

# **Plant Crist Electric Generating Plant Groundwater Monitoring Plan**

Volume III: Drawings

February 1984



**Gulf Power**

*the southern electric system*

## CHAPTER 4

### ASH CHARACTERISTICS

This chapter addresses the composition and characteristics of the ash generated at the Resources facility. Site-specific analytical data is available since the ash and the leachate from the ash building are analyzed quarterly for priority pollutant metals in accordance with the DERM permit and ash management regulations. These site-specific analytical data are reported as well as comparative data reported in technical literature. Future ash characteristics given the proposed capital improvements are considered.

### HISTORIC DATA

#### Total Ash Composition

Comprehensive ash analyses were performed for each boiler during the acceptance testing periods, from November 1988 to May 1990. Between four to eight hourly composite samples were obtained during the testing period for each boiler. Each sample was subjected to the following analyses: percent moisture, percent combustibles, and heavy metals (silver, arsenic, barium, cadmium, chromium, copper, nickel, lead, selenium, and zinc).

The percent moisture value represents moisture and volatile materials in the ash, based on weight loss upon drying at 105°C. The percent combustibles represent unoxidized organic material based upon the additional weight loss of dried material upon drying at 550°C in a muffle furnace and thermal decomposition of inorganics such as carbonates. Together both percent moisture and percent combustibles help define the degree of combustion of the influent fuel and thus the efficiency of the combustion process for the particular boiler from which the ash is generated.

**TABLE 4-1**  
**ASH ANALYSIS - RESOURCES**

Unit Date No. Samples		Boiler 1 (11/4/88) (8 samples)	Boiler 2 (5/9/89) (5 samples)	Boiler 3 (9/1/89) (5 samples)	Boiler 4(1) (11/8/89) (4 samples)
Parameter	Units				
Moisture	%	16.1-19.9	13.3-19.3	16.0-22.9	22-29
Combustibles	%	1.7-3.5	1.2-2.4	1.3-3.4	7.0-10.6
Arsenic	mg/kg	6.2-14	<2	<0.4-1.1	0.8-3.5
Barium	mg/kg	140-260	55-85	163-228	260-340
Cadmium	mg/kg	8.2-19	13-18	13-16	25-37
Chromium	mg/kg	55-68	65-78	34-70	48-68
Copper	mg/kg	210-480	820-3200	580-1460	1220-4000
Lead	mg/kg	460-970	810-1560	994-1840	1600-5100
Nickel	mg/kg	17-41	89-150	76-124	48-130
Selenium	mg/kg	<2-4	<1	<0.4-0.7	0.5-0.9
Silver	mg/kg	2.7-6.4	11-15	<2-2.2	<2
Zinc	mg/kg	1110-1900	2200-2600	1750-2500	3900-6300

- (1) These values are not representative of true operating conditions of Boiler No. 4 because at the time of this test the boiler was not operating properly. As a result, these values are not comparable to those for Boilers 1 through 3. A retest was performed in May 1990 but those results were presented in units and a format which is not comparable to the data provided in this table.

### Extraction Procedure Toxicity Testing

The previous discussion has focused on total ash composition. Data are also available for Extraction Procedure (EP) Toxicity Testing for the combined ash. The EP Toxicity Test is designed to simulate the leachate generation potential of a material by exposing it to a mildly acidic solution (pH = 5.0). In terms of environmental impact, these data represent the possible metal loadings to the offsite environment from the waste leachate, if not controlled, i.e., its Toxicity Characteristic.

The Toxicity Characteristic is used to determine if a waste should be considered, and subsequently managed as a hazardous waste. Under 40 CFR 261.4(b)(1), "a resource recovery facility managing solid waste shall not be deemed to be treating, storing, disposing of, or otherwise managing hazardous wastes for the purposes of regulation under this subtitle, if such facility":

- 1) receives and burns only household waste (from single and multiple-family dwellings, hotels, motels, and other residential sources), and solid waste from commercial or industrial sources that does not contain hazardous waste; and
- 2) does not accept hazardous wastes and the owner or operator of such facility has established an inspection procedure to assure that hazardous wastes are not received at or burned in such facility.

Resources meets the above-stated requirements, confirmed by spot-checking loads on the tipping floor for hazardous waste prior to dumping the waste loads in the holding pit. Therefore, the ash generated is exempt and need not be treated as a hazardous waste.

Results. EP toxicity data is available for the previously described boiler compliance testing and additional testing on composite ash samples taken quarterly during a period from July 1989

to July 1990. Table 4-2 provides a summary of the data. For comparative purposes a leachate sample from the ash monofill is also provided in Table 4-2.

As with the total metal data, the EP toxicity data also demonstrate wide variability, albeit to a lesser degree than found for the total ash concentrations. In numerous cases the sample analyses were below the detectable limit for that particular parameter. In the vast majority of the samples, the leachate concentrations were below the 1.0 parts per million (ppm) level. Certain samples did exceed the concentration levels for EP toxicity which are used to determine if a nonexempt solid waste is hazardous. However, this is immaterial given the exemption applying to the resource recovery facility. These samples included one sample each from Boilers 3 and 4 for lead and cadmium. However, with the exception of lead for Boiler 4 the average contaminant concentrations for all boilers were well below the nonexempt waste regulatory limits. For the Boiler 4 lead data, elimination of the single unusually high reported value would allow the average to drop below the nonexempt waste regulatory limits.

Due to the availability of an EP Toxicity Test sample and an actual leachate sample from the same time period a comparison of "theoretical" versus "actual" metal content can be made. For all parameters except chromium, the EP Toxicity data results for the composite ash are significantly higher than the actual leachate, often in the 0.4 to 1.0 order of magnitude range. Chromium was approximately five times greater in the leachate sample relative to the composite ash samples. While the normal variations present in grab sampling no doubt contribute to these differences, fundamental differences between laboratory and field leaching potential appear to exist.

Based upon the measured pH of the leachate (8.1), the potential for dissolution of metals by leachate is decreased relative to the lower pH value of the EP Toxicity Test (5.0). This factor would appear to primarily account for the differences in metallic content. Another factor could include redox reactions occurring in the ash monofill.

**TABLE 4-2**  
**EP TOXICITY TESTING<sup>1</sup> - RESOURCES**

Location Sample Date	Composite Ash (7/89-7/90)	Boiler 1 (11/4/88)	Boiler 2 (5/9/89)	Boiler 3 (9/1/89)	Boiler 4 (11/8/89)	Leachate (11/2/90)
Parameter						
Arsenic	<0.02-0.015	<0.05	<0.05	<0.01	<0.01	0.012
Barium	0.274-1.32	<0.1-0.6	<1.0	<2.5	<2.5	---
Cadmium	<0.001-0.82	0.3-0.6	<0.01-0.5	<0.5-2.5	0.7-1.2	0.04
Chromium	0.005-0.060	<0.05-0.07	<0.05	0.1	<1.0	0.22
Lead	0.001-3.58	0.2-2.2	<0.05-0.7	<1.0-6.3	3.6-59	0.030
Mercury	<0.0002-0.00027	<0.02	<0.02	<0.005-0.004	<0.01	<0.0002
Selenium	<0.0002-0.010	<0.01	<0.01-0.02	<0.01	<0.01	<0.002
Silver	<0.0002-0.0049	<0.05-0.87	<0.05	<0.5	<0.05	<0.002

<sup>1</sup> All data in mg/L

## COMPARATIVE DATA

Data for total ash content and EP Toxicity have been reported in the literature for various waste-to-energy facilities in the United States. These data are summarized in Tables 4-3 and 4-4, respectively. Table 4-3 also contains specific data from a 100 percent refuse derived fuel (RDF) facility as reported by Chrostowski (unpublished) for comparison with the Metro Dade Facility.

### Total Ash Composition

The comparative data presented in Table 4-3 varies widely as would be expected given the variability in facilities. These variabilities include type of facility (mass burn versus RDF), waste processing prior to combustion, and specific composition of the influent municipal solid waste. However, comparison of the Metro Dade Facility data in Table 4-1 with the RDF facility (unnamed) given in Table 4-3 provides insight into the variation in ash composition between reasonably similar facilities. The Metro-Dade facility exhibited relatively higher cadmium, copper, lead, and zinc concentrations. For arsenic, nickel and selenium the Metro Dade facility demonstrates relatively lower concentrations. Chromium values were comparable for the two facilities. In the absence of data concerning the design and operation of the unnamed facility, specific reasons for the differences cannot be assessed. However, the previously discussed factors affecting variability between facilities are probably applicable in this case.

A number of potentially toxic trace organic compounds have been identified in ash including polynuclear aromatic hydrocarbons (PAHs), chlorinated phenols, polychlorinated dibenzo-p-dioxins (PCDDs) including the highly toxic tetrachloro-p-dioxin (TCDD) compound, polychlorinated dibenzofurans (PCDFs), chlorinated benzenes, and chlorinated biphenyls (PCBs). Concentrations of these materials can range from the ng/g (part per billion) level to ug/g (part per million) level. A range of concentrations for two of these trace organics, PCDD and PCDF, are reported in Table 4-3.

TABLE 4-3

MUNICIPAL WASTE-TO-ENERGY ASH CHARACTERISTICS<sup>1</sup>

Parameter	Units	Range of Values	RDF Facility
Arsenic <sup>2</sup>	mg/kg	1 - 1,250	1,250
Barium <sup>2</sup>	mg/kg	80 - 9,000	---
Cadmium <sup>2</sup>	mg/kg	0.2 - 2,000	3
Chromium <sup>2</sup>	mg/kg	12 - 1,900	70
Copper <sup>2</sup>	mg/kg	69 - 5,900	100
Lead <sup>2</sup>	mg/kg	400 - 54,000	500
Nickel <sup>2</sup>	mg/kg	39 - 960	1,000
Selenium <sup>2</sup>	mg/kg	0.1 - 62	62
Zinc <sup>2</sup>	mg/kg	3,500 - 136,000	250
PCDD <sup>3</sup>	ng/g	6 - 350	N/A
PCDF <sup>3</sup>	ng/g	6 - 154	N/A

<sup>1</sup> Adapted from Lisk (1988), NUS (1987) and Clapp et. al. 1988.

<sup>2</sup> Range includes flyash and bottom ash values.

<sup>3</sup> Combined ash.



TABLE 4-4

EP TOXICITY TESTING - LITERATURE VALUES<sup>1</sup>

Parameter	Reported Values	
	Literature	CORRE
Arsenic	0.005 - 0.100	ND - 0.031
Barium	0.027 - 6.300	0.023 - 0.455
Cadmium	0.010 - 3.940	0.025 - 1.200
Chromium	0.0059 - 0.460	ND - 0.086
Lead	0.020 - 34.000	ND - 19.700
Mercury	ND - 6.000	ND - 0.203
Selenium	0.002 - 0.100	ND
Silver	0.001 - 0.100	ND

<sup>1</sup> All values in mg/L

Source: NUS/Office of Solid Waste. Characterization of Municipal Waste Combustion Ash, Ash Extracts, and Leachates - Coalition on Resource Recovery and the Environment. PB90-187154. 1990

ND Not Detected

CORRE Coalition on Resource Recovery and the Environment Study

## Extraction Procedure Toxicity Testing

The survey data available in Table 4-4 are comparable with the EP Toxicity data reported in Table 4-2 for the Metro Dade Facility ash. Comparison of these data show the Metro-Dade leachate data to be in the range of values reported in the literature with the exception of silver and lead in samples associated with Boilers No. 1 and 4, respectively. Thus, overall, the leachate from the Metro Dade Facility appears reasonable for a municipal waste-to-energy facility.

Ash analyses have typically focused on the heavy metals. However, the combined ash is primarily composed of glass, ceramics, dirt, rocks, and oxides or salts of silicon, aluminum, calcium, magnesium, iron and sodium (Kaiser 1977, Lisk 1988). Kenahan and Sullivan (1967) reported that glass and iron products can total up to 72 percent of bottom ash. Fly ash and bottom ash can also contain significant quantities of chlorides as well as sulfates. These materials present a relatively inert and non-toxic matrix. Data concerning the relative distribution of these inert materials are not available for the Metro Dade Facility.

### PROJECTED FUTURE CHARACTERISTICS

It is anticipated that the electrostatic precipitators (ESPs) currently in use at the Metro Dade Facility will be replaced with a dry scrubbing system/fabric filter system. Data have not yet been developed to determine the quantitative impacts of these air pollution control systems. However, certain generalized statements can be made:

1. Fly ash particle capture and removal will be improved, particularly for the smallest particles. These lightest particles are relatively enriched in the toxic metals, particularly volatile metals such as arsenic, selenium and mercury. Thus the overall mass rate of metals entering the ash handling system will increase.
2. Dry scrubbers use a slurry mixture of slaked lime ( $\text{Ca(OH)}_2$ ). Upon drying, a water molecule is removed and calcium oxide,  $\text{CaO}$ , also known as quick lime, results. It

is estimated that 1,100 pounds per hour (lbs/hr) per boiler of  $\text{Ca}(\text{OH})_2$  will be used resulting in approximately 832 lbs/hr per boiler of  $\text{CaO}$  which will enter the ash handling system. The  $\text{CaO}$  has a relatively minor heavy metal content and will not significantly increase the toxic metal loading to the ash system. However, the  $\text{CaO}$  will add to the total volume of ash (currently 9,400 lbs/hr per boiler). Thus the additional ash volume would tend to lower the metallic concentration of the ash.

3. The net effect in toxic metal concentration in the ash cannot be assessed until the relative increase in captured ash metal mass is measured. However, if the increase in metals captured is less than approximately 8.9 percent, then a decrease in toxic metal concentration will be achieved due to ash volume increases.
4. Due to the alkaline nature of  $\text{Ca}(\text{OH})_2$ , the combined ash will tend to have a higher ambient pH. This higher pH will retard the dissolution of metals in soluble form given the predominance of relatively insoluble metallic hydroxide compounds. Thus, toxic metal concentrations in resulting leachates should be relatively lower than for an ash not containing  $\text{Ca}(\text{OH})_2$  and  $\text{CaO}$ .
5. The relative density and cementaceous nature of  $\text{CaO}$  when damp will increase the overall density and adhesion of the ash, thus decreasing the degree of wind entrainment of ash particles.

Ash analyses subsequent to any modifications of the air pollution system can assess these predicted changes in ash characterization.

# SOLID WASTE AUTHORITY FILE COPY

## OF PALM BEACH COUNTY

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May 15, 1990

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To	VIC KAMATH	From	R. STATOM
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Dept.	SOLID/HAZ. WASTE	Phone #	407/640-4000
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Florida Department of Environmental Regulation  
1900 S. Congress Ave  
Suite A  
West Palm Beach, FL 33406

Attn. Alex Pavda

Re: NCRRRF Conditions of Certification XIV.E.9  
Ash Residue E.P. Toxicity Analysis Report

Dear Alex,

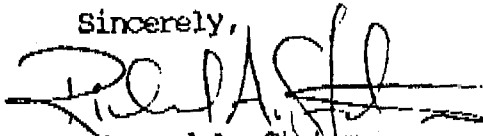
Please find the enclosed data on the E.P. Toxicity analyses performed on the ash residue from the Solid Waste Authority North County Regional Resource Recovery Facility as per the requirements of the Conditions of Certification Section XIV.E.9. The samples were collected during the period 1/17/90 - 1/19/90 by SWA staff under the direction of Dr. Frank Roethel of the Waste Management Institute, located at the Marine Sciences Research Center, State University of New York, Stony Brook, N.Y.. Attachment 1 is an excerpt from Dr. Roethel's proposal to the SWA which details the sampling and analytical methods used in the study. Samples were collected hourly for 16 hours per day over a 3 day period, and then composited every 8 hours, for a total of 6 samples per ash type. Samples were taken of bottom ash, fly ash, and the combined ash. The combined ash residue results reflect the material actually landfilled.

Attachment 2 shows the E. P. Toxicity results for the 3 groups of samples analyzed; fly ash composite, bottom ash composite, and combined ash composite. The fly ash composite analyses indicates that one parameter, lead, is in excess of the MCL (5.0 mg/l), at a mean average of 12.14 mg/l. All other fly ash composite analyses are below the MCLs. The bottom ash composite analyses indicates that all parameters are below the MCLs except for a single lead analysis (12.4 mg/l), which is tagged with a # sign. This lead value is significantly higher than the other samples, and after having performed a standard statistical test, the value was excluded from the mean average pursuant to the provisions of E.P.A. SW-846, Test Methods for Evaluating Solid Waste. The mean lead average for bottom ash would be below the MCL even if the high value was included. The combined ash composite analyses are all below the MCLs. As this is the material which is being landfilled, these results comply with the provisions of the Conditions of Certification.

The Dioxin analyses required by the Conditions of Certification are currently being conducted by the New York Department of Health in Albany, N.Y., and the results are anticipated to be ready in July.

If you have any questions or comments do not hesitate to contact me.

Sincerely,



Richard A. Statom  
Assistant Director  
Department of Environmental Programs

RAS

cc: Marc Bruner  
Joe Lurix, FDER  
John O'Mally, PBCHD

## Methods

### Sampling Program

Working with personnel from the West Palm Beach Solid Waste Authority and under the supervision of scientists from the Waste Management Institute, sufficient combined, bottom and fly ash will be collected to complete the initial phase of this investigation. Prior to sampling, a detailed protocol will be established that insures collection of representative samples of all three ash streams. Details of the protocol will be in accordance with those established in concert with the Long Island Regional Planning Board - New York State Energy Research and Development Authority (NYSERDA) ash characterization study.

## Organic Characterization

The New York State Department of Health laboratory in Albany, a laboratory certified by USEPA to conduct dioxin and furan analyses, will be subcontracted to characterize the dioxin and furan content of the combined ash, bottom ash and fly ash collected during Phase 1. One sample of each ash type will be analyzed; the results from the combined ash sample will address the permit requirement while the results of the additional ash streams will provide necessary information relative to ash stabilization and utilization. The dioxin/furan characterization will include the necessary homologs to permit establishing a 2378-TCDD toxicity equivalent for each sample.

The USEPA Method 8280 "Analysis of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo furans" uses a matrix specific extraction, analyte-specific clean-up, and high resolution capillary column gas chromatography/low resolution mass spectrometry (HRGC/LRMS) techniques. This laboratory has used this methodology for several years and has demonstrated proficiency in the performance of this analysis. The extraction procedure and methodology for the analysis of dioxins and furans is detailed in Appendix A.

## Inorganic Characterization

All three incineration ash types will be digested in replicate (n=5) using a hydrofluoric-boric acid digestion technique as reported in Silberman and Fisher (1979). This digestion method commonly utilizes the ability of HF to breakdown silicious materials and  $H_3BO_3$  is used to complex remaining fluoride ions and to dissolve insoluble metal fluorides formed during digestion.

Determination of the metal content of the digests will be accomplished using both flame and flameless techniques on a Perkin-Elmer Zeeman/5000 Atomic Absorption Spectrophotometer equipped with a HGA-500 graphite atomizer and a AS-40 autosampler.

TABLE 1. E. P. TOXICITY RESULTS

ASH TYPE	Ag (mg/L)	As (mg/L)	Ba (mg/L)	Cd (mg/L)	Cr (mg/L)	Hg (mg/L)	Pb (mg/L)	Se (mg/L)
FLY ASH COMPOSITE	< 0.0250	< 0.0250	2.23	< 0.1	0.0654	< 0.100	0.664	< 0.127
	< 0.0250	< 0.0250	1.07	< 0.1	0.0413	< 0.100	22.6	< 0.127
	< 0.0250	< 0.0250	1.24	< 0.1	0.0437	< 0.100	20.3	< 0.127
	< 0.0250	< 0.0250	1.69	< 0.1	0.0557	< 0.100	13.1	< 0.127
	< 0.0250	< 0.0250	1.40	< 0.1	0.0629	< 0.100	15.8	< 0.127
	< 0.0250	< 0.0250	0.699	< 0.1	0.0365	< 0.100	0.297	< 0.127
	< 0.0250	< 0.0250	1.39	< 0.1	0.0509	< 0.100	12.14	< 0.127
MEAN	< 0.0250	< 0.0250	1.39	< 0.1	0.0509	< 0.100	12.14	< 0.127
S.D.	0.000	0.000	0.529	0.000	0.0121	0.000	9.61	0.000
90% CI								
UPPER			2.26		0.07		27.96	
LOWER			0.52		0.03		-3.69	
BOTTOM ASH COMPOSITE	< 0.0125	< 0.0150	0.335	< 0.1	< .00550	< 0.100	12.4#	< 0.027
	< 0.0125	< 0.0150	0.121	< 0.1	0.00921	< 0.100	1.25	< 0.027
	< 0.0125	< 0.0150	0.571	< 0.1	< .00550	< 0.100	0.599	< 0.027
	< 0.0125	< 0.0150	1.06	< 0.1	< .00550	< 0.100	0.271	< 0.027
	< 0.0125	< 0.0150	0.257	< 0.1	< .00550	< 0.100	0.967	< 0.027
	< 0.0125	< 0.0150	0.651	< 0.1	< .00550	< 0.100	0.517	< 0.027
	< 0.0125	< 0.0150	0.499	< 0.1	0.002	< 0.100	0.72	< 0.027
MEAN	< 0.0125	< 0.0150	0.499	< 0.1	0.002	< 0.100	0.72	< 0.027
S.D.	0.000	0.000	0.338	0.000	0.004	0.000	0.39	0.000
90% CI								
UPPER			1.06		0.00772		1.36	
LOWER			-0.06		-0.00465		0.08	
COMBINED ASH COMPOSITE	< 0.0125	< 0.0150	1.10	0.256	< 0.0110	< 0.100	0.56	< 0.127
	< 0.0125	< 0.0150	0.646	0.497	< 0.0110	< 0.100	4.65	< 0.127
	< 0.0125	< 0.0150	0.424	0.555	< 0.0110	< 0.100	1.42	< 0.127
	< 0.0125	< 0.0150	0.424	0.371	< 0.0110	< 0.100	2.32	< 0.127
	< 0.0125	< 0.0150	0.309	0.520	< 0.0110	< 0.100	0.56	< 0.127
	< 0.0125	< 0.0150	0.703	0.578	< 0.0110	< 0.100	0.89	< 0.127
	< 0.0125	< 0.0150	0.601	0.463	< 0.0110	< 0.100	1.73	< 0.127
MEAN	< 0.0125	< 0.0150	0.601	0.463	< 0.0110	< 0.100	1.73	< 0.127
S.D.	0.000	0.000	0.286	0.124	0.000	0.000	1.58	0.000
90% CI								
UPPER			1.07	0.67			4.33	
LOWER			0.13	0.26			-0.86	



SUBJECT

DATE

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PAGE

CRIST ELECTRIC GENERATING PLANT  
GROUND WATER MONITORING PLAN

Feb. 27, 1984

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DRW 2

PLANT CRIST  
LIST OF DRAWINGS  
(Continued)

ESP-3016-99	Isopach Map, thickness - Unconfined Aquifer (Unit 2)
100	Structure Contour Map, Elevation - Top of Confining bed (Unit 3)
102	Isopach Map, Thickness - Confining Bed (Unit 3)
103	Structure Contour Map, elevation - Top of Confining Bed (Unit 4)
104	Isopach Map, Thickness - Confining Bed (Unit 4)
105	Structure Contour Map, Elevation - Top of Confined aquifer (Unit 5)
106	Plant Site Layout and Drainage Areas
107	Location of Proposed Ground-Water Monitoring Wells

OVERSIZE  
DRAWINGS  
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SEPARATELY