DCN 92-218-044-20

DOE/MC/22118--3274

DE93 009649

**FIELD STUDY OF DISPOSED WASTES
FROM ADVANCED COAL PROCESSES**

**DOE Quarterly Technical
Progress Report**

April to June 1992

Prepared by:

Radian Corporation
8501 Mo-Pac Boulevard
P.O. Box 201088
Austin, Texas 78720-1088

Prepared for:

Jerry L. Harness
Department of Energy
Morgantown Energy Technology Center
3610 Collins Ferry Road
P.O. Box 880
Morgantown, West Virginia 26505

Distribution:

Report Receipt (Mail Stop F07), DOE/METC (3)

Ray Butler, EERC

Andrew Covar/4

Larry Holcombe/4

Andy Weinberg/4

Tom Boyd, EPRI

Jerry Walker, Colorado Ute

Wayne Bahr IL/ENR

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

js

TABLE OF CONTENTS

	Page
1.0 OBJECTIVES	1
2.0 SUMMARY OF PREVIOUS WORK	1
2.1 Colorado	2
2.2 Ohio	2
2.3 Illinois	3
3.0 OBJECTIVES FOR THE CURRENT REPORTING PERIOD	4
4.0 ACTIVITIES FOR THE REPORTING PERIOD	5
4.1 Colorado Ute Site	5
4.2 Ohio Site	6
4.3 Illinois Site	12
5.0 ACTIVITIES PLANNED FOR THE NEXT QUARTER	16
APPENDIX A: TECHNICAL NOTE	

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

LIST OF FIGURES

		Page
1	Groundwater and Porewater Monitoring Locations at the Ohio Test Site	7
2	Major Element Concentrations in Groundwater Samples from Wells Downgradient of the Ohio North Cell for All Sampling Events	8
3	Major Element Concentrations in Groundwater Samples from Wells Downgradient of the Ohio South Cell for All Sampling Events	9
4	Major Element Concentrations in Groundwater Samples from Wells Upgradient of the Ohio Test Cells for All Sampling Events	10
5	Major Element Concentrations from Lysimeters at Different Depths in the Ohio South Cell for All Sampling Events	11
6	Groundwater and Porewater Monitoring Locations at the Illinois Test Site	13
7	Major Element Concentrations in Groundwater Samples from Wells Upgradient and Downgradient of the Illinois Test Cell for All Sampling Events	14
8	Trends in Concentrations of Major Elements with Depth in ASTM Deionized Water Leachates from Illinois 1992 Annual Core Samples . .	15
9	Average Major Element Concentrations in ASTM Leachate of Ash from the Illinois Test Cell	17

LIST OF TABLES

		Page
1	Chemical Characteristics of Liquid from Ohio, Event II	19
2	Chemical Characteristics of Liquid from Illinois, Event 4	27
3	Chemical Characteristics of Ash from Illinois, Event 4	35

1.0 OBJECTIVES

The Department of Energy/Morgantown Energy Technology Center (DOE/METC) has initiated research on the disposal of solid wastes from advanced coal processes. The objective of this research is to develop information to be used by private industry and government agencies for planning waste disposal practices associated with advanced coal processes. To accomplish this objective, DOE has contracted Radian Corporation and the North Dakota Energy & Environmental Research Center (EERC) to design, construct, and monitor a limited number of field disposal tests with advanced coal process wastes. These field tests will be monitored over a three year period with the emphasis on collecting data on the field disposal of these wastes.

There has been considerable research on the characteristics and laboratory leaching behavior of coal wastes -- a lesser amount on wastes from advanced coal processes. However, very little information exists on the field disposal behavior of these wastes. Information on field disposal behavior is needed (a) as input to predictive models being developed, b) as input to the development of rule of thumb design guidelines for the disposal of these wastes, and c) as evidence of the behavior of these wastes in the natural environment.

2.0 SUMMARY OF PREVIOUS WORK

This study is organized into four major Tasks. Tasks 1 and 2 were devoted to planning the Task 3 field study. Task 4 uses the results of the field testing to produce an Engineering Design Manual for the utilities and industrial users who manage wastes from advanced coal combustion technologies.

Task 1 identified and rated test design options. A Test Design Manual was prepared and submitted to METC in 1988. Specific test procedures suitable for each design option were identified under Task 2. These test methods were documented in a

Test Procedures Manual, submitted to METC in 1988. Also under Task 2, test sites were selected and site access was negotiated. Sites in Illinois and North Dakota were delayed at this stage, and the North Dakota site was dropped from consideration. Task 2 was completed and Final Test Plans were submitted to METC for three sites in 1988.

Task 3 progress for each of the test sites is summarized below:

2.1 Colorado

The test cell was constructed in June, 1989 with CFBC ash from a low sulfur western coal. The ash has low lime and sulfate content. Core samples were collected in June and December 1989, in March, June and December of 1990, in June 1991, and most recently in June 1992. No groundwater or porewater samples have been recovered. At this time the three year monitoring period at the Colorado site is completed; further field monitoring at this site is under discussion with the DOE and other parties.

The strength of core samples from the Colorado site is low to moderate (200 psi to 900 psi), with permeabilities of 2×10^{-3} to 3×10^{-4} . Laboratory leachates show moderate concentrations of calcium, sulfate, and other common ions. Trace element concentrations in test leachates are low compared to regulatory limits. No leachate has been generated from the test cell at this site.

2.2 Ohio

Two test cells were constructed, in February and April of 1989, using LIMB ash from an Ohio coal with 2.4% sulfur. The ash has a high lime and sulfate content. Test case 1 (north cell) was constructed with 25% moisture; test case 2 was constructed with 38% moisture to optimize compaction. The wastes expanded, heaved, and fractured during the first year, particularly in the south cell. Mineralogical changes

in the wastes with hydration and weathering are the primary cause. Core strength is moderate to low (2000 psi to < 100 psi) and highly variable because of fracturing. Field measurements of permeability vary from 3×10^{-3} to 5×10^{-5} cm/sec. Permeabilities are lowest in the north cell.

Large amounts of water were bound in the wastes in the first year as the waste saturated and hydrated. Starting in the second year, leachate appears to have migrated out of the south cell into downgradient wells. The leachate at the bottom of the test cell contains up to several thousand mg/L of sulfate, chloride, potassium, and sodium, with somewhat lower concentrations of calcium and silicon. Trace metal concentrations are generally low compared to regulatory limits, but a few samples contain arsenic at concentrations up to 0.35 mg/L.

Core samples were first collected in June, 1989, and quarterly and annual core sampling events have taken place according to schedule since that time. Water samples have been collected on a quarterly basis since October, 1989. Final core sampling for the three year monitoring period is scheduled for August, 1992. Further monitoring, on a limited basis, is under discussion with the DOE and Ohio Edison.

2.3 Illinois

The first Illinois test cell was completed in April, 1991, with bubbling FBC ash from a Illinois coal with 3.1% sulfur. A large excess of limestone is used in the combustor; the ash is high in lime relative to most FBC wastes, containing up to 30% CaO. The ash also contains abundant sulfate, but has relatively low concentrations of coal ash compared to other wastes included in this study. The two test cells planned for the second Illinois test case will evaluate the effects of added coal ash on cementitious reactions in the waste. Laboratory studies to define the optimum mix of FBC waste and coal fly ash are completed, and cell construction is planned for August, 1992.

The initial cell was instrumented and sampled in June 1991. Water samples and additional cores were collected in August and November, 1991, and February and May, 1992. No expansion has been noted at the site. The wastes are solidified with unconfined compressive strength between approximately 150 and 550 psi, although some fracture zones may be present in the waste and may reduce overall strength. The permeability measured on cores recovered from the test cell ranges from 1×10^{-6} to 2×10^{-4} ; field permeability measurements range from a high of 3×10^{-3} near the surface to a low of 2×10^{-5} at depth in the test cell.

3.0 OBJECTIVES FOR THE CURRENT REPORTING PERIOD

The specific objectives for the reporting period of April, 1992 to July, 1992 were as follows:

- Collect third annual core samples at the Colorado site in June, 1992. Make final field measurements on site to complete the three year monitoring period;
- Prepare a Technical Note on the surface water runoff from the Colorado Ute test cell;
- Collect quarterly samples at the Ohio site in May, 1992. Measure permeability and moisture content, and collect water samples from the wells and lysimeters;
- Collect the first annual cores and fourth quarterly water samples from the first Illinois test case in May, 1992. Make field measurements and collect data from the data logger;
- Analyze chemistry of all core and water samples collected;
- Complete preliminary laboratory testing for the second Illinois test case;
- Continue production of a video presentation on the project;

- Load all EERC data on the second annual cores from Colorado and Ohio and the first two sets of quarterly samples from Illinois into the project database;
- Draft a proposal to DOE/METC for continued field monitoring at the Ohio site beyond the present 3 year period;
- Complete Preliminary Assessment reports on the Ohio and Colorado sites for the DOE, pending receipt of DOE comments on the initial drafts; and
- Complete a memorandum detailing costs to complete the initial three years of monitoring at all sites for the DOE.

4.0 ACTIVITIES FOR THE REPORTING PERIOD

4.1 Colorado Ute Site

Third annual core samples were collected from the Colorado site June 17 and 18, 1992. The samples were distributed to the EERC and Radian laboratories for analysis. No results are available at this time.

A brief Technical Note discussing the surface runoff from the Colorado Ute test cell was prepared for the DOE. Calculations showed that runoff should constitute only about 0.2% of the water budget for the test site, with the vast majority of the rainwater falling at the site being evaporated. The chemistry of the one runoff sample collected at the site had a low dissolved solids content and a moderately alkaline pH. Data from this test cell indicate that there is a low possibility for appreciable impacts on surface water quality from runoff from FBC wastes similar to the Colorado Ute FBC material. The Technical Note is attached to this report as Appendix A.

4.2

Ohio Site

Quarterly water samples were collected from the Ohio site in May, 1992. Analytical results for these samples are presented in Table 1. A diagram of the Ohio site is shown in Figure 1. The upgradient and downgradient groundwater compositions measured to date are shown in Figures 2 through 4. In each figure, separate graphs are shown, each providing data for groundwater from a different depth interval. Figures 2 through 4 illustrate the strong dependence of the groundwater chemistry at the Ohio site on the depth of sampling.

As previously discussed, the chloride concentration in groundwater samples from the shallow well downgradient of the south cell (OHMW-06) appear to have been impacted by leachate from the test cell. Chloride concentrations have increased in OHMW-06, while the chloride concentrations in OHMW-03, completed at the same depth downgradient of the north cell, and in OHMW-08, completed at the same depth upgradient of the test cells, have remained stable. None of the other analytes in OHMW-06 show a similar pattern of increasing concentration. Statistical tests are being performed on this data to assess its significance.

Major element concentration in some of the lysimeters from the south cell are shown in Figure 5. Although all lysimeters at the site do not yield a sample every quarter, the overall trend has been towards decreasing concentration of major elements over time in both cells and at all depths. Eleventh quarter lysimeter samples were available only from OHLY-11 and OHLY-12 of the lysimeters shown in this figure. Data from these two lysimeters indicates a break in the trend towards lower major element concentrations. Major element concentrations may be stabilizing at these lower values as the waste in the tests cell become drier.

Figure 1. Groundwater and Porewater Monitoring Locations at the Ohio Test Site

Figure 2. Major Element Concentrations in Groundwater Samples from Wells Downgradient of Ohio North Cell for All Sampling Events

Figure 3. Major Element Concentrations in Groundwater Samples from Wells Downgradient of the Ohio South Cell for All Sampling Events

Figure 4. Major Element Concentrations in Groundwater Samples from Wells Upgradient of the Ohio Test Cells for All Sampling Events

OHLY-12, 1 foot below surface

OHLY-11, 3 feet below surface

OHLY-10, 6.5 feet below surface

OHLY-16, 8.5 feet below surface

Figure 5. Major Element Concentrations from Lysimeters at Different Depths in the Ohio South Cell for all Sampling Events

4.3 Illinois Site

The fourth set of quarterly water samples and the first set of annual core samples was collected in May, 1992, and analyzed in June. The analytical results for water samples are shown in Table 2, and those for ASTM leachates of the ash and soil samples are presented in Table 3. A diagram of the Illinois site is shown in Figure 6.

Major element concentrations in groundwater samples from the Illinois site are illustrated in Figure 7. Downgradient wells appear to have a higher variability in major element concentrations than do the upgradient wells. No clear compositional trends can be distinguished at this time.

Most of the lysimeters from the Illinois site remain dry. Water has been recovered from a few of the near-surface lysimeters installed in the test cell, but not enough data is available to show changes with depth or time. Sulfate, potassium, sodium, and chloride make up the major dissolved components in the porewater at this site.

The quarterly core samples have provided a more consistent record than the lysimeters in the first year of sampling at the Illinois site. Concentrations of highly soluble species including potassium, sodium, and chloride are lower in laboratory test leachates from the shallowest samples than in leachates from samples deeper in the cell, as shown in Figure 8. This trend suggests that the most soluble elements are gradually leaching through the test cell. The depletion of soluble constituents from the upper portions of the test cell is consistent with the pattern of leaching observed in the Ohio test cells. Calcium and sulfate concentrations in the ASTM deionized water leachates of the annual core samples do not exhibit significant changes with depth; the solubility of the mineral gypsum, which is a major constituent of the hydrated waste, controls the concentrations of calcium and sulfate in solution.

Figure 6. Groundwater and Porewater Monitoring Locations at the Illinois Test Site

Figure 7. Major Element Concentrations in Groundwater Samples from Wells Upgradient and Downgradient of the Illinois Test Cell for All Sampling Events

Figure 8. Trends in Concentrations of Major Elements with Depths in ASTM Deionized Water Leachates from Illinois 1992 Annual Core Samples

Although there appears to be some mobilization of soluble materials near the waste surface, the average major element concentrations in the ASTM deionized water leachates from core samples from all depths in the waste have not changed significantly since the test cell was completed. Figure 9 shows the average concentrations of calcium, chloride, potassium, sodium, and sulfate in leachates from core samples from each field sampling event and from the initial ash. There is more soluble sodium and potassium in the material sampled from the test cell than in the initial ash, but leachable concentrations of all the major elements have remained stable since the test cell was first sampled in June 1991.

Initial laboratory testing of mixtures of the Midwest Grain FBC waste and fly ash is nearly completed. Final tests for length change during curing and for freeze/thaw durability will be completed in July. Bench scale mixing tests of FBC/fly ash mixtures will also be carried out before the test cell construction plans are finalized.

5.0 ACTIVITIES PLANNED FOR NEXT QUARTER

The following activities are planned for the period of July 1992 through September 1992:

- The final sampling event at the Ohio site under the current three year scope is scheduled for August, 1992. Environmental monitoring measurements will be made, and water and core samples will be collected;
- Chemical analysis of core and water samples will continue;
- The fifth quarterly water samples from the first Illinois test case will be collected in August; other field measurements will also be made at that time;
- Construction of the second Illinois test case will begin;
- Radian will continue production of a short video presentation on the advanced coal wastes test program;

Figure 9. Average Major Element Concentrations in ASTM Leachate of Ash from the Illinois Test Cell

- EERC data will continue to be loaded onto the project database and reported as available. Complete results for the Colorado and Ohio sites will be provided with the final site reports, and
- Preliminary Case Reports on the Colorado and Ohio test cases will be finalized, and costs to complete the three year initial scope of testing at all sites will be submitted to METC.

Table 1

Chemical Characteristics of Liquid from Ohio, Event II

Parameter	Site ID / Location ID			
	Sample ID		Log Date	
	OH / OHMW01 OH312	OH / OHMW02 OH313	OH / OHMW03 OH314	OH / OHMW04 OH315
Units	5/24/92	5/24/92	5/24/92	5/24/92
Anions				
Chloride	200	51	49	260
Fluoride	1.1	0.41	0.40	1.2
Sulfate	500	830	780	300
Elements by ICPEs or AA				
Aluminum	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND
Barium	0.018	0.047	0.028	ND
Beryllium	ND	ND	ND	ND
Boron	1.1	ND	ND	1.0
Calcium	3.9	200	200	4.6
Chromium	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND
Copper	ND	ND	ND	ND
Iron	0.061	ND	0.11	ND
Lead	ND	ND	0.013	ND
Magnesium	2.9	140	170	2.3
Manganese	ND	0.17	0.21	ND
Molybdenum	ND	ND	ND	ND
Nickel	ND	ND	ND	ND
Potassium	13	7.6	5.5	5.0
Selenium	ND	ND	ND	ND
Silicon	3.0	5.9	6.1	3.0
Silver	ND	ND	ND	ND
Sodium	620	190	100	530
Strontium	0.17	1.3	0.61	0.13
Tin	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND
Zinc	ND	ND	ND	ND

() = Detection Limit ND = Not Detected NA = Not Analyzed @ = < 5X Det. Limit

CI-1

Table 1
(Continued)

Parameter	Units	Site ID / Location ID			
		OH / OHMW01	OH / OHMW02	OH / OHMW03	OH / OHMW04
		OH312	OH313	OH314	OH315
		5/24/92	5/24/92	5/24/92	5/24/92
Field measurements					
Conductivity	umhos/cm	2370	1750	1650	1760
Filterable Residue	mg/L	1625	1804	1834	1325
Redox (Eh)	mV	ND	16.9	ND	116.5
Temperature	deg. C	11.3	10.8	10.0	10.8
Total Alkalinity	meq/L	11.3	10.4	9.7	14.6
pH	pH units	9.83	7.03	6.94	8.74
		(.05)	(.05)	(.05)	(.05)
		(.03)	(.03)	(.03)	(.03)
		(.1)	(.1)	(.1)	(.1)
		(10)	(10)	(10)	(10)
		(1)	(1)	(1)	(1)
		(5)	(5)	(5)	(5)

Table 1
(Continued)

Parameter	Site ID / Location ID			
	Sample ID		Log Date	
	OH / OHMW05 OH316 5/24/92	OH / OHMW06 OH317 5/24/92	OH / OHMW07 OH318 5/24/92	OH / OHMW08 OH319 5/24/92
Units				
Anions				
Chloride	180	520	13	4.9
Fluoride	1.0	0.11	0.30	0.28
Sulfate	210	550	220	350
Elements by ICPES or AA				
Aluminum	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND
Barium	0.041	0.049	0.056	0.016
Beryllium	ND	ND	ND	ND
Boron	1.0	ND	ND	ND
Calcium	13	260	110	68
Chromium	ND	ND	ND	ND
Cobalt	ND	0.027	ND	ND
Copper	ND	ND	ND	ND
Iron	ND	4.6	ND	ND
Lead	ND	ND	ND	0.0060
Magnesium	8.4	80	ND	43
Manganese	ND	4.2	ND	0.031
Molybdenum	ND	ND	0.051	ND
Nickel	ND	0.036	ND	0.026
Potassium	7.0	15	8.0	6.1
Selenium	ND	ND	ND	ND
Silicon	3.5	4.8	4.9	4.2
Silver	ND	ND	ND	ND
Sodium	440	180	110	100
Strontium	0.43	1.1	0.60	1.3
Tin	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND
Zinc	ND	ND	ND	ND

() = Detection Limit ND = Not Detected NA = Not Analyzed Ø = < 5X Det. Limit

Table 1
(Continued)

		Site ID / Location ID		
		Sample ID		Log Date
		OH / OH#M05	OH / OH#M06	OH / OH#M07
		OH316	OH317	OH318
		5/24/92	5/24/92	5/24/92
Parameter	Units			
Field measurements				
Conductivity	umhos/cm	1450	1810	1560
Filterable Residue	mg/L	1234	1974	624
Redox (Eh)	mV	ND	17.3	ND
Temperature	deg. C	10.1	9.9	11.7
Total Alkalinity	meq/L	13.2	3.4	6.1
pH	pH units	8.29	6.48	11.99
		(5)	(5)	(5)
		(1)	(1)	(1)
		(10)	(10)	(10)
		(.1)	(.1)	(.1)
		(.03)	(.03)	(.03)
		(.05)	(.05)	(.05)
		960	733	ND
		11.4	4	8.38
		(.03)	(.03)	(.05)

Table 1
(Continued)

Site ID / Location ID Sample ID Log Date					
Parameter	Units	OH / OHBLNK OH320 5/24/92	OH / OHM04 OH321 5/24/92	OH / OHLY01 OH322 5/24/92	OH / OHLY11 OH324 5/24/92
Anions					
Chloride	mg/L	0.79	260	27	430
Fluoride	mg/L	ND	1.1	0.10	ND
Sulfate	mg/L	3.0	300	1700	1700
Elements by ICPEs or AA					
Aluminum	mg/L	ND	ND	ND	ND
Arsenic	mg/L	ND	ND	0.0099	ND
Barium	mg/L	ND	ND	0.027	0.033
Beryllium	mg/L	ND	ND	ND	ND
Boron	mg/L	ND	0.96	2.8	ND
Calcium	mg/L	ND	4.3	410	440
Chromium	mg/L	ND	ND	ND	ND
Cobalt	mg/L	ND	ND	ND	ND
Copper	mg/L	ND	ND	ND	ND
Iron	mg/L	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND
Magnesium	mg/L	ND	2.2	4.8	ND
Manganese	mg/L	ND	ND	ND	ND
Mo., bdenum	mg/L	ND	ND	0.35	0.84
Nickel	mg/L	ND	ND	ND	ND
Potassium	mg/L	ND	5.1	290	690
Selenium	mg/L	ND	ND	0.027	0.024
Silicon	mg/L	ND	2.9	42	43
Silver	mg/L	ND	ND	ND	ND
Sodium	mg/L	ND	510	220	200
Strontium	mg/L	ND	0.12	4.7	3.5
Tin	mg/L	ND	ND	ND	ND
Vanadium	mg/L	ND	ND	0.035	0.058
Zinc	mg/L	ND	ND	ND	ND

() = Detection Limit ND = Not Detected NA = Not Analyzed 0 = < 5X Det. Limit

Cl-5

Table 1
(Continued)

		Site ID / Location ID			
		Sample ID		Log Date	
		OH / OHBLNK		OH / OHLY01	
		OH320		OH322	
		5/24/92		5/24/92	
		OH / OHM04		OH / OHLY11	
		OH321		OH324	
		5/24/92		5/24/92	
Parameter	Units				

Field measurements					
Conductivity	umhos/cm	ND	1760	2750	3500
Filterable Residue	mg/L	ND	1321	3137	3918
Redox (Eh)	mV	18.3	ND	ND	ND
Temperature	deg. C	15.1	11.1	12.3	10.8
Total Alkalinity	meq/L	.1	14.6	.9	1.2
pH	pH units	7.35	8.75	8.31	9.78
		(5)	(5)	(5)	(5)
		(1)	(1)	(1)	(1)
		(10)	(10)	(10)	(10)
		(.1)	(.1)	(.1)	(.1)
		(.03)	(.03)	(.03)	(.03)
		(.05)	(.05)	(.05)	(.05)

Table 1
(Continued)

Parameter	Units	Site ID / Location ID			
		Sample ID		Log Date	
		OH / OHLY12 OH325	OH / OHLY14 OH326	OH / OHLY15 OH327	OH / OHLY20 OH329
		5/24/92	5/24/92	5/24/92	5/24/92
Anions					
Chloride	mg/L	NA	160 (0.26)	72 (0.26)	NA
Fluoride	mg/L	NA	ND (0.10)	ND (0.10)	NA
Sulfate	mg/L	NA	1500 (2.5)	890 (1.0)	NA
Elements by ICPEES or AA					
Aluminum	mg/L	ND	ND (0.20)	ND (0.20)	1.4 (0.20)
Arsenic	mg/L	0.0040 (0.0040)	0.016 (0.0040)	0.0092 (0.0040)	ND (0.0040)
Barium	mg/L	0.070 (0.010)	0.028 (0.010)	0.036 (0.010)	0.053 (0.010)
Beryllium	mg/L	ND	ND (0.0020)	ND (0.0020)	ND (0.0020)
Boron	mg/L	ND	ND (0.60)	ND (0.60)	ND (0.60)
Calcium	mg/L	160 (1.0)	440 (1.0)	220 (1.0)	120 (1.0)
Chromium	mg/L	ND	ND (0.010)	ND (0.010)	ND (0.010)
Cobalt	mg/L	ND	ND (0.010)	ND (0.010)	ND (0.010)
Copper	mg/L	ND	ND (0.020)	ND (0.020)	ND (0.020)
Iron	mg/L	ND	ND (0.050)	ND (0.050)	2.1 (0.050)
Lead	mg/L	ND	ND (0.0060)	ND (0.0060)	ND (0.0060)
Magnesium	mg/L	ND	ND (1.0)	ND (1.0)	ND (1.0)
Manganese	mg/L	ND	ND (0.010)	ND (0.010)	0.068 (0.010)
Molybdenum	mg/L	0.11 (0.050)	0.44 (0.050)	0.28 (0.050)	0.33 (0.050)
Nickel	mg/L	ND	ND (0.020)	ND (0.020)	ND (0.020)
Potassium	mg/L	38 (3.0)	330 (3.0)	240 (3.0)	650 (3.0)
Selenium	mg/L	0.020 (0.010)	0.020 (0.010)	0.014 (0.010)	ND (0.010)
Silicon	mg/L	29 (1.0)	32 (1.0)	55 (1.0)	4.7 (1.0)
Silver	mg/L	ND	ND (0.010)	ND (0.010)	ND (0.010)
Sodium	mg/L	12 (1.0)	84 (1.0)	110 (1.0)	180 (1.0)
Strontium	mg/L	1.2 (0.0030)	4.1 (0.0030)	2.9 (0.0030)	2.3 (0.0030)
Tin	mg/L	ND	ND (0.60)	ND (0.60)	ND (0.60)
Vanadium	mg/L	ND	0.056 (0.020)	0.023 (0.020)	ND (0.020)
Zinc	mg/L	0.028 (0.020)	ND (0.020)	ND (0.020)	0.025 (0.020)

() = Detection Limit ND = Not Detected NA = Not Analyzed 0 = < 5X Det. Limit

26

813

Table 2

Chemical Characteristics of Liquid from Illinois, Event 4

Parameter	Units	Site ID / Location ID			
		Sample ID		Log Date	
		IL / ILMW01 IL070	IL / ILMW02 IL071	IL / ILMW03 IL072	IL / ILMW04 IL073
		5/18/92	5/18/92	5/18/92	5/18/92
Anions					
Chloride	mg/L	25	13	11	22
		(.26)	(.26)	(.26)	(.26)
Fluoride	mg/L	.25	.19	.13	.28
		(.1)	(.1)	(.1)	(.1)
Sulfate	mg/L	440	1600	1900	350
		(.5)	(2.5)	(2.5)	(.5)
Elements by ICPEs or AA					
Aluminum	mg/L	ND	ND	ND	.29
		(.2)	(.2)	(.2)	(.2)
Arsenic	mg/L	ND	ND	ND	ND
		(.004)	(.004)	(.004)	(.004)
Barium	mg/L	.018	ND	ND	.025
		(.01)	(.01)	(.01)	(.01)
Beryllium	mg/L	ND	ND	ND	ND
		(.002)	(.002)	(.002)	(.002)
Boron	mg/L	1.1	ND	ND	1.2
		(.6)	(.6)	(.6)	(.6)
Cadmium	mg/L	ND	ND	ND	ND
		(.001)	(.001)	(.001)	(.001)
Calcium	mg/L	180	470	520	150
		(1)	(1)	(1)	(1)
Chromium	mg/L	ND	ND	ND	ND
		(.01)	(.01)	(.01)	(.01)
Cobalt	mg/L	ND	ND	ND	ND
		(.01)	(.01)	(.01)	(.01)
Copper	mg/L	ND	ND	ND	ND
		(.02)	(.02)	(.02)	(.02)
Iron	mg/L	.94	ND	ND	2
		(.05)	(.05)	(.05)	(.05)
Lead	mg/L	.0059	ND	ND	ND
		(.003)	(.003)	(.003)	(.003)
Magnesium	mg/L	96	240	300	82
		(1)	(1)	(1)	(1)
Manganese	mg/L	1.1	4	11	.36
		(.01)	(.01)	(.01)	(.01)
Molybdenum	mg/L	ND	ND	ND	ND
		(.05)	(.05)	(.05)	(.05)
Nickel	mg/L	ND	.021	.04	ND
		(.02)	(.02)	(.02)	(.02)
Potassium	mg/L	6.7	4	4.9	6.4
		(3)	(3)	(3)	(3)
Selenium	mg/L	ND	ND	ND	ND
		(.005)	(.005)	(.005)	(.005)
Silicon	mg/L	6.4	6.8	6.7	6.8
		(1)	(1)	(1)	(1)
Silver	mg/L	ND	ND	ND	ND
		(.01)	(.01)	(.01)	(.01)
Sodium	mg/L	110	62	61	170
		(1)	(1)	(1)	(1)
Strontium	mg/L	1.5	.86	1.1	1.6
		(.003)	(.003)	(.003)	(.003)
Tin	mg/L	ND	ND	ND	ND
		(.6)	(.6)	(.6)	(.6)
Vanadium	mg/L	ND	ND	ND	ND
		(.02)	(.02)	(.02)	(.02)

() = Detection Limit ND = Not Detected NA = Not Analyzed 0 = < 5X Det. Limit

C1-1

Table 2
(Continued)

Parameter	Site ID / Location ID			
	Sample ID			
	Log Date			
	IL / ILMW01 IL070 5/18/92	IL / ILMW02 IL071 5/18/92	IL / ILMW03 IL072 5/18/92	IL / ILMW04 IL073 5/18/92
Units				

Elements by ICPEs or AA, cont.				
Zinc	mg/L	ND	(.02)	ND
			(.02)	(.02)

Field measurements				
Conductivity	umhos/cm	1770	2850	1770
Filterable Residue	mg/L	1408	3317	1386
Redox (Eh)	mV	52.5	49.9	ND
Temperature	deg. C	14	13.9	13.2
Total Alkalinity	meq/L	12.2	10.2	14.6
pH	pH units	6.07	6.45	6.93
			(.05)	(.05)

Table 2
(Continued)

Site ID / Location ID
Sample ID
Log Date

Parameter	Units	IL / ILMW05		IL / ILMW06		IL / ILMW07		IL / ILMW07	
		IL074	5/18/92	IL075	5/18/92	IL076	5/18/92	IL080 Dup of IL076	5/18/92

Anions									
Chloride	mg/L	22	(.26)	18	(.26)	41	(.26)	41	(.26)
Fluoride	mg/L	.27	(.1)	.16	(.1)	.38	(.1)	.38	(.1)
Sulfate	mg/L	370	(.5)	1400	(2.5)	230	(.5)	230	(.5)

Elements by ICPEs or AA									
Aluminum	mg/L	ND	(.2)	ND	(.2)	ND	(.2)	ND	(.2)
Arsenic	mg/L	ND	(.004)	ND	(.004)	ND	(.004)	ND	(.004)
Barium	mg/L	.01	(.01)	ND	(.01)	.024	(.01)	.025	(.01)
Beryllium	mg/L	ND	(.002)	ND	(.002)	ND	(.002)	ND	(.002)
Boron	mg/L	1.2	(.6)	1	(.6)	1.6	(.6)	1.7	(.6)
Cadmium	mg/L	ND	(.001)	ND	(.001)	ND	(.001)	ND	(.001)
Calcium	mg/L	160	(1)	390	(1)	120	(1)	130	(1)
Chromium	mg/L	ND	(.01)	ND	(.01)	ND	(.01)	ND	(.01)
Cobalt	mg/L	ND	(.01)	ND	(.01)	ND	(.01)	ND	(.01)
Copper	mg/L	ND	(.02)	ND	(.02)	ND	(.02)	ND	(.02)
Iron	mg/L	.71	(.05)	ND	(.05)	1.7	(.05)	1.8	(.05)
Lead	mg/L	ND	(.003)	ND	(.003)	ND	(.003)	ND	(.003)
Magnesium	mg/L	87	(1)	230	(1)	68	(1)	70	(1)
Manganese	mg/L	.37	(.01)	1.6	(.01)	.35	(.01)	.33	(.01)
Molybdenum	mg/L	ND	(.05)	ND	(.05)	ND	(.05)	ND	(.05)
Nickel	mg/L	ND	(.02)	.031	(.02)	ND	(.02)	ND	(.02)
Potassium	mg/L	6.7	(3)	20	(3)	6.1	(3)	6.1	(3)
Selenium	mg/L	ND	(.005)	ND	(.005)	ND	(.005)	ND	(.005)
Silicon	mg/L	6.7	(1)	8	(1)	7.7	(1)	8	(1)
Silver	mg/L	ND	(.01)	ND	(.01)	ND	(.01)	ND	(.01)
Sodium	mg/L	170	(1)	170	(1)	160	(1)	160	(1)
Strontium	mg/L	1.6	(.003)	2.7	(.003)	1.3	(.003)	1.3	(.003)
Tin	mg/L	ND	(.6)	ND	(.6)	ND	(.6)	ND	(.6)
Vanadium	mg/L	ND	(.02)	ND	(.02)	ND	(.02)	ND	(.02)

() = Detection Limit ND = Not Detected NA = Not Analyzed 0 = < 5X Det. Limit

C1-3

Table 2

(Continued)

Parameter	Units	Site ID / Location ID			
		IL / ILMW05	IL / ILMW06	IL / ILMW07	IL / ILMW07
		IL074	IL075	IL076	IL080 Dup of IL076
		5/18/92	5/18/92	5/18/92	5/18/92

Elements by ICPEs or AA, cont.					
Zinc	mg/L	ND	ND	ND	ND
		(.02)	(.02)	(.02)	(.02)
Field measurements					
Conductivity	umhos/cm	1790	2820	1650	1650
Filterable Residue	mg/L	1409	3126	1106	1105
Redox (Eh)	mV	22.4	44.8	58.8	59.1
Temperature	deg. C	13.4	13.8	14.3	14.2
Total Alkalinity	meq/L	14.6	15.5	12.4	12.5
pH	pH units	6.69	6.26	6.3	6.35
		(.03)	(.03)	(.03)	(.03)
		(.05)	(.05)	(.05)	(.05)

Table 2
(Continued)

Parameter	Site ID / Location ID				Units
	Sample ID		Log Date		
	IL / ILMW08 IL077	IL / ILMW09 IL078	IL / ILBLNK IL079	IL / ILLY01 IL081	
	5/18/92	5/18/92	5/18/92	5/21/92	

Anions					
Chloride	12	(.26)	9.9	(.26)	NA
Fluoride	.21	(.1)	.19	(.1)	NA
Sulfate	1700	(2.5)	2800	(5)	NA

Elements by ICPEs or AA					
Aluminum	.34	(.2)	ND	(.2)	ND
Arsenic	ND	(.004)	ND	(.004)	.0047
Barium	ND	(.01)	ND	(.01)	ND
Beryllium	ND	(.002)	ND	(.002)	ND
Boron	ND	(.6)	ND	(.6)	ND
Cadmium	ND	(.001)	ND	(.001)	ND
Calcium	450	(1)	470	(1)	1.5
Chromium	ND	(.01)	ND	(.01)	.065
Cobalt	ND	(.01)	.013	(.01)	ND
Copper	ND	(.02)	ND	(.02)	.029
Iron	.76	(.05)	ND	(.05)	.056
Lead	ND	(.003)	ND	(.003)	.0061
Magnesium	300	(1)	620	(1)	ND
Manganese	1.6	(.01)	7.6	(.01)	ND
Molybdenum	ND	(.05)	ND	(.05)	.25
Nickel	ND	(.02)	.038	(.02)	ND
Potassium	4.1	(3)	5	(3)	1200
Selenium	ND	(.005)	ND	(.005)	ND
Silicon	8.2	(1)	5.5	(1)	890
Silver	ND	(.01)	ND	(.01)	ND
Sodium	78	(1)	88	(1)	700
Strontium	.53	(.003)	1.5	(.003)	.037
Tin	ND	(.6)	ND	(.6)	ND
Vanadium	ND	(.02)	ND	(.02)	.042

() = Detection Limit ND = Not Detected NA = Not Analyzed @ = < 5X Det. Limit

Table 2
(Continued)

		Site ID / Location ID			
		Sample ID		Log Date	
Parameter	Units	IL / ILMW08 IL077 5/18/92	IL / ILMW09 IL078 5/18/92	IL / ILMW09 IL079 5/18/92	IL / ILMW09 IL081 5/21/92
Elements by ICPEES or AA, cont.					
Zinc	mg/L	ND	.023 (.02)	ND (.02)	.035 (.02)
Field measurements					
Conductivity	umhos/cm	2850	3590 (5)	ND (5)	5040 (5)
Filterable Residue	mg/L	3485	5507 (1)	ND (1)	NA
Redox (Eh)	mV	63.6	74.1 (10)	ND (10)	ND (10)
Temperature	deg. C	12.9	11.6 (.1)	25.6 (.1)	18.5 (.1)
Total Alkalinity	meq/L	11.5	13.7 (.03)	.1 (.03)	NA
pH	pH units	6.21	6.02 (.05)	7.4 (.05)	10.48 (.05)

Table 2

(Continued)

Parameter	Site ID / Location ID		
	Sample ID		
	Log Date		
Units	IL / ILLY02	IL / ILLY05	IL / ILSW01
	IL082	IL085	IL089
	5/21/92	5/21/92	5/18/92

Anions

Chloride	mg/L	NA	NA	.66	(.026)
Fluoride	mg/L	NA	NA	.12	Ø
Sulfate	mg/L	NA	NA	330	(.5)

Elements by ICPEs or AA

Aluminum	mg/L	.72	Ø	ND	(.2)
Arsenic	mg/L	.014	Ø	.0045	Ø
Barium	mg/L	ND	ND	ND	(.01)
Beryllium	mg/L	ND	ND	ND	(.002)
Boron	mg/L	1.3	Ø	ND	(.6)
Cadmium	mg/L	ND	ND	ND	(.001)
Calcium	mg/L	2.1	Ø	1.2	(1)
Chromium	mg/L	.16	Ø	.08	(.01)
Cobalt	mg/L	ND	ND	ND	(.01)
Copper	mg/L	.048	Ø	.022	Ø
Iron	mg/L	.11	Ø	.09	Ø
Lead	mg/L	.05	Ø	ND	(.006)
Magnesium	mg/L	ND	ND	ND	(1)
Manganese	mg/L	ND	ND	ND	(.01)
Molybdenum	mg/L	.15	Ø	.1	Ø
Nickel	mg/L	ND	ND	ND	(.02)
Potassium	mg/L	2400	Ø	1300	(12)
Selenium	mg/L	ND	ND	ND	(.01)
Silicon	mg/L	33	Ø	1100	(4)
Silver	mg/L	ND	ND	ND	(.01)
Sodium	mg/L	1500	Ø	460	(4)
Strontium	mg/L	.023	Ø	.0068	Ø
Tin	mg/L	ND	ND	ND	(.6)
Vanadium	mg/L	.1	Ø	.025	Ø

() = Detection Limit ND = Not Detected NA = Not Analyzed Ø = < 5X Det. Limit

Table 2
(Continued)

Parameter	Units	Site ID / Location ID	
		Sample ID	Log Date
		IL / ILLY02 IL082 5/21/92	IL / ILLY05 IL085 5/21/92
		IL / ILSW01 IL089 5/18/92	

Elements by ICPEs or AA, cont.			
Zinc	mg/L	.031 @ (.02)	.04 @ (.02) ND (.02)
Field measurements			
Conductivity	umhos/cm	9710 (5)	3800 (5) 740 (5)
Filterable Residue	mg/L	NA	NA (1) 668 (1)
Redox (Eh)	mV	ND (10)	ND (10) ND (10)
Temperature	deg. C	12.9 (.1)	22.3 (.1) 24.4 (.1)
Total Alkalinity	meq/L	NA	NA (.03) .8 (.03)
Total Suspended Solids	mg/L	NA	NA (1) 4 (1)
pH	pH units	11.68 (.05)	10.56 (.05) 7.54 (.05)

Table 3

Chemical Characteristics of Ash from Illinois, Event 4

Site ID / Location ID
Sample ID
Log Date

Parameter	Units	IL / 92MAYIL01 92MAYIL01-5 5/20/92	IL / 92MAYIL01 92MAYIL01-1 5/20/92	IL / 92MAYIL01 92MAYIL01-2 5/20/92	IL / 92MAYIL01 92MAYIL01-4 5/20/92
Anions					
CaCO ₃ Equivalents	mg CO ₃ /g	48.3	58.3	48	58.9
Chloride	mg/L	33	20	10	74
Sulfate	mg/L	980	1000	910	1200
Elements by ICPES or AA					
Aluminum	mg/L	ND	ND	ND	ND
Arsenic	mg/L	.009	.012	.015	.015
Barium	mg/L	.13	.14	.11	.13
Beryllium	mg/L	ND	ND	ND	ND
Boron	mg/L	ND	ND	ND	ND
Cadmium	mg/L	ND	ND	ND	ND
Calcium	mg/L	1100	1200	1200	1100
Chromium	mg/L	ND	ND	.013	ND
Cobalt	mg/L	ND	ND	ND	ND
Copper	mg/L	ND	ND	ND	ND
Iron	mg/L	ND	ND	ND	ND
Lead	mg/L	ND	.0073	.0033	ND
Magnesium	mg/L	ND	ND	ND	ND
Manganese	mg/L	ND	ND	ND	ND
Molybdenum	mg/L	.093	.1	.074	.14
Nickel	mg/L	ND	ND	ND	ND
Potassium	mg/L	130	88	36	240
Selenium	mg/L	ND	ND	ND	ND
Silicon	mg/L	ND	ND	ND	ND
Silver	mg/L	ND	ND	ND	ND
Sodium	mg/L	86	53	17	180
Strontium	mg/L	11	13	8.5	9.9
Tin	mg/L	ND	ND	ND	ND
Vanadium	mg/L	ND	ND	ND	ND

() = Detection Limit ND = Not Detected NA = Not Analyzed $\emptyset$ = < 5X Det. Limit

02-1

Table 3
(Continued)

Parameter	Units	Site ID / Location ID			
		Sample ID	Log Date	Sample ID	Log Date
		IL / 92MAY11L01 92MAY11L01-.5 5/20/92	IL / 92MAY11L01 92MAY11L01-1 5/20/92	IL / 92MAY11L01 92MAY11L01-2 5/20/92	IL / 92MAY11L01 92MAY11L01-4 5/20/92
Elements by ICPEs or AA, cont.					
Zinc	mg/L	ND	(.02)	ND	(.02)
Field measurements					
Conductivity	umhos/cm	8860	(NA)	7880	(NA)
pH	pH units	12.08	(NA)	12.12	(NA)

Table 3

(Continued)

Site ID / Location ID
Sample ID
Log Date

Parameter	Units	IL / 92MAYIL01 92MAYIL01-6		IL / 92MAYIL01 92MAYIL01-8		IL / 92MAYIL01 92MAYIL01-9		IL / 92MAYIL01 92MAYIL01-9.5	
		5/20/92		5/20/92		5/20/92		5/20/92	

Anions									
CaCO3 Equivalents	mg CO3/g	64	(.2)	51.3	(.2)	50.9	(.2)	88.5	(.2)
Chloride	mg/l	97	(.26)	45	(.13)	13.2	(.028)	16.8	(.028)
Sulfate	mg/L	1200	(2.5)	1300	(1)	1229	(2.5)	1132	(2.5)

Elements by ICPEs or AA									
Aluminum	mg/L	ND	(.2)	ND	(.2)	ND	(.8)	ND	(.8)
Arsenic	mg/L	.012	(.004)	.015	(.004)	ND	(.004)	ND	(.004)
Barium	mg/L	.11	(.04)	.12	(.04)	.15	(.04)	.18	(.04)
Beryllium	mg/L	ND	(.002)	ND	(.002)	ND	(.008)	ND	(.008)
Boron	mg/L	ND	(.6)	ND	(.6)	ND	(.6)	ND	(.6)
Cadmium	mg/L	ND	(.001)	ND	(.001)	ND	(.001)	ND	(.001)
Calcium	mg/L	1100	(4)	1100	(4)	1300	(4)	1200	(4)
Chromium	mg/L	ND	(.01)	ND	(.01)	ND	(.04)	ND	(.04)
Chromium	mg/L	ND	(.01)	ND	(.01)	ND	(.04)	ND	(.04)
Cobalt	mg/L	ND	(.02)	ND	(.02)	ND	(.08)	ND	(.08)
Copper	mg/L	ND	(.05)	ND	(.05)	ND	(.2)	ND	(.2)
Iron	mg/L	ND	(.003)	ND	(.003)	.0043	(.003)	.003	(.003)
Lead	mg/L	ND	(1)	ND	(1)	ND	(1)	ND	(1)
Magnesium	mg/L	ND	(.01)	ND	(.01)	ND	(.04)	.17	(.04)
Manganese	mg/L	ND	(.05)	.18	(.05)	ND	(.2)	ND	(.2)
Molybdenum	mg/L	.22	(.02)	ND	(.02)	ND	(.08)	ND	(.08)
Nickel	mg/L	330	(3)	260	(3)	88	(12)	74	(12)
Potassium	mg/L	ND	(.005)	ND	(.005)	.011	(.005)	.012	(.005)
Selenium	mg/L	ND	(1)	ND	(1)	ND	(1)	ND	(1)
Silicon	mg/L	ND	(.01)	ND	(.01)	ND	(.04)	ND	(.04)
Silver	mg/L	280	(1)	190	(1)	61	(4)	51	(4)
Sodium	mg/L	12	(.012)	9.8	(.012)	8.8	(.012)	7.4	(.012)
Strontium	mg/L	ND	(.6)	ND	(.6)	ND	(2.4)	ND	(2.4)
Tin	mg/L	ND	(.02)	ND	(.02)	ND	(.08)	ND	(.08)
Vanadium	mg/L								

() = Detection Limit ND = Not Detected MA = Not Analyzed 0 = < 5X Det. Limit

02-3

Table 3
(Continued)

Parameter	Units	Site ID / Location ID Sample ID Log Date			
		IL / 92MAY11L01 92MAY11L01-6 5/20/92	IL / 92MAY11L01 92MAY11L01-8 5/20/92	IL / 92MAY11L01 92MAY11L01-9 5/20/92	IL / 92MAY11L01 92MAY11L01-9.5 5/20/92
Elements by ICPEs or AA, cont.					
Zinc	mg/L	ND	ND	ND	ND
		(.02)	(.02)	(.08)	(.08)
Field measurements					
Conductivity	umhos/cm	9620	9060	8510	8100
pH	pH units	12.42	12.42	12.24	12.28
		(NA)	(NA)	(NA)	(NA)
		(NA)	(NA)	(NA)	(NA)

Table 3
(Continued)

		Site ID / Location ID Sample ID Log Date		
Parameter	Units	IL / 92MAYIL02 92MAYIL02-.5 5/20/92	IL / 92MAYIL02 92MAYIL02-1 5/20/92	IL / 92MAYIL02 92MAYIL02-3 5/20/92
<hr/>				
Anions				
CaCO3 Equivalents	mg CO3/g	55.2	(.2)	126
			(.2)	(.2)
Field measurements				
Conductivity	umhos/cm	8010	(NA)	(NA)
pH	pH units	12.35	(NA)	12.59
			(NA)	9380
				12.67
				(NA)
				(NA)
				57.7
				(.2)
				5/20/92
				92MAYIL02-5
				IL / 92MAYIL02

Table 3
(Continued)

Site ID / Location ID		
Sample ID	Log Date	
IL / 92MAYIL02 92MAYIL02-7	IL / 92MAYIL02 92MAYIL02-8	IL / 92MAYIL02 92MAYIL02-9
5/20/92	5/20/92	5/20/92
Parameter		
Units		

Anions		
CaCO3 Equivalents	67	79.4
	(.2)	(.2)
		55.8
		(.2)
		83.2
		(.2)
Field measurements		
Conductivity	8180	8550
	(NA)	(NA)
pH	12.66	12.63
	(NA)	(NA)
		3810
		(NA)
		12.33
		(NA)

Table 3
(Continued)

Site ID / Location ID								
Parameter	Units	Sample ID						
		Beg. Depth - End Depth (ft.)						
		IL / 92MAYIL01 92MAYIL01-10 9.5 - 10	IL / 92MAYIL01 92MAYIL01-10.5 10 - 10.5	IL / 92MAYIL01 92MAYIL01-11 10.5 - 11	IL / 92MAYIL01 92MAYIL01-12 11.5 - 12			

Anions								
CaCO3 Equivalents	mg CO3/g	46.8	(.2)	66.1	(.2)	74.3	(.2)	34.2
Chloride	mg/L	23	(.13)	1.4	(.026)	2.4	(.028)	.9
Sulfate	mg/L	1100	(1)	68	(.05)	147	(2.5)	101

Elements by ICPES or AA								
Aluminum	mg/L	ND	(.2)	ND	(.2)	.7	(.2)	.66
Arsenic	%recvry	NA		NA		NA		93
Arsenic	mg/L	.014	(.004)	ND	(.004)	ND	(.004)	ND
Barium	mg/L	.11	(.04)	.013	(.01)	ND	(.01)	.016
Beryllium	mg/L	ND	(.002)	ND	(.002)	ND	(.002)	ND
Boron	mg/L	ND	(.6)	ND	(.6)	ND	(.6)	ND
Cadmium	%recvry	NA		NA		NA		94
Cadmium	mg/L	ND	(.001)	ND	(.001)	ND	(.001)	ND
Calcium	mg/L	1200	(4)	21	(1)	90	(1)	39
Chromium	mg/L	ND	(.01)	ND	(.01)	ND	(.01)	ND
Cobalt	mg/L	ND	(.01)	ND	(.01)	ND	(.01)	ND
Copper	mg/L	ND	(.02)	ND	(.02)	ND	(.02)	ND
Iron	mg/L	ND	(.05)	ND	(.05)	ND	(.05)	.82
Lead	%recvry	NA		NA		NA		117
Lead	mg/L	ND	(.003)	ND	(.003)	ND	(.003)	.0068
Magnesium	mg/L	ND	(1)	4.9	(1)	ND	(1)	9
Manganese	mg/L	ND	(.01)	ND	(.01)	ND	(.01)	.28
Molybdenum	mg/L	.14	(.05)	ND	(.05)	ND	(.05)	ND
Nickel	mg/L	ND	(.02)	ND	(.02)	ND	(.02)	ND
Potassium	mg/L	63	(3)	ND	(3)	ND	(3)	ND
Selenium	%recvry	NA		NA		NA		89
Selenium	mg/L	ND	(.005)	ND	(.005)	ND	(.005)	ND
Silicon	mg/L	ND	(1)	1.9	(1)	5.1	(1)	3.5
Silver	mg/L	ND	(.01)	ND	(.01)	ND	(.01)	ND

() = Detection Limit ND = Not Detected NA = Not Analyzed 0 = < 5X Det. Limit

D2-1

Table 3
(Continued)

Parameter	Site ID / Location ID				
	Sample ID				
	Beg. Depth - End Depth (ft.)				
	IL / 92MAY1L01 92MAY1L01-10 9.5 - 10	IL / 92MAY1L01 92MAY1L01-10.5 10 - 10.5	IL / 92MAY1L01 92MAY1L01-11 10.5 - 11	IL / 92MAY1L01 92MAY1L01-12 11.5 - 12	
Units					

Elements by ICPEs or AA, cont.					
Sodium	mg/L	57	10	(1)	1.7 0 (1)
Strontium	mg/L	9.2	.04	(.003)	.049 (.003)
Tin	mg/L	ND	ND	(.6)	ND (.6)
Vanadium	mg/L	ND	ND	(.02)	ND (.02)
Zinc	mg/L	ND	ND	(.02)	ND (.02)

Field measurements					
Conductivity	umhos/cm	8420	208	(NA)	263 (NA)
pH	pH units	12.31	9.27	(NA)	7.83 (NA)

Table 3
(Continued)

Parameter	Site ID / Location ID Sample ID Beg. Depth - End Depth (ft.)			
	IL / 92MAYIL01 92MAYIL01-14 14 - 14.5	IL / 92MAYIL01 92MAYIL01-15 14.5 - 15	IL / 92MAYIL02 92MAYIL02-10 9.5 - 10	IL / 92MAYIL02 92MAYIL02-10.5 10 - 10.5
Units				
Anions				
CaCO3 Equivalents	103	99	42.9	66.1
	(.2)	(.2)	(.2)	(.2)
Field measurements				
Conductivity	190	323	520	377
	(NA)	(NA)	(NA)	(NA)
pH	7.93	7.96	10.93	9.96
	(NA)	(NA)	(NA)	(NA)

Table 3
(Continued)

Parameter	Site ID / Location ID Sample ID Beg. Depth - End Depth (ft.)			
	IL / 92MAY1L02 92MAY1L02-11 10.5 - 11	IL / 92MAY1L02 92MAY1L02-12 11.5 - 12	IL / 92MAY1L02 92MAY1L02-14 13.5 - 14	IL / 92MAY1L02 92MAY1L02-16 15.5 - 16
Units				
Anions				
CaCO3 Equivalents	62.6	63	89.8	91.9
	(.2)	(.2)	(.2)	(.2)
Field measurements				
Conductivity	323	250	134	140
	(NA)	(NA)	(NA)	(NA)
pH	8.12	8.26	8.36	8.48
	(NA)	(NA)	(NA)	(NA)

APPENDIX A

Technical Note

Technical Note:

Surface Runoff from the Colorado-Ute Landfill Test Cell

Approximately 800 cubic yards of CFBC wastes from the Colorado Ute Nucla Station are under study in a landfill test cell in Montrose County, Colorado. During the 2 1/2 years of environmental monitoring at the test site, only one surface water runoff sample has been generated, and the total runoff volume from the 1600 sq. ft. test cell during the first year of monitoring, when the cell was uncovered, was less than 5 gallons. Of the 7.5 inches of annual rainfall at the site, nearly 90% is lost to evaporation; surface runoff is less than 0.2%. Runoff from the test cell is moderately alkaline, with a low dissolved and suspended solids content. Concentrations of all measured species are well below levels of regulatory concern. Data on the chemical analysis of the water and estimates of the amounts of runoff water which might be generated during other rainfall events are detailed below.

The FBC wastes in the landfill test cell were exposed to the elements during the first year after cell construction. During this time a flume was installed at the low point of the cell surface to measure total runoff volumes and to collect water samples for analysis. The total runoff volume measured by the flume during this time was approximately 1.4 gallons, although approximately 4 gallons of water was found in the collection bucket on December 16, 1990. The discrepancy is presumably due to water which trickled into the pail from the flume apron, without passing through the flow meter. Several rain events during late September and early October 1990 are responsible for the runoff water collected in December: the highest daily total rainfall occurred on October 2, 1990 when 1.13 inches of rain was measured at the site; the heaviest hourly rainfall occurred on September 17, 1990 when 0.42 inches of rain fell in one hour.

The low volume of runoff from the landfill test cell is related both to the generally dry climate of the site, and to the relatively high permeability of the waste surface, which allows most of the rainfall to be absorbed into the upper layers of the FBC wastes. Field measurements of the near-surface permeability of the Colorado FBC waste in December 1990 average 8.17×10^{-4} cm/sec, or 1.16 in/hr. This permeability appears to be sufficient to absorb rainfall from most events except heavy downpours. HELP model¹ predictions, based on climate data for Grand Junction with annual rainfall of 7.55 inches and a soil hydraulic conductivity of 1.00 in/hr, show nearly 90% of the water budget is lost to evaporation, with runoff accounting for less than 0.2%. At the Colorado site, absorbed rainfall is largely evaporated from the waste surface.

The composition of the single runoff sample collected from the Colorado site is shown in Table 1. The major inorganic components of the runoff water are calcium and sulfate, which are present at concentrations of 67 and 160 mg/L, respectively. Low concentrations of other common species including chloride, fluoride, magnesium and sodium are also present in the sample. Barium, strontium, lead and zinc were also detected in the runoff, while cadmium was found at the detection limit concentration. Some organic activity has probably taken place in the sample bucket between the time of the runoff events and the sample collection. The total organic carbon concentration of the sample is 460 mg/L, both nitrate and ammonia are present, and the oxidation-reduction potential is considerably lower than would be expected for a fresh runoff sample, all indicative of biological activity. The pH of the sample was measured as 9.01; this measurement may have been affected by bacterial action in the sample pail. Approximately 65 mg/L suspended solids are also present in the runoff.

The data available from the Colorado Ute landfill test cell suggest that only very intense rainfall events could produce significant volumes of runoff from the landfilled FBC wastes, given the climatic conditions at the site and the waste perme-

¹The Hydrologic Evaluation of Landfill Performance (HELP) Model. P.R. Schroeder, A.C. Gibson, and M.D. Smolen, 1984b. U.S. EPA/530-SW-84-010.

ability. Such events will produce runoff with a low total dissolved solids load, since under such conditions there is a high dilution factor and runoff is rapid. The chemistry of the only runoff sample collected from the test cell is consistent with these conclusions.

Table 1

Colorado Runoff Composition

Analyte	Result	Units	Detection Limit
Field Measurements:			
Alkalinity	ND	meq/L	1
Conductivity	2025.*	μ mhos/cm	--
pH	9.01	pH units	--
Redox vs. Ag/AgCl	-123	mV	--
Temperature	19	degrees C	--
Water Quality Parameters:			
Total Dissolved Solids	305	mg/L	.5
Total Organic Carbon	460	mg/L	10
Total Phenolics	.006	mg/L	.005
Total Suspended Solids	64.7	mg/L	.5
Anions:			
Ammonia as N	.52	mg/L	.01
Chloride	2.9	mg/L	.02
Fluoride	.52	mg/L	.1
Nitrate-Nitrite as N	1.1	mg/L	.04
Sulfate	160	mg/L	.1
Metals:			
Aluminum	ND	mg/L	.2
Arsenic	ND	mg/L	.005
Barium	.044	mg/L	.01
Beryllium	ND	mg/L	.002
Boron	ND	mg/L	.6
Cadmium	.001	mg/L	.001
Calcium	67	mg/L	1
Chromium	ND	mg/L	.01
Cobalt	ND	mg/L	.01
Copper	ND	mg/L	.01
Iron	ND	mg/L	.04
Lead	.018	mg/L	.003
Magnesium	4.8	mg/L	1
Manganese	ND	mg/L	.01
Molybdenum	ND	mg/L	.05
Nickel	ND	mg/L	.02
Phosphorus	ND	mg/L	.3
Potassium	ND	mg/L	3
Selenium	ND	mg/L	.005
Silver	ND	mg/L	.01
Sodium	7.9	mg/L	1
Strontium	.42	mg/L	.003
Vanadium	ND	mg/L	.02
Zinc	.24	mg/L	.02

* The field conductivity value is not consistent with the measured TDS or individual analyte concentrations, and is probably erroneous.

END

**DATE
FILMED**
4/9/93