/11/03						40.50		
02/02/04								64.30
02/02/04								
05/25/04								62.20

05/25/04								
07/22/04								70.60
07/22/04								
11/02/04	83.00							
11/02/04		69.70						
11/02/04			78.70					
11/02/04				2.95				
11/02/04					74.40			
11/02/04						47.20		
11/02/04							4.00	
11/18/04								68.40
11/18/04								
02/28/05								57.40
02/28/05								
05/12/05								
05/13/05								50.80
09/28/05								65.60
09/28/05								
11/30/05	79.70							
11/30/05			73.50					
12/27/05								63.40
12/27/05								
03/20/06								59.80
03/20/06								
06/21/06		60.30						
06/21/06				1.87				
06/21/06							4.00	
06/21/06								66.90
06/21/06								
06/23/06	76.50							
07/06/06					31.10			
07/06/06						49.20		
09/12/06								53.20
09/12/06								
09/26/06						37.80		
09/26/06							4.20	
09/28/06	0.52							
09/28/06		64.90						
09/28/06				1.97				
09/28/06					45.70			

MP008
40.90
35.10
29.80
29.60
26.00
24.90
27.70
28.20

30.10
33.90
41.00
38.20
38.00
8.12
7.27
8.80
8.01
10.40
11.60
10.90
14.30
5.99

5.28
8.41
4.00
7.57
0.10
9.69
33.50
20.20
32.00
30.30
33.90
49.00
53.90

52.20
55.70
55.80
48.10
41.92
24.80
56.00
51.60
18.60
42.90

Ellengowan
Fig 5.48 Sodium

Date	Maple Hill	Holes South	Packer V	MW1	MW2	MW3	MW4	Gilberton
10/24/1994				1.10				
10/24/1994					42.00			
10/24/1994						102.00		
10/24/1994							2.80	
12/08/94								8.10
12/14/1994				0.70				
12/14/1994						52.00		
12/19/1994	45.00							
12/19/1994		3.00						
2/2/1995								
2/2/1995				0.80				
2/2/1995						22.20		
2/7/1995					3.40			
2/7/1995							1.70	
2/23/1995				0.30				
2/23/1995						16.10		
03/14/95								11.10
3/15/1995								
3/15/1995				1.50				
3/15/1995					4.60			
3/15/1995						27.00		
3/15/1995							2.60	
4/20/1995	57.90							
4/20/1995		2.80						
4/20/1995			8.60					
4/20/1995				0.90				
4/20/1995					4.40			
4/20/1995						26.80		
4/20/1995							3.90	
6/1/1995				0.80				
6/1/1995					2.50			
6/1/1995						25.10		
6/1/1995							2.80	
06/05/95								12.80
7/21/1995								
7/24/1995			8.79					
8/17/1995	64.70							
8/17/1995		2.79						
09/19/95								12.10
10/26/1995				2.10				
10/26/1995						29.00		

11/7/1995	25.10							
11/7/1995			10.00					
11/8/1995		7.80						
12/05/95								12.10
12/13/1995					3.40			
12/14/1995					6.80			
12/14/1995							3.00	
01/16/96								
1/24/1996	6.60							
1/24/1996			7.80					
01/31/96								
2/8/1996		5.00						
02/19/96								
2/21/1996				2.10				
2/21/1996					2.40			
2/26/1996						10.50		
03/04/96								
03/13/96								
03/25/96								13.80
04/24/96								
5/21/1996	10.80							
5/21/1996		13.10						
5/21/1996			9.36					
5/21/1996						11.80		
6/4/1996	9.19							
6/4/1996		11.10						
6/4/1996			11.10					
6/4/1996					1.97			
6/4/1996						9.23		
6/18/1996	15.70							
6/18/1996		10.20						
6/18/1996			10.40					
6/18/1996				0.70				
6/18/1996					1.66			
6/18/1996						7.44		
06/24/96								14.00
06/26/96								
7/2/1996	156.00							
7/2/1996		12.10						
7/2/1996			10.30					
7/2/1996					1.79			
7/2/1996						8.92		
7/16/1996	72.80							
7/16/1996		11.90						
7/16/1996			11.00					
7/16/1996					1.73			
7/16/1996						9.61		

7/17/1996							1.20	
8/13/1996	68.80							
8/13/1996		11.90						
8/13/1996			9.48					
8/13/1996					1.66			
8/13/1996						8.65		
8/27/1996				0.70				
09/12/96								9.30
09/12/96								
12/17/1996	7.36							
12/17/1996		11.60						
12/17/1996			11.00					
12/17/1996				1.10				
12/17/1996					1.97			
12/17/1996						5.90		
12/17/1996							2.30	
12/18/96								8.90
12/18/96								
1/7/1997		10.10						
1/7/1997			15.20					
1/8/1997	26.70							
1/8/1997					1.71			
1/8/1997						6.72		
1/21/1997	10.80							
1/21/1997		10.80						
1/21/1997			11.20					
1/21/1997					2.06			
1/21/1997						6.42		
2/4/1997		11.00						
2/4/1997			9.99					
2/4/1997					1.42			
2/6/1997	8.52							
2/6/1997						5.13		
2/18/1997		10.50						
2/18/1997			10.30					
2/27/1997	11.10							
2/27/1997				0.00				
2/27/1997						5.93		
2/27/1997							1.40	
2/28/1997					1.58			
3/5/1997	16.20							
3/5/1997		9.37						
3/5/1997			7.82					
3/5/1997						5.41		
03/05/97								10.20
03/05/97								
3/6/1997					1.28			

3/18/1997	8.32							
3/18/1997		9.92						
3/18/1997			13.70					
3/18/1997					1.71			
3/18/1997						5.74		
4/3/1997	7.81							
4/3/1997		10.90						
4/3/1997			10.90					
4/3/1997					1.55			
4/3/1997						5.63		
4/15/1997	7.19							
4/15/1997		11.30						
4/15/1997			12.30					
4/15/1997					1.43			
4/15/1997						5.27		
4/29/1997	9.06							
4/29/1997		10.30						
4/29/1997			10.40					
4/29/1997					1.48			
4/29/1997						5.72		
5/27/1997	9.80							
5/27/1997		10.60						
5/27/1997			10.20					
5/27/1997				1.20				
5/27/1997					1.16			
5/27/1997						4.87		
06/19/97								11.00
06/19/97								
6/24/1997	9.48							
6/24/1997		9.79						
6/24/1997			12.30					
6/24/1997					1.28			
6/24/1997						4.45		
6/24/1997							2.70	
7/29/1997	9.38							
7/29/1997		10.80						
7/29/1997			10.70					
7/29/1997					1.44			
7/29/1997						4.17		
8/26/1997	78.80							
8/26/1997		10.90						
8/26/1997			10.10					
8/26/1997				1.04				
8/26/1997					2.73			
8/26/1997						5.09		
09/04/97								11.70
09/04/97								

10/28/1997				4.00				
11/17/97								13.00
11/17/97								
11/25/1997				1.00				
1/27/1998				0.90				
1/27/1998						2.70		
03/05/98								11.20
03/05/98								
3/30/1998					2.15			
3/30/1998							2.05	
05/18/98								7.40
05/18/98								
6/22/1998			13.23					
6/22/1998				0.67				
6/22/1998					1.31			
6/22/1998						2.25		
6/22/1998							1.48	
7/14/1998			9.20					
7/14/1998				0.53				
7/14/1998					0.98			
7/14/1998						1.60		
7/14/1998							1.15	
7/15/1998	67.50							
7/15/1998		10.30						
8/26/1998				0.53				
8/26/1998					1.44			
8/26/1998						0.89		
09/18/98								12.60
09/18/98								
9/28/1998			11.10					
9/28/1998				0.66				
9/28/1998					1.06			
9/28/1998						1.34		
9/28/1998								
10/19/1998			12.00					
10/19/1998				0.78				
10/19/1998								
10/19/1998						1.14		
10/19/1998								
11/05/98								14.30
11/05/98								
11/10/1998								
11/10/1998								
11/18/1998								
11/18/1998								
12/17/1998								
12/17/1998								

12/17/1998								
12/17/1998								
12/17/1998								
1/28/1999								
1/28/1999								
1/28/1999								
1/28/1999								
1/29/1999								
2/26/1999								
2/26/1999								
2/26/1999								
2/26/1999								
2/26/1999								
2/26/1999								
2/26/1999								
03/03/99								13.40
03/03/99								
3/29/1999								
3/29/1999								
3/29/1999								
3/29/1999								
3/29/1999								
4/27/1999								
4/27/1999								
4/27/1999								
4/27/1999								
4/27/1999								
5/12/1999								
5/12/1999								
6/9/1999								
6/9/1999								
6/9/1999								
6/9/1999								
6/10/1999								
06/23/99								13.60
06/23/99								
7/1/1999								
7/1/1999								
7/1/1999								
7/2/1999								
7/2/1999								
7/27/1999								
7/27/1999								
7/27/1999								
8/19/1999								
8/20/1999								
8/20/1999								

8/20/1999								
8/20/1999								
8/20/1999								
9/16/1999								
9/16/1999								
9/16/1999								
9/16/1999								
09/23/99								20.00
09/23/99								
10/28/1999								
10/28/1999								
10/28/1999								
10/28/1999								
11/19/1999								
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11/19/99								12.40
11/19/99								
12/20/1999	4.70							
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12/20/1999								
12/20/1999								
12/20/1999						2.50		
1/12/2000								
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03/03/00								9.40
03/03/00								
3/16/2000								
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06/06/00								14.50
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7/27/2000								
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08/17/00								
8/28/2000								
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12/11/00								13.60
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12/26/2000			11.30					
12/26/2000								
12/26/2000					3.61			
12/26/2000						0.86		
12/26/2000								
1/31/2001	2.80							
03/07/01								10.00
03/07/01								
3/20/2001								

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6/15/2001								
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06/19/01								12.90
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7/9/2001								
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8/10/2001								
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8/10/2001								
09/04/01								15.70
09/04/01								
9/26/2001								
9/26/2001								
9/26/2001								
9/26/2001								
9/26/2001								
10/26/2001								
10/26/2001								
11/21/2001	3.30							
11/21/2001		10.20						
11/21/2001			8.59					
11/21/2001								
11/21/2001								
11/21/2001						3.98		
11/21/2001								

12/19/01								13.30
12/26/2001								
12/26/2001								
12/26/2001								
1/23/2002								
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1/23/2002								
02/07/02								
2/25/2002								
2/25/2002								
2/25/2002								
2/25/2002								
2/25/2002								
03/14/02								14.70
03/14/02								
3/26/2002								
3/26/2002								
3/26/2002								
4/12/2002								
4/12/2002								
4/12/2002								
4/12/2002								
4/12/2002								
5/16/2002								
5/16/2002								
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5/16/2002								
6/13/2002								
6/13/2002								
6/13/2002								
6/13/2002								
6/13/2002								
6/13/2002								
07/03/02								16.40
07/03/02								
7/25/2002								
7/25/2002								
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7/25/2002								
7/25/2002								
8/15/2002								

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8/15/2002								
8/15/2002								
9/28/2002								
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9/28/2002								
9/30/2002								
09/30/02								14.30
09/30/02								
10/18/2002								
10/18/2002								
10/18/2002								
10/18/2002								
11/29/2002								
11/29/2002								
11/29/2002								
11/29/2002								
11/29/2002								
11/29/2002								
12/13/02								15.00
12/13/02								
1/9/2003	30.6							
1/9/2003		30.3						
1/9/2003			13.1					
1/9/2003				2.15				
1/9/2003					1.86			
1/9/2003						4.41		
1/9/2003								
02/25/03								14.20
02/25/03								
3/18/2003								
3/18/2003								
3/18/2003								
3/18/2003								
3/18/2003								
3/18/2003								
3/18/2003								
04/30/03								14.50
04/30/03								
5/14/2003								
5/14/2003								
5/14/2003								
5/14/2003								
5/14/2003								
5/14/2003								

5/14/2003								
07/21/03								15.60
07/21/03								
8/20/2003								
8/21/2003								
8/21/2003								
8/21/2003								
8/21/2003								
8/21/2003								
8/21/2003								
10/10/03								15.70
10/13/03								
11/10/2003			12.8					
11/11/2003								
11/11/2003								
11/11/2003				0.89				
11/11/2003					1.23			
11/11/2003						26.5		
11/11/2003								
02/02/04								14.90
02/02/04								
2/17/2004								
2/17/2004								
2/17/2004								
2/17/2004								
2/18/2004								
2/18/2004								
2/18/2004								
5/11/2004								
5/11/2004								
5/11/2004								
5/11/2004								
5/11/2004								
5/11/2004								
5/12/2004								
05/25/04								13.70
05/25/04								
07/22/04								14.10
07/22/04								
8/11/2004								
8/11/2004								
8/11/2004								
8/11/2004								
8/11/2004								
8/16/2004								
8/16/2004								
11/02/04	34.50							

11/02/04		5.14						
11/2/2004			13.1					
11/2/2004				0.70				
11/02/04					3.07			
11/02/04						32.1		
11/2/2004							1.17	
11/18/2004								12.90
11/18/2004								
2/28/2005								20.00
2/28/2005								
5/12/2005								
5/13/2005								12.05
9/28/2005								16.00
9/28/2005								
11/30/05	34.80							
11/30/2005			14.5					
12/27/2005								16.60
12/27/2005								
3/20/2006								16.60
3/20/2006								
06/21/06								
6/21/2006				0.61				
6/21/2006							2.34	
6/21/2006								17.10
6/21/2006								
06/23/06	44.70							
07/06/06					23.6			
07/06/06						15.4		
9/12/2006								16.5
9/12/2006								
09/26/06						20.6		
9/26/2006							1.56	
09/28/06	2.57							
09/28/06		2.96						
9/28/2006				0.81				
09/28/06					11.9			

MP008

6.90
7.10
8.80
9.60
11.60
13.70
11.40

9.20
8.90
8.50

12.40
11.80

12.00
4.20
4.60
3.62
4.68

4.41
4.38

4.70
3.45
4.70

4.95
4.23
4.09
4.54

3.60
5.34

4.68
4.39
4.46

8.98
192.00
8.46
9.03

10.10
10.30
9.74
9.00
9.31

8.92
12.40
9.19
5.80
10.40
10.20
4.99
10.00

Ellengowan

Fig 5.49a Total Suspended Solids

Date	MW1	MW2	MW3	MW4	Packer V	Maple Hill	Holes South	Gilberton
10/24/1994	72.00							
10/24/1994		140.00						
10/24/1994			80.00					
10/24/1994				152.00				
12/08/94								6.00
12/14/1994	90.00							
12/14/1994			636.00					
12/19/1994						24.00		
12/19/1994							39.00	
2/2/1995	80.00							
2/2/1995			63.00					
2/2/1995								
2/7/1995		94.00						
2/7/1995				102.00				
2/23/1995	46.00							
2/23/1995			48.00					
03/14/95								31.00
3/15/1995	136.00							
3/15/1995		1588.00						
3/15/1995			186.00					
3/15/1995				96.00				
3/15/1995								
4/20/1995	52.00							
4/20/1995		1024.00						
4/20/1995			146.00					
4/20/1995				234.00				
4/20/1995					4.00			
4/20/1995						23.00		
4/20/1995							42.00	
6/1/1995	79.00							
6/1/1995		1205.00						
6/1/1995			1665.00					
6/1/1995				176.00				
06/05/95								195.00
7/21/1995								
7/24/1995					33.00			
8/17/1995						61.00		
8/17/1995							54.00	
09/19/95								10.00
10/26/1995	108.00							
10/26/1995			1100.00					

11/7/1995					17.00			
11/7/1995						28.00		
11/8/1995							44.00	
12/05/95								24.00
12/13/1995		389.00						
12/14/1995		154.00						
12/14/1995				276.00				
01/16/96								
1/24/1996					18.00			
1/24/1996						40.00		
01/31/96								
2/8/1996							139.00	
02/19/96								
2/21/1996	88.00							
2/21/1996		83.00						
2/26/1996			71.00					
03/04/96								
03/13/96								
03/25/96								2.00
04/24/96								
5/21/1996			36.00					
5/21/1996					0.00			
5/21/1996						4.00		
5/21/1996							20.00	
6/4/1996		32.00						
6/4/1996			230.00					
6/4/1996					8.00			
6/4/1996						18.00		
6/4/1996							62.00	
6/18/1996	70.00							
6/18/1996		160.00						
6/18/1996			18.00					
6/18/1996					2.00			
6/18/1996						34.00		
6/18/1996							54.00	
06/24/96								48.00
06/26/96								
7/2/1996		48.00						
7/2/1996			8.00					
7/2/1996					0.00			
7/2/1996						14.00		
7/2/1996							14.00	
7/16/1996		84.00						
7/16/1996			184.00					
7/16/1996					0.00			
7/16/1996						42.00		
7/16/1996							16.00	

7/17/1996				90.00				
8/13/1996		64.00						
8/13/1996			14.00					
8/13/1996					4.00			
8/13/1996						46.00		
8/13/1996							28.00	
8/27/1996	24.00							
09/12/96								74.00
09/12/96								
12/17/1996	12.00							
12/17/1996		74.00						
12/17/1996			36.00					
12/17/1996				16.00				
12/17/1996					4.00			
12/17/1996						12.00		
12/17/1996							150.00	
12/18/96								7.00
12/18/96								
1/7/1997					6.00			
1/7/1997							18.00	
1/8/1997		8.00						
1/8/1997			22.00					
1/8/1997						8.00		
1/21/1997		56.00						
1/21/1997			14.00					
1/21/1997					4.00			
1/21/1997						4.00		
1/21/1997							14.00	
2/4/1997		36.00						
2/4/1997					8.00			
2/4/1997							0.00	
2/6/1997			0.00					
2/6/1997						0.00		
2/18/1997					18.00			
2/18/1997							24.00	
2/27/1997	5.00							
2/27/1997			8.00					
2/27/1997				7.00				
2/27/1997						0.00		
2/28/1997		30.00						
3/5/1997			4.00					
3/5/1997					12.00			
3/5/1997						0.00		
3/5/1997							14.00	
03/05/97								8.00
03/05/97								
3/6/1997		0.00						

3/18/1997		4.00						
3/18/1997			4.00					
3/18/1997					4.00			
3/18/1997						0.00		
3/18/1997							8.00	
4/3/1997		16.00						
4/3/1997			24.00					
4/3/1997					14.00			
4/3/1997						6.00		
4/3/1997							44.00	
4/15/1997		6.00						
4/15/1997			18.00					
4/15/1997					18.00			
4/15/1997						4.00		
4/15/1997							0.00	
4/29/1997		14.00						
4/29/1997			396.00					
4/29/1997					4.00			
4/29/1997						10.00		
4/29/1997							144.00	
5/27/1997	42.00							
5/27/1997		32.00						
5/27/1997			20.00					
5/27/1997					0.00			
5/27/1997						22.00		
5/27/1997							28.00	
06/19/97								40.00
06/19/97								
6/24/1997		74.00						
6/24/1997			22.00					
6/24/1997				120.00				
6/24/1997					30.00			
6/24/1997						14.00		
6/24/1997							16.00	
7/29/1997		286.00						
7/29/1997			138.00					
7/29/1997					12.00			
7/29/1997						30.00		
7/29/1997							36.00	
8/26/1997	41.00							
8/26/1997		20.90						
8/26/1997			14.00					
8/26/1997					16.00			
8/26/1997						42.00		
8/26/1997							6.00	
09/04/97								33.00
09/04/97								

10/28/1997	253.00							
11/17/97								48.00
11/17/97								
11/25/1997	56.00							
1/27/1998	20.00							
1/27/1998			230.00					
03/05/98								4.00
03/05/98								
3/30/1998		59.00						
3/30/1998				27.00				
05/18/98								18.00
05/18/98								
6/22/1998	8.00							
6/22/1998		92.00						
6/22/1998			28.00					
6/22/1998				44.00				
6/22/1998					4.00			
7/14/1998	20.00							
7/14/1998		108.00						
7/14/1998			24.00					
7/14/1998				36.00				
7/14/1998					12.00			
7/15/1998						28.00		
7/15/1998							60.00	
8/26/1998	36.00							
8/26/1998		24.00						
8/26/1998			160.00					
09/18/98								14.00
09/18/98								
9/28/1998	42.00							
9/28/1998		200.00						
9/28/1998			48.00					
9/28/1998								
9/28/1998					26.00			
10/19/1998	38.00							
10/19/1998								
10/19/1998			42.00					
10/19/1998								
10/19/1998					6.00			
11/05/98								10.00
11/05/98								
11/10/1998								
11/10/1998								
11/18/1998						48.00		
11/18/1998							22.00	
12/17/1998	26.00							
12/17/1998								

12/17/1998			164.00					
12/17/1998								
12/17/1998					8.00			
1/28/1999	46.00							
1/28/1999		376.00						
1/28/1999			42.00					
1/28/1999					12.00			
1/29/1999								
2/26/1999	54.00							
2/26/1999		114.00						
2/26/1999			50.00					
2/26/1999								
2/26/1999					6.00			
2/26/1999								
2/26/1999							32.00	
03/03/99								7.00
03/03/99								
3/29/1999	42.00							
3/29/1999		146.00						
3/29/1999			40.00					
3/29/1999								
3/29/1999					12.00			
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4/27/1999			10.00					
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4/27/1999					6.00			
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5/12/1999							33.00	
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6/9/1999			58.00					
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06/23/99								4.00
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7/27/1999	180.00							
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7/27/1999					24.00			
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8/20/1999			80.00					

8/20/1999					24.00			
8/20/1999								
8/20/1999							33.00	
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9/16/1999		115.00						
9/16/1999			61.00					
9/16/1999					19.00			
09/23/99								12.00
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10/28/1999	55.00							
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10/28/1999			67.00					
10/28/1999					14.00			
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1/12/2000								
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1/12/2000								
1/12/2000								
2/1/2000								
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2/1/2000						10.00		
03/03/00								11.00
03/03/00								
3/16/2000	79.00							
3/16/2000		251.00						
3/16/2000			48.00					
3/16/2000					29.00			
4/28/2000	28.00							
4/28/2000		108.00						
4/28/2000			30.00					
4/28/2000				30.00				
4/28/2000					24.00			
5/25/2000	21.00							
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5/25/2000			38.00					
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5/25/2000					53.00			
5/25/2000						6.00		
5/25/2000							78.00	
06/06/00								22.00
06/06/00								
6/21/2000	102.00							
6/21/2000		103.00						
6/21/2000			88.00					
6/21/2000				34.00				
6/21/2000					39.00			
7/27/2000		96.00						
7/27/2000			73.00					
7/27/2000				25.00				
7/27/2000					16.00			
7/27/2000						1.00		
7/27/2000							92.00	
08/17/00								11.00
08/17/00								
8/28/2000		118.00						
8/28/2000			68.00					
8/28/2000				12.00				
8/28/2000					35.00			
9/26/2000	134.00							
9/26/2000		147.00						
9/26/2000			68.00					
9/26/2000								
9/26/2000					20.00			
9/26/2000								
10/23/2000	97.00							
10/23/2000		170.00						
10/23/2000			63.00					
10/23/2000								
10/23/2000					7.00			
12/11/00								9.00
12/11/00								
12/26/2000	14.00							
12/26/2000		186.00						
12/26/2000			34.00					
12/26/2000								
12/26/2000					8.00			
12/26/2000							26.00	
1/31/2001						24.00		
03/07/01								9.00
03/07/01								
3/20/2001	146.00							

3/20/2001		142.00						
3/20/2001			76.00					
3/20/2001								
3/20/2001					5.00			
3/20/2001						1.00		
3/20/2001								
5/21/2001		188.00						
5/21/2001			82.00					
5/21/2001				13.00				
5/21/2001					17.00			
6/15/2001	104.00							
6/15/2001		167.00						
6/15/2001			76.00					
6/15/2001								
6/15/2001					6.00			
6/15/2001						6.00		
6/15/2001							38.00	
06/19/01								6.00
06/19/01								
7/9/2001	112.00							
7/9/2001		177.00						
7/9/2001			77.00					
7/9/2001								
7/9/2001					11.00			
8/10/2001	120.00							
8/10/2001		169.00						
8/10/2001			74.00					
8/10/2001								
8/10/2001					21.00			
8/10/2001						3.00		
8/10/2001							60.00	
09/04/01								20.00
09/04/01								
9/26/2001	98.00							
9/26/2001								
9/26/2001			65.00					
9/26/2001								
9/26/2001					1.00			
10/26/2001	101.00							
10/26/2001					3.00			
11/21/2001	103.00							
11/21/2001								
11/21/2001								
11/21/2001					8.00			
11/21/2001						7.00		
11/21/2001							112.00	
12/19/01								9.00

12/26/2001	86.00							
12/26/2001								
12/26/2001					25.00			
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1/23/2002					14.00			
1/23/2002						15.00		
1/23/2002							89.00	
02/07/02								
2/25/2002	82.00							
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2/25/2002					1.00			
2/25/2002						17.00		
2/25/2002							58.00	
03/14/02								5.00
03/14/02								
3/26/2002	95.00							
3/26/2002			71.00					
3/26/2002					8.00			
4/12/2002	68.00							
4/12/2002			36.00					
4/12/2002					6.00			
4/12/2002						9.00		
4/12/2002							84.00	
5/16/2002	16.00							
5/16/2002		41.00						
5/16/2002			103.00					
5/16/2002				27.00				
5/16/2002					11.00			
5/16/2002						36.00		
5/16/2002							44.00	
6/13/2002	8.00							
6/13/2002		34.00						
6/13/2002			171.00					
6/13/2002					18.00			
6/13/2002						46.00		
6/13/2002							42.00	
07/03/02								26.00
07/03/02								
7/25/2002	10.00							
7/25/2002		34.00						
7/25/2002			227.00					
7/25/2002					16.00			
7/25/2002						57.00		
7/25/2002							42.00	
8/15/2002	61.00							
8/15/2002		63.00						

8/15/2002								
8/15/2002					20.00			
8/15/2002						47.00		
8/15/2002							29.00	
9/28/2002	19.00							
9/28/2002		42.00						
9/28/2002					8.00			
9/30/2002								
09/30/02								13.00
09/30/02								
10/18/2002	9.00							
10/18/2002		46.00						
10/18/2002								
10/18/2002					6.00			
11/29/2002	66.00							
11/29/2002		52.00						
11/29/2002			512.00					
11/29/2002					1.00			
11/29/2002						50.00		
11/29/2002							31.00	
12/13/02								95.00
12/13/02								
1/9/2003	16.00							
1/9/2003		43.00						
1/9/2003			160.00					
1/9/2003								
1/9/2003					7.00			
1/9/2003						38.00		
1/9/2003							21.00	
02/25/03								25.00
02/25/03								
3/18/2003	16.00							
3/18/2003		61.00						
3/18/2003			129.00					
3/18/2003								
3/18/2003					3.00			
3/18/2003						115.00		
3/18/2003							24.00	
04/30/03								1.00
04/30/03								
5/14/2003	32.00							
5/14/2003		24.00						
5/14/2003			144.00					
5/14/2003								
5/14/2003					6.00			
5/14/2003								
5/14/2003							18.00	

07/21/03								6.00
07/21/03								
8/20/2003					15.00			
8/21/2003	16.00							
8/21/2003								
8/21/2003			204.00					
8/21/2003								
8/21/2003						47.00		
8/21/2003								
10/10/03								40.00
10/13/03								
11/10/2003					1.00			
11/11/2003	15.00							
11/11/2003		14.00						
11/11/2003			132.00					
11/11/2003								
11/11/2003						42.00		
11/11/2003							32.00	
02/02/04								90.00
02/02/04								
2/17/2004								
2/17/2004					3.00			
2/17/2004						36.00		
2/17/2004								
2/18/2004	12.00							
2/18/2004		14.00						
2/18/2004			96.00					
5/11/2004	7.00							
5/11/2004		31.00						
5/11/2004			95.00					
5/11/2004								
5/11/2004						28.00		
5/11/2004							64.00	
5/12/2004					2.00			
05/25/04								15.00
05/25/04								
07/22/04								8.00
07/22/04								
8/11/2004	3.00							
8/11/2004		3.00						
8/11/2004				26.00				
8/11/2004						27.00		
8/11/2004							54.00	
8/16/2004			79.00					
8/16/2004					10.00			
11/2/2004	76							
11/2/2004		16						

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11/2/2004						29		
11/2/2004							102	
11/18/2004								38
11/18/2004								
2/18/2005	30							
2/18/2005		26						
2/18/2005			103					
2/18/2005				35				
2/18/2005						32		
2/18/2005							74	
2/25/2005					4			
2/28/2005								3
2/28/2005								
5/6/2005	22							
5/6/2005		21						
5/6/2005			125					
5/6/2005				19				
5/6/2005					4			
5/6/2005						31		
5/6/2005							176	
5/12/2005								
5/13/2005								4
7/6/2005					11			
7/6/2005						42		
7/25/2005	17							
7/25/2005		58						
7/25/2005			112					
7/25/2005				36				
7/25/2005							176	
9/28/2005								21
9/28/2005								
11/30/2005					3			
11/30/2005						63		
12/27/2005								42
12/27/2005								
12/30/2005	14							
12/30/2005		182						
12/30/2005			574					
12/30/2005				107				
12/30/2005							70	
3/1/2006					10			
3/20/2006								16
3/20/2006								
3/27/2006	70							

3/27/2006		21						
3/27/2006			16					
3/27/2006				25				
3/27/2006							60	
6/21/2006	18							
6/21/2006				174				
6/21/2006							82	
6/21/2006								2
6/21/2006								
6/22/2006					10			
6/23/2006						6		
7/6/2006		93						
7/6/2006			20					
9/12/2006								6
9/12/2006								
9/26/2006			261					
9/26/2006				199				
9/28/2006	22							
9/28/2006		36						
9/28/2006						2		
9/28/2006							64	
10/4/2006					1			

MP008

78.00
110.00
90.00
69.00
104.00
149.00
125.00

220.00
160.00
566.00

328.00
61.00

30.00
14.00
42.00
70.00
18.00

13.00
22.00

2.00
32.00
45.00

15.00
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14.00
18.00

47.00
8.00
59.00

67.00
63.00
75.00
34.00

30.00
434.00
160.00
157.00
59.00

55
89
78
50
36
23

42
9

Ellengowan

Fig 5.49b Total Suspended Solids

Date	MW1	MW2	MW3	MW4	Packer V	Maple Hill	Holes South	Gilberton
10/24/1994	72.00							
10/24/1994		140.00						
10/24/1994			80.00					
10/24/1994				152.00				
12/08/94								6.00
12/14/1994	90.00							
12/14/1994			636.00					
12/19/1994						24.00		
12/19/1994							39.00	
2/2/1995	80.00							
2/2/1995			63.00					
2/2/1995								
2/7/1995		94.00						
2/7/1995				102.00				
2/23/1995	46.00							
2/23/1995			48.00					
03/14/95								31.00
3/15/1995	136.00							
3/15/1995		1588.00						
3/15/1995			186.00					
3/15/1995				96.00				
3/15/1995								
4/20/1995	52.00							
4/20/1995		1024.00						
4/20/1995			146.00					
4/20/1995				234.00				
4/20/1995					4.00			
4/20/1995						23.00		
4/20/1995							42.00	
6/1/1995	79.00							
6/1/1995		1205.00						
6/1/1995			1665.00					
6/1/1995				176.00				
06/05/95								195.00
7/21/1995								
7/24/1995					33.00			
8/17/1995						61.00		
8/17/1995							54.00	
09/19/95								10.00
10/26/1995	108.00							
10/26/1995			1100.00					

11/7/1995					17.00			
11/7/1995						28.00		
11/8/1995							44.00	
12/05/95								24.00
12/13/1995		389.00						
12/14/1995		154.00						
12/14/1995				276.00				
01/16/96								
1/24/1996					18.00			
1/24/1996						40.00		
01/31/96								
2/8/1996							139.00	
02/19/96								
2/21/1996	88.00							
2/21/1996		83.00						
2/26/1996			71.00					
03/04/96								
03/13/96								
03/25/96								2.00
04/24/96								
5/21/1996			36.00					
5/21/1996					0.00			
5/21/1996						4.00		
5/21/1996							20.00	
6/4/1996		32.00						
6/4/1996			230.00					
6/4/1996					8.00			
6/4/1996						18.00		
6/4/1996							62.00	
6/18/1996	70.00							
6/18/1996		160.00						
6/18/1996			18.00					
6/18/1996					2.00			
6/18/1996						34.00		
6/18/1996							54.00	
06/24/96								48.00
06/26/96								
7/2/1996		48.00						
7/2/1996			8.00					
7/2/1996					0.00			
7/2/1996						14.00		
7/2/1996							14.00	
7/16/1996		84.00						
7/16/1996			184.00					
7/16/1996					0.00			
7/16/1996						42.00		
7/16/1996							16.00	

7/17/1996				90.00				
8/13/1996		64.00						
8/13/1996			14.00					
8/13/1996					4.00			
8/13/1996						46.00		
8/13/1996							28.00	
8/27/1996	24.00							
09/12/96								74.00
09/12/96								
12/17/1996	12.00							
12/17/1996		74.00						
12/17/1996			36.00					
12/17/1996				16.00				
12/17/1996					4.00			
12/17/1996						12.00		
12/17/1996							150.00	
12/18/96								7.00
12/18/96								
1/7/1997					6.00			
1/7/1997							18.00	
1/8/1997		8.00						
1/8/1997			22.00					
1/8/1997						8.00		
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1/21/1997					4.00			
1/21/1997						4.00		
1/21/1997							14.00	
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2/6/1997			0.00					
2/6/1997						0.00		
2/18/1997					18.00			
2/18/1997							24.00	
2/27/1997	5.00							
2/27/1997			8.00					
2/27/1997				7.00				
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2/28/1997		30.00						
3/5/1997			4.00					
3/5/1997					12.00			
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3/5/1997							14.00	
03/05/97								8.00
03/05/97								
3/6/1997		0.00						

3/18/1997		4.00						
3/18/1997			4.00					
3/18/1997					4.00			
3/18/1997						0.00		
3/18/1997							8.00	
4/3/1997		16.00						
4/3/1997			24.00					
4/3/1997					14.00			
4/3/1997						6.00		
4/3/1997							44.00	
4/15/1997		6.00						
4/15/1997			18.00					
4/15/1997					18.00			
4/15/1997						4.00		
4/15/1997							0.00	
4/29/1997		14.00						
4/29/1997			396.00					
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4/29/1997						10.00		
4/29/1997							144.00	
5/27/1997	42.00							
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6/24/1997		74.00						
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7/29/1997		286.00						
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7/29/1997							36.00	
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09/04/97								

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7/15/1998							60.00	
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9/28/1998	42.00							
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12/17/1998	26.00							
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1/29/1999								
2/26/1999	54.00							
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2/26/1999			50.00					
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2/26/1999							32.00	
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03/03/99								
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6/21/2000			88.00					
6/21/2000				34.00				
6/21/2000					39.00			
7/27/2000		96.00						
7/27/2000			73.00					
7/27/2000				25.00				
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7/27/2000							92.00	
08/17/00								11.00
08/17/00								
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8/28/2000				12.00				
8/28/2000					35.00			
9/26/2000	134.00							
9/26/2000		147.00						
9/26/2000			68.00					
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9/26/2000					20.00			
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10/23/2000	97.00							
10/23/2000		170.00						
10/23/2000			63.00					
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12/26/2000	14.00							
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12/26/2000					8.00			
12/26/2000							26.00	
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03/07/01								
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6/15/2001			76.00					
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7/9/2001					11.00			
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1/23/2002							89.00	
02/07/02								
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2/25/2002			67.00					
2/25/2002					1.00			
2/25/2002						17.00		
2/25/2002							58.00	
03/14/02								5.00
03/14/02								
3/26/2002	95.00							
3/26/2002			71.00					
3/26/2002					8.00			
4/12/2002	68.00							
4/12/2002			36.00					
4/12/2002					6.00			
4/12/2002						9.00		
4/12/2002							84.00	
5/16/2002	16.00							
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5/16/2002						36.00		
5/16/2002							44.00	
6/13/2002	8.00							
6/13/2002		34.00						
6/13/2002			171.00					
6/13/2002					18.00			
6/13/2002						46.00		
6/13/2002							42.00	
07/03/02								26.00
07/03/02								
7/25/2002	10.00							
7/25/2002		34.00						
7/25/2002			227.00					
7/25/2002					16.00			
7/25/2002						57.00		
7/25/2002							42.00	
8/15/2002	61.00							
8/15/2002		63.00						

8/15/2002								
8/15/2002					20.00			
8/15/2002						47.00		
8/15/2002							29.00	
9/28/2002	19.00							
9/28/2002		42.00						
9/28/2002					8.00			
9/30/2002								
09/30/02								13.00
09/30/02								
10/18/2002	9.00							
10/18/2002		46.00						
10/18/2002								
10/18/2002					6.00			
11/29/2002	66.00							
11/29/2002		52.00						
11/29/2002			512.00					
11/29/2002					1.00			
11/29/2002						50.00		
11/29/2002							31.00	
12/13/02								95.00
12/13/02								
1/9/2003	16.00							
1/9/2003		43.00						
1/9/2003			160.00					
1/9/2003								
1/9/2003					7.00			
1/9/2003						38.00		
1/9/2003							21.00	
02/25/03								25.00
02/25/03								
3/18/2003	16.00							
3/18/2003		61.00						
3/18/2003			129.00					
3/18/2003								
3/18/2003					3.00			
3/18/2003						115.00		
3/18/2003							24.00	
04/30/03								1.00
04/30/03								
5/14/2003	32.00							
5/14/2003		24.00						
5/14/2003			144.00					
5/14/2003								
5/14/2003					6.00			
5/14/2003								
5/14/2003							18.00	

07/21/03								6.00
07/21/03								
8/20/2003					15.00			
8/21/2003	16.00							
8/21/2003								
8/21/2003			204.00					
8/21/2003								
8/21/2003						47.00		
8/21/2003								
10/10/03								40.00
10/13/03								
11/10/2003					1.00			
11/11/2003	15.00							
11/11/2003		14.00						
11/11/2003			132.00					
11/11/2003								
11/11/2003						42.00		
11/11/2003							32.00	
02/02/04								90.00
02/02/04								
2/17/2004								
2/17/2004					3.00			
2/17/2004						36.00		
2/17/2004								
2/18/2004	12.00							
2/18/2004		14.00						
2/18/2004			96.00					
5/11/2004	7.00							
5/11/2004		31.00						
5/11/2004			95.00					
5/11/2004								
5/11/2004						28.00		
5/11/2004							64.00	
5/12/2004					2.00			
05/25/04								15.00
05/25/04								
07/22/04								8.00
07/22/04								
8/11/2004	3.00							
8/11/2004		3.00						
8/11/2004				26.00				
8/11/2004						27.00		
8/11/2004							54.00	
8/16/2004			79.00					
8/16/2004					10.00			
11/2/2004	76							
11/2/2004		16						

11/2/2004			126					
11/2/2004				29				
11/2/2004					1			
11/2/2004						29		
11/2/2004							102	
11/18/2004								38
11/18/2004								
2/18/2005	30							
2/18/2005		26						
2/18/2005			103					
2/18/2005				35				
2/18/2005						32		
2/18/2005							74	
2/25/2005					4			
2/28/2005								3
2/28/2005								
5/6/2005	22							
5/6/2005		21						
5/6/2005			125					
5/6/2005				19				
5/6/2005					4			
5/6/2005						31		
5/6/2005							176	
5/12/2005								
5/13/2005								4
7/6/2005					11			
7/6/2005						42		
7/25/2005	17							
7/25/2005		58						
7/25/2005			112					
7/25/2005				36				
7/25/2005							176	
9/28/2005								21
9/28/2005								
11/30/2005					3			
11/30/2005						63		
12/27/2005								42
12/27/2005								
12/30/2005	14							
12/30/2005		182						
12/30/2005			574					
12/30/2005				107				
12/30/2005							70	
3/1/2006					10			
3/20/2006								16
3/20/2006								
3/27/2006	70							

3/27/2006		21						
3/27/2006			16					
3/27/2006				25				
3/27/2006							60	
6/21/2006	18							
6/21/2006				174				
6/21/2006							82	
6/21/2006								2
6/21/2006								
6/22/2006					10			
6/23/2006						6		
7/6/2006		93						
7/6/2006			20					
9/12/2006								6
9/12/2006								
9/26/2006			261					
9/26/2006				199				
9/28/2006	22							
9/28/2006		36						
9/28/2006						2		
9/28/2006							64	
10/4/2006					1			

MP008

78.00
110.00
90.00
69.00
104.00
149.00
125.00

220.00
160.00
566.00

328.00
61.00

30.00
14.00
42.00
70.00
18.00

13.00
22.00

2.00
32.00
45.00

15.00
14.00
28.00
18.00

14.00
18.00

47.00
8.00
59.00

67.00
63.00
75.00
34.00

30.00
434.00
160.00
157.00
59.00

55
89
78
50
36
23

42
9

Ellengowan
Fig 5.50 Temperature

Date	Holes South	Maple Hill	MW4	MW3	MW2	MW 1	Packer V	Gilberton
12/30/2005	54.32		49.82	49.82	49.46	49.28		
6/21/2006	62.96		66.38			58.46		
6/22/2006							59.54	
6/23/2006		83.66						
7/6/2006				61.16	60.98			
9/12/2006								63.5
9/26/2006			74.12	71.24				
9/28/2006	71.96	74.84			67.46	64.76		
10/4/2006							57.56	

MP008
58.28

Silverbrook / Big Gorilla
Fig 6.1 Sulfate

Date	Before Ash	After Ash
7/16/1986	112.00	
8/18/1986	124.00	
9/16/1986	160.00	
5/22/1989	87.00	
8/13/1989	103.00	
11/9/1989	115.00	
2/16/1990	104.00	
5/13/1990	110.00	
8/26/1990	115.00	
11/28/1990	105.00	
12/8/1990		
2/2/1991		
2/23/1991	94.00	
3/25/1991		
4/28/1991		
5/23/1991	110.00	
8/22/1991	137.00	
11/17/1991	129.00	
2/20/1992	135.00	
5/18/1992	89.00	
10/6/1992	102.00	
11/1/1992	54.00	
11/19/1992	120.00	
11/30/1992	70.00	
12/31/1992	82.00	
1/31/1993	83.00	
3/1/1993	83.00	
3/11/1993	95.00	
3/31/1993	31.00	
5/3/1993	16.00	
5/31/1993	61.60	
6/6/1993	42.00	
6/30/1993	37.40	
8/1/1993	51.00	
9/6/1993	77.00	
9/13/1993	130.00	
9/30/1993	139.00	
10/31/1993	76.00	
11/15/1993	125.00	
11/30/1993	18.00	
1/2/1994	57.00	
1/31/1994	21.00	

2/28/1994	56.00	
3/14/1994	84.00	
3/28/1994		
4/3/1994	49.00	
5/1/1994	65.00	
5/26/1994	72.00	
5/31/1994	30.00	
7/5/1994	105.00	
8/4/1994	88.00	
8/15/1994	82.00	
9/7/1994	69.00	
10/3/1994	43.00	
11/1/1994	51.00	
11/21/1994	125.00	
12/6/1994	39.00	
1/3/1995	40.00	
2/1/1995	38.00	
2/20/1995	89.00	
3/1/1995	65.00	
4/3/1995	27.00	
5/8/1995	68.00	
6/1/1995	78.00	
6/6/1995	116.00	
7/25/1995	77.00	
8/1/1995	64.00	
8/25/1995	130.00	
9/4/1995	84.00	
10/2/1995	124.00	
11/1/1995	115.00	
11/14/1995	94.00	
12/1/1995	104.00	
1/1/1996	99.00	
2/1/1996	96.00	
2/19/1996	96.00	
3/1/1996	86.00	
10/1/1996	120.00	
11/1/1996	125.00	
11/19/1996	138.00	
12/1/1996	116.00	
12/31/1996		
7/1/1998		145.00
8/12/1998		165.00
9/1/1998		188.00
10/19/1998		
11/17/1998		171.00
2/22/1999		96.00
4/22/1999		109.00

5/26/1999		
10/27/1999		156.00
1/26/2000		131.00
5/24/2000		110.00
7/26/2000		136.00
11/8/2000		280.00
5/21/2001		117.00
8/28/2001		200.00
10/1/2001		225.00
11/2/2001		320.00
12/3/2001		240.00
12/4/2001		265.00
3/11/2002		181.00
4/1/2002		170.00
5/3/2002		180.00
5/23/2002		125.00
6/3/2002		170.00
7/1/2002		200.00
8/6/2002		235.00
9/3/2002		250.00
9/10/2002		202.30
11/4/2002		210.00
1/2/2003		190.00
2/10/2003		220.00
3/5/2003		200.00
4/2/2003		180.00
4/28/2003		164.80
5/3/2003		136.00
6/2/2003		250.00
6/3/2003		178.10
9/18/2003		
10/6/2003		170.00
11/3/2003		180.00
12/9/2003		215.00
3/11/2004		214.00
8/10/2004		187.60

Silverbrook / Big Gorilla
Fig 6.2 Total Dissolved Solids

Date	Monitoring Point	Monitoring Point

Silverbrook / Big Gorilla
Fig 6.3 Specific Conductance

Date	Before Ash	After Ash
7/16/1986	317.00	
8/18/1986	351.00	
9/16/1986	409.00	
5/22/1989	340.00	
8/13/1989	250.00	
11/9/1989	340.00	
2/16/1990	330.00	
5/13/1990	250.00	
8/26/1990	290.00	
11/28/1990	270.00	
12/8/1990		
2/2/1991		
2/23/1991	255.00	
3/25/1991		
4/28/1991		
5/23/1991	260.00	
8/22/1991	310.00	
11/17/1991	395.00	
2/20/1992	355.00	
5/18/1992	310.00	
10/6/1992	290.00	
11/1/1992	298.00	
11/19/1992	310.00	
11/30/1992	284.00	
12/31/1992		
1/31/1993		
3/1/1993		
3/11/1993	310.00	
3/31/1993		
5/3/1993		
5/31/1993		
6/6/1993	260.00	
6/30/1993		
8/1/1993		
9/6/1993		
9/13/1993	310.00	
9/30/1993		
10/31/1993		
11/15/1993	325.00	
11/30/1993		
1/2/1994		
1/31/1994		

2/28/1994		
3/14/1994	350.00	
3/28/1994		
4/3/1994		
5/1/1994		
5/26/1994	295.00	
5/31/1994		
7/5/1994		
8/4/1994		
8/15/1994	290.00	
9/7/1994		
10/3/1994		
11/1/1994		
11/21/1994	310.00	
12/6/1994		
1/3/1995		
2/1/1995		
2/20/1995	350.00	
3/1/1995		
4/3/1995		
5/8/1995		
6/1/1995		
6/6/1995	380.00	
7/25/1995		
8/1/1995		
8/25/1995	310.00	
9/4/1995		
10/2/1995		
11/1/1995		
11/14/1995	320.00	
12/1/1995		
1/1/1996		
2/1/1996		
2/19/1996	310.00	
3/1/1996		
10/1/1996		
11/1/1996		
11/19/1996	340.00	
12/1/1996		
12/31/1996		
7/1/1998		
8/12/1998		
9/1/1998		
10/19/1998		
11/17/1998		482.00
2/22/1999		345.00
4/22/1999		480.00

5/26/1999		
10/27/1999		499.00
1/26/2000		431.00
5/24/2000		459.00
7/26/2000		419.00
11/8/2000		626.00
5/21/2001		517.00
8/28/2001		574.00
10/1/2001		
11/2/2001		
12/3/2001		
12/4/2001		650.00
3/11/2002		526.00
4/1/2002		
5/3/2002		
5/23/2002		548.00
6/3/2002		
7/1/2002		
8/6/2002		
9/3/2002		
9/10/2002		602.00
11/4/2002		569.00
1/2/2003		
2/10/2003		
3/5/2003		
4/2/2003		
4/28/2003		570.00
5/3/2003		
6/2/2003		
6/3/2003		536.00
9/18/2003		
10/6/2003		
11/3/2003		
12/9/2003		
3/11/2004		484.00
8/10/2004		508.00

Silverbrook / Big Gorilla
Fig 6.4 Aluminum

Date	Before Ash	After Ash
3/18/1986		
5/21/1986		
5/22/1989	0.10	
8/13/1989	5.15	
11/9/1989	5.30	
2/16/1990	0.95	
5/13/1990	1.40	
2/2/1991		
5/23/1991	1.00	
5/18/1992	4.60	
11/19/1992	4.80	
2/28/1993		
6/6/1993	4.40	
9/13/1993	1.15	
5/26/1994	3.74	
6/6/1995	3.72	
8/12/1998		6.81
10/19/1998		
11/17/1998		
2/22/1999		0.11
4/22/1999		4.59
5/26/1999		
10/27/1999		7.42
1/26/2000		
5/24/2000		3.96
7/26/2000		4.60
11/8/2000		10.60
5/21/2001		4.47
8/28/2001		8.40
12/3/2001		13.90
3/11/2002		5.50
5/23/2002		5.25
9/10/2002		7.98
11/4/2002		7.05
4/28/2003		6.96
6/3/2003		6.00
9/18/2003		
12/9/2003		
2/11/2004		4.12
3/11/2004		
8/10/2004		4.10

Silverbrook / Big Gorilla
Fig 6.5 Iron

Date	Before Ash	After Ash
7/16/1986	13.30	
8/18/1986	16.50	
9/16/1986	16.50	
11/1/1986		
2/1/1987		
5/1/1987		
8/1/1987		
11/1/1987		
2/1/1988		
5/1/1988		
8/1/1988		
11/1/1988		
2/1/1989		
5/22/1989	11.50	
8/13/1989	8.40	
11/9/1989	0.45	
2/16/1990	8.80	
5/13/1990	3.10	
8/26/1990	8.50	
11/28/1990	7.50	
12/8/1990		
2/2/1991		
2/23/1991	3.60	
3/25/1991		
4/28/1991		
5/23/1991	5.88	
8/22/1991	14.00	
11/17/1991	14.00	
2/20/1992	11.00	
5/18/1992	12.00	
10/6/1992	16.80	
11/1/1992	14.50	
11/19/1992	9.60	
11/30/1992	11.80	
12/31/1992	13.40	
1/31/1993	9.80	
3/1/1993	7.90	
3/11/1993	8.40	
3/31/1993	12.20	
5/3/1993	0.50	
5/31/1993	5.90	
6/6/1993	5.40	

6/30/1993	7.60	
8/1/1993	10.30	
9/6/1993	12.20	
9/13/1993	12.30	
9/30/1993	13.60	
10/31/1993	13.20	
11/15/1993	13.30	
11/30/1993	10.20	
1/2/1994	10.10	
1/31/1994	4.70	
2/28/1994	2.30	
3/14/1994	2.60	
3/28/1994		
4/3/1994	0.40	
5/1/1994	1.20	
5/26/1994	7.24	
5/31/1994	5.80	
7/5/1994	8.70	
8/4/1994	10.20	
8/15/1994	8.78	
9/7/1994	11.80	
10/3/1994	11.00	
11/1/1994	13.40	
11/21/1994	10.70	
12/6/1994	12.90	
1/3/1995	11.30	
2/1/1995	8.90	
2/20/1995	6.90	
3/1/1995	7.10	
4/3/1995	7.30	
5/8/1995	6.90	
6/1/1995	9.80	
6/6/1995	5.00	
7/25/1995	11.10	
8/1/1995	12.10	
8/25/1995	1.24	
9/4/1995	13.50	
10/2/1995	17.00	
11/1/1995	23.20	
11/14/1995	0.85	
12/1/1995	9.20	
1/1/1996	13.70	
2/1/1996	0.70	
2/19/1996	0.49	
3/1/1996	1.50	
10/1/1996	12.10	
11/1/1996	11.80	

11/19/1996	1.26	
12/1/1996	7.80	
12/31/1996		
2/1/1997		
5/1/1997		
8/1/1997		
11/1/1997		
2/1/1998		
5/1/1998		
7/1/1998		9.80
8/12/1998		13.60
9/1/1998		18.00
10/19/1998		
11/17/1998		24.30
2/22/1999		0.12
4/22/1999		14.80
5/26/1999		
10/27/1999		23.10
1/26/2000		19.90
5/24/2000		13.90
7/26/2000		14.20
11/8/2000		23.00
5/21/2001		18.20
8/28/2001		23.00
10/1/2001		20.70
11/2/2001		21.90
12/3/2001		21.00
12/4/2001		38.80
3/11/2002		2.22
4/1/2002		19.90
5/3/2002		17.40
5/23/2002		16.50
6/3/2002		17.00
7/1/2002		17.20
8/6/2002		14.60
9/3/2002		18.90
9/10/2002		21.10
11/4/2002		23.40
1/2/2003		14.60
2/10/2003		15.40
3/5/2003		15.70
4/2/2003		12.10
4/28/2003		1.69
5/3/2003		12.60
6/2/2003		11.00
6/3/2003		8.65
9/18/2003		

10/6/2003		14.50
11/3/2003		11.60
12/9/2003		10.40
3/11/2004		11.30
8/10/2004		12.90

Silverbrook / Big Gorilla
Fig 6.6 Manganese

Date	Before Ash	After Ash
7/16/1986	1.46	
8/18/1986	1.62	
9/16/1986		
5/22/1989	1.20	
8/13/1989	1.10	
11/9/1989	1.50	
2/16/1990	1.20	
5/13/1990	0.75	
8/26/1990	3.00	
11/28/1990	0.90	
12/8/1990		
2/2/1991		
2/23/1991	0.95	
3/25/1991		
4/28/1991		
5/23/1991	0.90	
8/22/1991	1.26	
11/17/1991	1.47	
2/20/1992	1.50	
5/18/1992	1.16	
10/6/1992	1.20	
11/1/1992	1.20	
11/19/1992	1.23	
11/30/1992	0.90	
12/31/1992	0.80	
1/31/1993	0.60	
3/1/1993	0.60	
3/11/1993	1.20	
3/31/1993	0.40	
5/3/1993	0.30	
5/31/1993	0.90	
6/6/1993	1.12	
6/30/1993	0.75	
8/1/1993	0.65	
9/6/1993	0.53	
9/13/1993	1.59	
9/30/1993	0.80	
10/31/1993	0.70	
11/15/1993	1.40	
11/30/1993	0.50	
1/2/1994	0.50	
1/31/1994	0.60	

2/28/1994	0.40	
3/14/1994	1.00	
3/28/1994		
4/3/1994	0.30	
5/1/1994	0.20	
5/26/1994	1.36	
5/31/1994	0.30	
7/5/1994	0.30	
8/4/1994	0.25	
8/15/1994	1.38	
9/7/1994	0.40	
10/3/1994	0.80	
11/1/1994	1.40	
11/21/1994	1.12	
12/6/1994	1.70	
1/3/1995	1.40	
2/1/1995	1.40	
2/20/1995	1.00	
3/1/1995	1.40	
4/3/1995	1.20	
5/8/1995	1.00	
6/1/1995	1.50	
6/6/1995	2.02	
7/25/1995	1.40	
8/1/1995	1.80	
8/25/1995	1.48	
9/4/1995	1.50	
10/2/1995	1.80	
11/1/1995	2.40	
11/14/1995	1.40	
12/1/1995	1.60	
1/1/1996	2.10	
2/1/1996	1.00	
2/19/1996	1.40	
3/1/1996	1.50	
10/1/1996	1.60	
11/1/1996	1.60	
11/19/1996	1.00	
12/1/1996	1.50	
12/31/1996		
7/1/1998		1.70
8/12/1998		1.60
9/1/1998		1.90
10/19/1998		
11/17/1998		12.50
2/22/1999		0.06
4/22/1999		1.59

5/26/1999		
10/27/1999		2.01
1/26/2000		1.67
5/24/2000		1.30
7/26/2000		1.35
11/8/2000		1.95
5/21/2001		1.54
8/28/2001		1.81
10/1/2001		1.60
11/2/2001		1.60
12/3/2001		1.40
12/4/2001		2.90
3/11/2002		1.88
4/1/2002		2.00
5/3/2002		0.86
5/23/2002		1.82
6/3/2002		0.92
7/1/2002		0.60
8/6/2002		1.60
9/3/2002		1.60
9/10/2002		2.11
11/4/2002		1.98
1/2/2003		1.60
2/10/2003		1.50
3/5/2003		1.50
4/2/2003		1.20
4/28/2003		1.70
5/3/2003		1.40
6/2/2003		1.60
6/3/2003		1.47
9/18/2003		
10/6/2003		1.50
11/3/2003		1.70
12/9/2003		1.60
3/11/2004		1.41
8/10/2004		8.76

Silverbrook / Big Gorilla
Fig 6.7 pH

Date	Before Ash	After Ash
7/16/1986	4	
8/18/1986	4.2	
9/16/1986	4	
5/22/1989		
8/13/1989		
11/9/1989		
2/16/1990		
5/13/1990		
8/26/1990		
11/28/1990		
12/8/1990		
2/2/1991		
2/23/1991		
3/25/1991		
4/28/1991		
5/23/1991		
8/22/1991		
11/17/1991		
2/20/1992		
5/18/1992		
10/6/1992	4	
11/1/1992	3.8	
11/19/1992		
11/30/1992	3.3	
12/31/1992		
1/31/1993		
3/1/1993		
3/11/1993		
3/31/1993		
5/3/1993		
5/31/1993		
6/6/1993		
6/30/1993		
8/1/1993		
9/6/1993		
9/13/1993		
9/30/1993		
10/31/1993		
11/15/1993	4.1	
11/30/1993		
1/2/1994		
1/31/1994		

2/28/1994		
3/14/1994	3.6	
3/28/1994		
4/3/1994	3.3	
5/1/1994	3.4	
5/26/1994	3.6	
5/31/1994	3.7	
7/5/1994	4	
8/4/1994	4	
8/15/1994	4	
9/7/1994	4.1	
10/3/1994	4	
11/1/1994	3.8	
11/21/1994	4.4	
12/6/1994	3.7	
1/3/1995	3.9	
2/1/1995	3.75	
2/20/1995	4	
3/1/1995	3.7	
4/3/1995	3.7	
5/8/1995	3.6	
6/1/1995	3.8	
6/6/1995	3.5	
7/25/1995	3.7	
8/1/1995	3.9	
8/25/1995	3.5	
9/4/1995	3.8	
10/2/1995	3.9	
11/1/1995	3.8	
11/14/1995	3.6	
12/1/1995	3.6	
1/1/1996	4	
2/1/1996	3.3	
2/19/1996	3.6	
3/1/1996	3.7	
10/1/1996	3.8	
11/1/1996	3.6	
11/19/1996	3.5	
12/1/1996	3.5	
12/31/1996		
7/1/1998		4.1
8/12/1998		4.3
9/1/1998		3.9
10/19/1998		
11/17/1998		4.2
2/22/1999		6.9
4/22/1999		4.1

5/26/1999		
10/27/1999		4.2
1/26/2000		4.3
5/24/2000		4
7/26/2000		4.3
11/8/2000		4.2
5/21/2001		4.2
8/28/2001		4.3
10/1/2001		4.4
11/2/2001		4.1
12/3/2001		4.2
12/4/2001		3.9
3/11/2002		4.1
4/1/2002		4.1
5/3/2002		4.1
5/23/2002		3.8
6/3/2002		3.9
7/1/2002		4.1
8/6/2002		3.5
9/3/2002		3.7
9/10/2002		4.1
11/4/2002		4.3
1/2/2003		3.9
2/10/2003		4.2
3/5/2003		4
4/2/2003		4
4/28/2003		3.5
5/3/2003		4.1
6/2/2003		4
6/3/2003		3.9
9/18/2003		
10/6/2003		4.2
11/3/2003		4.1
12/9/2003		4
3/11/2004		4.3
8/10/2004		3.6

Silverbrook / Big Gorilla
Fig 6.8 Calcium

Date	Before Ash	After Ash
3/18/1986	7.2	
5/21/1986		
5/22/1989		
8/13/1989	4.8	
11/9/1989	4.1	
2/16/1990	4.6	
5/13/1990	0.4	
2/2/1991		
5/23/1991	0.33	
5/18/1992	7	
11/19/1992	8.6	
2/28/1993	12.8	
6/6/1993	8.95	
9/13/1993	10.7	
5/26/1994	9.24	
6/6/1995	12.3	
8/12/1998		27
10/19/1998		
11/17/1998		26.6
2/22/1999		46.8
4/22/1999		19.3
5/26/1999		
10/27/1999		44.8
1/26/2000		22.2
5/24/2000		23.2
7/26/2000		27.6
11/8/2000		48.3
5/21/2001		31.3
8/28/2001		53.7
12/3/2001		43.4
3/11/2002		32.9
5/23/2002		25.7
9/10/2002		56.1
11/4/2002		42.8
4/28/2003		30
6/3/2003		38.7
9/18/2003		
12/9/2003		
2/11/2004		39.8
3/11/2004		
8/10/2004		34.6

Silverbrook / Big Gorilla
Fig 6.9 Chloride

Date	Before Ash	After Ash
7/16/1986		
8/18/1986		
9/16/1986		
5/22/1989		
8/13/1989	10.5	
11/9/1989	11.3	
2/16/1990	19	
5/13/1990	20	
8/26/1990		
11/28/1990		
12/8/1990		
2/2/1991		
2/23/1991		
3/25/1991		
4/28/1991		
5/23/1991	11.5	
8/22/1991		
11/17/1991		
2/20/1992		
5/18/1992	20	
10/6/1992		
11/1/1992		
11/19/1992	14	
11/30/1992		
12/31/1992		
1/31/1993		
3/1/1993	13.5	
3/11/1993		
3/31/1993		
5/3/1993		
5/31/1993	12	
6/6/1993		
6/30/1993		
8/1/1993		
9/6/1993		
9/13/1993	11.2	
9/30/1993		
10/31/1993		
11/15/1993		
11/30/1993		
1/2/1994		
1/31/1994		

2/28/1994		
3/14/1994		
3/28/1994		
4/3/1994		
5/1/1994		
5/26/1994	23.6	
5/31/1994		
7/5/1994		
8/4/1994		
8/15/1994	13.5	
9/7/1994		
10/3/1994		
11/1/1994		
11/21/1994	29.7	
12/6/1994		
1/3/1995		
2/1/1995		
2/20/1995	19.2	
3/1/1995		
4/3/1995		
5/8/1995		
6/1/1995		
6/6/1995	25	
7/25/1995		
8/1/1995		
8/25/1995	17.5	
9/4/1995		
10/2/1995		
11/1/1995		
11/14/1995	16.3	
12/1/1995		
1/1/1996		
2/1/1996		
2/19/1996	2	
3/1/1996		
10/1/1996		
11/1/1996		
11/19/1996	17	
12/1/1996		
12/31/1996		
7/1/1998		
8/12/1998		
9/1/1998		
10/19/1998		
11/17/1998		12
2/22/1999		3.5
4/22/1999		31

5/26/1999		
10/27/1999		19
1/26/2000		15
5/24/2000		19
7/26/2000		10
11/8/2000		10
5/21/2001		26
8/28/2001		17
12/3/2001		
12/4/2001		1
3/11/2002		19
5/23/2002		38
9/10/2002		11.3
11/4/2002		19.5
2/10/2003		
4/28/2003		35.9
6/3/2003		24.2
9/18/2003		
12/9/2003		
3/11/2004		12.4
8/10/2004		21.7

Silverbrook / Big Gorilla
Fig 6.10 Magnesium

Date	Monitoring Point	Monitoring Point
3/18/1986	4.4	
5/21/1986		
5/22/1989		
8/13/1989	2.4	
11/9/1989	7.3	
2/16/1990	6.5	
5/13/1990	4.1	
2/2/1991		
5/23/1991	9.8	
5/18/1992	5.8	
11/19/1992	6.9	
2/28/1993	7.1	
6/6/1993	5.6	
9/13/1993	9.18	
5/26/1994	6.61	
6/6/1995	6.76	
8/12/1998		9.6
10/19/1998		
11/17/1998		12.5
2/22/1999		6.21
4/22/1999		8.49
5/26/1999		
10/27/1999		12.1
1/26/2000		9.1
5/24/2000		7.45
7/26/2000		7.95
11/8/2000		10.7
5/21/2001		8.28
8/28/2001		9.75
12/3/2001		18.8
3/11/2002		9.91
5/23/2002		9.88
9/10/2002		9.64
11/4/2002		10.5
4/28/2003		9.51
6/3/2003		9.48
9/18/2003		
12/9/2003		
2/11/2004		8.51
3/11/2004		
8/10/2004		8.76

Silverbrook / Big Gorilla
Fig 6.11 Zinc

Date	Monitoring Point	Monitoring Point
3/18/1986	0.26	
5/21/1986		
5/22/1989		
8/13/1989	0.18	
11/9/1989	0.4	
2/16/1990	0.2	
5/13/1990	0.23	
2/2/1991		
5/23/1991	0.16	
5/18/1992	0.2	
11/19/1992	0.19	
2/28/1993	0.23	
6/6/1993	0.3	
9/13/1993	0.31	
5/26/1994	0.3	
6/6/1995	0.3	
8/12/1998		0.3
10/19/1998		
11/17/1998		3.41
2/22/1999		0.13
4/22/1999		0.25
5/26/1999		
10/27/1999		0.32
1/26/2000		0.24
5/24/2000		0.24
7/26/2000		0.22
11/8/2000		0.55
5/21/2001		0.35
8/28/2001		0.39
12/3/2001		0.63
3/11/2002		0.28
5/23/2002		0.25
9/10/2002		0.93
11/4/2002		0.28
4/28/2003		0.88
6/3/2003		0.33
9/18/2003		
12/9/2003		
2/11/2004		0.21
3/11/2004		
8/10/2004		0.22

Silverbrook / Big Gorilla
Fig 6.12 Potassium

Date	Monitoring Point	Monitoring Point
3/18/1986		
5/21/1986		
5/22/1989		
8/13/1989		
11/9/1989		
2/16/1990		
5/13/1990		
2/2/1991		
5/23/1991		
5/18/1992		
11/19/1992		
2/28/1993		
6/6/1993		
9/13/1993		
5/26/1994		
6/6/1995		
8/12/1998		
10/19/1998		0.00
11/17/1998	0.00	
2/22/1999	1.72	
4/22/1999	1.59	
5/26/1999		0.00
10/27/1999	2.40	0.00
1/26/2000	2.16	1.07
5/24/2000	1.68	1.00
7/26/2000	2.42	1.37
11/8/2000	3.30	<1.00
5/21/2001	2.54	3.32
8/28/2001	3.73	
12/3/2001	2.70	2.10
3/11/2002	2.69	3.50
5/23/2002	2.42	<0.001
9/10/2002	4.63	<0.001
11/4/2002	3.93	1.19
4/28/2003	3.49	<1.00
6/3/2003	3.24	<1.00
9/18/2003		<1.00
12/9/2003		<1.00
2/11/2004	3.55	
3/11/2004		<1.00
8/10/2004	3.34	<1.00

Silverbrook / Big Gorilla
Fig 6.13 Sodium

Date	Monitoring Point	Monitoring Point
5/13/1990	5.50	
2/2/1991		0.57
5/23/1991	10.00	
5/18/1992	12.00	0.50
5/31/1993	8.05	
6/6/1993		0.66
5/26/1994	11.90	0.35
8/15/1994	9.40	0.59
11/21/1994	10.70	1.67
2/20/1995	14.10	4.00
6/6/1995	11.20	1.32
8/25/1995	11.70	0.56
11/14/1995	11.20	0.60
2/19/1996	13.90	0.63
11/19/1996	12.70	
12/31/1996		0.54
8/12/1998		0.60
10/19/1998		0.64
11/17/1998	12.10	
2/22/1999	7.76	
4/22/1999	22.10	
5/26/1999		0.77
10/27/1999	16.50	0.86
1/26/2000	13.90	0.72
5/24/2000	17.90	0.37
7/26/2000	12.50	0.78
11/8/2000	15.10	0.73
5/21/2001	22.80	3.25
8/28/2001	31.30	
12/3/2001	4.30	2.00
3/11/2002	20.10	4.10
5/23/2002	29.00	0.74
9/10/2002	232.00	0.18
11/4/2002	20.60	0.90
4/28/2003	29.60	0.74
6/3/2003	23.10	0.96
9/18/2003		0.81
12/9/2003		1.43
2/11/2004	16.70	
3/11/2004		0.79
8/10/2004	21.70	0.69

Silverbrook / Big Gorilla
Fig 6.14 Aluminum

Date	MW-2	MW-4
3/18/1986		
5/21/1986		
5/22/1989	0.00	
8/13/1989		
11/9/1989		
2/16/1990		
5/13/1990		
2/2/1991	0.12	
5/23/1991		
5/18/1992	0.09	
11/19/1992		
2/28/1993		
6/6/1993	0.27	
9/13/1993		
5/26/1994	0.16	
6/6/1995	0.90	
8/12/1998	0.42	
10/19/1998		
11/17/1998		
2/22/1999		
4/22/1999		
5/26/1999	0.46	
10/27/1999	0.63	
1/26/2000		
5/24/2000	0.44	
7/26/2000	0.51	
11/8/2000	0.38	
5/21/2001	0.94	
8/28/2001		
12/3/2001	0.63	
3/11/2002	0.80	12.70
5/23/2002	1.11	8.18
9/10/2002	0.62	6.63
11/4/2002	1.23	7.00
4/28/2003	1.09	6.60
6/3/2003		7.00
9/18/2003	0.21	7.51
12/9/2003	0.49	7.68
2/11/2004		
3/11/2004	0.38	7.78
8/10/2004	0.32	7.08

Silverbrook / Big Gorilla
Fig 6.15 Calcium

Date	MW-2	MW-4
3/18/1986		
5/21/1986	4.05	
5/22/1989		
8/13/1989		
11/9/1989		
2/16/1990		
5/13/1990		
2/2/1991	0.75	
5/23/1991		
5/18/1992	2.48	
11/19/1992		
2/28/1993		
6/6/1993	2.95	
9/13/1993		
5/26/1994	1.45	
6/6/1995	5.26	
8/12/1998	3.48	
10/19/1998	4.11	
11/17/1998		
2/22/1999		
4/22/1999		
5/26/1999	3.45	
10/27/1999	3.92	
1/26/2000	3.05	
5/24/2000	3.45	
7/26/2000	6.65	
11/8/2000	2.90	
5/21/2001	34.60	
8/28/2001		
12/3/2001	11.10	
3/11/2002	2.09	35.00
5/23/2002	2.21	26.80
9/10/2002	2.36	23.70
11/4/2002	2.99	26.00
4/28/2003	3.22	24.60
6/3/2003	3.33	24.80
9/18/2003	3.24	30.80
12/9/2003	88.70	58.40
2/11/2004		
3/11/2004	2.09	44.20
8/10/2004	2.13	29.70

Silverbrook / Big Gorilla
Fig 6.16 Magnesium

Date	MW-2	MW-4
3/18/1986		
5/21/1986	4.56	
5/22/1989		
8/13/1989		
11/9/1989		
2/16/1990		
5/13/1990		
2/2/1991	4.60	
5/23/1991		
5/18/1992	2.68	
11/19/1992		
2/28/1993		
6/6/1993	4.95	
9/13/1993		
5/26/1994	1.91	
6/6/1995	3.07	
8/12/1998	0.52	
10/19/1998	5.60	
11/17/1998		
2/22/1999		
4/22/1999		
5/26/1999	4.52	
10/27/1999	5.90	
1/26/2000	0.26	
5/24/2000	2.53	
7/26/2000	2.89	
11/8/2000	3.13	
5/21/2001	3.71	
8/28/2001		
12/3/2001	3.30	
3/11/2002	3.44	17.10
5/23/2002	2.81	12.00
9/10/2002	3.64	10.50
11/4/2002	4.24	10.10
4/28/2003	2.62	10.80
6/3/2003	2.74	11.00
9/18/2003	4.89	11.70
12/9/2003	4.10	11.10
2/11/2004		
3/11/2004	2.25	12.40
8/10/2004	3.55	8.43

Silverbrook / Big Gorilla
Fig 6.17 Sodium

Date	MW-2	MW-4
2/2/1991	0.57	
5/18/1992	0.50	
6/6/1993	0.66	
5/26/1994	0.35	
8/15/1994	0.59	
11/21/1994	1.67	
2/20/1995	4.00	
6/6/1995	1.32	
8/25/1995	0.56	
11/14/1995	0.60	
2/19/1996	0.63	
12/31/1996	0.54	
8/12/1998	0.60	
10/19/1998	0.64	
5/26/1999	0.77	
10/27/1999	0.86	
1/26/2000	0.72	
5/24/2000	0.37	
7/26/2000	0.78	
11/8/2000	0.73	
5/21/2001	3.25	
12/3/2001	2.00	
3/11/2002	4.10	5.14
5/23/2002	0.74	5.01
9/10/2002	0.18	322.00
11/4/2002	0.90	5.17
4/28/2003	0.74	4.92
6/3/2003	0.96	5.00
9/18/2003	0.81	5.51
12/9/2003	1.43	6.34
2/11/2004		
3/11/2004	0.79	6.79
8/10/2004	0.69	5.75

Silverbrook / Big Gorilla
Fig 6.18 Iron

Date	MW-2	MW-4
7/16/1986	8.70	
8/18/1986	3.00	
9/16/1986	7.00	
5/22/1989	4.10	
8/13/1989	7.30	
2/16/1990	2.70	
8/26/1990	2.50	
12/8/1990	0.05	
2/2/1991	0.05	
2/23/1991	0.07	
3/25/1991	0.34	
4/28/1991	0.49	
5/23/1991	0.29	
8/22/1991	1.90	
11/17/1991	0.64	
2/20/1992	0.85	
5/18/1992	0.08	
11/19/1992	0.65	
3/11/1993	0.49	
6/6/1993	0.06	
9/13/1993	0.31	
11/15/1993	2.20	
3/28/1994	0.04	
5/26/1994	0.00	
8/15/1994	0.04	
11/21/1994	0.05	
2/20/1995	0.03	
6/6/1995	0.98	
8/25/1995	4.80	
11/14/1995	3.10	
2/19/1996	0.10	
12/31/1996	0.04	
8/12/1998	0.52	
10/19/1998	0.83	
5/26/1999	0.53	
10/27/1999	0.35	
1/26/2000	0.15	
5/24/2000	0.04	
7/26/2000	0.04	
11/8/2000	0.09	
5/21/2001	0.39	
12/3/2001	1.40	

3/11/2002	1.80	7.00
5/23/2002	0.03	17.10
9/10/2002	1.84	18.20
11/4/2002	0.17	8.82
4/28/2003	0.04	1.40
6/3/2003	0.10	0.55
9/18/2003	0.04	18.60
12/9/2003	0.18	18.20
3/11/2004	0.05	20.50
8/10/2004	0.04	17.10

Silverbrook / Big Gorilla
Fig 6.19 Manganese

Date	MW-2	MW-4
7/16/1986	0.36	
8/18/1986	0.27	
5/22/1989	0.34	
8/13/1989	0.36	
2/16/1990	0.31	
8/26/1990	0.34	
12/8/1990	0.21	
2/2/1991	0.36	
2/23/1991	0.45	
3/25/1991	0.23	
4/28/1991	0.35	
5/23/1991	0.52	
8/22/1991	0.40	
11/17/1991	0.50	
2/20/1992	0.65	
5/18/1992	0.35	
11/19/1992	0.49	
3/11/1993	0.34	
6/6/1993	0.70	
9/13/1993	0.85	
11/15/1993	1.96	
3/28/1994	0.20	
5/26/1994	0.12	
8/15/1994	0.13	
11/21/1994	0.11	
2/20/1995	0.20	
6/6/1995	0.49	
8/25/1995	1.00	
11/14/1995	2.00	
2/19/1996	2.00	
12/31/1996	0.20	
8/12/1998	0.52	
10/19/1998	0.54	
5/26/1999	0.31	
10/27/1999	0.47	
1/26/2000	0.26	
5/24/2000	0.13	
7/26/2000	0.17	
11/8/2000	0.21	
5/21/2001	0.25	
12/3/2001	0.19	
3/11/2002	0.20	2.48

5/23/2002	0.18	1.86
9/10/2002	0.31	1.56
11/4/2002	0.32	1.59
4/28/2003	0.18	1.59
6/3/2003	0.13	1.57
9/18/2003	0.37	1.66
12/9/2003	0.25	1.66
3/11/2004	0.12	1.70
8/10/2004	0.21	1.60

Silverbrook / Big Gorilla
Fig 6.20 Sulfates

Date	MW-2	MW-4
7/16/1986	25.00	
8/18/1986	34.00	
9/16/1986	23.00	
5/22/1989	38.00	
8/13/1989	29.00	
2/16/1990	36.00	
8/26/1990	35.00	
12/8/1990	22.00	
2/2/1991	27.00	
2/23/1991	29.00	
3/25/1991	18.00	
4/28/1991	22.00	
5/23/1991	31.00	
8/22/1991	29.00	
11/17/1991	28.50	
2/20/1992	36.50	
5/18/1992	21.00	
11/19/1992	30.00	
3/11/1993	18.00	
6/6/1993	23.00	
9/13/1993	29.00	
11/15/1993	30.00	
3/28/1994	17.40	
5/26/1994	15.50	
8/15/1994	29.80	
11/21/1994	16.50	
2/20/1995	17.50	
6/6/1995	21.00	
8/25/1995	1.00	
11/14/1995	0.00	
2/19/1996	1.00	
12/31/1996	22.00	
8/12/1998	0.30	
10/19/1998	41.00	
5/26/1999	0.00	
10/27/1999	27.00	
1/26/2000	26.00	
5/24/2000	20.00	
7/26/2000	20.00	
11/8/2000	*20.00*	
5/21/2001	32.00	
12/3/2001	*20.00*	

3/11/2002	*20.00*	216.00
5/23/2002	*20.00*	169.00
9/10/2002	45.00	127.80
11/4/2002	31.10	158.20
4/28/2003	30.20	165.60
6/3/2003	*20.00*	171.40
9/18/2003	27.10	192.20
12/9/2003	20.70	188.90
3/11/2004	*20.00*	198.00
8/10/2004	30.00	210.60

Silverbrook / Big Gorilla
Fig 6.21 Total Dissolved Solids

Date	MW-2	MW-4
7/16/1986	3.00	
8/18/1986	67.00	
9/16/1986	78.00	
5/22/1989	84.70	
8/13/1989	70.30	
2/16/1990	90.20	
8/26/1990	74.00	
12/8/1990	56.00	
2/2/1991	58.00	
2/23/1991	33.30	
3/25/1991	106.70	
4/28/1991	45.00	
5/23/1991	203.70	
8/22/1991	5.00	
11/17/1991	78.00	
2/20/1992	75.00	
5/18/1992	35.00	
11/19/1992	68.00	
3/11/1993	73.00	
6/6/1993	82.00	
9/13/1993	55.00	
11/15/1993	62.00	
3/28/1994	38.00	
5/26/1994	40.00	
8/15/1994	75.00	
11/21/1994	30.00	
2/20/1995	35.00	
6/6/1995	40.00	
8/25/1995	49.00	
11/14/1995	32.00	
2/19/1996	70.00	
12/31/1996	50.00	
8/12/1998	60.00	
10/19/1998	84.00	
5/26/1999	56.00	
10/27/1999	52.00	
1/26/2000	12.00	
5/24/2000	40.00	
7/26/2000	58.00	
11/8/2000	92.00	
5/21/2001	64.00	
12/3/2001	36.00	

3/11/2002	82.00	516.00
5/23/2002	42.00	384.00
9/10/2002	58.00	340.00
11/4/2002	64.00	356.00
4/28/2003	62.00	352.00
6/3/2003	52.00	288.00
9/18/2003	72.00	492.00
12/9/2003	40.00	403.00
3/11/2004	46.00	402.00
8/10/2004	68.00	392.00

Silverbrook / Big Gorilla
Fig 6.22 Specific Conductance

Date	Monitoring Point	Monitoring Point
7/16/1986	72.40	
8/18/1986	65.20	
9/16/1986	68.10	
5/22/1989	100.00	
8/13/1989	88.00	
2/16/1990	95.00	
8/26/1990	89.00	
12/8/1990	65.00	
2/2/1991	77.00	
2/23/1991	81.00	
3/25/1991	53.00	
4/28/1991	65.00	
5/23/1991	85.00	
8/22/1991	80.00	
11/17/1991	84.00	
2/20/1992	101.00	
5/18/1992	60.00	
11/19/1992	83.00	
3/11/1993	56.00	
6/6/1993	81.00	
9/13/1993	90.00	
11/15/1993	92.00	
3/28/1994	50.00	
5/26/1994	44.00	
8/15/1994	85.00	
11/21/1994	55.00	
2/20/1995	50.00	
6/6/1995	60.00	
8/25/1995	93.00	
11/14/1995	64.00	
2/19/1996	84.00	
12/31/1996	62.00	
8/12/1998	81.10	
10/19/1998	87.50	
5/26/1999	75.10	
10/27/1999	88.00	
1/26/2000	62.80	
5/24/2000	49.00	
7/26/2000	51.00	
11/8/2000	56.00	
5/21/2001	71.30	

12/3/2001	62.90	
3/11/2002	66.00	611.00
5/23/2002	59.20	516.00
9/10/2002	61.00	424.00
11/4/2002	83.20	428.00
4/28/2003	55.10	505.00
6/3/2003	53.40	518.00
9/18/2003	77.40	486.00
12/9/2003	55.50	505.00
3/11/2004	44.00	460.00
8/10/2004	57.40	449.00

Silverbrook / Big Gorilla

Fig 6.23 Lab pH

Date	MW-2	MW-4
7/16/1986	6.20	
8/18/1986	5.60	
9/16/1986	5.80	
9/13/1993	4.90	
11/15/1993	5.00	
3/28/1994	5.00	
5/26/1994	5.00	
8/15/1994	4.90	
11/21/1994	4.90	
2/20/1995	5.20	
6/6/1995	4.90	
8/25/1995	4.90	
11/14/1995	5.50	
2/19/1996	5.30	
12/31/1996	5.00	
8/12/1998	5.10	
10/19/1998	5.10	
5/26/1999	5.00	
10/27/1999	5.10	
1/26/2000	5.10	
5/24/2000	5.10	
7/26/2000	5.00	
11/8/2000	5.10	
5/21/2001	4.90	
12/3/2001	5.00	
3/11/2002	4.90	3.40
5/23/2002	5.00	3.70
9/10/2002	4.80	3.90
11/4/2002	4.90	3.80
4/28/2003	4.90	3.30
6/3/2003	5.00	3.30
9/18/2003	5.40	3.90
12/9/2003	5.20	3.60
3/11/2004	5.20	4.20
8/10/2004	5.20	4.00

Silverbrook / Big Gorilla
Fig 6.24 Potassium

Date	MW-5	MW-2
10/19/1998		0.00
5/26/1999		0.00
10/27/1999		0.00
1/26/2000		1.07
5/24/2000		1.00
7/26/2000		1.37
11/8/2000		<1.00
5/21/2001		3.32
12/3/2001		2.10
3/11/2002		3.50
5/23/2002		<0.001
9/10/2002		<0.001
11/4/2002		1.19
4/28/2003		<1.00
6/3/2003		<1.00
9/18/2003	70.90	<1.00
12/9/2003	55.90	<1.00
3/11/2004	67.10	<1.00
8/10/2004	61.10	<1.00

Silverbrook / Big Gorilla
Fig 6.25 Selenium

Date	Monitoring Point	Monitoring Point

Silverbrook / Big Gorilla
Fig 6.26 Sulfates

Date	MW-5	MW-2
7/16/1986		25.00
8/18/1986		34.00
9/16/1986		23.00
5/22/1989		38.00
8/13/1989		29.00
2/16/1990		36.00
8/26/1990		35.00
12/8/1990		22.00
2/2/1991		27.00
2/23/1991		29.00
3/25/1991		18.00
4/28/1991		22.00
5/23/1991		31.00
8/22/1991		29.00
11/17/1991		28.50
2/20/1992		36.50
5/18/1992		21.00
11/19/1992		30.00
3/11/1993		18.00
6/6/1993		23.00
9/13/1993		29.00
11/15/1993		30.00
3/28/1994		17.40
5/26/1994		15.50
8/15/1994		29.80
11/21/1994		16.50
2/20/1995		17.50
6/6/1995		21.00
8/25/1995		1.00
11/14/1995		0.00
2/19/1996		1.00
12/31/1996		22.00
8/12/1998		0.30
10/19/1998		41.00
5/26/1999		0.00
10/27/1999		27.00
1/26/2000		26.00
5/24/2000		20.00
7/26/2000		20.00
11/8/2000		*20.00*
5/21/2001		32.00
12/3/2001		*20.00*

3/11/2002	1728.00	*20.00*
5/23/2002		*20.00*
9/10/2002		45.00
11/4/2002		31.10
4/28/2003		30.20
6/3/2003		*20.00*
9/18/2003		27.10
12/9/2003	1526.00	20.70
3/11/2004	1408.00	*20.00*
8/10/2004	1485.00	30.00

Silverbrook / Big Gorilla
Fig 6.27 Alkalinity

Date	MW-5	MW-2
7/16/1986		27.00
8/18/1986		4.00
9/16/1986		0.00
5/22/1989		0.00
8/13/1989		1.40
2/16/1990		0.00
8/26/1990		1.00
12/8/1990		0.00
2/2/1991		0.00
2/23/1991		0.00
3/25/1991		4.80
4/28/1991		4.30
5/23/1991		6.30
8/22/1991		5.10
11/17/1991		2.80
2/20/1992		4.00
5/18/1992		2.40
11/19/1992		1.20
3/11/1993		3.00
6/6/1993		4.60
9/13/1993		2.10
11/15/1993		94.40
3/28/1994		2.40
5/26/1994		2.50
8/15/1994		2.30
11/21/1994		4.00
2/20/1995		3.10
6/6/1995		3.20
8/25/1995		2.80
11/14/1995		6.00
2/19/1996		6.50
12/31/1996		5.00
8/12/1998		11.80
10/19/1998		12.00
5/26/1999		10.80
10/27/1999		12.40
1/26/2000		11.80
5/24/2000		11.00
7/26/2000		11.80
11/8/2000		13.00
5/21/2001		4.60
12/3/2001		4.60

3/11/2002	25.40	5.00
5/23/2002		4.60
9/10/2002		3.00
11/4/2002		3.60
4/28/2003		3.60
6/3/2003		3.80
9/18/2003		6.40
12/9/2003	13.60	5.40
3/11/2004	16.80	4.60
8/10/2004	16.40	5.60

Silverbrook / Big Gorilla
Fig 6.28 Total Dissolved Solids

Date	MW-5	MW-2
7/16/1986		3.00
8/18/1986		67.00
9/16/1986		78.00
5/22/1989		84.70
8/13/1989		70.30
2/16/1990		90.20
8/26/1990		74.00
12/8/1990		56.00
2/2/1991		58.00
2/23/1991		33.30
3/25/1991		106.70
4/28/1991		45.00
5/23/1991		203.70
8/22/1991		5.00
11/17/1991		78.00
2/20/1992		75.00
5/18/1992		35.00
11/19/1992		68.00
3/11/1993		73.00
6/6/1993		82.00
9/13/1993		55.00
11/15/1993		62.00
3/28/1994		38.00
5/26/1994		40.00
8/15/1994		75.00
11/21/1994		30.00
2/20/1995		35.00
6/6/1995		40.00
8/25/1995		49.00
11/14/1995		32.00
2/19/1996		70.00
12/31/1996		50.00
8/12/1998		60.00
10/19/1998		84.00
5/26/1999		56.00
10/27/1999		52.00
1/26/2000		12.00
5/24/2000		40.00
7/26/2000		58.00
11/8/2000		92.00
5/21/2001		64.00
12/3/2001		36.00

3/11/2002	2794.00	82.00
5/23/2002		42.00
9/10/2002		58.00
11/4/2002		64.00
4/28/2003		62.00
6/3/2003		52.00
9/18/2003		72.00
12/9/2003	2646.00	40.00
3/11/2004	2470.00	46.00
8/10/2004	2856.00	68.00

Silverbrook / Big Gorilla
Fig 6.29 Specific Conductance

Date	Monitoring Point	Monitoring Point
7/16/1986		72.40
8/18/1986		65.20
9/16/1986		68.10
5/22/1989		100.00
8/13/1989		88.00
2/16/1990		95.00
8/26/1990		89.00
12/8/1990		65.00
2/2/1991		77.00
2/23/1991		81.00
3/25/1991		53.00
4/28/1991		65.00
5/23/1991		85.00
8/22/1991		80.00
11/17/1991		84.00
2/20/1992		101.00
5/18/1992		60.00
11/19/1992		83.00
3/11/1993		56.00
6/6/1993		81.00
9/13/1993		90.00
11/15/1993		92.00
3/28/1994		50.00
5/26/1994		44.00
8/15/1994		85.00
11/21/1994		55.00
2/20/1995		50.00
6/6/1995		60.00
8/25/1995		93.00
11/14/1995		64.00
2/19/1996		84.00
12/31/1996		62.00
8/12/1998		81.10
10/19/1998		87.50
5/26/1999		75.10
10/27/1999		88.00
1/26/2000		62.80
5/24/2000		49.00
7/26/2000		51.00
11/8/2000		56.00
5/21/2001		71.30

12/3/2001		62.90
3/11/2002	2730.00	66.00
5/23/2002		59.20
9/10/2002		61.00
11/4/2002		83.20
4/28/2003		55.10
6/3/2003		53.40
9/18/2003		77.40
12/9/2003	2510.00	55.50
3/11/2004	2350.00	44.00
8/10/2004	2630.00	57.40

Silverbrook / Big Gorilla
Fig 6.30 Selenium

Date	MW-5	MW-2
3/18/1986		0.0000
5/21/1986		
5/22/1989		0.0000
8/13/1989		0.0000
11/9/1989		0.0000
2/16/1990		0.0000
5/13/1990		0.0000
2/2/1991		
5/23/1991		0.0000
5/18/1992		0.0000
11/19/1992		0.0000
2/28/1993		0.0000
6/6/1993		0.0000
9/13/1993		0.0000
5/26/1994		0.2600
6/6/1995		0.0000
8/12/1998		
10/19/1998		
11/17/1998		0.0000
2/22/1999		0.0000
4/22/1999		0.0000
5/26/1999		
10/27/1999		0.0000
1/26/2000		0.0070
5/24/2000		0.0070
7/26/2000		0.0070
11/8/2000		*<0.007*
5/21/2001		*<0.007*
8/28/2001		*<0.007*
12/3/2001		*<0.007*
3/11/2002		*<0.007*
5/23/2002		*<0.007*
9/10/2002		*<0.007*
11/4/2002		*<0.007*
4/28/2003		*<0.007*
6/3/2003		*<0.007*
9/18/2003	0.123	
12/9/2003	0.12	
2/11/2004		*<0.005*
3/11/2004	0.098	
8/10/2004	0.058	*<0.005*

Silverbrook / Big Gorilla
Fig 6.31 Sulfates

Date	MW-5	Silverbrook
7/16/1986		112.00
8/18/1986		124.00
9/16/1986		160.00
5/22/1989		87.00
8/13/1989		103.00
11/9/1989		115.00
2/16/1990		104.00
5/13/1990		110.00
8/26/1990		115.00
11/28/1990		105.00
2/23/1991		94.00
5/23/1991		110.00
8/22/1991		137.00
11/17/1991		129.00
2/20/1992		135.00
5/18/1992		89.00
10/6/1992		102.00
11/1/1992		54.00
11/19/1992		120.00
11/30/1992		70.00
12/31/1992		82.00
1/31/1993		83.00
3/1/1993		83.00
3/11/1993		95.00
3/31/1993		31.00
5/3/1993		16.00
5/31/1993		61.60
6/6/1993		42.00
6/30/1993		37.40
8/1/1993		51.00
9/6/1993		77.00
9/13/1993		130.00
9/30/1993		139.00
10/31/1993		76.00
11/15/1993		125.00
11/30/1993		18.00
1/2/1994		57.00
1/31/1994		21.00
2/28/1994		56.00
3/14/1994		84.00
4/3/1994		49.00
5/1/1994		65.00

5/26/1994		72.00
5/31/1994		30.00
7/5/1994		105.00
8/4/1994		88.00
8/15/1994		82.00
9/7/1994		69.00
10/3/1994		43.00
11/1/1994		51.00
11/21/1994		125.00
12/6/1994		39.00
1/3/1995		40.00
2/1/1995		38.00
2/20/1995		89.00
3/1/1995		65.00
4/3/1995		27.00
5/8/1995		68.00
6/1/1995		78.00
6/6/1995		116.00
7/25/1995		77.00
8/1/1995		64.00
8/25/1995		130.00
9/4/1995		84.00
10/2/1995		124.00
11/1/1995		115.00
11/14/1995		94.00
12/1/1995		104.00
1/1/1996		99.00
2/1/1996		96.00
2/19/1996		96.00
3/1/1996		86.00
10/1/1996		120.00
11/1/1996		125.00
11/19/1996		138.00
12/1/1996		116.00
7/1/1998		145.00
8/12/1998		165.00
9/1/1998		188.00
11/17/1998		171.00
2/22/1999		96.00
4/22/1999		109.00
10/27/1999		156.00
1/26/2000		131.00
5/24/2000		110.00
7/26/2000		136.00
11/8/2000		280.00
5/21/2001		117.00
8/28/2001		200.00

10/1/2001		225.00
11/2/2001		320.00
12/3/2001		240.00
12/4/2001		265.00
3/11/2002	1728.00	181.00
4/1/2002		170.00
5/3/2002		180.00
5/23/2002		125.00
6/3/2002		170.00
7/1/2002		200.00
8/6/2002		235.00
9/3/2002		250.00
9/10/2002		202.30
11/4/2002		210.00
1/2/2003		190.00
2/10/2003		220.00
3/5/2003		200.00
4/2/2003		180.00
4/28/2003		164.80
5/3/2003		136.00
6/2/2003		250.00
6/3/2003		178.10
10/6/2003		170.00
11/3/2003		180.00
12/9/2003	1526.00	215.00
3/11/2004	1408.00	214.00
8/10/2004	1485.00	187.60

BD Mining
Fig 7.1 Iron

Date	MP006	MP007	MP008
04/28/86	38.00		
06/02/86	50.00		
07/24/86	54.00		
08/26/86	14.00		
10/08/86	60.00		
02/03/87	12.00		
03/27/88		62.00	
07/27/88	67.50	73.50	
08/14/88	60.56	72.20	
09/14/88	56.50	59.60	
10/16/88	57.70	66.74	
11/17/88	61.00	62.00	
12/14/88	57.20	67.20	
01/15/89	63.00	73.55	
02/14/89	61.00	66.00	
03/16/89	62.20	63.00	
04/06/89	57.10	56.74	
05/25/89	55.15		
06/13/89		80.00	
08/25/89	53.65	53.44	
12/14/89	52.15	79.15	
01/15/90	63.00	25.84	
02/01/90	51.46		
05/14/90	47.06	90.50	
08/29/90	48.50	81.40	
11/28/90	51.39	18.22	
02/27/91	50.86	99.10	
05/28/91	48.20		
08/28/91	52.56	90.25	
11/25/91	58.60	98.50	
02/25/92	51.76	77.20	
05/06/92	48.80	68.10	
08/23/92	42.78	31.06	
11/29/92	50.41	62.90	
02/10/93	44.38	57.90	
05/17/93	36.70	82.20	
08/04/93	46.09	80.50	
11/07/93	49.48	80.60	
03/25/94	45.45	72.30	
06/28/94	45.54	7.35	
08/09/94	46.94	116.20	
12/08/94	43.92	70.90	

03/14/95	40.95	43.03	
06/05/95	89.00	50.50	
09/19/95	45.80	71.00	
12/05/95	41.90	49.70	
01/16/96			108.00
01/31/96			125.00
02/19/96			166.00
03/04/96			172.00
03/13/96			121.00
03/25/96	42.60	45.90	
04/24/96			128.00
06/24/96	39.50	44.10	89.60
09/12/96	36.80	37.50	114.00
12/18/96	24.60		126.00
03/05/97	27.80		67.40
06/19/97	38.10		133.00
09/04/97	36.20		12.70
11/17/97	43.00		11.80
03/05/98	36.00		0.66
05/18/98	45.20		26.10
09/18/98	42.40		39.20
11/05/98	44.10		5.65
03/03/99	47.00		1.70
06/23/99	42.30		9.65
09/23/99	35.60		0.88
11/19/99	42.70		33.20
03/03/00	38.60		0.65
06/06/00	36.50		5.29
08/17/00	37.30		13.80
12/11/00	44.10		5.08
03/07/01	50.50		6.80
06/19/01	36.98		6.35
09/04/01	46.80		14.40
12/19/01	38.80		
02/07/02			32.20
03/14/02	44.80		5.23
07/03/02	41.70		31.10
09/30/02	44.60		41.60
12/13/02	49.60		38.70
02/25/03	42.10		50.90
04/30/03	39.00		48.30
07/21/03	42.80		41.40
10/10/03	41.60		54.00
02/02/04	41.20		56.00
05/25/04	37.70		50.90
07/22/04	34.50		51.30

BD Mining
Fig 7.2 Manganese

Date	MP006	MP007	MP008
04/28/86	8.70		
06/02/86	9.10		
07/24/86	10.70		
08/26/86	9.70		
10/08/86	12.00		
02/03/87	12.00		
03/27/88		4.80	
07/27/88	10.20	4.57	
08/14/88	11.66	6.58	
09/14/88	9.88	4.23	
10/16/88	6.02	12.66	
11/17/88	10.00	5.40	
12/14/88	11.20	5.30	
01/15/89	11.40	6.95	
02/14/89	10.60	5.30	
03/16/89	9.14	5.98	
04/06/89	11.84		
04/14/89		4.96	
05/25/89	8.75		
06/13/89		7.88	
08/25/89	10.11	4.94	
12/14/89	9.76	8.03	
01/15/90	11.40		
02/01/90	9.47	0.57	
05/14/90	9.80	8.38	
08/29/90	9.74	6.49	
11/28/90	10.86	9.16	
02/27/91	0.95		
05/28/91	9.27	9.79	
08/28/91	9.14	7.10	
11/25/91	11.29	9.29	
02/25/92	9.12	7.48	
05/06/92	9.13	6.21	
08/23/92	9.07	3.54	
11/29/92	10.84	6.22	
02/10/93	10.44	7.44	
05/17/93	7.84	6.44	
08/04/93	12.61	8.60	
11/07/93	9.17	7.69	
03/25/94	8.78	7.67	
06/28/94	9.72	7.63	
08/09/94	9.13	8.94	

12/08/94	8.38	6.69	
03/14/95	8.54	4.56	
06/05/95	9.81	5.44	
09/19/95	8.76	6.87	
12/05/95	7.20		
01/16/96			3.64
01/31/96			3.90
02/19/96			4.42
03/04/96			3.96
03/13/96			2.23
03/25/96	8.65	5.14	
04/24/96			2.22
06/24/96	8.10	4.40	0.03
09/12/96	7.97	4.53	2.24
12/18/96	9.38		2.67
03/05/97	7.18		2.76
06/19/97	8.17		2.65
09/04/97	7.77		2.49
11/17/97	9.20		2.62
03/05/98	7.92		1.31
05/18/98	6.61		0.52
09/18/98	7.79		0.73
11/05/98	8.54		0.60
03/03/99	7.01		0.30
06/23/99	8.64		0.70
09/23/99	7.82		0.32
11/19/99	8.44		1.32
03/03/00	9.10		0.22
06/06/00	9.28		0.33
08/17/00	7.90		1.41
12/11/00	7.90		0.30
03/07/01	9.20		0.30
06/19/01	8.70		0.83
09/04/01	9.50		0.23
12/19/01	8.70		0.73
03/14/02	8.44		0.70
07/03/02	7.72		1.52
09/30/02	7.79		2.39
12/13/02	7.88		1.73
02/25/03	8.83		3.17
04/30/03	7.31		2.28
07/21/03	8.52		2.84
10/10/03	9.18		5.14
02/02/04	8.03		4.86
05/25/04	7.68		4.78
07/22/04	7.64		4.80

BD Mining
Fig 7.3 Sulfates

Date	MP006	MP007	MP008
04/28/86	622.00		
06/02/86	616.00		
07/24/86	672.00		
08/26/86	644.00		
10/08/86	696.00		
02/03/87	760.00		
03/27/88		360.00	
07/27/88	600.00	395.00	
08/14/88	790.00	421.50	
09/14/88	720.50	320.20	
10/16/88	29.00	268.00	
11/17/88	33.00	115.00	
12/14/88	712.20	329.80	
01/15/89	705.00	344.20	
02/14/89	706.60	304.00	
03/16/89	722.00	324.00	
04/06/89	604.00		
04/14/89		306.70	
05/25/89	584.00		
06/13/89		423.00	
08/25/89	635.00	454.00	
12/14/89	605.00	249.00	
01/15/90	705.00		
02/01/90	353.50	34.90	
05/14/90	598.40	475.20	
08/29/90	345.80	406.60	
11/28/90	642.80	482.10	
02/27/91	685.60	588.40	
05/28/91	632.90	591.70	
08/28/91	606.00	478.00	
11/25/91	404.00	268.00	
02/25/92	585.00	416.00	
05/06/92	636.50	345.30	
08/23/92	618.92	325.28	
11/29/92	680.95	415.23	
02/10/93	624.93	444.47	
05/17/93	603.56	523.90	
08/04/93	657.30	520.17	
11/07/93	549.80	558.20	
03/25/94	633.81	551.93	
06/28/94	740.30	679.20	
08/09/94	707.21	545.67	

12/08/94	594.80	458.50	
03/14/95	659.44	351.87	
06/05/95	746.00	412.00	
09/19/95	568.00	429.00	
12/05/95	611.00	401.00	
03/25/96	801.00	456.00	
06/24/96	699.00	574.00	
09/12/96	717.00	459.00	
01/16/96			517.00
01/31/96			434.00
02/19/96			260.00
03/04/96			263.00
03/13/96			280.00
04/24/96			253.00
06/26/96			329.00
09/12/96			324.00
12/18/96	705.00		377.00
03/05/97	656.00		395.00
06/19/97	859.00		432.00
09/04/97	661.00		372.00
11/17/97	672.00		338.00
03/05/98	564.00		112.00
05/18/98	549.00		52.40
09/18/98	693.00		72.40
11/05/98	701.00		60.10
03/03/99	636.00		60.60
06/23/99	694.00		101.00
09/23/99	723.00		56.20
11/19/99	654.00		196.00
03/03/00	662.00		69.50
06/06/00	563.00		68.30
08/17/00	503.00		105.00
12/11/00	621.00		54.70
03/07/01	530.00		45.70
06/19/01	616.00		78.20
09/04/01	642.00		61.90
12/19/01	611.00		58.40
03/14/02	614.00		53.40
07/03/02	555.00		82.70
09/30/02	539.00		242.00
12/13/02	438.00		196.00
02/25/03	536.00		265.00
04/30/03	530.00		252.00
07/21/03	600.00		273.00
10/10/03	647.00		482.00
02/02/04	587.00		530.00
05/25/04	577.00		479.00

07/22/04	650.00		506.00

BD Mining

Fig 7.4 pH

Date	MP006	MP007	MP008
04/28/86	5.80		
06/02/86	6.05		
07/24/86	6.29		
08/26/86	6.29		
10/08/86			
02/03/87	6.21		
03/27/88		4.47	
07/27/88	5.84	5.43	
08/14/88	5.68	5.70	
09/14/88	5.68	5.47	
10/16/88	5.51	6.02	
11/17/88	5.92	5.63	
12/14/88	6.05	5.95	
01/15/89	6.05	5.51	
02/14/89	6.08	5.72	
03/16/89	6.29	5.83	
04/06/89	6.26	5.59	
05/25/89	6.80		
06/13/89		5.73	
08/25/89	5.82	4.50	
12/14/89	5.97	5.27	
01/15/90	6.05		
02/01/90	5.93	4.34	
05/14/90	6.20	5.60	
08/29/90	6.48	5.85	
11/28/90	6.30	5.68	
02/27/91	4.54	3.09	
05/28/91	6.00	5.82	
08/28/91	5.89	4.89	
11/25/91	5.78	5.63	
02/25/92	6.11	5.34	
05/06/92	6.45	6.02	
08/23/92	6.09	5.41	
11/29/92	5.88	5.66	
02/10/93	6.07	5.67	
05/17/93	5.58	4.82	
08/04/93	5.73	4.65	
11/07/93	5.69	5.10	
03/25/94	6.05	5.31	
06/28/94	5.98	5.04	6.42
08/09/94	5.72	5.37	5.64
12/08/94	6.06	5.71	6.24

03/14/95	6.13	5.33	6.05
06/05/95	6.15	5.30	6.25
09/19/95	5.88	5.11	6.40
12/05/95	6.03	5.65	6.20
01/16/96			6.42
01/31/96			5.64
02/19/96			6.24
03/04/96			6.05
03/13/96			6.25
03/25/96	6.32	5.51	5.96
04/24/96			6.40
06/24/96	6.09	4.47	6.20
09/12/96	6.02	4.82	5.96
12/18/96	6.26		6.31
03/05/97	6.99		6.41
06/19/97	6.00		6.01
09/04/97	6.13		4.34
11/17/97	5.82		3.59
03/05/98	5.95		3.93
05/18/98	6.06		6.30
09/18/98	6.11		6.39
11/05/98	6.03		5.58
03/03/99	6.02		5.70
06/23/99	6.03		6.18
09/23/99	6.24		5.77
11/19/99	5.82		5.92
03/03/00	6.14		5.49
06/06/00	6.46		6.08
08/17/00	6.23		4.16
12/11/00	6.09		4.70
03/07/01	6.12		5.07
06/19/01	5.96		4.85
09/04/01	6.04		4.97
12/19/01	6.04		6.42
03/14/02	6.07		5.52
07/03/02	5.79		5.63
09/30/02	5.96		5.98
12/13/02	6.26		6.32
02/25/03	5.87		6.10
04/30/03	5.93		6.05
07/21/03	6.15		5.70
10/10/03	6.06		
10/13/03			4.98
02/02/04	5.87		5.08
05/25/04	5.94		5.07
07/22/04	5.91		4.99

BD Mining
Fig 7.5 Specific Conductance

Date	MP006	MP007	MP008
04/28/86	1450.00		
06/02/86	1490.00		
07/24/86	1138.00		
08/26/86	1221.00		
10/08/86	1188.00		
02/03/87	1332.00		
03/27/88		470.00	
07/27/88	1260.00	729.00	
08/14/88	1440.00	626.00	
09/14/88	1414.00	655.00	
10/16/88	621.00	1555.00	
11/17/88	1485.00	734.00	
12/14/88	14.00	780.00	
01/15/89	1293.00	799.00	
02/14/89	1362.00	603.00	
03/16/89	1409.00	713.00	
04/06/89	1274.00		
04/14/89		598.00	
06/13/89		872.00	
05/25/89	1274.00		
08/25/89	1269.00	816.00	
12/14/89	1208.00	922.00	
01/15/90	1293.00		
02/01/90	1264.00	83.00	
05/14/90	1192.00	919.00	
08/29/90	1275.00	900.00	
11/28/90	1344.00	1064.00	
02/27/91	1177.00	1321.00	
05/28/91	1326.00	1155.00	
08/28/91	1269.00	956.00	
11/25/91	1400.00	1047.00	
02/25/92	1345.00	901.00	
05/06/92	1411.00	825.00	
08/23/92	1425.00	798.00	
11/29/92	1345.00	852.00	
02/10/93	1317.00	963.00	
05/17/93	1260.00	1077.00	
08/04/93	1419.00	981.00	
11/07/93	1350.00	1032.00	
03/25/94	1330.00	1037.00	
06/28/94	1402.00	1020.00	
08/09/94	1596.00	1363.00	

12/08/94	1231.00	912.00	
03/14/95	1386.00	794.00	
06/05/95	1313.00	769.00	
09/19/95	1488.00	997.00	
12/05/95	1351.00	887.00	
01/16/96			1136.00
01/31/96			750.00
02/19/96			790.00
03/04/96			669.00
03/13/96			715.00
03/25/96	1669.00	892.00	
04/24/96			691.00
06/24/96	1783.00	1403.00	833.00
09/12/96	1268.00	902.00	668.00
12/18/96	1200.00		762.00
03/05/97	1220.00		852.00
06/19/97	1344.00		831.00
09/04/97	1232.00		687.00
11/17/97	1271.00		674.00
03/05/98	1023.00		216.00
05/18/98	1201.00		201.00
09/18/98	1250.00		179.00
11/05/98	1365.00		158.00
03/03/99	1348.00		191.00
06/23/99	1281.00		207.00
09/23/99	1190.00		143.00
11/19/99	1268.00		231.00
03/03/00	1105.00		173.00
06/06/00	1166.00		181.10
08/17/00	1138.00		264.40
12/11/00	1332.00		146.20
03/07/01	1258.00		127.20
06/19/01	1181.00		178.90
09/04/01	1277.00		106.70
12/19/01	1225.00		
02/07/02			221.60
03/14/02	1186.00		154.10
07/03/02	1132.00		248.00
09/30/02	1167.00		603.00
12/13/02	1137.00		431.70
02/25/03	1113.00		568.00
04/30/03	1084.00		580.00
07/21/03	1190.00		604.00
10/10/03	1145.00		934.00
02/02/04	1197.00		978.00
05/25/04	1202.00		943.00
07/22/04	1309.00		965.00

BD Mining
Fig 7.6 Alkalinity

Date	MP006	MP007	MP008
04/28/86	2.00		
06/02/86	2.00		
07/24/86	72.00		
08/26/86	74.00		
10/08/86			
02/03/87	68.00		
03/27/88		1.00	
07/27/88	22.00	9.00	
08/14/88	51.00	21.00	
09/14/88	54.00	22.00	
10/16/88	22.00	79.00	
11/17/88	62.00	28.00	
12/14/88	44.00	17.00	
01/15/89	61.00	27.00	
02/14/89	67.00	13.00	
03/16/89	70.00	26.00	
04/06/89	83.00		
04/14/89		13.00	
05/25/89	92.00		
06/13/89		27.00	
08/25/89	76.00	0.00	
12/14/89	53.00	21.00	
01/15/90	61.00		
02/01/90	77.00	0.00	
05/14/90	37.00	22.00	
08/29/90	45.00	25.00	
11/28/90	67.00	26.00	
02/27/91	1.00	0.00	
05/28/91	42.00	28.00	
08/28/91	41.00	5.00	
11/25/91	50.00	17.00	
02/25/92	87.00	11.00	
05/06/92	83.00	36.00	
08/23/92	73.00	16.00	
11/29/92	60.00	24.00	
02/10/93	80.00	20.00	
05/17/93	71.00	5.00	
08/04/93	72.00	4.00	
11/07/93	69.00	10.00	
03/25/94	81.00	13.00	
06/28/94	30.00	3.00	
08/09/94	10.00	13.00	

12/08/94	71.86	24.63	
03/14/95	48.72	8.12	
06/05/95	71.50	11.76	
09/19/95	55.50	8.50	
12/05/95	56.50	18.90	
01/16/96			10.00
01/31/96			2.60
02/19/96			12.70
03/04/96			6.60
03/13/96			19.30
03/25/96	62.90	8.60	
04/24/96			65.10
06/24/96	14.70		4.20
09/12/96	9.85		4.93
12/18/96	81.90		29.30
03/05/97	84.40		55.30
06/19/97	40.20		1.96
09/04/97	9.80		0.98
11/17/97	73.30		0.00
03/05/98	86.20		0.00
05/18/98	99.50		29.60
09/18/98	74.40		14.60
11/05/98	71.50		6.50
03/03/99	95.70		5.50
06/23/99	80.40		6.03
09/23/99	61.60		2.20
11/19/99	61.80		13.80
03/03/00	78.12		2.17
06/06/00	71.00		1.00
08/17/00	64.70		*0.40*
12/11/00	91.20		2.05
03/07/01	89.00		*0.40*
06/19/01	72.50		1.96
09/04/01	80.50		1.05
12/19/01	68.30		38.80
03/14/02	67.70		7.20
07/03/02	70.00		15.40
09/30/02	77.40		18.40
12/13/02	26.80		8.25
02/25/03	65.10		104.20
04/30/03	65.30		17.50
07/21/03	85.50		19.10
10/10/03	20.30		*0.40*
02/02/04	31.60		3.10
05/25/04	51.30		*0.40*
07/22/04	64.00		6.10

BD Mining
Fig 7.7 Acidity

Date	MP006	MP007	MP008
04/28/86			
06/02/86	37.50		
07/24/86	164.00		
08/26/86	163.00		
10/08/86			
02/03/87	164.00		
03/27/88		167.00	
07/27/88	45.00	128.00	
08/14/88	77.00	133.00	
09/14/88	54.00	105.00	
10/16/88	87.00	57.00	
11/17/88	68.00	100.00	
12/14/88	51.00	113.00	
01/15/89	57.00	118.00	
02/14/89	72.00	116.00	
03/16/89	137.00	179.00	
04/06/89	32.00		
04/14/89		117.00	
05/25/89	19.00		
06/13/89		142.00	
08/25/89	35.00	266.00	
12/14/89	22.00	156.00	
01/15/90	57.00		
02/01/90	14.00	18.00	
05/14/90	20.00	160.00	
08/29/90	37.00	172.00	
11/28/90	41.00	158.00	
02/27/91	22.00	135.00	
05/28/91	27.00	184.00	
08/28/91	36.00	185.00	
11/25/91	58.00	168.00	
02/25/92	28.00	157.00	
05/06/92	29.00	104.00	
08/23/92	43.00	97.00	
11/29/92	18.00	103.00	
02/10/93	24.00	108.00	
05/17/93	16.00	197.00	
08/04/93	18.00	165.00	
11/07/93	0.00	148.00	
03/25/94	11.00	133.00	
06/28/94	11.00	121.00	
08/09/94	26.00	166.00	

12/08/94	14.17	124.69	
03/14/95	6.79	82.24	
06/05/95	47.30	89.90	
09/19/95	17.50	121.00	
12/05/95	18.50	10.00	
01/16/96			204.00
01/31/96			154.00
02/19/96			111.00
03/04/96			90.00
03/13/96			78.53
03/25/96	20.62	95.13	
04/24/96			76.90
06/24/96	29.80	190.00	84.10
09/12/96	11.40	98.80	76.70
12/18/96	84.80		83.20
03/05/97	79.50		159.00
06/19/97	3.25		90.70
09/04/97	0.88		42.30
11/17/97	22.30		81.60
03/05/98	0.00		23.80
05/18/98	0.00		0.00
09/18/98	12.90		0.00
11/05/98	28.20		0.00
03/03/99	15.83		1.65
06/23/99	18.30		6.90
09/23/99	54.60		7.25
11/19/99	94.30		33.30
03/03/00	25.52		4.31
06/06/00	*0.40*		2.55
08/17/00	20.60		7.41
12/11/00	83.50		15.70
03/07/01	*0.40*		6.55
06/19/01	75.50		47.20
09/04/01	69.30		7.76
12/19/01	16.80		*0.40*
03/14/02	14.70		1.30
07/03/02	18.40		20.80
09/30/02	28.10		51.30
12/13/02	9.67		32.20
02/25/03	21.10		*0.40*
04/30/03	5.70		49.50
07/21/03	*0.40*		56.50
10/10/03	7.00		107.00
02/02/04	16.60		109.00
05/25/04	10.50		102.00
07/22/04	7.60		95.60

BD Mining
Fig 7.8 Total Dissolved Solids

Date	MP006	MP007	MP008
04/28/86	1359.00		
06/02/86	1169.00		
07/24/86	1041.00		
08/26/86	1250.00		
10/08/86	1296.00		
02/03/87	1145.00		
03/27/88		582.00	
07/27/88	1130.00	653.00	
08/14/88	1222.00	655.00	
09/14/88	1117.90	542.00	
10/16/88	567.00	1218.00	
11/17/88	1245.00	597.00	
12/14/88	1105.00	565.00	
01/15/89	1150.00	650.00	
02/14/89		530.00	
03/16/89	1205.00	563.00	
04/06/89	1100.00		
04/14/89		524.00	
05/25/89	164.00		
06/13/89		2890.00	
08/25/89	0.00	899.00	
12/14/89	1033.00	923.00	
01/15/90	11.50		
02/01/90	984.00	322.00	
05/14/90	1025.00	826.00	
08/29/90	1079.00	727.00	
11/28/90	1071.00	830.00	
02/27/91	1042.00	912.00	
05/28/91	1036.00	990.00	
08/28/91	1140.00	829.00	
11/25/91	1090.00	799.00	
02/25/92	1129.00	768.00	
05/06/92	1100.00	634.00	
08/23/92	1103.00	576.00	
11/29/92	929.00	606.00	
02/10/93	972.00	726.00	
05/17/93	1001.00	837.00	
08/04/93	1078.00	786.00	
11/07/93	1092.00	774.00	
03/25/94	963.00	754.00	
06/28/94	1086.00	791.00	
08/09/94	984.00	826.00	

12/08/94	1023.00	773.00	
03/14/95	989.00	565.00	
06/05/95	1070.00	650.00	
09/19/95	997.00	668.00	
12/05/95	973.00	620.00	
01/16/96			818.00
01/31/96			970.00
02/19/96			495.00
03/04/96			448.00
03/13/96			394.00
03/25/96	1002.00	590.00	
04/24/96			403.00
06/24/96	1205.00	1023.00	586.00
09/12/96	1074.00	684.00	518.00
12/18/96	945.00		462.00
03/05/97	972.00		582.00
06/19/97	1000.00		664.00
09/04/97	1010.00		612.00
11/17/97	966.00		466.00
03/05/98	981.00		193.00
05/18/98	932.00		138.00
09/18/98	1058.00		124.00
11/05/98	1060.00		114.00
03/03/99	1016.00		116.00
06/23/99	1136.00		256.00
09/23/99	1046.00		116.00
11/19/99	1086.00		32.00
03/03/00	843.00		84.00
06/06/00	926.00		121.00
08/17/00	910.00		184.00
12/11/00	1099.00		151.00
03/07/01	986.00		103.00
06/19/01	960.00		154.00
09/04/01	1036.00		87.00
12/19/01	997.00		202.00
03/14/02	951.00		62.00
07/03/02	869.00		153.00
09/30/02	961.00		502.00
12/13/02	824.00		314.00
02/25/03	892.00		421.00
04/30/03	949.00		487.00
07/21/03	973.00		462.00
10/10/03	998.00		788.00
02/02/04	570.00		684.00
05/25/04	974.00		789.00
07/22/04	1030.00		805.00

BD Mining
Fig 7.9 Magnesium

Date	MP006	MP007	MP008
02/03/87	88.00		
03/27/88		20.00	
05/25/88	7.30		
07/27/88		2.10	
02/14/89		24.00	
05/25/89	88.00		
06/13/89		13.00	
08/28/89	71.40	25.80	
12/14/89	68.47	33.19	
02/19/90	74.36	1.81	
05/14/90	77.90	46.10	
08/29/90	58.76	28.70	
11/28/90	62.18	29.35	
02/27/91	68.09	40.80	
05/28/91	65.85	41.15	
08/28/91	68.00	28.80	
11/25/91	70.20	35.90	
02/25/92	65.60	30.50	
05/06/92	67.70	27.90	
08/23/92	55.10	16.66	
11/29/92	67.00	28.50	
02/10/93	66.10	34.60	
05/17/93	70.50	28.90	
08/04/93	20.11	19.89	
11/07/93	74.80	34.50	
03/25/94	64.70	34.60	
06/28/94	76.00	39.10	
08/09/94	70.10	40.10	
12/08/94	67.00	31.80	
03/14/95	68.20	23.90	
06/05/95	78.10	30.50	
09/19/95	61.30	25.30	
12/05/95	67.40	26.75	
01/16/96			40.90
01/31/96			35.10
02/19/96			29.80
03/04/96			29.60
03/13/96			26.00
03/25/96	79.00	31.00	
04/24/96			24.90
06/24/96	72.10	29.40	27.70
09/12/96	69.00	29.00	28.20

12/18/96	60.00		30.10
03/05/97	67.80		33.90
06/19/97	67.00		41.00
09/04/97	66.00		38.20
11/17/97	68.90		38.00
11/05/98	74.00		8.12
03/03/99	66.60		7.27
06/23/99	64.30		8.80
09/23/99	63.20		8.01
11/19/99	75.00		10.40
03/03/00	72.60		11.60
06/06/00	80.70		10.90
08/17/00	69.50		14.30
12/11/00	77.00		5.99
03/07/01	43.00		5.28
06/19/01	67.70		8.41
09/04/01	94.00		4.00
12/19/01	62.30		7.57
03/14/02	63.40		0.10
07/03/02	110.00		9.69
09/30/02	67.50		33.50
12/13/02	63.50		20.20
02/25/03	61.60		32.00
04/30/03	59.50		30.30
07/21/03	66.50		33.90
10/10/03	60.30		49.00
02/02/04	64.30		53.90
05/25/04	62.20		52.20
07/22/04	70.60		55.70

BD Mining
Fig 7.10 Nickel

Date	MP006	MP007	MP008
02/03/87			
05/25/88			
05/25/89			
08/28/89			
12/14/89			
02/19/90			
05/14/90			
08/29/90			
11/28/90			
02/27/91			
05/28/91			
08/28/91			
11/25/91			
02/25/92			
05/06/92			
08/23/92			
11/29/92			
02/10/93			
05/17/93			
08/04/93			
03/25/94	0.17	0.10	
06/28/94	0.14	0.09	
08/09/94	0.15	0.10	
12/08/94	0.11	0.07	
03/14/95	0.19	0.14	
06/05/95	0.18	0.04	
09/19/95	0.11	0.15	
12/05/95	0.15	0.09	
01/16/96			0.05
01/31/96			0.06
02/19/96			0
03/04/96			0
03/13/96			0
03/25/96	0.11	0.07	
04/24/96			0
06/24/96	0.16	0.17	
06/26/96			0.07
09/12/96	0.13	0.12	0.04
12/18/96	0.11		0.00
03/05/97	0.10		0.06
06/19/97	0.14		0.14
09/04/97	0.10		0.06

11/17/97	0.13		0.08
11/05/98	0.08		0.00
03/03/99	0.12		*<0.04*
06/23/99	0.18		*<0.04*
09/23/99	0.16		*<0.04*
11/19/99	0.16		*<0.04*
03/03/00	0.15		*<0.04*
06/06/00	0.10		*<0.04*
08/17/00	0.10		*<0.04*
12/11/00	0.15		*<0.04*
03/07/01	0.21		0.04
06/19/01	0.13		*<0.04*
09/04/01	0.15		0.04
12/19/01	0.10		0.01
03/14/02	0.10		0.01
07/03/02	0.11		*<0.01*
09/30/02	0.11		0.04
12/13/02	0.11		0.01
02/25/03	0.10		0.03
04/30/03	0.09		0.03
07/21/03	0.10		0.04
10/10/03	0.15		0.11
02/02/04	0.19		0.07
05/25/04	0.10		0.05
07/22/04	0.10		0.08

BD Mining

Fig 7.11 Sodium

Date	MP006	MP007	MP008
04/28/86			
06/02/86			
07/24/86			
08/26/86			
10/08/86			
02/03/87	13.10		
03/27/88		9.30	
07/27/88	5.50	10.40	
08/14/88			
09/14/88			
10/16/88			
11/17/88			
12/14/88			
01/15/89			
02/14/89			
03/16/89			
04/06/89			
05/25/89	10.80		
06/13/89		8.11	
08/25/89	13.72	7.18	
12/14/89	20.30	10.59	
01/15/90			
02/01/90	15.42	1.07	
05/14/90	22.80	27.00	
08/29/90	18.90	17.90	
11/28/90	8.95	9.98	
02/27/91	5.70	4.46	
05/28/91	14.97	12.02	
08/28/91	14.31	18.04	
11/25/91	17.56	18.03	
02/25/92	16.40	17.80	
05/06/92	12.80	18.50	
08/23/92	21.30	13.70	
11/29/92	11.80	23.40	
02/10/93	13.22	12.84	
05/17/93	28.50	26.70	
08/04/93	12.50	17.10	
11/07/93	11.10	14.10	
03/25/94	13.40	17.00	
06/28/94	8.80	12.10	
08/09/94	10.60	12.60	
12/08/94	8.10	11.30	

03/14/95	11.10	15.50	
06/05/95	12.80	19.50	
09/19/95	12.10	11.30	
12/05/95	12.10	17.20	
01/16/96			6.90
01/31/96			7.10
02/19/96			8.80
03/04/96			9.60
03/13/96			11.60
03/25/96	13.80	13.60	
04/24/96			13.70
06/24/96	14.00	20.20	11.40
09/12/96	9.30	15.20	9.20
12/18/96	8.90		8.90
03/05/97	10.20		8.50
06/19/97	11.00		12.40
09/04/97	11.70		11.80
11/17/97	13.00		12.00
03/05/98	11.20		4.20
05/18/98	7.40		4.60
09/18/98	12.60		3.62
11/05/98	14.30		4.68
03/03/99	13.40		4.41
06/23/99	13.60		4.38
09/23/99	20.00		4.70
11/19/99	12.40		3.45
03/03/00	9.40		4.70
06/06/00	14.50		4.95
08/17/00	14.90		4.23
12/11/00	13.60		4.09
03/07/01	10.00		4.54
06/19/01	12.90		3.60
09/04/01	15.70		5.34
12/19/01	13.30		4.68
03/14/02	14.70		4.39
07/03/02	16.40		4.46
09/30/02	14.30		8.98
12/13/02	15.00		192.00
02/25/03	14.20		8.46
04/30/03	14.50		9.03
07/21/03	15.60		10.10
10/10/03	15.70		10.30
02/02/04	14.90		9.74
05/25/04	13.70		9.00
07/22/04	14.10		9.31

BD Mining
Fig 7.12 Calcium

Date	MP006	MP007	MP008
02/03/87			
05/25/88			
05/25/89			
08/28/89			
12/14/89			
02/19/90			
05/14/90			
08/29/90			
11/28/90			
02/27/91			
05/28/91			
08/28/91			
11/25/91			
02/25/92			
05/06/92			
08/23/92			
11/29/92			
02/10/93			
05/17/93			
08/04/93			
03/25/94	125.07		
06/28/94	115.79		
08/09/94	143.73		
12/08/94	126.25	84.17	
03/14/95	138.68	62.52	
06/05/95	154.51	61.12	
09/19/95	150.00	74.00	
12/05/95	130.00	50.00	
01/16/96			70.00
01/31/96			26.00
02/19/96			33.00
03/04/96			57.00
03/13/96			26.00
03/25/96	160.00	70.00	
04/24/96			26.50
06/24/96	140.00	89.00	30.00
09/12/96	140.00	73.00	20.00
12/18/96	125.20		39.30
03/05/97	122.00		40.00
06/19/97	118.00		37.00
09/04/97	122.00		37.00
11/17/97	141.00		40.00

11/05/98	143.00		8.70
03/03/99	137.00		11.00
06/23/99	129.00		7.00
09/23/99	130.50		8.70
11/19/99	120.00		7.00
03/03/00	126.70		11.30
06/06/00	119.00		12.00
08/17/00	120.00		14.00
12/11/00	143.00		*0.50*
03/07/01	100.00		6.06
06/19/01	146.00		12.50
09/04/01	134.00		5.24
12/19/01	111.00		
02/07/02			7.79
03/14/02	96.30		6.65
07/03/02	127.00		10.60
09/30/02	126.00		41.80
12/13/02	116.00		25.00
02/25/03	102.00		31.70
04/30/03	107.00		36.20
07/21/03	118.00		41.40
10/10/03	111.00		
10/13/03			60.60
02/02/04	117.00		69.80
05/25/04	114.00		68.10
07/22/04	134.00		74.20

BD Mining
Fig 7.13 Chloride

Date	MP006	MP007	MP008
04/28/86			
06/02/86			
07/24/86			
08/26/86			
10/08/86			
02/03/87	8.00		
07/27/88	7.40	8.70	
08/14/88			
09/14/88			
10/16/88			
11/17/88			
12/14/88			
01/15/89			
02/14/89		11.00	
03/16/89			
04/06/89			
05/25/89	9.80		
06/13/89		7.20	
08/25/89	13.20		
08/28/89		10.00	
12/14/89	9.09	7.76	
01/15/90			
02/01/90	9.37	0.85	
05/14/90	11.29	8.35	
08/29/90	8.58	9.08	
11/28/90	8.40	8.30	
02/27/91	7.40	6.80	
05/28/91	7.90	7.40	
08/28/91	6.80	16.40	
11/25/91	7.60	18.60	
02/25/92	7.40	16.50	
05/06/92	8.75	11.12	
08/23/92	7.17	10.74	
11/29/92	10.57	16.87	
02/10/93	8.52	12.50	
05/17/93	7.96	11.78	
08/04/93	9.87	15.55	
11/07/93	7.64	16.98	
03/25/94	9.31	17.90	
06/28/94	7.93	14.32	
08/09/94		24.75	
12/08/94	7.54	17.00	

03/14/95	11.56	12.84	
06/05/95	13.70	21.10	
09/19/95	7.38	23.30	
12/05/95	0.06	17.50	
01/16/96			7.51
01/31/96			7.83
02/19/96			4.12
03/04/96			2.29
03/13/96			3.00
03/25/96	26.50	23.91	
04/24/96			5.52
06/24/96	7.71	16.90	1.94
09/12/96	8.12	20.40	2.52
12/18/96	8.15		2.34
03/05/97	8.02		2.47
06/19/97	12.80		0.00
09/04/97	9.75		4.87
11/17/97	8.07		2.58
03/05/98	9.15		2.12
05/18/98	9.90		0.00
09/18/98	9.07		0.54
11/05/98	10.20		3.52
03/03/99	7.50		0.52
06/23/99	10.20		0.66
09/23/99	10.70		0.63
11/19/99	11.40		0.80
03/03/00	11.20		0.86
06/06/00	11.90		1.47
08/17/00	23.70		0.76
12/11/00	26.80		*0.02*
03/07/01	9.66		0.61
06/19/01	14.40		0.57
09/04/01	17.90		0.98
12/19/01	9.82		2.95
03/14/02	12.50		1.51
07/03/02	37.30		1.48
09/30/02	14.40		24.40
12/13/02	21.10		1.16
02/25/03	22.40		2.78
04/30/03	12.10		1.80
07/21/03	12.40		1.23
10/10/03	13.70		1.77
02/02/04	15.20		1.79
05/25/04	10.50		2.66
07/22/04	13.10		1.47

BD Mining
Fig 7.14 Zinc

Date	MP006	MP007	MP008
02/03/87	0.27		
03/27/88		0.36	
05/25/88	0.33		
07/27/88		0.33	
02/14/89		0.50	
05/25/89	0.19		
06/13/89		0.26	
08/28/89	0.31	0.97	
12/14/89	0.26	0.56	
02/19/90	0.48	0.13	
05/14/90	0.25	0.66	
08/29/90	0.31	3.27	
11/28/90	0.26	0.27	
02/27/91	0.29	0.42	
05/28/91	0.36	0.35	
08/28/91	0.21	0.39	
11/25/91	0.29	0.39	
02/25/92	0.17	0.30	
05/06/92	0.21	0.29	
08/23/92	0.24	0.27	
11/29/92	0.26	0.31	
02/10/93	0.25	0.21	
05/17/93	0.24	0.40	
08/04/93	0.29	0.59	
11/07/93	0.30	0.54	
03/25/94	0.30	0.37	
06/28/94	0.29	0.32	
08/09/94	0.39	0.47	
12/08/94	0.19	0.43	
03/14/95	0.23	0.32	
06/05/95		0.39	
09/19/95	0.23	0.74	
12/05/95	0.24	1.17	
01/16/96			0.12
01/31/96			0.04
02/19/96			0.07
03/04/96			0.04
03/13/96			0.05
03/25/96	0.24	0.26	
04/24/96			0.03
06/24/96	0.39	1.01	0.09
09/12/96	0.28	0.80	0.07

12/18/96	0.20		0.09
03/05/97	0.22		0.56
06/19/97	0.22		0.43
09/04/97	0.20		0.25
11/17/97	0.22		0.27
11/05/98	0.17		0.00
03/03/99	0.18		0.06
06/23/99	0.29		0.13
09/23/99	0.23		0.06
11/19/99	0.20		0.09
03/03/00	0.21		0.29
06/06/00	0.20		0.09
08/17/00	0.19		0.08
12/11/00	0.18		0.13
03/07/01	0.25		0.21
06/19/01	0.36		0.12
09/04/01	0.11		0.04
12/19/01	0.17		0.05
03/14/02	0.17		0.05
07/03/02	0.20		0.03
09/30/02	0.46		0.10
12/13/02	0.01		0.07
02/25/03	0.30		0.10
04/30/03	0.15		0.09
07/21/03	0.19		0.10
10/10/03	0.20		0.27
02/02/04	0.20		0.18
05/25/04	0.18		0.19
07/22/04	0.18		0.16

BD Mining

Fig 7.15 Lead

Date	MP006	MP007	MP008	MP005
11/27/1985	<0.05			
7/31/1986	<0.005			
1/29/1987	<0.005			
02/03/87	0.01			
03/27/88		0.009		
05/25/88	0.00			
07/27/88		0		
02/14/89		0		
05/25/89	0.00			
06/13/89		0.22		
08/28/89	0.00	0.00		0
12/14/89	0.00	0.00		0
02/01/90		0.16		0.158
02/19/90	0.00			
05/14/90	0.00	0.00		0
08/29/90	0.00	0.00		0
11/28/90	0.00	0.00		0
02/27/91	0.00	0.15		0.138
05/28/91	0.00	0.00		0
08/28/91	0.00	0.00		0
11/25/91	0.13	0.12		0.12
02/25/92	0.00	0.00		0
05/06/92	0.00	0.00		0
08/23/92	0.12	0.00		0
11/29/92	0.14	0.00		
02/10/93	0.00	0.00		
05/17/93	0.10	0.00		0.18
08/04/93	0.00	0.00		
11/07/93	0.00	0.00		
03/25/94	0.00	0.00		
06/28/94	0.00	0.00		
08/09/94	0.00	0.00		
12/08/94	0.00	0.00		
03/14/95	0.00	0.00		
06/05/95	0.00	0.00		
09/19/95	0.00	0.00		
12/05/95	0.00	0.00		
01/16/96			0.00	
01/31/96			0.00	
02/19/96			0.00	
03/04/96			0.00	
03/13/96			0.00	

03/25/96	0.00	0.00		
04/24/96			0.10	
06/24/96	0.00	0.00		
06/24/96			0.00	
09/12/96	0.00	0.00	0.00	
12/18/96	0.00		0.00	
03/05/97	0.00		0.00	
06/19/97	0.00		0.00	
09/04/97	0.00		0.00	
11/17/97	0.00		0.00	
11/05/98	0.00		0.00	
03/03/99	0.12		<0.1	
06/23/99	0.16		0.18	
09/23/99	<0.1		<0.1	
11/19/99	<0.1		<0.1	
03/03/00	<0.1		<0.1	
06/06/00	<0.1		<0.1	
08/17/00	<0.1		<0.1	
12/11/00	<0.1		<0.1	
03/07/01	<0.1		<0.1	
06/19/01	<0.1		<0.1	
09/04/01	0.15		0.58	
12/19/01	<0.05		<0.5	
03/14/02	<0.05		<0.05	
07/03/02	<0.05		<0.05	
09/30/02	<0.05		<0.05	
12/13/02	<0.025		<0.025	
02/25/03	<0.025		<0.025	
04/30/03	<0.03		<0.025	
07/21/03	0.01		0.01	
10/10/03	0.01			
10/13/03			0.01	
02/02/04	<0.05		<0.05	
05/25/04	<0.05		<0.05	
07/22/04	<0.05		<0.05	

BD Mining
Fig 7.16 Chromium

Date	MP006	MP007	MP008	MP005
11/27/1985	0.06			
7/31/1986	<0.005			
1/29/1987	<0.05			
02/03/87	0.01			
03/27/88		0.01		
05/25/88	0.00			
07/27/88		0.00		
02/14/89		0.00		
05/25/89	0.00			
06/13/89		0.00		
08/28/89	0.00	0.00		0
12/14/89	0.00	0.00		0
02/01/90		0.00		0
02/19/90	0.00			
05/14/90	0.00	0.00		0
08/29/90	0.00	0.00		0
11/28/90	0.00	0.00		0
02/27/91	0.00	0.00		0
05/28/91	0.00	0.00		0
08/28/91	0.00	0.00		0
11/25/91	0.24	0.23		0.061
02/25/92	0.00	0.00		0
05/06/92	0.00	0.00		0
08/23/92	0.00	0.00		0
11/29/92	0.00	0.00		
02/10/93	0.00	0.00		
05/17/93	0.00	0.00		0
08/04/93	0.00	0.00		
11/07/93	0.00	0.00		
03/25/94	0.00	0.00		
06/28/94	0.00	0.00		
08/09/94	0.00	0.00		
12/08/94	0.00	0.00		
03/14/95	0.00	0.00		
06/05/95	0.00	0.00		
09/19/95	0.00	0.10		
12/05/95	0.00	0.00		
01/16/96			0.00	
01/31/96			0.00	
02/19/96			0.00	
03/04/96			0.00	
03/13/96			0.00	

03/25/96	0.00	0.00	0.00	
04/24/96			0.00	
06/24/96	0.00	0.00	0.00	
09/12/96	0.00	0.00	0.00	
12/18/96	0.00		0.00	
03/05/97	0.00		0.00	
06/19/97	0.00		0.06	
09/04/97	0.09		0.00	
11/17/97	0.00		0.00	
11/05/98	0.00		0.00	
03/03/99	<0.05		<0.05	
06/23/99	<0.05		<0.05	
09/23/99	<0.05		0.06	
11/19/99	<0.05		<0.05	
03/03/00	<0.05		<0.05	
06/06/00	<0.05		<0.05	
08/17/00	<0.05		<0.05	
12/11/00	<0.05		<0.05	
03/07/01	<0.05		<0.05	
06/19/01	<0.05		<0.05	
09/04/01	<0.05		<0.05	
12/19/01	<0.01			
02/07/02			<0.01	
03/14/02	<0.01		<0.01	
07/03/02	<0.01		0.01	
09/30/02	<0.01		<0.01	
12/13/02	<0.01		<0.01	
02/25/03	<0.01		<0.01	
04/30/03	<0.01		<0.01	
07/21/03	<0.01		<0.01	
10/10/03	<0.01			
10/13/03			<0.01	
02/02/04	<0.01		0.01	
05/25/04	<0.01		0.02	
07/22/04	<0.01		<0.005	

BD Mining

Fig 7.17 Cadmium

Date	MP006	MP007	MP008
02/03/87	0.01		
03/27/88		0.00	
05/25/88	0.00		
07/27/88		0.00	
02/14/89		0.00	
05/25/89	0.00		
06/13/89		0.00	
08/28/89	0.00	0.00	
12/14/89	0.00	0.00	
02/01/90		0.01	
02/19/90	0.00		
05/14/90	0.01	0.01	
08/29/90	0.00	0.00	
11/28/90	0.00	0.00	
02/27/91	0.00	0.00	
05/28/91	0.00	0.00	
08/28/91	0.00	0.00	
11/25/91	0.00	0.00	
02/25/92	0.00	0.00	
05/06/92	0.00	0.00	
08/23/92	0.01	0.00	
11/29/92	0.00	0.00	
02/10/93	0.01	0.01	
05/17/93	0.01	0.00	
08/04/93	0.02	0.00	
11/07/93	0.00	0.00	
03/25/94	0.00	0.00	
06/28/94	0.00	0.00	
08/09/94	0.00	0.00	
12/08/94	0.00	0.00	
03/14/95	0.00	0.00	
06/05/95	0.00	0.00	
09/19/95	0.00	0.00	
12/05/95	0.00	0.00	
01/16/96			0.00
01/31/96			0.00
02/19/96			0.00
03/04/96			0.00
03/13/96			0.00
03/25/96	0.00	0.00	
04/24/96			0.00
06/24/96	0.00	0.00	

06/26/96			0.00
09/12/96	0.01	0.00	0.00
12/18/96	0.00		0.00
03/05/97	0.00		0.00
06/19/97	0.00		0.00
09/04/97	0.01		0.01
11/17/97	0.00		0.00
11/05/98	0.00		0.00
03/03/99	<0.005		0.02
06/23/99	0.02		0.03
09/23/99	<0.005		0.01
11/19/99	0.02		0.02
03/03/00	<0.005		<0.005
06/06/00	<0.005		<0.005
08/17/00	<0.005		<0.005
12/11/00	<0.005		<0.005
03/07/01	<0.005		<0.005
06/19/01	<0.005		<0.005
09/04/01	<0.005		<0.005
12/19/01	<0.005		<0.005
03/14/02	0.01		<0.005
07/03/02	0.01		<0.005
09/30/02	0.01		0.01
12/13/02	<0.005		<0.005
02/25/03	<0.005		<0.005
04/30/03	<0.01		<0.005
07/21/03	<0.01		<0.01
10/10/03	<0.01		
10/13/03			0.01
02/02/04	<0.005		<0.005
05/25/04	<0.005		<0.005
07/22/04	<0.005		<0.005

BD Mining
Fig 7.18 Arsenic

Date	MP006	MP007	MP005
11/27/1985	<0.05		
7/31/1986	<0.005		
1/29/1987	<0.005		
02/03/87	0.01		
03/27/88		0.05	
05/25/88	0.01		
07/27/88		0.01	
02/14/89		0.00	
05/25/89	0.00		
06/13/89		0.00	
08/28/89	0.00	0.00	0
12/14/89	0.00	0.00	0
02/01/90	0.00	0.01	0
02/19/90	0.00		
05/14/90		0.00	0.003
08/29/90	0.00	0.00	0.0026
11/28/90	0.00	0.00	0.0014
02/27/91	0.00	0.00	0.002
05/28/91	0.00	0.00	0
08/28/91	0.01	0.01	0.01281
11/25/91	0.00	0.00	0
02/25/92	0.00	0.00	0
05/06/92	0.00	0.00	0
08/23/92	0.00	0.01	0.01
11/29/92	0.01	0.01	
02/10/93	0.00	0.01	
05/17/93	0.01	0.01	0
08/04/93	0.00	0.00	
11/07/93	0.00	0.00	
03/25/94	0.03	0.02	
06/28/94	0.00	0.00	
08/09/94	0.02	0.02	
12/08/94	0.01	0.00	
03/14/95	0.01	0.00	
06/05/95	0.06	0.00	
09/19/95	0.00	0.01	
12/05/95	0.00	0.01	
03/25/96	0.00	0.00	
06/24/96	0.01	0.02	
09/12/96	0.00	0.00	
12/18/96	0.00		
03/05/97	0.00		

06/19/97	0.00		
09/04/97	0.00		
11/17/97	0.00		
11/05/98	0.00		
03/03/99	<0.005		
06/23/99	<0.005		
09/23/99	0.01		
11/19/99	<0.005		
03/03/00	<0.005		
06/06/00	<0.005		
08/17/00	<0.005		
12/11/00	0.01		
03/07/01	0.01		
06/19/01	<0.005		
09/04/01	<0.005		
12/19/01	<0.05		
03/14/02	<0.005		
07/03/02	<0.007		
09/30/02	0.01		
12/13/02	0.01		
02/25/03	0.01		
04/30/03	<0.01		
07/21/03	<0.01		
10/10/03	<0.01		
02/02/04	<0.005		
05/25/04	<0.005		
07/22/04	<0.005		

EME Generation
Fig 8.1 Iron

Date	
Mar-94	0.8
May-94	
Aug-94	
Nov-94	0.48
Feb-95	0.56
May-95	0.6
Aug-95	0.56
Nov-95	0.56
Feb-96	0.5
May-96	0.28
Sep-96	1.56
Nov-96	0.38
Feb-97	0.88
May-97	0.36
Aug-97	0.81
Nov-97	0.31
Feb-98	0.61
May-98	0.44
Aug-98	
Nov-98	0.92
Feb-99	0.07
May-99	
Aug-99	0.53
Nov-99	0.62
Feb-00	
May-00	0.54
Aug-00	0.99
Nov-00	2.73
Mar-01	3.62
May-01	1
Aug-01	0.77
Nov-01	0.92
Feb-02	0.48
May-02	0.49
Aug-02	0.45
Nov-02	0.11
Feb-03	0.17
May-03	0.83
Aug-03	0.51
Nov-03	0.54
Feb-04	0.6
May-04	0.54

Aug-04	0.69
Nov-04	0.52

EME Generation
Fig 8.1a Managanese

Date	
Mar-94	0.06
May-94	
Aug-94	
Nov-94	0.16
Feb-95	0.56
May-95	0.04
Aug-95	0.16
Nov-95	0.16
Feb-96	0.04
May-96	0.06
Sep-96	0.12
Nov-96	0.08
Feb-97	0.05
May-97	0.03
Aug-97	0.08
Nov-97	0.04
Feb-98	0.1
May-98	0.04
Aug-98	
Nov-98	0.1
Feb-99	0.01
May-99	
Aug-99	0.11
Nov-99	0.1
Feb-00	
May-00	0.1
Aug-00	0.15
Nov-00	0.12
Mar-01	0.89
May-01	0.19
Aug-01	0.19
Nov-01	0.07
Feb-02	0.08
May-02	0.03
Aug-02	0.1
Nov-02	0.03
Feb-03	0.02
May-03	0.12
Aug-03	0.09
Nov-03	0.09
Feb-04	0.03
May-04	0.05

Aug-04	0.08
Nov-04	0.08

EME Generation

Fig 8.1b Aluminum

Date	
Mar-94	0.52
May-94	
Aug-94	
Nov-94	0.32
Feb-95	0.26
May-95	0.37
Aug-95	0.87
Nov-95	0.3
Feb-96	0.36
May-96	0.28
Sep-96	0.2
Nov-96	0.14
Feb-97	0.24
May-97	0.16
Aug-97	0.23
Nov-97	0.13
Feb-98	0.29
May-98	0.19
Aug-98	
Nov-98	0.53
Feb-99	0.08
May-99	
Aug-99	0.16
Nov-99	0.06
Feb-00	
May-00	0.17
Aug-00	1.41
Nov-00	1.38
Mar-01	2.91
May-01	0.5
Aug-01	0.32
Nov-01	0.13
Feb-02	0.35
May-02	0.11
Aug-02	0.16
Nov-02	0.04
Feb-03	0.1
May-03	0.35
Aug-03	0.31
Nov-03	0.27
Feb-04	0.15
May-04	0.1

Aug-04	0.22
Nov-04	0.19

EME Generation
Fig 8.2 Sulfates

Date	
Mar-94	20.1
May-94	
Aug-94	
Nov-94	18.5
Feb-95	42.74
May-95	23.68
Aug-95	22.33
Nov-95	19.84
Feb-96	21.67
May-96	23.57
Sep-96	23.5
Nov-96	22.34
Feb-97	23.11
May-97	24.04
Aug-97	14.59
Nov-97	22.52
Feb-98	20.13
May-98	22.91
Aug-98	
Nov-98	20.76
Feb-99	21.72
May-99	
Aug-99	22.94
Nov-99	17.21
Feb-00	
May-00	40.27
Aug-00	21.51
Nov-00	23.18
Mar-01	28.13
May-01	29.71
Aug-01	24.27
Nov-01	21.92
Feb-02	22.53
May-02	19.49
Aug-02	18.55
Nov-02	17.73
Feb-03	16.74
May-03	12.9
Aug-03	11.81
Nov-03	4.6
Feb-04	5.02
May-04	33.11

Aug-04	23.9
Nov-04	30.35

EME Generation

Fig 8.3 Alkalinity & Acidity

Date	Alkalinity	Acidity
Mar-94	76	-68
May-94		
Aug-94		
Nov-94	72	-68
Feb-95	74	-68
May-95	80	-70
Aug-95	86	-72
Nov-95	79	-69
Feb-96	74	-60
May-96	75	-62
Sep-96	79	-66
Nov-96	80	-64
Feb-97	79	-61
May-97	79	-63
Aug-97	81	-64
Nov-97	80	-62
Feb-98	79	-63
May-98	74	-60
Aug-98		
Nov-98	74	-66
Feb-99	76	-68
May-99		
Aug-99	78	-70
Nov-99	104	-64
Feb-00		
May-00	52	-34
Aug-00	78	-68
Nov-00	80	-70
Mar-01	78	-70
May-01	79	-71
Aug-01	76	-70
Nov-01	77	-65
Feb-02	73	-61
May-02	78	-70
Aug-02	73	-63
Nov-02	100	-94
Feb-03	75	-67
May-03	74	-66
Aug-03	77	-67
Nov-03	77	-69
Feb-04	73	-61

May-04	76	-66
Aug-04	78	-64
Nov-04	61	-45

EME Generation
Fig 8.5 pH

Date	
Mar-94	7.3
May-94	
Aug-94	
Nov-94	7.1
Feb-95	7.3
May-95	7.2
Aug-95	7.1
Nov-95	7.3
Feb-96	7.2
May-96	7.3
Sep-96	7.3
Nov-96	7.2
Feb-97	7.3
May-97	7.2
Aug-97	7.1
Nov-97	7.2
Feb-98	7.5
May-98	7.4
Aug-98	
Nov-98	7.2
Feb-99	7.3
May-99	
Aug-99	7.2
Nov-99	7.3
Feb-00	
May-00	7.3
Aug-00	7.2
Nov-00	7.2
Mar-01	7.1
May-01	7.2
Aug-01	7.3
Nov-01	7.3
Feb-02	7.2
May-02	7.4
Aug-02	7.2
Nov-02	7.2
Feb-03	7.5
May-03	7.5
Aug-03	7.2
Nov-03	7.3
Feb-04	7.3
May-04	7.4

Aug-04	7.3
Nov-04	7.5

EME Generation
Fig 8.9 Iron

Date	
Mar-94	1.32
May-94	
Aug-94	
Nov-94	0.4
Feb-95	0.47
May-95	0.92
Aug-95	1.04
Nov-95	0.94
Feb-96	0.48
May-96	0.72
Aug-96	0.88
Nov-96	0.98
Feb-97	0.8
May-97	1.32
Aug-97	1.27
Nov-97	0.76
Feb-98	0.37
May-98	0.76
Aug-98	
Nov-98	0.78
Feb-99	0.5
May-99	
Aug-99	0.92
Nov-99	0.81
Feb-00	
May-00	1.23
Aug-00	0.53
Nov-00	0.66
Mar-01	1.33
May-01	0.83
Aug-01	0.48
Nov-01	0.48
Feb-02	0.64
May-02	0.96
Aug-02	0.28
Nov-02	0.69
Feb-03	0.49
May-03	1.14
Aug-03	0.39
Nov-03	0.84
Feb-04	0.72
May-04	0.83

Aug-04	0.83
Nov-04	0.79

EME Generation

Fig 8.9a Manganese

Date	
Mar-94	0.2
May-94	
Aug-94	
Nov-94	0.24
Feb-95	0.12
May-95	0.08
Aug-95	0.5
Nov-95	0.3
Feb-96	0.12
May-96	0.14
Aug-96	0.14
Nov-96	0.17
Feb-97	0.17
May-97	0.16
Aug-97	0.44
Nov-97	0.12
Feb-98	0.06
May-98	0.09
Aug-98	
Nov-98	0.13
Feb-99	0.07
May-99	
Aug-99	0.36
Nov-99	0.2
Feb-00	
May-00	0.22
Aug-00	0.14
Nov-00	0.15
Mar-01	0.19
May-01	0.13
Aug-01	0.37
Nov-01	0.12
Feb-02	0.12
May-02	0.18
Aug-02	0.21
Nov-02	0.13
Feb-03	0.12
May-03	0.16
Aug-03	0.16
Nov-03	0.14
Feb-04	0.12
May-04	0.21

Aug-04	0.1
Nov-04	0.12

EME Generation
Fig 8.9b Aluminum

Date	
Mar-94	1.54
May-94	
Aug-94	
Nov-94	0.28
Feb-95	0.12
May-95	0.88
Aug-95	0.98
Nov-95	0.39
Feb-96	0.9
May-96	0.68
Aug-96	0.3
Nov-96	0.41
Feb-97	0.44
May-97	1.68
Aug-97	1.22
Nov-97	0.7
Feb-98	0.25
May-98	0.55
Aug-98	
Nov-98	0.74
Feb-99	0.38
May-99	
Aug-99	1.17
Nov-99	0.64
Feb-00	
May-00	1.93
Aug-00	0.26
Nov-00	0.22
Mar-01	1.16
May-01	0.13
Aug-01	0.34
Nov-01	0.52
Feb-02	1.56
May-02	1.74
Aug-02	0.08
Nov-02	0.21
Feb-03	0.11
May-03	2.78
Aug-03	0.14
Nov-03	0.34
Feb-04	0.3
May-04	0.36

Aug-04	0.6
Nov-04	0.2

EME Generation
Fig 8.10 Sulfates

Date	
Mar-94	36.91
May-94	
Aug-94	
Nov-94	224.06
Feb-95	44.74
May-95	68.21
Aug-95	547.22
Nov-95	124.31
Feb-96	38.45
May-96	57.5
Aug-96	92.13
Nov-96	46.42
Feb-97	53.78
May-97	41.25
Aug-97	135.74
Nov-97	46.79
Feb-98	34.32
May-98	33.4
Aug-98	
Nov-98	172.02
Feb-99	37.26
May-99	
Aug-99	368.68
Nov-99	47.69
Feb-00	
May-00	108.9
Aug-00	175
Nov-00	83.29
Mar-01	81
May-01	190.41
Aug-01	543.08
Nov-01	429.41
Feb-02	41.82
May-02	27.15
Aug-02	189.55
Nov-02	93.85
Feb-03	66.02
May-03	24.19
Aug-03	130.69
Nov-03	16.59
Feb-04	13.66
May-04	21.25

Aug-04	21.27
Nov-04	188.66

EME Generation
Fig 8.11 Alkalinity & Acidity

Date	Alkalinity	Acidity
Feb-94	22	-12
May-94		
Aug-94		
Nov-94	98	-90
Feb-95	24	-20
May-95	40	-30
Aug-95	130	-120
Nov-95	61	-45
Feb-96	21	-1
May-96	10	-4
Aug-96	56	-45
Nov-96	37	-21
Feb-97	29	-158
May-97	35	-14
Aug-97	94	-80
Nov-97	32	-20
Feb-98	26	-8
May-98	37	-22
Aug-98		
Nov-98	72	-84
Feb-99	28	-12
May-99		
Aug-99	104	-92
Nov-99	40	0
Feb-00		
May-00	52	-34
Aug-00	88	-80
Nov-00	66	-38
Feb-01	12	-32
May-01	82	-72
Aug-01	185	-17
Nov-01	124	-120
Feb-02	45	-35
May-02	32	-20
Aug-02	99	-87
Nov-02	69	-61
Feb-03	38	-28
May-03	37	-47
Aug-03	80	-78
Nov-03	53	-47
Feb-04	49	-17
May-04	63	-55

Aug-04	53	-41
Nov-04	78	-62

EME Generation
Fig 8.12 pH

Date	
Mar-94	6.3
May-94	
Aug-94	
Nov-94	7.3
Feb-95	6.9
May-95	7.1
Aug-95	7.3
Nov-95	7.3
Feb-96	7.1
May-96	7.3
Aug-96	7.3
Nov-96	7.1
Feb-97	7.2
May-97	7.2
Aug-97	7.2
Nov-97	6.9
Feb-98	7.3
May-98	7.3
Aug-98	
Nov-98	7.4
Feb-99	7.3
May-99	
Aug-99	7.3
Nov-99	7.2
Feb-00	
May-00	7.1
Aug-00	7.2
Nov-00	7.3
Mar-01	7.2
May-01	7.3
Aug-01	7.3
Nov-01	7.2
Feb-02	7.3
May-02	7.2
Aug-02	7.2
Nov-02	7.3
Feb-03	7.3
May-03	7.1
Aug-03	7.3
Nov-03	7.3
Feb-04	7.3
May-04	7.4

Aug-04	7.4
Nov-04	7.6

EME Generation

Fig 8.15 Stream Flow

Date	gpm
Mar-94	2000
May-94	
Aug-94	
Nov-94	500
Feb-95	4000
May-95	1000
Aug-95	150
Nov-95	600
Feb-96	2500
May-96	700
Aug-96	500
Nov-96	3500
Feb-97	600
May-97	700
Aug-97	600
Nov-97	1050
Feb-98	850
May-98	700
Aug-98	
Nov-98	350
Feb-99	600
May-99	
Aug-99	200
Nov-99	1000
Feb-00	
May-00	400
Aug-00	400
Nov-00	375
Mar-01	700
May-01	400
Aug-01	125
Nov-01	100
Feb-02	250
May-02	1000
Aug-02	150
Nov-02	350
Feb-03	450
May-03	800
Aug-03	750
Nov-03	850
Feb-04	1250
May-04	750

Aug-04	1250
Nov-04	900

EME Generation

Fig 8.16 Iron Loading

Date	(lbs/day)
Feb-94	3.17
May-94	
Aug-94	
Nov-94	2.4
Feb-95	22.6
May-95	11
Aug-95	1.9
Nov-95	6.8
Feb-96	14.4
May-96	6.1
Aug-96	5.3
Nov-96	41.2
Feb-97	5.8
May-97	11.1
Aug-97	9.1
Nov-97	9.6
Feb-98	3.8
May-98	6.4
Aug-98	
Nov-98	3.3
Feb-99	3.6
May-99	
Aug-99	2.2
Nov-99	9.7
Feb-00	
May-00	5.9
Aug-00	2.5
Nov-00	3
Feb-01	11.2
May-01	4
Aug-01	0.72
Nov-01	0.58
Feb-02	1.9
May-02	11.5
Aug-02	0.5
Nov-02	2.9
Feb-03	2.6
May-03	11
Aug-03	3.5
Nov-03	8.6
Feb-04	11
May-04	7.5

Aug-04	12.5
Nov-04	8.5

EME Generation

Fig 8.17 Sulfate Load

Date	(lbs/day)
Feb-94	886
May-94	
Aug-94	
Nov-94	1345
Feb-95	2149
May-95	819
Aug-95	986
Nov-95	896
Feb-96	1154
May-96	483
Aug-96	553
Nov-96	1951
Feb-97	387
May-97	347
Aug-97	978
Nov-97	590
Feb-98	350
May-98	281
Aug-98	
Nov-98	723
Feb-99	268
May-99	
Aug-99	885
Nov-99	573
Feb-00	
May-00	523
Aug-00	840
Nov-00	375
Feb-01	681
May-01	914
Aug-01	815
Nov-01	516
Feb-02	126
May-02	326
Aug-02	341
Nov-02	394
Feb-03	357
May-03	232
Aug-03	1177
Nov-03	169
Feb-04	205
May-04	191

Aug-04	319
Nov-04	2039

EME Generation

Fig 8.20 Iron

Date	
Mar-94	0.72
May-94	
Aug-94	
Nov-94	0.3
Feb-95	0.82
May-95	0.72
Aug-95	0.68
Nov-95	0.64
Feb-96	0.7
May-96	0.58
Aug-96	0.72
Nov-96	0.48
Feb-97	0.54
May-97	1.1
Aug-97	1.27
Nov-97	0.63
Feb-98	0.37
May-98	0.58
Aug-98	
Nov-98	0.58
Feb-99	0.27
May-99	
Aug-99	0.62
Nov-99	0.63
Feb-00	
May-00	0.37
Aug-00	0.24
Nov-00	0.46
Mar-01	0.8
May-01	0.59
Aug-01	0.85
Nov-01	0.14
Feb-02	0.56
May-02	0.6
Aug-02	1.12
Nov-02	0.39
Feb-03	0.23
May-03	0.1
Aug-03	0.43
Nov-03	1.03
Feb-04	0.84
May-04	0.89

Aug-04	0.75
Nov-04	0.56

EME Generation
Fig 8.20a Manganese

Date	
Mar-94	0.76
May-94	
Aug-94	
Nov-94	0.28
Feb-95	0.22
May-95	0.08
Aug-95	0.72
Nov-95	0.18
Feb-96	0.36
May-96	0.2
Aug-96	0.16
Nov-96	0.62
Feb-97	0.11
May-97	0.49
Aug-97	0.48
Nov-97	0.4
Feb-98	0.03
May-98	0.07
Aug-98	
Nov-98	0.06
Feb-99	0.02
May-99	
Aug-99	0.18
Nov-99	0.35
Feb-00	
May-00	0.05
Aug-00	0.08
Nov-00	0.07
Mar-01	0.13
May-01	0.12
Aug-01	0.38
Nov-01	0.29
Feb-02	0.22
May-02	0.06
Aug-02	0.17
Nov-02	0.13
Feb-03	0.23
May-03	0.04
Aug-03	0.18
Nov-03	0.14
Feb-04	0.25
May-04	0.26

Aug-04	0.22
Nov-04	0.08

EME Generation

Fig 8.20b Aluminum

Date	
Mar-94	0.98
May-94	
Aug-94	
Nov-94	0.3
Feb-95	0.98
May-95	0.59
Aug-95	0.77
Nov-95	0.28
Feb-96	1.39
May-96	0.68
Aug-96	0.32
Nov-96	0.6
Feb-97	0.41
May-97	2.03
Aug-97	2.34
Nov-97	1.06
Feb-98	0.33
May-98	0.41
Aug-98	
Nov-98	0.5
Feb-99	0.15
May-99	
Aug-99	0.98
Nov-99	0.64
Feb-00	
May-00	0.12
Aug-00	0.17
Nov-00	0.04
Mar-01	0.66
May-01	0.04
Aug-01	1.98
Nov-01	0.2
Feb-02	1.82
May-02	0.64
Aug-02	1.56
Nov-02	0.14
Feb-03	0.22
May-03	0.19
Aug-03	0.26
Nov-03	0.72
Feb-04	1.27
May-04	0.75

Aug-04	0.77
Nov-04	0.2

EME Generation
Fig 8.21 Sulfates

Date	
Mar-94	273.26
May-94	
Aug-94	
Nov-94	260.06
Feb-95	107.22
May-95	83.78
Aug-95	622.98
Nov-95	212.4
Feb-96	110.08
May-96	92.27
Aug-96	224.81
Nov-96	263.51
Feb-97	45.41
May-97	125.8
Aug-97	233.87
Nov-97	226.96
Feb-98	26.68
May-98	41.34
Aug-98	
Nov-98	119.49
Feb-99	35.34
May-99	
Aug-99	224.51
Nov-99	130.46
Feb-00	
May-00	92.47
Aug-00	432.04
Nov-00	79.76
Mar-01	38.08
May-01	125.61
Aug-01	886.86
Nov-01	1655.1
Feb-02	164.26
May-02	27.15
Aug-02	464.01
Nov-02	396.2
Feb-03	212
May-03	141.84
Aug-03	85.86
Nov-03	8.83
Feb-04	42.65
May-04	501.02

Aug-04	455.2
Nov-04	374.19

EME Generation

Fig 8.22 Acidity & Alkalinity

Date	Acidity	Alkalinity
Mar-94	-10	22
May-94		
Aug-94		
Nov-94	-86	90
Feb-95	-18	26
May-95	-30	42
Aug-95	-84	96
Nov-95	-51	67
Feb-96	-1	17
May-96	-4	10
Aug-96	-39	53
Nov-96	-17	30
Feb-97	-16	31
May-97	-11	28
Aug-97	-70	88
Nov-97	-15	30
Feb-98	-9	29
May-98	-20	36
Aug-98		
Nov-98	-92	100
Feb-99	-20	28
May-99		
Aug-99	-154	158
Nov-99	0	34
Feb-00		
May-00	-54	64
Aug-00	-70	80
Nov-00	-56	66
Mar-01	-32	40
May-01	-74	82
Aug-01	-98	104
Nov-01	-78	88
Feb-02	-34	42
May-02	-21	31
Aug-02	-86	96
Nov-02	-58	68
Feb-03	-27	37
May-03	-39	51
Aug-03	-84	96
Nov-03	-31	59
Feb-04	-22	40

May-04	-51	57
Aug-04	-50.2	70.2
Nov-04	-58	70

EME Generation
Fig 8.24 pH

Date	
Mar-94	6.5
May-94	
Aug-94	
Nov-94	7.3
Feb-95	7
May-95	7.1
Aug-95	7.3
Nov-95	7.3
Feb-96	7.2
May-96	7.3
Aug-96	7.3
Nov-96	7.3
Feb-97	7.2
May-97	7.2
Aug-97	7.2
Nov-97	7
Feb-98	7.3
May-98	7.3
Aug-98	
Nov-98	7.4
Feb-99	7.2
May-99	
Aug-99	7.3
Nov-99	7.3
Feb-00	
May-00	7.3
Aug-00	7.3
Nov-00	7.3
Mar-01	7.3
May-01	7.3
Aug-01	7.3
Nov-01	7.2
Feb-02	7.3
May-02	7.1
Aug-02	7.2
Nov-02	7.3
Feb-03	7.3
May-03	7.2
Aug-03	7.3
Nov-03	7.3
Feb-04	7.3
May-04	7.3

Aug-04	7.3
Nov-04	7.4

EME Generation
Fig 8.25 Stream Flow

Date	
Mar-94	3000
May-94	
Aug-94	
Nov-94	700
Feb-95	5000
May-95	1300
Aug-95	200
Nov-95	800
Feb-96	4000
May-96	1000
Aug-96	700
Nov-96	4000
Feb-97	900
May-97	1000
Aug-97	600
Nov-97	1500
Feb-98	1250
May-98	1050
Aug-98	
Nov-98	500
Feb-99	900
May-99	
Aug-99	300
Nov-99	1300
Feb-00	
May-00	550
Aug-00	500
Nov-00	475
Mar-01	900
May-01	500
Aug-01	200
Nov-01	180
Feb-02	350
May-02	1300
Aug-02	250
Nov-02	450
Feb-03	600
May-03	1000
Aug-03	950
Nov-03	1100
Feb-04	1400
May-04	1000

Aug-04	1650
Nov-04	1150

EME Generation

Fig 8.26 Iron Load

Date	(lbs/day)
Mar-94	25.9
May-94	
Aug-94	
Nov-94	2.5
Feb-95	49.2
May-95	11.2
Aug-95	1.6
Nov-95	6.1
Feb-96	33.6
May-96	7
Aug-96	6.1
Nov-96	23.1
Feb-97	5.8
May-97	13.2
Aug-97	9.1
Nov-97	11.3
Feb-98	5.5
May-98	7.3
Aug-98	
Nov-98	3.5
Feb-99	2.9
May-99	
Aug-99	2.2
Nov-99	9.8
Feb-00	
May-00	2.4
Aug-00	1.4
Nov-00	2.6
Mar-01	8.6
May-01	3.5
Aug-01	2.04
Nov-01	0.3
Feb-02	2.35
May-02	9.4
Aug-02	3.4
Nov-02	2.1
Feb-03	1.7
May-03	1.2
Aug-03	4.9
Nov-03	13.6
Feb-04	14.1
May-04	10.7

Aug-04	14.9
Nov-04	7.72

EME Generation
Fig 8.27 Sulfate Load

Date	
Feb-94	9843
May-94	
Aug-94	
Nov-94	2186
Feb-95	6437
May-95	1308
Aug-95	1496
Nov-95	2040
Feb-96	5287
May-96	1108
Aug-96	1889
Nov-96	12655
Feb-97	491
May-97	1510
Aug-97	1685
Nov-97	4088
Feb-98	400
May-98	521
Aug-98	
Nov-98	717
Feb-99	382
May-99	
Aug-99	809
Nov-99	2036
Feb-00	
May-00	611
Aug-00	2594
Nov-00	455
Feb-01	411
May-01	754
Aug-01	2130
Nov-01	3577
Feb-02	690
May-02	424
Aug-02	1393
Nov-02	2141
Feb-03	1527
May-03	1703
Aug-03	979
Nov-03	117
Feb-04	717
May-04	6016

Aug-04	9018
Nov-04	5167

EME Generation
Fig 8.30 Iron

Date	
Mar-94	0.66
May-94	
Aug-94	
Nov-94	0.1
Feb-95	0.36
May-95	0.22
Aug-95	0.1
Nov-95	0.07
Feb-96	1.08
May-96	0.36
Aug-96	1.04
Nov-96	0.48
Feb-97	1.89
May-97	1.11
Aug-97	0.77
Nov-97	0.57
Feb-98	1.31
May-98	0.43
Aug-98	
Nov-98	0.03
Feb-99	0.33
May-99	
Aug-99	0.04
Nov-99	0.3
Feb-00	
May-00	0.07
Aug-00	0.04
Nov-00	0.11
Mar-01	0.5
May-01	0.05
Aug-01	0.06
Nov-01	0.03
Feb-02	0.13
May-02	0.37
Aug-02	0.04
Nov-02	0.06
Feb-03	0.1
May-03	0.34
Aug-03	0.03
Nov-03	0.47
Feb-04	1.22
May-04	0.31

Aug-04	1.18
Nov-04	0.4

EME Generation
Fig 8.30a Manganese

Date	
Mar-94	2.44
May-94	
Aug-94	
Nov-94	2.22
Feb-95	0.94
May-95	0.76
Aug-95	2.48
Nov-95	1.67
Feb-96	1.24
May-96	2.2
Aug-96	1.44
Nov-96	1.58
Feb-97	1.61
May-97	2.52
Aug-97	1.72
Nov-97	1.06
Feb-98	1.57
May-98	1.35
Aug-98	
Nov-98	0.79
Feb-99	1.19
May-99	
Aug-99	0.13
Nov-99	0.81
Feb-00	
May-00	0.42
Aug-00	0.48
Nov-00	1.04
Mar-01	0.94
May-01	0.7
Aug-01	0.1
Nov-01	0.56
Feb-02	0.83
May-02	0.64
Aug-02	0.12
Nov-02	0.34
Feb-03	0.84
May-03	0.74
Aug-03	0.48
Nov-03	1.14
Feb-04	2.7
May-04	1.49

Aug-04	0.98
Nov-04	0.57

EME Generation
Fig 8.30b Aluminum

Date	
Mar-94	1.19
May-94	
Aug-94	
Nov-94	0.28
Feb-95	0.67
May-95	0.4
Aug-95	0.04
Nov-95	0.1
Feb-96	2.8
May-96	1.39
Aug-96	1.39
Nov-96	1.01
Feb-97	1.15
May-97	6.35
Aug-97	3.75
Nov-97	2.11
Feb-98	3.02
May-98	1.69
Aug-98	
Nov-98	0.04
Feb-99	1.19
May-99	
Aug-99	0.03
Nov-99	0.76
Feb-00	
May-00	0.05
Aug-00	0.09
Nov-00	0.12
Mar-01	0.93
May-01	0.06
Aug-01	0.4
Nov-01	0.05
Feb-02	0.34
May-02	0.62
Aug-02	0.05
Nov-02	0.1
Feb-03	0.55
May-03	0.91
Aug-03	0.04
Nov-03	2.31
Feb-04	5.25
May-04	2.77

Aug-04	2.6
Nov-04	1.08

EME Generation
Fig 8.31 Sulfates

Date	
Mar-94	936.05
May-94	
Aug-94	
Nov-94	928.9
Feb-95	764.86
May-95	661.86
Aug-95	1442.55
Nov-95	1291.67
Feb-96	358.91
May-96	494.48
Aug-96	1247.27
Nov-96	1123.12
Feb-97	319.72
May-97	552.56
Aug-97	1431.34
Nov-97	746.56
Feb-98	260.37
May-98	466.85
Aug-98	
Nov-98	722.8
Feb-99	282.5
May-99	
Aug-99	1061.64
Nov-99	438.82
Feb-00	
May-00	1905.88
Aug-00	2164.71
Nov-00	1328.8
Mar-01	1456.25
May-01	558.25
Aug-01	1258.8
Nov-01	3393.2
Feb-02	1190.8
May-02	219.38
Aug-02	3634.6
Nov-02	2567.5
Feb-03	1545.7
May-03	1565.4
Aug-03	3098.2
Nov-03	453.09
Feb-04	765.3
May-04	2193.5

Aug-04	2368.1
Nov-04	2524.3

EME Generation

Fig 8.32 Acidity & Alkalinity

Date	Acidity	Alkalinity
Mar-94	-2	14
May-94		
Aug-94		
Nov-94	-42	50
Feb-95	-22	30
May-95	-26	38
Aug-95	-26	40
Nov-95	-21	42
Feb-96	7	14
May-96	-5	25
Aug-96	-4	20
Nov-96	-5	26
Feb-97	-8	28
May-97	15	9
Aug-97	12	8
Nov-97	-1	18
Feb-98	7	13
May-98	-27	24
Aug-98		
Nov-98	-48	60
Feb-99	-8	18
May-99		
Aug-99	-72	76
Nov-99	0	20
Feb-00		
May-00	-28	36
Aug-00	-20	30
Nov-00	-33	43
Mar-01	-16	30
May-01	-40	52
Aug-01	-50	60
Nov-01	-41	53
Feb-02	-19	31
May-02	-11	31
Aug-02	-17	27
Nov-02	-40	52
Feb-03	-13	25
May-03	-22	34
Aug-03	-27	43
Nov-03	-10	22
Feb-04	-15	29

May-04	-2	16
Aug-04	-35.8	49.8
Nov-04	-22	32

EME Generation
Fig 8.33 pH

Date	
Mar-94	6.5
May-94	
Aug-94	
Nov-94	7
Feb-95	6.8
May-95	6.9
Aug-95	7
Nov-95	7
Feb-96	7.1
May-96	7.1
Aug-96	7
Nov-96	7
Feb-97	7
May-97	6.8
Aug-97	7.1
Nov-97	6.8
Feb-98	6.9
May-98	6.9
Aug-98	
Nov-98	7.1
Feb-99	7
May-99	
Aug-99	7.2
Nov-99	7.1
Feb-00	
May-00	7
Aug-00	7.1
Nov-00	7.2
Mar-01	7.1
May-01	7.2
Aug-01	7.2
Nov-01	7.1
Feb-02	7.2
May-02	7.3
Aug-02	7
Nov-02	7.1
Feb-03	7.1
May-03	7.1
Aug-03	7.1
Nov-03	7.2
Feb-04	6.8
May-04	6.7

Aug-04	7.2
Nov-04	7.3

EME Generation

Fig 8.35 Stream Flow

Date	
Mar-94	600
May-94	
Aug-94	
Nov-94	200
Feb-95	700
May-95	250
Aug-95	60
Nov-95	200
Feb-96	600
May-96	250
Aug-96	175
Nov-96	500
Feb-97	250
May-97	300
Aug-97	125
Nov-97	450
Feb-98	350
May-98	250
Aug-98	
Nov-98	60
Feb-99	250
May-99	
Aug-99	50
Nov-99	300
Feb-00	
May-00	100
Aug-00	90
Nov-00	100
Mar-01	200
May-01	110
Aug-01	60
Nov-01	70
Feb-02	85
May-02	225
Aug-02	70
Nov-02	100
Feb-03	100
May-03	90
Aug-03	175
Nov-03	225
Feb-04	300
May-04	225

Aug-04	300
Nov-04	225

EME Generation
Fig 8.36 Iron Loading

Date	
Mar-94	4.75
May-94	
Aug-94	
Nov-94	0.24
Feb-95	3.03
May-95	0.66
Aug-95	0.07
Nov-95	0.17
Feb-96	7.78
May-96	1.08
Aug-96	2.19
Nov-96	2.88
Feb-97	5.67
May-97	4.00
Aug-97	1.16
Nov-97	3.08
Feb-98	5.51
May-98	1.29
Aug-98	
Nov-98	0.02
Feb-99	0.99
May-99	
Aug-99	0.02
Nov-99	1.08
Feb-00	
May-00	0.08
Aug-00	0.04
Nov-00	0.13
Mar-01	1.20
May-01	0.07
Aug-01	0.04
Nov-01	0.03
Feb-02	0.13
May-02	1.00
Aug-02	0.03
Nov-02	0.07
Feb-03	0.12
May-03	0.37
Aug-03	0.06
Nov-03	1.27
Feb-04	4.39
May-04	0.84

Aug-04	4.25
Nov-04	1.08

EME Generation
Fig 8.37 Sulfate Load

Date	(lbs/day)
Mar-94	6743
May-94	
Aug-94	
Nov-94	2231
Feb-95	6428
May-95	1987
Aug-95	1039
Nov-95	3102
Feb-96	2586
May-96	1484
Aug-96	2621
Nov-96	6742
Feb-97	960
May-97	1990
Aug-97	2148
Nov-97	4034
Feb-98	1094
May-98	1401
Aug-98	
Nov-98	521
Feb-99	848
May-99	
Aug-99	637
Nov-99	1581
Feb-00	
May-00	2288
Aug-00	2339
Nov-00	1595
Mar-01	3497
May-01	737
Aug-01	907
Nov-01	2852
Feb-02	1215
May-02	593
Aug-02	3055
Nov-02	3083
Feb-03	1856
May-03	1692
Aug-03	6510
Nov-03	1224
Feb-04	2757
May-04	5926

Aug-04	8530
Nov-04	6819

EME Generation
Fig 8.40 Iron

Date	
Mar-94	496
May-94	
Aug-94	
Nov-94	1040
Feb-95	1215
May-95	1245
Aug-95	1520
Nov-95	1910
Feb-96	234
May-96	247.5
Aug-96	428
Oct-96	755
Feb-97	920
May-97	872
Aug-97	310
Nov-97	185.5
Feb-98	570
May-98	470
Aug-98	
Nov-98	664
Feb-99	184
May-99	
Aug-99	372
Nov-99	192
Feb-00	
May-00	612
Aug-00	440
Nov-00	468
Mar-01	420
May-01	670
Aug-01	556
Nov-01	592
Feb-02	518
May-02	310.5
Aug-02	840
Nov-02	528
Feb-03	895
May-03	465.5
Aug-03	758
Nov-03	644
Feb-04	699
May-04	857

Aug-04	616
Nov-04	979

EME Generation

Fig 8.40a Manganese

Date	
Mar-94	23
May-94	
Aug-94	
Nov-94	46
Feb-95	42.5
May-95	32
Aug-95	57
Nov-95	43
Feb-96	21.8
May-96	45
Aug-96	22.6
Oct-96	33.5
Feb-97	30.6
May-97	31.9
Aug-97	18.6
Nov-97	11.6
Feb-98	20.5
May-98	11.3
Aug-98	
Nov-98	17.5
Feb-99	13.4
May-99	
Aug-99	16.1
Nov-99	9.5
Feb-00	
May-00	18.5
Aug-00	16.8
Nov-00	16.1
Mar-01	16.4
May-01	24.9
Aug-01	23.4
Nov-01	22.8
Feb-02	20
May-02	15.5
Aug-02	12.55
Nov-02	15.45
Feb-03	16.15
May-03	19.45
Aug-03	20.8
Nov-03	15.26
Feb-04	14
May-04	19.5

Aug-04	12.65
Nov-04	20.1

EME Generation
Fig 8.40b Aluminum

Date	
Mar-94	28
May-94	
Aug-94	
Nov-94	99
Feb-95	149
May-95	141
Aug-95	72
Nov-95	168
Feb-96	39
May-96	49
Aug-96	82
Oct-96	72
Feb-97	50
May-97	27
Aug-97	33
Nov-97	40
Feb-98	39
May-98	41
Aug-98	
Nov-98	23
Feb-99	25
May-99	
Aug-99	77
Nov-99	38
Feb-00	
May-00	49
Aug-00	64
Nov-00	31
Mar-01	28
May-01	25
Aug-01	40
Nov-01	42
Feb-02	44
May-02	33
Aug-02	212
Nov-02	81
Feb-03	81
May-03	31
Aug-03	93
Nov-03	62
Feb-04	58
May-04	45

Aug-04	132
Nov-04	81

EME Generation
Fig 8.41 Sulfates

Date	
Mar-94	1271
May-94	
Aug-94	
Nov-94	6202
Feb-95	5364
May-95	6432
Aug-95	6485
Nov-95	7610
Feb-96	1852
May-96	3217
Aug-96	3398
Oct-96	3378
Feb-97	4492
May-97	5032
Aug-97	2852
Nov-97	1632
Feb-98	2978
May-98	2610
Aug-98	
Nov-98	5620
Feb-99	2035
May-99	
Aug-99	3357
Nov-99	2047
Feb-00	
May-00	3345
Aug-00	3137
Nov-00	4282
Mar-01	3298
May-01	5082
Aug-01	5339
Nov-01	4105
Feb-02	4065.5
May-02	2513
Aug-02	4900
Nov-02	337
Feb-03	5407
May-03	3595
Aug-03	4838
Nov-03	3826
Feb-04	2975
May-04	5529

Aug-04	6248
Nov-04	5905

EME Generation
Fig 8.42 Acidity

Date	
Mar-94	1260
May-94	
Aug-94	
Nov-94	3040
Feb-95	3330
May-95	3810
Aug-95	3200
Nov-95	5320
Feb-96	950
May-96	1300
Aug-96	1720
Oct-96	3350
Feb-97	2300
May-97	2075
Aug-97	1100
Nov-97	740
Feb-98	1600
May-98	1125
Aug-98	
Nov-98	7340
Feb-99	1320
May-99	
Aug-99	1400
Nov-99	690
Feb-00	
May-00	1822
Aug-00	1460
Nov-00	1296
Mar-01	1230
May-01	1690
Aug-01	1750
Nov-01	1840
Feb-02	1350
May-02	1090
Aug-02	3900
Nov-02	2120
Feb-03	2450
May-03	1460
Aug-03	2610
Nov-03	1880
Feb-04	1700
May-04	2050

Aug-04	2950
Nov-04	2920

EME Generation

Fig 8.43 pH

Date	
Mar-94	3
May-94	
Aug-94	
Nov-94	3
Feb-95	3
May-95	3
Aug-95	3
Nov-95	3
Feb-96	3
May-96	3
Aug-96	2.8
Oct-96	2.8
Feb-97	2.8
May-97	2.8
Aug-97	2.8
Nov-97	2.8
Feb-98	2.9
May-98	2.8
Aug-98	
Nov-98	3
Feb-99	3
May-99	
Aug-99	3
Nov-99	3.1
Feb-00	
May-00	3
Aug-00	3.1
Nov-00	3.1
Mar-01	3.2
May-01	3.2
Aug-01	2.9
Nov-01	3
Feb-02	3.1
May-02	2.9
Aug-02	2.9
Nov-02	2.8
Feb-03	3
May-03	3.1
Aug-03	3
Nov-03	2.8
Feb-04	3
May-04	2.9

Aug-04	2.9
Nov-04	2.7

EME Generation
Fig 8.45 Flow

Date	
Mar-94	250
May-94	
Aug-94	
Nov-94	50
Feb-95	160
May-95	210
Aug-95	80
Nov-95	70
Feb-96	500
May-96	450
Aug-96	350
Oct-96	290
Feb-97	300
May-97	135
Aug-97	400
Nov-97	500
Feb-98	450
May-98	300
Aug-98	
Nov-98	150
Feb-99	165
May-99	
Aug-99	100
Nov-99	300
Feb-00	
May-00	220
Aug-00	150
Nov-00	140
Mar-01	190
May-01	140
Aug-01	80
Nov-01	90
Feb-02	140
May-02	250
Aug-02	135
Nov-02	185
Feb-03	255
May-03	250
Aug-03	365
Nov-03	305
Feb-04	365
May-04	290

Aug-04	500
Nov-04	160

EME Generation
Fig 8.46 Iron Load

Date	
Mar-94	1489
May-94	
Aug-94	
Nov-94	624
Feb-95	2334
May-95	3139
Aug-95	1460
Nov-95	1605
Feb-96	1405
May-96	1337
Aug-96	1799
Oct-96	2629
Feb-97	3314
May-97	1413
Aug-97	1489
Nov-97	1114
Feb-98	3080
May-98	1693
Aug-98	
Nov-98	1196
Feb-99	365
May-99	
Aug-99	447
Nov-99	692
Feb-00	
May-00	1617
Aug-00	792
Nov-00	787
Mar-01	958
May-01	1126
Aug-01	534
Nov-01	640
Feb-02	871
May-02	932
Aug-02	1362
Nov-02	1173
Feb-03	2740
May-03	1397
Aug-03	3322
Nov-03	2358
Feb-04	3063
May-04	2984

Aug-04	3698
Nov-04	1881

EME Generation
Fig 8.47 Sulfate Loading

Date	
Feb-94	3815
May-94	
Aug-94	
Nov-94	3723
Feb-95	10305
May-95	16218
Aug-95	6229
Nov-95	6396
Feb-96	11118
May-96	17381
Aug-96	14279
Nov-96	11762
Feb-97	16180
May-97	8156
Aug-97	13697
Nov-97	9797
Feb-98	16090
May-98	9401
Aug-98	
Nov-98	10122
Feb-99	4032
May-99	
Aug-99	4031
Nov-99	7373
Feb-00	
May-00	8836
Aug-00	5650
Nov-00	7198
Feb-01	7524
May-01	8542
Aug-01	5128
Nov-01	4436
Feb-02	6834
May-02	7543
Aug-02	7942
Nov-02	749
Feb-03	16555
May-03	10791
Aug-03	21202
Nov-03	14011
Feb-04	13038
May-04	19251

Aug-04	37509
Nov-04	11344

EME Generation
Fig 8.50 Iron & Manganese

Date	Iron	Manganese
3/2/1994	1.26	0.56
11/9/1994	0.75	0.77
2/22/1995	1.92	1.2
5/22/1995	0.18	0.04
8/29/1995	0.26	0.16
11/6/1995	0.6	2.56
2/6/1996	0.2	1.94
5/20/1996	0.3	0.98
9/5/1996	0.2	0.47
11/14/1996	0.02	0.28
2/13/1997	0.1	0.66
5/15/1997	0.44	0.98
8/14/1997	0.24	0.44
11/13/1997	0.02	0.47
2/19/1998	0.07	0.168
5/15/1998		
8/13/1998	1.61	12
11/5/1998	1.9	4
2/11/1999	0.07	1.1
5/14/1999	0.25	0.51
8/12/1999	0.67	0.69
11/4/1999	0.94	1.9
2/17/2000	0.36	1.5
5/6/2000	0.95	0.53
8/17/2000	0.61	0.71
11/16/2000	13.85	12.8
2/14/2001	0.26	0.4
5/18/2001	0.24	0.41
8/14/2001	0.63	0.4
11/13/2001	1.3	0.4
1/21/2002	0.06	0.4
5/9/2002	0.17	0.18
8/8/2002	2.9	0.35
11/7/2002	0.46	1.8
2/13/2003	1.8	0.6
5/8/2003	1.08	0.23
8/21/2003	0.38	0.26
11/6/2003	0.21	0.2

2/12/2004	0.27	1.07
5/6/2004	0.05	0.18
8/12/2004	0.55	0.25
11/4/2004	0.38	0.14

EME Generation
Fig 8.51 Sulfates

Date	
3/2/1994	151.58
11/9/1994	165.42
2/22/1995	315.46
5/22/1995	187.66
8/29/1995	419.63
11/6/1995	473.62
2/6/1996	286.11
5/20/1996	276.39
9/5/1996	64
11/14/1996	77
2/13/1997	141
5/15/1997	235
8/14/1997	84
11/13/1997	75
2/19/1998	165
5/15/1998	
8/13/1998	877.99
11/5/1998	130
2/11/1999	139
5/14/1999	102
8/12/1999	68
11/4/1999	376
2/17/2000	253
5/6/2000	104
8/17/2000	226
11/16/2000	814
2/14/2001	219
5/18/2001	247
8/14/2001	345
11/13/2001	320
1/21/2002	319
5/9/2002	135
8/8/2002	285
11/7/2002	399
2/13/2003	281
5/8/2003	163
8/21/2003	269
11/6/2003	72

2/12/2004	83
5/6/2004	238
8/12/2004	243
11/4/2004	258

EME Generation
Fig 8.52 Alkalinity & Acidity

Date		
Date	Alkalinity	Acidity
3/2/1994	80	-66
11/9/1994	36	-28
2/22/1995	50	-42
5/22/1995	122	-112
8/29/1995	144	-134
11/6/1995	44	-11
2/6/1996	97	-74
5/20/1996	156	-84
9/5/1996	36	-18
11/14/1996	20	-4
2/13/1997	20	-2
5/15/1997	38	-16
8/14/1997	26	-2
11/13/1997	21	-3
2/19/1998	17	9
5/15/1998		
8/13/1998	16	62
11/5/1998	130	-124
2/11/1999	58	-46
5/14/1999	92	-80
8/12/1999	112	-98
11/4/1999	88	-70
2/17/2000	16	-6
5/6/2000	108	-98
8/17/2000	228	-218
11/16/2000	64	-50
2/14/2001	141	-141
5/18/2001	212	-210
8/14/2001	220	-220
11/13/2001	247	-239
1/21/2002	137	-123
5/9/2002	117	-109
8/8/2002	230	-222
11/7/2002	210	-202
2/13/2003	177	-169
5/8/2003	153	-145

8/21/2003	207	-197
11/6/2003	156	-144
2/12/2004	114	-104
5/6/2004	154	-144
8/12/2004	100	-90
11/4/2004	106	-90

EME Generation
Fig 8.53 pH

Date	
3/2/1994	7
11/9/1994	7
2/22/1995	6.8
5/22/1995	7.2
8/29/1995	7.4
11/6/1995	7
2/6/1996	7.2
5/20/1996	7
9/5/1996	7
11/14/1996	7
2/13/1997	7
5/15/1997	6.9
8/14/1997	6.9
11/13/1997	6.9
2/19/1998	6.8
5/15/1998	
8/13/1998	6.1
11/5/1998	7.5
2/11/1999	7
5/14/1999	7.1
8/12/1999	7.1
11/4/1999	6.9
2/17/2000	7
5/6/2000	7
8/17/2000	7.1
11/16/2000	7.1
2/14/2001	7.1
5/18/2001	7.2
8/14/2001	7.3
11/13/2001	7.2
1/21/2002	7.1
5/9/2002	6.9
8/8/2002	7.1
11/7/2002	7.1
2/13/2003	7
5/8/2003	7.1
8/21/2003	7
11/6/2003	7.1

2/12/04	7.3
5/6/04	7.2
8/12/04	7.2
11/4/04	7.1

EME Generation

Fig 8.54 Calcium & Magnesium

Date	Calcium	Magnesium
3/2/1994		
11/9/1994		
2/22/1995		
5/22/1995		
8/29/1995		
10/31/1995	108	22.6
11/6/1995		
11/15/1995	21	2.8
1/17/1996	48	13.6
2/14/1996	128	30
3/21/1996	62.5	15.3
5/20/1996		
9/5/1996	25.5	6.7
11/14/1996	22.5	6.95
2/13/1997	38	11.2
5/15/1997	68.5	15.95
8/14/1997	35	10.55
11/13/1997	19.6	6.2
2/19/1998	26	8.75
5/15/1998		
8/13/1998	267	61.2
11/5/1998	77.5	19.75
2/11/1999	147	14.2
5/14/1999		
8/12/1999	50	12
11/4/1999	106	27
2/17/2000	53	17
5/6/2000	58	15
8/17/2000	137	30
11/16/2000	208	61
2/14/2001	113	22
5/18/2001	129	27
8/14/2001	127	29
11/13/2001	112	32
1/21/2002	103	22
5/9/2002	78	31
8/8/2002	143	28
11/7/2002	142	31
2/13/2003	131	29
5/8/2003	100	18
8/21/2003	141	19
11/6/2003	92	19

2/12/2004	85	20
5/6/2004	108	23
8/12/2004	71	12
11/4/2004	65	9

EME Generation
Fig 8.55 Chloride

Date	
3/2/1994	
11/9/1994	
2/22/1995	
5/22/1995	
8/29/1995	
10/31/1995	7.41
11/15/1995	1.71
12/13/1995	4
1/17/1996	6.84
2/14/1996	8.64
3/21/1996	11.66
5/20/1996	
9/5/1996	10.6
11/14/1996	3.18
2/13/1997	7.4
5/15/1997	5.3
8/14/1997	5.3
11/13/1997	4.2
2/19/1998	4
5/15/1998	
8/13/1998	8
11/5/1998	8.4
2/11/1999	6.3
5/14/1999	14
8/12/1999	8.4
11/4/1999	9.5
2/17/2000	33
5/6/2000	7
8/17/2000	13
11/16/2000	23
2/14/2001	12
5/18/2001	13
8/14/2001	9
11/13/2001	15
1/21/2002	8.6
5/9/2002	10
8/8/2002	8.4
11/7/2002	10
2/13/2003	6.3
5/8/2003	111.07
8/21/2003	6.6
11/6/2003	4.8

2/12/2004	4.5
5/6/2004	6.2
8/12/2004	9
11/4/2004	2.9

EME Generation
Fig 8.56a Trace Elements

Date	As	Cd	Pb	Se
10/31/1995	0.002	0.002	0.05	0.002
11/15/1995	0.002	0.002	0.05	0.002
12/13/1995	0.002	0.002	0.05	0.002
1/17/1996	0.004	0.002	0.05	0.002
2/14/1996	0.002	0.002	0.05	0.002
3/21/1996	0.002	0.002	0.05	0.002
5/1/1996				
9/5/1996	0.002	0.002	0.05	0.002
11/14/1996	0.002	0.002	0.05	0.002
2/13/1997	0.002	0.002	0.05	0.002
5/15/1997	0.002	0.002	0.05	0.002
8/14/1997	0.002	0.002	0.05	0.002
11/13/1997	0.002	0.002	0.05	0.002
2/19/1998	0.002	0.002	0.05	0.002
5/1/1998	0.002	0.002	0.05	0.002
8/13/1998	0.002	0.002	0.05	0.002
11/5/1998	0.002	0.002	0.05	0.002
2/11/1999	0.002	0.002	0.05	0.002
5/1/1999	0.002	0.002	0.05	0.002
8/12/1999	0.002	0.002	0.05	0.002
11/4/1999	0.002	0.002	0.05	0.002
2/17/2000	0.002	0.002	0.05	0.002
5/6/2000	0.002	0.002	0.05	0.002
8/17/2000	0.002	0.002	0.05	0.002
11/16/2000	0.002	0.002	0.05	0.002
2/14/2001	0.002	0.002	0.05	0.002
5/18/2001	0.002	0.002	0.05	0.002
8/14/2001	0.002	0.002	0.05	0.002
11/13/2001	0.002	0.002	0.05	0.002
1/21/2002	0.002	0.002	0.05	0.002
5/9/2002	0.002	0.002	0.05	0.002
8/8/2002	0.002	0.002	0.05	0.002
11/7/2002	0.002	0.01	0.05	0.002
2/13/2003	0.002	0.01	0.05	0.002
5/8/2003	0.002	0.01	0.05	0.002
8/21/2003	0.002	0.002	0.05	0.002
11/6/2003	0.002	0.002	0.05	0.002
Feb-04	0.002	0.002	0.05	0.002
May-04	0.002	0.002	0.05	0.002
Aug-04	0.002	0.002	0.05	0.002
Nov-04	0.002	0.002	0.05	0.002

EME Generation
Fig 8.56b Nickel

Date	
10/31/1995	0.03
11/15/1995	<0.02
12/13/1995	0.08
1/17/1996	<0.02
2/14/1996	<0.02
3/21/1996	<0.02
5/1/1996	
9/5/1996	<0.02
11/14/1996	0.04
2/13/1997	<0.02
5/15/1997	<0.02
8/14/1997	<0.02
11/13/1997	<0.02
2/19/1998	<0.02
5/14/1998	
8/13/1998	0.24
11/5/1998	0.06
2/11/1999	<0.02
5/1/1999	
8/12/1999	<0.02
11/4/1999	0.04
2/17/2000	<0.02
5/6/2000	0.86
8/17/2000	<0.02
11/16/2000	0.2
2/14/2001	<0.02
5/18/2001	<0.02
8/14/2001	0.02
11/13/2001	0.07
2/21/2002	<0.02
5/9/2002	<0.02
8/8/2002	0.05
11/7/2002	0.05
2/13/2003	0.04
5/8/2003	0.03
8/21/2003	0.03
11/6/2003	<0.02
Feb-04	0.02
May-04	0.02
Aug-04	0.02
Nov-04	0.04

EME Generation
Fig 8.60 Iron & Manganese

Date	Fe	Mn
10/31/1995	1.02	1.7
11/15/1995	0.28	2.36
12/13/1995	0.38	1.22
1/17/1996	0.92	2.8
2/14/1996	0.4	1.82
3/21/1996	0.8	1.98
5/1/1996		
9/5/1996	2.22	1.55
11/19/1996	0.6	1.34
2/13/1997	0.23	1.59
5/15/1997	0.6	0.43
8/22/1997	5.34	3.84
11/13/1997	0.06	1.58
2/19/1998	0.86	2.23
5/15/1998	0.66	1.9
8/13/1998		
11/5/1998		
2/11/1998	0.23	1.1
5/10/1999	0.1	0.35
8/12/1999	3.8	1.5
11/4/1999	0.2	1.4
2/17/2000	0.15	1.3
5/6/2000	1.2	0.29
8/17/2000	2.15	1.93
11/16/2000	0.65	1.23
2/14/2001	1.46	0.94
5/18/2001	7.42	0.69
8/14/2001	4.4	1.34
11/13/2001		
2/21/2002	0.45	1
5/9/2002	5.58	8.64
8/8/2002	1.2	0.68
11/7/2002	0.86	3.4
2/13/2003	0.03	1.1
5/8/2003	0.32	0.59
8/21/2003	0.55	0.104
11/1/2003	0.8	1.25
Feb-04	5.1	2.6
May-04	0.06	0.38
Aug-04	0.57	0.79
Nov-04	0.63	0.59

EME Generation
Fig 8.61 Sulfates

Date	
10/31/1995	173.09
11/15/1995	227.78
12/13/1995	163.19
1/17/1996	220.25
2/14/1996	280.56
3/21/1996	184.66
5/1/1996	
9/5/1996	191
11/19/1996	141
2/13/1997	183
5/15/1997	151
8/22/1997	305
11/13/1997	144
2/19/1998	201
5/15/1998	157
8/13/1998	
11/5/1998	
2/11/1998	123
5/10/1999	99
8/12/1999	214
11/4/1999	132
2/17/2000	182
5/6/2000	103
8/17/2000	148
11/16/2000	160
2/14/2001	112
5/18/2001	114
8/14/2001	173
11/13/2001	
2/21/2002	236
5/9/2002	774
8/8/2002	141
11/7/2002	443
2/13/2003	214
5/8/2003	119
8/21/2003	181
11/6/2003	107
2/12/2004	185
5/6/2004	173
8/12/2004	302
11/4/2004	264

EME Generation

Fig 8.62 Alkalinity & Acidity

Date	Alkalinity	Acidity
10/31/1995	2	28
11/15/1995	6	25
12/13/1995	8	28
1/17/1996	0	74
2/14/1996	0	79
3/21/1996	0	55
5/1/1996		
9/5/1996	21	71
11/19/1996	3	23
2/13/1997	0	28
5/15/1997	32	-10
8/22/1997	0	82
11/13/1997	3	27
2/19/1998	10	98
5/15/1998	2	26
8/13/1998		
11/5/1998		
2/11/1998	4	18
5/10/1999	22	-12
8/12/1999	14	4
11/4/1999	4	36
2/17/2000	0	28
5/6/2000	22	-8
8/17/2000	200	-10
11/16/2000	22	-10
2/14/2001	11	-3
5/18/2001	34	-30
8/14/2001	63	-55
11/13/2001		
2/21/2002	20	-10
5/9/2002	0	108
8/8/2002	31	-19
11/7/2002	0	42
2/13/2003	3	7
5/8/2003	11	-3
8/21/2003	8	2
11/6/2003	10	1
2/12/2004	10	332
5/6/2004	20	-8
8/12/2004	10	-2
11/4/2004	17	-5

EME Generation
Fig 8.63 pH

Date	
10/31/1995	4.5
11/15/1995	4.5
12/13/1995	4.5
1/17/1996	4.2
2/14/1996	4.5
3/21/1996	4.2
5/1/1996	
9/5/1996	4.7
11/19/1996	4.5
2/13/1997	4.3
5/15/1997	5
8/22/1997	4.7
11/13/1997	4.8
2/19/1998	4.7
5/15/1998	4.7
8/13/1998	
11/5/1998	
2/11/1998	4.5
5/10/1999	5.2
8/12/1999	5.8
11/4/1999	5
2/17/2000	4
5/6/2000	5.3
8/17/2000	6.1
11/16/2000	6.4
2/14/2001	5.8
5/18/2001	5.9
8/14/2001	7.1
11/13/2001	
2/21/2002	4.8
5/9/2002	5.3
8/8/2002	6
11/7/2002	4.5
2/13/2003	5.9
5/8/2003	5.4
8/21/2003	5.9
11/6/2003	5.6
2/12/2004	5.4
5/6/2004	5.5
8/12/2004	5.6
11/4/2004	5.9

EME Generation
Fig 8.64 Calcium & Magnesium

Date	Ca	Mg
10/31/1995	35	11
11/15/1995	41	14
12/13/1995	38	13
1/17/1996	58	19
2/14/1996	51	17
3/21/1996	28	13
5/1/1996		
9/5/1996	46	14
11/19/1996	29	12
2/13/1997	32	14
5/15/1997	36	10
8/22/1997	55.5	28.5
11/13/1997	10.9	25
2/19/1998	31	16
5/15/1998	30	13
8/13/1998		
11/5/1998		
2/11/1998	137	14
5/10/1999		
8/12/1999	48	19
11/4/1999	51	19
2/17/2000	33	14
5/6/2000	29	10
8/17/2000	45	14
11/16/2000	34	13
2/14/2001	33	10
5/18/2001	51	16
8/14/2001	82	22
11/13/2001		
2/21/2002	0.02	16
5/9/2002	131	66
8/8/2002	38	11
11/7/2002	94	33
2/13/2003	52	17
5/8/2003	35	11
8/21/2003	52	14
11/6/2003	48	16
2/12/2004	372.85	219.23
5/6/2004	30	10
8/12/2004	21	7.3
11/4/2004	51	13

EME Generation
Fig 8.65 Chloride

Date	
10/31/1995	4.56
11/15/1995	5.13
12/13/1995	9.69
1/17/1996	5.7
2/14/1996	4.32
3/21/1996	10.6
5/1/1996	
9/5/1996	6.3
11/19/1996	7.4
2/13/1997	3.1
5/15/1997	4.2
8/22/1997	5.3
11/13/1997	3.1
2/19/1998	4.2
5/15/1998	18
8/13/1998	
11/5/1998	
2/11/1998	4.2
5/10/1999	5.3
8/12/1999	10
11/4/1999	8.4
2/17/2000	5.3
5/6/2000	4.2
8/17/2000	3.8
11/16/2000	11
2/14/2001	6
5/18/2001	8.6
8/14/2001	6
11/13/2001	
2/21/2002	4
5/9/2002	23
8/8/2002	3.2
11/7/2002	4.5
2/13/2003	3.3
5/8/2003	3.2
8/21/2003	3.8
11/6/2003	3.1
2/12/2004	70.23
5/6/2004	6.1
8/12/2004	2.7
11/4/2004	2.5

EME Generation
Fig 8.66 Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
10/31/1995	0.002	0.002	<0.05	0.002
11/15/1995	0.002	0.002	<0.05	0.002
12/13/1995	0.002	0.002	<0.05	0.002
1/17/1996	0.005	0.002	<0.05	0.005
2/14/1996	0.002	0.002	<0.05	0.002
3/21/1996	0.002	0.002	<0.05	0.002
5/1/1996				
9/5/1996	0.002	0.002	0.05	0.002
11/19/1996	0.002	0.002	0.05	0.002
2/13/1997	0.002	0.002	0.05	0.002
5/15/1997	0.002	0.002	0.05	0.002
8/22/1997				
11/13/1997				
2/19/1998	0.002	0.002	0.05	0.002
5/15/1998	0.002	0.002	0.05	0.002
8/13/1998				
11/5/1998				
2/11/1999	0.002	0.002	0.05	0.002
5/10/1999				
8/12/1999	0.002	0.002	0.05	0.002
11/4/1999	0.002	0.002	0.05	0.002
2/17/2000	0.002	0.002	0.05	0.002
5/6/2000	0.002	0.002	0.05	0.002
8/17/2000	0.002	0.002	0.05	0.002
11/16/2000	0.002	0.002	0.05	0.002
2/14/2001	0.002	0.002	0.05	0.002
5/18/2001	0.002	0.002	0.05	0.002
8/14/2001	0.002	0.002	0.05	0.002
11/13/2001				
2/21/2002	0.002	0.002	0.05	0.002
5/9/2002	0.002	0.002	0.05	0.002
8/8/2002	0.002	0.002	0.05	0.002
11/7/2002	0.002	0.01	0.05	0.002
2/13/2003	0.002	0.01	0.05	0.002
5/8/2003	0.002	0.01	0.05	0.002
8/21/2003	0.002	0.002	0.05	0.002
11/6/2003	0.002	0.002	0.05	0.002
2/12/2004	0.002	0.002	0.05	0.002
5/6/2004	0.002	0.002	0.05	0.002
8/12/2004	0.002	0.002	0.05	0.002
11/4/2004	0.002	0.002	0.05	0.002

EME Generation
Fig 8.66b Trace Elements

Date	Barium	Chromium	Silver
10/31/1995	<0.03	<0.02	<0.01
11/15/1995	<0.03	<0.02	<0.01
12/13/1995	<0.03	<0.02	<0.01
1/17/1996	<0.03	<0.02	<0.01
2/14/1996	<0.03	<0.02	<0.01
3/21/1996	<0.03	<0.02	<0.01
5/1/1996			
9/5/1996	<0.03	<0.02	<0.01
11/19/1996	0.12	<0.02	<0.01
2/13/1997	<0.03	<0.02	<0.01
5/15/1997	0.06	<0.02	<0.01
8/22/1997	0.04	<0.02	<0.01
11/13/1997	0.01	0.01	<0.01
2/19/1998	0.03	<0.02	0.05
5/15/1998	0.03	<0.02	<0.01
8/13/1998			
11/5/1998			
2/11/1999	0.08	<0.02	<0.01
5/10/1999			
8/12/1999	0.1	<0.02	<0.01
11/4/1999	0.04	<0.02	<0.01
2/17/2000	0.03	<0.02	0.03
5/6/2000	0.14	<0.02	<0.01
8/17/2000		<0.02	
11/16/2000		<0.02	
2/14/2001		<0.02	
5/18/2001		0.03	
8/14/2001		0.02	
11/13/2001			
2/21/2002		0.02	
5/9/2002		0.02	
8/8/2002		<0.02	
11/7/2002		<0.02	
2/13/2003		<0.02	
5/8/2003		<0.02	
8/21/2003		<0.02	
11/6/2003		<0.02	
2/12/2004		0.02	
5/6/2004		<0.02	
8/12/2004		<0.02	
11/4/2004		<0.02	

EME Generation
Fig 8.66c Trace Elements

Date	Nickel	Zinc
10/31/1995	0.02	0.06
11/15/1995	<0.02	0.11
12/13/1995	<0.02	0.08
1/17/1996	0.04	0.17
2/14/1996	<0.02	0.04
3/21/1996	<0.02	0.07
5/1/1996		
9/5/1996	<0.02	0.08
11/19/1996	0.1	0.92
2/13/1997	0.02	<0.005
5/15/1997	<0.02	<0.005
8/22/1997	0.08	0.18
11/13/1997	<0.02	<0.005
2/19/1998	0.05	0.09
5/15/1998	0.04	0.07
8/13/1998		
11/5/1998		
2/11/1999	<0.02	0.07
5/10/1999		
8/12/1999	0.03	0.08
11/4/1999	0.05	0.1
2/17/2000	0.03	0.07
5/6/2000	<0.02	<0.005
8/17/2000	<0.02	0.02
11/16/2000	0.03	0.02
2/14/2001	<0.02	0.03
5/18/2001	<0.02	0.03
8/14/2001	0.03	0.03
11/13/2001		
2/21/2002	0.02	0.08
5/9/2002	0.26	0.58
8/8/2002	0.04	0.02
11/7/2002	0.07	0.23
2/13/2003	0.08	0.07
5/8/2003	0.04	0.02
8/21/2003	0.03	0.01
11/6/2003	<0.02	0.04
2/12/2004	1.06	2.3
5/6/2004	0.02	0.01
8/12/2004	0.03	0.04
11/4/2004	<0.02	0.01

EME Generation
Fig 8.67a Chromium

Date	
10/31/1995	0.04
11/15/1995	<0.02
12/13/1995	0.03
1/17/1996	0.03
2/14/1996	0.03
3/21/1996	0.04
9/5/1996	0.04
11/14/1996	0.05
2/13/1997	0.49
5/15/1997	<0.02
8/14/1997	0.05
11/13/1997	0.05
2/19/1998	0.04
5/15/1998	0.05
8/13/1998	0.04
11/5/1998	0.05
2/11/1999	0.04
8/12/1999	0.04
11/4/1999	0.04
2/17/2000	0.04
5/6/2000	0.06
8/17/2000	0.07
11/16/2000	0.04
2/14/2001	0.04
5/18/2001	0.05
8/14/2001	0.05
11/13/2001	0.04
2/21/2002	0.06
5/9/2002	0.07
8/8/2002	0.05
11/7/2002	0.03
2/13/2003	0.04
5/8/2003	0.03
8/21/2003	0.05
11/6/2003	0.05
2/12/2004	0.03
5/6/2004	0.03
8/12/2004	0.02
11/4/2004	0.02

EME Generation

Fig 8.67b Chromium

Date	
10/31/1995	0.04
11/15/1995	<0.02
12/13/1995	0.03
1/17/1996	0.03
2/14/1996	0.03
3/21/1996	0.04
9/5/1996	0.04
11/14/1996	0.05
2/13/1997	
5/15/1997	<0.02
8/14/1997	0.05
11/13/1997	0.05
2/19/1998	0.04
5/15/1998	0.05
8/13/1998	0.04
11/5/1998	0.05
2/11/1999	0.04
8/12/1999	0.04
11/4/1999	0.04
2/17/2000	0.04
5/6/2000	0.06
8/17/2000	0.07
11/16/2000	0.04
2/14/2001	0.04
5/18/2001	0.05
8/14/2001	0.05
11/13/2001	0.04
2/21/2002	0.06
5/9/2002	0.07
8/8/2002	0.05
11/7/2002	0.03
2/13/2003	0.04
5/8/2003	0.03
8/21/2003	0.05
11/6/2003	0.05
2/12/2004	0.03
5/6/2004	0.03
8/12/2004	0.02
11/4/2004	0.02

EME Generation
Fig 8.67c Trace Elements

Date	Barium	Silver
10/31/1995	<0.03	<0.01
11/15/1995	<0.03	0.03
12/13/1995	<0.03	0.04
1/17/1996	<0.03	0.03
2/14/1996	<0.03	<0.01
3/21/1996	<0.03	<0.01
9/5/1996	<0.03	0.04
11/14/1996	0.05	0.1
2/13/1997	0.04	0.05
5/15/1997	0.07	<0.01
8/14/1997	0.03	0.05
11/13/1997	0.02	0.04
2/19/1998	0.02	0.05
5/15/1998	0.04	0.04
8/13/1998	<0.03	0.05
11/5/1998	0.13	0.04
2/11/1999	0.08	0.03
8/12/1999	0.05	0.04
11/4/1999	0.05	0.03
2/17/2000	0.03	0.03
5/6/2000	0.04	0.04
8/17/2000		
11/16/2000		
2/14/2001		
5/18/2001		
8/14/2001		
11/13/2001		
2/21/2002		
5/9/2002		
8/8/2002		
11/7/2002		
2/13/2003		
5/8/2003		
8/21/2003		
11/6/2003		
2/12/2004		
5/6/2004		
8/12/2004		
11/4/2004		

EME Generation

Fig 8.67d Trace Elements

Date	Nickel	Zinc
10/31/1995	0.05	0.16
11/15/1995	0.09	0.29
12/13/1995	0.1	0.4
1/17/1996	0.1	0.46
2/14/1996	0.07	0.65
3/21/1996	0.2	0.64
9/5/1996	0.08	0.41
11/14/1996	0.29	0.96
2/13/1997	0.23	0.17
5/15/1997	0.15	0.9
8/14/1997	0.33	0.9
11/13/1997	0.19	0.2
2/19/1998	0.1	0.75
5/15/1998	0.2	0.1
8/13/1998	0.11	0.55
11/5/1998	0.21	0.8
2/11/1999	0.47	1.2
5/1/1999		
8/12/1999	0.36	1.4
11/4/1999	0.37	1.05
2/17/2000	0.64	1.6
5/6/2000	0.86	3
8/17/2000	0.6	2.1
11/16/2000	0.35	1.2
2/14/2001	0.45	1.2
5/18/2001	0.4	1.6
8/14/2001	0.32	1.4
11/13/2001	0.29	0.92
2/21/2002	0.38	0.9
5/9/2002	0.53	1.52
8/8/2002	0.4	1.22
11/7/2002	0.44	1.32
2/13/2003	0.65	1.05
5/8/2003	0.33	1.1
8/21/2003	0.37	1.65
11/6/2003	0.73	1.38
2/12/2004	0.78	1.9
5/6/2004	0.68	1.47
8/12/2004	<0.002	0.83
11/4/2004	0.58	1.1

EME Generation
Fig 8.67e Trace Elements

Date	Copper
10/31/1995	0.03
11/15/1995	<0.01
12/13/1995	0.06
1/17/1996	0.09
2/14/1996	0.07
3/21/1996	0.06
9/5/1996	0.07
11/14/1996	0.04
2/13/1997	0.06
5/15/1997	0.04
8/14/1997	0.07
11/13/1997	0.04
2/19/1998	0.04
5/15/1998	0.05
8/13/1998	0.05
11/5/1998	0.05
2/11/1999	0.14
5/1/1999	
8/12/1999	0.05
11/4/1999	0.07
2/17/2000	0.12
5/6/2000	0.07
8/17/2000	0.08
11/16/2000	0.04
2/14/2001	0.06
5/18/2001	0.06
8/14/2001	0.09
11/13/2001	0.13
2/21/2002	0.06
5/9/2002	0.2
8/8/2002	0.11
11/7/2002	0.07
2/13/2003	0.07
5/8/2003	0.09
8/21/2003	0.13
11/6/2003	0.06
2/12/2004	0.1
5/6/2004	0.08
8/12/2004	0.04
11/4/2004	0.06

Hartley Strip Mine
Fig 9.1 Iron & Manganese

Date	Fe	Mn
Apr-88	0.1	0.88
Aug-88	0.09	2.51
Nov-88	3.14	2.49
Dec-88		
Dec-89		
Dec-90		
Dec-91		
Dec-92		
Dec-93		
Jun-94		
Dec-94		
Jul-95	0.82	0.54
Mar-96	0.83	0.04
Jun-96	0.07	0.21
Jul-96	0.2	0.07
Dec-96	4.7	0.15
Mar-97	0.36	0.1
Jun-97	5.78	0.19
Sep-97	0.27	4.74
Dec-97	0.21	0.03
Mar-98	0.33	0.03
Jun-98	1.2	0.56
Sep-98	0.09	0.03

Hartley Strip Mine
Fig 9.2 Sulfates

Date	Sulfates
Apr-88	260
Aug-88	460
Nov-88	400
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	203
Mar-96	82
Jun-96	116
Jul-96	187
Dec-96	49
Mar-97	63
Jun-97	94
Sep-97	137
Dec-97	83
Mar-98	45
Jun-98	320
Sep-98	73

Hartley Strip Mine

Fig 9.3 Acidity

Date	Acidity
Apr-88	1
Aug-88	2
Nov-88	420
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	7.7
Mar-96	2.2
Jun-96	1.8
Jul-96	19.4
Dec-96	36.4
Mar-97	34
Jun-97	31
Sep-97	32
Dec-97	15
Mar-98	16
Jun-98	22
Sep-98	46

Hartley Strip Mine
Fig 9.3 pH

Date	pH
Apr-88	7.12
Aug-88	7.05
Nov-88	
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	6.73
Mar-96	6.75
Jun-96	6.84
Jul-96	6.54
Dec-96	6.72
Mar-97	6.7
Jun-97	7.5
Sep-97	6.48
Dec-97	6.22
Mar-98	6.73
Jun-98	6.95
Sep-98	6.56

Hartley Strip Mine
Fig 9.3b Alkalinity

Date	
Apr-88	219
Aug-88	122
Nov-88	2
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	193
Mar-96	113
Jun-96	181
Jul-96	42
Dec-96	153
Mar-97	112
Jun-97	131
Sep-97	167
Dec-97	60
Mar-98	81
Jun-98	67
Sep-98	127

Hartley Strip Mine

Fig 9.4 Trace Elements

Date	Sb	Cd	Pb	Hg
Apr-88	0.001	0.01	0.04	0.0002
Nov-89	0.01	0.0009	0.0015	0.0001
Aug-90	0.01	0.0016	0.003	0.0001
Aug-91	0.03	0.0005	0.0051	0.0002
Jul-92	0.1	0.01	0.02	0.002
Jul-93	0.1	0.01	0.06	0.002
Aug-94				
Aug-95				
Aug-96				
Sep-97	0.002	0.0005	0.002	
Sep-98	0.002	0.01	0.002	0.004

Hartley Strip Mine
Fig 9.5 Iron & Manganese

Date	Fe	Mn
Apr-88	0.08	0.1
Aug-88	0.05	0.05
Nov-88	0.22	0.05
Dec-88		
Dec-89		
Dec-90		
Dec-91		
Dec-92		
Dec-93		
Jun-94		
Dec-94		
Jul-95	0.22	0.23
Mar-96	0.18	0.19
Jun-96	0.13	0.02
Jul-96	0.06	0.03
Dec-96	0.89	0.45
Mar-97	0.14	0.09
Jun-97	0.3	0.38
Sep-97	0.06	0.49
Dec-97	0.22	0.01
Mar-98		
Jun-98	0.4	0.02
Sep-98	0.01	0.03

Hartley Strip Mine
Fig 9.6 Sulfates

Date	
Apr-88	130
Aug-88	124
Nov-88	124
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	19
Mar-96	55
Jun-96	138
Jul-96	55
Dec-96	31
Mar-97	49
Jun-97	82
Sep-97	92
Dec-97	25
Mar-98	
Jun-98	1180
Sep-98	69

Hartley Strip Mine
Fig 9.7 Acidity

Date	
Apr-88	0
Aug-88	2
Nov-88	2
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	2.5
Mar-96	1
Jun-96	1
Jul-96	15
Dec-96	18
Mar-97	18
Jun-97	16
Sep-97	31
Dec-97	2
Mar-98	
Jun-98	39
Sep-98	17

Hartley Strip Mine

Fig 9.7a Lab pH

Date	
Apr-88	8.2
Aug-88	7.43
Nov-88	7.14
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	7.29
Mar-96	7.12
Jun-96	7.34
Jul-96	7.36
Dec-96	6.72
Mar-97	6.59
Jun-97	7.15
Sep-97	7.01
Dec-97	6.83
Mar-98	
Jun-98	6.9
Sep-98	7.15

Hartley Strip Mine
Fig 9.7b Akalinity

Date	
Apr-88	207
Aug-88	210
Nov-88	182
Dec-88	
Dec-89	
Dec-90	
Dec-91	
Dec-92	
Dec-93	
Jun-94	
Dec-94	
Jul-95	258
Mar-96	159
Jun-96	207
Jul-96	200
Dec-96	73
Mar-97	55
Jun-97	201
Sep-97	221
Dec-97	11
Mar-98	
Jun-98	134
Sep-98	209

Hartley Strip Mine
Fig 9.8 Trace Elements

Date	Sb	Cd	Pb	Hg
Apr-88	0.001	0.01	0.04	0.0002
Nov-89	0.01	0.0009	0.0045	0.0001
Aug-91	0.04	0.0003	0.0003	0.0002
Jul-92	0.1	0.01	0.02	0.002
Jul-93	0.1	0.01	0.1	0.002
Aug-94	0.1	0.01	0.001	0.002
Jul-95	0.11	0.01		0.002
Jul-96	0.1	0.01	0.05	0.002
Sep-97	0.002	0.0005	0.002	
Sep-98	0.002	0.01	0.003	0.0004

Hartley Strip Mine
Fig 9.9 Boron

Date	
3/16/1994	5.512
4/25/1994	6.857
7/28/1994	7.225
11/1/1994	5.505
3/14/1995	5.352
6/7/1995	2.616
9/7/1995	3.263
11/1/1995	7.23
1/15/1996	4.285
5/22/1996	8.675
7/8/1996	10.47
11/1/1996	6.984
2/4/1997	7.473
5/28/1997	10.3
8/6/1997	9.663
12/16/1997	12.32
2/9/1998	13.466
4/1/1998	12.03
8/10/1998	11.19
11/1/1998	
2/9/1999	
5/5/1999	11.81
8/2/1999	
11/4/1999	
3/2/2000	
6/2/2000	14.052
8/29/2000	

Hartley Strip Mine
Fig 9.10 Molybdenum

Date	
3/16/1994	0.0084
4/25/1994	0.003
7/28/1994	0.0023
11/1/1994	0
3/14/1995	0.0019
6/7/1995	0
9/7/1995	0
11/1/1995	0.005
1/15/1996	0.0022
5/22/1996	0
7/8/1996	0
11/1/1996	0
2/4/1997	0
5/28/1997	0.0064
8/6/1997	0.0012
11/1/1997	0.002
2/9/1998	0.0027
4/1/1998	0.0041
8/10/1998	0
11/1/1998	
2/9/1999	
5/5/1999	0.0027
8/2/1999	
11/4/1999	
3/2/2000	
6/2/2000	0.0027
8/29/2000	

Hartley Strip Mine
Fig 9.11 Managanese

Date	
3/16/1994	5850
4/25/1994	3179
7/28/1994	6028
11/1/1994	7237
3/14/1995	6031
6/7/1995	4442
9/7/1995	5662
11/1/1995	6957
1/15/1996	6684
5/22/1996	3757
7/8/1996	4788
11/1/1996	5281
2/4/1997	7439
5/28/1997	11320
8/6/1997	10180
11/1/1997	7330
2/9/1998	6582
4/1/1998	7599
8/10/1998	5207
11/1/1998	5054
2/9/1999	5291
5/5/1999	4196
8/2/1999	4091
11/4/1999	3597
3/2/2000	3867
6/2/2000	4180
8/29/2000	4056

Hartley Strip Mine
Fig 9.12 Sulfates

Date	
3/16/1994	1825
4/25/1994	2170
7/28/1994	2270
11/1/1994	1755.6
3/14/1995	1513.8
6/7/1995	1236.6
9/7/1995	1020.4
11/1/1995	2077.1
1/15/1996	1465.2
5/22/1996	2033.8
7/8/1996	2270.6
11/1/1996	1613.1
2/4/1997	1420
5/28/1997	2206.8
8/6/1997	2028.2
11/1/1997	2608.1
2/9/1998	2440.1
4/1/1998	2244
8/10/1998	2117.4
11/1/1998	1932.1
2/9/1999	2247.9
5/5/1999	2860.2
8/2/1999	2325
11/4/1999	2465
3/2/2000	2350
6/2/2000	2127.3
8/29/2000	2604

Hartley Strip Mine
Fig 9.12a Alkalinity

Date	
3/16/1994	309
4/25/1994	365.8
7/28/1994	420.6
11/1/1994	352.4
3/14/1995	264.2
6/7/1995	228.8
9/7/1995	232
11/1/1995	291
1/15/1996	225.8
5/22/1996	427
7/8/1996	458
11/1/1996	361.4
2/4/1997	419.8
5/28/1997	453.4
8/6/1997	498.6
11/1/1997	470.6
2/9/1998	446.2
4/1/1998	493.2
8/10/1998	589.4
11/1/1998	525.6
2/9/1999	477
5/5/1999	444
8/2/1999	488
11/4/1999	473
3/2/2000	461
6/2/2000	
8/29/2000	

Hartley Strip Mine
Fig 9.12b pH

Date	
3/16/1994	6.24
4/25/1994	6.26
7/28/1994	6.19
11/1/1994	6.11
3/14/1995	6.14
6/7/1995	6.23
9/7/1995	6.4
11/1/1995	6.3
1/15/1996	6.2
5/22/1996	6.5
7/8/1996	6.41
11/1/1996	6.3
2/4/1997	6.3
5/28/1997	6.47
8/6/1997	6.5
11/1/1997	6.4
2/9/1998	6.33
4/1/1998	6.45
8/10/1998	6.58
11/1/1998	6.46
2/9/1999	6.38
5/5/1999	6.35
8/2/1999	6.45
11/4/1999	6.46
3/2/2000	6.49
6/2/2000	6.51
8/29/2000	6.37

Hartley Strip Mine

Fig 9.12c Calcium

Date	
3/16/1994	409.6
4/25/1994	361.9
7/28/1994	458.9
11/1/1994	311.2
3/14/1995	308.44
6/7/1995	218.12
9/7/1995	285.48
11/1/1995	408.3
1/15/1996	324.32
5/22/1996	439.3
7/8/1996	497.9
11/1/1996	391.6
2/4/1997	423.4
5/28/1997	472.3
8/6/1997	487.7
11/1/1997	516.3
2/9/1998	522.5
4/1/1998	527.3
8/10/1998	501.2
11/1/1998	522.5
2/9/1999	541.4
5/5/1999	514.8
8/2/1999	575
11/4/1999	530.6
3/2/2000	515
6/2/2000	540
8/29/2000	426.7

Hartley Strip Mine
Fig 9.12d Potassium

Date	
3/16/1994	11.47
4/25/1994	15.09
7/28/1994	11.27
11/1/1994	15.79
3/14/1995	8.98
6/7/1995	7.99
9/7/1995	9.09
11/1/1995	11.67
1/15/1996	9.6
5/22/1996	15.62
7/8/1996	16.61
11/1/1996	10.15
2/4/1997	11.25
5/28/1997	15.74
8/6/1997	15.42
11/1/1997	17.92
2/9/1998	18.14
4/1/1998	16.23
8/10/1998	15.04
11/1/1998	18
2/9/1999	20.92
5/5/1999	20.76
8/2/1999	20.81
11/4/1999	20.86
3/2/2000	20.23
6/2/2000	18.5291
8/29/2000	26.1602

Hartley Strip Mine
Fig 9.12e Magnesium

Date	
3/16/1994	196700
4/25/1994	140840
7/28/1994	253850
11/1/1994	150440
3/14/1995	152920
6/7/1995	103500
9/7/1995	132600
11/1/1995	221450
1/15/1996	160980
5/22/1996	233400
7/8/1996	285550
11/1/1996	193900
2/4/1997	219650
5/28/1997	278150
8/6/1997	263200
11/1/1997	294500
2/9/1998	294500
4/1/1998	309600
8/10/1998	269900
11/1/1998	
2/9/1999	
5/5/1999	394500
8/2/1999	
11/4/1999	
3/2/2000	
6/2/2000	310720
8/29/2000	

Hartley Strip Mine
Fig 9.13 Boron

Date	
3/14/1994	3.064
4/25/1994	3.01
7/27/1994	4.44
11/21/1994	5.648
3/13/1995	5.584
6/6/1995	3.672
9/5/1995	4.654
11/28/1995	4.5
1/16/1996	4.747
5/22/1996	5.935
7/8/1996	5.742
11/25/1996	7.748
2/3/1997	11.57
5/29/1997	11.85
8/5/1997	11.82
12/15/1997	12.22
2/9/1998	11.75
4/1/1998	9.847
8/12/1998	9.814
11/1/1998	
2/9/1999	
5/4/1999	9.205
8/2/1999	
11/4/1999	
3/2/2000	
5/30/2000	9.843
8/24/2000	

Hartley Strip Mine
Fig 9.14 Molybdenum

Date	
3/14/1994	0.0086
4/25/1994	0.0047
7/27/1994	0.0049
11/21/1994	0.0029
3/13/1995	0.0019
6/6/1995	0.0023
9/5/1995	0
11/28/1995	0
1/16/1996	0.0015
5/22/1996	0
7/8/1996	0.0068
11/25/1996	0.0065
2/3/1997	0.0097
5/29/1997	0.0089
8/5/1997	0.0115
12/15/1997	0.0032
2/9/1998	0.0047
4/1/1998	0.0103
8/12/1998	0.01
11/1/1998	
2/9/1999	
5/4/1999	0.0096
8/2/1999	
11/4/1999	
3/2/2000	
5/30/2000	0.0083
8/24/2000	

Hartley Strip Mine
Fig 9.15 Manganese

Date	
3/14/1994	3008
4/25/1994	3525
7/27/1994	4254
11/1/1994	5489
3/13/1995	6104
6/6/1995	4055
9/5/1995	5698
11/1/1995	6764
1/16/1996	6748
5/22/1996	1129
7/8/1996	1898
11/1/1996	3028
2/3/1997	3284
5/29/1997	1224
8/5/1997	1834
11/1/1997	3132
2/9/1998	3019
4/1/1998	1124
8/12/1998	1220
11/1/1998	1997
2/9/1999	2752
5/4/1999	2627
8/2/1999	2822
11/4/1999	2008
3/2/2000	2406
5/30/2000	3180
8/24/2000	2110

Hartley Strip Mine
Fig 9.16 Sulfates

Date	
3/14/1994	3420
4/25/1994	3550
7/27/1994	2930
11/1/1994	4323.3
3/13/1995	3763
6/6/1995	3159.2
9/5/1995	3857.9
11/1/1995	4184.2
1/16/1996	3791
5/22/1996	3752.4
7/8/1996	3553.4
11/1/1996	3371.4
2/3/1997	3188.7
5/29/1997	3844.1
8/5/1997	3617
11/1/1997	3973.3
2/9/1998	3631.3
4/1/1998	3527.5
8/12/1998	3088.4
11/1/1998	4532
2/9/1999	3444.1
5/4/1999	3593
8/2/1999	3510
11/4/1999	3521
3/2/2000	3256
5/30/2000	3112.1
8/24/2000	3644

Hartley Strip Mine
Fig 9.16a Alkalinity

Date	
3/14/1994	512.4
4/25/1994	559.2
7/27/1994	557.6
11/1/1994	542.2
3/13/1995	523.6
6/6/1995	497.4
9/5/1995	480
11/1/1995	480
1/16/1996	508.4
5/22/1996	545.6
7/8/1996	591.6
11/1/1996	568.6
2/3/1997	561.6
5/29/1997	580.2
8/5/1997	560
11/1/1997	556.6
2/9/1998	563.6
4/1/1998	568.2
8/12/1998	591.4
11/1/1998	768.2
2/9/1999	567
5/4/1999	563
8/2/1999	547
11/4/1999	532
3/2/2000	536
5/30/2000	
8/24/2000	

Hartley Strip Mine
Fig 9.16c Calcium

Date	
3/14/1994	411.6
4/25/1994	453
7/27/1994	423.1
11/1/1994	434.6
3/13/1995	480
6/6/1995	401.3
9/5/1995	421.1
11/1/1995	459
1/16/1996	460.2
5/22/1996	436.7
7/8/1996	459.6
11/1/1996	511.6
2/3/1997	513.3
5/29/1997	503.1
8/5/1997	506
11/1/1997	514.1
2/9/1998	533.5
4/1/1998	544.5
8/12/1998	526.6
11/1/1998	479.5
2/9/1999	498.5
5/4/1999	492.8
8/2/1999	524.8
11/4/1999	497.5
3/2/2000	505.5
5/30/2000	519.9
8/24/2000	548

Hartley Strip Mine
Fig 9.16d Potassium

Date	
3/14/1994	9.92
4/25/1994	9.89
7/27/1994	7.4
11/1/1994	15.86
3/13/1995	9.06
6/6/1995	9.09
9/5/1995	9.49
11/1/1995	10
1/16/1996	10.03
5/22/1996	10.14
7/8/1996	10.43
11/1/1996	9
2/3/1997	10.18
5/29/1997	12.52
8/5/1997	12.81
11/1/1997	13.51
2/9/1998	13.46
4/1/1998	12.82
8/12/1998	11.7
11/1/1998	12.01
2/9/1999	13.36
5/4/1999	13.63
8/2/1999	13.2
11/4/1999	12.83
3/2/2000	13.1
5/30/2000	13.6441
8/24/2000	13.923

Hartley Strip Mine
Fig 9.16e Magnesium

Date	
3/14/1994	547100
4/25/1994	582300
7/27/1994	528400
11/1/1994	515000
3/13/1995	562000
6/6/1995	489400
9/5/1995	524600
11/1/1995	603700
1/16/1996	536000
5/22/1996	533700
7/8/1996	548200
11/1/1996	566600
2/3/1997	601000
5/29/1997	623800
8/5/1997	615200
11/1/1997	658900
2/9/1998	666500
4/1/1998	676100
8/12/1998	652300
11/1/1998	
2/9/1999	
5/4/1999	627900
8/2/1999	
11/4/1999	
3/2/2000	
5/30/2000	633300
8/24/2000	

Bloom Mining
Fig 10.1 Iron

DATE	
11/24/1995	9.7
12/18/1995	19.3
1/31/1996	7.92
2/28/1996	3.12
3/27/1996	3.03
4/24/1996	3
7/31/1996	1.04
10/14/1996	3.88
1/8/1997	0.53
4/1/1997	1.53
8/19/1997	2.25
12/16/1997	4.26
2/16/1998	0.46
5/20/1998	0.52
9/30/1998	3.79
11/24/1998	3.27
3/24/1999	0.43
6/29/1999	1.87
8/27/1999	6.27
11/9/1999	4.18
3/8/2000	0.64
6/26/2000	0.07
9/27/2000	0.26
12/27/2000	
3/16/2001	0.49
6/20/2001	1.86
Aug-01	1.77
Nov-01	1.13
Mar-02	2.46
Jun-02	1.08
Sep-02	1.92
Nov-02	2.14
Mar-03	0.5
Jun-03	0.41
Sep-03	0.18
Dec-03	0.27

Bloom Mining
Fig 10.2 Manganese

DATE	
11/24/1995	0.69
12/18/1995	0.92
1/31/1996	0.14
2/28/1996	0.09
3/27/1996	0.06
4/24/1996	0.38
7/31/1996	0.34
10/14/1996	0.48
1/8/1997	0.04
4/1/1997	0.07
8/19/1997	0.06
12/16/1997	0.18
2/16/1998	0.05
5/20/1998	0.1
9/30/1998	0.83
11/24/1998	1.21
3/24/1999	0.05
6/29/1999	0.57
8/27/1999	0.82
11/9/1999	0.79
3/8/2000	0.08
6/26/2000	0.2
9/27/2000	0.59
12/27/2000	
3/16/2001	0.06
6/25/2001	0.1
Aug-01	0.39
Nov-01	0.7
Mar-02	0.73
Jun-02	0.08
Sep-02	0.54
Nov-02	0.7
Mar-03	0.08
Jun-03	0.1
Sep-03	0.07
Dec-03	0.05

Bloom Mining
Fig 10.3 Sulfate

DATE	
11/24/1995	16
12/18/1995	7
1/31/1996	6
2/28/1996	7
3/27/1996	13
4/24/1996	10
7/31/1996	8
10/14/1996	15
1/8/1997	9
4/1/1997	6
8/19/1997	18
12/16/1997	14
2/16/1998	11
5/20/1998	8
9/30/1998	10
11/24/1998	11
3/24/1999	17
6/29/1999	20
8/27/1999	21
11/9/1999	14
3/8/2000	8
6/26/2000	14
9/27/2000	12
12/27/2000	
3/16/2001	9
6/25/2001	7
Aug-01	10
Nov-01	22
Mar-02	19
Jun-02	13
Sep-02	18
Nov-02	24
Mar-03	13
Jun-03	16
Sep-03	10
Dec-03	9

Bloom Mining
Fig 10.4 pH

DATE	
11/24/1995	6.1
12/18/1995	6
1/31/1996	5.4
2/28/1996	5.9
3/27/1996	6
4/24/1996	5.4
7/31/1996	5.4
10/14/1996	5.5
1/8/1997	5.2
4/1/1997	5.7
8/19/1997	5
12/16/1997	5.1
2/16/1998	5.6
5/20/1998	5.3
9/30/1998	5
11/24/1998	5
3/24/1999	5.3
6/29/1999	5.3
8/27/1999	4.7
11/9/1999	5.2
3/8/2000	5.5
6/26/2000	5.1
9/27/2000	5
12/27/2000	
3/16/2001	4.9
6/25/2001	5.5
Aug-01	4.9
Nov-01	4.9
Mar-02	4.5
Jun-02	5
Sep-02	4
Nov-02	5.3
Mar-03	5.1
Jun-03	4.9
Sep-03	5.3
Dec-03	4.9

Bloom Mining
Fig 10.5 Alkalinity

DATE	
11/24/1995	19
12/18/1995	17
1/31/1996	9
2/28/1996	10
3/27/1996	9
4/24/1996	8
7/31/1996	13
10/14/1996	8
1/8/1997	7
4/1/1997	10
8/19/1997	9
12/16/1997	9
2/16/1998	10
5/20/1998	10
9/30/1998	9
11/24/1998	10
3/24/1999	8
6/29/1999	8
8/27/1999	8
11/9/1999	9
3/8/2000	9
6/26/2000	9
9/27/2000	9
12/27/2000	
3/16/2001	11
6/25/2001	9
Aug-01	9
Nov-01	9
Mar-02	12
Jun-02	11
Sep-02	10
Nov-02	11
Mar-03	12
Jun-03	13
Sep-03	11
Dec-03	15

Bloom Mining
Fig 10.6 Acidty

DATE	
11/24/1995	9
12/18/1995	11
1/31/1996	12
2/28/1996	7
3/27/1996	3
4/24/1996	16
7/31/1996	4
10/14/1996	6
1/8/1997	11
4/1/1997	4
8/19/1997	8
12/16/1997	10
2/16/1998	8
5/20/1998	3
9/30/1998	8
11/24/1998	13
3/24/1999	2
6/29/1999	16
8/27/1999	15
11/9/1999	4
3/8/2000	12
6/26/2000	4
9/27/2000	17
12/27/2000	
3/16/2001	9
6/25/2001	10
Aug-01	18
Nov-01	2
Mar-02	4
Jun-02	14
Sep-02	7
Nov-02	19
Mar-03	11
Jun-03	2
Sep-03	4
Dec-03	21

Bloom Mining

Fig 10.7 Total Dissolved Solids

DATE	
11/24/1995	72
12/18/1995	28
1/31/1996	20
2/28/1996	44
3/27/1996	32
4/24/1996	24
7/31/1996	24
10/14/1996	44
1/8/1997	36
4/1/1997	16
8/19/1997	28
12/16/1997	20
2/16/1998	10
5/20/1998	10
9/30/1998	32
11/24/1998	92
3/24/1999	4
6/29/1999	40
8/27/1999	28
11/9/1999	88
3/8/2000	52
6/26/2000	76
9/27/2000	68
12/27/2000	
3/16/2001	48
6/25/2001	48
Aug-01	24
Nov-01	44
Mar-02	36
Jun-02	80
Sep-02	76
Nov-02	36
Mar-03	28
Jun-03	4
Sep-03	76
Dec-03	4

Bloom Mining
Fig 10.8 Calcium & Magnesium

DATE	Ca	Mg
11/24/1995	2.85	2.2
12/18/1995	2.7	2.1
1/31/1996	1.6	0.1
2/28/1996	1.1	1.4
3/27/1996	1.6	1.5
4/24/1996	1.9	1.7
4/1/1997	1.3	1.5
2/3/1998	1.5	1.6
3/24/1999	1.3	1.6
1/1/2000		
1/1/2001		
1/1/2002		
3/31/2003	1.6	1.6

Bloom Mining
Fig 10.9 Trace Elements

Date	As	Cd	Pb	Se
11/24/1995	<0.01	<0.005	<0.01	<0.01
12/18/1995	<0.01	<0.005	<0.005	<0.01
1/31/1996	<0.01	<0.02	<0.005	<0.01
2/28/1996	<0.01	<0.02	<0.005	<0.01
3/27/1996	<0.01	<0.02	<0.005	<0.01
4/24/1996	<0.01	<0.02	<0.005	<0.01
4/1/1997	<0.015	<0.03	<0.01	<0.01
2/3/1998	<0.015	<0.03	<0.005	<0.01
3/24/1999	<0.015	<0.03	<0.005	<0.02
1/1/2000				
1/1/2001				
1/1/2002				
3/31/2003	<0.015	<0.03	<0.01	0.05

Bloom Mining
Fig 10.10 Iron

DATE	
11/24/1995	0.03
12/18/1995	0.08
1/31/1996	0.03
2/28/1996	0.02
3/27/1996	0.23
4/24/1996	0.18
7/31/1996	0.04
10/14/1996	0.12
1/8/1997	0.09
4/1/1997	0.09
8/19/1997	0.22
10/28/1997	0.07
2/3/1998	0.07
5/20/1998	0.09
9/30/1998	0.21
11/24/1998	0.19
3/24/1999	0.07
6/29/1999	0.07
8/27/1999	0.07
11/9/1999	0.07
3/8/2000	0.07
6/26/2000	0.07
9/27/2000	0.07
12/27/2000	
3/16/2001	0.07
6/20/2001	0.07
8/21/2001	0.09
11/19/2001	0.07
3/1/2002	0.07
6/1/2002	0.07
9/1/2002	0.14
11/1/2002	
3/31/2003	0.22
6/30/2003	0.07
9/30/2003	0.07
12/18/2003	0.07

Bloom Mining
Fig 10.11 Manganese

DATE	
11/24/1995	3.96
12/18/1995	3.96
1/31/1996	2.77
2/28/1996	2
3/27/1996	2.99
4/24/1996	3.47
7/31/1996	3.16
10/14/1996	3.4
1/8/1997	2.97
4/1/1997	2.16
8/19/1997	7.17
10/28/1997	2.32
2/3/1998	2.06
5/20/1998	1.91
9/30/1998	6.36
11/24/1998	2.81
3/24/1999	1.46
6/29/1999	2.46
8/27/1999	3.91
11/9/1999	2.03
3/8/2000	1.6
6/26/2000	1.76
9/27/2000	4.23
12/27/2000	
3/16/2001	1.55
6/20/2001	3.92
8/21/2001	7.11
11/19/2001	5.63
3/1/2002	2.75
6/1/2002	1.75
9/1/2002	11
11/1/2002	
3/31/2003	14
6/30/2003	2.27
9/30/2003	2.33
12/18/2003	2.01

Bloom Mining

Fig 10.12 Sulfates

DATE	
11/24/1995	160
12/18/1995	162
1/31/1996	162
2/28/1996	115
3/27/1996	158
4/24/1996	175
7/31/1996	156
10/14/1996	161
1/8/1997	158
4/1/1997	131
8/19/1997	220
10/28/1997	126
2/3/1998	118
5/20/1998	136
9/30/1998	220
11/24/1998	281
3/24/1999	98
6/29/1999	97
8/27/1999	178
11/9/1999	111
3/8/2000	118
6/26/2000	107
9/27/2000	134
12/27/2000	
3/16/2001	108
6/20/2001	173
8/21/2001	212
11/19/2001	214
3/1/2002	164
6/1/2002	144
9/1/2002	277
11/1/2002	
3/31/2003	1231
6/30/2003	153
9/30/2003	158
12/18/2003	158

Bloom Mining
Fig 10.13 pH

DATE	
11/24/1995	4.3
12/18/1995	4.5
1/31/1996	4.4
2/28/1996	4.7
3/27/1996	4.9
4/24/1996	4.7
7/31/1996	4.4
10/14/1996	4.4
1/8/1997	4.3
4/1/1997	4.3
8/19/1997	4.2
12/16/1997	4.2
2/16/1997	4.3
5/20/1998	4.5
9/30/1998	4.3
11/24/1998	4.5
3/24/1999	4.9
6/29/1999	4.7
8/27/1999	4.1
11/9/1999	4.9
3/8/2000	5
6/26/2000	4.6
9/27/2000	4.5
12/27/2000	
3/16/2001	4.2
6/20/2001	4.5
8/21/2001	4.1
11/19/2001	4
3/1/2002	4.5
6/1/2002	4.3
9/1/2002	2.9
11/1/2002	
3/31/2003	4.4
6/30/2003	4
9/30/2003	5.3
12/18/2003	4

Bloom Mining
Fig 10.14 Alkalinity

DATE		
11/24/1995	3	
12/18/1995	5	
1/31/1996	5	
2/28/1996	5	
3/27/1996	5	
4/24/1996	5	
7/31/1996		7
10/14/1996		3
1/8/1997		3
4/1/1997		5
8/19/1997		5
10/28/1997		4
2/3/1998		5
5/20/1998		5
9/30/1998		5
11/24/1998		5
3/24/1999		5
6/29/1999		4
8/27/1999		3
11/9/1999		5
3/8/2000		5
6/26/2000		5
9/27/2000		6
12/27/2000		
3/16/2001		5
6/20/2001		4
8/21/2001		3
11/19/2001		1
3/1/2002		12
6/1/2002		7
9/1/2002		4
11/1/2002		
3/31/2003		7
6/30/2003		6
9/30/2003		12
12/18/2003		6

Bloom Mining

Fig 10.15 Acidity

DATE		
11/24/1995	20	
12/18/1995	17	
1/31/1996	16	
2/28/1996	11	
3/27/1996	15	
4/24/1996	17	
7/31/1996		14
10/14/1996		15
1/8/1997		18
4/1/1997		15
8/19/1997		15
12/16/1997		15
2/16/1998		16
5/20/1998		15
9/30/1998		17
11/24/1998		16
3/24/1999		12
6/29/1999		15
8/27/1999		18
11/9/1999		13
3/8/2000		12
6/26/2000		14
9/27/2000		16
12/27/2000		
3/16/2001		13
6/20/2001		20
8/21/2001		29
11/19/2001		16
3/1/2002		12
6/1/2002		10
9/1/2002		40
11/1/2002		
3/31/2003		79
6/30/2003		11
9/30/2003		11
12/18/2003		11

Bloom Mining

Fig 10.16 Total Dissolved Solids

DATE	
11/24/1995	258
12/18/1995	232
1/31/1996	204
2/28/1996	216
3/27/1996	240
4/24/1996	276
7/31/1996	234
10/14/1996	236
1/8/1997	244
4/1/1997	172
8/19/1997	307
12/16/1997	172
2/16/1998	164
5/20/1998	232
9/30/1998	320
11/24/1998	420
3/24/1999	140
6/29/1999	176
8/27/1999	204
11/9/1999	208
3/8/2000	268
6/26/2000	180
9/27/2000	312
12/27/2000	
3/16/2001	200
6/20/2001	348
8/21/2001	316
11/19/2001	392
3/1/2002	228
6/1/2002	300
9/1/2002	432
11/1/2002	
3/31/2003	1512
6/30/2003	260
9/30/2003	272
12/18/2003	248

Bloom Mining

Fig 10.17 Calcium & Magnesium

Date	Ca	Mg
11/24/1995	29.6	19.1
12/18/1995	30	19.9
1/31/1996	25.8	16.4
2/28/1996	16.8	15.9
3/27/1996	28	20
4/24/1996	27.7	18.7
4/1/1997	22.6	15.7
2/16/1998	18.1	14.4
3/24/1999	17.9	11.1
3/8/2000		
3/16/2001		
1/1/2002		
3/31/2003	182	129

Bloom Mining

Fig 10.18 Trace Elements

Date	As	Cd	Pb	Se
11/24/1995	<0.01	<0.005	<0.01	<0.025
12/18/1995	<0.01	<0.005	<0.005	<0.01
1/31/1996	<0.01	<0.02	<0.005	<0.01
2/28/1996	<0.01	<0.02	<0.005	<0.01
3/27/1996	<0.01	<0.02	<0.005	<0.01
4/24/1996	<0.01	<0.02	<0.005	<0.01
4/1/1997	<0.015	<0.03	<0.01	<0.01
2/16/1998	<0.015	<0.03	<0.005	<0.01
3/24/1999	<0.015	<0.03	<0.005	<0.015
3/31/2003	<0.015	<0.03	<0.01	<0.05

Bloom Mining
Fig 10.19 (INTENTIONALLY BLANK)

Bloom Mining
Fig 10.20 Iron

DATE	
11/24/1995	0.11
12/18/1995	0.13
1/31/1996	0.07
2/28/1996	0.1
3/27/1996	0.1
4/24/1996	0.09
7/31/1996	0.07
10/14/1996	0.06
1/8/1997	0.38
4/1/1997	0.47
8/19/1997	2.15
10/28/1997	0.11
2/3/1998	0.31
5/20/1998	0.34
9/30/1998	0.85
11/24/1998	0.99
3/24/1999	0.13
6/29/1999	0.46
8/27/1999	0.53
11/9/1999	0.21
3/8/2000	0.46
6/26/2000	0.94
9/27/2000	0.71
12/27/2000	0.25
3/16/2001	1.05
6/20/2001	0.47
8/21/2001	0.41
11/19/2001	0.07
3/1/2002	0.3
6/1/2002	0.21
9/1/2002	1.04
11/1/2002	1.22
3/31/2003	0.22
6/30/2003	0.26
9/30/2003	0.23
12/18/2003	0.26

Bloom Mining

Fig 10.21 Manganese

DATE	
11/24/1995	8.98
12/18/1995	15
1/31/1996	14.4
2/28/1996	9.26
3/27/1996	12.1
4/24/1996	12.2
7/31/1996	15.6
10/14/1996	13.1
1/8/1997	10.6
4/1/1997	9.44
8/19/1997	9.29
10/28/1997	8.79
2/3/1998	10.6
5/20/1998	12.1
9/30/1998	13.3
11/24/1998	9.06
3/24/1999	10.2
6/29/1999	7.34
8/27/1999	17.3
11/9/1999	12.5
3/8/2000	13.3
6/26/2000	15.8
9/27/2000	15.6
12/27/2000	9.64
3/16/2001	11.4
6/20/2001	12.3
8/21/2001	13.5
11/19/2001	18.8
3/1/2002	10.4
6/1/2002	15.6
9/1/2002	15.7
11/1/2002	11.9
3/31/2003	13.7
6/30/2003	15.8
9/30/2003	16
12/18/2003	14.8

Bloom Mining

Fig 10.22 Sulfates

DATE	
Nov-95	689
Dec-95	996
Jan-96	1113
Feb-96	656
Mar-96	793
Apr-96	875
Jul-96	990
Oct-96	874
Jan-97	721
Apr-97	686
Aug-97	845
Oct-97	856
Feb-98	905
May-98	967
Sep-98	1136
Nov-98	1285
Mar-99	913
Jun-99	958
Aug-99	1917
Nov-99	1361
Mar-00	1054
Jun-00	1134
Sep-00	1154
Dec-00	1098
Mar-01	1064
Jun-01	1053
Aug-01	1161
Nov-01	1225
Mar-02	1017
Jun-02	1169
Sep-02	1295
Nov-02	1181
Mar-03	1353
Jun-03	1151
Sep-03	1127
Dec-03	1028

Bloom Mining
Fig 10.23 pH

DATE	
11/24/1995	4.9
12/18/1995	5.3
1/31/1996	4.7
2/28/1996	4.9
3/27/1996	5
4/24/1996	5.3
7/31/1996	5.2
10/14/1996	5.3
1/8/1997	5.2
4/1/1997	5.1
8/19/1997	6.7
10/28/1997	6.2
2/3/1998	5.6
5/20/1998	4.6
9/30/1998	6.2
11/24/1998	6.3
3/24/1999	4.6
6/29/1999	5.6
8/27/1999	4.4
11/9/1999	5.2
3/8/2000	5.4
6/26/2000	4.8
9/27/2000	4.2
12/27/2000	4.9
3/16/2001	4.3
6/20/2001	4.9
8/21/2001	5.1
11/19/2001	5.5
3/2/2002	4.7
6/2/2002	4.1
9/2/2002	4
11/2/2002	4.44
3/31/2003	4.3
6/30/2003	4.2
9/30/2003	4.7
12/18/2003	4.2

Bloom Mining
Fig 10.24 Alkalinity

DATE	
11/24/1995	7
12/18/1995	10
1/31/1996	7
2/28/1996	7
3/27/1996	7
4/24/1996	10
7/31/1996	12
10/14/1996	7
1/8/1997	7
4/1/1997	8
8/19/1997	16
10/28/1997	20
2/3/1998	8
5/20/1998	8
9/30/1998	23
11/24/1998	14
3/24/1999	8
6/29/1999	9
8/27/1999	10
11/9/1999	10
3/8/2000	10
6/26/2000	10
9/27/2000	9
12/27/2000	8
3/16/2001	7
6/20/2001	8
8/21/2001	8
11/19/2001	9
3/2/2002	13
6/2/2002	9
9/2/2002	3
11/2/2002	8
3/31/2003	6
6/30/2003	9
9/30/2003	7
12/18/2003	7

Bloom Mining
Fig 10.25 Acidity

DATE	
11/24/1995	29
12/18/1995	41
1/31/1996	70
2/28/1996	20
3/27/1996	34
4/24/1996	32
7/31/1996	38
10/14/1996	26
1/8/1997	28
4/1/1997	25
8/19/1997	6
10/28/1997	7
2/3/1998	31
5/20/1998	65
9/30/1998	7
11/24/1998	8
3/24/1999	53
6/29/1999	30
8/27/1999	108
11/9/1999	42
3/8/2000	52
6/26/2000	98
9/27/2000	63
12/27/2000	53
3/16/2001	69
6/20/2001	85
8/21/2001	56
11/19/2001	37
3/2/2002	46
6/2/2002	77
9/2/2002	70
11/2/2002	54
3/31/2003	80
6/30/2003	82
9/30/2003	81
12/18/2003	83

Bloom Mining

Fig 10.26 Total Dissolved Solids

DATE	
11/24/1995	1004
12/18/1995	1336
1/31/1996	1224
2/28/1996	904
3/27/1996	1015
4/24/1996	1260
7/31/1996	1304
10/14/1996	1296
1/8/1997	1056
4/1/1997	948
8/19/1997	1196
10/28/1997	1256
2/3/1998	1284
5/20/1998	1343
9/30/1998	1500
11/24/1998	1516
3/24/1999	1292
6/29/1999	1324
8/27/1999	2196
11/9/1999	1756
3/8/2000	1592
6/26/2000	1736
9/27/2000	1765
12/27/2000	1556
3/16/2001	1472
6/20/2001	1668
8/21/2001	1672
11/19/2001	1315
3/2/2002	1492
6/2/2002	1660
9/2/2002	1840
11/2/2002	1710
3/31/2003	1440
6/30/2003	1600
9/30/2003	1604
12/18/2003	1405

Bloom Mining

Fig 10.27 Calcium & Magnesium

DATE		
11/24/1995	134	88
12/18/1995	186	130
1/31/1996	221	137
2/28/1996	92	55
3/27/1996	124	88
4/24/1996	139	105
4/1/1997	123	84
2/3/1998	178	96
1/1/1999		
3/24/1999	185	89
1/1/2000		
1/1/2002		
Jan-03		
Mar-03	182	127

Bloom Mining

Fig 10.28 Trace Elements

Date	As	Cd	Pb	Se
11/24/1995	<0.01	<0.005	<0.01	<0.025
12/18/1995	<0.01	<0.005	<0.005	<0.01
1/31/1996	<0.01	<0.02	<0.005	<0.01
2/28/1996	<0.01	<0.02	<0.005	<0.01
3/27/1996	<0.01	<0.02	<0.005	<0.01
4/24/1996	0.017	<0.02	<0.005	<0.01
4/1/1997	<0.015	<0.03	<0.028	<0.01
2/3/1998	<0.015	<0.03	<0.005	<0.01
3/24/1999	<0.015	<0.03	<0.005	<0.015
3/31/2003	<0.015	<0.03	<0.01	<0.05

Bloom Mining
Fig 10.29 Iron & Manganese

Date	Fe	Mn
11/24/1995	0.08	0.04
12/18/1995	0.55	0.05
1/31/1996	1.7	0.13
2/28/1996	0.94	0.04
3/27/1996	0.97	0.05
4/24/1996	0.32	0.04
7/31/1996	0.14	0.04
10/14/1996	0.27	0.06
1/8/1997	0.56	0.04
4/1/1997	0.62	0.06
8/19/1997		
10/28/1997	0.3	3.83
2/3/1998	0.45	0.92
5/20/1998	0.7	1.2
9/30/1998	0.29	2.18
11/24/1998	3.84	1.85
3/24/1999	0.62	2.45
6/29/1999	2.39	7.79
8/27/1999	0.36	2.1
11/9/1999	2.04	2.5
3/8/2000	2.14	1.66
6/26/2000	0.19	2.54
9/27/2000	0.64	3.06
12/27/2000	0.23	1.85
3/16/2001	0.43	1.67
6/20/2001	0.07	0.05
8/21/2001	2.36	4.89
11/19/2001	0.07	2.95
3/2/2002	0.11	2.06
6/2/2002	0.07	1.51
9/2/2002	0.1	3.94
11/2/2002	0.07	3.41
3/31/2003	0.31	2.91
6/30/2003	8.1	6.83
9/30/2003	5.5	4.9
12/18/2003	0.07	2.86

Bloom Mining
Fig 10.29a Sulfates & Total Dissolved Solids

DATE		
Date	SO4	TDS
11/24/1995	52	102
12/18/1995	79	128
1/31/1996	41	60
2/28/1996	30	92
3/27/1996	45	108
4/24/1996	73	132
7/31/1996	95	152
10/14/1996	90	184
1/8/1997	34	92
4/1/1997	179	242
8/19/1997		
10/28/1997	599	848
2/3/1998	281	400
5/20/1998	351	516
9/30/1998	666	912
11/24/1998	723	944
3/24/1999	350	528
6/29/1999	591	844
8/27/1999	284	556
11/9/1999	516	772
3/8/2000	418	680
6/26/2000	456	780
9/27/2000	604	876
12/27/2000	460	716
3/16/2001	316	532
6/20/2001	452	644
8/21/2001	484	720
11/19/2001	658	924
3/2/2002	731	676
6/2/2002	347	632
9/2/2002	771	1048
11/2/2002	701	792
3/31/2003	848	1000
6/30/2003	754	1036
9/30/2003	649	876
12/18/2003	614	808

Bloom Mining
Fig 10.29b Alkalinity & Acidity

Date	Alk	Acid
11/24/1995	11	10
12/18/1995	14	6
1/31/1996	12	6
2/28/1996	12	3
3/27/1996	12	3
4/24/1996	15	5
7/31/1996	21	5
10/14/1996	18	4
1/8/1997	11	4
4/1/1997	12	2
8/19/1997		
10/28/1997	13	4
2/3/1998	12	5
5/20/1998	52	5
9/30/1998	13	7
11/24/1998	9	6
3/24/1999	9	4
6/29/1999	10	7
8/27/1999	16	7
11/9/1999	12	5
3/8/2000	8	3
6/26/2000	13	6
9/27/2000	14	5
12/27/2000	13	7
3/16/2001	8	2
6/20/2001	9	3
8/21/2001	15	11
11/19/2001	9	3
3/2/2002	15	8
6/2/2002	11	3
9/2/2002	9	4
11/2/2002	9	4
3/31/2003	8	4
6/30/2003	10	18
9/30/2003	8	9
12/18/2003	9	6

Bloom Mining
Fig 10.29c pH

Date	Field pH before	Field pH after	Lab pH before
11/24/1995	5.9		6
12/18/1995	6.5		6.03
1/31/1996	6.2		6.08
2/28/1996	7		6.08
3/27/1996	6.7		6
4/24/1996	6.3		6.3
7/31/1996	6.5		6.23
10/14/1996	6.7		6.3
1/8/1997	6.6		5.9
4/1/1997	6.7		5.94
8/19/1997			
10/28/1997	6.4		5.8
2/3/1998	6.7		5.57
5/20/1998	5.9		6.07
9/30/1998	6.2		5.74
11/24/1998	6		5.58
3/24/1999	5.9		5.68
6/29/1999	6		5.55
8/27/1999	6.1		6.11
11/9/1999	6.1		5.93
3/8/2000	6.1		5.76
6/26/2000	6.2		5.98
9/27/2000	6.5		5.8
12/27/2000	6.2		5.8
3/16/2001	5.9		5.4
6/20/2001	6.3		5.4
8/21/2001	6.3		5.6
11/19/2001	5.7		5.9
3/2/2002	4.6		6.3
6/2/2002	5.8		6.2
9/2/2002	4.5		5.7
11/2/2002	6.22		5.7
3/31/2003	5.3		5.6
6/30/2003	5.3		5
9/30/2003	5.3		5.4
12/18/2003	4.5		5.3

Bloom Mining

Fig 10.29d Calcium & Magnesium

DATE	Ca	Mg
11/24/1995	12.8	5.4
12/18/1995	20.3	9.4
1/31/1996	10.9	2.9
2/28/1996	7.59	1.6
3/27/1996	11.6	4.3
4/24/1996	18.6	7.1
7/31/1996		
10/14/1996		
1/8/1997		
4/1/1997	42.2	19.5
8/19/1997		
10/28/1997		
2/3/1998	63.4	23.5
5/20/1998		
9/30/1998		
11/24/1998		
3/24/1999	93.3	30.8
6/29/1999		
8/27/1999		
11/9/1999		
3/8/2000		
6/26/2000		
9/27/2000		
12/27/2000		
3/16/2001		
6/20/2001		
8/21/2001		
11/19/2001		
3/2/2002		
6/2/2002		
9/2/2002		
11/2/2002		
3/31/2003	133	54.3
6/30/2003		
9/30/2003		
12/18/2003		
3/19/2004		
6/24/2004		
9/23/2004		
12/28/2004		

Bloom Mining

Fig 10.29e Trace Elements

DATE				
Date	**As**	**Cd**	**Pb**	**Se**
11/24/1995	<0.01	<0.005	<0.01	<0.01
12/18/1995	<0.01	<0.005	<0.005	<0.01
1/31/1996	<0.01	<0.02	<0.005	<0.01
2/28/1996	<0.01	<0.02	<0.005	<0.01
3/27/1996	<0.01	<0.02	<0.005	<0.01
4/24/1996	<0.01	<0.02	<0.005	<0.01
4/1/1997	<0.015	<0.03	<0.01	<0.01
2/3/1998	<0.015	<0.03	<0.005	<0.01
3/24/1999	<0.015	<0.03	<0.005	<0.015
3/31/2003	<0.015	<0.03	<0.01	<0.05

Bloom Mining

Fig 10.50 Iron & Manganese

DATE	Fe	Mn
Mar-01		
Jun-01	24.1	26
Aug-01		
Nov-01		
Mar-02		
Jun-02		
Sep-02	11.6	4.5
Nov-02	12.1	1.7
Mar-03		
Jun-03	8.41	0.93
Sep-03	8.89	4
Nov-03		
Mar-04	9.3	3.63
Jun-04	4.95	4.2
Sep-04	5.73	4.75
Nov-04	5.23	2.29

Bloom Mining

Fig 10.51 Sulfate, Total Dissolved Solids and Specific Conductance

Date	Sulfates	Specific Conductance	Total Dissolved Solds
Mar-01			
Jun-01	1578	1900	1936
Aug-01			
Nov-01			
Mar-02			
Jun-02			
Sep-02	1756	1070	2572
Nov-02	1917	2200	2760
Mar-03			
Jun-03	1851	2300	2780
Sep-03	1962	2800	2940
Nov-03			
Mar-04	2621	3500	3990
Jun-04	2905	3800	4385
Sep-04	2108	2900	3220
Nov-04	2521	3200	3760

Bloom Mining
Fig 10.52 pH

Date	Field pH	Lab pH
Mar-01		
Jun-01	5.6	5.4
Aug-01		
Nov-01		
Mar-02		
Jun-02		
Sep-02	5.7	5.7
Nov-02	6.2	6.3
Mar-03		
Jun-03	6.3	6.7
Sep-03	6.6	6.5
Nov-03		
Mar-04	6.9	6.6
Jun-04	6.5	7.1
Sep-04	6.6	7
Nov-04	6.9	6.4

Bloom Mining

Fig 10.53 Alkalinity & Acidity

DATE	Alkalinity	Acidity
Mar-01		
Jun-01	27	97
Aug-01		
Nov-01		
Mar-02		
Jun-02		
Sep-02	29	24
Nov-02	38	9
Mar-03		
Jun-03	36	8
Sep-03	15	8
Nov-03		
Mar-04	151	20
Jun-04	60	20
Sep-04	74	33
Nov-04	120	22

Bloom Mining
Fig 10.30 Flow

Date	Flow (gpm)
Sep-96	13.5
Oct-96	37
Nov-96	15
Dec-96	15
Jan-97	5.7
Feb-97	20
Mar-97	28
Apr-97	5.6
May-97	43
Jun-97	4.2
Jul-97	0.55
Aug-97	0.51
Sep-97	1
Oct-97	1.7
Nov-97	14
Dec-97	6.3
Jan-98	11.7
Feb-98	56
Mar-98	16
Apr-98	21
May-98	4
Jun-98	3.35
Jul-98	0.36
Aug-98	0.07
Sep-98	0
Oct-98	0
Nov-98	0
Dec-98	0
Jan-99	13
Feb-99	2.2
Mar-99	7.8
Apr-99	4.3
May-99	1.8
Jun-99	0.78
Jul-99	0
Aug-99	0
Sep-99	1.6
Oct-99	2
Nov-99	1.32
Dec-99	2.8
Jan-00	1.16

Feb-00	5.7
Mar-00	2.8
Apr-00	14
May-00	2.1
Jun-00	8.9
Jul-00	0.5
Aug-00	0.81
Sep-00	1.1
Oct-00	2.6
Nov-00	1.7
Dec-00	2
1-Jan	5.2
1-Feb	6.3
1-Mar	5.6
1-Apr	4
1-May	3.8
Jun-01	3.4
Jul-01	1.8
Aug-01	3.2
Sep-01	2.6
Oct-01	1.4
Nov-01	1.9
Dec-01	3.4
Jan-02	3.88
Feb-02	2.7
Mar-02	13.6
Apr-02	3.5
May-02	9.3
Jun-02	5.8
Jul-02	1.13
Aug-02	0.76
Sep-02	0.9
Oct-02	0.96
Nov-02	2.55
Dec-02	1.68
Jan-03	1.77
Feb-03	1.62
Mar-03	3.8
Apr-03	6.1
May-03	4.1
Jun-03	1.2
Jul-03	5.8
Aug-03	2.7
Sep-03	4.4
Oct-03	6.3
Nov-03	10.6
Dec-03	8.8

Bloom Mining
Fig 10.31 Acidity Load

Date	Load (lbs/day)
Sep-96	1.1
Oct-96	4
Nov-96	2
Dec-96	2.5
Jan-97	0.9
Feb-97	2.2
Mar-97	3
Apr-97	0.8
May-97	3.6
Jun-97	0.56
Jul-97	1
Aug-97	0.09
Sep-97	0.13
Oct-97	0.24
Nov-97	1.7
Dec-97	1.1
Jan-98	1.55
Feb-98	4.7
Mar-98	3
Apr-98	2.1
May-98	0.63
Jun-98	0.4
Jul-98	0.052
Aug-98	0.016
Sep-98	0
Oct-98	0
Nov-98	0
Dec-98	0
Jan-99	1.2
Feb-99	0.22
Mar-99	0.947
Apr-99	0.475
May-99	0.157
Jun-99	0.141
Jul-99	0
Aug-99	0
Sep-99	0.174
Oct-99	0.072
Nov-99	0.079
Dec-99	0.069
Jan-00	0.13

Feb-00	0.48
Mar-00	0.24
Apr-00	1.1
May-00	0.2
Jun-00	1.1
Jul-00	0.13
Aug-00	0.12
Sep-00	0.2
Oct-00	0.32
Nov-00	0.28
Dec-00	0.25
1-Jan	0.56
1-Feb	0.69
1-Mar	0.82
1-Apr	0.49
1-May	0.84
Jun-01	0.71
Jul-01	0.4
Aug-01	1.2
Sep-01	0.89
Oct-01	0.3
Nov-01	0.25
Dec-01	0.042
Jan-02	0.47
Feb-02	0.17
Mar-02	0.16
Apr-02	0.25
May-02	0.45
Jun-02	0.56
Jul-02	0.204
Aug-02	0.201
Sep-02	0.162
Oct-02	0.185
Nov-02	0.245
Dec-02	0.222
Jan-03	0.234
Feb-03	0.253
Mar-03	0.325
Apr-03	0.441
May-03	0.296
Jun-03	0.075
Jul-03	0.768
Aug-03	0.423
Sep-03	0.425
Oct-03	0.689
Nov-03	0.244
Dec-03	0.529

Bloom Mining

Fig 10.32 Iron Load

Date	Load (lbs/day)
Sep-96	0.013
Oct-96	0.014
Nov-96	0.006
Dec-96	0.011
Jan-97	0.001
Feb-97	0.017
Mar-97	0.024
Apr-97	0.005
May-97	0.036
Jun-97	0.004
Jul-97	0.001
Aug-97	0.001
Sep-97	0.002
Oct-97	0.002
Nov-97	0.012
Dec-97	0.005
Jan-98	0.01
Feb-98	0.047
Mar-98	0.014
Apr-98	0.018
May-98	0.003
Jun-98	0.003
Jul-98	0.001
Aug-98	0.0005
Sep-98	0
Oct-98	0
Nov-98	0
Dec-98	0
Jan-99	0.011
Feb-99	0.002
Mar-99	0.007
Apr-99	0.004
May-99	0.002
Jun-99	0.001
Jul-99	0
Aug-99	0
Sep-99	0.001
Oct-99	0.002
Nov-99	0.001
Dec-99	0.002
Jan-00	0.003

Feb-00	0
Mar-00	0
Apr-00	0
May-00	0
Jun-00	0
Jul-00	0
Aug-00	0
Sep-00	0
Oct-00	0
Nov-00	0
Dec-00	0
1-Jan	0.007
1-Feb	0
1-Mar	0
1-Apr	0
1-May	0
Jun-01	0
Jul-01	0
Aug-01	0
Sep-01	0
Oct-01	0
Nov-01	0
Dec-01	0
Jan-02	0
Feb-02	0
Mar-02	0.018
Apr-02	0
May-02	0
Jun-02	0
Jul-02	0
Aug-02	0
Sep-02	0
Oct-02	0
Nov-02	0
Dec-02	0
Jan-03	0
Feb-03	0
Mar-03	0
Apr-03	0
May-03	0
Jun-03	0
Jul-03	0
Aug-03	0
Sep-03	0
Oct-03	0
Nov-03	0
Dec-03	0

Bloom Mining
Fig 10.33 Manganese Load

Date	Load (lbs/day)
Sep-96	0.486
Oct-96	0.942
Nov-96	0.553
Dec-96	0.543
Jan-97	0.242
Feb-97	0.602
Mar-97	0.823
Apr-97	0.192
May-97	0.977
Jun-97	0.142
Jul-97	0.042
Aug-97	0.045
Sep-97	0.077
Oct-97	0.103
Nov-97	0.378
Dec-97	0.173
Jan-98	0.3
Feb-98	0.947
Mar-98	0.482
Apr-98	0.385
May-98	0.096
Jun-98	0.097
Jul-98	0.021
Aug-98	0.006
Sep-98	0
Oct-98	0
Nov-98	0
Dec-98	0
Jan-99	0.224
Feb-99	0.05
Mar-99	0.172
Apr-99	0.101
May-99	0.041
Jun-99	0.028
Jul-99	0
Aug-99	0
Sep-99	0.062
Oct-99	0.051
Nov-99	0.034
Dec-99	0.062
Jan-00	0.026

Feb-00	0.078
Mar-00	0.058
Apr-00	0.22
May-00	0.037
Jun-00	0.2
Jul-00	0.027
Aug-00	0.044
Sep-00	0.074
Oct-00	0.081
Nov-00	0.068
Dec-00	0.071
1-Jan	0.14
1-Feb	0.15
1-Mar	0.118
1-Apr	0.088
1-May	0.187
Jun-01	0.168
Jul-01	0.129
Aug-01	0.287
Sep-01	0.192
Oct-01	0.107
Nov-01	0.127
Dec-01	0.159
Jan-02	0.194
Feb-02	0.087
Mar-02	0.253
Apr-02	0.083
May-02	0.184
Jun-02	0.152
Jul-02	0.077
Aug-02	0.103
Sep-02	0.105
Oct-02	0.076
Nov-02	0.149
Dec-02	0.081
Jan-03	0.049
Feb-03	0.055
Mar-03	0.083
Apr-03	0.147
May-03	0.094
Jun-03	0.032
Jul-03	0.267
Aug-03	0.093
Sep-03	0.13
Oct-03	0.203
Nov-03	0.236
Dec-03	0.214

Bloom Mining

Fig 10.34 Sulfate Load

DATE	Load (lbs/day)
Sep-96	23
Oct-96	54
Nov-96	28
Dec-96	29
Jan-97	11
Feb-97	34
Mar-97	44
Apr-97	10
May-97	58
Jun-97	7
Jul-97	1.6
Aug-97	1.3
Sep-97	2.5
Oct-97	3.8
Nov-97	20
Dec-97	11
Jan-98	17
Feb-98	58
Mar-98	27
Apr-98	26
May-98	5.9
Jun-98	5.1
Jul-98	0.71
Aug-98	0.158
Sep-98	0
Oct-98	0
Nov-98	0
Dec-98	0
Jan-99	14
Feb-99	2.8
Mar-99	13
Apr-99	6.4
May-99	2.7
Jun-99	1.2
Jul-99	0
Aug-99	0
Sep-99	2.3
Oct-99	2.6
Nov-99	2.3
Dec-99	3.7
Jan-00	1

Feb-00	4.7
Mar-00	3.8
Apr-00	22
May-00	2.7
Jun-00	11.7
Jul-00	0.9
Aug-00	1.3
Sep-00	2.1
Oct-00	6.4
Nov-00	3.5
Dec-00	3.4
1-Jan	7.7
1-Feb	9.8
1-Mar	8.5
1-Apr	6.2
1-May	9
Jun-01	7.3
Jul-01	4.9
Aug-01	8.3
Sep-01	6.2
Oct-01	3.4
Nov-01	5.4
Dec-01	8.1
Jan-02	9.2
Feb-02	4.6
Mar-02	17
Apr-02	6
May-02	25
Jun-02	11.4
Jul-02	2.8
Aug-02	2.3
Sep-02	2.8
Oct-02	2.6
Nov-02	6.4
Dec-02	4.1
Jan-03	3.5
Feb-03	3.6
Mar-03	7.4
Apr-03	12
May-03	7.8
Jun-03	3.2
Jul-03	14
Aug-03	5.6
Sep-03	8.8
Oct-03	12.9
Nov-03	20
Dec-03	17

Bloom Mining
Fig 10.35 Flow

Date	Flow (gpm)
Aug-95	28
Sep-95	32
Oct-95	42
Nov-95	102
Dec-95	35
Jan-96	184
Feb-96	172
Mar-96	198
Apr-96	71
May-96	63
Jun-96	29
Jul-96	58
Aug-96	38
Sep-96	79
Oct-96	93
Nov-96	95
Dec-96	76
Jan-97	39
Feb-97	77
Mar-97	99
Apr-97	41
May-97	72
Jun-97	32
Jul-97	13
Aug-97	26
Sep-97	31
Oct-97	23
Nov-97	68
Dec-97	49
Jan-98	76
Feb-98	103
Mar-98	55
Apr-98	79
May-98	30
Jun-98	41
Jul-98	27
Aug-98	18
Sep-98	12
Oct-98	17
Nov-98	27
Dec-98	17

Jan-99	38
Feb-99	32
Mar-99	47
Apr-99	41
May-99	38
Jun-99	42
Jul-99	26
Aug-99	17
Sep-99	42
Oct-99	30
Nov-99	24
Dec-99	26
Jan-00	21
Feb-00	30
Mar-00	31
Apr-00	113
May-00	36
Jun-00	21
Jul-00	10
Aug-00	6.7
Sep-00	7
Oct-00	7.1
Nov-00	6.3
Dec-00	7.3
1-Jan	31
1-Feb	29
1-Mar	58
1-Apr	18
1-May	22
Jun-01	23
Jul-01	17
Aug-01	5
Sep-01	6
Oct-01	7
Nov-01	7
Dec-01	17
Jan-02	16
Feb-02	27
Mar-02	64
Apr-02	29
May-02	38
Jun-02	18
Jul-02	8
Aug-02	8.7
Sep-02	8.8
Oct-02	6.7
Nov-02	29

Dec-02	22
Jan-03	13
Feb-03	14
Mar-03	47
Apr-03	21
May-03	10
Jun-03	16
Jul-03	6.4
Aug-03	17
Sep-03	23
Oct-03	21
Nov-03	38
Dec-03	39
Jan-04	2.8
Feb-04	47
Mar-04	78
Apr-04	93
May-04	30
Jun-04	10
Jul-04	20
Aug-04	30

Bloom Mining

Fig 10.36 Acidity Load

Date	Load (lbs/day)
Aug-95	7.2
Sep-95	6.3
Oct-95	12
Nov-95	36
Dec-95	21
Jan-96	93
Feb-96	73
Mar-96	72
Apr-96	28
May-96	23
Jun-96	13
Jul-96	36
Aug-96	12
Sep-96	48
Oct-96	43
Nov-96	23
Dec-96	13
Jan-97	7.7
Feb-97	19
Mar-97	22
Apr-97	6
May-97	16
Jun-97	1.2
Jul-97	0.9
Aug-97	4.7
Sep-97	4.6
Oct-97	0
Nov-97	13
Dec-97	12
Jan-98	19
Feb-98	46
Mar-98	15
Apr-98	46
May-98	20
Jun-98	14
Jul-98	3
Aug-98	1
Sep-98	2
Oct-98	1.5
Nov-98	1
Dec-98	1.2

Jan-99	29
Feb-99	13
Mar-99	21
Apr-99	28
May-99	7
Jun-99	11
Jul-99	2
Aug-99	2
Sep-99	18
Oct-99	11.6
Nov-99	3.9
Dec-99	9.5
Jan-00	4.6
Feb-00	17
Mar-00	19
Apr-00	161
May-00	30
Jun-00	12
Jul-00	5
Aug-00	6.6
Sep-00	5.2
Oct-00	3.8
Nov-00	4.1
Dec-00	3.4
1-Jan	0
1-Feb	16
1-Mar	54
1-Apr	20
1-May	14
Jun-01	10.8
Jul-01	5.4
Aug-01	3.1
Sep-01	3.6
Oct-01	2.6
Nov-01	3
Dec-01	4.1
Jan-02	3.4
Feb-02	12.5
Mar-02	65
Apr-02	23
May-02	36
Jun-02	17
Jul-02	5.8
Aug-02	6.2
Sep-02	7.2
Oct-02	5
Nov-02	15

Dec-02	22
Jan-03	12.4
Feb-03	12
Mar-03	43
Apr-03	15
May-03	10.3
Jun-03	9.1
Jul-03	2.4
Aug-03	9.9
Sep-03	9.4
Oct-03	10
Nov-03	28
Dec-03	38
Jan-04	2.9
Feb-04	35
Mar-04	73
Apr-04	93
May-04	29
Jun-04	6.2
Jul-04	7.9
Aug-04	21

Bloom Mining

Fig 10.37 Iron Load

Date	Load (lbs/day)
Aug-95	0.065
Sep-95	0.063
Oct-95	0.076
Nov-95	0.099
Dec-95	0.047
Jan-96	0.22
Feb-96	0.62
Mar-96	0.24
Apr-96	0.03
May-96	0.04
Jun-96	0.04
Jul-96	0.08
Aug-96	0.06
Sep-96	0.1
Oct-96	0.6
Nov-96	0.32
Dec-96	0.65
Jan-97	0.11
Feb-97	0.35
Mar-97	0.55
Apr-97	0.39
May-97	0.38
Jun-97	0.45
Jul-97	0.09
Aug-97	0.62
Sep-97	0.22
Oct-97	0.11
Nov-97	0.13
Dec-97	0.36
Jan-98	0.95
Feb-98	0.44
Mar-98	0.11
Apr-98	0.28
May-98	0.77
Jun-98	0.32
Jul-98	0.16
Aug-98	0.19
Sep-98	0.09
Oct-98	0.06
Nov-98	0.04
Dec-98	0.03

Jan-99	0.07
Feb-99	0.04
Mar-99	0.04
Apr-99	0.07
May-99	0.08
Jun-99	0.11
Jul-99	0.07
Aug-99	0.07
Sep-99	0.2
Oct-99	0.09
Nov-99	0.05
Dec-99	0.076
Jan-00	0.42
Feb-00	1.7
Mar-00	0.079
Apr-00	0.37
May-00	0.088
Jun-00	0.17
Jul-00	0.041
Aug-00	0.059
Sep-00	0.071
Oct-00	0.032
Nov-00	0.019
Dec-00	0.019
1-Jan	0
1-Feb	0.082
1-Mar	0.15
1-Apr	0.048
1-May	0.081
Jun-01	0.066
Jul-01	0.036
Aug-01	0.03
Sep-01	0.052
Oct-01	0.033
Nov-01	0.029
Dec-01	0.047
Jan-02	0.02
Feb-02	0.053
Mar-02	0.233
Apr-02	0.057
May-02	0.13
Jun-02	0.048
Jul-02	0.024
Aug-02	0.029
Sep-02	0.061
Oct-02	0.04
Nov-02	0.089

Dec-02	0.085
Jan-03	0.059
Feb-03	0.061
Mar-03	0.086
Apr-03	0.042
May-03	0.016
Jun-03	0.044
Jul-03	0.026
Aug-03	0.059
Sep-03	0.067
Oct-03	0.055
Nov-03	0.13
Dec-03	0.115
Jan-04	0.01
Feb-04	0.14
Mar-04	0.19
Apr-04	0.21
May-04	0.09
Jun-04	0.04
Jul-04	0.04
Aug-04	0.07

Bloom Mining
Fig 10.38 Managanese Load

Date	Load (lbs/day)
Aug-95	6.7
Sep-95	7.1
Oct-95	8.2
Nov-95	13
Dec-95	6.8
Jan-96	32
Feb-96	26
Mar-96	28
Apr-96	10
May-96	10
Jun-96	4
Jul-96	12
Aug-96	7
Sep-96	14
Oct-96	16
Nov-96	11
Dec-96	9
Jan-97	4.7
Feb-97	11
Mar-97	12
Apr-97	4
May-97	8
Jun-97	4
Jul-97	2
Aug-97	4
Sep-97	4
Oct-97	3
Nov-97	7.2
Dec-97	6
Jan-98	9
Feb-98	18
Mar-98	8
Apr-98	14
May-98	4.8
Jun-98	6.7
Jul-98	4.8
Aug-98	3.9
Sep-98	2.3
Oct-98	2.7
Nov-98	3.2
Dec-98	1.7

Jan-99	6.2
Feb-99	4.4
Mar-99	6.4
Apr-99	6.5
May-99	4.9
Jun-99	5.2
Jul-99	4.1
Aug-99	3.2
Sep-99	8
Oct-99	4.8
Nov-99	3.7
Dec-99	3.9
Jan-00	2.6
Feb-00	3.9
Mar-00	6.4
Apr-00	29
May-00	6.2
Jun-00	3.7
Jul-00	1.9
Aug-00	1.8
Sep-00	1.4
Oct-00	1.2
Nov-00	1
Dec-00	1
1-Jan	2.8
1-Feb	4.1
1-Mar	11
1-Apr	3.7
1-May	3.4
Jun-01	3.4
Jul-01	2.6
Aug-01	1
Sep-01	1
Oct-01	1.1
Nov-01	1.2
Dec-01	1.9
Jan-02	1.9
Feb-02	3.8
Mar-02	14
Apr-02	5.4
May-02	7.8
Jun-02	3.6
Jul-02	1.4
Aug-02	1.7
Sep-02	1.5
Oct-02	1.2
Nov-02	4.7

Dec-02	3.3
Jan-03	3.1
Feb-03	2.3
Mar-03	6.9
Apr-03	3.5
May-03	1.3
Jun-03	3.1
Jul-03	1.1
Aug-03	3.3
Sep-03	4
Oct-03	3.6
Nov-03	7.7
Dec-03	6.9
Jan-04	0.41
Feb-04	6.4
Mar-04	12
Apr-04	15
May-04	5
Jun-04	1.8
Jul-04	2.7
Aug-04	5.5

Bloom Mining
Fig 10.39 Sulfate Load

Date	Load (lbs/day)
Aug-95	303
Sep-95	398
Oct-95	464
Nov-95	885
Dec-95	468
Jan-96	2147
Feb-96	1780
Mar-96	1753
Apr-96	779
May-96	663
Jun-96	303
Jul-96	701
Aug-96	395
Sep-96	834
Oct-96	1000
Nov-96	725
Dec-96	665
Jan-97	369
Feb-97	775
Mar-97	826
Apr-97	398
May-97	632
Jun-97	331
Jul-97	143
Aug-97	294
Sep-97	366
Oct-97	239
Nov-97	761
Dec-97	575
Jan-98	802
Feb-98	1201
Mar-98	661
Apr-98	922
May-98	377
Jun-98	541
Jul-98	360
Aug-98	272
Sep-98	175
Oct-98	268
Nov-98	459
Dec-98	224

Jan-99	477
Feb-99	428
Mar-99	573
Apr-99	483
May-99	509
Jun-99	589
Jul-99	443
Aug-99	347
Sep-99	624
Oct-99	428
Nov-99	381
Dec-99	410
Jan-00	286
Feb-00	344
Mar-00	468
Apr-00	2102
May-00	559
Jun-00	305
Jul-00	152
Aug-00	114
Sep-00	135
Oct-00	168
Nov-00	89
Dec-00	105
1-Jan	309
1-Feb	386
1-Mar	883
1-Apr	273
1-May	334
Jun-01	309
Jul-01	275
Aug-01	92
Sep-01	100
Oct-01	101
Nov-01	110
Dec-01	241
Jan-02	215
Feb-02	349
Mar-02	953
Apr-02	475
May-02	673
Jun-02	245
Jul-02	109
Aug-02	128
Sep-02	144
Oct-02	100
Nov-02	431

Dec-02	331
Jan-03	194
Feb-03	187
Mar-03	541
Apr-03	271
May-03	115
Jun-03	27
Jul-03	92
Aug-03	233
Sep-03	285
Oct-03	280
Nov-03	519
Dec-03	503
Jan-04	2.7
Feb-04	30
Mar-04	65
Apr-04	84
May-04	27
Jun-04	5.7
Jul-04	6
Aug-04	18

Bloom Mining
Fig 10.40 Manganese Load

Date	Load (lbs/day)
Aug-95	0.84
Sep-95	0.24
Oct-95	1.1
Nov-95	0.49
Dec-95	0.67
Jan-96	1.67
Feb-96	0.622
Mar-96	0.288
Apr-96	0.108
May-96	0.877
Jun-96	0.498
Jul-96	0.529
Aug-96	0.317
Sep-96	1.14
Oct-96	0.618
Nov-96	0.835
Dec-96	0.546
Jan-97	
Feb-97	
Mar-97	
Apr-97	
May-97	
Jun-97	
Jul-97	
Aug-97	
Sep-97	
Oct-97	
Nov-97	
Dec-97	
Jan-98	
Feb-98	
Mar-98	
Apr-98	1.46
May-98	0.73
Jun-98	0.42
Jul-98	0.18
Aug-98	0.19
Sep-98	0.28
Oct-98	0.09
Nov-98	0.03
Dec-98	0.06

Jan-99	0.32
Feb-99	0.3
Mar-99	0.26
Apr-99	0.33
May-99	0.44
Jun-99	0.54
Jul-99	0.54
Aug-99	0.53
Sep-99	
Oct-99	
Nov-99	
Dec-99	
Jan-00	0.394
Feb-00	0.703
Mar-00	0.343
Apr-00	0.634
May-00	0.555
Jun-00	0.688
Jul-00	0.153
Aug-00	0.332
Sep-00	0.259
Oct-00	0.364
Nov-00	0.491
Dec-00	0.325
1-Jan	1.1
1-Feb	0.731
1-Mar	1.23
1-Apr	0.506
1-May	0.385
Jun-01	0.746
Jul-01	0.475
Aug-01	0.29
Sep-01	0.53
Oct-01	0.46
Nov-01	0.36
Dec-01	0.48
Jan-02	0.51
Feb-02	1.1
Mar-02	0.67
Apr-02	0.89
May-02	0.37
Jun-02	0.97
Jul-02	0.79
Aug-02	0.71
Sep-02	0.6
Oct-02	0.55
Nov-02	1.2

Dec-02	1.1
Jan-03	0.88
Feb-03	0.709
Mar-03	1.24
Apr-03	0.61
May-03	0.67
Jun-03	1.6
Jul-03	0.95
Aug-03	1.2
Sep-03	1.2
Oct-03	2.4
Nov-03	2.7

Bloom Mining
Fig 10.41 Acidity Loading

Date	Load (lbs/day)
Aug-95	2.54
Sep-95	0.669
Oct-95	3.03
Nov-95	1.34
Dec-95	1.49
Jan-96	10.7
Feb-96	2.52
Mar-96	0.593
Apr-96	0.434
May-96	3.34
Jun-96	1.54
Jul-96	1.67
Aug-96	0.773
Sep-96	3.56
Oct-96	1.96
Nov-96	2.451
Dec-96	1.81
Jan-97	
Feb-97	
Mar-97	
Apr-97	
May-97	
Jun-97	
Jul-97	
Aug-97	
Sep-97	
Oct-97	
Nov-97	
Dec-97	
Jan-98	
Feb-98	
Mar-98	
Apr-98	6.4
May-98	5.2
Jun-98	1.7
Jul-98	-1
Aug-98	-1
Sep-98	-1
Oct-98	-1
Nov-98	-1
Dec-98	-1

Jan-99	0.54
Feb-99	0.59
Mar-99	1.2
Apr-99	-0.13
May-99	0.52
Jun-99	1
Jul-99	0.97
Aug-99	0.79
Sep-99	
Oct-99	
Nov-99	
Dec-99	
Jan-00	0.392
Feb-00	4
Mar-00	0.93
Apr-00	5.56
May-00	0.495
Jun-00	0.68
Jul-00	0
Aug-00	0.735
Sep-00	0.152
Oct-00	1
Nov-00	1.8
Dec-00	1.6
1-Jan	0
1-Feb	3.9
1-Mar	9
1-Apr	3.1
1-May	1.6
Jun-01	1.8
Jul-01	0.62
Aug-01	0
Sep-01	0
Oct-01	0.51
Nov-01	0
Dec-01	0.32
Jan-02	0
Feb-02	3
Mar-02	1.7
Apr-02	2.7
May-02	0.36
Jun-02	6.9
Jul-02	5.1
Aug-02	4.2
Sep-02	1.2
Oct-02	2.4
Nov-02	3.8

Dec-02	8.01
Jan-03	5.2
Feb-03	4.76
Mar-03	12.6
Apr-03	5.2
May-03	4.6
Jun-03	6.8
Jul-03	5.02
Aug-03	5.2
Sep-03	4.18
Oct-03	11.1
Nov-03	1.62

Sandy Hollow
Fig 11.1 Iron

Date	
Jan-96	4.79
Feb-96	3.55
Mar-96	0.99
Apr-96	0.24
May-96	0.77
Jun-96	0.33
Nov-96	0.92
Mar-97	0.57
Jun-97	3.01
Sep-97	0.32
Dec-97	1.3
Mar-98	0.36
Jun-98	0.19
Sep-98	1.05
Dec-98	28.4
Mar-99	0.37
May-99	2.79
Sep-99	3.12
Nov-99	0.93
Mar-00	1.74
May-00	1.12
Sep-00	
Dec-00	
Mar-01	
Jun-01	1.04

Sandy Hollow

Fig 11.2 Manganese

Date	Mn
Jan-96	0.48
Feb-96	0.30
Mar-96	0.1
Apr-96	0.03
May-96	0.07
Jun-96	0.04
Nov-96	0.1
Mar-97	0.02
Jun-97	0.24
Sep-97	0.03
Dec-97	0.15
Mar-98	0.03
Jun-98	0.03
Sep-98	0.21
Dec-98	3.94
Mar-99	0.02
May-99	0.23
Sep-99	0.16
Nov-99	0.05
Mar-00	0.1
May-00	0.07
1-Sep	
Dec-00	
1-Mar	
1-Jun	0.19

Sandy Hollow
Fig 11.3 Sulfates

Date	
Jan-96	31.5
Feb-96	28.7
Mar-96	26.3
Apr-96	26
May-96	28
Jun-96	32.9
Nov-96	31.6
Mar-97	27.4
Jun-97	29.8
Sep-97	27.7
Dec-97	30.1
Mar-98	29.4
Jun-98	28.8
Sep-98	29.8
Dec-98	32.3
Mar-99	32.7
May-99	37
Sep-99	31
Nov-99	20
Mar-00	35
May-00	29
1-Sep	
Dec-00	
1-Mar	
1-Jun	55

Sandy Hollow
Fig 11.4 pH

Date	
Jan-96	7.6
Feb-96	7.2
Mar-96	7
Apr-96	7.1
May-96	7
Jun-96	7.1
Nov-96	7.4
Mar-97	7.1
Jun-97	6.9
Sep-97	6.9
Dec-97	6.8
Mar-98	6.9
Jun-98	6.9
Sep-98	7
Dec-98	6.9
Mar-99	7.3
May-99	6.4
Sep-99	7.8
Nov-99	6.6
Mar-00	6
May-00	6.5
1-Sep	
Dec-00	
1-Mar	
1-Jun	6.7

Sandy Hollow

Fig 11.5 Total Dissolved Solids

Date	
Jan-96	210
Feb-96	210
Mar-96	180
Apr-96	190
May-96	190
Jun-96	190
Nov-96	190
Mar-97	184
Jun-97	195
Sep-97	174
Dec-97	150
Mar-98	134
Jun-98	150
Sep-98	176
Dec-98	171
Mar-99	161
May-99	116
Sep-99	156
Nov-99	141
Mar-00	144
May-00	135
1-Sep	
Dec-00	
1-Mar	
1-Jun	877

Sandy Hollow

Fig 11.6 Trace Elements

Date	As	Cd	Pb	Se
Jan-96	0.0002	0.005	0.0007	0.0003
Feb-96	0.0006	0.008	0.0007	0.0003
Mar-96	0.0026	0.002	0.007	0.003
Apr-96	0.0019	0.01	0.0007	0.0042
May-96	0.0002	0.005	0.0007	0.0003
Jun-96	0.0005	0.001	0.0007	0.0003
Nov-96				
Jun-97				
Dec-97				
Jun-98				
Dec-98				
Jun-99				
Sep-99	0.0025	0.0003	0.0008	0.0037

Sandy Hollow
Fig 11.7 Iron

Date	
Jan-96	0.15
Feb-96	0.17
Mar-96	0.28
Apr-96	0.21
May-96	0.39
Jun-96	0.12
Nov-96	0.28
Mar-97	0.11
Jun-97	0.34
Sep-97	0.07
Dec-97	0.22
Mar-98	0.04
Jun-98	0.33
Sep-98	0.11
Dec-98	0.06
Mar-99	0.05
May-99	1
Sep-99	4.9
Nov-99	1
Mar-00	0.62
May-00	0.64
Sep-00	9.34
Dec-00	2.05
Mar-01	2.87
Jun-01	0.25

Sandy Hollow

Fig 11.8 Manganese

Date	
Jan-96	0.23
Feb-96	0.32
Mar-96	0.37
Apr-96	0.28
May-96	0.03
Jun-96	0.03
Nov-96	0.02
Mar-97	0.02
Jun-97	0.08
Sep-97	0.02
Dec-97	0.03
Mar-98	0.02
Jun-98	0.12
Sep-98	0.36
Dec-98	0.23
Mar-99	0.13
May-99	2.58
Sep-99	2.38
Nov-99	2.26
Mar-00	1.3
May-00	1.01
Sep-00	1.51
Dec-00	0.45
Mar-01	0.37
Jun-01	0.11

Sandy Hollow
Fig 11.9 Sulfates

Date	
Jan-96	137
Feb-96	129
Mar-96	107
Apr-96	129
May-96	124
Jun-96	131
Nov-96	181
Mar-97	132
Jun-97	130
Sep-97	179
Dec-97	197
Mar-98	228
Jun-98	243
Sep-98	263
Dec-98	264
Mar-99	243
May-99	942
Sep-99	427
Nov-99	395
Mar-00	556
May-00	441
Sep-00	398
Dec-00	373
1-Mar	458
1-Jun	446

Sandy Hollow
Fig 11.10 pH

Date	
Jan-96	7.3
Feb-96	7.1
Mar-96	6.9
Apr-96	6.8
May-96	6.3
Jun-96	6.8
Nov-96	6.9
Mar-97	6.6
Jun-97	6.4
Sep-97	6.4
Dec-97	6.4
Mar-98	6.2
Jun-98	7
Sep-98	6.7
Dec-98	6.3
Mar-99	6.3
May-99	5.9
Sep-99	6.1
Nov-99	5.2
Mar-00	4.9
May-00	6.2
Sep-00	
Dec-00	6.7
1-Mar	
1-Jun	6.3

Sandy Hollow

Fig 11.11 Total Dissolved Solids

Date	
Jan-96	400
Feb-96	410
Mar-96	370
Apr-96	350
May-96	350
Jun-96	330
Nov-96	380
Mar-97	329
Jun-97	405
Sep-97	365
Dec-97	347
Mar-98	339
Jun-98	366
Sep-98	424
Dec-98	420
Mar-99	403
May-99	1377
Sep-99	703
Nov-99	886
Mar-00	894
May-00	698
Sep-00	684
Dec-00	644
1-Mar	610
1-Jun	733

Sandy Hollow

Fig 11.11a Chloride & Sodium

Date	Cl	Na
Jan-96	17.61	17.63
Feb-96	21.94	16.35
Mar-96	24.04	15.13
Apr-96	13.9	8.68
May-96	18.97	14.61
Jun-96	18.52	10.48
Nov-96	13.45	18.05
Mar-97	11.76	9.65
Jun-97	11.61	7.25
Sep-97	9.11	8.93
Dec-97	10.88	8
Mar-98	9.38	14.5
Jun-98	10.39	10.85
Sep-98	10.4	8.78
Dec-98	10.27	8.11
Mar-99	9.95	8.06
May-99	10.4	7.1
Sep-99	11.6	7.28
Nov-99	10.1	7.34
Mar-00	11	8.18
May-00	13.4	8.73
Sep-00	11.2	9.02
Dec-00	13.1	12
Mar-01	12.3	11.1
Jun-01	16.1	11.47

Sandy Hollow

Fig 11.12 Trace Elements

Date	As	Cd	Pb	Se
Jan-96	0.0002	0.006	0.0007	0.0003
Feb-96	0.0017	0.009	0.0007	0.003
Mar-96	0.0005	0.003	0.0007	0.0003
Apr-96	0.0009	0.01	0.0007	0.0002
May-96	0.0002	0.005	0.0007	0.0003
Jun-96	0.0002	0.002	0.0007	0.0003
Sep-97				
Sep-98				
Sep-99	0.0029	0.0006	0.0008	0.0023
Sep-00				
Sep-01	0.0029	0.0002	0.0019	0.0036

Sandy Hollow

Fig 11.13 Major Elements

DATE	Fe	Mn	Al
Feb-99	4.21	1.4	6.29
May-99	0.362	0.908	2.28
Aug-99	0.44	1.38	4.53
Oct-99	0.412	1.83	6.4
Jan-00	3.8	1.52	7.3
May-00	0.52	0.97	2.5
Aug-00	0.32	1.2	4.7
1-Mar	3	1.7	7.6
May-01	0.78	1.18	3.06

Sandy Hollow
Fig 11.14 Sulfates

Date	
Feb-99	261
May-99	176
Aug-99	337
Oct-99	445
Jan-00	216
May-00	166
Aug-00	253
1-Mar	343
May-01	178

Sandy Hollow

Fig 11.15 Acidity

Date	
Feb-99	88
May-99	30
Aug-99	36
Oct-99	34
Jan-00	88
May-00	38
Aug-00	38
1-Mar	94
May-01	48

Sandy Hollow
Fig 11.15a Alkalinity

Date	
Apr-94	6.4
May-94	17.8
Jun-94	7
Jul-94	5.8
Aug-94	0
Sep-94	0
Oct-94	
Nov-94	0
Dec-94	0
Jan-95	0
Apr-95	12.8
Sep-95	0
Nov-95	
Jan-96	0
Feb-96	0
Mar-96	0
Apr-96	0
May-96	0
Jun-96	0
Jul-96	0
Aug-96	6.8
Sep-96	8.8
Oct-96	3.4
Nov-96	5.4
Dec-96	0
Jan-97	0
Feb-97	0
Mar-97	0
Apr-97	0
May-97	2.8
Jun-97	1.2
Jul-97	3
Aug-97	27.8
Sep-97	
Oct-97	
Nov-97	0
Dec-97	0
Jan-98	0
Feb-98	0
Mar-98	0
Apr-98	0
May-98	

Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	0
Feb-99	0
Mar-99	0
Apr-99	0
May-99	4
Jun-99	0
Jul-99	6
Aug-99	6
Sep-99	6
Oct-99	66
Nov-99	92
Dec-99	10
Jan-00	0
Feb-00	0
Mar-00	0
Apr-00	0
May-00	0
Jun-00	0
Jul-00	0
Aug-00	6
Sep-00	8
Oct-00	10
Nov-00	0
Dec-00	0
Jan-01	
Feb-01	0
Mar-01	0
Apr-01	0
May-01	0
Jun-01	0
Jul-01	0
Aug-01	0
Sep-01	0
Oct-01	0
Nov-01	0
Dec-01	0
Jan-02	0
Feb-02	0
Mar-02	0
Apr-02	0

May-02	0
Jun-02	
Jul-02	0
Aug-02	0
Sep-02	2
Oct-02	6
Nov-02	0
Dec-02	0
Jan-03	0
Feb-03	0
Mar-03	0
Apr-03	0
May-03	0
Jun-03	0
Jul-03	0
Aug-03	0
Sep-03	0
Oct-03	2
Nov-03	0
Dec-03	0

Sandy Hollow
Fig 11.16 pH

Date	
Feb-99	3.4
May-99	3.8
Aug-99	4.4
Oct-99	4.6
Jan-00	3.4
May-00	3.6
Aug-00	4.2
1-Mar	3.3
May-01	3.6

Sandy Hollow
Fig 11.17 Flow

Date	(gal/min)
Feb-99	165
May-99	51
Aug-99	3
Oct-99	0.3
Jan-00	36
May-00	51
Aug-00	2.1
1-Mar	57
May-01	76

Sandy Hollow
Fig 11.18 Iron, Manganese, Alminum Load (lbs/day)

DATE	Fe	Mn	Al
Feb-99	8.35	2.77	12.47
May-99	0.27	0.556	1.39
Aug-99	0.015	0.049	0.163
Oct-99	0.001	0.0065	0.023
Jan-00	1.64	0.657	3.15
May-00	0.318	0.594	1.53
Aug-00	0.008	0.03	0.118
1-Mar	2.05	1.16	5.2
May-01	0.712	1.08	2.79

Sandy Hollow
Fig 11.19 Sulfate Load & Concentrations
mg/L, lbs/day

Date	SO4 Conc	SO4 Load
Feb-99	261	517
May-99	176	107
Aug-99	337	12.2
Oct-99	445	1.6
Jan-00	216	93.4
May-00	166	101.7
Aug-00	253	6.38
1-Mar	343	235
May-01	178	162

Sandy Hollow

Fig 11.20 Acidity Load

Date	
Feb-99	29.2
Mar-99	10.3
Apr-99	15.5
May-99	10.1
Jun-99	26.9
Jul-99	4.5
Aug-99	1.73
Sep-99	0.48
Oct-99	0
Nov-99	0
Dec-99	0.72
Jan-00	29.6
Feb-00	
Mar-00	
Apr-00	
May-00	
Jun-00	
Jul-00	
Aug-00	
Sep-00	
Oct-00	
Nov-00	
Dec-00	
Jan-01	0
Feb-01	50
Mar-01	60
Apr-01	29
May-01	10.3
Jun-01	30.2
Jul-01	15
Aug-01	8.6
Sep-01	4.5
Oct-01	15.1
Nov-01	6.4
Dec-01	2.28
Jan-02	9.14
Feb-02	20.4
Mar-02	36
Apr-02	27.4
May-02	11.5
Jun-02	8
Jul-02	4.1

Aug-02	3.1
Sep-02	0.91
Oct-02	0.72
Nov-02	6.15
Dec-02	31.2

CK Coal

Fig 12.1 Iron, Managanese, Alkalinity

DATE	Fe	Mn	Alk
Apr-94	147	16.4	9
May-94	14.5	9.14	26
Jun-94	0.81	8.1	8
Jul-94	4.18	8.14	0
Aug-94	11.9	8.9	0
Sep-94	12.9	10.4	6
Nov-94	20.5	11.8	16
Mar-95	19.6	17.3	18
Apr-95	38.8	19.8	44
Aug-95	46.6	18.1	53
Oct-95			
Jan-96	23.9	15.8	2
Apr-96	25.1	16.52	10
Jul-96	23.1	23.63	20
Oct-96	32.7	27.2	20
Apr-97	44.3	33.4	26
Jul-97	56	31.2	34
Oct-97	42.6	25.2	16
Jan-98	54	30.6	38
Apr-98	57	33	30
Jul-98	59.7	29	40
Oct-98	37.3	26	16
Jan-99	48.8	18	44
Apr-99	52.1	28	14
Jul-99			
Oct-99			

CK Coal
Fig 12.2 Sulfates & TDS

Date	SO4	TDS
4/19/1994	502	725
May-94	468	598
Jun-94	500	644
Jul-94	438	672
Aug-94	429	678
Sep-94	402	676
Nov-94	280	780
Mar-95	720	1172
Apr-95	915	1308
Aug-95	583	1208
Oct-95		
Jan-96	516	824
Apr-96	485	914
Jul-96	764	1264
Oct-96	947	1458
Apr-97	1212	1960
Jul-97	1103	2014
Oct-97	943	1496
Jan-98	1051	1756
Apr-98	1180	1884
Jul-98	1096	1109
Oct-98	794	1602
Jan-99	804	1352
Apr-99	1025	1647
Jul-99		
Oct-99		

CK Coal
Fig 12.3 pH & Chloride

DATE	pH	Cl
4/19/1994	6	2.5
May-94	6.2	2
Jun-94	6.4	3
Jul-94	6.2	3.5
Aug-94	6.4	2.4
Sep-94	6.1	2.2
Nov-94	6	6
Mar-95	6.2	4
Apr-95	6	4
Aug-95	6.2	1
Oct-95		
Jan-96	5	2.8
Apr-96	5.2	4
Jul-96	5	3
Oct-96	4.9	7.4
Apr-97	4.7	71.9
Jul-97	5	19
Oct-97	5.1	7
Jan-98	5.4	1
Apr-98	5.3	1
Jul-98	5.2	
Oct-98	5.1	
Jan-99	5.4	
Apr-99	5.6	
Jul-99		
Oct-99		

CK Coal
Fig 12.4 Alkalinity

Date	Alkalinity
4/19/1994	161
5/31/1994	0
6/22/1994	4
7/29/1994	44
8/23/1994	26
9/1/1994	12
11/30/1994	70
3/28/1995	72
4/21/1995	64
8/10/1995	40
10/11/1995	
1/18/1996	16
4/22/1996	66
7/9/1996	40
10/8/1996	100
4/23/1997	118
7/8/1997	180
10/16/1997	118
1/21/1998	120
4/14/1998	102
7/23/1998	112
10/29/1998	106
1/26/1999	0
4/13/1999	110
7/20/1999	
10/20/1999	

CK Coal

Fig 12.5 Calcium & Magnesium

Date	Ca	Mg
4/19/1994	85.5	70
May-94	84.5	47
Jun-94	62	45
Jul-94	75	50
Aug-94	56	40
Sep-94	64	49
Apr-96	95.5	75.1
Apr-97	204.7	153.1
Apr-98	184.1	156.4
Jan-99		
Apr-99	143.65	122.46
Jul-99		
Oct-99		

CK Coal
Fig 12.6 Trace Elements

DATE	As	Cd	Pb	Se
4/19/1994	0.004	<0.006	<0.04	<0.001
May-94	<0.0015	0.0011	0.0009	<0.0023
Jun-94	<0.0015	0.0007	0.002	<0.0023
Jul-94	<0.0015	0.0008	0.0009	<0.0023
Aug-94	0.0038	0.002	0.0099	<0.0023
Sep-94	0.0027	0.0013	0.0109	<0.0023
Jan-95				
Apr-96	<0.001	0.001	0.0021	<0.0023
Apr-97	0.0038	0.002	0.0018	<0.031
Apr-98	0.0038	0.001	0.007	<0.027
Jan-99				
Apr-99	0.0028	0.001	0.0033	<0.0027
Jul-99				
Oct-99				

CK Coal

Fig 12.7 Iron & Manganese

DATE	Fe	Mn
04/19/94	11.96	3.53
05/31/94	3.85	4.16
06/22/94	0.52	3.43
07/29/94	6.05	3.47
08/23/94	7.46	3.57
09/01/94	10.03	3.81
11/30/94	6.63	4.47
03/28/95	3.48	7.4
04/21/95	10.84	5.8
08/10/95	10.51	6.81
10/11/95	15.79	7.11
01/18/96	27.97	9.34
04/22/96	17.19	7.08
07/09/96	4.33	8.42
10/08/96	11.2	8.3
04/23/97	20.49	8.88
07/08/97	6.97	5.96
10/16/97	21.1	7.9
01/21/98	21.1	8.1
04/14/98	20.5	7.96
07/23/98	18.1	7.26
10/29/98	18.3	7.32
01/26/99	23.6	6.75
04/13/99	21.99	7.08
07/20/99	6.8	6.8
10/20/99	5.02	8.29

CK Coal
Fig 12.8 Sulfates

DATE	
04/19/94	147
05/31/94	225
06/22/94	236
07/29/94	220
08/23/94	200
09/01/94	170
11/30/94	101
03/28/95	540
04/21/95	199
08/10/95	194
10/11/95	272
01/18/96	458
04/22/96	194
07/09/96	233
10/08/96	236
04/23/97	248
07/08/97	233
10/16/97	242
01/21/98	217
04/14/98	209
07/23/98	220
10/29/98	218
01/26/99	258
04/13/99	217
07/20/99	200
10/20/99	207

CK Coal

Fig 12.9 ph & Chloride

DATE	pH	Cl
04/19/94	6.4	0.5
05/31/94	6.1	2
06/22/94	6.2	2.5
07/29/94	6	1.5
08/23/94	6.4	1.8
09/01/94	6.2	1.3
11/30/94	6.1	0.8
03/28/95	6.6	5
04/21/95	6.2	1.2
08/10/95	6.1	0.2
10/11/95	6	2
01/18/96	6	6.3
04/22/96	5.5	4
07/09/96	5.7	3
10/08/96	6.1	4
04/23/97	6.2	3.1
07/08/97	5.9	2.5
10/16/97	5.9	3.2
01/21/98	6.4	3.7
04/14/98	6	4
07/23/98	6.2	
10/29/98	6.5	
01/26/99	6.5	
04/13/99	6.8	
07/20/99	6	
10/20/99	6	

CK Coal

Fig 12.10 Total Dissolved Solids

DATE	TDS	Alk
04/19/94	202	7
05/31/94	266	48
06/22/94	228	38
07/29/94	272	46
08/23/94	224	32
09/01/94	322	30
11/30/94	258	28
03/28/95	938	66
04/21/95	348	22
08/10/95	320	22
10/11/95	460	42
01/18/96	498	56
04/22/96	358	16
07/09/96	398	22
10/08/96	416	40
04/23/97	430	64
07/08/97	448	60
10/16/97	412	90
01/21/98	464	88
04/14/98	494	96
07/23/98	506	93
10/29/98	420	88
01/26/99	456	80
04/13/99	416	82
07/20/99	366	38
10/20/99	342	64

CK Coal
Fig 12.10a Akalinity

Date	Alk
04/19/94	7
05/31/94	48
06/22/94	38
07/27/94	46
08/23/94	32
09/01/94	30
11/30/94	28
03/28/95	66
04/21/95	22
08/10/95	22
10/11/95	42
01/18/96	56
04/22/96	16
07/09/96	22
10/08/96	40
04/23/97	84
07/08/97	60
10/16/97	90
01/21/98	88
04/14/98	96
07/23/98	98
10/29/98	88
01/26/99	80
04/13/99	82
07/20/99	38
10/20/99	32

CK Coal

Fig 12.11 Calcium & Magnesium

Date	Ca	Mg
4/19/1994	27.5	19.9
5/31/1994	44	17
6/22/1994	28.3	15.2
7/29/1994	28	17
8/23/1994	13	13
9/1/1994	26	22
4/22/1996	47	27.1
4/23/1997	54.2	31.5
4/14/1998	53.3	35.9
4/13/1999	48.04	32.13
7/1/1999		
10/1/1999		

CK Coal

Fig 12.12 Trace Elements

Date	As	Cd	Pb	Se
04/19/94	<0.002	<0.006	<0.04	<0.001
05/27/94	<0.0015	0.0014	0.0014	<0.0023
06/22/94	<0.0015	0.0009	0.002	<0.0023
07/26/94	<0.0015	0.0061	0.0006	<0.0023
08/23/94	<0.0015	0.0027	0.0044	<0.0023
09/22/94	0.0054	<0.0001	0.001	<0.0023
04/01/95	0.0054	0.0061	0.0044	<0.0023
04/22/96	0.001	0.0002	<0.0006	<0.0230
04/23/97	0.011	0.0005	<0.0012	<0.0310
04/14/98	0.037	<0.0010	<0.0060	<0.027
04/13/99	<0.0014	0.0002	<0.0008	<0.0027
07/01/99				
10/01/99				

CK Coal

Fig 12.13 Iron

DATE	Fe
04/19/94	63.75
05/27/94	1.97
06/28/94	0.31
07/27/94	1.64
08/23/94	2.75
09/22/94	7.79
11/30/94	0.62
03/28/95	0.51
04/21/95	5.53
08/10/95	3.75
10/11/95	1.91
01/18/96	5.23
04/22/96	2.9
07/09/96	1.69
10/08/96	0.17
04/23/97	
07/08/97	
10/16/97	
01/21/98	
04/14/98	
07/23/98	1.14
10/29/98	1.09
01/26/99	0.65
04/13/99	1.42
07/20/99	1.42
10/20/99	2.55

CK Coal

Fig 12.14 Manganese & Chloride

Date	Mn	Cl
04/19/94	5.71	4.6
05/27/94	0.54	4
06/28/94	0.08	4.5
07/27/94	0.69	4.5
08/23/94	0.66	3.3
09/22/94	1.18	3.2
11/30/94	0.49	1.6
03/28/95	0.57	2.5
04/21/95	0.87	2.1
08/10/95	0.71	0.6
10/11/95	0.56	2
01/18/96	0.99	2
04/22/96	0.75	2
07/09/96	0.58	2
10/08/96	0.75	2.7
04/23/97		
07/08/97		
10/16/97		
01/21/98		
04/14/98		
07/23/98	0.86	
10/29/98	0.61	
01/26/99	0.78	
04/13/99	1.26	
07/20/99	1.12	
10/20/99	1	

CK Coal

Fig 12.15 Sulfates & Total Dissolved Solids

Date	TDS	SO4
04/19/94	352	160
05/27/94	408	193
06/28/94	410	186
07/27/94	384	231
08/23/94	416	193
09/22/94	472	126
11/30/94	490	92
03/28/95	568	192
04/21/95	624	200
08/10/95	600	194
10/11/95	572	181
01/18/96	616	252
04/22/96	656	192
07/09/96	584	174
10/08/96	562	195
04/23/97		
07/08/97		
10/16/97		
01/21/98		
04/14/98		
07/23/98	751	216
10/29/98	704	201
01/26/99	710	194
04/13/99	780	247
07/20/99	770	261
10/20/99	755	253

CK Coal
Fig 12.16 pH

DATE	pH
04/19/94	7.4
05/27/94	7.2
06/28/94	7.2
07/29/94	7.1
08/23/94	7
09/22/94	6.9
11/30/94	7
03/28/95	6.7
04/21/95	7.1
08/10/95	6
10/11/95	6
01/18/96	7
04/22/96	7.1
07/09/96	7
10/08/96	6.8
04/23/97	
07/08/97	
10/16/97	
01/21/98	
04/14/98	
07/23/98	6.7
10/29/98	6.8
01/26/99	6.8
04/13/99	6.9
07/20/99	7
10/20/99	7

CK Coal

Fig 12.17 Calcium & Magnesium

Date	Ca	Mg
04/19/94	75.5	24.55
05/27/94	81.5	22
06/28/94	80	20.8
07/27/94	87	23
08/23/94	60	18
09/22/94	96	27
04/01/95		
04/22/96	135.5	32.7
04/23/97	147.7	34.4
04/14/98	148.2	40.3
04/13/99		
07/01/99		
10/01/99		

CK Coal

Fig 12.18 Trace Elements

DATE	As	Cd	Pb	Se
04/19/94	<0.002	<0.006	<0.04	<0.001
05/27/94	<0.0015	0.0011	<0.0006	<0.0023
06/28/94	0.0028	0.0002	0.002	<0.0023
07/27/94	0.0037	0.0005	0.001	<0.0023
08/23/94	<0.0015	<0.0001	0.001	<0.0023
09/22/94	0.0102	0.0003	0.0008	<0.0023
04/22/96	<0.001	<0.0001	<0.0006	<0.023
04/23/97	<0.001	<0.0002	<0.0012	<0.031
04/14/98	<0.014	<0.001	<0.006	0.03

Buterbaugh
Fig 13.1 Iron

Date	
Dec-99	0.41
Feb-00	5.1
May-00	0.64
Sep-00	2.9
10/11/2000	0.53
10/24/2000	0.35
11/8/2000	0.31
11/22/2000	0.28
12/5/2000	0.35
12/26/2000	0.4
1/17/2001	2.03
3/12/2001	0.32
4/18/2001	0.48
5/24/2001	0.26
6/8/2001	0.33
9/17/2001	
12/20/2001	0.38
2/8/2002	1
3/15/2002	
6/12/2002	0.49
9/11/2002	
11/27/2002	0.5
3/18/2003	0.63
5/19/2003	0.74
6/5/2003	0.99
7/17/2003	2.7
9/3/2003	0.38
11/3/2003	0.67
12/16/2003	0.63

Buterbaugh
Fig 13.2 Manganese

Date	
Dec-99	1.31
Feb-00	1.3
May-00	1.8
Sep-00	4.1
10/11/2000	1.95
10/24/2000	2.44
11/8/2000	2.58
11/22/2000	2.46
12/5/2000	3.1
12/26/2000	2.94
1/1/2001	2.8
3/12/2001	5.05
4/1/2001	5.2
5/1/2001	4.48
6/8/2001	4.02
9/17/2001	
12/20/2001	2.06
2/2/2002	3
3/15/2002	
6/12/2002	5.72
9/11/2002	
11/27/2002	7.3
3/18/2003	3.88
5/19/2003	9.6
6/5/2003	9.3
7/17/2003	8.2
9/3/2003	0.44
11/3/2003	7.1
12/16/2003	7.39

Buterbaugh
Fig 13.3 Sulfate

Date	
Dec-99	106
Feb-00	124
May-00	191
Sep-00	154
10/11/2000	168
10/24/2000	198
11/8/2000	248
11/22/2000	232
12/5/2000	195
12/26/2000	230
1/1/2001	220
3/12/2001	360
4/1/2001	303
5/1/2001	304
6/8/2001	305
9/17/2001	
12/20/2001	217
2/2/2002	226
3/15/2002	
6/12/2002	622
9/11/2002	
11/27/2002	583
3/18/2003	389
5/19/2003	743
6/5/2003	658
7/17/2003	670
9/3/2003	450
11/3/2003	556
12/16/2003	537

Buterbaugh
Fig 13.4 Acidity

Date	
Dec-99	18
Jan-00	20
May-00	32
Sep-00	22
10/11/2000	26
10/24/2000	38
11/8/2000	50
11/22/2000	40
12/5/2000	36
12/26/2000	44
1/17/2001	30
3/12/2001	84
4/18/2001	68
5/24/2001	44
6/8/2001	44
9/17/2001	
12/20/2001	4
2/8/2002	30
3/15/2002	
6/12/2002	80
9/11/2002	
11/27/2002	70
3/18/2003	22
5/19/2003	96
6/5/2003	82
7/17/2003	80
9/3/2003	10
11/28/2003	21
12/16/2003	28

Buterbaugh

Fig 13.5 pH

Date	
Dec-99	
Feb-00	6.2
May-00	6.2
Sep-00	7
10/11/2000	4.7
10/24/2000	4.5
11/8/2000	4.5
11/22/2000	4.7
12/5/2000	4.6
12/26/2000	4.6
1/1/2001	
3/12/2001	4.4
4/18/2001	5
5/24/2001	4
6/8/2001	4.6
9/17/2001	
12/20/2001	5.8
2/8/2002	5.7
3/15/2002	
6/12/2002	4.6
9/11/2002	
11/22/2002	5.6
3/26/2003	5.8
5/19/2003	5
6/5/2003	4.6
7/17/2003	6
9/3/2003	5.5
11/3/2003	5.1
12/16/2003	5.3

Buterbaugh

Fig 13.6 Total Dissolved Solids

Date	
Dec-99	
Feb-00	
May-00	
Sep-00	
10/11/2000	288
10/24/2000	331
11/8/2000	374
11/22/2000	355
12/5/2000	358
12/26/2000	357
1/1/2001	
3/12/2001	594
4/1/2001	
5/1/2001	
6/8/2001	446
9/17/2001	
12/20/2001	352
2/2/2002	
3/15/2002	
6/12/2002	892
9/11/2002	
11/27/2002	885
3/18/2003	604
5/19/2003	
6/5/2003	903
7/17/2003	
9/3/2003	744
11/3/2003	
12/16/2003	927

Buterbaugh

Fig 13.7 Alkalinity

Date	
Dec-99	4
Feb-00	6
May-00	4
Sep-00	6
10/11/2000	4
10/24/2000	4
11/8/2000	4
11/22/2000	8
12/5/2000	4
12/26/2000	6
1/17/2001	6
3/12/2001	2
4/18/2001	2
5/24/2001	4
6/8/2001	4
9/17/2001	
12/20/2001	8
2/8/2002	4
3/15/2002	
6/12/2002	6
9/11/2002	
11/27/2002	6
3/18/2003	6
5/19/2003	6
6/5/2003	4
7/17/2003	4
9/3/2003	10
11/28/2003	7
12/16/2003	9

Buterbaugh

Fig 13.7a Calcium, Magnesium, & Chloride

Date			
Date	**Ca**	**Mg**	**Cl**
10/11/2000	29.5	18.4	1.4
10/24/2000	34.4	22	1.6
11/8/2000	36.7	24.5	1.6
11/22/2000	38.1	23	1.6
12/5/2000	38.2	21.8	1.1
12/26/2000	38.5	20.9	2
6/8/2001	52.6	24.3	1.4
11/21/2002	117	52.7	4.8
6/5/2003	122	62.6	37.6
Jun-04	138	84.9	2

Buterbaugh

Fig 13.7b Sodium & Potassium

Date		
10/11/2000	0.02	0.8
10/24/2000	0.12	0.97
11/8/2000	0.7	1.01
11/22/2000	2	1.93
12/5/2000	2.23	0.86
12/26/2000	2.21	0.92
1/1/2001		
3/12/2001		
4/1/2001		
5/1/2001		
6/8/2001	3.27	14
11/21/2002	3.23	3.01
6/5/2003	3.25	2.88
Jun-04	3.13	2.48

Buterbaugh
13.8 Trace Elements

Date

Buterbaugh

Fig 13.9 Iron

Date	
2/9/2000	2.71
3/14/2000	0.1
4/20/2000	0.2
5/18/2000	0.27
6/8/2000	0.21
7/20/2000	
9/25/2000	0.15
12/5/2000	0.03
3/12/2001	0.08
6/8/2001	0.36
9/17/2001	0.23
12/20/2001	0.26
3/15/2002	0.07
6/12/2002	0.37
9/11/2002	
11/21/2002	0.85
3/18/2003	0.93
6/5/2003	0.27
9/3/2003	0.48
12/16/2003	0.51
4-Mar	0.35
4-Jun	2.06
4-Sep	1.46

Buterbaugh
Fig 13.10 Manganese

Date	
2/9/2000	0.52
3/14/2000	0.03
4/20/2000	0.94
5/18/2000	0.06
6/8/2000	0.11
7/20/2000	
9/25/2000	0.03
12/5/2000	0.03
3/12/2001	0.03
6/8/2001	0.23
9/17/2001	0.02
12/20/2001	0.01
3/15/2002	0.01
6/12/2002	0.02
9/11/2002	
11/21/2002	0.02
3/18/2003	0.55
6/5/2003	0.02
9/3/2003	0.1
12/16/2003	0.07
4-Mar	0.03
4-Jun	0.14
4-Sep	1.07

Buterbaugh

Fig 13.11 Sulfates

Date	
2/9/2000	15
3/14/2000	18
4/20/2000	18
5/18/2000	14
6/8/2000	12
7/20/2000	
9/25/2000	15
12/5/2000	14
3/12/2001	18
6/8/2001	15
9/17/2001	22
12/20/2001	18
3/15/2002	15
6/12/2002	14
9/11/2002	
11/21/2002	26
3/18/2003	82
6/5/2003	25
9/3/2003	24
12/16/2003	16
4-Mar	15
4-Jun	20
4-Sep	26

Buterbaugh
Fig 13.12 Acidity

Date	
2/9/2000	4
3/14/2000	4
4/20/2000	2
5/18/2000	0
6/8/2000	0
7/20/2000	
9/25/2000	0
12/5/2000	6
3/12/2001	0
6/8/2001	0
9/17/2001	0
12/20/2001	8
3/15/2002	4
6/12/2002	0
9/11/2002	
11/21/2002	2
3/18/2003	4
6/5/2003	2
9/3/2003	6
12/16/2003	7
4-Mar	1
4-Jun	0
4-Sep	0

Buterbaugh
Fig 13.13 pH

Date	
2/9/2000	6.1
3/14/2000	5.9
4/20/2000	6.4
5/18/2000	6
6/8/2000	6
7/20/2000	
9/25/2000	6
12/5/2000	6.1
3/12/2001	5.9
6/8/2001	5.9
9/17/2001	6.8
12/20/2001	5.9
3/15/2002	5.9
6/12/2002	6
9/11/2002	
11/21/2002	6
3/18/2003	5.5
6/5/2003	5.7
9/3/2003	5.4
12/16/2003	5.3
4-Mar	4.5
4-Jun	6.1
4-Sep	5.4

Buterbaugh

Fig 13.14 Total Dissolved Solids

Date	
2/9/2000	36
3/14/2000	31
4/20/2000	48
5/18/2000	48
6/8/2000	33
7/20/2000	
9/25/2000	59
12/5/2000	38
3/12/2001	45
6/8/2001	35
9/17/2001	51
12/20/2001	46
3/15/2002	27
6/12/2002	31
9/11/2002	
11/21/2002	60
3/18/2003	142
6/5/2003	46
9/3/2003	43
12/16/2003	57
4-Mar	19
4-Jun	70
4-Sep	96

Buterbaugh

Fig 13.15 Alkalinity

Date	
2/9/2000	8
3/14/2000	6
4/20/2000	8
5/18/2000	12
6/8/2000	14
7/20/2000	
9/25/2000	18
12/5/2000	6
3/12/2001	8
6/8/2001	12
9/17/2001	16
12/20/2001	6
3/15/2002	8
6/12/2002	8
9/11/2002	
11/21/2002	8
3/18/2003	6
6/5/2003	8
9/3/2003	10
12/16/2003	10
4-Mar	9
4-Jun	26
4-Sep	48

Russelton

Fig 14.1 Iron & Manganese

Date	Fe	Mn
6/2/1994	0.05	0.19
9/28/1994	0.14	0.05
11/22/1994	3.99	0.08
3/31/1995	0.08	0.08
6/29/1995	10.4	0.18
9/8/1995	0.29	1.16
12/22/1995	0.18	0.09
3/18/1996	0.11	0.25
6/25/1996	0.19	0.1
7/31/1996	0.1	0.05
8/27/1996	0.12	0.12
9/17/1996	0.33	0.11
10/16/1996	0.2	0.17
11/27/1996	0.14	0.1
10/22/1997	0.09	0.09
12/16/1998	0.09	0.06
11/23/1999	0.09	0.03
10/9/2000	0.1	0.09
3/30/2001	0.17	0.2
6/7/2001	0.23	0.05
8/14/2001	0.61	0.22
11/8/2001	0.13	0.1
1/28/2002	0.17	0.1
4/5/2002	0.64	0.1
9/4/2002	0.44	0.85
12/4/2002	0.24	0.07
3/24/2003	0.12	0.15
6/5/2003	1.14	0.31
9/25/2003	0.63	0.05
12/9/2003	0.11	0.07
1/14/2004	0.43	0.2

Russelton
Fig 14.2 Sulfates

Date	
May-92	80
Jun-94	76
Sep-94	84
Nov-94	58
Mar-95	64
Jun-95	1890
Sep-95	105
Dec-95	93
Mar-96	58
Jun-96	60
Jul-96	77
Aug-96	115
Sep-96	67
Oct-96	102
Nov-96	49
Oct-97	131
Dec-98	166
Nov-99	163
Oct-00	130
Nov-00	117
Mar-01	54
Jun-01	97
Aug-01	154
1-Nov	147
2-Jan	104
2-Apr	97
2-Sep	154
2-Dec	182
3-Mar	111
3-Jun	133
3-Sep	111
3-Dec	91
4-Jan	83

Russelton
Fig 14.3 Acidity

Date	
May-92	2
Jun-94	2
Sep-94	2
Nov-94	2
Mar-95	2
Jun-95	290
Sep-95	2
Dec-95	2
Mar-96	2
Jun-96	2
Jul-96	2
Aug-96	2
Sep-96	2
Oct-96	2
Nov-96	2
Oct-97	2
Dec-98	2
Nov-99	2
Oct-00	2
Nov-00	2
Mar-01	2
Jun-01	2
Aug-01	2
Nov-01	2
Jan-02	2
Apr-02	2
Sep-02	2
Dec-02	2
Mar-03	2
Jun-03	2
Sep-03	2
Dec-03	2
Jan-04	2

Russelton

Fig 14.4 Trace Elements

Date	As	Cd	Pb	Se
Jun-96	0.0002	0.0002	0.0007	0.0024
Jul-96	0.0002	0.001	0.0007	0.0003
Aug-96	0.0028	0.003	0.0007	0.0003
Sep-96	0.0144	0.0002	0.0171	0.0051
Oct-96	0.0028	0.0002	0.0368	0.0119
Nov-96	0.0003	0.001	0.0043	0.0003
Oct-97	0.0008	0.004	0.0033	0.0007
Dec-98	0.0017	0.003	0.0008	0.0006
Nov-99	0.0002	0.001	0.0007	0.0003
Oct-00	0.0019	0.001	0.0021	0.0003
1-Nov	0.0007	0.002	0.0007	0.0002

Russelton
Fig 14.5 Iron & Manganese

Date	Fe	Mn
May-92	3.59	0.43
Jun-94	10.3	1.21
Sep-94	2.97	0.3
Nov-94	2.04	0.29
Mar-95	5.48	0.68
Jun-95	450	6.7
Sep-95	18.5	12.8
Dec-95	0.27	0.27
Mar-96	2.23	0.55
Jun-96	1.71	0.31
Sep-96	3.3	0.53
Dec-96	2.42	0.45
Feb-97	2.11	0.31
May-97	2.35	0.37
Oct-97	17.85	2.99
Dec-98	23.4	4.2
Nov-99	15	3.7
Oct-00	2.06	0.55
Nov-00	6.5	1.67
Mar-01	1.96	0.41
1-Jun	1.52	0.24
1-Aug	3.89	4.2
1-Nov	3.89	1.52
2-Jan	1.72	0.36
2-Apr	2.94	0.36
2-Sep	45.9	6.2
2-Dec	2.19	0.7
3-Mar	2.15	0.32
3-Jun	0.11	0.04
3-Sep	0.73	0.17
3-Dec	1.5	0.35
4-Jan	2.99	0.54

Russelton

Fig 14.6 Sulfate

Date	
May-92	156
Jun-94	210
Sep-94	132
Nov-94	144
Mar-95	152
1-Jun	244
1-Sep	790
1-Dec	152
1-Mar	126
1-Jun	145
1-Jul	211
1-Aug	616
1-Sep	165
1-Oct	270
1-Nov	79
Dec-96	139
Feb-97	87
May-97	89
Oct-97	469
Dec-98	735
Nov-99	570
Oct-00	133
Nov-00	235
1-Mar	123
1-Jun	118
1-Aug	401
1-Nov	260
2-Jan	133
2-Apr	147
2-Sep	699
2-Dec	267
3-Mar	133
3-Jun	104
3-Sep	147
3-Dec	126
4-Jan	144

Russelton
Fig 14.7 Acidity

Date	
May-92	2
Jun-94	2
Sep-94	2
Nov-94	2
Mar-95	2
Jun-95	2
Sep-95	292
Dec-95	2
Mar-96	2
Jun-96	2
Sep-96	2
Dec-96	2
Feb-97	2
May-97	2
Oct-97	45
Dec-98	79
Nov-99	43
Nov-00	2
Mar-01	2
Jun-01	2
Aug-01	2
Nov-01	2
Jan-02	2
Apr-02	2
Sep-02	2
Dec-02	2
Mar-03	2
Jun-03	2
Sep-03	2
Dec-03	2
Jan-04	2

Russelton

Fig 14.8 Trace Elements

Date	As	Cd	Pb	Se
Jun-96	0.0002	0.002	0.0007	0.0016
Jul-96	0.0002	0.004	0.0007	0.0003
Aug-96	0.0047	0.008	0.0007	0.0003
Sep-96	0.0002	0.0002	0.0015	0.006
Oct-96	0.0262	0.0002	0.0536	0.0113
Nov-96	0.0002	0.001	0.0029	0.0005
Oct-97	0.0008	0.001	0.0032	0.0007
Dec-98	0.0099	0.005	0.0013	0.0095
Nov-99	0.0007	0.001	0.0007	0.0014
Oct-00	0.0005	0.001	0.0011	0.0003
1-Nov	0.0002	0.001	0.0007	0.0002

Russelton

Fig 14.9 Iron, Manganese, Aluminum

Date	Fe	Mn	Al
May-92	23.3	0.35	5.08
May-94	26	0.61	9.8
Jun-94	49	1.21	14.1
Jul-94	3.7	0.66	0.82
Aug-94	7	0.15	1.2
Sep-94	3.9	0.07	2.4
Oct-94	63	0.15	5.4
Nov-94	2.1	0.05	4.4
Dec-94	23.2	0.24	4.1
Jan-95	14.4	0.38	1.4
Feb-95	3.01	0.05	1.05
Mar-95	13	0.27	2.56
Apr-95	7	0.14	1.29
May-95	2.3	0.07	0.78
Jun-95	13.2	0.3	3.1
Jul-95	8.1	0.23	3.4
Aug-95			
Sep-95	80	8.7	46
Oct-95	5	0.21	1.4
Nov-95	320	0.08	0.95
Dec-95	17	0.45	3.2
Jan-96	24.4	0.44	6.6
Feb-96	125	1.3	46
Mar-96	34	0.54	13.7
Apr-96	35	0.55	20
May-96	22	0.67	12
Jun-96	18.2	0.27	2.7
Jul-96	81	1.2	14
Aug-96			
Sep-96	49	0.8	6
Oct-96	20	0.4	2.3
Nov-96	7	0.2	1.7
Dec-96	29	0.4	6.3
Jan-97	16.3	0.19	3.7
Feb-97	23	0.42	4.26
Mar-97	31	0.68	4.9
Feb-98	22.4	0.48	5.35
Mar-98	358	22	295
Apr-98	23	0.5	3.1
May-98	53	0.9	16
Jun-98	63	1.75	1.45
Jul-98	34	1.3	7

Aug-98			
Sep-98			
Oct-98	90	1.7	12.8
Nov-98	5	0.24	1.1
Dec-98			
Jan-99	3.3	0.13	0.7
Feb-99	156	3.4	144
Mar-99	17	0.66	7
Apr-99	14	0.39	5.4
May-99	72	1.3	16
Jun-99	23	0.6	6.7
Jul-99	36	1.2	15
Aug-99	216	10	180
Sep-99			
Oct-99	3	0.1	1.3
Nov-99	6.4	0.14	6.4
Dec-99	1.3	0.02	4.6
Jan-00	10.7	0.22	4.3
Feb-00	27	0.4	2.8
Mar-00	3.5	0.1	1.3
Apr-00	3.3	7	1.8
May-00	71	6.3	114
Jun-00	8.2	0.13	8.4
Jul-00			
Aug-00	1.1	0.1	0.5
Sep-00	2.38	0.06	0.4
Oct-00	0.7	0.04	0.2
Nov-00			
Dec-00	19.8	0.8	6
1-Jan	3.1	0.31	0.8
1-Feb	3.2	0.15	1.1
1-Mar	1.8	0.05	0.9
1-Apr	3.3	0.27	1.24
1-May	2.26	0.37	0.73
1-Jun	5	0.31	1.5
1-Jul	3	0.3	1
1-Aug	7	0.2	0.8
1-Sep	1.4	0.1	0.5
1-Oct			
1-Nov	0.63	0.2	0.2
1-Dec	0.5	0.3	0.23
2-Jan	21.2	11.1	4.1
2-Feb	1.5	0.06	0.6
2-Mar	3	0.1	0.6
2-Apr	3.7	0.06	1
2-May	0.6	0.01	3
2-Jun	3.2	0.11	0.83

2-Jul			
2-Aug			
2-Sep			
2-Oct			
2-Nov	0.6	0.1	0.33
2-Dec	12.6	1.4	2.1
3-Jan	3.9	0.2	1.2
3-Feb	3.6	0.1	0.8
3-Mar	1.8	0.11	0.7
3-Apr	2.7	0.13	0.9
3-May	4.7	0.21	1.1
3-Jun	1.6	0.05	0.36
3-Jul	2.14	0.15	0.56
3-Aug	2.8	0.22	0.95
3-Sep	1.2	0.19	0.3
3-Oct	2.4	0.31	1.2
3-Nov	3.4	0.17	0.8
3-Dec	2.8	0.12	1
4-Jan	16	0.59	3.9
4-Feb	2.3	0.04	0.6
4-Mar	1.9	0.03	0.6
4-Apr	0.77	0.08	1.1

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Fig 14.10 Sulfates

Date	
May-92	267
May-94	293
1-Jun	565
1-Jul	352
1-Aug	144
1-Sep	76
1-Oct	120
1-Nov	100
Dec-94	234
Jan-95	100
Feb-95	42
Mar-95	197
Apr-95	93
May-95	79
Jun-95	192
Jul-95	139
Aug-95	
Sep-95	1930
Oct-95	145
Nov-95	198
Dec-95	170
Jan-96	177
Feb-96	825
Mar-96	348
Apr-96	284
May-96	277
Jun-96	172
Jul-96	630
Aug-96	
Sep-96	454
Oct-96	230
Nov-96	139
Dec-96	244
Jan-97	176
Feb-97	330
Mar-97	226
Feb-98	105
Mar-98	3980
Apr-98	226
May-98	425
Jun-98	123
Jul-98	425

Aug-98	
Sep-98	
Oct-98	550
Nov-98	128
Dec-98	
Jan-99	54
Feb-99	790
Mar-99	350
Apr-99	228
May-99	500
Jun-99	360
Jul-99	550
Aug-99	2300
Sep-99	
Oct-99	117
Nov-99	128
Dec-99	117
Jan-00	276
Feb-00	700
Mar-00	110
Apr-00	100
May-00	152
Jun-00	93
Jul-00	
Aug-00	140
Sep-00	93
Oct-00	105
Nov-00	
Dec-00	276
1-Jan	270
1-Feb	77
1-Mar	133
1-Apr	62
1-May	193
1-Jun	111
1-Jul	126
1-Aug	111
1-Sep	118
1-Oct	
1-Nov	104
1-Dec	118
2-Jan	352
2-Feb	104
2-Mar	310
2-Apr	126
2-May	104
2-Jun	196

2-Jul	
2-Aug	
2-Sep	
2-Oct	
2-Nov	154
2-Dec	451
3-Jan	111
3-Feb	111
3-Mar	126
3-Apr	126
3-May	133
3-Jun	104
3-Jul	189
3-Aug	111
3-Sep	90
3-Oct	100
3-Nov	266
3-Dec	100
4-Jan	231
4-Feb	91
4-Mar	83
4-Apr	63

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Fig 14.11 Acidity

Date	
May-92	20
1-May	72
1-Jun	180
1-Jul	2
1-Aug	2
1-Sep	2
1-Oct	2
1-Nov	2
Dec-94	390
Jan-95	2
Feb-95	2
Mar-95	2
Apr-95	2
May-95	2
Jun-95	2
Jul-95	2
Aug-95	
Sep-95	660
Oct-95	2
Nov-95	2
Dec-95	7
Jan-96	2
Feb-96	380
Mar-96	110
Apr-96	22
May-96	100
Jun-96	8
Jul-96	110
Aug-96	
Sep-96	270
Oct-96	2
Nov-96	2
Dec-96	200
Jan-97	2
Feb-97	64
Mar-97	800
Feb-98	30
Mar-98	920
Apr-98	40
May-98	250
Jun-98	140
Jul-98	50

Aug-98	
Sep-98	
Oct-98	170
Nov-98	2
Dec-98	
Jan-99	2
Feb-99	670
Mar-99	130
Apr-99	50
May-99	210
Jun-99	60
Jul-99	180
Aug-99	1670
Sep-99	
Oct-99	2
Nov-99	2
Dec-99	2
Jan-00	46
Feb-00	70
Mar-00	2
Apr-00	2
May-00	2
Jun-00	2
Jul-00	
Aug-00	2
Sep-00	2
Oct-00	2
Nov-00	
Dec-00	66
1-Jan	2
1-Feb	2
1-Mar	2
1-Apr	2
1-May	2
1-Jun	2
1-Jul	2
1-Aug	2
1-Sep	2
1-Oct	
1-Nov	2
1-Dec	2
2-Jan	30
2-Feb	2
2-Mar	2
2-Apr	2
2-May	2
2-Jun	2

2-Jul	
2-Aug	
2-Sep	
2-Oct	
2-Nov	2
2-Dec	44
3-Jan	2
3-Feb	2
3-Mar	2
3-Apr	2
3-May	2
3-Jun	2
3-Jul	2
3-Aug	2
3-Sep	2
3-Oct	2
3-Nov	2
3-Dec	2
4-Jan	16
4-Feb	2
4-Mar	2
4-Apr	2

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Fig 14.12 Trace Elements

Date	As	Cd	Pb	Se
Jun-96	0.0031	0.002	0.0007	0.0003
Jul-96	0.0036	0.007	0.0007	0.0003
Aug-96	0.08	0.022	0.0007	0.0392
Sep-96	0.0002	0.0002	0.0018	0.0026
Oct-96	0.0407	0.0002	0.037	0.0752
Nov-96	0.0002	0.001	0.0036	0.0003
Oct-97	0.0876	0.053	0.0038	0.0007
Dec-98	0.0002	0.002	0.0007	0.0003
Nov-99				
Oct-00	0.0028	0.001	0.0021	0.0003
1-Nov	0.0002	0.001	0.0007	0.0002

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Fig 14.13 Iron, Manganese, Aluminum Load

Date	Fe	Mn	Al
Nov-95	15	0.004	0.046
Dec-95	1	0.027	0.19
Jan-96	2	0.032	0.47
Feb-96	15	0.156	5.57
Mar-96	7.5	0.117	2.9
Apr-96	19	0.297	11
May-96	12	0.362	6.7
Jun-96	15	0.227	2.3
Jul-96	8	0.114	1.3
Aug-96	0	0	0
Sep-96	3	0.05	0.37
Oct-96	7.3	0.126	0.83
Nov-96	5.2	0.115	1.24
Dec-96	12	0.164	2.66
Jan-97	8.8	0.1	1.936
Feb-97	9.6	0.177	1.792
Mar-97	11.2	0.245	1.8
Feb-98	14.8	0.32	3.5
Mar-98	151	9.5	124
Apr-98	12.3	0.276	1.7
May-98	15.8	0.261	4.7
Jun-98	4.5	0.126	0.1
Jul-98	0.8	0.03	0.17
Aug-98	0	0	0
Sep-98	0	0	0
Oct-98	0.38	0.007	0.054
Nov-98	0.38	0.017	0.079
Dec-98	0	0	0
Jan-99	1.5	0.063	0.34
Feb-99	22	0.49	20
Mar-99	5.1	0.19	2.1
Apr-99	5.8	0.16	2.2
May-99	10.3	0.18	2.3
Jun-99	2.2	0.05	0.6
Jul-99	2.8	0.09	1.19
Aug-99	1	0.05	0.86
Sep-99	0	0	0
Oct-99	0.03	0.001	0.016
Nov-99	0.03	0.001	0.031
Dec-99	0.3	0.005	1.1
Jan-00	0.5	0.011	0.2
Feb-00	0.16	0.003	0.017

Mar-00	0.83	0.019	0.32
Apr-00	1.2	2.5	0.66
May-00	2.5	0.22	4.1
Jun-00	1.4	0.02	1.5
Jul-00	0	0	0
Aug-00	0.007	0.001	0.003
Sep-00	0.08	0.002	0.015
Oct-00	0.04	0.003	0.013
Nov-00	0	0	0
Dec-00	1.19	0.048	0.355
1-Jan	0.18	0.018	0.047
1-Feb	1.2	0.054	0.389
1-Mar	0.87	0.024	0.433
1-Apr	1.2	0.097	0.447
1-May	0.54	0.089	0.175
1-Jun	2.4	0.149	0.731
1-Jul	0.18	0.019	0.061
1-Aug	0.337	0.01	0.04
1-Sep	0.079	0.006	0.033
1-Oct	0	0	0
1-Nov	0.023	0.006	0.006
1-Dec	0.023	0.014	0.011
2-Jan	3.8	2	0.739
2-Feb	0.3	0.01	0.144
2-Mar	1.1	0.03	0.238
2-Apr	1.7	0.03	0.476
2-May	0.5	0	0.279
2-Jun	2.3	0.08	0.599
2-Jul	0	0	0
2-Aug	0	0	0
2-Sep	0	0	0
2-Oct	0	0	0
2-Nov	0.08	0.014	0.048
2-Dec	0.3	0.033	0.05
3-Jan	1.6	0.084	0.517
3-Feb	3.4	0.077	0.769
3-Mar	1.1	0.066	0.421
3-Apr	0.9	0.047	0.317
3-May	0.8	0.038	0.184
3-Jun	0.3	0.012	0.087
3-Jul	0.4	0.027	0.101
3-Aug	0.8	0.066	0.285
3-Sep	0.9	0.137	0.209
3-Oct	1.2	0.149	0.563
3-Nov	1.65	0.082	0.38
3-Dec	0.004	0.0002	0.95
4-Jan	7.6	0.28	1.9

4-Feb	1.6	0.029	0.418
4-Mar	1.15	0.018	0.367
4-Apr	1.38	0.144	1.94

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Fig 14.14 Sulfate

Date	
Nov-95	9.5
Dec-95	10.2
Jan-96	12.7
Feb-96	99.1
Mar-96	75.2
Apr-96	153
May-96	149
Jun-96	144
Jul-96	60
Aug-96	0
Sep-96	27
Oct-96	82
Nov-96	100
Dec-96	102
Jan-97	95
Feb-97	139
Mar-97	82
Feb-98	69
Mar-98	1674
Apr-98	122
May-98	128
Jun-98	8.9
Jul-98	10.2
Aug-98	0
Sep-98	0
Oct-98	2.3
Nov-98	9.2
Dec-98	0
Jan-99	25
Feb-99	113
Mar-99	105
Apr-99	95
May-99	72
Jun-99	34
Jul-99	43
Aug-99	11
Sep-99	0
Oct-99	1.4
Nov-99	0.6
Dec-99	28
Jan-00	13
Feb-00	4.2

Mar-00	26
Apr-00	36
May-00	5.4
Jun-00	16
Jul-00	0
Aug-00	0.8
Sep-00	3.3
Oct-00	6.3
Nov-00	0
Dec-00	16
1-Jan	16
1-Feb	28
1-Mar	64
1-Apr	22
1-May	46
1-Jun	53
1-Jul	7.6
1-Aug	5.3
1-Sep	7.1
1-Oct	0
1-Nov	3.75
1-Dec	5.7
2-Jan	63
2-Feb	25
2-Mar	111
2-Apr	60
2-May	100
2-Jun	141
2-Jul	0
2-Aug	0
2-Sep	0
2-Oct	0
2-Nov	22
2-Dec	10
3-Jan	46
3-Feb	106
3-Mar	75
3-Apr	45
3-May	23
3-Jun	25
3-Jul	34
3-Aug	33
3-Sep	64
3-Oct	48
3-Nov	128
3-Dec	0.15
4-Jan	111

4-Feb	65
4-Mar	49
4-Apr	112
May-04	69
Jun-04	42
Jul-04	48
Aug-04	29
Sep-04	25
Oct-04	159
Nov-04	31

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Fig 14.15 Iron Load

Date	
Apr-95	71
May-95	32
Jun-95	38
Jul-95	51
Aug-95	9
Sep-95	7.8
Oct-95	6.8
Nov-95	57
Dec-95	11
Jan-96	37
Feb-96	99
Mar-96	61
Apr-96	87
May-96	116
Jun-96	56
Jul-96	51
Aug-96	14
Sep-96	20
Oct-96	55
Nov-96	58
Dec-96	45
Jan-97	47
Feb-97	45
Mar-97	93
Apr-97	78
May-97	45
Jun-97	56
Jul-97	30
Aug-97	40
Sep-97	55
Oct-97	16
Nov-97	27
Dec-97	31
Jan-98	86
Feb-98	139
Mar-98	220
Apr-98	76
May-98	54
Jun-98	33
Jul-98	22
Aug-98	13
Sep-98	6.6

Oct-98	41
Nov-98	10
Dec-98	10
Jan-99	14
Feb-99	64
Mar-99	18
Apr-99	45
May-99	40
Jun-99	37
Jul-99	47
Aug-99	24
Sep-99	15
Oct-99	12
Nov-99	20
Dec-99	17
Jan-00	10
Feb-00	4
Mar-00	16
Apr-00	49
May-00	9
Jun-00	10
Jul-00	2
Aug-00	2
Aug-00	1
Oct-00	1
Nov-00	1
Dec-00	13
Jan-01	1
Feb-01	74
Mar-01	32
Apr-01	13
May-01	21
Jun-01	22
Jan-02	22
Feb-02	2.3
Mar-02	1.8
Apr-02	16.1
May-02	6.6
Jun-02	11.5
Jul-02	0.59
Aug-02	0
Sep-02	0
Oct-02	0
Nov-02	0.087
Dec-02	0.3
Jan-03	28.8
Feb-03	3.8

Mar-03	11.6
Apr-03	4.42
May-03	2.41
Jun-03	1.28
Jul-03	1.38
Aug-03	9.2
Sep-03	1.9
Oct-03	1.5
Nov-03	1.87
Dec-03	19.6
Jan-04	30.9
Feb-04	38.7
Mar-04	38.1
Apr-04	19.25

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Fig 14.16 Manganese Load

Date	
Apr-95	1.5
May-95	0.9
Jun-95	1.05
Jul-95	1.04
Aug-95	0.019
Sep-95	0.019
Oct-95	0.2
Nov-95	0.8
Dec-95	0.3
Jan-96	0.8
Feb-96	1.5
Mar-96	1.14
Apr-96	1.58
May-96	3.38
Jun-96	2.43
Jul-96	0.8
Aug-96	0.44
Sep-96	0.49
Oct-96	1.5
Nov-96	1.2
Dec-96	1.64
Jan-97	0.75
Feb-97	0.9
Mar-97	1.79
Apr-97	1.7
May-97	0.86
Jun-97	0.92
Jul-97	1.1
Aug-97	0.92
Sep-97	1.67
Oct-97	0.338
Nov-97	0.737
Dec-97	0.789
Jan-98	1.56
Feb-98	2.87
Mar-98	11.4
Apr-98	1.38
May-98	0.82
Jun-98	0.56
Jul-98	0.45
Aug-98	0.31
Sep-98	0.83

Oct-98	0.439
Nov-98	0.165
Dec-98	0.202
Jan-99	0.323
Feb-99	1.513
Mar-99	0.514
Apr-99	1.044
May-99	0.855
Jun-99	0.943
Jul-99	1.695
Aug-99	0.643
Sep-99	0.529
Oct-99	0.38
Nov-99	0.486
Dec-99	0.368
Jan-00	0.206
Feb-00	0.131
Mar-00	0.383
Apr-00	3.415
May-00	0.437
Jun-00	0.302
Jul-00	0.087
Aug-00	0.086
Aug-00	0.002
Oct-00	0.0024
Nov-00	0.052
Dec-00	0.394
Jan-01	0.058
Feb-01	2.085
Mar-01	1.535
Apr-01	0.556
May-01	0.74
Jun-01	1.773
2-Jan	2.64
2-Feb	0.15
2-Mar	0.09
2-Apr	0.61
2-May	0.36
2-Jun	0.59
2-Jul	0.04
2-Aug	0
2-Sep	0
2-Oct	0
2-Nov	0.014
2-Dec	0.03
3-Jan	0.92
3-Feb	0.112

3-Mar	1.38
3-Apr	0.323
3-May	0.317
3-Jun	0.119
3-Jul	0.094
3-Aug	0.467
3-Sep	0.23
3-Oct	0.185
3-Nov	0.108
3-Dec	0.951
4-Jan	3.14
4-Feb	1.09
4-Mar	1.98
4-Apr	1.26

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Fig 14.17 Aluminum Load

Date	
Apr-95	20
May-95	10
Jun-95	12
Jul-95	14
Aug-95	2.4
Sep-95	2.4
Oct-95	2.7
Nov-95	14.8
Dec-95	4.7
Jan-96	17
Feb-96	43
Mar-96	29
Apr-96	43
May-96	73
Jun-96	23
Jul-96	9.8
Aug-96	4.5
Sep-96	5.7
Oct-96	17.6
Nov-96	16
Dec-96	21
Jan-97	10
Feb-97	11
Mar-97	24
Apr-97	18
May-97	10
Jun-97	4.8
Jul-97	10
Aug-97	11
Sep-97	16
Oct-97	4.3
Nov-97	7.7
Dec-97	7.5
Jan-98	20.6
Feb-98	36
Mar-98	149
Apr-98	5
May-98	12
Jun-98	0.84
Jul-98	5.8
Aug-98	4.3
Sep-98	1.35

Oct-98	6.7
Nov-98	1.75
Dec-98	2.56
Jan-99	3.86
Feb-99	33.6
Mar-99	7.95
Apr-99	16.3
May-99	11.32
Jun-99	20.5
Jul-99	27
Aug-99	14.3
Sep-99	7.8
Oct-99	9.3
Nov-99	15.7
Dec-99	14.5
Jan-00	6.4
Feb-00	3.7
Mar-00	9.7
Apr-00	19.8
May-00	8.2
Jun-00	8.3
Jul-00	1.8
Aug-00	1.7
Aug-00	0.015
Oct-00	0.013
Nov-00	0.817
Dec-00	0.759
Jan-01	0.855
Feb-01	32.3
Mar-01	16
Apr-01	7.4
May-01	8.4
Jun-01	16
Jan-02	8.86
Feb-02	2.1
Mar-02	1.04
Apr-02	12.1
May-02	4.2
Jun-02	5.46
Jul-02	0.556
Aug-02	0
Sep-02	0
Oct-02	0
Nov-02	0.048
Dec-02	0.05
Jan-03	9.5
Feb-03	1.18

Mar-03	15
Apr-03	4.43
May-03	5.17
Jun-03	1.17
Jul-03	0.66
Aug-03	4.6
Sep-03	1.03
Oct-03	0.871
Nov-03	0.624
Dec-03	8.32
Jan-04	13
Feb-04	9.9
Mar-04	14.9
Apr-04	8.3

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Fig 14.18 Acidity Load

Date	
Apr-95	269
May-95	183
Jun-95	224
Jul-95	274
Aug-95	41
Sep-95	38
Oct-95	31
Nov-95	208
Dec-95	59
Jan-96	178
Feb-96	363
Mar-96	266
Apr-96	250
May-96	659
Jun-96	170
Jul-96	127
Aug-96	94
Sep-96	115
Oct-96	1046
Nov-96	453
Dec-96	659
Jan-97	233
Feb-97	316
Mar-97	627
Apr-97	314
May-97	32
Jun-97	61
Jul-97	147
Aug-97	158
Sep-97	211
Oct-97	76
Nov-97	109
Dec-97	111
Jan-98	396
Feb-98	443
Mar-98	662
Apr-98	265
May-98	178
Jun-98	103
Jul-98	75
Aug-98	64
Sep-98	31

Oct-98	91
Nov-98	44
Dec-98	36
Jan-99	70
Feb-99	313
Mar-99	100
Apr-99	209
May-99	143
Jun-99	221
Jul-99	294
Aug-99	129
Sep-99	19
Oct-99	85
Nov-99	131
Dec-99	133
Jan-00	55
Feb-00	39
Mar-00	88
Apr-00	215
May-00	95
Jun-00	57
Jul-00	4
Aug-00	14
Aug-00	0
Oct-00	0
Nov-00	8
Dec-00	77
Jan-01	8
Feb-01	274
Mar-01	169
Apr-01	77
May-01	101
Jun-01	131
2-Jan	115
2-Feb	18
2-Mar	17
2-Apr	91
2-May	47
2-Jun	57
2-Jul	6.1
2-Aug	0
2-Sep	0
2-Oct	0
2-Nov	0
2-Dec	1.1
3-Jan	103
3-Feb	4.1

3-Mar	103
3-Apr	35
3-May	47
3-Jun	12
3-Jul	7
3-Aug	47
3-Sep	9
3-Oct	4
3-Nov	3.6
3-Dec	134
4-Jan	209
4-Feb	138
4-Mar	225
4-Apr	112

Wildwood

Fig 15.1a Iron & Manganese

Date	Fe	Mn
Feb-94	9.3	4.6
Mar-94	503	28.3
Apr-94	42.2	4.3
May-94	30.3	3.2
Jun-94	344	15.7
Jul-94	4.81	1.7
Nov-94	0.7	1.25
Dec-94	0.29	1.14
Apr-95	0.04	0.08
May-95	0.04	0.04
Aug-95	0.04	0.84
Nov-95	0.41	0.72
Jan-96	0.18	0.04
Apr-96	1.07	0.22
Jul-96	0.39	0.15

Wildwood

Fig 15.1b Manganese

Date	
2/25/1994	0.94
3/31/1994	0.86
4/26/1994	0.33
5/27/1994	0.22
6/29/1994	5.04
7/28/1994	0.18
11/23/1994	0.27
4/12/1995	0.17
5/22/1995	0.2
8/18/1995	0.2
11/8/1995	0.2
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/1/1997	
4/25/1997	0.12
9/16/1997	
10/22/1997	
3/24/1998	
5/28/1998	4.36
9/29/1998	0.07
11/24/1998	0.21
3/1/1999	0.04
5/24/1999	0.06
8/20/1999	0.14
10/19/1999	0.57
2/24/2000	1.99
4/18/2000	1.31
7/25/2000	
11/20/2000	
3/16/2001	

Wildwood

Fig 15.2a Sulfates

Date	
Feb-94	782
Mar-94	825
Apr-94	804
May-94	1013
Jun-94	862
Jul-94	880
Nov-94	616
Dec-94	604
Apr-95	501
May-95	525
Aug-95	440
Nov-95	441
Jan-96	437
Apr-96	424
Jul-96	382

Wildwood

Fig 15.2b Sulfates

Date	
2/25/1994	156.4
3/31/1994	158.2
4/26/1994	143
5/27/1994	158
6/29/1994	66.9
7/28/1994	138
11/23/1994	118.2
4/12/1995	82
5/22/1995	104.6
8/18/1995	42.5
11/8/1995	44.1
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/1/1997	
4/25/1997	18.4
9/16/1997	
10/22/1997	
3/24/1998	
5/28/1998	641.4
9/29/1998	348.4
11/24/1998	313.9
3/1/1999	234.1
5/24/1999	187.5
8/20/1999	178.8
10/19/1999	197.5
2/24/2000	148.3
4/18/2000	824.9
7/25/2000	
11/20/2000	
3/16/2001	

Wildwood

Fig 15.3a pH

Date	
Feb-94	7.7
1-Mar	6.9
Apr-94	7.5
May-94	7.3
Jun-94	7.3
Jul-94	7.2
Nov-94	7.4
Dec-94	7
Apr-95	7.4
May-95	7.07
Aug-95	7.25
Nov-95	7.11
Jan-96	7.13
Apr-96	7.3
Jul-96	7.32
Oct-96	

Wildwood
Fig 15.3b pH

Date	
2/25/1994	7.5
3/31/1994	7.7
4/26/1994	8.1
5/27/1994	8
6/29/1994	7.8
7/28/1994	8
11/23/1994	7.8
4/12/1995	7.9
5/22/1995	7.72
8/18/1995	7.52
11/8/1995	7.12
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/1/1997	
4/25/1997	7.37
9/16/1997	
10/22/1997	
3/24/1998	
5/28/1998	
9/29/1998	6.8
11/24/1998	7.3
3/1/1999	7.3
5/24/1999	7.2
8/20/1999	6.8
10/19/1999	6.9
2/24/2000	7.2
4/18/2000	7
7/25/2000	
11/20/2000	
3/16/2001	

Wildwood

Fig 15.4a Acidity

Date	
Feb-94	0.2
Mar-94	0
Apr-94	0
May-94	0
Jun-94	0
Jul-94	0
Nov-94	0
Dec-94	0
Apr-95	0
May-95	0
Aug-95	0
Nov-95	0
Jan-96	0
Apr-96	0
Jul-96	0
Oct-96	0

Wildwood

Fig 15.4b Alkalinity

Date	
2/25/1994	165.75
3/31/1994	189.09
4/26/1994	195.63
5/27/1994	210.67
6/29/1994	254.61
7/28/1994	279.68
11/23/1994	325.68
4/12/1995	353.21
5/22/1995	369.88
8/18/1995	439.85
11/8/1995	465.81
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/1/1997	
4/25/1997	487.11
9/16/1997	
10/22/1997	
3/24/1998	
5/28/1998	230.48
9/29/1998	278.06
11/24/1998	291.53
3/1/1999	294.39
5/24/1999	282.76
8/20/1999	277.79
10/19/1999	266.78
2/24/2000	284.31
4/18/2000	271.59
7/25/2000	
11/20/2000	
3/16/2001	

Wildwood

Fig 15.5a Total Dissolved Solids

Date	
Feb-94	1415
Mar-94	1690
Apr-94	1700
May-94	1700
Jun-94	1690
Jul-94	1670
Nov-94	1200
Dec-94	1250
Apr-95	1260
May-95	1200
Aug-95	1230
Nov-95	1090
Jan-96	980
Apr-96	920
Jul-96	880
Oct-96	

Wildwood

Fig 15.5b Total Dissolved Solids

Date	
2/25/1994	700
3/31/1994	690
4/26/1994	680
5/27/1994	780
6/29/1994	810
7/28/1994	880
11/23/1994	760
4/12/1995	920
5/22/1995	880
8/18/1995	910
11/8/1995	900
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/1/1997	
4/25/1997	776
9/16/1997	
10/22/1997	
3/24/1998	
5/28/1998	1064
9/29/1998	840
11/24/1998	772
3/1/1999	670
5/24/1999	587
8/20/1999	553
10/19/1999	556
2/24/2000	616
4/18/2000	564
7/25/2000	
11/20/2000	
3/16/2001	

Wildwood

Fig 15.6a Trace Elements

Date	Arsenic	Cadmium	Lead	Selenium
Feb-94	0.0032	0.006	0.08	0.001
Mar-94	0.0026	0.061	0.207	0.0004
Apr-94	0.0415	0.012	0.0367	0.0487
May-94	0.1	0.02	0.02	0.003
Jun-94	0.009	0.02	0.29	0.05
Jul-94	0.009	0.009	0.004	0.006
Nov-94	0.007	0.012	0.076	0.006
Dec-94	0.0024	0.003	0.0023	0.0003

Wildwood
Fig 15.6b Chloride

Date	
2/25/1994	18.3
3/31/1994	17.99
4/26/1994	18.99
5/27/1994	17.99
6/29/1994	23.49
7/28/1994	22.99
11/23/1994	23.99
4/12/1995	31.99
5/22/1995	29.99
8/18/1995	27.99
11/8/1995	30.72
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/1/1997	
4/25/1997	40.8
9/16/1997	
10/22/1997	
3/24/1998	
5/28/1998	25.3
9/29/1998	19.43
11/24/1998	17.76
3/1/1999	26.46
5/24/1999	25.59
8/20/1999	18.48
10/19/1999	20.3
2/24/2000	25.57
4/18/2000	116.86
7/25/2000	
11/20/2000	
3/16/2001	

Wildwood

Fig 15.6c Calcium

Date	
2/25/1994	67.5
3/31/1994	52.9
4/26/1994	40.5
5/27/1994	34.35
6/29/1994	17.37
7/28/1994	18.29
11/23/1994	18.94
1/31/1996	13.3
1/20/1997	15.15
3/24/1998	
3/1/1999	161.86
2/24/2000	68.48

Wildwood

Fig 15.7a Iron & Manganese

Date	Fe	Mn
Feb-94	34	60
Mar-94	7.5	35.9
Apr-94	9.8	40
May-94	8.5	40
Jun-94	13	42
Jul-94	6.7	37
Apr-95	0.07	11
May-95	0.74	14
Aug-95	0.06	12
Oct-95	4.1	7
Jan-96	0.29	3.6
Apr-96	0.27	4
Jul-96	0.48	5.5
Oct-96	0.23	4.12
Jan-97		
Apr-97		
Sep-97	0.09	2.54
Oct-97	0.12	3.55
Mar-98	0.14	0.11
May-98	0.13	3.4
Sep-98	0.61	3.2
Nov-98	30	11
Mar-99	0.35	1.4
May-99	0.17	0.04
Aug-99	0.04	0.35
Oct-99	0.91	20
Feb-00	0.23	7.5
Apr-00	0.66	8.6
Jul-00	0.73	7.5
Nov-00	0.56	6.87
Mar-01	1.46	1.71
1-Sep	0.27	11.8
1-Oct	0.98	14.9
2-Feb	0.97	0.04
2-Apr	1.26	0.02

Wildwood
Fig 15.7b Manganese

Date	
2/25/1994	16.75
3/31/1994	20.1
4/26/1994	0.86
5/27/1994	0.36
6/29/1994	0.62
7/28/1994	0.32
11/23/1994	0.25
12/15/1994	1.18
4/12/1995	0.26
5/22/1995	0.25
8/18/1995	0.26
10/13/1995	0.27
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/20/1997	5.51
4/25/1997	4.04
9/16/1997	3.12
10/22/1997	2.84
3/24/1998	2.31
5/28/1998	2.29
9/29/1998	1.98
11/24/1998	1.41
3/1/1999	0.85
5/24/1999	0.89
8/20/1999	<0.02
10/19/1999	0.42
2/24/2000	0.3
4/18/2000	0.02
7/25/2000	0.07
11/20/2000	1.22
3/16/2001	0.3
6/19/2001	<0.02
9/6/2001	0.56
10/19/2001	0.63
2/1/2002	0.39
4/12/2002	0.21

Wildwood
Fig 15.7c Iron

Date	
2/25/1994	
3/31/1994	1.08
4/26/1994	0.69
5/27/1994	0.88
6/29/1994	1.5
7/28/1994	0.67
11/23/1994	0.12
12/15/1994	0.1
4/12/1995	<0.04
5/22/1995	0.06
8/18/1995	0.11
10/13/1995	0.7
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/20/1997	0.8
4/25/1997	0.09
9/16/1997	0.1
10/22/1997	0.07
3/24/1998	0.13
5/28/1998	
9/29/1998	1.29
11/24/1998	0.69
3/1/1999	1.28
5/24/1999	0.12
8/20/1999	0.07
10/19/1999	0.13
2/24/2000	0.05
4/18/2000	0.1
7/25/2000	0.08
11/20/2000	1.64
3/16/2001	1.35
6/19/2001	0.16
9/6/2001	0.29
10/19/2001	1.05
2/1/2002	0.1
4/12/2002	0.27

Wildwood

Fig 15.8a Sulfates

Date	
Feb-94	3683
Mar-94	3989
Apr-94	3725
May-94	4187
Jun-94	4167
Jul-94	4891
Apr-95	4032
May-95	3901
Aug-95	3864
Oct-95	4183
Jan-96	3619
Apr-96	3224
Jul-96	2532
Oct-96	2790
Jan-97	
Apr-97	
Sep-97	2179
Oct-97	2583
Mar-98	1174
May-98	2349
Sep-98	2319
Nov-98	2351
Mar-99	1367
May-99	1397
Aug-99	1416
Oct-99	2443
Feb-00	1731
Apr-00	1864
Jul-00	2265
Nov-00	1457
Mar-01	1600
1-Sep	1467
1-Oct	1829
2-Feb	1482
2-Apr	1053

Wildwood

Fig 15.8b Sulfates

Date	
2/25/1994	1720.1
3/31/1994	1892
4/26/1994	300.1
5/27/1994	250
6/29/1994	289
7/28/1994	318.3
11/23/1994	244.1
12/15/1994	1721
4/12/1995	235
5/22/1995	232.5
8/18/1995	221.1
10/13/1995	329.8
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/20/1997	497.5
4/25/1997	1073.1
9/16/1997	1128.5
10/22/1997	917.9
3/24/1998	971.4
5/28/1998	871.7
9/29/1998	912.1
11/24/1998	718.8
3/1/1999	525.1
5/24/1999	1141.5
8/20/1999	626.1
10/19/1999	610.2
2/24/2000	468.4
4/18/2000	584.8
7/25/2000	952.4
11/20/2000	
3/16/2001	674.3
6/19/2001	408.4
9/6/2001	631.8
10/19/2001	450.8
2/1/2002	609.9
4/12/2002	312.1

Wildwood
Fig 15.9 TDS

Date	
Feb-94	5555
Mar-94	
Apr-94	
May-94	5382
Jun-94	5434
Jul-94	5512
Apr-95	4652
May-95	4528
Aug-95	4646
Oct-95	4196
Jan-96	4000
Apr-96	4120
Jul-96	3874
Oct-96	3752
Jan-97	
Apr-97	
Sep-97	2617
Oct-97	2312
Mar-98	2499
May-98	2389
Sep-98	2602
Nov-98	2579
Mar-99	1556
May-99	1537
Aug-99	1629
Oct-99	2391
Feb-00	1846
Apr-00	1926
Jul-00	2014
Nov-00	1971
Mar-01	1979
1-Sep	2168
1-Oct	2216
2-Feb	2387
2-Apr	2159

Wildwood

Fig 15.10a pH

Date	
Feb-94	4
Mar-94	7
Apr-94	5
May-94	5.8
Jun-94	5.3
Jul-94	5.8
Apr-95	7.2
May-95	6.8
Aug-95	7.1
Oct-95	7.1
Jan-96	6.9
Apr-96	7
Jul-96	7
Oct-96	7.8
Sep-97	7.5
Oct-97	7.6
Mar-98	7.7
May-98	
Sep-98	7
Nov-98	7.4
Mar-99	7.9
May-99	7.7
Aug-99	7.4
Oct-99	6.9
Feb-00	7.8
Apr-00	7.8
Jul-00	7.5
Nov-00	7.8
Mar-01	8.5
1-Sep	7.7
1-Oct	7.6
2-Feb	8.2
2-Apr	8.3

Wildwood
Fig 15.10b pH

Date	
2/25/1994	7.5
3/31/1994	6.7
4/26/1994	6.8
5/27/1994	6.7
6/29/1994	7.1
7/28/1994	6.6
11/23/1994	7.2
12/15/1994	7.5
1/11/1995	6.7
4/12/1995	6.9
5/22/1995	6.68
8/18/1995	7.1
12/13/1995	7.2
1/1/1996	
4/1/1996	
7/1/1996	
10/28/1996	6.81
1/20/1997	7.36
4/25/1997	7.7
9/16/1997	7.22
10/22/1997	7.3
3/24/1998	
5/28/1998	
9/29/1998	6.8
11/24/1998	7.6
3/1/1999	7.2
5/24/1999	7.2
8/20/1999	7
10/19/1999	7.4
2/24/2000	7.4
4/18/2000	7.4
7/25/2000	
11/20/2000	
3/16/2001	
6/19/2001	
9/6/2001	
10/19/2001	
2/1/2002	
4/12/2002	

Wildwood

Fig 15.11a Acidity

Date	
Feb-94	180
Mar-94	116
Apr-94	149
May-94	59
Jun-94	67
Jul-94	92
Apr-95	0
May-95	0
Aug-95	0
Oct-95	0
Jan-96	0
Apr-96	0
Jul-96	0
Oct-96	0
Jan-97	
Apr-97	
Sep-97	0
Oct-97	0
Mar-98	0
May-98	0
Sep-98	0
Nov-98	0
Mar-99	0
May-99	0
Aug-99	0
Oct-99	0
Feb-00	0
Apr-00	0
Jul-00	0
Nov-00	0
Mar-01	0
Jun-01	
1-Sep	0
1-Oct	0
1-Feb	0
1-Apr	0

Wildwood

Fig 15.11b Alkalinity

Date	
Feb-94	<0.4
Mar-94	2.08
Apr-94	2.28
May-94	6.99
Jun-94	7.76
Jul-94	17.44
Apr-95	61.49
May-95	58.32
Aug-95	101.54
Oct-95	136.79
Jan-96	91.03
Apr-96	75.59
Jul-96	72.89
Oct-96	134.83
Mar-97	
Jul-97	
Sep-97	125.49
Oct-97	148.91
Mar-98	113.45
May-98	113.76
Sep-98	130.94
Nov-98	125.61
Mar-99	147.33
May-99	167.08
Aug-99	157.21
Oct-99	147.73
Feb-00	355.35
Apr-00	347.81
Jul-00	278.23
Nov-00	464.85
Mar-01	564.43
Jun-01	
1-Sep	297.59
1-Oct	273.8
2-Feb	408.72
2-Apr	424.86

Wildwood

Fig 15.11c Alkalinity

Date	
2/25/1994	<0.4
3/31/1994	0
4/26/1994	563.51
5/27/1994	533.33
6/29/1994	500.68
7/28/1994	493.93
11/23/1994	540.05
12/15/1994	257.59
4/12/1995	522.33
5/22/1995	515.6
8/18/1995	486.38
10/13/1995	468.95
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/20/1997	168.6
4/25/1997	85.23
9/16/1997	85.01
10/22/1997	102.37
3/24/1998	113.12
5/28/1998	184.02
9/29/1998	187.46
11/24/1998	254.04
3/1/1999	265.57
5/24/1999	259.94
8/20/1999	255.96
10/19/1999	289.4
2/24/2000	297.13
4/18/2000	311.1
7/25/2000	308.82
11/20/2000	
3/16/2001	367.86
6/19/2001	373.37
9/6/2001	460.91
10/19/2001	484.52
2/1/2002	493.67
4/12/2002	478.61

Wildwood

Fig 15.11d Alklinity

Date	
2/25/1994	249.1
3/31/1994	258.68
4/26/1994	242.02
5/27/1994	244.39
6/29/1994	237.24
7/28/1994	251.28
11/23/1994	254.16
12/15/1994	320.75
1/11/1995	267.23
4/12/1995	266.4
5/22/1995	276.77
8/18/1995	254.8
12/13/1995	249.26
1/1/1996	
4/1/1996	
7/1/1996	
10/28/1996	241.79
1/20/1997	247.55
4/25/1997	248.81
9/16/1997	251.03
10/22/1997	272.1
3/24/1998	
5/28/1998	264.08
9/29/1998	256.21
11/24/1998	255.1
3/1/1999	261.34
5/24/1999	155.02
8/20/1999	233.43
10/19/1999	238.53
2/24/2000	246.61
4/18/2000	201.45
7/25/2000	
11/20/2000	
3/16/2001	
6/19/2001	
9/6/2001	
10/19/2001	
2/1/2002	
4/12/2002	

Wildwood

Fig 15.12a Trace Elements

Date	As	Cd	Pb	Se
Feb-94	0.0236	0.012	0.23	<0.001
Mar-94	0.0011	0.036	0.0036	0.0076
Apr-94	0.056	0.035	0.0085	0.1279
May-94	0.0095	0.038	<0.0007	0.0095
Jun-94	0.0152	0.027	<0.0007	<0.0003
Jul-94	0.0131	0.026	<0.0007	0.0067
Jan-96	0.0058	0.02	<0.0007	<0.0003
Jan-97	<0.0002	0.023	<0.0007	0.002
Mar-98	0.0029	0.002	0.0001	0.0037
Mar-99	0.0053	<0.001	0.0046	0.0014
Feb-00	0.0075	<0.001	0.0015	0.0012
Mar-01	0.0088	<0.001	0.0046	0.086
Feb-02	<0.0002	<0.001	0.0045	<0.0008

Wildwood

Fig 15.12b Fluoride

Date	
Feb-94	1.053
Mar-94	0.73
Apr-94	1.28
May-94	0.88
Jun-94	0.88
Jul-94	0.95
Apr-95	1.04
22-May	1.05
8/18/1995	1.05
10/13/1995	5.95
1/31/1996	4.56
4/29/1996	4.2
7/31/1996	0.16
10/28/1996	0.76
9/16/1997	5.17
10/22/1997	4.47
3/24/1998	3.9
5/28/1998	3.52
9/29/1998	0.65
11/24/1998	4.06
3/1/1999	2.12
5/24/1999	2.25
8/20/1999	2.83
10/19/1999	4.22
2/24/2000	4.61
4/18/2000	3.86
7/25/2000	2.82
11/20/2000	2.99
3/16/2001	2.46
9/6/2001	3.51
10/19/2001	3.19
2/1/2002	1.05
4/12/2002	2.83

Wildwood

Fig 15.12c Fluoride

Date	
2/25/1994	0.2
3/31/1994	0.14
4/26/1994	0.19
5/27/1994	0.14
6/29/1994	0.19
7/28/1994	0.19
11/23/1994	0.15
12/15/1994	0.86
1/11/1995	0.15
4/12/1995	0.21
5/22/1995	0.14
8/18/1995	0.17
12/13/1995	2.61
1/1/1996	
4/1/1996	
7/1/1996	
10/28/1996	2.75
1/20/1997	2.54
4/25/1997	2.37
9/16/1997	2.96
10/22/1997	2.29
3/24/1998	
5/28/1998	1.9
9/29/1998	0.03
11/24/1998	2.15
3/1/1999	1.79
5/24/1999	1.43
8/20/1999	2.12
10/19/1999	1.46
2/24/2000	<0.01
4/18/2000	<0.01
7/25/2000	
11/20/2000	
3/16/2001	
6/19/2001	
9/6/2001	
10/19/2001	
2/1/2002	
4/12/2002	

Wildwood

Fig 15.12d Sodium

Date	
Feb-94	145.75
Mar-94	257.63
Apr-94	108.63
May-94	138.13
Jun-94	125.5
Jul-94	102.75
Apr-95	122
May-95	105.38
Aug-95	68.88
Oct-95	129.5
Jan-96	7.23
Apr-96	121.88
Jul-96	114.88
Oct-96	94.38
Sep-97	21.25
Oct-97	
Mar-98	115.28
May-98	102.5
Sep-98	103.75
Nov-98	115
Mar-99	110.61
May-99	121.25
Aug-99	101.25
Oct-99	87.42
Feb-00	118.4
Apr-00	246.64
Jul-00	207.88
Nov-00	231.25
Mar-01	182.28
1-Sep	268.75
1-Oct	219.82
2-Feb	113.64
2-Apr	356.92

Wildwood

Fig 15.12e Chloride

Date	
2/25/1994	48.5
3/31/1994	44.99
4/26/1994	99.97
5/27/1994	114.96
6/29/1994	110.47
7/28/1994	114.96
11/23/1994	115.96
12/15/1994	199.94
4/12/1995	104.97
5/22/1995	102.47
8/18/1995	109.97
10/13/1995	138.49
1/1/1996	
4/1/1996	
7/1/1996	
10/1/1996	
1/20/1997	56.31
4/25/1997	78.9
9/16/1997	104.58
10/22/1997	88.67
3/24/1998	110.85
5/28/1998	110.05
9/29/1998	105.22
11/24/1998	186.4
3/1/1999	124.26
5/24/1999	215.2
8/20/1999	110.26
10/19/1999	123.45
2/24/2000	145.78
4/18/2000	149.86
7/25/2000	127.14
11/20/2000	
3/16/2001	120.68
6/19/2001	178.75
9/6/2001	64.42
10/19/2001	99.3
2/1/2002	311.55
4/12/2002	139.98

Wildwood

Fig 15.12f Chloride

Date	
2/25/1994	136.3
3/31/1994	165.95
4/26/1994	189.94
5/27/1994	210.93
6/29/1994	217.43
7/28/1994	209.93
11/23/1994	179.94
12/15/1994	21.99
1/11/1995	182.44
4/12/1995	184.94
5/22/1995	164.95
8/18/1995	179.94
12/13/1995	635.2
1/1/1996	
4/1/1996	
7/1/1996	
10/28/1996	238.35
1/20/1997	158.3
4/25/1997	256.1
9/16/1997	233.25
10/22/1997	146.68
3/24/1998	
5/28/1998	182.8
9/29/1998	165.6
11/24/1998	146.75
3/1/1999	152.9
5/24/1999	101.8
8/20/1999	131.22
10/19/1999	144.1
2/24/2000	179.12
4/18/2000	139.28
7/25/2000	
11/20/2000	
3/16/2001	
6/19/2001	
9/6/2001	
10/19/2001	
2/1/2002	
4/12/2002	

Wildwood

Fig 15.12g Calcium

Date	
2/25/1994	189
3/31/1994	64.2
4/26/1994	69.85
5/27/1994	52.1
6/29/1994	58.45
7/28/1994	67.25
11/23/1994	52.75
12/15/1994	320.25
3/1/1995	
1/31/1996	55.05
1/20/1997	184.5
3/24/1998	185.88
3/10/1999	105.25
2/24/2000	107.57
3/16/2001	91.8
2/1/2002	99.76

Wildwood

Fig 15.13 Iron, Mangaese, Aluminum

Date	Fe	Mn	Al
Oct-93			
Nov-93			
Dec-93			
Jan-94			
Feb-94			
Mar-94			
Apr-94			
May-94	1.4	29	
Jun-94	0.93	31	55
Jul-94	0.88	36	10
Aug-94	0.57	32	47
Sep-94	0.6	31	46
Oct-94	0.9	32	23
Nov-94	1	27	52
Dec-94	1.6	30	50
Jan-95	1.8	27	50
Feb-95	2.1	28	47
Mar-95	1.6	27	54
Apr-95	1.5	28	52
May-95	1.2	29	52
Jun-95	1.4	30	47
Jul-95	1.5	30	46
Aug-95	0.9	28	44
Sep-95	0.64	32	51
Oct-95	0.57	32	28
Nov-95	0.51	25	33
Dec-95	0.47	29	50
Jan-96	0.64	27	52
Feb-96	1.1	25	39
Mar-96	1.8	24	43.5
Apr-96			
May-96	1.7	23	40
Jun-96			
Jul-96	1.4	24	49
Aug-96	1.2	29	48
Sep-96			
Oct-96	0.67	27	54
Nov-96			
Dec-96	1.8	24	45
Jan-97	1.43	24	63
Feb-97	1.4	25	46
Mar-97	1.44	23	47

Apr-97	1.1	21	53
May-97	1.1	22	55
Jun-97	1.1	20	53
Jul-97	1	24	
Aug-97	0.7	27	8.3
Sep-97	0.6	23	44
Oct-97	0.5	24	51
Nov-97	0.6	25	50
Dec-97			
Jan-98			
Feb-98			
Mar-98			
Apr-98			
May-98			
Jun-98			
Jul-98			
Aug-98			
Sep-98			
Oct-98			
Nov-98			
Dec-98			
Jan-99			
Feb-99			
Mar-99			
Apr-99			
May-99			
Jun-99			
Jul-99	0.7	19	33
Aug-99	3.4	21	43
Sep-99	0.55	22	37
Oct-99	0.44	24	43
Nov-99	0.48	25	54
Dec-99	0.59	26	47
Jan-00	0.45	32	42
Feb-00	0.4	34	43
Mar-00	0.35	28	31
Apr-00	0.55	26	41
May-00	0.58	24	41
Jun-00	0.98	26	46
Jul-00	0.63	24	41
Aug-00	0.66	25	45
Sep-00	0.59	26	49
Oct-00	0.58	26	53
Nov-00	0.59	22	56
Dec-00			
1-Jan			
1-Feb	0.52	28	63

1-Mar	0.59	31	63
1-Apr	0.83	26	44
1-May	0.62	24	51
1-Jun	0.66	24	39
1-Jul	0.55	21	53
1-Aug	0.49	20	47
1-Sep	0.42	21	46
1-Oct	0.46	21	46
1-Nov	0.38	21	47
1-Dec	0.71	20	46
2-Jan	0.51	23	54
2-Feb	0.61	23	50
2-Mar	0.58	23	53
2-Apr	0.65	32	44
2-May	0.53	28	40
2-Jun	0.54	25.8	41

Wildwood

Fig 15.14 Sulfates & Total Dissolved Solids

Date	Sulfates	TDS
Oct-93		
Nov-93		
Dec-93		
Jan-94		
Feb-94		
Mar-94		
Apr-94		
May-94	5083	
Jun-94	5852	6290
Jul-94	6076	5938
Aug-94	6058	6558
Sep-94	5573	6054
Oct-94	4702	5500
Nov-94	4675	5560
Dec-94	4371	5230
Jan-95	3533	4850
Feb-95	4038	4674
Mar-95	4274	4868
Apr-95	4547	5088
May-95	4476	5106
Jun-95	4098	4960
Jul-95	4480	4966
Aug-95	4660	5300
Sep-95	5051	5344
Oct-95	5536	5674
Nov-95	5490	5758
Dec-95	4892	5552
Jan-96	4885	4996
Feb-96	3080	4564
Mar-96	3119	
Apr-96		
May-96	4018	4144
Jun-96		
Jul-96	3527	4664
Aug-96	3586	4802
Sep-96		
Oct-96	4481	4980
Nov-96		
Dec-96	2968	4120
Jan-97	3030	3203
Feb-97	2810	3119
Mar-97	2945	

Apr-97	2651	2888
May-97	5181	2953
Jun-97	2462	2785
Jul-97	3339	
Aug-97	4938	3113
Sep-97	3178	3157
Oct-97	2375	2915
Nov-97	2085	2740
Dec-97		
Jan-98		
Feb-98		
Mar-98		
Apr-98		
May-98		
Jun-98		
Jul-98		
Aug-98		
Sep-98		
Oct-98		
Nov-98		
Dec-98		
Jan-99		
Feb-99		
Mar-99		
Apr-99		
May-99		
Jun-99		
Jul-99	2620	2382
Aug-99	2770	2490
Sep-99	2497	2814
Oct-99	3837	2652
Nov-99	4383	2915
Dec-99	4832	2861
Jan-00	2463	2931
Feb-00	3816	2976
Mar-00	4751	2901
Apr-00	5136	2657
May-00	3320	2737
Jun-00	4951	2840
Jul-00	3879	2832
Aug-00	3607	2817
Sep-00	3998	2936
Oct-00	4585	2937
Nov-00	3581	2883
Dec-00		
1-Jan		
1-Feb	3182	2945

1-Mar	3436	2911
1-Apr	3078	2791
1-May	2936	2671
1-Jun	3478	2779
1-Jul	3247	2612
1-Aug	6746	2562
1-Sep	3767	2636
1-Oct	2987	2689
1-Nov	2535	3101
1-Dec	2830	2741
2-Jan	3186	3022
2-Feb	3856	3054
2-Mar	2782	3039
2-Apr	2590	3050
2-May	2399	2867
2-Jun	2163	2795

Wildwood

Fig 15.15 Acidity

Date	
Oct-93	
Nov-93	
Dec-93	
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	454
Jun-94	499
Jul-94	452
Aug-94	456
Sep-94	531
Oct-94	467
Nov-94	458
Dec-94	482
Jan-95	436
Feb-95	453
Mar-95	424
Apr-95	431
May-95	433
Jun-95	419
Jul-95	428
Aug-95	436
Sep-95	463
Oct-95	446
Nov-95	388
Dec-95	400
Jan-96	440
Feb-96	391
Mar-96	418
Apr-96	
May-96	420
Jun-96	
Jul-96	472
Aug-96	402
Sep-96	
Oct-96	387
Nov-96	
Dec-96	396
Jan-97	426
Feb-97	414
Mar-97	385

Apr-97	448
May-97	423
Jun-97	415
Jul-97	420
Aug-97	415
Sep-97	414
Oct-97	381
Nov-97	446
Dec-97	
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	
Apr-99	
May-99	
Jun-99	
Jul-99	255
Aug-99	333
Sep-99	380
Oct-99	341
Nov-99	351
Dec-99	368
Jan-00	383
Feb-00	424
Mar-00	386
Apr-00	376
May-00	374
Jun-00	392
Jul-00	392
Aug-00	387
Sep-00	392
Oct-00	403
Nov-00	359
Dec-00	
1-Jan	
1-Feb	432

1-Mar	434
1-Apr	397
1-May	453
1-Jun	381
1-Jul	411
1-Aug	392
1-Sep	395
1-Oct	378
1-Nov	350
1-Dec	387
2-Jan	386
2-Feb	360
2-Mar	337
2-Apr	453
2-May	361
2-Jun	401

Wildwood

Fig 15.16 pH

Date	
Oct-93	
Nov-93	
Dec-93	
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	3.5
Jun-94	3
Jul-94	3.2
Aug-94	3.2
Sep-94	3.2
Oct-94	3
Nov-94	3.1
Dec-94	3
Jan-95	3.2
Feb-95	3.1
Mar-95	2.9
Apr-95	3.1
May-95	3.2
Jun-95	3
Jul-95	2.9
Aug-95	3.1
Sep-95	3.2
Oct-95	3
Nov-95	3.3
Dec-95	3.2
Jan-96	3.1
Feb-96	2.9
Mar-96	3.1
Apr-96	
May-96	4.1
Jun-96	
Jul-96	3.2
Aug-96	3.1
Sep-96	
Oct-96	3
Nov-96	
Dec-96	3.1
Jan-97	3.1
Feb-97	3.1
Mar-97	3.2

Apr-97	3.2
May-97	3.2
Jun-97	3.3
Jul-97	3.4
Aug-97	3.2
Sep-97	3.1
Oct-97	3.2
Nov-97	3.4
Dec-97	
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	
Apr-99	
May-99	
Jun-99	
Jul-99	3.6
Aug-99	3.3
Sep-99	3.4
Oct-99	3.1
Nov-99	3.4
Dec-99	3.3
Jan-00	3.4
Feb-00	3.3
Mar-00	3.5
Apr-00	3.3
May-00	3.3
Jun-00	3.2
Jul-00	3.2
Aug-00	3.3
Sep-00	3.3
Oct-00	3.2
Nov-00	3.1
Dec-00	
1-Jan	
1-Feb	3.3

1-Mar	3.4
1-Apr	3.3
1-May	3.3
1-Jun	3.2
1-Jul	3.2
1-Aug	3.2
1-Sep	3.1
1-Oct	3.4
1-Nov	3.5
1-Dec	3.3
2-Jan	3.3
2-Feb	3.3
2-Mar	3.4
2-Apr	3.3
2-May	3.3
2-Jun	3.2

Wildwood

Fig 15.17a Iron Load

Date	
5/27/1994	0.0168
6/28/1994	0.0335
7/28/1994	0.0275
8/24/1994	0.0062
9/21/1994	0.0142
10/19/1994	0.0275
17-Nov	0.03
12/15/1994	0.0792
1/11/1995	0.3348
2/20/1995	0.0256
3/16/1995	0.0996
4/12/1995	0.0181
5/22/1995	0.0533
6/7/1995	0.0336
7/13/1995	0.0565
8/18/1995	0.0281
9/25/1995	0.02
10/13/1995	0.0274
11/8/1995	0.0098
12/13/1995	0.0226
1/31/1996	0.0115
2/27/1996	0.0357
3/25/1996	0.1296
4/29/1996	
5/22/1996	0.1217
6/25/1996	
7/31/1996	0.0662
8/27/1996	0.1142
9/17/1996	
10/29/1996	0.0643
11/27/1996	
12/18/1996	0.546
1/20/1997	0.3089
2/12/1997	0.588
3/17/1997	0.7776
4/25/1997	0.0531
5/23/1997	0.0199
6/9/1997	0.0678
7/30/1997	0.0444
8/26/1997	0.0365
9/16/1997	0.0088
10/22/1997	0.0084

11/21/1997	0.0261
12/11/1997	
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
1/19/1999	
2/26/1999	
3/1/1999	
4/23/1999	
5/24/1999	
6/30/1999	
7/29/1999	0.0234
8/20/1999	0.1242
9/30/1999	0.002
10/19/1999	0.0011
11/23/1999	0.0013
12/20/1999	0.0021
1/6/2000	0.0143
2/24/2000	0.019
3/21/2000	0.0111
4/18/2000	0.0131
5/12/2000	0.0276
6/16/2000	0.0646
7/25/2000	0.0085
8/21/2000	0.0078
9/21/2000	0.0187
10/9/2000	0.0111
11/20/2000	0.0047
12/1/2000	
1/1/2001	
2/28/2001	0.0125
3/16/2001	0.0125
4/23/2001	0.1972
5/22/2001	0.0536
6/19/2001	0.0352
7/17/2001	0.0187
8/21/2001	0.0093
9/6/2001	0.0066

10/19/2001	0.0039
11/8/2001	0.0023
12/17/2001	0.0112
1/14/2002	0.0061
2/1/2002	0.0134
3/14/2002	0.0042
4/12/2002	0.0415
5/20/2002	0.0476
6/14/2002	0.0345

Wildwood
Fig 15.17b Load

Date	
5/27/1994	0.3552
6/28/1994	1.125
7/28/1994	1.1232
8/24/1994	0.3537
9/21/1994	0.7548
10/19/1994	0.9984
17-Nov	0.844
12/15/1994	1.4448
1/11/1995	5.013
2/20/1995	0.3372
3/16/1995	1.641
4/12/1995	0.3468
5/22/1995	1.2579
6/7/1995	0.7212
7/13/1995	1.0908
8/18/1995	0.8939
9/25/1995	1.0218
10/13/1995	1.572
11/8/1995	0.4963
12/13/1995	1.416
1/31/1996	0.4941
2/27/1996	0.7635
3/25/1996	1.7964
4/29/1996	
5/22/1996	1.692
6/25/1996	
7/31/1996	1.1328
8/27/1996	2.7792
9/17/1996	
10/29/1996	2.64
11/27/1996	
12/18/1996	7.215
1/20/1997	5.2704
2/12/1997	10.626
3/17/1997	12.663
4/25/1997	1.0406
5/23/1997	0.4194
6/9/1997	1.188
7/30/1997	1.1529
8/26/1997	1.2768
9/16/1997	0.3514
10/22/1997	0.43245

11/21/1997	1.1904
12/11/1997	
1/19/1999	
2/26/1999	
3/1/1999	
4/23/1999	
5/24/1999	
6/30/1999	
7/29/1999	0.6786
8/20/1999	0.7614
9/30/1999	0.0785
10/19/1999	0.0577
11/23/1999	0.0684
12/20/1999	0.095
1/6/2000	1.0296
2/24/2000	1.6323
3/21/2000	0.9045
4/18/2000	0.6332
5/12/2000	1.1809
6/16/2000	2.4758
7/25/2000	0.3342
8/21/2000	0.2922
9/21/2000	0.8253
10/9/2000	0.5078
11/20/2000	0.1786
2/28/2001	0.6756
3/16/2001	0.6674
4/23/2001	6.2631
5/22/2001	2.15
6/19/2001	1.2816
7/17/2001	0.7233
8/21/2001	0.3896
9/6/2001	0.339
10/19/2001	0.1683
11/8/2001	0.1263
12/17/2001	0.3263
1/14/2002	0.2849
2/1/2002	0.5257
3/14/2002	0.1694
4/12/2002	2.0665
5/20/2002	2.5133
6/14/2002	1.6503

Wildwood

Fig 15.17c Aluminum Load

Date	
5/27/1994	0
6/28/1994	1.98
7/28/1994	0.3307
8/24/1994	0.513
9/21/1994	1.11
10/19/1994	0.7238
17-Nov	1.6349
12/15/1994	2.4432
1/11/1995	9.135
2/20/1995	0.573
3/16/1995	3.285
4/12/1995	0.63
5/22/1995	2.2008
6/7/1995	1.1472
7/13/1995	1.683
8/18/1995	1.3884
9/25/1995	1.6037
10/13/1995	1.3728
11/8/1995	0.6374
12/13/1995	2.4096
1/31/1996	0.9414
2/27/1996	1.1775
3/25/1996	3.1226
4/29/1996	
5/22/1996	2.8944
6/25/1996	
7/31/1996	2.364
8/27/1996	4.6656
9/17/1996	
10/29/1996	5.256
11/27/1996	
12/18/1996	13.77
1/20/1997	13.6512
2/12/1997	19.32
3/17/1997	25.5474
4/25/1997	2.6076
5/23/1997	1.0323
6/9/1997	3.165
7/30/1997	
8/26/1997	0.4022
9/16/1997	0.685
10/22/1997	0.95325

11/21/1997	2.395
12/11/1997	
3/1/1999	
4/23/1999	
5/24/1999	
6/30/1999	
7/29/1999	1.1934
8/20/1999	1.5318
9/30/1999	0.1318
10/19/1999	0.1032
11/23/1999	0.1511
12/20/1999	0.1696
1/6/2000	1.3496
2/24/2000	2.0576
3/21/2000	0.9852
4/18/2000	0.9801
5/12/2000	1.9863
6/16/2000	4.3718
7/25/2000	0.5641
8/21/2000	0.5405
9/21/2000	1.5761
10/9/2000	1.0224
11/20/2000	0.4475
2/28/2001	1.512
3/16/2001	1.3411
4/23/2001	10.5589
5/22/2001	4.4774
6/19/2001	2.128
7/17/2001	1.8169
8/21/2001	0.9006
9/6/2001	0.7326
10/19/2001	0.3665
11/8/2001	0.282
12/17/2001	0.7405
1/14/2002	0.6475
2/1/2002	1.0879
3/14/2002	0.3912
4/12/2002	2.8428
5/20/2002	3.6218
6/14/2002	2.6391

Wildwood

Fig 15.18 Sulfates Load

Date	
5/27/1994	61
6/28/1994	211
7/28/1994	190
8/24/1994	65
9/21/1994	134
10/19/1994	147
17-Nov	155
12/15/1994	209
1/11/1995	636
2/20/1995	48
3/16/1995	256
4/12/1995	55
5/22/1995	188
6/7/1995	98
7/13/1995	162
8/18/1995	146
9/25/1995	157
10/13/1995	266
11/8/1995	105
12/13/1995	235
1/31/1996	88
2/27/1996	92
3/25/1996	225
4/29/1996	
5/22/1996	289
6/25/1996	
7/31/1996	169
8/27/1996	517
9/17/1996	
10/29/1996	430
11/27/1996	
12/18/1996	890
1/20/1997	654
2/12/1997	1180
3/17/1997	1574
4/25/1997	130
5/23/1997	96
6/9/1997	148
7/30/1997	161
8/26/1997	237
9/16/1997	49
10/22/1997	44

11/21/1997	99
12/11/1997	
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
1/19/1999	
2/26/1999	
3/1/1999	
4/23/1999	
5/24/1999	
6/30/1999	
7/29/1999	94
8/20/1999	100
9/30/1999	9
10/19/1999	9
11/23/1999	12
12/20/1999	17
1/6/2000	78
2/24/2000	181
3/21/2000	150
4/18/2000	122
5/12/2000	158
6/16/2000	470
7/25/2000	53
8/21/2000	43
9/21/2000	127
10/9/2000	88
11/20/2000	28
12/1/2000	
1/1/2001	
2/28/2001	76
3/16/2001	73
4/23/2001	731
5/22/2001	254
6/19/2001	186
7/17/2001	110
8/21/2001	128
9/6/2001	60

10/19/2001	24
11/8/2001	15
12/17/2001	45
1/14/2002	38
2/1/2002	85
3/14/2002	20
4/12/2002	165
5/20/2002	215
6/14/2002	138

Wildwood

Fig 15.19 Iron

Date	
Oct-93	6.97
Nov-93	1
Dec-93	1.04
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	1.06
Jul-94	1.16
Aug-94	0.76
Sep-94	0.75
Oct-94	0.89
Nov-94	1.03
Dec-94	1.51
Jan-95	1.78
Feb-95	1.85
Mar-95	1.65
Apr-95	1.64
May-95	1.42
Jun-95	1.58
Jul-95	1.56
Aug-95	1.1
Sep-95	0.9
Oct-95	0.8
Nov-95	0.7
Dec-95	0.63
Jan-96	0.6
Feb-96	1.05
Mar-96	1.8
Apr-96	1.5
May-96	1.64
Jun-96	1.61
Jul-96	1.37
Aug-96	1.26
Sep-96	1.13
Oct-96	0.78
Nov-96	1.24
Dec-96	1.75
Jan-97	1.47
Feb-97	1.44
Mar-97	1.59

Apr-97	1.14
May-97	1.16
Jun-97	1.15
Jul-97	1
Aug-97	0.89
Sep-97	0.67
Oct-97	0.57
Nov-97	0.6
Dec-97	0.91
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	0.68
Apr-99	0.7
May-99	0.66
Jun-99	
Jul-99	0.64
Aug-99	0.64
Sep-99	0.62
Oct-99	0.59
Nov-99	0.7
Dec-99	0.73
Jan-00	0.63
Feb-00	0.53
Mar-00	0.49
Apr-00	0.57
May-00	0.6
Jun-00	0.77
Jul-00	0.7
Aug-00	0.79
Sep-00	0.66
Oct-00	0.68
Nov-00	0.7
Dec-00	
1-Jan	
1-Feb	0.64

1-Mar	0.72
1-Apr	1
1-May	0.7
1-Jun	0.72
1-Jul	0.61
1-Aug	0.56
1-Sep	0.55
1-Oct	0.93
1-Nov	0.55
1-Dec	0.58
2-Jan	0.66

Wildwood

Fig 15.20 Manganese

Date	
Oct-93	49
Nov-93	45
Dec-93	41
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	31
Jul-94	35
Aug-94	38
Sep-94	31
Oct-94	31
Nov-94	28
Dec-94	27
Jan-95	26
Feb-95	26
Mar-95	27
Apr-95	27
May-95	28
Jun-95	30
Jul-95	28
Aug-95	26
Sep-95	31
Oct-95	32
Nov-95	31
Dec-95	30
Jan-96	25
Feb-96	22
Mar-96	21
Apr-96	22
May-96	22
Jun-96	24
Jul-96	22
Aug-96	26
Sep-96	26
Oct-96	23
Nov-96	26
Dec-96	23
Jan-97	21
Feb-97	25
Mar-97	21

Apr-97	21
May-97	23
Jun-97	19
Jul-97	23
Aug-97	26
Sep-97	22
Oct-97	23
Nov-97	23
Dec-97	22
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	5.2
Apr-99	22
May-99	19
Jun-99	
Jul-99	21
Aug-99	21
Sep-99	23
Oct-99	27
Nov-99	29
Dec-99	28
Jan-00	28
Feb-00	25
Mar-00	25
Apr-00	19
May-00	19
Jun-00	21
Jul-00	23
Aug-00	24
Sep-00	23
Oct-00	25
Nov-00	26
Dec-00	
1-Jan	
1-Feb	22

1-Mar	24
1-Apr	23
1-May	19
1-Jun	18
1-Jul	21
1-Aug	19
1-Sep	20
1-Oct	24
1-Nov	26
1-Dec	26
2-Jan	27

Wildwood
Fig 15.21 Aluminum

Date	
Oct-93	
Nov-93	
Dec-93	82
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	63
Jul-94	85
Aug-94	66
Sep-94	69
Oct-94	62
Nov-94	61
Dec-94	56
Jan-95	59
Feb-95	49
Mar-95	75
Apr-95	53
May-95	64
Jun-95	63
Jul-95	53
Aug-95	41
Sep-95	53
Oct-95	27
Nov-95	48
Dec-95	57
Jan-96	56
Feb-96	44
Mar-96	42
Apr-96	61
May-96	46
Jun-96	53
Jul-96	55
Aug-96	51
Sep-96	81
Oct-96	57
Nov-96	46
Dec-96	54
Jan-97	54
Feb-97	59
Mar-97	58

Apr-97	49
May-97	59
Jun-97	51
Jul-97	
Aug-97	51
Sep-97	6
Oct-97	60
Nov-97	50
Dec-97	56
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	44
Apr-99	43
May-99	38
Jun-99	
Jul-99	21
Aug-99	45
Sep-99	41
Oct-99	47
Nov-99	57
Dec-99	57
Jan-00	49
Feb-00	39
Mar-00	45
Apr-00	37
May-00	39
Jun-00	47
Jul-00	58
Aug-00	56
Sep-00	52
Oct-00	53
Nov-00	68
Dec-00	
1-Jan	
1-Feb	56

1-Mar	52
1-Apr	49
1-May	47
1-Jun	41
1-Jul	56
1-Aug	48
1-Sep	55
1-Oct	56
1-Nov	57
1-Dec	54
2-Jan	55

Wildwood

Fig 15.22 Sulfates

Date	
Oct-93	5066
Nov-93	5057
Dec-93	4950
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	5674
Jul-94	5525
Aug-94	5881
Sep-94	5506
Oct-94	5019
Nov-94	5214
Dec-94	4382
Jan-95	3924
Feb-95	4438
Mar-95	4340
Apr-95	4582
May-95	4772
Jun-95	3974
Jul-95	4156
Aug-95	4624
Sep-95	4821
Oct-95	5445
Nov-95	5308
Dec-95	4801
Jan-96	4648
Feb-96	3111
Mar-96	2837
Apr-96	3510
May-96	4203
Jun-96	3073
Jul-96	3551
Aug-96	5587
Sep-96	3737
Oct-96	4657
Nov-96	3063
Dec-96	3114
Jan-97	2960
Feb-97	2887
Mar-97	2823

Apr-97	2760
May-97	5799
Jun-97	2308
Jul-97	3339
Aug-97	5517
Sep-97	3019
Oct-97	2524
Nov-97	2357
Dec-97	3140
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	3920
Apr-99	2342
May-99	2588
Jun-99	
Jul-99	2421
Aug-99	3044
Sep-99	3229
Oct-99	2776
Nov-99	3867
Dec-99	2676
Jan-00	3556
Feb-00	4002
Mar-00	5545
Apr-00	4348
May-00	3320
Jun-00	4098
Jul-00	3537
Aug-00	3607
Sep-00	4375
Oct-00	4161
Nov-00	4005
Dec-00	
1-Jan	
1-Feb	3167

1-Mar	3662
1-Apr	2953
1-May	2534
1-Jun	3077
1-Jul	3322
1-Aug	2861
1-Sep	3485
1-Oct	3151
1-Nov	3159
1-Dec	2845
2-Jan	2892

Wildwood

Fig 15.23 pH

Date	
Oct-93	4.5
Nov-93	4
Dec-93	4.5
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	3
Jul-94	3.1
Aug-94	3.1
Sep-94	3.1
Oct-94	3.2
Nov-94	3.1
Dec-94	2.9
Jan-95	2.8
Feb-95	3.1
Mar-95	3
Apr-95	3.1
May-95	3.2
Jun-95	2.9
Jul-95	3
Aug-95	3.1
Sep-95	3.1
Oct-95	2.9
Nov-95	3.16
Dec-95	3.26
Jan-96	3.12
Feb-96	2.99
Mar-96	3.1
Apr-96	3
May-96	3.2
Jun-96	2.9
Jul-96	3.01
Aug-96	2.96
Sep-96	3.01
Oct-96	3.12
Nov-96	3.43
Dec-96	3
Jan-97	3
Feb-97	3.29
Mar-97	3.26

Apr-97	2.95
May-97	3.21
Jun-97	3.04
Jul-97	3.3
Aug-97	3.2
Sep-97	3
Oct-97	3
Nov-97	3.4
Dec-97	3.3
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	3.3
Apr-99	3.1
May-99	3
Jun-99	
Jul-99	3.4
Aug-99	3.2
Sep-99	3.3
Oct-99	2.9
Nov-99	3.1
Dec-99	3.2
Jan-00	3.3
Feb-00	3.3
Mar-00	3.3
Apr-00	3.2
May-00	3.3
Jun-00	3.1
Jul-00	3.2
Aug-00	3.3
Sep-00	3.2
Oct-00	3.3
Nov-00	3
Dec-00	
1-Jan	
1-Feb	3.1

1-Mar	3.3
1-Apr	3.3
1-May	3.2
1-Jun	3.1
1-Jul	3.1
1-Aug	3.1
1-Sep	3
1-Oct	3.3
1-Nov	3.2
1-Dec	3.4
2-Jan	3.2

Wildwood
Fig 15.24 Acidity

Date	
Oct-93	630
Nov-93	657
Dec-93	620
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	551
Jul-94	558
Aug-94	591
Sep-94	650
Oct-94	470
Nov-94	542
Dec-94	484
Jan-95	452
Feb-95	469
Mar-95	453
Apr-95	465
May-95	559
Jun-95	463
Jul-95	482
Aug-95	505
Sep-95	485
Oct-95	549
Nov-95	461
Dec-95	465
Jan-96	482
Feb-96	446
Mar-96	490
Apr-96	436
May-96	444
Jun-96	425
Jul-96	495
Aug-96	444
Sep-96	451
Oct-96	433
Nov-96	496
Dec-96	440
Jan-97	454
Feb-97	442
Mar-97	447

Apr-97	469
May-97	458
Jun-97	428
Jul-97	432
Aug-97	439
Sep-97	429
Oct-97	426
Nov-97	454
Dec-97	436
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	368
Apr-99	385
May-99	389
Jun-99	
Jul-99	379
Aug-99	382
Sep-99	405
Oct-99	428
Nov-99	448
Dec-99	409
Jan-00	453
Feb-00	390
Mar-00	388
Apr-00	365
May-00	365
Jun-00	416
Jul-00	391
Aug-00	402
Sep-00	435
Oct-00	418
Nov-00	445
Dec-00	
1-Jan	
1-Feb	441

1-Mar	426
1-Apr	398
1-May	405
1-Jun	394
1-Jul	439
1-Aug	427
1-Sep	467
1-Oct	478
1-Nov	439
1-Dec	425
2-Jan	466

Wildwood

Fig 15.25 Total Dissolved Solids

Date	
Oct-93	
Nov-93	
Dec-93	
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	6626
Jul-94	6312
Aug-94	6600
Sep-94	6132
Oct-94	5510
Nov-94	5754
Dec-94	5558
Jan-95	4726
Feb-95	4932
Mar-95	4884
Apr-95	4878
May-95	5054
Jun-95	5192
Jul-95	4692
Aug-95	5190
Sep-95	5136
Oct-95	5662
Nov-95	5796
Dec-95	5703
Jan-96	5174
Feb-96	4740
Mar-96	
Apr-96	4584
May-96	4438
Jun-96	4788
Jul-96	4508
Aug-96	5032
Sep-96	5460
Oct-96	4834
Nov-96	4544
Dec-96	4002
Jan-97	3142
Feb-97	3141
Mar-97	

Apr-97	2746
May-97	2901
Jun-97	2694
Jul-97	
Aug-97	3032
Sep-97	3026
Oct-97	2814
Nov-97	2742
Dec-97	2844
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	
Mar-99	2825
Apr-99	2335
May-99	2283
Jun-99	
Jul-99	2375
Aug-99	2389
Sep-99	2695
Oct-99	2522
Nov-99	2817
Dec-99	2801
Jan-00	2776
Feb-00	2777
Mar-00	2773
Apr-00	2486
May-00	2554
Jun-00	2540
Jul-00	2769
Aug-00	2676
Sep-00	2843
Oct-00	2797
Nov-00	2784
Dec-00	
1-Jan	
1-Feb	2673

1-Mar	2691
1-Apr	2534
1-May	2507
1-Jun	2559
1-Jul	2398
1-Aug	2505
1-Sep	2573
1-Oct	2591
1-Nov	3000
1-Dec	2854
2-Jan	3009

Wildwood

Fig 15.25b Sulfate & Total Dissolved Solids

DATE	Sulfate	TDS
Oct-93	5066	
Nov-93	5057	
Dec-93	4950	
Jan-94		
Feb-94		
Mar-94		
Apr-94		
May-94		
Jun-94	5674	
Jun-94		6626
Jul-94	5525	
Jul-94		6312
Aug-94	5881	
Aug-94		6600
Sep-94	5506	
Sep-94		6132
Oct-94	5019	
Oct-94		5510
Nov-94	5214	
Nov-94		5754
Dec-94	4382	
Dec-94		5558
Jan-95	3924	
Jan-95		4726
Feb-95	4438	
Feb-95		4932
Mar-95	4340	
Mar-95		4884
Apr-95	4582	
Apr-95		4878
May-95	4772	
May-95		5054
Jun-95	3974	
Jun-95		5192
Jul-95	4156	
Jul-95		4692
Aug-95	4624	
Aug-95		5190
Sep-95	4821	
Sep-95		5136
Oct-95	5445	
Oct-95		5662

Nov-95	5308	
Nov-95		5796
Dec-95	4801	
Dec-95		5703
Jan-96	4648	
Jan-96		5174
Feb-96	3111	
Feb-96		4740
Mar-96	2837	
Mar-96		
Apr-96	3510	
Apr-96		4584
May-96	4203	
May-96		4438
Jun-96	3073	
Jun-96		4788
Jul-96	3551	
Jul-96		4508
Aug-96	5587	
Aug-96		5032
Sep-96	3737	
Sep-96		5460
Oct-96	4657	
Oct-96		4834
Nov-96	3063	
Nov-96		4544
Dec-96	3114	
Dec-96		4002
Jan-97	2960	
Jan-97		3142
Feb-97	2887	
Feb-97		3141
Mar-97	2823	
Mar-97		
Apr-97	2760	
Apr-97		2746
May-97	5799	
May-97		2901
Jun-97	2308	
Jun-97		2694
Jul-97	3339	
Jul-97		
Aug-97	5517	
Aug-97		3032
Sep-97	3019	
Sep-97		3026
Oct-97	2524	

Oct-97		2814
Nov-97	2357	
Nov-97		2742
Dec-97	3140	
Dec-97		2844
Jan-98		
Jan-98		
Feb-98		
Feb-98		
Mar-98		
Mar-98		
Apr-98		
Apr-98		
May-98		
May-98		
Jun-98		
Jun-98		
Jul-98		
Jul-98		
Aug-98		
Aug-98		
Sep-98		
Sep-98		
Oct-98		
Oct-98		
Nov-98		
Nov-98		
Dec-98		
Dec-98		
Jan-99		
Jan-99		
Feb-99		
Feb-99		
Mar-99	3920	
Mar-99		2825
Apr-99	2342	
Apr-99		2335
May-99	2588	
May-99		2283
Jun-99		
Jun-99		
Jul-99	2421	
Jul-99		2375
Aug-99	3044	
Aug-99		2389
Sep-99	3229	
Sep-99		2695

Oct-99	2776	
Oct-99		2522
Nov-99	3867	
Nov-99		2817
Dec-99	2676	
Dec-99		2801
Jan-00	3556	
Jan-00		2776
Feb-00	4002	
Feb-00		2777
Mar-00	5545	
Mar-00		2773
Apr-00	4348	
Apr-00		2486
May-00	3320	
May-00		2554
Jun-00	4098	
Jun-00		2540
Jul-00	3537	
Jul-00		2769
Aug-00	3607	
Aug-00		2676
Sep-00	4375	
Sep-00		2843
Oct-00	4161	
Oct-00		2797
Nov-00	4005	
Nov-00		2784
Dec-00		
Dec-00		
1-Jan		
1-Jan		
1-Feb	3167	
1-Feb		2673
1-Mar	3662	
1-Mar		2691
1-Apr	2953	
1-Apr		2534
1-May	2534	
1-May		2507
1-Jun	3077	
1-Jun		2559
1-Jul	3322	
1-Jul		2398
1-Aug	2861	
1-Aug		2505
1-Sep	3485	

1-Sep		2573
1-Oct	3151	
1-Oct		2591
1-Nov	3159	
1-Nov		3000
1-Dec	2845	
1-Dec		2854
2-Jan	2892	
2-Jan		3009

Wildwood

Fig 15.26 Iron, Manganese, Aluminum Load

Date	Fe load	Mn load	Al load
Oct-93	0.16	1.18	
Nov-93	0.012	0.54	
Dec-93	0.049	1.97	3.92
Jan-94			
Feb-94			
Mar-94			
Apr-94			
May-94			
Jun-94	0.025	0.74	1.51
Jul-94	0.027	0.84	2.04
Aug-94	0.023	1.19	2.08
Sep-94	0.023	0.99	2.16
Oct-94	0.021	0.74	1.51
Nov-94	0.024	0.66	1.46
Dec-94	0.054	0.97	2.02
Jan-95	0.213	3.19	7.08
Feb-95	0.044	0.63	1.17
Mar-95	0.138	2.27	6.3
Apr-95	0.039	0.65	1.27
May-95	0.051	1.02	2.29
Jun-95	0.028	0.53	1.13
Jul-95	0.056	0.99	1.91
Aug-95	0.03	0.73	1.14
Sep-95			
Oct-95			
Nov-95			
Dec-95			
Jan-96			
Feb-96			
Mar-96			
Apr-96			
May-96			
Jun-96			
Jul-96			
Aug-96			
Sep-96			
Oct-96			
Nov-96			
Dec-96			
Jan-97			
Feb-97			
Mar-97			

Apr-97			
May-97			
Jun-97			
Jul-97			
Aug-97			
Sep-97			
Oct-97			
Nov-97			
Dec-97			
Jan-98			
Feb-98			
Mar-98			
Apr-98			
May-98			
Jun-98			
Jul-98			
Aug-98			
Sep-98			
Oct-98			
Nov-98			
Dec-98			
Jan-99	0.046	2.04	4.1
Feb-99	0.01	0.404	0.68
Mar-99	0.009	0.07	0.59
Apr-99	0.009	0.284	0.56
May-99	0.025	0.756	1.48
Jun-99			
Jul-99	0.005	0.18	0.17
Aug-99	0.019	0.63	1.35
Sep-99	0.003	0.13	0.22
Oct-99	0.004	0.16	0.28
Nov-99	0.004	0.15	0.3
Dec-99	0.005	0.21	0.41
Jan-00	0.005	0.22	0.39
Feb-00	0.007	0.34	0.53
Mar-00	0.009	0.47	0.86
Apr-00	0.018	0.62	1.19
May-00	0.017	0.54	1.1
Jun-00	0.018	0.51	1.13
Jul-00			
Aug-00			
Sep-00			
Oct-00			
Nov-00			
Dec-00			
1-Jan			
1-Feb			

1-Mar			
1-Apr			
1-May			
1-Jun			
1-Jul			
1-Aug			
1-Sep			
1-Oct			
1-Nov			
1-Dec			
2-Jan			

Wildwood

Fig 15.28 Sulfates Load

Date	
Oct-93	121
Nov-93	60
Dec-93	237
Jan-94	
Feb-94	
Mar-94	
Apr-94	
May-94	
Jun-94	136
Jul-94	132
Aug-94	183
Sep-94	171
Oct-94	120
Nov-94	125
Dec-94	157
Jan-95	470
Feb-95	106
Mar-95	364
Apr-95	109
May-95	171
Jun-95	71
Jul-95	149
Aug-95	127
Sep-95	
Oct-95	
Nov-95	
Dec-95	
Jan-96	
Feb-96	
Mar-96	
Apr-96	
May-96	
Jun-96	
Jul-96	
Aug-96	
Sep-96	
Oct-96	
Nov-96	
Dec-96	
Jan-97	
Feb-97	
Mar-97	

Apr-97	
May-97	
Jun-97	
Jul-97	
Aug-97	
Sep-97	
Oct-97	
Nov-97	
Dec-97	
Jan-98	
Feb-98	
Mar-98	
Apr-98	
May-98	
Jun-98	
Jul-98	
Aug-98	
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	268
Feb-99	54
Mar-99	52
Apr-99	30
May-99	100
Jun-99	
Jul-99	20
Aug-99	91
Sep-99	17
Oct-99	16
Nov-99	20
Dec-99	19
Jan-00	28
Feb-00	54
Mar-00	105
Apr-00	137
May-00	92
Jun-00	97
Jul-00	
Aug-00	
Sep-00	
Oct-00	
Nov-00	
Dec-00	
1-Jan	
1-Feb	

1-Mar	
1-Apr	
1-May	
1-Jun	
1-Jul	
1-Aug	
1-Sep	
1-Oct	
1-Nov	
1-Dec	
2-Jan	

Appendix 3 - Cumulative - Site Tabulations

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TABLE 3 All Sites CUMULATIVE	All Sites Monitoring Points Summary					Cumulative UPGRADIENT Site Monitoring Points Summary					Cumulative DOWNGRADIENT Site Monitoring Points Summary				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	30	6	27	2	0	6	1	6	1	0	24	5	21	1	0
Acidity (trend)	25	1	31	0	0	3	1	7	0	0	22	0	24	0	0
Alkalinity (trend)	13	8	23	0	0	1	3	4	0	0	12	5	19	0	0
Fe (iron)	25	3	32	6	57	8	2	3	2	13	17	1	29	4	44
Al (aluminum)	7	3	19	8	25	1	1	5	2	6	6	2	14	6	19
Mn (manganese)	22	2	45	5	64	5	0	8	2	13	17	2	37	3	51
Subtotal	**122**	**23**	**177**	**21**	**146**	**24**	**8**	**33**	**7**	**32**	**98**	**15**	**144**	**14**	**114**
Parameter Group Share (%)	**37.9%**	**7.1%**	**55.0%**	**6.5%**	**45.3%**	**36.9%**	**12.3%**	**50.8%**	**10.8%**	**49.2%**	**38.1%**	**5.8%**	**56.0%**	**5.4%**	**44.4%**
Trace Elements															
As (arsenic)	15	4	14	2	13	4	0	0	0	0	11	4	14	2	13
Se (selenium)	10	2	15	5	6	3	0	2	1	0	7	2	13	4	6
Pb (lead)	11	2	26	3	21	3	0	3	0	2	8	2	23	3	19
Cd (cadmium)	11	5	23	13	15	1	1	3	1	1	10	4	20	12	14
Cr (chromium)	2	1	8	5	1	0	0	0	0	0	2	1	8	5	1
Ni (nickel)	4	0	16	8	10	0	0	2	2	0	4	0	14	6	10
Zn (zinc)	3	2	15	2	1	1	0	2	0	0	2	2	13	2	1
Cu (copper)	0	0	7	1	0	0	0	0	0	0	0	0	7	1	0
Sb (antimony)	0	0	3	0	2	0	0	1	0	1	0	0	2	0	1
Mo (molybdenum)	0	0	2	1	1	0	0	0	0	0	0	0	2	1	1
B (boron)	0	0	2	0	2	0	0	0	0	0	0	0	2	0	2
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	4	0	0	0	0	0	0	0	0	0	4	0	0
Ag (silver)	0	0	3	1	0	0	0	0	0	0	0	0	3	1	0
Subtotal	**56**	**16**	**138**	**41**	**72**	**12**	**1**	**13**	**4**	**4**	**44**	**15**	**125**	**37**	**68**
Parameter Group Share (%)	**26.7%**	**7.6%**	**65.7%**	**19.5%**	**34.3%**	**46.2%**	**3.8%**	**50.0%**	**15.4%**	**15.4%**	**23.9%**	**8.2%**	**67.9%**	**20.1%**	**37.0%**
Other Ash Indicators															
Ca (calcium)	14	0	33	0	0	2	0	4	0	0	12	0	29	0	0
Mg (magnesium)	8	1	32	0	0	1	1	3	0	0	7	0	29	0	0
Na (sodium)	8	5	13	0	0	2	1	0	0	0	6	4	13	0	0
Cl (chloride)	7	0	29	5	0	2	0	2	1	0	5	0	27	4	0
K (potassium)	1	1	7	0	0	1	0	0	0	0	0	1	7	0	0
F (flouride)	0	0	7	2	0	0	0	1	0	0	0	0	6	2	0
SO4 (sulfates)	21	3	43	19	40	6	2	6	4	4	15	1	37	15	36
TDS (total dissolved solids)	14	1	31	19	22	3	1	4	3	2	11	0	27	16	20
S. Cond. (specific conductance)	6	1	8	1	1	2	1	0	0	0	4	0	8	1	1
Subtotal	**79**	**12**	**203**	**46**	**63**	**19**	**6**	**20**	**8**	**6**	**60**	**6**	**183**	**38**	**57**
Parameter Group Share (%)	**26.9%**	**4.1%**	**69.0%**	**15.6%**	**21.4%**	**42.2%**	**13.3%**	**44.4%**	**17.8%**	**13.3%**	**24.1%**	**2.4%**	**73.5%**	**15.3%**	**22.9%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**257**	**51**	**518**	**108**	**281**	**55**	**15**	**66**	**19**	**42**	**202**	**36**	**452**	**89**	**239**
COMPOSITE PARAMETER GROUP SHARE (%)	**31.1%**	**6.2%**	**62.7%**	**13.1%**	**34.0%**	**40.4%**	**11.0%**	**48.5%**	**14.0%**	**30.9%**	**29.3%**	**5.2%**	**65.5%**	**12.9%**	**34.6%**

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

Table 2: Monitoring Points Examination - All Sites CUMULATIVE

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

TABLE 3 **B&D Mining**	**Site Monitoring Points Summary**					**Downgradient Monitoring Points** **MP-006**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash										
pH (trend)	2	1	0	0	0		1			
Acidity (trend)	3	0	0	0	0	1				
Alkalinity (trend)	1	1	1	0	0			1		
Fe (iron)	2	0	1	0	3			1		1
Al (aluminum)	0	0	0	0	0					
Mn (manganese)	0	0	3	0	3			1		1
Subtotal	**8**	**2**	**5**	**0**	**6**	**1**	**1**	**3**	**0**	**2**
Parameter Group Share (%)	**53.3%**	**13.3%**	**33.3%**	**0.0%**	**40.0%**	**20.0%**	**20.0%**	**60.0%**	**0.0%**	**40.0%**
Trace Elements										
As (arsenic)	0	0	3	2	1			1		1
Se (selenium)	0	0	0	0	0					
Pb (lead)	1	0	3	0	4			1		1
Cd (cadmium)	1	1	2	2	2			1		1
Cr (chromium)	0	1	3	2	0			1	1	
Ni (nickel)	1	0	2	3	0	1			1	
Zn (zinc)	0	2	1	0	0			1		
Cu (copper)	0	0	0	0	0					
Sb (antimony)	0	0	0	0	0					
Mo (molybdenum)	0	0	0	0	0					
B (boron)	0	0	0	0	0					
Hg (mercury)	0	0	0	0	0					
Ba (barium)	0	0	0	0	0					
Ag (silver)	0	0	0	0	0					
Subtotal	**3**	**4**	**14**	**9**	**7**	**1**	**0**	**5**	**2**	**3**
Parameter Group Share (%)	**14.3%**	**19.0%**	**66.7%**	**42.9%**	**33.3%**	**16.7%**	**0.0%**	**83.3%**	**33.3%**	**50.0%**
Other Ash Indicators										
Ca (calcium)	1	0	2	0	0	1				
Mg (magnesium)	0	0	3	0	0			1		
Na (sodium)	0	0	3	0	0			1		
Cl (chloride)	1	0	2	0	0			1		
K (potassium)	0	0	0	0	0					
F (flouride)	0	0	0	0	0					
SO4 (sulfates)	0	0	3	2	1			1		1
TDS (total dissolved solids)	2	0	1	3	0	1			1	
S. Cond. (specific conductance)	1	0	2	0	0			1		
Subtotal	**5**	**0**	**16**	**5**	**1**	**2**	**0**	**5**	**1**	**1**
Parameter Group Share (%)	**23.8%**	**0.0%**	**76.2%**	**23.8%**	**4.8%**	**28.6%**	**0.0%**	**71.4%**	**14.3%**	**14.3%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**16**	**6**	**35**	**14**	**14**	**4**	**1**	**13**	**3**	**6**
COMPOSITE PARAMETER GROUP SHARE (%)	**28.1%**	**10.5%**	**61.4%**	**24.6%**	**24.6%**	**22.2%**	**5.6%**	**72.2%**	**16.7%**	**33.3%**

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

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
B&D Mining	MP-007					MP-008					MP-005				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)	1					1									
Acidity (trend)	1					1									
Alkalinity (trend)	1						1								
Fe (iron)	1				1	1				1					
Al (aluminum)															
Mn (manganese)			1		1			1		1	0	0	0	0	0
Subtotal	**4**	**0**	**1**	**0**	**2**	**3**	**1**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**80.0%**	**0.0%**	**20.0%**	**0.0%**	**40.0%**	**60.0%**	**20.0%**	**20.0%**	**0.0%**	**40.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Trace Elements															
As (arsenic)			1	1									1	1	
Se (selenium)															
Pb (lead)	1				1			1		1			1		1
Cd (cadmium)	1			1			1			1			1	1	
Cr (chromium)			1	1			1						1		
Ni (nickel)			1	1				1	1						
Zn (zinc)		1					1								
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**2**	**1**	**3**	**4**	**1**	**0**	**3**	**2**	**1**	**2**	**0**	**0**	**4**	**2**	**1**
Parameter Group Share (%)	**33.3%**	**16.7%**	**50.0%**	**66.7%**	**16.7%**	**0.0%**	**60.0%**	**40.0%**	**20.0%**	**40.0%**	**0.0%**	**0.0%**	**100.0%**	**50.0%**	**25.0%**
Other Ash Indicators															
Ca (calcium)			1					1							
Mg (magnesium)			1					1							
Na (sodium)			1					1							
Cl (chloride)			1			1									
K (potassium)															
F (flouride)															
SO4 (sulfates)			1	1				1	1						
TDS (total dissolved solids)	1			1				1	1						
S. Cond. (specific conductance)			1			1									
Subtotal	**1**	**0**	**6**	**2**	**0**	**2**	**0**	**5**	**2**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**14.3%**	**0.0%**	**85.7%**	**28.6%**	**0.0%**	**28.6%**	**0.0%**	**71.4%**	**28.6%**	**0.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
CHANGED SETS TOTALS	**7**	**1**	**10**	**6**	**3**	**5**	**4**	**8**	**3**	**4**	**0**	**0**	**4**	**2**	**1**
COMPOSITE PARAMETER GROUP SHARE (%)	**38.9%**	**5.6%**	**55.6%**	**33.3%**	**16.7%**	**29.4%**	**23.5%**	**47.1%**	**17.6%**	**23.5%**	**0.0%**	**0.0%**	**100.0%**	**50.0%**	**25.0%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - B&D Mining

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring			
Stream			
Surface mine discharge		1	
Leachate collection pond			
Gound Water Monitoring Point			
Wells			
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools		3	
Leachate collection pipe and spring			
Subtotals:	0	4	0
TOTAL POINTS:	4		

TABLE 3	Site Monitoring Points Summary					Upgradient Monitoring Point					Downgradient Monitoring Point				
Big Gorilla						MW-2					Silverbrook Discharge				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)	1	0	1	0	0	1							1		
Acidity (trend)	0	0	0	0	0										
Alkalinity (trend)	0	1	0	0	0		1								
Fe (iron)	1	0	1	0	2	1				1			1		1
Al (aluminum)	0	0	2	0	2			1		1			1		1
Mn (manganese)	1	0	1	0	2	1				1			1		1
Subtotal	**3**	**1**	**5**	**0**	**6**	**3**	**1**	**1**	**0**	**3**	**0**	**0**	**4**	**0**	**3**
Parameter Group Share (%)	**33.3%**	**11.1%**	**55.6%**	**0.0%**	**66.7%**	**60.00%**	**20.00%**	**20.00%**			**0.00%**	**0.00%**	**100.00%**		
Trace Elements															
As (arsenic)	0	0	0	0	0										
Se (selenium)	0	0	2	1	1			1	1				1		1
Pb (lead)	0	0	0	0	0										
Cd (cadmium)	0	0	0	0	0										
Cr (chromium)	0	0	0	0	0										
Ni (nickel)	0	0	0	0	0										
Zn (zinc)	0	0	2	0	0			1					1		
Cu (copper)	0	0	0	0	0										
Sb (antimony)	0	0	0	0	0										
Mo (molybdenum)	0	0	0	0	0										
B (boron)	0	0	0	0	0										
Hg (mercury)	0	0	0	0	0										
Ba (barium)	0	0	0	0	0										
Ag (silver)	0	0	0	0	0										
Subtotal	**0**	**0**	**4**	**1**	**1**	**0**	**0**	**2**	**1**	**0**	**0**	**0**	**2**	**0**	**1**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**25.0%**	**25.0%**	**0.00%**	**0.00%**	**100.00%**			**0.00%**	**0.00%**	**100.00%**		
Other Ash Indicators															
Ca (calcium)	0	0	2	0	0			1					1		
Mg (magnesium)	0	0	2	0	0			1					1		
Na (sodium)	0	1	1	0	0		1						1		
Cl (chloride)	1	0	1	0	0	1							1		
K (potassium)	1	0	1	0	0	1							1		
F (flouride)	0	0	0	0	0										
SO4 (sulfates)	0	1	1	1	0		1						1	1	
TDS (total dissolved solids)	0	1	1	1	0		1						1	1	
S. Cond. (specific conductance)	1	0	1	0	0	1							1		
Subtotal	**3**	**3**	**10**	**2**	**0**	**3**	**3**	**2**	**0**	**0**	**0**	**0**	**8**	**2**	**0**
Parameter Group Share (%)	**16.7%**	**16.7%**	**55.6%**	**12.5%**	**0.0%**	**37.50%**	**37.50%**	**0.00%**			**0.00%**	**0.00%**	**100.00%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**6**	**4**	**19**	**3**	**7**	**6**	**4**	**5**	**1**	**3**	**0**	**0**	**14**	**2**	**4**
COMPOSITE PARAMETER GROUP SHARE (%)	**20.7%**	**13.8%**	**65.5%**	**10.3%**	**24.1%**	**40.0%**	**26.7%**	**33.3%**	**6.7%**	**30.0%**	**0.0%**	**0.0%**	**100.0%**	**14.3%**	**25.0%**

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

Table 2: Monitoring Points Examination - Big Gorilla

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring			
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	1	1
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools		1	
Leachate collection pipe and spring			
Subtotals:	1	2	1
TOTAL POINTS:	4		

TABLE 3 Bloom	Site Monitoring Points Summary					Upgradient Monitoring Points Summary					Downgradient Monitoring Points Summary				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)	3	0	1	0	0	1	0	0	0	0	2	0	1	0	0
Acidity (trend)	2	0	4	0	0	0	0	1	0	0	2	0	3	0	0
Alkalinity (trend)	2	0	2	0	0	0	0	1	0	0	2	0	1	0	0
Fe (iron)	3	0	2	0	3	1	0	0	0	1	2	0	2	0	2
Al (aluminum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn (manganese)	2	0	4	0	3	0	0	1	0	1	2	0	3	0	2
Subtotal	**12**	**0**	**13**	**0**	**6**	**2**	**0**	**3**	**0**	**2**	**10**	**0**	**10**	**0**	**4**
Parameter Group Share (%)	**48.00%**	**0.00%**	**52.00%**			**40.00%**	**0.00%**	**60.00%**			**50.00%**	**0.00%**	**50.00%**		
Trace Elements															
As (arsenic)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Se (selenium)	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Pb (lead)	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0
Cd (cadmium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr (chromium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni (nickel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn (zinc)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**1**	**0**	**2**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**1**	**1**	**0**
Parameter Group Share (%)	**33.33%**	**0.00%**	**66.67%**			**0.00%**	**0.00%**	**100.00%**			**50.00%**	**0.00%**	**50.00%**		
Other Ash Indicators															
Ca (calcium)	2	0	2	0	0	1	0	0	0	0	1	0	2	0	0
Mg (magnesium)	2	0	2	0	0	1	0	0	0	0	1	0	2	0	0
Na (sodium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl (chloride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K (potassium)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	1	0	4	0	3	0	0	1	0	0	1	0	3	0	3
TDS (total dissolved solids)	0	0	4	2	1	0	0	1	0	0	0	0	3	2	1
S. Cond. (specific conductance)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Subtotal	**3**	**0**	**12**	**2**	**4**	**1**	**0**	**2**	**0**	**0**	**2**	**0**	**10**	**2**	**4**
Parameter Group Share (%)	**17.65%**	**0.00%**	**11.76%**			**33.33%**	**0.00%**	**0.00%**			**14.29%**	**0.00%**	**14.29%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**16**	**0**	**27**	**3**	**10**	**3**	**0**	**6**	**0**	**2**	**13**	**0**	**21**	**3**	**8**
COMPOSITE PARAMETER GROUP SHARE (%)	**37.2%**	**0.0%**	**62.8%**	**7.0%**	**23.3%**	**33.3%**	**0.0%**	**66.7%**	**0.0%**	**22.2%**	**38.2%**	**0.0%**	**61.8%**	**8.8%**	**23.5%**

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

TABLE 3	Upgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Bloom	MW-1					FA-30					MW-3				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1												1		
Acidity (trend)			1			1					1				
Alkalinity (trend)			1										1		
Fe (iron)	1				1	1					1				
Al (aluminum)															
Mn (manganese)			1		1	1					1				
Subtotal	**2**	**0**	**3**	**0**	**2**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**2**	**0**	**0**
Parameter Group Share (%)	**40.00%**	**0.00%**	**60.00%**			**100.00%**	**0.00%**	**0.00%**			**60.00%**	**0.00%**	**40.00%**		
Trace Elements															
As (arsenic)															
Se (selenium)			1												
Pb (lead)															
Cd (cadmium)															
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**0.00%**	**0.00%**	**100.00%**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**		
Other Ash Indicators															
Ca (calcium)	1												1		
Mg (magnesium)	1												1		
Na (sodium)															
Cl (chloride)															
K (potassium)													1		
F (flouride)															
SO4 (sulfates)			1			1							1		1
TDS (total dissolved solids)			1										1		1
S. Cond. (specific conductance)													1		
Subtotal	**1**	**0**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**2**
Parameter Group Share (%)	**33.33%**	**0.00%**	**0.00%**			**100.00%**	**0.00%**	**0.00%**			**0.00%**	**0.00%**	**100.00%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**3**	**0**	**6**	**0**	**2**	**4**	**0**	**0**	**0**	**0**	**3**	**0**	**7**	**0**	**2**
COMPOSITE PARAMETER GROUP SHARE (%)	**33.3%**	**0.0%**	**66.7%**	**0.0%**	**22.2%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**30.0%**	**0.0%**	**70.0%**	**0.0%**	**20.0%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Bloom	**FA-20**					**FA-19**					**FA-32**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)						1					1				
Acidity (trend)			1					1					1		
Alkalinity (trend)						1					1				
Fe (iron)								1		1			1		1
Al (aluminum)															
Mn (manganese)			1					1		1			1		1
Subtotal	**0**	**0**	**2**	**0**	**0**	**2**	**0**	**3**	**0**	**2**	**2**	**0**	**3**	**0**	**2**
Parameter Group Share (%)	**0.00%**	**0.00%**	**100.00%**			**40.00%**	**0.00%**	**60.00%**			**40.00%**	**0.00%**	**60.00%**		
Trace Elements															
As (arsenic)						1									
Se (selenium)															
Pb (lead)								1	1						
Cd (cadmium)															
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**50.00%**	**0.00%**	**50.00%**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**		
Other Ash Indicators															
Ca (calcium)						1							1		
Mg (magnesium)						1							1		
Na (sodium)															
Cl (chloride)															
K (potassium)															
F (flouride)															
SO4 (sulfates)								1		1			1		1
TDS (total dissolved solids)								1	1				1	1	
S. Cond. (specific conductance)															
Subtotal	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**1**	**1**	**0**	**0**	**3**	**1**	**1**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**33.33%**	**0.00%**	**66.67%**			**0.00%**	**0.00%**	**100.00%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**0**	**0**	**2**	**0**	**0**	**4**	**0**	**6**	**2**	**3**	**2**	**0**	**6**	**1**	**3**
COMPOSITE PARAMETER GROUP SHARE (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**40.0%**	**0.0%**	**60.0%**	**20.0%**	**30.0%**	**25.0%**	**0.0%**	**75.0%**	**12.5%**	**37.5%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - Bloom

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring		3	
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	1	1
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	1	4	1
TOTAL POINTS:	6		

TABLE 3	Site Monitoring Points Summary					Downgradient Monitoring Points					Downgradient Monitoring Points				
Buterbaugh						**BC-3**					**BC-14**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1	0	1	0	0			1			1				
Acidity (trend)	1	0	1	0	0	1							1		
Alkalinity (trend)	0	0	2	0	0			1					1		
Fe (iron)	2	0	0	0	2	1				1	1				1
Al (aluminum)	0	0	0	0	0										
Mn (manganese)	0	0	2	0	2			1		1			1		1
Subtotal	**4**	**0**	**6**	**0**	**4**	**2**	**0**	**3**	**0**	**2**	**2**	**0**	**3**	**0**	**2**
Parameter Group Share (%)	**40.00%**	**0.00%**	**60.00%**			**40.0%**	**0.0%**	**60.0%**			**40.00%**	**0.00%**	**60.00%**		
Trace Elements															
As (arsenic)	0	0	0	0	0										
Se (selenium)	0	0	1	0	0			1							
Pb (lead)	1	0	0	0	0	1									
Cd (cadmium)	0	0	1	0	0			1							
Cr (chromium)	0	0	0	0	0										
Ni (nickel)	0	0	0	0	0										
Zn (zinc)	0	0	0	0	0										
Cu (copper)	0	0	0	0	0										
Sb (antimony)	0	0	0	0	0										
Mo (molybdenum)	0	0	0	0	0										
B (boron)	0	0	0	0	0										
Hg (mercury)	0	0	0	0	0										
Ba (barium)	0	0	0	0	0										
Ag (silver)	0	0	0	0	0										
Subtotal	**1**	**0**	**2**	**0**	**0**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**33.33%**	**0.00%**	**66.67%**			**33.3%**	**0.0%**	**66.7%**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**		
Other Ash Indicators															
Ca (calcium)	0	0	2	0	0			1					1		
Mg (magnesium)	0	0	2	0	0			1					1		
Na (sodium)	0	1	1	0	0			1				1			
Cl (chloride)	0	0	2	0	0			1					1		
K (potassium)	0	0	2	0	0			1					1		
F (flouride)	0	0	0	0	0										
SO4 (sulfates)	0	0	2	1	0			1	1				1		
TDS (total dissolved solids)	0	0	2	1	0			1	1				1		
S. Cond. (specific conductance)	0	0	1	0	0								1		
Subtotal	**0**	**1**	**12**	**2**	**0**	**0**	**0**	**6**	**2**	**0**	**0**	**1**	**6**	**0**	**0**
Parameter Group Share (%)	**0.00%**	**6.67%**	**13.33%**			**0.0%**	**0.0%**	**25.0%**			**0.00%**	**14.29%**	**85.71%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**5**	**1**	**20**	**2**	**4**	**3**	**0**	**11**	**2**	**2**	**2**	**1**	**9**	**0**	**2**
COMPOSITE PARAMETER GROUP SHARE (%)	**19.2%**	**3.8%**	**76.9%**	**7.7%**	**15.4%**	**21.4%**	**0.0%**	**78.6%**	**14.3%**	**14.3%**	**16.7%**	**8.3%**	**75.0%**	**0.0%**	**16.7%**

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

Table 2: Monitoring Points Examination - Buterbaugh

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring		2	
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells			
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	0	2	0
TOTAL POINTS:	2		

TABLE 3 C&K Coal	Site Monitoring Points Summary					Upgradient Monitoring Points Summary					Downgradient Monitoring Points Summary				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	0	1	2	0	0	0	1	0	0	0	0	0	2	0	0
Acidity (trend)	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0
Alkalinity (trend)	0	0	3	0	0	0	0	1	0	0	0	0	2	0	0
Fe (iron)	2	0	1	0	3	1	0	0	0	1	1	0	1	0	2
Al (aluminum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn (manganese)	1	0	2	0	3	0	0	1	0	1	1	0	1	0	2
Subtotal	**4**	**1**	**9**	**0**	**6**	**1**	**1**	**3**	**0**	**2**	**3**	**0**	**6**	**0**	**4**
Parameter Group Share (%)	**28.57%**	**7.14%**	**64.29%**			**20.00%**	**20.00%**	**60.00%**			**33.33%**	**0.00%**	**66.67%**		
Trace Elements															
As (arsenic)	1	0	1	0	1	1	0	0	0	0	0	0	1	0	1
Se (selenium)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Pb (lead)	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0
Cd (cadmium)	1	2	0	1	0	0	1	0	0	0	1	1	0	1	0
Cr (chromium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni (nickel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn (zinc)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**0**	**0**	**0**	**1**	**2**	**2**	**1**	**1**
Parameter Group Share (%)	**37.50%**	**37.50%**	**25.00%**			**66.67%**	**33.33%**	**0.00%**			**20.00%**	**40.00%**	**40.00%**		
Other Ash Indicators															
Ca (calcium)	0	0	3	0	0	0	0	1	0	0	0	0	2	0	0
Mg (magnesium)	0	0	3	0	0	0	0	1	0	0	0	0	2	0	0
Na (sodium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl (chloride)	1	0	2	0	0	0	0	1	0	0	1	0	1	0	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	0	0	3	2	1	0	0	1	0	1	0	0	2	2	0
TDS (total dissolved solids)	0	0	3	2	1	0	0	1	0	1	0	0	2	2	0
S. Cond. (specific conductance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**1**	**0**	**14**	**4**	**2**	**0**	**0**	**5**	**0**	**2**	**1**	**0**	**9**	**4**	**0**
Parameter Group Share (%)	**5.26%**	**0.00%**	**21.05%**			**0.00%**	**0.00%**	**0.00%**			**7.14%**	**0.00%**	**28.57%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**8**	**4**	**25**	**5**	**9**	**3**	**2**	**8**	**0**	**4**	**5**	**2**	**17**	**5**	**5**
COMPOSITE PARAMETER GROUP SHARE (%)	**21.6%**	**10.8%**	**67.6%**	**13.5%**	**24.3%**	**23.1%**	**15.4%**	**61.5%**	**0.0%**	**30.8%**	**20.8%**	**8.3%**	**70.8%**	**20.8%**	**20.8%**

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

TABLE 3	Upgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
C&K Coal	MW-1A					MW-3A					MW-3B				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)		1						1					1		
Acidity (trend)			1								1				
Alkalinity (trend)			1					1					1		
Fe (iron)	1				1			1		1	1				1
Al (aluminum)															
Mn (manganese)			1		1			1		1	1				1
Subtotal	**1**	**1**	**3**	**0**	**2**	**0**	**0**	**4**	**0**	**2**	**3**	**0**	**2**	**0**	**2**
Parameter Group Share (%)	**20.00%**	**20.00%**	**60.00%**			**0.00%**	**0.00%**	**100.00%**			**60.00%**	**0.00%**	**40.00%**		
Trace Elements															
As (arsenic)	1							1		1					
Se (selenium)													1		
Pb (lead)	1						1								
Cd (cadmium)		1					1		1		1				
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**2**	**1**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**0**
Parameter Group Share (%)	**66.67%**	**33.33%**	**0.00%**			**0.00%**	**66.67%**	**33.33%**			**50.00%**	**0.00%**	**50.00%**		
Other Ash Indicators															
Ca (calcium)			1					1					1		
Mg (magnesium)			1					1					1		
Na (sodium)															
Cl (chloride)			1					1			1				
K (potassium)															
F (flouride)															
SO4 (sulfates)			1		1			1	1				1	1	
TDS (total dissolved solids)			1		1			1	1				1	1	
S. Cond. (specific conductance)															
Subtotal	**0**	**0**	**5**	**0**	**2**	**0**	**0**	**5**	**2**	**0**	**1**	**0**	**4**	**2**	**0**
Parameter Group Share (%)	**0.00%**	**0.00%**	**0.00%**			**0.00%**	**0.00%**	**100.00%**			**20.00%**	**0.00%**	**80.00%**		
	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
CHANGED SETS TOTALS	**3**	**2**	**8**	**0**	**4**	**0**	**2**	**10**	**3**	**3**	**5**	**0**	**7**	**2**	**2**
COMPOSITE PARAMETER GROUP SHARE (%)	**23.1%**	**15.4%**	**61.5%**	**0.0%**	**30.8%**	**0.0%**	**16.7%**	**83.3%**	**25.0%**	**25.0%**	**41.7%**	**0.0%**	**58.3%**	**16.7%**	**16.7%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - C&K Coal

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring			
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	2	
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	1	2	0
TOTAL POINTS:	3		

TABLE 3 **Ellengowan**	**Site Monitoring Points Summary**					**Upgradient Monitoring Points Summary**					**Downgradient Monitoring Points Summary**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	2	1	4	2	0	0	0	1	1	0	2	1	3	1	0
Acidity (trend)	3	0	2	0	0	0	0	1	0	0	3	0	1	0	0
Alkalinity (trend)	2	3	2	0	0	0	1	0	0	0	2	2	2	0	0
Fe (iron)	3	1	3	0	7	1	0	0	0	1	2	1	3	0	6
Al (aluminum)	3	1	3	3	4	0	0	1	0	1	3	1	2	3	3
Mn (manganese)	5	0	2	0	7	1	0	0	0	1	4	0	2	0	6
Subtotal	**18**	**6**	**16**	**5**	**18**	**2**	**1**	**3**	**1**	**3**	**16**	**5**	**13**	**4**	**15**
Parameter Group Share (%)	**45.0%**	**15.0%**	**40.0%**	**12.5%**	**45.0%**	**33.3%**	**16.7%**	**50.0%**	**16.7%**	**50.0%**	**47.1%**	**14.7%**	**38.2%**	**11.8%**	**44.1%**
Trace Elements															
As (arsenic)	1	0	1	0	2	0	0	0	0	0	1	0	1	0	2
Se (selenium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb (lead)	1	0	6	0	7	0	0	1	0	1	1	0	5	0	6
Cd (cadmium)	2	1	4	3	4	0	0	1	0	1	2	1	3	3	3
Cr (chromium)	2	0	0	2	0	0	0	0	0	0	2	0	0	2	0
Ni (nickel)	3	0	4	3	2	0	0	1	1	0	3	0	3	2	2
Zn (zinc)	1	0	6	1	1	0	0	1	0	0	1	0	5	1	1
Cu (copper)	0	0	2	1	0	0	0	0	0	0	0	0	2	1	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**10**	**1**	**23**	**10**	**16**	**0**	**0**	**4**	**1**	**2**	**10**	**1**	**19**	**9**	**14**
Parameter Group Share (%)	**29.4%**	**2.9%**	**67.6%**	**29.4%**	**47.1%**	**0.0%**	**0.0%**	**100.0%**	**25.0%**	**50.0%**	**33.3%**	**3.3%**	**63.3%**	**30.0%**	**46.7%**
Other Ash Indicators															
Ca (calcium)	5	0	2	0	0	0	0	1	0	0	5	0	1	0	0
Mg (magnesium)	3	1	3	0	0	0	1	0	0	0	3	0	3	0	0
Na (sodium)	5	2	0	0	0	1	0	0	0	0	4	2	0	0	0
Cl (chloride)	1	0	4	0	0	1	0	0	0	0	0	0	4	0	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
SO4 (sulfates)	4	1	2	1	4	1	0	0	0	0	3	1	2	1	4
TDS (total dissolved solids)	5	0	2	2	3	1	0	0	0	0	4	0	2	2	3
S. Cond. (specific conductance)	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Subtotal	**25**	**4**	**15**	**3**	**7**	**4**	**1**	**1**	**0**	**0**	**21**	**3**	**14**	**3**	**7**
Parameter Group Share (%)	**56.8%**	**9.1%**	**34.1%**	**6.8%**	**15.9%**	**66.7%**	**16.7%**	**16.7%**	**0.0%**	**0.0%**	**55.3%**	**7.9%**	**36.8%**	**7.9%**	**18.4%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**53**	**11**	**54**	**18**	**41**	**6**	**2**	**8**	**2**	**5**	**47**	**9**	**46**	**16**	**36**
COMPOSITE PARAMETER GROUP SHARE (%)	**43.7%**	**9.0%**	**47.2%**	**15.3%**	**34.7%**	**33.3%**	**11.1%**	**55.6%**	**12.5%**	**31.3%**	**45.2%**	**8.6%**	**46.1%**	**15.7%**	**35.3%**

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

TABLE 3	Upgradient Monitoring Point					Downgradient Monitoring Point					Downgradient Monitoring Point				
Ellengowan	**MW-1**					**MW-2**					**MW-3**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)			1	1				1			1				
Acidity (trend)			1			1							1		
Alkalinity (trend)		1						1					1		
Fe (iron)	1				1	1				1			1		1
Al (aluminum)			1		1	1			1		1				1
Mn (manganese)	1				1	1				1	1				1
Subtotal	**2**	**1**	**3**	**1**	**3**	**4**	**0**	**2**	**1**	**2**	**3**	**0**	**3**	**0**	**3**
Parameter Group Share (%)	**33.3%**	**16.7%**	**50.0%**	**16.7%**	**50.0%**	**66.7%**	**0.0%**	**33.3%**	**16.7%**	**33.3%**	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**50.0%**
Trace Elements															
As (arsenic)															
Se (selenium)															
Pb (lead)			1		1			1		1			1		1
Cd (cadmium)			1		1			1	1		1				1
Cr (chromium)															
Ni (nickel)			1	1				1					1	1	
Zn (zinc)			1					1					1		
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**4**	**1**	**2**	**0**	**0**	**4**	**1**	**1**	**1**	**0**	**3**	**1**	**2**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**25.0%**	**50.0%**	**0.0%**	**0.0%**	**100.0%**	**0.25**	**0.25**	**25.0%**	**0.0%**	**75.0%**	**0.25**	**0.5**
Other Ash Indicators															
Ca (calcium)			1			1							1		
Mg (magnesium)		1						1					1		
Na (sodium)	1					1					1				
Cl (chloride)	1							1					1		
K (potassium)															
F (flouride)															
SO4 (sulfates)	1					1				1			1		1
TDS (total dissolved solids)	1					1				1			1		1
S. Cond. (specific conductance)															
Subtotal	**4**	**1**	**1**	**0**	**0**	**4**	**0**	**2**	**0**	**2**	**1**	**0**	**5**	**0**	**2**
Parameter Group Share (%)	**66.7%**	**16.7%**	**16.7%**	**0.0%**	**0.0%**	**66.7%**	**0.0%**	**33.3%**	**0.0%**	**33.3%**	**16.7%**	**0.0%**	**83.3%**	**0.0%**	**33.3%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**6**	**2**	**8**	**2**	**5**	**8**	**0**	**8**	**2**	**5**	**5**	**0**	**11**	**1**	**7**
COMPOSITE PARAMETER GROUP SHARE (%)	**33.3%**	**11.1%**	**55.6%**	**12.5%**	**31.3%**	**44.4%**	**0.0%**	**55.6%**	**12.5%**	**31.3%**	**30.6%**	**0.0%**	**69.4%**	**6.3%**	**43.8%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Point					Downgradient Monitoring Point					Downgradient Monitoring Point				
Ellengowan	**MW-4**					**Monitoring Holes South**					**Maple Hill Shaft**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1							1	1				1		
Acidity (trend)						1					1				
Alkalinity (trend)	1						1					1			
Fe (iron)			1		1	1				1			1		1
Al (aluminum)	1			1				1		1			1		1
Mn (manganese)	1				1			1		1			1		1
Subtotal	**4**	**0**	**1**	**1**	**2**	**2**	**1**	**3**	**1**	**3**	**1**	**1**	**4**	**0**	**3**
Parameter Group Share (%)	**80.0%**	**0.0%**	**20.0%**	**20.0%**	**40.0%**	**33.3%**	**16.7%**	**50.0%**	**16.7%**	**50.0%**	**16.7%**	**16.7%**	**66.7%**	**0.0%**	**50.0%**
Trace Elements															
As (arsenic)								1		1	1				1
Se (selenium)															
Pb (lead)			1		1	1				1			1		1
Cd (cadmium)			1		1			1		1	1			1	
Cr (chromium)						1			1		1			1	
Ni (nickel)			1			1				1	1				1
Zn (zinc)			1					1		1			1	1	
Cu (copper)								1	1				1		
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**4**	**0**	**2**	**3**	**0**	**4**	**2**	**5**	**4**	**0**	**3**	**3**	**3**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0**	**0.5**	**42.9%**	**0.0%**	**57.1%**	**0.285714**	**0.714286**	**57.1%**	**0.0%**	**42.9%**	**0.428571**	**0.428571**
Other Ash Indicators															
Ca (calcium)	1					1					1				
Mg (magnesium)	1					1							1		
Na (sodium)	1						1				1				
Cl (chloride)								1					1		
K (potassium)															
F (flouride)								1					1		
SO4 (sulfates)	1					1				1			1		1
TDS (total dissolved solids)	1					1			1				1		1
S. Cond. (specific conductance)						1					1				
Subtotal	**5**	**0**	**0**	**0**	**0**	**5**	**1**	**2**	**1**	**1**	**3**	**0**	**5**	**0**	**2**
Parameter Group Share (%)	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**62.5%**	**12.5%**	**25.0%**	**12.5%**	**12.5%**	**37.5%**	**0.0%**	**62.5%**	**0.0%**	**25.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**9**	**0**	**5**	**1**	**4**	**10**	**2**	**9**	**4**	**9**	**8**	**1**	**12**	**3**	**8**
COMPOSITE PARAMETER GROUP SHARE (%)	**60.0%**	**0.0%**	**40.0%**	**7.1%**	**28.6%**	**46.2%**	**9.7%**	**44.0%**	**19.0%**	**42.9%**	**37.1%**	**5.6%**	**57.3%**	**14.3%**	**38.1%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Point				
Ellengowan	**Packer V**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash					
pH (trend)		1			
Acidity (trend)					
Alkalinity (trend)	1				
Fe (iron)		1			1
Al (aluminum)		1		1	
Mn (manganese)	1				1
Subtotal	**2**	**3**	**0**	**1**	**2**
Parameter Group Share (%)	**40.0%**	**60.0%**	**0.0%**	**20.0%**	**40.0%**
Trace Elements					
As (arsenic)					
Se (selenium)					
Pb (lead)			1		1
Cd (cadmium)		1		1	
Cr (chromium)					
Ni (nickel)	1			1	
Zn (zinc)	1				
Cu (copper)					
Sb (antimony)					
Mo (molybdenum)					
B (boron)					
Hg (mercury)					
Ba (barium)					
Ag (silver)					
Subtotal	**2**	**1**	**1**	**2**	**1**
Parameter Group Share (%)	**50.0%**	**25.0%**	**25.0%**	**0.5**	**0.25**
Other Ash Indicators					
Ca (calcium)	1				
Mg (magnesium)	1				
Na (sodium)		1			
Cl (chloride)					
K (potassium)					
F (flouride)					
SO4 (sulfates)		1		1	
TDS (total dissolved solids)	1			1	
S. Cond. (specific conductance)					
Subtotal	**3**	**2**	**0**	**2**	**0**
Parameter Group Share (%)	**60.0%**	**40.0%**	**0.0%**	**40.0%**	**0.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**7**	**6**	**1**	**5**	**3**
COMPOSITE PARAMETER GROUP SHARE (%)	**50.0%**	**41.7%**	**8.3%**	**35.7%**	**21.4%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - Ellengowan

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring			
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells			
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools	1	6	
Leachate collection pipe and spring			
Subtotals:	1	6	0
TOTAL POINTS:	7		

TABLE 3 **EME Generation**	**Site Monitoring Points Summary**					**Upgradient Monitoring Points Summary**					**Downgradient Monitoring Points Summary**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1	0	6	0	0	0	0	2	0	0	1	0	4	0	0
Acidity (trend)	2	0	5	0	0	0	0	2	0	0	2	0	3	0	0
Alkalinity (trend)	0	2	4	0	0	0	0	2	0	0	0	2	2	0	0
Fe (iron)	3	0	5	5	8	1	0	1	2	2	2	0	4	3	6
Al (aluminum)	1	0	5	5	6	0	0	2	2	2	1	0	3	3	4
Mn (manganese)	3	0	5	5	8	1	0	1	2	2	2	0	4	3	6
Subtotal	**10**	**2**	**30**	**15**	**22**	**2**	**0**	**10**	**6**	**6**	**8**	**2**	**20**	**9**	**16**
Parameter Group Share (%)	**23.81%**	**4.76%**	**71.43%**			**16.67%**	**0.00%**	**83.33%**			**26.67%**	**6.67%**	**66.67%**		
Trace Elements															
As (arsenic)	3	0	0	0	1	0	0	0	0	0	3	0	0	0	1
Se (selenium)	2	1	0	0	0	0	0	0	0	0	2	1	0	0	0
Pb (lead)	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Cd (cadmium)	1	0	1	1	0	0	0	0	0	0	1	0	1	1	0
Cr (chromium)	0	0	2	0	1	0	0	0	0	0	0	0	2	0	1
Ni (nickel)	0	0	3	0	3	0	0	0	0	0	0	0	3	0	3
Zn (zinc)	1	0	2	0	0	0	0	0	0	0	1	0	2	0	0
Cu (copper)	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0
Ag (silver)	0	0	3	1	0	0	0	0	0	0	0	0	3	1	0
Subtotal	**7**	**2**	**17**	**2**	**5**	**0**	**0**	**0**	**0**	**0**	**7**	**2**	**17**	**2**	**5**
Parameter Group Share (%)	**26.92%**	**7.69%**	**65.38%**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**26.92%**	**7.69%**	**65.38%**		
Other Ash Indicators															
Ca (calcium)	1	0	2	0	0	0	0	0	0	0	1	0	2	0	0
Mg (magnesium)	1	0	2	0	0	0	0	0	0	0	1	0	2	0	0
Na (sodium)	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0
Cl (chloride)	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0
K (potassium)	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	4	0	3	4	6	2	0	0	2	1	2	0	3	2	5
TDS (total dissolved solids)	1	0	2	1	2	0	0	0	0	0	1	0	2	1	2
S. Cond. (specific conductance)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Subtotal	**9**	**1**	**14**	**5**	**8**	**2**	**0**	**0**	**2**	**1**	**7**	**1**	**14**	**3**	**7**
Parameter Group Share (%)	**31.03%**	**3.45%**	**17.24%**			**50.00%**	**0.00%**	**50.00%**			**28.00%**	**4.00%**	**12.00%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**26**	**5**	**61**	**22**	**35**	**4**	**0**	**10**	**8**	**7**	**22**	**5**	**51**	**14**	**28**
COMPOSITE PARAMETER GROUP SHARE (%)	**28.3%**	**5.4%**	**66.3%**	**23.9%**	**38.0%**	**28.6%**	**0.0%**	**71.4%**	**57.1%**	**50.0%**	**28.2%**	**6.4%**	**65.4%**	**17.9%**	**35.9%**

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

TABLE 3	Upgradient Monitoring Points					Upgradient Monitoring Points					Downgradient Monitoring Points				
EME Generation	**MP-10**					**MP-11**					**MP-12**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)			1					1							
Acidity (trend)			1					1							
Alkalinity (trend)			1					1							
Fe (iron)			1	1	1	1			1	1			1	1	1
Al (aluminum)			1	1	1			1	1	1			1	1	1
Mn (manganese)			1	1	1	1			1	1	1			1	1
Subtotal	**0**	**0**	**6**	**3**	**3**	**2**	**0**	**4**	**3**	**3**	**1**	**0**	**2**	**3**	**3**
Parameter Group Share (%)	**0.00%**	**0.00%**	**100.00%**			**33.33%**	**0.00%**	**66.67%**			**33.33%**	**0.00%**	**66.67%**		
Trace Elements															
As (arsenic)															
Se (selenium)															
Pb (lead)															
Cd (cadmium)															
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**		
Other Ash Indicators															
Ca (calcium)															
Mg (magnesium)															
Na (sodium)															
Cl (chloride)															
K (potassium)															
F (flouride)															
SO4 (sulfates)	1			1	1	1			1						
TDS (total dissolved solids)															
S. Cond. (specific conductance)															
Subtotal	**1**	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**50.00%**	**0.00%**	**50.00%**			**50.00%**	**0.00%**	**50.00%**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**1**	**0**	**6**	**4**	**4**	**3**	**0**	**4**	**4**	**3**	**1**	**0**	**2**	**3**	**3**
COMPOSITE PARAMETER GROUP SHARE (%)	**14.3%**	**0.0%**	**85.7%**	**57.1%**	**57.1%**	**42.9%**	**0.0%**	**57.1%**	**57.1%**	**42.9%**	**33.3%**	**0.0%**	**66.7%**	**100.0%**	**100.0%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
EME Generation	**MP-13**					**MP-14**					**MP-15**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)			1					1					1		
Acidity (trend)			1					1			1				
Alkalinity (trend)			1										1		
Fe (iron)			1	1	1	1			1	1			1		1
Al (aluminum)			1	1	1	1			1	1					
Mn (manganese)			1	1	1	1			1	1			1		1
Subtotal	**0**	**0**	**6**	**3**	**3**	**3**	**0**	**2**	**3**	**3**	**1**	**0**	**4**	**0**	**2**
Parameter Group Share (%)	**0.00%**	**0.00%**	**100.00%**			**60.00%**	**0.00%**	**40.00%**			**20.00%**	**0.00%**	**80.00%**		
Trace Elements															
As (arsenic)											1				
Se (selenium)												1			
Pb (lead)												1			
Cd (cadmium)													1		
Cr (chromium)															
Ni (nickel)													1		1
Zn (zinc)											1				
Cu (copper)													1		
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)													1		
Ag (silver)													1		
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**3**	**0**	**1**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**#DIV/0!**	**#DIV/0!**	**#DIV/0!**			**28.57%**	**28.57%**	**42.86%**		
Other Ash Indicators															
Ca (calcium)													1		
Mg (magnesium)													1		
Na (sodium)															
Cl (chloride)													1		
K (potassium)															
F (flouride)															
SO4 (sulfates)			1	1	1	1			1	1			1		1
TDS (total dissolved solids)													1	1	
S. Cond. (specific conductance)															
Subtotal	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**5**	**1**	**1**
Parameter Group Share (%)	**0.00%**	**0.00%**	**100.00%**			**100.00%**	**0.00%**	**0.00%**			**0.00%**	**0.00%**	**100.00%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**0**	**0**	**7**	**4**	**4**	**4**	**0**	**2**	**4**	**4**	**3**	**2**	**12**	**1**	**4**
COMPOSITE PARAMETER GROUP SHARE (%)	**0.0%**	**0.0%**	**100.0%**	**57.1%**	**57.1%**	**66.7%**	**0.0%**	**33.3%**	**66.7%**	**66.7%**	**17.6%**	**11.8%**	**70.6%**	**5.9%**	**23.5%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points				
EME Generation	MP-19					MP-20				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash										
pH (trend)			1			1				
Acidity (trend)			1			1				
Alkalinity (trend)		1					1			
Fe (iron)			1		1	1				1
Al (aluminum)								1		1
Mn (manganese)			1		1			1		1
Subtotal	**0**	**1**	**4**	**0**	**2**	**3**	**1**	**2**	**0**	**3**
Parameter Group Share (%)	**0.00%**	**20.00%**	**80.00%**			**50.00%**	**16.67%**	**33.33%**		
Trace Elements										
As (arsenic)	1					1				1
Se (selenium)	1					1				
Pb (lead)										
Cd (cadmium)						1			1	
Cr (chromium)			1					1		1
Ni (nickel)			1		1			1		1
Zn (zinc)			1					1		
Cu (copper)			1					1		
Sb (antimony)										
Mo (molybdenum)										
B (boron)										
Hg (mercury)										
Ba (barium)			1					1		
Ag (silver)			1					1	1	
Subtotal	**2**	**0**	**4**	**0**	**1**	**3**	**0**	**4**	**1**	**3**
Parameter Group Share (%)	**33.33%**	**0.00%**	**66.67%**			**42.86%**	**0.00%**	**57.14%**		
Other Ash Indicators										
Ca (calcium)			1			1				
Mg (magnesium)			1			1				
Na (sodium)			1			1				
Cl (chloride)			1					1		
K (potassium)			1				1			
F (flouride)										
SO4 (sulfates)			1		1	1				1
TDS (total dissolved solids)			1		1	1				1
S. Cond. (specific conductance)						1				
Subtotal	**0**	**0**	**7**	**0**	**2**	**6**	**1**	**1**	**0**	**2**
Parameter Group Share (%)	**0.00%**	**0.00%**	**100.00%**			**75.00%**	**12.50%**	**12.50%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**2**	**1**	**15**	**0**	**5**	**12**	**2**	**7**	**1**	**8**
COMPOSITE PARAMETER GROUP SHARE (%)	**11.1%**	**5.6%**	**83.3%**	**0.0%**	**27.8%**	**57.1%**	**9.5%**	**33.3%**	**4.8%**	**38.1%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - EME Generation

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring		1	
Stream	1	2	
Surface mine discharge			
Leachate collection pond		1	
Gound Water Monitoring Point			
Wells	1		
Leachate collection pipe			1
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring		1	
Subtotals:	2	5	1
TOTAL POINTS:	8		

TABLE 3 E.P. Bender	Site Monitoring Points Summary					Upgradient Monitoring Points Summary					Downgradient Monitoring Points Summary				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1	0	2	0	0	1	0	0	0	0	0	0	2	0	0
Acidity (trend)	0	0	4	0	0	0	0	1	0	0	0	0	3	0	0
Alkalinity (trend)	0	1	3	0	0	0	1	0	0	0	0	0	3	0	0
Fe (iron)	0	1	3	1	3	0	1	0	0	1	0	0	3	1	2
Al (aluminum)	1	0	1	0	2	1	0	0	0	1	0	0	1	0	1
Mn (manganese)	0	0	5	0	4	0	0	1	0	1	0	0	4	0	3
Subtotal	**2**	**2**	**18**	**1**	**9**	**2**	**2**	**2**	**0**	**3**	**0**	**0**	**16**	**1**	**6**
Parameter Group Share (%)	**9.1%**	**9.1%**	**81.8%**	**4.5%**	**40.9%**	**33.3%**	**33.3%**	**33.3%**	**0.0%**	**50.0%**	**0.0%**	**0.0%**	**100.0%**	**6.3%**	**37.5%**
Trace Elements															
As (arsenic)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Se (selenium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb (lead)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd (cadmium)	0	0	2	2	0	0	0	0	0	0	0	0	2	2	0
Cr (chromium)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Ni (nickel)	0	0	4	2	2	0	0	1	1	0	0	0	3	1	2
Zn (zinc)	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**2**	**0**	**8**	**4**	**2**	**1**	**0**	**1**	**1**	**0**	**1**	**0**	**7**	**3**	**2**
Parameter Group Share (%)	**20.0%**	**0.0%**	**80.0%**	**40.0%**	**20.0%**	**50.0%**	**0.0%**	**50.0%**	**50.0%**	**0.0%**	**12.5%**	**0.0%**	**87.5%**	**37.5%**	**25.0%**
Other Ash Indicators															
Ca (calcium)	0	0	4	0	0	0	0	1	0	0	0	0	3	0	0
Mg (magnesium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Na (sodium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl (chloride)	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	0	0	3	3	0	0	0	1	1	0	0	0	2	2	0
TDS (total dissolved solids)	0	0	2	2	1	0	0	1	0	1	0	0	1	2	0
S. Cond. (specific conductance)	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0
Subtotal	**0**	**0**	**12**	**6**	**1**	**0**	**0**	**3**	**1**	**1**	**0**	**0**	**9**	**5**	**0**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**50.0%**	**8.3%**	**0.0%**	**0.0%**	**100.0%**	**33.3%**	**33.3%**	**0.0%**	**0.0%**	**100.0%**	**55.6%**	**0.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**4**	**2**	**38**	**11**	**12**	**3**	**2**	**6**	**2**	**4**	**1**	**0**	**32**	**9**	**8**
COMPOSITE PARAMETER GROUP SHARE (%)	**9.1%**	**4.5%**	**86.4%**	**25.0%**	**27.3%**	**27.3%**	**18.2%**	**54.5%**	**18.2%**	**36.4%**	**3.0%**	**0.0%**	**97.0%**	**27.3%**	**24.2%**

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

TABLE 3	**Upgradient Monitoring Points**					**Downgradient Monitoring Points**					**Downgradient Monitoring Points**				
E.P. Bender	**MP-11**					**MP-18**					**MW-1**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1														
Acidity (trend)			1					1							
Alkalinity (trend)		1						1							
Fe (iron)		1			1			1	1				1		1
Al (aluminum)	1				1			1		1					
Mn (manganese)			1		1			1					1		1
Subtotal	**2**	**2**	**2**	**0**	**3**	**0**	**0**	**5**	**1**	**1**	**0**	**0**	**2**	**0**	**2**
Parameter Group Share (%)	**33.3%**	**33.3%**	**33.3%**	**0.0%**	**50.0%**	**0.0%**	**0.0%**	**100.0%**	**20.0%**	**20.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**100.0%**
Trace Elements															
As (arsenic)											1				
Se (selenium)															
Pb (lead)															
Cd (cadmium)															
Cr (chromium)															
Ni (nickel)			1	1				1		1					
Zn (zinc)	1							1							
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**2**	**0**	**1**	**1**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**50.0%**	**0.0%**	**50.0%**	**50.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**50.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Other Ash Indicators															
Ca (calcium)			1					1							
Mg (magnesium)															
Na (sodium)															
Cl (chloride)								1							
K (potassium)															
F (flouride)															
SO4 (sulfates)			1	1				1	1						
TDS (total dissolved solids)			1		1										
S. Cond. (specific conductance)								1							
Subtotal	**0**	**0**	**3**	**1**	**1**	**0**	**0**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**33.3%**	**33.3%**	**0.0%**	**0.0%**	**100.0%**	**25.0%**	**0.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**3**	**2**	**6**	**2**	**4**	**0**	**0**	**11**	**2**	**2**	**1**	**0**	**2**	**0**	**2**
COMPOSITE PARAMETER GROUP SHARE (%)	**27.3%**	**18.2%**	**54.5%**	**18.2%**	**36.4%**	**0.0%**	**0.0%**	**100.0%**	**18.2%**	**18.2%**	**33.3%**	**0.0%**	**66.7%**	**0.0%**	**66.7%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points				
E.P. Bender	**MP-24**					**MP-19**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash										
pH (trend)			1					1		
Acidity (trend)			1					1		
Alkalinity (trend)			1					1		
Fe (iron)			1		1					
Al (aluminum)										
Mn (manganese)			1		1			1		1
Subtotal	**0**	**0**	**5**	**0**	**2**	**0**	**0**	**4**	**0**	**1**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**40.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**25.0%**
Trace Elements										
As (arsenic)										
Se (selenium)										
Pb (lead)										
Cd (cadmium)			1	1				1	1	
Cr (chromium)			1							
Ni (nickel)			1		1			1	1	
Zn (zinc)										
Cu (copper)										
Sb (antimony)										
Mo (molybdenum)										
B (boron)										
Hg (mercury)										
Ba (barium)										
Ag (silver)										
Subtotal	**0**	**0**	**3**	**1**	**1**	**0**	**0**	**2**	**2**	**0**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**33.3%**	**33.3%**	**0.0%**	**0.0%**	**100.0%**	**100.0%**	**0.0%**
Other Ash Indicators										
Ca (calcium)			1					1		
Mg (magnesium)										
Na (sodium)										
Cl (chloride)								1		
K (potassium)										
F (flouride)										
SO4 (sulfates)								1	1	
TDS (total dissolved solids)				1				1	1	
S. Cond. (specific conductance)				1						
Subtotal	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**4**	**2**	**0**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**200.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**50.0%**	**0.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**0**	**0**	**9**	**3**	**3**	**0**	**0**	**10**	**4**	**1**
COMPOSITE PARAMETER GROUP SHARE (%)	**0.0%**	**0.0%**	**100.0%**	**33.3%**	**33.3%**	**0.0%**	**0.0%**	**100.0%**	**40.0%**	**10.0%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - E.P. Bender

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring	1	2	
Stream			
Surface mine discharge		1	
Leachate collection pond			
Gound Water Monitoring Point			
Wells		1	
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	1	4	0
TOTAL POINTS:	5		

TABLE 3 **Ernest**	**Site Monitoring Points Summary**					**Upgradient Monitoring Points Summary**					**Downgradient Monitoring Points Summary**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	4	3	1	0	0	1	0	1	0	0	3	3	0	0	0
Acidity (trend)	1	1	5	0	0	0	1	0	0	0	1	0	5	0	0
Alkalinity (trend)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Fe (iron)	1	1	3	0	5	0	1	0	0	1	1	0	3	0	4
Al (aluminum)	1	1	6	0	7	0	1	1	0	1	1	0	5	0	6
Mn (manganese)	1	0	5	0	6	0	0	1	0	1	1	0	4	0	5
Subtotal	**8**	**6**	**21**	**0**	**18**	**1**	**3**	**3**	**0**	**3**	**7**	**3**	**18**	**0**	**15**
Parameter Group Share (%)	**22.9%**	**17.1%**	**60.0%**	**0.0%**	**51.4%**	**14.3%**	**42.9%**	**42.9%**	**0.0%**	**42.9%**	**25.0%**	**10.7%**	**64.3%**	**0.0%**	**53.6%**
Trace Elements															
As (arsenic)	2	0	1	0	2	0	0	0	0	0	2	0	1	0	2
Se (selenium)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pb (lead)	0	0	3	0	3	0	0	0	0	0	0	0	3	0	3
Cd (cadmium)	1	0	2	0	2	0	0	0	0	0	1	0	2	0	2
Cr (chromium)	0	0	2	1	0	0	0	0	0	0	0	0	2	1	0
Ni (nickel)	0	0	3	0	3	0	0	0	0	0	0	0	3	0	3
Zn (zinc)	0	0	3	1	0	0	0	0	0	0	0	0	3	1	0
Cu (copper)	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**4**	**0**	**17**	**2**	**10**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**17**	**2**	**10**
Parameter Group Share (%)	**19.0%**	**0.0%**	**81.0%**	**9.5%**	**47.6%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**19.0%**	**0.0%**	**81.0%**	**9.5%**	**47.6%**
Other Ash Indicators															
Ca (calcium)	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0
Mg (magnesium)	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
Na (sodium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl (chloride)	0	0	3	1	0	0	0	0	0	0	0	0	3	1	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	2	1	5	1	5	1	1	0	0	0	1	0	5	1	5
TDS (total dissolved solids)	0	0	3	0	3	0	0	0	0	0	0	0	3	0	3
S. Cond. (specific conductance)	1	1	2	0	0	1	1	0	0	0	0	0	2	0	0
Subtotal	**3**	**2**	**18**	**2**	**8**	**2**	**2**	**0**	**0**	**0**	**1**	**0**	**18**	**2**	**8**
Parameter Group Share (%)	**13.0%**	**8.7%**	**78.3%**	**8.7%**	**32.0%**	**50.0%**	**50.0%**	**0.0%**	**0.0%**	**0.0%**	**5.3%**	**0.0%**	**94.7%**	**10.5%**	**38.1%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**15**	**8**	**56**	**4**	**36**	**3**	**5**	**3**	**0**	**3**	**12**	**3**	**53**	**4**	**33**
COMPOSITE PARAMETER GROUP SHARE (%)	**19.0%**	**10.1%**	**70.9%**	**5.1%**	**45.6%**	**27.3%**	**45.5%**	**27.3%**	**0.0%**	**27.3%**	**17.6%**	**4.4%**	**77.9%**	**5.9%**	**48.5%**

TABLE 3	**Upgradient Monitoring Points**					**Upgradient Monitoring Points**					**Downgradient Monitoring Points**				
Ernest	**E-34**					**E-35**					**MW-1**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)			1			1					1				
Acidity (trend)							1						1		
Alkalinity (trend)															
Fe (iron)							1			1			1		1
Al (aluminum)			1		1		1						1		1
Mn (manganese)								1		1			1		1
Subtotal	**0**	**0**	**2**	**0**	**1**	**1**	**3**	**1**	**0**	**2**	**1**	**0**	**4**	**0**	**3**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**50.0%**	**20.0%**	**60.0%**	**20.0%**	**0.0%**	**40.0%**	**20.0%**	**0.0%**	**80.0%**	**0.0%**	**60.0%**
Trace Elements															
As (arsenic)											1				1
Se (selenium)															
Pb (lead)													1		1
Cd (cadmium)													1		1
Cr (chromium)															
Ni (nickel)													1		1
Zn (zinc)													1		
Cu (copper)													1		
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**5**	**0**	**4**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**16.7%**	**0.0%**	**83.3%**	**0.0%**	**66.7%**
Other Ash Indicators															
Ca (calcium)													1		
Mg (magnesium)													1		
Na (sodium)															
Cl (chloride)													1	1	
K (potassium)															
F (flouride)															
SO4 (sulfates)	1						1						1		1
TDS (total dissolved solids)													1		1
S. Cond. (specific conductance)	1						1								
Subtotal	**2**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**5**	**1**	**2**
Parameter Group Share (%)	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**20.0%**	**33.3%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**2**	**0**	**2**	**0**	**1**	**1**	**5**	**1**	**0**	**2**	**2**	**0**	**14**	**1**	**9**
COMPOSITE PARAMETER GROUP SHARE (%)	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**25.0%**	**14.3%**	**71.4%**	**14.3%**	**0.0%**	**28.6%**	**12.5%**	**0.0%**	**87.5%**	**6.3%**	**56.3%**

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Ernest	E-5					MW-2					E-17				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)		1					1								
Acidity (trend)			1			1									
Alkalinity (trend)															
Fe (iron)						1				1					
Al (aluminum)			1		1			1		1					
Mn (manganese)			1		1	1				1					
Subtotal	**0**	**1**	**3**	**0**	**2**	**3**	**1**	**1**	**0**	**3**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**0.0%**	**25.0%**	**75.0%**	**0.0%**	**50.0%**	**60.0%**	**20.0%**	**20.0%**	**0.0%**	**60.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Trace Elements															
As (arsenic)			1		1	1									
Se (selenium)						1									
Pb (lead)			1		1			1		1					
Cd (cadmium)			1		1	1									
Cr (chromium)			1	1				1							
Ni (nickel)			1		1			1		1					
Zn (zinc)			1	1				1							
Cu (copper)			1												
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)								1							
Ag (silver)															
Subtotal	**0**	**0**	**7**	**2**	**4**	**3**	**0**	**5**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**28.6%**	**57.1%**	**37.5%**	**0.0%**	**62.5%**	**0.0%**	**25.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Other Ash Indicators															
Ca (calcium)			1					1							
Mg (magnesium)			1												
Na (sodium)															
Cl (chloride)			1					1							
K (potassium)															
F (flouride)															
SO4 (sulfates)			1		1	1				1					
TDS (total dissolved solids)			1		1			1		1					
S. Cond. (specific conductance)					0										
Subtotal	**0**	**0**	**5**	**0**	**2**	**1**	**0**	**3**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**40.0%**	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**50.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**0**	**1**	**15**	**2**	**8**	**7**	**1**	**9**	**0**	**7**	**0**	**0**	**0**	**0**	**0**
COMPOSITE PARAMETER GROUP SHARE (%)	**0.0%**	**6.3%**	**93.8%**	**12.5%**	**50.0%**	**41.2%**	**5.9%**	**52.9%**	**0.0%**	**41.2%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**

TABLE 3	**Downgradient Monitoring Points**					**Downgradient Monitoring Points**					**Downgradient Monitoring Points**					**Downgradient Monitoring Points**				
Ernest	**E-52**					**E-4**					**E-7**					**E-70**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash																				
pH (trend)						1						1				1				
Acidity (trend)			1										1					1		
Alkalinity (trend)								1												
Fe (iron)													1		1			1		1
Al (aluminum)						1				1			1		1			1		1
Mn (manganese)													1		1			1		1
Subtotal	**0**	**0**	**1**	**0**	**0**	**2**	**0**	**1**	**0**	**1**	**0**	**1**	**4**	**0**	**3**	**1**	**0**	**4**	**0**	**3**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**66.7%**	**0.0%**	**33.3%**	**0.0%**	**33.3%**	**0.0%**	**20.0%**	**80.0%**	**0.0%**	**60.0%**	**20.0%**	**0.0%**	**80.0%**	**0.0%**	**60.0%**
Trace Elements																				
As (arsenic)																				
Se (selenium)																				
Pb (lead)																				
Cd (cadmium)																				
Cr (chromium)																				
Ni (nickel)																				
Zn (zinc)																				
Cu (copper)																				
Sb (antimony)																				
Mo (molybdenum)																				
B (boron)																				
Hg (mercury)																				
Ba (barium)																				
Ag (silver)																				
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Other Ash Indicators																				
Ca (calcium)																				
Mg (magnesium)																				
Na (sodium)																				
Cl (chloride)																				
K (potassium)																				
F (flouride)																				
SO4 (sulfates)								1	1				1		1			1		1
TDS (total dissolved solids)																				
S. Cond. (specific conductance)													1					1		
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**0**	**2**	**0**	**1**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**0.0%**	**0.0%**	**100.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**50.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**50.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**0**	**0**	**1**	**0**	**0**	**2**	**0**	**2**	**1**	**1**	**0**	**1**	**6**	**0**	**4**	**1**	**0**	**6**	**0**	**4**
COMPOSITE PARAMETER GROUP SHARE (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**50.0%**	**0.0%**	**50.0%**	**25.0%**	**25.0%**	**0.0%**	**14.3%**	**85.7%**	**0.0%**	**57.1%**	**14.3%**	**0.0%**	**85.7%**	**0.0%**	**57.1%**

Table 2: Monitoring Points Examination - Ernest

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring			
Stream	1	3	
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	3	
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools	1	2	
Leachate collection pipe and spring			
Subtotals:	3	8	0
TOTAL POINTS:	11		

TABLE 3 **Lawrence Coal Company**	**Site Monitoring Points Summary**					**Upgradient Monitoring Points Summary**					**Downgradient Monitoring Points Summary**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1	0	3	0	0	1	0	0	0	0	0	0	3	0	0
Acidity (trend)	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0
Alkalinity (trend)	2	0	2	0	0	1	0	0	0	0	1	0	2	0	0
Fe (iron)	0	0	2	0	2	0	0	1	0	1	0	0	1	0	1
Al (aluminum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn (manganese)	1	0	3	0	3	0	0	1	0	1	1	0	2	0	2
Subtotal	**5**	**0**	**11**	**0**	**5**	**2**	**0**	**3**	**0**	**2**	**3**	**0**	**8**	**0**	**3**
Parameter Group Share (%)	**31.3%**	**0.0%**	**68.8%**			**40.0%**	**0.0%**	**60.0%**			**27.3%**	**0.0%**	**72.7%**		
Trace Elements															
As (arsenic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Se (selenium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb (lead)	0	0	2	0	2	0	0	1	0	1	0	0	1	0	1
Cd (cadmium)	0	0	2	2	0	0	0	1	1	0	0	0	1	1	0
Cr (chromium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni (nickel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn (zinc)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	3	0	2	0	0	1	0	1	0	0	2	0	1
Mo (molybdenum)	0	0	2	1	1	0	0	0	0	0	0	0	2	1	1
B (boron)	0	0	2	0	2	0	0	0	0	0	0	0	2	0	2
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**0**	**0**	**11**	**3**	**7**	**0**	**0**	**3**	**1**	**2**	**0**	**0**	**8**	**2**	**5**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**			**0.0%**	**0.0%**	**100.0%**			**0.0%**	**0.0%**	**100.0%**		
Other Ash Indicators															
Ca (calcium)	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
Mg (magnesium)	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
Na (sodium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl (chloride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K (potassium)	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	2	0	2	1	3	0	0	1	0	1	2	0	1	1	2
TDS (total dissolved solids)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. Cond. (specific conductance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**2**	**0**	**8**	**1**	**3**	**0**	**0**	**1**	**0**	**1**	**2**	**0**	**7**	**1**	**2**
Parameter Group Share (%)	**18.2%**	**0.0%**	**9.1%**			**0.0%**	**0.0%**	**0.0%**			**20.0%**	**0.0%**	**10.0%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**7**	**0**	**30**	**4**	**15**	**2**	**0**	**7**	**1**	**5**	**5**	**0**	**23**	**3**	**10**
COMPOSITE PARAMETER GROUP SHARE (%)	**18.9%**	**0.0%**	**81.1%**	**10.8%**	**40.5%**	**22.2%**	**0.0%**	**77.8%**	**11.1%**	**55.6%**	**17.9%**	**0.0%**	**82.1%**	**10.7%**	**35.7%**

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

TABLE 3	Upgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Lawrence Coal Company	MW-2					MW-1					MW-206				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1							1					1		
Acidity (trend)			1			1									
Alkalinity (trend)	1					1							1		
Fe (iron)			1		1			1		1					
Al (aluminum)															
Mn (manganese)			1		1			1		1			1		
Subtotal	**2**	**0**	**3**	**#NAME?**	**2**	**2**	**0**	**3**	**0**	**2**	**0**	**0**	**3**	**0**	**0**
Parameter Group Share (%)	**40.0%**	**0.0%**	**60.0%**			**40.0%**	**0.0%**	**60.0%**			**0.0%**	**0.0%**	**100.0%**		
Trace Elements															
As (arsenic)															
Se (selenium)															
Pb (lead)			1		1			1		1					
Cd (cadmium)			1	1				1	1						
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)			1		1			1		1			1		
Mo (molybdenum)								1		1					
B (boron)													1		1
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**3**	**1**	**2**	**0**	**0**	**4**	**1**	**3**	**0**	**0**	**2**	**0**	**1**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**			**0.0%**	**0.0%**	**100.0%**			**0.0%**	**0.0%**	**100.0%**		
Other Ash Indicators															
Ca (calcium)													1		
Mg (magnesium)													1		
Na (sodium)															
Cl (chloride)															
K (potassium)													1		
F (flouride)															
SO4 (sulfates)			1		1	1			1				1		1
TDS (total dissolved solids)															
S. Cond. (specific conductance)															
Subtotal	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**0**	**1**
Parameter Group Share (%)	**0.0%**	**0.0%**	**0.0%**			**100.0%**	**0.0%**	**0.0%**			**0.0%**	**0.0%**	**100.0%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**2**	**0**	**7**	**#NAME?**	**5**	**3**	**0**	**7**	**2**	**5**	**0**	**0**	**9**	**0**	**2**
COMPOSITE PARAMETER GROUP SHARE (%)	**22.2%**	**0.0%**	**77.8%**	**#NAME?**	**55.6%**	**30.0%**	**0.0%**	**70.0%**	**20.0%**	**50.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**22.2%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Points				
Lawrence Coal Company	**MW-207**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash					
pH (trend)			1		
Acidity (trend)					
Alkalinity (trend)			1		
Fe (iron)					
Al (aluminum)					
Mn (manganese)	1				1
Subtotal	**1**	**0**	**2**	**0**	**1**
Parameter Group Share (%)	**33.3%**	**0.0%**	**66.7%**		
Trace Elements					
As (arsenic)					
Se (selenium)					
Pb (lead)					
Cd (cadmium)					
Cr (chromium)					
Ni (nickel)					
Zn (zinc)					
Cu (copper)					
Sb (antimony)					
Mo (molybdenum)			1	1	
B (boron)			1		1
Hg (mercury)					
Ba (barium)					
Ag (silver)					
Subtotal	**0**	**0**	**2**	**1**	**1**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**		
Other Ash Indicators					
Ca (calcium)			1		
Mg (magnesium)			1		
Na (sodium)					
Cl (chloride)					
K (potassium)			1		
F (flouride)					
SO4 (sulfates)	1				1
TDS (total dissolved solids)					
S. Cond. (specific conductance)					
Subtotal	**1**	**0**	**3**	**0**	**1**
Parameter Group Share (%)	**25.0%**	**0.0%**	**75.0%**		
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**2**	**0**	**7**	**1**	**3**
COMPOSITE PARAMETER GROUP SHARE (%)	**22.2%**	**0.0%**	**77.8%**	**11.1%**	**33.3%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - Lawrence Coal Company

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring			
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	3	
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	1	3	0
TOTAL POINTS:	4		

TABLE 3	**Site Monitoring Points Summary**					**Downgradient Monitoring Points**				
McDermott						**MW-1**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash										
pH (trend)	7	0	0	0	0	1				
Acidity (trend)	2	0	5	0	0	1				
Alkalinity (trend)	3	0	1	0	0					
Fe (iron)	0	0	4	0	4			1		1
Al (aluminum)	0	0	0	0	0					
Mn (manganese)	0	0	7	0	7			1		1
Subtotal	**12**	**0**	**17**	**0**	**11**	**2**	**0**	**2**	**0**	**2**
Parameter Group Share (%)	**41.4%**	**0.0%**	**58.6%**	**0.0%**	**37.9%**	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**50.0%**
Trace Elements										
As (arsenic)	0	4	3	0	1		1			
Se (selenium)	0	1	6	3	2			1	1	
Pb (lead)	1	0	6	1	3	1			1	
Cd (cadmium)	0	1	6	2	4			1	1	
Cr (chromium)	0	0	0	0	0					
Ni (nickel)	0	0	0	0	0					
Zn (zinc)	0	0	0	0	0					
Cu (copper)	0	0	0	0	0					
Sb (antimony)	0	0	0	0	0					
Mo (molybdenum)	0	0	0	0	0					
B (boron)	0	0	0	0	0					
Hg (mercury)	0	0	0	0	0					
Ba (barium)	0	0	0	0	0					
Ag (silver)	0	0	0	0	0					
Subtotal	**1**	**6**	**21**	**6**	**10**	**1**	**1**	**2**	**3**	**0**
Parameter Group Share (%)	**3.6%**	**21.4%**	**75.0%**	**21.4%**	**35.7%**	**25.0%**	**25.0%**	**50.0%**	**75.0%**	**0.0%**
Other Ash Indicators										
Ca (calcium)	1	0	6	0	0			1		
Mg (magnesium)	0	0	7	0	0			1		
Na (sodium)	0	0	4	0	0			1		
Cl (chloride)	0	0	4	0	0			1		
K (potassium)	0	0	0	0	0					
F (flouride)	0	0	0	0	0					
SO4 (sulfates)	0	0	7	0	6			1		
TDS (total dissolved solids)	0	0	6	0	6			1		1
S. Cond. (specific conductance)	0	0	0	0	0					
Subtotal	**1**	**0**	**34**	**0**	**12**	**0**	**0**	**6**	**0**	**1**
Parameter Group Share (%)	**2.9%**	**0.0%**	**97.1%**	**0.0%**	**34.3%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**16.7%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**14**	**6**	**72**	**6**	**33**	**3**	**1**	**10**		
COMPOSITE PARAMETER GROUP SHARE (%)	**15.2%**	**6.5%**	**78.3%**	**6.5%**	**35.9%**	**21.4%**	**7.1%**	**71.4%**	**0.0%**	**0.0%**

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

TABLE 3	**Downgradient Monitoring Points**					**Downgradient Monitoring Points**					**Downgradient Monitoring Points**				
McDermott	**MD-12**					**MW-2**					**MD-22**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1					1					1				
Acidity (trend)			1					1					1		
Alkalinity (trend)											1				
Fe (iron)								1		1			1		1
Al (aluminum)															
Mn (manganese)			1		1			1		1			1		1
Subtotal	**1**	**0**	**2**	**0**	**1**	**1**	**0**	**3**	**0**	**2**	**2**	**0**	**3**	**0**	**2**
Parameter Group Share (%)	**33.3%**	**0.0%**	**66.7%**	**0.0%**	**33.3%**	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**50.0%**	**40.0%**	**0.0%**	**60.0%**	**0.0%**	**40.0%**
Trace Elements															
As (arsenic)		1					1						1		1
Se (selenium)			1		1			1	1				1	1	
Pb (lead)			1		1			1		1			1		
Cd (cadmium)		1		1				1		1			1		1
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**2**	**2**	**1**	**2**	**0**	**1**	**3**	**1**	**2**	**0**	**0**	**4**	**1**	**2**
Parameter Group Share (%)	**0.0%**	**50.0%**	**50.0%**	**25.0%**	**50.0%**	**0.0%**	**25.0%**	**75.0%**	**25.0%**	**50.0%**	**0.0%**	**0.0%**	**100.0%**	**25.0%**	**50.0%**
Other Ash Indicators															
Ca (calcium)			1					1			1				
Mg (magnesium)			1					1					1		
Na (sodium)													1		
Cl (chloride)													1		
K (potassium)															
F (flouride)															
SO4 (sulfates)			1		1			1		1			1		1
TDS (total dissolved solids)								1		1			1		1
S. Cond. (specific conductance)															
Subtotal	**0**	**0**	**3**	**0**	**1**	**0**	**0**	**4**	**0**	**2**	**1**	**0**	**5**	**0**	**2**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**33.3%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**50.0%**	**16.7%**	**0.0%**	**83.3%**	**0.0%**	**33.3%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**1**	**2**	**7**			**1**	**1**	**10**			**3**	**0**	**12**		
COMPOSITE PARAMETER GROUP SHARE (%)	**10.0%**	**20.0%**	**70.0%**	**0.0%**	**0.0%**	**8.3%**	**8.3%**	**83.3%**	**0.0%**	**0.0%**	**20.0%**	**0.0%**	**80.0%**	**0.0%**	**0.0%**

* Note that any measurements depict

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
McDermott	MD-19					MW-3					MD-3				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)	1					1					1				
Acidity (trend)			1			1							1		
Alkalinity (trend)	1					1							1		
Fe (iron)								1		1					
Al (aluminum)															
Mn (manganese)			1		1			1		1			1		1
Subtotal	**2**	**0**	**2**	**0**	**1**	**3**	**0**	**2**	**0**	**2**	**1**	**0**	**3**	**0**	**1**
Parameter Group Share (%)	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**25.0%**	**60.0%**	**0.0%**	**40.0%**	**0.0%**	**40.0%**	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**25.0%**
Trace Elements															
As (arsenic)		1						1					1		
Se (selenium)			1		1		1						1		
Pb (lead)			1					1					1		1
Cd (cadmium)			1					1		1			1		1
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**1**	**3**	**0**	**1**	**0**	**1**	**3**	**0**	**1**	**0**	**0**	**4**	**0**	**2**
Parameter Group Share (%)	**0.0%**	**25.0%**	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**25.0%**	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**50.0%**
Other Ash Indicators															
Ca (calcium)			1					1					1		
Mg (magnesium)			1					1					1		
Na (sodium)								1					1		
Cl (chloride)								1					1		
K (potassium)															
F (flouride)															
SO4 (sulfates)			1		1			1		1			1		1
TDS (total dissolved solids)			1		1			1		1			1		1
S. Cond. (specific conductance)															
Subtotal	**0**	**0**	**4**	**0**	**2**	**0**	**0**	**6**	**0**	**2**	**0**	**0**	**6**	**0**	**2**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**50.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**33.3%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**33.3%**
	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
CHANGED SETS TOTALS	**2**	**1**	**9**			**3**	**1**	**11**			**1**	**0**	**13**		
COMPOSITE PARAMETER GROUP SHARE (%)	**16.7%**	**8.3%**	**75.0%**	**0.0%**	**0.0%**	**20.0%**	**6.7%**	**73.3%**	**0.0%**	**0.0%**	**7.1%**	**0.0%**	**92.9%**	**0.0%**	**0.0%**

* Note that any measurements depict

Table 2: Monitoring Points Examination - McDermott

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring		2	
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	3	
Leachate collection pipe			1
Hybrid Monitoring Point			
Mine pools		1	
Leachate collection pipe and spring			
Subtotals:	1	6	1
TOTAL POINTS:	8		

TABLE 3 **Russelton**	**Site Monitoring Points Summary**					**Upgradient Monitoring Points Summary**					**Downgradient Monitoring Points Summary**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acidity (trend)	3	0	0	0	0	1	0	0	0	0	2	0	0	0	0
Alkalinity (trend)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fe (iron)	2	0	1	0	3	1	0	0	0	1	1	0	1	0	2
Al (aluminum)	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1
Mn (manganese)	1	1	1	0	3	1	0	0	0	1	0	1	1	0	2
Subtotal	**6**	**1**	**3**	**0**	**7**	**3**	**0**	**0**	**0**	**2**	**3**	**1**	**3**	**0**	**5**
Parameter Group Share (%)	**60.0%**	**10.0%**	**30.0%**	**0.0%**	**70.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**66.7%**	**42.9%**	**14.3%**	**42.9%**	**0.0%**	**71.4%**
Trace Elements															
As (arsenic)	2	0	1	0	1	1	0	0	0	0	1	0	1	0	1
Se (selenium)	3	0	0	0	0	1	0	0	0	0	2	0	0	0	0
Pb (lead)	3	0	0	0	0	1	0	0	0	0	2	0	0	0	0
Cd (cadmium)	1	0	2	0	1	0	0	1	0	0	1	0	1	0	1
Cr (chromium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni (nickel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn (zinc)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**9**	**0**	**3**	**0**	**2**	**3**	**0**	**1**	**0**	**0**	**6**	**0**	**2**	**0**	**2**
Parameter Group Share (%)	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**16.7%**	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**0.0%**	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**25.0%**
Other Ash Indicators															
Ca (calcium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mg (magnesium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Na (sodium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl (chloride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	2	0	1	1	1	1	0	0	0	0	1	0	1	1	1
TDS (total dissolved solids)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. Cond. (specific conductance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**2**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**
Parameter Group Share (%)	**66.7%**	**0.0%**	**33.3%**	**33.3%**	**33.3%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**50.0%**	**0.0%**	**50.0%**	**50.0%**	**50.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**17**	**1**	**7**	**1**	**10**	**7**	**0**	**1**	**0**	**2**	**10**	**1**	**6**	**1**	**8**
COMPOSITE PARAMETER GROUP SHARE (%)	**68.0%**	**4.0%**	**28.0%**	**4.0%**	**40.0%**	**87.5%**	**0.0%**	**12.5%**	**0.0%**	**25.0%**	**58.8%**	**5.9%**	**35.3%**	**5.9%**	**47.1%**

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

TABLE 3	Upgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Russelton	S1-U					S1-D					D-8				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)															
Acidity (trend)	1					1					1				
Alkalinity (trend)															
Fe (iron)	1				1	1				1			1		1
Al (aluminum)													1		1
Mn (manganese)	1				1		1			1			1		1
Subtotal	**3**	**0**	**0**	**0**	**2**	**2**	**1**	**0**	**0**	**2**	**1**	**0**	**3**	**0**	**3**
Parameter Group Share (%)	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**66.7%**	**66.7%**	**33.3%**	**0.0%**	**0.0%**	**66.7%**	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**75.0%**
Trace Elements															
As (arsenic)	1					1							1		1
Se (selenium)	1					1					1				
Pb (lead)	1					1					1				
Cd (cadmium)			1			1							1		1
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**3**	**0**	**1**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**2**	**0**	**2**	**0**	**2**
Parameter Group Share (%)	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**50.0%**
Other Ash Indicators															
Ca (calcium)															
Mg (magnesium)															
Na (sodium)															
Cl (chloride)															
K (potassium)															
F (flouride)															
SO4 (sulfates)	1					1			1				1		1
TDS (total dissolved solids)															
S. Cond. (specific conductance)															
Subtotal	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**1**
Parameter Group Share (%)	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**100.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**7**	**0**	**1**	**0**	**2**	**7**	**1**	**0**	**1**	**2**	**3**	**0**	**6**	**0**	**6**
COMPOSITE PARAMETER GROUP SHARE (%)	**87.5%**	**0.0%**	**12.5%**	**0.0%**	**25.0%**	**87.5%**	**12.5%**	**0.0%**	**12.5%**	**25.0%**	**33.3%**	**0.0%**	**66.7%**	**0.0%**	**66.7%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - Russelton

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring		1	
Stream	1	1	
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells			
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	1	2	0
TOTAL POINTS:	3		

TABLE 3 Sandy Hollow	Site Monitoring Points Summary					Upgradient Monitoring Points Summary					Downgradient Monitoring Points Summary				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	2	0	1	0	0	0	0	1	0	0	2	0	0	0	0
Acidity (trend)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Alkalinity (trend)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Fe (iron)	1	0	2	0	3	0	0	1	0	1	1	0	1	0	2
Al (aluminum)	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1
Mn (manganese)	0	1	2	0	3	0	0	1	0	1	0	1	1	0	2
Subtotal	**4**	**2**	**6**	**0**	**7**	**0**	**0**	**3**	**0**	**2**	**4**	**2**	**3**	**0**	**5**
Parameter Group Share (%)	**33.3%**	**16.7%**	**50.0%**	**0.0%**	**58.3%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**66.7%**	**44.4%**	**22.2%**	**33.3%**	**0.0%**	**55.6%**
Trace Elements															
As (arsenic)	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0
Se (selenium)	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0
Pb (lead)	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0
Cd (cadmium)	2	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Cr (chromium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni (nickel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn (zinc)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**5**	**0**	**3**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**1**	**0**	**3**	**0**	**0**
Parameter Group Share (%)	**62.5%**	**0.0%**	**37.5%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**0.0%**
Other Ash Indicators															
Ca (calcium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mg (magnesium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Na (sodium)	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Cl (chloride)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	1	0	2	1	1	0	0	1	0	0	1	0	1	1	1
TDS (total dissolved solids)	0	0	2	2	0	0	0	1	1	0	0	0	1	1	0
S. Cond. (specific conductance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**2**	**0**	**5**	**3**	**1**	**0**	**0**	**2**	**1**	**0**	**2**	**0**	**3**	**2**	**1**
Parameter Group Share (%)	**28.6%**	**0.0%**	**71.4%**	**42.9%**	**14.3%**	**0.0%**	**0.0%**	**100.0%**	**50.0%**	**0.0%**	**40.0%**	**0.0%**	**60.0%**	**40.0%**	**20.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**11**	**2**	**14**	**3**	**8**	**4**	**0**	**5**	**1**	**2**	**7**	**2**	**9**	**2**	**6**
COMPOSITE PARAMETER GROUP SHARE (%)	**40.7%**	**7.4%**	**51.9%**	**11.1%**	**29.6%**	**44.4%**	**0.0%**	**55.6%**	**11.1%**	**22.2%**	**38.9%**	**11.1%**	**50.0%**	**11.1%**	**33.3%**

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

TABLE 3	Upgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Sandy Hollow	MW-1					MW-3					Point 119				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)			1			1					1				
Acidity (trend)													1		
Alkalinity (trend)											1				
Fe (iron)			1		1			1		1	1				1
Al (aluminum)												1			1
Mn (manganese)			1		1			1		1		1			1
Subtotal	**0**	**0**	**3**	**0**	**2**	**1**	**0**	**2**	**0**	**2**	**3**	**2**	**1**	**0**	**3**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**66.7%**	**33.3%**	**0.0%**	**66.7%**	**0.0%**	**66.7%**	**50.0%**	**33.3%**	**16.7%**	**0.0%**	**50.0%**
Trace Elements															
As (arsenic)	1							1							
Se (selenium)	1							1							
Pb (lead)	1							1							
Cd (cadmium)	1					1									
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**4**	**0**	**0**	**0**	**0**	**1**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**0.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Other Ash Indicators															
Ca (calcium)															
Mg (magnesium)															
Na (sodium)								1							
Cl (chloride)						1									
K (potassium)															
F (flouride)															
SO4 (sulfates)			1					1		1	1			1	
TDS (total dissolved solids)			1	1				1	1						
S. Cond. (specific conductance)															
Subtotal	**0**	**0**	**2**	**1**	**0**	**1**	**0**	**3**	**1**	**1**	**1**	**0**	**0**	**1**	**0**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**50.0%**	**0.0%**	**25.0%**	**0.0%**	**75.0%**	**25.0%**	**25.0%**	**100.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
GRAND TOTAL ALL DATA SETS	**4**	**0**	**5**	**1**	**2**	**3**	**0**	**8**	**1**	**3**	**4**	**2**	**1**	**1**	**3**
COMPOSITE PARAMETER GROUP SHARE (%)	**44.4%**	**0.0%**	**55.6%**	**11.1%**	**22.2%**	**27.3%**	**0.0%**	**72.7%**	**9.1%**	**27.3%**	**57.1%**	**28.6%**	**14.3%**	**14.3%**	**42.9%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - Sandy Hollow

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring		1	
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	1	
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	1	2	0
TOTAL POINTS:	3		

TABLE 3 **Swamp Poodle**	**Site Monitoring Points Summary**					**Upgradient Monitoring Points Summary**					**Downgradient Monitoring Points Summary**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	4	0	0	0	0	1	0	0	0	0	3	0	0	0	0
Acidity (trend)	2	0	2	0	0	1	0	0	0	0	1	0	2	0	0
Alkalinity (trend)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fe (iron)	2	0	2	0	4	1	0	0	0	1	1	0	2	0	3
Al (aluminum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn (manganese)	1	0	3	0	4	0	0	1	0	1	1	0	2	0	3
Subtotal	**9**	**0**	**7**	**0**	**8**	**3**	**0**	**1**	**0**	**2**	**6**	**0**	**6**	**0**	**6**
Parameter Group Share (%)	**56.3%**	**0.0%**	**43.8%**	**0.0%**	**50.0%**	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**50.0%**	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**50.0%**
Trace Elements															
As (arsenic)	1	0	3	0	3	1	0	0	0	0	0	0	3	0	3
Se (selenium)	1	0	3	0	3	1	0	0	0	0	0	0	3	0	3
Pb (lead)	0	0	4	1	2	0	0	1	0	0	0	0	3	1	2
Cd (cadmium)	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1
Cr (chromium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni (nickel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn (zinc)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**2**	**0**	**11**	**1**	**9**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**10**	**1**	**9**
Parameter Group Share (%)	**15.4%**	**0.0%**	**84.6%**	**7.7%**	**69.2%**	**66.7%**	**0.0%**	**33.3%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**10.0%**	**90.0%**
Other Ash Indicators															
Ca (calcium)	2	0	2	0	0	1	0	0	0	0	1	0	2	0	0
Mg (magnesium)	0	0	4	0	0	0	0	1	0	0	0	0	3	0	0
Na (sodium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl (chloride)	1	0	3	2	0	0	0	1	1	0	1	0	2	1	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO4 (sulfates)	1	0	3	0	4	0	0	1	0	1	1	0	2	0	3
TDS (total dissolved solids)	2	0	2	1	2	1	0	0	1	0	1	0	2	0	2
S. Cond. (specific conductance)	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Subtotal	**6**	**0**	**14**	**3**	**7**	**2**	**0**	**3**	**2**	**1**	**4**	**0**	**11**	**1**	**6**
Parameter Group Share (%)	**30.0%**	**0.0%**	**70.0%**	**15.0%**	**35.0%**	**40.0%**	**0.0%**	**60.0%**	**40.0%**	**20.0%**	**26.7%**	**0.0%**	**73.3%**	**6.7%**	**40.0%**
Parameter Change	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**17**	**0**	**32**	**4**	**24**	**7**	**0**	**5**	**2**	**3**	**10**	**0**	**27**	**2**	**21**
COMPOSITE PARAMETER GROUP SHARE (%)	**34.7%**	**0.0%**	**65.3%**	**8.2%**	**49.0%**	**58.3%**	**0.0%**	**41.7%**	**16.7%**	**25.0%**	**27.0%**	**0.0%**	**73.0%**	**5.4%**	**56.8%**

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

TABLE 3	Upgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Swamp Poodle	MW-1U					MW-3D					MW-2D				
Parameter Group & Parameter	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
AMD / Ash															
pH (trend)	1					1					1				
Acidity (trend)	1							1			1				
Alkalinity (trend)															
Fe (iron)	1				1			1		1	1				1
Al (aluminum)															
Mn (manganese)			1		1			1		1	1				1
Subtotal	**3**	**0**	**1**	**0**	**2**	**1**	**0**	**3**	**0**	**2**	**4**	**0**	**0**	**0**	**2**
Parameter Group Share (%)	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**50.0%**	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**50.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**50.0%**
Trace Elements															
As (arsenic)	1							1		1			1		1
Se (selenium)	1							1		1			1		1
Pb (lead)			1					1		1			1		1
Cd (cadmium)													1		1
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)															
Ba (barium)															
Ag (silver)															
Subtotal	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**0**	**3**	**0**	**0**	**4**	**0**	**4**
Parameter Group Share (%)	**66.7%**	**0.0%**	**33.3%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**100.0%**
Other Ash Indicators															
Ca (calcium)	1							1			1				
Mg (magnesium)			1					1					1		
Na (sodium)															
Cl (chloride)			1	1				1			1			1	
K (potassium)															
F (flouride)															
SO4 (sulfates)			1		1			1		1	1				1
TDS (total dissolved solids)	1			1				1		1	1				
S. Cond. (specific conductance)															1
Subtotal	**2**	**0**	**3**	**2**	**1**	**0**	**0**	**5**	**0**	**2**	**4**	**0**	**1**	**1**	**2**
Parameter Group Share (%)	**40.0%**	**0.0%**	**60.0%**	**40.0%**	**20.0%**	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**40.0%**	**80.0%**	**0.0%**	**20.0%**	**20.0%**	**40.0%**
Parameter Change	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**7**	**0**	**5**	**2**	**3**	**1**	**0**	**11**	**0**	**7**	**8**	**0**	**5**	**1**	**8**
COMPOSITE PARAMETER GROUP SHARE (%)	**58.3%**	**0.0%**	**41.7%**	**16.7%**	**25.0%**	**8.3%**	**0.0%**	**91.7%**	**0.0%**	**58.3%**	**61.5%**	**0.0%**	**38.5%**	**7.7%**	**61.5%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Points				
Swamp Poodle	**MW-4D**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash					
pH (trend)	1				
Acidity (trend)			1		
Alkalinity (trend)					
Fe (iron)			1		1
Al (aluminum)					
Mn (manganese)			1		1
Subtotal	**1**	**0**	**3**	**0**	**2**
Parameter Group Share (%)	**25.0%**	**0.0%**	**75.0%**	**0.0%**	**50.0%**
Trace Elements					
As (arsenic)			1		1
Se (selenium)			1		1
Pb (lead)			1	1	
Cd (cadmium)					
Cr (chromium)					
Ni (nickel)					
Zn (zinc)					
Cu (copper)					
Sb (antimony)					
Mo (molybdenum)					
B (boron)					
Hg (mercury)					
Ba (barium)					
Ag (silver)					
Subtotal	**0**	**0**	**3**	**1**	**2**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**33.3%**	**66.7%**
Other Ash Indicators					
Ca (calcium)			1		
Mg (magnesium)			1		
Na (sodium)					
Cl (chloride)			1		
K (potassium)					
F (flouride)					
SO4 (sulfates)			1		1
TDS (total dissolved solids)			1		1
S. Cond. (specific conductance)					
Subtotal	**0**	**0**	**5**	**0**	**2**
Parameter Group Share (%)	**0.0%**	**0.0%**	**100.0%**	**0.0%**	**40.0%**
Parameter Change	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**1**	**0**	**11**	**1**	**6**
COMPOSITE PARAMETER GROUP SHARE (%)	**8.3%**	**0.0%**	**91.7%**	**8.3%**	**50.0%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - Swamp Poodle

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring			
Stream			
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	3	
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	1	3	0
TOTAL POINTS:	4		

TABLE 3 Wildwood	Site Monitoring Points Summary					Upgradient Monitoring Points Summary					Downgradient Monitoring Points Summary				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)	1	0	5	0	0	0	0	1	0	0	1	0	4	0	0
Acidity (trend)	4	0	0	0	0	1	0	0	0	0	3	0	0	0	0
Alkalinity (trend)	2	0	2	0	0	0	0	0	0	0	2	0	2	0	0
Fe (iron)	3	0	2	0	5	1	0	0	0	1	2	0	2	0	4
Al (aluminum)	1	0	1	0	2	0	0	0	0	0	1	0	1	0	2
Mn (manganese)	6	0	0	0	6	1	0	0	0	1	5	0	0	0	5
Subtotal	**17**	**0**	**10**	**0**	**13**	**3**	**0**	**1**	**0**	**2**	**14**	**0**	**9**	**0**	**11**
Parameter Group Share (%)	**63.0%**	**0.0%**	**37.0%**	**0.0%**	**48.1%**	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**50.0%**	**60.9%**	**0.0%**	**39.1%**	**0.0%**	**47.8%**
Trace Elements															
As (arsenic)	2	0	0	0	1	0	0	0	0	0	2	0	0	0	1
Se (selenium)	2	0	0	1	0	0	0	0	0	0	2	0	0	1	0
Pb (lead)	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Cd (cadmium)	2	0	0	0	1	0	0	0	0	0	2	0	0	0	1
Cr (chromium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni (nickel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn (zinc)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu (copper)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb (antimony)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo (molybdenum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B (boron)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg (mercury)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag (silver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**8**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**1**	**2**
Parameter Group Share (%)	**100.0%**	**0.0%**	**0.0%**	**12.5%**	**25.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**100.0%**	**0.0%**	**0.0%**	**12.5%**	**25.0%**
Other Ash Indicators															
Ca (calcium)	2	0	1	0	0	0	0	0	0	0	2	0	1	0	0
Mg (magnesium)	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Na (sodium)	2	1	2	0	0	1	0	0	0	0	1	1	2	0	0
Cl (chloride)	1	0	3	2	0	0	0	0	0	0	1	0	3	2	0
K (potassium)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F (flouride)	0	0	5	2	0	0	0	1	0	0	0	0	4	2	0
SO4 (sulfates)	4	0	2	1	5	1	0	0	1	0	3	0	2	0	5
TDS (total dissolved solids)	4	0	1	2	3	1	0	0	1	0	3	0	1	1	3
S. Cond. (specific conductance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**15**	**1**	**14**	**7**	**8**	**3**	**0**	**1**	**2**	**0**	**12**	**1**	**13**	**5**	**8**
Parameter Group Share (%)	**50.0%**	**3.3%**	**46.7%**	**23.3%**	**26.7%**	**75.0%**	**0.0%**	**25.0%**	**50.0%**	**0.0%**	**46.2%**	**3.8%**	**50.0%**	**19.2%**	**30.8%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**40**	**1**	**24**	**8**	**23**	**6**	**0**	**2**	**2**	**2**	**34**	**1**	**22**	**6**	**21**
COMPOSITE PARAMETER GROUP SHARE (%)	**61.5%**	**1.5%**	**36.9%**	**12.3%**	**35.4%**	**75.0%**	**0.0%**	**25.0%**	**25.0%**	**25.0%**	**59.6%**	**1.8%**	**38.6%**	**10.5%**	**36.8%**

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

TABLE 3	Upgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Wildwood	MW-1					MW-2					MW-3				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)			1										1		
Acidity (trend)	1														
Alkalinity (trend)								1			1				
Fe (iron)	1				1			1		1					
Al (aluminum)															
Mn (manganese)	1				1	1				1					
Subtotal	**3**	**0**	**1**	**0**	**2**	**1**	**0**	**2**	**0**	**2**	**1**	**0**	**1**	**0**	**0**
Parameter Group Share (%)	**75.0%**	**0.0%**	**25.0%**	**0.0%**	**50.0%**	**33.3%**	**0.0%**	**66.7%**	**0.0%**	**66.7%**	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**0.0%**
Trace Elements															
As (arsenic)															
Se (selenium)															
Pb (lead)															
Cd (cadmium)															
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)	0	0	0	0	0	0	0	0	0	0					
Ba (barium)															
Ag (silver)															
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Other Ash Indicators															
Ca (calcium)						1									
Mg (magnesium)						1									
Na (sodium)	1					1						1			
Cl (chloride)								1	1				1	1	
K (potassium)															
F (flouride)			1					1					1	1	
SO4 (sulfates)	1			1		1				1					
TDS (total dissolved solids)	1			1											
S. Cond. (specific conductance)															
Subtotal	**3**	**0**	**1**	**2**	**0**	**4**	**0**	**2**	**1**	**1**	**0**	**1**	**2**	**2**	**0**
Parameter Group Share (%)	**75.0%**	**0.0%**	**25.0%**	**50.0%**	**0.0%**	**66.7%**	**0.0%**	**33.3%**	**16.7%**	**16.7%**	**0.0%**	**33.3%**	**66.7%**	**66.7%**	**0.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**6**	**0**	**2**	**2**	**2**	**5**	**0**	**4**	**1**	**3**	**1**	**1**	**3**	**2**	**0**
COMPOSITE PARAMETER GROUP SHARE (%)	**75.0%**	**0.0%**	**25.0%**	**25.0%**	**25.0%**	**55.6%**	**0.0%**	**44.4%**	**11.1%**	**33.3%**	**20.0%**	**20.0%**	**60.0%**	**40.0%**	**0.0%**

* Note that any measurements depi

TABLE 3	Downgradient Monitoring Points					Downgradient Monitoring Points					Downgradient Monitoring Points				
Wildwood	**MW-4**					**MW-5**					**SP-C**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash															
pH (trend)			1			1							1		
Acidity (trend)	1										1				
Alkalinity (trend)			1			1									
Fe (iron)	1				1						1				1
Al (aluminum)											1				1
Mn (manganese)	1				1	1				1	1				1
Subtotal	**3**	**0**	**2**	**0**	**2**	**3**	**0**	**0**	**0**	**1**	**4**	**0**	**1**	**0**	**3**
Parameter Group Share (%)	**60.0%**	**0.0%**	**40.0%**	**0.0%**	**40.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**33.3%**	**80.0%**	**0.0%**	**20.0%**	**0.0%**	**60.0%**
Trace Elements															
As (arsenic)	1					1				1					
Se (selenium)	1			1		1									
Pb (lead)	1					1									
Cd (cadmium)	1				1	1									
Cr (chromium)															
Ni (nickel)															
Zn (zinc)															
Cu (copper)															
Sb (antimony)															
Mo (molybdenum)															
B (boron)															
Hg (mercury)											0	0	0	0	0
Ba (barium)															
Ag (silver)															
Subtotal	**4**	**0**	**0**	**1**	**1**	**4**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**100.0%**	**0.0%**	**0.0%**	**25.0%**	**25.0%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**25.0%**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Other Ash Indicators															
Ca (calcium)	1							1							
Mg (magnesium)	1														
Na (sodium)			1					1							
Cl (chloride)	1							1							
K (potassium)															
F (flouride)			1	1				1							
SO4 (sulfates)	1				1			1		1	1				1
TDS (total dissolved solids)	1				1			1	1		1				1
S. Cond. (specific conductance)															
Subtotal	**5**	**0**	**2**	**1**	**2**	**0**	**0**	**6**	**1**	**1**	**2**	**0**	**0**	**0**	**2**
Parameter Group Share (%)	**71.4%**	**0.0%**	**28.6%**	**14.3%**	**28.6%**	**0.0%**	**0.0%**	**100.0%**	**16.7%**	**16.7%**	**100.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**12**	**0**	**4**	**2**	**5**	**7**	**0**	**6**	**1**	**3**	**6**	**0**	**1**	**0**	**5**
COMPOSITE PARAMETER GROUP SHARE (%)	**75.0%**	**0.0%**	**25.0%**	**12.5%**	**31.3%**	**53.8%**	**0.0%**	**46.2%**	**7.7%**	**23.1%**	**85.7%**	**0.0%**	**14.3%**	**0.0%**	**71.4%**

* Note that any measurements depi

TABLE 3	**Downgradient Monitoring Points**				
Wildwood	**DJ**				
Parameter Group & Parameter	**Decrease**	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
AMD / Ash					
pH (trend)			1		
Acidity (trend)	1				
Alkalinity (trend)					
Fe (iron)			1		1
Al (aluminum)			1		1
Mn (manganese)	1				1
Subtotal	**2**	**0**	**3**	**0**	**3**
Parameter Group Share (%)	**40.0%**	**0.0%**	**60.0%**	**0.0%**	**60.0%**
Trace Elements					
As (arsenic)					
Se (selenium)					
Pb (lead)					
Cd (cadmium)					
Cr (chromium)					
Ni (nickel)					
Zn (zinc)					
Cu (copper)					
Sb (antimony)					
Mo (molybdenum)					
B (boron)					
Hg (mercury)	0	0	0	0	0
Ba (barium)					
Ag (silver)					
Subtotal	**0**	**0**	**0**	**0**	**0**
Parameter Group Share (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Other Ash Indicators					
Ca (calcium)					
Mg (magnesium)					
Na (sodium)					
Cl (chloride)					
K (potassium)					
F (flouride)					
SO4 (sulfates)			1		1
TDS (total dissolved solids)	1				1
S. Cond. (specific conductance)					
Subtotal	**1**	**0**	**1**	**0**	**2**
Parameter Group Share (%)	**50.0%**	**0.0%**	**50.0%**	**0.0%**	**100.0%**
	Decrease	**No Change**	**Increase**	**≥ DWS***	**≥ 3X DWS**
CHANGED SETS TOTALS	**3**	**0**	**4**	**0**	**5**
COMPOSITE PARAMETER GROUP SHARE (%)	**42.9%**	**0.0%**	**57.1%**	**0.0%**	**71.4%**

* Note that any measurements depi

Table 2: Monitoring Points Examination - Wildwood

	Upgradient	Downgradient	Pore Water
Surface Water Monitoring Point			
Seep / Spring		2	
Stream	1	1	
Surface mine discharge			
Leachate collection pond			
Gound Water Monitoring Point			
Wells	1	4	
Leachate collection pipe			
Hybrid Monitoring Point			
Mine pools			
Leachate collection pipe and spring			
Subtotals:	2	7	0
TOTAL POINTS:	9		