

## Permit Review 6

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

#### **Site Summary**

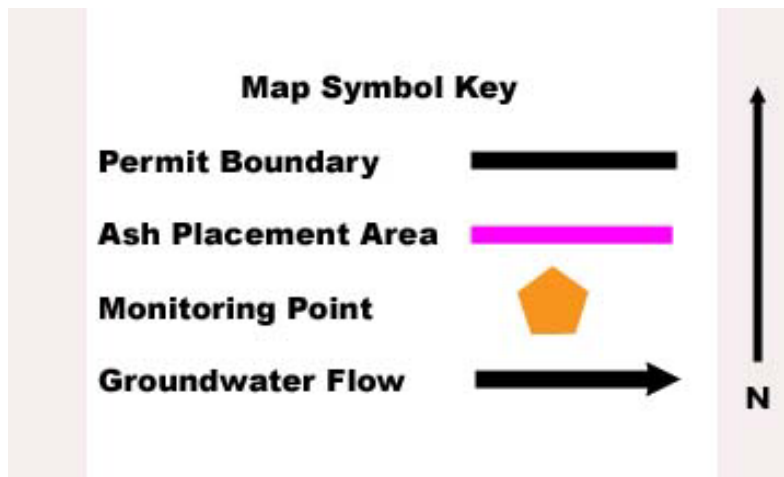
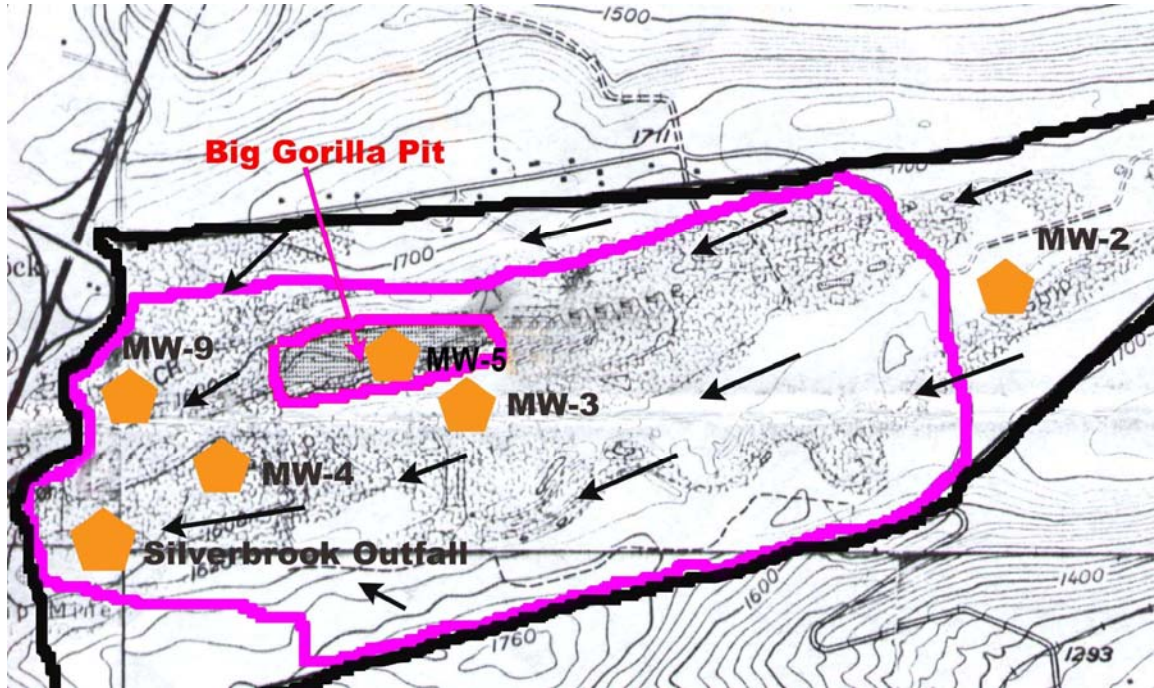
Northeastern Power Company's (NEPCO) Silverbrook Refuse Project is located partly in Kline Township, Schuylkill County and partly in Packer Township, Carbon County, Pennsylvania in the Silverbrook Basin. The Silverbrook Basin is about five miles long and a mile wide and is located between the eastern 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 materials indicate the shallow groundwater flow across the permit site is from the east toward 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 to 50 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.

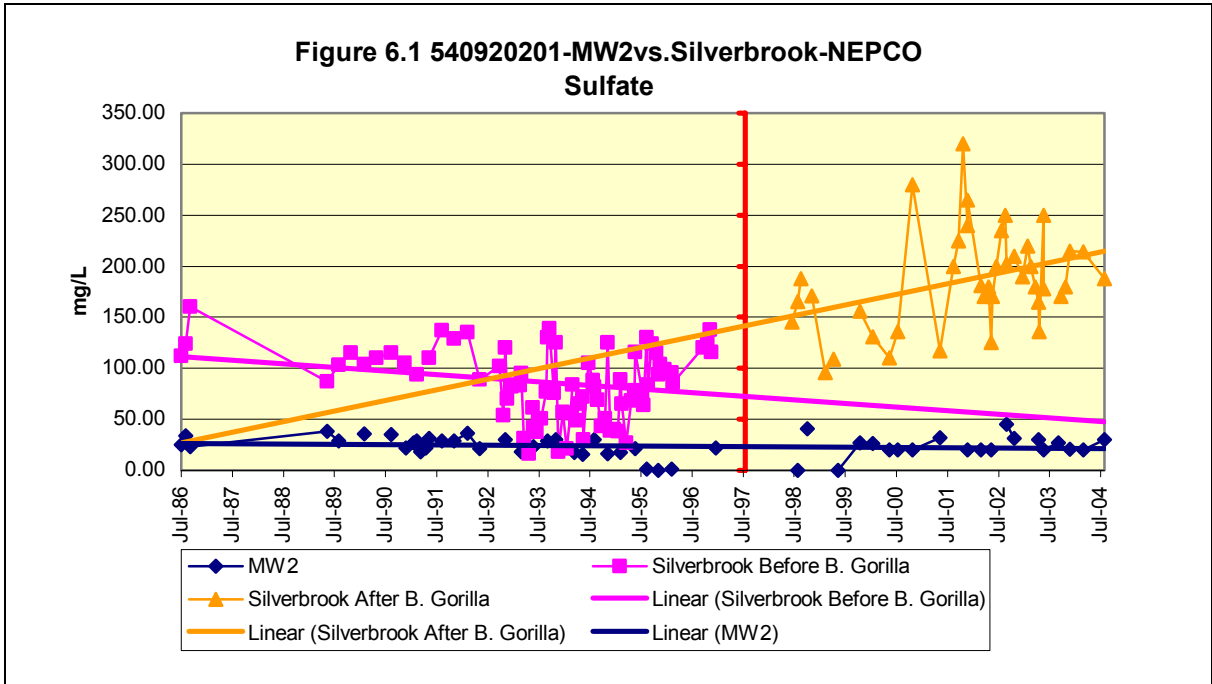
Other constituents that were elevated at the Silverbrook Outfall compared to MW2 behaved similarly. Before ash placement, aluminum (figure 6.4) concentrations were up to 10 times higher at the Silverbrook Outfall than at MW2. Iron (figure 6.5) concentrations were more than 20 times higher at the Silverbrook 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.

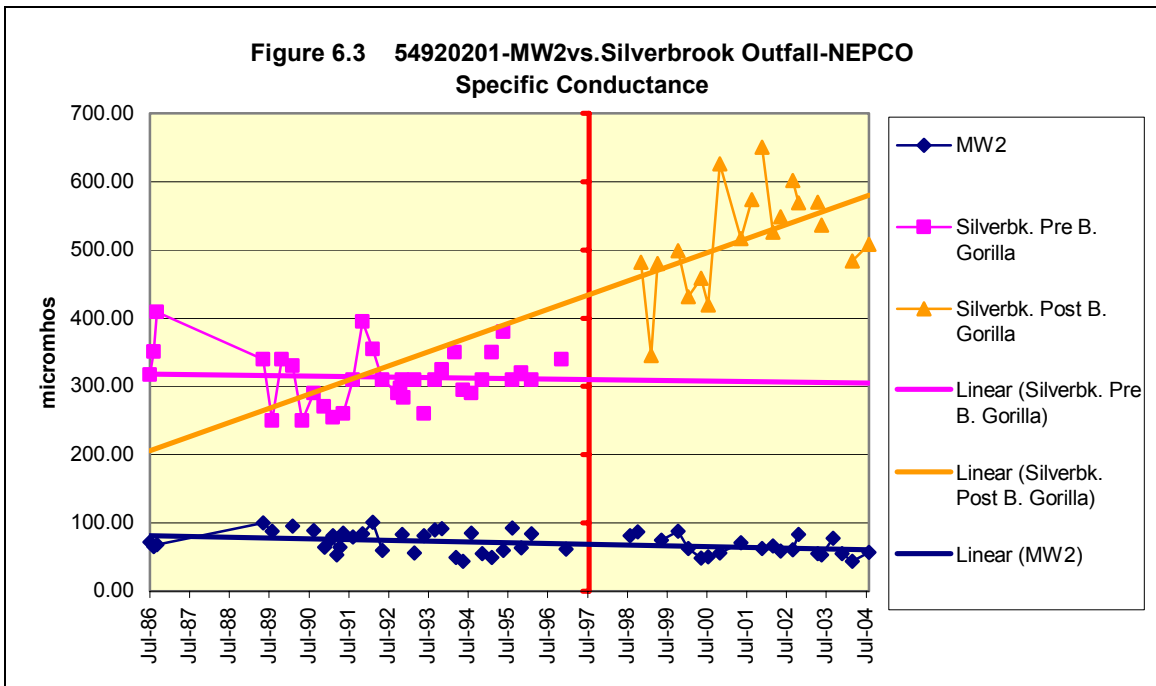
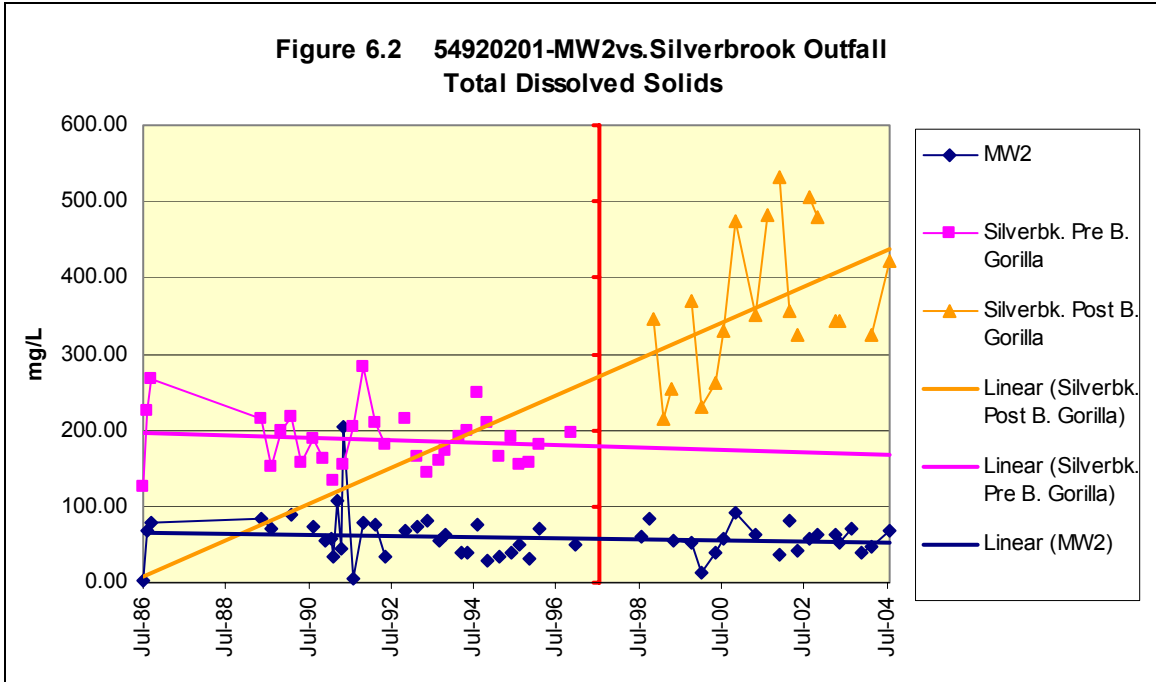
Due to the apparent affect of the ash, the Silverbrook Outfall effluent became slightly more alkaline (figure 6.7) after the Big Gorilla Project started. Before ash placement, average lab pH was 3.79, whereas, after ash placement, the average lab pH reading rose to 4.14. At the upgradient point MW2, 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.

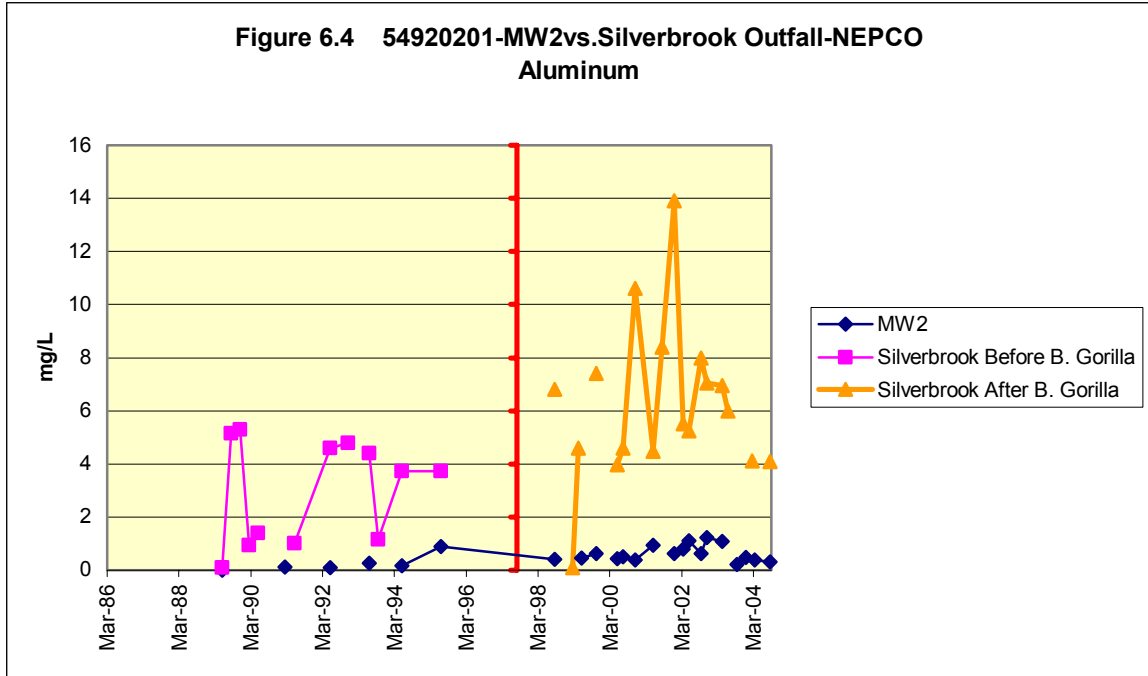
More ash-specific constituents such as calcium (figure 6.8) and chloride (figure 6.9) showed sharp increases in concentrations at the Silverbrook Outfall after ash placement started in Big Gorilla. Spikes in calcium levels at MW2 to 34.60 mg/L in May 2001 and 88.70 mg/L in December 2003 indicate the 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.

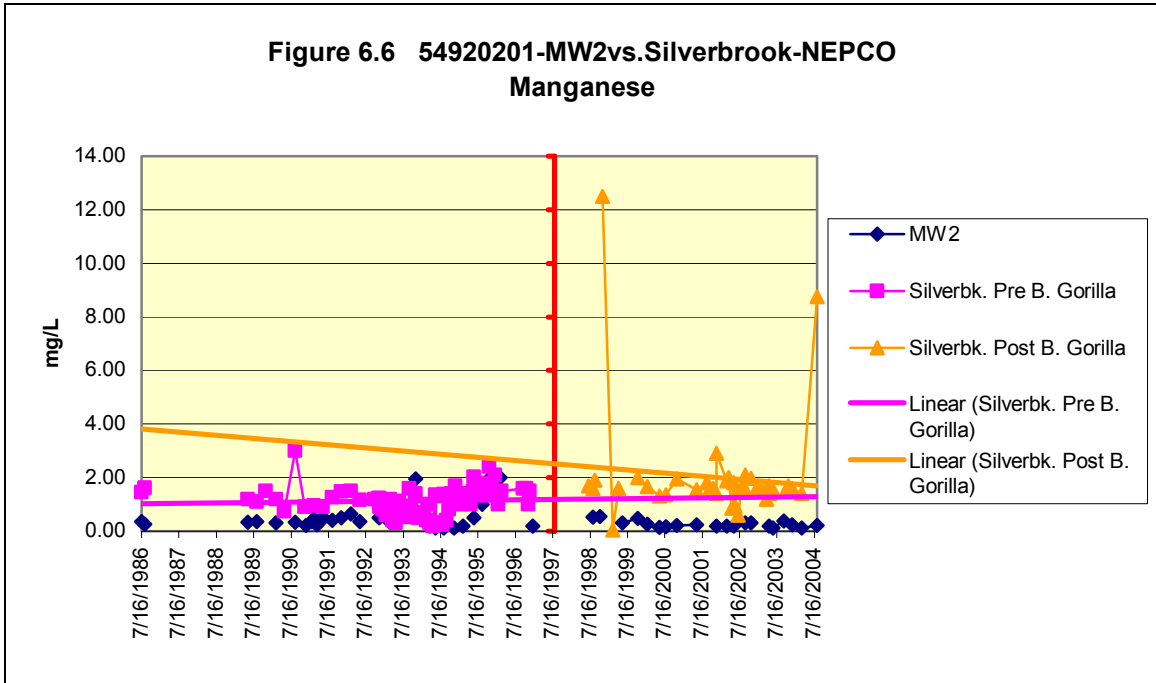
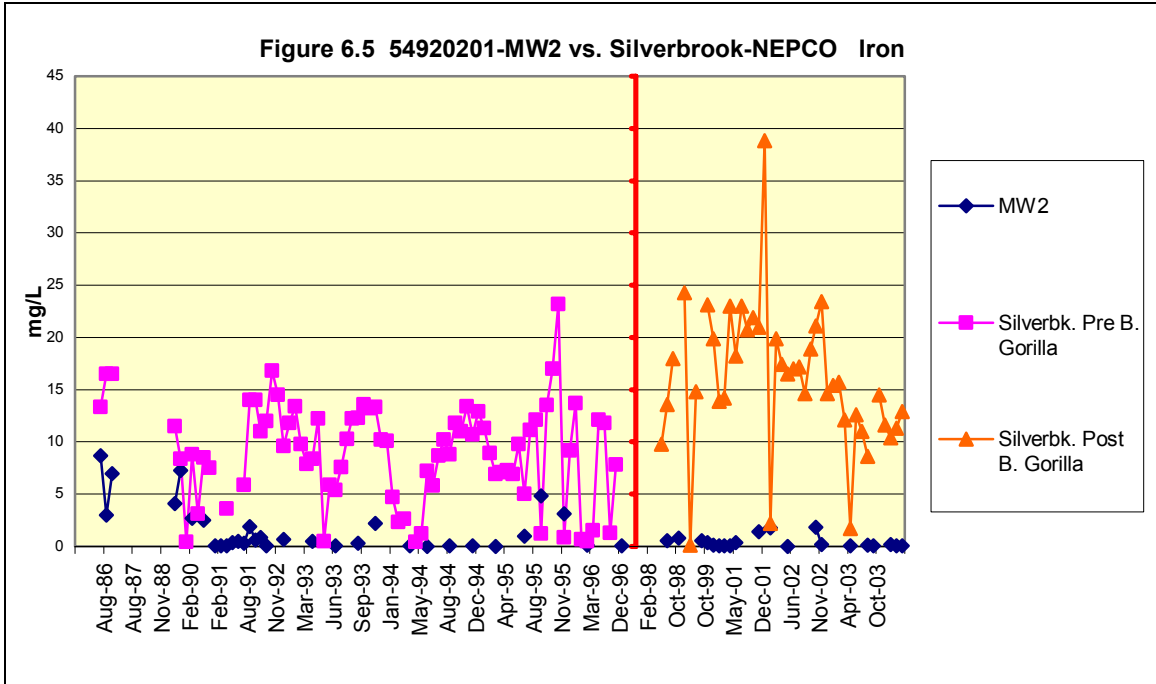
Concentrations of another ash-associated analyte, sodium, rose from an average of 10.95 mg/L before ash placement started at Big Gorilla to 18.73 mg/L afterwards at the Silverbrook Outfall. This higher average after ash placement does not include an anomalously high level of 232 mg/L measured on September 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

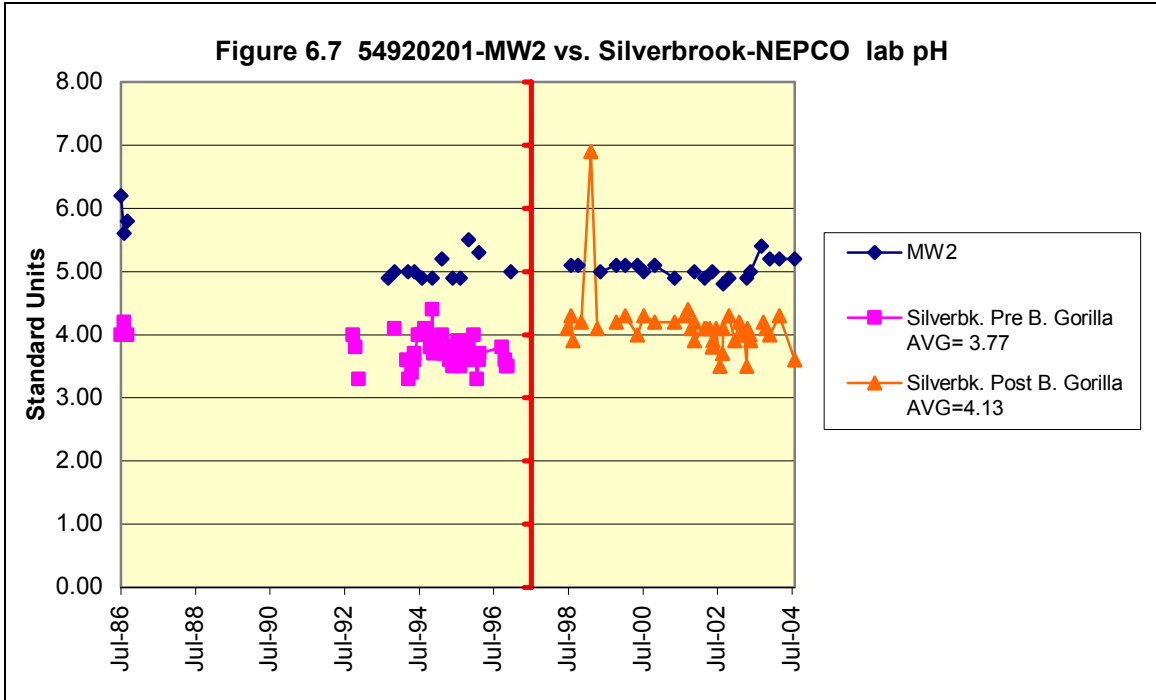
extremely high sodium levels in this sampling accurately reflected sodium concentrations in the water. Chloride levels in the September 2002 sampling were not high at any of the monitoring points. Nevertheless the PADEP Report states that the rising calcium at the Silverbrook Outfall is due to reclamation 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)

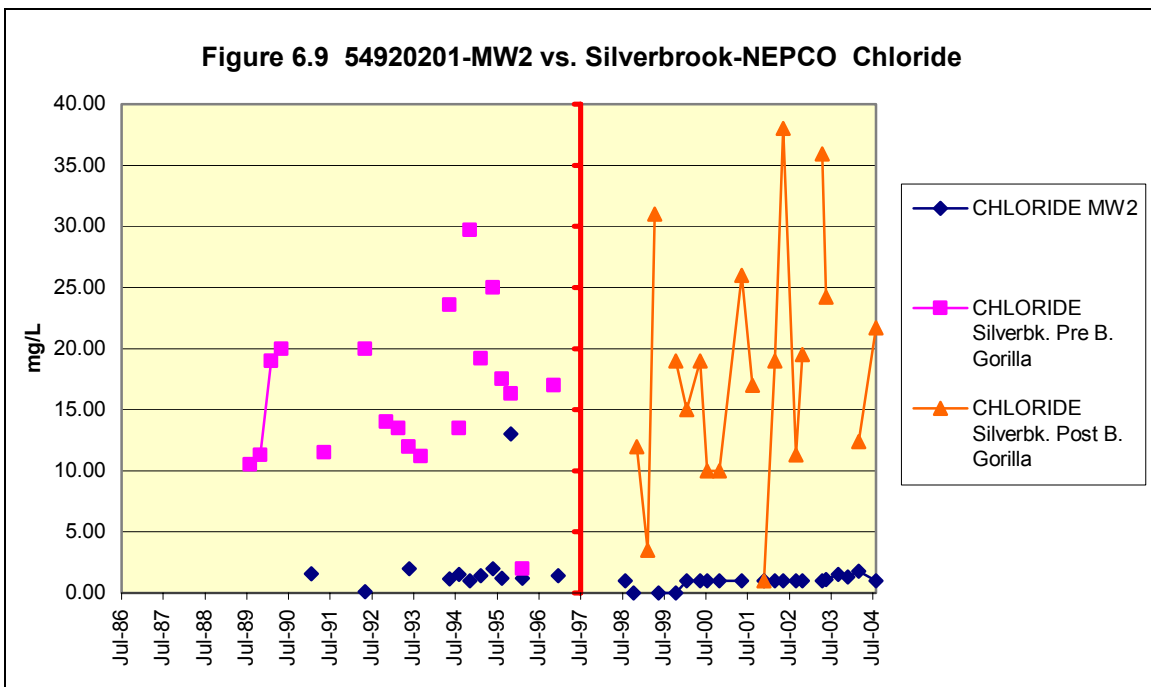
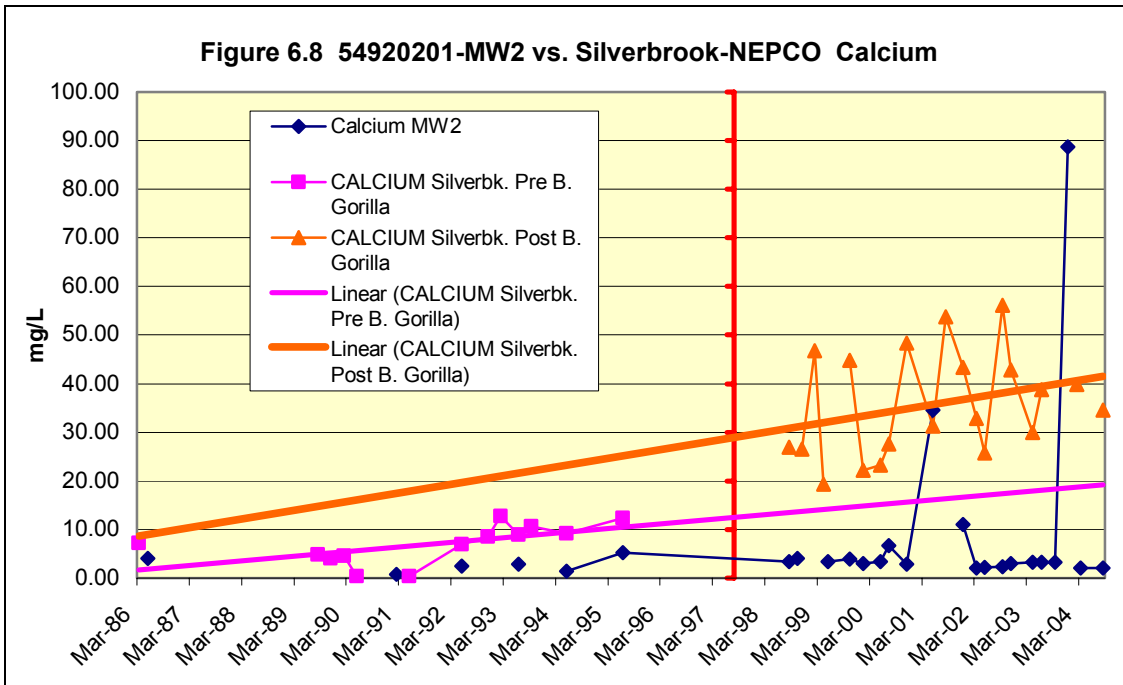


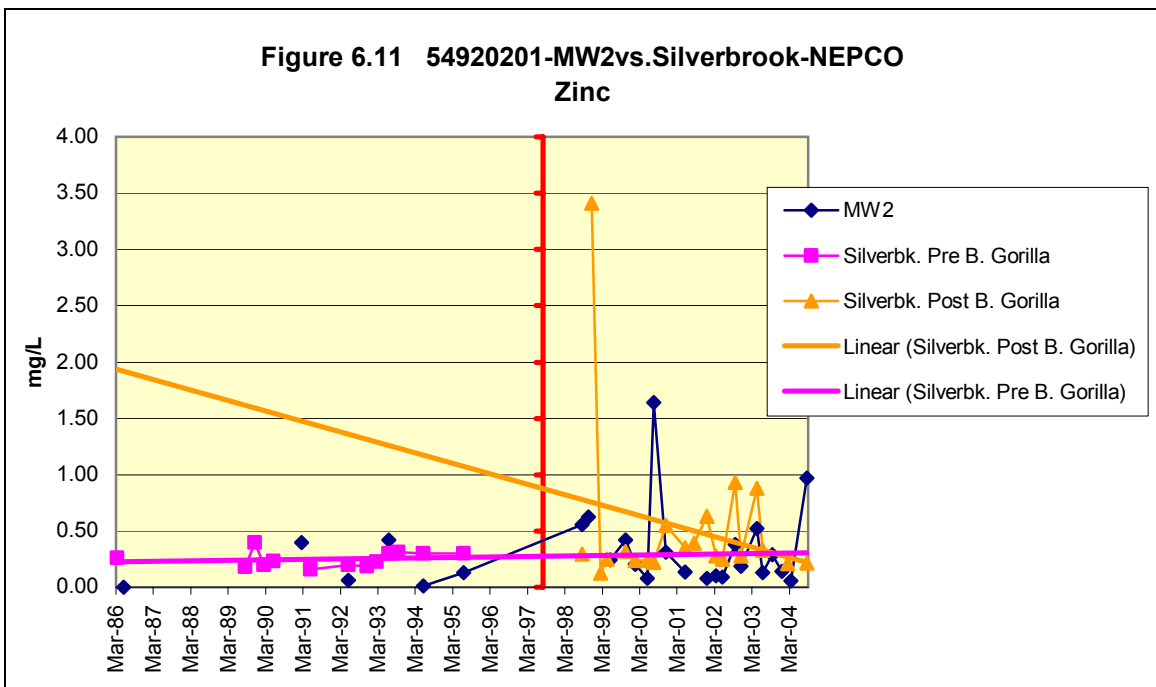
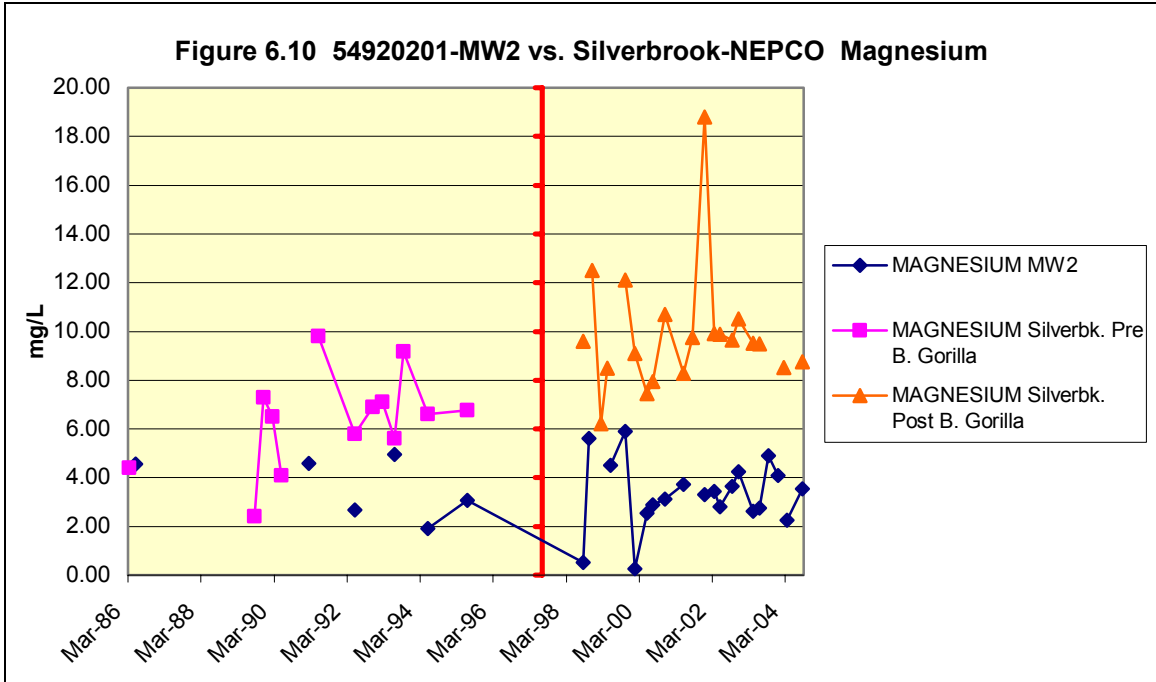


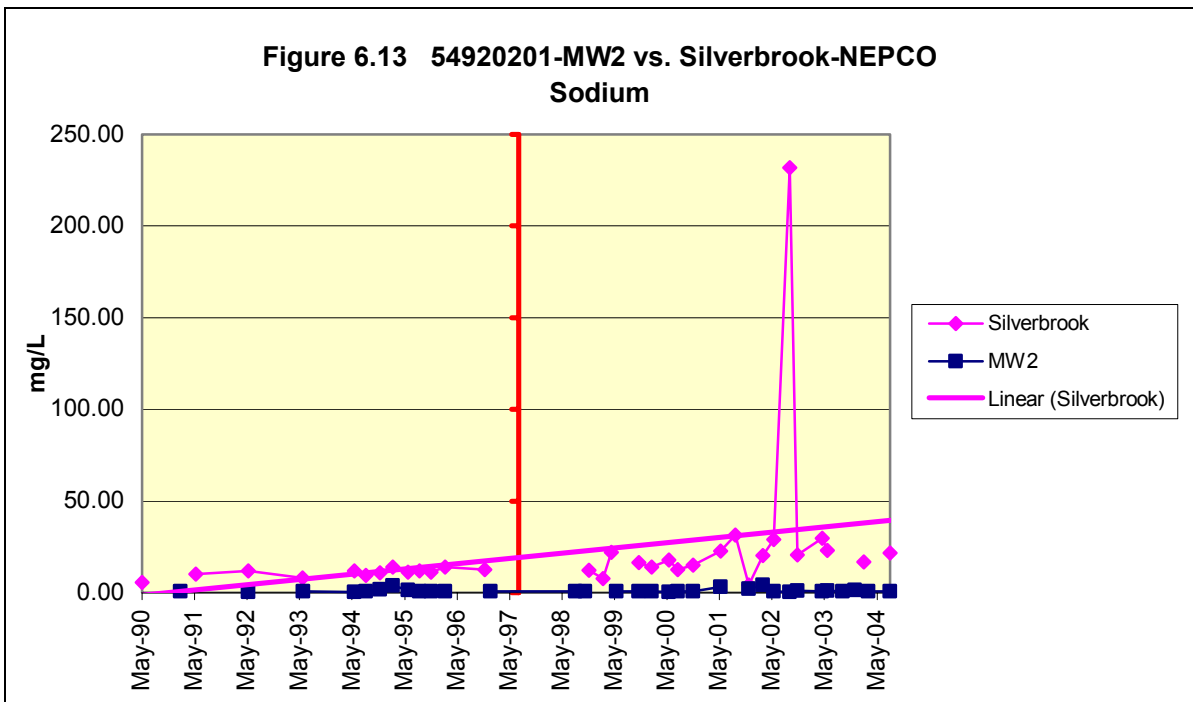
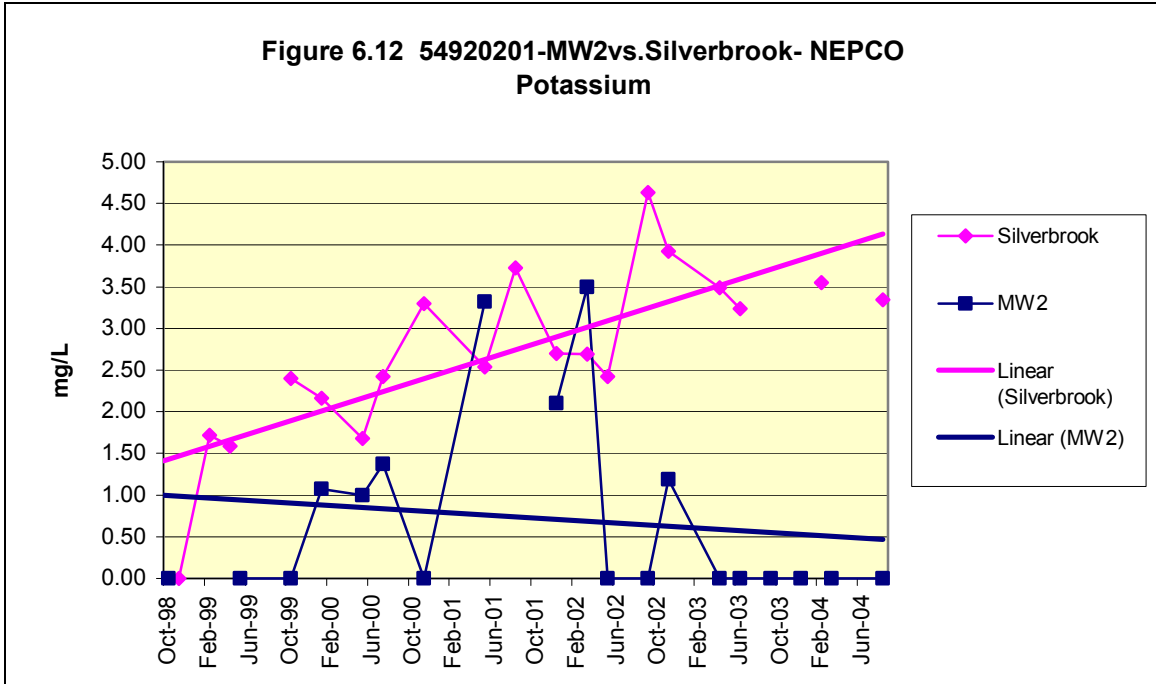












### **MW2 vs. MW4**

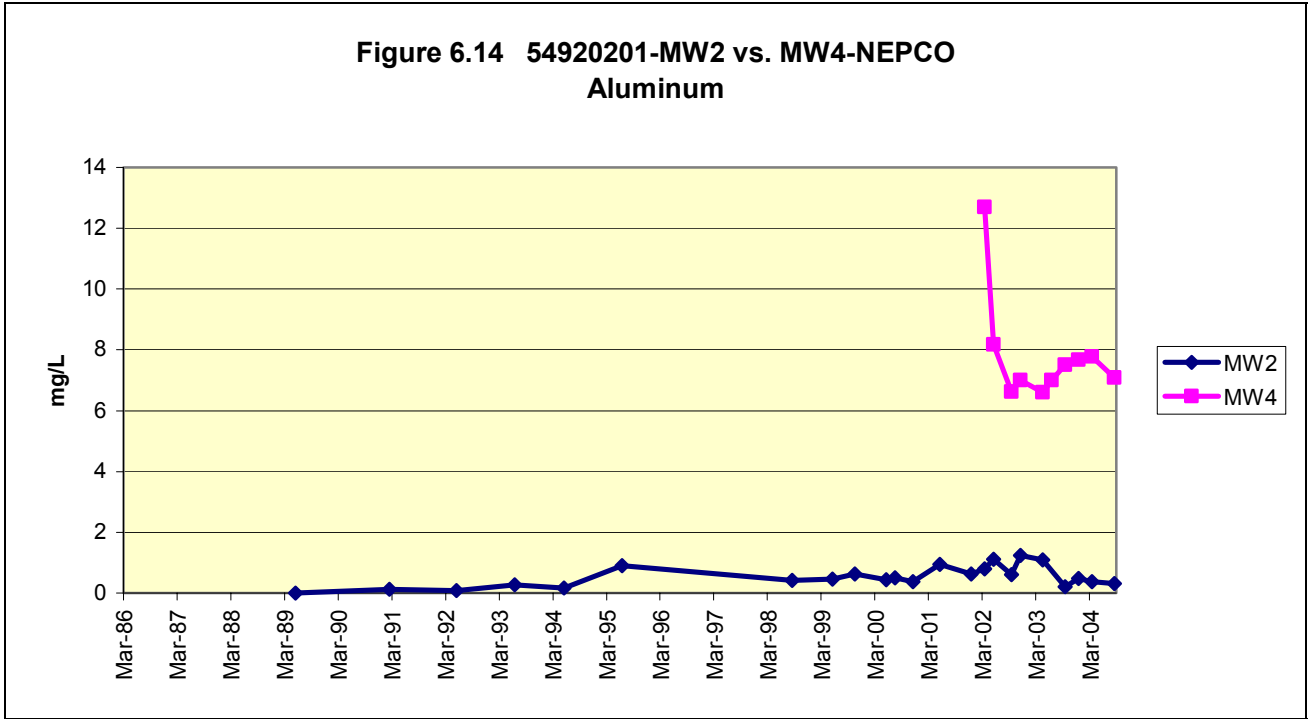
Although PADEP states that it does not know where groundwater goes from the Big Gorilla Pit, MW4 was placed west of the pit as ash placement in the pit was nearing completion, specifically to monitor the impact of the ash placed in the Big Gorilla mine pool. MW4 is closer than the Silverbrook Outfall 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 than the Silverbrook Outfall.

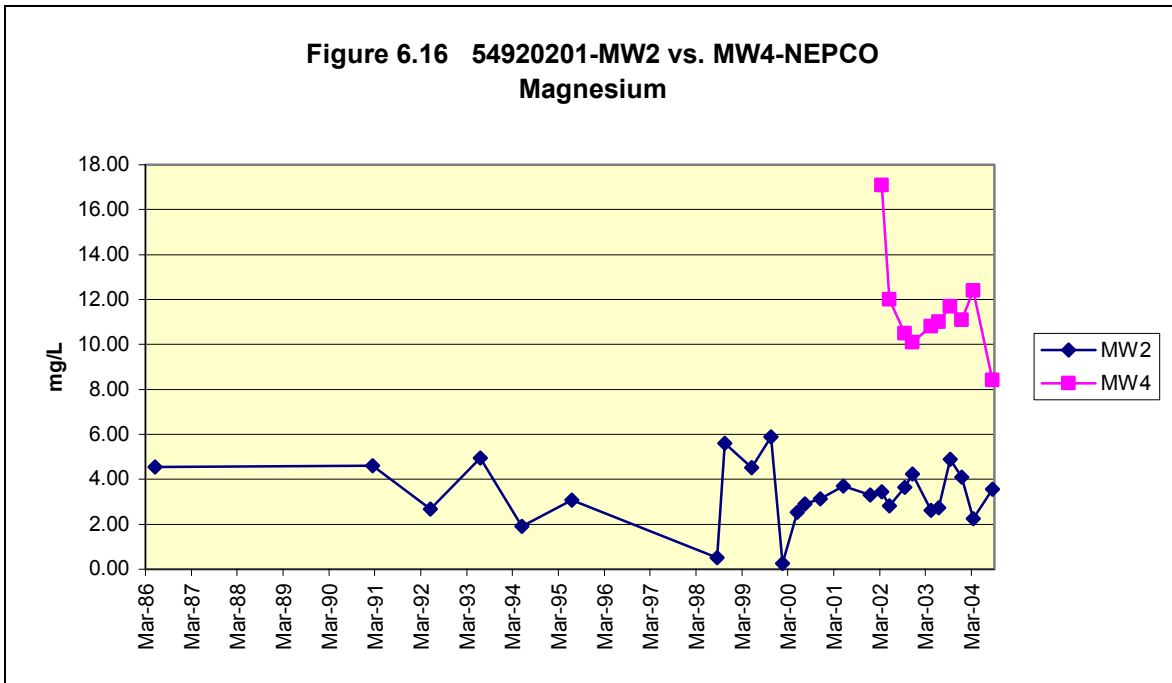
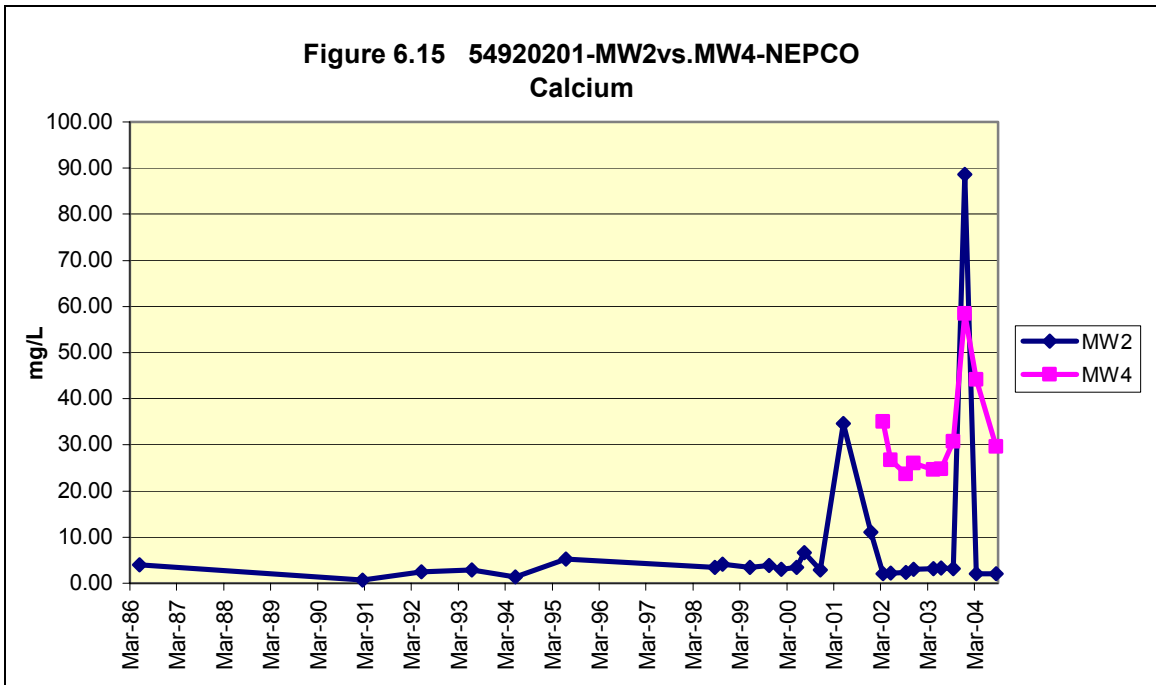
Monitoring data from March 2002 to October 2003 show marked concentration differences between the upgradient MW2 and MW4. Water at MW4 has higher concentrations of aluminum (figure 6.14), calcium (figure 6.15), magnesium (figure 6.16), sodium (figure 6.17), iron (figure 6.18) and manganese (figure 6.19) 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.

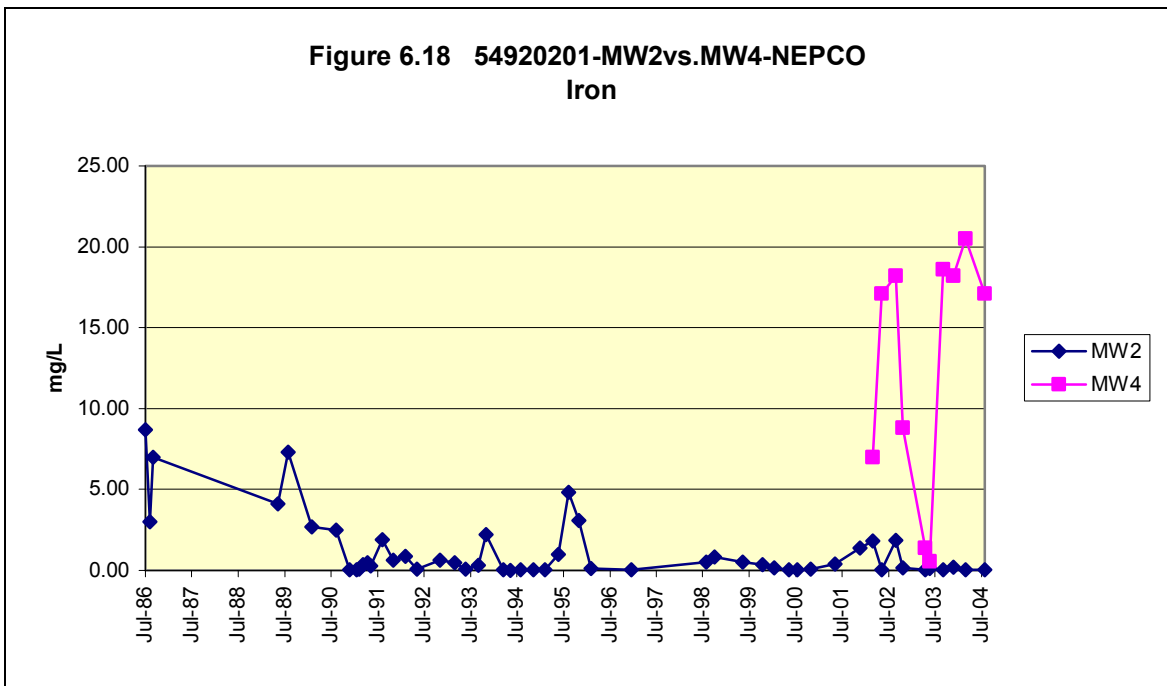
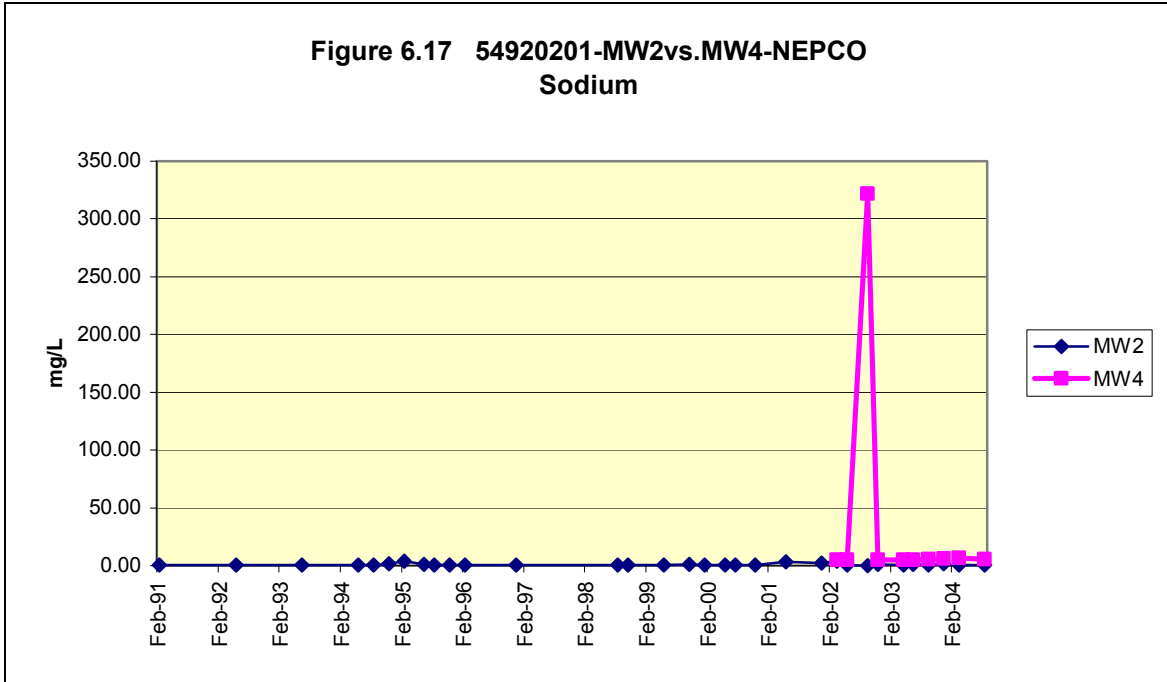
Nonetheless concentrations of aluminum, iron, and manganese were on average 5 to 10 times higher at MW4 than at MW2. In most cases aluminum, iron and manganese levels at MW4 were significantly above drinking water standards, while close to or meeting the DWS at MW2.

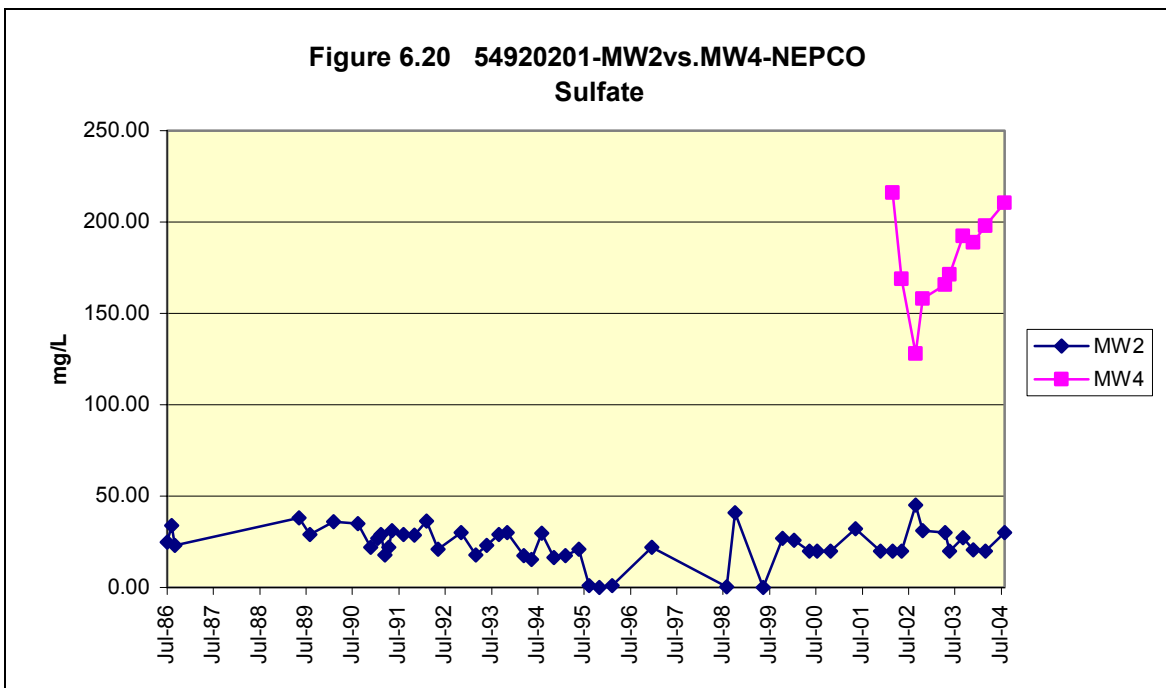
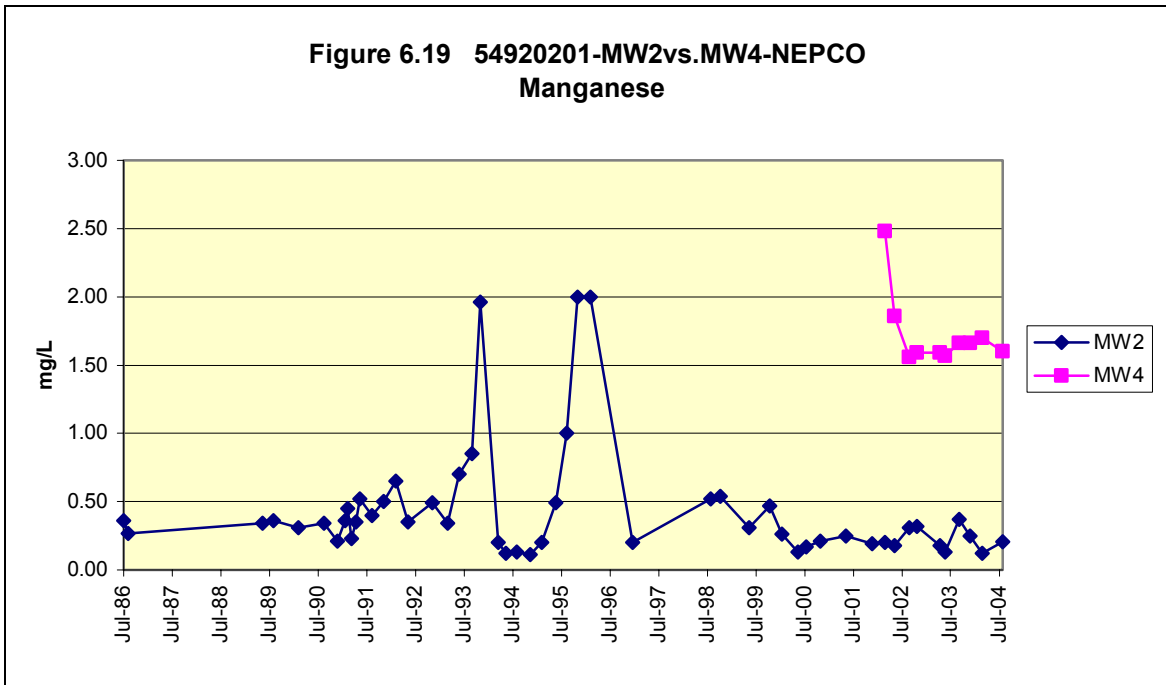
Average sulfate levels (figure 6.20) were eight times higher and average TDS levels (figure 6.21) were more than 6.5 times higher at MW4 than at MW2. While both of these constituents were elevated at MW4, except for a TDS concentration of 516 mg/L in March 2002, neither reached levels exceeding the DWS. 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.

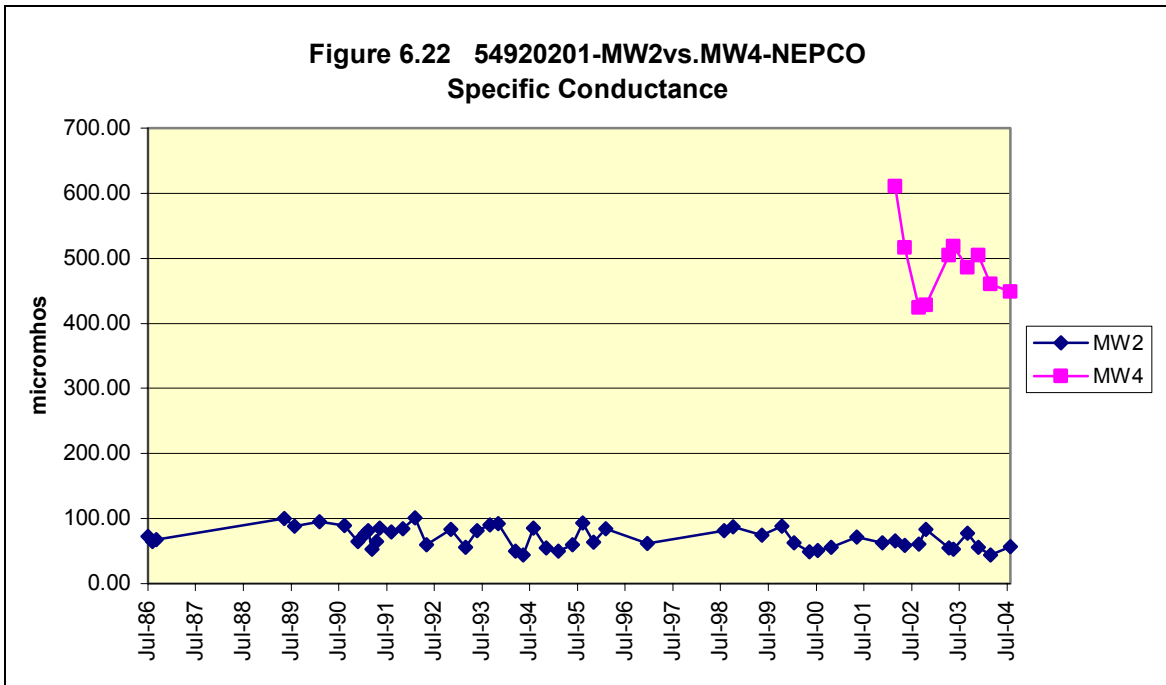
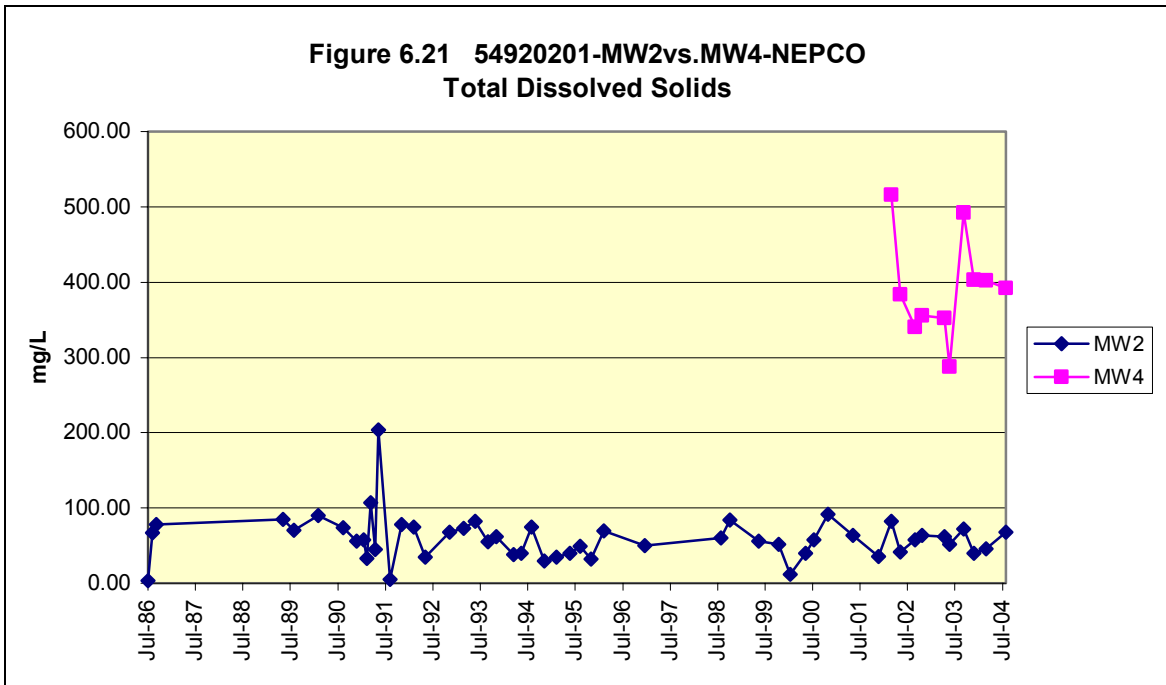
The deterioration at MW4 from aluminum, iron, manganese, sulfates, and TDS is similar to the degradation seen at the Silverbrook Outfall and attests to a general level of degradation seen as one moves from east to west across the Silverbrook permit. Like water at the Silverbrook Outfall, the higher levels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

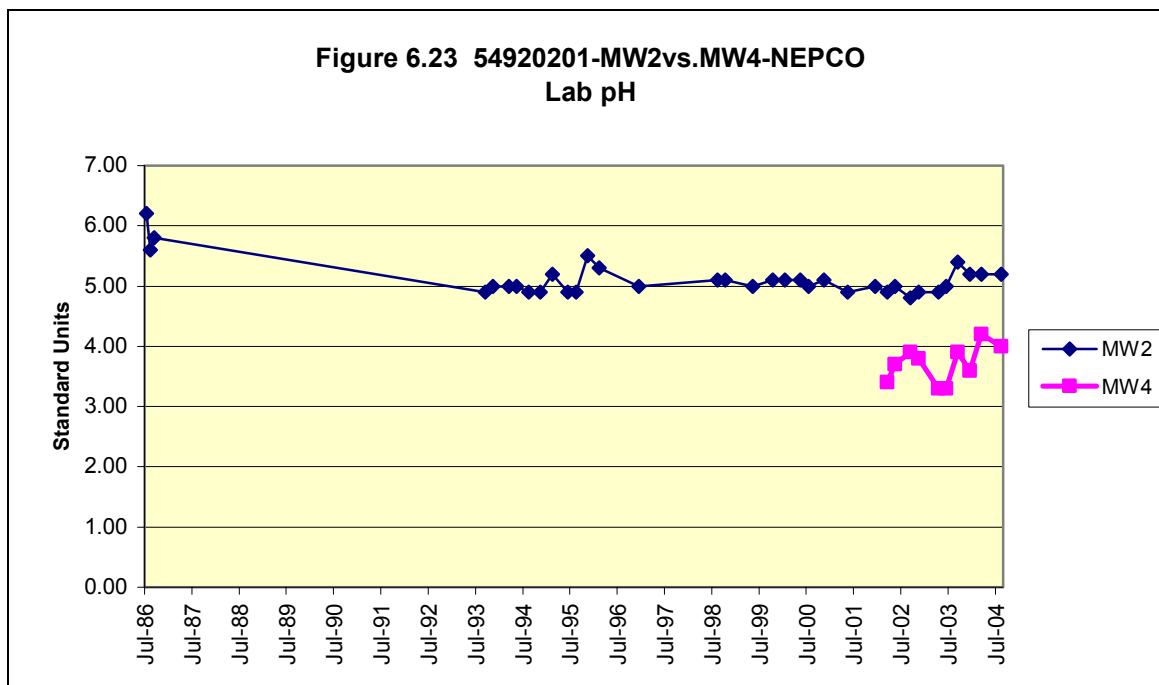












**MW5**

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 than 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 than 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).

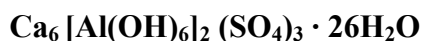
Additional data since reviewed indicates that selenium levels while still readily exceeding selenium at the other monitoring points, were at 0.60 mg/L in the fourth quarter of 2004 and 0.030 mg/L (below the DWS of 0.050 mg/L) in the first quarter of 2005 at MW5. On the other hand, lead levels in the 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:



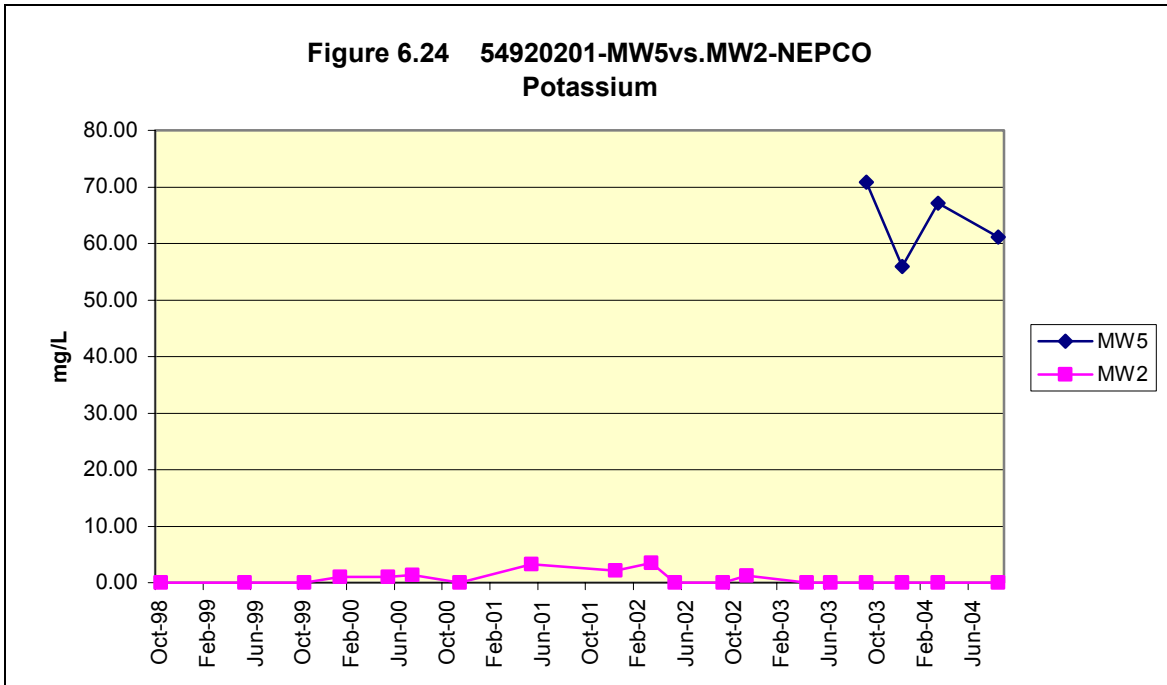
General conditions for Ettringite formation include: 1) a presence of soluble calcium, aluminum, and sulfate; 2) a source of alkalinity, with a pH environment from about 11 to 12.5; and 3) a source of water, as Ettringite is 38% water by weight. These conditions are present in varying degrees throughout 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)

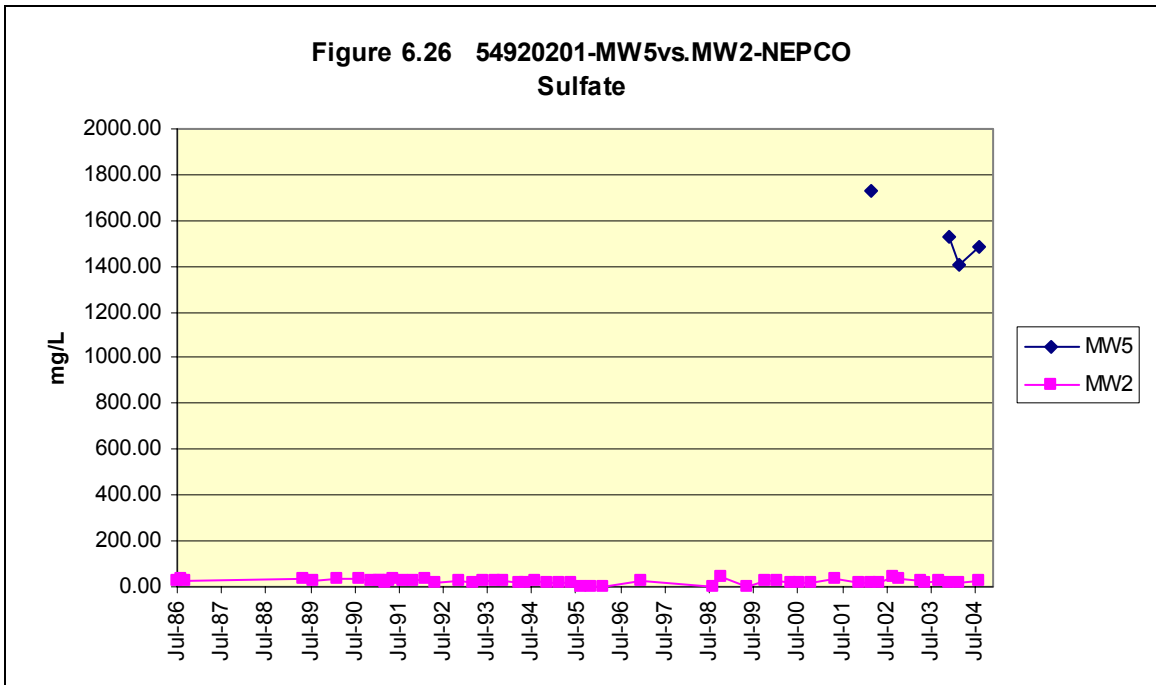
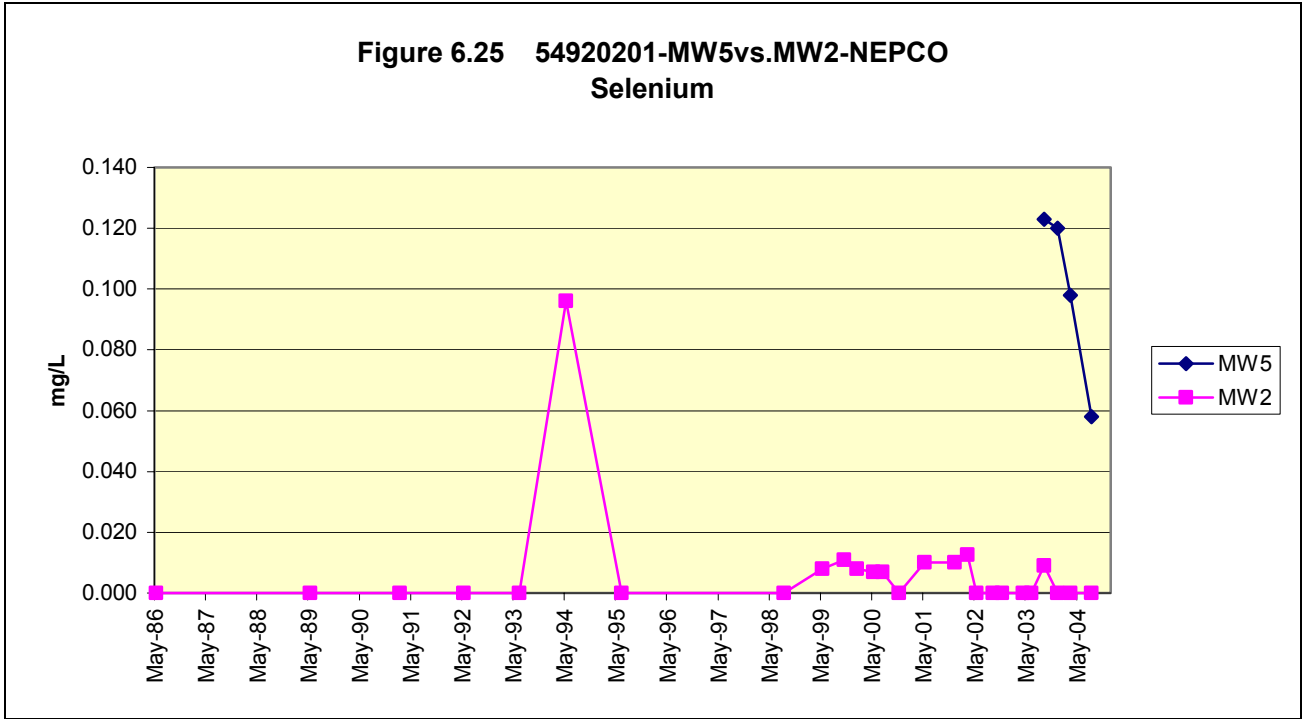
Under the right conditions, Ettringite can incorporate some trace elements into its crystal structure, substituting for the  $(\text{SO}_4)^{2-}$  anion complex. These trace elements must exist as oxyanions in aqueous solution. Ettringite has an anion incorporation preference in the order  $\text{B}(\text{OH})^4 > \text{SeO}_4^{2-} > \text{CrO}_4^{2-} > \text{MoO}_4^{2-}$ .

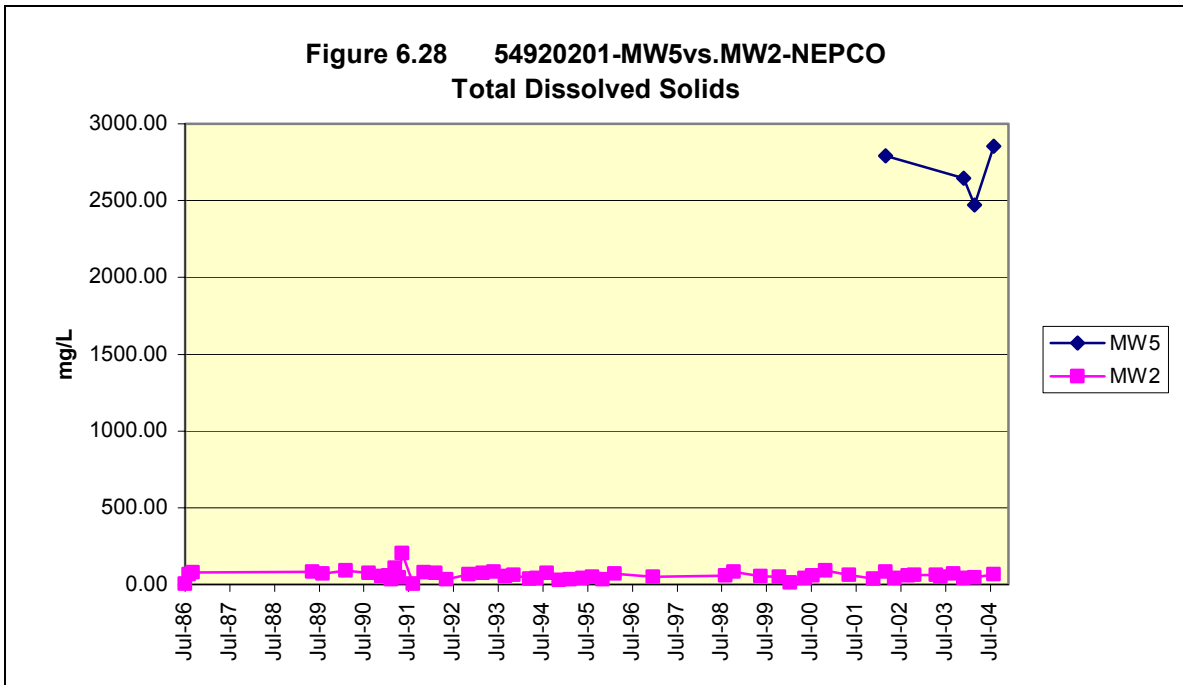
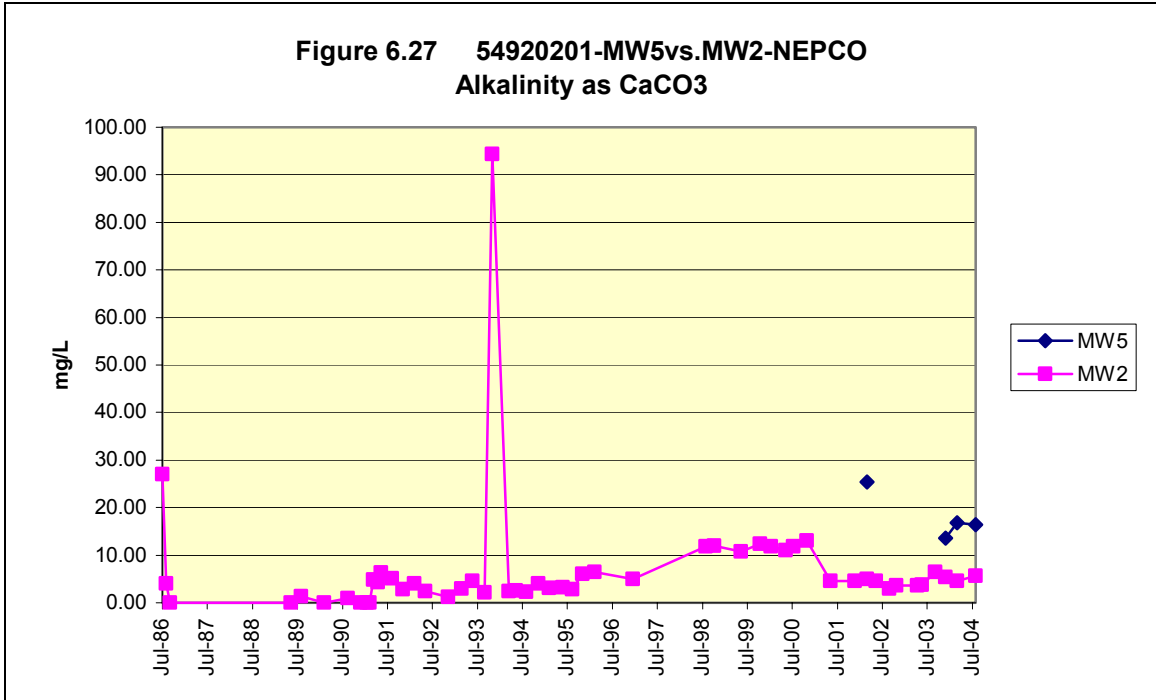
However, research also demonstrates that below a pH of 11, Ettringite starts to become unstable. If the pH containing Ettringite drops below about 10, the mineral breaks down, and any trace metal oxyanions are released into the surrounding water. The tendency for high pH to attenuate to lower pH in the 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.

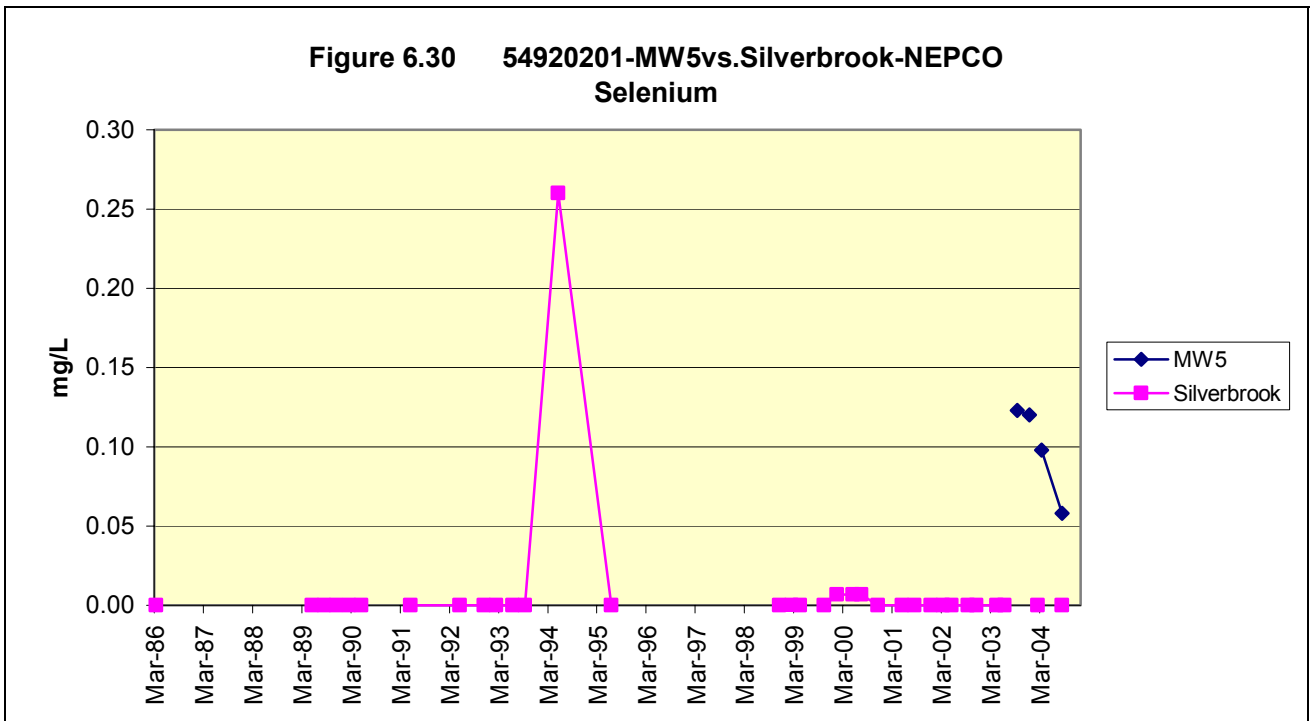
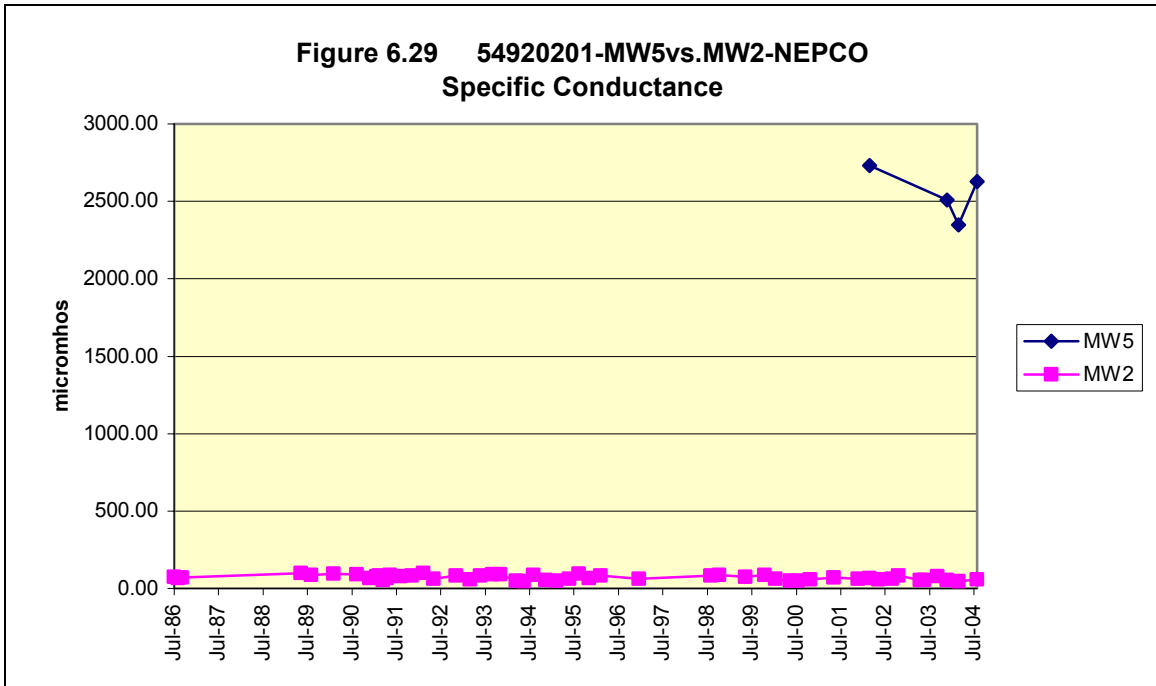
Collectively, the data from the Big Gorilla Pit water during ash placement, the 2001 and 2002 test borings in the Big Gorilla ash, and MW5 demonstrate that unhealthy levels of major and minor constituents and trace elements such as selenium, arsenic, chromium, lead and molybdenum have readily dissolved from this ash and that there is a consistent water table in the ash. Thus groundwater does leave the Big Gorilla Pit with

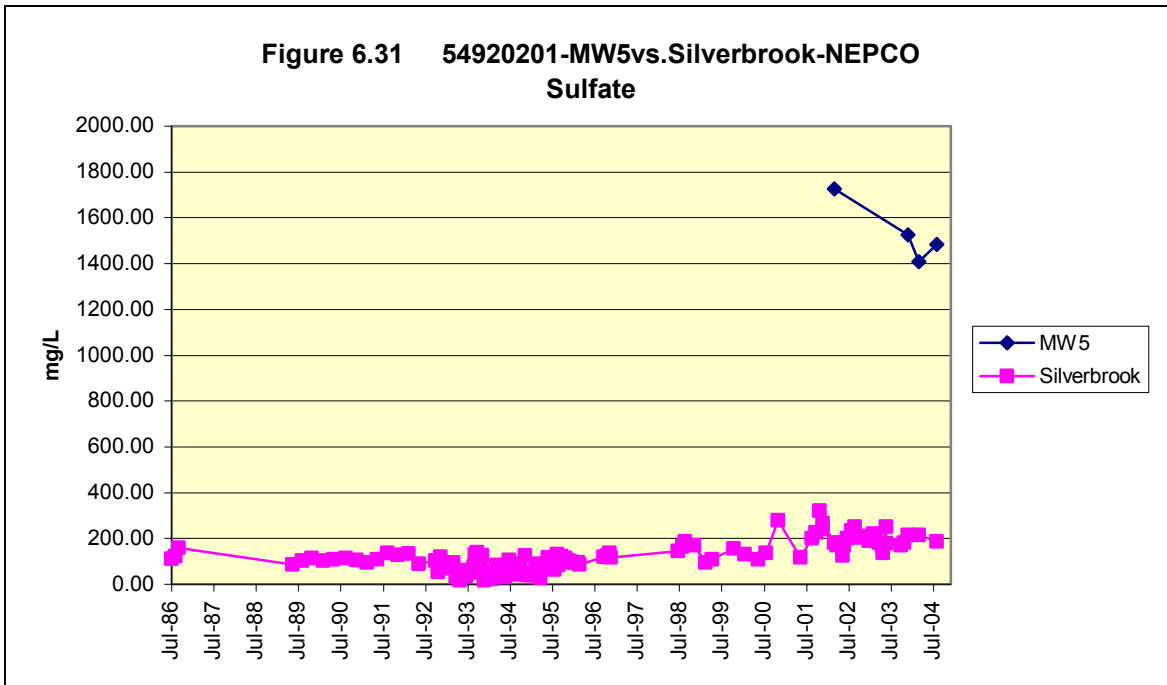
potentially harmful levels of constituents through unknown and, therefore, largely unmonitored pathways.











**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, re-mining, 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 re-mining 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.