Characterization of Coal Combustion By-Products for the Re-Evolution of Mercury into Ecosystems

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DISCLAIMER

ABSTRACT

There is concern that mercury (Hg) in coal combustion by-products might be emitted into the environment during processing to other products or after the disposal/landfill of these by-products. This perception may limit the opportunities to use coal combustion by-products in recycle/reuse applications and may result in additional, costly disposal regulations.

In this program, CONSOL conducted a comprehensive sampling and analytical program to include ash, flue gas desulfurization (FGD) sludge, and coal combustion by-products. This work is necessary to help identify potential problems and solutions important to energy production from fossil fuels. The program objective was to evaluate the potential for mercury emissions by leaching or volatilization, to determine if mercury enters the water surrounding an active FGD disposal site and an active fly ash slurry impoundment site, and to provide data that will allow a scientific assessment of the issue.

Toxicity Characteristic Leaching Procedure (TCLP) test results showed that mercury did not leach from coal, bottom ash, fly ash, spray dryer/fabric filter ash or forced oxidation gypsum (FOG) in amounts leading to concentrations greater than the detection limit of the TCLP method (1.0 ng/mL). Mercury was detected at very low concentrations in acidic leachates from all of the fixated and more than half of the unfixated FGD sludge samples, and one of the synthetic aggregate samples. Mercury was not detected in leachates from any sample when deionized water (DI water) was the leaching solution.

Mercury did not leach from electrostatic precipitator (ESP) fly ash samples collected during activated carbon injection for mercury control in amounts greater than the detection limit of the TCLP method (1.0 ng/mL).

Volatilization tests could not detect mercury loss from fly ash, spray dryer/fabric filter ash, unfixated FGD sludge, or forced oxidation gypsum; the mercury concentration of these samples all increased, possibly due to absorption from ambient surroundings. Mercury loss of 18-26% was detected after 3 and 6 months at 100 °F and 140 °F from samples of the fixated FGD sludge.

Water samples were collected from existing ground water monitoring wells around an active FGD disposal site (8 wells) and an active fly ash slurry impoundment (14 wells). These were wells that the plants have installed to comply with ground water monitoring requirements of their permits. Mercury was not detected in any of the water samples collected from monitoring wells at either site.

A literature review concluded that coal combustion byproducts can be disposed of in properly designed landfills that minimize the potentially negative impacts of water intrusion that carries dissolved organic matter (DOM). Dissolved organic matter and sulfate-reducing bacteria can promote the transformation of elemental or oxidized mercury into methyl mercury. The landfill should be properly designed and capped with clays or similar materials to minimize the wet-dry cycles that promote the release of methylmercury.

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INTRODUCTION

This is the Final Report of activities performed under DOE Cooperative Agreement No. DE-FC26-00NT40906. Specific research objectives were to:

- Determine the mercury concentration in coal combustion waste streams
- Determine if the mercury in these samples is leachable or volatile
- Evaluate the fate of mercury in coal fly ash during the manufacture of Portland cement
- Evaluate the fate of mercury in flue gas desulfurization (FGD) gypsum during the manufacture of wallboard
- Evaluate the fate of mercury in coal ash material used to make manufactured aggregate
- Compile a literature review of the mercury chemistry and transformation in eco-systems
- Evaluate the extent that mercury is leached and converted to methylmercury in sulfite sludge FGD landfills
- Evaluate the extent that mercury is leached and converted to methylmercury in fly ash slurry impoundments
- Report findings to the scientific community

There is concern that mercury (Hg) in coal combustion by-products might be emitted into the environment when coal combustion by-products are processed into other products (e.g., wallboard) or by dissolution into groundwater after disposal.[1] This perception may limit the opportunities to dispose of or to use coal combustion by-products in recycle/reuse applications.

In 1999, CONSOL Energy Inc., Research & Development, (CONSOL) conducted a study, co-funded by DOE and the Ohio Coal Development Office (OCDO), that showed that the mercury disposed of with fixated FGD solids did not leach or volatilize.[2-4] The solids passed the standard Toxicity Characteristic Leaching Procedure (TCLP), and no emission occurred when the FGD solids were exposed to temperatures up to 140 °F for three months. While these results are encouraging because they do not show any adverse environmental impacts, they represent a limited set of data. In this program, CONSOL developed a more comprehensive sampling and analytical program to include ash, FGD products, and coal combustion by-products. This work is necessary to help identify potential problems and solutions important to energy production from fossil fuels. The program objective is to evaluate the potential for mercury emissions by leaching or volatilization, and to provide data that will allow a scientific assessment of the issue.

CONCLUSIONS

Toxicity Characteristic Leaching Procedure (TCLP) test results showed that mercury did not leach from coal, bottom ash, fly ash, spray dryer/fabric filter ash or forced oxidation gypsum (FOG) in amounts leading to concentrations greater than the detection limit of the TCLP method (1.0 ng/mL). Mercury was detected at very low concentrations in acidic leachates from all of the fixated and more than half of the unfixated FGD sludge samples, and one of the synthetic aggregate samples. Mercury was not detected in leachates from any sample when deionized water (DI water) was the leaching solution.

Mercury did not leach from electrostatic precipitator (ESP) fly ash samples collected during activated carbon injection for mercury control in amounts greater than the detection limit of the TCLP method (1.0 ng/mL).

Volatilization tests could not detect mercury loss from fly ash, spray dryer/fabric filter ash, unfixated FGD sludge, or forced oxidation gypsum; the mercury concentration of these samples all increased, possibly due to absorption from ambient surroundings. Mercury loss of 18-26% was detected after 3 and 6 months at 100 °F and 140 °F from samples of the fixated FGD sludge.

Mercury was not detected in water samples collected from monitoring wells around an active FGD disposal site.

Mercury was not detected in water samples collected from monitoring wells around an active fly ash slurry surface impoundment.

A literature review concluded that coal combustion byproducts can be disposed of in properly designed landfills that minimize the potentially negative impacts of water intrusion that carries dissolved organic matter (DOM). Dissolved organic matter and sulfate-reducing bacteria can promote the transformation of elemental or oxidized mercury into methyl mercury. The landfill should be properly designed and capped with clays or similar materials to minimize the wet-dry cycles that promote the release of methylmercury.

RESULTS AND DISCUSSION

Literature Review of the Chemistry of Mercury in Both Natural and Industrial Environments Specific to Factors That Enhance or Inhibit Mercury Methylation. The objective of this task was to conduct a comprehensive literature review that includes data from recent studies (i.e., within the last two years) conducted as a result of a variety of clean water initiatives. The literature review is included in Appendix A. The review identified factors that can affect mercury methylation, including sulfur cycling, bacteria, iron-reducing sediments, molybdates, dry/wet cycling, dissolved organic matter (DOM), and solar radiation. A brief description of the factor effects follows.

Methylation occurs mainly in anoxic waters and is mediated by naturally occurring sulfate reducing bacteria (SRB) in the sediments. Increasing sulfate concentrations generally stimulate sulfate reduction and MeHg production, but if the sulfate concentrations get too high, buildup of sulfide inhibits MeHg production. Microbial methylation is suppressed in iron-reducing sandy sediments and inhibited by molybdates.

Some soil samples produced high levels of MeHg when they were rewetted following periods of dryness. It was found that when the soils were rewetted, sulfate (generated by air oxidation during the dry phase) fueled the growth of SRB, which, in turn, promoted Hg methylation and MeHg production.

The amount of dissolved Hg^{2+} present in a given system is greater in the presence of reactive DOM. The binding of Hg^{2+} to DOM under natural conditions is controlled by a small fraction of DOM molecules containing reactive thiol functional groups. Wetland enclosure (mesocosm) experiments, in which DOM was added to the mesocosms, showed enhanced methylation (both biotic and abiotic pathways) of Hg^{2+} and enhanced photo-oxidation of MeHg relative to control mesocosms.

Methylmercury photodegrades under UV light. Nitrate ions irradiated with solar ultraviolet radiation in water produce hydroxyl radicals, which catalyze the degradation reaction.

The implication of these findings, relative to coal combustion by-products, is that coal combustion byproducts can be disposed of in properly designed landfills that minimize the potentially negative impacts of water intrusion that carries dissolved organic matter that promotes the transformation of elemental or oxidized mercury into methyl mercury. The landfill should be properly designed and capped with clays or similar materials to minimize the wet-dry cycles that promote the release of methylmercury.

Sampling and Characterization of Coal Combustion Samples and By-Products. The objective was to obtain coal ash, FGD sludge, by-product feedstock, and by-product samples, and determine their mercury contents and potential for ground water contamination. The potential for mercury emissions from wallboard and manufactured aggregate was also determined. Table 1 is a list of the plants and the samples

collected from each plant. By agreement with the Contracting Officer, the plants are identified by code number. Plant personnel collected the samples using containers and instructions supplied by CONSOL. Samples were requested from plants 8 and 10, but the plant personnel did not collect the samples.

Analysis of Samples Received.

Coal Samples. Coal samples were collected from plants 1, 2, 3, 4, 5, 6, 7, 9, 12, and 13. The analyses of the samples are listed in Table 2. The mercury content of the coals ranged from 0.06 to 0.28 mg/kg (ppm) on an as determined basis.

Bottom Ash Samples. Bottom ash samples were collected from plants 2, 3, 5, 9, 12, 13, and 16. The analyses of the samples are listed in Table 3. The bottom ash samples contained very little mercury (0.01 to 0.04 mg/kg as determined).

Fly Ash Samples. ESP ash hopper samples were collected from plants 1, 2, 3, 4, 6, 9, 12, 13, 14, and 16. Fabric filter ash hopper samples were collected from plant 7. The analyses of the samples are listed in Table 4. The mercury content for these samples varied widely, ranging from 0.2 to 1.5 mg/kg (ppm) on an as determined basis. No statistically significant correlation was observed between the mercury content and the carbon content of the fly ash samples. ESP ash hopper samples were also collected during activated carbon injection tests at plant 9; these samples are designated 9a in the table. The mercury removal results from the activated carbon injection tests were not available; however, the mercury content of these samples was 0.7 to 1.2 mg/kg (ppm) on an as determined basis, which is 5 to 15 times higher than similar samples collected at the same plant without activated carbon injection. This indicates that the activated carbon removed a substantial amount of mercury from the flue gas.

FGD Sludge Samples. FGD sludge samples were collected from plants 1, 2, 4, 12, 13, and 15; the samples were filtered and air-dried. The analyses of the air-dried samples are listed in Table 5. The mercury content ranged from 0.21 to 0.95 mg/kg (ppm) on an as determined basis.

Fixated FGD Sludge Samples. Fixated FGD sludge samples were collected from plants 1, 3, and 4. The analyses of the air-dried samples are listed in Table 6. The mercury content in these samples ranged from 0.26 to 0.90 mg/kg (ppm) on an as determined basis.

Dry Scrubber Product Samples. Spray dryer/fabric filter samples were collected from plants 5 and 14. The analyses are listed in Table 7. The mercury content ranged from 0.31 to 0.76 mg/kg (ppm) on an as determined basis.

Other Samples. Other samples collected include circulating fluidized bed/fabric filter (CFB/FF) ash collected from plant 11, forced oxidation gypsum (FOG) from plant 13, and synthetic aggregates made from coal combustion by-products from plants 14 and 15. The analyses of these samples are listed in Table 8. The mercury content of the CFB/FF ash was 0.33 mg/kg. There was very little mercury in the FOG (0.02 mg/kg).

The mercury content of the two synthetic aggregate samples was the same (0.28 mg/kg), even though they were made from different starting materials.

Leaching Tests. Selected samples were leached using three different solutions: a 2.8 pH buffered solution, a 4.9 pH buffered solution, and DI water. The results are shown in Tables 9 to 14. The leaching tests were repeated on randomly selected samples, indicated by the letters "dup" after the run number in the last column of the tables. The mercury detection limit for the leachate solutions was 1.0 ng/mL (ppb). This detection limit would detect a mercury loss from the solid samples of 0.02 mg/kg. A value less than the detection limit indicates that less than 0.02 mg/kg mercury was leached from the solid sample.

The mercury content of the solid samples before and after leaching is given in the tables. However, because some materials can lose mass through dissolution of soluble solids, and other materials can gain mass through hydration of salts, the comparison of the mercury content of the solids before and after leaching is not necessarily indicative of mercury loss or gain.

Coal. Coal samples from plants 3 and 13 were subjected to leaching tests. The results are shown in Table 9. The sample from plant 13 was not leached with the 2.9 pH solution due to an oversight. The table shows that the leachates contained no detectable mercury.

Bottom Ash. Bottom ash samples from plants 3 and 13 were subjected to leaching tests. The results are shown in Table 10. The table shows that the leachates contained no detectable mercury. This is not unexpected, considering that the bottom ash samples had very little mercury (0.01 and 0.04 mg/kg).

Fly Ash. Fly ash samples from plants 1, 3, 4, 6, 7, 9, 13, and 16 (representing a cross-section of fly ash from many different coals) were subjected to leaching tests. The results are shown in Table 11. The ESP ash hopper samples collected during activated carbon injection tests at plant 9 were also subjected to the leaching tests; these samples are designated 9a in the table. The table shows that the leachates contained no detectable mercury, despite the high mercury content of some of the samples (over 1 mg/kg in some cases). The results also indicate that the mercury captured by the activated carbon in the plant 9a samples was not detectably leached by any of the three leaching solutions.

FGD Sludge. FGD sludge samples from plants 1, 4, and 15 were subjected to leaching tests. These represent a magnesium-lime scrubber, a natural oxidation limestone scrubber, and an inhibited oxidation limestone scrubber. The results are shown in Table 12. The table shows that the leachates obtained using DI water contained no detectable mercury. However, the more acidic solutions did leach mercury from the solids. The amount of mercury leached can be estimated in the following manner. In the TCLP procedure, 0.1 kg of solid material is leached using 2 L of leaching solution. If the solid loses 0.1 mg/kg, then 0.01 mg ends up in the 2 L of solution, and the solution thus contains 0.01 mg/2 L or 5 ng/mL. For example, the plant 1 sample contained 0.40

mg/kg of mercury; the 4.9 pH solution produced leachate containing 5.2 ng/L of mercury, meaning 0.0104 mg leached from 100 g of material; it leached 0.104 mg/kg, or about 25% of the 0.40 mg/kg of mercury in the original (unleached) sample. Using similar reasoning, the 2.9 pH solution leached about 50% of the mercury from the original sample. For the plant 4 samples, the 4.9 pH solution leached as much as 16% of the mercury, and the 2.9 pH solution leached as much as 13% of the mercury from the original sample. For the plant 15 sample, the 4.9 pH solution did not leach a detectable amount of mercury, but the 2.9 pH solution leached about 4% of the mercury from the original sample.

Fixated FGD Sludge. Fixated FGD sludge samples from plants 1, 3, and 4 were subjected to leaching tests. The results are shown in Table 13. The table shows that the leachates obtained using DI water contained no detectable mercury. However, the more acidic solutions did leach mercury from the plant 1 and plant 3 solids. For the plant 1 sample, the 4.9 pH solution did not leach a detectable amount of mercury, but the 2.8 pH solution leached about 10-15% of the mercury from some of the samples. For the plant 3 samples, the 4.9 pH solution leached up to 10% of the mercury, and the 2.8 pH solution leached 14-29% of the mercury from the original samples. No detectable mercury was leached from the plant 4 samples.

Comparing the leaching results for fixated vs. unfixated samples from plants 1 and 4 suggests that fixation reduces the percentage of mercury leached in these standard leaching tests.

Plant	% of Original Mercury Leached with pH 2.8 Solution		% of Original Mercury Leached with pH 4.9 Solution	
	Unfixated	Fixated	Unfixated	Fixated
1	54%	0-15%	26%	0%
4	0-13%	0%	0-16%	0%

Other Samples. Other samples leached include the circulating fluidized bed/fabric filter (CFB/FF) ash from plant 11, forced oxidation gypsum (FOG) from plant 13, spray dryer/fabric filter ash from plant 14, and synthetic aggregates made from coal combustion by-products from plants 14 and 15. The results are shown in Table 14. The table shows that the leachates contained no detectable mercury, except for the 4.9 pH leachate from one of the synthetic aggregate samples, which leached 20% of the mercury from the aggregate made from plant 14 coal combustion by-products. It is curious that there was no detectable mercury in the more acidic and less acidic leachates.

Because many of the leachates had concentrations less than the detection limit of one ng/mL, six TCLP filtrate samples were sent to an outside lab for mercury analysis by

cold vapor atomic fluorescence spectroscopy (CV-AFS); the CV-AFS has a detection limit of 0.2 ng/L (equivalent to 0.2 part per trillion). At the time of the study, CONSOL R&D did not have the capability to perform CV-AFS. Three leachate samples obtained from leaching one ESP fly ash sample from plants 4 and 9 were analyzed by this method. The results are listed in Table 15. The concentrations of mercury measured by CV-AFS in the three leachates from plant 4 fly ash ranged from 38 to 84 ng/L. This represents a range of 1-2.4% of the mercury in the original fly ash sample. The concentrations of mercury measured in the three leachates from the plant 9 fly ash sample ranged from 0.9 to 10.5 ng/L. This represents a range of 0.02-0.17% of the mercury in the original fly ash sample.

Volatilization Tests. Volatilization tests were performed by tamping the samples into aluminum pans to simulate compaction in a landfill, and placing them in 100 °F and 140 °F nitrogen-purged ovens for 3 and 6 months, as described in the Experimental Methods section. After the 3 and 6 month period, nearly all of the samples had an increased mercury concentration ranging from 5 to 133% increase; only the fixated FGD sludge samples from plant 3 showed a decrease in mercury concentration. The concentration increase could not be attributed to weight loss due to drying, because the starting moisture concentration was not very high and, thus, did not lose much weight. Contamination of the nitrogen purge was investigated and ruled out. Cross-contamination of the samples was considered, but ruled out because the amount of mercury gained by the samples was overwhelmingly higher than the amount lost by the few samples that lost mercury. The source of the mercury was not determined. A possibility is that the samples absorbed mercury from the ambient surroundings during handling, such as when loading into the ovens or when tamping into the sample holders. Tests at the University of Nevada-Reno demonstrated that coal combustion by-products can absorb substantial amounts of mercury from the ambient surroundings[5].

Fly Ash. Fly ash samples from plants 1, 3, 4, 6, 7, 9, 13, 14, and 16 were subjected to volatilization tests. The results are shown in Table 16. The ESP ash hopper samples collected during activated carbon injection tests at plant 9 were also subjected to the volatilization tests; these samples are designated 9a in the table. The table shows that all of the samples show an increase in mercury concentration of 0-143% after 3 months, and 6-133% after 6 months.

FGD Sludge. FGD sludge samples from plants 13 and 15 were subjected to volatilization tests. The results are shown in Table 17. The table shows that all of the samples show an increase in mercury concentration of 5-84%.

Fixated FGD Sludge. Fixated FGD sludge samples from plants 1 and 3 were subjected to volatilization tests. The results are shown in Table 18. The table shows that the samples from plant 1 showed an increase in mercury concentration of 0-40%, but the samples from plant 3 showed a decrease of 18-26%. The Plant 3 samples were the only samples that consistently showed a decrease of mercury in the volatilization tests.

Other Samples. Other samples tested include the circulating fluidized bed/fabric filter (CFB/FF) ash from plant 11, forced oxidation gypsum (FOG) from plant 13, and synthetic aggregates made from coal combustion by-products from plants 14 and 15. The results are shown in Table 19. The table shows that these samples also showed an increase in mercury concentration of 18-76%.

Characterization of Ground Water Around an Active FGD Disposal Site. The objective was to obtain ground water samples in and around the boundary area of an active FGD disposal site to determine the potential for mercury release into the local ecosystem. Samples were collected from monitoring wells that had been established as part of the environmental permitting process. Figure 1 is a diagram of the monitoring well sites. The samples were collected once each quarter for one year. Table 20 shows a summary of the results. The mercury concentrations in all of the well samples were all below the detection limit of 1.0 ng/mL.

Three wells were located up gradient of the FGD disposal area at this impoundment. Each well showed little quarter-to-quarter variation. The pH was 6.44 to 8.63 and the alkalinity range was 194 to 497 mg/L (ppm). The total dissolved solids (TDS) range was 446 to 626 mg/L. The chloride concentrations were low (maximum 3.5 mg/L) and the nitrate ranged from below the detection limit to 2.13 mg/L. The nitrite was below the detection limit of 0.05 mg/L, except one sample which contained 0.09 mg/L nitrite. The sulfide concentrations were all below 5.0 mg/L. The mercury concentration was below the detection limit of 1.0 ng/mL at all times.

Five wells were located down gradient of the FGD disposal area at this impoundment. Two to five down-gradient wells were sampled in each quarter; some wells were inaccessible during one or more quarters. The pH was 6.52 to 8.02, which is similar to the up-gradient well range. The alkalinity was 160 to 418 mg/L, which is also similar to the up-gradient wells. The TDS was generally higher than the up-gradient wells, with a range of 514 to 2230 mg/L. The chlorides were generally higher than up-gradient, but only one sample was above the Primary Drinking Water Standard (PDWS) of 250 mg/L. The maximum nitrate concentration was 0.83 mg/L, which is lower than the up-gradient wells. The nitrite concentrations were all below 0.05 mg/L, and the sulfide concentrations were all less than 5.0 mg/L except for MW9FD, which ranged from 12 to 22 mg/L in three of the four quarters and less than 1.0 mg/L in one quarter. This same well MW9FD always had the highest TDS.

Runoff water is collected in a pond on site. Samples were collected from two drainage troughs that lead to the pond. These “seep” locations were sampled in three of the four quarters; the wells were inaccessible during the winter quarter due to weather conditions. The mercury concentration was below the detection limit of 1.0 ng/mL for all of the seep samples. The pH range was 6.15 to 8.15, which is similar to the up-gradient and down-gradient wells. The seep samples had the lowest alkalinity (24-64 mg/L) and the highest TDS (2960-3780 mg/L) and chloride (325-855 mg/L) levels. All but one sample had less than 1.0 mg/L nitrate and less than 0.05 mg/L nitrite. The North seep had sulfide concentrations of 6.7 to 10 mg/L, but sulfide was below the detection limit of 1.0 mg/L in the South seep.

Figures 2 to 5 show comparisons of the up-gradient, down-gradient, and seep collection samples for pH, total alkalinity, total dissolved solids, and chlorides. The figures show substantially higher chloride concentrations in the down-gradient wells compared to the up-gradient wells, but not much difference in the pH or total alkalinity. The seep samples were higher than any of the other samples for TDS and chloride, and lowest in alkalinity. The chloride concentrations in the down-gradient well samples were less than the Primary Drinking Water Standard (PDWS) of 250 mg/L, except for one sample that contained 275 mg/L chloride. The nitrate and nitrite concentrations of the groundwater samples also were less than the PDWS concentrations of 10 mg/L and 1 mg/L, respectively. In general, the total dissolved solids were above the Secondary Drinking Water Standard (SDWS) of 500 mg/L, including the samples from two of the three up-gradient wells.

The pH of most samples were within the Secondary Drinking Water Standard range of 6.5-8.5; three of the 12 up-gradient well samples were outside of this range by 0.1 pH unit and 2 of the 6 seep samples were 6.15 to 6.31 pH.

Characterization of Ground and Surface Water from Active Fly Ash Slurry Surface Impoundments. The objective was to obtain ground water samples in and around an impoundment site to determine the potential for mercury release into the local ecosystem. Figure 6 is a diagram of the monitoring well sites. Samples were collected from monitoring wells that had been established as part of the environmental permitting process. The samples were collected once each quarter for one year. Table 21 shows a summary of the results. The mercury concentrations in all of the well samples were all below the detection limit of 1.0 ng/mL.

There is one up-gradient well at this impoundment, which was sampled during all four quarters. The samples showed little variation from quarter to quarter. The mercury concentration was below the method detection limit of 1.0 ng/mL for each of the four quarters. The pH ranged from 5.53 to 6.03. The alkalinity was 9-10 mg/L, the total dissolved solids (TDS) content was 54 to 88 mg/L, and all anions (chloride, nitrate, nitrite, and sulfide) were 10 mg/L or less.

There are four cross-gradient wells at this impoundment. Three to four were sampled in each quarter; some wells were inaccessible or dry during one or more quarters. One sample showed 1.0 ng/mL mercury during one quarter (MW105, June ‘03), otherwise all other cross-gradient samples were less than 1.0 ng/mL. The pH range was 5.06 to 6.77 and the alkalinity was 14 to 45 mg/L. One well (MW115) showed consistently high TDS (1030 to 1340 mg/L) and chloride (265 to 460 mg/L) compared to the other cross-gradient wells. The reason for this is not clear, but it is unlikely that the slurry pond is the source because the down-gradient wells were all lower in TDS and chloride than this well. Other anions measured at this well were below their detection limits except for sulfide, which was 2.4 mg/L for one sample. At another cross-gradient well (MW203) the TDS was 304-314 mg/L, which is a little higher than found in the other cross-gradient wells, but is within the same range as the down-gradient wells; other concentrations in this well were low: the TDS was 64 to 92 mg/L, the chloride was 1-3 mg/L, the nitrate was above the detection limit once (0.46 mg/L), and the nitrite and the

sulfide was below the detection limits. This well was only sampled twice because it was inaccessible during one season and dry during another. At the other two cross-gradient wells, TDS was less than 100 mg/L, chloride was 1-2 mg/L, the highest measured nitrate concentration was 0.1 mg/L, and the sulfide was less than 5.0 mg/L.

There are eight down-gradient wells at this impoundment. Seven to eight down-gradient wells were sampled in each quarter; some wells were inaccessible during one or more quarters. The mercury concentration at MW107 was 1.1 ng/mL in the 3rd quarter; otherwise, the mercury concentration was less than 1.0 ng/mL in all the down-gradient wells. The pH ranged from 5.15 to 7.39. The TDS was 68 to 394 mg/L. The other concentrations were relatively low.

There is a leachate underdrain system (LM1) and a leachate runoff collection site (LM2) at this impoundment. LM2 was dry three out of the four quarters, but a sample was collected from LM1 during each quarter. The mercury concentration was below 1.0 ng/mL for each leachate sample. The pH of the leachate samples was 6.84 to 7.80, the alkalinity was 169 to 583 and the TDS was 316 to 832 mg/L, which are both substantially higher than the monitoring wells.

Figures 7 to 10 show comparisons of the up-gradient, cross-gradient, down-gradient, and leachate collection samples for pH, total alkalinity, total dissolved solids, and chlorides. All four figures show slightly elevated concentrations in the down-gradient wells compared to the up-gradient wells. The leachate samples were higher than any of the other samples for pH and total alkalinity, and higher in TDS than the others except for one cross-gradient well which, as mentioned above, had unusually high concentration of TDS. The chloride concentration in LM1 and LM2 was 1-2 mg/L, which was lower than in the up-gradient well. The chloride concentrations in the groundwater samples were generally less than the Primary Drinking Water Standard of 250 mg/L. The nitrate and nitrite concentrations of the samples also were less than the PDWS concentrations of 10 mg/L and 1 mg/L, respectively, except for one cross-gradient sample that contained 16 mg/L nitrate. In general, the total dissolved solids were near the SDWS of 500 mg/L.

The pH of many samples were below the Secondary Drinking Water Standard range of 6.5-8.5; however, in all of the up-gradient well samples the pH was less than or equal to 6.0.

EXPERIMENTAL

Sample collection. Table 1 shows a matrix of the plants, the types of samples collected, and the number of samples of each type. Solid samples collected included coal, bottom ash, fly ash, FGD slurry, spray dryer solids, and manufactured aggregates. Coals burned at the plants from which these samples were selected include the Pittsburgh seam; Ohio 5, 6, or 11; Illinois 6; eastern low sulfur bituminous; Illinois/ Western Kentucky Blend; Powder River Basin; and southern Appalachian bituminous. All plants had an ESP or baghouse to control particulate emissions. Some plants had

SO_2 control technologies, including magnesium/lime scrubbers, limestone wet scrubbers, lime spray dryers, and circulating fluidized bed SO_2 scrubbers. At one plant, a carbon injection system was in place as a test for mercury control. Samples were collected from the ESP with (Plant Code 9a) and without (Plant Code 9) carbon injection for comparison.

The samples were collected by plant personnel using sample containers supplied by CONSOL. Written procedures for sampling were sent to the plant personnel to aid them in collecting proper samples. A copy of the procedures is included in the Appendix. The sample containers were pre-labeled, acid-washed 5-gal buckets, sealed with plastic tape. The plant personnel were requested to take several samples over a five-day period so that a representative sample was obtained. The sample buckets were then to be re-sealed with plastic tape and returned to CONSOL R&D. After arrival at CONSOL, the samples were analyzed, then stored in sealed containers until the leaching and volatilization tests were performed.

Leaching tests. The leaching tests were conducted by EPA method 1311 and ASTM Method D3987. The samples were leached with three different leachate solutions: 1) acetic acid buffered to a pH of 2.8, 2) acetic acid at a pH of 4.9, and 3) deionized water. The acetic acid buffered solutions are specified by the Toxicity Characterization Leaching Procedure – U.S. EPA Method 1311. The deionized water extraction is specified by the ASTM leaching procedure D3987. Except for the pH of the extraction media used, the two methods are identical. Figure 11 shows a flow chart of the leaching procedure. QA/QC procedures included performing a duplicate leaching on every third sample, as well as performing duplicate sample analyses, standards analyses, spiked-sample and reagent blank analyses.

Volatilization tests. Volatilization tests were performed using a methodology developed by CONSOL R&D. The samples were first analyzed for concentration of mercury, carbon, moisture, and ash, when they were received. The samples were then tamped by hand into 6”x3”x2” aluminum pans to simulate the compaction in a landfill operation prior to being placed in test ovens. The ovens were held at temperatures of 100 °F and 140 °F. These temperatures represent a typical range that the samples might incur at an actual landfill site. The samples were held at elevated temperatures for six months. Each oven was equipped with a continuous mercury-free nitrogen purge to prevent atmospheric mercury contamination of the samples; however, apparently this was not sufficient to prevent contamination, as nearly all of the samples showed an increase in mercury concentration after three and six months as described earlier. Samples from the pans were obtained and analyzed after three and six months. The mercury concentration in these samples was measured by ASTM Method D 6722.

Samples from monitoring wells. Ground water samples were collected in and around the boundary area of an active FGD disposal site and an active fly ash slurry impoundment. Samples were collected by plant personnel from existing monitoring wells that had been installed as part of the plant’s environmental permitting process. Plant personnel sample these wells quarterly to satisfy permit requirements to monitor the ground water quality hydraulically up gradient and down gradient from the disposal

sites. Samples of the FGD and fly ash feed material were also collected to establish the current mercury loading to the disposal site. Additional samples were collected at site run-off and under-drain locations. All samples were collected on a quarterly basis. CONSOL personnel accompanied plant personnel during the collection process. At times, some of the wells were deemed inaccessible by plant personnel due to weather conditions. Samples could not be collected from these wells at those times for safety reasons.

The field temperature and pH were measured before the samples were preserved for their return to the lab. On their return, they were analyzed for total mercury, alkalinity, acidity, major and trace metals, major anions, and sulfide. Any suspended solids were filtered and analyzed for major elements.

Sample analysis methods. The leachate mercury concentrations were determined by acid digestion followed by cold vapor atomic absorption (CVAA). The solids were analyzed by ASTM Method D 6722, "Total Mercury in Coal and Coal Combustion Residues by Direct Combustion Analysis." QA/QC procedures included performing duplicate sample analyses, standards analyses, spiked-sample and reagent blank analyses. The detection limit was 1.0 ng/mL. At the time these tests were planned, the concentration of mercury in leachates was unknown; this detection limit was believed to be adequate because it was half of the primary drinking water standard of 2.0 ng/mL. When the leaching tests revealed that almost all of the leachate concentrations were below the detection limit, selected samples were analyzed by a more sensitive method, cold vapor atomic fluorescence spectroscopy (CV-AFS), to determine how far below the detection limit the concentrations were. The CV-AFS has a detection limit of 0.2 ng/L. However, because this method is substantially more expensive than CVAA, it was not used for the majority of the samples.

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Table 1. Matrix of Samples Collected, Showing the Number of Samples of Each Sample Type

Plant Code	Coal Source	Particulate Control	FGD Type	Coal	Bottom Ash	Fly Ash (from ESP or Fabric Filter)	FGD Sludge or Spray Dryer Ash	Fixated FGD Sludge	Synthetic Aggregate Product	Forced Oxidation Gypsum	Circulating Fluidized Bed SO_2 Scrubber Product
1	Pittsburgh Seam	ESP	Mg/Lime	1		1	1	4			
2	Pittsburgh Seam	ESP	Forced Oxidation	4	4	4	4				
3	Ohio 5, 6, or 11	ESP	Mg/Lime	3	1	1		6			
4	Illinois 6	ESP	Natural Oxidation	3		3	2	1			
5	Eastern Low Sulfur Bituminous	Baghouse	Lime Spray Dryer	8	1		10				
6	Illinois/W KY Blend	ESP		3		3					
7	Powder River Basin	Baghouse		1		1					
8	Powder River Basin	Baghouse									
9	Powder River Basin	ESP		3	2	3					
9a	Powder River Basin	ESP (w/carbon injection for Hg control)				3					
10	Waste Bituminous Coal	Baghouse	CFB Boiler								
11	Southern Appalachian Bituminous	Baghouse	Circulating Fluidized Bed								1
12	Pittsburgh Seam	ESP	Mg/Lime	4	1	4	4				
13	Pittsburgh Seam	ESP	Mg/Lime	1	1	1	1			1	
14	Eastern Low Sulfur Bituminous	Baghouse	Lime Spray Dryer			1	1		1		
15	Pittsburgh Seam	ESP	Inhibited Oxidation				1		1		
16	Pittsburgh Seam	ESP			1	2					

Table 2. Coal Sample Analyses.

			Volatile	Fixed	Sulfur,			Hg					Oxygen	As Det.	Major Ash Elements (Dry) %										
Analytical	Plant	Ash	Matter	Carbon	Total	BTU/lb	MAF	ppm	Carbon	Hydrogen	Nitrogen	Chlorine	(DIFF)	Moisture	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Und
Number	Number	(Dry) %	(Dry) %	(Dry)%	(Dry)%		BTU/lb	(As Rec)	(Dry) %	(Dry) %	(Dry) %	(Dry) %	(Dry) %	%											
77147	1	12.60	39.96	47.44	4.07	12,996	14,870	0.12	71.55	4.90	1.23	0.061	5.59	1.50	45.33	21.29	0.88	24.64	2.93	0.75	0.49	1.88	0.42	2.31	-0.92
33348	2	9.86	39.18	50.96	3.33	13,077	14,507	0.09	72.96	5.05	1.54	0.170	7.09	4.71	48.04	17.57	0.92	18.33	5.22	0.87	0.78	2.19	0.10	3.65	2.33
33349	2	9.86	38.89	51.25	3.28	13,133	14,570	0.09	73.11	4.98	1.51	0.167	3.28	4.40	47.08	17.49	0.92	20.08	5.62	0.86	0.70	2.10	0.12	2.84	2.19
33350	2	10.02	40.08	49.90	3.33	13,104	14,563	0.10	72.73	4.91	1.47	0.143	7.40	4.64	47.42	17.46	0.92	19.42	5.80	0.87	0.71	2.14	0.14	3.00	2.12
33351	2	9.58	39.05	51.37	3.27	13,117	14,507	0.09	73.14	5.00	1.53	0.178	7.30	4.53	46.43	17.20	0.91	20.36	5.60	0.84	0.67	2.11	0.14	3.35	2.39
12131	3	13.12	39.33	47.55	3.35	12,510	14,399	0.28	70.36	4.56	1.42	0.097	7.09	4.69	45.55	22.31	0.99	24.05	2.49	0.83	0.32	2.03	0.46	2.37	-1.40
12132	3	12.53	39.59	47.88	3.27	12,587	14,390	0.23	70.38	4.55	1.43	0.083	7.76	4.94	44.51	23.94	1.07	22.43	2.76	0.83	0.31	2.02	0.40	2.21	-0.48
12133	3	11.93	40.01	48.06	2.96	12,659	14,374	0.23	71.00	4.59	1.46	0.072	7.99	5.05	44.70	22.87	1.01	23.63	2.75	0.84	0.31	1.98	0.39	2.31	-0.79
12848	4	9.73	41.79	48.48	4.24	12,831	14,214	0.06	69.80	4.95	1.39	0.175	9.72	7.23											
12850	4	9.62	41.54	48.84	4.31	12,854	14,222	0.06	69.75	4.93	1.42	0.165	9.80	8.57											
12852	4	9.62	41.93	48.45	4.37	12,827	14,192	0.06	69.71	4.96	1.45	0.172	9.72	7.20											
31640	5	7.03	37.09	55.07	1.86	14,206	15,087	0.11	77.95	4.90	1.51	0.104	6.65	2.10	47.99	23.67	1.02	17.43	2.30	0.80	0.66	1.89	0.34	1.90	2.00
31641	5	7.05	38.32	54.63	1.87	14,023	15,087	0.12	77.83	4.82	1.52	0.087	6.82	2.07	47.88	23.72	1.03	18.51	2.04	0.77	0.59	1.79	0.34	1.67	1.66
31642	5	7.05	38.09	54.86	1.87	14,052	15,118	0.11	77.92	4.88	1.53	0.096	6.65	2.10	48.68	24.12	1.03	17.86	1.90	0.78	0.60	1.91	0.32	1.60	1.20
31643	5	7.38	37.50	55.12	1.84	13,998	15,113	0.10	77.69	4.78	1.51	0.096	6.70	2.17	48.57	24.08	1.03	17.06	1.96	0.80	0.61	1.94	0.35	1.64	1.96
31644	5	7.40	37.88	54.72	1.87	14,017	15,137	0.11	78.02	4.86	1.53	0.097	6.22	2.20	47.74	23.74	1.01	18.25	2.13	0.77	0.63	1.94	0.34	1.84	1.61
31645	5	7.44	38.08	54.48	1.85	13,944	15,065	0.10	77.79	4.83	1.51	0.107	6.47	2.22	47.92	23.52	1.02	18.24	2.31	0.81	0.67	2.04	0.33	2.00	1.14
31626	5	7.06	37.97	54.97	1.92	13,970	15,031	0.10	77.94	4.84	1.52	0.099	6.62	1.99	48.05	23.89	1.02	18.46	2.11	0.77	0.57	1.79	0.33	1.68	1.33
31627	5	7.21	37.87	54.92	1.99	13,983	15,070	0.11	77.74	4.89	1.57	0.114	6.49	1.97	47.42	23.55	1.00	19.77	1.98	0.75	0.59	1.83	0.34	1.71	1.06
12674	6	8.27	36.19	55.54	1.51	13,400	14,608	0.09	74.46	4.61	1.44	0.114	9.60	3.69	54.99	21.99	1.09	12.85	3.14	0.99	1.13	2.21	0.33	1.55	-0.27
12676	6	8.68	35.97	55.35	1.52	13,354	14,623	0.10	74.08	4.57	1.44	0.109	9.60	3.17	54.91	22.01	1.07	13.61	3.27	0.97	1.10	2.16	0.31	1.83	1.24
12678	6	10.37	36.11	53.52	1.47	12,735	14,208	0.10	71.57	4.43	1.44	0.097	10.62	3.82	57.40	21.24	1.06	11.29	3.33	1.11	1.24	2.64	0.27	1.50	-1.08
30857	7	5.83	46.13	48.04	0.51			0.08	71.87	4.90	0.91	<0.020	15.98	6.75	29.94	17.57	1.36	4.01	18.26	6.39	2.06	0.72	0.27	17.32	2.10
13088	9	7.47	46.48	46.05	0.40	11,874	12,833	0.08	69.47	4.58	1.17	0.051	16.86	21.22	36.19	16.34	1.33	4.48	22.39	3.73	1.30	0.47	1.26	11.71	0.80
13084	9	6.40	46.55	47.05	0.38	12,010	12,831	0.06	70.30	4.63	1.12	0.038	17.13	21.36	31.94	16.18	1.48	4.67	23.72	4.37	1.17	0.33	1.12	14.50	0.52
13083	9	7.33	43.51	49.16	0.46	11,816	12,751	0.10	67.99	4.62	1.28	0.055	18.27	16.54	34.06	17.59	1.37	5.23	21.94	3.51	1.23	0.37	1.36	12.99	0.35
32609	12	9.62	39.51	50.87	4.48	13,296	14,711	0.10	73.35	4.97	1.48	0.041	6.06	2.44	41.19	20.04	0.83	29.98	2.72	0.72	0.66	1.61	0.26	3.15	-1.16
32610	12	9.49	39.75	50.76	4.69	13,361	14,762	0.09	73.70	5.00	1.49	0.051	5.58	2.27	38.61	18.35	0.79	31.40	2.55	0.66	0.45	1.49	0.19	3.12	2.39
32611	12	9.56	39.89	50.55	4.85	13,375	14,789	0.09	73.36	4.99	1.44	0.051	5.75	2.19	37.75	18.00	0.77	33.43	2.40	0.63	0.43	1.41	0.21	2.89	2.08
32612	12	9.11	40.17	50.72	4.87	13,454	14,803	0.10	73.89	4.98	1.44	0.041	5.67	2.21	36.66	20.14	0.82	32.82	2.86	0.68	0.48	1.55	0.23	2.80	0.96
22000	13	8.93	37.04	54.03	1.94	13,606	14,940	0.16	75.80	4.94	1.55	0.105	6.73	1.83	48.64	22.87	0.96	17.93	1.95	0.81	0.68	2.00	0.25	1.82	2.09

Table 3. Bottom Ash Sample Analyses

			Sulfur,	Hg		As Det.	Major Ash Elements (Dry) %										
Analytical	Plant	Ash	Total	ppm	Carbon	Moisture	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Und
Number	Number	(Dry) %	(Dry)%	(As Rec)	(Dry) %	%											
43189	2	100.16	0.06	0.02	0.07	0.27	49.41	18.95	0.98	22.50	4.20	3.08	0.59	2.56	0.24	0.16	-2.67
43190	2	99.93	0.09	0.02	0.11	1.32	50.30	19.36	0.98	23.34	5.04	1.56	0.71	2.56	0.24	0.22	-4.31
43191	2	99.69	0.09	0.02	0.35	0.10	49.12	19.11	0.96	22.61	4.95	1.11	0.69	2.40	0.22	0.23	-1.40
43192	2	100.06	0.10	0.02	0.08	1.33	50.22	19.12	0.97	22.67	4.58	1.15	0.59	2.17	0.20	0.24	-1.91
12139	3	99.56	0.17	0.04	0.1	0.02	43.29	21.92	1.05	26.36	2.66	0.78	0.26	1.71	0.36	0.43	1.18
31777	5	88.82	0.10	0.03	10.68	0.47	42.52	20.19	0.87	19.67	2.07	0.62	0.41	1.38	0.25	0.32	11.7
13087	9	98.63	0.07	<0.005	1.65	0.27	44.93	18.39	1.36	7.46	17.19	3.41	0.99	0.55	0.96	0.18	4.58
20238	9	99.06	0.10	<0.005	0.06	0.25	45.43	20.44	1.53	6.59	18.22	3.38	0.97	0.52	0.93	0.25	1.74
32621	12		0.25	0.01	0.21	0.04	37.83	17.14	0.81	39.10	3.29	0.69	0.33	1.24	0.18	0.62	-1.23
22001	13	96.95	0.06	0.01	2.60	0.06	46.26	21.56	1.03	24.25	3.01	0.83	0.47	1.54	0.27	0.14	0.64
31246	16	73.60	0.004	0.02	25.44	0.77	42.36	22.22	0.97	3.06	0.88	0.47	0.32	1.81	0.32	0.09	27.5

Table 4. Fly Ash Sample Analyses.

			Sulfur,	Hg		As Det.	Major Ash Elements (Dry) %										
Analytical	Plant	Ash	Total	ppm	Carbon	Moisture	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Und
Number	Number	(Dry) %	(Dry)%	(As Rec)	(Dry) %	%											
23171	1	88.40	0.33	0.34	10.45	0.30	42.01	20.17	0.93	17.83	2.78	0.72	0.48	1.88	0.40	0.82	11.98
33378	2	89.57	1.11	0.13	7.12	1.32	44.27	17.02	0.95	14.95	4.42	0.85	0.64	2.05	0.18	2.82	11.85
33379	2	98.41	0.80	0.03	0.72	0.51	49.00	17.99	1.00	16.85	4.96	0.85	0.80	2.19	0.10	2.03	4.23
33384	2	91.52	1.11	0.11	5.95	1.00	45.91	17.73	0.98	15.76	4.95	0.87	0.71	2.16	1.90	2.78	7.96
33385	2	99.05	0.70	0.02	0.38	0.30	50.87	18.98	1.04	16.44	4.92	0.90	0.80	2.34	1.40	1.91	1.66
12138	3	98.38	0.32	0.08	1.48	0.11	45.78	24.47	1.26	21.22	2.89	0.89	0.35	2.18	0.47	0.80	-0.31
012849	4	92.78	0.60	0.07	5.36	0.11											
012851	4	95.15	0.54	0.08	3.62	0.05											
012853	4	94.99	0.57	0.06	3.37	0.08											
012675	6	87.99	0.68	0.25	10.30	0.03	47.95	20.39	1.05	11.69	3.15	0.96	1.07	2.04	0.38	1.69	9.63
012677	6	94.20	0.33	0.14	5.09	0.06	53.51	21.09	1.06	12.61	3.15	0.96	1.07	2.09	0.30	0.82	3.34
012679	6	79.16	0.65	0.58	19.37	0.03	41.35	17.81	0.91	12.70	3.66	0.83	0.95	1.77	0.34	1.63	18.05
30856	7	96.40	1.10	1.49	2.16	0.17	32.91	20.23	1.49	5.19	20.06	6.65	3.78	0.68	0.35	2.82	5.84
013092	9	99.56	0.52	0.14	0.36	0.02	39.92	19.23	1.44	4.93	23.79	4.72	1.64	0.70	1.17	1.31	1.15
013089	9	99.59	0.55	0.12	0.18	0.09	36.10	19.49	1.52	5.50	25.13	4.73	1.76	0.36	1.52	1.37	2.52
013085	9	99.78	0.59	0.08	0.11	0.05	37.25	18.88	1.54	5.14	25.51	4.58	1.63	0.40	1.30	1.48	2.29
013078	9a	96.13	0.74	0.73	4.03	0.15	35.40	18.32	1.44	4.88	23.44	4.21	1.43	0.50	1.02	1.84	7.52
013079	9a	95.18	1.09	1.20	4.74	0.07	30.35	18.57	1.46	5.42	24.44	4.28	1.51	0.44	1.52	2.72	9.29
013080	9a	97.59	0.74	0.70	2.31	0.17	35.18	20.09	1.57	6.22	24.20	4.21	1.49	0.50	1.46	1.84	3.24
32615	12	94.09	0.50	0.11	4.98	0.40	36.61	16.60	0.79	31.39	2.73	0.64	0.40	1.34	0.15	1.47	7.88
32616	12	95.23	0.50	0.07	4.14	0.31	35.57	16.01	0.77	34.51	2.84	0.62	0.36	1.23	0.14	1.35	6.60
32617	12	92.92	0.60	0.13	5.93	0.31	37.27	17.22	0.83	28.91	2.78	0.66	0.43	1.40	0.18	1.71	8.61
32618	12	93.11	0.60	0.12	5.98	0.34	36.47	16.84	0.81	29.63	2.77	0.64	0.42	1.35	0.16	1.65	9.26
022002	13	95.39	0.34	0.08	3.53	0.05	47.36	21.55	1.07	20.31	2.31	0.78	0.73	1.85	0.32	0.84	2.88
013096	14	86.99	2.86	0.31	5.82	0.88	26.78	14.39	0.83	1.63	26.53	0.67	0.16	1.07	0.02	7.14	20.78
31209	16	79.93	0.10	0.25	19.30	0.31	47.06	23.19	1.01	4.15	1.02	0.53	0.36	2.24	0.40	0.32	19.72
23448	16	92.92	0.09	0.47	6.32	0.01	54.40	25.49	1.27	6.73	1.22	0.69	0.42	2.53	0.45	0.23	6.57

Table 5. Wet FGD Sludge Sample Analyses.

			Sulfur,	Hg		As Det.	Major Ash Elements (Dry) %										
Analytical	Plant	Ash	Total	ppm	Carbon	Moisture	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Und
Number	Number	(Dry) %	(Dry)%	(As Rec)	(Dry) %	%											
22509	1	95.41	19.43	0.40	1.16	1.66	1.77	0.42	0.02	0.21	41.41	1.10	0.08	<0.01	<0.01	48.58	6.41
33344	2	96.65	20.00	0.82	0.68	18.70	2.87	0.38	0.01	0.32	39.61	0.86	0.04	0.12	<0.01	49.99	5.80
33345	2	96.33	20.04	0.78	0.71	18.52	2.80	0.37	0.01	0.31	39.78	0.96	0.02	0.09	0.01	50.09	5.56
33346	2	96.25	19.99	0.83	0.75	18.61	2.95	0.39	0.02	0.33	39.71	1.03	0.01	0.10	0.01	49.97	5.48
33347	2	96.36	20.01	0.95	0.75	18.49	3.36	0.47	0.02	0.38	39.69	1.06	0.02	0.10	0.02	50.03	4.85
13082	4	92.58	18.56	0.21	1.03	0.09	1.23	0.20	0.01	0.23	42.33	0.32	0.05	0.13	<0.01	46.39	9.11
13081	4	92.69	18.83	0.25	1.02	0.10	1.76	0.31	0.01	0.31	42.49	0.35	0.05	0.10	<0.01	47.08	7.54
32623	12		19.27	0.73	0.13	12.15	2.57	0.55	0.02	0.30	32.70	3.03	0.02	0.06	<0.01	48.18	12.57
32624	12		18.28	0.64	0.07	12.23	2.04	0.46	0.02	0.24	32.02	3.28	0.02	0.06	<0.01	46.94	14.92
32625	12		19.05	0.65	0.10	11.36	2.13	0.50	0.02	0.27	32.78	2.74	0.03	0.06	<0.01	47.63	13.84
32625	12		19.29	0.61	0.12	13.17	1.90	0.46	0.02	0.26	32.26	3.54	0.03	0.05	<0.01	48.22	13.26
21999	13	85.17	19.27	0.37	0.82	1.38	1.69	0.58	0.03	0.28	32.46	6.84	0.29	0.20	<0.00	48.26	9.37
13098	15	88.27	16.19	0.41	3.41	4.01	1.02	0.19	0.01	0.17	43.33	0.90	0.21	0.06	<0.00	40.48	13.63

Table 6. Fixated FGD Sludge Sample Analyses.

Analytical Number	Plant Number	Ash (Dry) %	Sulfur, Total (Dry)%	Hg ppm (As Det)	Carbon (Dry) %	As Det. Moisture %	Major Ash Elements (Dry) %										
							SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Und
22508	1	93.27	13.48	0.34	3.39	2.56	13.82	6.38	0.30	5.05	31.26	1.05	0.25	0.46	0.06	33.70	7.67
23169	1	88.13	13.38	0.39	3.66	2.01	15.96	7.35	0.34	6.10	27.95	1.27	0.20	0.67	0.12	33.45	6.59
23259	1	89.15	13.37	0.36	3.91	1.08	14.87	6.82	0.31	6.07	29.09	1.34	0.19	0.58	0.12	33.42	7.19
30855	1	88.60	13.76	0.30	2.45	1.15	15.80	7.20	0.33	7.20	28.13	1.43	0.25	0.71	0.12	34.41	4.42
12134	3	96.97	13.94	0.90	1.10	10.68	14.39	7.34	0.36	6.00	29.80	1.37	0.13	0.60	0.04	34.84	5.13
13093	3	97.15	9.49	0.47	1.04	2.97	23.65	11.59	0.57	10.46	25.17	1.36	0.20	1.06	0.18	23.73	2.03
13094	3	97.02	10.38	0.52	1.02	4.57	20.76	11.17	0.53	8.34	28.59	1.50	0.18	0.93	0.10	25.94	1.96
13095	3	97.01	9.08	0.48	1.11	3.26	23.86	11.78	0.57	10.49	24.80	1.39	0.21	1.08	0.19	22.71	2.92
13086	4	92.81	4.70	0.26	1.63	0.29	35.32	18.07	1.38	4.82	21.65	3.89	1.12	0.41	1.28	11.76	0.30

Table 7. Spray Dryer Product Sample Analyses.

Analytical Number	Plant Number	Ash (Dry) %	Sulfur, Total (Dry)%	Hg ppm (As Det)	Carbon (Dry) %	As Det. Moisture %	Major Ash Elements (Dry) %										
							SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Und
31649	5	91.88	9.91	0.76	5.30	0.85	20.60	9.73	0.44	6.71	26.95	0.68	0.29	0.82	0.14	23.92	9.72
31654	5	90.88	9.47	0.70	5.96	0.91	20.06	9.49	0.43	6.83	27.16	0.67	0.28	0.80	0.14	22.97	11.17
31650	5	91.83	9.70	0.70	5.21	0.75	20.34	9.60	0.43	6.88	27.58	0.68	0.29	0.82	0.14	23.87	9.37
31655	5	91.73	9.63	0.68	5.41	0.77	20.16	9.51	0.43	6.80	27.42	0.67	0.29	0.82	0.13	23.37	10.40
31651	5	90.73	9.71	0.72	6.42	1.23	20.75	9.85	0.45	7.10	26.37	0.64	0.28	0.83	0.13	22.87	10.73
31656	5	90.77	9.49	0.68	6.13	1.13	20.32	9.56	0.43	7.10	26.83	0.66	0.28	0.81	0.13	22.50	11.38
31652	5	89.02	9.06	0.60	7.47	0.72	19.47	9.02	0.40	7.59	27.71	0.67	0.26	0.77	0.12	21.41	12.58
31657	5	92.11	10.27	0.70	4.86	1.14	19.58	9.35	0.42	6.17	28.04	0.67	0.30	0.82	0.13	23.91	10.61
31653	5	90.07	8.92	0.67	6.79	0.86	20.16	9.48	0.42	7.28	26.82	0.66	0.28	0.81	0.13	22.60	11.36
31658	5	92.05	10.21	0.72	5.06	1.08	19.84	9.41	0.43	6.32	27.69	0.67	0.29	0.82	0.14	23.65	10.74
13096	14	86.99	2.86	0.31	5.82	0.88	26.78	14.39	0.83	1.63	26.53	0.67	0.16	1.07	0.02	7.14	20.78

Table 8. Other Sample Analyses.

Analytical Number	Plant Number	Sample Type	Ash (Dry) %	Sulfur, Total (Dry)%	Hg ppm (As Rec)	Carbon (Dry) %	As Det. Moisture %	Major Ash Elements (Dry) %										
								SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Und
13038	11	CFB/FF Ash	72.16	5.02	0.33	12.14	0.53	26.72	13.73	0.68	4.38	19.35	0.82	0.27	1.14	0.06	12.56	20.29
31237	13	FOG Gypsum	82.45	18.29	0.02	0.08	3.87	0.44	0.17	0.01	0.17	33.62	0.04	0.01	0.03	<0.00	45.72	19.79
13097	14	Synthetic Aggregate	81.47	2.52	0.28	7.63	5.32	24.79	13.12	0.75	1.62	28.07	0.63	0.16	0.97	<0.00	6.29	23.60
13090	15	Synthetic Aggregate	92.14	8.32	0.28	4.75	1.49	23.77	10.3	0.61	3.58	25.57	0.75	0.51	0.97	0.16	20.79	12.99

Table 9. Coal Sample Leaching Test Results

Plant ID #	Mercury in Solids, mg/kg as det.				(Avg. Post-Leach/ Pre-Leach) x 100	Mercury in Leachate, ng/L			Run ID #
	pre-leaching	After leaching with pH 2.8 buffer solution	After leaching with pH 4.9 buffer solution	After leaching with DI H_20	%	pH 2.8	pH 4.9	DI H20	
3	0.28	0.35	0.35	0.42	133	<1.0	<1.0	<1.0	7727
3	0.23	0.23	0.23	0.18	93	<1.0	<1.0	<1.0	77122
3	0.23	0.39	0.33	0.34	154	<1.0	<1.0	<1.0	77122dup
13	0.16		0.14	0.12	80	<1.0	<1.0	<1.0	77140

Table 10. Bottom Ash Sample Leaching Test Results

Plant ID #	Mercury in Solids, mg/kg as det.				(Avg. Post-Leach/ Pre-Leach) x 100	Mercury in Leachate, ng/mL			Run ID #
	pre-leaching	After leaching with pH 2.8 buffer solution	After leaching with pH 4.9 buffer solution	After leaching with DI H_20	%	pH 2.8	pH 4.9	DI H20	
3	0.04	0.01	0.02	0.03	50	<1.0	<1.0	<1.0	77125
13	0.01	0.01	0.01	0.01	100	<1.0	<1.0	<1.0	77141

Table 11. Fly Ash Sample Leaching Test Results

Plant ID #	Mercury in Solids, mg/kg as det.				(Avg. Post-Leach/ Pre-Leach) x 100	Mercury in Leachate, ng/mL			Run ID #
	pre-leaching	After leaching with pH 2.8 buffer solution	After leaching with pH 4.9 buffer solution	After leaching with DI H_20	%	pH 2.8	pH 4.9	DI H20	
1	0.34	0.38	0.36	0.36	109	<1.0	<1.0	<1.0	77145
1	0.34	0.37	0.37	0.36	109	<1.0	<1.0	<1.0	77145dup
3	0.08	0.08	0.08	0.07	96	<1.0	<1.0	<1.0	77123
4	0.07	0.10	0.09	0.08	129	<1.0	<1.0	<1.0	77134
4	0.08	0.10	0.10	0.10	125	<1.0	<1.0	<1.0	77136
4	0.08	0.11	0.10	0.09	125	<1.0	<1.0	<1.0	77136dup
4	0.06	0.07	0.07	0.07	117	<1.0	<1.0	<1.0	77138
6	0.25	0.32	0.31	0.32	127	<1.0	<1.0	<1.0	77128
6	0.14	0.23	0.17	0.21	145	<1.0	<1.0	<1.0	77130
6	0.58	0.75	0.74	0.67	124	<1.0	<1.0	<1.0	77132
6	0.58	0.75	0.71	0.70	124	<1.0	<1.0	<1.0	77132dup
7	1.49	1.32	1.27	1.27	86	<1.0	<1.0	<1.0	77156
9	0.14	0.20	0.20	0.19	140	<1.0	<1.0	<1.0	77108
9	0.12	0.17	0.17	0.16	139	<1.0	<1.0	<1.0	77111
9	0.08	0.07	0.06	0.07	83	<1.0	<1.0	<1.0	77113
9	0.08	0.09	0.08	0.09	108	<1.0	<1.0	<1.0	77113dup
9a	0.73	1.32	1.16	1.01	159	<1.0	<1.0	<1.0	77118
9a	1.2	2.8	3.0	2.6	233	<1.0	<1.0	<1.0	77119
9a	1.2	2.7	3.0	2.7	233	<1.0	<1.0	<1.0	77119dup
13	0.08	0.1	0.09	0.09	117	<1.0	<1.0	<1.0	77142
16	0.47	0.51	0.52	0.52	110	<1.0	<1.0	<1.0	77150
16	0.25	0.11	0.26	0.27	85	<1.0	<1.0	<1.0	77153

Table 12. FGD Sludge Sample Leaching Test Results

Plant ID #	Mercury in Solids, mg/kg as det.				(Avg. Post-Leach/ Pre-Leach) x 100	Mercury in Leachate, ng/mL			Run ID #
	pre-leaching	After leaching with pH 2.8 buffer solution	After leaching with pH 4.9 buffer solution	After leaching with DI H_20	%	pH 2.8	pH 4.9	DI H20	
1	0.40	0.15	0.31	0.42	73	10.9	5.2	<1.0	77144
4	0.25	0.29	0.24	0.24	103	<1.0	2.0	<1.0	77115
4	0.21	0.21	0.20	0.22	100	1.4	<1.0	<1.0	77116
4	0.21	0.22	0.23	0.22	106	<1.0	1.0	<1.0	77116dup
15	0.65	0.57	0.53	0.54	84	1.3	<1.0	<1.0	77102

Table 13. Fixated FGD Sludge Sample Leaching Test Results

Plant ID #	Mercury in Solids, mg/kg as det.				(Avg. Post-Leach/ Pre-Leach) x 100	Mercury in Leachate, ng/mL			Run ID #
	pre-leaching	After leaching with pH 2.8 buffer solution	After leaching with pH 4.9 buffer solution	After leaching with DI H_20	%	pH 2.8	pH 4.9	DI H20	
1	0.34	0.27	0.32	0.35	92	2.6	<1.0	<1.0	77143
1	0.39	0.39	0.41	0.39	103	<1.0	<1.0	<1.0	77146
1	0.39	0.35	0.44	0.40	103	<1.0	<1.0	<1.0	77146dup
1	0.36	0.36	0.37	0.36	101	<1.0	<1.0	<1.0	77148
1	0.30	0.26	0.26	0.25	86	1.6	<1.0	<1.0	77155
3	0.47	0.41	0.47	0.47	96	6.6	2.5	<1.0	77103
3	0.47	0.40	0.46	0.47	94	6.8	2.4	<1.0	77103dup
3	0.52	0.39	0.50	0.48	88	6.6	1.7	<1.0	77104
3	0.48	0.41	0.46	0.45	92	5.7	1.5	<1.0	77105
3	0.48	0.42	0.48	0.47	95	4.4	<1.0	<1.0	77105dup
3	0.90	0.65	0.79	0.78	82	6.1	<1.0	<1.0	77139
4	0.26	0.41	0.24	0.23	113	<1.0	<1.0	<1.0	77114

Table 14. Other Sample Leaching Test Results

Sample Type	Plant ID #	Mercury in Solids, mg/kg as det.				(Avg. Post-Leach/ Pre-Leach) x 100	Mercury in Leachate, ng/mL			Run ID #
		pre-leaching	After leaching with pH 2.8 buffer solution	After leaching with pH 4.9 buffer solution	After leaching with DI H_20	%	pH 2.8	pH 4.9	DI H20	
CFB/FF Ash	11	0.33	0.53	0.36	0.50	140	<1.0	<1.0	<1.0	7726
CFB/FF Ash	11	0.33	0.45	0.43	0.41	130	<1.0	<1.0	<1.0	77126
FOG	13	0.02	0.01	0.01	0.01	50	<1.0	<1.0	<1.0	77158
SDA/FF Ash	14	0.52	0.56	0.57	0.54	107	<1.0	<1.0	<1.0	7720
Synthetic Aggregate	14	0.39	0.43	0.41	0.40	106	<1.0	3.9	<1.0	77101
Synthetic Aggregate	15	0.39	0.24	0.30	0.28	70	<1.0	<1.0	<1.0	7723
Synthetic Aggregate	15	0.39	0.27	0.26	0.29	70	<1.0	<1.0	<1.0	7723dup

Table 15. CV-AFS Analysis Results

Plant ID #	Mercury in Solids, mg/kg as det.				(Avg. Post-Leach/ Pre-Leach) x 100	Mercury in Leachate, ng/L Determined using CV-AFS			Run ID #
	pre-leaching	After leaching with pH 2.8 buffer solution	After leaching with pH 4.9 buffer solution	After leaching with DI H_20	%	pH 2.8	pH 4.9	DI H20	
4	0.07	0.10	0.09	0.08	129	50.4	38	83.7	77134
9	0.12	0.20	0.20	0.19	140	0.93	10.5	7.48	77111

Table 16. Fly Ash Sample Volatilization Test Results

						3 month Hg Results													6 month Hg Results											
						100 °F							140 °F						100 °F						140 °F					
	As	As Rec.	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.
Plant	Rec'vd	Hg conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.
Number	Analyt.#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%
1	023171	0.34	88.21	10.42	0.32	32A	030467	0.49	89.01	10.74	0.35	32B	30462	0.45	89.3	9.87	0.14	32A	31345	0.36	89.28	10.56	0.49	32B	31346	0.39	88.9	10.65	0.4
3	012138	0.08	98.28	1.48	0.11	8A	021788	0.09	98.36	1.27	0.18	8B	021781	0.10	97.92	1.40	0.23	8A	22756	0.12	97.89	1.17	0.17	8B	22757	0.17	98.4	1.19	0.08
4	012849	0.07	92.65	5.35	0.09	19A	021787	0.11	94.12	4.71	0.22	19B	021762	0.12	93.38	3.89	0.30	19A	22778	0.13	94.24	4.69	0.16	19B	22779	0.12	93.9	4.73	0.13
4	012851	0.08	95.02	3.62	0.04	21A	021773	0.09	95.72	3.14	0.28	21B	021765	0.10	95.55	2.42	0.14	21A	22780	0.11	96.56	2.61	0.08	21B	22781	0.13	96.4	2.98	0.02
4	012853	0.06	94.86	3.37	0.08	23A	021804	0.07	96.01	2.73	0.09	23B	021760	0.08	94.87	3.44	0.17	23A	22782	0.1	95.64	3.08	0.08	23B	22783	0.1	95.8	3.82	0.04
6	012675	0.25	87.91	10.30	0.03	16A	021777	0.34	87.78	10.04	0.53	16B	021758	0.32	87.69	10.04	0.33	16A	22772	0.38	88.32	9.63	0.33	16B	22773	0.34	89	9.33	0.34
6	012677	0.14	94.10	5.11	0.06	17A	021798	0.22	94.62	4.77	0.16	17B	021767	0.25	93.77	4.87	0.19	17A	22774	0.28	94.32	4.7	0.17	17B	22775	0.24	94.2	4.78	0.18
6	012679	0.58	79.17	19.36	0.03	18A	021803	0.72	80.18	18.80	0.43	18B	021766	0.69	79.10	18.30	0.44	18A	22776	0.69	81.19	17.33	0.45	18B	22777	0.69	81.3	16.94	0.35
7	030856	1.19	96.21	2.08	0.16	40A	031923	1.62	94.77	1.95	3.31	40B	31924	1.65	94.83	1.76	1.33	40A						40B					
9	013092	0.14	99.54	0.36	0.02	12A	021786	0.21	99.56	0.21	0.18	12B	021780	0.21	99.50	0.22	0.15	12A	22764	0.23	99.53	0.22	0.07	12B	22765	0.21	99.4	0.23	0.1
9	013089	0.12	99.50	0.18	0.09	14A	021801	0.15	99.68	0.14	0.04	14B	021782	0.17	99.63	0.31	0.11	14A	22768	0.18	99.59	0.22	0.02	14B	22769	0.17	99.6	0.21	0.08
9	013085	0.08	99.73	0.11	0.05	15A	021796	0.10	99.85	0.10	0.03	15B	021800	0.08	99.84	0.06	0.03	15A	22770	0.11	99.68	0.08	0.07	15B	22771	0.1	99.7	0.06	0.07
9a	013078	0.73	95.99	4.02	0.15	25A	021802	0.98	95.94	3.79	0.23	25B	021763	1.03	95.41	3.91	0.33	25A	22784	1.16	95.6	3.64	0.16	25B	22785	1.07	95.7	3.76	0.18
9a	013079	1.20	95.11	4.74	0.07	26A	021768	2.91	94.14	4.26	0.41	26B	021770	2.80	94.12	4.56	0.37	26A	22786	2.32	94.83	4.35	0.24	26B	22787	2.38	94.8	4.33	0.23
9a	013080	0.70	97.42	2.31	0.17	27A	021793	0.99	97.59	2.08	0.20	27B	021771	1.01	97.27	2.11	0.27	27A	22788	1.08	97.36	2.12	0.14	27B	22789	1.02	97.4	2.12	0.08
13	022002	0.08	95.28	3.53	0.07	31A	030465	0.11	96.11	3.42	0.3	31B	30466	0.12	96.07	3.38	0.13	31A	31343	0.09	96.29	3.45	0.43	31B	31344	0.09	96.1	3.49	0.21
14	013096	0.31	86.22	5.77	0.88	1A	021778	0.47	82.12	5.85	0.89	1B	021794	0.47	85.65	5.91	0.44	1A	22742	0.59	84.12	6.25	0.61	1B	22743	0.53	85.2	5.69	0.51
16	031209	0.25	79.61	19.29	0.34	37A	031928	0.83	80.14	19.55	0.73	37B	31929	0.59	80.09	19.47	0.71	37A						37B					

Table 17. FGD Sludge Sample Volatilization Test Results

						3 month Hg Results												6 month Hg Results											
						100 °F						140 °F						100 °F						140 °F					
	As	As Rec.	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.
Plant	Rec'vd	Hg conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.
Number	Analyt.#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%
13	022707	0.37			4.28	28A	030471	0.57	95.57	0.85	2.91	28B	30472	0.68	96.12	0.84	2.04	28A	31337	0.47	96.56	0.86	2.41	28B	31338	0.46	96.3	0.85	1.45
13	021999	0.37	84.19	0.82	1.32	28C	030473	0.43	85.46	0.70	5.37	28D	30468	0.39	86.33	0.72	3.98	28C	31339	0.3	85.73	0.68	4.81	28D	31340	0.4	87.4	0.73	3.52
15	013098	0.41	84.73	3.27	4.01	3A	021774	0.50	85.40	3.10	1.37	3B	021784	0.53	87.14	3.42	1.44	3A	22746	0.5	85.98	3.18	3.06	3B	22747	0.55	87.2	3.17	1.13

Table 18. Fixated FGD Sludge Sample Volatilization Test Results

						3 month Hg Results												6 month Hg Results											
						100 °F						140 °F						100 °F						140 °F					
	As	As Rec.	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.
Plant	Rec'vd	Hg conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.
Number	Analyt.#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%
1	023169	0.39	86.36	3.59	2.03	33A	030463	0.51	93.89	3.68	1.45	33B	30464	0.53	93.99	3.62	0.67	33A	31347	0.39	93.84	3.71	1.58	33B	31348	0.34	93.8	3.77	0.83
1	030855	0.30	87.32	2.41	1.06	39A	031926	0.42	96.15	2.58	1.25	39B	31927	0.34	95.63	2.58	1.09	39A						39B					
3	012134	0.90	86.39	0.98	10.71	5A	021805	0.67	96.64	0.98	0.72	5B	021775	0.70	89.52	0.88	1.03	5A	22750	0.71	95.71	1.01	0.98	5B	22751	0.74	95.9	1	0.84
3	012135	0.67	93.83	0.93	2.86	6A	021772	0.54	87.29	0.98	1.23	6B	021764	0.50	89.80	0.87	0.80	6A	22752	0.51	95.73	1.02	1.15	6B	22753	0.48	96.1	0.97	0.76
3	012136	0.70	92.77	0.91	4.38	7A	021795	0.50	96.60	1.03	0.98	7B	021761	0.52	90.62	0.91	0.95	7A	22754	0.55	95.76	1.01	1.03	7B	22755	0.54	96	0.97	0.74
3	012137	0.65	93.51	1.03	3.27	9A	021792	0.50	95.45	1.01	0.96	9B	021759	0.48	88.54	1.08	1.04	9A	22758	0.53	95.69	1.13	1	9B	22759	0.53	95.9	1.08	0.73

Table 19. Other Sample Volatilization Test Results

							3 month Hg Results												6 month Hg Results											
							100 °F						140 °F						100 °F						140 °F					
		As	As Rec.	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.	Pan	Pan	Pan Hg	Ash	Carbon	As Det.
Plant	Sample	Rec'vd	Hg conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.	ID	Analyt.	conc.	(Dry)	(Dry)	Moist.
Number	Type	Analyt.#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%	#	#	ppm	%	%	%
11	CFB/FF Ash	013038	0.33	72.20	12.14	0.54	11A	021797	0.48	84.35	12.17	0.68	11B	021785	0.48	71.78	12.02	0.73	11A	22762	0.54	83.09	12.3	0.75	11B	22763	0.58	84.1	11.74	0.68
13	FOG Gypsum	031237	0.02	82.45	0.08	3.87	42A	032581	0.04	98.86	0.09	19.99	42B	032582	0.02	98.72	0.09	19.64												
14	Synthetic Aggregate	013097	0.28	77.14	7.22	5.32	2A	021769	0.37	76.82	7.32	3.92	2B	021783	0.38	76.04	7.43	1.18	2A	22744	0.38	77.41	7.2	3.56	2B	22745	0.37	78.8	7.32	1.99
15	Synthetic Aggregate	013090	0.28	90.77	4.68	1.49	4A	021791	0.35	91.04	4.78	0.67	4B	021799	0.33	91.49	4.75	0.58	4A	22748	0.37	90.17	4.7	0.97	4B	22749	0.39	90.6	4.73	0.9

Table 20. Results of FGD Disposal Site Sampling at Up-gradient (Ending in U), Down Gradient (Ending in D), and Seep Locations.

Sample ID	Analytical Number	pH	Acidity as $CaCO_3$	Alkalinity as $CaCO_3$	Total Susp. Solids	Total Dis. Solids	Specific Condu.	Cl^{1-}	NO_3^{1-} as N	NO_2^{1-} as N	S^{2-}	Hg
			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb
1st Quarter (Sampled 7/30/02												
MW1FU	021990	6.71	-211	221	116	456	713	3.5	<0.02	<0.02	1.6	<1.0
MW1UU	021988	8.16	-410	418	10	558	960	2	0.57	<0.02	1.5	<1.0
MW2UU	021985	8.51	-489	495	29	620	1,050	2	2.13	<0.02	<1.0	<1.0
MW4FD	021984	6.55	-189	199	3	1,100	1,500	103	<0.02	<0.02	1.1	<1.0
MW8FD	021987	8.02	-382	390	9	710	1,220	85	0.22	<0.02	1.3	<1.0
MW9FD	021986	7.52	-249	249	6	2,230	2,720	90	<0.02	<0.02	21	<1.0
Seep North	021989	7.03	-23	45	12	3,780	5,070	855	0.1	<0.02	6.7	<1.0
Seep South	021983	7.80	-16	31	8	3,280	4,090	425	0.14	3.15	<1.0	<1.0
2nd Quarter (Sampled 11/12/02)												
MW1FU	023184	6.66	-210	216	11	448	593	<1.0	<0.05	<0.05	<1.0	<1.0
MW1UU	023182	8.09	-416	417	3	572	825	<1.0	0.26	<0.05	<1.0	<1.0
MW2UU	023188	7.90	-424	426	3	540	810	2	2.1	<0.05	<1.0	<1.0
MW4FD	023187	6.52	-192	197	3	1,050	1,270	105	0.08	<0.05	<1.0	<1.0
MW5FD	023185	7.30	-200	204	2	646	898	76	0.4	<0.05	<1.0	<1.0
MW8FD	023181	7.73	-381	385	2	700	1,050	100	<0.05	<0.05	<1.0	<1.0
MW9FD	023180	6.93	-244	288	1	1,900	2,150	275	<0.05	<0.05	12	<1.0
Seep North	023183	8.15	-43	64	6	3,350	4,110	625	0.6	<0.05	7.1	<1.0
Seep South	023186	7.11	-33	43	5	3,330	3,770	540	1.07	<0.05	<1.0	<1.0
3rd Quarter (Sampled 2/20/03)												
MW1FU	030677	6.58	-196	205	18	446	643	2	<0.05	<0.05	<1.0	<1.0
MW1UU	030676	8.12	-393	399	<1	560	885	<1	0.42	<0.05	<1.0	<1.0
MW2UU	030674	8.63	-490	497	<1	626	1,002	1.5	2.62	<0.05	<1.0	<1.0
MW4FD	Inaccessible due to inclement weather											
MW5FD	030673	7.51	-154	160	<1	514	759	46	0.66	<0.05	<1.0	<1.0
MW8FD	Inaccessible due to inclement weather											
MW9FD	030675	6.97	-219	235	<1	1,698	2,080	195	<0.05	<0.05	<1.0	<1.0
Seep North	Inaccessible due to inclement weather											
Seep South												
4th Quarter (Sampled 5/19/03)												
MW1FU	31564	6.44	-186	194	10	442	636	1	<0.02	0.09	<5.0	<1.0
MW1UU	31565	8.01	-411	417	3	574	913	1	0.41	<0.02	<5.0	<1.0
MW2UU	31572	8.06	-428	435	<1	542	901	2	1.5	<0.02	<5.0	<1.0
MW4FD	31569	6.54	-207	215	<1	1,190	1,480	120	0.06	<0.02	<5.0	<1.0
MW4UFD	31568	7.49	-414	418	32	1,050	1,500	75	0.37	<0.02	<5.0	<1.0
MW5FD	31570	7.40	-203	209	<1	580	848	47	0.83	<0.02	<5.0	<1.0
MW8FD	31566	7.69	-380	387	2	690	1,160	86.5	0.28	<0.02	<5.0	<1.0
MW9FD	31571	6.83	-218	225	<1	1,684	2,080	200	<0.02	<0.02	22	<1.0
Seep North	31573	6.15	-10	24	10	3,590	4,550	788	0.08	<0.02	10	<1.0
Seep South	31567	6.31	-13	24	5	2,960	3,540	325	<0.02	<0.02	<5.0	<1.0

Table 21. Results of Fly Ash Slurry Surface Impoundment Sampling at Up-gradient (Ending in U), Cross-gradient (Ending in C), Down-gradient (Ending in D), and Leachate Monitoring (LM) Locations.

Sample ID *	Analytical Number	pH	Acidity as $CaCO_3$	Alkalinity as $CaCO_3$	Total Susp. Solids	Total Dis. Solids	Specific Condu.	Cl^-	NO_3^- as N	NO_2^- as N	S^{2-}	Hg
			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb
1st Quarter (Sampled 12/9/02)												
MW101U	023427	5.53	-4	10	2	88	83	8	3.5	<0.1	<1.0	<1.0
MW105C	023426	6.77	-29	35	30	88	76	1	0.1	<0.1	1.9	<1.0
MW115C	023424	5.06	-1	14	6	1,340	1,840	455	<0.1	<0.1	<1.0	<1.0
MW202C	023432	6.43	-27	36	3	92	88	1	0.1	<0.1	1.0	<1.0
MW203C	Dry Well											
MW104D	Inaccessible Well											
MW106D	023425	6.38	-45	52	20	394	526	21	0.1	<0.1	<1.0	<1.0
MW107D	023428	5.15	0	8	5	290	367	21	<0.1	<0.1	<1.0	<1.0
MW109D	023421	6.35	-38	47	6	198	251	10	4.2	<0.1	1.5	<1.0
MW110D	023429	5.90	-34	44	7	234	414	16	<0.1	<0.1	<1.0	<1.0
MW112D	023430	6.23	-58	67	6	314	421	15	0.2	<0.1	<1.0	<1.0
MW114D	023422	6.89	-93	99	5	164	212	1	0.4	<0.1	<1.0	<1.0
MW201D	023423	6.48	-46	54	1	110	106	1	0.3	<0.1	<1.0	<1.0
LM1	023431	7.80	-211	218	7	462	646	2	0.5	<0.1	<1.0	<1.0
LM2	Dry Grab Site											
2nd Quarter (Sampled 3/17/03)												
MW101U	030844	6.03	-3	11	4	54	75.2	8	2.73	<0.05	<1.0	<1.0
MW105C	030840	6.77	-30	40	33	74	83	2	<0.05	<0.05	<1.0	<1.0
MW115C	030834	5.51	6	16	47	1,332	1,845	460	<0.05	<0.05	2.4	<1.0
MW202C	030839	6.52	-24	34	4	64	85.2	2	<0.05	<0.05	<1.0	<1.0
MW203C	030846	5.74	-12	23	7	314	412	3	0.46	<0.05	<1.0	<1.0
MW104D	030847	6.60	-42	49	7	106	133	2	16.01	<0.05	<1.0	<1.0
MW106D	030841	6.57	-37	48	16	350	488	24	<0.05	<0.05	<1.0	<1.0
MW107D	030838	5.54	1	9	2	248	383	22	<0.05	<0.05	<1.0	<1.0
MW109D	030835	6.84	-35	44	5	172	250	13	<0.05	<0.05	<1.0	<1.0
MW110D	030842	6.30	-40	53	2	294	408	19	<0.05	<0.05	<1.0	<1.0
MW112D	030845	6.41	-56	66	1	300	414	18	<0.05	<0.05	<1.0	<1.0
MW114D	030843	7.39	-98	107	3	144	221	2	<0.05	<0.05	<1.0	<1.0
MW201D	030833	6.64	-40	49	<1	68	104	2	<0.05	<0.05	<1.0	<1.0
LM1	030836	7.59	-161	169	1	316	462	2	0.72	<0.05	<1.0	<1.0
LM2	030837	7.28	-574	583	1	832	1,198	1	1.56	<0.05	<1.0	<1.0
3rd Quarter (Sampled 6/23/03)												
MW101U	031850	5.62	-3	11	1	58	82	8	3.01	<0.02	<5.0	<1.0
MW105C	031851	6.50	-32	40	8	72	90	2	0.08	<0.02	<5.0	1.0
MW115C	031859	5.62	-1	27	45	1,330	1,810	400	<0.02	<0.02	<5.0	<1.0
MW202C	031852	6.34	-25	34	1	66	84	2	<0.02	<0.02	<5.0	<1.0
MW203C	Inaccessible Well											
MW104D	Inaccessible Well											
MW106D	031853	6.30	-35	45	25	360	518	21	<0.02	<0.02	<5.0	<1.0
MW107D	031855	5.32	0	9	1	244	372	22	<0.02	<0.02	<5.0	1.1
MW109D	031860	6.78	-33	43	3	182	271	13	<0.02	<0.02	<5.0	<1.0
MW110D	031861	6.19	-39	52	1	288	441	18	<0.02	<0.02	<5.0	<1.0
MW112D	031856	6.25	-60	71	1	302	450	17	0.04	<0.02	<5.0	<1.0
MW114D	031857	7.06	-92	101	5	144	232	1	<0.02	<0.02	<5.0	<1.0
MW201D	031851	6.84	-74	82	1	110	162	2	0.05	<0.02	<5.0	<1.0
LM1	031858	7.41	-203	211	1	416	616	2	0.99	<0.02	<5.0	<1.0
4th Quarter (Sampled 9/9/03)												
MW101U	032886	5.70	1	9	19	68	84	10	3.46	<0.02	<5.0	<1.0
MW105C	032889	6.41	-27	38	16	90	90	1	<0.02	<0.02	<5.0	<1.0
MW115C	032881	5.75	-19	45	36	1,030	1,570	265	<0.02	<0.02	<5.0	<1.0
MW202C	032884	6.17	-24	35	7	86	94	1	<0.02	<0.02	<5.0	<1.0
MW203C	032883	5.52	-16	28	15	304	403	1	<0.02	<0.02	<5.0	<1.0
MW104D	Inaccessible Well											
MW106D	032880	6.17	-40	52	14	392	579	20	<0.02	<0.02	<5.0	<1.0
MW107D	032887	5.26	0	10	0	284	421	23	<0.02	<0.02	<5.0	<1.0
MW109D	032885	6.17	-30	40	10	196	278	14	<0.02	<0.02	<5.0	<1.0
MW110D	032890	6.03	-31	48	2	322	485	23	0.05	0.03	<5.0	<1.0
MW112D	032892	6.17	-58	69	1	308	471	17	<0.02	<0.02	<5.0	<1.0
MW114D	032891	6.56	-80	90	5	144	228	1	<0.02	<0.02	<5.0	<1.0
MW201D	032882	6.45	-43	54	1	100	116	5	<0.02	<0.02	<5.0	<1.0
LM1	032888	7.41	-262	273	3	512	647	1	0.6	<0.02	<5.0	<1.0

Figure 1. FGD Disposal Site

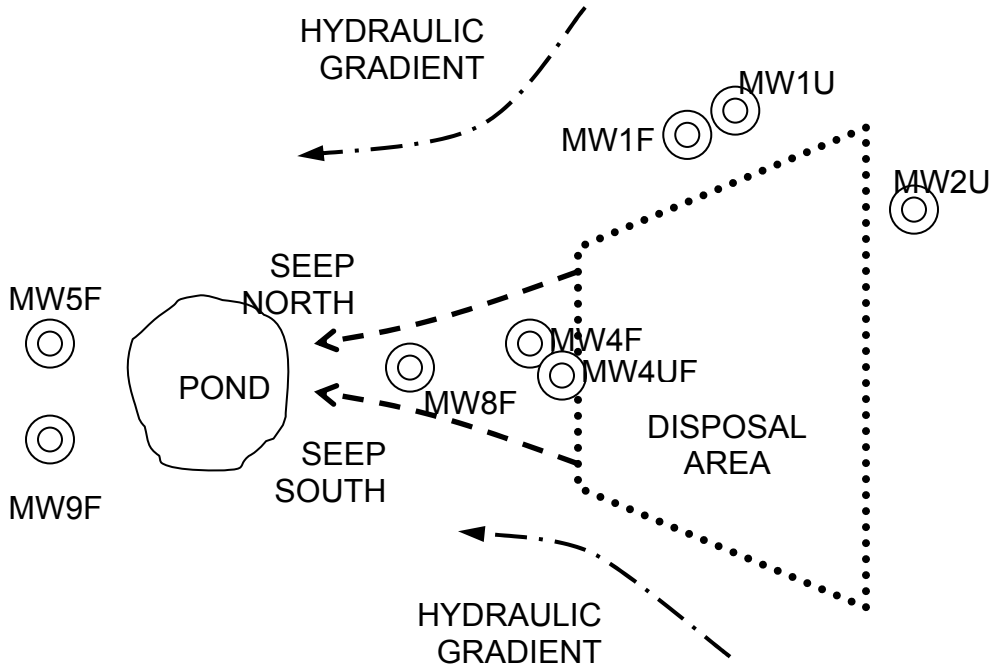

Figure 2. FGD Disposal Site pH Measurements.

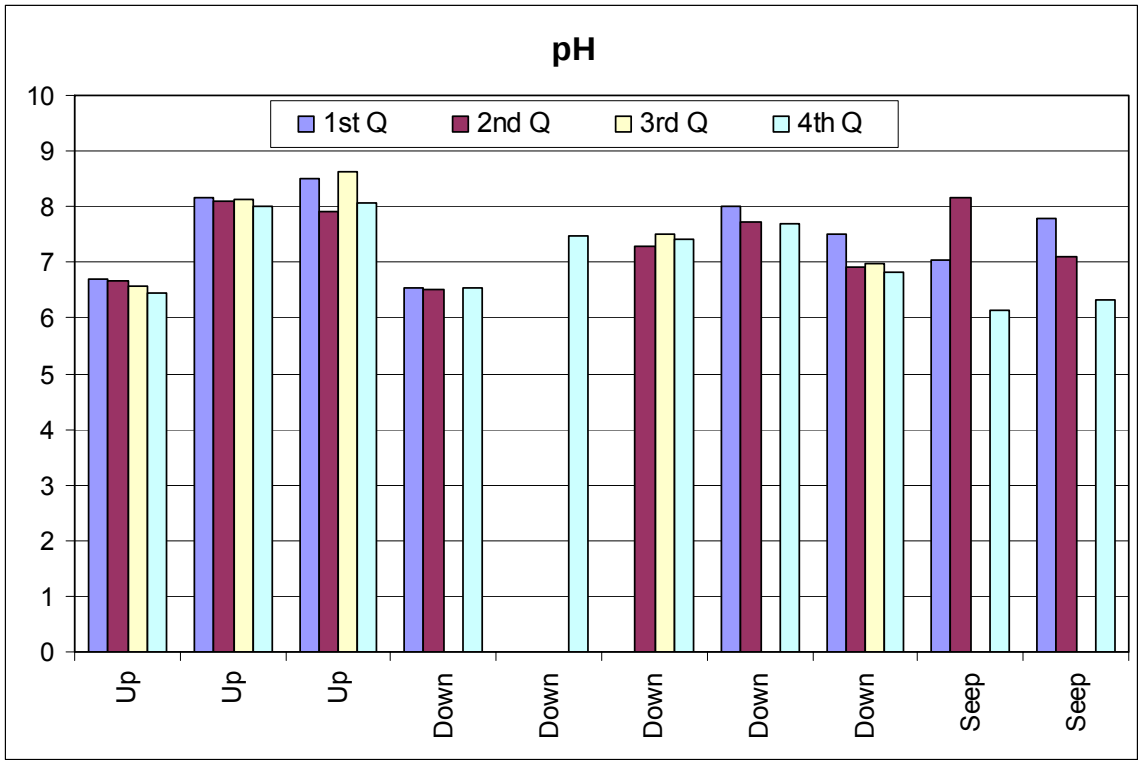

Figure 3. FGD Disposal Site Total Alkalinity Measurements.

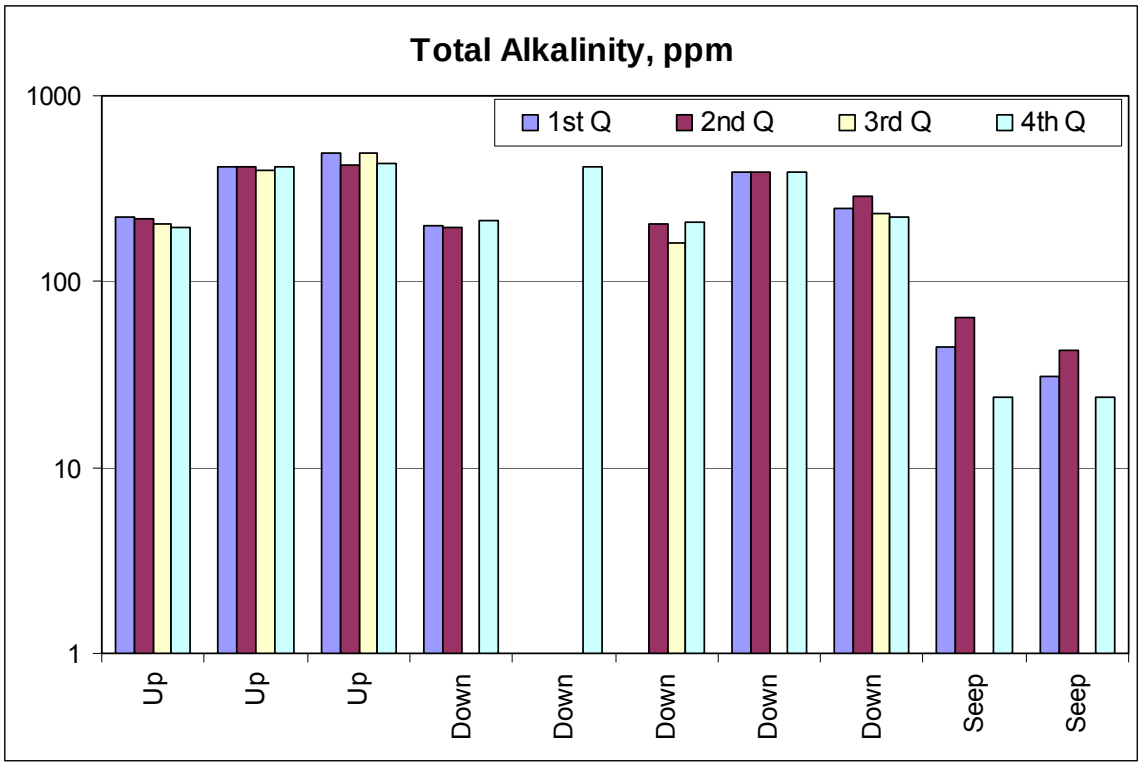

Figure 4. FGD Disposal Site Total Dissolved Solids Measurements.

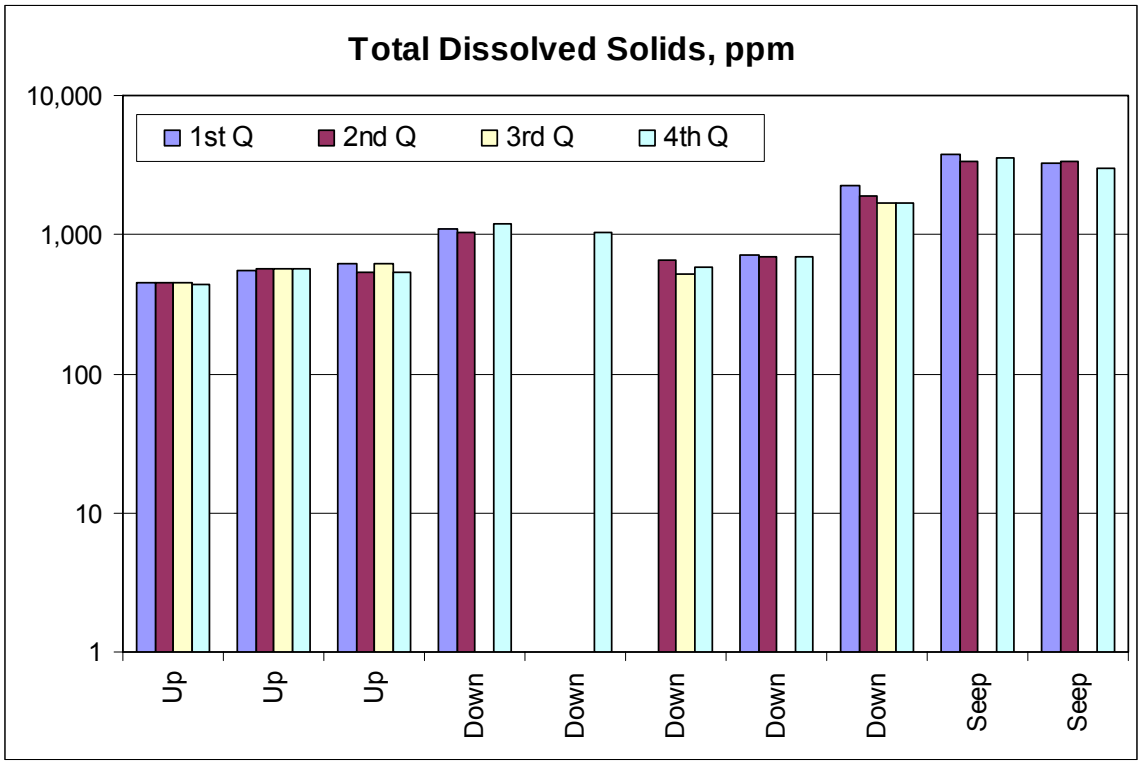

Figure 5. FGD Disposal Site Chloride Ion Measurements.

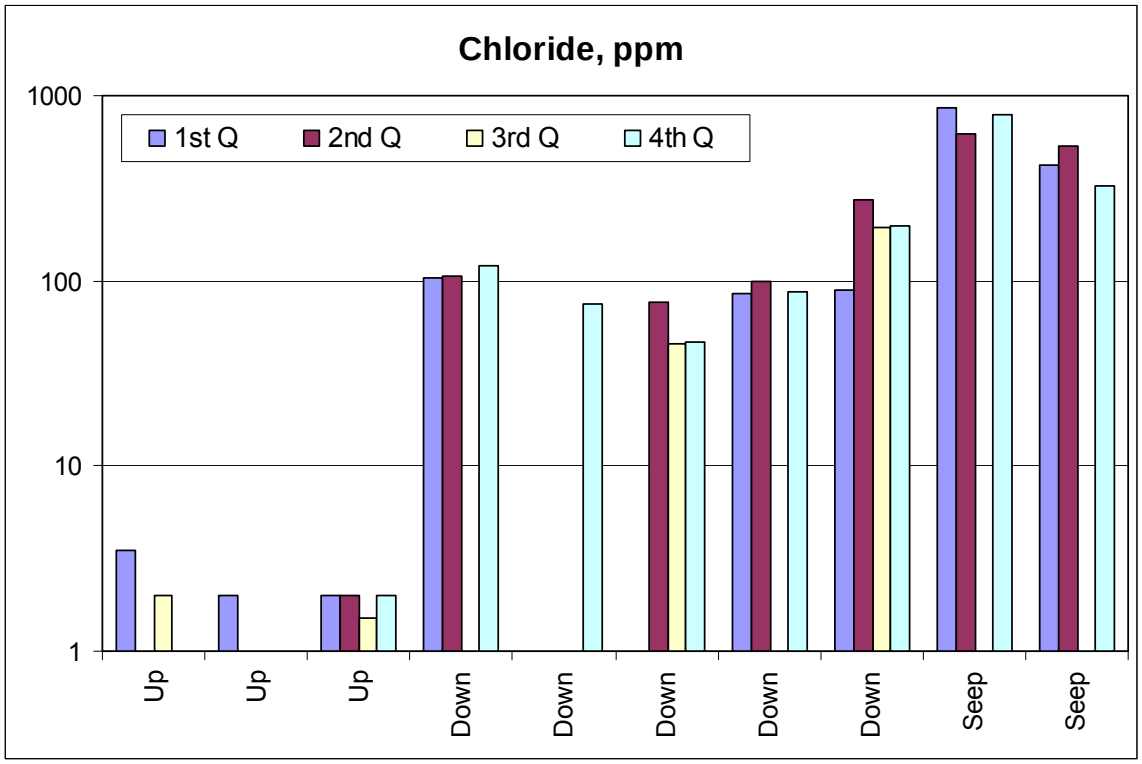

Figure 6. Fly Ash Slurry Impoundment Site

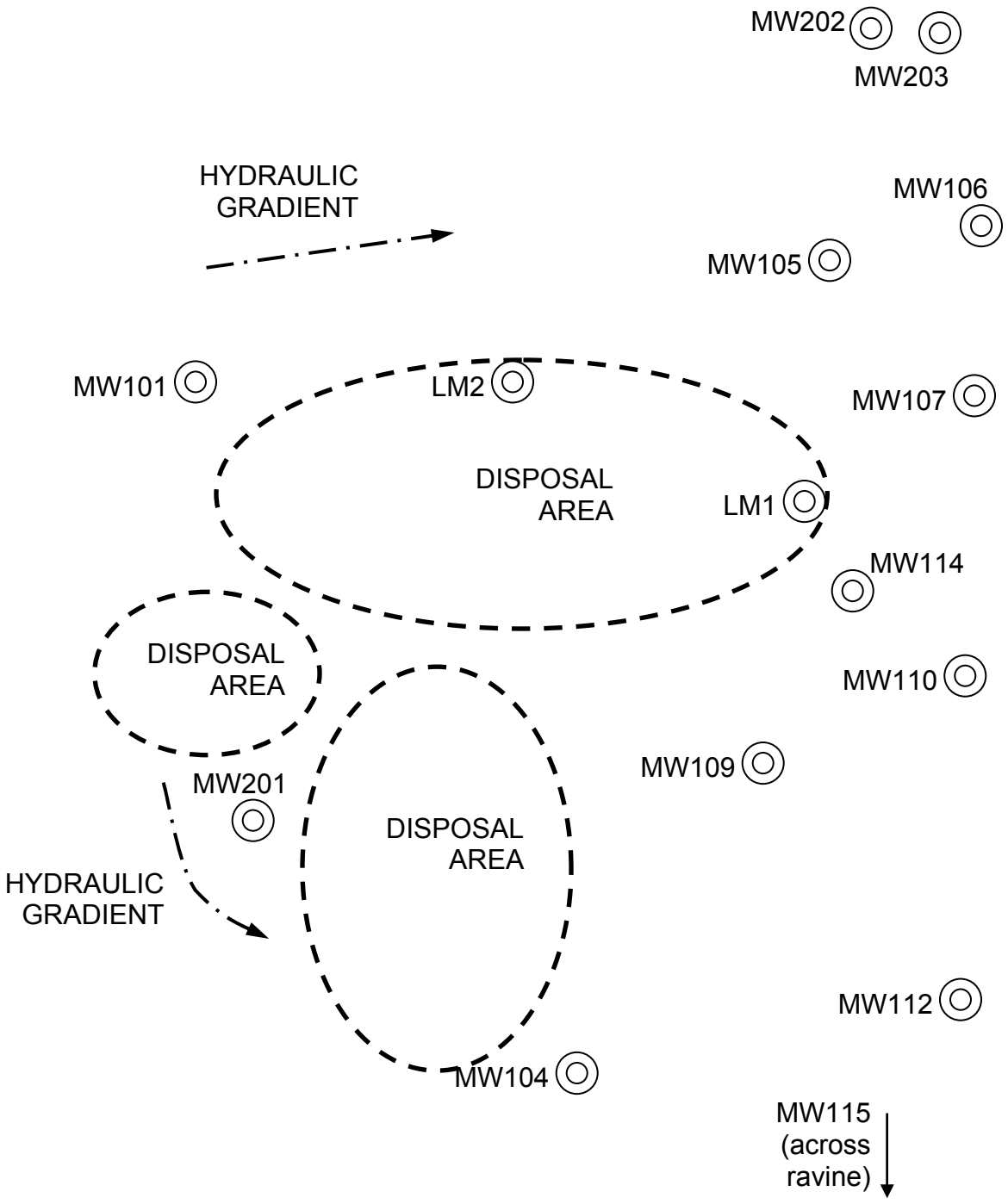

Figure 7. Fly Ash Slurry Surface Impoundment pH Measurements.

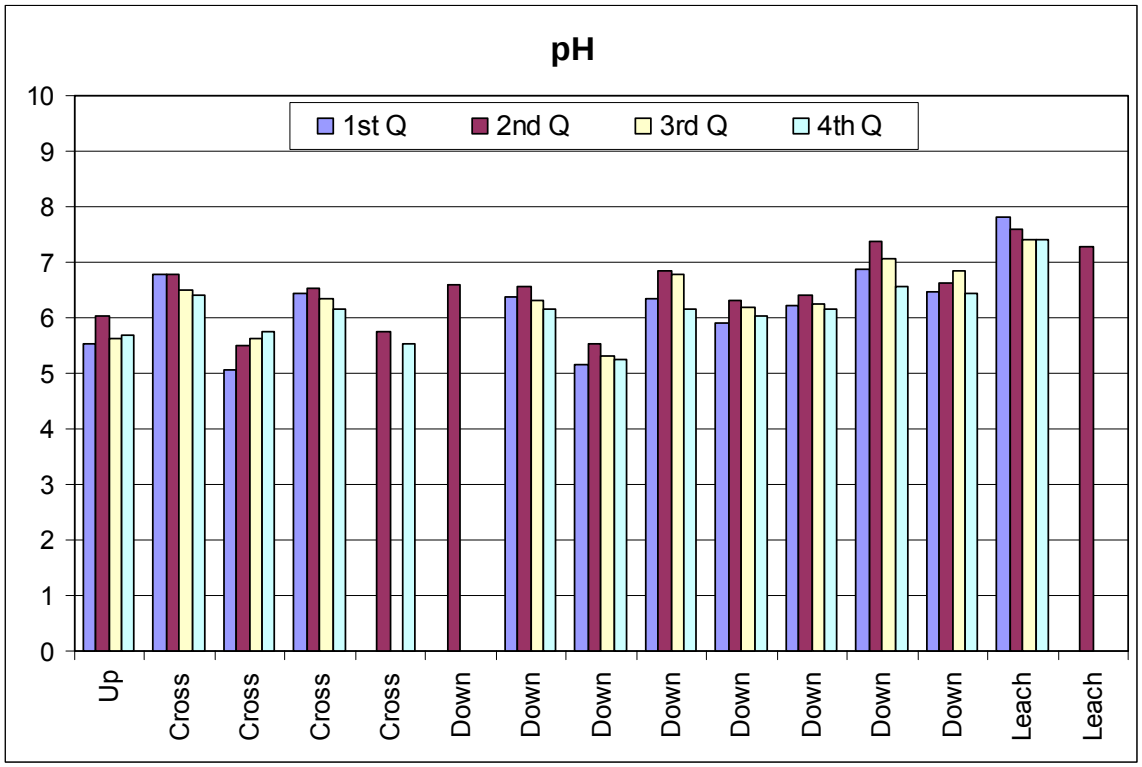

Figure 8. Fly Ash Slurry Surface Impoundment Total Alkalinity Measurements.

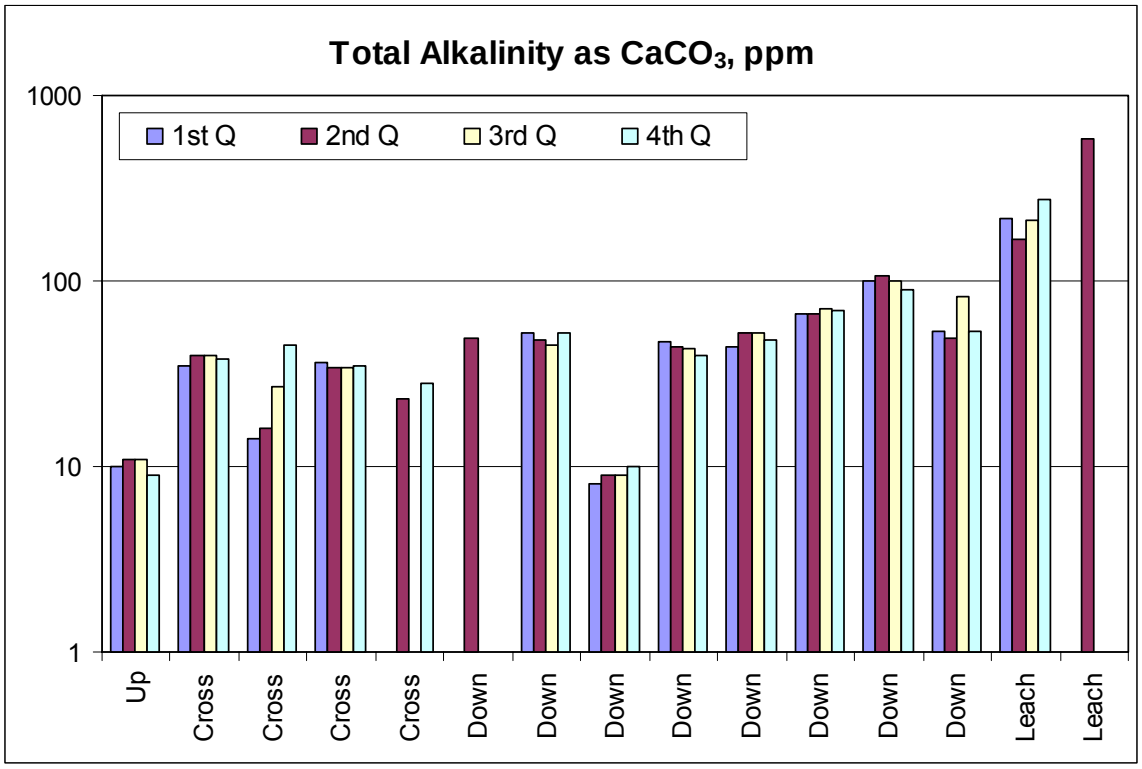

Figure 9. Fly Ash Slurry Surface Impoundment Total Dissolved Solids Measurements.

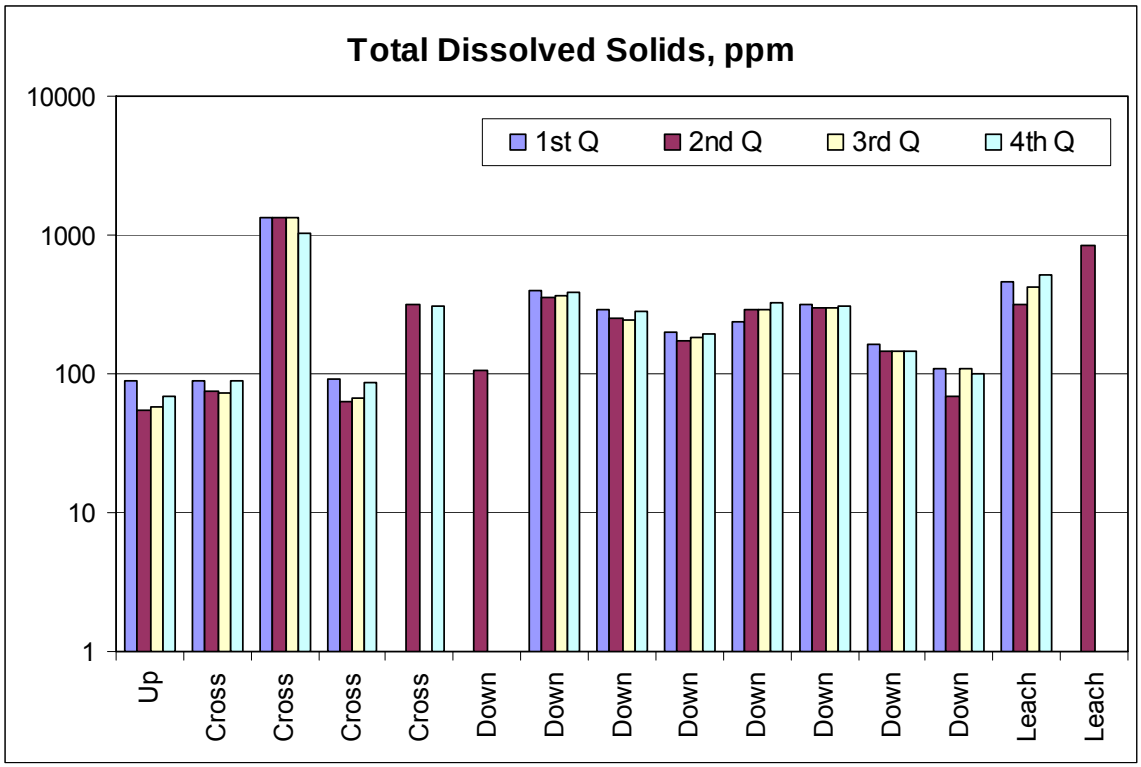

Figure 10. Fly Ash Slurry Surface Impoundment Chloride Ion Measurements.

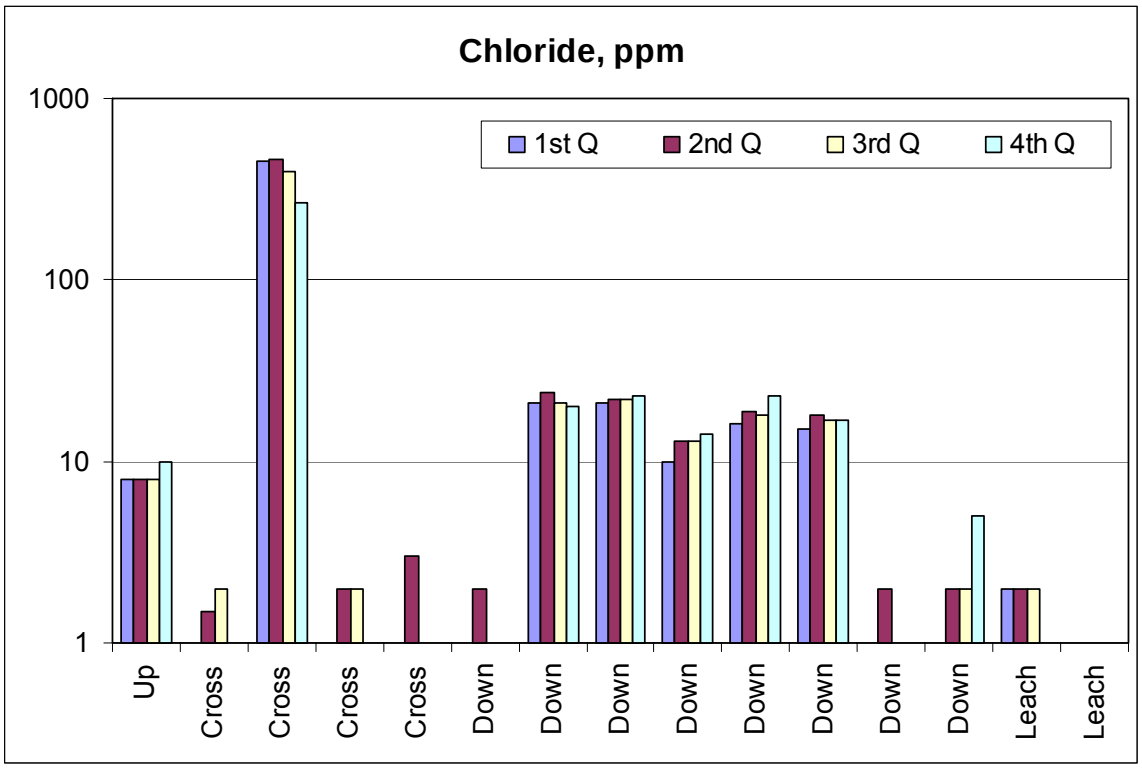

Figure 11. TCLP Procedure Flow Chart