FINAL REPORT

**VOLUME 1 of 2 - SAMPLING, RESULTS,
AND SPECIAL TOPICS**

on

**A STUDY OF TOXIC EMISSIONS FROM A COAL-FIRED
POWER PLANT UTILIZING AN ESP/WET FGD SYSTEM**

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by

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EXECUTIVE SUMMARY

This document is the Final Report on the project titled "A Study of Toxic Emissions from a Coal-Fired Power Plant Utilizing an ESP/Wet FGD System". This study was conducted for the U.S. Department of Energy, Pittsburgh Energy Technology Center (DOE-PETC), under Contract DE-AC22-93PC93251. The present study was one of a group of assessments of toxic emissions from coal-fired power plants, conducted for DOE-PETC during 1993. The motivation for those assessments was the mandate in the 1990 Clean Air Act Amendments that a study be made of emissions of hazardous air pollutants (HAPs) from electrical utilities. The results of this study will be used by the U.S. Environmental Protection Agency to evaluate whether regulation of HAPs emissions from utilities is warranted.

This report is organized in two volumes. Volume 1: Sampling, Results, and Special Topics describes the sampling effort conducted as the basis for this study, presents the concentration data on toxic chemicals in the several power plant streams, and reports the results of evaluations and calculations conducted with those data. Volume 2: Appendices includes process data log sheets, field sampling data sheets, uncertainty calculations, and quality assurance results.

This study involved measurements of a variety of toxic chemicals in solid, liquid, and gaseous samples from input, output, and process streams at a coal-fired power plant equipped with an electrostatic precipitator (ESP) and a wet scrubber flue gas desulfurization unit (Wet FGD; scrubber). The host plant for this study was the Coal Creek Station Unit No. 1, operated by Cooperative Power Association, in Underwood, North Dakota. Coal Creek Station is a two-unit, zero discharge, 1,100-megawatt, mine-mouth plant burning lignite from the Falkirk mine located adjacent to the plant. Measurements were conducted at Coal Creek on June 21-24, 26, and 27, 1993. During the measurements, Cooperative Power provided reproducible conditions for sampling by maintaining Unit 1 at full load and stable operating conditions.

The chemicals measured at Coal Creek were the following:

1. Six major and 16 trace elements, including mercury, chromium, cadmium, lead, selenium, arsenic, beryllium, and nickel.
2. Acids and corresponding anions (HCl, HF, chloride, fluoride, phosphate, sulfate).
3. Ammonia and cyanide.
4. Elemental carbon.
5. Radionuclides.
6. Volatile organic compounds (VOC).

7. Semivolatile organic compounds (SVOC) including polynuclear aromatic hydrocarbons (PAH), and polychlorinated dioxins and furans.
8. Aldehydes.

Some or all of these constituents were measured in solid, liquid, and gaseous input and output streams of the plant, and in flue gas at key points within the plant. In addition, particle size distributions were determined for flue gas particulate matter and for collected ESP ash. The measurement data are presented in Volume 1, Section 5.

The measurement data from this study were used to address several objectives:

1. To assess the emission levels of selected HAPs.
2. To determine for selected HAPs (a) the removal efficiencies of the ESP and scrubber units, (b) material balances in individual components of the plant, and (c) material balances for the plant as a whole.
3. To determine the particle size distribution of selected HAPs in the flue gas particulate.
4. To determine the vapor/particle phase distribution of selected HAPs in flue gas streams.
5. To determine the concentrations and vapor/particle distributions of HAPs, under conditions simulating dilution and cooling of the stack plume in the atmosphere.

These objectives were addressed by comparisons and calculations using the HAPs concentration data obtained during the field measurements, along with plant characteristics and operating conditions provided by Cooperative Power. The main results of this study in each of these areas are summarized below.

The emission rates of the measured HAPs were calculated based on the stack gas flow rate and the concentrations measured in the stack gas. Not unexpectedly, emission rates differed widely among the various types of HAPs. The emission rates are reported in Volume 1, Section 6.2, and are summarized in Tables ES-1 to ES-9. Shown in these tables are the HAPs name, the emission rate from Coal Creek Unit 1 in pounds per 10^{12} Btu ($\text{lb}/10^{12}$ Btu) (Curies/ 10^{12} Btu for radionuclides), and the total uncertainty ($\pm$) in each emission rate, in the same units. The latter value is shown to indicate the degree of uncertainty associated with each emission rate, and includes the effects of sampling and plant operating variability, as well as biases in sampling and analysis. The total uncertainty values are 95 percent confidence limits. The emission factors shown in Tables ES-1 to ES-9 should not be used without consideration of their associated total uncertainty values. Footnotes to

Tables ES-1 to ES-9 indicate the exclusion of outlier values, or the inclusion of non-detect values, in calculating the HAPs emission factors.

Removal efficiencies and mass balances were calculated for the major and trace elements. Removal efficiencies were calculated for several combinations of plant components: the full Unit 1 ESP, and the half ESP (ESP #1) where the full set of chemical measurements were made; the full scrubber including the bypass flow; the absorber (i.e., the spray tower portion of the scrubber only); the combination of the ESP and the scrubber; and the hypothetical combination of the ESP and an absorber that treats 100 percent of the flue gas (i.e., no scrubber bypass flow). Detailed removal efficiency results are presented in Section 6.3 of Volume 1. Some assumptions and estimates were necessary in performing some of the removal efficiency calculations. However, the removal efficiencies calculated for ESP #1, for the scrubber, and for the ESP/scrubber combination are based entirely on measurements, and consequently provide the most reliable indication of the performance of plant components. The average removal efficiencies of these components for the major and trace elements are summarized in Table ES-10. Also indicated in that table are instances in which outliers were excluded, or non-detect results included, in the removal efficiency calculations.

The ESP removal efficiencies in Table ES-10 exceed 98 percent for 16 of the 21 elements listed, with only cadmium (87.2 percent), mercury (14.4 percent), and selenium (87.2 percent) exhibiting efficiencies below 97 percent. The scrubber efficiencies are much lower, and also more variable. The variability is due to the relatively low concentrations of most elements in flue gas entering the scrubber, and the consequent difficulty of measuring differences in those concentrations. Table ES-10 indicates generally low removal efficiencies for the scrubber alone for the major and trace elements. The combination of the ESP and scrubber provides removal efficiencies greater than 99 percent for 17 of the 21 elements. Selenium and cadmium have removal efficiencies of 85 to 89 percent. However, the results in Table ES-10 show that the Coal Creek ESP and scrubber are particularly ineffective at removing mercury from the flue gas stream. This result is consistent with the volatility of that element and its compounds at flue gas conditions.

Mass balances were calculated across individual plant components and groups of components, for major and trace elements. The components considered in mass balance calculations were the coal pulverizers; the boiler; the ESP; the combination of boiler and ESP; the scrubber; the combination of the boiler, ESP, and scrubber; and the absorber. Detailed descriptions of the mass balance calculations and results are presented in Section 6.1 of Volume 1. A summary of the mass balance results for key plant components is shown in Table ES-11, which lists the average mass balance results (sum of outputs as a percentage of the sum of inputs) for each element in the boiler, the ESP, the scrubber, and in the combination of those components.

Table ES-11 shows that mass balance results were generally within ± 50 percent of balance for all elements in all plant components. For example, for the combination of boiler, ESP, and scrubber, 18 of the 21 elements exhibited mass balances within ± 50 percent, and in fact 16 of the 21 were within ± 30 percent. However, high or low mass balance results were found for a few elements (not always the same ones) on all plant components. Both major

and trace elements showed instances of high or low mass balances. These occurrences result primarily from uncertainties in the measured HAPs concentrations in the pertinent streams, and from the necessity of making assumptions about some streams.

The particle size distribution of elements in flue gas particulate matter was evaluated, and is presented as a Special Topic in Volume 1, Section 7.3. That evaluation shows that for most elements the great majority of the mass of the element in flue gas occurs in the size range greater than 10 micrometers aerodynamic diameter, which comprises the bulk of flue gas particulate. However, for a few elements, notably cadmium, selenium, vanadium, and lead, a substantial portion of the total flue gas loading is present in the size range less than 5 microns diameter. This effect occurs because the elemental composition of flue gas particulate differs among different size ranges. These results indicate that the effectiveness of toxic element removal by particulate removal equipment may vary from one element to another.

The vapor/particle phase distributions of elements, PAH/SVOC, and dioxins/furans were determined, and are presented as a Special Topic in Volume 1, Section 7.1. That evaluation shows that most of the elements measured exist entirely in the particle phase under all flue gas conditions encountered at Coal Creek. However, some elements, such as antimony, arsenic, lead, sodium, potassium, manganese, and boron, were found to be distributed between the vapor and particle phase, in proportions that depend on the flue gas particulate loading and temperature. At the stack, nearly all elements were found exclusively in the particle phase. Mercury alone was found almost entirely in the vapor phase at all flue gas locations where it was measured. Most PAH and SVOC compounds were found almost exclusively in the vapor phase, consistent with their volatility and the flue gas temperatures. Benzo-(a)-pyrene and other PAHs having five or more aromatic rings in their molecular structure were found only in the particle phase. A few PAH and SVOC of intermediate characteristics were distributed between the vapor and particle phases, in proportions that differed in a realistic manner with flue gas temperature. Relatively few dioxin/furan compounds could be detected in flue gas. Those that were detected were present predominantly in the vapor phase, again consistent with their volatility. Thus the element, PAH/SVOC, and dioxin/furan data appear to provide a coherent and credible picture of the phase distributions of these species in the flue gas.

Simulated plume conditions were achieved using the Plume Simulating Dilution Sampler (PSDS) at the Coal Creek Unit 1 stack. The PSDS extracts a flow of hot stack gas, and dilutes and cools it with a much larger flow of high purity air. The resulting gas is then sampled with the same methods used for the hot flue gas. Comparison of results from measurements made on hot stack gas with those made using the PSDS is presented as a Special Topic in Volume 1, Section 7.2. On an absolute basis, the concentration measurements made with the PSDS generally do not agree well with those made on the hot gas. However, the PSDS is primarily designed to address the relative effects of plume dilution on pollutants, and of necessity has certain features which increase the uncertainty of absolute concentration measurements. The results in Section 7.2 suggest the potential utility of the PSDS approach, but also indicate that further evaluation is needed of the absolute measurement capabilities of that approach.

Three other Special Topics were investigated in this study. Section 7.4 in Volume 1 compares data on vapor-phase elements (mercury, selenium, arsenic) in flue gas from the Multi-Metals train (EPA Method 29) to those from the Hazardous Element Sampling Train (HEST). The HEST is a novel technique that collects vapor phase elements on carbon-impregnated filters. This comparison shows that the HEST appears very promising for measurement of mercury in flue gas. Comparison of selenium and arsenic data from the two methods does not show good agreement, possibly as a result of the differing sampling conditions with the two methods. Further evaluation of the HEST would be valuable.

Section 7.5 in Volume 1 presents a comparison of VOC measurements in flue gas made by two distinct methods: solid sorbent traps used in a Volatile Organic Sampling Train (VOST), and collection of flue gas in Summa polished sampling canisters. Both methods produced data with a large degree of variability, and with obvious contamination from solvents used in the field study. Neither set of data presents a coherent picture of VOC levels in flue gas at Coal Creek. It is clear that further evaluation of these methods, perhaps under controlled conditions simulating flue gas, will be needed.

Finally, the mercury data from each component and sample fraction of the Method 29 train are considered separately, rather than collectively, in Section 7.6 of Volume 1. The purpose of this Special Topic is to assess the separation of mercury in the components of the Method 29 train. Nearly all the mercury is collected in the impinger portion of the train, rather than on the filter, i.e., mercury is present almost entirely in the vapor phase, as noted above. The proportions of mercury collected in the hydrogen peroxide impingers and the permanganate impingers (located downstream of the peroxide impingers) varied with location in the plant. At the ESP inlet and at the stack, most of the mercury was captured in the permanganate impingers; at the ESP outlet (scrubber inlet) most of the mercury was found in the peroxide impingers. Although the Method 29 train was not designed to separate elemental and oxidized forms of mercury, these results suggest that the proportions of elemental and oxidized mercury in flue gas vary with location in the plant.

TABLE ES-1. EMISSION FACTORS FOR ELEMENTS (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Aluminum	578	169
Potassium	109	34
Sodium	218	32
Titanium	42	16
Antimony	0.18	0.09
Arsenic	1.2	0.58
Barium	162	61
Beryllium	ND < 1.7 #	1.7
Boron	19	49
Cadmium	ND < 3.2 #	3.2
Calcium	1310	513
Chromium	10 a	NC
Cobalt	1.5 ##	3.0
Copper	1.5 a ##	NC
Lead	0.69	0.21
Manganese	30	26
Mercury	9.5	7.5
Molybdenum	0.51 a	NC
Nickel	5.1 a	NC
Selenium	8.3	7.4
Vanadium	4.4	2.4

Uncertainty = 95 % confidence limit.

ND < = Analyte not detected.

NC = Not calculated.

= Average emission factor includes three non-detects out of three measurements.

= Average emission factor includes one or two non-detects out of three measurements.

a = Emission factor based on two sets of measurements due to outliers.

TABLE ES-2. EMISSION FACTORS FOR AMMONIA AND CYANIDE (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Ammonia	ND < 3.7 #	3.7
Cyanide	51	51

Uncertainty = 95% confidence limit.

ND < = Analyte not detected.

= Average emission factor includes three non-detects out of three measurements.

TABLE ES-3. EMISSION FACTORS FOR ANIONS (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Hydrogen Chloride	1340	285
Hydrogen Fluoride	3980	3560
Chloride (Particulate) **	3.5 ##	7.6
Fluoride (Particulate) **	146	64
Sulfate (Particulate) **	1220	1600
Phosphate (Particulate) **	7.8 ##	19

Uncertainty = 95% confidence limit.

= Average emission factor includes one or two non-detects out of three measurements.

** = Sampling for anions was conducted at a single point in the duct; traverses were not made.

TABLE ES-4. EMISSION FACTORS FOR VOC (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Chloromethane	106	72
Bromomethane	4.3 ##	4.7
Vinyl Chloride	ND < 6.5 #	6.5
Chloroethane	ND < 6.5 #	6.5
Methylene Chloride	NC	NC
Acetone	NC	NC
Carbon Disulfide	3.4 ##	1.1
1,1-Dichloroethene	ND < 6.5 #	6.5
1,1-Dichloroethane	ND < 6.5 #	6.5
trans-1,2-Dichloroethene	ND < 6.5 #	6.5
Chloroform	ND < 6.5 #	6.5
1,2-Dichloroethane	3.2 ##	0.74
2-Butanone	9.8	10
1,1,1-Trichloroethane	ND < 6.5 #	6.5
Carbon Tetrachloride	ND < 6.5 #	6.5
Vinyl Acetate	ND < 6.5 #	6.5
Bromodichloromethane	ND < 6.5 #	6.5
1,2-Dichloropropane	ND < 6.5 #	6.5
cis-1,3-Dichloropropylene	ND < 6.5 #	6.5
Trichloroethene	ND < 6.5 #	6.5
Dibromochloromethane	ND < 6.5 #	6.5
1,1,2-Trichloroethane	ND < 6.5 #	6.5
Benzene	41	38
trans-1,3-Dichloropropylene	ND < 6.5 #	6.5
2-Chloroethylvinylether	ND < 6.5 #	6.5
Bromoform	3.1 ##	0.82
4-Methyl-2-Pentanone	6.0 ##	12
2-Hexanone	12	28
Tetrachloroethene	ND < 6.5 #	6.5
1,1,2,2-Tetrachloroethane	ND < 6.5 #	6.5
Toluene	24	21
Chlorobenzene	3.3 ##	0.81
Ethylbenzene	ND < 6.5 #	6.5
Styrene	3.3 ##	0.89
Xylenes (Total)	3.5 ##	1.3

Uncertainty = 95 % confidence limit.

ND < = Analyte not detected.

NC = Not calculated.

= Average emission factor includes three non-detects out of three measurements.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE ES-5. EMISSION FACTORS FOR PAH/SVOC (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Benzylchloride	0.0057 ##	0.021
Acetophenone	0.54	0.66
Hexachloroethane	ND < 0.0017 #	0.0017
Naphthalene	0.25	0.20
Hexachlorobutadiene	ND < 0.0017 #	0.0017
Quinoline	ND < 0.017 #	0.017
2-Chloroacetophenone	0.13	0.062
2-Methylnaphthalene	0.041	0.020
1-Methylnaphthalene	0.015	0.0084
Hexachlorocyclopentadiene	ND < 0.0017 #	0.0017
Biphenyl	0.023	0.010
Acenaphthylene	0.010	0.020
2,6-Dinitrotoluene	ND < 0.0017 #	0.0017
Acenaphthene	0.017	0.024
Dibenzofuran	0.052	0.034
2,4-Dinitrotoluene	0.0065 ##	0.014
Fluorene	0.042	0.044
Hexachlorobenzene	ND < 0.0017 #	0.0017
Pentachlorophenol	ND < 0.0017 #	0.0017
Phenanthrene	0.31	0.55
Anthracene	0.015	0.0081
Fluoranthene	0.042	0.036
Pyrene	0.016	0.012
Benz(a)anthracene	0.0021	0.0019
Chrysene	0.0053	0.0058
Benzo(b & k)fluoranthene	0.0045	0.0055
Benzo(e)pyrene	0.0011	0.00094
Benzo(a)pyrene	0.00086 ##	0.0015
Indeno(1,2,3-c,d)pyrene	0.00063 ##	0.0011
Dibenz(a,h)anthracene	0.00072	0.00049
Benzo(g,h,i)perylene	0.00059 ##	0.00091

Uncertainty = 95% confidence limit.

ND < = Analyte not detected.

= Average emission factor includes three non-detects out of three measurements.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE ES-6. EMISSION FACTORS FOR ALDEHYDES (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Formaldehyde	1.8 ##	3.1
Acetaldehyde	67	28
Acrolein	ND < 2.2 #	2.2
Propionaldehyde	12	12

Uncertainty = 95 % confidence limit.

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE ES-7. EMISSION FACTORS FOR RADIONUCLIDES (mCi/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Pb-212	4.8 ##	6.0
Th-234	ND < 49 #	49
Pb-210	55 ##	76
Pb-211	ND < 78 #	78
Ra-226	4.1 ##	0.73
Ra-228	ND < 14 #	14
Th-229	ND < 31 #	31
Th-230	ND < 341 #	341
U-234	ND < 1520 #	1520
U-235	ND < 13 #	13

Uncertainty = 95 % confidence limit.

ND < = Analyte not detected.

= Average emission factor includes three non-detects out of three measurements.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE ES-8. EMISSION FACTORS FOR PARTICULATE MATTER (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
Particulate Matter	10400	31100

Uncertainty = 95% confidence limit.

TABLE ES-9. EMISSION FACTORS FOR DIOXINS/FURANS (lb/10¹² BTU)

Analyte	Emission Factor	Uncertainty
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND < 1.97E-06 #	1.97E-06
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND < 2.41E-06 #	2.41E-06
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND < 2.10E-06 #	2.10E-06
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND < 3.15E-06 #	3.15E-06
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND < 3.26E-06 #	3.26E-06
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	3.23E-06	3.98E-06
Octachlorodibenzo-p-dioxin	1.51E-05	1.69E-05
2,3,7,8-Tetrachlorodibenzofuran	9.89E-06	5.63E-06
1,2,3,7,8-Pentachlorodibenzofuran	ND < 4.34E-06 #	4.34E-06
2,3,4,7,8-Pentachlorodibenzofuran	ND < 3.67E-06 #	3.67E-06
1,2,3,4,7,8-Hexachlorodibenzofuran	ND < 3.86E-06 #	3.86E-06
1,2,3,6,7,8-Hexachlorodibenzofuran	ND < 3.06E-06 #	3.06E-06
1,2,3,7,8,9-Hexachlorodibenzofuran	ND < 5.26E-06 #	5.26E-06
2,3,4,6,7,8-Hexachlorodibenzofuran	ND < 1.87E-06 #	1.87E-06
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND < 2.33E-05 #	2.33E-05
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND < 3.82E-06 #	3.82E-06
Octachlorodibenzofuran	6.29E-06 ##	2.25E-06

Uncertainty = 95% confidence limit.

ND < = Analyte not detected.

= Average emission factor includes three non-detects out of three measurements.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE ES-10. AVERAGE REMOVAL EFFICIENCIES OF COAL CREEK PLANT COMPONENTS (percent)

Element	Removal Efficiency		
	ESP #1	Scrubber	ESP + Scrubber
Aluminum	99.5	32.7	99.5
Potassium	99.8	48.3	99.9
Silicon	99.8##	75.9#	99.9#
Sodium	98.8	33.8	99.1
Titanium	99.9	18.6	99.8
Antimony	97.9	76.1	99.6
Arsenic	99.9	29.1	99.9
Barium	99.3	-13.6	99.0
Beryllium	97.9#	53.3#	98.5#
Boron	98.7	71.0	99.8
Cadmium	87.2#	46.2#	85.6#
Chromium	98.9 ^(a) ##	29.9 ^(a) ##	99.6 ^(a)
Cobalt	99.6#	44.7##	99.2##
Copper	99.2	71.4 ^(a) ##	99.7 ^(a) ##
Lead	99.8	26.7	99.8
Manganese	99.7	5.1	99.6
Mercury	14.4	-8.9	-0.9
Molybdenum	99.3	54.1 ^(a)	99.7 ^(a)
Nickel	99.1 ^(a) ##	2.7 ^(a) ##	99.6 ^(a)
Selenium	87.2	39.7	88.7
Vanadium	99.6	9.6	99.4

(a) One outlier value excluded from calculation; replaced with average of other two data points.

Of the three calculations contributing to the average value shown, all three include a non-detect measurement.

Of the three calculations contributing to the average value shown, one or two include a non-detect measurement.

TABLE ES-11. AVERAGE MASS BALANCE RESULTS (PERCENT) FOR
ELEMENTS IN COAL CREEK PLANT COMPONENTS

Element	Component			
	Boiler	ESP	Scrubber	Boiler + ESP + Scrubber
Aluminum	74	542	81	130
Potassium	88	143	50	108
Silicon	147	93##	20#	140#
Sodium	91	327	45	187
Titanium	113	112	59#	119#
Antimony	98	41	30	49
Arsenic	141	71#	131#	109#
Barium	92	231	128	129
Beryllium	83	99#	44#	82#
Boron	141	93	42	135
Cadmium	285#	82#	77#	234#
Chromium	124 ^(a)	83 ^(a) ##	53 ^(a) ##	109 ^(a)
Cobalt	109	81#	129#	95#
Copper	91	127	41 ^(a) #	104 ^(a) #
Lead	115	98	71	113#
Manganese	124	100	82	123
Mercury	64#	167	119#	74#
Molybdenum	84#	90#	53 ^(a) ##	81 ^(a) #
Nickel	99 ^(a) ##	57 ^(a) ##	54 ^(a) #	71 ^(a) ##
Selenium	115#	82	58#	88#
Vanadium	89	138	82	103

- (a) One outlier value excluded from calculation; replaced with average of other two data points.
- # Of the three calculations contributing to the average value shown, all three include a non-detect measurement.
- ## Of the three calculations contributing to the average value shown, one or two include a non-detect measurement.

RECOMMENDATIONS

The experience gained in studying emissions of hazardous air pollutants (HAPs) from the Coal Creek Station led to the following recommendations for future studies at power plant utilizing an electrostatic precipitator (ESP) and wet flue gas desulfurization (FGD) system:

SAMPLING

1. Measuring Substances in Parallel Flue Gas Streams

The Coal Creek Station has parallel ducts from the economizer to two ESPs and the scrubber system. Battelle recommends that at power plants with complicated parallel duct configurations, measurements be made of all HAPs under study at each flue gas inlet and outlet duct for each system under study. Reliance on measurement of flue gas flow rate and particulate matter concentration only, with assumptions about the chemical composition of the ash, may not provide accurate results for mass balance calculations.

2. Number of Sample Sets to Collect

Battelle recommends that four sets of samples be collected for a study of HAPs. If measurements from one of the four samples cannot be used, or yield results that cannot be explained, three samples remain to provide the average and estimate of variability.

3. Quality Assurance Samples

Battelle recommends that a minimum of two field sampling train blanks be processed at each flue gas sampling site for each group of 3-4 sample sets that are collected. Two train blanks will provide more confidence in the blank results, and if one train blank yields anomalous results, the other train blank may be used alone.

4. Hazardous Element Sampling Train

The HEST sampler shows promise for measurement of mercury in flue gas, but comparisons of arsenic and selenium results from HEST to those from EPA Method 29 do not show good agreement. The sensitivity of As and Se vapor/particle distributions to temperature, and the differences in sampling conditions between the HEST and Method 29 procedures may be the causes of the latter difference. Battelle recommends comparison of Coal Creek data with other HEST data sets, followed by further evaluation of the HEST method.

5. Plume Simulating Dilution Sampler

- a. Many HAPS could not be measured using the PSDS in one day of sampling, because their concentrations in the diluted flue gas were below their detection limits for a single day of sampling. Battelle recommends that results of this project be combined with experience in using the PSDS to measure HAPS generated in a laboratory-scale combustion facility (with higher concentration of HAPS), to design a power plant study specifically tailored to evaluating the efficacy of the PSDS for measuring HAPS emitted from power plants. Significantly longer sampling times will likely be required.
- b. The flow rate of diluted flue gas through an adsorbent material or impinger solution cannot be as large as that passed through the filter in the PSDS. As a result, the detection limits of solid-phase substances in PSDS sampling differ greatly from those of vapor-phase substances. Special consideration should be given to collecting vapor samples in parallel to lower the detection limit for vapor species to an acceptable level.

6. Collection of Volatile Organic Compounds

- a. Battelle recommends an investigation of the variability in measurements by both the canister method and the volatile organic sampling train (VOST) method. The use of internal standards spiked on the VOST adsorbent or into the evacuated canister prior to sampling would aid in assessing changes in VOC concentrations following sample collection. Battelle also recommends that a continuous (or near continuous) instrument for monitoring one or more of the VOCs be used to assess fluctuation of VOC concentrations in flue gas. For example, an automated gas chromatograph equipped with a photoionization detector or mass selective detector could provide data on one or two key VOC at intervals of 30 minutes or less.
- b. Dichloromethane and acetone, used as solvents for other sampling, were found in both the VOST and canister samples. Battelle recommends that VOC sampling apparatus be kept away from these compounds if either is to be measured. The need for measuring (e.g.) dichloromethane must be balanced against the cost and extra effort to ensure that the VOC samples are not contaminated by this solvent in the field.

7. Samples of Liquid Process Streams

Battelle recommends that a minimum of two samples of each liquid stream such as scrubber slurry, scrubber make-up water, and slurry blowdown be

collected and analyzed separately for each data set. This will provide important information on variability of the reported concentrations and is preferred compared to collecting two or more samples from each location, combining them, and analyzing the composite sample for each data set.

8. Use of Out-of-Duct Cyclones

If size-segregated fly ash is to be collected downstream of control equipment for particulate matter, and if available sampling ports or duct configurations at that location do not permit cyclones to be inserted into the duct, Battelle recommends that size-segregated sampling not be conducted. The low particle loadings at such a location and the deposition of particles in sampling lines leading to out-of-duct cyclones may prevent adequate determination of the particle size distribution in the duct.

9. Scrubber/Absorber Sampling and Mass Balance

The most complex plant component to address at Coal Creek, from both a sampling and a mass balance standpoint, was the scrubber (wet FGD). The variable or intermittent nature of some streams, the mixed solid/liquid form of some streams, the generally ill-defined mass flow rates of several streams, and the consistently low concentrations of flue gas constituents at that point in the plant, all make the scrubber difficult to handle in a mass balance study. Isolation of the absorber from the scrubber as a separate unit is also subject to uncertainties in determining the bypassed flow fraction. Battelle cautions that at power plants with a comparable scrubber, awareness of and planning for these complexities is needed.

ANALYSIS

1. Sample Digestion

For better quantification of major and trace elements in a single sample, separate aliquots of the sample should be digested for analysis if possible. Separate digestions will allow dilutions typically necessary for accurate determination of major elements without affecting detection of trace elements.

2. Calcium Analyses

Hydrofluoric acid, required by Method 29, may react with calcium compounds to form insoluble calcium fluoride during digestion of samples. This will lead to reported calcium concentrations being based upon soluble calcium rather than total calcium. Battelle recommends that formation of the precipitate be inhibited by heating the sample in 0.5 M acetic acid, or that the precipitate be redissolved using 4 percent boric acid after driving off the excess HF.

3. Quinoline Analysis

Quinoline should be deleted from the list of target PAH/SVOC analytes in gas and solid samples. This compound was not detected in the samples analyzed by Battelle on this program. If this compound is eliminated from the list of target analytes, the second GC/MS analysis required to determine this compound can be eliminated, thereby improving cost and time efficiencies.

4. SVOC Sample Treatment

Once sufficient data have been obtained on the vapor/particulate distribution of semivolatile organic analytes (PAH/SVOC and dioxins/furans) in coal-fired emissions, vapor and solid phase samples for semivolatile organic compounds should be combined for analysis as a single sample to improve detection limits.

5. PIXE Analyses

Proton-induced X-ray emission analysis (PIXE) was initially used in this study for elemental analysis of coal samples. PIXE detection limits were found to be insufficient for several elements. As a result, Battelle recommends that PIXE not be used for that purpose in future studies.

6. Filter Blanks

Blank problems were found for some major elements with the high-purity quartz fiber filters used in this study. Battelle recommends that an alternative filter substrate be found, perhaps Teflon or Teflon-coated quartz, for use in future studies.

VOLUME 1 - SAMPLING/RESULTS/SPECIAL TOPICS

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LIST OF ABBREVIATIONS AND ACRONYMS

μg	microgram, i.e., 1×10^{-6} gram
μl or μL	microliter, i.e., 1×10^{-6} liter
μm	micrometer, i.e., 1×10^{-6} meter
ALD	aldehydes
ASTM	American Society for Testing and Materials, and techniques specified by that organization
BCO	Battelle Columbus Operations
Btu	British thermal unit
C or $^{\circ}\text{C}$	degrees Centigrade
C6	hexane
CAAA	1990 Clean Air Act Amendments
CN	cyanide, CN^- ; as in hydrogen cyanide, HCN
CTE	Commercial Testing and Engineering Company
CTE-Denver	Commercial Testing and Engineering Company, Denver, CO, Laboratory
CV-AAS	cold vapor atomic absorption spectrometry
D_{50}	particle size for which the collection efficiency of a device or stage is 50 percent
DCM	dichloromethane (i.e., methylene chloride)
Dioxins	see PCDD
DL Ratio	detection limit ratio, indicates the portion of a result that is contributed by non-detect values
DNPH	2,4-Dinitrophenylhydrazine, reagent used for aldehyde sampling
DOE-PETC	Department of Energy, Pittsburgh Energy Technology Center

dscm	dry standard cubic meter (standard conditions are 68°F and 29.92 in. Hg)
EA	Element Analysis Corporation
E	emission factor
EPA	U.S. Environmental Protection Agency
ESP	electrostatic precipitator
F or °F	degrees Fahrenheit
F	filter
FGD	flue gas desulfurization
Furans	see PCDF
g	gram
GC/HRMS	gas chromatography/high resolution mass spectrometry
GC/MS	gas chromatography/mass spectrometry
GF-AAS	graphite furnace atomic absorption spectrometry
HAPs	hazardous air pollutants
HEST	hazardous Element Sampling Train
HPLC/UV	high performance liquid chromatography with ultraviolet absorption detection
hr	hour
IC	ion chromatography
ICP/AES	inductively coupled plasma atomic emission spectrometry
ID	identification (of a sample)
in. Hg	inches of mercury (Hg); unit of pressure, one inch of mercury equals 0.4898 pound per square inch
ISE	ion selective electrode

IT	International Technology Corporation
K	degrees Kelvin, i.e., absolute temperature
kg	kilogram, i.e., 1×10^3 g (1 kg = 2.20 lb)
klb	kilo-pounds, i.e., 1×10^3 pounds
kPa	kilo Pascals, i.e., 1×10^3 Pascals; a unit of pressure (6,892.9 Pascals = 1 pound per square inch)
L	liter
lb	pound
mCi	milli-Curie, i.e., 1×10^{-3} Curie (one Curie equals 3.7×10^{10} radioactive disintegrations per second)
MEOH	methanol
mg	milligram, i.e., 1×10^{-3} gram
min	minute
MJ	mega Joules, i.e., 1×10^6 Joules (1055 Joules equal one Btu)
ml or mL	milliliter, i.e., 1×10^{-3} liter
MM5	Modified Method 5
MUM	Multi-Metals Train (EPA Method 29)
MW	megawatts
NA	data not available, sample not available, or sample not analyzed
NC	not calculated
Ncm or Nm ³	normal cubic meter; standard conditions are 32°F and 29.92 in. Hg; dry; normalized to 3 percent oxygen unless specifically stated otherwise
ND	not detected (generally accompanied by indication of the detection limit, e.g., ND < 4.0)
NDIR	non-dispersive infrared
ng	nanogram, i.e., 1×10^{-9} gram

NO _x	oxides of nitrogen (nitric oxide, NO, and nitrogen dioxide, NO ₂)
PAH	polynuclear aromatic hydrocarbons
PCDD	polychlorinated dibenzo-p-dioxins; congener classes include tetra-, (TCDD); penta-, (PeCDD); hexa-, (HxCDD); hepta-, (HpCDD); and octa-, (OCDD) chlorinated species
PCDF	polychlorinated dibenzofurans; congener classes include tetra-, (TCDF); penta-, (PeCDF); hexa-, (HxCDF); hepta-, (HpCDF); and octa-, (OCDF) chlorinated species
pCi	pico-Curie, i.e., 1×10^{-12} Curie (one Curie equals 3.7×10^{10} radioactive disintegrations per second)
pg	picogram, i.e., 1×10^{-12} gram
PIXE	proton induced X-ray emission spectrometry
ppbv	part per billion by volume, i.e., 1×10^{-9} v/v, measure of gaseous concentration in air
ppm	part per million, i.e., 1×10^{-6} by volume (generally of a pollutant in air or stack gas)
PSDS	Plume Simulating Dilution Sampler
psi or psig	pounds per square inch (gauge); i.e., pressure above atmospheric pressure
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Program Plan
RAD	radionuclide analyses
RE	removal efficiency
RTI	Research Triangle Institute, quality assurance auditors for the project
s	second (of time)
SD	standard deviation
SO ₂	sulfur dioxide
SVOC	semivolatile organic compounds

TU	total ($\pm$) uncertainty
VOC	volatile organic compounds
VOST	Volatile Organic Sampling Train
X	XAD resin, for SVOC collection in Modified Method 5 train

1.0 INTRODUCTION

The Clean Air Act Amendments (CAAA) of 1990 direct that a study be made of emissions of hazardous air pollutants (HAPs) from electric utilities. Results of the study will be used by the United States Environmental Protection Agency (EPA) to evaluate whether or not regulation of emissions of HAPs from this industrial sector is warranted. If a finding is made that regulation is warranted for specific HAPs, rulemaking activities will proceed. In addition, control strategies must be developed for those HAPs that are to be regulated.

This report presents information from a project that is a part of the study identified above. The project was conducted for the U.S. Department of Energy's Pittsburgh Energy Technology Center as one of a group of assessments of toxic emissions from coal-fired power plants. The project is "A Study of Toxic Emissions from a Coal-Fired Power Plant Utilizing an ESP/Wet FGD System." The host power plant for this project was Cooperative Power Association's Coal Creek Station. Coal Creek Station is a mine-mouth plant burning lignite. The pollution control technology employed by the plant consists of an electrostatic precipitator (ESP) followed by a wet flue gas desulfurization (FGD) system.

1.1 Objectives

The objectives of this project are:

- (1) To collect and analyze representative solid, liquid, and gas samples of input and output streams of the power plant for selected hazardous air pollutants (HAPs) that are listed in Title III of the 1990 Clean Air Act Amendments, and to assess the emission levels of these pollutants.
- (2) To determine for selected HAPs (a) the removal efficiencies of pollution control subsystems at the power plant, (b) material balances in specified process components, and (c) an overall material balance for the power plant.
- (3) To determine the concentrations of selected HAPs associated with the particulate fraction of the flue gas stream as a function of particle size.
- (4) To determine the distributions of selected HAPs associated with the vapor and particulate phase fractions in the flue gas streams while assessing the emission levels of these pollutants.

- (5) To determine the concentrations of selected HAPs associated with the vapor and particulate phase fractions under simulated plume conditions at the power plant while assessing the emission levels of these pollutants.

1.1.1 Objectives of DOE and EPA

The U.S. DOE will use the results of this project in its Flue Gas Cleanup Program to provide technology options that will allow for existing and future coal use in a manner that respects the environment. Under this program, control systems are being developed for airborne emissions of HAPs from coal-fired power plants. Results of this project along with the other projects in the assessment of toxic emissions will provide a database on the efficacy of a variety of control systems for HAPs generated by combustion of a variety of coals.

The U.S. EPA will use the results of this project along with other data to help fulfill the mandate in the CAAA for the Utility Toxics Study. Data on emissions along with results on removal efficiencies will be used to assess whether or not regulation of HAPS is warranted for the electric utility industry.

1.1.2 Substances Measured

To meet the objectives of the project, measurements were made of the concentrations of a comprehensive set of substances. The analytes that were measured are listed in Tables 1-1 through 1-8.

Major and trace elements are listed in Table 1-1. Major elements are not HAPs; they were measured to provide additional parameters to be used in the material balance calculations. Because these elements exist at much higher concentrations in coal and fly ash than do the trace elements that are classified as HAPs, they are expected to have less uncertainty in their determination. Hence they can serve as benchmarks for the material balance calculations of trace elements. Six major elements were measured. (Calcium was measured in flue gas only, but not in solid or liquid samples.) Sixteen trace elements were measured.

Other inorganic substances that were measured include the anions chloride, fluoride, phosphate, and sulfate. These anions were measured in solid, liquid, and flue gas process streams. In addition, ammonia and cyanide were measured in flue gas and liquid streams. Elemental carbon was measured in flue gas streams. The ten radionuclides listed in Table 1-1 were also measured.

Organic substances that were measured include semi-volatile organic compounds (SVOC), volatile organic compounds (VOC), and aldehydes. Semi-volatile organic compounds include polynuclear aromatic hydrocarbons (PAH), other SVOC, and polychlorinated dioxins and furans. Table 1-2 lists PAH and other SVOC that were measured in flue gas and solid process streams. These compounds were measured in both the vapor and particle phases of the flue gas streams. Table 1-3 lists PAH and other SVOC that were measured in liquid process streams. Dioxins/furans that were measured are listed in Table 1-4. These compounds were measured only in selected flue gas streams.

Volatile organic compounds were measured in both flue gas and liquid process streams. Table 1-5 contains a list of VOC that were measured in flue gas streams using a volatile organic sampling train (VOST) (see Section 7.5 and Appendix B for details). Canisters were used to collect VOC from flue gas streams as an alternative collection method for comparison. The compounds measured in canister samples are listed in Table 1-6. Table 1-7 lists VOC measured in liquid process streams.

Measurements were made of four aldehydes in flue gas and liquid process streams. These compounds are listed in Table 1-8.

1.1.3 Target Detection Limits

Target detection limits for the substances cited in Section 1.1.2 were developed based upon the intended use of the data by the DOE and EPA subject to resource and schedule constraints of the project. Target detection limits account for the planned volume of sample to be collected and the analytical detection limit for an analyte in a given quantity of sample. The target detection limits for the project are listed in Tables 1-9 and 1-10. For some of the analytes listed in Table 1-9, the analytical method is noted. The right hand column in Table 1-9 gives the target detection limits in nanograms for each analyte in a sample. Using this

information, the target detection limits for substances in flue gas samples are shown in Table 1-10. Target detection limits were not developed for major elements and sulfur because these elements were present in all samples at levels far above their detection limits.

The greatest challenge in meeting the target detection limits for flue gas streams was collecting sufficient material from the flue gas streams at the exit of control equipment. This in turn depended principally upon the quantity of flue gas that was collected in these process streams. The sampling rate and duration of sampling were selected to meet the target detection limits shown in Table 1-10.

1.1.4 Particle Size Range

The need for the Utility Toxics Study mandated in the CAAA is driven by concern over the impact of emissions on public health. To collect data with the most relevance to issues of public health, samples of size-segregated particulate matter in the range of particle diameters that are inhaled into the respiratory system were collected from flue gas. Particulate matter collected for analysis for metals and for SVOC was collected in three particle size ranges. For this purpose, two glass cyclone collectors with 50 percent particle diameter cut points of 10 μm and 5 μm preceded a filter in the sampling train.

In addition, at selected flue gas locations cascade impactors were used to measure the size distribution of particle mass. Particle mass was collected in seven size ranges below about 10 μm .

1.2 Scope of Project

Three sets of measurements were made on the substances identified in Section 1.1.2. Each set of measurements was conducted over a two-day period. Each two-day period consisted of one day devoted to collecting samples for organic analysis followed by a day devoted to inorganic substances.

In addition to measuring the concentration of substances in process streams, several special topics were investigated. These include the following:

- Measuring the distribution of elements and SVOC in the vapor and particle phases
- Collecting samples using a plume simulating dilution sampler (PSDS) at the stack
- Measuring the concentration of elements and selected organic compounds in three particle size ranges
- Measuring mercury, arsenic, and selenium using a hazardous element sampling train (HEST) for comparison to U.S. EPA Method 29 measurements
- Collecting VOC in canisters to compare results with samples collected with a volatile organic sampling train (VOST).

1.3 Quality Assurance Audits

A quality assurance program was implemented to evaluate adherence to planned sampling and analytical procedures in the project Quality Assurance Project Plan (QAPP). Internal audits conducted by Battelle were supplemented by external audits conducted by Research Triangle Institute (RTI) under contract to the U.S. EPA.

1.3.1 Internal Audits

Battelle conducted an internal quality assurance/quality control (QA/QC) program for the project that was described in the QAPP. Internal QA/QC was the direct responsibility of the field sampling team and laboratory personnel at all levels. Battelle assigned a QA project officer to the project. She conducted both field and laboratory audits to document Battelle's adherence to the QAPP.

1.3.2 External Audits

The external QA program included a review of the QAPP for the project by RTI and both performance evaluation audits and technical systems audits at the power plant. Performance evaluation audits consisted of RTI challenging monitors with calibration gases

and spiking adsorbent material and filters with analytes. Technical systems audits consisted of RTI observing the procedures for sampling and handling samples to evaluate adherence to procedures in the QAPP.

1.4 Project Organization

Several organizations contributed to the project. An organization chart is shown in Figure 1-1. Battelle was the prime contractor and reported to DOE. The Industrial Commission of the State of North Dakota cost-shared a portion of the project with the DOE. The Lignite Research Council is an advisory group to the Industrial Commission and provided technical review and comments. Battelle worked directly with the host utility, Cooperative Power Association, through a Host Site Agreement. Cooperative Power also shared in the cost of this project through substantial in-kind support in the form of facility modifications, rigging, materials and labor, utilities for the field facilities, and in dedicating plant staff to the project for the field period.

The external QA program was conducted principally by RTI under contract to the U.S. EPA. The DOE and EPA coordinated the external audit activities. A final QA review of this report was conducted by the University of North Dakota Energy and Environmental Research Center, under contract with the DOE.

A round robin program for coal analysis was coordinated by Consol, Inc. under contract to DOE. For this program, coal samples from eight power plants and a quality control sample were sent to Battelle and the other prime contractors in DOE's program.

Battelle used a major subcontractor, Chester Environmental, for sampling and some analyses. Chester conducted both hot flue gas sampling and sampling using its PSDS. Chester Environmental analyzed HEST samples for mercury and VOST samples for VOC. Zande Environmental Services analyzed liquid samples for VOC. Commercial Testing & Engineering Company (CTE) generated composite samples from solid process samples and analyzed liquid and solid samples for elements. International Technology Corporation provided radionuclide analyses. Element Analysis Corporation analyzed coal samples for elements.

1.5 Organization of the Report

This first volume of the report describes the sampling conducted at Coal Creek, and the results of chemical analyses and calculations based on that sampling effort. Section 1 is this Introduction. The host utility site is described in Section 2, and operating parameters during the test are also reported. In Section 3 the schedule for sampling is summarized along with information on the samples that were collected. Mass balance calculations for ash content of the process streams are illustrated, and results are presented. Oxygen content of the flue gas at several locations is presented to estimate the infiltration of air into the flue gas. Sulfur dioxide concentrations in the flue gas before the scrubber system are also reported. Comparisons and discussion of various aspects of the sampling are presented, and deviations from the QAPP* are noted.

Section 4 of this report presents the analytical methods, and Section 5 presents the analytical results of the sampling described here. Section 6 presents mass balance, removal efficiency, and emission factor calculations and results. The several Special Topics noted in Section 1.2 are described in Section 7.

Volume 2 of this report presents several Appendices of supporting information. Appendix A shows log sheets of plant operating data provided by Coal Creek personnel. Appendix B presents external QA audit results, and Appendix C presents descriptions of sampling methods. Appendix D shows field data sheets and calculations from all the flue gas sampling locations. Appendices E and F describe analytical methods and show internal QA results, respectively. Appendix G describes the calculation of uncertainties, and presents an example uncertainty calculation.

* Study of Toxic Emissions from a Coal-Fired Power Plant Demonstrating the ICCT WSA-SNOX Project and a Plant Utilizing an ESP/Wet FGD System, Management Plan on DOE Contract DE-AC22-93PC93251, Section 4: Coal Creek Site-Specific Plans. Prepared for DOE-PETC by Battelle, Columbus, Ohio, June 21, 1993.

TABLE 1-1. INORGANIC SUBSTANCES MEASURED IN SOLID, LIQUID,
AND GAS PROCESS STREAMS

Major Elements

Al, K, Ti, Si, Na; Ca^(a)

Trace Elements

As, Se, Hg, Cd, Cr, Mo, B, Sb, Ba, Be,
Pb, Mn, Ni, V, Cu, Co

Anions

Cl⁻, F⁻, PO₄⁼, SO₄⁼

Other

NH₃, CN⁻, C

Radionuclides

U²³⁴, U²³⁵, Th²²⁹, Th²³⁰, Th²³⁴, Ra²²⁶,
Ra²²⁸, Pb²¹⁰, Pb²¹¹, Pb²¹²

(a) Calcium measured in flue gas streams only.

TABLE 1-2. PAH AND OTHER SVOC MEASURED IN FLUE GAS AND
SOLID PROCESS STREAMS

PAH	SVOC
Naphthalene	Acetophenone
1-Methylnaphthalene	Benzyl chloride
2-Methylnaphthalene	2-Chloroacetophenone
Biphenyl	Dibenzofuran
Acenaphthene	2,4-Dinitrotoluene
Acenaphthylene	2,6-Dinitrotoluene
Phenanthrene	Hexachlorobenzene
Anthracene	Hexachlorobutadiene
Fluorene	Hexachlorocyclopentadiene
Fluoranthene	Hexachloroethane
Pyrene	Pentachlorophenol
Benz[a]anthracene	Quinoline
Chrysene	
Benzo[e]pyrene	
Benzo[a]pyrene	
Benzo[b and k]fluoranthene	
Indeno[1,2,3-c,d]pyrene	
Benzo[g,h,i]perylene	
Dibenzo[a,h]anthracene	

TABLE 1-3. PAH AND OTHER SVOC MEASURED IN LIQUID PROCESS STREAMS

Acetophenone	Bis-(2-ethylhexyl)phthalate
Biphenyl	2-Chloroacetophenone
2-Methylphenol ^(a)	Dibenzofuran
3-Methylphenol	1,2-Dichlorobenzene ^(b)
4-Methylphenol	1,3-Dichlorobenzene
Dibutylphthalate	1,4-Dichlorobenzene
4,6-Dinitro-o-cresol	2,4-Dinitrophenol
2,4-Dinitrotoluene	2,6-Dinitrotoluene
Hexachlorobenzene	Hexachlorobutadiene
Hexachlorocyclopentadiene	Hexachloroethane
Nitrobenzene	4-Nitrophenol
Pentachloronitrobenzene	Pentachlorophenol
Phenol	Quinoline
2,4,5-Trichlorophenol	2,4,6-Trichlorophenol
Naphthalene	2-Methylnaphthalene
Acenaphthene	Acenaphthylene
Fluorene	Fluoranthene
Phenanthrene	Anthracene
Pyrene	Benz[a]anthracene
Chrysene	Benzo[a]pyrene
Benzo[e]pyrene	Indeno[1,2,3-cd]pyrene
Benzo[g,h,i]perylene	Dibenzo[a,h]anthracene

(a) 2-Methylphenol, 3-Methylphenol, 4-Methylphenol = o,m,p-Cresol, respectively.

(b) 1,2-Dichlorobenzene, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene = o,m,p-Dichlorobenzene, respectively.

TABLE 1-4. DIOXINS AND FURANS MEASURED IN FLUE GAS
PROCESS STREAMS

Dioxins	Furans
2,3,7,8-TCDD ^(a)	2,3,7,8-TCDF ^(b)
1,2,3,7,8-PeCDD	1,2,3,7,8-PeCDF
1,2,3,4,7,8-HxCDD	2,3,4,7,8-PeCDF
1,2,3,6,7,8-HxCDD	1,2,3,4,7,8-HxCDF
1,2,3,7,8,9-HxCDD	1,2,3,6,7,8-HxCDF
1,2,3,4,6,7,8-HpCDD	1,2,3,7,8,9-HxCDF
OCDD	2,3,4,6,7,8-HxCDF
Total TCDD	1,2,3,4,6,7,8-HpCDF
Total PeCDD	1,2,3,4,7,8,9-HpCDF
Total HxCDD	OCDF
Total HpCDD	Total TCDF
	Total PeCDF
	Total HxCDF
	Total HpCDF
	Total HpCDF

(a) TCDD = tetrachloro-dibenzo-p-dioxin; PeCDD = pentachloro-DD;
HxCDD = hexachloro-DD; HpCDD = hepta chloro-DD;
OCDD = octachloro-DD.

(b) TCDF = tetrachloro-dibenzofuran; PeCDF = pentachloro-DF;
HxCDF = hexachloro-DF; HpCDF = heptachloro-DF;
OCDF = octachloro-DF.

TABLE 1-5. LIST OF VOC COLLECTED BY VOST FROM FLUE GAS PROCESS STREAMS

Chloromethane	2-Butanone	2-Chloroethylvinylether
Bromomethane	1,1,1-Trichloroethane	Bromoform
Vinyl chloride	Carbon tetrachloride	4-Methyl-2-pentanone
Chloroethane	Vinyl acetate	2-Hexanone
Methylene chloride	Bromodichloromethane	Tetrachloroethene
Acetone	1,2-Dichloropropane	1,1,2,2-Tetrachloroethane
Carbon disulfide	cis-1,3-Dichloropropene	Toluene
1,1-Dichloroethene	Trichloroethylene	Chlorobenzene
1,1-Dichloroethane	Dibromochloromethane	Ethylbenzene
trans-1,2-Dichloroethene	1,1,2-Trichloroethane	Styrene
Chloroform	Benzene	Xylenes (Total)
1,2-Dichloroethane	trans-1,3-Dichloropropene	Hexane

TABLE 1-6. LIST OF VOC COLLECTED IN CANISTERS FROM FLUE GAS
PROCESS STREAMS

Dichlorodifluoromethane (Freon-12)	trans-1,3-dichloropropene
Chloromethane	1,1,2-Trichloroethane
1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon-114)	Toluene
Vinyl chloride	1,2-Dibromoethane
Bromomethane	Tetrachloroethene
Chloroethane	Chlorobenzene
Trichlorofluoromethane (Freon-11)	Ethylbenzene
1,1-Dichloroethene	m&p-xylene
Methylene chloride	Styrene
3-Chloropropene	1,1,2,2-Tetrachloroethane
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	o-xylene
1,1-Dichloroethane	4-Ethyltoluene
cis-1,2-Dichloroethene	1,3,5-Trimethylbenzene
Chloroform	1,2,4-Trimethylbenzene
1,2-Dichloroethane	Benzyl chloride
1,1,1-Trichloroethane	m-dichlorobenzene
Benzene	p-dichlorobenzene
Carbon tetrachloride	o-dichlorobenzene
1,2-Dichloropropane	1,2,4-Trichlorobenzene
Trichloroethylene	Hexachlorobutadiene
cis-1,3-dichloropropene	

TABLE 1-7. LIST OF VOC MEASURED IN LIQUID PROCESS STREAMS

Acrylonitrile	Benzene	Bromomethane
2-Butanone	Bromoform	Carbon disulfide
Carbon tetrachloride	Chloroethane	Chloromethane
Chlorobenzene	Chloroprene	Cumene
1,1-Dichloroethane	1,2-Dichloroethane	1,2-Dibromoethane
cis-1,3-Dichloropropene	trans-1,3-Dichloropropene	1,4-Dioxane
Ethylbenzene	Iodomethane	Methylene chloride
Methyl methacrylate	4-Methyl-2-pentanone	Styrene
Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane
Trichloroethylene	Vinyl acetate	Vinyl bromide
Vinyl chloride	o-Xylene	m+p-Xylene

TABLE 1-8. ALDEHYDES MEASURED IN
FLUE GAS AND LIQUID
PROCESS STREAMS

Formaldehyde
Acetaldehyde
Acrolein
Propionaldehyde

TABLE 1-9. TARGET ANALYTICAL DETECTION LIMITS

Target Analyte	Estimated Instrument Detection Limit, ng/mL	Final Sample Volume, mL	Estimated Detection Limit, ng
Elements^(c)			
Mo (ICP-AES)	25 ^(a)	450, or 25 ^(b)	11250, or 625 ^(b)
B (ICP-AES)	20	450, or 25	9000, or 500
Sb (GF-AAS)	5	450, or 25	2250, or 125
As (GF-AAS)	1	450, or 25	450, or 25
Ba (ICP-AES)	5	450, or 25	2250, or 125
Be (ICP-AES)	5	450, or 25	2250, or 125
Cd (GF-AAS)	5	450, or 25	2250, or 125
Cr (ICP-AES)	20	450, or 25	9000, or 500
Pb (GF-AAS)	1	450, or 25	450, or 25
Mn (ICP-AES)	5	450, or 25	2250, or 125
Hg (CV-AAS)	0.5	450, or 25	225, or 12.5
Ni (ICP-AES)	20	450, or 25	9000, or 500
Se (GF-AAS)	2	450, or 25	900, or 50
V (ICP-AES)	10	450, or 25	4500, or 250
Cu (ICP-AES)	10	450, or 25	4500, or 250
Co (ICP-AES)	15	450, or 25	6750, or 375
Volatile Elements^(d)			
As	1.6 ng/cm ²		16
Se	1.9 ng/cm ²		19
Hg	2.5 ng/cm ²		25
Ammonia	500 ^(a)		225000
Cyanide	250 ^(a)		112500
Anions			
F ⁻	10 ^(a)		4500 or 100 ^(b)
Cl ⁻	10		4500 or 100
PO ₄ ⁼	100		45000 or 1000
SO ₄ ⁼	25		11250 or 250
VOC - Liquid Samples	5-100 µg/L of sample		

ng = nanogram; µg = microgram; L = liter; cm = centimeter; pCi = picoCuries; g = grams;
ppbv = parts per billion by volume.

TABLE 1-9. (Continued)

Target Analyte	Estimated Instrument Detection Limit, ng/mL	Final Sample Volume, mL	Estimated Detection Limit, ng
SVOC - Liquid Samples	5-100 $\mu\text{g/L}$ of sample		
SVOC/PAH - Gas and Solid Samples	10-100	0.1-1	1-100
VOC - Canister		15	2 ppbv
VOC-VOST			25
Dioxin/Furan			
TCDD/TCDF	10	0.02	0.2
PeCDD/PeCDF	20	0.02	0.4
HxCDD/HxCDF	20	0.02	0.4
HpCDD/HpCDF	20	0.02	0.4
OCDD/OCDF	30	0.02	0.6
Aldehydes	6	20	120
Radionuclides	0.2 pCi/g		

- (a) Instrument detection limit is also equal to the detection limit in liquid samples.
- (b) The first number applies to the gas sample, and the second number applies to the solid sample. Except as noted, detection limits are the product of the instrument detection limit and the final sample volume.
- (c) Acronym within parentheses refers to analysis method for elements: ICP-AES = inductively coupled plasma atomic emission spectrometry; GF-AAS = graphite furnace atomic absorption spectrometry; and CV-AAS = cold vapor atomic absorption spectrometry.
- (d) Samples are analyzed by direct x-ray fluorescence of carbon-impregnated filters from HEST sampler. Sample liquid volume is not applicable.

TABLE 1-10. TARGET GASEOUS EMISSION DETECTION LIMITS

Element	Analytical Detection Limit (ng)	Gas Volume Sampled (Ncm)	Emission Detection Limit ($\mu\text{g}/\text{Ncm}$)
Mo	11250	7.6	1.5
B	9000	7.6	1.2
Sb	2250	7.6	0.3
As	450	7.6	0.06
Ba	2250	7.6	0.3
Be	2250	7.6	0.3
Cd	2250	7.6	0.3
Cr	9000	7.6	1.2
Pb	450	7.6	0.06
Mn	2250	7.6	0.3
Hg	225	7.6	0.03
Ni	9000	7.6	1.2
Se	900	7.6	0.12
V	4500	7.6	0.6
Cu	4500	7.6	0.6
Co	6750	7.6	0.9
Ammonia	225000	0.3	750
Cyanide	112500	0.59	191
Anions			
F ⁻	4500	1.5	3
Cl ⁻	4500	1.5	3
PO ₄ ⁼	45000	1.5	30
SO ₄ ⁼	11250	1.5	7.5
SVOC ^(a)	1-100	7.6	0.1-10 ^(c)
Dioxins/Furans			
TCDD/TCDF	0.2	7.6	0.03 ^(c)
PeCDD/PeCDF	0.4	7.6	0.053 ^(c)
HxCDD/HxCDF	0.4	7.6	0.053 ^(c)
HpCDD/HpCDF	0.4	7.6	0.053 ^(c)
OCDD/OCDF	0.6	7.6	0.08 ^(c)
Aldehydes	120	0.06	2
VOC - Canister	2 ppbv	NA ^(b)	6
VOC - VOST	25	0.003-0.018	1.4-8.3

(a) Calculated target emission detection limit will range from 0.1 to 10 ng/Ncm depending upon SVOC compound and matrix.

(b) NA = Not applicable.

(c) Detection limits shown for SVOC and dioxins/furans are in (ng/Ncm).

ppbv = part per billion by volume.

M/3-Kahy/11-1

Figure 1-1. Project Organization

2.0 SITE DESCRIPTION

The host site for this study was the Coal Creek Station Unit No. 1, operated by Cooperative Power. This section describes the plant, including key individual components such as the ESP and the wet FGD unit (scrubber). Following descriptions of the plant, the flue gas and solid/liquid process streams at which samples were collected are described. This section concludes with presentation of the expected and actual operating conditions of the plant.

2.1 Plant Description

2.1.1 General

The Coal Creek Station is located about 50 miles north of Bismarck, North Dakota, near Underwood, North Dakota. Coal Creek Station is a two-unit, zero discharge, 1,100-megawatt, mine-mouth plant located in a lignite field. The two units are identical. The study described in this report was conducted on Unit No. 1. Each unit has a tangentially fired, water walled, dry bottom furnace, with a Combustion Engineering Controlled Circulation boiler. The furnace is fueled by lignite that is conveyed into the plant from the Falkirk mine located adjacent to the plant. Coal is fed to the boiler through eight pulverizers, of which seven are in operation at any one time. Each unit is equipped with an electrostatic precipitator (ESP) for particulate removal, and with a wet flue gas desulfurization unit (FGD, denoted as scrubber) for sulfur dioxide (SO_2) removal. Each of these components is described below.

A schematic of the Coal Creek Unit 1 process flow is shown in Figure 2-1. The sampling locations for this study are numbered in Figure 2-1, and are listed in Table 2-1, which shows the sample location numbering scheme developed for this study. Figure 2-1 and Table 2-1 distinguish three types of sampling locations: flue gas/particulate sampling locations, designated G; solid sampling locations, designated S; and liquid sampling locations, designated L.

2.1.2 Unit 1 Boiler

The Combustion Engineering boiler at Coal Creek Unit 1 is a balanced-draft, divided-furnace design. The boiler is of conventional type with a furnace deflection arch and a radiant reheater wall. The unit was designed to burn North Dakota lignite with a nominal composition of approximately 39 percent moisture, 37 percent carbon, and 7 percent ash, with an average heating value of about 6,250 Btu/lb. At full load, the boiler is rated to burn 508,000 kg (560 tons) of lignite per hour to produce 1,696,000 kg (3,737,000 lb) of steam at 1.8×10^7 kPa (2,620 pounds per square inch) pressure, at 813 K (1,005°F) superheat and reheat. The furnace volume is 96 ft by 43 feet by 205 feet high, and is divided into two cells by a center wall. The nominal furnace combustion rate is 7,600 Btu per hour per cubic foot. The maximum gas temperature at the exit of the furnace is 1,300 K (1,900°F).

Lignite is supplied to the plant from the nearby Falkirk mine by a conveyer system over 3 miles long. A series of conveyers and silos allows for supply of the plant, and for movement of coal in and out of yard storage supplies. The lignite is crushed, prior to being supplied to eight silos in each unit of the plant. The crushed lignite from the silos is then pulverized in eight 110-inch diameter bowl mills, manufactured by Combustion Engineering, which grind the coal to a fineness of 65 percent through a 200 mesh screen. Only seven of the eight mills are in operation at any time. The pulverizing process also reduces the moisture content of the coal by about half. The pulverized lignite is transported to the furnace pneumatically, and injected into the furnace through tangential nozzles at eight levels in the windbox registers in the front and rear furnace walls. In this study, samples of both the crushed and the pulverized coal supplied to the Unit 1 boiler were obtained on all sampling days. The lag time for the crushed coal to be fired in the boiler is a few hours. The corresponding lag time for the pulverized coal is a matter of seconds, because of the rapid delivery of coal to the nozzles.

Each of the eight coal feeders on Unit 1 is calibrated quarterly. Inspection of records from the quarterly calibrations done before and after the present study indicated a total Unit 1 error of 0.18 percent (actual coal feed rate higher than indicated). Assuming that the feed rate error accumulated linearly with time, the estimated coal feed rate error at the time of the present study was 0.14 percent. This is consistent with the long-term stability of the scale calibration, according to plant personnel. The coal feed rate data used in this report have not

been corrected for this 0.14 percent error, but error in coal feed rate has been included in the Error Analysis, in Appendix G. A summary of the plant coal feeder calibration results is shown in Appendix A.

Coal Creek Unit 1 is designed to achieve low NO_x production by means of the tangential firing, which produces a vortex in the furnace, causing mixing of the fuel and air streams throughout the furnace. Precise control of fuel and air flows in individual locations is not needed. Internal recirculation of gas within the furnace vortex provides low NO_x production, and results in a long residence time for combustion, favoring low hydrocarbon and CO emissions. Reduction of NO_x is also achieved by addition of overfire air.

Soot blowing at Unit 1 is conducted continuously on at least some portion of the furnace, using a total of 262 steam soot blowers installed in the furnace. The soot blowers consist of 204 wall blowers distributed above and below the fuel nozzle levels, and 58 retractable soot blowers, of which 56 are located at the furnace arch, reheater and superheater, and two are located at the bottom of the furnace. All soot blowing is conducted by a programmable controller.

2.1.3 Electrostatic Precipitator

As shown in Figure 2-1, gas leaving the Unit 1 boiler travels through an economizer and then through two parallel air preheaters on its way to the two parallel halves of the ESP. The two halves of the ESP are shown as ESP #1 and ESP #2 in Figure 2-1. Gas leaving the preheaters is divided into four ducts, two of which connect to each half of the ESP. The ESP is constructed as two separate shells or halves, permitting operation with one shell under reduced load conditions. Each shell (i.e., ESP half) consists of 6 rows of 4 hoppers each, with one transformer/rectifier for each hopper. Figure 2-2 illustrates schematically the numbering of the ESP fields. The design conditions for the whole ESP are 2.3 million actual cubic feet of flue gas per minute (at 321°F and 26.14 in Hg), with an operating temperature of 321°F. The ESP provides a specific collecting area of 599 square feet per 1000 actual cubic feet per minute of gas flow, a power density of 3.05 watts per square foot, a gas velocity of 4.2 feet per second, and an overall gas treatment time of about 18 seconds. The ESP is rated at a removal efficiency of 99.5 percent at inlet particulate loadings of greater than 1.16 grains per actual cubic foot (2.65 grams per actual cubic meter). At lower inlet

loadings, the outlet particulate loading is rated to be no higher than 0.0058 grains per actual cubic foot (0.013 grams per actual cubic meter).

Ash from the 48 hoppers is removed by a pressurized pneumatic system that dumps two hoppers at a time. In normal operation at full load, the dumping of ESP hoppers takes about one hour in total, with successively shorter dump times required for successive hopper rows (i.e., 25 minutes for row 1, 15 minutes for row 2, etc.). During the present study, hopper rows 3 through 6 were put on hold from the dumping cycle, to allow accumulation of more ash so that samples could be collected. This action consequently shortened the dumping cycle of the first two rows, due to more frequent cycling of dumping. However, the shortened dumping cycle of rows 1 and 2 did not impair the collection of sample from those rows. Flue gas leaves the ESP in four ducts which connect to four induced draft fans. The gas flow from these fans recombines into two ducts that connect to the Unit 1 scrubber system.

2.1.4 Scrubber (Wet FGD System)

The Coal Creek Unit 1 scrubber is a Combustion Engineering Air Quality Control System (AQCS), which removes SO_2 from the flue gas by means of four countercurrent spray towers using an alkali slurry. The system is designed to remove 90 percent of the SO_2 from up to 60 percent of the flue gas flow. The unscrubbed flue gas is recombined with the scrubbed gas to reheat it. Flexibility in responding to variations in fuel sulfur content is provided by the variable gas bypass flow, and by the capability of operating with fewer than four spray towers at a time.

Each spray tower has three levels of spray nozzles oriented countercurrent (i.e., downward) to the flue gas flow. A slurry liquid to flue gas ratio of 60 gallons per minute per 1000 actual cubic feet per minute is maintained to achieve the 90 percent removal efficiency. Slurry droplets are removed from the gas stream by a bulk entrainment separator and two levels of mist eliminators. The flue gas leaving the top of the scrubber towers contains essentially no entrained droplets, but is saturated with water vapor at the exit temperature of about 135°F. Mixing of 40 percent unscrubbed flue gas at the inlet temperature of about 320°F with 60 percent scrubbed flue gas at 135°F results in a stack gas

temperature of about 210°F. At an inlet SO₂ level of 1000 ppm, an efficiency of 90 percent on 60 percent of the flue gas produces a stack SO₂ level of 460 ppm.

Figure 2-1 shows the flow schematic of the scrubber. Alkaline slurry is pumped to the spray towers from two slurry reaction tanks, and drains back after collection at the bottom of the scrubber. The scrubber slurry is maintained at a pH of about 7 by intermittent automatic introduction of lime slurry into the reaction tanks. The lime slurry is made up as needed from commercial pebble lime and scrubber makeup water, to a nominal solids content of 15 percent. This slurry is added to the reaction tanks, along with scrubber makeup water for tank level control. Scrubber makeup water also enters the system as an intermittent flow of mist eliminator wash water (not shown in Figure 2-1).

Table 2-2 shows information on the composition of the scrubber slurry in the Unit 1 scrubber. Most of these analyses were done after the field measurements reported here, but are considered representative of the scrubber slurry composition for the study period.

The plant circulating water used throughout the Coal Creek plant is treated with several additives. Listed below are the additives and the annual quantities used; these values apply to the entire plant circulating water system, not to Unit 1 or the scrubber specifically.

Sulfuric acid (H₂SO₄) - 2,000 tons per year

Polymaleic acid - 6,600 pounds per year

Polyacrylate - 36,500 pounds per year

Chlorine - 125 tons per year

Chlorine dioxide (ClO₂) - 65 tons per year

Zinc chloride (ZnCl₂) - 75,000 pounds per year

The scrubber bypass flow can be adjusted by means of dampers in the flow line. The bypass flow results from the convergence (from opposite directions) of the two combined flow streams downstream of the four induced draft fans at the outlet of the ESP. At the convergence point, the combined bypass flows turn vertically to meet the scrubbed flue gas flow exiting the scrubber. As a result of the contorted bypass flow path, the gas velocity profile in the bypass duct is highly non-uniform.

During the six days of measurements in this study, the scrubber was operated in a normal manner. As a result, scrubber operation varied in response to variations in the sulfur

content of the feed coal. Because of this factor, all four of the scrubber spray towers were in service on the first, fifth, and sixth days of measurements, but only three were in service on the second, third, and fourth days. Changeover between the two modes of operation was done after the completion of flue gas measurements on each day.

2.1.5 Continuous Emission Monitoring

Continuous emission monitoring (CEM) at Coal Creek Unit 1 consists of a Lear Siegler CM50 analyzer and SM810 dual SO₂/NO_x analyzer in the stack, and four Westinghouse oxygen sensors in the furnace. The stack analyzers were calibrated on June 16, 1993, just before the start of this study; the furnace sensors undergo monthly checks, and a full gas calibration was done in July 1992. The plant SO₂ measurements at the stack were augmented for this study by SO₂ measurements at the ESP outlet, Location 5a (see Figure 2-1). The latter measurements are summarized later in this section, and described in Section 3.3.2.

2.2 Process Streams

2.2.1 Flue Gas Streams

Referring to Figure 2-1, the flue gas leaves the boiler and economizer and then flows in two ducts into two air preheaters. The sampling locations at the exit of the air preheaters and inlet to the ESPs are shown as Locations 4a and 4b. At each of these locations inside the building, vertical traversing over a 13-foot length was required through two sets of ports separated by a beam. Location 4a was the primary location with the full complement of sampling at that location. On every organic sampling day, a Method 5 sampling train was also used to determine the particle mass loading at Location 4b, in the duct leading to ESP #2. Glass cyclones were used in an extractive mode (i.e., outside of the duct) ahead of the filter at both Locations 4a and 4b, to prolong the amount of time that sampling could be conducted before the filter became loaded. The composition of the flue gas stream at Locations 4a and 4b was assumed to be identical, and the ratio of the mass loading at Location 4b to that at Location 4a was used to infer the level of pollutants at Location 4b.

Both Locations 4a and 4b were non-ideal sampling locations, in that sharp changes in flue gas direction occur immediately upstream of these locations, as flue gas exits the air preheaters.

The flue gas exits the two ESPs in four ducts which subsequently are combined into two ducts leading into the scrubber system. Location 5a was the primary location at the ESP outlet/scrubber inlet, and the full complement of sampling was conducted there. On alternate days with the measurements at Location 4b (i.e., on the inorganic sampling days), sampling was conducted at Location 5b for particulate mass and elements and vapor phase arsenic, selenium, and mercury. Vertical traversing through the 4.5-m (14 ft. 9 in.) rectangular duct was required outdoors at Locations 5a and 5b. The glass cyclones were operated in extractive mode just upstream of the heated filter in the heated box for the Multi-Metals (Method 29) and Modified Method 5 trains at Locations 5a and 5b.

To evaluate the removal efficiency of the scrubber system for sulfur dioxide and HAPs in flue gas, the concentrations of substances at the outlet (Location 6a) and inlet (Location 5a) were sampled. The concentration of sulfur dioxide at Location 5a was monitored with a continuous emissions monitor (CEM) that had been brought to the site. The bypass flow rate around the absorbers in the scrubber system was measured by full traversing in the bypass duct at the start of measurements. The SO₂ concentration in the bypass flow is assumed to be the same as that measured at Location 5a. The Coal Creek CEM instruments provided data on the concentration of sulfur dioxide in the stack, which is used with other data to assess the efficiency of the scrubber for SO₂ removal. For each sampling day, the bypass flow rate was determined from measurements of the temperature and moisture content in the bypass flow, outlet of the absorber, and combined flow stream (i.e., bypass plus scrubber flue gas). At the outlet location in the stack, HAPs measurements were also made by Plume Simulating Dilution Sampling (PSDS), which involves diluting a flow of stack gas with clean air to simulate dilution in the atmosphere. The HAPs measurements made in this manner were designated as Location 6b.

Table 2-3 summarizes the flue gas flows and characteristics found at Locations 4a, 4b, 5a, 5b, and 6a on each of the sampling days. (Note that in Table 2-3 flue gas flow rates are shown in Ncm/min both normalized to 3 percent oxygen and at actual oxygen content.) The observed particulate loading values upstream and downstream of the ESP are fully consistent with the designed performance of the ESP, as described above. Comparison of the

Location 5a and Location 6a data also indicates some particulate removal in the scrubber. A decreasing trend in particulate loading was observed at Locations 4a, 5a, and 6a, on the three inorganic sampling days. Loadings measured at Location 5b agree very closely with those at 5a on the first two days, but do not corroborate the continued decrease in loading on the third day. A review of plant operating conditions, daily coal analyses (e.g., ash content), particulate size distributions, and flue gas sampling results (e.g., leak tests, isokinetic ratios) has not indicated a reason for the apparent trend in particulate loading (see Section 2.3.2).

The flue gas conditions and flow rates found at Location 4b (Table 2-3) are consistent with those at 4a, but the particulate loadings at Location 4b are only one-half to two-thirds of those at Location 4a. Coal Creek staff have indicated that the loadings found at Location 4a are reasonable, and that nominally the same loadings would be expected at Location 4b. Somewhat higher flue gas oxygen values were found at Location 4b relative to those at Location 4a, possibly indicating leakage of air. However, the small differences in oxygen content and flue gas flows at Locations 4a and 4b do not seem sufficient to account for the distinctly lower particulate loading at 4b. Inspection of data sheets from the field sampling also did not disclose any error that would cause the apparently low particulate loadings found at Location 4b.

Comparison with previous measurements suggests that the lower particulate loadings at Location 4b may in fact be characteristic of Unit 1. During November of 1980, flue gas measurements were made at various Unit 1 locations by Interpoll, Inc. (Interpoll Report No. 0-887, Emission Tests at Coal Creek Station, 1980). Those measurements included three separate sampling runs at both Locations 4a and 4b. Measured flue gas flow rates were 19,970-20,140 dscm/min at Location 4a, and 21,500-22,300 dscm/min at Location 4b, in good agreement with the flow rate data in Table 2-3 (e.g., under conditions at Location 4a, 1 dscm = 0.83 Ncm). Measured particulate loading data were reported in pounds per hour for both Locations 4a and 4b in the Interpoll report. At Location 4a, values ranged from 22,658 to 23,435 lb/hr, equivalent to a loading of about 10,500 mg/Ncm, similar to the results in Table 2-3. However, at Location 4b, Interpoll reported mass loadings varying from 12,367 to 22,357 lb/hr, averaging 17,020 lb/hr. Thus the Interpoll results indicated variable and low particulate loadings at 4b relative to 4a, consistent with the findings of this study (Table 2-3). The cause of the different mass loadings found at Locations 4a and 4b is not clear, since the two locations are nominally identical. However, it may result from the change in

flow direction immediately upstream of these locations. It is also noteworthy that the Interpoll study reported flow rates at Locations 5a and 5b in good agreement with those in Table 2-3, and particulate mass loadings at those same locations of about 20 to 50 mg/dscm, also consistent with the results shown here.

A comparison was done of the measured flue gas flow rates reported in Table 2-3, with flow rates calculated on the basis of flue gas oxygen content and the daily coal consumption in Unit 1. That comparison was done for each of the three inorganic sampling days. The ratios of the measured to the calculated flow rates at Locations 4, 5, and 6 were as follows: Location 4, average 1.14 (range of 1.12 to 1.16 for three values); Location 5, 1.02 (1.00 to 1.04); and Location 6, 1.04 (1.039 to 1.044). For Locations 4 and 5, the values are based on summing the flows measured at 4a and 4b, and at 5a and 5b, respectively. This comparison indicates close agreement between the measured and expected flue gas flow rates. The poorest agreement is found at Location 4; this is not unexpected given the flow characteristics of Locations 4a and 4b, as noted above.

2.2.2 Solid and Liquid Streams

Solid process samples collected included boiler feed coal (Location 1), run-of-mine coal (Location 14), bottom ash (Location 2), economizer ash (Location 3), pyrite rejects (Location 7), ESP ash (Location 8), and lime (Location 15). Boiler feed coal was collected once a day from each of seven coal feed ducts downstream of the pulverizers by Coal Creek staff, and was composited on-site by ASTM procedures by Coal Creek staff. A single run-of-mine coal sample (prior to the pulverizers) was collected daily prior to the pulverizers by Coal Creek staff. Bottom ash samples were collected twice a day by Coal Creek personnel from three hoppers located below the boiler. Economizer ash was collected from six hoppers located below the economizer. Pyrite rejects were collected by Coal Creek personnel from seven hoppers located below the pulverizers. The precipitator ash was collected from ESP #1 only, which contains of 24 hoppers. The lime sample was collected from a hopper located upstream of the lime slurry preparation tank.

Liquid process samples collected included river make-up water (Location 9), circulating water (Location 10), scrubber make-up water (Location 11), lime feed slurry (Location 16), and slurry blowdown (Location 17). River water samples were collected from

an area behind the cooling towers where the river water runs into holding ponds. Scrubber make-up water is a combination of water from the cooling tower and return ponds. Scrubber make-up water was collected upstream of the lime slurry preparation tank. Lime feed slurry is a combination of lime and scrubber make-up. This sample was collected prior to the scrubber system. Slurry blowdown samples were collected between the reaction tanks and the absorber spray pumps which feed the absorber spray towers. No coal pile runoff sample (Location 13) could be collected during the study because of insufficient rain.

2.3 Plant Operating Conditions

2.3.1 Nominal Conditions

After consultation with Coal Creek staff and review of information about the plant, expected plant operating conditions and allowable ranges of those conditions for testing were established. Table 2-4 lists those operating conditions.

2.3.2 Actual Operating Conditions

Effort was made to compile information on all of the plant operating data listed in Table 4.5 of the Statement of Work for this project. Data on operating parameters measured during the study are presented below. In addition, some of the desired operating data are not routinely measured, but are reported in the plant description in Section 2.1, above.

Examples of such data include furnace gas temperature; feeder-to-furnace lag time; ESP characteristics and dumping procedures; scrubber characteristics; slurry pH, specific gravity, and composition (Table 2-2); additives; coal mass flow calibrations; and soot blowing procedures. Some other data are not measured at Coal Creek, and cannot be reported. These include air feed rate; solid lime feed rate; scrubber recycle ratio and mist eliminator pressure drop; and stack concentrations of CO and CO₂.

In order to document the operating conditions at Unit 1 during the present study, a variety of data were collected. Instantaneous plant process data were collected approximately hourly by plant staff on data sheets provided by Battelle. In addition, copies of some plant

data records were obtained. Copies of the Battelle process data sheets are contained in Appendix A.

Table 2-5 presents average values, ranges, and standard deviations of actual plant operating conditions for each test day for Coal Creek. Tables 2-6 to 2-15 present ESP operating data for the same time period. Table 2-16 shows coal analysis data provided by Coal Creek for the days of the present study. The process data that are reported in Table 2-5 are:

- Lignite feed rate, klb/hr
- Load, MW
- Steam generation rate, klb/hr
- Steam temperature, superheater outlet, °F
- Steam temperature, reheater outlet, °F
- Steam pressure at drum, psi gauge
- Excess O₂ at the furnace outlet, percent
- Excess O₂ at the stack, percent
- SO₂ at scrubber inlet, ppm
- SO₂ in the stack, ppm
- NO_x in the stack, ppm
- SO₂ emissions, lb/10⁶ Btu
- NO_x emissions, lb/10⁶ Btu
- Opacity, percent (based on 6-minute running average data)
- Scrubber inlet temperature, °F
- Scrubber outlet (i.e., stack) temperature, °F
- Lime feed slurry flow rate to reaction Tank A, gpm
- Lime feed slurry flow rate to reaction Tank B, gpm
- Barometric pressure, in. Hg.

Only the hourly data for the actual daily test periods were used in calculating daily average values for plant operating conditions.

The daily average lignite feed rate ranged from 881 to 911 klb/hr, a range of 3.4 percent. The daily average load ranged from 557.8 to 562.7 MW, a range of 0.9 percent of the actual load. The daily average steam generation rate ranged from 3895 to 3928 klb/hr, (491 to 495 kg/sec), a range of 0.8 percent of the actual steam generation rate.

The daily average steam temperature at the superheater outlet varied only from 1002 to 1006°F, a range of less than 0.4 percent. The steam temperature at the reheater outlet was also stable, varying only from 1004 to 1006°F. The drum steam pressure ranged from 2768 to 2784 psig, a total range of 0.6 percent.

The daily average excess oxygen readings at the furnace outlet and at the stack ranged from 3.47 to 3.55 percent and from 5.13 to 5.30 percent, respectively. Thus, the daily average excess oxygen values varied over ranges of 2.3 percent and 3.3 percent, respectively, of the actual excess oxygen values measured at the furnace outlet and at the stack, respectively.

The daily average SO₂ at the scrubber inlet ranged from 755 to 866 ppm, a range of 13.8 percent relative to the average of the daily values. The daily average SO₂ in the stack ranged from 386 to 421 ppm, a range of 8.5 percent of the average SO₂ value. A simplistic calculation shows that the observed scrubber inlet and outlet SO₂ values appear consistent with the anticipated performance of the scrubber. For example, the average inlet value on June 22 of 863 ppm, if scrubbed at 90 percent efficiency on 60 percent of the flow, would give a stack SO₂ value of 397 ppm. This value compares well with the observed stack value of 417 ppm. More detail on the SO₂ measurements is provided in Section 3.3.3. The daily average NO_x in the stack ranged from 285 to 304 ppm, a range of 6.5 percent of the NO_x value.

The SO₂ and NO_x emission rates in lb/10⁶ Btu ranged from 1.07 to 1.17, and from 0.56 to 0.61, respectively. Both emission rates show a range of about 9 percent in the daily values.

The daily average opacity, based on 6-minute average data, ranged from 9.0 to 10.8 percent, a range of 19 percent of the opacity value. Short-term low opacity readings were found to be associated with periods of calibrating the opacity monitor. Those data have been left in the data set, because it was not always clear which data points may have been affected by calibration activities.

The daily average gas temperature at the inlet of the scrubber ranged from 311°F to 327°F (428 K to 437 K), a range of 2.1 percent of the absolute gas temperature at that location. The daily average gas temperature in the stack ranged from 219°F to 243°F (377 K to 390 K), a range of 3.5 percent of the absolute gas temperature at that location.

The lime feed slurry is provided to the two scrubber reaction tanks as needed to maintain a pH of 7 in the slurry pumped to the absorber spray towers. As a result, the flow rates of lime slurry to both reaction tanks A and B (Table 2-5) were quite variable. The daily average flows of lime feed slurry ranged from 34 to 69 gallons per minute, and 21 to 82 gallons per minute, to Tank A and Tank B, respectively. On a given day, the flows to the two tanks were quite different, as well. For example, the minimum daily average flow to Tank A coincided with the maximum daily average flow to Tank B, and vice versa. Within a given day, flows to each tank ranged widely, sometimes even dropping to zero. The collection of samples from the scrubber area was sometimes hampered by the variable and intermittent nature of these flows, as noted in Section 3.2.4.

Barometric pressure exhibited a gradual rise throughout the week, resulting in heavy rain and high winds during the first few days of sampling, followed by near-perfect weather for the last two days. The pressure values listed in Table 2-5 were recorded at Location 5a, the primary outdoor sampling location.

Comparing the data reported in Table 2-5 to the expected operating conditions given in Table 2-4 shows that the expected operating conditions were achieved.

Tables 2-6 through 2-15 show operating parameters during this study for the Unit 1 ESP. Tables 2-6 through 2-10 present results for ESP #1 (Figure 2-1), which comprises hoppers 1 to 24, and Tables 2-11 through 2-15 present results for ESP #2, hoppers 25 to 48. Figure 2-2 shows the layout of the hoppers in both parts of the ESP. Within each of the two sets of tables, the following five parameters are shown for each sampling day and field (i.e., hopper), in order: primary current (AC amps); primary voltage (AC volts); secondary current (milliamps); secondary voltage (kilo volts); and power (kilowatts). Reading across a row in any of these tables shows the daily averages and standard deviations of the indicated parameter in a single field. The values of the various parameters differ widely among fields, but were relatively constant for any single field. The data in Tables 2-6 through 2-15 have been reviewed for trends, but no consistent trends have been found that appear to explain (e.g.) the decreasing flue gas particulate loading at Location 5a (Table 2-3).

Table 2-16 shows results from analysis of daily composite run-of-mine lignite samples from each day of the study. Several different characteristics of the coal are shown, on both a dry and wet (i.e., as-received) basis. Some variation in coal composition was noted during the study. For example, ash content was higher, and sulfur content and heating value lower,

on June 24 than on other days. The variation in sulfur content, alluded to in Section 2.1.4 in the context of scrubber operations, is clearly evident in Table 2-16. However, the lignite composition was within expected ranges for all characteristics.

No problems of any kind were encountered in operation of the plant at any time during the field study. Operating conditions remained stable near the nominal values at all times. No deviations from the sampling plan resulted from operation of the plant during sampling. One small deviation from the plan was the finding before sampling began that the condenser water sampling locations, originally designated in the sampling plan as Locations 11 and 12, were redundant with the make-up water, Location 9 (Figure 2-1). As a result, the condenser water locations were omitted from sampling, and designation 11 was assigned to the scrubber make-up water (Figure 2-1). Location 12 was dropped from the sampling location list (see Table 2-1).

2.3.3 Process Trends Graphs

Figures 2-3 through 2-8 are plots of key operating conditions shown in Table 2-5 against time for each test day. The values shown are the actual values recorded on the hour, each hour, by plant personnel. When plant staff recorded data for periods longer than the actual sampling period (e.g., generally data were recorded from 7:00 a.m. while sampling began about 9:00 or 10:00 a.m.), all of the data are shown on the plots. Figures 2-3 through 2-8, respectively, show lignite feed rates; load and steam flow; furnace and stack excess oxygen; SO₂ and NO_x emissions; opacity; and FGD inlet and outlet (stack) temperatures. Part "a" of each figure shows data from days on which organic constituents were sampled (June 21, 23, and 26), and part "b" shows data from days on which inorganic constituents were sampled (June 22, 24, and 27) (see Section 3.1.1). As can be seen from Figures 2-3 through 2-8 and the low values for the standard deviations for operating conditions reported in Table 2-5, Coal Creek No. 1 was operated at nearly constant conditions for the period of the study.

TABLE 2-1. IDENTIFICATION OF SAMPLING POINTS

Location ^(a)	Description	Coal Creek
1	Boiler feed coal	S ^(b)
2	Bottom ash	S
3	Economizer ash	S
4	ESP inlet	G
5	ESP outlet	G
6	Scrubber outlet (stack)	G
7	Pyrite rejects	S
8	ESP ash	S
9	Make-up water	L
10	Outlet of pond/ Circulating water	L
11	Scrubber make-up water	L
13	Coal pile runoff	L
14	Run-of-Mine coal	S
15	Lime input	S
16	Lime feed slurry	L
17	Slurry blowdown	L

(a) See Figure 2-1 for locations in the process streams at Coal Creek.

(b) S = solid stream, G = flue gas stream, L = liquid stream.

TABLE 2-2. COMPOSITION OF LIQUID PHASE OF SLURRY USED IN COAL CREEK
UNIT 1 SCRUBBER SPRAY TOWERS^(a)

Parameter	Average Value	Range
Specific Gravity	1.06	1.04-1.07
pH	7	-(b)
Percent Solids (by wt.)	7.3	6.2-7.8
Total Dissolved Solids (ppm)	13,595	12,661-15,170
SO ₄ ⁼ (ppm)	9,990	9,220-11,070
Na (ppm)	2,396	2,220-2,625
Mg (ppm)	1,065	990-1,220
Cl (ppm)	900	855-1,010
Ca (ppm)	654	610-720
SiO ₂ (ppm)	10.2	9.9-10.5
PO ₄ ⁼ (ppm)	<0.5	-
CaCO ₃ (ppm)	<1 ^(c)	-
Ca(OH) ₂ (ppm)	<1 ^(c)	-

- (a) Based on four samples (two from each of two reaction tanks), 9/29/93, except for specific gravity, which is from daily values obtained June 21-27, 1993.
- (b) No variation.
- (c) Based on pH.

TABLE 2-3. FLUE GAS CHARACTERISTICS AT SAMPLING LOCATIONS

Location ^(a) / Test Day	Flue Gas Characteristics						
	Temperature (°C)	Static ^(b) Pressure (in. Hg)	Percent Moisture	Oxygen (%) ^(c)	Particle Loading ^(e) (mg/Ncm)	Duct Flow ^(e) (Ncm/min)	Duct Flow ^(f) (Ncm/min)
Location 4a							
6/21/93	177	-1.2	12.6	5.0		17,066	19,213
6/22/93	173	-1.2	12.3	5.0	13,449	17,133	19,288
6/23/93	167	-1.2	18.7	5.0		15,865	17,861
6/24/93	166	-1.1	13.9	5.0	12,678	17,059	19,205
6/26/93	168	-1.1	15.1	5.0		16,307	18,359
6/27/93	167	-1.1	15.0	5.0	11,252	16,557	18,640
Location 4b							
6/21/93	178	-1.2	15.3	6.0	7,600	17,197	20,659
6/23/93	172	-1.2	14.3	6.0	9,485	16,921	20,327
6/26/93	170	-1.2	14.9	7.0	7,949	15,775	20,315
Location 5a							
6/21/93	175	0.5	12.9	5.0		15,768	17,752
6/22/93	176	0.5	15.9	5.0	39.6	15,445	17,388
6/23/93	171	0.5	16.3	5.0		15,064	16,959
6/24/93	170	0.5	14.3	5.0	17.2	15,526	17,479
6/26/93	170	0.5	15.5	5.0		16,878	19,001
6/27/93	170	0.5	14.4	5.0	10.2	16,848	18,968
Location 5b							
6/22/93	185	1.2 ^(d)	18.3	7.0	42.2	14,073	18,123
6/24/93	176	1.2	14.8	7.0	20.9	14,843	19,115
6/27/93	175	1.2	14.6	8.5	41.3	13,100	18,910
Location 6a							
6/21/93	115	-0.1	17.2	7.0		33,131	42,666
6/22/93	121	-0.1	17.0	8.0	33.5	30,688	42,582
6/23/93	122	-0.1	15.4	8.0		30,621	42,490
6/24/93	111	-0.2	16.9	8.0	6.4	30,677	42,568
6/26/93	108	-0.1	16.5	8.0		29,674	41,175
6/27/93	107	-0.1	17.1	8.0	2.1	30,166	41,858

- (a) 4a = ESP #1 inlet; 4b = ESP #2 inlet; 5a = ESP #1 outlet; 5b = ESP #2 outlet; 6a = Scrubber outlet (stack).
- (b) Pressure is relative to atmospheric.
- (c) O₂ data are shown to the nearest 0.5 percent.
- (d) Flue gas static pressure at Location 5b should be essentially equal to that at 5a, however, operator records from sampling at 5b are ambiguous. The values shown were used in all calculations.
- (e) Normalized to 3 percent O₂ in flue gas.
- (f) Flow rate at actual O₂ content (i.e., not normalized to 3 percent O₂).

TABLE 2-4. COAL CREEK UNIT 1 EXPECTED OPERATING CONDITIONS AND PERMITTED DEVIATION

Parameter(a)	Nominal Expected Value	Allowable Range
Boiler Operating Conditions		
Load, MW (gross)	564	545-575
Flue gas oxygen monitor readings, percent	3.5	3.0-4.5
Steam temperature at superheater outlet, °F	1,000	980-1,020
Steam temperature at reheater outlet, °F	1,000	980-1,020
Drum steam pressure, psig	2,760	2710-2,810
Throttle steam flow, lb/hr	3,850,000	3.7-4.0x10 ⁶
Pulverizers in operation	7	7
Scrubber Operating Conditions		
Slurry pH	7	
Inlet gas temperature, °F	320	Actual
Stack gas temperature, °F	224	Actual
Emissions		
Stack opacity, 6-minute average, percent	<10	<15
Stack SO ₂ , ppm	410	355-456
Stack NO _x , ppm	295-345	245-390

- (a) 1,000°F = 811 K
 980°F = 800 K
 1,020°F = 822 K
 2,760 psi = 1.90 x 10⁷ kPa
 2,710 psi = 1.87 x 10⁷ kPa
 2,810 psi = 1.94 x 10⁷ kPa
 3.85 x 10⁶ lbs/hr = 486 kg/s
 3.7 x 10⁶ lbs/hr = 467 kg/s
 4.0 x 10⁶ lbs/hr = 504 kg/s.

TABLE 2-5. DAILY AVERAGE VALUES FOR KEY OPERATING CONDITIONS
FOR COAL CREEK UNIT 1

Date	Average	Range	Standard Deviation
Lignite Feed Rate, klb/hr			
June 21, 1993	890	877-901	7
June 22, 1993	897	889-913	8
June 23, 1993	907	889-937	13
June 24, 1993	911	901-919	6
June 26, 1993	888	871-907	10
June 27, 1993	881	853-895	12
Load, MW			
June 21, 1993	559.6	558-562	1.1
June 22, 1993	558.8	556-560	1.6
June 23, 1993	559.8	555-567	3.2
June 24, 1993	557.8	554-562	2.3
June 26, 1993	560.9	559-563	1.3
June 27, 1993	562.7	560-567	2.0
Steam Generation Rate at Throttle, klb/hr			
June 21, 1993	3927	3895-3977	18
June 22, 1993	3923	3895-3936	12
June 23, 1993	3895	3835-3959	32
June 24, 1993	3915	3877-3927	14
June 26, 1993	3905	3888-3920	10
June 27, 1993	3928	3906-4000	26
Steam Temperature, Superheater Outlet, °F			
June 21, 1993	1002	994-1007	3
June 22, 1993	1003	1000-1008	2
June 23, 1993	1005	999-1013	4
June 24, 1993	1004	994-1009	4
June 26, 1993	1006	1003-1009	2
June 27, 1993	1004	997-1008	3
Steam Temperature, Reheater Outlet, °F			
June 21, 1993	1004	998-1007	3
June 22, 1993	1004	1001-1006	2
June 23, 1993	1005	1002-1010	2
June 24, 1993	1004	1001-1005	1
June 26, 1993	1006	1003-1009	2
June 27, 1993	1004	997-1006	3

TABLE 2-5. (Continued)

Date	Average	Range	Standard Deviation
Steam Pressure at Drum, psig			
June 21, 1993	2777	2789-2763	6
June 22, 1993	2779	2767-2788	6
June 23, 1993	2768	2742-2800	17
June 24, 1993	2776	2765-2784	14
June 26, 1993	2775	2765-2784	6
June 27, 1993	2784	2772-2811	11
Excess O₂ at Furnace Outlet, percent			
June 21, 1993	3.55	3.5-3.8	0.09
June 22, 1993	3.51	3.4-3.6	0.06
June 23, 1993	3.50	3.4-3.7	0.10
June 24, 1993	3.50	3.4-3.6	0.04
June 26, 1993	3.47	3.3-3.6	0.08
June 27, 1993	3.53	3.4-3.7	0.08
Excess O₂ in Stack, percent			
June 21, 1993	5.13	5.0-5.4	0.09
June 22, 1993	5.21	5.1-5.3	0.06
June 23, 1993	5.30	5.2-5.4	0.06
June 24, 1993	5.22	5.1-5.3	0.06
June 26, 1993	5.14	5.0-5.2	0.07
June 27, 1993	5.16	5.1-5.3	0.07
SO₂ at Scrubber Inlet, ppm			
June 22, 1993	863	720-960	79
June 23, 1993	767	640-820	49
June 24, 1993	755	660-840	47
June 26, 1993	768	670-920	70
June 27, 1993	866	780-920	48
SO₂ in Stack (Scrubber Outlet), ppm			
June 21, 1993	386	307-409	13
June 22, 1993	417	403-426	7
June 23, 1993	407	310-431	33
June 24, 1993	421	405-430	8
June 26, 1993	421	410-435	8
June 27, 1993	416	400-434	11

TABLE 2-5. (Continued)

Date	Average	Range	Standard Deviation
NO_x in Stack, ppm			
June 21, 1993	295	287-302	5
June 22, 1993	291	282-300	6
June 23, 1993	304	293-319	6
June 24, 1993	295	284-309	9
June 26, 1993	289	271-305	11
June 27, 1993	285	270-309	17
SO₂ at Stack, lb/10⁶ Btu			
June 21, 1993	1.07	1.02-1.13	0.04
June 22, 1993	1.16	1.12-1.17	0.02
June 23, 1993	1.16	1.12-1.20	0.03
June 24, 1993	1.17	1.12-1.20	0.02
June 26, 1993	1.16	1.13-1.19	0.02
June 27, 1993	1.15	1.10-1.19	0.03
NO_x at Stack, lb/10⁶ Btu			
June 21, 1993	0.58	0.57-0.60	0.01
June 22, 1993	0.58	0.56-0.59	0.01
June 23, 1993	0.61	0.59-0.65	0.02
June 24, 1993	0.59	0.52-0.62	0.03
June 26, 1993	0.57	0.53-0.60	0.02
June 27, 1993	0.56	0.51-0.61	0.03
Opacity, based on 6-minute running average, percent			
June 21, 1993	9.8	8.4-13.0	0.8
June 22, 1993	10.2	8.9-14.0	1.0
June 23, 1993	10.8	1.0 ^(a) -15.8	1.6
June 24, 1993	9.4	8.5-12.0	0.6
June 26, 1993	9.2	8.3-11.2	0.7
June 27, 1993	9.0	0.7 ^(a) -11.3	1.0
Scrubber Inlet Temperature, °F			
June 21, 1993	327	319-331	4.4
June 22, 1993	325	321-328	2.3
June 23, 1993	317	308-322	4.3
June 24, 1993	311	308-312	1.1
June 26, 1993	311	310-314	1.2
June 27, 1993	312	307-316	3.2

TABLE 2-5. (Continued)

Date	Average	Range	Standard Deviation
Scrubber Outlet (Stack) Gas Temperature, °F			
June 21, 1993	231	227-233	2.0
June 22, 1993	239	232-247	5.0
June 23, 1993	243	234-251	4.9
June 24, 1993	226	219-230	3.2
June 26, 1993	222	214-225	2.9
June 27, 1993	219	215-225	3.8
Lime Feed Slurry Flow Rate to reaction Tank A, gpm			
June 21, 1993	56	45-65	6.6
June 22, 1993	69	65-75	4.5
June 23, 1993	50	15-90	25.1
June 24, 1993	34	0-60	22.5
June 26, 1993	43	33-52	6.1
June 27, 1993	49	20-70	13.4
Lime Feed Slurry Flow Rate to Reaction Tank B, gpm			
June 21, 1993	71	60-75	5.2
June 22, 1993	21	0-40	10.9
June 23, 1993	46	30-75	16.7
June 24, 1993	82	60-125	17.0
June 26, 1993	52	42-56	4.3
June 27, 1993	59	40-82	13.9
Barometric Pressure, inches of Hg			
June 21, 1993	27.48	(b)	-
June 22, 1993	27.48	-	-
June 23, 1993	27.64	27.60-27.67	0.03
June 24, 1993	27.63	27.62-27.64	0.01
June 26, 1993	27.87	27.86-27.88	0.01
June 27, 1993	27.84	27.82-27.86	0.02

(a) Suspect value occurred during instrument calibration.

(b) No variation in measurements.

TABLE 2-6. COAL CREEK, ESP NO. 1, PRIMARY CURRENT (AC AMPERES)

Field	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
1	11.3	2.32	12.1	2.33	14.4	2.04	21.3	1.6	18.7	2.36	16	1.6
2	43.8	2.82	47.8	2.57	52.1	3.3	51.2	2.41	59.1	2.02	61.1	2.47
3	18.9	0.49	20.7	0.94	18.7	0.83	22.4	0.98	21.1	0.74	20.5	0.5
4	5	0.41	4.89	0.31	5.36	0.46	5.18	0.72	5	0.47	5.64	0.64
5	55.8	3.51	58.6	2.11	61.9	6.38	74.8	2.76	72.8	2.1	66.5	2.43
6	37.1	2.75	38.8	1.93	44.6	2.76	48.2	1.75	50.4	1.42	49.2	1.27
7	84	3.92	87.3	2.05	86.9	7.17	100	3.45	101	2.82	93.5	2.84
8	36.3	0.62	37.4	0.68	36.4	1.32	39.6	0.64	39.2	0.63	38.3	0.45
9	99.9	2.69	103	2.38	97.1	4.81	101	2.43	99.7	2.75	92.1	2.35
10	91.2	4.14	90.3	2.75	92.8	3.05	92.7	2.83	100	2.26	106	2.71
11	120	3.28	119	3.56	115	5.33	120	2.68	117	2.21	111	3.22
12	115	3.49	110	4.96	109	2.53	105	3.65	105	3.87	112	3.21
13	29.7	1.25	27.3	3.37	28.9	1.12	30.3	4.83	27	2.62	30.9	5.7
14	128	8.55	138	7.13	146	0.93	151	2.1	149	0.92	151	2.69
15	80.8	4.3	85.8	3.42	95.6	7.97	103	2.81	109	3.48	105	2.42
16	119	2.04	123	1.95	126	3	133	0.72	133	0.67	135	1.3
17	70.8	3.24	72.8	2.3	80.3	5.69	83.9	2.39	90.7	2.94	86.8	3.04
18	124	1.38	128	0.5	130	2.39	136	1.28	135	1.91	137	1.7
19	82.6	4.23	85	4.32	90.5	7.39	95.5	2.54	104	1.71	101	4.56
20	179	0.72	179	0.31	180	0.92	179	0.64	180	0.47	179	0.66
21	120	6.61	125	5.2	129	9.56	134	2.64	141	1.64	139	4.31
22	131	5.4	134	4.53	153	3.52	148	4.05	159	4.92	150	9.47
23	133	5.84	135	6.11	139	6.08	141	8.98	141	2.16	141	2.99
24	225	0.47	225	0.47	225	0.46	224	0.66	224	0.47	224	0.57

TABLE 2-7. COAL CREEK, ESP NO. 1, PRIMARY VOLTAGE (AC VOLTS)

Field	Day											
	<u>June 21</u>		<u>June 22</u>		<u>June 23</u>		<u>June 24</u>		<u>June 26</u>		<u>June 27</u>	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
1	138	10.9	143	8	153	8.14	179	8.72	165	6.65	159	7.3
2	276	8.13	279	5.95	292	7.37	284	5.74	299	2.83	302	3.14
3	226	2.14	226	3.42	224	1.71	229	1.38	228	0.57	227	1.16
4	125	5.02	123	6.15	126	4.29	118	4.55	131	2.79	131	2.42
5	270	5.16	270	3.7	275	8.4	289	3.82	289	3.2	279	3.8
6	225	5.95	226	3.8	238	4.42	239	2.54	244	3.02	244	2.37
7	271	5.22	273	3.09	276	7.59	285	3.35	289	1.94	282	3.45
8	8.75	0.43	8.56	0.5	8	0	8.09	0.51	8.44	0.5	8	0.43
9	256	4.82	259	3.25	258	7.48	266	2.7	268	4.45	260	2.57
10	254	5.8	252	3	256	2.82	254	3.22	260	2.45	268	2.93
11	255	5.05	253	3.68	252	7.35	262	2.37	262	1.63	255	2.5
12	262	4.32	258	5.1	260	4.25	256	4.93	260	3.18	265	5.69
13	199	5.09	202	2.62	203	6.55	205	5.57	209	4.32	207	7.16
14	421	14.9	428	13.9	446	1.87	447	2.27	447	1.15	448	2.48
15	269	4.41	272	4.03	284	8.45	287	3.86	295	4.54	292	2.67
16	305	1.8	307	2.45	306	1.73	308	1.08	308	0	301	27.8
17	247	4.13	247	3.85	256	7.02	255	4.71	266	3.59	262	3.82
18	304	1.26	305	0.68	306	1.37	308	0.83	308	2.17	309	0.9
19	264	5.48	266	5.33	272	8.03	272	5.51	284	2.3	282	5.69
20	310	1.38	309	1.52	308	0.99	305	1.29	309	0.67	307	1.23
21	269	5.52	272	4.87	274	8.24	275	2.93	284	1.37	279	6
22	249	4.09	250	2.28	265	2.32	257	2.46	270	2.08	260	3.16
23	269	5.49	269	5.85	272	5.01	274	2.53	275	2.66	274	2.38
24	295	0.64	294	0.5	293	1.14	290	0.66	292	0.31	292	1.21

TABLE 2-8. COAL CREEK, ESP NO. 1, SECONDARY CURRENT (MILLIAMPERES)

Field	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
1	10.1	4.97	11.4	5.52	17.5	5.63	36.4	3.7	29	5.73	22.1	4.17
2	184	15.2	202	12.9	227	17.6	220	12.5	264	9.76	277	13.2
3	59.6	0.95	65.9	4.75	56.9	3.05	73.5	4.42	66.9	3.54	65.1	3.68
4	8.67	2.09	8.89	1.29	8.64	1.76	7.82	2.69	9.78	1.4	11.1	1.24
5	174	13.6	184	7.69	197	24.8	247	11.9	238	7.91	215	9.4
6	169	16.3	179	10.1	212	16.1	232	10.5	245	8.9	236	6.96
7	301	16.9	315	8.5	310	29.7	365	15.3	368	12.7	337	11.4
8	120	1.09	123	2.53	121	3.76	132	3.13	130	2.79	124	1.93
9	361	10.3	372	9.46	345	20.8	362	11	357	9.12	325	9.49
10	306	17.1	302	11.1	310	12.4	310	11.3	339	9.41	362	11.7
11	549	18.5	539	19.9	517	29.7	542	15.2	530	11.9	496	17.9
12	517	19.1	491	25.9	483	14.7	458	18.4	460	21	498	13.1
13	65.4	4.97	71.9	2.33	67.1	7.7	76.9	3.34	77	3.37	76.7	4.27
14	829	77.3	912	63.8	985	9.3	1024	17.2	1012	6.69	1025	20.4
15	330	21.3	354	16.8	405	41.6	437	14.6	473	16.8	450	13.9
16	544	11.6	566	8.82	576	16.2	614	5.64	616	5.61	622	5.51
17	281	16.4	291	11.8	327	28.3	346	13.3	377	14.1	358	15.7
18	640	1.19	639	1.26	640	0	640	0	641	1.57	640	0.57
19	312	19.1	321	20.7	346	33.7	369	10.6	406	8.77	393	21.1
20	831	5.48	832	3.68	830	7.07	828	5.52	835	3.08	828	4.67
21	552	36.5	576	28.2	596	53.8	627	14.4	668	10.9	651	22.3
22	532	25.3	550	14.9	639	15.8	614	13	671	16	618	15.1
23	556	29.4	568	32.3	583	30.9	599	31.1	592	11.4	591	16.6
24	1089	4.97	1085	2.57	1074	2.22	1070	3.22	1070	2.79	1067	5.56

TABLE 2-9. COAL CREEK, ESP NO. 1, SECONDARY VOLTAGE (KILOVOLTS)

Field	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
1	40.8	1.74	41.5	1.06	43.8	1.51	46.5	1.44	44.5	1	43.9	1.15
2	50	0.82	50	0.4	51.5	0.46	50.6	0.43	51	0.2	51.2	0.7
3	53.3	0.52	53.1	0.44	54.5	2.75	56.5	4.53	53.8	0.11	53.7	0.17
4	37.3	1.32	36.5	1.57	37.4	0.95	35.6	1.42	38.8	0.62	38.1	1.22
5	48.2	0.59	48.2	0.45	49.1	0.72	49.8	0.39	50	0.33	48.9	0.62
6	50.5	0.95	50	1.17	52.3	0.52	52	0.52	52.8	0.63	52.8	0.54
7	50.6	0.65	50.7	0.54	51.6	0.63	53.1	2.99	52.6	0.27	51.9	0.5
8	53.3	0.27	53.2	0.5	53.6	0.07	53.7	0.17	53.8	0.1	53.8	0.11
9	46.4	1.02	46.9	0.61	47.4	1.02	48.7	0.31	49	0.57	48.1	0.43
10	46.8	0.76	46.8	0.43	47.7	0.19	47.6	0.29	48.1	0.33	48.7	0.32
11	45.3	0.84	45.2	0.31	45.9	1.07	47.6	0.36	47.8	0.19	46.5	0.71
12	43.2	0.46	43.1	0.3	43.6	0.56	41.1	8.59	44.1	0.13	44.3	0.71
13	39.2	0.6	39.4	0.34	40	0.45	39.7	0.75	40.3	0.82	39.2	3.41
14	50.9	0.84	51.2	0.95	52.5	0.23	52.6	0.25	52.8	0.13	52.6	0.23
15	46.9	0.58	47.1	0.39	48.6	0.72	48.5	0.38	49.4	0.54	49	0.24
16	53	0.39	53.2	0.34	53.5	0.15	55.4	3.96	53.6	0.23	53.7	0.15
17	46.9	0.46	46.7	0.42	47.9	0.61	47.5	0.54	48.8	0.4	48.4	0.43
18	53.4	0.27	53.5	0.16	53.6	1.29	53.7	0.25	53.8	0.21	53.6	0.27
19	45	0.61	45.2	0.43	46.1	0.81	45.8	0.61	47.3	0.26	46.8	0.65
20	51.2	0.48	51.2	0.36	51.5	0.14	51.1	0.39	51.7	0.11	51.4	0.22
21	49.7	0.63	50	0.53	50.5	0.79	51.1	2.85	51.4	0.2	50.8	0.7
22	41.1	0.58	41.4	0.31	43.4	0.26	42.5	0.21	44	0.24	42.8	0.41
23	51.3	0.8	51.5	0.78	52.6	0.64	52.6	0.25	53.1	0.48	52.7	0.25
24	49.9	0.49	49.6	0.29	50.3	0.12	49.9	0.23	50.4	0.03	50	0.25

TABLE 2-10. COAL CREEK, ESP NO. 1, POWER (KILOWATTS)

Field	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
1	0.38	0.2	0.44	0.23	0.72	0.26	1.65	0.22	1.23	0.27	0.92	0.21
2	9.19	0.89	10	0.7	11.6	0.99	11.1	0.69	13.4	0.51	14.1	0.57
3	3.13	0.07	3.46	0.26	3	0.18	3.91	0.26	3.53	0.18	3.44	0.19
4	0.28	0.1	0.28	0.04	0.27	0.09	0.22	0.09	0.32	0.06	0.36	0.05
5	8.32	0.74	8.81	0.41	9.61	1.37	12.2	0.64	11.9	0.42	10.5	0.56
6	8.48	0.95	8.89	0.61	11	0.95	12	0.62	12.9	0.61	12.4	0.47
7	15.2	1.03	15.9	0.56	16	1.73	19	0.86	19.3	0.7	17.4	0.72
8	6.33	0.08	6.51	0.18	6.42	0.21	7.04	0.17	6.94	0.18	6.63	0.11
9	16.7	0.71	17.4	0.62	16.3	1.36	17.6	0.57	17.4	0.58	15.6	0.55
10	14.2	0.98	14.1	0.63	14.7	0.63	14.7	0.59	16.2	0.51	17.6	0.68
11	24.8	1.22	24.3	1	23.7	1.9	25.7	0.83	25.3	0.59	23	1.02
12	22.3	0.96	21.1	1.25	21	0.89	20	0.98	20.3	0.94	22	0.89
13	2.52	0.21	2.8	0.12	2.64	0.33	3	0.15	3.08	0.19	3.03	0.2
14	42.2	4.61	46.7	4.08	51.6	0.59	53.8	1.04	53.3	0.46	53.9	1.11
15	15.4	1.17	16.6	0.92	19.7	2.33	21.2	0.83	23.3	1.05	22	0.78
16	28.8	0.77	30.1	0.64	30.8	0.93	32.8	0.31	33	0.35	33.3	0.33
17	13.1	0.89	13.6	0.63	15.6	1.56	16.4	0.74	18.3	0.8	17.3	0.88
18	34.1	0.21	34.2	0.16	34.2	0.12	34.3	0.15	34.4	0.19	34.2	0.19
19	14	1.06	14.5	1.04	15.9	1.86	16.9	0.63	19.2	0.5	18.3	1.25
20	42.5	0.61	42.6	0.45	42.6	0.45	42.3	0.52	43.1	0.19	42.5	0.35
21	27.4	2.17	28.8	1.71	30.1	3.22	31.4	0.95	34.3	0.65	33.1	1.47
22	21.8	1.35	22.7	0.77	27.7	0.82	26.1	0.67	29.5	0.84	26.4	0.87
23	28.5	1.93	29.3	2.11	30.6	2.05	31.9	0.84	31.4	0.87	31.1	1.01
24	54.3	0.48	53.8	0.37	54	0.12	53.3	0.38	53.9	0.15	53.3	0.5

TABLE 2-11. COAL CREEK, ESP NO. 1, PRIMARY CURRENT (AC AMPERES)

Field	Day											
	June 21	June 22	June 23	June 24	June 26	June 27						
	Avg.: SD:	Avg.: SD:	Avg.: SD:	Avg.: SD:	Avg.: SD:	Avg.: SD:						
25	80.9 2.6	83.1 2.09	78 2.95	81.9 1.08	79.3 0.94	80.9 1.78						
26	55.8 2.3	56.5 1.58	57.5 2.27	60.1 0.67	61.1 1.1	61.2 0.94						
27	176 7.69	175 7.26	188 9.27	189 41.2	212 3.25	208 5.94						
28	2 0	2 0	2 0	2 0	2 0	2 0						
29	152 6.32	156 5.02	159 4.98	168 1.4	167 2.26	167 3.42						
30	8.75 6.81	7 0.71	10.9 3.29	10.2 5.22	18 11.9	17.3 8.48						
31	173 15.5	177 8.76	184 12.6	200 9.29	195 7.3	197 13.3						
32	78.3 4.64	79.1 4.99	90.6 9.45	105 2.83	114 3.11	104 3.39						
33	222 3.35	224 0.71	223 0.64	224 1.08	223 0.68	224 0.64						
34	91.3 3.96	96.8 5.43	100 4.94	104 1.05	102 2.58	107 7.2						
35	225 0.28	225 0.33	225 0.29	224 0.5	224 0.79	225 0.39						
36	151 5.41	147 8.48	159 10.7	165 7.5	175 4.78	166 8.28						
37	8 0.82	7.5 0.71	7.09 0.67	8.09 0.29	7.33 0.47	7.73 0.45						
38	16.3 0.62	16.4 0.48	12.2 0.39	13.5 0.5	12.4 0.5	12.7 0.45						
39	7.58 0.76	7.63 0.48	6.64 0.88	8.27 0.62	8.33 0.67	8.27 1.05						
40	43.1 1.71	41.1 1.27	33.1 1.38	38.7 1.21	36.6 0.68	37.6 1.15						
41	16.4 3.09	16.3 2.77	13.8 2.72	17.5 2.27	18.2 0.42	17.4 1.55						
42	60.3 2.59	62.3 2.17	52.1 1.38	53.2 1.34	48.9 0.74	45.2 9.94						
43	13.4 0.49	13.5 0.5	12.5 0.66	14 0	14 0	14.8 2.92						
44	29.7 2.39	30.8 2.17	24.4 0.77	25.8 0.39	25.3 1.7	24.5 0.78						
45	58.4 3.88	56.8 1.71	58.5 4.34	67.5 1.97	70 3.16	68.1 2.47						
46	101 6.31	95 5.83	91.7 3.91	90.5 6.42	97 4.32	95.7 5.46						
47	99.1 3.88	95.3 2.22	92.3 3.31	96.3 2.56	98.1 2.51	100 2.61						
48	132 5.76	133 3.34	134 3.19	132 2.93	131 2.6	127 2.78						

TABLE 2-12. COAL CREEK, ESP NO. 2, PRIMARY VOLTAGE (AC AMPERES)

Field	Day											
	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
25	285	2.33	285	2.26	281	2.06	283	0.94	281	0.83	282	0.83
26	221	6.41	228	5.36	235	4.66	241	1.3	241	2.9	240	3.14
27	324	6.37	323	5.45	333	5.85	338	3.05	337	32.2	345	4.52
28	31.4	1.75	31.4	1.32	32.3	0.62	32.4	2.14	32.6	2.17	33.2	2.25
29	316	5.06	318	3.91	320	4.45	324	1.64	324	3.28	324	3.74
30	122	27	124	2.69	142	17	139	22.7	163	41.5	165	35.6
31	304	11.5	307	6.16	312	8.82	321	6.44	319	5.58	321	9.14
32	255	4.69	255	5.85	265	9.15	277	4.22	285	3.6	273	3.09
33	333	2.9	333	1.54	334	1.04	332	1.47	335	0.83	334	1.21
34	287	5.82	292	6.4	294	5.28	298	1.56	298	3.71	297	8.18
35	201	0.47	201	0.33	201	0	199	1.16	201	0.31	201	0
36	301	4	296	7.09	305	7.41	308	6.53	318	3.47	309	5.76
37	181	7.03	180	4.74	186	2.89	191	1.47	190	1.76	190	1.56
38	223	4.04	223	1.36	213	1.3	216	0.57	214	1.29	214	1.44
39	158	6.95	159	4.44	156	5.24	166	4.43	161	6.87	161	7.84
40	248	3.02	244	1.94	234	1.8	240	1.29	238	0.94	239	1.34
41	204	13.4	201	11.5	194	12.1	200	11.3	210	1.05	211	13.1
42	262	2.02	261	2.74	254	1.37	255	1.56	251	2	245	21.8
43	177	0.71	176	0.99	174	1.48	177	0.9	177	0.94	181	13.1
44	227	2.11	227	2.17	221	0.79	222	0.39	223	2.31	222	1.23
45	244	5.15	241	2.4	244	3.77	252	3.2	255	5.43	255	3.69
46	265	4.75	260	3.6	260	3.6	267	4.91	276	3.3	272	3.65
47	269	5.24	266	1.76	267	3.73	271	2.27	275	2.57	276	5.53
48	261	5.04	260	2.47	261	4.05	267	2.08	268	2.21	264	2.66

TABLE 2-13. COAL CREEK, ESP NO. 2, SECONDARY CURRENT (DC MILLIAMPERES)

Field	Day											
	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
25	347	12.4	357	10.6	331	14.2	350	4.76	337	4.18	346	9.88
26	255	15.8	268	15	279	17.8	305	6.43	307	8.41	311	12.9
27	814	42.1	809	41.2	874	51.1	942	20.4	993	15.6	972	28.8
28	0	0	0	0	0	0	0	0	0	0	0	0
29	695	36.5	713	30.2	664	209	776	8.33	773	11.3	773	17.9
30	21.7	24.8	14	2.24	26.7	12.1	25.3	19.1	55	45.2	52.1	31.2
31	864	92.9	889	48.3	917	73.7	1010	51.6	985	41.3	995	72.3
32	308	19.9	312	22.4	362	44.3	428	13.6	473	15.9	421	17.1
33	1088	18.5	1092	7.38	1089	6.08	1087	4.92	1091	4.57	1086	5.69
34	533	7.95	538	6.65	542	5.75	548	1.92	548	3.98	542	9.57
35	1042	2.72	1037	1.8	1034	1.53	1030	2.78	1034	4.67	1030	4.69
36	669	28.8	645	46.8	713	60.4	745	41.2	800	28.6	749	45.7
37	8.08	1.8	7.13	1.54	3.18	1.9	9.82	0.72	4.56	1.83	6.36	1.97
38	39.7	1.25	38.9	1.36	29.5	0.78	30	0	30	0	29.7	0.86
39	17.9	2.87	17.9	2.32	13.5	1.62	18.8	2.52	18.9	2.85	17.8	3.69
40	118	5.2	113	3.33	82.8	3.49	103	4.09	92.2	2.74	96.9	5.48
41	62.1	14.8	61.3	13	47.4	12.4	65.4	11.7	68.8	1.69	78.2	35.2
42	247	12.9	255	11.1	205	5.99	209	7.24	191	3.46	175	44.8
43	35.8	2.11	36.3	2.9	31.9	2.78	40	0	39.4	0.83	39.6	7.43
44	82.5	5.65	85.6	7.23	65.2	3.21	70.5	0.89	69.3	7.57	65.7	3.44
45	188	15.2	181	6.28	186	16	221	8.36	240	30.4	222	9.32
46	355	25.2	329	23.7	314	14.9	310	24.6	325	38.3	318	36.1
47	305	13.4	290	7.84	278	12.3	292	8.76	298	9.09	306	10.5
48	462	23.9	465	12.9	465	13.6	460	11.6	456	10.1	440	10.9

TABLE 2-14. COAL CREEK, ESP NO. 2, SECONDARY VOLTAGE (KILOVOLTS)

Field	Day											
	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
25	53.8	0.16	53.7	0.24	53.9	0.03	53.9	0.11	54	0.04	53.9	0.13
26	51.6	0.72	51.6	0.76	53.1	0.36	53.4	0.11	53.4	0.21	52.8	0.49
27	47.9	0.65	47.9	0.52	49.3	0.52	49.7	0.37	50.9	0.39	50.3	0.53
28	7.96	0.52	7.91	0.38	7.9	0.17	7.89	0.64	7.99	0.69	7.91	0.63
29	51.8	0.62	52	0.49	52.8	0.47	53	0.28	53	0.43	53	0.51
30	33.2	4.31	34.4	0.64	37.1	2.8	36.6	3.76	40.1	6.1	40.3	5.59
31	46.9	1.25	47.6	0.72	49	0.9	49.6	0.72	49.7	0.69	49.9	1.17
32	49.3	0.83	49.5	0.59	50.7	0.74	51.5	0.53	52.1	0.33	50.9	0.37
33	51.1	0.58	51.5	0.09	52.6	0.15	51.8	0.28	52.7	0.19	52.5	0.31
34	51.8	0.71	52.3	0.53	52.6	0.47	53	0.23	53.2	0.43	52.6	0.87
35	44.4	0.05	44.4	0.03	44.4	0.04	44.4	0.03	44.4	0.04	44.4	0
36	49	0.53	48.6	0.85	50.2	0.73	50.3	0.91	51.4	0.4	50.5	0.6
37	50.4	1.64	50.3	1.06	52.7	0.54	53.2	0.39	53.5	0.35	53.2	0.45
38	53.5	0.62	53.6	0.15	53.9	0.04	53.9	0.09	53.8	0.21	53.8	0.16
39	39	1.29	39	0.99	39.2	0.76	40.4	0.71	39.7	1.68	39.6	1.15
40	53.4	0.39	53.3	0.27	53.8	0.06	53.8	0.11	53.8	0.14	53.8	0.11
41	51.8	2.18	51.3	1.72	51.6	1.75	51.4	1.98	53.6	0.19	53.1	0.63
42	52.7	0.31	52.4	0.5	53.3	0.17	53.6	0.15	53.4	0.54	53.6	0.16
43	53.7	0.35	53.7	0.12	53.8	0.09	54	0.09	53.9	0.05	54	0.05
44	53.6	0.22	53.7	0.24	53.8	0.08	53.9	0.09	54	0	53.9	0.13
45	45.3	0.52	45.1	0.33	45.8	0.2	46.2	0.46	46.7	1.2	46.7	0.5
46	46.5	0.81	46.3	0.31	47.2	0.44	48.5	0.5	49	1.05	48.5	1.1
47	46.5	0.93	46.4	0.46	47.6	0.27	47.7	0.26	48.2	0.28	48.4	0.63
48	46.7	0.96	47	0.43	48.1	0.48	49.1	0.17	49.1	0.32	48.8	0.48

TABLE 2-15. COAL CREEK, ESP NO. 2, POWER (KILOWATTS)

Field	Day											
	June 21		June 22		June 23		June 24		June 26		June 27	
	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:	Avg.:	SD:
25	18.6	0.71	19.1	0.63	17.8	0.77	18.9	0.27	18.1	0.24	18.6	0.52
26	13.1	0.97	13.8	0.92	14.8	1.04	16.2	0.34	16.3	0.47	16.4	0.68
27	39	2.54	38.7	2.34	43.1	2.96	46.7	1.31	50.4	1.16	48.9	1.89
28	0	0	0	0	0	0	0	0	0	0	0	0
29	36	2.31	37.1	1.9	38.4	1.84	41.1	0.64	41	0.87	41	1.3
30	0.78	1.22	0.43	0.08	0.99	0.55	0.95	0.96	2.42	2.43	2.24	1.58
31	40.6	5.36	42.3	2.93	45.4	4.46	50.1	3.27	48.9	2.73	49.7	4.73
32	15.1	1.08	15.4	1.29	18.3	2.51	22	0.87	24.6	0.95	21.4	0.96
33	55.6	1.51	56.2	0.44	57.2	0.45	56.2	0.54	57.4	0.36	57	0.47
34	27.6	0.79	28.1	0.65	28.5	0.56	29	0.23	29.2	0.44	28.5	0.96
35	44.7	5.02	46	0.1	45.9	0.07	45.7	0.15	45.9	0.16	45.7	0.21
36	33.6	4.1	31.4	2.81	35.8	3.57	37.4	2.67	41.1	1.75	37.8	2.74
37	0.36	0.09	0.31	0.08	0.15	0.11	0.48	0.04	0.2	0.11	0.3	0.1
38	2.08	0.06	2.04	0.07	11.1	30	1.6	0	1.59	0.03	1.47	0.34
39	0.64	0.11	0.65	0.1	0.48	0.08	0.72	0.11	0.69	0.12	0.66	0.15
40	6.25	0.3	5.98	0.19	4.41	0.18	5.48	0.23	4.92	0.13	5.17	0.3
41	3.18	0.86	3.1	0.73	2.54	0.94	3.34	0.72	3.62	0.1	4.1	1.9
42	13	0.64	13.3	0.61	10.9	0.35	11.1	0.38	9.04	3.17	9.31	2.4
43	1.86	0.13	1.89	0.16	1.69	0.13	2.1	0	2.08	0.04	2.08	0.41
44	4.38	0.31	4.24	0.89	3.45	0.18	3.59	0.48	3.7	0.42	3.48	0.17
45	8.47	0.75	8.1	0.28	8.45	0.76	12.9	8.71	11.2	1.72	10.3	0.54
46	16.5	1.26	15.2	1.11	14.8	0.73	15	1.3	15.9	2.15	14.9	2.49
47	14.1	0.9	13.4	0.41	13.2	0.65	13.9	0.41	14.3	0.51	14.7	0.61
48	21.6	1.37	21.8	0.66	22.3	0.82	22.5	0.63	22.4	0.58	21.4	0.69

TABLE 2-16. RUN-OF-MINE LIGNITE CHARACTERISTICS ON SAMPLING DAYS, COAL CREEK UNIT 1^(a)

Date	Moisture		Ash		Heat Content			Sulfur		
	Percent Moisture (Total)	Percent Moisture (Air Dried)	Percent Ash (As received)	Percent Ash (Dry Basis)	Btu/lb (As received)	Btu/lb (Dry Basis)	Btu/lb (Moisture and Ash Free)	Percent Sulfur (As Received)	Percent Sulfur (Dry Basis)	Percent Soluble Sodium in Ash
June 21, 1993	36.82	31.35	11.28	17.85	6378	10095	12287	0.78	1.23	0.70
June 22, 1993	38.14	32.61	8.93	14.44	6356	10275	12009	0.60	0.96	0.73
June 23, 1993	38.42	33.50	10.09	16.38	6217	10095	12073	0.58	0.94	0.95
June 24, 1993	38.30	33.39	11.78	19.10	5977	9688	11975	0.57	0.92	1.09
June 26, 1993	38.88	35.20	10.51	17.19	6180	10110	12209	0.86	1.40	0.67
June 27, 1993	39.29	35.32	9.94	16.38	6274	10334	12358	0.95	1.57	0.65

(a) Results provided by Coal Creek.

Figure 2-1. Process Flow Diagram and Sampling Locations for the Coal Creek Station Unit No. 1

Figure 2-2. Location of numbered fields in Coal Creek ESP

Coal Creek No. 1

Figure 2-3a. Lignite feed rate on organic sampling days.

Coal Creek No. 1

Coal Creek #1

Figure 2-4a. Load and steam flow on organic sampling days.

Coal Creek #1

Figure 2-4b. Load and steam flow on inorganic sampling days.

Coal Creek No. 1

Figure 2-5a. Excess O₂ at furnace outlet and stack on organic sampling days.

Figure 2-5b Excess O₂ at furnace outlet and stack on inorganic sampling days.

Coal Creek No. 1

Figure 2-6a. SO₂ and NO_x emissions on organic sampling days.

Figure 2-6b. SO₂ and NO_x emissions on inorganic sampling days.

Coal Creek No. 1

Figure 2-7a. Opacity on organic sampling days.

Coal Creek No. 1

Figure 2-7b. Opacity on inorganic sampling days.

Figure 2-8a. FGD system temperatures on organic sampling days.

Coal Creek No. 1

Figure 2-8b. FGD system temperatures on inorganic sampling days.

3.0 SAMPLING

3.1 Field Schedule

3.1.1 Overall Schedule

The overall schedule of the field effort at Coal Creek is illustrated in Table 3-1, which lists the dates and activities for the entire period that project staff were on-site at Coal Creek. As Table 3-1 indicates, the actual sampling at Coal Creek took place on six days, June 21-24, 26, and 27. Those 6 days comprised three 2-day sampling sets. Within each 2-day set, flue gas sampling on the first day was devoted to measurement of organic constituents, and on the second day to measurement of inorganic constituents. The three "organic" sampling days were June 21, 23, and 26; the "inorganic" sampling days were June 22, 24, and 27. Details on the types of sampling conducted and the number of samples obtained are presented in the next section of this report. The collection of process (i.e., solid and liquid) samples did not vary from day to day, but the analyses subsequently conducted on those samples did vary. Process samples collected on "organic" days were analyzed for organic constituents; those collected on "inorganic" days were analyzed for inorganic constituents.

3.1.2 Daily Schedules

On each organic sampling day, sampling was conducted for semivolatile organic compounds (SVOC) for approximately 6 hours while traversing the duct with a Modified Method 5 train. Three canister samples were collected for volatile organic compounds (VOC) at each flue gas location for about 30 minutes each. A set of three volatile organic sampling train (VOST) samples was also collected in parallel with the canister collections, for 5, 10, and 30 minutes. An impinger train was used to collect samples for aldehydes for 1 hour. Flue gas particulate matter was measured on each organic day at Location 4b.

On the inorganic days, sampling was conducted for both gas and solid phase elements for about 6 hours while traversing the duct. A hazardous element sampling train (HEST)

was used to collect vapor phase arsenic, selenium, and mercury over a 4-hour period by a carbon impregnated filter. Meanwhile at another port three impinger trains were used consecutively to collect acid gases/anions, ammonia, and cyanide. Flue gas particulate matter, elements, and volatile metals were measured on each inorganic day at Location 5b.

The sampling plan described planned daily sampling schedules that were coordinated among all the sampling locations, so that flue gas methods were conducted simultaneously at all locations. In practice, strict coordination of sampling methods in the field is difficult, because of the different constraints in sampling at different locations, difficulties in communications, and the need to conduct multiple sampling methods at each site simultaneously. Nevertheless, reasonable coordination of flue gas methods was achieved at Coal Creek. Figures 3-1a to 3-1f show the actual schedules of flue gas sampling on the six sampling days at Coal Creek. The daily schedules are arranged chronologically, i.e., Figures 3-1a to 3-1f correspond to June 21-24, 26, and 27, respectively.

The corresponding daily schedules of solid/liquid sample collection are shown in Figures 3-2a through 3-2f, which represent June 21-24, 26, and 27, respectively. Boiler feed coal and run-of-mine coal were collected by Coal Creek personnel. Bottom ash samples were collected twice daily by Coal Creek personnel and composited into a single sample. The schedules that Coal Creek staff followed in these sample collections were generally coincident with the flue gas sampling, but were not explicitly recorded. As a result, the times of collection of those samples are shown as "estimated" in Figures 3-2a to f. Economizer ash, pyrite rejects, and lime samples were collected once a day. Pyrite rejects were also collected by Coal Creek personnel. ESP ash samples were collected once a day from rows 1 and 2, and sometimes from row 3. Very little sample was obtained from row 3 hoppers. No sample was ever obtained from rows 4, 5, and 6 of the ESP. One sample a day was collected from each of the liquid sampling locations except where noted. Liquid sample collections generally took place early in each sampling day. It should be noted that all ash hoppers (bottom ash, ESP, pyrite rejects, economizer) were emptied on the morning of each sampling day before sampling began. Thus the ash samples from each day represent ash that collected in the various hoppers over periods of no more than a few hours during the daily sampling schedule.

3.1.3 Deviations and Modifications to Schedule

Some delays and problems were encountered in the field at Coal Creek that required either additional effort or deviations from the sampling plan. A problem was caused by the complete blockage of the sampling ports at both ESP outlet ducts (Locations 5a and 5b). Each of those ducts was fitted with eight ports, which were found on inspection to be completely plugged with a concrete-like material formed from the fly ash. Because the flue gas at those locations is at positive pressure and very wet, the sampling ports act as cold spots and promote the condensation of water and consequent formation of the hard material. Battelle staff used pipes, an electric jackhammer, and tools fabricated on the spot in the plant shop to open the plugged ports. This effort required about a day and a half and diverted effort from installation of equipment at the two locations. This delay led to other delays in other activities because time spent opening ports on June 19 and 20 could not be used for a final equipment setup, collecting method blanks, and conducting dry runs. This necessarily led to slower performance of sampling in the first days of the program.

The onset of sampling on the first day of sampling (June 21) was also delayed by over half a day for modification of the crane provided by Coal Creek to lift the 16-foot sampling probe in vertical traverses at Location 5a. That crane was put in place 2 days earlier, but was found to be about 18 inches too low to provide complete clearance of the probe in changing ports. Raising the crane took fully half the day on June 21 and delayed the start of sampling that day.

Field sampling at the outdoor locations (5a and 5b) was made difficult due to highly variable weather conditions, and a contingency day was required on June 25 due to severe winds (see below). The following are deviations or modifications to the planned sampling schedule at Coal Creek:

- (1) The plan calls for two collections each day from the first two rows of the electrostatic precipitator and one collection from half of the hoppers in each of the last four rows. Because of the long time periods required for the last four rows to collect material combined with the sequence of dumping hoppers, Battelle and the DOE representative decided that only one sample would be collected each day from the first two rows. See Section 3.2.4 of this report for more detail on efforts to obtain ESP samples.

- (2) On Thursday, June 24, very high winds were experienced at the plant. Although most sampling was completed, the increasing winds made further work atop the duct at Location 5a dangerous. For that reason, sampling at 5a was discontinued after the acid gas (Method 26A fluoride/chloride) sample. The ammonia and cyanide samples were collected on the next sampling day. (These samples were collected on Saturday, June 26.)
- (3) Also on June 24, the particulate mass sampling at the parallel ESP outlet location (Location 5b) was shortened because of the winds. The hand-operated hoist used at that location was on wheels and was unstable in the high winds. For safety reasons, the particulate measurement was stopped before sampling the last port at the downwind edge of the duct. The other seven ports at that location were sampled with full isokinetic traverses so the sample is considered representative, and no attempt was made to make up the sampling at the last port.
- (4) On Friday, June 25, the high winds experienced on the previous day continued. The personnel conducting sampling at Location 5a found some equipment blown over when they arrived at the site. Due to the continuing extreme gusty winds, they requested that they not be required to sample. After checking weather forecasts for the next few days, Battelle's Field Sampling Manager and DOE On-Site Representative decided to cancel sampling for the day. This decision was approved in discussions with Battelle's Project Manager and with DOE's Contracting Officer's Representative. The fifth sampling day was Saturday, June 26, and the sixth day was Sunday, June 27. The rescheduling of these last 2 days was discussed with Coal Creek staff, who provided constant load on both days.

3.2 Samples Collected

3.2.1 Types and Numbers of Samples

The primary kinds of chemicals measured in various flue gas, solid, and liquid samples from Coal Creek are summarized in Table 3-2. That table shows the chemicals measured, and also provides indication of the sample matrices from which samples were collected. More detail on the sampling and analysis conducted for Coal Creek is given in Tables 3-3 and 3-4, which show the constituents measured in samples from the solid/liquid and flue gas locations, respectively. The sampling locations are numbered in Tables 3-3 and 3-4 as was indicated in Figure 2-1 and Table 2-1.

The methods used to collect samples from flue gas streams are summarized in Table 3-5. The sampling methods are described in detail in the QAPP. Size-fractionated particle samples were collected in the Multi-Metals and Modified Method 5 trains at Locations 4a and 5a. Glass cyclones with particle diameter cut points of 10 μm and 5 μm were fabricated for this project and were used ahead of the filter in each of these sampling trains at those locations. Glass cyclones were also used in the particulate sampling at Locations 4b and 5b. No cyclones were used at the stack locations (6a,b).

The daily sampling schedule on both organic and inorganic days was essentially the same at all flue gas locations. Thus the numbers of samples collected at each site was nominally the same. The actual numbers of sample runs of various types performed at the Coal Creek flue gas locations are shown in Table 3-6. In some instances, problems in the field led to a sample being missed or lost. Those occurrences and the resulting deviations are described later in this report.

The numbers of solid and liquid samples collected on each day are shown in Table 3-7. For most solid/liquid samples, the number of samples collected was the same every day. The number of ESP ash samples varied depending on the availability of samples from hoppers in row 3. On June 24, no samples could be obtained from Locations 16 and 17a.

3.2.1.1 Flue Gas Streams. Table 3-4 shows the summary of substances measured in samples collected at each of the flue gas sampling locations. As noted above, Locations 4a, 5a, 6a, and 6b were the primary flue gas sampling points. Sampling at Locations 4b and 5b was restricted to particle mass loading and trace element determination (5b only). Sampling at 4b and 5b took place on alternate days, i.e., particulate mass sampling at 4b occurred on the organic sampling days, and particulate mass and trace element measurements were made at 5b on inorganic days. As Table 3-4 indicates, several types of substances were measured using methods that separated vapor- and particulate-phase material in the flue gas. For SVOC and elements the vapor/particle phase distribution was determined. Ammonia and cyanide were measured in the vapor phase only. The particulate filters used with the ammonia and cyanide trains at Locations 4a, 5a, and 6a were used for radionuclide and elemental carbon analyses. Those filters were collected in isokinetic sampling at a single point in the duct. All filters used for all analytes were Pallflex quartz.

In addition to hot flue gas sampling, samples were also collected from the stack (Location 6b) using Chester Environmental's Plume Simulating Dilution Sampler (PSDS). For this project hot flue gas is sampled at about 0.35 dry standard liters/s (0.75 cubic feet per minute), diluted by a factor of 25 to 30 with an oxygen/nitrogen mixture, and then drawn into the respective sample collection trains. The oxygen/nitrogen mixture is at a ratio of 21:79 to simulate pure air. The same measurements were made in the final diluted gas as in the flue gas itself (Table 3-5), however, the PSDS is an isokinetic, nontraversing method. Radionuclide and carbon analyses were not done on samples from Location 6b, since the single 8-in. by 10-in. PSDS filter used each day at that site collected particulate loadings sufficient only for metals and anions analysis.

3.2.1.2 Solid and Liquid Streams. The solid and liquid sampling shown in Table 3-7 was accomplished as follows. Liquid samples from Locations 9-11, 16 and 17 were collected once on each of the six sampling days. Despite heavy rain on one of the sampling days, an insufficient quantity of water was present as coal pile runoff (Location 13) for Coal Creek personnel to collect a sample. Solid samples included coal, ash from combustion, and lime. The frequency of sample collection depended upon the type of sample. Coal Creek personnel provided a single daily sample of run-of-mine coal (Location 14). They also collected on a daily basis a composite sample of pulverized coal (Location 1), by collecting portions of coal once from each of seven coal pulverizers during the period of flue gas measurements each day. Also, they sampled pyrite rejects (Location 7) from each of the seven mills once daily. This sample was collected dry from a pan inserted into the reject hoppers.

A sample of boiler bottom ash was collected by Coal Creek personnel twice each day from each of three chambers at the bottom of the boiler. These samples were combined into a daily composite sample. A sample from each of six economizer hoppers (Location 3) was collected once each day and combined into a daily composite.

The plan called for providing a daily composite ESP hopper ash sample (Location 8) from each of the six rows from ESP #1. Each row contains four hoppers which dump into a closed pneumatic system. Samples were collected from a feeder vessel beneath each ESP hopper and above the pneumatic line. Hoppers from the first three rows were to be sampled

twice a day, and half the hoppers in each of the last three rows were to be sampled once each day. However, during the 6-day period of sampling, no ash was collected from the last three rows because it had not built up to the level of the sampling port in spite of delaying dumping of the hoppers for up to several days. Ash was collected from two hoppers in row 3 on two sampling days: ash was easily collected from the first two rows twice each day.

3.2.2 Compositing Procedures

Solid samples were obtained at Coal Creek in multiple collections during each sampling day, as described above. The purpose of this approach was to obtain samples representative of the range of plant operating conditions that occurred during each sampling day. The multiple samples collected at each solid sampling location on each day were then composited into a single daily sample. Portions of the resulting daily composite samples were then distributed to the various analytical laboratories as needed.

The solid samples from Coal Creek that underwent sample compositing were boiler feed coal (Location 1), bottom ash (Location 2), economizer ash (Location 3), pyrite rejects (Location 7), ESP ash (Location 8), run-of-mine coal (Location 14), and FGD scrubber lime (Location 15). With the exception of the run-of-mine coal samples (Location 14), all compositing was done by the Commercial Testing and Engineering Company (CTE) in Conneaut, Ohio. The run-of-mine coal samples were collected daily by Coal Creek personnel under the direction of Battelle staff. Coal Creek personnel used standard ASTM procedures to compile a daily composite sample of about 3 kg, and provided that daily composite to Battelle. Distribution of the run-of-mine coal for analysis was then done by Battelle personnel in Columbus, Ohio.

Battelle prepared a set of instructions, in the form of tables, for the compositing and apportioning of the samples. These instructions are shown in Table 3-8. Each page of Table 3-8 addresses a different type of solid sample, beginning with the run-of-mine coal, then proceeding through Locations 1, 2, 3, 7, 8, and 15 in order. Shown in these tables are the sample identification, dates, and sample apportioning procedures. With the exception of ESP ash, all the composite samples were prepared from equal quantities of all the individual samples collected on a given day. For ESP ash, composite daily samples were prepared for

each row of ESP hoppers, using equal quantities of each sample from each hopper in that row. The separate row composite samples then underwent separate analyses, as indicated in Table 3-8.

During the compositing the system for identifying the samples was altered, and a composite sample ID was established. Those composite ID's are shown in Table 3-8. The date was kept, although in a slightly different format; however, the sampling site number was replaced with a term descriptive of the source of the sample. Examples of the two sets of ID's are shown in Table 3-9.

Solid samples taken on organic days were analyzed for SVOC. Thus only two portions were made from the samples on these days -- one for the SVOC analysis and the other for an archive. On the inorganic days four to six portions were made from the composites. Analyses for metals were required for the samples taken from each of the seven sampling sites. Most of these analyses were performed by CTE at its laboratory in Denver (CTE-Denver). Metals analysis for the coal samples was shared by CTE-Denver (beryllium and boron), Battelle (chromium, cobalt, nickel, vanadium, molybdenum, sodium, arsenic, antimony, cadmium, and mercury), and Element Analysis Corporation (EA) (the remaining metals). Analyses covering ultimate/proximate, moisture, heat, carbon, sulfur, and particle size were performed by the Conneaut laboratory of CTE. Analyses for chlorine, fluorine, phosphates, and sulfates were performed by Battelle's Columbus Operations (BCO). The International Technology (IT) Corporation ran the radiological (RAD) analysis of the samples for gamma-emitting isotopes. Sample portions analyzed by each of these laboratories are indicated in Table 3-8.

In general, a portion of sample overly sufficient for each analysis was taken from the composite. If the composite contained only a limited amount of material, the amounts allocated for analysis were cut down to the minimum amounts required. If there was insufficient material for even the minimum requirements, then radionuclide and particle size determinations, in that order, were dropped from the schedule. Only for ESP ash was sample size occasionally insufficient. Of the seven ESP ash composite samples collected on the inorganic days, radionuclide analysis was done on three samples, and particle size determination was done on five samples.

3.2.3 Numbers of Analyses

The number and type of analyses conducted on the collected gas, solid, and liquid samples are listed in Table 3-10 according to sampling location and sampling method. The number of samples collected is provided for reference, and discrepancies between number of samples collected and number of samples analyzed are noted as appropriate.

3.2.4 Problems and Deviations in Sampling

The following are the specific deviations from the QAPP that resulted from occurrences at Coal Creek. Also noted are minor changes in sampling procedures that were implemented in the field.

- (1) The plan calls for four impingers to be used in the Modified Method 5 sampling train for semivolatile organic compounds. Five impingers were used in these trains. The five impingers were configured as follows:

- Impinger #1 - deionized water to cover inlet tube
- Impinger #2 - 100 mL deionized water
- Impinger #3 - 100 mL deionized water
- Impinger #4 - empty
- Impinger #5 - one-half full of 3-8 mesh silica gel.

The impingers were recovered as follows:

- Impinger #1 - Weigh and record. Rinse with 50/50 methanol/dichloromethane and add the rinse to the sample.
- Impinger #2 - Weigh and record. Discard the water. Rinse with 50/50 mixture of methanol/dichloromethane.
- Impinger #3 - Weigh and record. Discard the water. Rinse with 50/50 mixture of methanol/dichloromethane.
- Impinger #4 - Weigh and record. Discard the water. Rinse with 50/50 mixture of methanol/dichloromethane.
- Impinger #5 - Weigh and record. Discard into plastic bag for recycling.

- (2) The plan states that on each sampling day for quality control, "leak-check the sampling train before and after any move from one sampling port to another during a run or if a filter change takes place." At Locations 4a, 4b, 5a, and 5b leak checks were performed on a routine basis only before and after each sampling run, not between each port change, since the train was not broken down to make a port change. At Location 6a, the trains needed to be partially broken down to move them between ports. The procedure followed was to "leak-check the train if a filter change takes place or if the train is broken down during moves between ports."
- (3) The sampling plan states that scrubber slurry blowdown samples would be collected at Location 17 downstream of the two reaction tanks. These samples were actually collected from two lines between the scrubber reaction tanks and the spray towers. These samples were designated 17a and 17b, respectively (see Figure 2-1).
- (4) Water samples were not collected at Locations 11 and 12 as listed in the plan. Personnel at Coal Creek determined after the site visit that samples collected at these locations would have the same composition as samples collected at Location 9 (make-up water).
- (5) The plan calls the sample at Location 10 Pond Water. This was called circulating water at the recommendation of Coal Creek staff. The new Location 10 is shown in Figure 2-1. What was shown as Location 10 in the plan is now called Location 11 and is called Scrubber Makeup Water.
- (6) The plan states that make-up water from Location 9, the pond water from Location 10, and the condenser water from Locations 11 and 12 (these were not collected - see item No. 4) would be collected in polyethylene bottles. This is incorrect. The samples from Locations 9 and 10 were collected in glass bottles.
- (7) The plan states that the lime samples from Location 15 would be collected in glass bottles. These samples were collected in polyethylene bottles.
- (8) A deviation from the plan occurred on June 23 and 24 when the sulfur dioxide monitor was calibrated only once. These calibrations were within 10 ppm of the 491 ppm standard. This did not materially affect the calculations of the performance of the flue gas desulfurization system.
- (9) On Monday, June 21, difficulties were experienced at the ESP #1 outlet (Location 5a) in leak checking of the miniature impinger setup used for cooling of the gas going into the Summa cans. Considerable time was expended trying to solve the leak problem, to the point that the canister and VOST samples were being delayed, and rapid shipment of those samples was being jeopardized. At that point, Battelle's Field Sampling Manager decided to cancel the canister sampling at that location on that day. The VOST samples were taken and were shipped on time.

- (10) On Tuesday, June 22, problems occurred in collecting the various impinger samples at the ESP #1 outlet (Location 5a). These difficulties resulted during leak test procedures and were corrected by rerunning the acid gas and ammonia samples. However, due to the extreme length of the sampling day the cyanide sample was not taken. As a result, no filter was collected for carbon and radionuclide analyses from Location 5a on this day.
- (11) The availability of samples from the various rows of the ESP hoppers was less than planned. All hoppers in rows 1 and 2 provided plenty of sample, but little to no sample could be obtained from the later rows. The following is a summary of efforts made to collect samples from all ESP rows.
- a. On June 21 an attempt was made to sample from all hoppers fitted for sampling in all rows. Ash was obtained from seven of eight hoppers in rows 1 and 2, but not from any in rows 3-6.
 - b. At approximately 1800 hours on June 21 rows 3-6 were put on hold; i.e., removed from the normal cycling of dumping, to allow ash to build up in these hoppers.
 - c. Sampling of rows 1 and 2 took place daily and provided good sample collection at all times.
 - d. On June 24 at 1550 row 3 was sampled but no sample could be obtained. Row 3 was put back on hold at 1600 hours.
 - e. At 1400 hours on June 26 row 3 was sampled and samples were recovered from hoppers 3 and 4 but only a trace from hoppers 1 and 2. Rows 4-6 were still on hold since June 21.
 - f. Rows 1-6 were all sampled on June 27. Samples were obtained from rows 1 through 3, but again no samples could be obtained from hopper rows 4-6. This indicates efficient performance of the ESP as a whole.
- (12) After completion of flue gas and process sampling on June 27, one of the ammonia impinger samples from the Chester Environmental hot stack location (Location 6a) was dropped during chain-of-custody transfer to Battelle staff. Battelle's Field Sampling Manager was unaware of the loss of this sample until the next day, at which time preparations to leave Coal Creek made rerunning the sample impossible. As a result, this sample was lost.
- (13) The planned collection of method blanks on June 20 was disrupted by the effort of opening the sampling ports at Locations 5a and 5b. Method blanks for the organic methods were obtained that day, but method blanks for the inorganic methods at the Battelle sites (Locations 4a and 5a) were postponed. These blanks were subsequently overlooked at the end of the study in the

activities of sampling and packing. As a result, the inorganic method blanks for Battelle at Coal Creek were not taken. Method blanks for those methods were obtained for Chester Environmental's locations at Coal Creek.

- (14) On June 24, effort was spent by Chester Environmental staff at Locations 6a and 6b in responding to the needs of the RTI auditors on-site at that time. Specifically, the RTI auditors required that an extra VOST run (i.e., three sets of VOST traps) be taken while sampling from an audit cylinder standard. This procedure was carried out, but took a substantial amount of time. Due to the late hour after completion of this audit, Chester staff requested that the aldehyde runs for this day be postponed. Battelle's Field Sampling Manager agreed, and the aldehyde samples from these sites were run on June 25 from 09:25 to 10:25.
- (15) The sampling plan states that pulverized coal samples would be collected in polyethylene bottles. Coal Creek staff collected each of the samples and sealed them in polyethylene bags.
- (16) Bottom ash samples were collected only once a day from each of three hoppers instead of twice a day.
- (17) Pyrite rejects were collected from seven hoppers once a day. Material was originally collected in an aluminum pan placed directly inside each hopper. Once the pan was full, it was removed and the sample was put into a larger plastic pan to allow for thorough mixing. The sample was quartered and one quarter was put into a glass sample bottle. The rest of the sample was discarded. This procedure differed from that stated in the plan, which involved direct transfer of the sample from the pan to the glass container.
- (18) The sampling plan states that each NUVA feeder below the ESP hoppers would be equipped with a side sampling port and a small cup which would extend into the center. The NUVA feeders were actually modified with a two valve arrangement located near the bottom of the feeder. During the dumping process, the top valve was open to allow sample to flow out of the feeder and into a short section of pipe between the two valves. The top valve was then closed and the bottom valve was opened to allow the sample to flow into the glass sample bottle.
- (19) The plan assumed that a single sample would be collected of each liquid stream once each day. In practice, for the purposes of the various analyses, multiple containers of each liquid sample were collected simultaneously. At each liquid process sampling location (9, 10, 11, 16, 17A, and 17B), the following sample bottles were collected:

- 1 - 4 liter bottle for SVOC analysis (Organic Days - only)
- 1 - 40 mL vial for Anions analysis (Inorganic Days - only)
- 4 - 500 mL bottles for Elements, NH_3 , and CN^- analysis
- 3 - VOA vials for VOC analysis.

- (20) Run-of-Mine coal samples were collected by Coal Creek staff and sealed in polyethylene bags, rather than in polyethylene bottles as stated in the plan.
- (21) The PSDS used a single 8-in. x 10-in. filter upstream of all the sampling trains at Location 6b. The low particulate loadings on those filters did not allow all the desired analyses to be conducted. As a result, PSDS filters from the inorganic sampling days were used for elemental and anion analyses, but no carbon or radionuclide analyses were done on those samples.
- (22) On June 24 no samples could be collected at Locations 16 and 17a despite repeated attempts to do so. No lime slurry was being prepared at the times when sampling personnel visited Location 16 (see Section 2.3.2), and no sample could be obtained from Location 17a. However, a sample of slurry blowdown was collected at Location 17b.
- (23) Because of interference from SO_2 and water, chromatographic analysis of canister samples for VOC could not be accomplished for six early-eluting VOC. The six VOC for which analyses could not be done are the first six listed in the left column of Table 1-6. In addition, hexane was not analyzed in the VOST samples (see Table 1-5).

3.3 Mass Flows

3.3.1 Ash/Solids Mass Balances

Using the data produced by the emissions tests on Coal Creek Unit 1, mass balances were performed on the pulverizer, the boiler, the ESP, the combined boiler and ESP, the scrubber; the combined boiler, ESP, and scrubber system; and the absorber. The term scrubber refers to the total FGD unit, i.e., that part of the system from upstream of the bypass flow split to downstream of the recombination of scrubbed and bypass flows. The term absorber, on the other hand, refers specifically to that portion of the scrubber that conveys the scrubbed flue gas flow (i.e., up to 60 percent of the total flow). Separate mass balances were calculated for each test run.

Assumptions. In performing these calculations, the following assumptions were made:

General:

- It was assumed that the coal fired during each day of the test was of uniform composition, as represented by analysis of the daily coal samples.
- It was assumed that the boiler was operating at constant conditions during each day of the test. This assumption is supported by the plant process data in Section 2.3, which verify that the plant operated at as nearly constant conditions as practical.
- For each test day, it was assumed that samples collected from flue gas streams at any specific time were representative of the flue gas stream being sampled at all times. Thus, only one metals/particulate sample was collected each test day, and these samples were assumed to be representative of conditions throughout the day. Considering the stability of the fuel and the boiler operating conditions, this assumption is reasonable. Also, considering the cost of collecting all samples simultaneously, and the fact that some samples require longer sampling times than others, this assumption was necessary.
- For each test day, it was assumed that samples collected from process streams at any specific time were representative of the process stream being sampled at all times. Thus, only a few process samples were collected each test day from each process stream, and these samples were assumed to be representative of conditions throughout the day. Considering the stability of the fuel and the boiler operating conditions, this assumption is reasonable. Also, considering the cost of collecting all samples simultaneously and more frequently, this assumption was necessary.
- It was assumed that samples collected from both the flue gas streams and the process streams were representative of the stream from which they were sampled. In some cases there is reason to doubt this assumption. For example, particulate samples collected from flue gas flowing in a horizontal duct, where large particles may be present and concentrated toward the bottom of the duct (as at Location 4a and 4b), may not contain a representative fraction of the large particles. However, the limited availability of sampling locations requires this assumption.

Pulverizer Ash Balance:

- The plant system provides no practical means for measuring the flow of material (pyrites) rejected from the pulverizer. Thus, based on data collected at other plants, it was assumed that the pyrite reject stream was equal to 0.2 percent by mass of the incoming coal stream.

- The moisture content of the pyrite rejects was not determined. Because both the pyrite rejects and the pulverized coal have been exposed to the drying environment inside of the pulverizer, it was considered reasonable to assume that the moisture content of the pyrite rejects was the same as that for the pulverized coal. In any case, this assumption has little bearing on the results as the quantity of pyrite rejects is small.

Boiler Ash Balance:

- The plant system provides no practical means for measuring the flow of materials exiting the boiler as bottom ash and as economizer hopper ash. Knowing that the material flow into and out of the boiler must be in balance, it was assumed that the combined flow rates of materials exiting the furnace as bottom ash and economizer hopper ash was equal to the difference between (1) the ash entering the furnace with the coal and (2) the ash exiting the boiler in flue gas particulate.
- Based on generally accepted industry estimates for pulverized-coal-fired dry-bottom boilers, the quantity of ash exiting the boiler as bottom ash was assumed to account for 75 percent of the combined flow of bottom ash and economizer hopper ash.
- Based on generally accepted industry estimates for pulverized-coal-fired dry-bottom boilers, the quantity of ash exiting the boiler as economizer hopper ash was assumed to account for 25 percent of the combined flow of bottom ash and economizer ash.
- The carbon analysis for economizer ash from June 27 was far out of line compared to the results for the other two days, i.e., 14.4 percent carbon as compared to 0.08 and 0.04 percent carbon. As a result, the 14.4 percent value was judged an outlier, and the average of the other two results was substituted for it in all calculations.
- Particulate sampling was not done at the ESP #2 inlet (Location 4b) during the days devoted to the metals runs. Instead, particulate emissions data for that location for each of the metals runs was assumed to be equal to the particulate emissions data for the respective organic runs, conducted on the respective previous days.

ESP Ash Balance:

- The plant system provides no practical means for measuring the flow of material exiting the ESP as collected fly ash. Knowing that the material flow into and out of the ESP must be in balance, it was assumed that the total flow rate of the material from the ESP hoppers was equal to the difference between (1) the particulate entering the ESP with the flue gas and (2) the particulate exiting the ESP with the flue gas.

- Particulate sampling was not done at the ESP #2 inlet (Location 4b) during the metals runs. Instead, particulate emissions data for the ESP inlet for each of the metals runs was assumed to be equal to the particulate emissions data for the respective organic runs, conducted on the respective previous days.
- The plant system provides no practical means for measuring the flow of material exiting individual ESP hoppers as collected fly ash. Thus, it was necessary to make some assumption to permit compositing samples and/or analytical results for the various hoppers into a single value. Unlike some other units, the system at Coal Creek did not permit estimating the relative quantities collected in the various hoppers by measuring the time required to dump the hoppers. Thus, it was assumed that each of the first three rows of hoppers of the ESP was equally efficient at removing fly ash from the flue gas stream; only three of the six rows were used in this evaluation because essentially no material was found to be collected in the last three rows, even over a several-day period. Based on the ash balance, it was calculated that each of the first three rows of the ESP was 86.7 percent efficient, resulting in an overall ESP efficiency of 99.8 percent.

Scrubber System Ash/Solids Balance:

- The fraction of flue gas flowing through the bypass was calculated using gas temperatures and moisture content for the bypass duct, at the absorber tower outlets, and in the stack. This is the same approach used by plant personnel to estimate the bypass flow. It was assumed that the bypass flow rate was constant during each day of the test and that the flow rate was equal to the average bypass flow rate for the day.
- Because a large fraction of the solids entering and exiting the scrubber are not ash but solids associated with the lime used to capture SO_2 , and because it is impossible to separate ash from identical materials present in the lime (e.g., CaO), it was impossible to perform an ash mass balance on the scrubber. Rather, a non-carbon solids mass balance was performed.
- The plant system provides no practical means for measuring the flow of material exiting the absorber system as slurry blowdown. Knowing that the material flows into and out of the absorber system must be in balance, it was assumed that the flow rate of solids exiting the scrubber with the blowdown stream was equal to the difference between (1) the sum of the ash entering the scrubber with the flue gas stream, the solids entering the scrubber with the lime feed stream and makeup water stream, and the SO_2 converted from a gas to a solid (as CaSO_4) in the absorber, and (2) the solids exiting the scrubber with the flue gas stream.
- The plant system provides no practical means for sampling the flow of material exiting the absorber system as slurry blowdown. However, the material exiting the reaction tanks as blowdown is identical in composition to the material

supplied to the absorbers from the reaction tanks. Since sampling ports were available on the lines carrying material from the reaction tanks to the absorbers, these ports were used to collect the equivalent of scrubber blowdown slurry.

- No sample was obtained for the lime feed slurry for the second metals test (June 24), as described in Section 3.2.4. Thus, it was assumed that the composition of the lime feed slurry for the second metals test was equal to the average value for the first and third tests.
- The plant system provides no practical means for measuring the flow of makeup water to the absorber system. Knowing that the water flows into and out of the absorber system must be in balance, the flow rate of water entering the scrubber system as makeup water was calculated as the difference between (1) the water entering the scrubber with the flue gas plus that entering with the lime feed slurry, and (2) the water exiting the scrubber with the flue gas plus that exiting the scrubber in the blowdown stream. As a result of the above described assumptions, the calculation of the slurry blowdown flow rate and the makeup water flow rate are strongly dependent upon the measured solids content of these streams. It should be recognized that it is difficult to obtain representative samples from a slurry stream and, thus, the results may reflect these sampling difficulties.
- The calculated makeup water flow rates (320,000 to 410,000 lb/hr) were somewhat greater than the value of 292,000 lb/hr estimated by the plant. Because of uncertainties regarding the calculated values, the plant estimate was adopted for mass balance calculations.

Ash/Solids Mass Balance Calculations. Tables 3-11 through 3-13 show the mass balance calculations for ash/solids for the three inorganic days. "Solids" is used to describe the mass balance for the scrubber system because it is impossible to differentiate combustion ash versus CaO and other solids entering the system with the lime and makeup water.

Table 3-11 shows the particulate emissions calculations; results calculated in this table served as input to Tables 3-12 and 3-13.

Table 3-12 shows calculations for the scrubber for sulfur, solids, and water. Because of the several liquid streams entering and exiting the scrubber, it was considered necessary to perform a separate calculation on this device. Some results from the scrubber mass balance calculation served as input for the overall ash/solids mass balance calculation shown in Table 3-13.

Table 3-13 shows the mass balance calculations for ash/solids for the three inorganic days. Separate calculations are shown for the pulverizer; the boiler; the ESP; the combined boiler and ESP; the scrubber; the combined boiler, ESP, and scrubber system; and the absorber. The comments column for each table gives details regarding the calculations. Results from the mass balance calculation shown in this table served as input for the element mass balance calculations shown in Section 6.

Tables 3-11 (lines 22 and 23) and 3-13 (lines 86 and 87) indicate the bypass and absorber flow fractions for the scrubber, determined from the flue gas temperature and moisture data. The bypass flow is calculated as 64.4, 58.1, and 54.4 percent for the three inorganic days.

Tables 3-14 and 3-15 show the values of major stream flows at Coal Creek Unit 1 that factor into the mass balance calculations. Table 3-14 shows stream flow values for the three inorganic sampling days, i.e., the days for which mass balance calculations were done. Table 3-15 shows similar information for the organic sampling days. Values for several streams are missing in Table 3-15, because particulate loading in flue gas was not determined on the organic sampling days.

Ash/Solids Mass Balance Results. Table 3-16 summarizes the mass balance results for ash and for solids. The nature of the assumptions that were made in performing the ash balance calculations essentially forced many of the ash/solids balances to show near perfect closure, as can be seen from the calculations reported in Table 3-13. These assumptions were necessary because it was not possible to measure all mass flow rates, and some of the mass flow rates were calculated by differences between the mass flow rates that were measured. Thus, the near perfect closure for the ash mass balances should not be taken as an indicator of the quality of the emissions tests.

Figure 3-3 shows the average ash flows for the entire boiler-ESP-scrubber system. Nearly all (99.7 percent) of the ash emitted by the boiler is captured in the ESP. The absorber appears to capture all remaining particulate in the scrubber inlet stream. It should be noted that the values shown in Figure 3-3 for lime slurry, make-up water, and blowdown are solids, but not necessarily ash. The solids in the lime slurry and the blowdown streams are primarily lime and lime reaction products.

3.3.2 Oxygen in Flue Gas

Table 3-17 gives the daily average flue gas O₂ levels based on plant instruments at the furnace outlet (ahead of the air preheater) and in the stack for the three runs for which coal analyses were available. Also shown in Table 3-17 are the O₂ values measured in conjunction with particulate sampling at the ESP inlet (Locations 4a, 4b), the ESP outlet (Locations 5a, 5b), and the stack (Location 6a). Some discrepancies between particulate sampling O₂ data and plant instrument O₂ data are evident in Table 3-17. For example, at the stack location, the plant data showed only a 5.2 percent O₂ value, while the particulate sampling data showed an 8.0 percent O₂ value.

These plant data suggest that the total air increased by about 14 percent as the flue gas passed through the air preheater, the ESP, and the scrubber unit. A 14 percent total air leakage across the air preheater, ESP, and scrubber unit is believable.

As noted in Section 2.2.1, the O₂ values obtained during sampling were used in a comparison of measured flue gas flow rates to those calculated from theoretical considerations of coal combustion. Good agreement was found in that comparison.

3.3.3 SO₂ Measurements at the FGD Inlet

A non-dispersive infrared (NDIR) analyzer was used to determine the SO₂ concentration in flue gas at the FGD inlet. The analyzer is a Horiba Model PIR-200. The NDIR analyzer determines SO₂ in flue gas on a dry basis.

Flue gas was sampled from one of the ports at the FGD inlet (Location 5a) using a Teflon diaphragm pump. Moisture was removed from the sample gas by an ice bath condenser before entering the analyzer. The NDIR analyzer was calibrated before the study with a 491 ppm SO₂ span gas, and the same standard was used as a field span gas. Generally, field calibrations were performed twice a day, once in the morning and once after completion of the day's sampling. SO₂ measurements were made from June 22 through June 27. Data were recorded manually by the flue gas sampling personnel at Location 5a roughly every half hour during sampling on those days.

Table 3-18 shows the SO₂ field calibration results. The instrument zero and span values are shown for each calibration, and indicate that the NDIR analyzer's response was stable within a few percent throughout the field period. A field audit of the analyzer by RTI also showed agreement within 3 percent with the audit value (see Appendix B).

Table 3-19 shows the flue gas SO₂ concentrations recorded on each sampling day June 22-24, 26, and 27. The daily averages and standard deviations are shown as well. As a credibility check the mass flow rates of SO₂ (in lb/hr) at Location 5a, based on the measured flows and daily average SO₂ concentrations at Location 5a, were compared to those expected based on boiler feed coal sulfur content and combustion conditions. Comparisons done for June 22, 24, and 27 give ratios of measured/calculated lb/hr SO₂ of 1.15, 1.02, and 1.06, respectively, averaging 1.08. The relatively higher measured/calculated ratio on June 22 is thought to result from incomplete removal of water vapor from the NDIR sample gas flow early in the day, resulting in a small positive interference in the NDIR data. Some loss of sulfur in bottom ash and ESP ash is also expected (perhaps 5 percent), that if included in these calculations would increase the measured/calculated SO₂ ratios. On the other hand, the SO₂ measurements at Location 5a were made in the center of the duct, and may overestimate the SO₂ concentration if air in-leakage has occurred near the sides of the duct. This factor would tend to lower the measured/calculated ratios. Considering these small opposing factors, the agreement between measured and calculated SO₂ is good, and supports the validity of both the flow rates and SO₂ concentrations measured at Location 5a.

The purpose of making the SO₂ measurements was to assess the performance of the scrubber. In addition, the SO₂ data can be used to estimate the bypass/absorber flow split in the scrubber, using an assumed absorber efficiency for SO₂. The bypass flow was measured by full traverses in the bypass duct on June 20, the day before flue gas measurements began. That measurement indicated a bypass flow of about 36 percent of the total flow measured at Locations 5a and 5b on subsequent days. However, given the non-uniformity of the bypass flow and the alterations in scrubber operation that occurred in response to varying coal sulfur content (see Section 2.1.4), it is not clear that that measurement is applicable to the study days. Instead, bypass flow has been calculated on the basis of temperature and moisture data in the scrubber. Table 3-20 shows the results of evaluations done using the measured SO₂ data and those calculated bypass data.

Table 3-20 contains three data columns. The left column shows the percent bypass flow, calculated for each inorganic day listed, from the temperature and moisture data. The middle column indicates the bypass flow percentage, calculated on the basis of the SO_2 values in lb/hr at the scrubber (see lines 27-29 of Table 3-12), and assuming a 90 percent efficiency for SO_2 removal in the absorber. Comparison of the two columns of bypass results indicates that the SO_2 data provide only approximate agreement with the temperature/moisture results. However, both sets of results indicate a lower bypass fraction on June 27, consistent with the higher coal sulfur content on that day. The third (i.e., right-most) data column in Table 3-20 shows the absorber efficiency calculated from the sulfur removed in the scrubber and the percent of gas scrubbed. The percent sulfur removal was calculated from the values in Table 3-12 (lines 27-29). The percent of gas scrubbed in the absorber was taken as 100 percent minus the bypass percentage determined from temperature and moisture data (left column, Table 3-20). The calculated absorber efficiencies range from 73 to 107 percent, averaging 89.5 percent. The individual efficiency values vary considerably, probably due to uncertainties in the temperature, moisture, flow, and SO_2 data. These results suggest that reliance on a single determination of scrubber efficiency based on such data would not be appropriate.

TABLE 3-1. OVERALL SCHEDULE OF ACTIVITIES AT
COAL CREEK STATION

Date	Activity
June 17, 1993	Personnel and equipment arrived at site, security inventory conducted.
June 18-19	Equipment set up at the various sampling locations. Site preparations.
June 20	Continued setup, collected reagent and method blanks. Site preparations.
June 21-24	Sampling at all locations. RTI audits June 23 and 24.
June 25	Down day due to weather.
June 26-27	Sampling completed. Packing for departure and security inventory begun.
June 28-29	Packing completed. Personnel and equipment left Coal Creek.

TABLE 3-2. ANALYTES MEASURED IN SAMPLES FROM COAL CREEK

Organic Analytes

Semivolatile Organic Compounds (SVOC)

Polynuclear Aromatic Hydrocarbons (PAHs)	19 compounds (flue gas and solid samples)
Other SVOC	12 compounds (flue gas and solid samples)
PAH/SVOC	44 compounds (liquid samples)
Polychlorinated Dioxins/Furans (PCDD/PCDF)	17 compounds and 8 compound classes (flue gas samples)

Volatile Organic Compounds

35 compounds (flue gas samples by canister)
 35 compounds (flue gas samples by VOST)
 33 compounds (liquid samples)

Aldehydes

4 compounds (gas and liquid samples)

Inorganic Analytes

Trace elements (vapor phase)

As, Se, Hg (flue gas samples)

Trace elements

As, Se, Hg, Cd, Cr, Mo, B, Sb, Ba, Be, Pb, Mn, Ni, V, Cu, Co (all samples)

Major elements

Al, K, Ti, Si, Na (all samples);
 Ca (flue gas samples)

Anions

Cl⁻, F⁻, PO₄⁼, SO₄⁼ (all samples)

Other inorganics

NH₃, CN⁻ (flue gas and liquid samples)

Elemental carbon

(Flue gas)

Radionuclides (solid phase)

U²³⁴, U²³⁵, Th²²⁹, Th²³⁰, Th²³⁴, Ra²²⁶, Ra²²⁸, Pb²¹⁰, Pb²¹¹, Pb²¹² (flue gas)

TABLE 3-3. MEASUREMENTS MADE ON SOLID AND LIQUID PROCESS STREAMS
AT COAL CREEK

Substance	Sampling Location ^(a)									
	1	2	3	7	8	14	15	16 ^(b)	17 ^(b)	L ^(c)
SVOC PAH/SVOC		•	•		•			•	•	•
VOC										•
Aldehydes										•
Elements	•	•	•	•	•	•	•	•	•	•
Anions	•	•	•	•	•	•	•	•	•	•
Cyanide										•
Ammonia										•
Carbon		•	•	•	•					
Radionuclides	•	•	•		•		•			
Particle Size Distribution					•					
Ultimate/Proximate	•					•				
Moisture	•					•	•			
Sulfur				•						
Solids Content ^(d)										•

(a) Locations 1, 2, 3, 7, 8, 14, and 15 are solid process streams.

(b) Solids from samples of liquid streams.

(c) Liquid process streams are 9, 10, 11, 13, 16, and 17.

(d) Streams 16 and 17 only.

TABLE 3-4. MEASUREMENTS MADE ON FLUE GAS
STREAMS AT COAL CREEK

Substance	Sampling Location					
	4a	4b	5a	5b	6a	6b
SVOC ^(a)						
PAH/SVOC	•		•	•	•	•
Dioxins/Furans	•		•		•	•
VOC	•		•		•	•
Aldehydes	•		•		•	•
Elements ^(a)	•		•	•	•	•
Anions ^(a)	•		•		•	•
Cyanide	•		•		•	
Ammonia	•		•		•	
Carbon	•		•		•	
Radionuclides	•		•		•	
Particle Mass	•	•	•	•	•	•
Particle Size Distribution					•	•

(a) These substances were measured by methods that distinguish between vapor phase and particle phase material.

TABLE 3-5. FLUE GAS SAMPLING METHODS

Substance	Sampling Method ^(a)
SVOC	Modified Method 5 (Method 23)(i,t)
VOC	Summa Canister from Modified Method 5 Train Volatile Organic Sampling Train (VOST)
Aldehydes	Impingers, EPA Method TO-5
Elements	Multi-Metals Train (Method 29) for Vapor and Particulate (i,t) HEST Carbon-impregnated Filter for Vapor Only
Anions	Method 26A (Modified) (i)
Ammonia	APHA 401 - Impinger (i)
Cyanide	APHA 808 - Impinger (i)
Carbon	Filter on Ammonia and Cyanide Trains (Locations 4a, 5a, 6a) (i)
Radionuclides	Filter on Ammonia and Cyanide Trains (Locations 4a, 5a, 6a) (i)
Particle Mass	Cyclones and Filter on Method 29 Trains (Locations 4a, 5a) (i,t) Filter on Method 29 Train (Location 6a) (i,t) Cyclones and Filter on Method 5 Trains (Locations 4b, 5b) (i,t) Filter on PSDS (Location 6b) (i)
Particle Size Distribution	Cascade Impactors (i)

(a) Characteristics of methods indicated in parentheses: i = isokinetic, t = traversing.

TABLE 3-6. NUMBER OF SAMPLES AT COAL CREEK
FLUE GAS SAMPLING LOCATIONS

Run Type	Location					
	4a	4b	5a	5b	6a	6b
Organic						
Modified Method 5 (SVOC)	3		3		3	3
Canisters ^(b) (VOC)	9		6		9	10 ^(f)
VOST ^(b) (VOC)	9		9		12 ^(c)	9
TO-5 (Aldehydes)	3		3		3	3
Inorganic						
Multi-Metals Train	3		3		3	3
HEST Sampler	4 ^(d)		3	3	3	3
Method 26A (Anions)	3		3		3	3
APHA 401 (Ammonia)	3		3		2	3
APHA 808 (Cyanide)	3		2		3	3
Method 26A Filter (Carbon)	3		2		3	
Method 26A Filter (Radionuclides)	3		2		3	
Method 5 (Particle Mass)		3		3 ^(e)		
Impactors (Particle Size Distribution)					3	3
Cyclones (Particle Size Distribution)	3	3	3	3		

- (a) All samples collected using Plume Simulating Dilution Sampler (PSDS).
(b) Each canister run used three canisters; each VOST run used three sets of VOST cartridges.
(c) Includes VOST audit run on June 23, 1993.
(d) Includes special HEST QA run on June 25, 1993.
(e) Also analyzed for elements.
(f) Only nine analyzed.

TABLE 3-7. NUMBER OF PROCESS SAMPLES COLLECTED ON EACH
SAMPLING DAY AT COAL CREEK

Location No.	DATE					
	6/21/93	6/22/93	6/23/93	6/24/93	6/26/93	6/27/93
1. Boiler Feed Coal	7	7	7	7	7	7
2. Bottom Ash	3	3	3	3	3	3
3. Economizer Ash	6	6	6	6	6	6
7. Pyrite Rejects	7	7	7	7	7	7
8. Precipitator Ash	7	8	8	8	11	10
9. River Water	1	1	1	1	1	1
10. Circulating Water	1	1	1	1	1	1
11. Scrubber Make-Up Water	1	1	1	1	1	1
13. Coal Pile Runoff	0	0	0	0	0	0
14. Run-of-Mine Coal	1	1	1	1	1	1
15. Lime Input	1	1	1	1	1	1
16. Lime Slurry	1	1	1	0	1	1
17A. Slurry Blowdown	1	1	1	0	1	1
18B. Slurry Blowdown	1	1	1	1	1	1

TABLE 3-8. COAL CREEK PLANT SAMPLE COMPOSITING AND SPLITTING SCHEDULE (BY DAY)

PULVERIZER INLET COAL - RUN OF MINE (Composited by Coal Creek)							
Sample #	Matrix	Sample Date	Sample Size	Composite ID	Splits	Minimum Split Wt	Analyzing Laboratory
AF Sample 6/21/93	COAL	Jun 21, 1993		JN2193COAL	Archive		BCO
	ORG						
AF Sample 6/22/93	COAL	Jun 22, 1993		JN2293COAL	Metals	20 grams	EA
	INORG				ULTI/PROX.	100 grams	CTE
					MOIST., HEAT		
					CL/F/PO4	20 grams	BCO
					Be,B	50 grams	CTE-Denver
					Archive		BCO
					RAD	1300 grams	IT
AF Sample 6/23/93	COAL	Jun 23, 1993		JN2393COAL	Archive		BCO
	ORG						
AF Sample 6/24/93	COAL	Jun 24, 1993		JN2493COAL	Metals	20 grams	EA
	INORG				ULTI/PROX.	100 grams	CTE
					MOIST., HEAT		
					CL/F/PO4	20 grams	BCO
					Be,B	50 grams	CTE-Denver
					Archive		BCO
					RAD	1300 grams	IT
AF Sample 6/26/93	COAL	Jun 26, 1993		JN2693COAL	Archive		BCO
	ORG						
AF Sample 6/27/93	COAL	Jun 27, 1993		JN2793COAL	Metals	20 grams	EA
	INORG				ULTI/PROX.	100 grams	CTE
					MOIST., HEAT		
					CL/F/PO4	20 grams	BCO
					Be,B	50 grams	CTE-Denver
					Archive		BCO
					RAD	1300 grams	IT

TABLE 3-8. (Continued)

BOILER FEED COAL							
Sample #	Matrx	Sample Date	Sample Size	Composite ID	Solids	Minimum Split Wt.	Analyzing Laboratory
C-1-PRS-621	11	BOFEED	Jun 21, 1993	JN2193BOFED	Archive		BCO
	12						
	13	ORG					
	15						
	16						
	17						
	18						
C-1-PRS-622	11	BOFEED	Jun 22, 1993	JN2293BOFED	Metals	20 grams	EA
	12				ULTI/PROX.	200 grams	CTE
	13	INORG			MOIST. HEAT		
	15				CL/F/PO4	20 grams	BCO
	16				RAD	1300 grams	IT
	17				Be.B	50 grams	CTE-Denver
	18				Archive		BCO
C-1-PRS-623	11	BOFEED	Jun 23, 1993	JN2393BOFED	Archive		BCO
	12						
	14	ORG					
	15						
	16						
	17						
	18						
C-1-PRS-624	11	BOFEED	Jun 24, 1993	JN2493BOFED	Metals	20 grams	EA
	12				ULTI/PROX	200 grams	CTE
	13	INORG			MOIST. HEAT		
	15				CL/F/PO4	20 grams	BCO
	16				RAD	1300 grams	IT
	17				Be.B	50 grams	CTE-Denver
	18				Archive		BCO
C-1-PRS-626	11	BOFEED	Jun 26, 1993	JN2693BOFED	Archive		BCO
	12						
	13	ORG					
	15						
	16						
	17						
	18						
C-1-PRS-627	11	BOFEED	Jun 27, 1993	JN2793BOFED	Metals	20 grams	EA
	12				ULTI/PROX	200 grams	CTE
	13	INORG			MOIST. HEAT		
	15				CL/F/PO4	20 grams	BCO
	16				RAD	1300 grams	IT
	17				Be.B	50 grams	CTE-Denver
	18				Archive		BCO

TABLE 3-8. (Continued)

BOTTOM ASH							
Sample #		Matrix	Sample Date	Sample Size	Composite ID	Splits	Minimum Split Wt. Analyzing Laboratory
C-2-PRS-621	2-11	BOTT	Jun 21, 1993		JN2193BOTT	SVOC	20 grams BCO
	2-12					Archive	BCO
	2-13	ORG					
C-2-PRS-622	2-11	BOTT	Jun 22, 1993		JN2293BOTT	Metals	20 grams CTE-Denver
	2-12					RAD	600 grams IT
	2-13	INORG				C	25 grams CTE
						F/Cl/PO4/SO4	25 grams BCO
						Archive	BCO
C-2-PRS-623	2-11	BOTT	Jun 23, 1993		JN2393BOTT	SVOC	20 grams BCO
	2-12					Archive	BCO
	2-13	ORG					
C-2-PRS-624	2-11	BOTT	Jun 24, 1993		JN2493BOTT	Metals	20 grams CTE-Denver
	2-12					RAD	600 grams IT
	2-13	INORG				C	25 grams CTE
						F/Cl/PO4/SO4	25 grams BCO
						Archive	BCO
C-2-PRS-626	2-11	BOTT	Jun 26, 1993		JN2693BOTT	SVOC	20 grams BCO
	2-12					Archive	BCO
	2-13	ORG					
C-2-PRS-627	2-11	BOTT	Jun 27, 1993		JN2793BOTT	Metals	20 grams CTE-Denver
	2-12					RAD	600 grams IT
	2-13	INORG				C	25 grams CTE
						F/Cl/PO4/SO4	25 grams BCO
						Archive	BCO

TABLE 3-8. (Continued)

ECONOMIZER ASH							
Sample #		Matrix	Sample Date	Sample Size	Composite ID	Splits	Minimum Split Wt. Analyzing Laboratory
C-3-PRS-621	3A	ECON	Jun 21, 1993		JN2193ECON	SVOC	20 grams BCO
	3B					Archive	BCO
	3C	ORG					
	3D						
	3E						
	3F						
C-3-PRS-622	3A	ECON	Jun 22, 1993		JN2293ECON	Metals	20 grams CTE-Denver
	3B					RAD	600 grams IT
	3C	INORG				C	25 grams CTE
	3D					F/CL/PO4/SO4	25grams BCO
	3E					Archive	BCO
	3F						
C-3-PRS-623	3A	PYREJ	Jun 23, 1993		JN2393ECON	SVOC	20 grams BCO
	3B					Archive	BCO
	3C	ORG					
	3D						
	3E						
	3F						
C-3-PRS-624	3A	ECON	Jun 24, 1993		JN2493ECON	Metals	20 grams CTE-Denver
	3B					RAD	600 grams IT
	3C	INORG				C	25 grams CTE
	3D					F/CL/PO4/SO4	25grams BCO
	3E					Archive	BCO
	3F						
C-3-PRS-626	3A	ECON	Jun 26, 1993		JN2693ECON	SVOC	20 grams BCO
	3B					Archive	BCO
	3C	ORG					
	3D						
	3E						
	3F						
C-3-PRS-627	3A	ECON	Jun 27, 1993		JN2793ECON	Metals	20 grams CTE-Denver
	3B					RAD	600 grams IT
	3C	INORG				C	25 grams CTE
	3D					F/CL/PO4/SO4	25grams BCO
	3E					Archive	BCO
	3F						

TABLE 3-8. (Continued)

PULVERIZER OUTLET - PYRITE REJECTS								
Sample #		Matrix	Sample Date	Sample Size	Composite ID	Splits	Minimum Split Wt.	Analyzing Laboratory
C-7-PRS-621	7-1	PYREJ	Jun 21, 1993		JN2193PYREJ	Archive		BCO
	7-2							
	7-3	ORG						
	7-4							
	7-5							
	7-6							
	7-7							
C-7-PRS-622	7-1	PYREJ	Jun 22, 1993		JN2293PYREJ	Metals	20 grams	CTE-Denver
	7-2					S/C	25 grams	CTE
	7-3	INORG				CL/F/PO4	20 grams	BCO
	7-4					Rad	800 grams	IT
	7-5					Archive		BCO
	7-6							
	7-7							
C-7-PRS-623	7-1	PYREJ	Jun 23, 1993		JN2393PYREJ	Archive		BCO
	7-2							
	7-3	ORG						
	7-4							
	7-5							
	7-6							
	7-7							
C-7-PRS-624	7-1	PYREJ	Jun 24, 1993		JN2493PYREJ	Metals	20 grams	CTE-Denver
	7-2					S/C	25 grams	CTE
	7-3	INORG				CL/F/PO4	20 grams	BCO
	7-4					Rad	300 grams	IT
	7-5					Archive		BCO
	7-6							
	7-7							
C-7-PRS-626	7-1	PYREJ	Jun 26, 1993		JN2693PYREJ	Archive		BCO
	7-2							
	7-3	ORG						
	7-4							
	7-5							
	7-6							
	7-7							
C-7-PRS-627	7-1	PYREJ	Jun 27, 1993		JN2793PYREJ	Metals	20 grams	CTE-Denver
	7-2					S/C	25 grams	CTE
	7-3	INORG				CL/F/PO4	20 grams	BCO
	7-4					Rad	300 grams	IT
	7-5					Archive		BCO
	7-6							
	7-7							

TABLE 3-8. (Continued)

ESP FLY ASH											
Sample #	Matrix	Sample Date	Row	Row Comp.	Wt. of Row Comp.	Day Composite ID	Splits	Minimum Split Wt.	Analyzing Laboratory		
C-8-PRS-821	ESP ASH	Jun 21, 1993	1-1	Row 1 ESP	Equal amounts from each of four samples	JN2193ESPA	SVOC	20 gms	BCO		
	1-2		Archive					BCO			
	1-3										
	1-4										
	ORG			2-2	Row 2 ESP	Equal amounts from each of three samples		SVOC	20 gms	BCO	
			2-3	Archive					BCO		
			2-4								
C-8-PRS-822	ESP Ash	Jun 22, 1993	8-1-1	Row 1 ESP	Equal amounts of each of four samples	JN2293ESPA	Metals	20 gms	CTE-Denver		
	8-1-2		RAD				1000 gms	IT			
	8-1-3		C				25 gms	CTE			
	8-1-4		F/Cl/PO4/SO4				20 gms	BCO			
	INORG			Size	200 gms	CTE					
			Archive		BCO						
			8-2-1	Row 2 ESP	Equal amounts from each of four samples		Metals	20 gms	CTE-Denver		
			8-2-2				RAD	1000 gms	IT		
			8-2-3				C	25 gms	CTE		
			8-2-4				F/Cl/PO4/SO4	20 gms	BCO		
			Size	200 gms	CTE						
			Archive		BCO						
	C-8-PRS-823		ESP ASH	Jun 23, 1993	8-1-1	Row 1 ESP	Equal amounts from each of four samples	JN2393ESPA	SVOC	20 gms	BCO
			8-1-2		Archive					BCO	
			8-1-3								
			8-1-4								
ORG			8-2-1		Row 2 ESP	Equal amounts from each of four samples		SVOC	20 gms	BCO	
		8-2-2	Archive						BCO		
		8-2-3									
		8-2-4									
C-8-PRS-824	ESP ASH	Jun 24, 1993	8-1-1	Row 1 ESP	Equal amounts from each of four samples	JN2493ESPA	Metals	20 gms	CTE-Denver		
	8-1-2		RAD				1000 gms	IT			
	8-1-3		C				25 gms	CTE			
	8-1-4		F/Cl/PO4/SO4				20 gms	BCO			
	INORG			Size	200 gms	CTE					
			Archive								
			8-2-1	Row 2 ESP	Equal amounts from each of four samples		Metals	20 gms	CTE-Denver		
			8-2-2				RAD	1000 gms	IT		
			8-2-3				C	25 gms	CTE		
			8-2-4				F/Cl/PO4/SO4	20 gms	BCO		
			Size	200 gms	CTE						
			Archive		BCO						
	C-8-PRS-825		ESP ASH	Jun 25, 1993	8-1-1	Row 1 ESP	Equal amounts from each of four samples	JN2593ESPA	SVOC	20 gms	BCO
			8-1-2		Archive					BCO	
			8-1-3								
			8-1-4								
ORG			8-2-1		Row 2 ESP	Equal amounts from each of four samples		SVOC	20 gms	BCO	
		8-2-2	Archive						BCO		
		8-2-3									
		8-2-4									
		8-3-1/2	Row 3 ESP		Equal amounts from each of five samples		SVOC	20 gms	BCO		
		8-3-31					Archive		BCO		
		8-3-32									
		8-3-41									
		8-3-42									
C-8-PRS-826		ESP ASH	Jun 26, 1993		8-1-1	Row 1 ESP	Equal amounts from each of four samples	JN2693ESPA	SVOC	20 gms	BCO
		8-1-2			Archive					BCO	
		8-1-3									
	8-1-4										
	ORG			8-2-1	Row 2 ESP	Equal amounts from each of four samples		SVOC	20 gms	BCO	
		8-2-2		Archive					BCO		
		8-2-3									
		8-2-4									
		8-3-1/2		Row 3 ESP	Equal amounts from each of five samples		SVOC	20 gms	BCO		
		8-3-31					Archive		BCO		
		8-3-32									
		8-3-41									
		8-3-42									
	C-8-PRS-827	ESP ASH		Jun 27, 1993	8-1-1	Row 1 ESP	Equal amounts from each of four samples	JN2793ESPA	Metals	20 gms	CTE-Denver
		8-1-2			RAD				1000 gms	IT	
		8-1-3			C				25 gms	CTE	
8-1-4		F/Cl/PO4/SO4	20 gms		BCO						
INORG			Size		200 gms	CTE					
		Archive			BCO						
		8-2-1	Row 2 ESP		Equal amounts from each of four samples		Metals	20 gms	CTE-Denver		
		8-2-2					RAD	1000 gms	IT		
		8-2-3					C	25 gms	CTE		
		8-2-4					F/Cl/PO4/SO4	20 gms	BCO		
		Size	200 gms		CTE						
		Archive			BCO						
		8-3-3	Row 3 ESP		Equal amounts from each of two samples		Metals	20 gms	CTE-Denver		
		8-3-4					RAD	1000 gms	IT		
							C	25 gms	CTE		
							F/Cl/PO4/SO4	20 gms	BCO		
		Size	200 gms	CTE							
		Archive		BCO							

TABLE 3-8. (Continued)

LIME							
Sample #	Matrix	Sample Date	Sample Size	Composite ID	Splits	Minimum Split Wt.	Analyzing Laboratory
C-15-PRS-621	LIME	Jun 21, 1993		JN2193LIME	Archive		BCO
	ORG						
C-15-PRS-622	LIME	Jun 22, 1993		JN2293LIME	Moisture	100 grams	CTE
	INORG				Metals	20 grams	CTE-Denver
					RAD	1000 grams	IT
					F/CL/PO4	25 grams	BCO
					Archive		BCO
C-15-PRS-623	LIME	Jun 23, 1993		JN2393LIME	Archive		BCO
	ORG						
C-15-PRS-624	LIME	Jun 24, 1993		JN2493LIME	Moisture	100 grams	CTE
	INORG				Metals	20 grams	CTE-Denver
					RAD	1000 grams	IT
					F/CL/PO4	25 grams	BCO
					Archive		BCO
C-15-PRS-626	LIME	Jun 26, 1993		JN2693LIME	Archive		BCO
	ORG						
C-15-PRS-627	LIME	Jun 27, 1993		JN2793LIME	Moisture	100 grams	CTE
	INORG				Metals	20 grams	CTE-Denver
					RAD	1000 grams	IT
					F/CL/PO4	25 grams	BCO
					Archive		BCO

Acronyms and Abbreviations Used in Table 3-8

AF Sample - designation for run-of-mine coal; Archive - remainder of sample after compositing and aliquotting have been done; B - analysis for boron; BCO - Battelle Columbus Operations, Columbus, Ohio; Be - analysis for beryllium; BOFED and BOFEED - boiler feed coal sample; BOTT - bottom ash sample; C - analysis for carbon; CL/F/PO₄/(SO₄) - analysis for chloride, fluorine, phosphate, and (sulfate); CTE - Commercial Testing and Engineering Company; CTE-Denver - Commercial Testing and Engineering Company, Denver, Colorado; EA - Element Analysis Corporation, Tallahassee, Florida; ECON - economizer ash sample; ESP - electrostatic precipitator; ESP ASH and ESP A - sample of fly ash from electrostatic precipitators; HEAT - analysis of coal for Btu/lb; INORG - inorganic sampling day; IT - International Technology Corporation, Kingston, Tennessee; JN - June; JN2193 - June 21, 1993, date sample was taken; LIME - lime sample; Metals - analyses for major and trace elements; MOIST - moisture analysis; ORG - organic sampling day; PRS - process sample; PYREJ - pyrite reject sample; RAD - radiological analysis by gamma scan; S/C - analyses for sulfur and carbon; Size - analysis of sample for particle size distribution; SVOC - analysis for semi-volatile organic compounds; ULTI/PROX - ultimate/proximate analysis.

TABLE 3-9. EXAMPLES OF SAMPLE AND COMPOSITE IDs

Description of Sample	Example of Original Sample ID	Composite ID Made Up of the Corresponding Samples
Run of Mine Coal from the Pulverizer Inlet	AF Sample 6/11/93 (Sampling Location 14)	JN2293COAL
Coal Fed Into Boiler	C-1-PRS-622	JN2293BOFED
Bottom Ash	C-2-PRS-622	JN2293BOTT
Economizer Ash	C-3-PRS-622	JN2293ECON
Pyrite Rejects from the Pulverizer Outlet	C-7-PRS-622	JN2293PYREJ
Fly Ash from Electrostatic Precipitator	C-8-PRS-622 (Row 8-1-1)	JN2293ESPA (Row 1)
Lime	C-15-PRS-622	JN2292LIME

TABLE 3-10. NUMBER OF ANALYSES CONDUCTED

COAL CREEK STATION			Number	NUMBER OF ANALYSES																		
NUMBER OF GAS SAMPLES			Samples																			
ANALYZED (10/12/93)****			Collected	VOC-Summa	VOC-VOST	VOC-Liquid	Aldehydes#	Gas/Solid SVOC	Liquid SVOC	Dioxins/Furans	Volatile As, Hg, Se	Elements##	NH4	Cl/F	PO4	SO4	CN	Rad	C	Mass Loading	PSD	Ult/Prox
4a	ESP #1 Inlet	Summa**	9	9																		
		Aldehyde Train	3																			
		Method 23 Train	3				9															
		HEST	3					6														
		Method 29 Train	3								3											
		NH4 Train	3									6										
		CN Train	3										3									
		Method 26A Train	3											3					3	3		
		VOST*****	9		9									6	3	3			***	***		
		Cyclones (M29)																				
		Filter	3																			
		5-10 microns	3									3									3	
		>10 microns	3									3									3	
5a	ESP #1 Outlet	Summa**	6	6																		
		Aldehyde Train	3				9															
		Method 23 Train	3					6														
		HEST	3																			
		Method 29 Train	3								3											
		NH4 Train	3									6										
		CN Train	2										3						3	3		
		Method 26A Train	3															2	***	***		
		VOST*****	9		9									6	3	3						
		Cyclones (M29)																				
		Filter	3																			
		5-10 microns	1									3									3	
		>10 microns	1									1									1	
4b	ESP #2 Inlet	Method 5	3																			
5b	ESP #2 Outlet	Method 5	3																		3	
		HEST	3									3									3	
											3											
**Three Summa canisters were planned to be collected in each of three runs for a total of 9 samples.																						
***Single filter from both NH4 and CN trains analyzed for radionuclides and carbon.																						
****Numbers include entrained fly ash; exclude OAVQC samples.																						
*****Three VOST samples were collected in each run; each VOST sample consists of two cartridges.																						
#Each aldehyde train sample provided multiple components (i.e., separate impingers) for analysis.																						
#Each Method 29 train provided 2 components: front half (excluding filter and cyclones) and back half for element (excluding Hg) analysis. Hg analysis conducted on 4 components (excluding filter and cyclones)																						

**Three Summa canisters were planned to be collected in each of three runs for a total of 9 samples.

***Single filter from both NH4 and CN trains analyzed for radionuclides and carbon.

****Numbers include entrained fly ash; exclude QA/QC samples.

*****Three VOST samples were collected in each run; each VOST sample consists of two cartridges.

#Each aldehyde train sample provided multiple components (i.e., separate impingers) for analysis.

##Each Method 29 train provided 2 components: front half (excluding filter and cyclones) and back half for element (excluding Hg) analysis. Hg analysis conducted on 4 components (excluding filter and cyclones).

TABLE 3-10. (Continued)

COAL CREEK STATION			Number	NUMBER OF ANALYSES																		
NUMBER OF GAS SAMPLES			Samples																			
ANALYZED (10/12/93) - CONT'D			Collected	VOC-Summa	VOC-VOST	VOC-Liquid	Aldehydes#	Gas/Solid SVOC	Liquid SVOC	Dioxins/ Furans	Volatile As, Hg, Se	Elements##	NH4	Cl/F	PO4	SO4	CN	Rad	C	Mass Loading	PSD	Ult/Prox
6a	FGD Outlet	Summa**	9	9																		
	(Hot)	Aldehyde Train	3				8															
		Method 23 Train	3					6		6												
		HEST	3									3										
		Method 29 Train	3										6									
		NH4 Train	2											2					3	3		
		CN Train	3															3	***	***		
		Method 26A Train	3												6	3	3					
		VOST*****	9		9																	
		Cyclones (M29)																				
		Filter	3									3									3	
		Impactors	3																			3
6b	FGD Outlet	Summa** ###	10	9																		
	(Dilute)	Aldehyde Train	3				5															
		Method 23 Train	3					6		6												
		HEST	3									3										
		Method 29 Train	3										6									
		NH4 Train	3											3								
		CN Train	3															3				
		Method 26A Train	3												6	3	3					
		VOST*****	9		9																	
		Cyclones (M29)																				
		Filter	3									3									3	
		Impactors	3																			3
###One extra Summa sample was collected at Location 6b but was lost in analysis.																						
COAL CREEK STATION																						
TOTAL NUMBER OF GAS SAMPLE ANALYSES				33	36	0	31	24	0	12	15	47	11	24	12	12	11	9	9	26	6	0
(10/12/93)																						
				VOC-Summa	VOC-VOST	VOC-Liquid	Aldehydes#	Gas/Solid SVOC	Liquid SVOC	Dioxins/ Furans	Volatile As, Hg, Se	Elements##	NH4	Cl/F	PO4	SO4	CN	Rad	C	Mass Loading	PSD	Ult/Prox

TABLE 3-10. (Continued)

COAL CREEK STATION		NUMBER OF PROCESS SAMPLES TO BE ANALYZED (10/29/93)		NUMBER OF ANALYSES																	
Number Samples Collected	VOC-Summa	VOC-VOST	VOC-Liquid	Aldehydes	Gas/Solid SVOC	Liquid SVOC	Dioxins/Furans	As, Hg, Se	Elements	NH4	CNF	PO4	SO4	CN	Rad C	Mass Loading	PSD	UN/Prox	Surf	Moisture	
13	Coal Pile Runoff (Liquid)	0																			
14	Run-of-Mine Coal (Solid)	3																			
1	Boiler Feed Coal (Solid)	3																			
3	Economizer Ash (Solid)	3																			
8	ESP Ash (Solid)	7																			
2	Bottom Ash (Solid)	3																			
7	Pyrite Rejects (Solid)	3																			
13	Lime (Solid)	3																			
18	Lime Slurry (Liquid)	3*																			
17a, 17b	Slurry Blowdown (Liquid)	8*																			
8	River Water (Liquid)	3																			
10	Circulating Water (Liquid)	3																			
11	Scrubber Makeup (Liquid)	3																			
*Number of composite samples generated; ESP ash composed by row. *Element analyses for liquid samples includes dissolved (filtrate) and total (unfiltered) analyses. *Sample not collected from Locations 18 and 17a on one hopper test day.																					
TOTAL NUMBER OF PROCESS SAMPLE ANALYSES																					
FOR COAL CREEK STATION:																					
TOTAL NUMBER OF GAS AND PROCESS SAMPLE ANALYSES FOR COAL CREEK STATION:																					

TABLE 3-11. CALCULATIONS OF PARTICULATE EMISSIONS, FOR THE THREE
INORGANIC SAMPLING DAYS

Particulate Emissions: Metals Runs

Test Date			Average			Comments
			M-1 6/22/93	M-2 6/24/93	M-3 6/27/93	
Boiler Outlet (Location 4a)						
1. Gas flow rate, dry, 3% O2	Ncm/min		17132.71	17058.98	16557.11	From Table 3-14
2. Particulate loading	mg/Ncm		13448.9	12678.2	11252.2	From Appendix D-11
3a. Particulate emissions	kg/hr		13824.96	12976.63	11178.24	#2*#1+66/(1000000)
3b. Particulate emissions	lb/hr		30484.64	28613.47	24648.62	#3a+2.265
Boiler Outlet (Location 4b)						
4. Gas flow rate, dry, 3% O2	Ncm/min		17197.26	16928.84	16774.97	From Table 3-14
5. Particulate loading	mg/Ncm		7688	9484.8	7949.2	From Appendix D-11
6a. Particulate emissions	kg/hr		7841.925	9829.445	7523.961	#5*#4+66/(1000000)
6b. Particulate emissions	lb/hr		17291.44	21232.93	16596.26	#6a+2.265
Boiler Outlet, Total						
7. Gas flow rate, dry, 3% O2	Ncm/min		34329.91	33979.82	32332.08	#1+#4
8a. Particulate emissions	kg/hr		21066.89	22666.07	18762.14	#3a+#6a
8b. Particulate emissions	lb/hr		47775.49	49846.39	41238.22	#3b+#6b
ESP Outlet (Location 5a)						
9. Gas flow rate, dry, 3% O2	Ncm/min		15445.02	15525.85	10648.46	From Table 3-14
10. Particulate loading	mg/Ncm		39.6	17.2	10.2	From Appendix D-11
11a. Particulate emissions	kg/hr		36.69736	16.62268	10.31126	#10*#9+66/(1000000)
11b. Particulate emissions	lb/hr		80.91768	35.83068	22.73633	#11a+2.265
ESP Outlet (Location 5b)						
12. Gas flow rate, dry, 3% O2	Ncm/min		14972.04	14843.14	13100.10	From Table 3-14
13. Particulate loading	mg/Ncm		42.2	26.9	41.3	From Appendix D-11
14a. Particulate emissions	kg/hr		35.63242	18.61336	32.46266	#13*#12+66/(1000000)
14b. Particulate emissions	lb/hr		78.56956	41.04233	71.57884	#14a+2.265
ESP Outlet, Total						
15. Gas flow rate, dry, 3% O2	Ncm/min		29517.05	28968.99	20948.57	#9+#12
16a. Particulate emissions	kg/hr		72.32978	34.63598	42.77332	#11a+#14a
16b. Particulate emissions	lb/hr		159.4872	76.37233	94.31516	#11b+#14b
Stack (Location 6)						
17. Gas flow rate, dry, 3% O2	Ncm/min		30088	30677	30166	From Table 3-14
18. Particulate loading	mg/Ncm		33.5	6.4	2.1	From Appendix D-11
19a. Particulate emissions	kg/hr		61.68288	11.77997	3.860916	#18*#17+66/(1000000)
19b. Particulate emissions	lb/hr		136.6168	25.97483	8.381626	#19a+2.265
Scrubber Gas Flows						
20. Bypass flow rate, dry	dNcm/min		****	****	****	From temperature balance
21. Flow rate into absorber	dNcm/min		****	****	****	100-#22
22. Bypass flow rate, dry	percent		64.4	58.1	54.4	
23. Flow rate into absorber	percent		35.6	41.9	45.6	

TABLE 3-11. (Continued)

Particulate Emission Factors

Coal Firing Rate					
24. Coal feed rate	lb/hr	896860	918828	881368	From Table 2-5
25. Coal heating value	Btu/lb	6132	5918	6082	From Table 5-105
26a. Coal feed rate	10 ⁶ Btu/h	5499.178	5388.411	5342.884	#24/#25/1000000
26b. Coal feed rate	MJ/hr	5881632.	5884774.	5836659.	#26a*1055
Boiler emissions					
27a. Particulate emissions	kg/hr	21666.89	22666.87	18782.14	#8a
27b. Particulate emissions	lb/hr	47775.49	49846.39	41238.22	#8b
28a. Particulate emission factor	g/MJ	3.734619	3.976601	3.317948	(#27a/#26b)*1000
28b. Particulate emission factor	lb/10 ⁶ Btu	8.687751	9.258666	7.718459	#27b/#26a
ESP emissions					
29a. Particulate emissions	kg/hr	72.32978	34.63598	42.77332	#16a
29b. Particulate emissions	lb/hr	159.4872	76.37233	94.31516	#16b
30a. Particulate emission factor	g/MJ	.0124671	.0668928	.0675884	(#29a/#26b)*1000
30b. Particulate emission factor	lb/10 ⁶ Btu	.0298828	.0141734	.0176527	#29b/#26a
Scrubber emissions					
31a. Particulate emissions	kg/hr	61.68288	11.77997	3.886916	#19a
31b. Particulate emissions	lb/hr	136.8188	25.97483	8.381828	#19b
32a. Particulate emission factor	g/MJ	.0186328	.0028722	.0006743	(#31a/#26b)*1000
32b. Particulate emission factor	lb/10 ⁶ Btu	.0247829	.0048285	.0015887	#31b/#26a
Absorber emissions					
33a. Particulate emissions	kg/hr	15.18258	-8.34353	-19.4678	#31a-(#29a+#22/100)
33b. Particulate emissions	lb/hr	33.38181	-18.3975	-42.9284	#31b-(#29b+#22/100)
34a. Particulate emission factor	g/MJ	.0073122	-.003583	-.007574	(#33a/(#26b+#22/100))*1000
34b. Particulate emission factor	lb/10 ⁶ Btu	.0178182	-.008149	-.017619	#33b/(#26a+#22/100)

Removal Efficiencies

35. ESP	percent	99.66617	99.84678	99.77129	99.76142	(#28b-#30b)*100/#28b
36. Scrubber	percent	14.71994	65.98921	91.11382	57.27432	(#30b-#32b)*100/#30b
37. Absorber	percent	41.34818	157.4922	199.8118	132.8838	(#30b-#34b)*100/#30b
38. ESP+partial scrubber	percent	99.71531	99.94789	99.97988	99.88096	(#28b-#32b)*100/#28b
39. ESP+full scrubber	percent	99.88428	188.8881	188.2283	188.8482	(1-(1-(#37/100)))+(1-(#35/100))*100
40. ESP #11	percent	99.73456	99.87653	99.98778	99.83981	

Standard deviation

ESP	.0987898
Scrubber	38.93543
Absorber	82.84753
ESP+partial scrubber	.1443323
ESP+full scrubber	.2188549
ESP #11	.0923114

95 percent confidence interval

ESP	.2253532
Scrubber	96.72878
Absorber	283.8338
ESP+partial scrubber	.3585784
ESP+full scrubber	.5367535

TABLE 3-12. CALCULATIONS FOR THE SCRUBBER

Sulfur and scrubber analysis

Test Date	M-1 6/22/93	M-2 6/24/93	M-3 6/27/93	Average
S02 Released in Furnace				
1. Coal delivery rate	lb/hr	806800	918820	881360
2. Sulfur in AR coal	percent	.54	.58	.83
3. Sulfur into pulverizer	lb/hr	4842.72	5282.756	7315.288
4. Moisture in feed coal	percent	37.9	38.46	38.69
5. Coal feed, dry	lb/hr	558912.8	560518.6	540381.8
6. Pyrite rejects (dry)	lb/hr	1793.6	1821.64	1762.72
7. Sulfur in pyrite rejects (dry)	percent	19.82	18.82	31.72
8. Sulfur in pyrite rejects	lb/hr	351.9843	328.2595	559.1348
9. Sulfur into furnace	lb/hr	4490.816	4954.496	6766.153
10. S02 released in furnace	lb/hr	8973.227	9899.721	13499.60
Gas flow into scrubber				
11. S02 into scrubber, at 3% O2	ppm	971.5654	849.979	974.9428
12. Dry flue gas into scrubber	Ncm/min	29517.85	30366.99	29948.57
13. Dry flue gas into scrubber	Ncm	1042394.	1072451.	1057084.
14. S02 into scrubber	Ncm	1012.753	911.5605	1031.103
15. S02 into scrubber	lb/hr	18859.89	9774.527	11056.36
16. Moisture into scrubber	vol. percent	15.85	14.51	14.52
17. Moisture into scrubber	Ncm	198339.1	182824.3	179049.1
18. Moisture into scrubber	lb/hr	592054.1	548888.3	541726.0
Gas flow exiting scrubber				
19. S02 exiting scrubber, at 3% O2	ppm	578.4984	584.1798	577.0183
20. Flue gas exiting scrubber	dhcm/min	30688	30677	30100
21. Flue gas exiting scrubber	Ncm	1083716.	1083328.	1065282.
22. S02 exiting scrubber	Ncm	626.9194	632.8579	615.3243
23. S02 exiting scrubber	lb/hr	6722.383	6780.848	6598.838
24. Moisture exiting scrubber	vol. percent	17.84	16.94	17.11
25. Moisture exiting scrubber	Ncm	222595.5	228943.5	219893.6
26. Moisture exiting scrubber	lb/hr	671229.3	606247.9	603861.0
Scrubber calculations based on S02 measured at Location 5				
27. S02 entering scrubber	lb/hr	18859.89	9774.527	11056.36
28. S02 exiting scrubber	lb/hr	6722.383	6780.848	6598.838
29. S02 removed in scrubber	lb/hr	4137.241	2988.488	4458.334
30. CaO required to capture S02	lb/lb	.8753746	.8753746	.8753746
31. CaO required to capture S02	lb/hr	3621.638	2618.845	3982.713
32. CaO in lime	percent	90.89	96.09	90.89
33. Dry lime required to capture S02	lb/hr	4028.828	2983.813	4332.616
34. Moisture in lime	percent	.24	.24	.24
35. Lime required to capture S02	lb/hr	4029.691	2918.799	4342.437

From Table 2-5
From Table 5-105
#1+2/100
From Table 5-105
#1+(100-#4)/100
#02+21
From Table 5-107
#6+7/100
#3-#8
#9+84.66/32.66

From Table 2-5, converted to 3% O2
From Table 3-11
#12+35.314
#13+21/100
#14+60+.08082*(84.664/28.9)
From Appendix D-11
(#16+213)/(100-21)
#17+60+.08082*(18.616/28.9)

From Table 2-5, converted to 3% O2
From Table 3-11
#20+35.314
#21+21/100
#22+60+.08082*(84.664/28.9)
From Appendix D-11
(#24+21)/(100-21)
#25+60+.08082*(18.616/28.9)

#15
#23
#27-28
56.08/64.084
#29+36
From plant data
#31/(22/100)
From Table 5-106
#33/((100-34)/100)

TABLE 3-12. (Continued)

Scrubber calculations based on sulfur in coal

36. SO ₂ entering scrubber	lb/hr	8973.227	9899.721	13499.86
37. SO ₂ exiting scrubber	lb/hr	6722.363	6786.648	6598.638
38. SO ₂ removed in scrubber	lb/hr	2250.864	3113.073	6901.222
39. CaO required to capture SO ₂	lb/lb	.8753746	.8753746	.8753746
40. CaO required to capture SO ₂	lb/hr	1970.349	2726.637	6041.514
41. CaO in lime	percent	98.89	98.89	98.89
42. Dry lime required to capture SO ₂	lb/hr	2187.898	3625.468	6766.887
43. Moisture in lime	percent	.24	.24	.24
44. Lime required to capture SO ₂	lb/hr	2192.352	3632.738	6722.220

#10
#23
#36-#37
56.68/64.664
#38-#39
From plant data
#40/(#41/100)
From Table 5-186
#42/((100-#43)/100)

Lime feed slurry flow into absorber system

45. Lime slurry feed rate, Tank A	gpm	88	34	49
46. Lime slurry feed rate, Tank B	gpm	28	83	59
47. Lime slurry feed rate, total	gpm	88	117	108
48. Lime slurry feed rate, total	cu ft/hr	785.936	938.574	866.376
49. Density of lime feed slurry	lb/cu ft	62.38736	63.54654	64.46586
50. Lime slurry feed rate, total	lb/hr	43985.81	59643.13	55799.69
51. Water in lime feed slurry	percent	95.32	94.47	91.76
52. Water in lime feed slurry	lb/hr	41926.51	56344.86	51261.80
53. Solids in lime feed slurry	percent	4.68	5.53	8.24
54. Solids in lime feed slurry	lb/hr	2058.498	3298.265	4597.895
55. CaO in lime feed slurry	lb/hr	1854.501	2971.487	4142.243
56. Inerts in lime feed slurry	lb/hr	203.9972	326.8588	455.6514

From Table 2-5
From Table 2-5
#45-#48
#47+.002228+3600
From measurement
#48-#49
From measurement
#50-#51/100
100-#51
#52-#53/100
#54-((#32/100)
#54-((100-#32)/100)

Solids Mass Balance for Scrubber

57. Fly ash into scrubber	lb/hr	159.3915	76.32651	94.26199
58. Solids in lime feed slurry	lb/hr	2058.498	3298.265	4597.895
59. Solids in scrubber makeup water	lb/hr	2751.38	2751.38	2751.38
60. SO ₂ captured (as SO ₃)	lb/hr	2813.053		
SO ₂ captured (as SO ₃)	lb/hr		3734.988	5571.874
61. Non-carbon scrubber emissions	lb/hr	136.0188	25.88132	8.367618
62. Solids in scrubber blowdown	lb/hr	7646.312	9834.998	13886.98
63. Total non-carbon solids in	lb/hr	7782.323	9860.879	9860.879
64. Total non-carbon solids out	lb/hr	7782.323	9860.879	13815.35
65. Solid in - solids out	lb/hr	0	0	-3154.47
66. Solids out/solids in		1	1	1.319888

From Table 3-13
#54
#76+.0094
#38+86/64
#29+86/64
From Table 3-13
#57-#58-#59-#60-#61
#57-#58-#59-#60
#61-#62
#64-#63
#63/#64

Scrubber blowdown

67. Solids in scrubber blowdown	lb/hr	7646.312	9834.998	13886.98
68. Solids content of blowdown	percent	7.825	7.825	7.825
69. Total blowdown flow	lb/hr	97716.45	125686.9	166223.4
70. Water content of blowdown	lb/hr	90070.14	115851.9	152336.4

#62
From measurement
#67/(#68/100)
#69-#67

Water Balance for Scrubber

71. Flue gas moisture exiting scrub.	lb/hr	671229.3	666247.9	663881.8
72. Water in scrubber blowdown	lb/hr	98070.14	115851.9	153216.4
73. Total water exiting scrubber	lb/hr	761299.5	782099.8	816298.2
74. Flue gas moisture into scrubber	lb/hr	592054.1	548888.3	541726.8
75. Water in lime feed slurry	lb/hr	41926.51	56344.86	51261.80
76. Scrubber makeup water	lb/hr	292700	292700	292700
77. Total water into scrubber	lb/hr	926880.6	897933.1	885627.7
78. Water in - water out	lb/hr	-165381.	-115833.	-69329.5

#26
#70
#71-#72
#18
#52
#73-#74-#75
#74-#75-#76
#73-#77

TABLE 3-13. ASH/SOLIDS MASS BALANCES FOR COAL CREEK

Ash/Solids Mass Balances for Coal Creek Test

Test Date		M-1 6/22/93	M-2 6/24/93	M-3 6/27/93	Average	Comments
Pulverizer						
1. Coal feed	lb/hr	896800	910820	881360		From Table 2-5
2. Moisture in feed coal	percent	37.9	38.48	38.69		From Table 5-105
3. Coal feed, dry	lb/hr	556912.8	580518.6	540381.8		#1*((100-#2)/100)
4. Ash in feed coal, dry basis	percent	15.98	18.52	18.82		From Table 5-105
5. Ash in feed coal	lb/hr	88994.67	103808.8	98888.86	94583.88	#3*(#4/100)
6. Pyrite rejects, dry	lb/hr	1113.826	1121.837	1088.724		Assume 0.2 percent of #3
7. Carbon in pyrite rejects	percent	15.54	15.54	18.26		From Table 5-103
8. Ash in pyrite rejects	percent	84.46	84.46	81.74		100-#7
9. Ash in pyrite rejects	lb/hr	940.7371	940.8281	883.3835	923.6498	#6*(#8/100)
10. Coal burned, dry	lb/hr	555799.8	559397.8	539281.1		#3-#8
11. Moisture in coal fired	percent	17.81	17.76	18.34		From Table 5-104
12. Pulv. coal fired, as received	lb/hr	689718.8	688261.4	668398.1		#10/((100-#11)/100)
13. Ash in pulv. coal, dry basis	percent	17.16	17.5	14.98		From Table 5-104
14. Ash in pulverized coal	lb/hr	95375.18	97894.58	88784.31	91351.33	#10*(#13/100)
15. Total ash out	lb/hr	98315.84	98841.41	81687.89		#9-#14
16. Ash in - ash out	lb/hr	-7321.18	4966.643	9221.168	2288.878	#5-#15
17. Ash out/ash in		1.082266	.9521555	.8985446	.9776551	#15/#5
Boiler Furnace						
18. Ash in pulverized coal	lb/hr	95375.18	97894.58	88784.31		#14
19. Furnace particulate emissions	lb/hr	47775.49	49846.39	41238.22	46286.70	From Table 3-11
20. Comb. carbon in furnace part.	percent	0	.04	.06		From Table 5-102
21. Ash in furnace particulate	percent	100	99.96	99.94		100-#20
22. Ash in furnace particulate	lb/hr	47775.49	49826.46	41213.47	46271.81	#19*(#21/100)
23. Bottom ash, as ash	lb/hr	35699.71	36051.09	29678.13	33809.64	Assume 75% of #18-#22
24. Comb. carbon in bottom ash	percent	.35	.18	.2		From Table 5-103
25. Ash in bottom ash	percent	99.65	99.82	99.8		100-#24
26. Bottom ash, total material	lb/hr	35825.18	36116.18	29737.68		#23/((#25/100))
27. Economizer hopper ash, as ash	lb/hr	11899.98	12017.03	9892.788	11269.88	Assume 25% of #18-#22
28. Comb. carbon in hopper ash	percent	.08	.04	.06		From Table 5-103, except Run 3
29. Ash in economizer hopper ash	percent	99.92	99.96	99.94		100-#28
30. Econ. hopper waste, total	lb/hr	11909.43	12021.84	9898.648		#27/((#29/100))
31. Total ash out	lb/hr	95375.18	97894.58	88784.31		#22-#23-#27
32. Ash in - Ash out	lb/hr	1.46e-11	0	0	4.85e-12	#18-#31
33. Ash out/ash in		1	1	1	1	#31/#18

TABLE 3-13. (Continued)

ESP		lb/hr	percent	lb/hr	percent	From Table 3-11
34.	ESP inlet particulate	47775.49	99.94	49846.39	41238.22	From Table 5-102
35.	Comb. carbon in ESP inlet	0	.64	0	.66	100-#35
36.	Ash in ESP inlet	100	99.96	99.94		100-#35
37.	Ash in ESP inlet	47775.49	49826.46	41213.47	46271.81	From Table 3-11
38.	ESP emissions	159.4872	76.37233	94.81616		From Table 5-102
39.	Comb. carbon in ESP emissions	0	.66	0	.12	100-#39
40.	Ash in ESP emissions	99.94	99.94	99.88		100-#39
41.	Ash in ESP emissions	159.3915	76.32651	94.28199	169.9733	From Table 5-103
42.	ESP hopper particulate	47616.89	49770.62	41143.90		From Table 5-103
43.	Comb. carbon in ESP particulate	0	.62	0	.61	100-#43
44.	Ash in ESP particulate catch	99.98	99.98	99.99		100-#43
45.	Ash in ESP particulate catch	47606.48	49766.67	41139.79	46168.78	From Table 5-103
46.	Total ash out	47765.87	49836.39	41233.99		From Table 5-103
47.	Ash in - Ash out	9.618892	-9.93873	-26.5154	-6.94587	From Table 5-103
48.	Ash out/ash in	.9997987	1.000199	1.000498	1.000165	From Table 5-103
Boiler and ESP						
49.	Ash to furnace	95375.18	97894.58	86784.31		From Table 5-103
50.	Bottom ash, as ash	35099.71	36651.69	29678.13		From Table 5-103
51.	Economizer hopper ash, as ash	11899.98	12617.63	9892.788		From Table 5-103
52.	Ash in ESP part. catch	47606.48	49766.67	41139.79		From Table 5-103
53.	Ash in ESP outlet emissions	159.3915	76.32651	94.28199		From Table 5-103
54.	Total ash out	95365.49	97904.52	86804.82		From Table 5-103
55.	Ash in - Ash out	9.618892	-9.93873	-26.5154	-6.94587	From Table 5-103
56.	Ash out/ash in	.9998991	1.000102	1.000254	1.000085	From Table 5-103
Scrubber (entire scrubber system)						
57.	Scrubber inlet emissions	159.4872	76.37233	94.31516		From Table 3-11
58.	Comb. carbon in scrub. inlet part.	0	.66	0	.12	From Table 5-102
59.	Ash in scrubber inlet particulate	99.94	99.94	99.88		100-#59
60.	Ash in scrubber inlet particulate	159.3915	76.32651	94.28199	169.9733	From Table 3-12
61.	Solids in lime feed slurry	2058.498	3298.265	4597.895	3318.210	From Table 3-12
62.	Solids in scrubber makeup water	2761.38	2761.38	2761.38	2761.38	From Table 3-12
63.	S02 captured (as S03)	2813.653	3734.968	5571.874		From Table 3-12
64.	Solids exiting scrub. in blowdown	7646.312	9834.998	13666.98	16162.76	From Table 3-12
65.	Scrubber particulate emissions	136.0108	25.97483	8.381026		From Table 3-11
66.	Comb. carbon in scrubber emissions	0	.36	0	.16	From Table 5-102
67.	Non-carbon scrubber emissions	100	99.64	99.84		100-#66
68.	Non-carbon scrubber emissions	136.0108	25.88132	8.367616	56.75323	From Table 5-102
69.	Total non-carbon solids in	7782.323	9866.879	13615.35		From Table 5-102
70.	Total non-carbon solids out	7782.323	9866.879	13615.35		From Table 5-102
71.	Solids in - solids out	0	0	0	0	From Table 5-102
72.	Solids out/solids in	1	1	1	1	From Table 5-102

TABLE 3-13. (Continued)

Boiler, ESP, and FGD					
73. Ash to furnace	lb/hr	95375.10	97894.58	88784.31	#18
74. Bottom ash, as ash	lb/hr	35899.71	36851.89	29878.13	#23
75. Economizer hopper ash, as ash	lb/hr	11899.90	12817.83	9892.788	#27
76. Ash in ESP part. catch	lb/hr	47888.48	49788.87	41139.79	#45
77. Solids in lime feed slurry	lb/hr	2858.498	3298.265	4597.895	#81
78. Solids in scrubber makeup water	lb/hr	2751.38	2751.38	2751.38	#62
79. SO ₂ captured (as SO ₃)	lb/hr	2813.853	3734.988	5571.874	#83
80. Solids exiting scrub. in blowdown	lb/hr	7846.312	9834.998	13888.98	#64
81. Non-carbon scrubber emissions	lb/hr	138.8188	25.88132	8.387818	#88
82. Total non-carbon solids in	lb/hr	182998.8	187879.1	93785.48	#73+77+78+79
83. Total non-carbon solids out	lb/hr	182988.4	187889.1	93725.97	#74+75+76+80+81
84. Solids in - solids out	lb/hr	9.618892	-9.93873	-28.5154	#82-83
85. Solids out/solids in		.9999888	1.888892	1.888219	#83/#82
Scrubber (absorber only)					
86. Gas bypassing absorber	percent	84.4	58.1	54.4	From temperature balance
87. Gas passing through absorber	percent	35.6	41.9	45.6	188-88
88. Absorber inlet emissions	lb/hr	182.7897	44.37232	51.38745	#57+88/188
89. Ash bypassing absorber	lb/hr	182.8481	44.34578	51.24588	#88+88/188
90. Ash in absorber inlet particulate	lb/hr	58.74337	31.98881	42.95811	#88+87/188
91. Solids in lime feed slurry	lb/hr	2858.498	3298.265	4597.895	#81
92. Solids in scrubber makeup water	lb/hr	2751.38	2751.38	2751.38	#62
93. SO ₂ captured (as SO ₃)	lb/hr	2813.853	3734.988	5571.874	#83
94. Solids exiting scrub. in blowdown	lb/hr	7846.312	9834.998	13888.98	#64
95. Non-carbon absorber emissions	lb/hr	33.38284	-18.4844	-42.8783	#88-98
96. Total non-carbon solids in	lb/hr	7725.588	9828.899	12972.39	#89+91+92+93
97. Total non-carbon solids out	lb/hr	7679.875	9818.534	12984.18	#94+95
98. Solids in - solids out	lb/hr	45.98475	12.38489	8.289775	#96-97
99. Solids out/solids in		.9948581	.9987428	.9993818	#97/#96

TABLE 3-14. MAJOR STREAM FLOWS FOR INORGANIC SAMPLING DAYS

Stream	Units	Date		
		June 22	June 24	June 27
Coal feed to pulverizer	lb/hr	896,800	910,820	881,360
Coal feed to boiler ^(a)	lb/hr	669,718	680,201	660,398
Bottom ash ^(a)	lb/hr	35,825	36,116	29,738
Economizer hopper ash ^(a)	lb/hr	11,909	12,022	9,899
Flue gas flow at ESP inlet ^(b)	Ncm/min ^(d)	34,330	33,980	32,332
Flue gas flow at ESP outlet	Ncm/min ^(d)	29,518	30,369	29,949
Flue gas flow at stack	Ncm/min ^(d)	30,688	30,677	30,166
Particulate at ESP inlet	lb/hr	47,775	49,846	41,238
Particulate at ESP outlet	lb/hr	159	76	94
Particulate at stack	lb/hr	136	26	8
Lime slurry feed rate to scrubber	gal/min	88	117	108
ESP catch ^(c)	lb/hr	47,616	49,770	41,144

(a) Estimated total material flow at these locations.

(b) ESP inlet flow at ESP 2 (Location 4b) based on organic days sampling.

(c) By difference.

(d) Dry, at 3 percent oxygen.

TABLE 3-15. MAJOR STREAM FLOWS FOR ORGANIC SAMPLING DAYS

Stream	Units	Date		
		June 21	June 23	June 26
Coal feed to pulverizer	lb/hr	890,000	907,000	888,000
Coal feed to boiler ^(a)	lb/hr	NC	NC	NC
Bottom ash ^(a)	lb/hr	NC	NC	NC
Economizer hopper ash ^(a)	lb/hr	NC	NC	NC
Flue gas flow at ESP inlet	Ncm/min ^(d)	34,263	32,786	32,082
Flue gas flow at ESP outlet ^(b)	Ncm/min ^(d)	29,841	29,907	29,978
Flue gas flow at stack	Ncm/min ^(d)	35,131	30,621	29,674
Particulate at ESP inlet	lb/hr	NM	NM	NM
Particulate at ESP outlet	lb/hr	NM	NM	NM
Particulate at stack	lb/hr	NM	NM	NM
Lime slurry feed rate to scrubber	gal/min	127	96	95
ESP catch ^(c)	lb/hr	NC	NC	NC

(a) Estimated total material flow at these locations.

(b) ESP outlet flow from ESP 2 (Location 5b) based on inorganic days sampling.

(c) By difference.

(d) Dry, 3 percent oxygen.

NM Not measured.

NC Not calculated.

TABLE 3-16. MASS BALANCE RESULTS FOR ASH AND SOLIDS (percent)^(a)

Plant Component(s)	6/22/93	6/24/93	6/27/93	Average
Pulverizer	108	95	90	98
Boiler	100	100	100	100
ESP	100	100	100	100
Boiler and ESP	100	100	100	100
Scrubber	100	100	100	100
Boiler, ESP, and Scrubber	100	100	100	100
Absorber	99	100	100	100

(a) Output as a percentage of input.

TABLE 3-17. FLUE GAS OXYGEN VALUES (Values in percent)

	June 22, 1993	June 24, 1993	June 27, 1993
Plant O ₂ value at furnace outlet	3.51	3.50	3.53
O ₂ value at ESP inlet from particulate ^(a) sampling	5.0/6.0	5.0/6.0	5.0/7.0
O ₂ value at ESP outlet from particulate ^(b) sampling	5.0/7.0	5.0/7.0	5.0/8.5
Plant O ₂ value at stack	5.21	5.22	5.16
O ₂ value at stack from particulate sampling	8.0	8.0	8.0

(a) The two values are for Locations 4a/4b.

(b) The two values are for Locations 5a/5b.

TABLE 3-18. FLUE GAS SO₂ CALIBRATION DATA

Date	Time	Zero Readings ^(a)		Span Readings ^(a)	
		Before	After	Before	After
June 22	0730	0	0	491 ^(b)	491
	2026	0	0	480	491
June 23	0830	-1	0	500	490
June 24	0830	0	0	490	490
June 26	0837	+1	0	490	490
	1758	-1	0	510	490
June 27	0835	+1	0	480	490
	1740	0	0	490	490

(a) All values in ppm.

(b) Span readings based on 491 ppm standard.

TABLE 3-19. FLUE GAS SO₂ CONCENTRATIONS, FGD INLET, COAL CREEK

DATE:	6/22		6/23		6/24		6/26		6/27	
	Time	SO ₂ (ppm)	Time	SO ₂ (ppm)	Time	SO ₂ (ppm)	Time	SO ₂ (ppm)	Time	SO ₂ (ppm)
	1100	900	1246	760	1008	660	1037	690	935	800
	1130	900	1308	750	1254	720	1106	680	1040	800
	1200	900	1348	780	1329	740	1121	720	1115	880
	1300	900	1429	780	1358	750	1131	740	1156	920
	1554	940	1505	780	1437	740	1211	800	1228	890
	1605	920	1543	820	1507	720	1223	760	1308	900
	1633	930	1623	800	1544	840	1240	670	1321	880
	1700	940	1657	800	1647	760	1306	720	1353	900
	1727	940	1723	760	1657	780	1331	720	1420	900
	1743	960	1926	640	1720	800	1352	710	1452	920
	1806	880			1735	800	1329	820	1527	900
	1828	880					1501	850	1548	890
	1847	870					1519	810	1608	840
	1856	820					1546	830	1643	790
	1918	800					1623	840	1718	780
	2020	760					1727	920		
	2031	700								
	2057	740								
	2128	720								
	AVG	863	AVG	767	AVG	755	AVG	768	AVG	866
	STDEV	79	STDEV	49	STDEV	47	STDEV	70	STDEV	48

TABLE 3-20. EVALUATION OF SCRUBBER BYPASS AND ABSORBER EFFICIENCY
USING SO₂ DATA

Date	Scrubber Bypass Flow ^(a) (Percent)	Estimated Bypass Flow ^(b) (Percent)	Absorber Efficiency (Percent) ^(c)
June 22, 1993	64.4	57.7	107
June 24, 1993	58.1	66.0	73.0
June 27, 1993	54.4	55.2	88.4
Average			89.5

(a) Calculated from flue gas temperature and moisture data.

(b) Calculated from SO₂ mass flow rates (lb/hr) in Table 3-12, assuming 90 percent absorber efficiency for SO₂ removal.

(c) Calculated from SO₂ mass flow rates (lb/hr) in Table 3-12, and based on bypass flow values in the left column (see footnote (a)).

Organic Sampling Day Schedule Coal Creek 6/21/93

Figure 3-1a. Schedule of Flue Gas Sampling Conducted at Coal Creek, June 21, 1993

Inorganic Sampling Day Schedule Coal Creek

6/22/93

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Method and Site

Figure 3-1b. Schedule of Flue Gas Sampling Conducted at Coal Creek, June 22, 1993

Organic Sampling Day Schedule Coal Creek 6/23/93

HTC/CLW/11-02

Figure 3-1c. Schedule of Flue Gas Sampling Conducted at Coal Creek, June 23, 1993

Inorganic Sampling Day Schedule Coal Creek 6/24/93

NKA/Kch/11-05

Figure 3-1d. Schedule of Flue Gas Sampling Conducted at Coal Creek, June 24, 1993

Organic Sampling Day Schedule Coal Creek 6/26/93

Figure 3-1e. Schedule of Flue Gas Sampling Conducted at Coal Creek, June 26, 1993

Inorganic Sampling Day Schedule Coal Creek

6/27/93

Figure 3-1f. Schedule of Flue Gas Sampling Conducted at Coal Creek, June 27, 1993

Process Sampling Day Schedule Coal Creek 6/21/93

Figure 3-2a. Schedule of Solid and Liquid Sample Collections at Coal Creek, June 21, 1993

Process Sampling Day Schedule Coal Creek 6/22/93

Figure 3-2b. Schedule of Solid and Liquid Sample Collections at Coal Creek, June 22, 1993

Process Sampling Day Schedule Coal Creek 6/23/93

Figure 3-2c. Schedule of Solid and Liquid Sample Collections at Coal Creek, June 23, 1993

Process Sampling Day Schedule Coal Creek 6/24/93

Figure 3-2d. Schedule of Solid and Liquid Sample Collections at Coal Creek, June 24, 1993

Process Sampling Day Schedule Coal Creek 6/26/93

Figure 3-2e. Schedule of Solid and Liquid Sample Collections at Coal Creek, June 26, 1993

Process Sampling Day Schedule Coal Creek 6/27/93

Figure 3-2f. Schedule of Solid and Liquid Sample Collections at Coal Creek, June 27, 1993

Figure 3-3. Ash balance for Coal Creek Unit 1.

4.0 SAMPLE ANALYSIS

4.1 Analytical Methods

A summary of the sample preparation procedures and analytical techniques used to analyze the gas, solid, and liquid samples collected on this project are listed in Table 4-1 along with the identity of the laboratory conducting the analyses. Specific details of the analytical procedures are provided in the **Analytical Plan*** prepared for this project. Any deviations from the analytical procedures cited in the Analytical Plan are described in Appendix F, and QA/QC data associated with the analyses are summarized in Appendix E. Requirements for the preservation and storage of samples after collection are detailed in Table C-2, Appendix C.

***Study of Toxic Emissions from a Coal-Fired Power Plant Demonstrating the ICCT WSA-SNOX Project and a Plant Utilizing an ESP/Wet FGD System, Management Plan on DOE Contract DE-AC22-93PC93251, Section 4: Coal Creek Site-Specific Plans. Prepared for DOE-PETC by Battelle, Columbus, Ohio, June 21, 1993.**

TABLE 4-1. LABORATORY ANALYTICAL PROCEDURES

Sample Matrix	Analyte Class	Sample Preparation Procedure	Analytical Technique	Analytical Laboratory
Gas ^(a) (includes particulate in gas stream)	Elements			
	Ba, Be, Cr, Co, Mn, Ni, V, B, Mo, Cu, Al, Si, Ti, K, Na, Ca	Acid digestion ^(c)	ICP-AES	CTE
	As, Sb, Se, Pb, Cd	Acid digestion ^(c)	GF-AAS	CTE
	Hg	Acid/KMnO ₄ digestion ^(c)	CV-AAS	Battelle ^(b)
	Ammonia/Cyanide	None	ISE	Battelle
	Anions	CO ₃ ⁼ /HCO ₃ ⁻ extraction ^(d)	IC	Battelle
	VOC ^(a)	None	GC/MS	Chester
	PAH/SVOC	Solvent Extraction	GC/MS	Battelle
	Dioxins/Furans	Solvent Extraction	GC/HRMS	Battelle
	Aldehydes	None	HPLC/UV	Battelle
	Radionuclides	-	Gamma radiation	IT
	Ultimate/Proximate and Related Analyses	-	ASTM	CTE
Solid	Elements			
	Ba, Be, Cr, Co, Mn, Ni, V, B, Mo, Cu, Al, Si, Ti, K, Na	Acid digestion	ICP-AES	CTE
	As, Sb, Se, Pb, Cd	Acid digestion	GF-AAS	CTE
	Hg	Acid/KMnO ₄ digestion	CV-AAS	CTE
	Anions	CO ₃ ⁼ /HCO ₃ ⁻ extraction	IC	Battelle
	PAH/SVOC	Solvent extraction	GC/MS	Battelle
	Radionuclides	-	Gamma radiation	IT
	Ultimate/Proximate and Related Analyses	-	ASTM	CTE

TABLE 4-1. (Continued)

Sample Matrix	Analyte Class	Sample Preparation Technique	Analytical Technique	Analytical Laboratory
Liquid	Elements			
	Ba, Be, Cr, Co, Mn, Ni, V, B, Mo, Cu, Al, Si, Ti, K, Na	Acid digestion	ICP-AES	CTE
	As, Sb, Se, Pb, Cd	Acid digestion	GF-AAS	CTE
	Hg	KMnO ₄ digestion	CV-AAS	CTE
	Ammonia/Cyanide	None	ISE	Battelle
	Anions	Helium purge	IC	Battelle
	VOC			Zande
	PAH/SVOC	Solvent extraction	GC/MS	Battelle
	Aldehydes	DNPH derivatization	HPLC/UV	Battelle

VOC = Volatile organic compounds.

PAH/SVOC = Polynuclear aromatic hydrocarbons and other semivolatile organic compounds.

ICP-AES = Inductively coupled plasma atomic emission spectrometry.

GF-AAS = Graphite furnace atomic absorption spectrometry.

CV-AAS = Cold vapor atomic absorption spectrometry.

ISE = Ion selective electrode.

IC = Ion chromatography.

GC/MS = Gas chromatography/mass spectrometry

GC/HRMS = Gas chromatography/high resolution mass spectrometry.

HPLC/UV = High performance liquid chromatography/ultraviolet detection.

ASTM = ASTM-specified techniques.

CTE = Commercial Testing and Engineering Laboratory.

IT = International Technology, Inc.

(a) Does not include HEST samples and VOC-canister samples for which procedures and results are presented in Section 7.

(b) Location 5b particulate samples (Method 5) were analyzed by CTE.

(c) As specified in Method 29.

(d) For anions in gas samples, impinger solutions were analyzed directly without preparation; particulate filters were extracted with carbonate/bicarbonate ($\text{CO}_3^{2-}/\text{HCO}_3^-$) eluent, and the extract solution was analyzed.

5.0 ANALYTICAL RESULTS

Analytical results are presented in Section 5. Analytical data were reduced according to specifications provided by DOE. These specifications are reproduced exactly below (with Battelle interpretation in *italics*):

"TREATMENT OF NON-DETECTS, VALUES OUTSIDE OF THE CALIBRATION RANGE AND BLANKS

Treatment of non-detects (analytical results for which the concentration of the species of interest is below the detection limit of the method) and blank values is of critical importance in this program because detection levels and blank concentrations are often on the same order of magnitude as sample values. When the results are then used for risk assessments or policy decisions, treatment of the data becomes important. This discussion describes how blank and non-detect values are to be treated in presenting/developing reported results.

Non-Detects

The discussion presented below explains how averages, sums, and reported emission values are to be calculated for all species given various combinations of detected and non-detected values.

All values detected. The arithmetic average or sum is taken, as appropriate. No special techniques required.

All values below the detection limit. For individual test runs or species, the data are to be reported as "ND < (detection limit)." For cases where all three runs (*or multiple species*) are below the detection limit, the average is reported as non-detected less than the average detection limit of the three runs (*species*).

Some values are detected and some are non-detects. As an approximation, half of the detection limit for non-detect values and the actual value for detects will be used to determine reported values. As an example of averaging, an average for three test runs with results of 10, 8, and ND < 6 would be 7. As an example for summing (such as for mercury fractions), individual species values of 50, ND < 1 and ND < 2 would be summed to provide a value of $50 + .5 + 1$ or 51.5. In reporting these types of sums or averages no "<" sign is used. The only exception to this rule occurs when the average (*or sum*) is less than the highest detection limit of the non-detected values. In this case, the averages or sums is reported as "ND < (the highest detection limit)." For example, 5, ND < 4 and ND < 3 would be reported as "ND < 4."

This approach is also used to obtain test train totals which required analyses of separate fractions for each individual run. Specifically, the volatile, metals, and anion test train totals for each run are obtained by addition of test train fractions which were analyzed separately.

Fractions from the volatile test train included separate analyses of the tenax and tenax/charcoal tubes for each sample period. Separate analyses were conducted on the filterable and gaseous test train components for both the metals and anion test trains.

Detection limit ratio. These methods of treating the data may result in some loss of information in going from raw data to final values. Specifically, what is often lost is the amount of a final emission value that is attributable to detection limits and the amount that is attributable to measured values. In order to quantify and present this information, all results in this report are presented along with the "Detection Limit Component Ratio," (*DL Ratio*) which is calculated as the ratio of the contribution of detection limit values to a final emission result.

For example, a set of three values of 16, ND < 6, and ND < 5 should be reported as 7, with a detection limit ratio of 26% $((3+2.5)/(16+3+2.5))$, while a set of values of 12, ND < 6, and 9 should be reported as 8, with a detection limit ratio of 13%. The different ratios provide insight as to the extent something is "really there," and hopefully can help provide better information to those making decisions on risk and policy issues.

Values Outside the Calibration Range

It is possible that the reported lab data will be outside the calibration range of the instrument. Data reported below the lower detection will be flagged with a qualifier (e.g., "J"). Data with the "J" flag will have been tentatively identified and tentatively quantified. Data reported above the upper detection limit will be flagged with a qualifier (e.g., "E"). Data with the "E" flag will have been positively identified and tentatively quantified. Data with both qualifiers will be estimates. Consider J and E values to be quantitatively representative when calculating averages. Neither flag should cause a value to be weighted more or less important. The J and E data qualifiers should appear in the respective laboratory analytical report. The data qualifiers need not appear on the calculated data summaries.

Blank Values

The level and treatment of blank values is important in interpreting data, since in some cases species are detected but not at levels significantly higher than blanks. In these cases measured values may not represent emissions, but rather just limitations of the method. However, most of the test methods used in this program either do not allow subtraction of blanks or are silent on how to treat blank values.

When a method does not specify how the sample will be blank corrected, the appropriate blank train values should be subtracted. Laboratory and site/reagent blanks will be analyzed and the results evaluated for identification of contamination. If a sample compound is blank corrected the data will be flagged by a "B". If the value is blank corrected below the detection limit it should be reported as "ND < (detection limit) BC." A "C" flag indicates that the blank value was greater than the sampled value. In no case should the blank corrected values be reported below the method detection limit."

Gas samples and train blanks were corrected for field reagent blanks, where available. After field reagent blank corrections, samples were corrected for train blanks. These blank corrections are designated in footnotes to the Section 5 tables rather than flagged with a "B" as indicated in the above DOE specifications. Any additional flags used

to qualify the analytical data are included as appropriate in the Section 5 tables with defining footnotes in each table where used.

Averages were calculated for the three samples collected at a single location on each of the three sampling days (i.e., inorganic or organic). Specifications provided by DOE, as reproduced above, were used to calculate averages. A standard deviation (SD) was calculated for the three sampling days assuming a sample, not a population (i.e., using N-1 in the denominator). It must be noted that results from the three individual measurements shown in Section 5 tables were used to conduct three separate calculations of mass balances, removal efficiencies, and power plant emissions, in Section 6. The average result of those three separate calculations was then calculated. The average concentrations shown in Section 5 were not used in such calculations.

It should be noted that DL Ratio values were calculated and are shown in subsequent tables only when a detected value is shown for the average, not when the average is a non-detect value. In other words, an average value which is itself a non-detect (i.e., ND <), whether based entirely or partially on individual non-detect values, is not shown with an associated DL Ratio value. This approach eliminates unnecessary repetition of high DL Ratio values for results which are already indicated as non-detect values.

In parts of Section 5 blank values for analytes in flue gas are shown, in units of (e.g.) $\mu\text{g}/\text{Nm}^3$. The blank results shown were calculated from blank samples using a representative or average sampled flue gas volume; as such they are for illustration only. Blank subtraction from actual samples was always done by subtracting the mass of analyte in the blank, then dividing by the sampled flue gas volume appropriate for each sample.

In a few instances, individual measured values were found which appeared to be outliers. Those values are footnoted in the Section 5 data tables, and are excluded from the calculation of mass balances, removal efficiencies, and emission factors. Average values for the accepted data were substituted in place of the outliers in mass balance calculations. Where pertinent, the reasons for considering individual values as outliers are noted.

Finally, one exception was made to the use of half the detection limit value for non-detects. When calculating the emission factor for a species for which all three values are non-detects, the non-detect values, rather than half those values, were used. This approach avoids underestimating both the magnitude and the uncertainty of the emissions.

5.1 Elements

5.1.1. Elements in Flue Gas Samples

Tables 5-1 through 5-11 show the concentrations of elements measured in flue gas samples at Coal Creek. Tables 5-1 through 5-10 show results for actual samples, and Table 5-11 shows results for blank samples. These tables present various types of data, so introduction of the tables is needed.

Among Tables 5-1 to 5-10, all the odd-numbered tables (e.g., 5-1) show element concentrations in flue gas particulate samples. The results are shown in micrograms of analyte per gram of particulate matter ($\mu\text{g/g}$). The odd-numbered tables 5-1 through 5-9 show such results for samples from Locations 4a, 5a, 5b, 6a, and 6b, respectively.

The even-numbered tables 5-2, 5-4, 5-8, and 5-10 show the total element concentrations (particle plus vapor phases) in flue gas at Locations 4a, 5a, 6a, and 6b, respectively. These results are in micrograms of analyte per normal cubic meter of flue gas ($\mu\text{g/Nm}^3$). These total concentrations thus include the particulate element concentrations shown in the corresponding odd-numbered tables (5-1, 5-3, 5-7, 5-9), reckoned relative to flue gas volume rather than to particulate mass. The distribution of these elements between the gas and particulate phases is discussed in Section 7.1.2.

At Location 5b, particulate samples were collected using a Method 5 train, rather than a Multi-Metals (Method 29) train. As a result, no vapor-phase element data are available with which to calculate the total elemental concentrations in flue gas. Consequently, Table 5-6 differs from the other even-numbered tables in that it shows not the total element concentration, but the concentration of elements in flue gas particulate at Location 5b, in units of micrograms per normal cubic meter of flue gas ($\mu\text{g/Nm}^3$). Caution is required in evaluating the data, since the particulate values in Table 5-6 are not directly comparable to the total values in Tables 5-2, 5-4, 5-8, and 5-10. Vapor-phase element concentrations of Hg, As, and Se were measured at Location 5b with a HEST sampler, as described in Section 7.4.

At the request of DOE, calcium was included in the elements measured in flue gas. However, this element was not determined in solid (Section 5.1.2) or liquid (Section 5.1.3) samples, and no mass balance calculation was performed for calcium.

Measured elemental concentrations in flue gas exhibited substantial variability. In a very few cases, outlier values were found which exceeded the data variations considered reasonable and which led to extreme values for mass balance or removal efficiency results. These outliers generally appear to come from sample contamination, though the exact origin of the contamination is not known. **Outlier values are flagged in Tables 5-2 (2 places) and in Table 5-8 (4 places). These outliers have been excluded from the calculation of average values in this section, and from the mass balance, emission factor, and removal efficiency calculations in Section 6. For each of the six outliers indicated, the average value of the remaining two data points was substituted for the outlier value in mass balance calculations.**

Background levels of some elements were detected in the train blanks collected and analyzed with these flue gas samples (Table 5-11). The detected elements included arsenic, chromium, mercury, selenium, silicon, and sodium. These elements were detected either in the filter (selenium, silicon), back half H₂O₂ impinger solution (arsenic, sodium, chromium), and KMnO₄ impinger solution (mercury). Background levels in filters are not unexpected and have been documented.* An H₂O₂ field reagent blank did contain trace levels of mercury and therefore the mercury contamination is attributed to field or reagent contamination. In all cases, these elements were not detected in laboratory method blanks so laboratory contamination is not considered a source of the contamination.

* Berg, Torunn; Royset, Oddvar; and Eiliv Steinnes, Blank Values of Trace Elements in Aerosol Filters Determined by ICP-MS, Atmospheric Environment, Vol. 27A, No. 15, pp 1435-2439, 1993.

TABLE 5.1. ELEMENTS IN PARTICULATE MATTER FROM ESP-1 INLET (LOCATION 4a) ($\mu\text{g/g}$)

Analyte	C-4a-MUM-622	C-4a-MUM-624	C-4a-MUM-627	AVERAGE	DL RATIO	SD
Aluminum	3270	3810	1950	3010		957
Potassium	2280	2590	1370	2080		634
Silicon	46100	52600	38600	45800		7010
Sodium	534	703	556	598		92
Titanium	609	703	551	621		77
Antimony	0.808	1.70	1.52	1.3		0.47
Arsenic	19.0	21.4	20.2	20		1.2
Barium	410	476	303	396		87
Beryllium	0.68	0.85	0.65	0.72		0.11
Boron	226	241	273	247		24
Cadmium	0.177	0.338	0.345	0.29		0.09
Calcium	6970	6910	7090	6990		92
Chromium	13.5	21.8	66.5	34		28
Cobalt	3.99	4.88	3.77	4.2		0.6
Copper	9.86	12.6	10.1	11		1.5
Lead	6.14	8.23	5.61	6.7		1.4
Manganese	161	179	189	176		15
Mercury	0.002	0.0004	0.001	0.001		0.001
Molybdenum	2.47	4.12	4.18	3.6		1.0
Nickel	8.84	13.9	36.2	20		15
Selenium	1.54	2.20	1.65	1.8		0.35
Vanadium	15.7	21.6	15.7	18		3.4

DL Ratio = Detection limit ratio.

SD = Standard deviation.

Calcium and silicon values are soluble concentrations only.

Samples corrected for C-6a + b-MUM-620 train blank.

TABLE 5-2. ELEMENTS IN GAS SAMPLES FROM ESP-1 INLET (LOCATION 4a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-4a-MUM-622	C-4a-MUM-624	C-4a-MUM-627	AVERAGE	DL RATIO	SD
Aluminum	208000	214000	135000	186000		44000
Potassium	145000	145000	93500 *	128000		29700
Silicon	2930000	2950000	2640000	2840000		173000
Sodium	34200	39500	38500	37400		2820
Titanium	38700	39400	37800	38600		802
Antimony	51.5	95.3	104	84		28
Arsenic	1210	1200	1380	1260		101
Barium	26100	26700	20700	24500		3300
Beryllium	44.4	49.2	45.2	46		2.5
Boron	14400	13500	18800	15600		2840
Cadmium	13.0	20.7	25.0	20		6.1
Calcium	443000	389000	489000	440000		50100
Chromium	862	1220	4550 #	1040		NC
Cobalt	255	275	259	263		11
Copper	631	709	693	678		41
Lead	390	460	384	412		42
Manganese	10200	10100	13000	11100		1650
Mercury	12.7	15.7	12.7	14		1.7
Molybdenum	158	231	286	225		64
Nickel	565	779	2480 #	672		NC
Selenium	99.0	123	113	112		12
Vanadium	998	1210	1080	1100		107

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

= Outlier value, not used in calculations.

NC = Not calculated.

Calcium and silicon values are soluble concentrations only.

* Excludes result for potassium in back-half catch (358627 μg) which was considered an outlier.

Samples corrected for C-6a+b-MUM-620 train blank.

TABLE 5-3. ELEMENTS IN PARTICULATE MATTER FROM ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g/g}$)

Analyte	C-5a-MUM-622		C-5a-MUM-624		C-5a-MUM-627		AVERAGE		DL RATIO	SD	
Aluminum	4610		7020		8750		6790			2080	
Potassium	658		1180		900		913			261	
Silicon	31500	ND <	42400	ND <	59700	ND <	59700			5530	
Sodium	1920		2040		1250		1740			426	
Titanium	174		259		332		255			79	
Antimony	0.800		1.58		1.42		1.3			0.41	
Arsenic	9.00		16.8		19.8		15			5.6	
Barium	936		903		2670		1500			1010	
Beryllium	ND <	0.970	ND <	0.683	ND <	0.978	ND <	0.88		0.17	
Boron	1880		283		84.7		749			984	
Cadmium	ND <	15.0	ND <	32.9	ND <	46.3	ND <	31		16	
Calcium	7300		12900		19600		13300			6160	
Chromium	107		33.2		ND <	36.4	53		11%	48	
Cobalt	ND <	4.56	ND <	7.04	ND <	10.1	ND <	7.2		2.8	
Copper	9.51		29.0		15.2		18			10	
Lead	5.53		4.85		6.87		5.8			1.0	
Manganese	83.0		125		162		123			39	
Mercury	0.067		0.484		0.377		0.31			0.22	
Molybdenum	9.6		8.68		5.07		7.8			2.4	
Nickel	59.3	ND <	16.7	ND <	8.32	24		17%		31	
Selenium	60.7		112		53.4		75			32	
Vanadium	21.7		33.9		44.4		33			11	

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Calcium and silicon values are soluble concentrations only.

Samples corrected for C-6a+b-MUM-620 train blank.

TABLE 5-4. ELEMENTS IN GAS SAMPLES FROM ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-5a-MUM-622	C-5a-MUM-624	C-5a-MUM-627	AVERAGE	DL RATIO	SD
Aluminum	1220	837	654	904		289
Potassium	794	179	109	361		377
Silicon	7900	ND < 4630	ND < 4230	ND < 4630		3280
Sodium	913	355	133	467		402
Titanium	65.4	51.3	44.6	54		11
Antimony	3.15	0.569	0.342	1.4		1.6
Arsenic	2.22	1.84	1.41	1.8		0.41
Barium	233	100	190	174		68
Beryllium	ND < 2.14	ND < 2.09	ND < 1.90	ND < 2.0		0.12
Boron	465	66.2	74.3	202		228
Cadmium	ND < 3.62	ND < 3.59	ND < 3.27	ND < 3.5		0.19
Calcium	2280	1570	1540	1800		419
Chromium	27.5	4.68	ND < 2.59	11	4%	14
Cobalt	ND < 2.14	ND < 2.09	ND < 1.90	ND < 2.0		0.12
Copper	5.85	6.61	4.35	5.6		1.1
Lead	1.40	0.568	0.520	0.83		0.49
Manganese	58.9	23.8	15.1	33		23
Mercury	9.61	8.47	17.4	12		4.9
Molybdenum	2.56	1.14	0.533	1.4		1.0
Nickel	15.8	ND < 3.06	ND < 2.25	6.2	14%	8.4
Selenium	16.3	16.4	12.8	15		2.0
Vanadium	6.41	4.75	4.09	5.1		1.2

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Calcium and silicon values are soluble concentrations only.

Samples corrected for C-6a + b-MUM-620 train blank.

TABLE 5-5. ELEMENTS IN PARTICULATE MATTER FROM ESP-2 OUTLET (LOCATION 5b) ($\mu\text{g/g}$)

Analyte	C-5b-PM-622		C-5b-PM-624		C-5b-PM-627		AVERAGE	DL RATIO	SD
Aluminum		13500		20000		24900	19500		5720
Potassium		312		1160		1100	857		473
Silicon		NA		NA		NA	NA		NA
Sodium		25600		5190		5360	12000		11700
Titanium		1070		1650		1420	1380		292
Antimony	ND <	30.7	ND <	75.0	ND <	36.4	ND <	47	24
Arsenic		68.4	ND <	75.0		77.1	ND <	75	21
Barium		7140		11600		8740	9160		2260
Beryllium	ND <	10.2	ND <	25.0	ND <	12.1	ND <	16	8.0
Boron		NA		NA		NA	NA		NA
Cadmium	ND <	10	ND <	25.0	ND <	12.1	ND <	16	8.0
Calcium		45900		78800		82500	69100		20100
Chromium		134		464		371	323		170
Cobalt		33.7	ND <	50.0		56.3	ND <	50	16
Copper		95.8		109		93.3	99		8.2
Lead		243		117	ND <	36.4	126	5%	113
Manganese		655		1130		1990	1260		678
Mercury		7.24		225		6.67	80		126
Molybdenum	ND <	102 C		230	ND <	121	ND <	121	101
Nickel		85.6		192		160	146		54
Selenium		134		242		154	177		58
Vanadium		85.7		143		95.2	108		30

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

C = Blank-corrected concentration below detection/calibration limit.

Sample results corrected for filter and acetone reagent blanks.

TABLE 5-6. ELEMENTS IN GAS SAMPLES FROM ESP-2 OUTLET (LOCATION 5b) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-5b-PM-622		C-5b-PM-624		C-5b-PM-627		AVERAGE		DL RATIO	SD
Aluminum		569		416		1030		672		319
Potassium		13.2		25.8 C		45.2 C		28		16
Silicon		NA		NA		NA		NA		NA
Sodium		1080		108 C		221 C		470		532
Titanium		45.1		34.4		58.6		46		12
Antimony	ND <	1.29	ND <	1.56	ND <	1.50	ND <	1.5		0.14
Arsenic		2.88	ND <	1.56		3.18		2.3	11 %	1.3
Barium		301		241		361		301		60
Beryllium	ND <	0.43	ND <	0.52	ND <	0.50	ND <	0.48		0.047
Boron		NA		NA		NA		NA		NA
Cadmium	ND <	0.43	ND <	0.52	ND <	0.50	ND <	0.48		0.047
Calcium		1930		1640		3400		2320		944
Chromium		5.63		9.67		15.3		10		4.8
Cobalt		1.42	ND <	1.04		2.32		1.4	12 %	0.90
Copper		4.04		2.26		3.85		3.4		1.0
Lead		10.2		2.44	ND <	1.50		4.5	6 %	5.1
Manganese		27.5		23.6		82.0		44		33
Mercury		0.31		4.69		0.28		1.8		2.5
Molybdenum	ND <	4.32 C		4.79	ND <	5.00 C	ND <	5.0		1.4
Nickel		3.61		4.00		6.59		4.7		1.6
Selenium		5.65		5.05		6.33		5.7		0.64
Vanadium		3.61		2.97		3.93		3.5		0.49

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

C = Blank-corrected concentration below detection/calibration limit.

Sample results corrected for filter and acetone reagent blanks.

Samples collected with Method 5 train; therefore, results only represent particulate emissions.

TABLE 5-7. ELEMENTS IN PARTICULATE MATTER FROM SCRUBBER OUTLET (LOCATION 6a) (µg/g)

Analyte	C-6a-MUM-622	C-6a-MUM-624	C-6a-MUM-627*	AVERAGE	DL RATIO	SD
Aluminum	3930	17100	38200	19700		17300
Potassium	396	2550	5230	2730		2420
Silicon	ND < 14800	ND < 66700	ND < 173000	ND < 84800		80644
Sodium	ND < 582	4660	11500	5480	2 %	5650
Titanium	191	655	1600	815		718
Antimony	1.06	2.98	9.24	4.4		4.3
Arsenic	9.26	37.1	80.7	42		36
Barium	1210	4710	11500	5810		5230
Beryllium	0.59	1.86	5.19	2.5		2.4
Boron	41.1	213	595	283		284
Cadmium	ND < 21.6	ND < 97.4	ND < 253	ND < 124		118
Calcium	8980	32600	93100	44900		43400
Chromium	1040	ND < 76.7	ND < 1290	ND < 1290		505
Cobalt	13.2	12.3	39.8	22		16
Copper	69.4	33.4	71.6	58		21
Lead	4.86	19.0	48.7	24		22
Manganese	153	206	668	342		283
Mercury	0.086	0.386	1.12	0.53		0.53
Molybdenum	45.2	10.5	28.7	28		17
Nickel	974	45.0	588	536		467
Selenium	68.0	234	366	223		149
Vanadium	29.4	102	221	118		97

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Calcium and silicon values are soluble concentrations only.

Samples corrected for C-6a+b-MUM-620 train blank.

* Average result of duplicate analyses.

TABLE 5-8. ELEMENTS IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6a-MUM-622	C-6a-MUM-624	C-6a-MUM-627*	AVERAGE	DL RATIO	SD
Aluminum	859	788	678	775		91
Potassium	139	165	134	146		16
Silicon	ND < 5820	ND < 5400	ND < 1930	ND < 4380		2140
Sodium	306	295	275	292		15
Titanium	66.1	53.6	48.6	56		9.1
Antimony	0.305	0.206	0.230	0.25		0.052
Arsenic	2.00	1.61	1.36	1.7		0.32
Barium	256	204	192	217		34
Beryllium	ND < 2.38	ND < 2.21	ND < 2.21	ND < 2.3		0.10
Boron	10.4	55.8	11.5	26		26
Cadmium	ND < 4.51	ND < 4.19	ND < 4.2	ND < 4.3		0.19
Calcium	2090	1570	1610	1760		289
Chromium	219 #	5.13	20.9	13		NC
Cobalt	3.96	ND < 2.21	ND < 2.21	ND < 2.2		1.6
Copper	15.9 #	2.77	ND < 2.66	ND < 2.7		NC
Lead	1.06	0.861	0.849	0.92		0.12
Manganese	55.8	26.8	37.7	40		15
Mercury	11.2	17.1	9.74	13		3.9
Molybdenum	9.68 #	0.67	0.70	0.68		NC
Nickel	205 #	3.16	10.6	6.9		NC
Selenium	15.3	11.0	7.14	11		4.1
Vanadium	7.33	5.51	4.77	5.9		1.3

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

= Outlier value, not used in calculations.

NC = Not calculated.

Calcium and silicon values are soluble concentrations only.

* Average result of duplicate analyses.

Samples corrected for C-6a+b-MUM-620 train blank.

TABLE 5-9. ELEMENTS IN DILUTE PARTICULATE MATTER FROM SCRUBBER OUTLET (LOCATION 6b) (µg/g)

Analyte	C-6b-MUM-622		C-6b-MUM-624		C-6b-MUM-627		AVERAGE	DL RATIO	SD	
Aluminum	5810		4110		3270		4400		1290	
Potassium	850		299		ND <	156	409	6%	397	
Silicon	NA		NA			NA	NA		NA	
Sodium	671		653			483	602		104	
Titanium	291		219			242	251		36	
Antimony	ND <	8.95	ND <	9.34	ND <	15.6	ND <	11	3.7	
Arsenic		13.4		9.34	ND <	15.6	ND <	16	2.9	
Barium		2110		1690		1800		1870	218	
Beryllium	ND <	8.94	ND <	9.33	ND <	15.6	ND <	11	3.7	
Boron		NA		NA		NA		NA	NA	
Cadmium		8.94	ND <	9.33	ND <	15.6	ND <	16	2.3	
Calcium		16100		11300		15900		14400	2720	
Chromium	ND <	44.7		5.05		8.93	ND <	45	9.1	
Cobalt	ND <	17.9		18.7		31.2		20	15%	11
Copper		9.10		4.80		8.17		7.4	2.3	
Lead		8.95		9.34	ND <	15.6	ND <	16	0.81	
Manganese		98.5		74.8		117		97	21	
Mercury		5.05		0.233		1.79		2.4	2.5	
Molybdenum	ND <	0.00		6.99	ND <	0.00		6.99	NA	
Nickel	ND <	17.9	ND <	18.7	ND <	31.2	ND <	23	7.4	
Selenium		49.2		46.6		48.3		48	1.3	
Vanadium		44.7		28.0		31.2		35	8.9	

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

Calcium and silicon values are soluble concentrations only.

Samples corrected for C-6a+b-MUM-620 train blank.

TABLE 5-10. ELEMENTS IN DILUTE GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6b) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6b-MUM-622		C-6b-MUM-624		C-6b-MUM-627		AVERAGE	DL RATIO	SD
Aluminum		1010		682		907	866		168
Potassium	ND <	2530	ND <	2540	ND <	1530	ND <	2200	581
Silicon	ND <	1470	ND <	1480	ND <	1780	ND <	1580	176
Sodium	ND <	1900	ND <	1850	ND <	2020	ND <	1920	87
Titanium	ND <	1170	ND <	1180	ND <	1410	ND <	1250	136
Antimony	ND <	2.80	ND <	2.83		5.47	ND <	2.8	2.3
Arsenic		2.00		0.955	ND <	0.907		1.1	0.79
Barium		301		203		173		226	67
Beryllium	ND <	29	ND <	28	ND <	31	ND <	29	1.4
Boron	ND <	89	ND <	86	ND <	94	ND <	90	4.1
Cadmium	ND <	69.8	ND <	34.3	ND <	41.0	ND <	48	19
Calcium		2510		1610		1780		1970	478
Chromium	ND <	35	ND <	62	ND <	67	ND <	55	18
Cobalt	ND <	30	ND <	29	ND <	32	ND <	30	1.5
Copper	ND <	70	ND <	68	ND <	74	ND <	71	3.3
Lead		77.1	ND <	2.70	ND <	1.95		26	44
Manganese	ND <	216	ND <	210	ND <	229	ND <	218	10
Mercury		0.835		4.38	ND <	0.404		1.8	2.3
Molybdenum	ND <	12.7	ND <	12.3	ND <	13.5	ND <	13	0.59
Nickel	ND <	33	ND <	32	ND <	35	ND <	33	1.6
Selenium		7.40		7.13		6.11		6.9	0.68
Vanadium	ND <	57	ND <	55	ND <	61	ND <	58	3.1

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Calcium and silicon values are soluble concentrations only.

Samples corrected for C-6a+b-MUM-620 train blank.

TABLE 5-11. ELEMENTS IN BLANK GAS SAMPLES ($\mu\text{g}/\text{Nm}^3$)

Analyte	Train Blank	
	C-6a+6b-MUM-620	C-6b-MUM-622
Aluminum	ND < 6.54	ND < 17.8
Potassium	ND < 33.9	ND < 92.4
Silicon	15500	42200
Sodium	208	566
Titanium	ND < 12.6	ND < 34.5
Antimony	ND < 0.144	ND < 4.32
Arsenic	0.222	6.63
Barium	ND < 0.853	ND < 2.33
Beryllium	ND < 0.575	ND < 1.57
Boron	ND < 7.33	ND < 20.0
Cadmium	ND < 2.09	ND < 5.69
Calcium	ND < 13.7	ND < 37.5
Chromium	4.99	13.6
Cobalt	ND < 1.71	ND < 4.67
Copper	ND < 1.93	ND < 5.26
Lead	ND < 3.16	ND < 94.7
Manganese	ND < 2.23	ND < 6.09
Mercury	0.532	15.5
Molybdenum	ND < 0.154	ND < 0.421
Nickel	ND < 1.93	ND < 5.26
Selenium	0.440	13.1
Vanadium	ND < 0.609	ND < 1.66

ND < = Not detected, value following ND < is detection limit.

Calcium and silicon values are soluble concentrations only.

5.1.2. Elements in Solid Samples

Tables 5-12 through 5-18 present the results of analyses for elements in solid samples. All results are reported in microgram of analyte per gram of sample ($\mu\text{g/g}$). Tables 5-12 through 5-18, respectively, present results for seven types of solid samples, in the following order: boiler feed coal (Location 1); bottom ash (Location 2); economizer ash (Location 3); pyrite rejects (Location 7); ESP ash (Location 8); run-of-mine coal (Location 14); and lime (Location 15). In each table, the individual daily composite sample results are shown, along with the average and standard deviation of those results. The composite sample identification scheme and compositing procedures are described in Section 3.2.2. Note that Table 5-16 shows element results for daily composite samples from hopper rows 1, 2, and 3 of the ESP. For rows 1 and 2, three samples and the corresponding average and standard deviation are shown. For row 3, only a single composite sample was analyzed, due to insufficient sample on other days.

All of the sample results in Tables 5-12 through 5-18 are on an as-received (i.e., wet) basis. This is important particularly for the coal samples, since the moisture content of boiler feed coal (Table 5-12) is reduced by about half relative to that of run-of-mine coal (Table 5-17), due to drying in the pulverizing process. Coal moisture data and ultimate/proximate results are shown in Section 5.10.

As described on page 4-1, both boiler feed coal and run-of-mine coal samples were re-analyzed to improve upon results obtained by PIXE analysis. The element data for boiler feed coal (Table 5-12) and for run-of-mine coal (Table 5-17) include the re-analysis results.

Results from the coal analysis round robin coordinated by Consol, Inc. (Consol) for DOE/PETC are discussed in Appendix B Auditing of this report. For the elements not detected in boiler feed coal (Table 5-12), results from the round robin study were used instead in mass balance calculations presented later in this report. In addition, round robin results which differed significantly (greater than 30 percent relative percent difference) from the results reported in Table 5-12 were also used in mass balance calculations. The round-robin results that were adopted include the following:

Analyte	Average Table 5-12 Result ($\mu\text{g/g}$, as received)	Round Robin Result Used in Mass Balance Calculations ($\mu\text{g/g}$, dry)
Antimony	ND < 37	0.75
Arsenic	9.4	7.64
Barium	326	568
Boron	143	126
Cadmium	ND < 0.9	0.079
Lead	7.3	3.31
Mercury	0.08	0.145
Molybdenum	2.3	3.98
Nickel	2.6	7.26
Selenium	ND < 1.3	0.8

TABLE 5-12. ELEMENTS IN BOILER FEED COAL (LOCATION 1) ($\mu\text{g/g}$)

Analyte	JN2293BOFED	JN2493BOFED	JN2793BOFED	AVERAGE	DL RATIO	SD
Aluminum	7850	8870	7030	7920		922
Potassium	1660	1870	1250	1590		315
Silicon	21100	23300	17500	20600		2930
Sodium (a)	595	980	630	735		213
Titanium	394	438	349	394		45
Antimony	ND < 41.7	ND < 38.1	ND < 30.7	ND < 37		5.6
Arsenic (c)	8.6	10.2	9.5	9.4		0.80
Barium	284	368	326	326		42
Beryllium (d)	0.70	0.70	0.60	0.67		0.06
Boron (d)	140	150	140	143		5.8
Cadmium (a)	ND < 0.9	ND < 0.9	ND < 0.9	ND < 0.9		0
Chromium (a)	8.4	9.7	6.6	8.2		1.6
Cobalt (a)	2.4	2.6	1.7	2.2		0.47
Copper	7.06	7.75	6.14	7.0		0.81
Lead	7.23	7.06	7.68	7.3		0.32
Manganese	92.1	93.5	106	97		7.9
Mercury (b)	0.068	0.072	0.088	0.08		0.01
Molybdenum (a)	2.0	3.0	1.9	2.3		0.61
Nickel (a)	1.5	4.1	2.2	2.6		1.3
Selenium	ND < 1.44	ND < 1.47	ND < 1.00	ND < 1.3		0.26
Vanadium (a)	15.7	17.8	12.9	15		2.5

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Elements determined by PIXE analysis (conducted by Element Analysis Corporation) except where indicated.

(a) ICP analysis conducted by Battelle.

(b) CVAA analysis conducted by Battelle.

(c) GFAA analysis conducted by Battelle.

(d) ICP analysis conducted by CTE.

TABLE 5-13. ELEMENTS IN BOTTOM ASH (LOCATION 2) (µg/g)

Analyte	JN2293BOTT		JN2493BOTT		JN2793BOTT		AVERAGE		DL RATIO	SD
Aluminum	71100		72900		70000		71300			1460
Potassium	10900		11300		8700		10300			1400
Silicon	226000		231000		189000		215000			22900
Sodium	6300		7500		6200		6670			723
Titanium	3700		3300		3100		3370			306
Antimony	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0		0
Arsenic		19.0		17.0		26.0		21		4.7
Barium		3880		4650		4920		4480		540
Beryllium		4.1		4.7		4.2		4.3		0.29
Boron		780		710		990		827		146
Cadmium	ND <	2.0	ND <	2.0	ND <	2.0	ND <	2.0		0
Chromium		45		55		89		63		23
Cobalt		20		14		6.2		13		6.9
Copper		32		36		34		34		2.0
Lead		11		10		9		10		1.0
Manganese		790		870		900		853		57
Mercury	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02		0
Molybdenum	ND <	40	ND <	40	ND <	40	ND <	40		0
Nickel		40		36		30		35		5.0
Selenium	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0		0
Vanadium		110		120		100		110		10

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-14. ELEMENTS IN ECONOMIZER ASH (LOCATION 3) ($\mu\text{g/g}$)

Analyte	JN2293ECON		JN2493ECON		JN2793ECON		AVERAGE	DL RATIO	SD
Aluminum		73000		76000		75600	74900		1630
Potassium		10800		11700		9100	10500		1320
Silicon		213000		223000		183000	206000		20800
Sodium		4700		7800		7200	6570		1640
Titanium		3200		3500		3700	3470		252
Antimony	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0	0
Arsenic		40		46		59		48	9.7
Barium		4200		4500		3900	4200		300
Beryllium		4.7		4.9		4.4	4.7		0.23
Boron		1130		980		1310	1140		165
Cadmium	ND <	2.0	ND <	2.0	ND <	2.0	ND <	2.0	0
Chromium		60		66		56	61		5.0
Cobalt		15		18		14	16		1.8
Copper		47		50		54	50		3.5
Lead		17		19		23	20		3.1
Manganese		910		825		1200	978		197
Mercury	ND <	0.02	ND <	0.02		0.02	ND <	0.02	0.01
Molybdenum	ND <	40		44	ND <	40	ND <	40	14
Nickel		35	ND <	35		34	ND <	35	10
Selenium	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0	0.0
Vanadium		120		125		120	122		2.9

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-15. ELEMENTS IN PYRITE REJECTS (LOCATION 7) ($\mu\text{g/g}$)

Analyte	JN2293PYREJ		JN2493PYREJ		JN2793PYREJ		AVERAGE	DL RATIO	SD
Aluminum	9400		13000		5700		9370		3650
Potassium	2200		3200		600		2000		1310
Silicon	130000		97800		31000		86300		50500
Sodium	3600		4900		2400		3630		1250
Titanium	300		460		120		293		170
Antimony	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0	0
Arsenic		93.0		107		133		111	20
Barium		230		310		240		260	44
Beryllium	ND <	2.0	ND <	2.0	ND <	2.0	ND <	2.0	0
Boron		60		88	ND <	50		58	14% 32
Cadmium	ND <	2.0	ND <	2.0	ND <	2.0	ND <	2.0	0
Chromium	ND <	2		5	ND <	2		2.2	30% 2.1
Cobalt		10		7.1		21		13	7.4
Copper	ND <	2	ND <	2	ND <	2	ND <	2.0	0
Lead	ND <	4	ND <	4	ND <	4	ND <	4	0
Manganese		210		200		370		260	95
Mercury		1.11	ND <	1.26		0.86	ND <	1.3	0.24
Molybdenum	ND <	40		40	ND <	40	ND <	40	12
Nickel		18		17		13		16	2.6
Selenium	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0	0
Vanadium		16		20		14		17	3.1

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-16. ELEMENTS IN ESP ASH (LOCATION 8) (µg/g)

Analyte	JN2293ESPA-1		JN2493ESPA-1		JN2793ESPA-1		AVERAGE	DL RATIO	SD	JN2293ESPA-2		JN2493ESPA-2		JN2793ESPA-2		AVERAGE	DL RATIO	SD	JN2793ESPA-3	
Aluminum	78600		76100		78700		77800		1470	80600		82500		82600		81900		1130	83800	
Potassium	13800		17300		12300		14500		2570	15200		15300		12700		14400		1470	15000	
Silicon	212000		218000		202000		211000		8080	215000		221000		205000		214000		8080	212000	
Sodium	7100		15200		8100		10100		4420	6300		8900		8900		8030		1500	9300	
Titanium	3600		3400		3400		3470		115	3400		3500		3700		3530		153	3500	
Antimony	ND <	4	ND <	4	ND <	4	ND <	4	0	ND <	4.0	8.2	ND <	4.0	4.1	33%	3.6	8.5		
Arsenic	59		68		84		70		13	83		91		101	92		9.02	104		
Barium	4600		3500		5100		4400		819	4550		5000		5300	4950		377	6100		
Beryllium	3.6		3.5		3.6		3.6		0.06	3.6		3.9		1.9	3.1		1.1	4.1		
Boron	1030		1120		1210		1120		90	1240		1160		1250	1220		49	1190		
Cadmium	ND <	2	ND <	2	ND <	2	ND <	2	0	ND <	2.0	ND <	2.0	ND <	2.0	ND <	2.0	0	ND <	2.00
Chromium	68		67		60		65		4.4	74		75		71	73		2.1	77		
Cobalt	25		8.9		16		17		8.1	15		15		17	16		1.2	18		
Copper	69		63		67		66		3.1	68		80		90	79		11	98		
Lead	29		33		30		31		2.1	37		44		47	43		5.1	63		
Manganese	820		810		1000		877		107	850		870		1000	907		81	900		
Mercury	0.02		0.03		0.03		0.03		0.01	0.03		0.03		0.03	0.03		0	0.03		
Molybdenum	ND <	30	ND <	30	ND <	30	ND <	30	0	ND <	30	ND <	30	ND <	30	ND <	30	0	ND <	30
Nickel	29		32		28		30		2.1	23		28		29	27		3.2	51		
Selenium	5.8		4.9		5.4		5.4		0.45	6.10		8.00	ND <	4.00	5.4	25%	3.1	9.0		
Vanadium	120		120		110		117		5.77	140		140		130	137		5.77	150		

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-17. ELEMENTS IN RUN-OF-MINE COAL (LOCATION 14) (µg/g)

Analyte	JN2293COAL		JN2493COAL		JN2793COAL		AVERAGE		DL RATIO	SD
Aluminum		6220		4430		5880		5510		951
Potassium		1250		744		1020		1000		254
Silicon		16000		10000		14000		13300		3060
Sodium		473		815		492		593		192
Titanium		328		372		301		334		36
Antimony	ND <	36.2	ND <	29.9	ND <	33.1	ND <	33		3.1
Arsenic		7.3		9.91		12.7		10		2.7
Barium		248		347		389		328		72
Beryllium		0.42		0.46		0.34		0.41		0.061
Boron		95		88		79		87		8.0
Cadmium		0.37		0.42		0.9		0.56		0.29
Chromium		5.04		6.18		5.46 J		5.6		0.58
Cobalt		5.06		6.16		10.6		7.3		2.9
Copper		5.82		5.07		4.59		5.2		0.62
Lead		4.22 J		8.37		3.81 J		5.5		2.5
Manganese		98.4		75.3		99.8		91		14
Mercury		0.052		0.13		0.036		0.072		0.049
Molybdenum	ND <	0.84	ND <	0.84		1.81		0.88	32%	0.80
Nickel		4.46		5.09		4.2		4.6		0.46
Selenium	ND <	1.12		0.57 J		0.61 J	ND <	1.1		0.03
Vanadium		13.0		11.3		13.9		13		1.4

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Elements determined by PIXE analysis conducted by Element Analysis Corporation.

TABLE 5-18. ELEMENTS IN LIME (LOCATION 15) ($\mu\text{g/g}$)

Analyte	JN2293LIME		JN2493LIME		JN2793LIME		AVERAGE DL RATIO		SD
Aluminum		1600		1600		1500		1570	58
Potassium		80		120		160		120	40
Silicon		4700		4860		4090		4550	406
Sodium		70		70		70		70	0
Titanium		60		120		60		80	35
Antimony	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0	0
Arsenic	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0	0
Barium		29		21		21		24	4.6
Beryllium	ND <	2.0	ND <	2.0	ND <	2.0	ND <	2.0	0
Boron	ND <	50	ND <	50	ND <	50	ND <	50	0
Cadmium	ND <	2.0	ND <	2.0		2.0	ND <	2.0	0.6
Chromium	ND <	2		2.4	ND <	2	ND <	2	0.8
Cobalt	ND <	4	ND <	4	ND <	4	ND <	4	0
Copper	ND <	2	ND <	2	ND <	2	ND <	2	0
Lead	ND <	4	ND <	4	ND <	4	ND <	4	0
Manganese		200		210		230		213	15
Mercury	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Molybdenum	ND <	40	ND <	40	ND <	40	ND <	40	0
Nickel		7.9		11.0	ND <	4.0		7.0	4.6
Selenium	ND <	4.0	ND <	4.0	ND <	4.0	ND <	4.0	0
Vanadium		4.5		6.7		8.1		6.4	1.8

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

5.1.3. Elements in Liquid Samples

Tables 5-19 through 5-28 show the analytical results for elements in liquid samples. All results are reported in milligrams of element per liter of sample (mg/L). Results are shown for samples of river water (Location 9), circulating water (Location 10), scrubber makeup water (Location 11), lime slurry (Location 16), and slurry blowdown (Locations 17a, 17b). For each type of sample, two tables are provided: an odd-numbered table (e.g., 5-19) shows total element results, and an even-numbered table (e.g., 5-20) shows dissolved element results. Each table shows the individual sample results as well as the average and standard deviation of those results. Note that for lime slurry (Location 16) (Tables 5-25 and 5-26) only two individual samples are shown, since no sample could be collected at that location on June 24, 1993, as described in Section 3.2.4. Results shown in Tables 5-27 and 5-28 for slurry blowdown are indicated only as Location 17 data. These results are from samples composed of equal volumes of 17a and 17b samples from the indicated day.

It should be noted that the detection limits shown for dissolved elements are in many cases higher than the corresponding detection limits for total elements. This is due to the fact that liquid samples collected in the field for elemental analysis were acidified after collection, thereby invalidating the dissolved elemental concentrations. Untreated samples of smaller volume, collected for anion analysis, were used for dissolved element analysis. Because of the small sample volume, detection limits are higher for these samples.

TABLE 5-19. TOTAL ELEMENTS IN RIVER WATER (LOCATION 9) (mg/L)

Analyte	C-9-PRL-622		C-9-PRL-624		C-9-PRL-627		AVERAGE		DL RATIO	SD
Aluminum		0.07		0.17		0.12		0.119		0.05
Potassium		3.6		3.6		3.8		3.7		0.14
Silicon		3.3		3.6		3.3		3.4		0.16
Sodium		53.1		52.7		49.5		52		2.0
Titanium	ND <	0.005	ND <	0.005		0.005	ND <	0.005		0.001
Antimony	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020		0
Arsenic	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020		0
Barium		0.057		0.055		0.050		0.054		0.004
Beryllium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0
Boron		0.09		0.07	ND <	0.05		0.062	13%	0.03
Cadmium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0
Chromium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0
Cobalt	ND <	0.01	ND <	0.01	ND <	0.01	ND <	0.010		0
Copper	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0
Lead	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020		0
Manganese		0.015		0.021		0.012		0.016		0.005
Mercury	ND <	0.0002	ND <	0.0002	ND <	0.0002	ND <	0.0002		0
Molybdenum	ND <	0.07		0.11	ND <	0.05	ND <	0.070		0.05
Nickel	ND <	0.01	ND <	0.01	ND <	0.01	ND <	0.010		0
Selenium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020		0
Vanadium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-20. DISSOLVED ELEMENTS IN RIVER WATER (LOCATION 9) (mg/L)

Analyte	C-9-PRL-622		C-9-PRL-624		C-9-PRL-627		AVERAGE	DL RATIO	SD
Aluminum	ND <	0.20	ND <	0.20	ND <	0.20	ND <	0.20	0
Potassium		2.4		2.5		2.3		2.4	0.10
Silicon		6.4		5.7		5.5		5.9	0.48
Sodium		52.6		49.6		51.4		51	1.5
Titanium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Antimony	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Arsenic	ND <	0.04	ND <	0.04	ND <	0.04	ND <	0.04	0
Barium		0.16		0.17		0.11		0.15	0.03
Beryllium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Boron		0.82		0.63		0.45		0.63	0.19
Cadmium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Chromium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Cobalt	ND <	0.20	ND <	0.20	ND <	0.20	ND <	0.20	0
Copper	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Lead	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Manganese	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Mercury	ND <	0.0010	ND <	0.0008	ND <	0.0008	ND <	0.0009	0.0001
Molybdenum	ND <	0.20	ND <	0.20	ND <	0.20	ND <	0.20	0
Nickel	ND <	0.04	ND <	0.04	ND <	0.04	ND <	0.04	0
Selenium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Vanadium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-21. TOTAL ELEMENTS IN CIRCULATING WATER (LOCATION 10) (mg/L)

Analyte	C-10-PRL-622		C-10-PRL-624		C-10-PRL-627		AVERAGE	DL RATIO	SD
Aluminum		0.43		0.53		0.53	0.50		0.06
Potassium		40.5		44.2		42.6	42		1.9
Silicon		31.7		35.1		32.4	33		1.8
Sodium		660		673		647	660		13
Titanium	ND <	0.005	ND <	0.050	ND <	0.005	ND <	0.020	0.026
Antimony	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020	0
Arsenic	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020	0
Barium		0.132		0.187		0.233	0.18		0.051
Beryllium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005	0
Boron		1.35		1.47		1.33	1.4		0.08
Cadmium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005	0
Chromium		0.026		0.026		0.029	0.027		0.002
Cobalt	ND <	0.01	ND <	0.01	ND <	0.01	ND <	0.009	0
Copper		0.040		0.040		0.039	0.040		0.001
Lead	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020	0
Manganese		0.057		0.065		0.062	0.061		0.004
Mercury		0.0030		0.0020		0.0002	0.002		0.0014
Molybdenum		0.10		0.11		0.11	0.107		0.01
Nickel	ND <	0.10	ND <	0.01	ND <	0.01	ND <	0.040	0.05
Selenium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020	0
Vanadium		0.013		0.007		0.013	0.011		0.004

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-22. DISSOLVED ELEMENTS IN CIRCULATING WATER (LOCATION 10) (mg/L)

Analyte	C-10-PRL-622		C-10-PRL-624		C-10-PRL-627		AVERAGE	DL RATIO	SD
Aluminum	ND<	0.20	ND<	0.20	ND<	0.20	ND<	0.20	0
Potassium		39.0		34.4		38.1		37	2.4
Silicon		34.0		34.5		35.3		35	0.66
Sodium		570		550		560		560	10
Titanium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02	0
Antimony	ND<	0.02	ND<	0.02	ND<	0.02	ND<	0.02	0
Arsenic	ND<	0.04	ND<	0.04	ND<	0.04	ND<	0.04	0
Barium		0.230		0.190		0.200		0.21	0.02
Beryllium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02	0
Boron		2.04		1.84		1.70		1.9	0.17
Cadmium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02	0
Chromium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02	0
Cobalt	ND<	0.20	ND<	0.20	ND<	0.20	ND<	0.20	0
Copper		0.060		0.020		0.020		0.03	0.02
Lead	ND<	0.02	ND<	0.02	ND<	0.02	ND<	0.02	0
Manganese	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02	0
Mercury	ND<	0.001	ND<	0.001	ND<	0.001	ND<	0.00	0
Molybdenum	ND<	0.20	ND<	0.20	ND<	0.20	ND<	0.20	0
Nickel	ND<	0.04	ND<	0.04	ND<	0.04	ND<	0.04	0
Selenium	ND<	0.02	ND<	0.02	ND<	0.02	ND<	0.02	0
Vanadium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-23. TOTAL ELEMENTS IN SCRUBBER MAKEUP (LOCATION 11) (mg/L)

Analyte	C-11-PRL-622		C-11-PRL-624		C-11-PRL-627		AVERAGE		DL RATIO	SD
Aluminum		0.19		0.29		0.25		0.24		0.05
Potassium		101		110		97.7		103		6.4
Silicon		19.6		18.8		20.0		19		0.6
Sodium		1250		1300		1230		1260		36
Titanium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0
Antimony	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020		0
Arsenic	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020		0
Barium		0.140		0.124		0.176		0.15		0.027
Beryllium	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0
Boron		11.2		12.0		10.8		11		0.61
Cadmium		0.006	ND <	0.005		0.005	ND <	0.005		0.002
Chromium		0.016		0.014		0.014		0.015		0.001
Cobalt	ND <	0.01	ND <	0.01	ND <	0.01	ND <	0.010		0
Copper	ND <	0.005	ND <	0.005	ND <	0.005	ND <	0.005		0
Lead	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.020		0
Manganese		0.109		0.106		0.124		0.11		0.010
Mercury	ND <	0.0002	ND <	0.0002	ND <	0.0002	ND <	0.0002		0
Molybdenum		0.60		0.63		0.55		0.59		0.04
Nickel	ND <	0.01	ND <	0.01	ND <	0.01	ND <	0.010		0
Selenium		0.02	ND <	0.02	ND <	0.02	ND <	0.02		0.01
Vanadium		0.042		0.044		0.045		0.044		0.002

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-24. DISSOLVED ELEMENTS IN SCRUBBER MAKEUP (LOCATION 11) (mg/L)

Analyte	C-11-PRL-622		C-11-PRL-624		C-11-PRL-627		AVERAGE	DL RATIO	SD
Aluminum	ND <	0.20	ND <	0.20	ND <	0.20	ND <	0.20	0
Potassium		76.3		85.3		74.8		79	5.7
Silicon		23.6		22.4		24.1		23	0.87
Sodium		960		980		880		940	53
Titanium	ND <	0.020	ND <	0.020	ND <	0.020	ND <	0.02	0
Antimony	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Arsenic	ND <	0.04	ND <	0.04	ND <	0.04	ND <	0.04	0
Barium		0.120		0.070		0.090		0.09	0.03
Beryllium	ND <	0.020	ND <	0.020	ND <	0.020	ND <	0.02	0
Boron		12.8		13.4		12.9		13	0.32
Cadmium	ND <	0.020	ND <	0.020	ND <	0.020	ND <	0.02	0
Chromium	ND <	0.020	ND <	0.020	ND <	0.020	ND <	0.02	0
Cobalt	ND <	0.04	ND <	0.20	ND <	0.20	ND <	0.15	0.09
Copper		0.030	ND <	0.020	ND <	0.020	ND <	0.02	0.003
Lead	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Manganese		0.070	ND <	0.020		0.040		0.04	8% 0.03
Mercury	ND <	0.0010	ND <	0.0008	ND <	0.0010	ND <	0.001	0.0001
Molybdenum		0.48		0.67		0.44		0.53	0.12
Nickel	ND <	0.04	ND <	0.02	ND <	0.04	ND <	0.03	0.01
Selenium	ND <	0.02	ND <	0.02	ND <	0.02	ND <	0.02	0
Vanadium		0.040		0.040		0.030		0.04	0.006

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-25. TOTAL ELEMENTS IN LIME SLURRY (LOCATION 16) (mg/L)

Analyte	C-16-PRL-622		C-16-PRL-627		AVERAGE	DL RATIO	SD
Aluminum		77.7		66.0	72		8.3
Potassium		18.1		16.9	17		0.88
Silicon		180		164	172		11
Sodium		89.7		78.0	84		8.3
Titanium		1.96		1.52	1.7		0.31
Antimony	ND <	0.02	ND <	0.02	ND <	0.02	0
Arsenic		0.046	ND <	0.02		0.03	18 %
Barium		1.49		1.41		1.4	0.058
Beryllium		0.006		0.006		0.006	0
Boron		0.490		0.435		0.46	0.039
Cadmium	ND <	0.005	ND <	0.005	ND <	0.005	0
Chromium		0.281		0.334		0.31	0.037
Cobalt	ND <	0.005		0.028		0.02	73 %
Copper		0.142		0.132		0.14	0.007
Lead		0.026		0.021		0.02	0.004
Manganese		13.0		11.4		12	1.1
Mercury	ND <	0.0020	ND <	0.0020	ND <	0.002	0
Molybdenum		0.08	ND <	0.05		0.053	24 %
Nickel		1.25		0.39		0.82	0.61
Selenium	ND <	0.02	ND <	0.02	ND <	0.020	0
Vanadium		0.290		0.250		0.27	0.028

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-26. DISSOLVED ELEMENTS IN LIME SLURRY (LOCATION 16) (mg/L)

Analyte	C-16-PRL-622		C-16-PRL-627		AVERAGE		DL RATIO	SD
Aluminum	ND <	0.20		0.32		0.21	44 %	NC
Potassium		42.5		50.5		47		NC
Silicon		0.6		0.6		0.62		NC
Sodium		230		220		225		NC
Titanium	ND <	0.020	ND <	0.020	ND <	0.02		NC
Antimony	ND <	0.02	ND <	0.02	ND <	0.02		NC
Arsenic	ND <	0.04	ND <	0.04	ND <	0.04		NC
Barium		2.28		3.01		2.6		NC
Beryllium	ND <	0.020		0.020	ND <	0.02		NC
Boron		0.73		0.51		0.62		NC
Cadmium	ND <	0.020	ND <	0.020	ND <	0.02		NC
Chromium		0.100		0.190		0.15		NC
Cobalt	ND <	0.20	ND <	0.20	ND <	0.20		NC
Copper	ND <	0.020		0.040		0.03	50 %	NC
Lead	ND <	0.02	ND <	0.02	ND <	0.02		NC
Manganese	ND <	0.020	ND <	0.020	ND <	0.02		NC
Mercury	ND <	0.0020	ND <	0.0020	ND <	0.002		NC
Molybdenum	ND <	0.20		0.40		0.25		NC
Nickel		0.07	ND <	0.04		0.05	22 %	NC
Selenium	ND <	0.02	ND <	0.02	ND <	0.02		NC
Vanadium		0.080		0.020		0.05		NC

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NC = Not calculated.

TABLE 5-27. TOTAL ELEMENTS IN SLURRY BLOWDOWN (LOCATION 17) (mg/L)

Analyte	C-17-PRL-622	C-17-PRL-624	C-17-PRL-627	AVERAGE	DL RATIO	SD
Aluminum	14.7	44.5	26.9	29		15
Potassium	32.6	106	168	102		68
Silicon	20.1	30.3	17.3	23		6.8
Sodium	323	1220	1800	1114		744
Titanium	0.414	1.52	0.825	0.92		0.56
Antimony	ND < 0.02	ND < 0.02	ND < 0.02	ND < 0.020		0
Arsenic	0.09	0.13	0.04	0.087		0.04
Barium	1.18	2.95	2.15	2.1		0.89
Beryllium	ND < 0.005	ND < 0.005	ND < 0.005	ND < 0.005		0
Boron	5.40	10.1	16.5	11		5.6
Cadmium	ND < 0.005	0.005	ND < 0.005	ND < 0.005		0.001
Chromium	0.085	0.102	0.053	0.080		0.025
Cobalt	0.01	0.01	ND < 0.01	ND < 0.01		0.004
Copper	0.023	0.096	0.041	0.053		0.038
Lead	0.02	0.02	ND < 0.02	ND < 0.02		0.01
Manganese	2.42	5.06	3.83	3.8		1.3
Mercury	0.021	0.0530	0.063	0.046		0.022
Molybdenum	0.34	0.61	0.92	0.62		0.29
Nickel	0.08	0.16	0.09	0.11		0.05
Selenium	ND < 0.02	ND < 0.02	ND < 0.02	ND < 0.020		0
Vanadium	0.097	0.245	0.111	0.15		0.08

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Samples represent composite of equal volumes of samples collected at location 17a and 17b, except for 6/24/93 when only location 17b was collected.

TABLE 5-28. DISSOLVED ELEMENTS IN SLURRY BLOWDOWN (LOCATION 17) (mg/L)

Analyte	C-17-PRL-622		C-17-PRL-624		C-17-PRL-627		AVERAGE		DL RATIO	SD
Aluminum	ND<	0.20	ND<	0.20	ND<	0.20	ND<	0.20		0
Potassium		110		240		180		177		65
Silicon		17.6		18.1		18.6		18.1		0.50
Sodium		1420		2600		1920		1980		592
Titanium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02		0
Antimony	ND<	0.02	ND<	0.02	ND<	0.02	ND<	0.02		0
Arsenic	ND<	0.04	ND<	0.04	ND<	0.04	ND<	0.04		0
Barium		0.040		0.060		0.060		0.05		0.01
Beryllium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02		0
Boron		20.8		24.5		20.6		22		2.2
Cadmium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02		0
Chromium	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02		0
Cobalt	ND<	0.20	ND<	0.20		0.20	ND<	0.20		0.06
Copper	ND<	0.020	ND<	0.020	ND<	0.020	ND<	0.02		0
Lead	ND<	0.02	ND<	0.02	ND<	0.02	ND<	0.02		0
Manganese		1.06		1.34		1.05		1.2		0.16
Mercury	ND<	0.0008	ND<	0.0008	ND<	0.0008	ND<	0.0008		0
Molybdenum		1.22		0.77		0.86		0.95		0.24
Nickel	ND<	0.04		0.05	ND<	0.04	ND<	0.04		0.02
Selenium		0.06		0.13		0.09		0.09		0.04
Vanadium		0.030	ND<	0.020		0.040		0.03	13%	0.02

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

5.2 Ammonia and Cyanide

5.2.1. Ammonia and Cyanide in Flue Gas Samples

Tables 5-29 through 5-33 present analytical results for ammonia (NH_3) and cyanide (CN) in flue gas samples. These species were measured in the gas phase only. Tables 5-29 to 5-33 show results from the ESP inlet (Location 4a), ESP outlet (Location 5a), scrubber outlet (hot) (Location 6a), scrubber outlet (dilute) (Location 6b), and from blank samples, respectively. All results are shown in micrograms of analyte per normal cubic meter of flue gas ($\mu\text{g}/\text{Nm}^3$). Each table shows both NH_3 and CN results. Individual sample results are shown, as well as the average and standard deviation of those results.

Tables 5-29 through 5-31 show that NH_3 was measured at an average of $35 \mu\text{g}/\text{Nm}^3$ at the ESP inlet, but was not detected at the ESP outlet (Location 5a) or at the scrubber outlet (Location 6a). In contrast, CN was measured at all three locations, with considerable variability in the concentrations observed. Average CN concentrations at Locations 4a, 5a, and 6a were $91 (\pm 45)$, 122 , and $68 (\pm 27) \mu\text{g}/\text{Nm}^3$, respectively. Removal of CN in the ESP and scrubber is apparently not efficient.

The NH_3 and CN results from Location 6b (Table 5-32) do not agree well with those from Location 6a (Table 5-31). The NH_3 results from Location 6b are dominated by one high value, and the CN results are all non-detects. The results from Location 6b are affected by the small sample volumes obtained, and the consequent high blank levels when referenced to flue gas concentrations (illustrated in Table 5-33).

TABLE 5-29. AMMONIA AND CYANIDE IN GAS SAMPLES FROM ESP-1 INLET (LOCATION 4a) ($\mu\text{g}/\text{Nm}^3$)

	C-4a-NH3-622	C-4a-NH3-624	C-4a-NH4-627			
Analyte	C-4a-CN-622	C-4a-CN-624	C-4a-CN-627	AVERAGE	DL RATIO	SD
Ammonia	31.3	24.8	49.2	35		13
Cyanide	38.8	121	114	91		45

DL Ratio = Detection limit ratio.

SD = Standard deviation.

Sample results corrected for train blank.

TABLE 5-30. AMMONIA AND CYANIDE IN GAS SAMPLES FROM ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g}/\text{Nm}^3$)

	C-5a-NH4-622		C-5a-NH4-626		C-5a-NH4-627				
Analyte	C-5a-CN-626		C-5a-CN-627		AVERAGE		DL RATIO		SD
Ammonia	ND<	9.11	ND<	8.84	ND<	9.09	ND<	9.0	0.15
Cyanide	NA		130		114		122		NC

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

NC = Not calculated.

Sample results corrected for train blank.

TABLE 5-31. AMMONIA AND CYANIDE IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) ($\mu\text{g}/\text{Nm}^3$)

	C-6a-NH4-622		C-6a-NH4-624		C-6a-NH4-627			
Analyte	C-6a-CN-622		C-6a-CN-624		C-6a-CN-627		AVERAGE DL RATIO	SD
Ammonia	ND <	5.06	ND <	4.85	ND <	5.13	ND < 5.0	0.15
Cyanide		56.1		48.4		99.0	68	27

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Sample results corrected for train blank.

TABLE 5-32. AMMONIA AND CYANIDE IN DILUTE GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6b) ($\mu\text{g}/\text{Nm}^3$)

	C-6b-NH4-622		C-6b-NH4-624		C-6b-NH4-627			
Analyte	C-6b-CN-622		C-6b-CN-624		C-6b-CN-627		AVERAGE DL RATIO	SD
Ammonia	825	ND<	134	ND<	141	321	14%	437
Cyanide	ND<	9.86	ND<	10.3	ND<	10.9	10	0.52

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Sample results corrected for train blank.

TABLE 5-33. AMMONIA AND CYANIDE IN BLANK GAS SAMPLES ($\mu\text{g}/\text{Nm}^3$)

	4a, 5a, 6a	6b
	TRAIN BLANK	TRAIN BLANK
	C-6a+b-NH ₄ -620	C-6a+b-NH ₄ -620
Analyte	C-6a+b-CN-620	C-6a+b-CN-620
Ammonia	114	1340
Cyanide	3.30	65.5

DL Ratio = Detection limit ratio.

SD = Standard deviation.

Sample results corrected for field reagent blank.

5.2.2. Ammonia and Cyanide in Liquid Samples

Tables 5-34 through 5-36 show the analytical results for ammonia and cyanide in river water (Location 9), circulating water (Location 10), and scrubber makeup water (Location 11), respectively. All results are in milligrams per liter of sample (mg/L). Each table shows both ammonia data and cyanide data. Each table shows individual sample results, plus the average and standard deviation. Ammonia was detected in all three liquid streams. Cyanide was not detected in river water, and was found in circulating water at less than 0.01 mg/L, but was present in scrubber makeup water at about 0.30 mg/L.

TABLE 5-34. AMMONIA AND CYANIDE IN RIVER WATER (LOCATION 9) (mg/L)

Analyte	C-9-PRL-622	C-9-PRL-624	C-9-PRL-627	AVERAGE	DL RATIO	SD
Ammonia	0.044	0.048	0.047	0.046		0.0021
Cyanide	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-35. AMMONIA AND CYANIDE IN CIRCULATING WATER (LOCATION 10) (mg/L)

Analyte	C-10-PRL-622	C-10-PRL-624	C-10-PRL-627	AVERAGE	DL RATIO	SD
Ammonia	0.145	0.194	0.168	0.17		0.025
Cyanide	0.007	0.006	0.006	0.006		0.0006

DL Ratio = Detection limit ratio.

SD = Standard deviation.

TABLE 5-36. AMMONIA AND CYANIDE IN SCRUBBER MAKEUP (LOCATION 11) (mg/L)

Analyte	C-11-PRL-622	C-11-PRL-624	C-11-PRL-627	AVERAGE	DL RATIO	SD
Ammonia	0.047	0.073	0.045	0.055		0.015
Cyanide	0.29	0.31	0.3	0.30		0.01

DL Ratio = Detection limit ratio.

SD = Standard deviation.

5.3 Anions

5.3.1. Anions in Flue Gas Samples

Tables 5-37 through 5-41 present the analytical results for gaseous (HCl, HF) and particulate (chloride, fluoride, sulfate, phosphate) anionic species in flue gas streams. Shown are results for individual samples, as well as the average and standard deviation of those results. Results are presented for each of the following flue gas locations, in order of presentation: ESP #1 inlet (Location 4a), ESP #1 outlet (Location 5a), scrubber outlet (hot) (Location 6a), scrubber outlet (dilute) (Location 6b); and for blank samples. Each table shows results in micrograms per normal cubic meter of flue gas ($\mu\text{g}/\text{Nm}^3$).

Tables 5-37 through 5-40 show that at all locations, HCl and HF concentrations far exceeded those of particulate chloride and fluoride; essentially all the chloride and fluoride was present as the gaseous acids. Considerable variability was observed in results for both HCl and HF. The ESP did not appear to reduce the levels of HCl and HF; if anything higher levels are shown at Location 5a than at Location 4a, though the differences are largely within the variability of the results. Interestingly, the average HCl concentration was reduced by the scrubber (compare Tables 5-38 and 5-39), but HF was reduced to a smaller extent. Comparison of Tables 5-37 and 5-38 also shows that particulate sulfate was removed by the ESP with about 98 percent efficiency. On the other hand, the scrubber caused a small increase in sulfate, probably the result of carryover from the spray towers (Tables 5-39 and 5-40, relative to Table 5-38). Phosphate was present at only very low levels in all samples.

The hot and dilute sampling results from the scrubber outlet (Tables 5-39 and 5-40) show reasonable agreement for all analytes. In particular, the dilute sampling results (Table 5-40) confirm the observation noted above, that HCl concentrations appear to be reduced by passage through the scrubber to a much larger extent than are the HF concentrations.

Table 5-41 illustrates that blank anion concentrations in flue gas were well below the measured values.

TABLE 5-37. ANIONS IN GAS SAMPLES FROM ESP-1 INLET (LOCATION 4a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-4a-FCL-622		C-4a-FCL-624		C-4a-FCL-627		AVERAGE	DL RATIO	SD
Hydrogen Chloride		1900		1640		5920	3150		2400
Hydrogen Fluoride		4720		1460		1800	2660		1790
Chloride (Particulate)		2		12.3		14	10		6.6
Fluoride (Particulate)		7		29.4		13	17		12
Sulfate (Particulate)		9620		20800		14000	14800		5630
Phosphate (Particulate)	ND <	1	ND <	1.69	ND <	2	ND <	1	0.48

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

HCl and HF samples corrected by subtracting CO₃/HCO₃ field reagent blank C-4a-FCL-622 and train blank C-6a+b-FCL-620 (corrected for field reagent blank).

Filter samples (all except location 6b) corrected by subtracting uncorrected train blank C-6a+b-FCL-620.

Filter samples (location 6b) corrected by subtracting filter blank C-6b-MUM-627.

Conversion to $\mu\text{g}/\text{Nm}^3$ performed after blank corrections.

TABLE 5-38. ANIONS IN GAS SAMPLES FROM ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-5a-FCL-622	C-5a-FCL-624	C-5a-FCL-627	AVERAGE	DL RATIO	SD
Hydrogen Chloride	2760	2180	6170	3700		2160
Hydrogen Fluoride	6350	5310	4760	5470		807
Chloride (Particulate)	ND < 0.88 C	6.75	ND < 0.89 C	2.5	12%	3.6
Fluoride (Particulate)	39.1	69.8	32.9	47		20
Sulfate (Particulate)	85.1	475	480	347		227
Phosphate (Particulate)	3.08	4.91	5.30	4.4		1.2

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

C = Blank-corrected concentration below detection/calibration limit.

HCl and HF samples corrected by subtracting CO₃/HCO₃ field reagent blank C-4a-FCL-622 and train blank C-6a+b-FCL-620 (corrected for field reagent blank).

Filter samples (all except location 6b) corrected by subtracting uncorrected train blank C-6a+b-FCL-620.

Filter samples (location 6b) corrected by subtracting filter blank C-6b-MUM-627.

Conversion to $\mu\text{g}/\text{Nm}^3$ performed after blank corrections.

TABLE 5-39. ANIONS IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6a-FCL-622	C-6a-FCL-624	C-6a-FCL-627	AVERAGE	DL RATIO	SD
Hydrogen Chloride	1980	1720	1690	1800		160
Hydrogen Fluoride	7330	5280	3410	5340		1960
Chloride (Particulate)	8.83	ND <	0.953 C	4.72	4.7 3%	4.2
Fluoride (Particulate)	173	233	183	196		32
Sulfate (Particulate)	1160	2600	1120	1630		843
Phosphate (Particulate)	21.6	ND <	1.92	9.20	11 3%	10

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

C = Blank-corrected concentration below detection/calibration limit.

HCl and HF samples corrected by subtracting CO₃/HCO₃ field blank C-4a-FCL-622 and train blank

C-6a+b-FCL-620 (corrected for field reagent blank).

Filter samples (all except location 6b) corrected by subtracting uncorrected train blank C-6a+b-FCL-620.

Filter samples (location 6b) corrected by subtracting filter blank C-6b-MUM-627.

Conversion to $\mu\text{g}/\text{Nm}^3$ performed after blank corrections.

TABLE 5-40. ANIONS IN DILUTE GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6b) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6b-FCL-622	C-6b-FCL-624	C-6b-FCL-627	AVERAGE	DL RATIO	SD
Hydrogen Chloride	1160	1390	932	1160		229
Hydrogen Fluoride	6600	5340	3190	5040		1720
Chloride (Particulate)	9.38	11.1	8.49	10		1.3
Fluoride (Particulate)	77.0	64.0	42.1	61		18
Sulfate (Particulate)	1320	1270	978	1190		184
Phosphate (Particulate)	9.83	12.5	9.23	11		1.7

DL Ratio = Detection limit ratio.

SD = Standard deviation.

HCl and HF samples corrected by subtracting CO₃/HCO₃ field reagent blank C-4a-FCL-622 and train blank C-6a+b-FCL-620 (corrected for field reagent blank).

Filter samples (all except location 6b) corrected by subtracting uncorrected train blank C-6a+b-FCL-620.

Filter samples (location 6b) corrected by subtracting filter blank C-6b-MUM-627.

TABLE 5-41. ANIONS IN BLANK GAS SAMPLES ($\mu\text{g}/\text{Nm}^3$)

Analyte	Part A		Part B	
	TRAIN BLANK		TRAIN BLANK	
	C-6-a+b-FCL-620		C-6-a+b-FCL-620	
Hydrogen Chloride	14.3		460	
Hydrogen Fluoride	0.507		26.8	
Chloride (Particulate)	5.09		4.32	
Fluoride (Particulate)	0.963	ND <	0.179	
Sulfate (Particulate)	54.6		37.2	
Phosphate (Particulate)	ND <	1.74	ND <	0.864

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

HCl and HF samples corrected by subtracting CO₃/HCO₃ field reagent blank C-4a-FCL-622 and train blank C-6a+b-FCL-620 (corrected for field reagent blank).

Filter samples (all except location 6b) corrected by subtracting uncorrected train blank C-6a+b-FCL-620.

Filter samples (location 6b) corrected by subtracting filter blank C-6b-MUM-627.

Conversion to $\mu\text{g}/\text{Nm}^3$ performed after blank corrections.

5.3.2. Anions in Solid Samples

Tables 5-42 through 5-48 present the analytical results for anions (fluoride, chloride, phosphate, sulfate) in solid samples. These tables show results for samples of boiler feed coal (Location 1), bottom ash (Location 2), economizer ash (Location 3), pyrite rejects (Location 7), ESP ash (Location 8), run-of-mine coal (Location 14), and lime (Location 15), respectively. All results are in micrograms of analyte per gram of sample ($\mu\text{g/g}$). Each of these tables shows results for individual daily composite samples, as well as the average and standard deviation of those results. The composite sample identification numbers, and the procedures for preparing composites, are presented in Section 3.2.2.

Table 5-42 shows anions in boiler feed coal, and lists both total fluoride and chloride (average values from the coal analysis round robin, Appendix B) and soluble fluoride and chlorine (from aqueous extraction of pulverized coal). The total anion results in Table 5-42 are on a dry basis, whereas all other results in Tables 5-42 through 5-48 are on an as-received basis.

The most noticeable feature of the data in Tables 5-43, -44, and -46 is the high concentrations of sulfate in bottom ash, economizer ash, and ESP ash, respectively. Among the ESP samples (Table 5-46) the sulfate content appears to increase progressing from hopper row 1 to row 2 and row 3. This likely results from the tendency for sulfate to be present in fine particles. Chloride predominates over fluoride in samples of bottom ash (Table 5-43) and pyrite rejects (Table 5-45), but the opposite is true in samples of ESP ash (Table 5-46). These differences are likely due to the chemical form in which these materials exist as a result of the combustion process. Phosphate was not detected in any of the solid samples.

TABLE 5-42. ANIONS IN BOILER FEED COAL (LOCATION 1) ($\mu\text{g/g}$)

Analyte	JN2293BOFED		JN2493BOFED		JN2793BOFED		AVERAGE	DL RATIO	SD
Chloride (soluble)	ND <	0.2		1.02	ND <	0.2	0.41	16 %	0.53
Chloride (total)*							40000		
Fluoride (soluble)		0.883		0.818		1.02	0.91		0.10
Fluoride (total)*							56.9		
Sulfate		NA		NA		NA			
Phosphate	ND <	1.00	ND <	1.00	ND <	1.00	ND <	1.0	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

* Total fluoride and chloride results are averages for Coal Creek coal (samples E and N) from five laboratories in the coal analysis round robin. Total fluoride and chloride are on a dry basis, all others are as received. Soluble chloride and fluoride are from aqueous extraction of pulverized coal, which provides an incomplete measurement.

TABLE 5-43. ANIONS IN BOTTOM ASH (LOCATION 2) ($\mu\text{g/g}$)

Analyte	JN2293BOTT		JN2493BOTT		JN2793BOTT		AVERAGE	DL RATIO	SD
Chloride		249		237		150	212		54
Fluoride		3.29		2.72		2.71	2.9		0.33
Sulfate		4140		3530		3370	3680		406
Phosphate	ND <	1.00	ND <	1.00	ND <	1.00	ND <	1.0	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-44. ANIONS IN ECONOMIZER ASH (LOCATION 3) ($\mu\text{g/g}$)

Analyte	JN2293ECON	JN2493ECON	JN2793ECON	AVERAGE	DL RATIO	SD
Chloride	ND < 1.00	ND < 1.00	ND < 1.00	ND < 1.0		0
Fluoride	1.82	1.71	2.23	1.9		0.27
Sulfate	1570	1590	414	1190		673
Phosphate	ND < 1.00	ND < 1.00	ND < 1.00	ND < 1.0		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-45. ANIONS IN PYRITE REJECTS (LOCATION 7) ($\mu\text{g/g}$)

Analyte	JN2293PYREJ	JN2493PYREJ	JN2793PYREJ	AVERAGE	DL RATIO	SD
Chloride	6.29	11.7	10.9	9.6		2.9
Fluoride	0.31	ND < 0.2	ND < 0.2	0.17	39%	0.12
Sulfate	NA	NA	NA			
Phosphate	ND < 1.00	ND < 1.00	ND < 1.00	ND < 1.0		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

TABLE 5-46. ANIONS IN ESP ASH (LOCATION 8) ($\mu\text{g/g}$)

Analyte	AVERAGE								AVERAGE							
	JN2293ESPA R-1	JN2493ESPA R-1	JN2793ESPA R-1	ESPA R-1	DL RATIO	SD	JN2293ESPA R-2	JN2493ESPA R-2	JN2793ESPA R-2	ESPA R-2	DL RATIO	SD	JN2793ESPA R-3			
Chloride	ND <	1.00	ND <	1.00	ND <	1.0	0	ND <	1.00	ND <	1.00	ND <	1.0	0	ND <	1.00
Fluoride		13.3		18.1		15.5	2.4		25.4		32.2		26.4	3.7		28.6
Sulfate		2300		2510		3150	443		4290		4320		3990	182		5470
Phosphate	ND <	5.00	ND <	5.00	ND <	5.00	0	ND <	5.00	ND <	5.00	ND <	5.00	0	ND <	5.00

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-47. ANIONS IN RUN-OF-MINE COAL (LOCATION 14) ($\mu\text{g/g}$)

Analyte	JN2293COAL		JN2493COAL		JN2793COAL		AVERAGE		DL RATIO	SD
Chloride		0.778		2.81		0.679		1.4		1.2
Fluoride		0.844		1.07		0.789		0.90		0.15
Sulfate		NA		NA		NA				
Phosphate	ND<	1.00	ND<	1.00	ND<	1.00	ND<	1.0		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

TABLE 5-48. ANIONS IN LIME (LOCATION 15) ($\mu\text{g/g}$)

Analyte	JN2293LIME		JN2493LIME		JN2793LIME		AVERAGE		DL RATIO	SD
Chloride	ND<	10.0	ND<	10.0	ND<	10.0	ND<	10		0
Fluoride	ND<	1.00	ND<	1.00	ND<	1.00	ND<	1.0		0
Sulfate		NA		NA		NA				
Phosphate	ND<	1.00	ND<	1.00	ND<	1.00	ND<	1.0		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

5.3.3. Anions in Liquid Samples

Tables 5-49 through 5-53 present the analytical results for anions (chloride, fluoride, phosphate, sulfate) in liquid samples. All anion results are presented in milligrams of analyte per liter (mg/L), and represent the dissolved quantities of these anions. Tables 5-49 through 5-53, respectively, show results for river water (Location 9); circulating water (Location 10); scrubber makeup water (Location 11); lime slurry (Location 16); and slurry blowdown (Locations 17a and 17b). Each of these tables shows results for individual samples, as well as the average and standard deviation of those results. Note that only two individual samples are shown from Locations 16 and 17a (Tables 5-52 and 5-53, respectively), because no samples could be obtained from these locations on June 24, 1993, as described in Section 3.2.4.

Sulfate and chloride are the dominant anions in all the liquid samples. Comparison of Tables 5-49 and 5-50 shows that anion concentrations in river water are low, relative to those in the plant circulating water. The difference in composition is probably largely due to the addition of additives such as sulfuric acid, chlorine, and ClO_2 to the circulating water, as noted in Section 2.1.4. The scrubber makeup water (Table 5-51) shows anion levels further elevated due to the contribution of recycled pond water to this stream (see Figure 2-1).

The composition of the slurry blowdown (Location 17a,b) is shown in Table 5-53. Note that the concentrations of sulfate and chloride in these samples are very similar to those shown in Table 2-2, from analyses of representative slurry samples by Coal Creek staff.

Comparison of Tables 5-50 through 5-52 shows that anion levels in lime slurry (Table 5-52) are lower than those in circulating water and makeup water, which are used to prepare the lime slurry. This apparent discrepancy is not a result of analytical error, but rather is due to the preparation of the lime slurry from relatively small proportions of water and relatively large proportions of solid lime. The latter contains no detectable chloride, fluoride, or phosphate (see Table 5-48); the lime was not analyzed for sulfate. As a result, the lime slurry is expected to have an anion content lower than the water used in preparing it. Note that the anion content of the slurry blowdown (Table 5-53) is much higher than that of the lime slurry (Table 5-52). This difference is likely due to a combination of factors,

including collection of HCl, HF, and SO₂ from the flue gas; dilution of the lime slurry with makeup water; and evaporation of water into the flue gas in the scrubber.

TABLE 5-49. ANIONS IN RIVER WATER (LOCATION 9) (mg/L)

Analyte	C-9-PRL-622	C-9-PRL-624	C-9-PRL-627	AVERAGE	DL RATIO	SD
Chloride	9.42	9.34	8.91	9.2		0.27
Fluoride	0.493	0.48	0.496	0.49		0.0068
Phosphate	ND < 0.400	ND < 0.400	ND < 0.400	ND < 0.40		0
Sulfate	170	176	176	174		3.5

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-50. ANIONS IN CIRCULATING WATER (LOCATION 10) (mg/L)

Analyte	C-10-PRL-622	C-10-PRL-624	C-10-PRL-627	AVERAGE	DL RATIO	SD
Chloride	241	241	245	242		2.3
Fluoride	6.37	6.26	6.46	6.4		0.10
Phosphate	ND < 0.400	ND < 0.400	ND < 0.400	ND < 0.40		0
Sulfate	3700	3700	3900	3770		115

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-51. ANIONS IN SCRUBBER MAKEUP (LOCATION 11) (mg/L)

Analyte	C-11-PRL-622	C-11-PRL-624	C-11-PRL-627	AVERAGE	DL RATIO	SD
Chloride	444	402	431	426		22
Fluoride	9.75	10.3	9.56	9.9		0.38
Phosphate	ND < 0.400	ND < 0.400	ND < 0.800	ND < 0.53		0.23
Sulfate	5630	5540	5270	5480		187

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-52. ANIONS IN LIME SLURRY (LOCATION 16) (mg/L)

Analyte	C-16-PRL-622	C-16-PRL-627	AVERAGE	DL RATIO	SD
Chloride	12.7	13	13		NC
Fluoride	ND < 0.0200	ND < 0.0200	ND < 0.020		NC
Phosphate	ND < 0.400	ND < 0.400	ND < 0.40		NC
Sulfate	149	143	146		NC

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-53. ANIONS IN SLURRY BLOWDOWN (LOCATIONS 17a,17b) (mg/L)

Analyte	C-17a-PRL-622		C-17a-PRL-627		AVERAGE	DL RATIO	SD	C-17b-PRL-622		C-17b-PRL-624	C-17b-PRL-627		AVERAGE	DL RATIO	SD
Chloride	850		812		831		NC	848		920	747		838		87
Fluoride	20		22.2		21		NC	20.3		23	19		21		2.0
Phosphate	ND <	0.400	ND <	4.00	ND <	2.2	NC	ND <	4.00	ND <	4.00	ND <	4.00	ND <	4.0
Sulfate	9010		8740		8870		NC	9090		10000	8830		9310		614

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

5.4 Volatile Organic Compounds (VOC)

5.4.1. VOC in Flue Gas Samples

Tables 5-54 through 5-58 show VOC analytical results from VOST samples collected at the flue gas sampling locations. VOC results from Summa canisters are presented in Special Topics, Section 7.5. Tables 5-54 through 5-58 show results in micrograms per normal cubic meter of flue gas ($\mu\text{g}/\text{Nm}^3$). All these tables show individual sample results, plus the average and standard deviation of those results. In order of presentation, results are provided for VOST samples from the ESP # inlet (Location 4a), ESP #1 outlet (Location 5a), scrubber outlet (hot) (Location 6a), scrubber outlet (dilute) (Location 6b), and for blank samples.

It should be noted that methylene chloride and acetone were used as solvents to rinse sampling probes on the Modified Method 5 and Multi-Metals trains, respectively. The elevated levels of methylene chloride and acetone in the VOC samples are believed to be attributable to contamination from such use, and do not indicate flue gas concentrations of these compounds. One extremely high value for chloromethane was also observed (Table 5-55), and is not considered a valid measurement.

The VOC concentrations, and the number of VOC detected, were higher at Location 4a than at other locations. However, the results show substantial variability, and in general do not present a clear picture of VOC levels and behavior in the flue gas streams. Even compounds such as benzene, which are not affected by contamination from use as solvents, show wide variations in measured concentrations. This variability results in large uncertainty in any emission calculations or comparisons done with the VOC data. However, in general the results indicate very low levels of VOC in flue gas.

TABLE 5-54. VOC IN GAS SAMPLES FROM ESP-1 INLET (LOCATION 4a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-4a-VOS-621	C-4a-VOS-623	C-4a-VOS-626	AVERAGE	DL RATIO	SD
Chloromethane	25.2	247	981	418		500
Bromomethane	3.46 J	4.78 J	ND < 5.89	ND < 5.9		0.95
Vinyl Chloride	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Chloroethane	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Methylene Chloride	23.8	19.4	13.6	19		5.1
Acetone	19.0	23.4	16.9	20		3.3
Carbon Disulfide	4.10 J	5.77	6.75	5.5		1.3
1,1-Dichloroethene	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
1,1-Dichloroethane	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
trans-1,2-Dichloroethene	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Chloroform	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
1,2-Dichloroethane	60.1	ND < 5.58	2.96 J	22	4%	33
2-Butanone	24.3	18.2	6.17	16		9.2
1,1,1-Trichloroethane	ND < 6.84	ND < 5.58	7.83	ND < 6.8		2.7
Carbon Tetrachloride	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Vinyl Acetate	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Bromodichloromethane	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
1,2-Dichloropropane	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
cis-1,3-Dichloropropylene	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Trichloroethene	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Dibromochloromethane	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
1,1,2-Trichloroethane	3.38 J	ND < 5.58	ND < 5.89	ND < 5.9		0.31
Benzene	412	3.29 J	29.9	148		229
trans-1,3-Dichloropropylene	3.78	ND < 5.58	ND < 5.89	ND < 5.9		0.53
2-Chloroethylvinylether	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Bromoform	3.88	ND < 5.58	ND < 5.89	ND < 5.9		0.59
4-Methyl-2-Pentanone	19.8	10.6	4.70	12		7.6
2-Hexanone	10.9	5.45	4.22	6.9		3.6
Tetrachloroethene	7.19	ND < 5.58	ND < 5.89	ND < 5.9		2.5
1,1,2,2-Tetrachloroethane	ND < 6.84	ND < 5.58	ND < 5.89	ND < 6.1		0.66
Toluene	80.5	8.47	11.43	33		41
Chlorobenzene	69.5	ND < 5.58	3.03	25	4%	38
Ethylbenzene	65.7	5.88	6.17	26		34
Styrene	85.3	ND < 5.58	ND < 5.89	30	6%	48
Xylenes (Total)	368	50.1	40.7	153		186

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Sample results corrected for train blank.

J = Concentration detected below calibration range.

TABLE 5-55. VOC IN GAS SAMPLES FROM ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-5a-VOS-621	C-5a-VOS-623	C-5a-VOS-626	AVERAGE	DL RATIO	SD
Chloromethane	46	1250	1790000	597000		1030000
Bromomethane	4.67	12.0	4.15	6.9		4.4
Vinyl Chloride	ND < 7.58	31.8	ND < 7.84	13	20 %	16
Chloroethane	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Methylene Chloride	558	200	41.7	267		265
Acetone	9.29	93.4	99.6	67		50
Carbon Disulfide	4.99	1.26	ND < 7.84	ND < 7.8		1.9
1,1-Dichloroethene	ND < 7.58	1.44	ND < 7.84	ND < 7.8		1.4
1,1-Dichloroethane	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
trans-1,2-Dichloroethene	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Chloroform	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
1,2-Dichloroethane	10.3	ND < 0.20	ND < 7.84	ND < 7.8		5.2
2-Butanone	12.6	29.1	11.9	18		9.7
1,1,1-Trichloroethane	ND < 7.58	0.56	6.62	ND < 7.6		3.0
Carbon Tetrachloride	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Vinyl Acetate	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Bromodichloromethane	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
1,2-Dichloropropane	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
cis-1,3-Dichloropropylene	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Trichloroethene	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Dibromochloromethane	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
1,1,2-Trichloroethane	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Benzene	64.9	289	4.49	120		150
trans-1,3-Dichloropropylene	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
2-Chloroethylvinylether	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Bromoform	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
4-Methyl-2-Pentanone	ND < 7.58	ND < 2.26	ND < 7.84	ND < 5.9		3.1
2-Hexanone	3.95	6.99	ND < 7.84	ND < 7.8		1.8
Tetrachloroethene	3.95	3.54	ND < 7.84	ND < 7.8		0.23
1,1,2,2-Tetrachloroethane	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Toluene	8.25	3.08	ND < 7.84	ND < 7.8		2.8
Chlorobenzene	7.55	11.8	ND < 7.84	ND < 7.8		3.9
Ethylbenzene	ND < 7.58	ND < 0.20	ND < 7.84	ND < 5.2		4.3
Styrene	12.6	22.8	ND < 7.84	13	10 %	9.5
Xylenes (Total)	ND < 7.58	ND < 0.20	ND < 7.84	ND < 7.8		4.3

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Sample results corrected for train blank.

TABLE 5-56. VOC IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) ($\mu\text{g}/\text{Nm}^3$)

Analyte		C-6a-VOS-621	C-6a-VOS-623	C-6a-VOS-626	AVERAGE	DL RATIO	SD		
Chloromethane		134	102	181	139		40		
Bromomethane	ND<	8.60	3.96	8.84	ND<	8.6	2.7		
Vinyl Chloride	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Chloroethane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Methylene Chloride		816	368	296	493		282		
Acetone		27.0	40.7	34.6	34		6.9		
Carbon Disulfide	ND<	8.60	5.18	ND<	8.16	ND<	8.6	0.58	
1,1-Dichloroethene	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
1,1-Dichloroethane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
trans-1,2-Dichloroethene	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Chloroform	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
1,2-Dichloroethane		4.32	ND<	8.61	ND<	8.16	ND<	8.6	0.14
2-Butanone		7.70	19.5	11.8	13		6.0		
1,1,1-Trichloroethane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Carbon Tetrachloride	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Vinyl Acetate	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Bromodichloromethane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
1,2-Dichloropropane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
cis-1,3-Dichloropropylene	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Trichloroethene	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Dibromochloromethane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
1,1,2-Trichloroethane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Benzene		61.3	66.1	31.4	53		19		
trans-1,3-Dichloropropylene	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
2-Chloroethylvinylether	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Bromoform	ND<	8.60	4.00	ND<	8.16	ND<	8.6	0.16	
4-Methyl-2-Pentanone	ND<	8.60	15.4	ND<	8.16	ND<	8.6	6.5	
2-Hexanone		7.80	33.4	5.17	15		16		
Tetrachloroethene	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
1,1,2,2-Tetrachloroethane	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Toluene		39.1	33.5	20.2	31		9.7		
Chlorobenzene		4.39	ND<	8.61	ND<	8.16	ND<	8.6	0.16
Ethylbenzene	ND<	8.60	ND<	8.61	ND<	8.16	ND<	8.5	0.26
Styrene		4.47	ND<	8.61	ND<	8.16	ND<	8.6	0.19
Xylenes (Total)		4.54	5.30	ND<	8.16	ND<	8.2	0.61	

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

Sample results corrected for train blank.

TABEL 5-57. VOC IN DILUTE GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6b) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6b-VOS-621	C-6b-VOS-623	C-6b-VOS-626	AVERAGE	DL RATIO	SD
Chloromethane	27.2	113	67.6	69		43
Bromomethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Vinyl Chloride	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Chloroethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Methylene Chloride	2080	1200	611	1300		739
Acetone	19.7	26.8	6.43	18		10
Carbon Disulfide	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
1,1-Dichloroethene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
1,1-Dichloroethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
trans-1,2-Dichloroethene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Chloroform	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
1,2-Dichloroethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
2-Butanone	26.8	22.5	ND< 12.6	19	11%	11
1,1,1-Trichloroethane	ND< 4.99	5.85	7.48	ND< 5.0		2.5
Carbon Tetrachloride	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Vinyl Acetate	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Bromodichloromethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
1,2-Dichloropropane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
cis-1,3-Dichloropropylene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Trichloroethene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Dibromochloromethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
1,1,2-Trichloroethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Benzene	6.10	4.88	ND< 12.6	ND< 13		0.77
trans-1,3-Dichloropropylene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
2-Chloroethylvinylether	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Bromoform	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
4-Methyl-2-Pentanone	ND< 11.4	5.92	ND< 12.6	ND< 13		0.31
2-Hexanone	ND< 11.4	7.05	ND< 12.6	ND< 13		0.67
Tetrachloroethene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
1,1,2,2-Tetrachloroethane	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Toluene	19.2	6.33	ND< 12.6	ND< 13		7.4
Chlorobenzene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Ethylbenzene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Styrene	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87
Xylenes (Total)	ND< 11.4	ND< 11.0	ND< 12.6	ND< 12		0.87

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

Sample results corrected for train blank.

TABLE 5-58. VOC IN BLANK GAS SAMPLE ($\mu\text{g}/\text{Nm}^3$)

Analyte	C4a-VOS-621	
Chloromethane	ND <	3.83
Bromomethane	ND <	3.83
Vinyl Chloride	ND <	3.83
Chloroethane	ND <	3.83
Methylene Chloride		480
Acetone	ND <	3.83
Carbon Disulfide	ND <	3.83
1,1-Dichloroethene	ND <	3.83
1,1-Dichloroethane	ND <	3.83
trans-1,2-Dichloroethene	ND <	3.83
Chloroform	ND <	3.83
1,2-Dichloroethane	ND <	3.83
2-Butanone	ND <	3.83
1,1,1-Trichloroethane	ND <	3.83
Carbon Tetrachloride	ND <	3.83
Vinyl Acetate	ND <	3.83
Bromodichloromethane	ND <	3.83
1,2-Dichloropropane	ND <	3.83
cis-1,3-Dichloropropylene	ND <	3.83
Trichloroethene	ND <	3.83
Dibromochloromethane	ND <	3.83
1,1,2-Trichloroethane	ND <	3.83
Benzene	ND <	3.83
trans-1,3-Dichloropropylene	ND <	3.83
2-Chloroethylvinylether	ND <	3.83
Bromoform	ND <	3.83
4-Methyl-2-Pentanone	ND <	3.83
2-Hexanone	ND <	3.83
Tetrachloroethene	ND <	3.83
1,1,2,2-Tetrachloroethane	ND <	3.83
Toluene		2.47 J
Chlorobenzene	ND <	3.83
Ethylbenzene	ND <	3.83
Styrene	ND <	3.83
Xylenes (Total)	ND <	3.83

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

J = Concentration detected below calibration range.

Train blank results corrected for field reagent blank.

5.4.2. VOC in Liquid Samples

Tables 5-59 through 5-63 show the analytical results for VOC in liquid samples. All results are in micrograms of analyte per liter of sample ($\mu\text{g/L}$). These tables show results for river water (Location 9), circulating water (Location 10), scrubber makeup water (Location 11), slurry blowdown (Locations 17a, 17b), and blank water, respectively. Each table shows the individual sample results as well as the average and standard deviation of those results. Note that for slurry blowdown samples, individual and average values are shown for both sampling locations 17a and 17b in the same table (Table 5-62). None of the target VOC were detected in any of the water samples.

TABLE 5-59. VOC IN RIVER WATER (LOCATION 9) ($\mu\text{g/L}$)

Analyte	C-9-PRL-621		C-9-PRL-623		C-9-PRL-626		AVERAGE		DL RATIO	SD
Acrylonitrile	ND<	10	ND<	10	ND	10	ND<	10		0
Benzene	ND<	5	ND<	5	ND	5	ND<	5		0
Bromomethane	ND<	5	ND<	5	ND	5	ND<	5		0
Bromoform	ND<	5	ND<	5	ND	5	ND<	5		0
2-Butanone	ND<	50	ND<	50	ND	50	ND<	50		0
Carbon disulfide	ND<	10	ND<	10	ND	10	ND<	10		0
Carbon tetrachloride	ND<	5	ND<	5	ND	5	ND<	5		0
Chlorobenzene	ND<	5	ND<	5	ND	5	ND<	5		0
Chloroethane	ND<	5	ND<	5	ND	5	ND<	5		0
Chloromethane	ND<	5	ND<	5	ND	5	ND<	5		0
Chloroprene	ND<	5	ND<	5	ND	5	ND<	5		0
Cumene	ND<	5	ND<	5	ND	5	ND<	5		0
1,2-Dibromoethane	ND<	5	ND<	5	ND	5	ND<	5		0
1,1-Dichloroethane	ND<	5	ND<	5	ND	5	ND<	5		0
1,2-Dichloroethane	ND<	5	ND<	5	ND	5	ND<	5		0
cis-1,3-Dichloropropylene	ND<	5	ND<	5	ND	5	ND<	5		0
trans-1,3-Dichloropropylene	ND<	5	ND<	5	ND	5	ND<	5		0
1,4-Dioxane	ND<	50	ND<	50	ND	50	ND<	50		0
Ethylbenzene	ND<	5	ND<	5	ND	5	ND<	5		0
Iodomethane	ND<	5	ND<	5	ND	5	ND<	5		0
Methylene chloride	ND<	5	ND<	5	ND	5	ND<	5		0
Methyl methacrylate	ND<	10	ND<	10	ND	10	ND<	10		0
4-Methyl-2-pentanone	ND<	10	ND<	10	ND	10	ND<	10		0
Styrene	ND<	5	ND<	5	ND	5	ND<	5		0
Toluene	ND<	5	ND<	5	ND	5	ND<	5		0
1,1,1-Trichloroethane	ND<	5	ND<	5	ND	5	ND<	5		0
1,1,2-Trichloroethane	ND<	5	ND<	5	ND	5	ND<	5		0
Trichloroethylene	ND<	5	ND<	5	ND	5	ND<	5		0
Vinyl acetate	ND<	10	ND<	10	ND	10	ND<	10		0
Vinyl bromide	ND<	5	ND<	5	ND	5	ND<	5		0
Vinyl chloride	ND<	5	ND<	5	ND	5	ND<	5		0
o-Xylene	ND<	5	ND<	5	ND	5	ND<	5		0
m+p-Xylene	ND<	10	ND<	10	ND	10	ND<	10		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-60. VOC IN CIRCULATING WATER (LOCATION 10) (µg/L)

Analyte	C-10-PRL-621		C-10-PRL-623		C-10-PRL-626		AVERAGE		DL RATIO	SD
Acrylonitrile	ND<	10	ND<	10	ND<	10	ND<	10		0
Benzene	ND<	5	ND<	5	ND<	5	ND<	5		0
Bromomethane	ND<	5	ND<	5	ND<	5	ND<	5		0
Bromoform	ND<	5	ND<	5	ND<	5	ND<	5		0
2-Butanone	ND<	50	ND<	50	ND<	50	ND<	50		0
Carbon disulfide	ND<	10	ND<	10	ND<	10	ND<	10		0
Carbon tetrachloride	ND<	5	ND<	5	ND<	5	ND<	5		0
Chlorobenzene	ND<	5	ND<	5	ND<	5	ND<	5		0
Chloroethane	ND<	5	ND<	5	ND<	5	ND<	5		0
Chloromethane	ND<	5	ND<	5	ND<	5	ND<	5		0
Chloroprene	ND<	5	ND<	5	ND<	5	ND<	5		0
Cumene	ND<	5	ND<	5	ND<	5	ND<	5		0
1,2-Dibromoethane	ND<	5	ND<	5	ND<	5	ND<	5		0
1,1-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5		0
1,2-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5		0
cis-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5		0
trans-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5		0
1,4-Dioxane	ND<	50	ND<	50	ND<	50	ND<	50		0
Ethylbenzene	ND<	5	ND<	5	ND<	5	ND<	5		0
Iodomethane	ND<	5	ND<	5	ND<	5	ND<	5		0
Methylene chloride	ND<	5	ND<	5	ND<	5	ND<	5		0
Methyl methacrylate	ND<	10	ND<	10	ND<	10	ND<	10		0
4-Methyl-2-pentanone	ND<	10	ND<	10	ND<	10	ND<	10		0
Styrene	ND<	5	ND<	5	ND<	5	ND<	5		0
Toluene	ND<	5	ND<	5	ND<	5	ND<	5		0
1,1,1-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5		0
1,1,2-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5		0
Trichloroethylene	ND<	5	ND<	5	ND<	5	ND<	5		0
Vinyl acetate	ND<	10	ND<	10	ND<	10	ND<	10		0
Vinyl bromide	ND<	5	ND<	5	ND<	5	ND<	5		0
Vinyl chloride	ND<	5	ND<	5	ND<	5	ND<	5		0
o-Xylene	ND<	5	ND<	5	ND<	5	ND<	5		0
m+p-Xylene	ND<	10	ND<	10	ND<	10	ND<	10		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-61. VOC IN SCRUBBER MAKEUP (LOCATION 11) ($\mu\text{g/L}$)

Analyte	C-11-PRL-621		C-11-PRL-623		C-11-PRL-626		AVERAGE DL RATIO		SD
Acrylonitrile	ND<	10	ND<	10	ND<	10	ND<	10	0
Benzene	ND<	5	ND<	5	ND<	5	ND<	5	0
Bromomethane	ND<	5	ND<	5	ND<	5	ND<	5	0
Bromoform	ND<	5	ND<	5	ND<	5	ND<	5	0
2-Butanone	ND<	50	ND<	50	ND<	50	ND<	50	0
Carbon disulfide	ND<	10	ND<	10	ND<	10	ND<	10	0
Carbon tetrachloride	ND<	5	ND<	5	ND<	5	ND<	5	0
Chlorobenzene	ND<	5	ND<	5	ND<	5	ND<	5	0
Chloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0
Chloromethane	ND<	5	ND<	5	ND<	5	ND<	5	0
Chloroprene	ND<	5	ND<	5	ND<	5	ND<	5	0
Cumene	ND<	5	ND<	5	ND<	5	ND<	5	0
1,2-Dibromoethane	ND<	5	ND<	5	ND<	5	ND<	5	0
1,1-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0
1,2-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0
cis-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5	0
trans-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5	0
1,4-Dioxane	ND<	50	ND<	50	ND<	50	ND<	50	0
Ethylbenzene	ND<	5	ND<	5	ND<	5	ND<	5	0
Iodomethane	ND<	5	ND<	5	ND<	5	ND<	5	0
Methylene chloride	ND<	5	ND<	5	ND<	5	ND<	5	0
Methyl methacrylate	ND<	10	ND<	10	ND<	10	ND<	10	0
4-Methyl-2-pentanone	ND<	10	ND<	10	ND<	10	ND<	10	0
Styrene	ND<	5	ND<	5	ND<	5	ND<	5	0
Toluene	ND<	5	ND<	5	ND<	5	ND<	5	0
1,1,1-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0
1,1,2-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0
Trichloroethylene	ND<	5	ND<	5	ND<	5	ND<	5	0
Vinyl acetate	ND<	10	ND<	10	ND<	10	ND<	10	0
Vinyl bromide	ND<	5	ND<	5	ND<	5	ND<	5	0
Vinyl chloride	ND<	5	ND<	5	ND<	5	ND<	5	0
o-Xylene	ND<	5	ND<	5	ND<	5	ND<	5	0
m+p-Xylene	ND<	10	ND<	10	ND<	10	ND<	10	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-62. VOC IN SLURRY BLOWDOWN (LOCATION 17a, 17b). (µg/L)

Analyte	C-17a-PRL-62		C-17a-PRL-623		C-17a-PRL-626 AVERAGE		DL RATIO	SD	C-17b-PRL-62		C-17b-PRL-623		C-17b-PRL-626 AVERAGE		DL RATIO	SD		
Acrylonitrile	ND<	10	ND<	10	ND<	10	ND<	10	0	ND<	10	ND<	10	ND<	10	ND<	10	0
Benzene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Bromomethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Bromoform	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
2-Butanone	ND<	50	ND<	50	ND<	50	ND<	50	0	ND<	50	ND<	50	ND<	50	ND<	50	0
Carbon disulfide	ND<	10	ND<	10	ND<	10	ND<	10	0	ND<	10	ND<	10	ND<	10	ND<	10	0
Carbon tetrachloride	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Chlorobenzene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Chloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Chloromethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Chloroprene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Cumene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
1,2-Dibromoethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
1,1-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
1,2-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
cis-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
trans-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
1,4-Dioxane	ND<	50	ND<	50	ND<	50	ND<	50	0	ND<	50	ND<	50	ND<	50	ND<	50	0
Ethylbenzene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Iodomethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Methylene chloride	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Methyl methacrylate	ND<	10	ND<	10	ND<	10	ND<	10	0	ND<	10	ND<	10	ND<	10	ND<	10	0
4-Methyl-2-pentanone	ND<	10	ND<	10	ND<	10	ND<	10	0	ND<	10	ND<	10	ND<	10	ND<	10	0
Styrene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Toluene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
1,1,1-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
1,1,2-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Trichloroethylene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Vinyl acetate	ND<	10	ND<	10	ND<	10	ND<	10	0	ND<	10	ND<	10	ND<	10	ND<	10	0
Vinyl bromide	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
Vinyl chloride	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
o-Xylene	ND<	5	ND<	5	ND<	5	ND<	5	0	ND<	5	ND<	5	ND<	5	ND<	5	0
m+p-Xylene	ND<	10	ND<	10	ND<	10	ND<	10	0	ND<	10	ND<	10	ND<	10	ND<	10	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-63. VOC IN LIQUID BLANK SAMPLES (µg/L)

Analyte	TRIP BLANK 6/21/93		TRIP BLANK 6/23/93		FIELD BLANK C-9-PRL-623		FIELD BLANK C-9-PRL-626		TRIP BLANK 6/26/93	
Acrylonitrile	ND<	10	ND<	10	ND<	10	ND<	10	ND<	10
Benzene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Bromomethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Bromoform	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
2-Butanone	ND<	50	ND<	50	ND<	50	ND<	50	ND<	50
Carbon disulfide	ND<	10	ND<	10	ND<	10	ND<	10	ND<	10
Carbon tetrachloride	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Chlorobenzene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Chloroethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Chloromethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Chloroprene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Cumene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
1,2-Dibromoethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
1,1-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
1,2-Dichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
cis-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
trans-1,3-Dichloropropylene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
1,4-Dioxane	ND<	50	ND<	50	ND<	50	ND<	50	ND<	50
Ethylbenzene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Iodomethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Methylene chloride	ND<	5		7.9	ND<	5	ND<	5		7.4
Methyl methacrylate	ND<	10	ND<	10	ND<	10	ND<	10	ND<	10
4-Methyl-2-pentanone	ND<	10	ND<	10	ND<	10	ND<	10	ND<	10
Styrene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Toluene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
1,1,1-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
1,1,2-Trichloroethane	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Trichloroethylene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Vinyl acetate	ND<	10	ND<	10	ND<	10	ND<	10	ND<	10
Vinyl bromide	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
Vinyl chloride	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
o-Xylene	ND<	5	ND<	5	ND<	5	ND<	5	ND<	5
m+p-Xylene	ND<	10	ND<	10	ND<	10	ND<	10	ND<	10

ND< = Not detected, value following ND< is detection limit.

5.5 PAH/SVOC

5.5.1. PAH/SVOC in Flue Gas Samples

Tables 5-64 through 5-68 present analytical results for PAH and other SVOC in samples from flue gas streams. The values shown are the total (particulate plus vapor phase) flue gas concentrations determined from the filter (F) and XAD resin (X) portions of the Modified Method 5 trains, respectively. Individual sample results as well as the average and standard deviation of those results are shown in each table. Tables 5-64 through 5-68 present the PAH/SVOC results in nanograms of analyte per normal cubic meter of flue gas (ng/Nm^3). Data are presented for PAH/SVOC at ESP #1 inlet (Location 4a), ESP #1 outlet (Location 5a), scrubber outlet (hot) (Location 6a), scrubber outlet (dilute) (Location 6b), and for blank samples, in that order.

Note that the concentrations reported for the analytes benzo(b and k)fluoranthene may include some contribution from the co-eluting non-target compound benzo(j)-fluoranthene. Similarly, the concentrations reported for chrysene may include a contribution from the co-eluting non-target compound triphenylene.

Comparison of Tables 5-64 and 5-65 shows that average levels of most PAH/SVOC decreased or stayed constant through the ESP, though variability in the measured levels makes it difficult to draw conclusions. Dibenzofuran was a notable exception, showing concentrations at Location 5a averaging nearly a factor of 10 higher than at Location 4a. The PAH/SVOC concentrations at the scrubber outlet (Tables 5-66 and 5-67) are generally much lower than those upstream of the scrubber, though care must be used in the comparison since the hot (Table 5-66) and dilute (Table 5-67) results do not show good quantitative agreement. The low PAH concentrations and the difficulty of measurements in the power plant environment may contribute to the observed variability in PAH/SVOC. However, previous data are insufficient to define what normal variability should be.

Acetophenone concentrations at the ESP-1 inlet (Table 5-64) show wide variability. Degradation of the XAD-2 resin is a possible cause of the high acetophenone values. However, the same might have been expected at other locations, and the data show no indication of such a problem. Acetophenone is a common combustion product, and in

general the relative concentrations are credible. Dibenzofuran was higher at the ESP outlet (Table 5-65) than at the ESP inlet (Table 5-64); the consistency of the results suggests possible formation of dibenzofuran in the flue gas.

The blank PAH/SVOC values shown in Table 5-68 are somewhat higher than are found ordinarily in ambient air sampling. This is not unexpected considering that these were true field blanks, opened and handled in the power plant environment. The Location 6b blank values are inflated by the low sample volume achievable through the XAD resin with the PSDS system.

TABLE 5-64. PAH/SVOC IN GAS SAMPLES FROM ESP-1 INLET (LOCATION 4a) (ng/Nm³)

Analyte	C-4A-MM5- F+X-621	C-4A-MM5- F+X-623	C-4A-MM5- F+X-626	AVERAGE	DL RATIO	SD
Benzylchloride	1010	889	6100	2670		2970
Acetophenone	2650	33500	140000	58700		72100
Hexachloroethane	ND < 13.7	ND < 13.2	ND < 13.8	ND < 14		0.30
Naphthalene	1310	1840	3700	2280		1260
Hexachlorobutadiene	ND < 13.7	ND < 13.2	ND < 13.8	ND < 14		0.30
Quinoline	ND < 13.7	ND < 13.2	ND < 13.8	ND < 14		0.30
2-Chloroacetophenone	844	921	1830	1200		548
2-Methylnaphthalene	2110	1310	1010	1480		569
1-Methylnaphthalene	997	608	423	676		293
Hexachlorocyclopentadiene	ND < 13.7	ND < 13.2	ND < 13.8	ND < 14		0.30
Biphenyl	2250	20600	64900	29200		32200
Acenaphthylene	339	190	ND < 2.75	177	0%	169
2,6-Dinitrotoluene	30400	9100	27800	22400		11600
Acenaphthene	2820	1220	1390	1810		879
Dibenzofuran	4400	1690	958	2350		1810
2,4-Dinitrotoluene	931	557	715	735		188
Fluorene	2440	2060	1230	1910		619
Hexachlorobenzene	ND < 13.7	ND < 13.2	ND < 13.8	ND < 14		0.30
Pentachlorophenol	ND < 13.7	ND < 13.2	ND < 13.8	ND < 14		0.30
Phenanthrene	8940	41800	6070	18900		19900
Anthracene	1030	2970	497	1499		1300
Fluoranthene	2040	35400	2770	13403		19100
Pyrene	1270	5970	1220	2820		2730
Benz(a)anthracene	169	716	90.2	325		341
Chrysene	767	3530	418	1570		1700
Benzo(b & k)fluoranthene	342	325	107	258		131
Benzo(e)pyrene	103	3.77	ND < 2.75	36	1%	58
Benzo(a)pyrene	3.30	3.61	ND < 2.75	2.8	17%	1.2
Indeno(1,2,3-c,d)pyrene	3.02	3.09	ND < 2.75	ND < 2.8		0.97
Dibenz(a,h)anthracene	3.03	ND < 2.64	ND < 2.75	ND < 2.8		0.97
Benzo(g,h,i)perylene	3.48	2.70	ND < 2.75	ND < 2.8		1.1

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

The reported F+X data (ng/Nm³) are the sum of the corrected filter data and the corrected XAD-2 data. The corrected filter and XAD-2 data were obtained by dividing the corrected total amount (ng) with the corresponding sample volume (Nm³). The field blanks used for the background correction are C-4A-MM5-F-620, and C-4A-MM5-X-620.

TABLE 5-65. PAH/SVOC IN GAS SAMPLES FROM ESP-1 OUTLET (LOCATION 5a) (ng/Nm³)

Analyte	C-5A-MM5- F+X-621	C-5A-MM5- F+X-623	C-5A-MM5- F+X-626	AVERAGE	DL RATIO	SD
Benzylchloride	10200	380	380	3650		5670
Acetophenone	4130	179	3450	2590		2110
Hexachloroethane	ND < 7.21	ND < 9.50	ND < 8.74	ND < 8.5		1.2
Naphthalene	7800	913	2420	3710		3620
Hexachlorobutadiene	ND < 7.21	ND < 9.50	ND < 8.74	ND < 8.5		1.2
Quinoline	ND < 7.21	ND < 9.50	ND < 8.74	ND < 8.5		1.2
2-Chloroacetophenone	757	82.1	1340	726		629
2-Methylnaphthalene	1440	329	842	870		556
1-Methylnaphthalene	1220	240	571	677		498
Hexachlorocyclopentadiene	ND < 7.21	ND < 9.50	ND < 8.74	ND < 8.5		1.2
Biphenyl	21200	10700	8220	13400		6890
Acenaphthylene	16.9	19.7	74.8	37		33
2,6-Dinitrotoluene	1470	741	2960	1720		1130
Acenaphthene	812	372	237	474		300
Dibenzofuran	19700	19700	16300	18600		1960
2,4-Dinitrotoluene	2060	2130	1580	1920		299
Fluorene	7280	8680	7650	7870		725
Hexachlorobenzene	ND < 7.21	ND < 9.50	ND < 8.74	ND < 8.5		1.2
Pentachlorophenol	7.88	ND < 9.50	ND < 8.74	ND < 8.7		1.9
Phenanthrene	14100	26600	23900	21500		6580
Anthracene	680	685	1210	858		305
Fluoranthene	920	3990	4430	3110		1910
Pyrene	196	277	273	249		46
Benz(a)anthracene	28.7	137	210	125		91
Chrysene	529	3120	5140	2930		2310
Benzo(b & k)fluoranthene	85.3	174	316	192		116
Benzo(e)pyrene	24.8	27.2	31.6	28		3.4
Benzo(a)pyrene	9.90	5.35	ND < 1.75	5.7	5%	4.5
Indeno(1,2,3-c,d)pyrene	ND < 1.44	ND < 1.90	ND < 1.75	ND < 1.7		0.23
Dibenz(a,h)anthracene	ND < 1.44	ND < 1.90	ND < 1.75	ND < 1.7		0.23
Benzo(g,h,i)perylene	ND < 1.44	ND < 1.90	ND < 1.75	ND < 1.7		0.23

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

The reported F+X data (ng/Nm³) are the sum of the corrected filter data and the corrected XAD-2 data. The corrected filter and XAD-2 data were obtained by dividing the corrected total amount (ng) with the corresponding sample volume (Nm³). The field blanks used for the background correction are C-4A-MM5-F-620, and C-4A-MM5-X-620.

TABLE 5-66. PAH/SVOC IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) (ng/Nm³)

Analyte	C-6A-MM5- F+X-621	C-6A-MM5- F+X-623	C-6A-MM5- F+X-626	AVERAGE	DL RATIO	SD
Benzylchloride	ND < 2.18	ND < 2.28	21.0	7.8	10%	12
Acetophenone	471	530	1160	720		382
Hexachloroethane	ND < 2.18	ND < 2.28	ND < 2.26	ND < 2.2		0.054
Naphthalene	211	357	450	339		121
Hexachlorobutadiene	ND < 2.18	ND < 2.28	ND < 2.26	ND < 2.2		0.054
Quinoline	ND < 21.8	ND < 22.8	ND < 22.6	ND < 22		0.54
2-Chloroacetophenone	157	135	203	165		35
2-Methylnaphthalene	61.2	49.2	49.8	53		6.7
1-Methylnaphthalene	23.3	17.6	18.2	20		3.1
Hexachlorocyclopentadiene	ND < 2.18	ND < 2.28	ND < 2.26	ND < 2.2		0.054
Biphenyl	33.7	29.5	27.0	30		3.4
Acenaphthylene	11.8	4.03	25.7	14		11
2,6-Dinitrotoluene	ND < 2.18	ND < 2.28	ND < 2.26	ND < 2.2		0.054
Acenaphthene	33.1	10.0	24.0	22		12
Dibenzofuran	82.5	60.9	58.0	67		13
2,4-Dinitrotoluene	15.1	8.71	ND < 2.26	8.7	5%	7.0
Fluorene	75.8	45.3	40.0	54		19
Hexachlorobenzene	ND < 2.18	ND < 2.28	ND < 2.26	ND < 2.2		0.054
Pentachlorophenol	ND < 2.18	ND < 2.28	ND < 2.26	ND < 2.2		0.054
Phenanthrene	643	448	118	403		265
Anthracene	22.5	18.0	16.9	19		3.0
Fluoranthene	72.1	44.9	47.5	55		15
Pyrene	26.5	15.9	20.8	21		5.3
Benz(a)anthracene	3.59	2.63	1.96	2.7		0.82
Chrysene	9.63	6.52	4.47	6.9		2.6
Benzo(b & k)fluoranthene	8.49	3.55	5.40	5.8		2.5
Benzo(e)pyrene	1.26	0.923	1.97	1.4		0.53
Benzo(a)pyrene	1.29	ND < 0.456	1.87	1.1	7%	0.83
Indeno(1,2,3-c,d)pyrene	0.818	ND < 0.456	1.44	0.83	9%	0.61
Dibenz(a,h)anthracene	0.807	0.764	1.28	0.95		0.29
Benzo(g,h,i)perylene	0.911	ND < 0.456	1.16	0.77	10%	0.48

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

The reported F+X data (ng/Nm³) are the sum of the corrected filter data and the corrected XAD-2 data. The corrected filter and XAD-2 data were obtained by dividing the corrected total amount (ng) with the corresponding sample volume (Nm³).

The field blanks used for the background correction are C-6A+B-MM5-F-620, and C-6A+B-MM5-X-620.

TABLE 5-67. PAH/SVOC IN DILUTE GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6b) (ng/Nm³)

Analyte	C-6B-MM5- F+X-621		C-6B-MM5- F+X-623		C-6B-MM5- F+X-626		AVERAGE	DL RATIO	SD
Benzylchloride	ND <	70.8	ND <	67.4		1470	513	4%	829
Acetophenone		3220		12100		7780	7700		4440
Hexachloroethane	ND <	70.8	ND <	67.4	ND <	64.6	ND <	68	3.1
Naphthalene		2580		3920		841	2450		1540
Hexachlorobutadiene	ND <	70.8	ND <	67.4	ND <	64.6	ND <	68	3.1
Quinoline	ND <	708	ND <	674	ND <	646	ND <	676	31
2-Chloroacetophenone	ND <	70.8		1320		4620	1990	1%	2360
2-Methylnaphthalene		1070		305		98.0	491		512
1-Methylnaphthalene		402		147		62.5	204		177
Hexachlorocyclopentadiene	ND <	70.8	ND <	67.4	ND <	64.6	ND <	68	3.1
Biphenyl		127		54.8		26.1	69		52
Acenaphthylene		137		47.0		55.8	80		49
2,6-Dinitrotoluene		537		1080		812	810		272
Acenaphthene		210		111		117	146		55
Dibenzofuran		189		141	ND <	64.6	121	9%	80
2,4-Dinitrotoluene		48.6		123		234	135		93
Fluorene		401		211		63.1	225		169
Hexachlorobenzene	ND <	70.8	ND <	67.4	ND <	64.6	ND <	68	3.1
Pentachlorophenol	ND <	70.8	ND <	67.4	ND <	64.6	ND <	68	3.1
Phenanthrene		849		1190		258	766		472
Anthracene		129		118		79.6	109		26
Fluoranthene		199		495		329	341		148
Pyrene		194		299		198	230		59
Benz(a)anthracene	ND <	14.2	ND <	13.5		12.9	ND <	14	3.5
Chrysene	ND <	14.2	ND <	13.5	ND <	12.9	ND <	14	0.63
Benzo(b & k)fluoranthene		21.3		29.2		141	64		67
Benzo(e)pyrene	ND <	14.2	ND <	13.5		33.5	16	29%	15
Benzo(a)pyrene	ND <	14.2	ND <	13.5		63.3	26	18%	33
Indeno(1,2,3-c,d)pyrene	ND <	14.2	ND <	13.5	ND <	12.9	ND <	14	0.63
Dibenz(a,h)anthracene	ND <	14.2	ND <	13.5		16.0	ND <	14	5.3
Benzo(g,h,i)perylene	ND <	14.2	ND <	13.5		13.3	ND <	14	3.7

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

The reported F+X data (ng/Nm³) are the sum of the corrected filter data and the corrected XAD-2 data. The corrected filter and XAD-2 data were obtained by dividing the corrected total amount (ng) with the corresponding sample volume (Nm³).

The field blanks used for the background correction are C-6B-MM5-F-627, and C-6A+B-MM5-X-620.

TABLE 5-68. PAH/SVOC IN BLANK GAS SAMPLES (ng/Nm³)

Analyte	C-4A-MM5-F+X-620	C-5A-MM5-F+X-620	C-6A+B-MM5-F+X-620	C-6B-MM5-F-627 + C-6A+B-MM5-X-620
Benzylchloride	3.56	ND < 0.837	4.14	ND < 67.5
Acetophenone	18.7	8.47	68.8	1430
Hexachloroethane	ND < 1.33	ND < 0.837	ND < 2.18	ND < 67.5
Naphthalene	34.9	32.5	117	3420
Hexachlorobutadiene	ND < 1.33	ND < 0.837	ND < 2.18	ND < 67.5
Quinoline	ND < 13.5	ND < 8.37	ND < 2.18	ND < 67.5
2-Chloroacetophenone	ND < 1.33	ND < 0.837	3.53	108
2-Methylnaphthalene	4.15	2.31	5.75	99.7
1-Methylnaphthalene	2.05	1.07	3.56	51.8
Hexachlorocyclopentadiene	ND < 1.35	ND < 0.837	ND < 2.18	ND < 67.5
Biphenyl	3.70	1.61	2.53	48.6
Acenaphthylene	4.64	0.201	2.08	ND < 13.5
2,6-Dinitrotoluene	683 E	201 E	1370	33000 E
Acenaphthene	3.44	3.89	6.66	125
Dibenzofuran	6.61	3.50	6.77	127
2,4-Dinitrotoluene	15.2	3.54	6.47	110
Fluorene	5.49	3.69	8.02	157
Hexachlorobenzene	ND < 1.35	ND < 0.837	ND < 2.18	ND < 67.5
Pentachlorophenol	ND < 1.33	ND < 0.837	ND < 2.18	ND < 67.5
Phenanthrene	22.2	26.5	32.2	542
Anthracene	2.12	2.17	2.32	31.9
Fluoranthene	9.68	12.9	12.3	175
Pyrene	7.18	7.25	4.28	64.0
Benz(a)anthracene	0.316	0.704	ND < 0.436	ND < 13.5
Chrysene	1.44	2.65	0.867	ND < 13.5
Benzo(b & k)fluoranthene	6.98	1.92	1.23	ND < 13.5
Benzo(e)pyrene	2.36	0.731	ND < 0.436	ND < 13.5
Benzo(a)pyrene	0.288	0.538	ND < 0.436	ND < 13.5
Indeno(1,2,3-c,d)pyrene	ND < 0.271	19.9	ND < 0.436	ND < 13.5
Dibenz(a,h)anthracene	ND < 0.271	0.917	ND < 0.436	ND < 13.5
Benzo(g,h,i)perylene	ND < 0.271	0.290	ND < 0.436	ND < 13.5

ND < = Not detected, value following ND < is detection limit.

E = Concentration detected above calibration limit.

For field blanks C-4A-MM5-F-620, and C-4A-MM5-X-620, the assumed sample volume for these field blanks are the average sample volumes of all the field samples (filters and XAD-2) collected at location 4A. Data reported in C-4A-MM5-F+X-620 are the sum of the data in C-4A-MM5-F-620 and C-4A-MM5-X-620 (individual F,X results are reported in Section 7.1.3).

For field blanks C-5A-MM5-F-620, and C-5A-MM5-X-620, the assumed sample volume for these field blanks are the average sample volumes of all the field samples (filters and XAD-2) collected at location 5A. Data reported in C-5A-MM5-F+X-620 are the sum of the data in C-5A-MM5-F-620 and C-5A-MM5-X-620 (individual F,X results are reported in Section 7.1.3).

For field blanks C-6A+B-MM5-F-620, and C-6A+B-MM5-X-620 the assumed sample volume for these field blanks are the average sample volumes of all the field samples (filters and XAD-2) collected at location 6A. Data reported in C-6A+B-MM5-F+X-620 are the sum of the data in C-6A+B-MM5-F-620 and C-6A+B-MM5-X-620 (individual F,X results are reported in Section 7.1.3).

The assumed sample volume for field blank C-6B-MM5-F-627 is the average sample volume of all the filter samples collected at location 6B and for field blank C-6A+B-MM5-620 is the average sample volume of all the XAD-2 samples collected at location 6B. Data reported in C-6B-MM5-F-627 + C-6A+B-MM5-X-620 are the sum of data in these two field blanks (individual F, X results are reported in Section 7.1.3).

The field blank C-5A-MM5-F+X=620 was contaminated and had a high value of Indeno(1,2,3-c,d)pyrene.

To correct for train blanks, the F+X value in the field blank was not used directly to correct for the field sample because the F and X were analyzed separately. Instead, the individual components from the train (XAD-2 or X and the filter or F) were subtracted from the individual components of the samples separately. The field blank C-4A-MM4-F+X-620 (F, X) was used for correction for samples collected at Location 4A and 5A. The field blank -6A+B, and 6B were used for correction for samples collected at Location 6A and 6B.

5.5.2. PAH/SVOC in Solid Samples

Tables 5-69 through 5-71 show PAH/SVOC analytical results in samples of bottom ash (Location 2), economizer ash (Location 3), and ESP ash (Location 8), respectively. All results are in nanograms of analyte per gram of sample (ng/g). Shown in each table are individual sample results, along with the average and standard deviation of those results.

Note that the concentrations reported for the analytes benzo(b and k)fluoranthene may include some contribution from the co-eluting non-target compound benzo(j)fluoranthene. Similarly, the concentrations reported for chrysene may include a contribution from the co-eluting non-target compound triphenylene.

The most prevalent SVOC in the solid samples is 2,6-dinitrotoluene, which is present at average levels of 10-20 ng/g, except in the row 3 ESP ash sample (Table 5-71) where its concentration is 192 ng/g. That sample in general had higher PAH/SVOC concentrations than did the other samples analyzed. 2,4-Dinitrotoluene was also present at relatively elevated levels in the ESP ash, but not in bottom ash (Table 5-69) or in economizer ash (Table 5-70). The generally low concentrations of PAH/SVOC found in the solid samples are consistent with their potential to volatilize at the elevated temperatures at which these solid materials are formed and collected in the plant.

TABLE 5-69. PAH/SVOC IN BOTTOM ASH (LOCATION 2) (ng/g)

Analyte	JN2193BOTT	JN2393BOTT	JN2693BOTT	AVERAGE	DL RATIO	SD
Benzylchloride	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0
Acetophenone	1.75	0.771	1.12	1.2		0.49
Hexachloroethane	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0
Naphthalene	10.2	0.947	1.44	4.2		5.2
Hexachlorobutadiene	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0
Quinoline	ND < 2.50	ND < 2.50	ND < 2.50	ND < 2.5		0
2-Chloroacetophenone	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0
2-Methylnaphthalene	9.88	1.56	1.73	4.4		4.8
1-Methylnaphthalene	4.69	0.665	0.767	2.0		2.3
Hexachlorocyclopentadiene	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0
Biphenyl	2.08	0.371	0.379	0.94		0.99
Acenaphthylene	1.53	0.170	0.125	0.61		0.80
2,6-Dinitrotoluene	12.9	11.3	13.4	13		1.1
Acenaphthene	1.52	0.483	0.286	0.76		0.66
Dibenzofuran	5.25	0.830	0.817	2.3		2.6
2,4-Dinitrotoluene	4.35	1.54	1.58	2.5		1.6
Fluorene	6.44	1.40	1.47	3.1		2.9
Hexachlorobenzene	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0
Pentachlorophenol	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0
Phenanthrene	12.5	3.24	2.67	6.1		5.5
Anthracene	3.02	0.515	0.499	1.3		1.4
Fluoranthene	7.69	1.44	1.15	3.4		3.7
Pyrene	5.20	0.906	0.735	2.3		2.5
Benz(a)anthracene	2.83	0.418	0.359	1.2		1.4
Chrysene	2.39	0.386	0.402	1.1		1.2
Benzo(b & k)fluoranthene	3.39	0.516	0.431	1.4		1.7
Benzo(e)pyrene	1.21	0.192	0.165	0.52		0.60
Benzo(a)pyrene	1.71	0.226	0.168	0.70		0.87
Indeno(1,2,3-c,d)pyrene	2.15	0.293	0.160	0.87		1.1
Dibenz(a,h)anthracene	0.454	0.129	0.102	0.23		0.20
Benzo(g,h,i)perylene	2.20	0.336	0.185	0.91		1.1

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

The estimated detection limit is 0.25 ng/g for each SVOC, 2.5 ng/g for quinoline, and 0.05 ng/g for each PAH when the sample size is 20 g. The reported data are corrected for the data in the laboratory method blank. Quinoline was determined from the methanol (MEOH) fraction and other target compounds were determined from the hexane/dichloromethane (C6/DCM) fraction.

The final volume of the MEOH is 1 mL of the sample matrix and the final volume of C6/DCM fraction is concentrated down to 100 µl.

TABLE 5-70. PAH/SVOC IN ECONOMIZER ASH (LOCATION 3) (ng/g)

Analyte	JN2193ECON		JN2393ECON		JN2693ECON		AVERAGE		DL RATIO	SD
Benzylchloride	ND <	0.25	ND <	0.25	ND <	0.25	ND <	0.25		0
Acetophenone		0.811		0.247		0.0715		0.38		0.39
Hexachloroethane	ND <	0.25	ND <	0.25	ND <	0.25	ND <	0.25		0
Naphthalene		1.27		0.651		0.214		0.71		0.53
Hexachlorobutadiene	ND <	0.25	ND <	0.25	ND <	0.25	ND <	0.25		0
Quinoline	ND <	2.50	ND <	2.50	ND <	2.50	ND <	2.5		0
2-Chloroacetophenone	ND <	0.25	ND <	0.25	ND <	0.25	ND <	0.25		0
2-Methylnaphthalene		1.77		0.763		0.351		0.96		0.73
1-Methylnaphthalene		0.805		0.260		0.133		0.40		0.36
Hexachlorocyclopentadiene	ND <	0.25	ND <	0.25	ND <	0.25	ND <	0.25		0
Biphenyl		0.377		0.117		0.0296		0.17		0.18
Acenaphthylene		0.075		0.069		0.039		0.061		0.019
2,6-Dinitrotoluene		19.4		12.8		12.0		15		4.1
Acenaphthene		0.625		0.296		0.0348		0.32		0.30
Dibenzofuran		1.10		0.272		0.0437		0.47		0.56
2,4-Dinitrotoluene		3.97		1.17		0.804		2.0		1.7
Fluorene		1.93		0.479		0.168		0.86		0.94
Hexachlorobenzene	ND <	0.25	ND <	0.25	ND <	0.25	ND <	0.25		0
Pentachlorophenol	ND <	0.25	ND <	0.25	ND <	0.25	ND <	0.25		0
Phenanthrene		3.09		1.94		0.728		1.9		1.2
Anthracene		0.260		0.604		0.138		0.33		0.24
Fluoranthene		0.643		2.78		0.298		1.2		1.3
Pyrene		0.355		4.21		0.309		1.6		2.2
Benz(a)anthracene		0.179		2.75		0.08		1.0		1.5
Chrysene		0.228		2.52		0.101		0.95		1.4
Benzo(b & k)fluoranthene		0.290		6.20		0.162		2.2		3.5
Benzo(e)pyrene		0.171		1.48	ND <	0.05		0.56	1%	0.80
Benzo(a)pyrene		0.125		3.04	ND <	0.05		1.1	1%	1.7
Indeno(1,2,3-c,d)pyrene		0.105		2.28	ND <	0.05		0.80	1%	1.3
Dibenz(a,h)anthracene		0.055		0.256	ND <	0.05		0.11	7%	0.13
Benzo(g,h,i)perylene		0.177		1.76	ND <	0.05		0.66	1%	0.96

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

The estimated detection limit is 0.25 ng/g for each SVOC, 2.5 ng/g for quinoline, and 0.05 ng/g for each PAH when the sample size 20 g. The reported data are corrected for the data in the laboratory method blank. Quinoline was determined from the methanol (MEOH) fraction and other target compounds were determined from the hexane/dichloromethane (C6/DCM) fraction.

The final volume of the MEOH is 1 mL of the sample matrix and the final volume of C6/DCM fraction is concentrated down to 100 µl.

TABLE 5-71. PAH/SVOC IN ESP ASH (LOCATION 8) (ng/g)

Analyte	JN2193ESPA-1	JN2393ESPA-1	JN2693ESPA-1	AVERAGE	DL RATIO	SD	JN2193ESPA-2	JN2393ESPA-2	JN2693ESPA-2	AVERAGE	DL RATIO	SD	JN2693ESPA-3
Benzylchloride	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.64
Acetophenone	0.479	0.142	0.137	0.25		0.20	0.836	0.360	0.488	0.56		0.25	7.37
Hexachloroethane	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.64
Naphthalene	2.75	0.879	0.638	1.4		1.2	2.98	0.756	0.844	1.5		1.3	17.0
Hexachlorobutadiene	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.64
Quinoline	ND < 2.50	ND < 2.50	ND < 2.50	ND < 2.5		0	ND < 2.50	ND < 2.50	ND < 2.50	ND < 2.5		0	ND < 6.4
2-Chloroacetophenone	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.64
2-Methylnaphthalene	4.97	1.30	0.860	2.4		2.3	5.48	1.40	1.47	2.8		2.3	10.5
1-Methylnaphthalene	3.09	0.713	0.439	1.4		1.5	3.36	0.810	0.851	1.7		1.5	18.5
Hexachlorocyclopentadiene	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.64
Biphenyl	0.529	0.126	0.117	0.26		0.24	0.673	0.387	0.179	0.41		0.25	2.04
Acenaphthylene	0.193	0.080	0.119	0.13		0.057	0.202	0.232	0.104	0.18		0.067	0.378
2,6-Dinitrotoluene	19.2	5.10	9.36	11		7.2	22.1	24.6	21.1	23		1.8	192
Acenaphthene	0.196	0.150	0.147	0.16		0.027	0.216	0.513	0.184	0.30		0.18	0.831
Dibenzofuran	1.90	0.222	0.164	0.76		0.99	2.39	0.778	0.609	1.3		0.98	3.87
2,4-Dinitrotoluene	27.2	6.17	10.6	15		11	31.8	32.4	9.23	24		13	0.64
Fluorene	1.96	0.271	0.205	0.81		0.99	2.21	1.03	0.915	1.4		0.71	2.08
Hexachlorobenzene	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.64
Pentachlorophenol	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.25	ND < 0.25	ND < 0.25	ND < 0.25		0	ND < 0.64
Phenanthrene	2.43	1.30	0.760	1.5		0.85	2.55	1.62	2.21	2.1		0.47	3.75
Anthracene	0.220	0.206	0.149	0.19		0.038	0.434	0.244	0.130	0.27		0.15	1.86
Fluoranthene	0.573	0.534	0.339	0.48		0.13	0.684	0.669	0.832	0.73		0.090	0.507
Pyrene	0.544	0.359	0.258	0.39		0.15	0.672	0.585	0.737	0.66		0.076	0.163
Benz(a)anthracene	0.684	0.230	0.248	0.39		0.26	0.692	0.678	0.897	0.76		0.12	3.73
Chrysene	0.899	0.310	0.405	0.54		0.32	0.751	0.805	0.607	0.72		0.10	8.00
Benzo(b & k)fluoranthene	0.520	0.343	0.299	0.39		0.12	0.444	0.523	0.756	0.57		0.16	4.70
Benzo(e)pyrene	0.491	0.237	0.221	0.32		0.15	0.381	0.363	0.769	0.50		0.23	1.95
Benzo(a)pyrene	0.251	0.095	0.110	0.15		0.086	0.254	0.266	0.185	0.24		0.044	3.89
Indeno(1,2,3-c,d)pyrene	0.198	0.107	0.140	0.15		0.046	0.193	0.188	0.176	0.19		0.009	1.83
Dibenz(a,h)anthracene	0.115	ND < 0.05	ND < 0.05	0.055	30%	0.052	0.117	ND < 0.05	ND < 0.05	0.056	30%	0.053	0.13
Benzo(g,h,i)perylene	0.503	0.113	0.288	0.30		0.20	0.352	0.397	0.187	0.31		0.11	4.84

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

The estimated detection limit is 0.25 ng/g for each SVOC, 2.5 ng/g for quinoline, and 0.05 ng/g for each PAH when the sample size

20 g. The reported data are corrected for the data in the laboratory method blank. Quinoline was determined from the methanol (MEOH) fraction and other target compounds were determined from the hexane/dichloromethane (C6/DCM) fraction.

The final volume of the MEOH is 1 mL of the sample matrix and the final volume of C6/DCM fraction is concentrated down to 100 µl.

5.5.3. PAH/SVOC in Liquid Samples

Tables 5-72 through 5-77 show the analytical results for PAH and other SVOC in samples of river water (Location 9), circulating water (Location 10), scrubber makeup water (Location 11), lime slurry (Location 16), scrubber blowdown (Locations 17a, 17b), and blank water, respectively. All results are in micrograms of analyte per liter of sample ($\mu\text{g/L}$). Individual sample results as well as averages and standard deviations are shown. Note that the concentrations shown for chrysene in liquid samples may include a contribution from the co-eluting non-target compound triphenylene. None of the listed PAH/SVOC were present in any liquid sample at detectable levels.

TABLE 5-72. PAH/SVOC IN RIVER WATER (LOCATION 9) ($\mu\text{g/L}$)

Analyte	C-9-PRL-621	C-9-PRL-623	C-9-PRL-626	AVERAGE	DL RATIO	SD
Phenol	ND < 10	ND < 10	ND < 10	ND < 10		0
1,3-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
1,4-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
1,2-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
3-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
4-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Acetophenone	ND < 9	ND < 9	ND < 9	ND < 9		0
Hexachloroethane	ND < 10	ND < 10	ND < 10	ND < 10		0
Nitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Naphthalene	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorobutadiene	ND < 10	ND < 10	ND < 10	ND < 10		0
Quinoline	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Chloroacetophenone	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Methylnaphthalene	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorocyclopentadiene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4,6-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4,5-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Biphenyl	ND < 10	ND < 10	ND < 10	ND < 10		0
Acenaphthylene	ND < 10	ND < 10	ND < 10	ND < 10		0
Acenaphthene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4-Dinitrophenol	ND < 50	ND < 50	ND < 50	ND < 50		0
4-Nitrophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Dibenzofuran	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,6-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10		0
Fluorene	ND < 10	ND < 10	ND < 10	ND < 10		0
4,6-Dinitro-2-methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pentachloronitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pentachlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Phenanthrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Di-n-butylphthalate	ND < 10	ND < 10	ND < 10	ND < 10		0
Fluoranthene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benz(a)anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Bis(2-ethylhexyl)phthalate	ND < 10	ND < 10	ND < 10	ND < 10		0
Chrysene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(e)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(a)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Indeno(1,2,3-cd)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Dibenz(a,h)anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(g,h,i)perylene	ND < 10	ND < 10	ND < 10	ND < 10		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-73. PAH/SVOC IN CIRCULATING WATER (LOCATION 10) (µg/L)

Analyte	C-10-PRL-621	C-10-PRL-623	C-10-PRL-626	AVERAGE	DL RATIO	SD
Phenol	ND < 10	ND < 10	ND < 10	ND < 10		0
1,3-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
1,4-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
1,2-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
3-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
4-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Acetophenone	ND < 9	ND < 9	ND < 9	ND < 9		0
Hexachloroethane	ND < 10	ND < 10	ND < 10	ND < 10		0
Nitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Naphthalene	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorobutadiene	ND < 10	ND < 10	ND < 10	ND < 10		0
Quinoline	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Chloroacetophenone	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Methylnaphthalene	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorocyclopentadiene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4,6-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4,5-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Biphenyl	ND < 10	ND < 10	ND < 10	ND < 10		0
Acenaphthylene	ND < 10	ND < 10	ND < 10	ND < 10		0
Acenaphthene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4-Dinitrophenol	ND < 50	ND < 50	ND < 50	ND < 50		0
4-Nitrophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Dibenzofuran	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,6-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10		0
Fluorene	ND < 10	ND < 10	ND < 10	ND < 10		0
4,6-Dinitro-2-methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pentachloronitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pentachlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Phenanthrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Di-n-butylphthalate	ND < 10	ND < 10	ND < 10	ND < 10		0
Fluoranthene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benz(a)anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Bis(2-ethylhexyl)phthalate	ND < 10	ND < 10	ND < 10	ND < 10		0
Chrysene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(e)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(a)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Indeno(1,2,3-cd)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Dibenz(a,h)anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(g,h,i)perylene	ND < 10	ND < 10	ND < 10	ND < 10		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-74. PAH/SVOC IN SCRUBBER MAKEUP (LOCATION 11) (µg/L)

Analyte	C-11-PRL-621	C-11-PRL-623	C-11-PRL-626	AVERAGE	DL RATIO	SD
Phenol	ND < 10	ND < 10	ND < 10	ND < 10		0
1,3-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
1,4-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
1,2-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
3-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
4-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Acetophenone	ND < 9	ND < 9	ND < 9	ND < 9		0
Hexachloroethane	ND < 10	ND < 10	ND < 10	ND < 10		0
Nitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Naphthalene	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorobutadiene	ND < 10	ND < 10	ND < 10	ND < 10		0
Quinoline	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Chloroacetophenone	ND < 10	ND < 10	ND < 10	ND < 10		0
2-Methylnaphthalene	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorocyclopentadiene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4,6-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4,5-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Biphenyl	ND < 10	ND < 10	ND < 10	ND < 10		0
Acenaphthylene	ND < 10	ND < 10	ND < 10	ND < 10		0
Acenaphthene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4-Dinitrophenol	ND < 50	ND < 50	ND < 50	ND < 50		0
4-Nitrophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Dibenzofuran	ND < 10	ND < 10	ND < 10	ND < 10		0
2,4-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10		0
2,6-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10		0
Fluorene	ND < 10	ND < 10	ND < 10	ND < 10		0
4,6-Dinitro-2-methylphenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Hexachlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pentachloronitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pentachlorophenol	ND < 10	ND < 10	ND < 10	ND < 10		0
Phenanthrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Di-n-butylphthalate	ND < 10	ND < 10	ND < 10	ND < 10		0
Fluoranthene	ND < 10	ND < 10	ND < 10	ND < 10		0
Pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benz(a)anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Bis(2-ethylhexyl)phthalate	ND < 10	ND < 10	ND < 10	ND < 10		0
Chrysene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(e)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(a)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Indeno(1,2,3-cd)pyrene	ND < 10	ND < 10	ND < 10	ND < 10		0
Dibenz(a,h)anthracene	ND < 10	ND < 10	ND < 10	ND < 10		0
Benzo(g,h,i)perylene	ND < 10	ND < 10	ND < 10	ND < 10		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-75. PAH/SVOC IN LIME SLURRY (LOCATION 16) (µg/L)

Analyte	C-16-PRL-621		C-16-PRL-623		C-16-PRL-626		AVERAGE	DL RATIO	SD
Phenol	ND <	10	ND <	10	ND <	10	ND <	10	0
1,3-Dichlorobenzene	ND <	10	ND <	10	ND <	10	ND <	10	0
1,4-Dichlorobenzene	ND <	10	ND <	10	ND <	10	ND <	10	0
1,2-Dichlorobenzene	ND <	10	ND <	10	ND <	10	ND <	10	0
3-Methylphenol	ND <	10	ND <	10	ND <	10	ND <	10	0
2-Methylphenol	ND <	10	ND <	10	ND <	10	ND <	10	0
4-Methylphenol	ND <	10	ND <	10	ND <	10	ND <	10	0
Acetophenone	ND <	9	ND <	9	ND <	9	ND <	9	0
Hexachloroethane	ND <	10	ND <	10	ND <	10	ND <	10	0
Nitrobenzene	ND <	10	ND <	10	ND <	10	ND <	10	0
Naphthalene	ND <	10	ND <	10	ND <	10	ND <	10	0
Hexachlorobutadiene	ND <	10	ND <	10	ND <	10	ND <	10	0
Quinoline	ND <	10	ND <	10	ND <	10	ND <	10	0
2-Chloroacetophenone	ND <	10	ND <	10	ND <	10	ND <	10	0
2-Methylnaphthalene	ND <	10	ND <	10	ND <	10	ND <	10	0
Hexachlorocyclopentadiene	ND <	10	ND <	10	ND <	10	ND <	10	0
2,4,6-Trichlorophenol	ND <	10	ND <	10	ND <	10	ND <	10	0
2,4,5-Trichlorophenol	ND <	10	ND <	10	ND <	10	ND <	10	0
Biphenyl	ND <	10	ND <	10	ND <	10	ND <	10	0
Acenaphthylene	ND <	10	ND <	10	ND <	10	ND <	10	0
Acenaphthene	ND <	10	ND <	10	ND <	10	ND <	10	0
2,4-Dinitrophenol	ND <	50	ND <	50	ND <	50	ND <	50	0
4-Nitrophenol	ND <	10	ND <	10	ND <	10	ND <	10	0
Dibenzofuran	ND <	10	ND <	10	ND <	10	ND <	10	0
2,4-Dinitrotoluene	ND <	10	ND <	10	ND <	10	ND <	10	0
2,6-Dinitrotoluene	ND <	10	ND <	10	ND <	10	ND <	10	0
Fluorene	ND <	10	ND <	10	ND <	10	ND <	10	0
4,6-Dinitro-2-methylphenol	ND <	10	ND <	10	ND <	10	ND <	10	0
Hexachlorobenzene	ND <	10	ND <	10	ND <	10	ND <	10	0
Pentachloronitrobenzene	ND <	10	ND <	10	ND <	10	ND <	10	0
Pentachlorophenol	ND <	10	ND <	10	ND <	10	ND <	10	0
Phenanthrene	ND <	10	ND <	10	ND <	10	ND <	10	0
Anthracene	ND <	10	ND <	10	ND <	10	ND <	10	0
Di-n-butylphthalate	ND <	10	ND <	10	ND <	10	ND <	10	0
Fluoranthene	ND <	10	ND <	10	ND <	10	ND <	10	0
Pyrene	ND <	10	ND <	10	ND <	10	ND <	10	0
Benz(a)anthracene	ND <	10	ND <	10	ND <	10	ND <	10	0
Bis(2-ethylhexyl)phthalate	ND <	10	ND <	10	ND <	10	ND <	10	0
Chrysene	ND <	10	ND <	10	ND <	10	ND <	10	0
Benzo(e)pyrene	ND <	10	ND <	10	ND <	10	ND <	10	0
Benzo(a)pyrene	ND <	10	ND <	10	ND <	10	ND <	10	0
Indeno(1,2,3-cd)pyrene	ND <	10	ND <	10	ND <	10	ND <	10	0
Dibenz(a,h)anthracene	ND <	10	ND <	10	ND <	10	ND <	10	0
Benzo(g,h,i)perylene	ND <	10	ND <	10	ND <	10	ND <	10	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-76. PAH/SVOC IN SCRUBBER BLOWDOWN (LOCATIONS 17a, 17b) (µg/L)

Analyte	C-17a-PRL-621	C-17a-PRL-623	C-17a-PRL-626	AVERAGE	DL RATIO SD	C-17b-PRL-621	C-17b-PRL-623	C-17b-PRL-626	AVERAGE	DL RATIO SD
Phenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
1,3-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
1,4-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
1,2-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
3-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
4-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Acetophenone	ND < 9	ND < 9	ND < 9	ND < 9	0	ND < 9	ND < 9	ND < 9	ND < 9	0
Hexachloroethane	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Nitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Naphthalene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Hexachlorobutadiene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Quinoline	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2-Chloroacetophenone	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2-Methylnaphthalene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Hexachlorocyclopentadiene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2,4,6-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2,4,5-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Biphenyl	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Acenaphthylene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Acenaphthene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2,4-Dinitrophenol	ND < 50	ND < 50	ND < 50	ND < 50	0	ND < 50	ND < 50	ND < 50	ND < 50	0
4-Nitrophenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Dibenzofuran	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2,4-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
2,6-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Fluorene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
4,6-Dinitro-2-methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Hexachlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Pentachloronitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0
Pentachlorophenol	ND < 10	ND < 10	ND < 10	ND < 10	0	ND < 10	ND < 10	ND < 10	ND < 10	0

TABLE 5-76. (Continued)

Analyte	C-17a-PRL-621	C-17a-PRL-623	C-17a-PRL-626	AVERAGE	DL RATIO	SD	C-17b-PRL-621	C-17b-PRL-623	C-17b-PRL-626	AVERAGE	DL RATIO	SD
Phenanthrene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Anthracene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Di-n-butylphthalate	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Fluoranthene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Pyrene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Benz(a)anthracene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Bis(2-ethylhexyl)phthalate	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Chrysene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Benzo(e)pyrene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Benzo(a)pyrene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Indeno(1,2,3-cd)pyrene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Dibenz(a,h)anthracene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0
Benzo(g,h,i)perylene	ND < 10	ND < 10	ND < 10	ND < 10	0	0	ND < 10	ND < 10	ND < 10	ND < 10	0	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-77. PAH/SVOC IN LIQUID BLANK SAMPLES (µg/L)

Analyte	FIELD BLANK C-9-PRL-623	FIELD BLANK C-9-PRL-626	TRIP BLANK C-9-PRL-626	METHOD BLANK 06/24/93 *	METHOD BLANK 06/25/93 **	METHOD BLANK 06/29/93 ***	METHOD BLANK 06/29/93 ****
Phenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
1,3-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
1,4-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
1,2-Dichlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
3-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
4-Methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Acetophenone	ND < 9	ND < 9	ND < 9	ND < 9	ND < 9	ND < 9	ND < 9
Hexachloroethane	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Nitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Naphthalene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Hexachlorobutadiene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Quinoline	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2-Chloroacetophenone	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2-Methylnaphthalene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Hexachlorocyclopentadiene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2,4,6-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2,4,5-Trichlorophenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Biphenyl	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Acenaphthylene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Acenaphthene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2,4-Dinitrophenol	ND < 50	ND < 50	ND < 50	ND < 50	ND < 50	ND < 50	ND < 50
4-Nitrophenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Dibenzofuran	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2,4-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
2,6-Dinitrotoluene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Fluorene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
4,6-Dinitro-2-methylphenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10

TABLE 5-77. (Continued)

Analyte	FIELD BLANK C-9-PRL-623	FIELD BLANK C-9-PRL-626	TRIP BLANK C-9-PRL-626	METHOD BLANK 06/24/93 *	METHOD BLANK 06/25/93 **	METHOD BLANK 06/29/93 ***	METHOD BLANK 06/29/93 ****
Hexachlorobenzene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Pentachloronitrobenzene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Pentachlorophenol	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Phenanthrene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Anthracene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Di-n-butylphthalate	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Fluoranthene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Pyrene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Benz(a)anthracene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Bis(2-ethylhexyl)phthalate	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Chrysene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Benzo(e)pyrene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Benzo(a)pyrene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Indeno(1,2,3-cd)pyrene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Dibenz(a,h)anthracene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10
Benzo(g,h,i)perylene	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10	ND < 10

* = blank correlates w/ all -621 samples

** = blank correlates w/ C-9,10,11,16,-623 samples

*** = blank correlates w/ C-9FB,9TB,17A,17B-623 samples and C16,17A,17B-626 samples

**** = blank correlates to C-9,10,11-626

5.6. Dioxins/Furans in Flue Gas Samples

Tables 5-78 through 5-80 show the analytical results for dioxins/furans in flue gas samples from the hot and dilute sampling locations at the Unit 1 stack (Locations 6a and 6b) and for blank samples, respectively. For all three sets of samples, results are presented in picograms per normal cubic meter of flue gas (pg/Nm³). Results from individual samples are listed, as well as the average and standard deviation of those results. In all cases the values shown represent the total analyte concentration in flue gas (i.e., vapor plus particulate phases).

Relatively few dioxins/furans were detected in flue gas. Detection limits for these compounds in the PSDS sampling at Location 6b (Table 5-79) were considerably higher than those from the hot stack sampling at Location 6a (Table 5-78), due to the difference in gas volumes sampled through the XAD resin. The primary dioxin/furan compounds detected were OCDD, OCDF, 2,3,7,8-TCDF, and one isomer of HpCDD. Congener classes detected were total HpCDD, total TCDF, and total PCDF. One isomer of HpCDF was detected at Location 6b, but not at 6a.

TABLE 5-78. DIOXINS/FURANS IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) (pg/Nm³)

Analyte	C-6a-MM5-621		C-6a-MM5-623		C-6a-MM5-626 *		AVERAGE	DL RATIO	SD
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND <	2.31	ND <	2.43	ND <	3.05	ND <	2.6	0.40
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND <	2.21	ND <	4.40	ND <	2.97	ND <	3.2	1.1
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND <	2.94	ND <	3.34	ND <	1.94	ND <	2.7	0.72
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND <	3.19	ND <	4.56	ND <	4.73	ND <	4.2	0.84
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND <	4.67	ND <	4.94	ND <	3.18	ND <	4.3	0.95
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin		1.77 J		6.1 J		5.1 J		4.3	2.3
Octachlorodibenzo-p-dioxin		9.95 K		29.3 K		21.3 K		20	9.7
2,3,7,8-Tetrachlorodibenzofuran		15.1		12.7 L		10.8		13	2.2
1,2,3,7,8-Pentachlorodibenzofuran	ND <	6.68	ND <	4.56	ND <	5.73	ND <	5.7	1.1
2,3,4,7,8-Pentachlorodibenzofuran	ND <	4.48	ND <	5.85	ND <	4.15	ND <	4.8	0.90
1,2,3,4,7,8-Hexachlorodibenzofuran	ND <	5.12	ND <	5.64	ND <	4.41	ND <	5.1	0.62
1,2,3,6,7,8-Hexachlorodibenzofuran	ND <	3.84	ND <	4.65	ND <	3.57	ND <	4.0	0.56
1,2,3,7,8,9-Hexachlorodibenzofuran	ND <	7.91	ND <	6.72	ND <	5.94	ND <	6.9	0.99
2,3,4,6,7,8-Hexachlorodibenzofuran	ND <	2.20	ND <	2.93	ND <	2.24	ND <	2.5	0.41
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND <	51.3	ND <	23.2	ND <	14.8	ND <	30	19
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND <	3.91	ND <	5.54	ND <	5.70	ND <	5.0	0.99
Octachlorodibenzofuran		7.76 J	ND <	19.4		7.37 J	ND <	19	1.2
Total Tetrachlorodibenzo-p-dioxin		ND*		ND		ND		ND	ND
Total Pentachlorodibenzo-p-dioxin		ND		ND		ND		ND	ND
Total Hexachlorodibenzo-p-dioxin		ND		ND		ND		ND	ND
Total Heptachlorodibenzo-p-dioxin	ND <	9.20 C	ND <	16.8 C	ND <	15.3 C	ND <	14	4.0
Total Tetrachlorodibenzofuran		114		72.5		78.5		88	22
Total Pentachlorodibenzofuran		17.4		12.4 L		12.4 L		14	2.9
Total Hexachlorodibenzofuran		ND		ND		ND		ND	ND
Total Heptachlorodibenzofuran		ND		ND		ND		ND	ND

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

C = Blank-corrected concentration below detection/calibration limit.

J = Concentration detected below calibration range.

K = Total value in the calibration range, but individual values from the XAD or filter fraction or both were below the calibration range.

L = Isotope ratio for this analyte slightly outside theoretical value range.

Total sample non detect values are the average detection limit from the XAD and Filter fractions.

Total sample values from XAD and filter fractions containing one hit and one non detect were calculated as :
hit + (non detect/2).

* Total congener class results do not include any contribution from non detects. Congener class detection limits are equivalent to those for the 2,3,7,8-substituted isomers shown.

OCDD-13C12 recovery response factors were slightly above the +30 % limit from initial calibration on each analysis day.

** = several isotope ratios in the continuing calibration were slightly out of the theoretical range on the day these samples were analyzed.

Sample results corrected for train blank.

TABLE 5-79. DIOXINS/FURANS IN DILUTE GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6b) (pg/Nm³)

Analyte	C-6b-MM5-621 **	C-6b-MM5-623	C-6b-MM5-626	AVERAGE	DL RATIO	SD
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND < 16.1	ND < 35.9	ND < 29.6	ND < 27		10
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND < 33.5	ND < 42.6	ND < 26.9	ND < 34		7.9
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND < 43.1	ND < 60.3	ND < 12.0	ND < 38		25
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND < 47.1	ND < 44.2	ND < 37.7	ND < 43		4.8
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND < 69.7	ND < 87.4	ND < 31.0	ND < 63		29
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ND < 219	12 J	ND < 93.3	ND < 219		49
Octachlorodibenzo-p-dioxin	ND < 1310 C,K	ND < 1410 C,K,L	ND < 1410 C,K	ND < 1380		58
2,3,7,8-Tetrachlorodibenzofuran	ND < 32.4	ND < 36.8	ND < 20.3	ND < 30		8.5
1,2,3,7,8-Pentachlorodibenzofuran	ND < 33.0	ND < 51.6	ND < 16.4	ND < 34		18
2,3,4,7,8-Pentachlorodibenzofuran	ND < 25.9	ND < 41.2	ND < 37.0	ND < 35		7.9
1,2,3,4,7,8-Hexachlorodibenzofuran	ND < 32.1	ND < 47.8	ND < 27.6	ND < 36		11
1,2,3,6,7,8-Hexachlorodibenzofuran	ND < 27.1	ND < 51.3	ND < 25.8	ND < 35		14
1,2,3,7,8,9-Hexachlorodibenzofuran	ND < 75.1	ND < 102	ND < 78.4	ND < 85		15
2,3,4,6,7,8-Hexachlorodibenzofuran	ND < 56.7	ND < 37.1	ND < 19.6	ND < 38		19
1,2,3,4,6,7,8-Heptachlorodibenzofuran	138 J	ND < 151	ND < 62.1	ND < 151		54
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND < 153	ND < 80.2	ND < 31.9	ND < 88		61
Octachlorodibenzofuran	ND < 147	246 J	ND < 87.6	ND < 147		109
Total Tetrachlorodibenzo-p-dioxin	ND*	ND	ND	ND		ND
Total Pentachlorodibenzo-p-dioxin	ND	ND	ND	ND		ND
Total Hexachlorodibenzo-p-dioxin	ND	ND	ND	ND		ND
Total Heptachlorodibenzo-p-dioxin	ND < 9.20 C	ND < 16.8 C	ND < 15.3 C	ND < 14		4.0
Total Tetrachlorodibenzofuran	ND	ND	ND	ND		ND
Total Pentachlorodibenzofuran	ND	ND	ND	ND		ND
Total Hexachlorodibenzofuran	ND	ND	ND	ND		ND
Total Heptachlorodibenzofuran	131	ND < 116	ND < 47.0	ND < 116		55

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

C = Blank-corrected concentration below detection/calibration limit.

J = Concentration detected below calibration range.

K = Total value in the calibration range, but individual values from the XAD or filter fraction or both were below the calibration range.

L = Isotope ratio for this analyte slightly outside theoretical value range.

Total sample non detect values are the average detection limit from the XAD and Filter fractions.

Total sample values from XAD and filter fractions containing one hit and one non detect were calculated as :
hit + (non detect/2).

* Total congener class results do not include any contribution from non detects. Congener class detection limits are equivalent to those for the 2,3,7,8-substituted isomers shown.

OCDD-13C12 recovery response factors were slightly above the +30% limit from initial calibration on each analysis day.

HpCDD-13C12, HpCDF-13C12 continuing calibration recovery response factors slightly out of +/- 30% limit for analysis of C-6B-MM5-623 XAD, C-6B-MM5-627 filter, and C-6B-MM5-621 filter.

** = several isotope ratios in the continuing calibration were slightly out of the theoretical range on the day these samples

TABLE 5-80. DIOXINS/FURANS IN BLANK GAS SAMPLES (pg/Nm³)

Analyte	6a TRAIN BLANK	6b TRAIN BLANK	FILTER BLANK	
	C-6a+b-MM5-620 **	C-6a+b-MM5-620 **	C-6b-MM5-627	METHOD BLANK
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND < 1.41	ND < 18.4	ND < 2.37	ND < 2.20
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND < 1.90	ND < 35.0	ND < 2.31	9.36 J
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND < 1.62	ND < 25.8	ND < 2.13	ND < 17.9
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND < 2.11	ND < 27.0	ND < 1.47	15.7 J
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND < 2.04	ND < 32.8	ND < 2.66	ND < 22.8
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	9.61 J	143 J	ND < 5.52	36.3
Octachlorodibenzo-p-dioxin	59.3 K	1050 K	17.7 J	189
2,3,7,8-Tetrachlorodibenzofuran	ND < 1.39	ND < 21.9	ND < 0.77	ND < 2.58
1,2,3,7,8-Pentachlorodibenzofuran	ND < 1.89	ND < 28.4	ND < 0.97	7.87 J
2,3,4,7,8-Pentachlorodibenzofuran	ND < 1.27	ND < 16.7	ND < 2.00	ND < 13.3
1,2,3,4,7,8-Hexachlorodibenzofuran	ND < 2.33	ND < 30.8	ND < 0.97	14.8 J
1,2,3,6,7,8-Hexachlorodibenzofuran	ND < 1.97	ND < 31.0	ND < 1.68	13.1 J
1,2,3,7,8,9-Hexachlorodibenzofuran	ND < 3.87	ND < 59.7	ND < 3.95	ND < 23.6
2,3,4,6,7,8-Hexachlorodibenzofuran	ND < 1.28	ND < 18.5	ND < 1.47	ND < 23.4
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND < 9.74	ND < 122	ND < 3.63	20.7 K
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND < 2.70	ND < 40.2	ND < 2.29	37.2
Octachlorodibenzofuran	ND < 6.54	ND < 83.2	2.42 J	132
Total Tetrachlorodibenzo-p-dioxin	ND*	ND	ND	ND
Total Pentachlorodibenzo-p-dioxin	ND	ND	ND	6.74
Total Hexachlorodibenzo-p-dioxin	ND	ND	ND	12.9
Total Heptachlorodibenzo-p-dioxin	13.5 J	147 J	ND	28
Total Tetrachlorodibenzofuran	ND	ND	ND	ND
Total Pentachlorodibenzofuran	ND	ND	ND	4.47
Total Hexachlorodibenzofuran	ND	ND	ND	21.4
Total Heptachlorodibenzofuran	ND	ND	ND	45.2

ND < = Not detected, value following ND < is detection limit.

J = Concentration detected below calibration range.

K = Total value in the calibration range, but individual values from the XAD or filter fraction or both were below the calibration range.

Total sample non detect values are the average detection limit from the XAD and Filter fractions.

Total sample values from XAD and filter fractions containing one hit and one non detect were calculated as :
hit + (non detect/2).

* Total congener class results do not include any contribution from non detects. Congener class detection limits are equivalent to those for the 2,3,7,8-substituted isomers shown.

OCDD-13C12 recovery response factors were slightly above the +30 % limit from initial calibration on each analysis day.

** = several isotope ratios in the continuing calibration were slightly out of the theoretical range on the day these samples were analyzed.

Train blank results corrected for field reagent blank.

Method Blank values are average of the laboratory Filter Method Blank and XAD Method Blank results; laboratory Filter Method Blank appears contaminated.

5.7 Aldehydes

5.7.1. Aldehydes in Flue Gas Samples

Tables 5-81 through 5-85 show the analytical results for the aldehydes in samples from flue gas streams. Results are shown for samples from ESP #1 inlet (Location 4a), ESP #1 outlet (Location 5a), scrubber outlet (hot) (Location 6a), scrubber outlet (dilute) (Location 6b), and from blank samples, in that order. For each set of samples, results are shown in micrograms per normal cubic meter of flue gas ($\mu\text{g}/\text{Nm}^3$). In all tables, individual sample results are shown, as well as the average and standard deviation of those results.

Acetaldehyde was the primary aldehyde measured, though formaldehyde, propionaldehyde and acrolein were also found in some samples. The measured concentrations were highly variable. This factor, coupled with the confusion introduced by inadvertently using the RTI spike samples for sampling on June 23 (Tables 5-81 and 5-82), makes comparison difficult. The aldehyde results from Locations 6a and 6b (Tables 5-83 and 5-84, respectively) do not agree well, either quantitatively or in the species detected.

TABLE 5-81. ALDEHYDES IN GAS SAMPLES FROM ESP-1 INLET (LOCATION 4a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-4a-ALD-621	C-4a-ALD-623 *	C-4a-ALD-626	AVERAGE	DL RATIO	SD
Formaldehyde	ND < 2.42	247	3.75	2.5	24%	NC
Acetaldehyde	764	ND < 2.42	26.8	264	0%	433
Acrolein	ND < 2.42	ND < 2.42	ND < 2.42	ND < 2.4		0
Propionaldehyde	3.19	ND < 2.42	4.80	3.1	13%	1.8

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NC = Not calculated.

* Sample 4a-ALD-623 was spiked by RTI auditors and inadvertently used for field sampling.

The formaldehyde level in this sample was not included in the calculations because of the contamination from the spiking.

Sample results corrected for train blank.

TABLE 5-82. ALDEHYDES IN GAS SAMPLES FROM ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-5a-ALD-621	C-5a-ALD-623 *	C-5a-ALD-626	AVERAGE	DL RATIO	SD
Formaldehyde	ND < 2.42	445	ND < 2.42	ND < 2.4		NC
Acetaldehyde	22.0	69.2	3.3	31		34
Acrolein	ND < 2.42	9.00	ND < 2.42	3.8	21%	4.5
Propionaldehyde	ND < 2.42	13.0	ND < 2.42	5.1	16%	6.8

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

NC = Not calculated.

* Sample 5a-ALD-623 was spiked by RTI auditors and inadvertently used for field sampling.

The formaldehyde level in this sample was not included in the calculations because of the contamination from the spiking.

Sample results corrected for train blank.

TABLE 5-83. ALDEHYDES IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6a-ALD-621	C-6a-ALD-624	C-6a-ALD-626	AVERAGE	DL RATIO	SD
Formaldehyde	4.01	ND < 2.98	ND < 2.98	ND < 3.0		1.5
Acetaldehyde	92.3	73.8	98.5	88		13
Acrolein	ND < 2.76	ND < 2.98	ND < 2.98	ND < 2.9		0.12
Propionaldehyde	21.9	12.3	12.8	16		5.4

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Sample results corrected for train blank.

TABLE 5-84. ALDEHYDES IN DILUTE GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6b) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6b-ALD-621	C-6b-ALD-624	C-6b-ALD-626	AVERAGE	DL RATIO	SD
Formaldehyde	29.8	12.8	20.2	21		8.5
Acetaldehyde	35.7	ND < 2.98	ND < 2.98	13	8%	20
Acrolein	ND < 2.76	ND < 2.98	ND < 2.98	ND < 2.9		0.12
Propionaldehyde	ND < 2.76	ND < 2.98	ND < 2.98	ND < 2.9		0.12

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

Sample results corrected for train blank.

TABLE 5-85. ALDEHYDES IN BLANK GAS SAMPLES ($\mu\text{g}/\text{Nm}^3$)

Analyte	H2O FIELD BLANK C-4a-ALD-620	DNPH FIELD BLANK C-4a-ALD-620	H2O FIELD BLANK C-5a-ALD-620	DNPH FIELD BLANK C-5a-ALD-620	TRAIN BLANK C-6a+b-ALD-620	DNPH BLANK C-5a-ALD-626 *	DNPH BLANK C-4a-ALD-621 *
Formaldehyde	3.95	ND < 2.43	11.2	ND < 2.43	11.6	ND < 2.43	ND < 2.43
Acetaldehyde	ND < 2.43	ND < 2.43	ND < 2.43	4.08	26.9	ND < 2.43	ND < 2.43
Acrolein	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43
Propionaldehyde	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43	ND < 2.43

ND < = Not detected, value following ND < is detection limit.

* Sample and field blank results corrected for average areas in DNPH Blank C-4a-ALD-621 and C-5a-ALD-626.

5.7.2. Aldehydes in Liquid Samples

Tables 5-86 through 5-90 show the analytical results for aldehydes in samples of river water (Location 9), circulating water (Location 10), scrubber makeup water (Location 11), lime slurry (Location 16), and slurry blowdown (Locations 17a, 17b), respectively. All results are in micrograms of analyte per liter of sample ($\mu\text{g/L}$). Each table shows individual sample results, as well as the average and standard deviation of those results. Formaldehyde was the primary aldehyde found in liquid samples, but even this compound was not detected in all samples. Acetaldehyde was the only other aldehyde detected, in two samples of lime slurry (Table 5-89). Formaldehyde was measured in all three samples of lime slurry (Table 5-89), but was measured in slurry blowdown only in samples from June 26 (Table 5-90). The reason for the latter observation is unclear, since Tables 5-81 through 5-84 do not show unusual concentrations of formaldehyde in flue gas on that day.

TABLE 5-86. ALDEHYDES IN RIVER WATER (LOCATION 9)($\mu\text{g/L}$)

Analyte	C-9-PRL-621	C-9-PRL-623	C-9-PRL-626	AVERAGE DL RATIO	SD
Formaldehyde	41.0	ND < 6.00	ND < 6.00	16 13%	22
Acetaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Acrolein	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Propionaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-87. ALDEHYDES IN CIRCULATING WATER (LOCATION 10) ($\mu\text{g/L}$)

Analyte	C-10-PRL-621	C-10-PRL-623	C-10-PRL-626	AVERAGE DL RATIO	SD
Formaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Acetaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Acrolein	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Propionaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-88. ALDEHYDES IN SCRUBBER MAKEUP (LOCATION 11) ($\mu\text{g/L}$)

Analyte	C-11-PRL-621	C-11-PRL-623	C-11-PRL-626	AVERAGE DL RATIO	SD
Formaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Acetaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Acrolein	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Propionaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-89. ALDEHYDES IN LIME SLURRY (LOCATION 16) ($\mu\text{g/L}$)

Analyte	C-16-PRL-621	C-16-PRL-623	C-16-PRL-626	AVERAGE DL RATIO	SD
Formaldehyde	15.0	7.87	14.3	12	3.9
Acetaldehyde	8.15	ND < 6.00	6.40	ND < 6.0	2.6
Acrolein	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0
Propionaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0	0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-90. ALDEHYDES IN SLURRY BLOWDOWN (LOCATION 17a, 17b) (µg/L)

Analyte	C-17a-PRL-621	C-17a-PRL-623	C-17a-PRL-626	AVERAGE	DL RATIO	SD	C-17b-PRL-621	C-17b-PRL-623	C-17b-PRL-626	AVERAGE	DL RATIO	SD
Formaldehyde	ND < 6.00	ND < 6.00	76.1	27	7%	42	ND < 6.00	ND < 6.00	64.5	23	9%	35
Acetaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0		0	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0		0
Acrolein	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0		0	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0		0
Propionaldehyde	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0		0	ND < 6.00	ND < 6.00	ND < 6.00	ND < 6.0		0

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

5.8 Radionuclides

5.8.1. Radionuclides in Flue Gas Samples

Tables 5-91 through 5-94 present analytical results for radionuclides in flue gas samples. The results shown are for analyses of flue gas particulate collected by single-point, isokinetic sampling during the total duration of the ammonia and cyanide sampling runs. As is shown in the tables, the filter samples collected in this manner were designated as NH_4 , CN, $\text{NH}_4 + \text{CN}$, or $\text{CN} + \text{NH}_4$ filters. Tables 5-91 through 5-94 show results in pico-Curies per normal cubic meter of flue gas (pCi/Nm^3). Results are shown for samples from the ESP #1 inlet (Location 4a), ESP #1 outlet (Location 5a), scrubber outlet (Location 6a), and from blank samples, in that order. Note that no sample for radionuclide analysis was obtained at Location 5a on June 22, 1993, and that the sample originally planned for June 24 at that location had to be rescheduled to June 26. Radionuclide analyses were not conducted on the filter samples from dilute sampling at Location 6b, because of insufficient sample.

Pb-212, Pb-210, and Ra-226 were the only radionuclides detected in flue gas particulate samples. The detected values are too infrequent to draw any conclusions about removal of radionuclides in the ESP or scrubber.

TABLE 5-91. RADIONUCLIDES IN GAS SAMPLES FROM ESP-1 INLET (LOCATION 4a) (pCi/Nm³)

Analyte	C-4a-CN-622		C-4a-NH4-624		C-4a-CN+NH4-627		AVERAGE	DL RATIO	SD
Pb-212		25.0	ND<	32.5	ND<	39.2	ND<	39	4.4
Th-234	ND<	292	ND<	295	ND<	241	ND<	276	31
Pb-210	ND<	301	ND<	443	ND<	392	ND<	378	72
Pb-211	ND<	331	ND<	384	ND<	392	ND<	369	33
Ra-226	ND<	39.1	ND<	29.2		453		162	7% 252
Ra-228	ND<	102	ND<	73.8	ND<	83.9	ND<	87	14
Th-229	ND<	174	ND<	180	ND<	190	ND<	182	8.0
Th-230	ND<	1860	ND<	1650	ND<	2040	ND<	1850	195
U-234	ND<	7220	ND<	7380	ND<	9230	ND<	7940	1120
U-235	ND<	90.2	ND<	67.9	ND<	83.9	ND<	81	12

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

Sample results corrected for train blank.

TABLE 5-92. RADIONUCLIDES IN GAS SAMPLES FROM ESP-1 OUTLET (LOCATION 5a) (pCi/Nm³)

Analyte	C-5a-CN+NH4-626		C-5a-NH4-627		AVERAGE		DL RATIO	SD
Pb-212	ND<	27		20	ND<	27		NC
Th-234	ND<	328	ND<	330	ND<	329		NC
Pb-210	ND<	287	ND<	421	ND<	354		NC
Pb-211	ND<	388	ND<	360	ND<	374		NC
Ra-226	ND<	39		128		74	13%	NC
Ra-228	ND<	90	ND<	84	ND<	87		NC
Th-229	ND<	185	ND<	186	ND<	186		NC
Th-230	ND<	1760	ND<	1860	ND<	1810		NC
U-234	ND<	7460	ND<	7810	ND<	7630		NC
U-235	ND<	75	ND<	87	ND<	81		NC

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

NC = Not calculated.

Sample results corrected for train blank.

TABLE 5-93. RADIONUCLIDES IN GAS SAMPLES FROM SCRUBBER OUTLET (LOCATION 6a) (pCi/Nm³)

Analyte	C-6a-NH4+CN-622	C-6a-NH4-CN-624	C-6a-NH4+CN-627	AVERAGE	DL RATIO	SD
Pb-212	ND< 21.2		22.1	ND< 18.8	ND< 21	7.0
Th-234	ND< 180	ND< 117		ND< 135	ND< 144	32
Pb-210		ND< 221		ND< 222	ND< 221	93
Pb-211	ND< 229	ND< 221		ND< 239	ND< 230	9.1
Ra-226	ND< 24.5		12.7	ND< 22.2	ND< 25	0.84
Ra-228	ND< 40.8	ND< 45.9		ND< 41.0	ND< 43	2.9
Th-229	ND< 89.8	ND< 98.6		ND< 87.1	ND< 92	6.0
Th-230	ND< 1010	ND< 1020		ND< 990	ND< 1010	15
U-234	ND< 4410	ND< 4420		ND< 4610	ND< 4480	113
U-235	ND< 40.8	ND< 37.4		ND< 37.6	ND< 39	1.9

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

Sample results corrected for train blank.

TABLE 5-94. RADIONUCLIDES IN BLANK GAS SAMPLES (pCi/Nm³)

Analyte	TRAIN BLANK	REAGENT
	C-6a+b-NH4+CN-620	C-4-5-6-a-BLANK
Pb-212	ND< 26.0	17.3
Th-234	ND< 218	ND< 284
Pb-210	ND< 284	ND< 284
Pb-211	ND< 308	ND< 308
Ra-226	ND< 30.8	ND< 33.1
Ra-228	ND< 68.6	ND< 61.5
Th-229	ND< 142	ND< 137
Th-230	ND< 1420	ND< 1320
U-234	ND< 5920	ND< 6150
U-235	ND< 52.1	ND< 59.2

Train blank results corrected for field reagent blank.

5.8.2. Radionuclides in Solid Samples

Tables 5-95 through 5-101 show analytical results for radionuclides in solid samples, in units of pico-Curies per gram of sample (pCi/g). Each table shows analytical results for individual samples, as well as the average and standard deviations of those results. Tables 5-95 through 5-101, respectively, show results for boiler feed coal (Location 1), bottom ash (Location 2), economizer ash (Location 3), pyrite rejects (Location 7), ESP ash (Location 8), run-of-mine coal (Location 14), and lime (Location 15).

Several radionuclides were measured in the solid samples. Ra-226, Th-234, and U-234 were generally the radionuclides present at the highest concentrations. Radionuclide concentrations in bottom ash (Table 5-96), economizer ash (Table 5-97), and ESP ash (Table 5-99) were generally higher than those in the pyrite rejects (Table 5-98). Very low radionuclide levels were found in lime (Table 5-101). Radionuclide concentrations in run-of-mine coal (Table 5-100) were generally higher than those in boiler feed coal (Table 5-95), though the cause of the difference is not clear. Pyrite rejects (Table 5-98) exhibited radionuclide levels too low to account for the reduction in activity in the coal stream.

TABLE 5-95. RADIONUCLIDES IN BOILER FEED COAL (LOCATION 1) (pCi/g)

Analyte	JN2293BOFED	JN2493BOFED	JN2793BOFED	AVERAGE	DL RATIO	SD
Pb-210	0.572	0.650	1.05	0.76		0.26
Pb-212	0.190	0.239	0.205	0.21		0.025
Ra-226	ND <	0.155	0.522	0.500	0.37	7% 0.25
Ra-228	0.180	0.269	ND <	0.21	ND <	0.082
Th-234	0.90	1.19	1.20	1.1		0.17
Pb-211	ND <	0.775	ND <	0.98	ND <	0.85 0.11
Th-229	ND <	0.29	ND <	0.31	ND <	0.28 0.015
Th-230	ND <	3.60	ND <	4.70	ND <	3.70 4.0 0.61
U-234	ND <	13.0	ND <	12.4	ND <	20.0 20 3.0
U-235	ND <	0.13	0.121	ND <	0.19	ND < 0.19 0.028

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-96. RADIONUCLIDES IN BOTTOM ASH (LOCATION 2) (pCi/g)

Analyte	JN2293BOTT	JN2493BOTT	JN2793BOTT	AVERAGE	DL RATIO	SD
Pb-210	0.821	0.809	1.33	0.99		0.30
Pb-212	1.44	1.53	1.53	1.5		0.052
Ra-226	3.67	3.91	5.02	4.2		0.72
Ra-228	1.36	1.53	1.56	1.5		0.11
Th-234	4.13	4.50	5.83	4.8		0.89
Pb-211	ND <	1.00	ND <	1.10	ND <	1.1 0.058
Th-229	ND <	0.47	ND <	0.50	ND <	0.51 0.49 0.021
Th-230	ND <	6.80	ND <	7.03	ND <	7.00 7.0 2.1
U-234	ND <	29.0	ND <	25.2	ND <	33.2 29 9.4
U-235	0.249	0.327	0.491	0.36		0.12

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 5-97. RADIONUCLIDES IN ECONOMIZER ASH (LOCATION 3) (pCi/g)

Analyte	JN2293ECON	JN2493ECON	JN2793ECON	AVERAGE	DL RATIO	SD
Pb-210	2.16	1.84	2.41	2.1		0.29
Pb-212	1.60	1.77	1.91	1.8		0.16
Ra-226	4.46	4.41	5.81	4.9		0.79
Ra-228	1.57	1.63	1.68	1.6		0.055
Th-234	5.61	4.56	6.71	5.6		1.1
Pb-211	ND< 1.10	ND< 1.20	ND< 1.20	ND< 1.2		0.058
Th-229	ND< 0.54	ND< 0.51	ND< 0.56	ND< 0.54		0.025
Th-230	ND< 7.70	6.24	7.17	ND< 7.7		1.7
U-234	42.3	30.5	36.7	37		5.9
U-235	0.472	0.281	0.419	0.39		0.10

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-98. RADIONUCLIDES IN PYRITE REJECTS (LOCATION 7) (pCi/g)

Analyte	JN2293PYREJ	JN2493PYREJ	JN2793PYREJ	AVERAGE	DL RATIO	SD
Pb-210	0.408	ND< 0.47	1.17	0.60	13%	0.50
Pb-212	0.108	0.152	0.057	0.11		0.048
Ra-226	0.232	0.213	ND< 0.11	0.17	11%	0.10
Ra-228	0.159	0.204	ND< 0.28	ND< 0.28		0.033
Th-234	0.515	ND< 0.475	ND< 0.65	ND< 0.65		0.20
Pb-211	ND< 0.75	ND< 0.93	ND< 1.10	ND< 0.93		0.18
Th-229	ND< 0.36	ND< 0.33	ND< 0.48	ND< 0.39		0.08
Th-230	ND< 3.60	ND< 3.75	ND< 5.30	ND< 4.2		0.94
U-234	ND< 11.0	ND< 13.5	ND< 18.0	ND< 14		3.5
U-235	ND< 0.11	ND< 0.16	ND< 0.18	ND< 0.15		0.036

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-99. RADIONUCLIDES IN ESP ASH (LOCATION 8) (pCi/g)

Analyte	JN2293ESPA-1	JN2493ESPA-1	AVERAGE	DL RATIO	SD	JN2293ESPA-2
Pb-210	3.33	3.61	3.5		NC	150
Pb-212	1.74	1.62	1.7		NC	59.9
Ra-226	4.67	4.84	4.8		NC	169
Ra-228	1.66	1.67	1.7		NC	58.2
Th-234	6.40	5.15	5.8		NC	179
Pb-211	ND< 1.10	ND< 1.20	ND< 1.2		NC	ND< 38.0
Th-229	ND< 0.49	ND< 0.51	ND< 0.50		NC	ND< 16.0
Th-230	ND< 0.70	5.84	3.1	6%	NC	ND< 230
U-234	29.9	31.3	31		NC	ND< 720
U-235	0.437	0.335	0.39		NC	ND< 8.40

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

NC = Not calculated.

Insufficient sample was obtained to conduct radionuclide analysis on JN2793ESPA-1, JN2493ESPA-2, JN2793ESPA-2, and on any Row 3 samples (JN2_93ESPA-3); therefore, data are not presented for these samples.

TABLE 5-100. RADIONUCLIDES IN RUN-OF-MINE COAL (LOCATION 14) (pCi/g)

Analyte	JN2293COAL	JN2493COAL	JN2793COAL	AVERAGE	DL RATIO	SD
Pb-210	2.30	2.69	1.90	2.3		0.40
Pb-212	0.508	0.524	0.482	0.50		0.021
Ra-226	1.38	1.14	1.67	1.4		0.27
Ra-228	0.523	0.480	0.860	0.62		0.21
Th-234	4.89	3.82	4.47	4.4		0.54
Pb-211	ND< 1.80	ND< 1.40	ND< 1.80	ND< 1.7		0.23
Th-229	ND< 0.75	ND< 0.67	ND< 0.81	ND< 0.74		0.070
Th-230	ND< 0.81	ND< 10	ND< 8.90	ND< 6.6		5.0
U-234	ND< 27.0	ND< 46.0	24.7	ND< 46		6.0
U-235	ND< 0.25	0.201	0.257	ND< 0.25		0.066

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND< = Not detected, value following ND< is detection limit.

TABLE 5-101. RADIONUCLIDES IN LIME (LOCATION 15) (pCi/g)

Analyte	JN2293LIME		JN2493LIME		JN2793LIME	AVERAGE	DL RATIO	SD
Pb-210	ND <	0.47	ND <	0.05	0.276	ND <	0.47	0.14
Pb-212		0.0351		0.0316	ND <	0.047	ND <	0.0060
Ra-226		0.900		0.020	0.859		0.59	0.50
Ra-228	ND <	0.11	ND <	0.09	ND <	0.12	ND <	0.11
Th-234		0.949		0.764	0.872		0.86	0.093
Pb-211	ND <	0.60	ND <	0.65	ND <	0.54	ND <	0.60
Th-229	ND <	0.23	ND <	0.24	ND <	0.23	ND <	0.23
Th-230	ND <	3.20	ND <	3.10	ND <	2.90	ND <	3.1
U-234	ND <	11.0		9.58	11.0	ND <	11	2.86
U-235	ND <	0.14	ND <	0.12	0.106	ND <	0.14	0.024

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

5.9. Carbon Analyses

Tables 5-102 and 5-103 show the results of analyses for carbon in flue gas particulate samples, and in solid samples, respectively. Table 5-102 shows results for carbon, as a percent by weight on a dry basis, in particulate samples collected at ESP #1 inlet (Location 4a), ESP #1 outlet (Location 5a), and the scrubber outlet (Location 6a). Results are shown for each location for each of three sampling days, except that no sample was obtained at Location 5a on the first day. Note that the second sample at Location 5a was postponed due to weather conditions, as noted in Section 3.2.4. The results are variable, but consistently indicate carbon content of less than 0.4 percent in the particulate matter. The average carbon content of the particulate samples at Location 6a is higher than at the two upstream locations. As noted in Section 2.2.1, particulate loading at Location 6a was also somewhat lower than at Location 5a. The implication is that the scrubber may preferentially remove some particulate matter of low carbon content. However, with the variability observed it is difficult to firmly ascribe the observed differences to any characteristic of the plant.

Table 5-103 shows the carbon content, in weight percent on a dry basis, in pyrite rejects, bottom ash, economizer ash, and ESP ash. An average carbon content of 16 percent was found in pyrite rejects, far higher than in the other samples. This result is not surprising, since the pyrite rejects will necessarily contain some coal carried out with the rejects. The carbon content of economizer ash and ESP ash (Table 5-103) is consistent with the results for flue gas particulate (Table 5-102), as expected given the common source for these materials. **The one exception is the extreme value of 14.4 percent carbon reported for one economizer ash sample. That value is almost certainly incorrect, though a review of the analytical results has not disclosed the error. This value has been excluded as an outlier, and is not used in any calculations.** The carbon content of bottom ash is somewhat higher than that of the other ash samples.

TABLE 5-102. CARBON IN FLUE GAS PARTICULATE SAMPLES (weight % dry)

Location	JN2293	JN2493	JN2793	AVERAGE	DL RATIO	SD
4a	ND < 0.01	0.04	0.06	0.04	5%	0.028
5a	NA	ND < 0.01 *	0.12	0.06	4%	NC
6a	ND < 0.01	0.36	0.16	0.18	1%	0.18

DL Ratio = Detection limit ratio.

SD = Standard deviation.

NA = Sample not available, sample not analyzed, or data not available.

NC = Not calculated.

* = Due to high winds on June 24, this sample was taken on June 26.

Sample results corrected for train blank.

TABLE 5-103. CARBON IN PYRITE REJECTS, BOTTOM ASH, ECONOMIZER ASH, AND ESP ASH (% BY WEIGHT, DRY BASIS)

Location	JN2293	JN2493	JN2793	AVERAGE	DL RATIO	SD
Pyrite Rejects	15.5	15.5	18.3	16		1.6
Bottom Ash	0.35	0.18	0.2	0.24		0.093
Economizer Ash	0.08	0.04	14.4 #	0.06		NC
ESP Ash: Row 1	0.02	0.02	0.01	0.017		0.0058
ESP Ash: Row 2	0.02	0.02	0.01	0.017		0.0058
ESP Ash: Row 3	0.06	NA	NA	0.06		NC

DL Ratio = Detection limit ratio.

SD = Standard deviation.

NA = Not analyzed due to insufficient sample.

NC = Not calculated.

= Outlier value, not used in calculations.

5.10. Ultimate/Proximate and Related Solid Sample Analyses

Tables 5-104 through 5-107 present results of ultimate/proximate analyses of coal samples, and of other related analyses conducted on other solid samples. Tables 5-104 and 5-105 show ultimate/proximate results for boiler feed coal (Location 1) and run-of-mine coal (Location 14), respectively. Moisture content values for boiler feed coal, run-of-mine coal, and lime (Location 15) are shown in percent by weight in Table 5-106. Table 5-107 presents results for sulfur in pyrite rejects, in weight percent sulfur on a dry basis. In all of Tables 5-104 to 5-107, individual sample results are shown, as well as the average and standard deviation of those results.

On a dry basis, the results for boiler feed coal (Table 5-104) and run-of-mine coal (Table 5-105) are virtually identical. This is not unexpected, since the removal of pyrite rejects in the pulverizer removes only about 0.2 percent by weight of the incoming run-of-mine coal stream. Tables 5-104 to 5-106 show that the two coal streams differ markedly in moisture content, however. The process of pulverizing the run-of-mine coal reduces its moisture content by about half, from 38 to 18 percent, on average. The lime used in the scrubber exhibited a moisture content of only 0.13 percent on average.

Table 5-107 shows the sulfur content of pyrite rejects averaged 23 percent, much higher than the 1 percent sulfur content of the dry coal (Table 5-105). However, because only a small fraction of the run-of-mine coal mass is removed as pyrite rejects, the sulfur removed in the pyrite rejects amounts to less than 5 percent of the sulfur originally in the run-of-mine coal.

TABLE 5-104. ULTIMATE/PROXIMATE RESULTS FOR BOILER FEED COAL (LOCATION 1)

Analyte	JN2293BOFED	JN2493BOFED	JN2793BOFED	AVERAGE	DL RATIO	SD
Proximate Analysis (as received), percent						
Moisture	17.0	17.8	18.3	18		0.67
Ash	14.2	14.4	12.2	14		1.2
Volatile matter	33.5	34.2	33.6	34		0.36
Fixed Carbon (diff) *	35.2	33.7	35.9	35		1.1
Sulfur	0.80	0.80	0.97	0.86		0.10
Ultimate Analysis (dry), percent						
Carbon	58.7	58.1	61.1	59		1.6
Hydrogen	3.83	3.71	4.26	3.9		0.29
Nitrogen	0.93	0.88	0.83	0.88		0.05
Sulfur	0.96	0.97	1.19	1.0		0.13
Ash	17.2	17.5	15.0	17		1.4
Oxygen (diff) *	18.4	18.9	17.6	18		0.64
Heating Value, Btu/lb						
As received	8179	8046	8384	8203		170
Dry	9855	9783	10267	9968		261
MAF	11896	11858	12076	11943		116

DL Ratio = Detection limit ratio.

SD = Standard deviation.

MAF = Moisture and ash free.

* diff = Calculated by difference.

TABLE 5-105. ULTIMATE/PROXIMATE RESULTS FOR RUN OF MINE COAL (LOCATION 14)

Analyte	JN2293COAL	JN2493COAL	JN2793COAL	AVERAGE	DL RATIO	SD
Proximate Analysis (as received), percent						
Moisture	37.9	38.5	38.7	38		0.41
Ash	9.9	11.4	10.3	11		0.77
Volatile matter	26.0	25.8	25.2	26		0.41
Fixed Carbon (diff) *	26.2	24.4	25.8	25		0.98
Sulfur	0.54	0.58	0.83	0.65		0.16
Ultimate Analysis (dry), percent						
Carbon	59.0	57.3	58.5	58		0.88
Hydrogen	3.86	3.91	3.99	3.9		0.07
Nitrogen	0.87	0.82	0.85	0.85		0.03
Sulfur	0.87	0.95	1.36	1.1		0.26
Ash	16.0	18.5	16.8	17		1.3
Oxygen (diff) *	19.4	18.5	18.5	19		0.52
Heating Value, Btu/lb						
As received	6132	5916	6062	6037		110
Dry	9875	9613	9887	9792		155
MAF	11753	11798	11886	11812		68

DL Ratio = Detection limit ratio.

SD = Standard deviation.

MAF = Moisture and ash free.

* diff = Calculated by difference.

TABLE 5-106. MOISTURE IN BOILER FEED COAL, RUN-OF-MINE COAL, AND LIME (%)

Location	JN2293	JN2493	JN2793	AVERAGE DL RATIO	SD
Boiler Feed Coal	17.0	17.8	18.3	18	0.67
Run-of-Mine Coal	37.9	38.5	38.7	38	0.41
Lime	0.24	0.07	0.09	0.13	0.093

DL Ratio = Detection limit ratio.

SD = Standard deviation.

TABLE 5-107. SULFUR IN PYRITE REJECTS (% BY WEIGHT, DRY BASIS)

Analyte	JN2293PYREJ	JN2493PYREJ	JN2793PYREJ	AVERAGE DL RATIO	SD
Sulfur	19.6	18.0	31.7	23	7.5

DL Ratio = Detection limit ratio.

SD = Standard deviation.

5.11. Particulate Size Distribution

The particle size distribution of flue gas particulate was determined in two ways. Glass cyclones with nominal 50 percent cutoff sizes of 10 μm and 5 μm aerodynamic diameter, respectively, were used with the Multi-Metals trains at the ESP #1 inlet (Location 4a) and outlet (Location 5a). These cyclones were used in an extractive mode, i.e., outside the duct. The glass cyclones were designed for this study, and were installed in the heated filter box of the train during sampling. The designed aerodynamic cut points of the cyclones were 10 μm and 5 μm ; insufficient time was available to test the cut points before the study. A Teflon flex line connected the sampling probe to the cyclones. Particle size distributions were also measured at the scrubber outlet (Locations 6a and 6b) using cascade impactors. The impactors used were Pilat Mark III Source Test cascade impactors with glass fiber impaction stages and backup filter. The glass fiber material was Reeve Angel 934H; this material is reported to minimize weight gain from SO_2/SO_3 adsorption. Furthermore, the particle size distribution of ash collected in the ESP was determined. This determination was done for samples from ESP hopper rows 1 and 2 only, because insufficient sample was available from row 3. The purpose of this section is to present the various particle size distribution data, and to make comparisons regarding the flue gas particulate and the methods used to determine the size distributions.

Table 5-108 shows size distribution data for ESP ash. Both mesh screen and particle counter sizing were used; note that the screen method provides a geometric particle diameter, whereas the Coulter counter provides a volumetric diameter. The sizing method and μm size cut for each stage are indicated at the left of Table 5-108. The data shown are the cumulative percent mass of the sample that occurs at particle sizes smaller than the indicated cut sizes. Results are shown for three samples of row 1 ash, and for two samples of row 2 ash, along with the average and standard deviation for each row. The average particle size distributions of row 1 and row 2 ESP ash are plotted in Figure 5-1. Note that the "kink" in the average distributions at about 40 μm is likely an artifact of using the two separate techniques to determine particle sizes.

The row 1 ash exhibited the following average distribution characteristics: 75 percent of the mass was found in particles smaller than about 28 μm diameter, 50 percent in

particles smaller than $14.5\ \mu\text{m}$, and 25 percent in particles smaller than about $9\ \mu\text{m}$. Approximately 30 percent of the mass of row 1 ash was in particles smaller than $10\ \mu\text{m}$, and approximately 4.5 percent was in particles smaller than $5\ \mu\text{m}$. The row 2 ash showed a similar distribution, but shifted slightly toward smaller particle sizes. The corresponding size distribution characteristics for row 2 were: 75 percent of the mass below about $28\ \mu\text{m}$, 50 percent below about $13\ \mu\text{m}$, and 25 percent below $8\ \mu\text{m}$. Approximately 36 percent of the mass of row 2 ash was in particles smaller than $10\ \mu\text{m}$, and about 7.5 percent in particles smaller than $5\ \mu\text{m}$.

Table 5-109 shows flue gas particulate size distribution data from the ESP #1 inlet (Location 4a), determined using the cyclones. Because the cyclones were used outside the duct, the probe wash particulate catch is included in Table 5-109. This table shows the fraction collected and its nominal size range, and the mass and percent of total mass in that fraction for each sample. The results shown were reproducible from day to day, indicating good precision in the determination of the particle size distribution. The average distribution results indicate that at least 66 percent of the particulate is greater than $10\ \mu\text{m}$ in diameter. The $5\text{-}10\ \mu\text{m}$ and $<5\ \mu\text{m}$ ranges each contain about 12 percent of the mass, and the probe wash contains about 10 percent.

The flue gas particulate present at Location 4a is almost completely removed by the ESP (see, e.g., Table 2-3). Thus it is of interest to compare the size distribution determined for the ESP ash (Table 5-108) to that determined in the flue gas upstream of the ESP using the glass cyclones and filter (Table 5-109). However, the ESP sizing in multiple ranges of volumetric and geometric size is not directly comparable to the Location 4a sizing in a few ranges of aerodynamic particle size. Furthermore, the probe wash particulate is of indeterminate size. Although preferential collection of larger particles would be expected in the probe and flexible line during sampling, the probe wash cannot be properly apportioned to the other size ranges. For a rough comparison to the ESP ash data, ranges of mass within each size fraction have been calculated by assigning all of the probe wash particulate to each range in turn. This results in a range of possible mass fractions within each size range. The results are shown in Table 5-110. This table compares the distribution of ESP ash and flue gas particulate size distributions in three size ranges: $>10\ \mu\text{m}$, $5\text{-}10\ \mu\text{m}$, and $<5\ \mu\text{m}$. All results are rounded to the nearest percent mass. Table 5-110 shows that the

fraction of flue gas particulate occurring in particles greater than 10 μm diameter agrees quite well with the corresponding values for ESP ash. This result indicates that the large cyclone did provide a cut point of about 10 μm , as designed. The flue gas results for the total fraction of particulate < 10 μm in size (24-44 percent) also bracket the totals shown for row 1 ESP ash (30 percent) and row 2 ESP ash (36 percent), respectively. However, the breakdown of particle size below 10 μm does not provide good agreement. The cyclones at the ESP #1 inlet indicate less mass in the 5-10 μm range than do the ESP ash results, and more mass in the < 5 μm range than do the ESP ash results. This difference could be explained by the small cyclone providing too high a size cut at the ESP #1 inlet. Another contribution to the difference may be the relatively lower efficiency of the ESP for removal of fine particles. In other words, the ESP ash samples may contain less mass in particles < 5 μm diameter, relative to the flue gas particulate, because of the greater penetration of such fine particles in the ESP. Overall, the results in Table 5-110 indicate that extractive sampling using the glass cyclones provided a broad but reasonable picture of the particulate size distribution at the ESP inlet, but with uncertainty introduced by the collection of particulate in the sampling probe.

Table 5-111 shows the size distribution data from the ESP #1 outlet (Location 5a). At this location, most of the particulate (average 78 percent) was collected in the probe wash. Negligible amounts were collected in either cyclone, and only about 21 percent was collected on the filter. At this location, the particulate loading was less than 1 percent of that at the ESP inlet, and the probe and flexible line were longer, due to the size of the duct. Table 5-111 indicates that under those conditions, the extractive sampling using glass cyclones was not effective in determining the particulate size distribution. The absence of material in either cyclone, the presence of material on the filter, and the location of sampling downstream of the ESP, all suggest that the particulate was primarily in the < 5 μm size fraction, but no quantitative conclusions can be reached from the data. These uncertainties preclude the estimation of ESP efficiency as a function of particle size based on the cyclone data.

Particle size distribution data at the scrubber outlet hot and dilute sampling locations (6a and 6b) are shown in Tables 5-112 and 5-113, respectively. Shown in these tables are the impactor stage designation, the corresponding size cut (D_{50}), the percent mass retained

in that stage, and the cumulative mass through successive stages. The cumulative masses less than the indicated size are also shown graphically in Figures 5-2 and 5-3 for Locations 6a and 6b, respectively. Table 5-112 shows that the cut sizes of the impactor stages were consistent at Location 6a over all three impactor runs, and that the particulate size distribution was determined with good precision. About 70 percent of the flue gas particulate mass at Location 6a was found in the size ranges from 0.85 to 6.3 μm , with about 20 percent in larger particles (Figure 5-2). Less than 10 percent of the mass was found in smaller particles.

The corresponding size distribution data from the dilute sampling at the scrubber outlet (Location 6b) are shown in Table 5-113 and Figure 5-3. The particle size distribution at this location is closely similar to that at Location 6a (Table 5-112 and Figure 5-2) but shifted slightly toward finer particles. For example, Table 5-113 and Figure 5-3 show on average about 85 percent of the particle mass in the size range from 0.85 to 6.9 μm diameter, with only about 5.5 percent at larger sizes. As was observed in the hot stack data (Table 5-112), the dilute sampling data indicate less than 10 percent of the mass in particles smaller than 0.85 μm (Table 5-113). The smaller amounts of large particles (i.e., $> 6.9 \mu\text{m}$) in the dilute sampling results may be due to losses of some larger particles in the plumbing of the PSDS sampler upstream of the impactor. The particulate size data from Locations 6a and 6b are consistent with the suggested likely predominance of particles smaller than 5 μm at the ESP outlet, Location 5a (see discussion of Table 5-111, above).

As a quality assurance check, the total particulate loading determined by Method 29 sampling at Location 6a was compared to that inferred at that location from the sum of particulate mass collected on the several impactor stages. It must be noted that these two approaches are markedly different. Method 29 used isokinetic multi-point sampling over 8 hours in horizontal traverses of the duct; sample volumes were 4 to 5 Ncm. In contrast, the impactor runs at Location 6a were isokinetic samples of 2 hours' duration at a single point in the duct; sample volumes were about 1.5 Ncm. Furthermore, sampling with these two methods was not simultaneous; Method 29 runs occurred on June 22, 24, and 27, whereas the Location 6a impactor runs were conducted on June 21, 23, and 26. Nevertheless, the two sets of data should give similar loading results. A comparison of the two data sets is shown below:

Flue Gas Particulate Loading Measured at Location 6a (mg/Ncm)

Date	Method 29	Impactor
6/21/93		16.9
6/22/93	33.5	
6/23/93		22.3
6/24/93	6.4	
6/26/93		12.0
6/27/93	2.1	

The loading data indicate reasonable agreement between the two methods, considering the different time periods and approaches of the measurements.

The fractional particle collection efficiency of the ESP and scrubber combined was evaluated by comparing the size distribution of particles collected in the ESP row 1 (Table 5-108) with that obtained by the impactor at the scrubber outlet (Table 5-112). This approach implicitly assumes that the row 1 ESP size distribution represents the inlet particulate size distribution. The average size distributions listed in the tables were used. The percent mass for several size intervals was calculated by interpolating the listed values. The calculated values were then multiplied by the measured average particulate load values (12,460 mg/Ncm at the ESP inlet and 14 mg/Ncm at the stack).

Figure 5-4 is a plot of the calculated fractional collection efficiency as a function of the particle diameter (the curve plotted is for illustration only). The efficiency for particles larger than 3 μm is seen to be higher than 98 percent. The efficiency for 1.6 μm particles is only 48 percent. However, considering that this particle size is very close to the lower limit of the Coulter counter, the uncertainty of the calculated efficiency for the 1.6 μm particles is relatively high.

TABLE 5-108. PARTICULATE SIZE DISTRIBUTION OF ESP ASH (PERCENT OF SAMPLE MASS SMALLER THAN INDICATED PARTICLE SIZE)

Micron Size		JN2293ESPA-1	JN2493ESPA-1	JN2793ESPA-1	AVERAGE	DL RATIO	SD	JN2293ESPA-2	JN2493ESPA-2	AVERAGE	DL RATIO	SD
Screen Analysis	210	96.87	97.80	98.48	97.72		0.81	99.36	99.20	99.28		NC
	106	93.42	94.90	96.39	94.90		1.5	98.20	98.00	98.10		NC
	75	88.14	90.30	92.79	90.41		2.3	95.87	95.50	95.69		NC
	45	86.58	74.30	80.27	80.38		6.1	83.73	73.20	78.47		NC
Coulter Counter	40.30	86.05	73.64	79.13	79.61		6.2	82.38	72.60	77.49		NC
	32.00	82.17	72.75	77.85	77.59		4.7	81.37	72.15	76.76		NC
	25.40	76.24	68.53	73.32	72.70		3.9	77.67	70.65	74.16		NC
	20.20	67.95	61.25	65.22	64.81		3.4	72.45	63.58	68.02		NC
	16.00	56.51	52.00	55.15	54.55		2.3	64.07	57.42	60.75		NC
	12.70	42.45	40.91	43.21	42.19		1.2	54.62	43.48	49.05		NC
	10.08	29.85	30.11	31.76	30.57		1.0	42.95	28.70	35.83		NC
	8.00	19.89	20.33	20.72	20.31		0.42	29.64	19.48	24.56		NC
	6.35	8.89	11.90	9.67	10.15		1.6	19.04	11.40	15.22		NC
	5.05	3.27	5.96	4.15	4.46		1.4	10.19	5.29	7.74		NC
	4.00	0.91	2.35	1.23	1.50		0.76	5.63	1.69	3.66		NC
	3.17	0.18	0.70	0.21	0.36		0.29	1.95	0.31	1.13		NC
	2.52	0.08	0.13	0.05	0.09		0.04	0.39	0.06	0.23		NC
	2.00	0.07	0.02	0.04	0.04		0.03	0.05	0.05	0.05		NC
	1.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		NC

DL Ratio = Detection limit ratio.

SD = Standard deviation.

TABLE 5-109. PARTICLE SIZE DISTRIBUTION AT ESP #1 INLET (LOCATION 4a)

Particulate Fraction	Sampling Day						Average Percent Mass (Std. Dev.)
	June 22		June 24		June 27		
	Mass (g)	Fraction (%)	Mass (g)	Fraction (%)	Mass (g)	Fraction (%)	
Probe Wash	5.6914	10.83	5.6014	12.08	4.7298	8.36	10.41 (1.77)
> 10 μm ^(a)	33.5146	63.75	29.8922	64.48	39.7251	70.18	66.14 (2.87)
5-10 μm ^(b)	6,8369	13.00	4.9454	10.67	6.7213	11.87	11.85 (0.95)
< 5 μm ^(c)	6.5312	12.42	5.9225	12.77	5.4276	9.59	11.59 (1.42)
Total	52.5741	100.00	46.3615	100.00	56.6038	100.00	

- (a) From coarse cyclone (10 μm aerodynamic cut).
 (b) From fine cyclone (5 μm aerodynamic cut).
 (c) From filter.

TABLE 5-110. COMPARISON OF ESP INLET FLUE GAS PARTICULATE AND
ESP ASH SIZE DISTRIBUTIONS

Size Range	Percent Mass in Size Range		
	ESP #1 Inlet ^(a) Flue Gas Particulate	ESP Ash ^(b) Row 1	ESP Ash ^(b) Row 2
> 10 μm	66-77 ^(c)	70	64
5-10 μm	12-22	25	28
< 5 μm	12-22	5	8

(a) See Table 5-109.

(b) See Table 5-108.

(c) Lower value shown was calculated assuming none of probe wash particulate is in the indicated size range; higher value was calculated assuming all of the probe was particulate is in the indicated size range.

TABLE 5-111. PARTICLE SIZE DISTRIBUTION AT ESP #1 OUTLET (LOCATION 5a)

Particulate Fraction	Sampling Day						Average Percent Mass (Std. Dev.)
	June 22		June 24		June 27		
	Mass (g)	Fraction (%)	Mass (g)	Fraction (%)	Mass (g)	Fraction (%)	
Probe Wash	0.1705	83.78	0.0845	93.37	0.0342	58.36	78.50 (14.77)
> 10 μm ^(a)	0.0026	1.28	NR ^(d)	-	NR	-	< 1
5-10 μm ^(b)	0.0024	1.18	NR	-	NR	-	< 1
< 5 μm ^(c)	0.0280	13.76	0.0060	6.63	0.0244	41.64	20.68 (15.11)
Total	0.2035	100.00	0.0905	100.00	0.0586	100.00	

(a) From coarse cyclone (10 μm aerodynamic cut).

(b) From fine cyclone (5 μm aerodynamic cut).

(c) From filter.

(d) NR = No particulate recovered.

TABLE 5-112. PARTICULATE SIZE DISTRIBUTION AT SCRUBBER OUTLET (LOCATION 6a)

Impactor Stage	Sampling Day									Average % Mass by Stage (Std. Dev.)
	June 21			June 23			June 26			
	Aerodynamic Cut	Cumulative		Aerodynamic Cut	Cumulative		Aerodynamic Cut	Cumulative		
	D ₅₀ (μm)	% Mass	% Mass ^(b)	D ₅₀ (μm)	% Mass	% Mass ^(b)	D ₅₀ (μm)	% Mass	% Mass ^(b)	
RAPC ^(a)	6.45	24.49	75.51	6.34	16.98	83.02	6.21	17.82	82.18	19.76 (3.36)
3	3.20	18.78	56.73	3.14	27.36	55.66	3.08	21.26	60.92	22.47 (3.61)
4	1.61	28.16	28.57	1.57	29.87	25.79	1.53	25.86	35.06	27.96 (1.64)
5	0.88	17.96	10.61	0.86	17.61	8.18	0.83	22.41	12.65	19.33 (2.18)
6	0.40	4.49	6.12	0.39	3.77	4.41	0.38	5.17	7.48	4.48 (0.57)
7	0.13	1.63	4.49	0.12	1.26	3.15	0.11	2.87	4.61	1.92 (0.69)
Filter		4.49	0.00		3.15	0.00		4.61	0.0	4.08 (0.66)

(a) Right angle pre-collector.

(b) Percent mass in particles smaller than the indicated cut size.

TABLE 5-113. PARTICULATE SIZE DISTRIBUTION AT SCRUBBER OUTLET,
DILUTE SAMPLING (LOCATION 6b)

Stage	Sampling Day									Average % Mass by Stage (Std. Dev.)	
	June 21-22			June 23-24			June 26-27				
	Aerodynamic		Cumulative	Aerodynamic		Cumulative	Aerodynamic		Cumulative		
	Cut			Cut			Cut				
	D ₅₀ (μm)	% Mass	% Mass ^(a)	D ₅₀ (μm)	% Mass	% Mass ^(a)	D ₅₀ (μm)	% Mass	% Mass ^(a)		
Inlet	7.01	2.5	97.5	6.93	6.45	93.55	6.83	7.69	92.31	5.55	(2.21)
3	3.16	17.5	80.0	3.13	32.26	61.29	3.09	15.38	76.93	21.71	(7.51)
4	1.57	35.0	45.0	1.55	29.03	32.26	1.53	35.90	41.03	33.31	(3.05)
5	0.86	37.5	7.5	0.85	22.58	9.68	0.83	30.77	10.26	30.28	(6.10)
6	0.40	2.5	5.0	0.40	4.84	4.84	0	5.13	5.13	4.16	(1.18)
7	0.14	0.0	5.0	0.14	1.61	3.23	0	5.13	0.0	2.25	(2.14)
Filter		5.0	0.00		3.23	0.00		0.00	0.0	2.74	(2.07)

(a) Percent mass in particles smaller than the indicated cut size.

Figure 5-1. Average size distributions of row 1 and row 2 ESP ash.

Figure 5-2. Particulate size distribution (impactor data) at scrubber outlet, hot flue gas sampling (Location 6a).

Figure 5-3. Particulate size distribution (impactor data) at scrubber outlet, dilute sampling (Location 6b).

Figure 5-4. Estimated ESP removal efficiency as a function of particle size.

6.0 DATA ANALYSIS AND INTERPRETATION

6.1 Element Mass Balances

Figures 6-1 through 6-5 show the boundaries for the mass balance calculations and show the equipment components included in the various mass balances, as follows:

Figure 6-1. Mass balance on each of the pulverizer, the boiler, and the ESP

Figure 6-2. Mass balance on the combined boiler and ESP

Figure 6-3. Mass balance on the scrubber

Figure 6-4. Mass balance on the combined boiler, ESP, and scrubber

Figure 6-5. Mass balance on the absorber.

6.1.1 Element Mass Balance Calculations

Assumptions necessary for calculating the element mass balances included those required for the ash mass balances (Section 3.3.1). Additional assumptions were:

- Element sampling was not done at Location 4a. Element data for this location were obtained by assuming that the relationship between element concentrations at Locations 4a and 4b was identical to the relationship between particulate loadings at these locations. Hence, the element concentrations at Location 4b were calculated by

$$\text{Elements \#4b} = \text{Elements \#4a} \times \text{Particulate \#4b/Particulate \#4a}$$

- The element sampling train was not run at Location 5a. Element data for this location were obtained by assuming that the relationship between element concentrations at Locations 5a and 5b was identical to the relationship between particulate loadings at these locations. Hence, the element concentrations at Location 5b were calculated by

$$\text{Elements \#5b} = \text{Elements \#5a} \times \text{Particulate \#5b/Particulate \#5a}$$

- A value equal to one-half of the detection limit was used in the element mass balance calculations when non-detect values were reported.

- Round-robin coal analysis results were used in place of data obtained in this sampling and analysis effort for antimony, arsenic, barium, boron, cadmium, lead, mercury, molybdenum, nickel, and selenium.
- Metals concentration data for chromium and nickel at Location 4a on June 27 and for chromium, nickel, molybdenum, and copper at Location 6a on June 22 were believed to suffer from contamination, probably from stainless steel. Hence, these data were not used in the calculations. Instead, the average of the metal concentrations for the other two runs were substituted for the suspect data.

Table 6-1 shows the mass balance calculations for one of the 21 elements of interest, aluminum. Mass balances for each of the elements were performed in the same way, using separate but identical spreadsheets for each element. Separate mass balance calculations are shown for the pulverizer; the boiler; the ESP; the combined boiler and ESP; the scrubber; the combined boiler, ESP, and scrubber system; and the absorber. The comments column gives details regarding the calculations.

The mass balances for the absorber were calculated by adjusting the inputs and outputs of the scrubber system to account for the gas bypassing the absorber.

6.1.2 Element Mass Balance Results

Tables 6-2 through 6-22 show the results of the mass balance calculations for the 21 elements of interest as follows:

Table 6-2.	Aluminum
Table 6-3.	Antimony
Table 6-4.	Arsenic
Table 6-5.	Barium
Table 6-6.	Beryllium
Table 6-7.	Boron
Table 6-8.	Cadmium
Table 6-9.	Chromium
Table 6-10.	Cobalt
Table 6-11.	Copper
Table 6-12.	Lead
Table 6-13.	Manganese
Table 6-14.	Mercury
Table 6-15.	Molybdenum
Table 6-16.	Nickel

Table 6-17.	Potassium
Table 6-18.	Selenium
Table 6-19.	Silicon
Table 6-20.	Sodium
Table 6-21.	Titanium
Table 6-22.	Vanadium

Figures 6-6 through 6-26 show the results of the mass balances for the individual elements. Each is discussed in the appropriate section for the element.

The following paragraphs summarize the results for each element. In Tables 6-2 to 6-22, mass balance results that were based on one or more non-detect values are flagged by shading of the pertinent portion of the table. Many of the calculations involved at least one non-detect, but in most cases the impact on the results was small. Cases in which non-detects or outliers in the data strongly affected the results are noted in the description of the tables.

Aluminum. Figure 6-6 shows the mass balance results for aluminum. From this figure it can be seen that:

- Little of the aluminum is rejected with the pulverizer rejects.
- About 61 percent of the aluminum in the pulverized coal was found to exit the furnace as bottom ash and economizer ash.
- About 13 percent of the aluminum in the pulverized coal was found to exit the furnace as fly ash.
- There is some uncertainty regarding the above results because the ESP catch was found to be far greater (about 68 percent of the aluminum in the pulverized coal) than would be consistent with those data.
- Over 99 percent of the aluminum entering the ESP is captured there.
- The fraction of aluminum in the flue gas that is captured in the absorber is uncertain, with estimates ranging from 20 to 87 percent, depending upon which data are used. This uncertainty is probably not important because it relates to such a small fraction of the aluminum in the pulverized coal.

Table 6-2 shows that the aluminum content of the two streams exiting the pulverizer equalled 90 to 150 percent (average 112 percent) of the measured aluminum content of the raw coal supplied to the pulverizer.

The aluminum content of the three streams exiting the boiler equalled 72 to 79 percent (average 74 percent) of the measured aluminum content of the pulverized coal burned in the boiler.

The aluminum content of the two streams exiting the ESP equalled 455 to 661 percent (average 542 percent) of the measured aluminum content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the aluminum content of the four streams exiting these devices equalled 122 to 137 percent (average 130 percent) of the measured aluminum content of the pulverized coal fired in the boiler.

The aluminum content of the two streams exiting the scrubber equalled 58 to 113 percent (average 81 percent) of the measured aluminum content of the flue gas entering the scrubber and of the lime feed slurry and the makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total aluminum content of the streams exiting these devices equalled 122 to 136 percent (average 130 percent) of the measured aluminum content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The aluminum content of the two streams exiting the absorber equalled 33 to 118 percent (average 69 percent) of the measured aluminum content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

Antimony. Figure 6-7 shows the mass balance results for antimony. From this figure it can be seen that:

- Very little of the antimony is rejected with the pulverizer rejects.
- About 22 percent of the antimony in the pulverized coal was found to exit the furnace as bottom ash and economizer ash.
- About 75 percent of the antimony in the pulverized coal was found to exit the furnace as fly ash.

- About 35 percent of the antimony entering the ESP is found in the ESP ash.
- Less than 2 percent of the antimony entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- There is some uncertainty regarding the above results because over 60 percent of the antimony in the stream entering the ESP was unaccounted for in the streams exiting the ESP.
- The fraction of antimony in the flue gas that is captured in the absorber is uncertain. This uncertainty is not of great importance because it relates to a very small fraction of the antimony in the pulverized coal.

Table 6-3 shows that the antimony content of the two streams exiting the pulverizer equalled 2.6 to 3.1 percent (average 2.8 percent) of the measured antimony content of the raw coal supplied to the pulverizer. The antimony analysis of the raw coal is suspect.

The antimony content of the three streams exiting the boiler equalled 67 to 114 percent (average 98 percent) of the measured antimony content of the pulverized coal burned in the boiler.

The antimony content of the two streams exiting the ESP equalled 24 to 62 percent (average 41 percent) of the measured antimony content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the antimony content of the four streams exiting these devices equalled 42 to 57 percent (average 49 percent) of the measured antimony content of the pulverized coal fired in the boiler.

The antimony content of the two streams exiting the scrubber equalled 14 to 40 percent (average 30 percent) of the measured antimony content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total antimony content of the streams exiting these devices equalled 42 to 57 percent (average 49 percent) of the measured antimony content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The antimony content of the two streams exiting the absorber equalled -75 to 19 percent (average -14 percent) of the measured antimony content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

Arsenic. Figure 6-8 shows the mass balance results for arsenic. From this figure it can be seen that:

- About 2 percent of the arsenic is rejected with the pulverizer rejects.
- About 29 percent of the arsenic in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 111 percent of the arsenic in the pulverized coal was found to exit the furnace as fly ash. There is uncertainty because boiler exit streams accounted for 140 percent of the arsenic in the feed coal.
- About 71 percent of the arsenic in the fly ash entering the ESP was captured in the ESP ash.
- Only about 0.2 percent of the arsenic entering the ESP with the fly ash was found to exit the ESP with the fly ash. Thus, there is some uncertainty regarding the above results because about 29 percent of the arsenic entering the ESP was not accounted for in the exit streams.
- About 80 percent of the arsenic in the flue gas entering the absorber was captured there. This result might be questionable because it relates to such low arsenic levels.

Table 6-4 shows that the arsenic content of the two streams exiting the pulverizer equalled 38 to 67 percent (average 51 percent) of the measured arsenic content of the raw coal supplied to the pulverizer.

The arsenic content of the three streams exiting the boiler equalled 128 to 156 percent (average 141 percent) of the measured arsenic content of the pulverized coal burned in the boiler.

The arsenic content of the two streams exiting the ESP equalled 69 to 75 percent (average 72 percent) of the measured arsenic content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the arsenic content of the four streams exiting these devices equalled 97 to 119 percent (average 109 percent) of the measured arsenic content of the pulverized coal fired in the boiler.

The arsenic content of the two streams exiting the scrubber equalled 71 to 196 percent (average 131 percent) of the measured arsenic content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total arsenic content of the streams exiting these devices equalled 97 to 119 percent (average 109 percent) of the measured arsenic content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The arsenic content of the two streams exiting the absorber equalled 51 to 261 percent (average 152 percent) of the measured arsenic content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for arsenic for each day for the scrubber; boiler, ESP, and scrubber; and absorber involved the use of non-detect values. Hence, the mass balance results for these components are less reliable.

Barium. Figure 6-9 shows the mass balance results for barium. From this figure it can be seen that:

- Little (less than 0.2 percent) of the barium is rejected with the pulverizer rejects.
- About 64 percent of the barium in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 29 percent of the barium in the pulverized coal was found to exit the furnace as fly ash.
- About 227 percent of the barium in the fly ash entering the ESP was found in the ESP ash. Thus the ESP barium catch was found to be far greater than the barium entering the ESP with the fly ash.
- Only about 1 percent of the barium entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- About 40 percent of the barium in the flue gas entering the absorber is captured in the absorber. However, there is some uncertainty regarding these data as they only relate to a very small fraction of the barium in the pulverized coal.

Table 6-5 shows that the barium content of the two streams exiting the pulverizer equalled 89 to 142 percent (average 111 percent) of the measured barium content of the raw coal supplied to the pulverizer.

The barium content of the three streams exiting the boiler equalled 85 to 103 percent (average 92 percent) of the measured barium content of the pulverized coal burned in the boiler.

The barium content of the two streams exiting the ESP equalled 176 to 279 percent (average 231 percent) of the measured barium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the barium content of the four streams exiting these devices equalled 128 to 130 percent (average 129 percent) of the measured barium content of the pulverized coal fired in the boiler.

The barium content of the two streams exiting the scrubber equalled 61 to 213 percent (average 128 percent) of the measured barium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total barium content of the streams exiting these devices equalled 128 to 130 percent (average 129 percent) of the measured barium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The barium content of the two streams exiting the absorber equalled 20 to 309 percent (average 152 percent) of the measured barium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

Beryllium. Figure 6-10 shows the mass balance results for beryllium. From this figure it can be seen that:

- Little (less than 0.4 percent) of the beryllium is rejected with the pulverizer rejects.
- About 45 percent of the beryllium in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 38 percent of the beryllium in the pulverized coal was found to exit the furnace as fly ash.

- About 95 percent of the beryllium in the fly ash entering the ESP was captured there.
- Only about 3 percent of the beryllium entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The data suggest that essentially all of the beryllium remaining in the flue gas entering the absorber is captured in the absorber. However, these data deal with a very small fraction of the beryllium in the pulverized coal.

Table 6-6 shows that the beryllium content of the two streams exiting the pulverizer equalled 114 to 133 percent (average 124 percent) of the measured beryllium content of the raw coal supplied to the pulverizer.

The beryllium content of the three streams exiting the boiler equalled 77 to 89 percent (average 83 percent) of the measured beryllium content of the pulverized coal burned in the boiler.

The beryllium content of the two streams exiting the ESP equalled 90 to 111 percent (average 99 percent) of the measured beryllium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the beryllium content of the four streams exiting these devices equalled 80 to 87 percent (average 82 percent) of the measured beryllium content of the pulverized coal fired in the boiler.

The beryllium content of the two streams exiting the scrubber equalled 28 to 55 percent (average 44 percent) of the measured beryllium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total beryllium content of the streams exiting these devices equalled 78 to 86 percent (average 82 percent) of the measured beryllium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The beryllium content of the two streams exiting the absorber equalled -39 to 6 percent (average -11 percent) of the measured beryllium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for beryllium for all components except the pulverizer and the boiler involved the use of non-detect values. Hence, the mass balance results for these components are less reliable.

Boron. Figure 6-11 shows the mass balance results for boron. From this figure it can be seen that:

- Little (about 0.1 percent) of the boron is rejected with the pulverizer rejects.
- About 59 percent of the boron in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 84 percent of the boron in the pulverized coal was found to exit the furnace as fly ash. There is uncertainty regarding this result as the boron exiting the boiler was found to equal 143 percent of the boron in the feed coal.
- About 88 percent of the boron in the fly ash entering the ESP was captured there.
- Only about 2 percent of the boron entering the ESP with the fly ash was found to exit the ESP with the fly ash. Thus, there is some uncertainty regarding the above results because about 10 percent of the boron entering the ESP was not accounted for in the exit streams.
- The fraction of boron in the flue gas entering the absorber that is captured in the absorber is uncertain. This uncertainty is probably not important because it relates to such a small fraction of the boron in the pulverized coal.

Table 6-7 shows that the boron content of the two streams exiting the pulverizer equalled 82 to 98 percent (average 89 percent) of the measured boron content of the raw coal supplied to the pulverizer.

The boron content of the three streams exiting the boiler equalled 129 to 164 percent (average 141 percent) of the measured boron content of the pulverized coal burned in the boiler.

The boron content of the two streams exiting the ESP equalled 73 to 104 percent (average 93 percent) of the measured boron content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the boron content of the four streams exiting these devices equalled 131 to 136 percent (average 133 percent) of the measured boron content of the pulverized coal fired in the boiler.

The boron content of the two streams exiting the scrubber equalled 12 to 76 percent (average 42 percent) of the measured boron content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total boron content of the streams exiting these devices equalled 131 to 139 percent (average 135 percent) of the measured boron content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The boron content of the two streams exiting the absorber equalled -15 to 73 percent (average 31 percent) of the measured boron content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

Cadmium. Figure 6-12 shows the mass balance results for cadmium. From this figure it can be seen that:

- About 0.25 percent of the cadmium in the raw coal is rejected with the pulverizer rejects.
- About 102 percent of the cadmium in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 180 percent of the arsenic in the pulverized coal was found to exit the furnace as fly ash. Thus, about 282 percent of the cadmium in the pulverized coal is accounted for in the boiler exit streams, creating uncertainty regarding these results.
- About 60 percent of the cadmium in the fly ash entering the ESP was captured there.
- Only about 20 percent of the cadmium entering the ESP with the fly ash was found to exit the ESP with the fly ash. Thus, there is some uncertainty regarding the above results because about 20 percent of the cadmium entering the ESP was not accounted for in the exit streams.

- About 77 percent of the cadmium in the flue gas entering the absorber was captured there. This result might be questionable because it relates to such low cadmium levels.

Table 6-8 shows that the cadmium content of the two streams exiting the pulverizer equalled 6 to 14 percent (average 10 percent) of the measured cadmium content of the raw coal supplied to the pulverizer.

The cadmium content of the three streams exiting the boiler equalled 227 to 319 percent (average 285 percent) of the measured cadmium content of the pulverized coal burned in the boiler.

The cadmium content of the two streams exiting the ESP equalled 59 to 106 percent (average 82 percent) of the measured cadmium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the cadmium content of the four streams exiting these devices equalled 225 to 274 percent (average 244 percent) of the measured cadmium content of the pulverized coal fired in the boiler.

The cadmium content of the two streams exiting the scrubber equalled 46 to 125 percent (average 77 percent) of the measured cadmium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total cadmium content of the streams exiting these devices equalled 212 to 246 percent (average 234 percent) of the measured cadmium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The cadmium content of the two streams exiting the absorber equalled -21 to 151 percent (average 50 percent) of the measured cadmium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for cadmium for all components involved the use of non-detect values.

Chromium. Figure 6-13 shows the mass balance results for chromium. From this figure it can be seen that:

- Little (less than 0.1 percent) of the chromium is rejected with the pulverizer rejects.
- About 50 percent of the chromium in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 70 percent of the chromium in the pulverized coal was found to exit the furnace as fly ash. Thus, there is some uncertainty regarding the above results because about 120 percent of the chromium entering the boiler was found in the exit streams.
- About 79 percent of the chromium in the fly ash entering the ESP was captured there.
- About 1 percent of the chromium entering the ESP with the fly ash was found to exit the ESP with the fly ash.

Table 6-9 shows that the chromium content of the two streams exiting the pulverizer equalled 91 to 124 percent (average 111 percent) of the measured chromium content of the raw coal supplied to the pulverizer.

The chromium content of the three streams exiting the boiler equalled 96 to 161 percent (average 124 percent) of the measured chromium content of the pulverized coal burned in the boiler.

The chromium content of the two streams exiting the ESP equalled 67 to 111 percent (average 83 percent) of the measured chromium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the chromium content of the four streams exiting these devices equalled 94 to 132 percent (average 109 percent) of the measured chromium content of the pulverized coal fired in the boiler.

The chromium content of the two streams exiting the scrubber equalled 19 to 75 percent (average 53 percent) of the measured chromium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total chromium content of the streams exiting these devices equalled 94 to 132 percent (average 109 percent) of the measured chromium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The chromium content of the two streams exiting the absorber equalled -83 to 65 percent (average 13 percent) of the measured chromium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that chromium mass balances for each day for the pulverizer, and for most components for 6/27/93, involved the use of non-detect values. Hence, the mass balance results for these calculations are less reliable.

Cobalt. Figure 6-14 shows the mass balance results for cobalt. From this figure it can be seen that:

- Little (about 0.25 percent) of the cobalt is rejected with the pulverizer rejects.
- About 43 percent of the cobalt in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 66 percent of the cobalt in the pulverized coal was found to exit the furnace as fly ash.
- About 80 percent of the cobalt in the fly ash entering the ESP was captured there.
- Less than 1 percent of the cobalt entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The data suggest that little of the cobalt remaining in the flue gas is captured in the absorber. However, these data deal with a very small fraction of the cobalt in the pulverized coal.

Table 6-10 shows that the cobalt content of the two streams exiting the pulverizer equalled 12 to 36 percent (average 27 percent) of the measured cobalt content of the raw coal supplied to the pulverizer.

The cobalt content of the three streams exiting the boiler equalled 102 to 113 percent (average 109 percent) of the measured cobalt content of the pulverized coal burned in the boiler.

The cobalt content of the two streams exiting the ESP equalled 45 to 127 percent (average 81 percent) of the measured cobalt content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the cobalt content of the four streams exiting these devices equalled 68 to 127 percent (average 95 percent) of the measured cobalt content of the pulverized coal fired in the boiler.

The cobalt content of the two streams exiting the scrubber equalled 38 to 290 percent (average 129 percent) of the measured cobalt content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total cobalt content of the streams exiting these devices equalled 68 to 128 percent (average 95 percent) of the measured cobalt content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The cobalt content of the two streams exiting the absorber equalled -7 to 460 percent (average 164 percent) of the measured cobalt content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that cobalt mass balances for each day for all components except the pulverizer and boiler involved the use of non-detect values. Hence, the mass balance results for these components are less reliable.

Copper. Figure 6-15 shows the mass balance results for copper. From this figure it can be seen that:

- Very little of the copper is rejected with the pulverizer rejects.
- About 37 percent of the copper in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 54 percent of the copper in the pulverized coal was found to exit the furnace as fly ash.
- About 123 percent of the copper in the fly ash entering the ESP was found in the ESP ash.
- Only about 1 percent of the copper entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The data suggest that all of the copper remaining in the flue gas is captured in the absorber. However, these data deal with a very small fraction of the copper in the pulverized coal.

Table 6-11 shows that the copper content of the two streams exiting the pulverizer equalled 91 to 114 percent (average 102 percent) of the measured copper content of the raw coal supplied to the pulverizer.

The copper content of the three streams exiting the boiler equalled 83 to 101 percent (average 91 percent) of the measured copper content of the pulverized coal burned in the boiler.

The copper content of the two streams exiting the ESP equalled 115 to 148 percent (average 127 percent) of the measured copper content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the copper content of the four streams exiting these devices equalled 98 to 110 percent (average 105 percent) of the measured copper content of the pulverized coal fired in the boiler.

The copper content of the two streams exiting the scrubber equalled 25 to 62 percent (average 41 percent) of the measured copper content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total copper content of the streams exiting these devices equalled 98 to 109 percent (average 104 percent) of the measured copper content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The copper content of the two streams exiting the absorber equalled -36 to 30 percent (average -12 percent) of the measured copper content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that copper mass balances for each day for the pulverizer; scrubber; boiler, ESP, and scrubber; and absorber involved the use of non-detect values. Hence, the mass balance results for these components are less reliable.

Lead. Figure 6-16 shows the mass balance results for lead. From this figure it can be seen that:

- Very little of the lead is rejected with the pulverizer rejects.

- About 31 percent of the lead in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 84 percent of the arsenic in the pulverized coal was found to exit the furnace as fly ash. Thus, about 115 percent of the lead in the pulverized coal is accounted for in the boiler exit streams.
- About 97 percent of the lead in the fly ash entering the ESP was captured in the ESP ash.
- Less than 1 percent of the lead entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- About 40 percent of the lead in the flue gas entering the absorber was captured there. However, this result might be questionable because it relates to such low lead levels.

Table 6-12 shows that the lead content of the two streams exiting the pulverizer equalled 24 to 53 percent (average 42 percent) of the measured lead content of the raw coal supplied to the pulverizer.

The lead content of the three streams exiting the boiler equalled 106 to 130 percent (average 115 percent) of the measured lead content of the pulverized coal burned in the boiler.

The lead content of the two streams exiting the ESP equalled 94 to 104 percent (average 98 percent) of the measured lead content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the lead content of the four streams exiting these devices equalled 102 to 126 percent (average 113 percent) of the measured lead content of the pulverized coal fired in the boiler.

The lead content of the two streams exiting the scrubber equalled 58 to 90 percent (average 71 percent) of the measured lead content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total lead content of the streams exiting these devices equalled 102 to 126 percent (average 113 percent) of the measured lead content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The lead content of the two streams exiting the absorber equalled 41 to 87 percent (average 58 percent) of the measured lead content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that lead mass balances for each day for the pulverizer; scrubber; boiler, ESP, and scrubber; and absorber involved the use of non-detect values. Hence, the mass balance results for these components are less reliable.

Manganese. Figure 6-17 shows the mass balance results for manganese. From this figure it can be seen that:

- Little (about 0.5 percent) of the manganese is rejected with the pulverizer rejects.
- About 61 percent of the manganese in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 63 percent of the manganese in the pulverized coal was found to exit the furnace as fly ash. Thus, there is some uncertainty regarding the above results because about 125 percent of the manganese entering the boiler was found in the exit streams.
- About 98 percent of the manganese in the fly ash entering the ESP was captured there.
- Less than 1 percent of the manganese entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The data suggest that little (possibly 10 percent) of the manganese remaining in the flue gas entering the absorber is captured in the absorber. However, these data deal with a very small fraction of the manganese in the pulverized coal.

Table 6-13 shows that the manganese content of the two streams exiting the pulverizer equalled 70 to 93 percent (average 81 percent) of the measured manganese content of the raw coal supplied to the pulverizer.

The manganese content of the three streams exiting the boiler equalled 122 to 127 percent (average 124 percent) of the measured manganese content of the pulverized coal burned in the boiler.

The manganese content of the two streams exiting the ESP equalled 87 to 109 percent (average 100 percent) of the measured manganese content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the manganese content of the four streams exiting these devices equalled 114 to 129 percent (average 123 percent) of the measured manganese content of the pulverized coal fired in the boiler.

The manganese content of the two streams exiting the scrubber equalled 57 to 96 percent (average 82 percent) of the measured manganese content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total manganese content of the streams exiting these devices equalled 113 to 129 percent (average 123 percent) of the measured manganese content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The manganese content of the two streams exiting the absorber equalled 47 to 95 percent (average 78 percent) of the measured manganese content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

Mercury. Figure 6-18 shows the mass balance results for mercury. From this figure it can be seen that:

- About 2 percent of the mercury is rejected with the pulverizer rejects.
- About 0.6 percent of the mercury in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 64 percent of the mercury in the pulverized coal was found to exit the furnace with the fly ash. Thus, about 35 percent of the mercury remains unaccounted for in the boiler exit streams.
- About 2 percent of the mercury in the fly ash entering the ESP was captured there.
- About 150 percent of the mercury entering the ESP with the fly ash was found to exit the ESP with the fly ash. There is some uncertainty regarding the above results because more mercury was found to be exiting the ESP than entering it.

- About 20 percent of the mercury in the flue gas entering the absorber was captured there.

Table 6-14 shows that the mercury content of the two streams exiting the pulverizer equalled 71 to 250 percent (average 166 percent) of the measured mercury content of the raw coal supplied to the pulverizer.

The mercury content of the three streams exiting the boiler equalled 56 to 77 percent (average 64 percent) of the measured mercury content of the pulverized coal burned in the boiler.

The mercury content of the two streams exiting the ESP equalled 63 to 351 percent (average 167 percent) of the measured mercury content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the mercury content of the four streams exiting these devices equalled 49 to 209 percent (average 102 percent) of the measured mercury content of the pulverized coal fired in the boiler.

The mercury content of the two streams exiting the scrubber equalled 31 to 203 percent (average 119 percent) of the measured mercury content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total mercury content of the streams exiting these devices equalled 61 to 96 percent (average 74 percent) of the measured mercury content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The mercury content of the two streams exiting the absorber equalled -51 to 344 percent (average 153 percent) of the measured mercury content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for mercury for all components except the pulverizer (6/22/93 and 6/27/93 only) and the ESP involved the use of non-detect values. Hence, the mass balance results for this element are subject to uncertainty.

Molybdenum. Figure 6-19 shows the mass balance results for molybdenum. From this figure it can be seen that:

- About 5 percent of the molybdenum is rejected with the pulverizer rejects.
- About 45 percent of the molybdenum in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 38 percent of the molybdenum in the pulverized coal was found to exit the furnace as fly ash. Thus, there is some uncertainty regarding the above results because only about 83 percent of the molybdenum entering the boiler was found in the exit streams.
- About 82 percent of the molybdenum in the fly ash entering the ESP was captured there.
- Only about 0.3 percent of the molybdenum entering the ESP with the fly ash was found to exit the ESP with the fly ash. Thus, there is some uncertainty regarding the above results because about 18 percent of the molybdenum entering the ESP was not accounted for in the exit streams.
- Although results show that all of the molybdenum remaining in the flue gas is captured in the absorber, there is uncertainty because the molybdenum entering the scrubber is such a small fraction of the molybdenum in the pulverized coal.

Table 6-15 shows that the molybdenum content of the two streams exiting the pulverizer equalled 136 to 596 percent (average 442 percent) of the measured molybdenum content of the raw coal supplied to the pulverizer.

The molybdenum content of the three streams exiting the boiler equalled 69 to 97 percent (average 84 percent) of the measured molybdenum content of the pulverized coal burned in the boiler.

The molybdenum content of the two streams exiting the ESP equalled 59 to 129 percent (average 90 percent) of the measured molybdenum content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the molybdenum content of the four streams exiting these devices equalled 66 to 90 percent (average 77 percent) of the measured molybdenum content of the pulverized coal fired in the boiler.

The molybdenum content of the two streams exiting the scrubber equalled 20 to 97 percent (average 53 percent) of the measured molybdenum content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total molybdenum content of the streams exiting these devices equalled 73 to 93 percent (average 81 percent) of the measured molybdenum content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The molybdenum content of the two streams exiting the absorber equalled 17 to 97 percent (average 52 percent) of the measured molybdenum content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for molybdenum for all components except the scrubber and absorber involved the use of non-detect values, and that the mass balances for the scrubber and absorber for 6/24/93 involved the use of non-detect values.

Nickel. Figure 6-20 shows the mass balance results for nickel. From this figure it can be seen that:

- Little (less than 0.5 percent) of the nickel is rejected with the pulverizer rejects.
- About 37 percent of the nickel in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 63 percent of the nickel in the pulverized coal was found to exit the furnace as fly ash.
- About 55 percent of the nickel in the fly ash entering the ESP was captured there.
- Less than 1 percent of the nickel entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The data suggest that none of the nickel remaining in the flue gas is captured in the absorber.

Table 6-16 shows that the nickel content of the two streams exiting the pulverizer equalled 88 to 106 percent (average 99 percent) of the measured nickel content of the raw coal supplied to the pulverizer.

The nickel content of the three streams exiting the boiler equalled 90 to 113 percent (average 99 percent) of the measured nickel content of the pulverized coal burned in the boiler.

The nickel content of the two streams exiting the ESP equalled 47 to 72 percent (average 57 percent) of the measured nickel content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the nickel content of the four streams exiting these devices equalled 57 to 82 percent (average 72 percent) of the measured nickel content of the pulverized coal fired in the boiler.

The nickel content of the two streams exiting the scrubber equalled 15 to 106 percent (average 54 percent) of the measured nickel content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total nickel content of the streams exiting these devices equalled 56 to 77 percent (average 71 percent) of the measured nickel content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The nickel content of the two streams exiting the absorber equalled -29 to 107 percent (average 38 percent) of the measured nickel content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for nickel for most components involved the use of non-detect values.

Potassium. Figure 6-21 shows the mass balance results for potassium. From this figure it can be seen that:

- About 0.3 percent of the potassium is rejected with the pulverizer rejects.
- About 44 percent of the potassium in the pulverized coal was found to exit the furnace as bottom ash and economizer ash.
- About 45 percent of the potassium in the pulverized coal was found to exit the furnace as fly ash.
- About 10 percent of the potassium in the pulverized coal was unaccounted for.

- There is some uncertainty regarding the above results because the ESP catch was found to be 140 percent of the potassium in the fly ash entering the ESP.
- Only about 0.3 percent of the potassium entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The fraction of potassium remaining in the flue gas that is captured in the absorber is uncertain. This uncertainty relates to only a very small fraction of the potassium in the pulverized coal.

Table 6-17 shows that the potassium content of the two streams exiting the pulverizer equalled 92 to 188 percent (average 127 percent) of the measured potassium content of the raw coal supplied to the pulverizer.

The potassium content of the three streams exiting the boiler equalled 84 to 93 percent (average 88 percent) of the measured potassium content of the pulverized coal burned in the boiler.

The potassium content of the two streams exiting the ESP equalled 130 to 149 percent (average 143 percent) of the measured potassium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the potassium content of the four streams exiting these devices equalled 104 to 110 percent (average 107 percent) of the measured potassium content of the pulverized coal fired in the boiler.

The potassium content of the two streams exiting the scrubber equalled 12 to 98 percent (average 50 percent) of the measured potassium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total potassium content of the streams exiting these devices equalled 107 to 111 percent (average 108 percent) of the measured potassium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The potassium content of the two streams exiting the absorber equalled 6 to 98 percent (average 48 percent) of the measured potassium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

Selenium. Figure 6-22 shows the mass balance results for selenium. From this figure it can be seen that:

- Little (about 0.5 percent) of the selenium is rejected with the pulverizer rejects.
- About 21 percent of the selenium in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 95 percent of the selenium in the pulverized coal was found to exit the furnace as fly ash. Thus, there is some uncertainty regarding the above results because about 116 percent of the selenium entering the boiler was found in the exit streams.
- About 60 percent of the selenium in the fly ash entering the ESP was captured there.
- Only about 20 percent of the selenium entering the ESP with the fly ash was found to exit the ESP with the fly ash. Thus, there is some uncertainty regarding the above results because only about 80 percent of the selenium entering the ESP was not accounted for in the exit streams.
- The data suggest that essentially all of the selenium remaining in the flue gas is captured in the absorber.

Table 6-18 shows that the selenium content of the two streams exiting the pulverizer equalled 81 to 89 percent (average 86 percent) of the measured selenium content of the raw coal supplied to the pulverizer.

The selenium content of the three streams exiting the boiler equalled 100 to 130 percent (average 115 percent) of the measured selenium content of the pulverized coal burned in the boiler.

The selenium content of the two streams exiting the ESP equalled 70 to 98 percent (average 82 percent) of the measured selenium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the selenium content of the four streams exiting these devices equalled 95 to 99 percent (average 97 percent) of the measured selenium content of the pulverized coal fired in the boiler.

The selenium content of the two streams exiting the scrubber equalled 25 to 89 percent (average 58 percent) of the measured selenium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total selenium content of the streams exiting these devices equalled 74 to 99 percent (average 88 percent) of the measured selenium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The selenium content of the two streams exiting the absorber equalled -60 to 73 percent (average 8 percent) of the measured selenium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for selenium for all components except the ESP involved the use of non-detect values. Hence, the mass balances results for these components are less reliable.

Silicon. Figure 6-23 shows the mass balance results for silicon. From this figure it can be seen that:

- About 1 percent of the silicon is rejected with the pulverizer rejects.
- About 70 percent of the silicon in the pulverized coal was found to exit the furnace as bottom ash and economizer ash.
- About 76 percent of the silicon in the pulverized coal was found to exit the furnace as fly ash. Thus, there is some uncertainty regarding the above results because about 145 percent of the sodium entering the boiler was found in the exit streams.
- Over 92 percent of the silicon entering the ESP is captured there.
- Only about 0.2 percent of the silicon entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The data suggest that essentially all of the silicon remaining in the flue gas is captured in the absorber. Uncertainty with regard to this value is probably not important because it relates to less than 0.1 percent of the silicon in the pulverized coal.

Table 6-19 shows that the silicon content of the two streams exiting the pulverizer equalled 94 to 175 percent (average 123 percent) of the measured silicon content of the raw coal supplied to the pulverizer.

The silicon content of the three streams exiting the boiler equalled 143 to 149 percent (average 147 percent) of the measured silicon content of the pulverized coal burned in the boiler.

The silicon content of the two streams exiting the ESP equalled 86 to 98 percent (average 93 percent) of the measured silicon content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the silicon content of the four streams exiting these devices equalled 137 to 147 percent (average 141 percent) of the measured silicon content of the pulverized coal fired in the boiler.

The silicon content of the two streams exiting the scrubber equalled 12 to 30 percent (average 20 percent) of the measured silicon content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total silicon content of the streams exiting these devices equalled 136 to 147 percent (average 140 percent) of the measured silicon content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The silicon content of the two streams exiting the absorber equalled -64 to 11 percent (average -23 percent) of the measured potassium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for silicon for most components except the pulverizer and the boiler involved the use of non-detect values. Hence, the mass balances results for these components are less reliable.

Sodium. Figure 6-24 shows the mass balance results for sodium. From this figure it can be seen that:

- Less than 1 percent of the sodium is rejected with the pulverizer rejects.

- About 61 percent of the sodium in the pulverized coal was found to exit the furnace as bottom ash and economizer ash.
- About 28 percent of the sodium in the pulverized coal was found to exit the furnace as fly ash.
- There is some uncertainty regarding the above results because the ESP catch was found to be far greater (about 94 percent of the sodium in the pulverized coal) than would be consistent with those data.
- About 330 percent of the sodium entering the ESP was found in the ESP ash.
- Less than 2 percent of the sodium entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- The fraction of sodium remaining in the flue gas that is captured in the absorber is uncertain. This uncertainty relates to a very small fraction of the sodium in the pulverized coal.

Table 6-20 shows that the sodium content of the two streams exiting the pulverizer equalled 91 to 97 percent (average 94 percent) of the measured sodium content of the raw coal supplied to the pulverizer.

The sodium content of the three streams exiting the boiler equalled 78 to 101 percent (average 91 percent) of the measured sodium content of the pulverized coal burned in the boiler.

The sodium content of the two streams exiting the ESP equalled 240 to 463 percent (average 327 percent) of the measured sodium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the sodium content of the four streams exiting these devices equalled 143 to 162 percent (average 154 percent) of the measured sodium content of the pulverized coal fired in the boiler.

The sodium content of the two streams exiting the scrubber equalled 9 to 87 percent (average 45 percent) of the measured sodium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total sodium content of the streams exiting these devices equalled 161 to 216 percent (average 187 percent) of the

measured sodium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The sodium content of the two streams exiting the absorber equalled 619 to 6,208 percent (average 3,254 percent) of the measured sodium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber. The source of these very high mass balance values may be carryover of slurry solids into the flue gas stream.

Titanium. Figure 6-25 shows the mass balance results for titanium. From this figure it can be seen that:

- Less than 1 percent of the titanium is rejected with the pulverizer rejects.
- About 58 percent of the titanium in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 55 percent of the titanium in the pulverized coal was found to exit the furnace as fly ash. Thus, there is some uncertainty regarding the above results because about 115 percent of the titanium entering the boiler was found in the exit streams.
- About 112 percent of the titanium in the fly ash entering the ESP was captured there.
- Only about 0.2 percent of the titanium entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- About 67 percent of the titanium in the flue gas entering the absorber was captured there. However, these data deal with a very small fraction of the titanium in the pulverized coal.

Table 6-21 shows that the titanium content of the two streams exiting the pulverizer equalled 87 to 90 percent (average 88 percent) of the measured titanium content of the raw coal supplied to the pulverizer.

The titanium content of the three streams exiting the boiler equalled 106 to 117 percent (average 113 percent) of the measured titanium content of the pulverized coal burned in the boiler.

The titanium content of the two streams exiting the ESP equalled 102 to 125 percent (average 112 percent) of the measured titanium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the titanium content of the four streams exiting these devices equalled 111 to 130 percent (average 119 percent) of the measured titanium content of the pulverized coal fired in the boiler.

The titanium content of the two streams exiting the scrubber equalled 40 to 91 percent (average 59 percent) of the measured titanium content of the flue gas entering the scrubber and of the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total titanium content of the streams exiting these devices equalled 111 to 130 percent (average 119 percent) of the measured titanium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The titanium content of the two streams exiting the absorber equalled -11 to 85 percent (average 26 percent) of the measured titanium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

It should be noted that mass balances for each day for titanium for the scrubber; boiler, ESP, and scrubber; and absorber involved the use of non-detect values. Hence, the mass balances results for these components are less reliable.

Vanadium. Figure 6-26 shows the mass balance results for vanadium. From this figure it can be seen that:

- Less than 0.2 percent of the vanadium is rejected with the pulverizer rejects.
- About 49 percent of the vanadium in the pulverized coal was found to exit the furnace with the bottom ash and economizer ash.
- About 40 percent of the vanadium in the pulverized coal was found to exit the furnace as fly ash.
- About 135 percent of the vanadium in the fly ash entering the ESP was found in the ESP ash.

- Only about 0.6 percent of the vanadium entering the ESP with the fly ash was found to exit the ESP with the fly ash.
- Little of the vanadium in the flue gas entering the absorber was captured there.

Table 6-22 shows that the vanadium content of the two streams exiting the pulverizer equalled 70 to 118 percent (average 93 percent) of the measured vanadium content of the raw coal supplied to the pulverizer.

The vanadium content of the three streams exiting the boiler equalled 85 to 95 percent (average 89 percent) of the measured vanadium content of the pulverized coal burned in the boiler.

The vanadium content of the two streams exiting the ESP equalled 119 to 166 percent (average 138 percent) of the measured vanadium content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the vanadium content of the four streams exiting these devices equalled 99 to 107 percent (average 103 percent) of the measured vanadium content of the pulverized coal fired in the boiler.

The vanadium content of the two streams exiting the scrubber equalled 59 to 109 percent (average 82 percent) of the measured vanadium content of the flue gas entering the scrubber the lime feed slurry and makeup water supplied to the scrubber.

Considering the boiler, the ESP, and the scrubber together, the total vanadium content of the streams exiting these devices equalled 99 to 107 percent (average 103 percent) of the measured vanadium content of the pulverized coal fired in the boiler and of the lime feed slurry and the makeup water supplied to the scrubber.

The vanadium content of the two streams exiting the absorber equalled 39 to 112 percent (average 73 percent) of the measured vanadium content of the flue gas entering the absorber and of the lime feed slurry and the makeup water supplied to the scrubber.

6.1.3 Discussion of Element Mass Balance Results

Tables 6-23 through 6-29 report the mass balance results in a way that is probably more useful for evaluating the mass balances. In each of these tables, mass balance results

are reported for one device (boiler, ESP, etc.) or for part or all of the system. Shaded areas indicate results based at least in part on non-detect values. In Part a of each of these tables, the elements are listed in alphabetical order. In the second portion of each of these tables (Part b), the elements are listed in order based on the average values for the ratio of the output to the input.

Table 6-23 shows the mass balances for the pulverizer. It can be seen that balances within ± 30 percent were achieved for 14 of the 21 elements and for all five of the major elements.

Table 6-24 shows the mass balances for the boiler. It can be seen that balances within ± 25 percent were achieved for 15 of the 21 elements, and within ± 50 percent for 20 of the 21, the exception being cadmium.

Table 6-25 shows the mass balances for the ESP. It can be seen that balances within ± 50 percent were achieved for 16 of the 21 elements and the mass balances were within ± 30 percent for 13 of the elements. Less than 50 percent of the incoming material was found in the exit stream for one element, and more than 150 percent of the incoming material was found in the exit stream for four elements. Three of the five major elements (silicon, titanium, and potassium) produced mass balances within ± 50 percent. Unfortunately, for two of the other major elements (sodium and aluminum) the exit stream accounted for over 300 percent of the incoming material.

Table 6-26 shows the mass balances for the combined boiler and the ESP. Conducting a mass balance for this combination of devices eliminates the effect of any sampling problems at the exit of the boiler (entrance to the ESP) because this stream drops out of the calculation. It can be seen that balances within ± 55 percent were achieved for 20 of the 21 elements and that balances were within ± 25 percent for 13 of the elements. More than 200 percent of the incoming material was found in the exit stream for one element, cadmium. Four of the major elements (potassium, titanium, aluminum, and silicon) produced mass balances within ± 41 percent, and for the other major element (sodium), the exit stream accounted for 154 percent of the incoming material.

Results for the combined boiler and ESP tended to parallel the results for the boiler alone.

Table 6-27 shows the mass balances for the scrubber. It can be seen that balances within ± 50 percent were achieved for 15 of the 21 elements. From 30 to 50 percent of the incoming material was found in the exit stream for five elements. For two of the major elements (sodium and silicon) the exit stream accounted for less than 50 percent of the incoming material.

Table 6-28 shows the mass balances for the combined boiler, ESP, and scrubber. Conducting a mass balance for this combination of devices eliminates the effect of any sampling problems at the both the inlet and the exit of the ESP because these flow points drop out of the calculation. Again, it can be seen that balances within ± 50 percent were achieved for 18 of the 21 elements, and the balances were within ± 30 percent for 16 of the elements. Less than 50 percent of the incoming material was found in the exit stream for one element (antimony), and more than 150 percent of the incoming material was found in the exit stream for two elements (sodium and cadmium). In both cases, the elements that were out of balance were the same ones as reported out of balance for the boiler and ESP combination. Three of the major elements (titanium, potassium, and aluminum) produced mass balances within ± 30 percent. Because of the impact of the scrubber, mass balances for 12 of the 21 elements involved the use of non-detect values.

Table 6-29 shows the mass balances for the absorber. This plant component was the most difficult to address because of multiple input and output streams. The absorber also received the lowest flue gas concentrations, increasing the uncertainty of measurements in the flue gas streams. It can be seen that balances within ± 50 percent were achieved for only 6 of the 21 elements. Less than 50 percent of the incoming material was found in the exit stream for ten elements, and more than 150 percent of the incoming material was found in the exit stream for five elements. For one of the major elements (sodium) the exit stream accounted for more than 3200 percent of the incoming material.

6.2 Emission Factor Determinations

6.2.1 Emission Factor Calculations

For most analytes, emission factors (E) were calculated both in pounds per 10^{12} Btu ($\text{lb}/10^{12}$ Btu) and in micrograms of analyte per mega-Joule ($\mu\text{g}/\text{MJ}$) as follows:

$$E, \text{ lb}/10^{12} \text{ Btu} = \frac{\text{Loading, } \mu\text{g}/\text{Ncm} \times \text{Flue gas flow rate, Ncm/min} \times 60 \text{ min/hr}}{1,000,000 \mu\text{g/g} \times 453.6 \text{ g/lb} \times \text{Firing rate, } 10^{12} \text{ Btu/hr}}$$

and

$$E, \mu\text{g}/\text{MJ} = \frac{\text{Loading, } \mu\text{g}/\text{Ncm} \times \text{Flue gas flow rate, Ncm/min} \times 60 \text{ min/hr}}{\text{Firing rate, MJ/hr}}$$

where the firing rate in MJ/hr equals the firing rate in 10^{12} Btu/hr times 1.055×10^9 .

Concentrations in pCi/Ncm were used to calculate emission factors for radionuclides in pCi/MJ and mCi/ 10^{12} Btu. All emission factors were based on flows and concentrations measured at Location 6a, in the Unit 1 stack. As noted above, in some cases engineering judgment was used to eliminate outlying values from the calculations.

An example emission factor calculation is shown below, indicating both the calculation procedure and the location of the primary data within this report. This example calculation is for aluminum on June 22, 1993.

Example:

Aluminum loading in stack gas = $859 \mu\text{g}/\text{Ncm}$ (Table 5-8, page 5-13)

Stack gas flow rate = $30,688 \text{ Ncm/min}$ (Table 2-3, page 2-17)

Coal feed rate = $897,000 \text{ lb/hr}$ (Table 2-5, page 2-19)

Firing rate = $897,000 \text{ lb/hr} \times 6,132 \text{ Btu/lb}$ (Table 5-105, p. 5-112)

$$= 5.50 \times 10^9 \text{ Btu/hr}$$

$$= 5.50 \times 10^{-3} (10^{12} \text{ Btu/hr}).$$

Therefore the aluminum EF is

$$\text{EF} = \frac{859 \mu\text{g}/\text{Ncm} \times 30,688 \text{ Ncm/min} \times 60 \text{ min/hr}}{1 \times 10^6 \mu\text{g/g} \times 453.6 \text{ g/lb} \times 5.50 \times 10^{-3} (10^{12} \text{ Btu/hr})}$$

$$EF = 634 \text{ lb}/10^{12} \text{ Btu}$$

This result can be found at the top of the first data column in Table 6-30, which shows emission factors for elements. The same emission rate can be calculated in $\mu\text{g}/\text{MJ}$ by converting the firing rate to MJ/hr , i.e.

$$\begin{aligned} \text{Firing rate} &= 5.50 \times 10^{-3} (1.055 \times 10^9) \\ &= 5.80 \times 10^6 \text{ MJ/hr} \end{aligned}$$

Then

$$EF = \frac{859 \mu\text{g}/\text{Ncm} \times 30,688 \text{ Ncm}/\text{min} \times 60 \text{ min}/\text{hr}}{5.80 \times 10^6 \text{ MJ/hr}}$$

$$EF = 273 \mu\text{g}/\text{MJ}, \text{ found as the first entry in Table 6-31.}$$

6.2.2 Emission Factor Results

Tables 6-30 through 6-47 show the emission factor results for all analytes, calculated as described in Section 6.2.1. Individual results are shown, as well as the overall average emission factor and the total uncertainty (TU) of the average factor. The TU factors are calculated as indicated in Appendix G, and include total $\pm$ uncertainty arising from both precision (i.e., sampling and plant operating variability) and bias (i.e., sampling and analytical biases). The TU values provide an important indication of the uncertainty in measured plant emissions; the emission factor results should not be used without consideration of their associated TU values. Within Tables 6-30 through 6-47, the even-numbered tables (e.g., 6-30) show emission factors in English units ($\text{lb}/10^{12} \text{ Btu}$); the odd-numbered tables (e.g., 6-31) show emission factors in metric units ($\mu\text{g}/\text{MJ}$). Units unique to the radionuclide emissions are as noted in Section 6.2.1.

6.3 Removal Efficiencies

6.3.1 Removal Efficiency Calculations

Removal efficiencies were calculated for each element for each inorganic run. Calculations were made separately for ESP #1 and for the full Unit 1 ESP; for the scrubber;

the absorber; the combination of the ESP and the scrubber; and the combination of the ESP and the absorber (assuming all flue gas is scrubbed). Description of these components is given in Section 6.3.2, below. The calculation for removal efficiency (RE) in the ESP (both the complete ESP and ESP #1) was:

$$\text{RE, percent} = \frac{(\text{Emissions, ESP inlet} - \text{Emissions, ESP outlet}) \times 100}{\text{Emissions, ESP inlet}}$$

The calculation for removal efficiency (RE) for the combined ESP and the existing partial scrubber was:

$$\text{RE, percent} = \frac{(\text{Emissions, ESP inlet} - \text{Emissions, stack}) \times 100}{\text{Emissions, ESP inlet}}$$

The calculation for removal efficiency (RE) in the existing partial scrubber (alone) was:

$$\text{RE, percent} = \frac{(\text{Emissions, ESP outlet} - \text{Emissions, stack}) \times 100}{\text{Emissions, ESP outlet}}$$

The calculation for removal efficiency (RE) in the absorber was:

$$\text{RE, percent} = \frac{[(\text{Emissions, ESP outlet} - \text{Emissions, bypass}) - (\text{Emissions, stack} - \text{Emissions, bypass})] \times 100}{(\text{Emissions, ESP outlet} - \text{Emissions, bypass})}$$

The removal efficiency for the ESP and a hypothetical full scrubber performing at the same efficiency as the absorber was calculated by applying the removal efficiency of the absorber to the bypass stream and then calculating the expected emissions decrease across the ESP and full scrubber as was done for the ESP and partial scrubber (above).

A sample calculation of removal efficiencies for aluminum is included in the sample mass balance calculation shown in Table 6-1.

6.3.2 Removal Efficiency Results

Tables 6-48 through 6-68 show the results of the removal efficiencies for the 21 metals of interest as follows:

Table 6-48.	Aluminum
Table 6-49.	Antimony
Table 6-50.	Arsenic
Table 6-51.	Barium
Table 6-52.	Beryllium
Table 6-53.	Boron
Table 6-54.	Cadmium
Table 6-55.	Chromium
Table 6-56.	Cobalt
Table 6-57.	Copper
Table 6-58.	Lead
Table 6-59.	Manganese
Table 6-60.	Mercury
Table 6-61.	Molybdenum
Table 6-62.	Nickel
Table 6-63.	Potassium
Table 6-64.	Selenium
Table 6-65.	Silicon
Table 6-66.	Sodium
Table 6-67.	Titanium
Table 6-68.	Vanadium

Each of these tables shows removal efficiencies for the indicated element in plant components or groups of components. Removal efficiencies for the various system components and groups of components are presented in tables as follows:

Table 6-69.	ESP #1
Table 6-70.	ESP
Table 6-71.	Scrubber
Table 6-72.	Absorber
Table 6-73.	ESP and partial scrubber
Table 6-74.	ESP and full scrubber

The designation of plant components in Tables 6-48 to 6-74 requires some definition. The term "ESP #1" refers to that half of the Unit 1 ESP where the full set of chemical measurements were made (at Locations 4a and 5a). For ESP #1, removal efficiencies are based entirely on measured values. The term "ESP" refers to the entire ESP, including that half where only particulate and minimal element measurements were made (at Locations 4b and 5b). For the whole ESP, removal efficiencies are based on a mixture of measured and calculated values, because of assumptions noted in Section 6.1.1. The term "scrubber" means the entire FGD system, encompassing the bypass flow path and the absorbers, whereas the term "absorber" means the actual absorber section of the scrubber. Removal efficiencies for the scrubber are lower than those for the absorber, since the scrubber

includes the unscrubbed bypass flow. Removal efficiencies shown for the scrubber are based on measured values, whereas those for the absorber are based as well on calculations used to back out the bypass flow. The term "ESP and partial scrubber" refers to the system as operated at Coal Creek, with partial scrubbing of the flue gas in the absorbers, and partial bypass around the absorbers. The removal efficiencies calculated for this combination of components (Table 6-73) are based on measured values at the plant. In addition, Table 6-74 shows results for the "ESP and full scrubber". The removal efficiencies in that table are for a hypothetical situation in which all of the flue gas passes through an absorber (i.e., no bypass) having the removal efficiencies shown in Table 6-72. These results are intended to show the efficiencies provided by full scrubbing of flue gas. Finally, it should be noted that shaded areas in any of Tables 6-48 to 6-74 indicate removal efficiencies that are based at least in part on non-detect values. In some cases, engineering judgment has been used to eliminate outlying or suspect values from the calculations of removal efficiencies, as noted in the tables.

6.3.3 Discussion of Removal Efficiency Results

Figures 6-6 through 6-26, which show the mass balances graphically, and the accompanying text for the individual elements in the mass balance section are helpful in evaluating the removal efficiency results. The following section presents more complete data on removal efficiency and presents data separately for each applicable boiler component.

It should first be noted that some negative values are reported for removal efficiencies in the tables. Negative values indicate that more of an element was found in the exit of a control device than was found at the inlet. For the ESP, it is difficult to imagine that the negative values indicated for mercury are real; they probably reflect sampling and analysis difficulties. For the scrubber/absorber, negative values are a possibility as the flue gas might pick up trace quantities of an element in the absorber towers. Also, since the scrubber/absorber is downstream of the ESP, it is treating a very clean flue gas as regards most elements. Hence, the normal scatter of data associated with sampling and analysis is likely to produce some negative values.

For ESP #1 (Table 6-69), removal efficiencies for 13 of the 21 elements were greater than 99 percent, and removal efficiencies for 16 of the 21 elements were greater than 98

percent. Only mercury gave a low removal efficiency, consistent with its presence primarily in the vapor phase (see Section 7.1). The removal efficiencies for cadmium and selenium were only in the 87 percent range.

When considering the entire ESP (Table 6-70), similar results were obtained. Removal efficiencies for 10 of the 21 elements were greater than 99 percent, and removal efficiencies for 16 of the 21 elements were greater than 98 percent. Only mercury gave a low removal efficiency. Note that the average efficiency for Hg is dominated by one large negative value; positive but low efficiencies were found for the first two test days. The removal efficiencies for cadmium and selenium were only in the 80 percent range.

The scrubber unit (Table 6-71) and the absorber (Table 6-72) gave relatively low removal efficiencies. The scrubber removed 25 to 80 percent of elements in the flue gas stream for 15 of the elements. The scrubber was essentially ineffective for removing barium, manganese, mercury, nickel, titanium, and vanadium from the flue gas.

Absorber results are similar to those for the scrubber but show higher removal efficiencies, reflecting the fact that all of the gas in the absorber is treated. For some elements, removal efficiencies of over 100 percent were obtained for the absorber; this is physically impossible. It reflects the fact that these values were calculated from scrubber and bypass flow data.

For the combination of the ESP and partial scrubbing (Table 6-73), removal efficiencies for 17 of the 21 elements were greater than 99 percent, and removal efficiencies for 18 of the 21 elements were greater than 98 percent. Only mercury gave a low removal efficiency (less than 1 percent). The removal efficiencies for cadmium and selenium were about 87 percent.

For the combination of the ESP and the full scrubbing (Table 6-74), removal efficiencies for 18 of the 21 elements were greater than 99 percent, and removal efficiencies for 19 of the 21 elements were greater than 98 percent. Results for mercury are extremely variable. The removal efficiency for cadmium was only about 90 percent.

Removal efficiency results for the ESPs and the ESP and partial scrubbing are expected to be reliable. Removal efficiency results for the scrubber and for the absorber are less reliable as they involve differences between very low emission values and analytical accuracy can significantly affect results. The reduced reliability of these results is reflected in the higher standard deviations obtained for these data.

TABLE 6-1. SAMPLE MASS BALANCE CALCULATION: ALUMINUM

Metals Calculations: Aluminum

Test Date		M-1 6/22/93	M-2 6/24/93	M-3 6/27/93	Average	Comments
Flue gas loadings						
Boiler Outlet (Location 4a)						
1. Gas flow rate, dry, 3% O ₂	Ncm/min	17132.766	17058.98	16557.11		From Table 3-11
2. Metal loading	ug/Ncm	267665.69	214261.4	134861.6		From Table 5-2
3a. Metal emissions	g/hr	213472.51	219243.4	133915.5		#1*#2*60/1000000
3b. Metal emissions	lb/hr	470.61846	483.3409	295.2282	416.3958	#3a/453.6
Boiler Outlet (Location 4b)						
4. Gas flow rate, dry, 3% O ₂	Ncm/min	17197.263	16926.84	15774.97		From Table 3-11
5. Metal loading	ug/Ncm	117352.29	160248.1	95231.57		#2*(partic. 4b)/(partic. 4a)
6a. Metal emissions	g/hr	121687.87	162691.9	90136.48		#4*#5*60/1000000
6b. Metal emissions	lb/hr	266.94857	358.6682	198.7136	274.7768	#6a/453.6
Boiler Outlet (Location 4a and 4b)						
7. Gas flow rate, dry, 3% O ₂	Ncm/min	34329.969	33979.82	32332.68		#1*#4
8a. Metal emissions	g/hr	334566.38	381935.3	224652.6	313515.9	#3a*#6a
8b. Metal emissions	lb/hr	737.56697	842.6691	493.9418	691.1726	#3b*#6b
ESP Outlet (Location 5a)						
9. Gas flow rate, dry, 3% O ₂	Ncm/min	15445.617	15525.85	16848.46		From Table 3-11
10. Metal loading	ug/Ncm	1219.1747	837.3519	653.6963		From Table 5-4
11a. Metal emissions	g/hr	1129.8164	786.6359	666.8266		#9*#10*60/1000000
11b. Metal emissions	lb/hr	2.4987637	1.719656	1.456836	1.889885	#11a/453.6
ESP Outlet (Location 5b)						
12. Gas flow rate, dry, 3% O ₂	Ncm/min	14672.837	14843.14	13166.16		From Table 3-11
13. Metal loading	ug/Ncm	1299.2215	1617.486	2646.865		#10*(partic. 5b)/(partic. 5a)
14a. Metal emissions	g/hr	1697.6246	986.1566	2686.465		#12*#13*60/1000000
14b. Metal emissions	lb/hr	2.4184832	1.997698	4.586431	3.666871	#14a/453.6
ESP Outlet (Location 5a and 5b)						
15. Gas flow rate, dry, 3% O ₂	Ncm/min	29517.854	30368.99	29948.57		#9*#12
16a. Metal emissions	g/hr	2226.8344	1686.192	2741.226	2218.684	#11a*#14a
16b. Metal emissions	lb/hr	4.9692476	3.717354	6.043267	4.869956	#11b*#14b
Stack (Location 6a)						
17. Gas flow rate, dry, 3% O ₂	dNcm/min	30688	30677	30166		From Table 3-11
18. Metal loading	ug/dNcm	859.3261	787.8397	677.6315		From Table 5-8
19a. Metal emissions	g/hr	1582.2686	1456.114	1226.486	1419.626	#17*#18*60/1000000
19b. Metal emissions	lb/hr	3.4882274	3.196899	2.763893	3.129673	#19a/453.6

TABLE 6-1. (Continued)

Scrubber Gas Flows						
20. Bypass flow rate, dry	dNcm/min	****	****	****		
21. Flow rate into scrubber	dNcm/min	****	****	****		
22. Bypass flow rate, dry	percent	84.4	58.1	54.4		From temperature balance
23. Flow rate into absorber	percent	35.6	41.9	45.6		100-#22

Metal mass balances						
Pulverizer						
24. Coal feed	lb/hr	896800	910820	881360		From Table 3-13
25. Metal in raw coal	ug/g	6220	4420	5880		From Table 5-17
26. Metal to pulverizer	lb/hr	5578.096	4025.824	5182.397	4928.772	#24+#25/1000000
27. Pyrite rejects	lb/hr	1342.1203	1363.129	1323.443		From Table 3-13
28. Metal in pyrite rejects	ug/g	9400	13000	5700		From Table 5-16
29. Metal in pyrite rejects	lb/hr	12.615930	17.72008	7.543026	12.62674	#27+#28/1000000
30. Pulv. coal fired	lb/hr	669718.01	680201.4	660398.1		From Table 3-13
31. Metal in pulverized coal	ug/g	7850	8870	7030		From Table 5-12
32. Metal in pulverized coal	lb/hr	5257.2864	6033.386	4642.599	5311.090	#30+#31/1000000
33. Total metal out	lb/hr	5269.9023	6051.107	4650.142		#29+#32
34. Metal in - Metal out	lb/hr	308.19371	-2026.28	532.2545	-394.945	#26-#33
35. Metal out/metal in		.94474930	1.503073	.8972957	1.115039	#33/#26
Boiler Furnace						
36. Pulverized fuel fired	lb/hr	669718.01	680201.4	660398.1		From Table 3-13
37. Metal in pulverized coal	ug/g	7850	8870	7030		From Table 5-12
38. Metal in pulverized coal	lb/hr	5257.2864	6033.386	4642.599		#36+#37/1000000
39. Furnace metal emissions	lb/hr	737.56697	842.0091	493.9418		#8b
40. Bottom ash	lb/hr	35825.101	36110.10	29737.60		From Table 3-13
41. Metal in bottom ash	ug/g	71100	72900	70000		From Table 5-13
42. Metal in bottom ash	lb/hr	2547.1647	2632.864	2081.632	2420.553	#40+#41/1000000
43. Economizer hopper ash	lb/hr	11909.432	12021.84	9898.648		From Table 3-13
44. Metal in hopper ash	ug/g	73000	76000	75000		From Table 5-14
45. Metal in hopper ash	lb/hr	869.38853	913.6598	748.3378	843.7954	#43+#44/1000000
46. Total metal out	lb/hr	4154.1202	4388.533	3323.912		#39+#42+#45
47. Metal in - Metal out	lb/hr	1103.1682	1644.853	1318.687	1355.589	#38-#46
48. Metal out/metal in		.79016434	.7273748	.7159593	.7444995	#46/#38
ESP						
49. ESP inlet metal emissions	lb/hr	737.56697	842.0091	493.9418	691.1726	#8b
50. ESP outlet metal emissions	lb/hr	4.9092470	3.717354	6.043267	4.889956	#18b
51. ESP hopper particulate	lb/hr	47615.999	49770.02	41143.90		From Table 3-13
52. Metal in ESP particulate catch	ug/g	78900	76950	79200		Calculated from data in Table 5-18
53. Metal in ESP particulate catch	lb/hr	3750.9023	3829.803	3258.597	3616.101	#51+#52/1000000
54. Total metal out	lb/hr	3761.8116	3833.521	3264.640		#50+#53
55. Metal in - Metal out	lb/hr	-3024.245	-2991.51	-2770.70	-2928.82	#49-#54
56. Metal out/metal in		5.1002984	4.552026	6.009363	5.420829	#54/#49
Boiler and ESP						
57. Metal in pulverized coal	lb/hr	5257.2864	6033.386	4642.599		#38
58. Metal out, boiler process streams	lb/hr	3416.5532	3548.524	2829.970		#42+#45
59. Total metal out, ESP	lb/hr	3761.8116	3833.521	3264.640		#54
60. Total metal out	lb/hr	7178.3648	7380.044	6094.610		#50+#59
61. Metal in - Metal out	lb/hr	-1921.078	-1346.66	-1452.01	-1573.25	#57-#60
62. Metal out/metal in		1.3654126	1.223201	1.312758	1.300457	#60/#57

TABLE 6-1. (Continued)

Scrubber (entire scrubber system)					
63. Metal in scrubber inlet stream	lb/hr	4.9092478	3.717354	6.643287	#16b
64. Lime slurry feed rate	lb/hr	43958.635	58445.08	53949.23	From Table 3-12
65. Metal in lime feed slurry	ug/g	77.7	86	72	From Table 5-18
66. Metal in lime feed slurry	lb/hr	3.4155859	3.857378	3.884345	#64+65/1000000
67. Scrubber makeup water	lb/hr	292780	292780	292780	From Table 3-12
68. Metal in scrubber makeup water	ug/g	.19	.29	.25	From Table 5-23
69. Metal in scrubber makeup water	lb/hr	.055613	.084883	.073175	#67+68/1000000
70. Scrubber blowdown flow	lb/hr	95085.983	122288.6	181812.7	From Table 3-12
71. Metal in scrubber blowdown	ug/g	14.7	44.5	28.9	From Table 5-27
72. Metal in scrubber blowdown	lb/hr	1.3965888	5.437925	4.347382	#70+71/1000000
73. Metal in scrubber outlet emissions	lb/hr	3.4882274	3.198899	2.783893	#19b
74. Total metal in	lb/hr	6.3884459	7.659888	18.08679	#63+68+69
75. Total metal out	lb/hr	4.8848154	8.834824	7.051275	#72+73
76. Metal in - Metal out	lb/hr	8.4956385	-.975217	2.949512	#74+75
77. Metal out/metal in		.58288252	1.127319	.7658728	#75/74
Boiler, ESP, and Scrubber					
78. Metal in pulverized coal	lb/hr	5257.2864	8833.388	4642.599	#38
79. Metal added with lime	lb/hr	3.4155859	3.857378	3.884345	#68
80. Metal out, boiler process streams	lb/hr	3418.5532	3548.524	2829.978	#42+45
81. Metal in ESP particulate catch	lb/hr	3758.9823	3829.883	3258.597	#53
82. Metal out, scrubber blowdown	lb/hr	1.3965888	5.437925	4.347382	#72
83. Metal in scrubber emissions	lb/hr	3.4882274	3.198899	2.783893	#19b
84. Total metal in	lb/hr	5268.7819	8837.243	4646.483	#78+79
85. Total metal out	lb/hr	7178.3484	7384.982	6895.618	#80+81+82+83
86. Metal in - Metal out	lb/hr	-1917.638	-1347.72	-1449.14	#84+85
87. Metal out/metal in		1.3645214	1.223234	1.311878	#85/84
Scrubber (absorber only)					
88. Metal in absorber inlet stream	lb/hr	1.7478919	1.557571	2.755738	#16b+23/100
89. Metal in bypass flow	lb/hr	3.1815558	2.159783	3.287537	#16b+22/100
90. Metal in lime feed slurry	lb/hr	3.4155859	3.857378	3.884345	#68
91. Metal in scrubber makeup water	lb/hr	.055613	.084883	.073175	#69
92. Metal in scrubber blowdown	lb/hr	1.3965888	5.437925	4.347382	#72
93. Metal in scrubber emissions	lb/hr	.32667238	1.837118	-.583844	#73+89
94. Total metal in	lb/hr	6.2188888	5.499825	6.713249	#88+90+91
95. Total metal out	lb/hr	1.7232683	6.475841	3.763738	#92+93
96. Metal in - Metal out	lb/hr	3.4956385	-.975217	2.949512	#94+95
97. Metal out/metal in		.33819888	1.177318	.5888432	#95/94
Metal Emission Factors					
Firing Rate					
98. Coal feed rate	lb/hr	898888	918828	881388	From Table 3-13
99. Coal heating value	Btu/lb	8132	5918	8882	From Table 5-185
100a. Firing rate	1000 Btu/hr	5499.1778	5388.411	5342.884	#98+99/1000000
100b. Firing rate	MJ/hr	5881832.4	5884774.	5638659.	#100a+1055

TABLE 6-1. (Continued)

Boiler emissions		g/hr		#8a	
101a. Metal emissions	334560.38	381935.3	224852.0	#8a	
101b. Metal emissions	737.56697	842.0091	493.9418	#8b	
102a. Metal emission factor	57686.594	67185.67	39749.08	#101a*1000000/#100b	
102b. Metal emission factor	134123.14	156263.0	92449.91	#101b*1000000/#100a	
ESP emissions					
103a. Metal emissions	2226.8344	1686.192	2741.226	#10a	
103b. Metal emissions	4.9892470	3.717354	6.043267	#10b	
104a. Metal emission factor	383.82894	296.6155	486.3211	#103a*1000000/#100b	
104b. Metal emission factor	892.72384	689.8795	1131.104	#103b*1000000/#100a	
Scrubber emissions (entire scrubber system)					
105a. Metal emissions	1582.2655	1456.114	1226.486	#19a	
105b. Metal emissions	3.4882274	3.196899	2.703893	#19b	
106a. Metal emission factor	272.72668	255.0873	217.5910	#105a*1000000/#100b	
106b. Metal emission factor	634.31862	593.2916	506.0813	#105b*1000000/#100a	
Scrubber emissions (absorber flow only)					
107a. Metal emissions	148.17859	470.4368	-264.741	#107b*453.0	
107b. Metal emissions	.32667238	1.037110	-.583644	#93	
108a. Metal emission factor	71.743946	197.5028	-102.999	#107a*1000000/(#100b*#23/100)	
108b. Metal emission factor	106.86478	459.3596	-239.560	#107b*1000000/(#100a*#23/100)	
Removal Efficiencies					
109. ESP	99.334400	99.55851	98.77652	99.22315	(#102b-#104b)*100/#102b
110. Scrubber system	28.945774	14.00089	55.25776	32.73474	(#104b-#106b)*100/#104b
111. Absorber	81.308354	33.41452	121.1793	78.63406	(#104b-#108b)*100/#104b
112. ESP and partial scrubber	99.527063	99.62632	99.45259	99.53333	(#102b-#106b)*100/#102b
113. ESP and full scrubber	99.875588	99.70083	100.2591	99.94692	1-(1-(#111/100))*(1-(#109/100)))+100
114. ESP #11	99.470747	99.84421	99.58854	99.54050	((#3b-#11b)/#3b)*100
Standard deviation					
115. ESP					4026919
116. Scrubber system					20.88788
117. Absorber					43.94346
118. ESP and partial scrubber					.0840433
119. ESP and full scrubber					.2833598
120. ESP #11					.0916850

TABLE 6-2. MATERIAL BALANCE CLOSURES FOR ALUMINUM (Percent)

System	M-1 6/22/93	M-2 6/24/93	M-3 6/27/93	Average	Standard Deviation
Pulverizer	94.47	150.31	89.73	111.50	33.69
Boiler	79.02	72.74	71.59	74.45	4.00
ESP	510.03	455.28	660.94	542.08	106.51
Boiler & ESP	136.54	122.32	131.28	130.05	7.19
Scrubber	58.29	112.73	70.51	80.51	28.57
Boiler, ESP, & Scrubber	136.45	122.32	131.19	129.99	7.14
Absorber (only)	33.02	117.73	56.06	68.94	43.80

TABLE 6-3. MATERIAL BALANCE CLOSURES FOR ANTIMONY (Percent)

System	M-1 6/22/93	M-2 6/24/93	M-3 6/27/93	Average	Standard Deviation
Pulverizer	2.58	3.10	2.78	2.82	0.26
Boiler	66.73	112.28	113.67	97.56	26.71
ESP	61.66	37.88	23.53	41.02	19.26
Boiler & ESP	49.93	56.79	41.73	49.48	7.54
Scrubber	14.21	34.59	40.28	29.70	13.71
Boiler, ESP, & Scrubber	47.38	56.61	41.55	48.51	7.59
Absorber (only)	(74.67)	13.62	19.29	(13.92)	52.69

TABLE 6-4. MATERIAL BALANCE CLOSURES FOR ARSENIC (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	66.78	48.94	38.40	51.37	14.34
Boiler	128.05	137.79	155.74	140.53	14.05
ESP	69.17	75.05	70.15	71.46	3.15
Boiler & ESP	96.97	110.23	119.08	108.76	11.13
Scrubber	126.24	195.88	70.85	130.99	62.65
Boiler, ESP, & Scrubber	97.13	110.56	119.02	108.90	11.04
Scrubber	144.75	261.38	51.16	152.43	105.32
Absorber (only)					

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-5. MATERIAL BALANCE CLOSURES FOR BARIUM (Percent)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	142.10	100.62	89.48	110.73	27.73
Boiler	89.17	102.99	85.09	92.42	9.38
ESP	237.79	175.73	278.90	230.81	51.94
Boiler & ESP	129.54	128.04	129.38	128.99	0.82
Scrubber	111.34	213.28	60.55	128.39	77.78
Boiler, ESP, & Scrubber	129.58	128.24	129.15	128.99	0.68
Scrubber					
Absorber (only)	126.89	309.06	19.92	151.96	146.19

TABLE 6-6. MATERIAL BALANCE CLOSURES FOR BERYLLIUM (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	124.83	113.97	132.67	123.82	9.39
Boiler	76.94	88.60	84.25	83.26	5.89
ESP	111.33	95.14	89.96	98.81	11.15
Boiler & ESP	80.76	86.63	80.05	82.48	3.61
Scrubber	54.89	47.56	28.38	43.61	13.69
Boiler, ESP, & Scrubber	80.41	86.16	78.46	81.68	4.00
Absorber (only)	5.34	0.79	(39.38)	(11.08)	24.61

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-7. MATERIAL BALANCE CLOSURES FOR BORON (Percent)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	82.30	88.04	97.69	89.34	7.77
Boiler	132.06	128.58	163.75	141.47	19.38
ESP	101.52	103.53	72.64	92.57	17.28
Boiler & ESP	133.17	131.25	136.02	133.48	2.40
Scrubber	11.68	38.95	76.05	42.23	32.31
Boiler, ESP, & Scrubber	131.32	132.90	139.29	134.50	4.22
Absorber (only)	(15.20)	36.11	73.48	31.46	44.52

TABLE 6-8. MATERIAL BALANCE CLOSURES FOR CADMIUM (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	13.64	11.90	5.54	10.36	4.26
Boiler	226.90	309.97	319.13	285.33	50.81
ESP	105.77	81.86	58.52	82.05	23.63
Boiler & ESP	233.72	273.52	225.31	244.19	25.75
Scrubber	125.00	46.31	59.98	76.77	42.25
Boiler, ESP, & Scrubber	242.57	245.78	212.17	233.51	18.55
Absorber (only)	151.31	(21.89)	19.19	49.53	90.50

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-9. MATERIAL BALANCE CLOSURES FOR CHROMIUM (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	124.49	117.34	90.60	110.81	17.86
Boiler	95.73	114.95	160.93	123.87	33.51
ESP	111.07	70.89	67.20	83.05	24.34
Boiler & ESP	101.75	93.75	132.23	109.24	20.31
Scrubber	19.45	74.53	63.94	52.64	29.23
Boiler, ESP, & Scrubber	99.99	93.66	131.93	108.53	20.52
Absorber (only)	(82.55)	64.82	55.26	12.51	82.46

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-10. MATERIAL BALANCE CLOSURES FOR COBALT (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	35.72	31.69	12.31	26.57	12.51
Boiler	112.00	101.76	113.05	108.94	6.24
ESP	126.74	45.23	70.51	80.83	41.72
Boiler & ESP	127.06	68.39	88.19	94.55	29.85
Scrubber	290.28	58.99	38.42	129.23	139.85
Boiler, ESP, & Scrubber	127.85	68.32	87.71	94.63	30.36
Absorber (only)	460.47	37.02	(6.68)	163.61	258.02

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-11. MATERIAL BALANCE CLOSURES FOR COPPER (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	90.62	114.19	100.27	101.69	11.85
Boiler	83.44	88.93	100.71	91.03	8.82
ESP	147.78	117.14	115.07	126.66	18.31
Boiler & ESP	106.07	97.99	110.14	104.73	6.19
Scrubber	34.72	61.67	25.15	40.52	18.94
Boiler, ESP, & Scrubber	105.66	97.73	109.24	104.21	5.89
Absorber (only)	(29.69)	30.20	(36.43)	(11.98)	36.68

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-12. MATERIAL BALANCE CLOSURES FOR LEAD (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	48.69	24.31	53.26	42.09	15.56
Boiler	107.73	129.59	106.46	114.59	13.00
ESP	103.50	96.44	93.98	97.98	4.94
Boiler & ESP	110.37	126.12	101.73	112.74	12.37
Scrubber	65.92	89.92	58.21	71.35	16.54
Boiler, ESP, & Scrubber	110.34	126.22	101.68	112.75	12.44
Absorber (only)	45.57	87.09	40.54	57.73	25.55

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-13. MATERIAL BALANCE CLOSURES FOR MANGANESE (Percent)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	70.22	93.13	80.52	81.29	11.47
Boiler	122.19	127.38	122.38	123.99	2.94
ESP	109.08	102.88	86.93	99.63	11.42
Boiler & ESP	127.53	129.18	113.57	123.43	8.57
Scrubber	56.87	92.54	95.89	81.77	21.62
Boiler, ESP, & Scrubber	126.74	128.83	113.45	123.01	8.34
Absorber (only)	47.30	91.92	95.38	78.20	26.21

TABLE 6-14. MATERIAL BALANCE CLOSURES FOR MERCURY (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	176.03	70.83	250.16	165.67	90.11
Boiler	56.47	76.72	59.85	64.35	10.85
ESP	87.83	63.12	350.64	167.20	159.35
Boiler & ESP	49.68	48.65	208.59	102.30	92.05
Scrubber	123.28	202.66	30.87	118.94	85.98
Boiler, ESP, & Scrubber	60.90	96.24	65.82	74.32	19.14
Absorber (only)	165.16	344.23	(51.51)	152.63	198.16

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-15. MATERIAL BALANCE CLOSURES FOR MOLYBDENUM (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	594.49	595.97	136.27	442.24	264.98
Boiler	68.55	96.98	85.71	83.75	14.31
ESP	128.93	82.88	59.37	90.40	35.39
Boiler & ESP	75.90	90.00	65.89	77.26	12.12
Scrubber	20.15	41.47	97.30	52.97	39.84
Boiler, ESP, & Scrubber	77.04	93.27	73.21	81.17	10.65
Absorber (only)	17.26	40.56	97.26	51.69	41.15

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-16. MATERIAL BALANCE CLOSURES FOR NICKEL (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	101.50	88.06	106.28	98.61	9.45
Boiler	95.58	112.65	89.89	99.37	11.84
ESP	71.95	52.23	47.11	57.10	13.12
Boiler & ESP	81.63	76.62	56.66	71.64	13.21
Scrubber	14.97	105.80	41.88	54.22	46.66
Boiler, ESP, & Scrubber	79.42	76.83	56.41	70.88	12.60
Absorber (only)	(29.10)	106.65	37.25	38.27	67.88

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-17. MATERIAL BALANCE CLOSURES FOR POTASSIUM (Percent)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	99.44	188.35	91.91	126.57	53.64
Boiler	93.03	88.08	83.69	88.27	4.67
ESP	130.01	148.15	149.44	142.54	10.86
Boiler & ESP	106.94	109.72	104.18	106.95	2.77
Scrubber	11.81	41.07	98.33	50.40	44.01
Boiler, ESP, & Scrubber	106.94	110.67	107.57	108.39	2.00
Absorber (only)	6.07	40.26	98.30	48.21	46.63

TABLE 6-18. MATERIAL BALANCE CLOSURES FOR SELENIUM (Percent)^(a)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	89.08	86.68	80.78	85.51	4.27
Boiler	100.47	129.78	114.35	114.87	14.66
ESP	98.49	69.50	79.35	82.45	14.74
Boiler & ESP	99.28	96.77	94.53	96.86	2.37
Scrubber	88.66	60.38	24.68	57.91	32.06
Boiler, ESP, & Scrubber	98.78	90.68	73.89	87.78	12.70
Absorber (only)	72.53	11.12	(59.78)	7.96	66.21

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-19. MATERIAL BALANCE CLOSURES FOR SILICON (Percent)^(a)

System	6/22/92	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	99.77	174.77	93.66	122.73	45.17
Boiler	149.06	142.68	148.01	146.58	3.42
ESP	97.53	93.79	86.36	92.56	5.69
Boiler & ESP	147.24	138.13	136.59	140.55	5.75
Scrubber	11.59	30.00	19.19	20.26	9.25
Boiler, ESP, & Scrubber	146.96	138.08	136.37	140.47	5.68
Absorber (only)	(63.84)	11.44	(16.51)	(22.97)	38.05

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-20. MATERIAL BALANCE CLOSURES FOR SODIUM (Percent)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	95.08	90.70	96.68	94.15	3.10
Boiler	101.14	78.00	95.29	91.47	12.03
ESP	277.70	462.58	240.48	326.92	118.95
Boiler & ESP	155.25	162.45	142.83	153.51	9.92
Scrubber	9.34	39.85	86.65	45.28	38.94
Boiler, ESP, & Scrubber	161.48	184.07	216.36	187.31	27.58
Absorber (only)	619.11	2,935.29	6,208.22	3,254.21	2,808.17

TABLE 6-21. MATERIAL BALANCE CLOSURES FOR TITANIUM (Percent)^(a)

System	6/22/92	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	89.84	88.11	86.94	88.30	1.46
Boiler	116.77	106.11	115.85	112.91	5.91
ESP	124.90	109.41	101.53	111.95	11.89
Boiler & ESP	129.74	111.00	116.16	119.17	9.60
Scrubber	40.03	90.84	44.75	58.54	28.07
Boiler, ESP, & Scrubber	129.72	111.03	116.68	119.14	9.58
Absorber (only)	(11.13)	84.49	3.40	25.72	51.75

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-22. MATERIAL BALANCE CLOSURES FOR VANADIUM (Percent)

System	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Pulverizer	90.37	117.90	69.69	92.66	24.19
Boiler	84.77	87.54	95.04	89.12	5.31
ESP	166.02	129.00	119.12	138.05	24.73
Boiler & ESP	107.02	98.94	103.87	103.28	4.07
Scrubber	78.36	109.33	58.51	82.07	25.61
Boiler, ESP, & Scrubber	107.02	99.09	103.70	103.27	3.99
Absorber (only)	67.85	112.47	39.47	73.27	36.80

TABLE 6-23a. MATERIAL BALANCE RESULTS: PULVERIZER (Percent)^(a)

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	94.47	150.31	89.73	111.50	33.69
Antimony	2.58	3.10	2.78	2.82	0.26
Arsenic	66.78	48.94	38.40	51.37	14.34
Barium	142.10	100.62	89.48	110.73	27.73
Beryllium	124.82	113.97	132.67	123.82	9.39
Boron	82.30	88.04	97.69	89.34	7.77
Cadmium	13.64	11.90	5.54	10.36	4.26
Chromium	124.49	117.34	90.60	110.81	17.86
Cobalt	35.72	31.69	12.31	26.57	12.51
Copper	90.62	114.19	100.27	101.69	11.85
Lead	48.69	24.31	53.26	42.09	15.56
Manganese	70.22	93.13	80.52	81.29	11.47
Mercury	176.03	70.83	250.16	165.67	90.11
Molybdenum	594.49	595.97	136.27	442.24	264.98
Nickel	101.50	88.06	106.28	98.61	9.45
Potassium	99.44	188.35	91.91	126.57	53.64
Selenium	89.08	86.68	80.78	85.51	4.27
Silicon	99.77	174.77	93.66	122.73	45.17
Sodium	95.08	90.70	96.68	94.15	3.10
Titanium	89.84	88.11	86.94	88.30	1.46
Vanadium	90.37	117.90	69.69	92.66	24.19

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-23b. MATERIAL BALANCE RESULTS: PULVERIZER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Antimony	2.58	3.10	2.78	2.82	0.26
Cadmium	13.64	11.90	5.54	10.36	4.26
Cobalt	35.72	31.69	12.31	26.57	12.51
Lead	48.69	24.31	53.26	42.09	15.56
Arsenic	66.78	48.94	38.40	51.37	14.34
Manganese	70.22	93.13	80.52	81.29	11.47
Selenium	89.08	86.68	80.78	85.51	4.27
Titanium	89.84	88.11	86.94	88.30	1.46
Boron	82.30	88.04	97.69	89.34	7.77
Vanadium	90.37	117.90	69.69	92.66	24.19
Sodium	95.08	90.70	96.68	94.15	3.10
Nickel	101.50	88.06	106.28	98.61	9.45
Copper	90.62	114.19	100.27	101.69	11.85
Barium	142.10	100.62	89.48	110.73	27.73
Chromium	124.49	117.34	90.60	110.81	17.86
Aluminum	94.47	150.31	89.73	111.50	33.69
Silicon	99.77	174.77	93.66	122.73	45.17
Beryllium	124.82	113.97	132.67	123.82	9.39
Potassium	99.44	188.35	91.91	126.57	53.64
Mercury	176.03	70.83	250.16	165.67	90.11
Molybdenum	594.49	595.97	136.27	442.24	264.98

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-24a. MATERIAL BALANCE RESULTS: BOILER (Percent)^(a)

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	79.02	72.74	71.59	74.45	4.00
Antimony	66.73	112.28	113.67	97.56	26.71
Arsenic	128.05	137.79	155.74	140.53	14.05
Barium	89.17	102.99	85.09	92.42	9.38
Beryllium	76.94	88.60	84.25	83.26	5.89
Boron	132.06	128.58	163.75	141.47	19.38
Cadmium	226.90	309.97	319.13	285.33	50.81
Chromium	95.73	114.95	160.93	123.87	33.51
Cobalt	112.00	101.76	113.05	108.94	6.24
Copper	83.44	88.93	100.71	91.03	8.82
Lead	107.73	129.59	106.46	114.59	13.00
Manganese	122.19	127.38	122.38	123.99	2.94
Mercury	56.47	76.72	59.85	64.35	10.85
Molybdenum	68.55	96.98	85.71	83.75	14.31
Nickel	95.58	112.65	89.89	99.37	11.84
Potassium	93.03	88.08	83.69	88.27	4.67
Selenium	100.47	129.78	114.35	114.87	14.66
Silicon	149.06	142.68	148.01	146.58	3.42
Sodium	101.14	78.00	95.29	91.47	12.03
Titanium	116.77	106.11	115.85	112.91	5.91
Vanadium	84.77	87.54	95.04	89.12	5.31

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-24b. MATERIAL BALANCE RESULTS: BOILER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Mercury	56.47	76.72	59.85	64.35	10.85
Aluminum	79.02	72.74	71.59	74.45	4.00
Beryllium	76.94	88.60	84.25	83.26	5.89
Molybdenum	68.55	96.98	85.71	83.75	14.31
Potassium	93.03	88.08	83.69	88.27	4.67
Vanadium	84.77	87.54	95.04	89.12	5.31
Copper	83.44	88.93	100.71	91.03	8.82
Sodium	101.14	78.00	95.29	91.47	12.03
Barium	89.17	102.99	85.09	92.42	9.38
Antimony	66.73	112.28	113.67	97.56	26.71
Nickel	95.58	112.65	89.89	99.37	11.84
Cobalt	112.00	101.76	113.05	108.94	6.24
Titanium	116.77	106.11	115.85	112.91	5.91
Lead	107.73	129.59	106.46	114.59	13.00
Selenium	100.47	129.78	114.35	114.87	14.66
Chromium	95.73	114.95	160.93	123.87	33.51
Manganese	122.19	127.38	122.38	123.99	2.94
Arsenic	128.05	137.79	155.74	140.53	14.05
Boron	132.06	128.58	163.75	141.47	19.38
Silicon	149.06	142.68	148.01	146.58	3.42
Cadmium	226.90	309.97	319.13	285.33	50.81

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-25a. MATERIAL BALANCE RESULTS: ELECTROSTATIC PRECIPITATOR
(Percent)^(a)

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	510.03	455.28	660.94	542.08	106.51
Antimony	61.66	37.88	23.53	41.02	19.26
Arsenic	69.17	75.05	70.15	71.46	3.15
Barium	237.79	175.73	278.80	230.81	51.94
Beryllium	111.33	95.14	89.96	98.81	11.15
Boron	101.52	103.53	72.64	92.57	17.28
Cadmium	105.77	81.86	58.52	82.05	23.63
Chromium	111.07	70.89	67.20	83.05	24.34
Cobalt	126.74	45.23	70.51	80.83	41.72
Copper	147.78	117.14	115.07	126.66	18.31
Lead	103.50	96.44	93.98	97.98	4.94
Manganese	109.08	102.88	86.93	99.63	11.42
Mercury	87.83	63.12	350.64	167.20	159.35
Molybdenum	128.93	82.88	59.37	90.40	35.39
Nickel	71.95	52.23	47.11	57.10	13.12
Potassium	130.01	148.15	149.44	142.54	10.86
Selenium	98.49	69.50	79.35	82.45	14.74
Silicon	97.53	93.79	86.36	92.56	5.69
Sodium	277.70	462.58	240.48	326.92	118.95
Titanium	124.90	109.41	101.53	111.95	11.89
Vanadium	166.02	129.00	119.12	138.05	24.73

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-25b. MATERIAL BALANCE RESULTS: ELECTROSTATIC PRECIPITATOR
(Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Antimony	61.66	37.88	23.53	41.02	19.26
Nickel	71.95	52.23	47.11	57.10	13.12
Arsenic	69.17	75.05	70.15	71.46	3.15
Cobalt	126.74	45.23	70.51	80.83	41.72
Cadmium	105.77	81.86	58.52	82.05	23.63
Selenium	98.49	69.50	79.35	82.45	14.74
Chromium	111.07	70.89	67.20	83.05	24.34
Molybdenum	128.93	82.88	59.37	90.40	35.39
Silicon	97.53	93.79	86.36	92.56	5.69
Boron	101.52	103.53	72.64	92.57	17.28
Lead	103.50	96.44	93.98	97.98	4.94
Beryllium	111.33	95.14	89.96	98.81	11.15
Manganese	109.08	102.88	86.93	99.63	11.42
Titanium	124.90	109.41	101.53	111.95	11.89
Copper	147.78	117.14	115.07	126.66	18.31
Vanadium	166.02	129.00	119.12	138.05	24.73
Potassium	130.01	148.15	149.44	142.54	10.86
Mercury	87.83	63.12	350.64	167.20	159.35
Barium	237.79	175.73	278.80	230.81	51.94
Sodium	277.70	462.58	240.48	326.92	118.95
Aluminum	510.03	455.28	660.94	542.08	106.51

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-26a. MATERIAL BALANCE RESULTS: BOILER AND ESP (Percent)^(a)

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	136.54	122.32	131.28	130.05	7.19
Antimony	49.93	56.79	41.73	49.48	7.54
Arsenic	96.97	110.23	119.08	108.76	11.13
Barium	129.54	128.04	129.38	128.99	0.82
Beryllium	80.76	86.63	80.05	82.48	3.61
Boron	133.17	131.25	136.02	133.48	2.40
Cadmium	233.72	273.52	225.31	244.19	25.75
Chromium	101.75	93.75	132.23	109.24	20.31
Cobalt	127.06	68.39	88.19	94.55	29.85
Copper	106.07	97.99	110.14	104.73	6.19
Lead	110.37	126.12	101.73	112.74	12.37
Manganese	127.53	129.18	113.57	123.43	8.57
Mercury	49.68	48.65	208.59	102.30	92.05
Molybdenum	75.90	90.00	65.89	77.26	12.12
Nickel	81.63	76.62	56.66	71.64	13.21
Potassium	106.94	109.72	108.18	106.95	2.77
Selenium	99.28	96.77	94.53	96.86	2.37
Silicon	147.24	138.13	136.59	140.65	5.75
Sodium	155.25	162.45	142.83	153.51	9.92
Titanium	129.74	111.00	116.76	119.17	9.60
Vanadium	107.02	98.94	103.87	103.28	4.07

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-26b. MATERIAL BALANCE RESULTS: BOILER & ESP (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Antimony	49.93	56.79	41.73	49.48	7.54
Nickel	81.63	76.62	56.66	71.64	13.21
Molybdenum	75.90	90.00	65.89	77.26	12.12
Beryllium	80.76	86.63	80.05	82.48	3.61
Cobalt	127.06	68.39	88.19	94.55	29.85
Selenium	99.28	96.77	94.53	96.86	2.37
Mercury	49.68	48.65	208.59	102.30	92.05
Vanadium	107.02	98.94	103.87	103.28	4.07
Copper	106.07	97.99	110.14	104.73	6.19
Potassium	106.94	109.72	108.18	106.95	2.77
Arsenic	96.97	110.23	119.08	108.76	11.13
Chromium	101.75	93.75	132.23	109.24	20.31
Lead	110.37	126.12	101.73	112.74	12.37
Titanium	129.74	111.00	116.76	119.17	9.60
Manganese	127.53	129.18	113.57	123.43	8.57
Barium	129.54	128.04	129.38	128.99	0.82
Aluminum	136.54	122.32	131.28	130.05	7.19
Boron	133.17	131.25	136.02	133.48	2.40
Silicon	147.24	138.13	136.59	140.65	5.75
Sodium	155.25	162.45	142.83	153.51	9.92
Cadmium	233.72	273.52	225.31	244.19	25.75

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-27a. MATERIAL BALANCE RESULTS: SCRUBBER (Percent)^(a)

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	58.29	112.73	70.51	80.51	28.57
Antimony	14.21	34.59	40.28	29.70	13.71
Arsenic	126.24	195.88	70.85	130.99	62.65
Barium	111.34	213.28	60.55	128.39	77.78
Beryllium	54.89	47.56	28.38	43.61	13.69
Boron	11.68	38.95	76.05	42.23	32.31
Cadmium	125.00	46.31	58.98	76.77	42.25
Chromium	19.45	74.53	63.94	52.64	29.23
Cobalt	290.28	58.99	32.42	129.23	139.85
Copper	34.72	61.67	25.15	40.52	18.94
Lead	65.92	89.92	58.21	71.35	16.54
Manganese	56.87	92.54	95.89	81.77	21.62
Mercury	123.28	202.66	30.87	118.94	85.98
Molybdenum	20.15	41.47	97.30	52.97	39.84
Nickel	14.97	105.80	41.88	54.22	46.66
Potassium	11.81	41.07	98.33	50.40	44.01
Selenium	88.66	60.38	24.68	57.91	32.06
Silicon	11.59	30.00	19.19	20.26	9.25
Sodium	9.34	39.85	86.65	45.28	38.94
Titanium	40.03	90.84	44.75	58.54	28.07
Vanadium	78.36	109.33	58.51	82.07	25.61

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-27b. MATERIAL BALANCE RESULTS: SCRUBBER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Silicon	11.59	30.00	19.19	20.26	9.25
Antimony	14.21	34.59	40.28	29.70	13.71
Copper	34.72	61.67	25.15	40.52	18.94
Boron	11.68	38.95	76.05	42.23	32.31
Beryllium	54.89	47.56	28.38	43.61	13.69
Sodium	9.34	39.85	86.65	45.28	38.94
Potassium	11.81	41.07	98.33	50.40	44.01
Chromium	19.45	74.53	63.94	52.64	29.23
Molybdenum	20.15	41.47	97.30	52.97	39.84
Nickel	14.97	105.80	41.88	54.22	46.66
Selenium	88.66	60.38	24.68	57.91	32.06
Titanium	40.03	90.84	44.75	58.54	28.07
Lead	65.92	89.92	58.21	71.35	16.54
Cadmium	125.00	46.31	58.98	76.77	42.25
Aluminum	58.29	112.73	70.51	80.51	28.57
Manganese	56.87	92.54	95.89	81.77	21.62
Vanadium	78.36	109.33	58.51	82.07	25.61
Mercury	123.28	202.66	30.87	118.94	85.98
Barium	111.34	213.28	60.55	128.39	77.78
Cobalt	290.28	58.99	32.42	129.23	139.85
Arsenic	126.24	195.88	70.85	130.99	62.65

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-28a. MATERIAL BALANCE RESULTS: BOILER, ESP & SCRUBBER
(Percent)^(a)

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	136.45	122.32	131.19	129.99	7.14
Antimony	47.38	56.61	41.55	48.51	7.59
Arsenic	97.13	110.56	119.02	108.90	11.04
Barium	129.58	128.24	129.15	128.99	0.68
Beryllium	80.41	86.16	78.46	81.68	4.00
Boron	131.32	132.90	139.29	134.50	4.22
Cadmium	242.57	245.78	212.17	233.51	18.55
Chromium	99.99	93.66	131.93	108.53	20.52
Cobalt	127.85	68.32	87.71	94.63	30.36
Copper	105.66	97.73	109.24	104.21	5.89
Lead	110.34	126.22	101.68	112.75	12.44
Manganese	126.74	128.83	113.45	123.01	8.34
Mercury	60.90	96.24	65.82	74.32	19.14
Molybdenum	77.04	93.27	73.21	81.17	10.65
Nickel	79.42	76.83	56.41	70.88	12.60
Potassium	106.94	110.67	107.57	108.39	2.00
Selenium	98.78	90.68	73.89	87.78	12.70
Silicon	146.96	138.08	136.37	140.47	5.68
Sodium	161.48	184.07	216.36	187.31	27.58
Titanium	129.72	111.03	116.68	119.14	9.58
Vanadium	107.02	99.09	103.70	103.27	3.99

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-28b. MATERIAL BALANCE RESULTS: BOILER, ESP & SCRUBBER
(Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Antimony	47.38	56.61	41.55	48.51	7.59
Nickel	79.42	76.83	56.41	70.88	12.60
Mercury	60.90	96.24	65.82	74.32	19.14
Molybdenum	77.04	93.27	73.21	81.17	10.65
Beryllium	80.41	86.16	78.46	81.68	4.00
Selenium	98.78	90.68	73.89	87.78	12.70
Cobalt	127.85	68.32	87.71	94.63	30.36
Vanadium	107.02	99.09	103.70	103.27	3.99
Copper	105.66	97.73	109.24	104.21	5.89
Potassium	106.94	110.67	107.57	108.39	2.00
Chromium	99.99	93.66	131.93	108.53	20.52
Arsenic	97.13	110.56	119.02	108.90	11.04
Lead	110.34	126.22	101.68	112.75	12.44
Titanium	129.72	111.03	116.68	119.14	9.58
Manganese	126.74	128.83	113.45	123.01	8.34
Barium	129.58	128.24	129.15	128.99	0.68
Aluminum	136.45	122.32	131.19	129.99	7.14
Boron	131.32	132.90	139.29	134.50	4.22
Silicon	146.96	138.08	136.37	140.47	5.68
Sodium	161.48	184.07	216.36	187.31	27.58
Cadmium	242.57	245.78	212.17	233.51	18.55

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-29a. MATERIAL BALANCE RESULTS: ABSORBER (Percent)^(a)

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	33.02	117.73	56.06	68.94	43.80
Antimony	(74.67)	13.62	19.29	(13.92)	52.69
Arsenic	144.75	261.38	51.16	152.43	105.32
Barium	126.89	309.06	19.92	151.96	146.19
Beryllium	5.34	0.79	(39.38)	(11.08)	24.61
Boron	(15.20)	36.11	73.48	31.46	44.52
Cadmium	151.31	(21.89)	19.19	49.53	90.50
Chromium	(82.55)	64.82	55.26	12.51	82.46
Cobalt	460.47	37.02	(6.68)	163.61	258.02
Copper	(29.69)	30.20	(36.43)	(11.98)	36.68
Lead	45.57	87.09	40.54	57.73	25.55
Manganese	47.30	91.92	95.38	78.20	26.81
Mercury	165.16	344.23	(51.51)	152.63	198.16
Molybdenum	17.26	40.56	97.26	51.69	41.15
Nickel	(29.10)	106.65	37.25	38.27	67.88
Potassium	6.07	40.26	98.30	48.21	46.63
Selenium	72.53	11.12	(59.78)	7.96	66.21
Silicon	(63.84)	11.44	(16.51)	(22.97)	38.05
Sodium	619.11	2,935.29	6,208.22	3,254.21	2,808.17
Titanium	(11.13)	84.89	3.40	25.72	51.75
Vanadium	67.85	112.47	39.47	73.27	36.80

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-29b. MATERIAL BALANCE RESULTS: ABSORBER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Silicon	(63.84)	11.44	(16.51)	(22.97)	38.05
Antimony	(74.67)	13.62	19.29	(13.92)	52.69
Copper	(29.69)	30.20	(36.43)	(11.98)	36.68
Beryllium	5.34	0.79	(39.38)	(11.08)	24.61
Selenium	72.53	11.12	(59.78)	7.96	66.21
Chromium	(82.55)	64.82	55.26	12.51	82.46
Titanium	(11.13)	84.89	3.40	25.72	51.75
Boron	(15.20)	36.11	73.48	31.46	44.52
Nickel	(29.10)	106.65	37.25	38.27	67.88
Potassium	6.07	40.26	98.30	48.21	46.63
Cadmium	151.31	(21.89)	19.19	49.53	90.50
Molybdenum	17.26	40.56	97.26	51.69	41.15
Lead	45.57	87.09	40.54	57.73	25.55
Aluminum	33.02	117.73	56.06	68.94	43.80
Vanadium	67.85	112.47	39.47	73.27	36.80
Manganese	47.30	91.92	95.38	78.20	26.81
Barium	126.89	309.06	19.92	151.96	146.19
Arsenic	144.75	261.38	51.16	152.43	105.32
Mercury	165.16	344.23	(51.51)	152.63	198.16
Cobalt	460.47	37.02	(6.68)	163.61	258.02
Sodium	619.11	2,935.29	6,208.22	3,254.21	2,808.17

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-30. EMISSION FACTORS FOR ELEMENTS (lb/10¹² BTU)

Analyte	C-6a-MUM-622		C-6a-MUM-624		C-6a-MUM-627		AVERAGE	TU
Aluminum		634		593		506	578	169
Potassium		103		124		100	109	34
Sodium		226		222		206	218	32
Titanium		48.8		40.3		36.3	42	16
Antimony		0.225		0.155		0.172	0.18	0.09
Arsenic		1.47		1.21		1.02	1.2	0.58
Barium		189		154		143	162	61
Beryllium	ND <	1.76	ND <	1.67	ND <	1.65	ND <	1.7
Boron		7.65		42.0		8.59	19	49
Cadmium	ND <	3.33	ND <	3.15	ND <	3.13	ND <	3.2
Calcium		1540		1180		1200	1310	513
Chromium		#		3.86		15.6	10	NC
Cobalt		2.92	ND <	0.833 *	ND <	0.826 *	1.5 ##	3.0
Copper		#		2.08	ND <	0.992 *	1.5 ##	NC
Lead		0.784		0.648		0.634	0.69	0.21
Manganese		41.1		20.2		28.2	30	26
Mercury		8.27		12.9		7.27	9.5	7.5
Molybdenum		#		0.507		0.520	0.51	NC
Nickel		#		2.38		7.89	5.1	NC
Selenium		11.3		8.31		5.33	8.3	7.4
Vanadium		5.40		4.15		3.56	4.4	2.4

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

NC = Not calculated.

* = Emission factor calculated using one half of the detection limit.

= Outlier data (see section 5), not used in calculation.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-31. EMISSION FACTORS FOR ELEMENTS ($\mu\text{g}/\text{MJ}$)

Analyte	C-6a-MUM-622	C-6a-MUM-624	C-6a-MUM-627	AVERAGE	TU
Aluminum	273	255	218	249	73
Potassium	44.2	53.3	43.1	47	14
Sodium	97.1	95.5	88.5	94	14
Titanium	21.0	17.4	15.6	18	7.0
Antimony	0.0969	0.0667	0.0740	0.079	0.040
Arsenic	0.635	0.521	0.437	0.53	0.25
Barium	81.3	66.1	61.7	70	26
Beryllium	ND <	ND <	ND <	ND <	0.73
Boron	3.29	18.1	3.70	8.4	21
Cadmium	ND <	ND <	ND <	ND <	1.4
Calcium	663	508	516	564	221
Chromium	#	1.66	6.73	1.8	NC
Cobalt	1.26	ND <	0.359 *	0.66 ##	1.3
Copper	#	0.897	ND <	0.427 *	NC
Lead	0.337	0.279	0.273	0.30	0.092
Manganese	17.7	8.69	12.1	13	11
Mercury	3.56	5.55	3.13	4.1	3.2
Molybdenum	#	0.218	0.224	0.10	NC
Nickel	#	1.02	3.39	1.0	NC
Selenium	4.86	3.58	2.30	3.6	3.2
Vanadium	2.33	1.79	1.53	1.9	1.0

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

NC = Not calculated.

* = Emission factor calculated using one half of the detection limit.

= Outlier data (see section 5), not used in calculation.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-32. EMISSION FACTORS FOR AMMONIA AND CYANIDE (lb/10¹² BTU)

Analyte	C-6a-NH4-622		C-6a-NH4-624		C-6a-NH4-627		AVERAGE		TU
	C-6a-CN-622		C-6a-CN-624		C-6a-CN-627				
Ammonia	ND <	3.73	ND <	3.65	ND <	3.83	ND <	3.7	3.7
Cyanide		41.4		36.4		74.0		51	51

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

TABLE 6-33. EMISSION FACTORS FOR AMMONIA AND CYANIDE (μg/MJ)

Analyte	C-6a-NH4-622		C-6a-NH4-624		C-6a-NH4-627		AVERAGE		TU
	C-6a-CN-622		C-6a-CN-624		C-6a-CN-627				
Ammonia	ND <	1.61	ND <	1.57	ND <	1.65	ND <	1.6	1.6
Cyanide		17.8		15.7		31.8		22	22

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

TABLE 6-34. EMISSION FACTORS FOR ANIONS (lb/10¹² BTU)

Analyte	C-6a-FCL-622	C-6a-FCL-624	C-6a-FCL-627	AVERAGE	TU
Hydrogen Chloride	1460	1290	1260	1340	285
Hydrogen Fluoride	5410	3980	2550	3980	3560
Chloride (Particulate) **	6.52	ND < 0.359 *	3.52	3.5 ##	7.6
Fluoride (Particulate) **	127	175	137	146	64
Sulfate (Particulate) **	859	1960	836	1220	1600
Phosphate (Particulate) **	15.9	ND < 0.721 *	6.87	7.8 ##	19

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

** = Sampling for anions was conducted at a single point in the duct; traverses were not made.

TABLE 6-35. EMISSION FACTORS FOR ANIONS (μg/MJ)

Analyte	C-6a-FCL-622	C-6a-FCL-624	C-6a-FCL-627	AVERAGE	TU
Hydrogen Chloride	628	555	542	577	123
Hydrogen Fluoride	2330	1710	1100	1710	1530
Chloride (Particulate) **	2.80	ND < 0.154 *	1.52	1.5 ##	3.3
Fluoride (Particulate) **	54.9	75.4	58.9	63	28
Sulfate (Particulate) **	370	843	360	525	689
Phosphate (Particulate) **	6.85	ND < 0.310 *	2.96	3.4 ##	8.2

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

** = Sampling for anions was conducted at a single point in the duct; traverses were not made.

TABLE 6-36. EMISSION FACTORS FOR VOC (lb/10⁶ BTU)

Analyte	C-6a-VOS-621	C-6a-VOC-623	C-6a-VOC-626	AVERAGE	TU
Chloromethane	109	75.6	133	106	72
Bromomethane	ND < 3.51 *	2.93	6.47	4.3 ##	4.7
Vinyl Chloride	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Chloroethane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Methylene Chloride	NC	NC	NC	NC	NC
Acetone	NC	NC	NC	NC	NC
Carbon Disulfide	ND < 3.51 *	3.83	ND < 2.99 *	3.4 ##	1.1
1,1-Dichloroethene	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
1,1-Dichloroethane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
trans-1,2-Dichloroethene	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Chloroform	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
1,2-Dichloroethane	3.52	ND < 3.18 *	ND < 2.99 *	3.2 ##	0.74
2-Butanone	6.28	14.4	8.60	9.8	10
1,1,1-Trichloroethane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Carbon Tetrachloride	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Vinyl Acetate	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Bromodichloromethane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
1,2-Dichloropropane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
cis-1,3-Dichloropropylene	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Trichloroethene	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Dibromochloromethane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
1,1,2-Trichloroethane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Benzene	50.0	48.9	23.0	41	38
trans-1,3-Dichloropropylene	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
2-Chloroethylvinylether	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Bromoform	ND < 3.51 *	2.96	ND < 2.99 *	3.1 ##	0.82
4-Methyl-2-Pentanone	ND < 3.51 *	11.4	ND < 2.99 *	6.0 ##	12
2-Hexanone	6.36	24.7	3.79	12	28
Tetrachloroethene	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
1,1,2,2-Tetrachloroethane	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Toluene	31.9	24.8	14.8	24	21
Chlorobenzene	3.58	ND < 3.18 *	ND < 2.99 *	3.3 ##	0.81
Ethylbenzene	ND < 7.02	ND < 6.37	ND < 5.97	ND < 6.5	6.5
Styrene	3.64	ND < 3.18 *	ND < 2.99 *	3.3 ##	0.89
Xylenes (Total)	3.70	3.92	ND < 2.99 *	3.5 ##	1.3

TU = Total uncertainty (95% confidence limit).

ND < = Analyte not detected.

NC = Not calculated.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-37. EMISSION FACTORS FOR VOC ($\mu\text{g}/\text{MJ}$)

Analyte	C-6a-VOS-621	C-6a-VOC-623	C-6a-VOC-626	AVERAGE	TU
Chloromethane	46.9	32.5	57.1	46	31
Bromomethane	ND < 1.51 *	1.26	2.79	1.9 ##	2.0
Vinyl Chloride	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Chloroethane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Methylene Chloride	NC	NC	NC	NC	NC
Acetone	NC	NC	NC	NC	NC
Carbon Disulfide	ND < 1.51 *	1.65	ND < 1.29 *	1.5 ##	0.47
1,1-Dichloroethene	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
1,1-Dichloroethane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
trans-1,2-Dichloroethene	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Chloroform	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
1,2-Dichloroethane	1.52	ND < 1.37 *	ND < 1.29 *	1.4 ##	0.32
2-Butanone	2.70	6.19	3.70	4.2	4.5
1,1,1-Trichloroethane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Carbon Tetrachloride	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Vinyl Acetate	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Bromodichloromethane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
1,2-Dichloropropane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
cis-1,3-Dichloropropylene	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Trichloroethene	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Dibromochloromethane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
1,1,2-Trichloroethane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Benzene	21.5	21.1	9.90	17	16
trans-1,3-Dichloropropylene	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
2-Chloroethylvinylether	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Bromoform	ND < 1.51 *	1.27	ND < 1.29 *	1.4 ##	0.35
4-Methyl-2-Pentanone	ND < 1.51 *	4.89	ND < 1.29 *	2.6 ##	5.0
2-Hexanone	2.74	10.6	1.63	5.0	12
Tetrachloroethene	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
1,1,2,2-Tetrachloroethane	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Toluene	13.7	10.7	6.36	10	9.2
Chlorobenzene	1.54	ND < 1.37 *	ND < 1.29 *	1.4 ##	0.35
Ethylbenzene	ND < 3.02	ND < 2.74	ND < 2.57	ND < 2.8	2.8
Styrene	1.57	ND < 1.37 *	ND < 1.29 *	1.4 ##	0.38
Xylenes (Total)	1.59	1.69	ND < 1.29 *	1.5 ##	0.54

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

NC = Not calculated.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-38. EMISSION FACTORS FOR PAH/SVOC (lb/10¹² BTU)

Analyte	C-6a-MM5-F+X-621		C-6a-MM5-F+X-623		C-6a-MM5-F+X-626		AVERAGE	TU
Benzylchloride	ND <	0.000887 *	ND <	0.000842 *		0.0154	0.0057 ##	0.021
Acetophenone		0.384		0.392		0.851	0.54	0.66
Hexachloroethane	ND <	0.00177	ND <	0.00168	ND <	0.00165	ND <	0.0017
Naphthalene		0.172		0.264		0.329	0.25	0.20
Hexachlorobutadiene	ND <	0.00177	ND <	0.00168	ND <	0.00165	ND <	0.0017
Quinoline	ND <	0.0177	ND <	0.0168	ND <	0.0165	ND <	0.017
2-Chloroacetophenone		0.128		0.100		0.149	0.13	0.062
2-Methylnaphthalene		0.0499		0.0364		0.0364	0.041	0.020
1-Methylnaphthalene		0.0190		0.0130		0.0133	0.015	0.0084
Hexachlorocyclopentadiene	ND <	0.00177	ND <	0.00168	ND <	0.00165	ND <	0.0017
Biphenyl		0.0275		0.0219		0.0197	0.023	0.010
Acenaphthylene		0.00961		0.00298		0.0188	0.010	0.020
2,6-Dinitrotoluene	ND <	0.00177	ND <	0.00168	ND <	0.00165	ND <	0.0017
Acenaphthene		0.0270		0.00738		0.0175	0.017	0.024
Dibenzofuran		0.0673		0.0450		0.0425	0.052	0.034
2,4-Dinitrotoluene		0.0123		0.00644	ND <	0.000827 *	0.0065 ##	0.014
Fluorene		0.0618		0.0335		0.0293	0.042	0.044
Hexachlorobenzene	ND <	0.00177	ND <	0.00168	ND <	0.00165	ND <	0.0017
Pentachlorophenol	ND <	0.00177	ND <	0.00168	ND <	0.00165	ND <	0.0017
Phenanthrene		0.525		0.331		0.0866	0.31	0.55
Anthracene		0.0184		0.0133		0.0123	0.015	0.0081
Fluoranthene		0.0588		0.0332		0.0348	0.042	0.036
Pyrene		0.0216		0.0118		0.0152	0.016	0.012
Benz(a)anthracene		0.00293		0.00194		0.00144	0.0021	0.0019
Chrysene		0.00785		0.00482		0.00327	0.0053	0.0058
Benzo(b & k)fluoranthene		0.00693		0.00262		0.00395	0.0045	0.0055
Benzo(e)pyrene		0.00103		0.000683		0.00144	0.0011	0.00094
Benzo(a)pyrene		0.00105	ND <	0.000168 *		0.00137	0.00086 ##	0.0015
Indeno(1,2,3-c,d)pyrene		0.000667	ND <	0.000168 *		0.00106	0.00063 ##	0.0011
Dibenz(a,h)anthracene		0.000658		0.000565		0.000938	0.00072	0.00049
Benzo(g,h,i)perylene		0.000743	ND <	0.000168 *		0.000850	0.00059 ##	0.00091

TU = Total uncertainty (95% confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-39. EMISSION FACTORS FOR PAH/SVOC (µg/MJ)

Analyte	C-6a-MM5-F+X-621		C-6a-MM5-F+X-623		C-6a-MM5-F+X-626		AVERAGE	TU
Benzylchloride	ND <	0.000382 *	ND <	0.000363 *		0.00663	0.0025 ##	0.0090
Acetophenone		0.165		0.169		0.366	0.23	0.29
Hexachloroethane	ND <	0.000764	ND <	0.000725	ND <	0.000712	ND <	0.00073
Naphthalene		0.0739		0.114		0.142	0.11	0.085
Hexachlorobutadiene	ND <	0.000764	ND <	0.000725	ND <	0.000712	ND <	0.00073
Quinoline	ND <	0.00764	ND <	0.00725	ND <	0.00712	ND <	0.0073
2-Chloroacetophenone		0.0549		0.0431		0.0641	0.054	0.026
2-Methylnaphthalene		0.0215		0.0157		0.0157	0.018	0.0084
1-Methylnaphthalene		0.00817		0.00561		0.00574	0.0065	0.0036
Hexachlorocyclopentadiene	ND <	0.000764	ND <	0.000725	ND <	0.000712	ND <	0.00073
Biphenyl		0.0118		0.00941		0.00850	0.010	0.0044
Acenaphthylene		0.00414		0.00128		0.00809	0.0045	0.0085
2,6-Dinitrotoluene	ND <	0.000764	ND <	0.000725	ND <	0.000712	ND <	0.00073
Acenaphthene		0.0116		0.00318		0.00755	0.0074	0.010
Dibenzofuran		0.0290		0.0194		0.0183	0.022	0.015
2,4-Dinitrotoluene		0.00531		0.00277	ND <	0.000356 *	0.0028 ##	0.0061
Fluorene		0.0266		0.0144		0.0126	0.018	0.019
Hexachlorobenzene	ND <	0.000764	ND <	0.000725	ND <	0.000712	ND <	0.00073
Pentachlorophenol	ND <	0.000764	ND <	0.000725	ND <	0.000712	ND <	0.00073
Phenanthrene		0.226		0.143		0.0373	0.14	0.23
Anthracene		0.00790		0.00574		0.00531	0.0063	0.0035
Fluoranthene		0.0253		0.0143		0.0150	0.018	0.015
Pyrene		0.00928		0.00507		0.00655	0.0070	0.0053
Benz(a)anthracene		0.00126		0.000836		0.000618	0.00091	0.00081
Chrysene		0.00338		0.00208		0.00141	0.0023	0.0025
Benzo(b & k)fluoranthene		0.00298		0.00113		0.00170	0.0019	0.0024
Benzo(e)pyrene		0.000443		0.000294		0.000620	0.00045	0.00041
Benzo(a)pyrene		0.000453	ND <	0.000073 *		0.000588	0.00037 ##	0.00066
Indeno(1,2,3-c,d)pyrene		0.000287	ND <	0.000073 *		0.000454	0.00027 ##	0.00048
Dibenz(a,h)anthracene		0.000283		0.000243		0.000404	0.00031	0.00021
Benzo(g,h,i)perylene		0.000320	ND <	0.000073 *		0.000366	0.00025 ##	0.00039

TU = Total uncertainty (95% confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-40. EMISSION FACTORS FOR DIOXINS/FURANS (lb/10¹² BTU)

Analyte	C-6a-MM5-621	C-6a-MM5-623	C-6a-MM5-626	AVERAGE	TU
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND < 1.88E-06	ND < 1.80E-06	ND < 2.23E-06	ND < 1.97E-06	1.97E-06
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND < 1.80E-06	ND < 3.25E-06	ND < 2.17E-06	ND < 2.41E-06	2.41E-06
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND < 2.40E-06	ND < 2.47E-06	ND < 1.42E-06	ND < 2.10E-06	2.10E-06
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND < 2.60E-06	ND < 3.38E-06	ND < 3.46E-06	ND < 3.15E-06	3.15E-06
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND < 3.81E-06	ND < 3.65E-06	ND < 2.33E-06	ND < 3.26E-06	3.26E-06
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.44E-06	4.53E-06	3.72E-06	3.23E-06	3.98E-06
Octachlorodibenzo-p-dioxin	8.11E-06	2.17E-05	1.56E-05	1.51E-05	1.69E-05
2,3,7,8-Tetrachlorodibenzofuran	1.23E-05	9.38E-06	7.94E-06	9.89E-06	5.63E-06
1,2,3,7,8-Pentachlorodibenzofuran	ND < 5.44E-06	ND < 3.37E-06	ND < 4.19E-06	ND < 4.34E-06	4.34E-06
2,3,4,7,8-Pentachlorodibenzofuran	ND < 3.65E-06	ND < 4.33E-06	ND < 3.04E-06	ND < 3.67E-06	3.67E-06
1,2,3,4,7,8-Hexachlorodibenzofuran	ND < 4.18E-06	ND < 4.17E-06	ND < 3.23E-06	ND < 3.86E-06	3.86E-06
1,2,3,6,7,8-Hexachlorodibenzofuran	ND < 3.13E-06	ND < 3.44E-06	ND < 2.62E-06	ND < 3.06E-06	3.06E-06
1,2,3,7,8,9-Hexachlorodibenzofuran	ND < 6.45E-06	ND < 4.97E-06	ND < 4.35E-06	ND < 5.26E-06	5.26E-06
2,3,4,6,7,8-Hexachlorodibenzofuran	ND < 1.79E-06	ND < 2.16E-06	ND < 1.64E-06	ND < 1.87E-06	1.87E-06
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND < 4.18E-05	ND < 1.71E-05	ND < 1.09E-05	ND < 2.33E-05	2.33E-05
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND < 3.19E-06	ND < 4.10E-06	ND < 4.17E-06	ND < 3.82E-06	3.82E-06
Octachlorodibenzofuran	6.33E-06	ND < 7.16E-06 *	5.40E-06	6.29E-06 ##	2.25E-06

TU = Total uncertainty (95% confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-41. EMISSION FACTORS FOR DIOXINS/FURANS (μg/MJ)

Analyte	C-6a-MM5-621	C-6a-MM5-623	C-6a-MM5-626	AVERAGE	TU
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND < 8.09E-07	ND < 7.75E-07	ND < 9.60E-07	ND < 8.48E-07	8.48E-07
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND < 7.75E-07	ND < 1.40E-06	ND < 9.34E-07	ND < 1.04E-06	1.04E-06
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND < 1.03E-06	ND < 1.06E-06	ND < 6.11E-07	ND < 9.04E-07	9.04E-07
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND < 1.12E-06	ND < 1.45E-06	ND < 1.49E-06	ND < 1.36E-06	1.36E-06
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND < 1.64E-06	ND < 1.57E-06	ND < 1.00E-06	ND < 1.40E-06	1.40E-06
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	6.20E-07	1.95E-06	1.60E-06	1.39E-06	1.71E-06
Octachlorodibenzo-p-dioxin	3.49E-06	9.34E-06	6.71E-06	6.51E-06	7.28E-06
2,3,7,8-Tetrachlorodibenzofuran	5.31E-06	4.04E-06	3.42E-06	4.26E-06	2.42E-06
1,2,3,7,8-Pentachlorodibenzofuran	ND < 2.34E-06	ND < 1.45E-06	ND < 1.80E-06	ND < 1.87E-06	1.87E-06
2,3,4,7,8-Pentachlorodibenzofuran	ND < 1.57E-06	ND < 1.86E-06	ND < 1.31E-06	ND < 1.58E-06	1.58E-06
1,2,3,4,7,8-Hexachlorodibenzofuran	ND < 1.80E-06	ND < 1.79E-06	ND < 1.39E-06	ND < 1.66E-06	1.66E-06
1,2,3,6,7,8-Hexachlorodibenzofuran	ND < 1.35E-06	ND < 1.48E-06	ND < 1.13E-06	ND < 1.32E-06	1.32E-06
1,2,3,7,8,9-Hexachlorodibenzofuran	ND < 2.78E-06	ND < 2.14E-06	ND < 1.87E-06	ND < 2.26E-06	2.26E-06
2,3,4,6,7,8-Hexachlorodibenzofuran	ND < 7.70E-07	ND < 9.30E-07	ND < 7.06E-07	ND < 8.05E-07	8.05E-07
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND < 1.80E-05	ND < 7.37E-06	ND < 4.67E-06	ND < 1.00E-05	1.00E-05
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND < 1.37E-06	ND < 1.76E-06	ND < 1.79E-06	ND < 1.64E-06	1.64E-06
Octachlorodibenzofuran	2.72E-06	ND < 3.08E-06 *	2.32E-06	2.71E-06 ##	9.68E-07

TU = Total uncertainty (95% confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-42. EMISSION FACTORS FOR ALDEHYDES (lb/10¹² BTU)

Analyte	C-6a-ALD-621	C-6a-ALD-623	C-6a-ALD-626	AVERAGE	TU
Formaldehyde	3.27	ND < 1.10 *	ND < 1.09 *	1.8 ##	3.1
Acetaldehyde	75.3	54.6	72.1	67	28
Acrolein	ND < 2.25	ND < 2.20	ND < 2.18	ND < 2.2	2.2
Propionaldehyde	17.8	9.08	9.36	12	12

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-43. EMISSION FACTORS FOR ALDEHYDES (μg/MJ)

Analyte	C-6a-ALD-621	C-6a-ALD-623	C-6a-ALD-626	AVERAGE	TU
Formaldehyde	1.41	ND < 0.474 *	ND < 0.469 *	0.78 ##	1.3
Acetaldehyde	32.4	23.5	31.0	29	12
Acrolein	ND < 0.970	ND < 0.948	ND < 0.938	ND < 1.0	1.0
Propionaldehyde	7.67	3.91	4.03	5.2	5.3

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-44. EMISSION FACTORS FOR RADIONUCLIDES (mCi/10¹² BTU)

Analyte	C-6a-NH4 + CN-622		C-6a-NH4 + CN-624		C-6a-NH4 + CN-627		AVERAGE	TU
Pb-212	ND <	3.55 *		7.54	ND <	3.18 *	4.8 ##	6.0
Th-234	ND <	60.1	ND <	40.0	ND <	45.7	ND <	49
Pb-210		90.7	ND <	37.7 *	ND <	37.6 *	55 ##	76
Pb-211	ND <	76.5	ND <	75.4	ND <	81.0	ND <	78
Ra-226	ND <	4.10 *		4.34	ND <	3.76 *	4.1 ##	0.73
Ra-228	ND <	13.7	ND <	15.7	ND <	13.9	ND <	14
Th-229	ND <	30.1	ND <	33.6	ND <	29.5	ND <	31
Th-230	ND <	339	ND <	348	ND <	335	ND <	341
U-234	ND <	1480	ND <	1510	ND <	1560	ND <	1520
U-235	ND <	13.7	ND <	12.8	ND <	12.7	ND <	13

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-45. EMISSION FACTORS FOR RADIONUCLIDES (pCi/MJ)

Analyte	C-6a-NH4 + CN-622		C-6a-NH4 + CN-624		C-6a-NH4 + CN-627		AVERAGE	TU
Pb-212	ND <	3.37 *		7.15	ND <	3.02 *	4.5 ##	5.7
Th-234	ND <	57.0	ND <	37.9	ND <	43.3	ND <	46
Pb-210		86.0	ND <	35.7 *	ND <	35.6 *	52 ##	72
Pb-211	ND <	72.5	ND <	71.5	ND <	76.8	ND <	74
Ra-226	ND <	3.89 *		4.12	ND <	3.56 *	3.9 ##	0.69
Ra-228	ND <	13.0	ND <	14.8	ND <	13.2	ND <	14
Th-229	ND <	28.5	ND <	31.9	ND <	28.0	ND <	29
Th-230	ND <	321	ND <	330	ND <	318	ND <	323
U-234	ND <	1400	ND <	1430	ND <	1480	ND <	1440
U-235	ND <	13.0	ND <	12.1	ND <	12.1	ND <	12

TU = Total uncertainty (95 % confidence limit).

ND < = Analyte not detected.

* = Emission factor calculated using one half of the detection limit.

= Average emission factor includes one or two non-detects out of three measurements.

TABLE 6-46. EMISSION FACTORS FOR PARTICULATE MATTER (lb/10¹² BTU)

Analyte	C-6a-MUM-622	C-6a-MUM-624	C-6a-MUM-627	AVERAGE	TU
Particulate Matter	24700	4820	1560	10400	31100

TU = Total uncertainty (95 % confidence limit).

TABLE 6-47. EMISSION FACTORS FOR PARTICULATE MATTER (μg/MJ)

Analyte	C-6a-MUM-622	C-6a-MUM-624	C-6a-MUM-627	AVERAGE	TU
Particulate Matter	10600	2070	671	4480	13400

TU = Total uncertainty (95 % confidence limit).

TABLE 6-48. REMOVAL EFFICIENCIES FOR ALUMINUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.33	99.56	98.78	99.22	0.33
Scrubber	28.95	14.00	55.26	32.73	17.05
Absorber	81.31	33.41	121.18	78.63	35.88
ESP and partial scrubber	99.53	99.62	99.45	99.53	0.07
ESP and full scrubber	99.88	99.71	100.26	99.95	0.23
ESP #1	99.47	99.64	99.51	99.54	0.07

TABLE 6-49. REMOVAL EFFICIENCIES FOR ANTIMONY (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	93.06	99.33	99.17	97.18	2.92
Scrubber	90.23	67.01	71.01	76.08	10.14
Absorber	253.46	159.93	155.72	189.70	45.12
ESP and partial scrubber	99.32	99.78	99.76	99.62	0.21
ESP and full scrubber	110.65	100.40	100.46	103.84	4.82
ESP #1	94.48	99.46	99.67	97.87	2.40

TABLE 6-50. REMOVAL EFFICIENCIES FOR ARSENIC (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.79	99.83	99.74	99.79	0.03
Scrubber	8.94	20.00	58.34	29.09	21.17
Absorber	25.11	47.72	127.94	66.92	44.12
ESP and partial scrubber	99.81	99.86	99.89	99.86	0.03
ESP and full scrubber	99.84	99.91	100.07	99.94	0.10
ESP #1	99.83	99.86	99.90	99.86	0.03

TABLE 6-51. REMOVAL EFFICIENCIES FOR BARIUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	98.99	99.58	97.68	98.75	0.79
Scrubber	(10.83)	(86.53)	56.51	(13.62)	58.43
Absorber	(30.42)	(206.51)	123.92	(37.67)	135.00
ESP and partial scrubber	98.88	99.21	98.99	99.03	0.14
ESP and full scrubber	98.68	98.71	100.56	99.31	0.88
ESP #1	99.19	99.66	99.07	99.31	0.25

TABLE 6-52. REMOVAL EFFICIENCIES FOR BERYLLIUM (Percent)^(a)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	97.26	97.58	94.64	96.49	1.32
Scrubber	38.52	48.23	73.20	53.32	14.61
Absorber	108.20	115.11	160.52	127.94	23.21
ESP and partial scrubber	98.32	98.75	98.56	98.54	0.18
ESP and full scrubber	100.22	100.36	103.24	101.28	1.39
ESP #1	97.82	98.05	97.85	97.91	0.10

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-53. REMOVAL EFFICIENCIES FOR BORON (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	96.33	99.45	99.00	98.26	1.38
Scrubber	97.76	22.95	92.40	71.04	34.07
Absorber	274.60	54.77	202.63	177.33	91.51
ESP and partial scrubber	99.92	99.57	99.92	99.81	0.16
ESP and full scrubber	106.41	99.75	101.03	102.40	2.89
ESP #1	97.08	99.55	99.60	98.74	1.18

TABLE 6-54. REMOVAL EFFICIENCIES FOR CADMIUM (Percent)^(a)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	85.96	74.14	84.17	81.42	5.20
Scrubber	(53.38)*	54.75	37.73	46.24	NC
Absorber	(149.94)*	130.67	82.74	106.71	NC
ESP and partial scrubber	78.46	88.30	90.14	85.63	5.13
ESP and full scrubber	64.90	107.93	97.27	90.03	18.30
ESP #1	88.82	79.17	93.65	87.22	6.02

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

NC = Not calculated.

* = Value excluded from calculation of average.

TABLE 6-55. REMOVAL EFFICIENCIES FOR CHROMIUM (Percent)^(a)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	96.35	99.55	99.70	98.53	1.55
Scrubber	85.50	2.94	1.31	29.92	39.31
Absorber	240.18	7.02	2.88	83.36	110.90
ESP and partial scrubber	99.47	99.57	99.70	99.58	0.09
ESP and full scrubber	105.12	99.59	99.71	101.47	2.58
ESP #1	97.09	99.64	99.88	98.87	1.26

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-56. REMOVAL EFFICIENCIES FOR COBALT (Percent)^(a)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.52	99.57	99.06	99.38	0.23
Scrubber	(271.68)*	28.82	60.47	44.65	NC
Absorber	(736.16)*	68.78	132.61	100.70	NC
ESP and partial scrubber	98.22	99.69	99.63	99.18	0.68
ESP and full scrubber	95.88	99.86	100.31	98.68	1.99
ESP #1	99.62	99.65	99.62	99.63	0.01

(a) Shaded values indicate at least one non-detect value was used in calculating the result.
 NC = Not calculated.

* = Value not used to calculate average.

TABLE 6-57. REMOVAL EFFICIENCIES FOR COPPER (Percent)^(a)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	98.95	98.95	98.41	98.77	0.26
Scrubber	65.17	61.62	87.50	71.43	11.45
Absorber	183.05	147.07	191.89	174.01	19.38
ESP and partial scrubber	99.63	99.60	99.80	99.68	0.09
ESP and full scrubber	100.87	100.49	101.46	100.94	0.40
ESP #1	99.16	99.15	99.36	99.23	0.10

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-58. REMOVAL EFFICIENCIES FOR LEAD (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.59	99.86	99.66	99.70	0.11
Scrubber	23.45	(38.47)*	29.84	26.65	NC
Absorber	65.88	(91.82)*	65.43	65.66	NC
ESP and partial scrubber	99.69	99.81	99.76	99.75	0.05
ESP and full scrubber	99.86	99.73	99.88	99.83	0.07
ESP #1	99.68	99.89	99.86	99.81	0.09

NC = Not calculated.

* = Value excluded from calculation of average.

TABLE 6-59. REMOVAL EFFICIENCIES FOR MANGANESE (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.35	99.73	99.63	99.57	0.16
Scrubber	4.69	(2.88)	13.60	5.14	6.74
Absorber	13.18	(6.88)	29.83	12.04	15.01
ESP and partial scrubber	99.38	99.73	99.68	99.60	0.16
ESP and full scrubber	99.43	99.72	99.74	99.63	0.14
ESP #1	99.48	99.79	99.85	99.71	0.16

TABLE 6-60. REMOVAL EFFICIENCIES FOR MERCURY (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	14.24	39.15	(248.05)	(64.89)	129.92
Scrubber	(17.79)	(84.98)	75.96	(8.94)	66.00
Absorber	(49.97)	(202.82)	166.58	(28.74)	151.55
ESP and partial scrubber	(1.02)	(12.55)	16.33	(0.92)	11.87
ESP and full scrubber	(28.62)	(84.25)	331.73	72.95	184.39
ESP #1	31.75	50.99	(39.56)	14.39	38.95

TABLE 6-61. REMOVAL EFFICIENCIES FOR MOLYBDENUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	98.17	99.45	99.53	99.05	0.62
Scrubber	73.00	45.97	43.45	54.14	13.38
Absorber	205.07	109.72	95.28	136.69	48.71
ESP and partial scrubber	99.51	99.70	99.73	99.65	0.10
ESP and full scrubber	101.92	100.05	99.98	100.65	0.90
ESP #1	98.54	99.55	99.81	99.30	0.55

TABLE 6-62. REMOVAL EFFICIENCIES FOR NICKEL (Percent)^(a)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	96.83	99.78	99.71	98.77	1.37
Scrubber	84.85	(88.39)	11.49	2.65	71.00
Absorber	238.35	(210.96)	25.19	17.53	183.51
ESP and partial scrubber	99.52	99.58	99.74	99.61	0.09
ESP and full scrubber	104.38	99.31	99.78	101.16	2.29
ESP #1	97.48	99.82	99.88	99.06	1.12

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-63. REMOVAL EFFICIENCIES FOR POTASSIUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.38	99.86	99.70	99.65	0.20
Scrubber	82.23	15.55	47.01	48.26	27.24
Absorber	230.98	37.12	103.09	123.73	80.48
ESP and partial scrubber	99.89	99.88	99.84	99.87	0.02
ESP and full scrubber	100.81	99.91	100.01	100.24	0.40
ESP #1	99.51	99.89	99.88	99.76	0.18

TABLE 6-64. REMOVAL EFFICIENCIES FOR SELENIUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	81.47	84.93	71.29	79.23	5.79
Scrubber	4.41	38.57	76.08	39.69	29.27
Absorber	12.39	92.05	166.84	90.43	63.07
ESP and partial scrubber	82.28	90.74	93.13	88.72	4.65
ESP and full scrubber	83.76	98.80	119.19	100.59	14.52
ESP #1	85.25	87.87	88.49	87.20	1.40

TABLE 6-65. REMOVAL EFFICIENCIES FOR SILICON (Percent)^(a)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.60	99.91	99.80	99.77	0.13
Scrubber	71.42	(6.55)*	80.35	75.89	NC
Absorber	200.61	(15.63)	176.20	120.39	96.70
ESP and partial scrubber	99.89	99.91	99.96	99.92	0.03
ESP and full scrubber	100.40	99.90	100.15	100.15	0.20
ESP #1	99.68	99.93	99.92	99.84	0.11

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

NC = Not calculated.

* = Value not used to calculate average.

TABLE 6-66. REMOVAL EFFICIENCIES FOR SODIUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	96.97	98.98	99.12	98.36	0.98
Scrubber	66.28	24.17	10.98	33.81	23.58
Absorber	186.17	57.68	24.08	89.31	69.85
ESP and partial scrubber	98.98	99.23	99.22	99.14	0.12
ESP and full scrubber	102.61	99.57	99.33	100.50	1.49
ESP #1	97.59	99.18	99.65	98.81	0.88

TABLE 6-67. REMOVAL EFFICIENCIES FOR TITANIUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.81	99.85	99.70	99.79	0.06
Scrubber	(2.06)	4.62	53.24	18.60	24.64
Absorber	(5.80)	11.03	116.75	40.66	54.24
ESP and partial scrubber	99.80	99.86	99.86	99.84	0.03
ESP and full scrubber	99.80	99.87	100.05	99.91	0.11
ESP #1	99.85	99.88	99.88	99.87	0.02

TABLE 6-68. REMOVAL EFFICIENCIES FOR VANADIUM (Percent)

Component(s)	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
ESP	99.27	99.56	99.03	99.29	0.21
Scrubber	(15.23)	(6.01)	50.04	9.60	28.84
Absorber	(42.77)	(14.34)	109.73	17.54	66.21
ESP and partial scrubber	99.16	99.53	99.52	99.40	0.17
ESP and full scrubber	98.96	99.49	100.09	99.52	0.46
ESP #1	99.42	99.64	99.61	99.56	0.10

TABLE 6-69. REMOVAL EFFICIENCIES FOR THE ELECTROSTATIC
PRECIPITATOR #1 (Percent)^a

Element	6/22/92	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	99.47	99.64	99.51	99.54	0.07
Antimony	94.48	99.46	99.67	97.87	2.40
Arsenic	99.83	99.86	99.90	99.86	0.03
Barium	99.19	99.66	99.07	99.31	0.25
Beryllium	97.82	98.05	97.85	97.91	0.10
Boron	97.08	99.55	99.60	98.74	1.18
Cadmium	88.82	79.17	93.65	87.22	6.02
Chromium	97.09	99.64	99.88	98.87	1.26
Cobalt	99.62	99.65	99.62	99.63	0.01
Copper	99.16	99.15	99.36	99.23	0.10
Lead	99.68	99.89	99.86	99.81	0.09
Manganese	99.48	99.79	99.85	99.71	0.16
Mercury	31.75	50.99	(39.56)	14.39	38.95
Molybdenum	98.54	99.55	99.81	99.30	0.55
Nickel	97.48	99.82	99.88	99.06	1.12
Potassium	99.51	99.89	99.88	99.76	0.18
Selenium	85.25	87.87	88.49	87.20	1.40
Silicon	99.68	99.93	99.92	99.84	0.11
Sodium	97.59	99.18	99.65	98.81	0.88
Titanium	99.85	99.88	99.88	99.87	0.02
Vanadium	99.42	99.64	99.61	99.56	0.10

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-70. REMOVAL EFFICIENCIES FOR THE ELECTROSTATIC PRECIPITATOR (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	99.33	99.56	98.78	99.22	0.33
Antimony	93.06	99.33	99.17	97.18	2.92
Arsenic	99.79	99.83	99.74	99.79	0.03
Barium	98.99	99.58	97.68	98.75	0.79
Beryllium	97.26	97.58	94.64	96.49	1.32
Boron	96.33	99.45	99.00	98.26	1.38
Cadmium	85.96	74.14	84.17	81.42	5.20
Chromium	96.35	99.55	99.70	98.53	1.55
Cobalt	99.52	99.57	99.06	99.38	0.23
Copper	98.95	98.95	98.41	98.77	0.26
Lead	99.59	99.86	99.66	99.70	0.11
Manganese	99.35	99.73	99.63	99.57	0.16
Mercury	14.24	39.15	(248.05)	(64.89)	129.92
Molybdenum	98.17	99.45	99.53	99.05	0.62
Nickel	96.83	99.78	99.71	98.77	1.37
Potassium	99.38	99.86	99.70	99.65	0.20
Selenium	81.47	84.93	71.29	79.23	5.79
Silicon	99.60	99.91	99.80	99.77	0.13
Sodium	96.97	98.98	99.12	98.36	0.98
Titanium	99.81	99.85	99.70	99.79	0.06
Vanadium	99.27	99.56	99.03	99.29	0.21

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-71. REMOVAL EFFICIENCIES FOR THE SCRUBBER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	28.95	14.00	55.26	32.73	17.05
Antimony	90.23	67.01	71.01	76.08	10.14
Arsenic	8.94	20.00	58.34	29.09	21.17
Barium	(10.83)	(86.53)	56.51	(13.62)	58.43
Beryllium	38.52	48.23	73.20	53.32	14.61
Boron	97.76	22.95	92.40	71.04	34.07
Cadmium	(53.38)*	54.75	37.73	46.24	NC
Chromium	85.50	2.94	1.31	29.92	39.31
Cobalt	(271.68)*	28.82	60.47	44.65	NC
Copper	65.17	61.62	87.50	71.43	11.45
Lead	23.45	(38.47)*	29.84	26.65	NC
Manganese	4.69	(2.88)	13.60	5.14	6.74
Mercury	(17.79)	(84.98)	75.96	(8.94)	66.00
Molybdenum	73.00	45.97	43.45	54.14	13.38
Nickel	84.85	(88.39)	11.49	2.65	71.00
Potassium	82.23	15.55	47.01	48.26	27.24
Selenium	4.41	38.57	76.08	39.69	29.27
Silicon	71.42	(6.55)*	80.35	75.89	NC
Sodium	66.28	24.17	10.98	33.81	23.58
Titanium	(2.06)	4.62	53.24	18.60	24.64
Vanadium	(15.23)	(6.01)	50.04	9.60	28.84

(a) Shaded values indicate at least one non-detect value was used in calculating the result.
 NC = Not calculated.

* = Values not used to calculate average.

TABLE 6-72. REMOVAL EFFICIENCIES FOR THE ABSORBER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	81.31	33.41	121.18	78.63	35.88
Antimony	253.46	159.93	155.72	189.70	45.12
Arsenic	25.11	47.72	127.94	66.92	44.12
Barium	(30.42)	(206.51)	123.92	(37.67)	135.00
Beryllium	108.20	115.11	160.52	127.94	23.21
Boron	274.60	54.77	202.63	177.33	91.51
Cadmium	(149.94)*	130.67	82.74	106.71	NC
Chromium	240.18	7.02	2.88	83.36	110.90
Cobalt	(763.16)*	68.78	132.61	100.70	NC
Copper	183.05	147.07	191.89	174.01	19.38
Lead	65.88	(91.82)*	65.43	65.66	NC
Manganese	13.18	(6.88)	29.83	12.04	15.01
Mercury	(49.97)	(202.82)	166.58	(28.74)	151.55
Molybdenum	205.07	109.72	95.28	136.69	48.71
Nickel	238.35	210.96	25.19	17.53	183.51
Potassium	230.98	37.12	103.09	123.73	80.48
Selenium	12.39	92.05	166.84	90.43	63.07
Silicon	200.61	(15.63)	176.20	120.39	96.70
Sodium	186.17	57.68	24.08	89.31	69.85
Titanium	(5.80)	11.03	116.75	40.66	54.24
Vanadium	(42.77)	(14.34)	109.73	17.54	66.21

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

NC = Not calculated.

* = Value not used to calculate average.

TABLE 6-73. REMOVAL EFFICIENCIES FOR THE ELECTROSTATIC PRECIPITATOR AND PARTIAL SCRUBBER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	99.53	99.62	99.45	99.53	0.07
Antimony	99.32	99.78	99.76	99.62	0.21
Arsenic	99.81	99.86	99.89	99.86	0.03
Barium	98.88	99.21	98.99	99.03	0.14
Beryllium	98.33	98.75	98.56	98.54	0.18
Boron	99.92	99.57	99.92	99.81	0.16
Cadmium	78.46	88.30	90.14	85.63	5.13
Chromium	99.47	99.57	99.70	99.58	0.09
Cobalt	98.22	99.69	99.63	99.18	0.68
Copper	99.63	99.60	99.80	99.68	0.09
Lead	99.69	99.81	99.76	99.75	0.05
Manganese	99.38	99.73	99.68	99.60	0.16
Mercury	(1.02)	(12.55)	16.33	(0.92)	11.87
Molybdenum	99.51	99.70	99.73	99.65	0.10
Nickel	99.52	99.58	99.74	99.61	0.09
Potassium	99.89	99.88	99.84	99.87	0.02
Selenium	82.28	90.74	93.13	88.72	4.65
Silicon	99.89	99.91	99.96	99.92	0.03
Sodium	98.98	99.23	99.22	99.14	0.12
Titanium	99.80	99.86	99.86	99.84	0.03
Vanadium	99.16	99.53	99.52	99.40	0.17

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

TABLE 6-74. REMOVAL EFFICIENCIES FOR THE ELECTROSTATIC PRECIPITATOR AND FULL SCRUBBER (Percent)^a

Element	6/22/93	6/24/93	6/27/93	Average	Standard Deviation
Aluminum	99.88	99.71	100.26	99.95	0.23
Antimony	110.65	100.40	100.46	103.84	4.82
Arsenic	99.84	99.91	100.07	99.94	0.10
Barium	98.68	98.71	100.56	99.31	0.88
Beryllium	100.22	100.36	103.24	101.28	1.39
Boron	106.41	99.75	101.03	102.40	2.89
Cadmium	64.90	107.93	97.27	90.03	18.30
Chromium	105.12	99.59	99.71	101.47	2.58
Cobalt	95.88	99.86	100.31	98.68	1.99
Copper	100.87	100.49	101.46	100.94	0.40
Lead	99.86	99.73	99.88	99.83	0.07
Manganese	99.43	99.72	99.74	99.63	0.14
Mercury	(28.62)	(84.25)	331.73	72.95	184.39
Molybdenum	101.92	100.05	99.98	100.65	0.90
Nickel	104.38	99.31	99.78	101.16	2.29
Potassium	100.81	99.91	100.01	100.24	0.40
Selenium	83.76	98.80	119.19	100.59	14.52
Silicon	100.40	99.90	100.15	100.15	0.20
Sodium	102.61	99.57	99.33	100.50	1.49
Titanium	99.80	99.87	100.05	99.91	0.11
Vanadium	98.96	99.49	100.09	99.52	0.46

(a) Shaded values indicate at least one non-detect value was used in calculating the result.

Figure 6-1. Boundaries for Mass Balance on the Pulverizer, the Boiler, and the ESP

Figure 6-2. Boundary for Mass Balance on the Combined Boiler and ESPs

Figure 6-3. Boundary for Mass Balance on the Scrubber

Figure 6-4. Boundary for Mass Balance on Combined Boiler, ESP, and Scrubber

Figure 6-5. Boundary for Mass Balance on the Absorber

Figure 6-6. Aluminum balance for Coal Creek Unit 1.

Figure 6-7. Antimony balance for Coal Creek Unit 1.

Figure 6-8. Arsenic balance for Coal Creek Unit 1.

Figure 6-9. Barium balance for Coal Creek Unit 1.

Figure 6-10. Beryllium balance for Coal Creek Unit 1.

Figure 6-11. Boron balance for Coal Creek Unit 1.

Figure 6-12. Cadmium balance for Coal Creek Unit 1.

Figure 6-13. Chromium balance for Coal Creek Unit 1.

Figure 6-14. Cobalt balance for Coal Creek Unit 1.

Figure 6-15. Copper balance for Coal Creek Unit 1.

Figure 6-16. Lead balance for Coal Creek Unit 1.

Figure 6-17. Manganese balance for Coal Creek Unit 1.

Figure 6-18. Mercury balance for Coal Creek Unit 1.

Figure 6-19. Molybdenum balance for Coal Creek Unit 1.

Figure 6-20. Nickel balance for Coal Creek Unit 1.

Figure 6-21. Potassium balance for Coal Creek Unit 1.

Figure 6-22. Selenium balance for Coal Creek Unit 1.

Figure 6-23. Silicon balance for Coal Creek Unit 1.

Figure 6-24. Sodium balance for Coal Creek Unit 1.

Figure 6-25. Titanium balance for Coal Creek Unit 1.

Figure 6-26. Vanadium balance for Coal Creek Unit 1.

7.0 SPECIAL TOPICS

7.1 Vapor/Particulate Comparisons

7.1.1 Introduction

This section discusses the distribution of selected chemicals between the vapor and particulate phases in flue gas samples collected at various sampling locations at Coal Creek. As detailed earlier in this report, samples were collected from flue gas streams at the: (1) inlet to ESP #1 - Location 4a, (2) outlet to ESP #1 - Location 5a, (3) outlet of the scrubber; hot flue - Location 6a, and (4) outlet of the scrubber; diluted, cooled flue - Location 6b. The standard sampling methods used at these locations separated the vapor- and particulate-phases of the pollutants present in the flue gas streams so as to allow separate analyses of the concentrations in the two phases.

Vapor- and particulate-phase samples collected from the various sampling locations were analyzed individually for the target air toxics within specific groups of species, namely, elements, PAH/SVOC, and dioxins/furans. The results of these analyses are presented subsequently in this section. For each group of species, the corrected vapor- and particulate-phase concentrations of individual air toxics in the sampled flue gas are presented. Concentration data are provided separately for each of the five sampling locations. For each group of species, the vapor and particulate-phase concentrations measured in blank gas samples and/or method blanks are also presented.

The phase distribution results obtained are discussed briefly within each group of species. Differences in phase distribution of individual air toxics among the various sampling locations are examined. The potential for sampling artifacts to arise during the separation of the vapor- and particulate phases is noted where applicable.

Samples with different detection limits for vapor- and particulate-phase air toxics concentrations are also identified in the discussions presented in this section. Specifically, samples collected at Location 6b (scrubber outlet; diluted and cooled) using the PSDS suffered from the serious problem of widely differing sample collection volumes for the two phases. The particulate-phase samples collected at this location had typical flue gas sample

volumes of ~ 6 Ncm, whereas vapor-phase flue gas sample volumes were ~ 0.2 Ncm. The cause of this difference is the operation of the PSDS. All of the diluted flue gas flow in the PSDS is drawn through the 8-in. x 10-in. particulate filter. However, most of that filtered flow then passes through a high-volume pump and is discarded. Relatively little of the flow is sampled by the MUM or MM5 trains. (Further detail on the PSDS is given in Section 7.2). The disproportionately different flue gas sample volumes between the particulate and vapor phase samples resulted in widely different detection limits. Thus, particulate phase species were detected at Location 6b at much smaller levels and with less uncertainty than the vapor-phase species. Comparisons of vapor and particulate-phase compositions at this location are therefore skewed by the large differences in the corresponding detection limits. In this section, these comparisons are omitted for species present in the vapor phase at levels close to the vapor-phase detection limit. Comparisons are only provided for cases where the vapor-phase levels were sufficiently high to be detected with a reasonable degree of confidence.

Each sub-section also presents a table of the average distribution of individual species concentrations between the vapor and particulate phases in the flue gas at the various sampling locations. This table provides a summary of the differences in composition of the vapor and particulate phases for each group of species.

7.1.2 Elements

Table 7.1-1 shows a summary of the average phase distribution of the various elements at each sampling location. The data in Table 7.1-1 were derived by averaging the phase distributions measured in the sets of three samples collected at each location. The particulate and vapor phase concentrations measured in individual samples at each location are presented in subsequent tables in this sub-section.

The vapor- and particulate-phase concentrations (in $\mu\text{g}/\text{Ncm}$) of elements determined from flue gas samples are presented in Tables 7.1-2 through 7.1-5. Table 7.1.6 shows the corresponding vapor- and particulate-phase concentrations of the elements in two train blank samples.

Tables 7.1-1 and 7.1-2 show that at Location 4a, the inlet to ESP #1, most of the elements were present almost entirely in the particulate phase, with little variability among the three samples (evidenced by the low standard deviations in Table 7.1-1). At Location 5a, outlet of ESP #1, particulate phase concentrations of the elements shown in Table 7.1-3 were significantly lower in magnitude than the corresponding concentrations at Location 4a. This result is consistent with the operation of the ESP. However, the vapor phase concentrations of many elements were similar both at the inlet and outlet of the ESP. Consequently, the average percentage phase distributions shown in Table 7.1-1 for Location 5a show greater fractions of elements in the vapor phase than at Location 4a. Results observed at Location 6a (scrubber outlet; hot flue) were similar to those at Location 5a, but with a trend toward a greater fraction in the particle phase. This result is likely due to the lower temperatures at Location 6a. The particulate and vapor phase concentrations measured in individual samples at Location 6a are presented in Table 7.1-4. Elements present in both particulate and vapor phases at fraction greater than 5 percent at Locations 5a and 6a include aluminum, boron, cadmium, calcium, copper, manganese, potassium, sodium, antimony, lead, and selenium. For boron, potassium, and lead there is considerable variability in the particulate/vapor distribution among the three samples at Locations 5a and 6a, as evidenced by the high standard deviations shown in Table 7.1-1. In the case of manganese, there was apparently a greater fraction present in the vapor phase than in the particulate phase at both 5a and 6a locations. Antimony appeared to be predominantly in the vapor phase at Location 5a.

Tables 7.1-1 and 7.1-5 show the average phase distributions and concentrations, respectively, at Location 6b (scrubber outlet; diluted) for the elements. A number of the elements that were detected at other sampling locations were not detectable at this location. All of the elements detected at Location 6a, except for aluminum and selenium were present only in the particulate phase. Both of these elements were present predominantly in the particulate phase, but were detected at a low level in the vapor phase as well. Overall, these results are consistent with the dilution and cooling of the flue gas in the PSDS.

Table 7.1-1 and Tables 7.1-2 through 7.1-4 reveal that at Locations 4a (ESP #1 inlet), 5a (ESP #1 outlet), and 6a (scrubber outlet; hot) mercury is predominantly (>99 percent) present in the vapor phase, results which are consistent with the vapor pressure characteristics of mercury.

Table 7.1-5 presents the mercury concentrations measured in samples collected at Location 6b (scrubber outlet; cool,diluted). The mercury data from samples at this location are somewhat scattered, with mercury detected in the particulate phase in two of three samples, and in the vapor phase in one of three samples. However, the concentrations measured in both phases vary by nearly an order of magnitude between samples. These results contrast with the concentrations measured at Location 6a, which were generally consistent among samples. In addition, the total mercury concentrations measured at Location 6b (Table 7.1-5) were nearly a factor of ten lower than the corresponding concentrations measured at Location 6a. For these reasons, the vapor/particulate phase distribution for mercury at Location 6b is not interpreted further.

7.1.3 PAH/SVOC

Table 7.1-7 shows a summary of the average phase distribution of PAH/SVOC compounds at each sampling location. The data in Table 7.1-7 were derived by averaging the phase distributions measured in the sets of three samples collected at each location. The particulate and vapor phase PAH/SVOC concentrations (both in ng/Ncm) measured in individual samples at each location are presented in Tables 7.1-8 through 7.1-11. Table 7.1-7 provides a convenient means of following trends in the phase distribution of individual PAH/SVOC compounds. The average phase distribution data in Table 7.1-7 and the individual concentrations shown in Table 7.1-8 show that at Location 4a (ESP #1 inlet), most of the PAH/SVOC species are only in the vapor phase. These include compounds such as naphthalene, biphenyl and dibenzofuran. One exception to this vapor-only distribution among the SVOC compounds is pentachlorophenol; however, the results for this compound must be interpreted with caution because of the high vapor-phase detection limit for pentachlorophenol.

Among the PAH, the three-ring compounds phenanthrene and anthracene, the four-ring compounds fluoranthene, benz(a)anthracene, and chrysene, and the 5-ring compounds benzo(b and k)fluoranthene are predominantly in the vapor phase. The 5-ring PAH, benzo(e)pyrene is split between the particulate and vapor phases, while benzo(a)pyrene and the remainder of the ≥ 5 -ring PAH compounds are present only in the particulate phase.

These results are largely consistent with the vapor pressure characteristics of the various PAH/SVOC compounds and the temperature of the flue gas at this location.

The phase distributions at Location 5a (ESP #1 outlet), shown in both Table 7.1-7 (average percent) and Table 7.1-9 (concentrations), are largely similar to the distributions at Location 4a. Most SVOC/PAH compounds are in the vapor phase only, except for a few SVOC and ≥ 5 -ring PAH which are found in the particulate phase. The particulate-phase concentrations at Location 5a are significantly reduced compared with those at Location 4a, a result that is consistent with the operation of the ESP. The total PAH concentrations are also generally consistent, with the levels at Location 4a being higher than the levels at Location 5a on corresponding days in two of the three days of sampling.

The phase distributions at Location 6a (scrubber outlet; hot), shown in both Table 7.1-7 (average percent) and Table 7.1-10 (concentrations), are largely similar to the observations at Locations 4a and 5a. Again, most SVOC/PAH compounds are in the vapor phase only, except for a few SVOC and ≥ 5 -ring PAH which are found in the particulate phase. A somewhat larger fraction of the 5-ring PAH, benzo(b and k)fluoranthene, now appears in the particulate phase, a result that is consistent with the lower temperatures downstream of the scrubber compared with the temperatures at the ESP locations.

The phase distributions at Location 6b (scrubber outlet; cooled;diluted) are shown in both Table 7.1-7 (average percent) and Table 7.1-11 (concentrations). The problems associated with low flue gas sample volumes for the vapor phase samples, as discussed earlier, limit the comparisons possible with the results at this location. A few observations can nevertheless be made from the data at Location 6b. Once again, similar to the other locations, a large number of PAH/SVOC are in the vapor phase only. However, compared with the other locations, additional species are present in both particulate and vapor phases, namely, 2,6-dinitrotoluene, 2,4-dinitrotoluene and dibenzofuran. The 3- and 4-ring PAH compounds appear to be present exclusively in the vapor-phase despite the ambient temperature conditions in the PSDS. However, the ~ 2 s residence time within the PSDS is short and may not be sufficient to permit the redistribution of these PAH as a result of vapor condensation mechanisms.

Finally, it must be noted that the reference sampling method (Method 23) utilized for this group of species may yield an artifactual bias toward higher vapor-phase concentrations.

This sampling artifact arises from the possibility of desorption of PAH/SVOC adsorbed on the surface of fly-ash collected on the filter, during the course of sampling. The compounds desorbed from the particulate matter would then be collected in the XAD resin trap, and analyzed as vapor-phase constituents. This desorption artifact is also referred to as "blow-off" in the literature and is commonly observed in ambient air sampling. However, the use of a heated and temperature-equilibrated filter for source sampling in Method 23 reduces the likelihood of desorption-related sampling artifacts. The conclusions derived above regarding the phase distribution of PAH/SVOC are therefore likely to be largely accurate.

7.1.4 Dioxins/Furans

Table 7.1-12 shows a summary of the average phase distribution of dioxins/furans at each sampling location. The data in Table 7.1-12 were derived by averaging the phase distributions measured in the sets of three samples collected at each location. The particulate and vapor phase dioxin/furan concentrations (in pg/Ncm) measured in individual samples at each location are presented in Tables 7.1-13 and 7.1-14. The corresponding concentrations in the blank train samples are shown in Table 7.1-15.

For this group of air toxics, samples were collected only at two locations: (1) outlet of the scrubber; hot flue - Location 6a, and (2) outlet of the scrubber; diluted, cooled flue - Location 6b. Table 7.1-15 shows the corresponding vapor- and particulate-phase concentrations of the individual dioxin and furan compounds in the train blank from each location, in the filter blank, and in the method blank. Note that the concentrations shown in Tables 7.1-13 and 7.1-14 are corrected for train blank concentrations. Concentrations are presented both for individual congeners and for total congener classes in the upper and lower portions of the three tables, respectively.

Table 7.1-12 provides a convenient means of following trends in the phase distribution of individual dioxins/furans. The results shown in Table 7.1-12, combined with the concentration data shown in Tables 7.1-13 and 7.1-14, reveal that the vapor and particulate-phase concentrations of most dioxin and furan compounds in the flue gas sampled were below the detection limit. Tables 7.1-12 and 7.1-13 show that the only compounds with measured concentrations at Location 6a are a single congener each of

heptachlorodibenzo-p-dioxin and tetrachlorodibenzofuran, as well as octachlorodibenzo-p-dioxin and octachlorodibenzofuran. Other than 2,3,7,8-tetrachlorodibenzofuran, small amounts of the detectable dioxins/furans were present in the particulate phase -- this result is consistent with typical distributions of the higher chlorinated species between both the particulate and vapor phases. For most cases with reported concentrations for these species, the values detected were below the calibration range.

A summary of concentrations at Location 6a for total congener classes shown in the lower part of Table 7.1-12 does highlight, however, that the few classes with reportable concentrations were found only in the vapor-phase samples. The detection limits for vapor and particulate phases were similar, to within a factor of five, for most classes in the three samples collected at Location 6a. Therefore, it may be reasonably concluded that at this location, the target dioxins and furans are typically present at less than detectable levels in both phases, and when detected were present only in the vapor phase.

The concentrations measured at Location 6b, as shown in Table 7.1-14, reveal generally similar results. The flue gas at this location was diluted and cooled prior to sampling. The results in Table 7.1-12 and 7.1-14 show even fewer detectable target species at Location 6b than the number detected at Location 6a (Table 7.1-13). This result is consistent with the higher vapor phase detection limits for these samples because of the low sample collection volumes, as discussed in the introduction to this section. A single congener each of heptachloro-dibenzo-p-dioxin and -dibenzofuran, as well as octachlorodibenzofuran were detected in one of the three samples (not all in the same sample) at this location. The few species with reportable concentrations at 6b were found only in the vapor-phase samples.

The samples collected and analyzed at Location 6b typically had a ten- to fifty-fold higher detection limit for vapor-phase concentrations compared with the detection limit for particulate concentrations. The detection limit for particulate concentrations in the samples collected at Location 6b was, however, very similar to the particulate concentration detection limits for samples collected at Location 6a. Since the reported concentrations were only from the vapor-phase samples, it can be concluded that detectable levels of dioxin and furan species are present only in the vapor-phase even after the flue gas from the scrubber is cooled.

The potential for sampling artifacts from the desorption of vapor from particulate matter were discussed previously for PAH/SVOC. Such sampling artifacts may also arise for dioxins and furans. However, as stated previously, the use of a heated and temperature-equilibrated filter for source sampling in Method 23 reduces the likelihood of desorption-related sampling artifacts. The conclusions derived above regarding the phase distribution of dioxins and furans are therefore likely to be largely accurate.

7.1.5 Summary

In summary, the phase distribution results show a credible picture for most elements and for the organic species. Observed distributions appear to vary in a realistic way with changes in temperature at different sampling locations. Results from the PSDS appear to suffer from the differing detection limits achieved for vapor and particle phase species with that approach; improvement of phase distribution measurements with the PSDS is needed.

TABLE 7.1-1. SUMMARY OF AVERAGE PHASE DISTRIBUTIONS OF ELEMENTS AT EACH SAMPLING LOCATION

SPECIES	Percentage Phase Distribution; P: Particulate; V: Vapor													
	Location 4a				Location 5a				Location 6a				Location 6b	
	P	V	±SD		P	V	±SD		P	V	±SD		P	V
<i>Elements (ICP)</i>														
Aluminum	99.5	0.5	0.6		93.1	6.9	1.5		94.1	5.9	1.3		70.7	29.3
Barium	99.9	0.1	0.1		99.6	0.4	0.7		99.6	0.4	0.6		100	0
Beryllium	100	0	0		100	0	0		100	0	0		100	0
Boron	99.5	0.5	0.5		51.6	48.4	48.2		72.1	27.9	48.3		ND	ND
Cadmium	100	0	0		82.1	17.9	31		100	0	0		ND	ND
Calcium	99.6	0.4	0.4		86.2	13.8	6.4		91.6	8.4	3.5		100	0
Chromium	100	0	0		100	0	0		100	0	0		100	0
Cobalt	100	0	0		100	0	0		100	0	0		100	0
Copper	99.3	0.7	0.2		37.7	62.3	11.9		100	0	0		100	0
Manganese	99.8	0.2	0.4		3.9	96.1	1.9		39.8	60.2	15.2		100	0
Molybdenum	99.8	0.2	0.4		100	0	0		100	0	0		ND	ND
Nickel	99.7	0.3	0.3		100	0	0		100	0	0		100	0
Potassium	99.9	0.1	0.1		73.5	26.5	45.9		100	0	0		100	0
Silicon	100	0	0		96.5	3.5	1.7		98.5	1.5	1.4		ND	ND
Sodium	99.2	0.8	0.4		59.3	40.7	6.5		61	39	13.1		100	0
Titanium	100	0	0.1		100	0	0		100	0	0		100	0
Vanadium	100	0	0		100	0	0		100	0	0		100	0
<i>Elements (GFAA)</i>														
Antimony	100	0	0		22	78	13.7		100	0	0		NA	NA
Arsenic	100	0	0		100	0	0		98.3	1.7	1.6		NA	NA
Lead	100	0	0		68.3	31.7	54.9		100	0	0		NA	NA
Selenium	100	0	0		73.3	26.7	23.7		89.6	10.4	4.2		88.7	11.3
Mercury	0.5	99.5	0.5		0.1	99.9	0.1		0.1	99.8	0.03		NA	NA

P,V,SD: Averages and standard deviation derived from the three samples at each location

ND: Not detected in all three samples at this location

NA: Not available because of analytical uncertainties, for samples collected at location 6b (see text)

TABLE 7.1-2. VAPOR/PARTICULATE DISTRIBUTION FOR ELEMENTS FROM ESP-1 INLET (LOCATION 4a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-4a-MUM-622			C-4a-MUM-624			C-4a-MUM-627		
	Vapor	Solid	Total	Vapor	Solid	Total	Vapor	Solid	Total
Aluminum		54.2	208000		578	213600		1650	133000
Potassium	ND <	123	145000		203	145000	ND <	95.9	93400
Silicon		646	2930000		252	2950000		728	2640000
Sodium		229	34000		155	39400		482	38000
Titanium	ND <	57.3	38700	ND <	61.6	39400		53.6	37700
Antimony	ND <	0.179	51.3	ND <	0.191	95.2	ND <	0.139	104
Arsenic	ND <	0.0230	1210		0.132	1200		4.03	1380
Barium		5.06	26100		55.6	26700		9.68	20700
Beryllium	ND <	2.81	43	ND <	3.00	48	ND <	2.19	44.2
Boron		57.7	14300	ND <	4.37	13500		196	18600
Cadmium	ND <	3.32	11.3	ND <	3.55	18.9	ND <	2.70	23.6
Calcium		249	443000		1420	387000		4030	485000
Chromium	ND <	3.07	861	ND <	3.28	1220		2.83	4550
Cobalt	ND <	2.81	253	ND <	3.00	273	ND <	2.19	258
Copper		5.08	626		4.87	704		3.24	690
Lead	ND <	0.1023	390	ND <	0.109	461	ND <	0.0795	384
Manganese	ND <	9.97	10200		65.7	10000	ND <	7.75	13000
Mercury		12.6	0.140		15.7	ND < 0.0093		12.6	0.0475
Molybdenum		1.05	157	ND <	0.546	231	ND <	0.40	286
Nickel		3.45	562	ND <	3.28	778		4.20	2480
Selenium		1.033	98.0	ND <	0.191	123		0.635	113
Vanadium	ND <	2.81	996	ND <	3.00	1210	ND <	2.19	1070

ND < = Not detected, value following ND < is detection limit.

TABLE 7.1-3. VAPOR/PARTICULATE DISTRIBUTION FOR ELEMENTS FROM ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-5a-MUM-622			C-5a-MUM-624			C-5a-MUM-627									
	Vapor	Solid	Total	Vapor	Solid	Total	Vapor	Solid	Total							
Aluminum	84.8	1130	1220		69.8	767	837		34.7	619	654					
Potassium	632	162	794	ND <	99	129	179	ND <	90.8	63.7	109					
Silicon	155	7740	7890		265	ND <	4630	ND <	222	ND <	4230	ND <	4230			
Sodium	442	472	913		132	223	355		65.3	ND <	88.3		133			
Titanium	ND <	45.1	42.9	65.4	ND <	46.1	28.3	51.3	ND <	42.1	23.5		44.6			
Antimony		2.96	0.197	3.15		0.396	0.173	0.569		0.241	0.100		0.342			
Arsenic	ND <	0.0175	2.21	2.22	ND <	0.0171	1.83	1.84	ND <	0.0156	1.40		1.41			
Barium		2.68	230	233	ND <	2.47	98.7	100	ND <	2.25	189		190			
Beryllium	ND <	2.14	0.238	ND <	2.14	ND <	2.09	0.075	ND <	2.09	ND <	1.90	0.069	ND <	1.90	
Boron	ND <	3.31	463	465		35.3	30.9	66.2		68.3	6.00		74.3			
Cadmium	ND <	2.53	ND <	3.68	ND <	3.68	ND <	2.66	ND <	3.59	ND <	2.42	ND <	3.28	ND <	3.28
Calcium		482	1790	2280		160	1410	1570		156	1380		1540			
Chromium	ND <	2.14	26.4	27.5	ND <	2.1	3.63	4.68	ND <	1.90	ND <	2.58	ND <	2.58		
Cobalt	ND <	2.14	1.12	ND <	2.14	ND <	2.09	0.770	ND <	2.09	ND <	1.90	0.716	ND <	1.90	
Copper		3.51	2.34	5.85		3.44	3.17	6.61		3.27	1.076		4.35			
Lead	ND <	0.0778	1.36	1.40	ND <	0.0759	0.530	0.568	ND <	0.0693	0.487		0.521			
Manganese		38.5	20.4	58.9		10.10	13.7	23.8	ND <	7.27	11.5		15.1			
Mercury		9.59	ND <	0.0066	9.60		8.41	0.0530	8.47		17.4	0.0267	17.4			
Molybdenum	ND <	0.389	2.37	2.56	ND <	0.380	0.949	1.14	ND <	0.346	0.359		0.533			
Nickel	ND <	2.53	14.6	15.8	ND <	2.47	1.83	ND <	3.06	ND <	2.25	ND <	0.589	ND <	2.25	
Selenium		1.34	14.9	16.3		4.18	12.2	16.4		9.04	3.78		12.8			
Vanadium	ND <	2.14	5.34	6.41	ND <	2.09	3.71	4.75	ND <	1.90	3.14		4.09			

ND < = Not detected, value following ND < is detection limit.

TABLE 7.1-4. VAPOR/PARTICULATE DISTRIBUTION OF ELEMENTS FROM SCRUBBER OUTLET (LOCATION 6a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6a-MUM-622			C-6a-MUM-624			C-6a-MUM-627*		
	Vapor	Solid	Total	Vapor	Solid	Total	Vapor	Solid	Total
Aluminum		38.2	821		52.2	736		45.6	632
Potassium	ND <	113	82.8	ND <	109	110	ND <	95.3	86.5
Silicon		107	ND <		164	ND <	ND <	64.2	ND <
Sodium		165	ND <		94.5	200		84.9	190
Titanium	ND <	52.6	39.9	ND <	50.8	28.2	ND <	44.3	26.4
Antimony	ND <	0.167	0.222	ND <	0.155	0.128	ND <	0.155	0.153
Arsenic		0.0652	1.93	ND <	0.0199	1.60		0.0263	1.33
Barium		2.85	253	ND <	2.66	203	ND <	2.66	191
Beryllium	ND <	2.38	0.123	ND <	2.21	0.080	ND <	2.21	0.086
Boron	ND <	3.58	8.58	ND <	46.7	9.15	ND <	3.32	9.84
Cadmium	ND <	3.10	ND <	ND <	2.88	ND <	ND <	2.55	ND <
Calcium		214	1870		168	1400		70.3	1540
Chromium	ND <	2.62	218	ND <	2.44	ND <	ND <	2.43	19.7
Cobalt	ND <	2.38	2.77	ND <	2.21	0.529	ND <	2.21	0.658
Copper	ND <	2.86	14.5	ND <	2.66	1.44	ND <	2.66	1.18
Lead	ND <	0.0954	1.02	ND <	0.0886	0.816	ND <	0.0885	0.804
Manganese		23.9	31.9		18.0	8.86		26.7	11.0
Mercury		11.2	ND <		17.1	ND <		9.73	ND <
Molybdenum	ND <	0.477	9.45	ND <	0.443	0.452	ND <	0.443	0.475
Nickel	ND <	2.62	203	ND <	2.44	1.94	ND <	2.43	9.34
Selenium		1.10	14.2		0.979	10.1		1.09	6.05
Vanadium	ND <	2.38	6.13	ND <	2.21	4.41	ND <	2.21	3.66

ND < = Not detected, value following ND < is detection limit.

* Average result of duplicate analyses.

TABLE 7.1-5. VAPOR/PARTICULATE DISTRIBUTION OF ELEMENTS FROM SCRUBBER OUTLET - DILUTE (LOCATION 6b) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6b-MUM-622				C-6b-MUM-624				C-6b-MUM-627									
	Vapor		Solid		Total		Vapor		Solid		Total							
Aluminum	ND <	539	744		1010	ND <	523	420		682	653	254		907				
Potassium	ND <	2530	109	ND <	2530	ND <	2540	30.6	ND <	2540	ND <	3050	ND <	12.1	ND <	1530		
Silicon	ND <	1470	NA	ND <	1470	ND <	1480	NA	ND <	1480	ND <	1780	NA	ND <	1780			
Sodium	ND <	1900	85.8	ND <	1900	ND <	1850	66.8	ND <	1850	ND <	2020	37.5	ND <	2020			
Titanium	ND <	1170	37.2	ND <	1170	ND <	1180	22.5	ND <	1180	ND <	1410	18.8	ND <	1410			
Antimony	ND <	4.44	ND <	1.14	ND <	2.79	ND <	4.72	ND <	0.955	ND <	2.84	4.87	ND <	1.21	5.47		
Arsenic	ND <	0.571		1.72		2.00		NA		0.955		0.955	ND <	0.606	ND <	1.21	ND <	0.908
Barium	ND <	63.4		270		301	ND <	61.6		172		203	ND <	67.4		140		173
Beryllium	ND <	57.1	ND <	1.14	ND <	29.1	ND <	55.4	ND <	0.955	ND <	28.2	ND <	60.6	ND <	1.21	ND <	30.9
Boron	ND <	88.8		NA	ND <	88.8	ND <	86.2		NA	ND <	86.2	ND <	94.3		NA	ND <	94.3
Cadmium	ND <	69.8		1.14	ND <	69.8	ND <	67.7	ND <	0.955	ND <	34.3	ND <	80.9	ND <	1.21	ND <	41.0
Calcium	ND <	904		2060		2510	ND <	908		1160		1610	ND <	1090		1240		1780
Chromium	ND <	63.4	ND <	5.72	ND <	34.6	ND <	61.6		0.517	ND <	61.6	ND <	67.4		0.693	ND <	67.4
Cobalt	ND <	57.1	ND <	2.29	ND <	29.7	ND <	55.4		1.91	ND <	28.7	ND <	60.6		2.42	ND <	31.5
Copper	ND <	69.8		1.16	ND <	69.8	ND <	67.7		0.491	ND <	67.7	ND <	74.1		0.634	ND <	74.1
Lead		76.0		1.14		77.1	ND <	2.70		0.955	ND <	2.70	ND <	2.70	ND <	1.21	ND <	1.95
Manganese	ND <	216		12.6	ND <	216	ND <	209		7.65	ND <	210	ND <	229		9.10	ND <	229
Mercury	ND <	0.381		0.646		0.837		4.35	ND <	0.0477		4.38	ND <	0.404		0.139	ND <	0.404
Molybdenum	ND <	12.7	ND <	0	ND <	12.7	ND <	12.3		0.716	ND <	12.3	ND <	13.5	ND <	0	ND <	13.5
Nickel	ND <	63.4	ND <	2.29	ND <	32.9	ND <	61.6	ND <	1.91	ND <	31.7	ND <	67.4	ND <	2.42	ND <	34.9
Selenium		1.10		6.30		7.40	ND <	4.72		4.77		7.13	ND <	4.72		3.75		6.11
Vanadium	ND <	57.1		5.72	ND <	56.6	ND <	55.4		2.86	ND <	55.1	ND <	60.6		2.42	ND <	61.1

ND < = Not detected, value following ND < is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

TABLE 7.1-6. VAPOR/PARTICULATE DISTRIBUTION OF ELEMENTS IN BLANK GAS SAMPLES ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-6a-MUM-620			C-6b-MUM-620		
	Vapor	Solid	Total	Vapor	Solid	Total
Aluminum	ND<	14.6	ND<	2.53	ND<	6.54
Potassium	ND<	81.3	ND<	10.2	ND<	33.9
Silicon		51.3		15400		15500
Sodium		153	ND<	54.7		208
Titanium	ND<	37.7	ND<	0.088	ND<	12.6
Antimony	ND<	0.150	ND<	0.0696	ND<	0.145
Arsenic		0.147		0.0750		0.222
Barium	ND<	1.93	ND<	0.316	ND<	0.853
Beryllium	ND<	1.71	ND<	0.005	ND<	0.575
Boron		5.86	ND<	1.61		7.33
Cadmium	ND<	2.14	ND<	2.06	ND<	2.09
Calcium	ND<	29.1	ND<	6.06	ND<	13.7
Chromium		3.36	ND<	1.63		4.99
Cobalt	ND<	1.71	ND<	0.077	ND<	1.71
Copper	ND<	1.93		0.513	ND<	1.93
Lead		3.08		0.0857		3.17
Manganese	ND<	6.43	ND<	0.135	ND<	2.23
Mercury		0.505	ND<	0.018		0.532
Molybdenum	ND<	0.428	ND<	0.017	ND<	0.154
Nickel	ND<	1.93		0.074	ND<	1.93
Selenium	ND<	0.150		0.364		0.439
Vanadium	ND<	1.71	ND<	0.057	ND<	0.609

ND< = Not detected, value following ND< is detection limit.

TABLE 7.1-7. SUMMARY OF AVERAGE PHASE DISTRIBUTIONS OF PAH/SVOC AT EACH SAMPLING LOCATION

SPECIES	Percentage Phase Distribution; P: Particulate; V: Vapor											
	Location 4a			Location 5a			Location 6a			Location 6b		
	ESP#1 Inlet			ESP#1 Outlet			FGD Outlet (Hot)			FDG Out (Diluted)		
	P	V	±SD	P	V	±SD	P	V	±SD	P	V	±SD
PAH/SVOC												
Benzylchloride	0.3	99.7	0.5	0	100	0	0	100	ND	0	100	ND
Acetophenone	0.2	99.8	0.3	0	100	0	0	100	0	4.7	95.3	2.3
Hexachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	0.1	99.9	0.1	0	100	0.1	0.8	99.4	0.3	0.1	99.9	0.1
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Quinoline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroacetophenone	0.6	99.4	0.3	0	100	0.1	0	100	0	0	100	0
1-Methylnaphthalene	0.2	99.8	0.1	0.1	99.9	0.1	1.9	98.1	0.4	0.4	99.6	0.5
2-Methylnaphthalene	0.2	99.8	0.1	0	100	0	0	100	0	0.5	99.5	0.3
Hexachlorocyclopentadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biphenyl	0.1	99.9	0.2	0	100	0	0.8	99.2	1.4	0	100	0
Acenaphthylene	0	100	0	0	100	0	0	100	0	0	100	0
2,6-Dinitrotoluene	0	100	0	0	100	0	ND	ND	ND	100	0	0
Acenaphthene	0.4	99.6	0.2	0.4	99.6	0.3	2.8	97.4	4.5	1.4	98.6	1
Dibenzofuran	0.4	99.6	0.1	0	100	0	1.9	98.1	3.3	33.9	66.1	57.2
2,4-Dinitrotoluene	0	100	0	0	100	0	0	100	0	68.9	33.1	57.3
Fluorene	0.4	99.6	0.1	0	100	0	2.7	97.3	3	0.9	99.1	0.8
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	100	0	ND	100	0	0	ND	ND	ND	ND	ND	ND
Phenanthrene	0.4	99.6	0.2	0.1	99.9	0.1	1.3	98.7	2.3	0.5	99.5	0.6
Anthracene	0.4	99.6	0.3	0.1	99.9	0.1	0.8	99.2	1.4	1.8	98.2	0.6
Fluoranthene	0.5	99.5	0.2	0.3	99.7	0.4	0	100	0	0.8	99.2	0.3
Pyrene	0.4	99.6	0.1	1.7	98.3	2.2	0.9	99.1	1.5	0.9	99.1	0.3
Benz(a)anthracene	0.8	99.2	0.3	0.6	99.4	0.3	8.8	91.2	15.2	NA	NA	NA
Chrysene	0.4	99.6	0.1	0.1	99.9	0.1	0	100	0	NA	NA	NA
Benzo(b & k)fluoranthene	3.1	96.9	0.8	1.1	98.9	0.9	17.8	82.2	15.9	3.5	96.5	4.1
Benzo(e)pyrene	67.8	32.2	55.7	1.4	98.6	1.3	47	53	50.3	NA	NA	NA
Benzo(a)pyrene	100	0	0	13.6	86.4	11.7	100	0	0	NA	NA	NA
Indeno(1,2,3-c,d)pyrene	100	0	0	100	0	0	100	0	0	NA	NA	NA
Dibenzo(a,h)anthracene	100	0	0	100	0	0	84.8	15.2	26.4	NA	NA	NA
Benzo(g,h,i)perylene	100	0	0	100	0	0	100	0	0	NA	NA	NA

P,V,SD: Averages and standard deviation derived from the three samples at each location

ND: Not detected in all three samples at this location

NA: Not available because of analytical uncertainties, for samples collected at location 6b (see text)

TABLE 7.1-8. VAPOR/PARTICULATE DISTRIBUTION FOR PAH/SVOC FROM ESP-1 INLET (LOCATION 4a) (ng/Nm³)

Analyte	C-4a-MM5- F-621	C-4a-MM5- X-621	C-4a-MM5- F+X-621	C-4a-MM5- F-623	C-4a-MM5- X-623	C-4a-MM5- F+X-623	C-4a-MM5- F-626	C-4a-MM5- X-626	C-4a-MM5- F+X-626
Benzylchloride	8.42	1000	1010	ND < 1.32	889	889	ND < 1.38	6100	6100
Acetophenone	12.2	2640	2650	4.08	33500	33500	10.2	140000	140000
Hexachloroethane	ND < 1.37	ND < 13.7	ND < 13.7	ND < 1.32	ND < 13.2	ND < 13.2	ND < 1.38	ND < 13.8	ND < 13.8
Naphthalene	ND < 0.27	1310	1310	ND < 0.26	1840	1840	7.33	3690	3700
Hexachlorobutadiene	ND < 1.37	ND < 13.7	ND < 13.7	ND < 1.32	ND < 13.2	ND < 13.2	ND < 1.38	ND < 13.8	ND < 13.8
Quinoline	ND < 13.7	ND < 13.7	ND < 13.7	ND < 13.2	ND < 13.2	ND < 13.2	ND < 13.8	ND < 13.8	ND < 13.8
2-Chloroacetophenone	7.86	836	844	4.48	917	921	5.83	1820	1830
2-Methylnaphthalene	6.81	2100	2110	1.41	1310	1310	1.89	1000	1010
1-Methylnaphthalene	2.91	994	997	0.519	607	608	0.73	422	423
Hexachlorocyclopentadiene	ND < 1.37	ND < 13.7	ND < 13.7	ND < 1.32	ND < 13.2	ND < 13.2	ND < 1.38	ND < 13.8	ND < 13.8
Biphenyl	6.59	2240	2250	9.18	20500	20500	9.05	64900	64900
Acenaphthylene	ND < 0.27	339	339	ND < 0.26	189	190	ND < 0.28	ND < 2.75	ND < 2.75
2,6-Dinitrotoluene	ND < 1.37	30400	30400	ND < 1.32	9100	9100	ND < 1.38	27800	27800
Acenaphthene	16.7	2810	2820	3.39	1220	1220	6.32	1390	1390
Dibenzofuran	14.8	4390	4400	5.28	1680	1690	5.55	952	958
2,4-Dinitrotoluene	ND < 1.37	931	931	ND < 1.32	556	557	ND < 1.38	714	715
Fluorene	12.8	2430	2440	6.08	2050	2060	5.63	1230	1230
Hexachlorobenzene	ND < 1.37	ND < 13.7	ND < 13.7	ND < 1.32	ND < 13.2	ND < 13.2	ND < 1.38	ND < 13.8	ND < 13.8
Pentachlorophenol	1.41	ND < 13.7	ND < 13.7	ND < 1.32	ND < 13.2	ND < 13.2	ND < 1.38	ND < 13.8	ND < 13.8
Phenanthrene	34.5	8910	8940	62.5	41700	41800	32.4	6040	6070
Anthracene	4.16	1030	1030	4.17	2970	2970	3.49	494	497
Fluoranthene	13.2	2020	2040	68.7	35400	35400	14.5	2760	2770
Pyrene	6.22	1260	1270	15.3	5960	5970	5.41	1210	1220
Benz(a)anthracene	1.76	168	169	3.93	712	716	0.78	89.4	90.2
Chrysene	2.58	765	767	17.2	3520	3530	1.11	417	418
Benzo(b & k)fluoranthene	11.2	330	342	7.01	318	325	4.07	103	107
Benzo(e)pyrene	3.58	99.6	103	2.45	ND < 2.64	3.77	1.07	ND < 2.75	ND < 2.75
Benzo(a)pyrene	1.93	ND < 2.73	3.30	2.29	ND < 2.64	3.61	0.57	ND < 2.75	ND < 2.75
Indeno(1,2,3-c,d)pyrene	1.65	ND < 2.73	3.02	1.77	ND < 2.64	3.09	0.33	ND < 2.75	ND < 2.75
Dibenz(a,h)anthracene	1.66	ND < 2.73	3.03	0.519	ND < 2.64	ND < 2.64	0.56	ND < 2.75	ND < 2.75
Benzo(g,h,i)perylene	2.11	ND < 2.73	3.48	1.38	ND < 2.64	2.70	0.47	ND < 2.75	ND < 2.75

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 7.1-9. VAPOR/PARTICULATE DISTRIBUTION FOR PAH/SVOC FROM ESP-1 OUTLET (LOCATION 5a) (ng/Nm³)

Analyte	C-5a-MM5- F-621	C-5a-MM5- X-621	C-5a-MM5- F+X-621	C-5a-MM5- F-623	C-5a-MM5- X-623	C-5a-MM5- F+X-623	C-5a-MM5- F-626	C-5a-MM5- X-626	C-5a-MM5- F+X-626
Benzylchloride	ND < 0.721	10200	10200	ND < 0.950	379	380	ND < 0.874	380	380
Acetophenone	1.22	4130	4130	ND < 0.950	178	179	3.08	3450	3450
Hexachloroethane	ND < 0.721	ND < 7.21	ND < 7.21	ND < 0.950	ND < 9.50	ND < 9.50	ND < 0.874	ND < 8.74	ND < 8.74
Naphthalene	7.54	7790	7800	ND < 0.190	913	913	ND < 0.175	2420	2420
Hexachlorobutadiene	ND < 0.721	ND < 7.21	ND < 7.21	ND < 0.950	ND < 9.50	ND < 9.50	ND < 0.874	ND < 8.74	ND < 8.74
Quinoline	ND < 7.21	ND < 7.21	ND < 7.21	ND < 9.50	ND < 9.50	ND < 9.50	ND < 8.74	ND < 8.74	ND < 8.74
2-Chloroacetophenone	0.789	756	757	ND < 0.950	81.7	82.1	ND < 0.874	1330	1340
2-Methylnaphthalene	1.18	1440	1440	ND < 0.190	329	329	0.839	841	842
1-Methylnaphthalene	0.606	1220	1220	ND < 0.190	240	240	0.495	570	571
Hexachlorocyclopentadiene	ND < 0.721	ND < 7.21	ND < 7.2	ND < 0.950	ND < 9.50	ND < 9.50	ND < 0.874	ND < 8.74	ND < 8.74
Biphenyl	1.32	21200	21200	0.198	10700	10700	0.835	8220	8220
Acenaphthylene	ND < 0.144	16.8	16.9	ND < 0.190	19.6	19.7	ND < 0.175	74.7	74.8
2,6-Dinitrotoluene	ND < 0.721	1470	1470	ND < 0.950	741	741	ND < 0.874	2960	2960
Acenaphthene	1.85	810	812	0.559	372	372	1.69	236	237
Dibenzofuran	3.85	19700	19700	1.22	19700	19700	2.82	16300	16300
2,4-Dinitrotoluene	ND < 0.721	2060	2060	ND < 0.950	2130	2130	ND < 0.874	1580	1580
Fluorene	4.07	7280	7280	1.46	8680	8680	3.60	7640	7650
Hexachlorobenzene	ND < 0.721	ND < 7.21	ND < 7.21	ND < 0.950	ND < 9.50	ND < 9.50	ND < 0.874	ND < 8.74	ND < 8.74
Pentachlorophenol	4.27	ND < 7.21	7.88	ND < 0.950	ND < 9.50	ND < 9.50	1.33	ND < 8.74	ND < 8.74
Phenanthrene	23.9	14100	14100	12.1	26600	26600	17.6	23900	23900
Anthracene	1.38	679	680	0.537	684	685	0.833	1200	1210
Fluoranthene	6.62	913	920	2.34	3990	3990	4.75	4420	4430
Pyrene	8.21	188	196	0.474	276	277	1.72	272	273
Benz(a)anthracene	0.274	28.4	28.7	0.435	137	137	0.843	209	210
Chrysene	1.16	528	529	0.595	3120	3120	4.62	5140	5140
Benzo(b & k)fluoranthene	1.81	83.5	85.3	1.41	173	174	1.02	314	316
Benzo(e)pyrene	0.552	24.3	24.8	0.573	26.7	27.2	ND < 0.175	31.5	31.6
Benzo(a)pyrene	0.527	9.37	9.90	1.17	4.18	5.35	ND < 0.175	ND < 1.75	ND < 1.75
Indeno(1,2,3-c,d)pyrene	0.615	ND < 1.44	ND < 1.44	0.240	ND < 1.90	ND < 1.90	0.611	ND < 1.75	ND < 1.75
Dibenz(a,h)anthracene	0.309	ND < 1.44	ND < 1.44	0.398	ND < 1.90	ND < 1.90	0.458	ND < 1.75	ND < 1.75
Benzo(g,h,i)perylene	0.521	ND < 1.44	ND < 1.44	0.400	ND < 1.90	ND < 1.90	0.642	ND < 1.75	ND < 1.75

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 7.1-10. VAPOR/PARTICULATE DISTRIBUTION FOR PAH/SVOC FROM SCRUBBER OUTLET (LOCATION 6a) (ng/Nm³)

Analyte	C-6a-MM5- F-621		C-6a-MM5- X-621		C-6a-MM5- F+X-621		C-6a-MM5- F-623		C-6a-MM5- X-623		C-6a-MM5- F+X-623		C-6a-MM5- F-626		C-6a-MM5- X-626		C-6a-MM5- F+X-626	
Benzylchloride	ND <	2.18	ND <	2.18	ND <	2.18	ND <	2.28	ND <	2.28	ND <	2.28	ND <	2.26		19.9		21.0
Acetophenone	ND <	2.18		470		471	ND <	2.28		529		530	ND <	2.26		1160		1160
Hexachloroethane	ND <	2.18	ND <	2.18	ND <	2.18	ND <	2.28	ND <	2.28	ND <	2.28	ND <	2.26	ND <	2.26	ND <	2.26
Naphthalene		1.98		209		211		1.91		355		357		1.26		448		450
Hexachlorobutadiene	ND <	2.18	ND <	2.18	ND <	2.18	ND <	2.28	ND <	2.28	ND <	2.28	ND <	2.26	ND <	2.26	ND <	2.26
Quinoline	ND <	21.8	ND <	21.8	ND <	21.8	ND <	22.8	ND <	22.8	ND <	22.8	ND <	22.6	ND <	22.6	ND <	22.6
2-Chloroacetophenone	ND <	2.18		155		157	ND <	2.28		134		135	ND <	2.26		202		203
2-Methylnaphthalene		0.874		60.3		61.2		1.12		48.1		49.2		1.05		48.7		49.8
1-Methylnaphthalene	ND <	0.435		23.1		23.3	ND <	0.456		17.4		17.6	ND <	0.452		18.0		18.2
Hexachlorocyclopentadiene	ND <	2.18	ND <	2.18	ND <	2.18	ND <	2.28	ND <	2.28	ND <	2.28	ND <	2.26	ND <	2.26	ND <	2.26
Biphenyl	ND <	0.435		33.5		33.7	ND <	0.456		29.3		29.5		0.642		26.3		27.0
Acenaphthylene	ND <	0.435		11.6		11.8	ND <	0.456		3.80		4.03	ND <	0.452		25.5		25.7
2,6-Dinitrotoluene	ND <	2.18	ND <	2.18	ND <	2.18	ND <	2.28	ND <	2.28	ND <	2.28	ND <	2.26	ND <	2.26	ND <	2.26
Acenaphthene	ND <	0.435		32.8		33.1	ND <	0.456		9.75		9.98		1.89		22.1		24.0
Dibenzofuran	ND <	2.18		81.5		82.5	ND <	2.28		59.7		60.9		3.35		54.7		58.0
2,4-Dinitrotoluene	ND <	2.18		14.0		15.1	ND <	2.28		7.57		8.71	ND <	2.26	ND <	2.26	ND <	2.26
Fluorene		0.739		75.1		75.8		0.461		44.8		45.3		2.46		37.6		40.0
Hexachlorobenzene	ND <	2.18	ND <	2.18	ND <	2.18	ND <	2.28	ND <	2.28	ND <	2.28	ND <	2.26	ND <	2.26	ND <	2.26
Pentachlorophenol	ND <	2.18	ND <	2.18	ND <	2.18	ND <	2.28	ND <	2.28	ND <	2.28	ND <	2.26	ND <	2.26	ND <	2.26
Phenanthrene	ND <	0.435		643		643	ND <	0.456		448		448		4.68		114		118
Anthracene		0.564		21.9		22.5	ND <	0.456		17.8		18.0	ND <	0.452		16.6		16.9
Fluoranthene	ND <	0.435		71.8		72.1	ND <	0.456		44.7		44.9	ND <	0.452		47.3		47.5
Pyrene	ND <	0.435		26.2		26.5	ND <	0.456		15.7		15.9		0.535		20.3		20.8
Benz(a)anthracene	ND <	0.435		3.38		3.59	ND <	0.456		2.40		2.63		0.517		1.45		1.96
Chrysene	ND <	0.435		9.41		9.63	ND <	0.456		6.29		6.52	ND <	0.452		4.24		4.47
Benzo(b & k)fluoranthene		2.60		5.89		8.49	ND <	0.456		3.32		3.55		1.24		4.16		5.40
Benzo(e)pyrene		1.04	ND <	0.435		1.26	ND <	0.456		0.695		0.923		0.809		1.16		1.97
Benzo(a)pyrene		1.07	ND <	0.435		1.29	ND <	0.456	ND <	0.456	ND <	0.456		1.64	ND <	0.452		1.87
Indeno(1,2,3-c,d)pyrene		0.600	ND <	0.435		0.818	ND <	0.456	ND <	0.456	ND <	0.456		1.22	ND <	0.452		1.44
Dibenz(a,h)anthracene		0.589	ND <	0.435		0.807		0.536	ND <	0.456		0.764		0.696		0.585		1.28
Benzo(g,h,i)perylene		0.694	ND <	0.435		0.911	ND <	0.456	ND <	0.456	ND <	0.456		0.935	ND <	0.452		1.16

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 7.1-11. VAPOR/PARTICULATE DISTRIBUTION FOR PAH/SVOC FROM SCRUBBER OUTLET-DILUTE (LOCATION 6b) (ng/Nm³)

Analyte	C-6b-MM5- F-621		C-6b-MM5- X-621		C-6b-MM5- F+X-621		C-6b-MM5- F-623		C-6b-MM5- X-623		C-6b-MM5- F+X-623		C-6b-MM5- F-626		C-6b-MM5- X-626		C-6b-MM5- F+X-626	
Benzylchloride	ND <	1.58	ND <	70.8	ND <	70.8	ND <	1.69	ND <	67.4	ND <	67.4	ND <	1.71		1470		1470
Acetophenone		129		3090		3220		349		11700		12100		568		7210		7780
Hexachloroethane	ND <	1.58	ND <	70.8	ND <	70.8	ND <	1.69	ND <	67.4	ND <	67.4	ND <	1.71	ND <	64.6	ND <	64.6
Naphthalene		0.775		2580		2580		1.39		3920		3920		1.57		839		841
Hexachlorobutadiene	ND <	1.58	ND <	70.8	ND <	70.8	ND <	1.69	ND <	67.4	ND <	67.4	ND <	1.71	ND <	64.6	ND <	64.6
Quinoline	ND <	15.8	ND <	708	ND <	708	ND <	16.9	ND <	674	ND <	674	ND <	17.1	ND <	646	ND <	646
2-Chloroacetophenone	ND <	1.58	ND <	70.8	ND <	70.8	ND <	1.69		1320		1320	ND <	1.71		4620		4620
2-Methylnaphthalene		0.428		1070		1070		0.494		305		305		1.02		97.0		98.0
1-Methylnaphthalene		0.444		401		402		0.803		146		147		0.465		62.0		62.5
Hexachlorocyclopentadiene	ND <	1.58	ND <	70.8	ND <	70.8	ND <	1.69	ND <	67.4	ND <	67.4	ND <	1.71	ND <	64.6	ND <	64.6
Biphenyl	ND <	0.317		127		127	ND <	0.339		54.8		54.8	ND <	0.343		26.1		26.1
Acenaphthylene	ND <	0.317		137		137	ND <	0.339		47.0		47.0	ND <	0.343		55.8		55.8
2,6-Dinitrotoluene		537	ND <	70.8		537		1080	ND <	67.4		1080		812	ND <	64.6		812
Acenaphthene		0.435		210		210		2.15		109		111		2.25		115		117
Dibenzofuran	ND <	1.58		189		189		2.54		139		141		2.33	ND <	64.6	ND <	64.6
2,4-Dinitrotoluene		48.6	ND <	70.8		48.6		123	ND <	67.4		123		1.76		232		234
Fluorene		0.636		400		401		1.61		209		211		1.12		62.0		63.1
Hexachlorobenzene	ND <	1.58	ND <	70.8	ND <	70.8	ND <	1.69	ND <	67.4	ND <	67.4	ND <	1.71	ND <	64.6	ND <	64.6
Pentachlorophenol	ND <	1.58	ND <	70.8	ND <	70.8	ND <	1.69	ND <	67.4	ND <	67.4	ND <	1.71	ND <	64.6	ND <	64.6
Phenanthrene	ND <	0.317		849		849		6.28		1180		1190		2.84		255		258
Anthracene		1.49		128		129		2.20		116		118		1.84		77.7		79.6
Fluoranthene		0.927		198		199		4.90		490		495		2.72		327		329
Pyrene		1.36		193		194		2.78		296		299		2.40		196		198
Benz(a)anthracene	ND <	0.317	ND <	14.2	ND <	14.2		0.789	ND <	13.5	ND <	13.5	ND <	0.343		12.9		12.9
Chrysene		0.538	ND <	14.2	ND <	14.2		1.97	ND <	13.5	ND <	13.5		1.07	ND <	12.9	ND <	12.9
Benzo(b & k)fluoranthene		1.72		19.6		21.3		0.703		28.5		29.2	ND <	0.343		141		141
Benzo(e)pyrene		0.514	ND <	14.2	ND <	14.2	ND <	0.339	ND <	13.5	ND <	13.5	ND <	0.343		33.5		33.5
Benzo(a)pyrene		0.771	ND <	14.2	ND <	14.2	ND <	0.339	ND <	13.5	ND <	13.5	ND <	0.343		63.3		63.3
Indeno(1,2,3-c,d)pyrene	ND <	0.317	ND <	14.2	ND <	14.2		0.518	ND <	13.5	ND <	13.5	ND <	0.343	ND <	12.9	ND <	12.9
Dibenz(a,h)anthracene	ND <	0.317	ND <	14.2	ND <	14.2		0.593	ND <	13.5	ND <	13.5	ND <	0.343		16.0		16.0
Benzo(g,h,i)perylene	ND <	0.317	ND <	14.2	ND <	14.2		0.656	ND <	13.5	ND <	13.5	ND <	0.343		13.3		13.3

DL Ratio = Detection limit ratio.

SD = Standard deviation.

ND < = Not detected, value following ND < is detection limit.

TABLE 7.1-12. SUMMARY OF AVERAGE PHASE DISTRIBUTIONS OF DIOXINS/FURANS AT EACH SAMPLING LOCATION

SPECIES	Percentage Phase Distribution; P: Particulate; V: Vapor											
	Location 4a ESP#1 Inlet			Location 5a ESP#1 Outlet			Location 6a FGD Outlet (Hot)			Location 6b FDG Out (Diluted)		
	P	V	±SD	P	V	±SD	P	V	±SD	P	V	±SD
Dioxins/Furans												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	-	-	-	-	-	-	33.3	66.7	57.7	0	100	0
Octachlorodibenzo-p-dioxin	-	-	-	-	-	-	39.7	60.3	22.2	ND	ND	ND
2,3,7,8-Tetrachlorodibenzofuran	-	-	-	-	-	-	0	100	0	ND	ND	ND
1,2,3,7,8-Pentachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
2,3,4,7,8-Pentachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,4,7,8-Hexachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,6,7,8-Hexachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,7,8,9-Hexachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
2,3,4,6,7,8-Hexachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
1,2,3,4,6,7,8-Heptachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	0	100	0
1,2,3,4,7,8,9-Heptachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
Octachlorodibenzofuran	-	-	-	-	-	-	26.2	73.8	37	0	100	0
Total Tetrachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
Total Pentachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
Total Hexachlorodibenzo-p-dioxin	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
Total Heptachlorodibenzo-p-dioxin	-	-	-	-	-	-	0	100	0	0	100	0
Total Tetrachlorodibenzofuran	-	-	-	-	-	-	0	100	0	ND	ND	ND
Total Pentachlorodibenzofuran	-	-	-	-	-	-	0	100	0	ND	ND	ND
Total Hexachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	ND	ND	ND
Total Heptachlorodibenzofuran	-	-	-	-	-	-	ND	ND	ND	0	100	0

P,V,SD: Averages and standard deviation derived from the three samples at each location

-: No samples analyzed for dioxins/furans from locations 4a and 5a

ND: Not detected in all three samples at this location

TABLE 7.1-13. VAPOR/PARTICULATE DISTRIBUTION FOR DIOXINS/FURANS FROM FGD OUTLET (LOCATION 6a) (pg/Nm³)

Analyte	C-6a-MM5-621					C-6a-MM5-623					C-6a-MM5-626				
	VAPOR		SOLID		TOTAL	VAPOR		SOLID		TOTAL	VAPOR		SOLID		TOTAL
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND <	3.30	ND <	1.31	ND < 2.31	ND <	2.29	ND <	2.56	ND < 2.43	ND <	3.80	ND <	2.31	ND < 3.05
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND <	3.17	ND <	1.26	ND < 2.21	ND <	3.99	ND <	4.81	ND < 4.40	ND <	4.16	ND <	1.79	ND < 2.97
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND <	4.49	ND <	1.40	ND < 2.94	ND <	2.40	ND <	4.27	ND < 3.34	ND <	2.25	ND <	1.64	ND < 1.94
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND <	4.96	ND <	1.42	ND < 3.19	ND <	2.46	ND <	6.67	ND < 4.56	ND <	6.63	ND <	2.83	ND < 4.73
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND <	6.03	ND <	3.32	ND < 4.67	ND <	3.04	ND <	6.84	ND < 4.94	ND <	2.34	ND <	4.02	ND < 3.18
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.91 J		ND <	9.20	1.77 J	ND <	16.8	2.43 J		6.12 J	2.52 J		ND <	15.3	5.08 J
Octachlorodibenzo-p-dioxin	8.15 J		ND <	1.80 J	9.95 K		11.0	18.4 J		29.3 K	13.1		ND <	8.19 J	21.3 K
2,3,7,8-Tetrachlorodibenzofuran		14.2	ND <	1.80	15.1	11.8 L	ND <	1.76		12.7 L	10.1		ND <	1.43	10.8
1,2,3,7,8-Pentachlorodibenzofuran	ND <	11.5	ND <	1.87	ND < 6.68	ND <	6.23	ND < 2.89	ND <	4.56	ND <	8.73	ND <	2.73	ND < 5.73
2,3,4,7,8-Pentachlorodibenzofuran	ND <	7.42	ND <	1.53	ND < 4.48	ND <	5.69	ND < 6.02	ND <	5.85	ND <	6.60	ND <	1.70	ND < 4.15
1,2,3,4,7,8-Hexachlorodibenzofuran	ND <	8.18	ND <	2.06	ND < 5.12	ND <	6.26	ND < 5.02	ND <	5.64	ND <	6.48	ND <	2.34	ND < 4.41
1,2,3,6,7,8-Hexachlorodibenzofuran	ND <	6.39	ND <	1.29	ND < 3.84	ND <	4.33	ND < 4.97	ND <	4.65	ND <	4.75	ND <	2.40	ND < 3.57
1,2,3,7,8,9-Hexachlorodibenzofuran	ND <	10.3	ND <	5.53	ND < 7.91	ND <	5.50	ND < 7.95	ND <	6.72	ND <	7.21	ND <	4.68	ND < 5.94
2,3,4,6,7,8-Hexachlorodibenzofuran	ND <	3.11	ND <	1.29	ND < 2.20	ND <	1.52	ND < 4.33	ND <	2.93	ND <	1.79	ND <	2.70	ND < 2.24
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND <	92.3	ND <	10.2	ND < 51.3	ND <	29.8	ND < 16.5	ND <	23.2	ND <	17.6	ND <	12.1	ND < 14.8
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND <	5.68	ND <	2.14	ND < 3.91	ND <	3.37	ND < 7.71	ND <	5.54	ND <	5.17	ND <	6.23	ND < 5.70
Octachlorodibenzofuran		5.65 J	ND <	4.22	7.76 J	ND <	7.88	ND <	30.8	ND <	19.4	3.51 J		3.86 J	7.37 J
Total Tetrachlorodibenzo-p-dioxin		ND*			ND		ND		ND		ND				
Total Pentachlorodibenzo-p-dioxin		ND			ND		ND		ND		ND				
Total Hexachlorodibenzo-p-dioxin		ND			ND		ND		ND		ND				
Total Heptachlorodibenzo-p-dioxin	1.91				ND < 9.20 C	ND	ND < 16.8 C	ND < 16.8 C		2.52			ND <	15.3 C	
Total Tetrachlorodibenzofuran		114			114		72.5		ND		72.5		78.5		78.5
Total Pentachlorodibenzofuran		17.4			17.4		12.4 L		ND		12.4 L		12.4 L		12.4 L
Total Hexachlorodibenzofuran		ND			ND		ND		ND		ND				
Total Heptachlorodibenzofuran		ND			ND		ND		ND		ND				

ND < = Not detected, value following ND < is detection limit.

C = Blank-corrected concentration below detection/calibration limit.

J = Concentration detected below calibration range.

K = Total value in the calibration range, but individual values from the XAD or filter fraction or both were below the calibration range.

L = Isotope ratio for this analyte slightly outside theoretical value range.

Total sample non detect values are the average detection limit from the XAD and Filter fractions.

Total sample values from XAD and filter fractions containing one hit and one non detect were calculated as :
hit + (non detect/2).

* Total congener class results do not include any contribution from non detects. Congener class detection limits are equivalent to those for the 2,3,7,8-substituted isomers shown.

OCDD-13C12 recovery response factors were slightly above the +30 % limit from initial calibration on each analysis day.

Sample results corrected for train blank.

TABLE 7.1-14. VAPOR/PARTICULATE DISTRIBUTION FOR DIOXINS/FURANS FROM FGD OUTLET - DILUTE (LOCATION 6b) (pg/Nm³)

Analyte	C-6b-MM5-621 **					C-6b-MM5-623					C-6b-MM5-626					
	VAPOR		SOLID		TOTAL	VAPOR		SOLID		TOTAL	VAPOR		SOLID		TOTAL	
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND <	31.2	ND <	1.00	ND < 16.1	ND <	70.1	ND <	1.56	ND < 35.9	ND <	57.0	ND <	2.14	ND < 29.6	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND <	64.7	ND <	2.39	ND < 33.5	ND <	83.1	ND <	2.04	ND < 42.6	ND <	51.2	ND <	2.64	ND < 26.9	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND <	83.8	ND <	2.49	ND < 43.1	ND <	119	ND <	2.06	ND < 60.3	ND <	21.7	ND <	2.16	ND < 12.0	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND <	91.2	ND <	2.97	ND < 47.1	ND <	86.8	ND <	1.62	ND < 44.2	ND <	73.1	ND <	2.35	ND < 37.7	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND <	137	ND <	2.60	ND < 69.7	ND <	173	ND <	2.10	ND < 87.4	ND <	60.2	ND <	1.88	ND < 31.0	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ND <	431	ND <	6.73	ND < 219	13.4 J		ND <	7.34	12.0 J		ND <	183	ND <	3.50	ND < 93.3
Octachlorodibenzo-p-dioxin	ND <	2560 C	ND <	63.3 C	ND < 1310 C	ND <	2760 C	ND <	68.2 C	ND < 1410 C	ND <	2760 C	ND <	68.2 C	ND < 1410 C	
2,3,7,8-Tetrachlorodibenzofuran	ND <	62.1	ND <	2.70	ND < 32.4	ND <	71.5	ND <	2.06	ND < 36.8	ND <	38.4	ND <	2.17	ND < 20.3	
1,2,3,7,8-Pentachlorodibenzofuran	ND <	64.3	ND <	1.67	ND < 33.0	ND <	101	ND <	2.11	ND < 51.6	ND <	29.8	ND <	2.93	ND < 16.4	
2,3,4,7,8-Pentachlorodibenzofuran	ND <	49.8	ND <	1.98	ND < 25.9	ND <	80.6	ND <	1.92	ND < 41.2	ND <	72.2	ND <	1.79	ND < 37.0	
1,2,3,4,7,8-Hexachlorodibenzofuran	ND <	60.7	ND <	3.54	ND < 32.1	ND <	92.3	ND <	3.22	ND < 47.8	ND <	52.7	ND <	2.56	ND < 27.6	
1,2,3,6,7,8-Hexachlorodibenzofuran	ND <	51.8	ND <	2.39	ND < 27.1	ND <	99.6	ND <	2.90	ND < 51.3	ND <	48.8	ND <	2.70	ND < 25.8	
1,2,3,7,8,9-Hexachlorodibenzofuran	ND <	145	ND <	5.00	ND < 75.1	ND <	201	ND <	3.60	ND < 102	ND <	153	ND <	3.41	ND < 78.4	
2,3,4,6,7,8-Hexachlorodibenzofuran	ND <	112	ND <	1.93	ND < 56.7	ND <	72.2	ND <	1.94	ND < 37.1	ND <	36.6	ND <	2.56	ND < 19.6	
1,2,3,4,6,7,8-Heptachlorodibenzofuran		131 J	ND <	14.0	138 J	ND <	293	ND <	9.41	ND < 151	ND <	118	ND <	6.20	ND < 62.1	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND <	301	ND <	5.21	ND < 153	ND <	156	ND <	4.08	ND < 80.2	ND <	59.4	ND <	4.42	ND < 31.9	
Octachlorodibenzofuran	ND <	287	ND <	7.05	ND < 147	243 J		ND <	5.91	246 J		ND <	167	ND <	8.31	ND < 87.6
Total Tetrachlorodibenzo-p-dioxin		ND*			ND		ND			ND		ND		ND		ND
Total Pentachlorodibenzo-p-dioxin		ND			ND		ND			ND		ND		ND		ND
Total Hexachlorodibenzo-p-dioxin		ND			ND		ND			ND		ND		ND		ND
Total Heptachlorodibenzo-p-dioxin		ND			ND		13.4			4.47		ND		ND		ND
Total Tetrachlorodibenzofuran		ND			ND		ND			ND		ND		ND		ND
Total Pentachlorodibenzofuran		ND			ND		ND			ND		ND		ND		ND
Total Hexachlorodibenzofuran		ND			ND		ND			ND		ND		ND		ND
Total Heptachlorodibenzofuran		131			131		ND			ND		ND		ND		ND

ND < = Not detected, value following ND < is detection limit.

C = Blank-corrected concentration below detection/calibration limit.

J = Concentration detected below calibration range.

K = Total value in the calibration range, but individual values from the XAD or filter fraction or both were below the calibration range.

L = Isotope ratio for this analyte slightly outside theoretical value range.

Total sample non detect values are the average detection limit from the XAD and Filter fractions.

Total sample values from XAD and filter fractions containing one hit and one non detect were calculated as :
hit + (non detect/2).

* Total congener class results do not include any contribution from non detects. Congener class detection limits are equivalent to those for the 2,3,7,8-substituted isomers shown.

OCDD-13C12 recovery response factors were slightly above the +30 % limit from initial calibration on each analysis day.

** = several isotope ratios in the continuing calibration were slightly out of the theoretical range on the day these samples were analyzed.

Sample results corrected for train blank.

TABLE 7.1-15. VAPOR/PARTICULATE DISTRIBUTION FOR DIOXINS/FURANS IN BLANK GAS SAMPLES (pg/Nm³)

Analyte	6a TRAIN BLANK C-6a + b-MM5-620				6b TRAIN BLANK C-6a + b-MM5-620 **				FILTER BLANK	METHOD BLANK										
	VAPOR	SOLID	TOTAL		VAPOR	SOLID	TOTAL		C-6b-MM5-627	VAPOR	SOLID	TOTAL								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND <	1.16	ND <	1.66	ND <	1.41	ND <	35.2	ND <	1.66	ND <	18.4	ND <	2.37	ND <	2.16	ND <	2 23	ND <	2.20
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND <	2.27	ND <	1.52	ND <	1.90	ND <	68.5	ND <	1.52	ND <	35.0	ND <	2.31	ND <	5.24	6.74 J		9.36 J	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND <	1.66	ND <	1.57	ND <	1.62	ND <	50.0	ND <	1.57	ND <	25.8	ND <	2.13	ND <	5.62	ND <	30 1	ND <	17.9
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND <	1.70	ND <	2.52	ND <	2.11	ND <	51.4	ND <	2.52	ND <	27.0	ND <	1.47	ND <	5.56	12.9 J		15.7 J	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND <	2.11	ND <	1.96	ND <	2.04	ND <	63.6	ND <	1.96	ND <	32.8	ND <	2.66	ND <	10.4	ND <	35 3	ND <	22.8
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	4.58 J		5.03 J		9.61 J		138 J	5.03 J	143 J	5.52	16.7	28 0		36.3						
Octachlorodibenzo-p-dioxin	34.0 J		25.3 J		59.3 K		1025 J	25.3 J	1050 K	17.7 J		54.1		135						189
2,3,7,8-Tetrachlorodibenzofuran	ND <	1.41	ND <	1.36	ND <	1.39	ND <	42.4	ND <	1.36	ND <	21.9	ND <	0.77	ND <	1.67	ND <	3.49	ND <	2.58
1,2,3,7,8-Pentachlorodibenzofuran	ND <	1.82	ND <	1.95	ND <	1.89	ND <	54.9	ND <	1.95	ND <	28.4	ND <	0.97	ND <	6.80	4.47 J		7.87 J	
2,3,4,7,8-Pentachlorodibenzofuran	ND <	1.06	ND <	1.48	ND <	1.27	ND <	32.0	ND <	1.48	ND <	16.7	ND <	2.00	ND <	4.72	ND <	21.8	ND <	13.3
1,2,3,4,7,8-Hexachlorodibenzofuran	ND <	1.96	ND <	2.70	ND <	2.33	ND <	59.0	ND <	2.70	ND <	30.8	ND <	0.97	ND <	6.78	11.4 J		14.8 J	
1,2,3,6,7,8-Hexachlorodibenzofuran	ND <	1.99	ND <	1.95	ND <	1.97	ND <	60.1	ND <	1.95	ND <	31.0	ND <	1.68	ND <	6.22	9.99 J		13.1 J	
1,2,3,7,8,9-Hexachlorodibenzofuran	ND <	3.82	ND <	3.91	ND <	3.87	ND <	115	ND <	3.91	ND <	59.7	ND <	3.95	ND <	12.0	ND <	35 1	ND <	23.6
2,3,4,6,7,8-Hexachlorodibenzofuran	ND <	1.18	ND <	1.38	ND <	1.28	ND <	35.7	ND <	1.38	ND <	18.5	ND <	1.47	ND <	8.86	ND <	37.9	ND <	23.4
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND <	7.68	ND <	11.8	ND <	9.74	ND <	232	ND <	11.8	ND <	122	ND <	3.63	ND <	10.4	15% J		20.7 K	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND <	2.57	ND <	2.83	ND <	2.70	ND <	77.6	ND <	2.83	ND <	40.2	ND <	2.29	ND <	14.9	29.7		37.2	
Octachlorodibenzofuran	ND <	5.26	ND <	7.82	ND <	6.54	ND <	159	ND <	7.82	ND <	83.2	2.42 J		22.5 J		109		132	
Total Tetrachlorodibenzo-p-dioxin																				
Total Pentachlorodibenzo-p-dioxin																	6.74		6.74	
Total Hexachlorodibenzo-p-dioxin																	12.9		12.9	
Total Heptachlorodibenzo-p-dioxin	4.58		8.89		13.5		138		8.89		147						28.0		28.0	
Total Tetrachlorodibenzofuran																				
Total Pentachlorodibenzofuran																	4.47		4.47	
Total Hexachlorodibenzofuran																	21.4		21.4	
Total Heptachlorodibenzofuran																	45.2		45.2	

ND < = Not detected, value following ND < is detection limit.

C = Blank-corrected concentration below detection/calibration limit.

J = Concentration detected below calibration range.

K = Total value in the calibration range, but individual values from the XAD or filter fraction or both were below the calibration range.

L = Isotope ratio for this analyte slightly outside theoretical value range.

Total sample non detect values are the average detection limit from the XAD and Filter fractions.

Total sample values from XAD and filter fractions containing one hit and one non detect were calculated as :

hit + (non detect/2).

* Total congener class results do not include any contribution from non detects. Congener class detection limits are equivalent to those for the 2,3,7,8-substituted isomers shown.

OCDD-13C12 recovery response factors were slightly above the +30 % limit from initial calibration on each analysis day

7.2 Plume Simulating Dilution Sampling (PSDS)

7.2.1 Introduction

Dilution sampling was included in the original scope of work at the stack location for the purposes of observing the probable plume effects of dilution and cooling on the stack emissions as typically measured by conventional hot stack sampling methods. Condensation and secondary reactions within the plume can cause the character and chemistry of the emission to be quite different at points of exposure than at the stack. By comparing the results of simultaneously conducted hot and dilute sampling, insight to these differences and their implications regarding air toxics exposures may be gained.

7.2.2 Sampling

7.2.2.1 Location and Schedule. Both the dilution scrubber sampling (Location 6b) and conventional hot sampling (Location 6a) were conducted at the FGD outlet. The sampling was performed at the 350 foot level (about mid-elevation) in the stack serving Unit 1. The sampling area is in a 7-8 foot radial annulus between the outer and inner stack walls, and is accessed by an external elevator. The inner stack is of brick/mortar construction having an inside diameter of 25 feet.

All hot sampling was conducted through four test ports spaced at 90° intervals on the stack circumference. The ports are 4-in. MPT nipples mounted about 52 in. above the floor grating. This sampling location meets EPA Reference Method 1 criteria as the ports are situated about eight stack diameters above the nearest upstream disturbance and about thirteen diameters below the exit.

Dilution sampling was conducted through a fifth port (4-in. MPT nipple) which was installed through a cast iron access plate on the inner stack wall at 52 in. above the floor grating. The dilution sampler was rigidly coupled to this port and remained stationary for all sampling.

Two diluent gas tube trailers were located on ground level at the base of the stack. Samples and sampling trains were shuttled between the lab and the sampling deck in the

elevator as required. The diluent gas was delivered from the tube trailers, through a pressure regulating manifold mounted at ground level, up to the sampling deck through a 0.75-in. Teflon line. Communication between ground level and the sampling deck was by two-way radio.

The dilution sampling schedule was virtually identical to the hot stack (Location 6a) sampling schedule as described in Section 3.1. The primary difference was with the dilute particulate sampling times, which were no less than eight hours each day for both the 8-in. x 10-in. filter and the cascade impactor.

7.2.2.2 Description. The following types of sampling were conducted at the dilution sampling location (6b):

- SVOC*
PAH/SVOC
Dioxins/Furans
- VOC
- Aldehydes
- Elements*
- Anions*
- Cyanide
- Ammonia
- Particle Mass
- Particle Size Distribution

* These substances were measured by methods which distinguish between vapor phase and particle phase.

All of the dilute gas samples were taken with Chester Environmental's plume simulating dilution sampler (PSDS) at the scrubber outlet location (6b) as described previously. The sampling configuration is shown schematically in Figure 7.2-1. The flue gas sample was removed from the stack through a single port, without traversing (traversing is

prohibited by the size and configuration of the PSDS and peripherals). After dilution, mixing and retention, particle samples were taken onto an 8-in. x 10-in. quartz filter for mass and the appropriate chemical analyses, and into a cascade impactor for size distribution by mass. Gas phase samples were taken from a common gas sampling manifold following the 8-in. x 10-in. particle filter.

The major components of the PSDS are the inlet nozzle, transfer tube, mixing and aging (dilution) chamber, and the various particle and gas phase sampling apparatus. All of the wetted surfaces in the sampler are stainless steel, Teflon or Viton. A brief description of these major components and the general operating procedures is provided in the following paragraphs.

Inlet Nozzle. A conventional Method 5 buttonhook sampling nozzle was installed on the transfer tube to extract a hot flue gas sample isokinetically. The nozzle was sized on-site to match sample flow with stack gas velocity within the targeted range of diluent gas rate (~ 20 -25 dscfm) and dilution ratio (~ 25 -35:1).

Transfer Tube. The sample entering the inlet nozzle passes through the transfer tube and into the dilution chamber for dilution, aging and collection, along with secondary particles formed in the dilution process. The transfer tube is maintained at stack temperature to prevent premature condensation. An S-type pitot tube and a thermocouple are installed on the transfer tube to monitor stack gas velocity and temperature. The flow rate through the transfer tube is established by the difference between the total stack pressure at the inlet nozzle and the static pressure in the dilution chamber. This pressure difference, monitored with a magnehelic gage installed between the upstream port of the pitot and the dilution chamber, is referred to as chamber pressure. The chamber pressure - flow relationship is established by calibration of the nozzle/transfer tube assembly as an integrated unit. The operating chamber pressure was determined on-site using this calibration with the appropriate temperature and pressure corrections for the actual stack conditions encountered.

Dilution Chamber. The dilution chamber facilitates mixing of the flue gas with dilution gas, cooling and aging of this mixture to simulate the dilution processes occurring in

a plume, and distribution of the aged mixture to the various sampling devices. The chamber flows were balanced by throttling the dilution gas (supplied under pressure) as required to establish the operating chamber pressure (for the specified flue gas flow rate through the transfer tube) while maintaining the necessary sampling device flow rates (withdrawn under vacuum).

The dilution sampler was operated according to Chester Environmental's PSDS Standard Operating Procedure, as modified to accommodate the special requirements of this project. The appropriate operating points for balancing source gas and dilution gas flows within prescribed targets were established and maintained on-site, using a calculation spreadsheet and a portable computer. The spreadsheet contains calibration constants for all of the appropriate dilution sampler components (transfer tube/nozzle combinations, flow metering orifice) and accepts operator inputs for actual ambient, stack, and sampling parameters. At start-up, initial operating points were calculated using inputs estimated from prior tests or default values. Over the course of each day's testing, the spreadsheet was updated with actual operating conditions and the appropriate operating points maintained. The operating parameters were manually recorded at 15 minute intervals on special field data sheets designed for this project.

Particle Sampling. Dilute particle samples were collected with an 8-in. x 10-in. high-purity quartz fiber filter and with a Pilat Mark 3 cascade impactor from two parallel circuits exiting the dilution chamber.

In one circuit the impactor was used to collect particles in eight size ranges. Particles in each size range were collected on pre-weighed glass fiber substrates for gravimetric (mass distribution) analyses. The sample flow was established and maintained at a rate of about 1.0 dscfm with a Method 5 type pump and meter box.

The second circuit was used to provide bulk particulate sample quantities across the entire size range. The circuit consisted of an 8-in. x 10-in. filter holder containing a pre-weighed 8-in. x 10-in. high purity quartz filter which was analyzed for mass, elements and anions for inorganic days, and for PAH/SVOC and dioxin/furans for organic days. A dilute sample flow rate of about 20-25 dscfm was maintained by a high-volume centrifugal blower,

controlled with a Variac. The flow rate was monitored with a calibrated sharp-edged orifice installed downstream of the filter.

Because of the low concentrations after dilution (< 1 mg/dscm), particulate samples were collected for as long as the dilution sampler was operated on any given sampling day. This ranged from 8-10 hours, as required to complete the daily sampling schedules. Because of the combination of low concentration and low flow rate, the cascade impactor was operated for two consecutive days without changing substrates. This provided for three runs of 16-20 hour duration.

Gas Phase Sampling. All of the dilute gas phase samples were taken from a common gas sampling manifold installed downstream of the 8-in. x 10-in. filter between the metering orifice and the blower. Samples were taken for the same analyses as for the hot gas phase samples, with equipment and methods of essentially the same description (back-half only). The dilute samples were each taken from the manifold through a separate shut-off valve and Teflon tube into the appropriate sample collection means. The sampling rates were generally higher than the corresponding hot sampling rates (except VOST and SUMMA), but still within the range of conventional Method 5 equipment (0.8-1 dscfm).

7.2.2.3 Conditions. The dilute gas sampling conditions result from the mixing of the source gas with the dilution gas, at a dilution ratio of 25:1 or more (dilution ratio is defined as the volumes of dilution gas per one volume of source gas, at wet standard conditions). Accordingly, the composition of the dilution gas is of controlling significance. The purpose of the dilution gas is to simulate atmospheric plume cooling and condensation, while minimizing artifact formation and without adding background contamination.

The targeted dilute sample gas conditions are near ambient temperatures and < 30 percent relative humidity, after 2 seconds residence time. These conditions are considered appropriate to provide adequate condensation and equilibration of analyte species and to minimize artifact formation due to acidic condensate on sample substrates. The residence time is achieved by configuring the dilution chamber. In order to achieve the temperature and relative humidity objectives the dilution gas should be delivered at ambient temperature (or less) and virtually bone dry, i.e. less than 5 ppm moisture.

A cryogenically pure mixture of 21 percent oxygen/79 percent nitrogen (by volume) was used for the dilution gas. This composition is preferred over 100 percent nitrogen, for this project, in order to insure that the formation of specific OXY-PAH compounds is not inhibited by low oxygen levels within the dilution chamber, relative to the actual ambient plume environment. Because both component gases were of cryogenic origin, maximum dryness and organic background purity were insured. The dilution gas was delivered pre-mixed to the test site in high volume (40,000 scf) compressed gas tube-trailers. A delivery manifold on the trailer provided pressure regulation (25-30 psig) and activated carbon filtration of the gas prior to delivery to the sampling location. The gas was delivered to the sampling location through teflon line to a control manifold connected to the inlet of the dilution chamber. The control manifold consists of a rate control valve, temperature and pressure instrumentation, and final HEPA filtration.

The targeted dilute gas sampling conditions, and the actual conditions realized for each sampling day are shown in Table 7.2-1.

7.2.3 Analytical

The analytical methods and the analytical QA/QC applied to the samples collected with the PSDS were the same as those described in Section 4.1 for like analytes in flue gas samples. The only noteworthy exception is with the range of analyses performed on the dilute particulate samples (8-in. x 10-in. filter). The dilute particulate samples were not analyzed for carbon or radionuclides.

7.2.4 Results

The analytical results for the samples collected with the PSDS are shown in tables presented in Sections 5.0 and 7.1. Each table of Section 5.0 presents, for each analyte being reported, the results for each of three replicate sample runs plus the associated average and standard deviation. The results are presented as "whole train" results without distinction between particulate and vapor phases. The tables of Section 7.1 present separate particulate

(front half) and vapor phase (back half) results for runs which were so configured. All results are corrected for train blanks as appropriate.

All concentration results which are reported in units of mass/Ncm were calculated using the source gas volume (normal cubic meters) associated with the actual diluted gas volume which was sampled from the PSDS. Therefore, these results can be compared directly with the hot sampling results on a concentration basis.

7.2.5 Data Analysis

In the following paragraphs, the dilution sampling results (Location 6b) are compared with the hot stack sampling results (Location 6a). The comparisons are made on a concentration basis by analyte group. Before proceeding with data comparisons some of the constraints of the PSDS methods relative to the conventional reference methods should be discussed.

The current configuration of the PSDS was originally conceived and designed for the purpose of developing PM₁₀ source profiles or "fingerprints" to be used in chemical mass balance receptor modeling studies. These source measured profiles had to represent the source chemistry as it would impact a downwind ambient receptor. Therefore, the PSDS was configured for high dilution and residence time and to accept ambient PM₁₀ sampling devices. The result was a large stationary sampler exhibiting the following limitations relative to conventional the requirements of reference methods:

- Single point versus traversing operation
- No flow totalizer (dry gas meter) is used for source gas flow
- Sample recoveries are incomplete (no probe or dilution chamber rinse).

These factors are of little consequence to the original PSDS objective of "relative chemistry", but should be recognized when comparing results with the more "absolute" reference methods. Accordingly, there is more uncertainty with PSDS sample volumes (10-15 percent for individual primary flow measurements, 25-40 percent propagated through dilution ratio calculation and secondary flow measurements). Also, concentration measurements may be biased low due to unrecovered sample. It is difficult to quantify these sample loss effects on

a case by case basis, but it should be noted that PM_{10} and mercury vapor transmission efficiencies have been tested at over 90 percent.

7.2.5.1 PAH/SVOC. PAH/SVOC data are tabulated in Section 5.5.1. The comparison of the PAH/SVOC results is rather curious, as it shows the PSDS (6b) concentrations to be higher than the hot concentrations (6a) by a factor of about 8, as an average across all species reported. Excluding non-detects, the total PAH/SVOC average concentrations/standard deviations are 16,486/11,448 and 2,019/922 for the PSDS and hot stack samples, respectively. These concentrations represent total recoveries (particulate plus vapor) in units of ng/Ncm. Both the hot and PSDS profiles are similar in that acetophenone, naphthalene and chloroacetophenone are the dominant species, in decreasing order of concentration. The 2,019 ng/Ncm measured at the hot location is perhaps on the low side, but still consistent with the range of total PAH stack concentrations indicated by previous work^{1,2,3}. The PSDS concentrations are expected to be enriched in the particulate phase, but this degree of total PAH enrichment seems high. Contamination of the PSDS recoveries would cause them to be artificially high, but the consistency of the trend from day to day and the similarity of the speciation profiles suggest a more systematic process. Even a propagated error in PSDS sample volumes of 40-50 percent would not account for these differences.

It appears as if the compounds are being formed in the dilution process. Although unexpected it is conceivable, particularly among the oxygenated, nitrated and halogenated compounds. Given the presence of oxides of nitrogen, hydrogen chloride, hydrogen fluoride and the addition of excess oxygen, a variety of gas phase and cross-phase reactions may be occurring within the dilution chamber. 2,6-Dinitrotoluene is undetected in the hot samples but appears well above detection in the PSDS samples. 2,4-Dinitrotoluene is enriched by a factor of 16 over the hot samples, and benzo(a)pyrene by a factor of 24. Still, this degree of enrichment seems quite high for the 3-4 second residence times realized in the dilution chamber.

It must be noted that there is a high degree of variability in the total PAH/SVOC concentrations from day to day at all locations. Standard deviations of 50-150 percent of the three run average are not uncommon. The most consistent indication across the runs is the

phase distribution of the recovered compounds. On the average only 1 percent of the total PAH/SVOC recovered from the hot samples was in the particulate phase, compared with about 8 percent for the PSDS samples. This trend is consistent with the expectation for nucleation/condensation during the dilution and cooling process.

7.2.5.2 Dioxins/Furans. The dioxin/furan data from Locations 6a and 6b are tabulated in Section 5.6. The dioxin/furan results for both the PSDS and hot samples are dominated by non-detects, particularly the PSDS samples. In both the PSDS and hot samples the detected compounds are reported at levels which are on the same order as the detection limits (~ 10 - 150 pg/Ncm for PSDS samples and ~ 1 - 30 pg/Ncm for hot samples). Given this and the high variability (standard deviations of 50-90 percent of reported averages), the value of any comparison is questionable. Nonetheless, it is interesting to note that 100 percent of the detected compounds in the PSDS samples were found in the vapor phase, while the hot samples showed from 50-80 percent detected in the vapor phase for individual isomers and 100 percent in the vapor phase for the total congener groups. This is counter to expectations.

7.2.5.3 Aldehydes. Aldehyde data from flue gas samples are shown in Section 5.7.1. The aldehyde results show the PSDS samples to be enriched in formaldehyde ($21 \mu\text{g/Ncm}$ versus <3.0) and depleted in acetaldehyde ($13 \mu\text{g/Ncm}$ versus 88) and propionaldehyde ($<2.9 \mu\text{g/Ncm}$ versus 16), relative to the hot samples. Acrolein was not detected in any of the PSDS or hot samples. From prior similar work³, it is expected that the PSDS samples would be enriched in all of the aldehyde species, presumably due to their formation in the acidic environment within the dilution chamber. It is not clear why these results are inconsistent.

7.2.5.4 VOC. Only the VOC results from the VOST samples, shown in Section 5.4.1, will be considered in this section. The SUMMA results are compared with the VOST results for all locations in Section 7.5.

The only VOC compounds appearing with any consistency in both the PSDS and hot stack sample sets are chloromethane, methylene chloride (i.e., dichloromethane), acetone,

2-butanone, benzene and toluene. Excluding non-detects, the average total VOC concentration ($\mu\text{g}/\text{Ncm}$) and standard deviation over all runs is 1,406/803 for the PSDS samples and 778/380 for the hot stack samples. Methylene chloride clearly dominates both totals at 1,300 $\mu\text{g}/\text{Ncm}$ in the PSDS samples and 493 $\mu\text{g}/\text{Ncm}$ in the hot stack samples. Both methylene chloride and acetone were used in the field as probe rinse solvents; contamination from that use, rather than actual presence in flue gas, is believed to be the cause of the elevated levels of these VOC. 2-Butanone is enriched in the PSDS by a factor of about 1.5. The remaining compounds are depleted in the PSDS by factors ranging from 0.1 to 0.5. The compounds most depleted in the PSDS are benzene (by a factor of about 0.1) and toluene (by a factor of 0.2 to 0.5). It is tempting to relate the depletion of these single ring aromatic compounds to the enrichment of the multiple ring PAH compounds discussed above. On a concentration basis the apparent net depletion of benzene and toluene mass exceeds the net enrichment of PAH mass (at least 58 $\mu\text{g}/\text{Ncm}$ versus ~ 14 $\mu\text{g}/\text{Ncm}$), but other VOC removal mechanisms may be at work in the PSDS such as adsorption onto the cooler filter deposit or Teflon surfaces.

Again, variability in the data is high and the results should be considered accordingly.

7.2.5.5 Elements. The results for the elements are presented in Section 5.1.1, Tables 5-8 and 5-10, from the hot stack and PSDS samples, respectively. Because they are relatively inert to chemical change, the total concentration of each element is expected to be essentially the same in the PSDS and the hot stack samples, excluding any sampling or analytical error. Depending on the particulate loading and size distribution in the stack, the PSDS samples might be expected to compare low due to unrecoverable particle losses in the nozzle and transfer tube. The phase distribution is expected to change for the more volatile elements because the PSDS is operated at near ambient temperatures. Accordingly, particle phase enrichment is expected for some elements in the PSDS samples.

Relative to these expectations, the average results for most of the elements detected in both the PSDS and hot stack samples compare reasonably well. The elements reported above detection limits in both the PSDS and hot stack samples are aluminum, arsenic, barium, calcium, lead, mercury, and selenium. Of these, average aluminum, barium, and

calcium concentrations from the PSDS are slightly enriched, relative to the hot samples, by factors of 1.1, 1.04, and 1.1, respectively. The arsenic and selenium concentrations are depleted by factors of 0.6 and 0.6, respectively. The difference between the PSDS and hot stack concentrations for each of these elements is within the standard deviation of the respective averages.

The average lead concentration reported for the PSDS samples exceeds the corresponding hot sample average by a factor of 28 ($26 \mu\text{g/Ncm}$ versus $0.92 \mu\text{g/Ncm}$). This large discrepancy is due to a conspicuously high vapor phase lead concentration ($77.1 \mu\text{g/Ncm}$) reported in the PSDS sample for the first sampling day. Vapor phase lead was not detected in the PSDS samples for the second and third sampling days, and particle phase lead was detected in the first two samples at concentrations of $1.1 \mu\text{g/Ncm}$ and $0.96 \mu\text{g/Ncm}$. Considering the low volatility of lead and the low operating temperature of the PSDS, it appears that the high vapor phase lead concentration is the result of contamination or calculation error. Exclusion of this result from the total average brings the PSDS lead results into more reasonable agreement with the hot stack results.

Mercury was reported above the detection limit in all of the hot samples, but non-detects were reported for two of the vapor phase and one of the particle phase samples from the PSDS. The average total mercury concentrations ($\mu\text{g/Ncm}$)/standard deviations are 1.8/2.3 for the PSDS samples and 13/3.9 for the hot stack samples. The corresponding average particulate fractions are 0.40 and 0.002. Although the depletion of mercury in the PSDS samples seems excessive, the shift in relative phase distribution is as expected. Considering the variability among the reported results, the uncertainty of mercury measurements by Method 29, and the possibility of loss of mercury to the interior surfaces of the PSDS, the differences between the PSDS and hot stack results may be understandable. The results of mercury measurements by Method 29 and the HEST method are compared for all locations in Section 7.4.

The elements detected only in the hot samples include antimony, boron, chromium, cobalt, copper, manganese, molybdenum, nickel, potassium, sodium, titanium, and vanadium. Of these, the chromium, copper, molybdenum and nickel results may be suspect because they are dominated by conspicuously high levels for the first sampling day (C-6A-MUM-622). A review of the field log indicates that some abnormally large particle deposits

(typical of "port scrapings") were noted on the filter during recovery of the 6A-MUM-622 train. The ports at the 6a/6b locations were stainless steel which is typically alloyed using all of the suspect elements. Accordingly, the elimination of these outliers from the 6A-MUM-622 results is justified, and the respective hot stack average concentrations fall within the range of the PSDS limits of detection, as with the rest of the elements detected only in the hot samples.

7.2.5.6 Anions. The anion results presented in Section 5.3.1 show gas phase hydrogen chloride (HCl) and hydrogen fluoride (HF) and particle phase chlorides, fluorides, sulfates and phosphates. Comparing the average concentrations, the PSDS samples are depleted slightly in HCl and HF by factors of 0.65 and 0.94. The corresponding average concentrations ($\mu\text{g}/\text{Ncm}$)/standard deviations are 1160/229 and 5040/1720 for the PSDS samples and 1800/160 and 5340/1960 for the hot samples, for HCl and HF, respectively. Of the particulate anions, chlorides are enriched in the PSDS samples by a factor of 2.1 but the differences are not considered significant because the levels are very low ($4\text{--}11 \mu\text{g}/\text{Ncm}$) and include a non-detect for one of the hot stack samples. Fluoride and sulfate particulate are depleted in the PSDS samples by factors of 0.31 and 0.73, respectively. Phosphate particulate averages $11 \mu\text{g}/\text{Ncm}$ for both PSDS and hot stack samples.

Normally, particulate anions are expected to be enriched during the dilution process, which is not evidenced in these results. Perhaps the formation of sulfate and the other particulate anions is accelerated "in-stack" by the scrubber process and the corresponding low temperature/high moisture environment within the stack.

7.2.5.7 Ammonia and Cyanide. Ammonia was detected in only the first of the PSDS samples (C-6b-NH4-622) at a concentration of $825 \mu\text{g}/\text{Ncm}$, and in none of the hot stack samples. This degree of variability and uncertainty brings the value of comparison into question.

The cyanide results indicate non-detects in all of the PSDS samples and an average concentration of $68 \mu\text{g}/\text{Ncm}$ (27 standard deviation) for the hot stack samples. This complete depletion of cyanide in the PSDS is not understood at this time.

7.2.5.8 Particle Size Distribution. The results of the particle size distributions as measured by cascade impactors from the hot stack and the PSDS are shown in Section 5.11, Tables 5-112 and 5-113, respectively. Similar size distributions were found at the two locations, with a slight shift toward finer particles in the PSDS results. The mass median diameters (classic aerodynamic D_{50}) are $2.6\ \mu\text{m}$ for the hot stack and $2.0\ \mu\text{m}$ for the PSDS, respectively. The shift toward the smaller diameter in the PSDS is expected to be due to the loss of some larger particles in the PSDS nozzle and transfer tube, plus the enrichment of fine particles due to condensation/nucleation processes within the dilution chamber.

7.2.6 Summary

The comparison of absolute concentration results from the PSDS and hot sampling generally does not provide good agreement. Although agreement is found for a few analytes, and for some analyte characteristics (e.g., PAH phase distribution), most results do not agree well. Further evaluation is needed, perhaps under controlled conditions that minimize contamination and sampling variability, to assess the PSDS as a quantitative sampling approach for stack gas.

References

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3. Topical Report to U.S. Department of Energy, "Characterization of Air Toxics from a Laboratory Coal-Fired Combustor." Battelle Contract No. DE-AC22-91PC90366, September, 1993.

TABLE 7.2-1. PSDS SAMPLING CONDITIONS

	Dilution Sampling Parameters					Dilution Chamber Conditions			Stack Conditions		Volume Sampled	
	Source Gas Rate (dscfm)	Diluent Gas Rate (dscfm)	Dilution Ratio	Isokinetic Ratio (%)	Sampling Time (min)	Temp (°F)	Moisture (% vol)	Particle Conc. (mg/dscm)	Temp (°F)	Moisture (% vol)	(Nem source gas)	
											8"x10" Filter	Cascade Impactor
Targeted	0.6-1.0	20-25	25-35:1	100	480	= <90	<1%	<1	220	17.3		
Daily Average												
C-6B-621	0.78	22.33	28.78	103.3	480	111	0.58		240	17.19	6.06	0.28
C-6B-622	0.77	22.11	28.75	103.7	510	106	0.57	0.279	250	17.04	5.95	0.27
C-6B-623	0.77	22.16	28.96	103.2	480	99	0.51		250	15.35	5.69	0.26
C-6B-624	0.78	22.41	28.73	103.6	600	77	0.57	0.186	235	16.94	7.10	0.34
C-6B-626	0.77	22.16	28.89	103.5	480	89	0.55		226	16.54	5.61	0.27
C-6B-627	0.77	22.19	28.78	103.7	480	90	0.57	0.173	225	17.11	5.66	0.28

Figure 7.2-1. Dilute Sampling Schematic

7.3 Particulate Size Distribution of Elements in Flue Gas Streams

7.3.1 Introduction

This section discusses the distribution of elemental concentrations among the various particulate size fractions collected at two sampling locations at Coal Creek. Samples were collected at Locations 4a (ESP #1 Inlet) and 5a (ESP #1 Outlet) using a Multi-Metals sampling train. Various particulate size fractions were collected separately in the train, using glass cyclones upstream of the particulate filter. The large cyclone had collection characteristics such that the $> 10 \mu\text{m}$ aerodynamic size particles were collected in it, the small cyclone collected particles in the $5\text{-}10 \mu\text{m}$ aerodynamic size range, and the downstream quartz filter collected the $< 5 \mu\text{m}$ size fraction.

The sampling constraints of Locations 4a and 5a necessitated the use of a substantial length of heated flexible tubing to connect the sampling probe to the inlet of the large cyclone. Of the two sampling locations, a longer length of flexible tubing was required at Location 5a than at Location 4a. The particulate fraction collected in this tubing, together with that in the sampling probe, were collectively analyzed and are referred to here as the Probe Rinse particulate fraction. Due to the length of the tubing and complexity of the flow path, the particulate size range collected as the Probe Rinse fraction is difficult to estimate. For this reason this collection material is excluded from some of the subsequent discussion. However, it is expected from aerosol dynamics that larger particles would be preferentially removed in the probe and tubing compared with smaller aerosols.

The various particulate fractions collected in samples at each of the two locations were analyzed for elemental concentrations. Tables 7.3-1 and 7.3-2 provide the measured concentrations of the various elements in each of the three known particulate size fractions at Locations 4a and 5a, respectively. No samples were collected in the cyclones at Location 5a on two of the three sampling days, and on the other day only very small samples were collected in the cyclones (Table 7.3-2). On average at Location 5a, 78.5 percent of the particulate mass collected was found in the probe rinse, 20.7 percent was found on the filter, and less than 1 percent was found in the cyclones. At Location 4a, the particulate mass loading was much higher, and the collected particle mass was more evenly distributed. On

average at Location 4a, 10.4 percent of the particulate mass was found in the probe rinse, 66.1 percent in the large ($>10\ \mu\text{m}$) cyclone, 11.9 percent in the small ($5\text{-}10\ \mu\text{m}$) cyclone, and 11.6 percent on the filter (see Section 5.11).

7.3.2. Average Distribution of Elemental Concentrations

A more informative picture of the particulate size distribution of elemental pollutants in the flue gas is provided in Tables 7.3-3 and 7.3-4. These two tables provide the average percentage distributions of elemental flue gas concentrations among the various fractions, including the probe rinse, at Locations 4a and 5a, respectively. The data in Tables 7.3-3 and 7.3-4 have been derived by averaging the elemental concentrations measured in the respective particulate size fractions in each of the three samples collected at the two locations. A concentration value of zero was used in the calculations for non-detected elements in any specific size fraction. Each entry in the tables is the average percentage of the total flue gas loading of the indicated elements, that is contributed by the indicated size of particles. The sum of the percentages across the row for each element equals 100 percent. For example, in Table 7.3-3, aluminum in flue gas at Location 4a exists about 6 percent in $<5\ \mu\text{m}$ particles, 14.5 percent in $5\text{-}10\ \mu\text{m}$ particles, 63.8 percent in $10\ \mu\text{m}$ particles, and 15.8 percent in particles collected in the probe and flexible tubing. Tables 7.3-3 and 7.3-4 thus provide a perspective on the distribution of individual elements among the various particulate fractions in the flue gas stream at each sampling location.

Table 7.3-3 shows that at Location 4a, the inlet to ESP #1, the Large Cyclone or $>10\ \mu\text{m}$ particulate fraction contained the largest proportion of the elemental concentrations for all but two elements, cadmium and selenium. For most elements, the Large Cyclone or $>10\ \mu\text{m}$ size fraction typically contained over 50 percent of the total particulate phase flue gas concentration. Table 7.3-3 also shows that the Probe Rinse fraction typically contained 10-15 percent of the total flue gas concentration of most elements, with the exception of cadmium, antimony and selenium.

Table 7.3-3 shows that substantial fractions (>25 percent) of the total cadmium, vanadium, lead, and selenium concentrations were in the Filter or $<5\ \mu\text{m}$ size fraction. The

Small Cyclone or 5-10 μm fraction consistently contained between 10 and 20 percent of the total particle phase elemental concentrations for all elements.

At Location 5a (ESP #1 outlet) (Table 7.3-4), the Filter and Probe Rinse were the only fractions with interpretable averages for elemental concentrations, since no measurable cyclone fractions were collected in two of the three samples at this location. In some cases in Table 7.3-4, the percentages for an element in each size fraction do not add up to 100 percent across a row. This is due to exclusion of the one sample in which small quantities of material were collected in the cyclones (see Table 7.3-2). The average distributions at this location shown in Table 7.3-4 indicate that the Probe Rinse contained the majority of the total particulate-phase concentrations for all elements. For some elements, such as barium, vanadium, and lead, the Filter or $<5 \mu\text{m}$ fraction also contained a substantial fraction of the total particulate concentration. The latter results suggest that these elements are present in the fine particulate fraction to a greater extent than other elements. In general, however, no distinctive patterns of increasing concentration with decreasing particle size could be observed for any of the elements from the data collected.

Overall, the results in Tables 7.3-4 and 7.3-5 are consistent with existing data on the particulate size distributions of trace elements in power plant emissions.

7.3.3 Elemental Content Ratios

The elemental concentrations in Tables 7.3-1 and 7.3-2 can also be interpreted in terms of the elemental content in each of the various particulate fractions. Tables 7.3-5 and 7.3-6 show the average elemental content for the four particulate size collection fractions at Locations 4a and 5a, respectively. The data in Tables 7.3-5 and 7.3-6 have been derived by averaging the elemental concentration data (in $\mu\text{g}/\text{Ncm}$) in the three samples at each location (Tables 7.3-1 - 7.3-2), multiplying the average concentrations by the average sample volume (in Ncm), and dividing by the average particulate mass (in g) collected of each size fraction, for each of the two sampling locations. A zero value for the elemental concentration was used in the calculations for non-detected elements in any particular size fraction. Thus the entries in Tables 7.3-5 and 7.3-6 show the elemental composition (in $\mu\text{g}/\text{g}$) of each particle size fraction.

Table 7.3-5 shows that at Location 4a, many of the elements, such as beryllium, cobalt, copper, manganese, molybdenum, nickel, potassium, sodium, and titanium, are relatively evenly present in all size fractions. By contrast, some elements such as chromium, vanadium, lead and selenium have higher elemental contents in the Filter ($<5\ \mu\text{m}$) size fraction compared with the larger size fractions. Some elements, such as lead and selenium have elemental contents that increase progressively from large to small size fractions. Antimony and arsenic have higher elemental contents in the Filter and Small Cyclone fraction than for the Large Cyclone fraction. Finally, a number of elements such as aluminum, barium, calcium, have higher elemental contents in the Large Cyclone size fraction than in the smaller size fractions. Note that the elemental contents of silicon may be subject to positive bias from the contribution of silicon from the quartz fiber filter substrate.

Table 7.3-6 shows that at Location 5a, the elemental contents in the Filter fraction for many elements are very different from the corresponding elemental contents in the Probe Rinse fraction. This result suggests that the size fractions collected in the Filter and Probe Rinse are quite different from each other. In the case of elements with similar elemental contents in the Filter and Probe Rinse fraction, such as cobalt, copper, and potassium, the results may be a consequence of the relatively uniform content of these elements across all size fractions (see Table 7.3-6). For some elements, such as copper, manganese, titanium and arsenic, the Filter or $<5\ \mu\text{m}$ size fraction elemental contents in Table 7.3-6 are consistent with the corresponding elemental contents in Table 7.3-5. For other elements, such as aluminum, barium and calcium, the elemental contents in the Filter fraction at Location 5a are substantially higher than the corresponding contents at Location 4a. Interpretation of the similarities and differences between the elemental contents in the various size fractions at the two sampling locations is complicated by the fact that a much longer length of probe to large cyclone sampling line was required at Location 5a than at Location 4a. Hence, it is not possible to compare the elemental content of corresponding size fractions, such as the probe rinse or filter, at the two sampling locations. Further study will be necessary to better understand the information contained in the elemental content data.

TABLE 7.3-1. PARTICULATE SIZE DISTRIBUTION OF ELEMENTS IN ESP-1 INLET (LOCATION 4a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-4a-MUM-622				C-4a-MUM-624				C-4a-MUM-627			
	Filter	Large Cyclone	Small Cyclone	Total	Filter	Large Cyclone	Small Cyclone	Total	Filter	Large Cyclone	Small Cyclone	Total
Aluminum	7760	136000	33300	177000	18200	129000	28600	176000	7100	88300	18300	114000
Potassium	14400	92800	26900	134000	18100	84100	21800	124000	6960	69900	16500	93400
Silicon	262000	2110000	412000	2790000	355000	1970000	326000	2650000	200000	1890000	302000	2400000
Sodium	2540	20900	6180	29600	4580	20800	6060	31400	2590	22800	5930	31400
Titanium	3550	28400	5030	36900	4160	26500	4230	34900	2400	27400	4190	34000
Antimony	12.6	15.5	15.9	44.0	17.0	33.1	13.9	64.0	11.3	45.1	17.6	74.1
Arsenic	169	427	246	841	257	510	236	1000	163	794	278	1240
Barium	2290	17200	3460	23000	881	18700	4210	23800	731	17200	1640	19500
Beryllium	6.95	28.2	5.27	40.4	8.31	27.2	4.77	40.3	5.03	28.2	5.01	38.3
Boron	1350	9920	2410	13700	1540	8490	1950	12000	1020	13300	2350	16700
Cadmium	6.82	ND <	0.146	8.34	7.86	ND <	0.156	9.29	5.91	6.41	3.82	16.1
Calcium	19100	326000	50900	396000	24800	280000	36900	342000	32800	361000	47200	441000
Chromium	335	353	122	810	642	332	108	1080	296	3460	689	4450
Cobalt	26.5	162	30.3	219	31.3	159	27.4	218	19.0	175	28.7	223
Copper	102	380	110	592	129	376	98.1	603	81.8	410	104	597
Lead	97.6	207	85.7	390	124	185	74.3	383	92.2	209	82.6	384
Manganese	1160	7280	1310	9750	1330	6140	965	8430	1170	8910	1550	11600
Molybdenum	32.9	88.8	31.2	153	49.3	97.7	31.7	179	28.1	170	44	242
Nickel	175	290	57.3	523	329	289	50.4	668	163	1870	354	2380
Selenium	29.2	34.3	18.7	82.2	39.5	31.4	13.4	84.3	37.9	20.7	14.5	73.1
Vanadium	235	587	120	942	355	599	107	1060	222	614	114	951

ND < = Not detected, value following ND < is detection limit.

Samples corrected for C-6a + b-MUM-620 train blank.

Filter results exclude probe rinses.

TABLE 7.3-2. PARTICULATE SIZE DISTRIBUTION OF ELEMENTS IN ESP-1 OUTLET (LOCATION 5a) ($\mu\text{g}/\text{Nm}^3$)

Analyte	C-5a-MUM-622						C-5a-MUM-624					C-5a-MUM-627												
	Filter	Large Cyclone	Small Cyclone		Total		Filter	Large Cyclone	Small Cyclone		Total		Filter	Large Cyclone	Small Cyclone		Total							
Aluminum		407	ND <	2.52	ND <	2.52		410		118		NA		NA		118		290		NA		NA		290
Potassium		5.88	ND <	1.01	ND <	1.01		6.89		21.9		NA		NA		21.9		28.9		NA		NA		28.9
Silicon	ND <	4750		23.1		20.2	ND <	4750	ND <	4630		NA		NA	ND <	4630	ND <	4230		NA		NA	ND <	4230
Sodium		38.4	ND <	3.83	ND <	3.83		42.2		4.37		NA		NA		4.37		23.9		NA		NA		23.9
Titanium		17.1	ND <	2.48	ND <	2.48		19.6		5.05		NA		NA		5.05		12.3		NA		NA		12.3
Antimony		0.0778		0.002		0.0097		0.0894		0.0418		NA		NA		0.0418		0.572		NA		NA		0.572
Arsenic		0.603	ND <	0.012	ND <	0.0117		0.615		0.246		NA		NA		0.246		0.572		NA		NA		0.572
Barium		156	ND <	0.851	ND <	0.851		157		44.2		NA		NA		44.2		111		NA		NA		111
Beryllium		0.0506	ND <	0.135	ND <	0.135		0.185		0.0161		NA		NA		0.0161		0.0394		NA		NA		0.0394
Boron		5.40	ND <	1.34	ND <	1.34		6.74	ND <	0.0131		NA		NA	ND <	0.0131		2.83		NA		NA		2.83
Cadmium	ND <	3.68	ND <	0.109	ND <	0.109	ND <	1.30	ND <	3.59		NA		NA	ND <	3.59	ND <	3.28		NA		NA	ND <	3.28
Calcium		826		6.25		4.19		836		234		NA		NA		234		713		NA		NA		713
Chromium		0.479		6.86		17.6		25.0		0.0949		NA		NA		0.0949		0.249		NA		NA		0.249
Cobalt	ND <	0.0107		0.140		0.154		0.299		0.0494		NA		NA		0.0494		0.128		NA		NA		0.128
Copper		0.569	ND <	0.0361	ND <	0.0361		0.605		0.148		NA		NA		0.148		0.421		NA		NA		0.421
Lead		0.501		0.0807		0.0788		0.661		0.230		NA		NA		0.230		0.435		NA		NA		0.435
Manganese		5.99	ND <	1.33	ND <	1.33		7.33		1.68		NA		NA		1.68		5.08		NA		NA		5.08
Molybdenum		1.79	ND <	0.104	ND <	0.104		1.90	ND <	0.0248		NA		NA	ND <	0.0248		0.0476		NA		NA		0.0476
Nickel	ND <	0.0076		3.80		8.92		12.7	ND <	0.0074		NA		NA	ND <	0.0074		0.124		NA		NA		0.124
Selenium		0.221		0.0894		0.0486		0.360		0.0190		NA		NA		0.0190		0.285		NA		NA		0.285
Vanadium		2.64	ND <	0.172	ND <	0.172		2.81		0.798		NA		NA		0.798		1.78		NA		NA		1.78

ND< = Not detected, value following ND< is detection limit.

NA = Sample not available, sample not analyzed, or data not available.

Samples corrected for C-6a+b-MUM-620 train blank.

Filter results exclude probe rinses.

TABLE 7.3-3. AVERAGE DISTRIBUTION OF ELEMENTAL FLUE GAS CONCENTRATIONS AT LOCATION 4a

SPECIES	Percentage Elemental Distribution							
	Filter < 5 μ m		Small Cyclone 5 - 10 μ m		Large Cyclone >10 μ m		Probe Rinse Unknown size	
	%	$\pm$ SD%	%	$\pm$ SD%	%	$\pm$ SD%	%	$\pm$ SD%
<i>Elements (ICP)</i>								
Aluminum	6	3.4	14.5	4.1	63.8	14	15.8	4.9
Barium	5.3	3.5	12.7	5.4	72.2	3.5	9.8	4.3
Beryllium	15	3.7	11.2	0.5	62	1.2	11.8	5.4
Boron	8.4	1.7	14.4	1.6	68.3	16.1	8.9	4.2
Cadmium	38.1	5.4	12	8	11.9	0	37.4	19
Calcium	5.8	1.6	10.3	1.7	73.5	9.2	10.4	0.3
Chromium	19.2	8.6	13.9	15	62.6	81.6	4.3	2
Cobalt	9.8	2.4	11	0.6	63.3	3.2	15.8	4.7
Copper	15.5	3.5	15.4	0.9	57.7	2.8	11.4	5.4
Manganese	11.1	0.9	11.5	2.6	67.2	12.6	10.2	5.4
Molybdenum	16.4	5	16	3.3	52.9	19.8	14.7	11.4
Nickel	17.5	7.3	12.1	13.6	64.1	71.6	6.3	2.9
Potassium	10.3	4.4	17	4	64.3	9	8.4	8.3
Silicon	9.6	2.7	12.2	2	70.2	3.9	8	2.7
Sodium	8.7	3.1	16.3	0.3	58	3.1	17	4.9
Titanium	8.7	2.3	11.6	1.2	71	2.4	8.6	3.7
Vanadium	24.7	6.7	10.4	0.6	54.9	1.2	10	4.5
<i>Elements (GFAA)</i>								
Antimony	16.3	3.6	19	2.3	37.3	17.9	27.4	16.1
Arsenic	15.6	4.2	20.1	1.8	45.7	15.3	18.6	9.1
Lead	25.4	4.1	19.6	1.4	48.7	3.2	6.3	10.8
Selenium	31.9	4.9	14	2.5	25.9	6.4	28.2	12.2

TABLE 7.3-4. AVERAGE DISTRIBUTION OF ELEMENTAL FLUE GAS CONCENTRATIONS AT LOCATION 5a

SPECIES	Percentage Elemental Distribution							
	Filter		Small Cyclone		Large Cyclone		Probe Rinse	
	<u>< 5 μm</u>		<u>5 - 10 μm</u>		<u>>10 μm</u>		<u>Unknown size</u>	
	%	$\pm$ SD%	%	$\pm$ SD%	%	$\pm$ SD%	%	$\pm$ SD%
<i>Elements (ICP)</i>								
Aluminum	32.3	17.3	ND	-	ND	-	67.5	25
Barium	59.9	32.5	ND	-	ND	-	39.8	7.3
Beryllium	20.5	10.2	ND	-	ND	-	27.3	8.8
Boron	2.5	1.1	ND	-	ND	-	97.8	152
Cadmium	ND	-	ND	-	ND	-	ND	-
Calcium	38.7	20.5	ND	-	ND	-	61.1	18.4
Chromium	1.8	1.3	ND	-	ND	-	23.6	0
Cobalt	10.2	6.4	ND	-	ND	-	31.6	13.5
Copper	17.2	9.7	ND	-	ND	-	81.7	53.7
Manganese	27.2	14.5	ND	-	ND	-	67.1	23
Molybdenum	ND	-	ND	-	ND	-	ND	-
Nickel	0	0	ND	-	ND	-	22.4	19.4
Potassium	15.9	10	ND	-	ND	-	83.5	51
Silicon	0	0	ND	-	ND	-	99.4	116.2
Sodium	ND	-	ND	-	ND	-	ND	-
Titanium	35.5	18.8	ND	-	ND	-	59.4	21.6
Vanadium	42.2	22.3	ND	-	ND	-	55	19.7
<i>Elements (GFAA)</i>								
Antimony	37.6	11.5	ND	-	ND	-	59.9	29
Arsenic	26.1	10.9	ND	-	ND	-	73.9	24.4
Lead	49	17.9	ND	-	ND	-	44.4	41.4
Selenium	1.7	1.4	ND	-	ND	-	97.8	56.4

ND : Not detected in all three samples at this location or concentrations too low for interpretation.

TABLE 7.3-5. AVERAGE CONTENT OF INDIVIDUAL ELEMENTS IN PARTICULATE MATTER COLLECTED IN THE FOUR PARTS OF THE SAMPLING TRAIN AT LOCATION 4a

SPECIES	Elemental Content							
	Filter ≤ 5 μm		Small Cyclone 5 - 10 μm		Large Cyclone ≥ 10 μm		Probe Rinse Unknown size	
	μg/g	±SD	μg/g	±SD	μg/g	±SD	μg/g	±SD
<i>Elements (ICP)</i>								
Aluminum	7763	4396	18174	5217	14383	3150	22952	7177
Barium	916	606	2111	901	2158	104	1888	830
Beryllium	5	1	3	0	3	0	4	2
Boron	918	187	1524	170	1292	304	1079	513
Cadmium	5	1	1	1	0	0	5	3
Calcium	18016	4856	30622	4967	39340	4937	35723	980
Chromium	299	134	208	225	169	220	75	35
Cobalt	18	4	20	1	20	1	33	10
Copper	73	17	71	4	47	2	60	29
Manganese	861	67	866	199	908	170	886	473
Molybdenum	26	8	24	5	14	5	26	20
Nickel	156	65	105	118	100	111	63	29
Potassium	9260	3997	14800	3522	10043	1411	8432	8355
Silicon	191634	54939	235715	39330	243295	13492	179375	60056
Sodium	2279	816	4119	85	2625	141	4957	1440
Titanium	2373	629	3051	323	3345	113	2616	1113
Vanadium	191	52	78	4	73	2	86	38
<i>Elements (GFAA)</i>								
Antimony	8	1	11	1	4	2	18	11
Arsenic	117	3	172	15	70	24	185	90
Lead	67	3	55	4	24	2	20	35
Selenium	24	4	11	2	4	1	25	11

TABLE 7.3-6. AVERAGE CONTENT OF INDIVIDUAL ELEMENTS IN PARTICULATE MATTER
COLLECTED IN THE FOUR PARTS OF THE SAMPLING
TRAIN AT LOCATION 5a

SPECIES	Elemental Content							
	Filter ≤ 5 μm		Small Cyclone 5 - 10 μm		Large Cyclone >10 μm		Probe Rinse Unknown size	
	μg/g	±SD	μg/g	±SD	μg/g	±SD	μg/g	±SD
<i>Elements (ICP)</i>								
Aluminum	75338	40328	ND	-	ND	-	31774	11756
Barium	28699	15582	ND	-	ND	-	3852	705
Beryllium	10	5	ND	-	ND	-	3	1
Boron	1141	503	ND	-	ND	-	9152	14220
Cadmium	ND	-	ND	-	ND	-	ND	-
Calcium	163823	87003	ND	-	ND	-	52281	14044
Chromium	76	54	ND	-	ND	-	198	0
Cobalt	25	15	ND	-	ND	-	40	7
Copper	105	59	ND	-	ND	-	101	66
Manganese	1179	629	ND	-	ND	-	588	201
Molybdenum	ND	-	ND	-	ND	-	ND	-
Nickel	0	0	ND	-	ND	-	69	59
Potassium	5242	3275	ND	-	ND	-	5542	3387
Silicon	0	0	ND	-	ND	-	127361	148987
Sodium	ND	-	ND	-	ND	-	ND	-
Titanium	3189	1687	ND	-	ND	-	1075	391
Vanadium	482	255	ND	-	ND	-	127	45
			ND	-	ND	-		
<i>Elements (GFAA)</i>			ND	-	ND	-		
Antimony	19	4	ND	-	ND	-	5	3
Arsenic	163	6	ND	-	ND	-	75	25
Lead	130	13	ND	-	ND	-	20	18
Selenium	70	13	ND	-	ND	-	563	325

ND : Not detected in all three samples at this location or concentrations too low for interpretation.

7.4 Comparison of HEST and Method 29 Methods for Volatile Elements

7.4.1 Introduction

Volatile trace elements (arsenic, As, mercury, Hg, and selenium, Se) were measured at Locations 4a, 5a, 6a, and 6b in the flue gas stream (as described in Section 3) using both Chester Environmental's HEST and EPA's Method 29 (M29). In addition, the HEST alone was used for volatile elements at Location 5b. For this Special Topic, only the gas phase results from the two methods are compared even though both methods have the capability of particle phase sampling. The HEST uses carbon impregnated filters (CIFs) to absorb gas phase elements. The filters are returned to the laboratory where the elements are quantified using X-ray fluorescence methods. Method 29 traps vapor phase elements in impinger solutions. These solutions are later analyzed in the laboratory using either atomic absorption or emission methods. These results are referred to as "back half" results.

7.4.2 Data Analysis

7.4.2.1 Overview. The HEST results are generally consistent with expectations and internally consistent with both the behavior of the elements and the expected impacts of the control equipment. The HEST results are often not in good agreement with Method 29 (M29). The two methods were in best agreement for Hg. In this case, the HEST Hg results were lower than M29 by an average factor of 1.54. This difference, however, is small relative to the over 8 fold average difference for Se. In the case of Se, the HEST results are greater than the M29 results and closer to the expected flue gas concentrations. The As results are generally below both methods' detection limits.

7.4.2.2 Mercury. The Hg results from both methods are listed in Table 7.4-1. The average HEST results at the flue sampling locations range from 7.20 to 9.64 $\mu\text{g/Ncm}$, while the average M29 results range from 1.58 to 13.6 $\mu\text{g/Ncm}$. The lowest M29 results were reported for the PSDS sampler (Location 6b) and are thought to be low in part because of the

very low Hg concentrations in the diluted stack gas and because of method detection limitations.

Both methods give slightly higher results at Location 4a, which is upstream of the ESP, than at post-ESP locations. The average HEST results at the four locations downstream of the ESP were very consistent, ranging from 7.20 to 8.11 $\mu\text{g}/\text{Ncm}$. Moreover, there was excellent agreement at Location 6 between the PSDS sampler and the in-stack sampler results, i.e., 8.11 and 8.05 $\mu\text{g}/\text{Ncm}$, respectively.

The HEST Hg result for the first run at Location 5b is about 15 fold lower than the other measurements at that location. This result is suspect. However, reviews of field and analytical data, as well as x-ray spectra and elemental ratios, have not disclosed the cause of this outlier.

The HEST results exhibit substantially better precision than the M29 results. Although the HEST results are lower than the M29 results, the HEST results may be more representative because of the method's higher precision and because of consistency with the Se measurements (Section 7.4.2.3). The M29 Se results, for example, suggest that the HEST Se results are over 8 fold too high. The HEST results, however, are unlikely to be 8 fold too high for Se, while at the same time 1.5 times too low for Hg. Both elements are measured simultaneously on the same carbon impregnated filter (CIF) by x-ray fluorescence, and are highly unlikely to have biases in opposite directions by more than 5 to 15 percent.

The RTI Hg spike cannot be evaluated at this time because the spike values are not available. The use of liquid spikes, however, is not considered a valid test for this procedure for the following reasons:

- The CIF trapping process is thought to be a chemical surface reaction that takes place in the gas phase. Use of liquid standards would not duplicate this process.
- The absorbed Hg is quantified by x-ray fluorescence analysis which measured about 1 cm^2 of the filter and assumes a uniform surface density over the exposed filter. There is no assurance (and indeed it is unlikely) that the spike was distributed uniformly over the same surface of the filter as was exposed to the stack gas.
- The liquid spike may have a different mean penetration depth than absorption of gaseous Hg.

7.4.2.3 Selenium. Selenium results from HEST and M29 samples are shown in Table 7.4-2. The Se results are difficult to compare for the two methods because the vapor phase of this element is very sensitive to temperature in the typical temperature ranges sampled. Previous in-stack measurements, for example, have shown that most of the Se is in the vapor phase at temperatures above about 300°F, while particles are the predominant phase below about 200°F. Since Method 29 requires filtering of particles outside of the stack in a box typically heated to about 250°F, the particle to gas phase ratio may be significantly different from that measured in-stack with the HEST, which may be at significantly higher temperatures. It is likely that this is part of the explanation for the observed differences measured at Locations 4a and 5a. However, this argument breaks down when the results from Location 6a are considered (Table 7.4-2). Poor agreement between HEST and M29 is found at this location, even though the in-stack temperature is very close to that at which the M29 filter is maintained (e.g., see Table 7.2-1). The low vapor phase concentrations measured with the PSDS sampler by both methods are as expected based on the likelihood that all of the Se will have condensed from the vapor phase at the low dilution temperatures.

The low vapor phase Se concentrations reported by both methods at the ESP inlet (Location 4a) may also be an artifact of the heavy particle loading. A thick layer of brown particles formed on both the HEST and M29 filters within a few minutes of sample collection. Subsequent acidic gases (such as SeO_2) drawn through this layer of particles may have been adsorbed by the particle layer. This might contribute to the apparently higher vapor phase Se concentrations at the ESP outlet relative to the inlet.

7.4.2.4 Arsenic. All of the HEST As results are below the method's detection limits, which are substantially below the M29 detection limits and reported results. The low HEST gas phase As concentration is consistent with previous measurements. The few positive values reported by M29 at Location 6a are close enough to the method's detection limit to be suspect. The two positive values reported by M29 at Location 4a differ by more than 30 fold, and, as such, are suspect. The primary observation is that very low vapor phase As levels are indicated by both methods in most cases.

7.4.3 Summary

The results shown for Hg by the HEST appear highly promising, and support further evaluation of the HEST for Hg measurements. The Se measurements suggest that care must be exercised in selecting sampling conditions for this element, since its vapor/particle phase distribution is very sensitive to temperature in the normal range of sampling conditions. This observation is supported by the Se vapor/particle distribution data in Table 7.1-1.

Comparisons of total (vapor plus particle) Se data from HEST and M29 would be of interest. The As results indicate that vapor-phase As levels may not be significant, even in hot flue gas.

TABLE 7.4-1. MERCURY ($\mu\text{g}/\text{Ncm}$)

Run Location, Date	MERCURY	
	HEST	M29
4a, 6/22	9.40	12.6
6/24	8.74	15.7
6/27	11.0	12.6
mean ^(a)	9.64	13.6
s.d. ^(a,b)	0.90	1.46
method ratio ^(c)	1.41	
5a, 6/22	5.20	9.59
6/24	7.32	8.41
6/27	9.05	17.4
mean	7.20	11.8
s.d.	1.59	3.99
method ratio	1.64	
5b, 6/22	0.694	not sampled
6/24	11.8	
6/27	11.4	
mean	7.96	
s.d.	5.14	
method ratio		
6a, 6/22	8.64	11.2
6/24	7.39	17.1
6/27	8.08	9.73
mean	8.05	12.7
s.d.	0.51	3.18
method ratio	1.58	
6b, 6/22	6.21	ND < 0.381
6/24	8.46	4.35
6/27	9.81	ND < 0.404
mean	8.11	1.58
s.d.	1.48	1.96
method ratio	0.195	
Hg Spike		
Control	66.3	not sampled
4a, 6/25	17.9	
ratio (d)	3.71	

- Less-than values are assumed to equal one-half their value when they are used in mean and s.d. calculations involving reported concentrations. Less-than values are assumed to equal their full values when they are used in mean and s.d. calculations that involve only other less-than values.
- True population s.d. (assumes arguments comprise entire data set).
- Method ratio = M29 mean/HEST mean.
- Ratio = control/(4a, 6/25).

TABLE 7.4-2. SELENIUM ($\mu\text{g}/\text{Ncm}$)

Run Location, Date	SELENIUM	
	HEST	M29
4a, 6/22	5.99	1.033
6/24	2.73	ND < 0.191
6/27	3.00	0.635
mean (a)	3.91	0.588
s.d. (a,b)	1.47	0.384
method ratio (c)	0.150	
5a, 6/22	33.1	1.34
6/24	38.8	4.18
6/27	34.3	9.04
mean (a)	35.3	4.85
s.d. (a,b)	2.44	3.18
method ratio (c)	0.137	
5b, 6/22	35.7	not sampled
6/24	26.8	
6/27	37.3	
mean (a)	33.3	
s.d. (a,b)	4.62	
method ratio (c)		
6a, 6/22	20.2	1.10
6/24	14.1	0.979
6/27	8.26	1.09
mean (a)	14.2	1.06
s.d. (a,b)	4.91	0.05
method ratio (c)	0.074	
6b, 6/22	ND < 0.308	1.10
6/24	ND < 0.268	ND < 4.72
6/27	ND < 0.366	ND < 4.72
mean (a)	ND < 0.314	1.94
s.d. (a,b)	0.040	0.59
method ratio (c)	> 6.18	

- Less-than values are assumed to equal one-half their value when they are used in mean and s.d. calculations involving reported concentrations. Less-than values are assumed to equal their full values when they are used in mean and s.d. calculations that involve only other less-than values.
- True population s.d. (assumes arguments comprise entire data set).
- Method ratio = M29 mean/HEST mean.

TABLE 7.4-3. ARSENIC ($\mu\text{g}/\text{Ncm}$)

Run Location, Date	ARSENIC	
	HEST	M29
4a, 6/22	ND < 0.029	ND < 0.023
6/24	ND < 0.028	0.132
6/27	ND < 0.025	4.03
mean (a)	ND < 0.028	1.39
s.d. (a,b)	0.001	1.87
method ratio (c)	100	
5a, 6/22	ND < 0.011	ND < 0.0175
6/24	ND < 0.010	ND < 0.0171
6/27	ND < 0.008	ND < 0.0156
mean (a)	ND < 0.010	ND < 0.0167
s.d. (a,b)	0.001	0.0008
method ratio (c)	ND ratio = 1.72	
5b, 6/22	ND < 0.007	not sampled
6/24	ND < 0.014	
6/27	ND < 0.012	
mean (a)	ND < 0.012	
s.d. (a,b)	0.003	
method ratio (c)		
6a, 6/22	ND < 0.012	0.0652
6/24	ND < 0.010	ND < 0.0199
6/27	ND < 0.012	0.0263
mean (a)	ND < 0.012	0.0338
s.d. (a,b)	0.002	0.023
method ratio (c)	5.68	
6b, 6/22	ND < 0.469	ND < 0.571
6/24	ND < 0.375	not available
6/27	ND < 0.555	ND < 0.606
mean (a)	ND < 0.466	ND < 0.589
s.d. (a,b)	0.073	0.018
method ratio (c)	ND ratio = 1.26	

- Less-than values are assumed to equal one-half their value when they are used in mean and s.d. calculations involving reported concentrations. Less-than values are assumed to equal their full values when they are used in mean and s.d. calculations that involve only other less-than values.
- True population s.d. (assumes arguments comprise entire data set).
- Method ratio = M29 mean/HEST mean.

7.5 Comparison of VOST and Summa Canisters for VOCs

7.5.1 Introduction

The purpose of this Special Topic is to compare the analytical results from two established techniques that have been frequently used for collecting and analyzing volatile organic compounds (VOCs) from various air matrices. The canister methodology made use of a flow orifice attached to the inlet of the evacuated canister, that permitted the collection of a time integrated flue gas sample once the canister valve was opened. Canister samples were collected via a glass side arm on the modified Method 5 sampling trains. The VOST methodology made use of two adsorbent tubes, Tenax and Tenax/Charcoal, a pump and flow controller assembly to actively sample the flue gas. Details on sampling and analysis with these methods are contained in the Management/Sampling and Analysis Plans, and elsewhere in this report and are not repeated here.

The target list of VOCs for the canister methodology included the 41 components that are listed in US EPA's TO-14 Methodology. Results were obtained for 35 of those; six early-eluting compounds could not be determined due to interference from SO₂ and water in the sample. The target list for the VOST Methodology included 36 components and originates from SW-846, Method 5041 for VOCs. Thirty-five of those components were measured; hexane was not measured. Twenty compounds were common to both lists. The Method 5041 list contains 8 oxygenated species not on the TO-14 list. The TO-14 list includes several chlorinated and aromatic species not on the VOST target list.

For the Coal Creek program, samples were collected with both methods at four locations during three test days. The location descriptions and dates are as follows:

Location 4a - Gas samples from ESP #1 Inlet

Sampling Dates - 6/21/93, 6/23/93, 6/26/93

Location 5a - Gas samples from ESP #1 Outlet

Sampling Dates - 6/21/93(no cans collected), 6/23/93, 6/26/93

Location 6a - Gas samples from FGD Outlet

Sampling Dates - 6/21/93, 6/23/93, 6/26/93

Location 6b - Dilute gas samples from FGD Outlet

Sampling Dates - 6/21/93, 6/23/93, 6/26/93

At each sampling location, three samples were sequentially collected with each method for each test run. For the VOST sampling, each set was comprised of a 5 minute, 10 minute and 30 minute sample at a nominal flow rate of 0.5 L/min. The sampling was carried out in that order, i.e. from short to long sampling times. This distributive volume approach was used to determine if breakthrough had occurred for any species and to extend the detection level for those species not exhibiting breakthrough. Canister sampling was initiated close to the start of each VOST collection time. However, the canisters were fitted with an orifice designed to fill the canister over a fixed time period of 30 minutes. As a result, start and stop times for individual VOST and canister samples generally do not coincide.

Because of problems encountered in canister sample analysis during earlier power plant studies, i.e. rapid deterioration of the analytical columns and poor analytical precision, a preliminary sampling effort was carried out at a coal-fired plant in Niles, Ohio prior to the present study. Several canister samples were collected from the stack at the site and returned to Battelle for analysis. The preconcentration trap on the gas chromatograph/mass spectrometer had previously contained glass beads and was normally cooled to -160 C during sample collection. For the samples collected in this preliminary study, the cryo-trap was replaced with a two component adsorbent trap (Supelco #2-0321). This type of trap is normally employed for the analyses of VOCs in water when using purge and trap procedures. Previous Battelle work has also shown that this adsorbent combination works well in capturing and releasing ambient concentrations of the TO-14 species. Purging the trap with zero air after sample collection to dry the trap reduces residual moisture so that column plugging does not occur.

The analytical results from repeated injections of the preliminary canister samples did show much better precision than earlier work with the cryo-trap, however, several broad component peaks were still found to elute from the analytical column. These peaks were subsequently identified as column bleed peaks by the mass spectrometer (e.g. siloxane mass fragments). Apparently sufficient acidic gases were still present in the vapor phase to cause this column stripping to occur. Several column manufacturers have concurred that the

bonded phase on the fused silica columns will be readily stripped in the presence of strong acids.

Further efforts were carried out to test an air scrubber to remove strong acid compounds ahead of the adsorbent trap. Previous studies at Battelle had indicated that a sodium bicarbonate (NaHCO_3) denuder worked very well in removing gaseous SO_2 from humidified air streams. The denuder system operated at flows of 10 to 20 liters/minute. For the low flow conditions required with the adsorbent trap (i.e. 15 cc/minute), a 10 cm long by 0.2 cm i.d. trap packed with 60/80 mesh NaHCO_3 was fabricated and placed in-line. Analytical results with this scrubber indicated a great reduction in column artifact peaks. Results from the analyses of a 6 ppb standard mixture of TO-14 compounds with and without the NaHCO_3 scrubber also indicated reasonable agreement. No concentration differences were observed with benzene and toluene, however about a 20 percent loss was observed with less volatile species such as hexachlorobutadiene. The latter result probably occurs because the less volatile TO-14 compounds are more likely to adhere to the NaHCO_3 surface.

Based upon the positive results with the NaHCO_3 scrubber, this device was inserted in-line for the analyses of all canister samples from Coal Creek.

7.5.2 Data Analysis

A total of 36 VOST and 33 canister samples were collected. Tables 7.5-1 through 7.5-23 show the results from individual sample runs. Each table contains the three runs on the indicated date using the specified method. The "ND <" label indicates that the analyte was not detected. The detection level (DL) is indicated to the right of the label. For the VOST samples, the DL values changed as a function of the sampled volume. For the canister samples, the DL values remained constant because the same volume was always analyzed. In scanning the data it is evident that the reported concentrations vary considerably from run to run with both methods. To further examine the data, three of the more frequently occurring compounds - dichloromethane (i.e., methylene chloride), benzene and toluene - were selected and compared for the 33 runs in which data from both methods were available. Table 7.5-24 shows these results. In viewing the table, a great deal of variability is evident for these three compounds for the three daily runs. For most of the

data, concentrations in the first run of a set were generally much higher than the two subsequent runs. In quite a few instances the values from the first run were one to two orders of magnitude higher than the other runs that day. This observation suggests contamination of the sampling equipment before sampling; this possibility should be evaluated in future work. Poor agreement was also observed between methods for individual runs. Furthermore, there does not appear to be a consistent bias between methods.

Dichloromethane (DCM) (50/50 with methanol) was used in the field study as a solvent to rinse sampling apparatus. It is suspected that the unreasonably high concentrations of DCM in the samples are probably due to contamination from this source. However, we did not observe unreasonably high DCM in the field spike canister sample. In this case a portion of the trip spike was directed through the sampling manifold and into a second evacuated canister (i.e. field spike sample).

In order to better determine if a bias exists between methods, the individual values from the three daily runs for benzene and toluene were first averaged and then compared. Figure 7.5-1 shows the results in bar graph form. The upper bar graph contains the benzene data; the lower bar graph contains the toluene data. There appears to be a somewhat consistent bias for benzene for most of the data set. The VOST daily averages are generally higher than the canister averages at the 4a, 5a, and 6a locations. At Location 6b the benzene values from the canisters values were considerably higher than the VOST data. For toluene daily averages, the VOST results are consistently higher at Locations 6a and 6b. However at Location 5a the canister values are much higher. At Location 4a the daily averages are more comparable between methods.

These two plots also show a trend over time. In all cases the daily averages obtained at each location on the first test day are higher than values on subsequent test days. We have no explanation for this result.

The benzene and toluene daily averages at each location were then averaged and the results are shown in Figure 7.5-2. The benzene results are depicted on the upper bar graph; the toluene results are shown on the lower bar graph. The VOST benzene results are 2 to 3 times higher than the canister benzene values at Locations 4a, 5a and 6a. The results at Location 6b show the opposite behavior. The VOST toluene results are higher than the corresponding canister toluene results at Locations 4a, 6a and 6b. However, the canister

toluene result at Location 5a is significantly higher than the VOST value. The results in Figure 7.5-2 also indicate that for each method the benzene concentrations at Locations 5a and 6a are similar. The benzene concentrations at Location 6a decrease proportionately for both methods. The canister benzene value at Location 6b is significantly higher than the VOST benzene value. The toluene results do not appear to exhibit any trend.

7.5.3 Conclusions

The following conclusions are made from the above analyses:

1. Dichloromethane concentrations are artifact values and are probably due to contamination from DCM/methanol washing of the sampling manifold and associated equipment.
2. The VOCs, whether collected by VOST or canisters, do not exhibit consistent concentration levels at the various sampling locations in the Coal Creek power plant.
3. The VOST and canister collection methods do not give comparable results. This finding may result in part because the two methods did not sample over exactly the same time periods. The highly variable VOC concentration levels observed with both methods complicate efforts to compare the two methods.
4. The canister approach has advantages in terms of simplicity of sample collection and sample handling after collection. Analysis costs may also be lower, since only one canister rather than two sorbent traps must be analyzed for each sample.

7.5.4 Recommendations

The following recommendations are made from the above analyses:

1. Greater care needs to be exerted to eliminate the solvent (dichloromethane) contamination or carry over into the sampling apparatus. This problem was consistently observed in both the VOST and canister sampling trains.
2. The reason why both methods show such large run to run variability is not understood at this time. More internal QC checks may be helpful in focusing in on the problem. The use of internal standards spiked on the Tenax adsorbent or into the evacuated canister prior to sampling would aid in determining if

reactions are occurring with the VOCs following sample collection. The potential for contamination before sampling should also be evaluated.

3. The employment of an on-line continuous or automated instrument for monitoring one or more of the VOCs would help a good deal in determining how much the VOC concentrations actually fluctuate in the flue gas stream. For example, an automated gas chromatograph equipped with a photoionization detector or mass selective detector could provide data on one or two key VOC at intervals of 30 minutes or less.

TABLE 7.5-1. VOC IN VOST GAS SAMPLES FROM ESP #1 INLET (Location 4a) - 6/21/93 ($\mu\text{g}/\text{Nm}^3$)

	C4A-VOS-6211		C4A-VOS-6212		C4A-VOS-6213	
Chloromethane	ND<	12.04		35.46		34.15
Bromoethane	ND<	12.04		3.29 J	ND<	2.15
Vinyl Chloride	ND<	12.04	ND<	6.34	ND<	2.15
Chloroethane	ND<	12.04	ND<	6.34	ND<	2.15
Methylene Chloride		50.06		15.45		5.85
Acetone		30.81		23.31		2.92
Carbon Disulfide	ND<	12.04		3.79 J		2.49
1,1-Dichloroethene	ND<	12.04	ND<	6.34	ND<	2.15
1,1-Dichloroethane	ND<	12.04	ND<	6.34	ND<	2.15
trans-1,2-Dichloroethene	ND<	12.04	ND<	6.34	ND<	2.15
Chloroform	ND<	12.04	ND<	6.34	ND<	2.15
1,2-Dichloroethane		176.19	ND<	6.34	ND<	2.15
2-Butanone		39.96		30.91		1.98 J
1,1,1-Trichloroethane	ND<	12.04	ND<	6.34	ND<	2.15
Carbon Tetrachloride	ND<	12.04	ND<	6.34	ND<	2.15
Vinyl Acetate	ND<	12.04	ND<	6.34	ND<	2.15
Bromodichloromethane	ND<	12.04	ND<	6.34	ND<	2.15
1,2-Dichloropropane	ND<	12.04	ND<	6.34	ND<	2.15
cis-1,3-Dichloropropene	ND<	12.04	ND<	6.34	ND<	2.15
Trichloroethene	ND<	12.04	ND<	6.34	ND<	2.15
Dibromochloromethane	ND<	12.04	ND<	6.34	ND<	2.15
1,1,2-Trichloroethane	ND<	12.04		3.04 J	ND<	2.15
Benzene		1205.41		28.37		1.55 J
trans-1,3-Dichloropropene	ND<	12.04	ND<	6.34		2.15
2-Chloroethylvinylether	ND<	12.04	ND<	6.34	ND<	2.15
Bromoform	ND<	12.04		4.56 J	ND<	2.15
4-Methyl-2-Pentanone		25.99		31.16		2.15
2-Hexanone		9.15 J		22.55	ND<	2.15
Tetrachloroethene		17.33	ND<	6.34	ND<	2.15
1,1,2,2-Tetrachloroethane	ND<	12.04	ND<	6.34	ND<	2.15
Toluene		152.60		68.90		19.95
Chlorobenzene		204.28	ND<	6.34	ND<	2.15
Ethylbenzene		117.94		63.83		15.31
Styrene		249.36		5.32 J		1.21 J
7 Xylenes (Total)		608.49		389.85		106.12

TABLE 7.5-2. VOC IN VOST GAS SAMPLES FROM ESP #1 INLET (Location 4a) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

	C4A-VOS-6231	C4A-VOS-6232	C4A-VOS-6233
Chloromethane	534.58	183.15	24.59
Bromoethane	ND < 8.47	9.16	ND < 1.91
Vinyl Chloride	ND < 8.47	ND < 6.36	ND < 1.91
Chloroethane	ND < 8.47	ND < 6.36	ND < 1.91
Methylene Chloride	44.13	10.94	3.13
Acetone	47.17	16.53	6.42
Carbon Disulfide	5.09 J	4.58 J	7.64
1,1-Dichloroethene	ND < 8.47	ND < 6.36	ND < 1.91
1,1-Dichloroethane	ND < 8.47	ND < 6.36	ND < 1.91
trans-1,2-Dichloroethene	ND < 8.47	ND < 6.36	ND < 1.91
Chloroform	ND < 8.47	ND < 6.36	ND < 1.91
1,2-Dichloroethane	ND < 8.47	ND < 6.36	ND < 1.91
2-Butanone	34.28	14.50	5.88
1,1,1-Trichloroethane	ND < 8.47	ND < 6.36	ND < 1.91
Carbon Tetrachloride	ND < 8.47	ND < 6.36	ND < 1.91
Vinyl Acetate	ND < 8.47	ND < 6.36	ND < 1.91
Bromodichloromethane	ND < 8.47	ND < 6.36	ND < 1.91
1,2-Dichloropropane	ND < 8.47	ND < 6.36	ND < 1.91
cis-1,3-Dichloropropene	ND < 8.47	ND < 6.36	ND < 1.91
Trichloroethene	ND < 8.47	ND < 6.36	ND < 1.91
Dibromochloromethane	ND < 8.47	ND < 6.36	ND < 1.91
1,1,2-Trichloroethane	ND < 8.47	ND < 6.36	ND < 1.91
Benzene	ND < 8.47	ND < 6.36	2.44
trans-1,3-Dichloropropene	ND < 8.47	ND < 6.36	ND < 1.91
2-Chloroethylvinylether	ND < 8.47	ND < 6.36	ND < 1.91
Bromoform	ND < 8.47	ND < 6.36	ND < 1.91
4-Methyl-2-Pentanone	17.65	9.41	4.74
2-Hexanone	11.88	ND < 6.36	1.29 J
Tetrachloroethene	ND < 8.47	ND < 6.36	ND < 1.91
1,1,2,2-Tetrachloroethane	ND < 8.47	ND < 6.36	ND < 1.91
Toluene	17.31	5.34 J	2.75
Chlorobenzene	ND < 8.47	ND < 6.36	ND < 1.91
Ethylbenzene	11.20	4.07 J	2.37
Styrene	ND < 8.47	ND < 6.36	ND < 1.91
7 Xylenes (Total)	99.44	33.58	17.34

TABLE 7.5-3. VOC IN VOST GAS SAMPLES FROM ESP #1 INLET (Location 4a) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

	C4A-VOS-6261		C4A-VOS-6262		C4A-VOS-6263	
Chloromethane		2593.16		349.71	ND<	1.87
Bromoethane	ND<	10.65	ND<	5.15	ND<	1.87
Vinyl Chloride	ND<	10.65	ND<	5.15	ND<	1.87
Chloroethane	ND<	10.65	ND<	5.15	ND<	1.87
Methylene Chloride		28.50		7.01		5.36
Acetone		23.83		10.72		16.26
Carbon Disulfide		7.66 J		6.39		6.19
1,1-Dichloroethene	ND<	10.65	ND<	5.15	ND<	1.87
1,1-Dichloroethane	ND<	10.65	ND<	5.15	ND<	1.87
trans-1,2-Dichloroethene	ND<	10.65	ND<	5.15	ND<	1.87
Chloroform	ND<	10.65	ND<	5.15	ND<	1.87 J
1,2-Dichloroethane	ND<	10.65	ND<	5.15		0.97
2-Butanone	ND<	10.65	ND<	5.15		10.60 J
1,1,1-Trichloroethane		15.74		6.19		1.57
Carbon Tetrachloride	ND<	10.65	ND<	5.15	ND<	1.87
Vinyl Acetate	ND<	10.65	ND<	5.15	ND<	1.87
Bromodichloromethane	ND<	10.65	ND<	5.15	ND<	1.87
1,2-Dichloropropane	ND<	10.65	ND<	5.15	ND<	1.87
cis-1,3-Dichloropropene	ND<	10.65	ND<	5.15	ND<	1.87
Trichloroethene	ND<	10.65	ND<	5.15	ND<	1.87
Dibromochloromethane	ND<	10.65	ND<	5.15	ND<	1.87
1,1,2-Trichloroethane	ND<	10.65	ND<	5.15	ND<	1.87
Benzene	ND<	10.65		5.57		78.91
trans-1,3-Dichloropropene	ND<	10.65	ND<	5.15	ND<	1.87
2-Chloroethylvinylether	ND<	10.65	ND<	5.15	ND<	1.87
Bromoform	ND<	10.65	ND<	5.15	ND<	1.87
4-Methyl-2-Pentanone		10.63	ND<	5.15		0.89 J
2-Hexanone	ND<	10.65	ND<	5.15		4.77
Tetrachloroethene	ND<	10.65	ND<	5.15	ND<	1.87
1,1,2,2-Tetrachloroethane	ND<	10.65	ND<	5.15	ND<	1.87
Toluene		27.66		2.68 J		3.95
Chlorobenzene	ND<	10.65	ND<	5.15		1.20 J
Ethylbenzene		14.89	ND<	5.15		1.04 J
Styrene	ND<	10.65	ND<	5.15	ND<	1.87
7 Xylenes (Total)		104.24		12.37		5.36

TABLE 7.5-4. VOC IN VOST GAS SAMPLES FROM ESP #1 OUTLET (Location 5a) - 6/21/93 ($\mu\text{g}/\text{Nm}^3$)

	C5A-VOS-6211	C5A-VOS-6212	C5A-VOS-6213
Chloromethane	25.33	90.27	22.53
Bromoethane	ND < 13.17	6.11 J	ND < 2.62
Vinyl Chloride	ND < 13.17	ND < 6.95	ND < 2.62
Chloroethane	ND < 13.17	ND < 6.95	ND < 2.62
Methylene Chloride	1552.33	21.66	101.34
Acetone	14.25	5.56 J	8.07
Carbon Disulfide	ND < 13.17	5.56 J	2.83
1,1-Dichloroethene	ND < 13.17	ND < 6.95	ND < 2.62
1,1-Dichloroethane	ND < 13.17	ND < 6.95	ND < 2.62
trans-1,2-Dichloroethene	ND < 13.17	ND < 6.95	ND < 2.62
Chloroform	ND < 13.17	ND < 6.95	ND < 2.62
1,2-Dichloroethane	ND < 13.17	ND < 6.95	20.96
2-Butanone	26.38	ND < 6.95	7.96
1,1,1-Trichloroethane	ND < 13.17	ND < 6.95	ND < 2.62
Carbon Tetrachloride	ND < 13.17	ND < 6.95	ND < 2.62
Vinyl Acetate	ND < 13.17	ND < 6.95	ND < 2.62
Bromodichloromethane	ND < 13.17	ND < 6.95	ND < 2.62
1,2-Dichloropropane	ND < 13.17	ND < 6.95	ND < 2.62
cis-1,3-Dichloropropene	ND < 13.17	ND < 6.95	ND < 2.62
Trichloroethene	ND < 13.17	ND < 6.95	ND < 2.62
Dibromochloromethane	ND < 13.17	ND < 6.95	ND < 2.62
1,1,2-Trichloroethane	ND < 13.17	ND < 6.95	ND < 2.62
Benzene	6.33 J	4.17 J	184.34
trans-1,3-Dichloropropene	ND < 13.17	ND < 6.95	ND < 2.62
2-Chloroethylvinylether	ND < 13.17	ND < 6.95	ND < 2.62
Bromoform	ND < 13.17	ND < 6.95	ND < 2.62
4-Methyl-2-Pentanone	ND < 13.17	ND < 6.95	ND < 2.62
2-Hexanone	ND < 13.17	ND < 6.95	1.78 J
Tetrachloroethene	ND < 13.17	ND < 6.95	1.78 J
1,1,2,2-Tetrachloroethane	ND < 13.17	ND < 6.95	ND < 2.62
Toluene	17.41	ND < 6.95	3.88
Chlorobenzene	ND < 13.17	ND < 6.95	12.58
Ethylbenzene	ND < 13.17	ND < 6.95	ND < 2.62
Styrene	ND < 13.17	ND < 6.95	27.67
7 Xylenes (Total)	ND < 13.17	ND < 6.95	ND < 2.62

TABLE 7.5-5. VOC IN VOST GAS SAMPLES FROM ESP #1 INLET (Location 5a) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

	C5A-VOS-6231	C5A-VOS-6232	C5A-VOS-6233
Chloromethane	2085.56	1460.86	205.13
Bromoethane	28.42	3.82 J	3.78
Vinyl Chloride	58.60	23.45	13.21
Chloroethane	ND < 0.06	ND < 0.13	ND < 0.41
Methylene Chloride	309.61	247.67	43.29
Acetone	162.85	113.47	3.96
Carbon Disulfide	ND < 0.06	3.54 J	ND < 0.41
1,1-Dichloroethene	ND < 0.06	4.10 J	ND < 0.41
1,1-Dichloroethane	ND < 0.06	ND < 0.13	ND < 0.41
trans-1,2-Dichloroethene	ND < 0.06	ND < 0.13	ND < 0.41
Chloroform	ND < 0.06	ND < 0.13	ND < 0.41
1,2-Dichloroethane	ND < 0.06	ND < 0.13	ND < 0.41
2-Butanone	52.68	34.36	ND < 0.41
1,1,1-Trichloroethane	ND < 0.06	ND < 0.13	1.58 J
Carbon Tetrachloride	ND < 0.06	ND < 0.13	ND < 0.41
Vinyl Acetate	ND < 0.06	ND < 0.13	ND < 0.41
Bromodichloromethane	ND < 0.06	ND < 0.13	ND < 0.41
1,2-Dichloropropane	ND < 0.06	ND < 0.13	ND < 0.41
cis-1,3-Dichloropropene	ND < 0.06	ND < 0.13	ND < 0.41
Trichloroethene	ND < 0.06	ND < 0.13	ND < 0.41
Dibromochloromethane	ND < 0.06	ND < 0.13	ND < 0.41
1,1,2-Trichloroethane	ND < 0.06	ND < 0.13	ND < 0.41
Benzene	12.43 J	848.54	6.43
trans-1,3-Dichloropropene	ND < 0.06	ND < 0.13	ND < 0.41
2-Chloroethylvinylether	ND < 0.06	ND < 0.13	ND < 0.41
Bromoform	ND < 0.06	ND < 0.13	ND < 0.41
4-Methyl-2-Pentanone	6.51 J	ND < 0.13	ND < 0.41
2-Hexanone	14.21 J	6.55 J	ND < 0.41
Tetrachloroethene	ND < 0.06	10.37	ND < 0.41
1,1,2,2-Tetrachloroethane	ND < 0.06	ND < 0.13	ND < 0.41
Toluene	ND < 0.06	9.00	ND < 0.41
Chlorobenzene	ND < 0.06	35.19	ND < 0.41
Ethylbenzene	ND < 0.06	ND < 0.13	ND < 0.41
Styrene	ND < 0.06	68.18	ND < 0.41
7 Xylenes (Total)	ND < 0.06	ND < 0.13	ND < 0.41

TABLE 7.5-6. VOC IN VOST GAS SAMPLES FROM ESP #1 INLET (Location 5a) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

	C5A-VOS-6261	C5A-VOS-6262	C5A-VOS-6263
Chloromethane	5346029	1332.68	9040.32
Bromoethane	ND< 14.52	4.10 J	ND< 2.17
Vinyl Chloride	ND< 14.52	ND< 6.84	ND< 2.17
Chloroethane	ND< 14.52	ND< 6.84	ND< 2.17
Methylene Chloride	20.92	98.68	5.38
Acetone	166.14	110.50	22.22
Carbon Disulfide	ND< 14.52	ND< 6.84	ND< 2.17
1,1-Dichloroethene	ND< 14.52	ND< 6.84	ND< 2.17
1,1-Dichloroethane	ND< 14.52	ND< 6.84	ND< 2.17
trans-1,2-Dichloroethene	ND< 14.52	ND< 6.84	ND< 2.17
Chloroform	ND< 14.52	ND< 6.84	ND< 2.17
1,2-Dichloroethane	ND< 14.52	ND< 6.84	ND< 2.17
2-Butanone	27.31	7.38	ND< 2.17
1,1,1-Trichloroethane	14.52	ND< 6.84	1.91 J
Carbon Tetrachloride	ND< 14.52	ND< 6.84	ND< 2.17
Vinyl Acetate	ND< 14.52	ND< 6.84	ND< 2.17
Bromodichloromethane	ND< 14.52	ND< 6.84	ND< 2.17
1,2-Dichloropropane	ND< 14.52	ND< 6.84	ND< 2.17
cis-1,3-Dichloropropene	ND< 14.52	ND< 6.84	ND< 2.17
Trichloroethene	ND< 14.52	ND< 6.84	ND< 2.17
Dibromochloromethane	ND< 14.52	ND< 6.84	ND< 2.17
1,1,2-Trichloroethane	ND< 14.52	ND< 6.84	ND< 2.17
Benzene	8.71 J	3.29 J	1.47 J
trans-1,3-Dichloropropene	ND< 14.52	ND< 6.84	ND< 2.17
2-Chloroethylvinylether	ND< 14.52	ND< 6.84	ND< 2.17
Bromoform	ND< 14.52	ND< 6.84	ND< 2.17
4-Methyl-2-Pentanone	ND< 14.52	ND< 6.84	ND< 2.17
2-Hexanone	ND< 14.52	ND< 6.84	ND< 2.17
Tetrachloroethene	ND< 14.52	ND< 6.84	ND< 2.17
1,1,2,2-Tetrachloroethane	ND< 14.52	ND< 6.84	ND< 2.17
Toluene	ND< 14.52	ND< 6.84	ND< 2.17
Chlorobenzene	ND< 14.52	ND< 6.84	ND< 2.17
Ethylbenzene	ND< 14.52	ND< 6.84	ND< 2.17
Styrene	ND< 14.52	ND< 6.84	ND< 2.17
7 Xylenes (Total)	ND< 14.52	ND< 6.84	ND< 2.17

TABLE 7.5-7. VOC IN VOST GAS SAMPLES FROM FGD OUTLET (Location 6a) - 6/21/93 ($\mu\text{g}/\text{Nm}^3$)

	C6A-VOS-6211	C6A-VOS-6212	C6A-VOS-6213
Chloromethane	342.52	57.29	ND < 2.76
Bromoethane	ND < 14.97	ND < 8.08	ND < 2.76
Vinyl Chloride	ND < 14.97	ND < 8.08	ND < 2.76
Chloroethane	ND < 14.97	ND < 8.08	ND < 2.76
Methylene Chloride	2391.13	17.48	38.05
Acetone	27.64	45.31	8.05
Carbon Disulfide	ND < 14.97	ND < 8.08	ND < 2.76
1,1-Dichloroethene	ND < 14.97	ND < 8.08	ND < 2.76
1,1-Dichloroethane	ND < 14.97	ND < 8.08	ND < 2.76
trans-1,2-Dichloroethene	ND < 14.97	ND < 8.08	ND < 2.76
Chloroform	ND < 14.97	ND < 8.08	ND < 2.76
1,2-Dichloroethane	ND < 14.97	ND < 8.08	1.43 J
2-Butanone	ND < 14.97	14.24	ND < 2.76
1,1,1-Trichloroethane	ND < 14.97	ND < 8.08	ND < 2.76
Carbon Tetrachloride	ND < 14.97	ND < 8.08	ND < 2.76
Vinyl Acetate	ND < 14.97	ND < 8.08	ND < 2.76
Bromodichloromethane	ND < 14.97	ND < 8.08	ND < 2.76
1,2-Dichloropropane	ND < 14.97	ND < 8.08	ND < 2.76
cis-1,3-Dichloropropene	ND < 14.97	ND < 8.08	ND < 2.76
Trichloroethene	ND < 14.97	ND < 8.08	ND < 2.76
Dibromochloromethane	ND < 14.97	ND < 8.08	ND < 2.76
1,1,2-Trichloroethane	ND < 14.97	ND < 8.08	ND < 2.76
Benzene	63.10	ND < 8.08	116.75
trans-1,3-Dichloropropene	ND < 14.97	ND < 8.08	ND < 2.76
2-Chloroethylvinylether	ND < 14.97	ND < 8.08	ND < 2.76
Bromoform	ND < 14.97	ND < 8.08	ND < 2.76
4-Methyl-2-Pentanone	ND < 14.97	ND < 8.08	ND < 2.76
2-Hexanone	12.62 J	ND < 8.08	6.73
Tetrachloroethene	ND < 14.97	ND < 8.08	ND < 2.76
1,1,2,2-Tetrachloroethane	ND < 14.97	ND < 8.08	ND < 2.76
Toluene	67.30	ND < 8.08	46.00
Chlorobenzene	ND < 14.97	ND < 8.08	1.65 J
Ethylbenzene	ND < 14.97	ND < 8.08	ND < 2.76
Styrene	ND < 14.97	ND < 8.08	1.88 J
7 Xylenes (Total)	ND < 14.97	ND < 8.08	2.10 J

TABLE 7.5-8. VOC IN VOST GAS SAMPLES FROM FGD OUTLET (Location 6a) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

	C6A-VOS-6231	C6A-VOS-6232	C6A-VOS-6233
Chloromethane	275.52	ND <	7.63
Bromoethane	ND < 15.51		3.36 J
Vinyl Chloride	ND < 15.51	ND <	7.63
Chloroethane	ND < 15.51	ND <	7.63
Methylene Chloride	214.71		198.17
Acetone	70.74		42.81
Carbon Disulfide	ND < 15.51		6.42 J
1,1-Dichloroethene	ND < 15.51	ND <	7.63
1,1-Dichloroethane	ND < 15.51	ND <	7.63
trans-1,2-Dichloroethene	ND < 15.51	ND <	7.63
Chloroform	ND < 15.51	ND <	7.63
1,2-Dichloroethane	ND < 15.51	ND <	7.63
2-Butanone	50.88		6.12 J
1,1,1-Trichloroethane	ND < 15.51	ND <	7.63
Carbon Tetrachloride	ND < 15.51	ND <	7.63
Vinyl Acetate	ND < 15.51	ND <	7.63
Bromodichloromethane	ND < 15.51	ND <	7.63
1,2-Dichloropropane	ND < 15.51	ND <	7.63
cis-1,3-Dichloropropene	ND < 15.51	ND <	7.63
Trichloroethene	ND < 15.51	ND <	7.63
Dibromochloromethane	ND < 15.51	ND <	7.63
1,1,2-Trichloroethane	ND < 15.51	ND <	7.63
Benzene	73.22		62.69
trans-1,3-Dichloropropene	ND < 15.51	ND <	7.63
2-Chloroethylvinylether	ND < 15.51	ND <	7.63
Bromoform	6.83 J	ND <	7.63
4-Methyl-2-Pentanone	40.96	ND <	7.63
2-Hexanone	68.26		19.27
Tetrachloroethene	ND < 15.51	ND <	7.63
1,1,2,2-Tetrachloroethane	ND < 15.51	ND <	7.63
Toluene	34.75		33.03
Chlorobenzene	ND < 15.51	ND <	7.63
Ethylbenzene	ND < 15.51	ND <	7.63
Styrene	ND < 15.51	ND <	7.63
7 Xylenes (Total)	ND < 15.51	ND <	7.63

TABLE 7.5-9. VOC IN VOST GAS SAMPLES FROM FGD OUTLET (Location 6a) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

	C6A-VOS-6261	C6A-VOS-6262	C6A-VOS-6263
Chloromethane	358.11	159.81	25.75
Bromoethane	15.92	8.08	2.52
Vinyl Chloride	ND< 14.19	ND< 7.76	ND< 2.52
Chloroethane	ND< 14.19	ND< 7.76	ND< 2.52
Methylene Chloride	842.42	38.86	7.17
Acetone	78.44	17.10	8.18
Carbon Disulfide	ND< 14.19	ND< 7.76	ND< 2.52
1,1-Dichloroethene	ND< 14.19	ND< 7.76	ND< 2.52
1,1-Dichloroethane	ND< 14.19	ND< 7.76	ND< 2.52
trans-1,2-Dichloroethene	ND< 14.19	ND< 7.76	ND< 2.52
Chloroform	ND< 14.19	ND< 7.76	ND< 2.52
1,2-Dichloroethane	ND< 14.19	ND< 7.76	ND< 2.52
2-Butanone	30.13	ND< 7.76	ND< 2.52
1,1,1-Trichloroethane	ND< 14.19	ND< 7.76	ND< 2.52
Carbon Tetrachloride	ND< 14.19	ND< 7.76	ND< 2.52
Vinyl Acetate	ND< 14.19	ND< 7.76	ND< 2.52
Bromodichloromethane	ND< 14.19	ND< 7.76	ND< 2.52
1,2-Dichloropropane	ND< 14.19	ND< 7.76	ND< 2.52
cis-1,3-Dichloropropene	ND< 14.19	ND< 7.76	ND< 2.52
Trichloroethene	ND< 14.19	ND< 7.76	ND< 2.52
Dibromochloromethane	ND< 14.19	ND< 7.76	ND< 2.52
1,1,2-Trichloroethane	ND< 14.19	ND< 7.76	ND< 2.52
Benzene	40.36	28.29	25.65
trans-1,3-Dichloropropene	ND< 14.19	ND< 7.76	ND< 2.52
2-Chloroethylvinylether	ND< 14.19	ND< 7.76	ND< 2.52
Bromoform	ND< 14.19	ND< 7.76	ND< 2.52
4-Methyl-2-Pentanone	ND< 14.19	ND< 7.76	ND< 2.52
2-Hexanone	ND< 14.19	ND< 7.76	4.54
Tetrachloroethene	ND< 14.19	ND< 7.76	ND< 2.52
1,1,2,2-Tetrachloroethane	ND< 14.19	ND< 7.76	ND< 2.52
Toluene	32.40	14.61	13.53
Chlorobenzene	ND< 14.19	ND< 7.76	ND< 2.52
Ethylbenzene	ND< 14.19	ND< 7.76	ND< 2.52
Styrene	ND< 14.19	ND< 7.76	ND< 2.52
7 Xylenes (Total)	ND< 14.19	ND< 7.76	ND< 2.52

TABLE 7.5-10. VOC IN DILUTE VOST GAS SAMPLES FROM FGD OUTLET (Location 6b) - 6/21/93 ($\mu\text{g}/\text{Nm}^3$)

	C6B-VOS-6211		C6B-VOS-6212		C6B-VOS-6213	
Chloromethane	ND<	21.32		9.76		61.05
Bromoethane	ND<	21.32	ND<	9.76	ND<	3.12
Vinyl Chloride	ND<	21.32	ND<	9.76	ND<	3.12
Chloroethane	ND<	21.32	ND<	9.76	ND<	3.12
Methylene Chloride		5848.14		299.13		97.26
Acetone		37.54		16.84		4.62
Carbon Disulfide	ND<	21.32	ND<	9.76	ND<	3.12
1,1-Dichloroethene	ND<	21.32	ND<	9.76	ND<	3.12
1,1-Dichloroethane	ND<	21.32	ND<	9.76	ND<	3.12
trans-1,2-Dichloroethene	ND<	21.32	ND<	9.76	ND<	3.12
Chloroform	ND<	21.32	ND<	9.76	ND<	3.12
1,2-Dichloroethane	ND<	21.32	ND<	9.76	ND<	3.12
2-Butanone		27.30		26.23		26.72
1,1,1-Trichloroethane		8.53 J	ND<	9.76	ND<	3.12
Carbon Tetrachloride	ND<	21.32	ND<	9.76	ND<	3.12
Vinyl Acetate	ND<	21.32	ND<	9.76	ND<	3.12
Bromodichloromethane	ND<	21.32	ND<	9.76	ND<	3.12
1,2-Dichloropropane	ND<	21.32	ND<	9.76	ND<	3.12
cis-1,3-Dichloropropene	ND<	21.32	ND<	9.76	ND<	3.12
Trichloroethene	ND<	21.32	ND<	9.76	ND<	3.12
Dibromochloromethane	ND<	21.32	ND<	9.76	ND<	3.12
1,1,2-Trichloroethane	ND<	21.32	ND<	9.76	ND<	3.12
Benzene	ND<	21.32	ND<	9.76		2.75 J
trans-1,3-Dichloropropene	ND<	21.32	ND<	9.76	ND<	3.12
2-Chloroethylvinylether	ND<	21.32	ND<	9.76	ND<	3.12
Bromoform	ND<	21.32	ND<	9.76	ND<	3.12
4-Methyl-2-Pentanone	ND<	21.32	ND<	9.76	ND<	3.12
2-Hexanone	ND<	21.32	ND<	9.76	ND<	3.12
Tetrachloroethene	ND<	21.32	ND<	9.76	ND<	3.12
1,1,2,2-Tetrachloroethane	ND<	21.32	ND<	9.76	ND<	3.12
Toluene		51.19	ND<	9.76	ND<	3.12
Chlorobenzene	ND<	21.32	ND<	9.76	ND<	3.12
Ethylbenzene	ND<	21.32	ND<	9.76	ND<	3.12
Styrene	ND<	21.32	ND<	9.76	ND<	3.12
7 Xylenes (Total)	ND<	21.32	ND<	9.76	ND<	3.12

TABLE 7.5-11. VOC IN DILUTE VOST GAS SAMPLES FROM FGD OUTLET (Location 6b) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

	C6B-VOS-6231	C6B-VOS-6232	C6B-VOS-6233
Chloromethane	54.49	128.68	155.11
Bromoethane	ND< 18.13	ND< 11.24	ND< 3.51
Vinyl Chloride	ND< 18.13	ND< 11.24	ND< 3.51
Chloroethane	ND< 18.13	ND< 11.24	ND< 3.51
Methylene Chloride	3423.78	150.28	29.90
Acetone	45.77	18.00	16.70
Carbon Disulfide	ND< 18.13	ND< 11.24	ND< 3.51
1,1-Dichloroethene	ND< 18.13	ND< 11.24	ND< 3.51
1,1-Dichloroethane	ND< 18.13	ND< 11.24	ND< 3.51
trans-1,2-Dichloroethene	ND< 18.13	ND< 11.24	ND< 3.51
Chloroform	ND< 18.13	ND< 11.24	ND< 3.51
1,2-Dichloroethane	ND< 18.13	ND< 11.24	ND< 3.51
2-Butanone	28.33	17.55	21.62
1,1,1-Trichloroethane	10.17 J	ND< 11.24	ND< 3.51
Carbon Tetrachloride	ND< 18.13	ND< 11.24	ND< 3.51
Vinyl Acetate	ND< 18.13	ND< 11.24	ND< 3.51
Bromodichloromethane	ND< 18.13	ND< 11.24	ND< 3.51
1,2-Dichloropropane	ND< 18.13	ND< 11.24	ND< 3.51
cis-1,3-Dichloropropene	ND< 18.13	ND< 11.24	ND< 3.51
Trichloroethene	ND< 18.13	ND< 11.24	ND< 3.51
Dibromochloromethane	ND< 18.13	ND< 11.24	ND< 3.51
1,1,2-Trichloroethane	ND< 18.13	ND< 11.24	ND< 3.51
Benzene	7.26 J	ND< 11.24	ND< 3.51
trans-1,3-Dichloropropene	ND< 18.13	ND< 11.24	ND< 3.51
2-Chloroethylvinylether	ND< 18.13	ND< 11.24	ND< 3.51
Bromoform	ND< 18.13	ND< 11.24	ND< 3.51
4-Methyl-2-Pentanone	ND< 18.13	ND< 11.24	3.09
2-Hexanone	ND< 18.13	ND< 11.24	6.46 J
Tetrachloroethene	ND< 18.13	ND< 11.24	ND< 3.51
1,1,2,2-Tetrachloroethane	ND< 18.13	ND< 11.24	ND< 3.51
Toluene	11.62 J	ND< 11.24	ND< 3.51
Chlorobenzene	ND< 18.13	ND< 11.24	ND< 3.51
Ethylbenzene	ND< 18.13	ND< 11.24	ND< 3.51
Styrene	ND< 18.13	ND< 11.24	ND< 3.51
7 Xylenes (Total)	ND< 18.13	ND< 11.24	ND< 3.51

TABLE 7.5-12. VOC IN DILUTE VOST GAS SAMPLES FROM FGD OUTLET (Location 6b) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

	C6B-VOS-6261	C6B-VOS-6262	C6B-VOS-6263
Chloromethane	63.69	107.27	31.79
Bromoethane	ND < 23.40	ND < 11.07	ND < 3.42
Vinyl Chloride	ND < 23.40	ND < 11.07	ND < 3.42
Chloroethane	ND < 23.40	ND < 11.07	ND < 3.42
Methylene Chloride	1795.40	31.03	6.58
Acetone	ND < 23.40	ND < 11.07	2.06
Carbon Disulfide	ND < 23.40	ND < 11.07	ND < 3.42 J
1,1-Dichloroethene	ND < 23.40	ND < 11.07	ND < 3.42
1,1-Dichloroethane	ND < 23.40	ND < 11.07	ND < 3.42
trans-1,2-Dichloroethene	ND < 23.40	ND < 11.07	ND < 3.42
Chloroform	ND < 23.40	ND < 11.07	ND < 3.42
1,2-Dichloroethane	ND < 23.40	ND < 11.07	ND < 3.42
2-Butanone	ND < 23.40	ND < 11.07	ND < 3.42
1,1,1-Trichloroethane	ND < 23.40	8.42	2.33
Carbon Tetrachloride	ND < 23.40 J	ND < 11.07	ND < 3.42 J
Vinyl Acetate	ND < 23.40	ND < 11.07	ND < 3.42
Bromodichloromethane	ND < 23.40	ND < 11.07	ND < 3.42
1,2-Dichloropropane	ND < 23.40	ND < 11.07	ND < 3.42
cis-1,3-Dichloropropene	ND < 23.40	ND < 11.07	ND < 3.42
Trichloroethene	ND < 23.40	ND < 11.07	ND < 3.42
Dibromochloromethane	ND < 23.40	ND < 11.07	ND < 3.42
1,1,2-Trichloroethane	ND < 23.40	ND < 11.07	ND < 3.42
Benzene	ND < 23.40	ND < 11.07	ND < 3.42
trans-1,3-Dichloropropene	ND < 23.40	ND < 11.07	ND < 3.42
2-Chloroethylvinylether	ND < 23.40	ND < 11.07	ND < 3.42
Bromoform	ND < 23.40	ND < 11.07	ND < 3.42
4-Methyl-2-Pentanone	ND < 23.40	ND < 11.07	ND < 3.42
2-Hexanone	ND < 23.40	ND < 11.07	ND < 3.42
Tetrachloroethene	ND < 23.40	ND < 11.07	ND < 3.42
1,1,2,2-Tetrachloroethane	ND < 23.40	ND < 11.07	ND < 3.42
Toluene	ND < 23.40	ND < 11.07	ND < 3.42
Chlorobenzene	ND < 23.40	ND < 11.07	ND < 3.42
Ethylbenzene	ND < 23.40	ND < 11.07	ND < 3.42
Styrene	ND < 23.40	ND < 11.07	ND < 3.42
7 Xylenes (Total)	ND < 23.40	ND < 11.07	ND < 3.42

TABLE 7.5-13. VOC IN SUMMA GAS SAMPLES FROM ESP #1 INLET (Location 4a) - 6/21/93 ($\mu\text{g}/\text{Nm}^3$)

Compound		C4A CAN6211		C4A CAN6212		C4A CAN6213
Trichlorofluoromethane		6.61		14.34		12.93
1,1-Dichloroethene	ND<	2.66		4.31	ND<	2.66
Dichloromethane		760.31 E		4028.81 E		161.62
3-Chloropropene		13.31		2.67		20.85
1,1,2-Trichloro-1,2,2-trifluoroethane		195.31		962.32		60.00
1,1-Dichloroethane		4.27	ND<	2.72	ND<	2.72
cis-1,2-dichloroethene	ND<	2.66	ND<	2.66	ND<	2.66
Trichloromethane	ND<	3.27	ND<	3.27	ND<	3.27
1,2-Dichloroethane	ND<	2.72	ND<	2.72	ND<	2.72
1,1,1-Trichloroethane	ND<	3.65	ND<	3.65		3.94
Benzene		261.81	ND<	2.14		10.71
Carbon tetrachloride	ND<	4.23	ND<	4.23	ND<	4.23
1,2-Dichloropropane	ND<	3.10	ND<	3.10	ND<	3.10
Trichloroethene	ND<	3.60	ND<	3.60	ND<	3.60
cis-1,3-Dichloropropene		49.68		3.38		5.56
trans-1,3-Dichloropropene		23.30	ND<	3.05	ND<	3.05
1,1,2-Trichloroethane	ND<	3.65	ND<	3.65	ND<	3.65
Toluene		230.10		7.14	ND<	2.52
1,2-Dibromoethane	ND<	5.16		13.97	ND<	5.16
Tetrachloroethene	ND<	4.55	ND<	4.55	ND<	4.56
Chlorobenzene		112.34		89.44		3.86
Ethylbenzene		5.46	ND<	2.91		7.42
m+p-Xylene		22.81	ND<	2.91		16.88
Styrene		6.70		5.66		3.94
1,1,2,2-Tetrachloroethane	ND<	4.61	ND<	4.61	ND<	4.61
o-Xylene		12.25	ND<	2.91		6.47
4-Ethyl toluene	ND<	3.29	ND<	3.29	ND<	3.29
1,3,5-Trimethylbenzene	ND<	3.29		15.29		9.30
1,2,4-Trimethylbenzene		3.58	ND<	3.29	ND<	3.29
Benzyl chloride	ND<	3.48	ND<	3.48	ND<	3.48
m-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
p-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
o-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
1,2,4-Trichlorobenzene	ND<	4.96	ND<	4.96	ND<	4.96
Hexachlorobutadiene	ND<	7.16	ND<	7.16	ND<	7.16

TABLE 7.5-14. VOC IN SUMMA GAS SAMPLES FROM ESP #1 INLET (Location 4a) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

Compound	C4A CAN6231		C4A CAN6232		C4A CAN6233	
Trichlorofluoromethane		22.53		22.73		23.61
1,1-Dichloroethene	ND<	2.66	ND<	2.66	ND<	2.66
Dichloromethane		2232.72 E		2256.81 E		1731.75 E
3-Chloropropene		55.67		59.38		41.25
1,1,2-Trichloro-1,2,2-trifluoroethane		151.78		172.74		153.60
1,1-Dichloroethane		4.28	ND<	2.72	ND<	2.72
cis-1,2-dichloroethene	ND<	2.66	ND<	2.66	ND<	2.66
Trichloromethane	ND<	3.27	ND<	3.27	ND<	3.27
1,2-Dichloroethane	ND<	2.72	ND<	2.72	ND<	2.72
1,1,1-Trichloroethane	ND<	3.65	ND<	3.65		5.36
Benzene		118.42		8.79		3.37
Carbon tetrachloride	ND<	4.23		6.52		7.83
1,2-Dichloropropane	ND<	3.10	ND<	3.10	ND<	3.10
Trichloroethene	ND<	3.60	ND<	3.60	ND<	3.60
cis-1,3-Dichloropropene		40.80		53.20		51.24
trans-1,3-Dichloropropene	ND<	3.05	ND<	3.05	ND<	3.05
1,1,2-Trichloroethane	ND<	3.65	ND<	3.65	ND<	3.65
Toluene	ND<	2.52		5.83		6.33
1,2-Dibromoethane	ND<	5.16	ND<	5.16		16.12
Tetrachloroethene	ND<	4.55	ND<	4.55	ND<	4.56
Chlorobenzene		36.29		36.69		26.53
Ethylbenzene		3.76	ND<	2.91	ND<	2.91
m+p-Xylene		3.14		3.75	ND<	2.91
Styrene		5.87	ND<	2.85	ND<	2.85
1,1,2,2-Tetrachloroethane	ND<	4.61	ND<	4.61	ND<	4.61
o-Xylene	ND<	2.91	ND<	2.91	ND<	2.91
4-Ethyl toluene	ND<	3.29	ND<	3.29	ND<	3.29
1,3,5-Trimethylbenzene	ND<	3.29	ND<	3.29	ND<	3.29
1,2,4-Trimethylbenzene	ND<	3.29	ND<	3.29	ND<	3.29
Benzyl chloride	ND<	3.48	ND<	3.48	ND<	3.48
m-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
p-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
o-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
1,2,4-Trichlorobenzene	ND<	4.96	ND<	4.96	ND<	4.96
Hexachlorobutadiene	ND<	7.16	ND<	7.16	ND<	7.16

TABLE 7.5-15. VOC IN SUMMA GAS SAMPLES FROM ESP #1 INLET (Location 4a) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

Compound	C4A CAN6261		C4A CAN6262		C4A CAN6263	
Trichlorofluoromethane		11.45		31.08		18.09
1,1-Dichloroethene	ND<	2.66	ND<	2.66	ND<	2.66
Dichloromethane		73.51		1493.40 E		902.45 E
3-Chloropropene	ND<	2.11		31.08		17.11
1,1,2-Trichloro-1,2,2-trifluoroethane		12.17		71.86		56.26
1,1-Dichloroethane	ND<	2.72	ND<	2.72	ND<	2.72
cis-1,2-dichloroethene	ND<	2.66	ND<	2.66	ND<	2.66
Trichloromethane	ND<	3.27	ND<	3.27	ND<	3.27
1,2-Dichloroethane	ND<	2.72	ND<	2.72	ND<	2.72
1,1,1-Trichloroethane	ND<	3.65	ND<	3.65	ND<	3.65
Benzene		4.83		11.08		14.85
Carbon tetrachloride	ND<	4.23	ND<	4.23	ND<	4.23
1,2-Dichloropropane	ND<	3.10	ND<	3.10	ND<	3.10
Trichloroethene	ND<	3.60	ND<	3.60	ND<	3.60
cis-1,3-Dichloropropene	ND<	3.05		7.89	ND<	3.05
trans-1,3-Dichloropropene	ND<	3.05	ND<	3.05	ND<	3.05
1,1,2-Trichloroethane	ND<	3.65	ND<	3.65	ND<	3.65
Toluene	ND<	2.52	ND<	2.52	ND<	2.52
1,2-Dibromoethane	ND<	5.16	ND<	5.16	ND<	5.16
Tetrachloroethene	ND<	4.55	ND<	4.55	ND<	4.56
Chlorobenzene	ND<	3.10		4.67		5.94
Ethylbenzene	ND<	2.91	ND<	2.91	ND<	2.91
m+p-Xylene	ND<	2.91	ND<	2.91	ND<	2.91
Styrene	ND<	2.85	ND<	2.85	ND<	2.85
1,1,2,2-Tetrachloroethane	ND<	4.61	ND<	4.61	ND<	4.61
o-Xylene	ND<	2.91	ND<	2.91	ND<	2.91
4-Ethyl toluene	ND<	3.29	ND<	3.29	ND<	3.29
1,3,5-Trimethylbenzene	ND<	3.29	ND<	3.29	ND<	3.29
1,2,4-Trimethylbenzene	ND<	3.29	ND<	3.29	ND<	3.29
Benzyl chloride	ND<	3.48	ND<	3.48	ND<	3.48
m-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
p-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
o-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
1,2,4-Trichlorobenzene	ND<	4.96	ND<	4.96	ND<	4.96
Hexachlorobutadiene	ND<	7.16	ND<	7.16	ND<	7.16

TABLE 7.5-16. VOC IN SUMMA GAS SAMPLES FROM ESP #1 OUTLET (Location 5a) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

Compound	C5A CAN6231		C5A CAN6232		C5A CAN6233
Trichlorofluoromethane	6.78	ND<	3.76		9.35
1,1-Dichloroethene	51.37	ND<	2.66	ND<	2.66
Dichloromethane	2956.15	E	17519	E	1292.74
3-Chloropropene	4097.29	E	8.03		68.91
1,1,2-Trichloro-1,2,2-trifluoroethane	1116.40	E	854.52	E	2016.83
1,1-Dichloroethane		2.84 ND<	2.72	ND<	2.72
cis-1,2-dichloroethene	ND<	2.66 ND<	2.66	ND<	2.66
Trichloromethane		33.91 ND<	3.27	ND<	3.27
1,2-Dichloroethane	ND<	2.72 ND<	2.72		9.14
1,1,1-Trichloroethane		17.17 ND<	3.65		10.90
Benzene		185.71	23.51		55.75
Carbon tetrachloride	ND<	4.23 ND<	4.23	ND<	4.23
1,2-Dichloropropane		7.11 ND<	3.10	ND<	3.10
Trichloroethene	ND<	3.60 ND<	3.60	ND<	3.60
cis-1,3-Dichloropropene		11.10	17.53		16.23
trans-1,3-Dichloropropene		15.33 ND<	3.05	ND<	3.05
1,1,2-Trichloroethane		24.54 ND<	3.65	ND<	3.65
Toluene		275.57	4.03		5.17
1,2-Dibromoethane		9.18 ND<	5.16		7.50
Tetrachloroethene	ND<	4.55 ND<	4.55	ND<	4.56
Chlorobenzene		51.64	44.65		331.98
Ethylbenzene		18.36 ND<	2.91		5.29
m+p-Xylene		285.01 ND<	2.91		14.15
Styrene		21.33 ND<	2.85	ND<	2.85
1,1,2,2-Tetrachloroethane		27.83 ND<	4.61	ND<	4.61
o-Xylene		21.90 ND<	2.91		7.05
4-Ethyl toluene		5.97 ND<	3.29	ND<	3.29
1,3,5-Trimethylbenzene		6.07 ND<	3.29	ND<	3.29
1,2,4-Trimethylbenzene		26.77 ND<	3.29		6.70
Benzyl chloride		26.52 ND<	3.48		10.95
m-Dichlorobenzene	ND<	4.03 ND<	4.03	ND<	4.03
p-Dichlorobenzene	ND<	4.03 ND<	4.03	ND<	4.03
o-Dichlorobenzene	ND<	4.03 ND<	4.03	ND<	4.03
1,2,4-Trichlorobenzene	ND<	4.96 ND<	4.96	ND<	4.96
Hexachlorobutadiene	ND<	7.16 ND<	7.16	ND<	7.16

TABLE 7.5-17. VOC IN SUMMA GAS SAMPLES FROM ESP #1 OUTLET (Location 5a) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

Compound		C5A CAN6261		C5A CAN6262		C5A CAN6263
Trichlorofluoromethane	ND<	3.76		5.06		10.23
1,1-Dichloroethene		2.75	ND<	2.66	ND<	2.66
Dichloromethane		6.66		1528.20 E		388.67
3-Chloropropene		141807 E		45.34		9.05
1,1,2-Trichloro-1,2,2-trifluoroethane		197.54		474.51		286.22
1,1-Dichloroethane	ND<	2.72	ND<	2.72	ND<	2.72
cis-1,2-dichloroethene	ND<	2.66	ND<	2.66	ND<	2.66
Trichloromethane		4.23	ND<	3.27	ND<	3.27
1,2-Dichloroethane		3.88	ND<	2.72	ND<	2.72
1,1,1-Trichloroethane	ND<	3.65		8.52	ND<	3.65
Benzene		11.48		9.14		5.72
Carbon tetrachloride	ND<	4.23	ND<	4.23	ND<	4.23
1,2-Dichloropropane	ND<	3.10	ND<	3.10	ND<	3.10
Trichloroethene	ND<	3.60	ND<	3.60	ND<	3.60
cis-1,3-Dichloropropene		37.47	ND<	3.05	ND<	3.05
trans-1,3-Dichloropropene		50.54	ND<	3.05	ND<	3.05
1,1,2-Trichloroethane		4.73	ND<	3.65	ND<	3.65
Toluene		85.15	ND<	2.52	ND<	2.52
1,2-Dibromoethane	ND<	5.16	ND<	5.16	ND<	5.16
Tetrachloroethene	ND<	4.55	ND<	4.55	ND<	4.55
Chlorobenzene		10.89		19.39		12.95
Ethylbenzene		19.33		5.03	ND<	2.91
m+p-Xylene		457.03		15.20	ND<	2.91
Styrene		4.96	ND<	2.85	ND<	2.85
1,1,2,2-Tetrachloroethane		41.27	ND<	4.61	ND<	4.61
o-Xylene	ND<	2.91		5.95	ND<	2.91
4-Ethyl toluene		18.36	ND<	3.29	ND<	3.29
1,3,5-Trimethylbenzene		11.38	ND<	3.29	ND<	3.29
1,2,4-Trimethylbenzene		34.75	ND<	3.29	ND<	3.29
Benzyl chloride		29.42	ND<	3.48	ND<	3.48
m-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
p-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
o-Dichlorobenzene	ND<	4.03	ND<	4.03	ND<	4.03
1,2,4-Trichlorobenzene	ND<	4.96	ND<	4.96	ND<	4.96
Hexachlorobutadiene	ND<	7.16	ND<	7.16	ND<	7.16

TABLE 7.5-18. VOC IN SUMMA GAS SAMPLES FROM FGD OUTLET (Location 6a) - 6/21/93 ($\mu\text{g}/\text{Nm}^3$)

Compound		C6A CAN6211		C6A CAN6212		C6A CAN6213
Trichlorofluoromethane		8.59		14.39		11.38
1,1-Dichloroethene	ND<	3.05	ND<	3.05	ND<	3.05
Dichloromethane		560.65		41.98		286.35
3-Chloropropene		15.29		3.10		7.73
1,1,2-Trichloro-1,2,2-trifluoroethane		15.56		19.10		18.07
1,1-Dichloroethane	ND<	3.11	ND<	3.11	ND<	3.11
cis-1,2-dichloroethene	ND<	3.05	ND<	3.05	ND<	3.05
Trichloromethane	ND<	3.74	ND<	3.74	ND<	3.74
1,2-Dichloroethane	ND<	3.11	ND<	3.11	ND<	3.11
1,1,1-Trichloroethane	ND<	4.17		10.23		13.89
Benzene		17.37		15.63		15.35
Carbon tetrachloride	ND<	4.83	ND<	4.83	ND<	4.83
1,2-Dichloropropane	ND<	3.54	ND<	3.54	ND<	3.54
Trichloroethene	ND<	4.11	ND<	4.11	ND<	4.11
cis-1,3-Dichloropropene		11.54		20.21	ND<	3.48
trans-1,3-Dichloropropene	ND<	3.48	ND<	3.48	ND<	3.48
1,1,2-Trichloroethane	ND<	4.17	ND<	4.17	ND<	4.17
Toluene	ND<	2.88		14.08	ND<	2.88
1,2-Dibromoethane	ND<	5.90	ND<	5.90	ND<	5.90
Tetrachloroethene	ND<	5.21	ND<	5.21	ND<	5.22
Chlorobenzene		6.01	ND<	3.54		4.20
Ethylbenzene	ND<	3.33		3.79	ND<	3.33
m+p-Xylene	ND<	3.33		6.06	ND<	3.33
Styrene	ND<	3.26	ND<	3.26	ND<	3.26
1,1,2,2-Tetrachloroethane	ND<	5.27	ND<	5.27	ND<	5.27
o-Xylene	ND<	3.33	ND<	3.33	ND<	3.33
4-Ethyl toluene	ND<	3.77	ND<	3.77	ND<	3.77
1,3,5-Trimethylbenzene	ND<	3.77	ND<	3.77	ND<	3.77
1,2,4-Trimethylbenzene	ND<	3.77	ND<	3.77	ND<	3.77
Benzyl chloride	ND<	3.98	ND<	3.98	ND<	3.98
m-Dichlorobenzene	ND<	4.61	ND<	4.61	ND<	4.61
p-Dichlorobenzene	ND<	4.61	ND<	4.61	ND<	4.61
o-Dichlorobenzene	ND<	4.61	ND<	4.61	ND<	4.61
1,2,4-Trichlorobenzene	ND<	5.68	ND<	5.68	ND<	5.68
Hexachlorobutadiene	ND<	8.19	ND<	8.19	ND<	8.19

TABLE 7.5-19. VOC IN SUMMA GAS SAMPLES FROM FGD OUTLET (Location 6a) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

Compound	C6A		C6A		C6A	
	CAN6231		CAN6232		CAN6233	
Trichlorofluoromethane		16.78		47.69		16.50
1,1-Dichloroethene		5.64 ND<		3.28 ND<		3.28
Dichloromethane		3783.50 E		9182.14 E		6908.08 E
3-Chloropropene		81.81		296.01		6.21
1,1,2-Trichloro-1,2,2-trifluoroethane		29.03		77.47		27.61
1,1-Dichloroethane	ND<	3.35	ND<	3.35	ND<	3.35
cis-1,2-dichloroethene	ND<	3.28	ND<	3.28	ND<	3.28
Trichloromethane	ND<	4.03	ND<	4.03	ND<	4.03
1,2-Dichloroethane	ND<	3.35	ND<	3.35	ND<	3.35
1,1,1-Trichloroethane	ND<	4.50	ND<	4.50	ND<	4.50
Benzene		50.91		62.10		18.27
Carbon tetrachloride	ND<	5.21	ND<	5.21	ND<	5.21
1,2-Dichloropropane	ND<	3.82	ND<	3.82	ND<	3.82
Trichloroethene	ND<	4.43	ND<	4.43	ND<	4.43
cis-1,3-Dichloropropene		8.70		24.23		7.74
trans-1,3-Dichloropropene	ND<	3.75	ND<	3.75	ND<	3.75
1,1,2-Trichloroethane	ND<	4.50	ND<	4.50	ND<	4.50
Toluene		7.76		3.90	ND<	3.11
1,2-Dibromoethane		20.13	ND<	6.36	ND<	6.36
Tetrachloroethene	ND<	5.61	ND<	5.61	ND<	5.62
Chlorobenzene		9.96		19.41		5.05
Ethylbenzene	ND<	3.59	ND<	3.59	ND<	3.59
m+p-Xylene	ND<	3.59		22.94	ND<	3.59
Styrene	ND<	3.51	ND<	3.51	ND<	3.51
1,1,2,2-Tetrachloroethane	ND<	5.68	ND<	5.68	ND<	5.68
o-Xylene	ND<	3.59	ND<	3.59	ND<	3.59
4-Ethyl toluene	ND<	4.06	ND<	4.06	ND<	4.06
1,3,5-Trimethylbenzene		10.62		5.65	ND<	4.06
1,2,4-Trimethylbenzene	ND<	4.06	ND<	4.06	ND<	4.06
Benzyl chloride	ND<	4.29	ND<	4.29	ND<	4.29
m-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
p-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
o-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
1,2,4-Trichlorobenzene	ND<	6.12	ND<	6.12	ND<	6.12
Hexachlorobutadiene	ND<	8.82	ND<	8.82	ND<	8.82

TABLE 7.5-20. VOC IN SUMMA GAS SAMPLES FROM FGD OUTLET (Location 6a) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

Compound	C6A CAN6261		C6A CAN6262		C6A CAN6263	
Trichlorofluoromethane	15.14		15.29		16.20	
1,1-Dichloroethene	28.08	ND<	3.28	ND<	3.28	
Dichloromethane	3232.68	E	4866.46	E	3954.43	E
3-Chloropropene	20.55		77.21		16.55	
1,1,2-Trichloro-1,2,2-trifluoroethane	15.65		14.68		14.88	
1,1-Dichloroethane	ND<	3.35	ND<	3.35	ND<	3.35
cis-1,2-dichloroethene	67.26		39.37		17.95	
Trichloromethane	5.79	ND<	4.03	ND<	4.03	
1,2-Dichloroethane	19.88	ND<	3.35	ND<	3.35	
1,1,1-Trichloroethane	24.24	ND<	4.50	ND<	4.50	
Benzene	6.35		7.06		5.83	
Carbon tetrachloride	ND<	5.21	ND<	5.21	ND<	5.21
1,2-Dichloropropane	ND<	3.82	ND<	3.82	ND<	3.82
Trichloroethene	ND<	4.43	ND<	4.43	ND<	4.43
cis-1,3-Dichloropropene		7.15		7.29		19.60
trans-1,3-Dichloropropene		7.95	ND<	3.75	ND<	3.75
1,1,2-Trichloroethane	ND<	4.50	ND<	4.50	ND<	4.50
Toluene		12.71		6.56		3.83
1,2-Dibromoethane	ND<	6.36	ND<	6.36	ND<	6.36
Tetrachloroethene	ND<	5.61	ND<	5.61	ND<	5.62
Chlorobenzene		6.12	ND<	3.82	ND<	3.82
Ethylbenzene	ND<	3.59		4.00	ND<	3.59
m+p-Xylene	ND<	3.59		4.47	ND<	3.59
Styrene	ND<	3.51	ND<	3.51	ND<	3.51
1,1,2,2-Tetrachloroethane		17.47		8.07	ND<	5.68
o-Xylene	ND<	3.59	ND<	3.59	ND<	3.59
4-Ethyl toluene	ND<	4.06	ND<	4.06	ND<	4.06
1,3,5-Trimethylbenzene	ND<	4.06	ND<	4.06	ND<	4.06
1,2,4-Trimethylbenzene	ND<	4.06	ND<	4.06	ND<	4.06
Benzyl chloride	ND<	4.29	ND<	4.29	ND<	4.29
m-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
p-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
o-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
1,2,4-Trichlorobenzene	ND<	6.12	ND<	6.12	ND<	6.12
Hexachlorobutadiene	ND<	8.82	ND<	8.82	ND<	8.82

TABLE 7.5-21. VOC IN DILUTE SUMMA GAS SAMPLES FROM FGD OUTLET (Location 6b) - 6/21/93 ($\mu\text{g}/\text{Nm}^3$)

Compound		C6B CAN6211		C6B CAN6212		C6B CAN6213
Trichlorofluoromethane		8.84		9.35		11.34
1,1-Dichloroethene	ND<	3.05	ND<	3.05	ND<	3.05
Dichloromethane		60.05		23.66		21.34
3-Chloropropene	ND<	2.42	ND<	2.42	ND<	2.42
1,1,2-Trichloro-1,2,2-trifluoroethane		13.64		15.49		18.25
1,1-Dichloroethane	ND<	3.11	ND<	3.11	ND<	3.11
cis-1,2-dichloroethene	ND<	3.05	ND<	3.05	ND<	3.05
Trichloromethane	ND<	3.74	ND<	3.74	ND<	3.74
1,2-Dichloroethane	ND<	3.11	ND<	3.11	ND<	3.11
1,1,1-Trichloroethane	ND<	4.17	ND<	4.17	ND<	4.17
Benzene		7.46		8.23		14.61
Carbon tetrachloride	ND<	4.83	ND<	4.83	ND<	4.83
1,2-Dichloropropane	ND<	3.54	ND<	3.54	ND<	3.54
Trichloroethene	ND<	4.11	ND<	4.11	ND<	4.11
cis-1,3-Dichloropropene	ND<	3.48		6.91	ND<	3.48
trans-1,3-Dichloropropene	ND<	3.48	ND<	3.48	ND<	3.48
1,1,2-Trichloroethane	ND<	4.17	ND<	4.17	ND<	4.17
Toluene	ND<	2.88	ND<	2.88	ND<	2.88
1,2-Dibromoethane		7.83		9.20	ND<	5.90
Tetrachloroethene	ND<	5.21	ND<	5.21	ND<	5.22
Chlorobenzene	ND<	3.54	ND<	3.54	ND<	3.54
Ethylbenzene	ND<	3.33	ND<	3.33	ND<	3.33
m+p-Xylene		3.65	ND<	3.33	ND<	3.33
Styrene	ND<	3.26	ND<	3.26		9.33
1,1,2,2-Tetrachloroethane	ND<	5.27	ND<	5.27	ND<	5.27
o-Xylene	ND<	3.33	ND<	3.33	ND<	3.33
4-Ethyl toluene	ND<	3.77	ND<	3.77	ND<	3.77
1,3,5-Trimethylbenzene	ND<	3.77		4.32		10.56
1,2,4-Trimethylbenzene	ND<	3.77	ND<	3.77	ND<	3.77
Benzyl chloride	ND<	3.98	ND<	3.98	ND<	3.98
m-Dichlorobenzene	ND<	4.61	ND<	4.61	ND<	4.61
p-Dichlorobenzene	ND<	4.61	ND<	4.61	ND<	4.61
o-Dichlorobenzene	ND<	4.61	ND<	4.61	ND<	4.61
1,2,4-Trichlorobenzene	ND<	5.68	ND<	5.68	ND<	5.68
Hexachlorobutadiene	ND<	8.19	ND<	8.19	ND<	8.19

Note! Concentrations need to be multiplied by average dilution factor of 28.9 for comparison with VOST sample.

TABLE 7.5-22. VOC IN DILUTE SUMMA GAS SAMPLES FROM FGD OUTLET (Location 6b) - 6/23/93 ($\mu\text{g}/\text{Nm}^3$)

Compound		C6B CAN6231		C6B CAN6232		C6B CAN6233
Trichlorofluoromethane		15.87		25.22		14.93
1,1-Dichloroethene	ND<	3.28	ND<	3.28	ND<	3.28
Dichloromethane		157.79		53.00		56.85
3-Chloropropene		20.56		13.94		9.40
1,1,2-Trichloro-1,2,2-trifluoroethane		25.85		38.98		24.88
1,1-Dichloroethane	ND<	3.35	ND<	3.35	ND<	3.35
cis-1,2-dichloroethene	ND<	3.28	ND<	3.28	ND<	3.28
Trichloromethane	ND<	4.03	ND<	4.03	ND<	4.03
1,2-Dichloroethane	ND<	3.35	ND<	3.35	ND<	3.35
1,1,1-Trichloroethane	ND<	4.50	ND<	4.50	ND<	4.50
Benzene		14.07		19.29		11.62
Carbon tetrachloride	ND<	5.21	ND<	5.21	ND<	5.21
1,2-Dichloropropane	ND<	3.82	ND<	3.82	ND<	3.82
Trichloroethene	ND<	4.43	ND<	4.43	ND<	4.43
cis-1,3-Dichloropropene		7.03		13.42		7.59
trans-1,3-Dichloropropene	ND<	3.75	ND<	3.75	ND<	3.75
1,1,2-Trichloroethane	ND<	4.50	ND<	4.50	ND<	4.50
Toluene	ND<	3.11	ND<	3.11	ND<	3.11
1,2-Dibromoethane		12.30		19.03	ND<	6.36
Tetrachloroethene	ND<	5.61	ND<	5.61	ND<	5.61
Chlorobenzene	ND<	3.82		5.91	ND<	3.82
Ethylbenzene	ND<	3.59		6.40	ND<	3.59
m+p-Xylene	ND<	3.59		4.46	ND<	3.59
Styrene	ND<	3.51	ND<	3.51	ND<	3.51
1,1,2,2-Tetrachloroethane	ND<	5.68	ND<	5.68	ND<	5.68
o-Xylene	ND<	3.59	ND<	3.59	ND<	3.59
4-Ethyl toluene	ND<	4.06	ND<	4.06	ND<	4.06
1,3,5-Trimethylbenzene	ND<	4.06	ND<	4.06	ND<	4.06
1,2,4-Trimethylbenzene	ND<	4.06	ND<	4.06	ND<	4.06
Benzyl chloride	ND<	4.29	ND<	4.29	ND<	4.29
m-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
p-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
o-Dichlorobenzene	ND<	4.97	ND<	4.97	ND<	4.97
1,2,4-Trichlorobenzene	ND<	6.12	ND<	6.12	ND<	6.12
Hexachlorobutadiene	ND<	8.82	ND<	8.82	ND<	8.82

Note! Concentrations need to be multiplied by average dilution factor of 28.9 for comparison with VOST sample.

TABLE 7.5-23. VOC IN DILUTE SUMMA GAS SAMPLES FROM FGD OUTLET (Location 6b) - 6/26/93 ($\mu\text{g}/\text{Nm}^3$)

Compound	C6B		C6B		C6B	
	CAN6261		CAN6262		CAN6263	
Trichlorofluoromethane		14.18		13.59		15.02
1,1-Dichloroethane	ND*	3.28	ND*	3.28	ND*	3.28
Dichloromethane		6886.97 E		398.00		308.63
3-Chloropropene		7.32		6.42		4.37
1,1,2-Trichloro-1,2,2-trifluoroethane		14.20		13.79		14.61
1,1-Dichloroethane	ND*	3.35	ND*	3.35	ND*	3.35
cis-1,2-dichloroethene		3.80	ND*	3.28	ND*	3.28
Trichloromethane	ND*	4.03	ND*	4.03	ND*	4.03
1,2-Dichloroethane	ND*	3.35	ND*	3.35	ND*	3.35
1,1,1-Trichloroethane	ND*	4.50	ND*	4.50	ND*	4.50
Benzene	ND*	2.64		2.98	ND*	2.64
Carbon tetrachloride	ND*	5.21	ND*	5.21	ND*	5.21
1,2-Dichloropropane	ND*	3.82	ND*	3.82	ND*	3.82
Trichloroethene	ND*	4.43	ND*	4.43	ND*	4.43
cis-1,3-Dichloropropene		24.89	ND*	3.75		32.88
trans-1,3-Dichloropropene	ND*	3.75	ND*	3.75	ND*	3.75
1,1,2-Trichloroethane	ND*	4.50	ND*	4.50	ND*	4.50
Toluene	ND*	3.11	ND*	3.11	ND*	3.11
1,2-Dibromoethane	ND*	6.36	ND*	6.36	ND*	6.36
Tetrachloroethene	ND*	5.61	ND*	5.61	ND*	5.62
Chlorobenzene	ND*	3.82	ND*	3.82	ND*	3.82
Ethylbenzene	ND*	3.59	ND*	3.59	ND*	3.59
m+p-Xylene	ND*	3.59	ND*	3.59	ND*	3.59
Styrene	ND*	3.51	ND*	3.51	ND*	3.51
1,1,2,2-Tetrachloroethane	ND*	5.68	ND*	5.68	ND*	5.68
o-Xylene	ND*	3.59	ND*	3.59	ND*	3.59
4-Ethyl toluene	ND*	4.06	ND*	4.06	ND*	4.06
1,3,5-Trimethylbenzene	ND*	4.06	ND*	4.06	ND*	4.06
1,2,4-Trimethylbenzene	ND*	4.06	ND*	4.06	ND*	4.06
Benzyl chloride	ND*	4.29	ND*	4.29	ND*	4.29
m-Dichlorobenzene	ND*	4.97	ND*	4.97	ND*	4.97
p-Dichlorobenzene	ND*	4.97	ND*	4.97	ND*	4.97
o-Dichlorobenzene	ND*	4.97	ND*	4.97	ND*	4.97
1,2,4-Trichlorobenzene	ND*	6.12	ND*	6.12	ND*	6.12
Hexachlorobutadiene	ND*	8.82	ND*	8.82	ND*	8.82

Note! Concentrations need to be multiplied by average dilution factor of 28.9 for comparison with VOST sample.

TABLE 7.5-24. COMPARISON OF CAN AND VOST RESULTS FOR SELECT COMPOUNDS ($\mu\text{g}/\text{Nm}^3$)

Test Run I.D.	Dichloromethane		Benzene		Toluene	
	CAN	VOST	CAN	VOST	CAN	VOST
C4A-6211	760.31 E	50.06	261.81	1205.	230.10	152.6
C4A-6212	4028 E	15.45	ND< 2.14	28.37	7.14	68.9
C4A-6213	161.62	5.85	10.71	1.55 J	ND< 2.52	19.95
C4A-6231	2233 E	44.13	118.42	ND< 8.47	ND< 2.52	17.31
C4A-6232	2256 E	10.94	8.79	ND< 6.36	5.83	5.34 J
C4A-6233	1731 E	3.13	3.37	2.44	6.33	2.75
C4A-6261	73.51	28.5	4.83	ND< 10.65	ND< 2.52	27.66
C4A-6262	1493 E	7.01	11.08	5.57	ND< 2.52	2.68 J
C4A-6263	902.45 E	5.36	14.85	78.91	ND< 2.52	3.95
C5A-6231	2956 E	309.6	185.71	12.43 J	275.57	ND< 0.06
C5A-6232	17519 E	247.6	23.51	848.5	4.03	9
C5A-6233	1293 E	43.29	55.75	6.43	5.17	ND< 0.41
C5A-6261	6.66	20.92	11.48	8.71 J	85.15	ND< 14.52
C5A-6262	1528 E	98.68	9.14	3.29 J	ND< 2.52	ND< 6.84
C5A-6263	388.67	5.38	5.72	1.47 J	ND< 2.52	ND< 2.17
C6A-6211	560.65	2391.	17.37	63.1	ND< 2.88	67.3
C6A-6212	41.98	17.48	15.63	ND< 8.08	14.08	ND< 8.08
C6A-6213	286.35	38.05	15.35	116.7	ND< 2.88	46
C6A-6231	3784 E	214.7	50.91	73.22	7.76	34.75
C6A-6232	9182 E	198.1	62.10	62.69	3.90	33.03
C6A-6233	6908 E	689.7	18.27	62.53	ND< 3.11	32.72
C6A-6261	3233 E	842.4	6.35	40.36	12.71	32.40
C6A-6262	4866 E	38.86	7.06	28.29	6.56	14.61
C6A-6263	3954 E	7.17	5.83	25.65	3.83	13.53
C6B-6211	1735.4	5848.	215.6	ND< 21.32	ND< 2.88	51.19
C6B-6212	683.8	299.1	237.8	ND< 9.76	ND< 2.88	ND< 9.76
C6B-6213	616.7	97.26	422.2	2.75 J	ND< 2.88	ND< 3.12
C6B-6231	4560.1	3423.	406.6	7.26 J	ND< 3.11	11.62 J
C6B-6232	1531.7	150.2	557.5	ND< 11.24	ND< 3.11	ND< 11.24
C6B-6233	1643.0	29.9	335.8	ND< 3.51	ND< 3.11	ND< 3.51
C6B-6261	199033	1795.	ND< 2.64	ND< 23.4	ND< 3.11	ND< 23.4
C6B-6262	11502	31.03	86	ND< 11.07	ND< 3.11	ND< 11.07
C6B-6263	8919.4	6.58	ND< 2.64	ND< 3.42	ND< 3.11	ND< 3.42

Figure 7.5-1. Can vs VOST comparison for benzene and toluene daily averages

Figure 7.5-2. Can vs VOST comparison for benzene and toluene location averages

7.6 Mercury Results for Individual Method 29 Components

The individual components of the Method 29 (M29) train were analyzed separately for mercury at the request of DOE, rather than combining front-half and back-half components as is standard practice in Method 29 procedures. The results for these individual component analyses are presented in Table 7.7-1, for each of the three inorganic sampling days at the ESP inlet (Location 4a), ESP outlet (Location 5a), and scrubber outlet (Location 6a).

The results in Table 7.6-1 show that at both locations the great majority of mercury was found in the impinger components of the M29 train. At the ESP outlet, most of the mercury (54 to 88 percent, averaging 67 percent) was captured in the H_2O_2 impingers; the KMnO_4 impingers (which are located downstream of the H_2O_2 impingers in the Method 29 train) captured a smaller fraction of the mercury (11 to 46 percent, averaging 32 percent). The opposite is true for the ESP inlet and scrubber outlet, where most of the mercury was captured in the KMnO_4 impingers (59 to 77 percent, averaging 67 percent) with the remainder primarily in the H_2O_2 impingers (23 to 41 percent, averaging 33 percent). Results from the scrubber outlet (Location 6a) were particularly consistent, indicating 32 to 37 percent in the H_2O_2 impingers, and 63 to 68 percent in the KMnO_4 impingers.

The M29 train was not designed to separate elemental and oxidized forms of mercury. However, it is reasonable to assume that the more soluble oxidized forms of mercury may be preferentially removed in the peroxide impingers. Under this assumption, the results indicate that the proportions of elemental and oxidized mercury vary with location in the plant. Specifically, the results in Table 7.6-1 suggest that elemental mercury is relatively higher with respect to oxidized mercury at the ESP inlet and at the stack than at the intermediate location at the ESP outlet (scrubber inlet).

TABLE 7.6-1. RESULTS FOR MERCURY IN GAS SAMPLES FROM COAL CREEK

Sample Component	ESP INLET						ESP OUTLET						SCRUBBER OUTLET					
	C-4A-MUM-822		C-4A-MUM-824		C-4A-MUM-827		C-5A-MUM-822		C-5A-MUM-824		C-5A-MUM-827		C-6A-MUM-822		C-6A-MUM-824		C-6A-MUM-827	
	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total	ug/Nm ³	Percent of Total
H2O2 Impinger	3.88	31%	3.67	23%	5.15	41%	5.76	60%	7.47	88%	9.42	54%	4.18	37%	5.82	34%	3.07	32%
KMNO4 Impinger	8.70	68%	12.00	77%	7.46	59%	3.82	40%	0.94	11%	7.99	46%	7.01	63%	11.23	66%	6.66	68%
Acid Probe Rinse	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Acetone Probe Rinse	0.03	0.2%	0	0%	0.03	0.3%	0	0%	0.04	1%	0.02	0.1%	0	0%	0	0%	0	0%
Filter	0.11	1%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Large Cyclones	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Small Cyclones	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Total	12.72		15.67		12.64		9.58		8.45		17.43		11.20		17.05		9.73	