ENHANCING THE USE OF COALS
BY GAS REBURNING - SORBENT INJECTION

Environmental Monitoring Report
City Water, Light and Power's Lakeside Station Unit 7
Optimization Testing Period
July 28, - October 1, 1993

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1.0 INTRODUCTION

Energy and Environmental Research Corporation (EER) has completed demonstrations of Gas Reburning-Sorbent Injection (GR-SI) at two field sites. The discussions which follow pertain to measurements taken from the demonstration at City Water, Light and Power's (CWLP) Lakeside Station Unit 7 in Springfield, Illinois, which was performed under a Clean Coal Technology Program (Round 1) through the principal sponsorship of the U.S. Department of Energy. Cosponsors include the Gas Research Institute, the Illinois State Department of Energy and Natural Resources and the host utility. Environmental monitoring was conducted for two purposes, to satisfy the requirements of operating permits granted by the Illinois Environmental Protection Agency (IEPA) and to verify environmental acceptability of the GR-SI process.

The GR-SI demonstration program at Lakeside Unit 7 was performed in three phases. Phase I - Design and Permitting, entailed characterization of the host boiler, then finalization of process and engineering design of the GR-SI system. Phase I was initiated in June 1987 and completed in March 1989. Phase II - Construction and Startup, was initiated upon completion of design tasks and was completed in February 1993. Phase III - Operation, Data Collection, Reporting and Disposition, was conducted from July 1993 to June 1994. In Phase III, the GR-SI system performance was evaluated initially through optimization tests, which are short-term tests in which specific operating parameters are varied to determine their impact on emissions and boiler performance. The optimization testing included GR only tests, SI only tests, and GR-SI tests. Results from these tests, carried out from July 28 to October 1, 1993, are presented in this report. Following Optimization testing, long-term GR-SI operation was initiated to demonstrate the combined technology over an extended period with the unit under dispatch load control. Long-term GR-SI testing was conducted from October 4, 1993 to June 3, 1994. The long-term environmental monitoring data are presented in a separate report.

Environmental monitoring in Phases I and II was limited to compliance monitoring as required by IEPA. Adherence to a particulate matter emissions limit of $0.1 \text{ lb}/10^6 \text{ Btu}$ was determined by monitoring of opacity, with any opacity excursions greater than 30% required for reporting to IEPA. The National Pollutant Discharge Elimination System (NPDES) permit required monitoring of aqueous discharges to Lake Springfield and Sugar Creek. Limits on 30 day average and maximum daily concentrations of specific pollutants are specified by the NPDES permit and vary with the nature of the discharge. The common limits are for pH, total suspended solids and oil/grease. For some aqueous streams, limits of total iron, copper, residual chlorine, are also specified. GR-SI operation was thought potentially to impact outfalls 004 and 008, which are the ash pond discharge and the water runoff from the coal pile, respectively. Outfall 004 has a pH limit of 6 to 9, 30 day average limits of total suspended solids (15 mg/l) and oil/grease (15 mg/l), and daily maximum limits of total suspended solids (30 mg/l) and oil/grease (20 mg/l). Outfall 008 has the same limits for pH, total suspended solids and oil/grease, but an additional total iron limit for 30 day average (2 mg/l) and daily maximum (4 mg/l). Compliance with these limits was determined by weekly or bimonthly monitoring, as specified by the NPDES permit.

In Phase III testing of the GR-SI system, a wide range of additional measurements were taken by EER to verify that emissions control goals for the project were met and that other discharges were either unaffected or acceptable. Emissions were measured with a Continuous Emissions Monitoring System (CEMS), which extracted gas at the boiler exit. Gas samples were plumbed, conditioned by moisture removal and then analyzed by instruments for NO_x , SO_2 , CO , CO_2 , O_2 , and hydrocarbons (HC). The data were averaged and corrected to a standard O_2 concentration. A wide range of process data from plant instrumentation was also recorded. These include opacity, particulate loading (during long-term testing), noise levels near plant equipment and fly ash leaching characterization.

2.0 GAS REBURNING-SORBENT INJECTION

GR-SI is an advanced pollution control technology designed to reduce NO_x and SO_2 (by 60% and 50%, respectively, in this application). It has been under development from pilot to full scale for the last two decades. In this program, GR-SI has been demonstrated at two coal fired utility boilers in Illinois, with tangential and cyclone firing configuration. GR involves the injection of natural gas in the area above the coal burners to form a fuel rich region in which NO_x formed in the burner region is reduced by a variety of hydrocarbon fragments and free radicals to N_2 . The quantity of natural gas used is typically in the 15 to 25% gas heat input range. Burnout (Overfire) air is injected higher up in the furnace to burn out the fuel under overall fuel lean conditions. The flows of coal, burner air, natural gas, and overfire air produce three zones designated as Burner Zone, Reburning Zone, and Burnout Zone, each with its unique stoichiometry. Typical stoichiometries for this unit are 1.1, 0.9, and 1.18 for the three zones, respectively. The SI process involves injection of dry hydrated lime sorbent ($\text{Ca}(\text{OH})_2$) into the upper furnace cavity for capture of SO_2 . The micron-sized sorbent (mean diameter under 5 microns) is conveyed to the boiler and injected with air. In the upper furnace the sorbent first undergoes calcination to form a highly reactive Calcium Oxide (CaO), then undergoes sulfation to form Calcium Sulfate (CaSO_4) and Calcium Sulfite (CaSO_3). These solids are then collected with the fly ash by the particulate removal device, an Electrostatic Precipitator in the case of Lakeside Unit 7. The SI process is applied typically with a Ca (Sorbent) to S (Coal) molar ratio of 1.5 to 2.5.

Natural gas firing in GR has several environmental benefits in addition to NO_x control. These include reduction in SO_2 at a level corresponding to the gas heat input, a modest reduction in CO_2 , and acceptable CO emissions from judicious design of the overfire air system. Additional benefits include reductions in the quantity of bottom ash, bottom ash sluice water, and fly ash. The reduction in fly ash should result in lower stack opacity. The emissions of N_2O , which were not measured at this site, are unaffected by GR as demonstrated at another GR-SI project at Illinois Power Company's Hennepin Station Unit 1. At this site, N_2O emissions under GR-SI reached a peak of 4.3 ppm, and typically averaged 0.5 to 3.2 ppm over the test periods.

The SI process reduces SO_2 emissions by 30 to 50 percent, depending on boiler-specific factors, the type of sorbent, and injection details. The major GR-SI waste product (fly ash/spent sorbent mixture) is conveyed pneumatically from the ESP hoppers to a special silo. A dustless unloader

is then used to convey the ash with water addition to trucks, which then carry it to a landfill for disposal.

3.0 DESCRIPTION OF HOST UNIT

City Water, Light and Power's Lakeside Station Unit 7 is a 33 MW_e cyclone fired boiler. At its maximum continuous rating the unit produces 320,000 lb/hr steam, at a temperature of 910°F and pressure of 875 psig. It fires crushed high sulfur Illinois bituminous coal in 2 7-ft diameter cyclone furnaces. Flue gases flow through a refractory-lined primary furnace, a secondary furnace, secondary and primary superheaters, a two-drum steam generating bank, a regenerative air heater, an ESP, then to the stack. It operates in cycling service, normally coming on line during the summer months. It is equipped with an F. L. Smidth ESP which receives flue from both Units 7 and 8. The ESP has a Specific Collection Area (SCA) of 500 ft²/ 1000 ACFM under full load of both units. Typically, both bottom and fly ash are sluiced to an on-site ash pond, but due to changes in the fly ash composition under GR-SI this was discontinued during the course of this project. Under GR-SI operation, the bottom ash sluicing to the pond continued, but fly ash was collected dry in an ash silo and then trucked to a landfill.

4.0 RESULTS

4.1 AIR EMISSIONS

Extensive air emissions measurements were made under the various operating conditions. The CEMS data averaged over the test periods are tabulated in Tables 1 through 3. Table 1 lists data from GR-only operation. Table 2 shows SI-only data and Table 3 shows limited GR-SI data obtained before initiation of long-term testing. For comparison, the pre-project baseline emissions under full load (33 MW_e) measured in 1988, are summarized below.

<u>Unit</u>	<u>NO_x</u>	<u>SO₂</u>	<u>Particulate Matter</u>
lb/10 ⁶ Btu	0.95	5.05	0.00733

Baseline testing conducted in Phase III (1993 - 1994) indicated that the NO_x emissions vary with electric load according to the equation: NO_x = 0.522 + 0.0134*(load). This equation may be used over the normal boiler load range of 19 to 34 MW_e. In Phase III, baseline SO₂ emissions were found to be 5.9 lb/10⁶ Btu.

GR testing was carried from 7/28/93 to 9/8/93 and then again on 9/30/93 over a range of operating conditions. The total duration under GR mode was 58.5 hours. The average gas heat input was 23% and average boiler O₂ level was 4.0%. Average emissions for all GR tests were:

<u>Species</u>	<u>NO_x</u>	<u>NO_x</u>	<u>SO₂</u>	<u>SO₂</u>	<u>CO₂</u>	<u>CO</u>
Unit	ppm	lb/10 ⁶ Btu	ppm	lb/10 ⁶ Btu	%	ppm
	273	0.363	2448	4.552	14.3	150

TABLE 1. GR OPTIMIZATION TESTING EMISSIONS SUMMARY.

Test I.D.	Test Date	Gross Power (MW)	Gas Heat (% totl)	Ca/S Molar Ratio	CEMS O2 (% dry)	Plant O2 (% wet)	CO (ppm @ 3% O2)	CO2 (% @ 3% O2)	NOx (ppm @ 3% O2)	NOx (lb/MBtu)	SO2 (ppm @ 3% O2)	SO2 (lb/MBtu)
GR-5B	7/28/93	33	23.4	0.00	3.57	2.93	174	14.3	265	0.352	2426	4.509
GR-5C	7/28/93	33	23.4	0.00	3.50	2.82	229	14.3	264	0.350	2409	4.476
GR-5A	7/29/93	35	23.2	0.00	3.48	2.91	87	14.4	288	0.383	2512	4.669
GR-4A	7/29/93	35	21.8	0.00	3.59	3.08	54	14.4	302	0.401	2544	4.733
GR-3A	7/30/93	34	19.5	0.00	3.27	2.68	83	14.6	303	0.403	2624	4.874
GR-2A	7/30/93	34	16.1	0.00	3.26	2.69	27	14.7	351	0.469	2726	5.106
GR-5D	7/30/93	35	23.1	0.00	3.52	2.91	82	14.4	322	0.429	2535	4.713
GR-5E	7/30/93	34	22.8	0.00	3.46	2.75	141	14.4	321	0.426	2515	4.676
GR-5F	7/30/93	34	22.6	0.00	3.51	2.50	432	14.3	323	0.429	2506	4.661
GR-5G	7/30/93	35	22.8	0.00	3.46	2.78	92	14.3	289	0.384	2501	4.651
GR-15B	8/2/93	26	22.6	0.00	4.00	3.45	28	14.4	309	0.411	2525	4.703
GR-15A	8/2/93	26	22.6	0.00	3.65	3.21	34	14.5	285	0.379	2518	4.682
GR-15C	8/2/93	26	22.5	0.00	4.17	3.65	7	14.5	314	0.418	2497	4.646
GR-14A	8/2/93	26	25.0	0.00	3.65	3.21	41	14.4	277	0.368	2420	4.488
GR-13A	8/2/93	26	20.5	0.00	4.08	3.59	7	14.5	316	0.422	2517	4.691
GR-12A	8/2/93	26	19.6	0.00	4.17	3.63	6	14.6	334	0.445	2562	4.780
GR-11A	8/2/93	26	16.5	0.00	3.95	3.34	6	14.7	374	0.501	2644	4.951
GR-25A	8/11/93	19	23.9	0.00	3.84	3.01	134	14.1	204	0.271	2372	4.404
GR-25B	8/11/93	19	23.9	0.00	3.96	3.16	85	14.1	215	0.285	2343	4.350
GR-25C	8/11/93	20	24.0	0.00	3.65	2.93	104	14.1	217	0.289	2347	4.358
GR-24A	8/11/93	19	22.2	0.00	3.62	2.99	70	14.1	223	0.296	2401	4.467
GR-22A	8/11/93	19	17.0	0.00	3.69	3.13	21	14.3	269	0.358	2542	4.761
GR-15D	8/12/93	27	23.2	0.00	3.13	2.36	486	14.3	243	0.322	2458	4.571
GR-15E	8/12/93	27	23.1	0.00	3.08	2.36	451	14.3	225	0.299	2452	4.559
GR-15F	8/12/93	27	23.3	0.00	2.92	2.26	496	14.3	196	0.261	2454	4.558
GR-5A2	8/13/93	33	24.6	0.00	3.95	3.06	253	14.3	308	0.408	2417	4.486
GR-8A	8/13/93	34	24.8	0.00	3.98	3.11	154	14.3	325	0.431	2390	4.434
GR-5H	8/13/93	33	24.9	0.00	4.62	3.72	105	14.3	351	0.465	2366	4.390
GR-5I	8/13/93	32	24.9	0.00	5.02	4.09	44	14.2	368	0.488	2383	4.420
GR-15G	8/17/93	25	21.4	0.00	3.54	2.88	31	14.4	280	0.373	2398	4.466
GR-15G2	8/17/93	25	23.6	0.00	3.76	3.12	12	14.3	290	0.385	2316	4.305
GR-15H	8/17/93	25	23.5	0.00	4.79	3.89	12	14.2	326	0.433	2290	4.254
GR-15I	8/17/93	25	23.5	0.00	5.36	4.30	16	14.1	334	0.444	2283	4.241
GR-8B	8/18/93	33	24.8	0.00	3.84	3.12	49	14.3	311	0.412	2324	4.311
GR-5I	8/18/93	33	24.8	0.00	4.79	3.92	14	14.2	346	0.459	2317	4.299
GR-25D	8/19/93	19	22.2	0.00	4.96	4.00	12	14.2	310	0.412	2360	4.393
GR-25E	8/19/93	19	22.2	0.00	4.92	4.10	9	14.2	303	0.404	2347	4.368
GR-25E2	8/19/93	19	21.9	0.00	3.51	2.96	233	14.2	191	0.254	2368	4.408
GR-25F	8/19/93	19	22.0	0.00	3.55	2.98	276	14.2	171	0.227	2351	4.376
GR-25G	8/20/93	19	22.7	0.00	3.85	3.12	75	14.4	233	0.310	2394	4.452
GR-25G2	8/20/93	19	25.5	0.00	3.55	2.83	225	14.3	222	0.293	2304	4.272
GR-25H	8/20/93	19	25.6	0.00	5.05	4.15	19	14.2	275	0.365	2282	4.230
GR-25I	8/20/93	19	25.7	0.00	4.49	3.72	23	14.2	252	0.334	2273	4.213
GR-25F2	8/20/93	19	25.9	0.00	4.54	3.74	54	14.2	248	0.329	2261	4.190
GR-25E3	8/20/93	19	25.8	0.00	4.40	3.60	77	14.2	260	0.345	2256	4.182
GR-25D2	8/20/93	19	25.3	0.00	4.24	3.23	203	14.2	264	0.349	2274	4.206
GR-14A2	8/23/93	24	24.4	0.00	3.98	3.28	326	14.3	228	0.303	2394	4.443
GR-15A2	8/23/93	24	23.2	0.00	3.97	3.27	390	14.3	234	0.311	2412	4.483
GR-5E2	8/23/93	31	25.2	0.00	3.63	3.08	117	14.2	276	0.366	2271	4.211

Note: MBtu = Million Btu

TABLE 1. GR OPTIMIZATION TESTING EMISSIONS SUMMARY. (CONTINUED)

Test I.D.	Test Date	Gross Power (MW)	Gas Heat (% totl)	Ca/S Molar Ratio	CEMS O ₂ (% drv)	Plant O ₂ (% wet)	CO (ppm @ 3% O ₂)	CO ₂ (% @ 3% O ₂)	NO _x (ppm @ 3% O ₂)	NO _x (lb/MBtu)	SO ₂ (ppm @ 3% O ₂)	SO ₂ (lb/MBtu)
GR-14A2	8/31/93	24	25.0	0.00	3.77	2.71	353	14.4	269	0.357	2496	4.628
GR-15F2	8/31/93	24	24.1	0.00	3.49	2.61	255	14.4	248	0.329	2518	4.675
GR-15E2	8/31/93	24	24.0	0.00	3.55	2.49	434	14.4	278	0.370	2514	4.668
GR-19A	8/31/93	24	24.1	0.00	4.10	3.13	186	14.4	282	0.375	2508	4.656
GR-25H2	9/1/93	19	25.7	0.00	4.89	3.91	91	14.1	213	0.282	2397	4.442
GR-1A	9/2/93	35	11.6	0.00	2.53	2.39	79	14.9	392	0.528	2767	5.210
GR-1A2	9/2/93	34	12.0	0.00	4.17	3.61	7	14.8	537	0.722	2726	5.129
GR-5G2	9/2/93	34	25.0	0.00	2.23	1.85	477	14.1	228	0.302	2438	4.538
GR-5C2	9/2/93	33	25.4	0.00	3.57	3.16	30	14.2	302	0.400	2390	4.432
GR-5D2	9/2/93	33	25.3	0.00	3.58	3.13	28	14.2	322	0.427	2387	4.426
GR-25A	9/3/93	20	23.6	0.00	4.23	3.97	33	14.3	250	0.332	2503	4.650
GR-25B2	9/3/93	19	25.5	0.00	3.90	3.75	62	14.3	249	0.329	2435	4.512
GR-25I2	9/7/93	19	25.8	0.00	4.64	3.75	204	14.3	201	0.266	2524	4.677
GR-25J	9/7/93	19	25.6	0.00	5.46	4.47	68	14.3	232	0.308	2498	4.631
GR-H2	9/7/93	20	25.6	0.00	3.88	3.05	495	14.3	174	0.231	2480	4.597
GR-27B	9/8/93	19	22.9	0.00	4.15	3.05	529	14.4	171	0.227	2556	4.753
GR-27C	9/8/93	19	23.0	0.00	4.73	3.64	515	14.3	185	0.246	2520	4.684
GR-27D	9/8/93	19	22.9	0.00	5.35	4.23	219	14.2	208	0.276	2529	4.700
GR-27E	9/8/93	19	23.0	0.00	6.02	4.82	67	14.2	238	0.316	2540	4.722
GR-28A	9/8/93	19	19.7	0.00	5.26	4.17	167	14.4	223	0.298	2644	4.932
GR-28B	9/8/93	19	18.0	0.01	4.97	3.97	168	14.5	227	0.304	2699	5.045
GR-18A	9/30/93	23	26.0	0.00	5.66	4.60	92	13.8	223	0.295	2390	4.429
GR Average		25	23.0	0.00	4.04	3.30	150	14.3	273	0.363	2448	4.552

TABLE 2. SI OPTIMIZATION TESTING EMISSIONS SUMMARY.

Test I.D.	Test Date	Gross Power (MW)	Gas Heat (% totl)	Ca/S Molar Ratio	CEMS O ₂ (% drv)	Plant O ₂ (% wet)	CO (ppm @ 3% O ₂)	CO ₂ (% @ 3% O ₂)	NO _x (ppm @ 3% O ₂)	NO _x (lb/MBtu)	SO ₂ (ppm @ 3% O ₂)	SO ₂ (lb/MBtu)
SI-15	9/10/93	20	0.0	1.23	5.84	4.61	13	15.4	588	0.802	2470	4.705
SI-17	9/10/93	20	0.0	2.34	5.61	4.33	12	15.4	603	0.822	2083	3.972
SI-19	9/10/93	20	0.0	3.46	5.36	4.14	13	15.1	589	0.803	1761	3.357
SI-2	9/13/93	33	0.0	2.05	3.99	2.96	13	15.3	704	0.960	1967	3.767
SI-8	9/13/93	33	0.0	2.01	3.95	2.92	13	15.3	669	0.913	1129	2.147
SI-2A	9/14/93	33	0.0	2.09	4.46	3.33	9	15.4	732	0.998	1732	3.304
SI-8A	9/14/93	33	0.0	2.16	4.16	3.05	9	15.5	746	1.017	1551	2.958
SI-14	9/17/93	20	0.0	1.95	6.01	4.34	17	15.2	590	0.804	2193	4.181
SI-16	9/17/93	20	0.0	1.87	5.54	4.49	10	15.2	569	0.775	2151	4.102
SI-26	9/20/93	24	0.0	1.93	5.01	3.89	14	15.4	586	0.797	2126	4.043
SI-27	9/20/93	24	0.0	1.94	4.71	3.69	12	15.5	591	0.805	2138	4.074
SI-2B	9/22/93	33	0.0	2.27	3.96	3.19	16	15.3	681	0.929	1716	3.276
SI-8B	9/22/93	33	0.0	2.15	3.68	3.01	13	15.2	697	0.950	1693	3.229
SI-11B	9/22/93	34	0.0	2.15	3.31	2.79	13	15.2	689	0.939	1761	3.357
SI-3	9/23/93	33	0.0	1.10	4.24	3.45	10	15.4	744	1.014	2096	3.996
SI-6	9/23/93	33	0.0	2.10	4.04	3.20	12	15.4	750	1.022	1553	2.965
SI-10	9/23/93	33	0.0	2.87	4.02	3.06	14	15.3	790	1.077	1186	2.267
SI Average		28	0.0	2.10	4.58	3.56	13	15.3	666	0.907	1842	3.512

Note: MBtu = Million Btu

TABLE 3. GR-SI OPTIMIZATION TESTING EMISSIONS SUMMARY.

Test I.D.	Test Date	Gross Power (MW)	Gas Heat (% totl)	Ca/S Molar Ratio	CEMS O2 (% drv)	Plant O2 (% wet)	CO (ppm @ 3% O2)	CO2 (% @ 3% O2)	NOx (ppm @ 3% O2)	NOx (lb/MBtu)	SO2 (ppm @ 3% O2)	SO2 (lb/MBtu)
GRSI-11A	9/30/93	27	24.7	2.25	3.28	2.23	370	13.9	224	0.298	1191	2.211
GRSI-11B	10/1/93	24	22.4	2.13	4.56	3.41	71	14.1	233	0.311	1546	2.878
GR-SI Average		25	23.5	2.19	3.92	2.82	221	14.0	229	0.304	1369	2.545

Note: MBtu = Million Btu

All concentrations in ppm and percent (%) have been corrected to 3% O₂. The NO_x data indicate a reduction of 58% from the baseline at 25 MW_e. The 23% reduction in SO₂ is due to fuel replacement. CO emissions were on average at an acceptable level, 150 ppm.

SI-only operation was evaluated over 16.8 hours, with an average Ca/S molar ratio was 2.10 and the O₂ level was 4.6%. The average emissions measured under this condition were:

<u>Species</u>	<u>NO_x</u>	<u>NO_x</u>	<u>SO₂</u>	<u>SO₂</u>	<u>CO₂</u>	<u>CO</u>
Unit	ppm	lb/10 ⁶ Btu	ppm	lb/10 ⁶ Btu	%	ppm
	666	0.907	1842	3.512	15.3	13

Under SI-only operation, SO₂ emissions were reduced by 40% from the baseline level. The NO_x level is slightly below that under baseline operation, due to air staging. Under SI operation, CO emissions were very low.

Only two days of GR-SI testing were completed before initiation of long-term testing. Two tests had a total duration of 1.7 hours under GR-SI mode. The average gas heat input was 23.5% and the average Ca/S molar ratio was 2.19. Average emissions measured under this condition were:

<u>Species</u>	<u>NO_x</u>	<u>NO_x</u>	<u>SO₂</u>	<u>SO₂</u>	<u>CO₂</u>	<u>CO</u>
Unit	ppm	lb/10 ⁶ Btu	ppm	lb/10 ⁶ Btu	%	ppm
	229	0.304	1369	2.545	14.0	221

These data reflect a reduction in NO_x emissions of 65% from the baseline at 25 MW_e. These tests were preceded by modification of reburning fuel injectors to improve reburning efficiency. Therefore, they were expected to show higher NO_x reductions than the previous GR tests. SO₂ emissions were reduced on average by 57%.

Early in Optimization Testing, emission of hydrocarbons (HC) were measured. The Beckman Model 402 instrument was difficult to keep operational while sampling flue gas. Therefore, HC emissions were only measured under GR operation. Overall, low levels were measured, as indicated below:

Average HC (ppm)	6.2
Maximum HC (ppm)	30.8
Minimum HC (ppm)	0.6

These measurements were all taken under GR operation. The ppm concentrations have been corrected to 3% O₂.

The flue gas opacity at the ESP outlet was logged by the Boiler Performance Monitoring System (BPMS), along with other operating/performance parameters. Since sorbent injection increases

the particulate loading at the ESP inlet, there is potential for increase in opacity. The opacity, averaged for the three test conditions, increased only marginally when sorbent was injected. The average, maximum, and minimum opacity for each condition were as follows:

Baseline Average Opacity (%)	4.8
Baseline Maximum Opacity (%)	7.1
Baseline Minimum Opacity (%)	2.0
GR Average Opacity (%)	4.0
GR Maximum Opacity (%)	6.8
GR Minimum Opacity (%)	2.1
SI Average Opacity (%)	5.4
SI Maximum Opacity (%)	5.9
SI Minimum Opacity (%)	4.2
GR-SI Average Opacity (%)	5.6
GR-SI Maximum Opacity (%)	5.9
GR-SI Minimum Opacity (%)	5.4

The ESP had sufficient capacity to collect the added particulate matter, maintaining low emissions. The Excess Opacity Reports, found in Appendix A, show that the opacity exceeded 30% only during start-up of Units 7 or 8.

4.2 SOLID WASTE

The major waste product of GR-SI operation is the high calcium solid material, which is a mixture of normal coal fly ash and spent and unreacted sorbent. This material was not sluiced to the ash pond, but was pneumatically conveyed to a storage silo, then loaded onto trucks with a dustless unloader for disposal at a landfill. While it was not expressly required by the Environmental monitoring Plan, a Toxicity Characteristic Leaching Procedure (TCLP) analysis of the fly ash/spent sorbent mixture is included as Table 4. The levels of various constituents in both the raw sample, listed in the "Total" column, and in the TCLP extract are very low. The concentrations of 23 organic compounds in the TCLP are below the regulatory limit in each case. The evaluation was conducted by a commercial laboratory according to 40 CFR Part 261.

4.3 NOISE

Noise levels in various areas of the plant were measured and are listed below:

TABLE 4. EVALUATION OF FLY ASH/SPENT SORBENT MIXTURE.

Total Alkalinity	30.5% as NH_4OH		
Soluble Alkalinity	6.6% NH_4OH		
Insoluble Alkalinity	25.3% as $\text{Ca}(\text{OH})_2$		
Ash Content	100.0%		
Odor of Sample	None		
Open Cup Flash Point	> 180 F		
Paint Filter	Pass		
Physical Appearance	Grey Ash		
Reactive Sulfide	< 5.0		
Total Cyanide	< 5.0		
Total Phenolics	< 10.0		
Total Solids	100.0%		
Water Reactivity	Dissolved in Water		
pH (10% solution)	12.26 (units)		
	Total		TCLP
Arsenic	19		0.25
Barium	26		--
Cadmium	4		<0.1
Chromium	32		<0.1
Copper	25		<0.1
Lead	34		0.29
Mercury	0.09		--
Nickel	38		0.10
Selenium	10		0.35
Silver	<2.5		--
Zinc	130		<0.1

Note: Unless Otherwise Indicated, All Results Expressed as ppm

TABLE 4. EVALUATION OF FLY ASH/SPENT SORBENT MIXTURE. (CONTINUED)
ANALYSIS OF EXTRACT FROM TCLP

Compound	Concentration	Method Detection Limit	Regulatory Limit
1. Benzene	<0.25	0.01	0.50
2. Carbon Tetrachloride	<0.25	0.01	0.50
3. Chlorobenzene	<50	0.01	100.00
4. Chloroform	<3.0	0.01	6.00
5. o-Cresol	<100.0	0.01	200.00
6. m-Cresol	<100.0	0.01	200.00
7. p-Cresol	<100.0	0.01	200.00
Total Cresol	<100.0	0.01	200.00
8. 1,4-Dichlorobenzene	<3.75	0.01	7.50
9. 1,2-Dichloroethane	<0.25	0.01	0.50
10. 1,1-Dichloroethene	<0.35	0.01	0.70
11. 2,4-Dinitrotoluene	<0.07	0.01	0.13
12. Hexachlorobenzene	<0.07	0.01	0.13
13. Hexachloro-1,3- butadiene	<0.25	0.01	0.50
14. Hexachloroethane	<1.50	0.01	3.00
15. Methyl Ethyl Ketone	<100.0	0.01	200.00
16. Nitrobenzene	<1.00	0.01	2.00
17. Pentachlorophenol	<50.0	0.01	100.00
18. Pyridine	<2.50	0.01	5.00
19. Tetrachloroethylene	<0.35	0.01	0.70
20. Trichloroethylene	<0.25	0.01	0.50
21. 2,4,5-Trichlorophenol	<200.00	0.01	400.00
22. 2,4,6-Trichlorophenol	<1.00	0.01	2.00
23. Vinyl Chloride	<0.10	0.01	0.20

Note: All Results Expressed as ppm

<u>Location</u>	<u>Noise Level (db)</u>
Ash Silo Unloader Room	100
Sorbent Silo	90
Plant second floor at FGR fan area	90
Outside fifth floor CEMS enclosure	90

These are instantaneous readings, i.e. not averaged over any time period. The measurements are all above the Occupational Safety and Health Administration's (OSHA) 'action limit' of 85 decibels, which applies to an 8 hour average. Personnel working for extended periods in these areas would be required to use protective equipment.

4.4 AQUEOUS DISCHARGE

Water discharge monitoring conducted by CWLP personnel, as required by the NPDES permit, show that all limits were met. The Discharge Monitoring Reports are found in Appendix B.

5.0 CONCLUSIONS

Application of GR, SI, and GR-SI to CWLP's Lakeside Station Unit 7 resulted in significant reductions in emissions without deleterious effects on the environment. Under GR-SI, NO_x emissions were reduced by 65% and under GR-only operation they were reduced by 58%. The GR-SI tests were carried out after modification of reburning fuel injectors to improve the process efficiency. SO₂ emissions were reduced by 57% under GR-SI and by 40% under SI-only operation. Emissions of CO were higher under GR operation, but still acceptable averaging 150 ppm over all GR tests. Emissions of hydrocarbons and particulate matter, quantified by opacity measurement, were relatively unchanged. The opacity exceeded the 30% limit only during start-up of either Units 7 or 8. A TCLP test of the solid waste product of GR-SI, the fly ash/spent sorbent mixture, indicated that it is not a hazardous material. GR-SI equipment produces a noise level somewhat above 85 decibels, therefore, workers near the GR-SI equipment should wear audiometric protective devices. The aqueous discharge monitoring reports show that all limits were met.

APPENDIX A

EXCESS OPACITY REPORTS

CITY WATER, LIGHT & POWER
3100 Stevenson Drive

UNIT OPACITY CEM
DOWNTIME REPORT

Unit: Lakeside

Month/Year: July 1993

Date	Start-End	Component	Cause	Corrective Action Taken
7/11	15:42	Opacity Monitor	Lightning strike caused circuit board to fail	Replaced Circuit Board Recal.
7/13	15:06			
7/24	21:00	Opacity Monitor	Lightning strike caused circuit board to fail	Replaced faulty circuit board. The new board immediately failed and another board had to be ordered. The new board was set to arrive on 8/4/93
7/31	23:54			

CITY WATER, LIGHT & POWER
3100 Stevenson Drive

EXCESS OPACITY REPORT

Unit: Lakeside

Opacity Limit: 30%

Month/Year: July 1993

Boiler Hours

Unit #7 - 491

Unit #8 - 700

Date	Start	Opacity (%)	Cause	Corrective Action Taken
7-16	19:18	79.0	Startup #7&8	
	:24	66.0	"	
	:30	53.0	"	
7-17	01:24	44.0	:	
	:42	40.0	"	
	:48	44.0	"	
	:54	37.0	"	
	02:24	35.0	"	
	10:18	37.0	"	
	:24	44.0	"	
	:30	35.0	"	
	:36	32.0	"	
	11:12	36.0	"	
	:18	39.0	"	
	:24	54.0	"	
	12:06	50.0	"	
	20:36	60.0	"	
	:42	68.0	"	
	:48	79.0	"	
	:54	71.0	"	
	21:00	73.0	"	
	:06	81.0	"	
	:12	62.0	"	
	:18	68.0	"	
	:24	40.0	"	
7-18	06:18	39.0	Startup #7&8	
	:24	33.0	"	
	:36	57.0	"	
	:42	33.0	"	
	:48	35.0	"	
	07:54	90.0	"	
	08:00	68.0	"	
	:06	56.0	"	
	:12	41.0	"	
	:18	31.0	"	
	09:18	38.0	"	
	:30	58.0	"	
	:36	66.0	"	
	:42	68.0	"	
	:48	69.0	"	
	:54	44.0	"	

CITY WATER, LIGHT & POWER
3100 Stevenson Drive

UNIT OPACITY CEM
DOWNTIME REPORT

Unit: Lakeside

Month/Year: August 1993

Date	Start-End	Component	Cause	Corrective Action Taken
8/1	00:00	Opacity Monitor	Faulty Circuit Board	Replaced circuit board &
8/3	17:43			recal opacity monitor
8/9	12:15	Signal Processor	Faulty Circuit Board	Replaced linearazation
8/18	12:49			board in the control room and replaced the signal processor board at the 1/2 deck
8/25	18:00-21:00	Paper Tract	Paper Jam	Adjusted paper tract

CITY WATER, LIGHT & POWER
3100 Stevenson Drive

EXCESS OPACITY REPORT

Unit: Lakeside

Opacity Limit: 30%

Month/Year: August 1993

Boiler Hours
Unit #7 - 451
Unit #8 - 497

Date	Start	Opacity (%)	Cause	Corrective Action Taken
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N O N E

CITY WATER, LIGHT & POWER
3100 Stevenson Drive

UNIT OPACITY CEM
DOWNTIME REPORT

Unit: Lakeside

Month/Year: September 1993

Date	Start-End	Component	Cause	Corrective Action Taken
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N O N E

CITY WATER, LIGHT & POWER
3100 Stevenson Drive

EXCESS OPACITY REPORT

Unit: Lakeside

Opacity Limit: 30%

Month/Year: September 1993

Boiler Hours

Unit #7 - 441

Unit #8 - 58

Date	Start	Opacity (%)	Cause	Corrective Action Taken
9-7	02:12	63.0	Startup #7	
	:18	52.0	"	
	:24	47.0	"	
	:30	31.0	"	
	:48	36.0	"	
	:54	42.0	"	
	03:00	43.0	"	
	:06	38.0	"	
	07:12	59.0	"	
	:18	39.0	"	
	:30	57.0	"	
	:36	62.0	"	
	:42	57.0	"	
	:48	52.0	"	
	:54	44.0	"	
	08:00	34.0	"	
	:12	44.0	"	
	:18	49.0	"	
	:24	43.0	"	
	:30	33.0	"	
	:42	46.0	"	
	:48	47.0	"	
	:54	46.0	"	
	09:06	35.0	"	
9-13	00:18	67.0	Startup #7	
	:24	40.0	"	
	:54	49.0	"	
	01:00	46.0	"	
	:06	41.0	"	
	:12	79.0	"	
	:18	56.0	"	
	03:54	67.0	"	
	04:00	32.0	"	
	:06	57.0	"	
	:12	57.0	"	
	:18	57.0	"	
	:24	53.0	"	
	:30	53.0	"	
	:36	49.0	"	
	05:06	43.0	"	
	:12	51.0	"	
	:30	39.0	"	
	:36	40.0	"	
	:42	45.0	"	
	:48	36.0	"	
	:54	43.0	"	
	06:00	31.0	"	
	:42	41.0	"	
	08:06	41.0	"	
	:18	48.0	"	
	:24	47.0	"	

Excess Opacity Report
 Lakeside - September 1993
 Page -2-

Date	Start	Opacity (%)	Cause	Corrective Action Taken
9-20	00:00	64.0	Startup #7	
	:06	56.0	"	
	:12	42.0	"	
	:18	35.0	"	
	:24	46.0	"	
	:30	35.0	"	
	:36	31.0	"	
	01:24	77.0	"	
	:30	50.0	"	
	:36	35.0	"	
	:42	70.0	"	
	:48	66.0	"	
	:54	59.0	"	
	02:00	57.0	"	
	:06	44.0	"	
	:18	59.0	"	
	:36	37.0	"	
	:42	43.0	"	
	:48	48.0	"	
	:54	41.0	"	
	03:18	36.0	"	
	:24	37.0	"	
	:30	50.0	"	
	:36	41.0	"	
	05:06	60.0	"	
	:12	40.0	"	
	:18	51.0	"	
	:24	42.0	"	
	:36	36.0	"	
	:42	47.0	"	
	:48	53.0	"	
	:54	49.0	"	
	06:06	34.0	"	
	:18	44.0	"	
	:24	51.0	"	
	:30	49.0	"	
	:36	74.0	"	
	:42	78.0	"	
	:48	72.0	"	
	:54	64.0	"	
	07:00	64.0	"	
9-21	19:48	45.0	Startup #7	
	:54	45.0	"	
	20:00	37.0	"	
	:06	32.0	"	
	:36	45.0	"	
9-22	00:24	33.0	Startup #7	
	:30	72.0	"	
	:36	53.0	"	
	:42	38.0	"	
	05:18	47.0	"	
	:24	43.0	"	
	:30	59.0	"	
	:36	57.0	"	
	:42	55.0	"	
	:48	49.0	"	
	:54	50.0	"	
	06:00	55.0	"	
	:06	46.0	"	
	:18	38.0	"	
	:24	43.0	"	

Excess Opacity Report
 Lakeside - September 1993
 Page -3-

Date	Start	Opacity (%)	Cause	Corrective Action Taken
9-24	10:48	50.0	Shutdown #7	
9-27	01:36	35.0	Startup #8	
	:42	50.0	"	
	:48	52.0	"	
	:54	55.0	"	
	02:00	57.0	"	
	:06	57.0	"	
	:12	58.0	"	
	:18	58.0	"	
	:24	59.0	"	
	:30	63.0	"	
	:36	66.0	"	
	:42	77.0	"	
	:48	80.0	"	
	:54	68.0	"	
	03:00	63.0	"	
	:06	60.0	"	
	:12	58.0	"	
	:18	56.0	"	
	:24	61.0	"	
	:30	61.0	"	
	:36	76.0	"	
	:42	71.0	"	
	:48	59.0	"	
	:54	67.0	"	
	04:00	74.0	"	
	:06	76.0	"	
	:12	58.0	"	
	:18	37.0	"	
	:30	59.0	"	
	:36	68.0	"	
	:42	59.0	"	
	:48	46.0	"	
	:54	69.0	"	
	05:00	58.0	"	
	:06	65.0	"	
	:12	63.0	"	
	:18	46.0	"	
	:24	58.0	"	
	:30	67.0	"	
	:36	65.0	"	
	:42	42.0	"	
	09:24	52.0	"	
	:30	51.0	"	
	:36	36.0	"	
	10:24	33.0	"	
	:30	46.0	"	
	12:00	38.0	"	
	:18	34.0	"	
	:24	46.0	"	
	:30	33.0	"	
	13:18	45.0	"	
	:24	35.0	"	
	:36	32.0	"	
	:42	33.0	"	

APPENDIX B

WATER DISCHARGE MONITORING REPORTS

5

City Water, Light & Power
Seventh & Monroe
Springfield, IL 62757
(217) 786-4080

Flow could only be measured once due to Sugar Creek being above discharge point.

IL 51	TL_0024767	PRIME NUMBER II	(4 16)	102 191	004 105	SAC	120 211	122-23	124-250	TO	91 3 10	YEAR	MO	DAY	120-211	120-231	120-311	LATITUDE	LONGITUDE
										REPORTING PERIOD FROM									

REPORTING PLANNING FROM

PARAMETER	REPORTED	QUANTITY			UNITS	TEST	CONCENTRATION			METHOD	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		MINIMUM	AVERAGE	MAXIMUM			MINIMUM	AVERAGE	MAXIMUM			
Flow	REPORTED	5.194	5.194	5.194	MGD						1/30	ESTT
	PLUMB CONDITION										1/7	ESTT
pH	REPORTED										2/7	GRAB
	PLUMB CONDITION						7.4	8.3	8.9		2/7	GRAB
Total Suspended Solids	REPORTED										2/7	COMP
	PLUMB CONDITION						2	9	17		2/7	COMP
Oil and Grease	REPORTED										2/30	GRAB
	PLUMB CONDITION						1	15	20	mg/l	2/30	GRAB
Boron	REPORTED										2/30	GRAB
	PLUMB CONDITION						5.2	5.3	5.4	mg/l	2/30	GRAB
	REPORTED											COMP
	PLUMB CONDITION											COMP
	REPORTED											COMP
	PLUMB CONDITION											COMP
	REPORTED											
	PLUMB CONDITION											

NAME OF PRINCIPAL EXECUTIVE OFFICER

Frasco, Lynn A.

DATE

10/1/81

TIME OF THE OFFICER

General Manager,
Public Utilities

DATE

10/1/81

TIME

1:15

DAY

DAY

I certify that I am familiar with the information contained in this report and that to the best of my knowledge and belief such information is true, complete, and accurate.

SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER

[Signature]

11-632-0092
WLC 242 Y1/79

This Agency is authorized to require this information under Illinois Revised Statutes, 1979, Chapter 111 1/2, Section 1042. Disclosure of this information is required. Failure to do so may result in a civil penalty up to \$10,000.00 per day of violation or a fine up to \$25,000.00 per day of violation and imprisonment up to one year. This form has been approved by the Federal Bureau of Investigation.

DISCHARGE MONITORING REPORT

City Water, Light & Power
Seventh & Monroe
Springfield, IL 62757
(217) 786-4080

Summary

No discharge during this period.

03	10	011
YE-ALT	MO	DAY

WORKING COMMITTEE

I certify that I am familiar with the information contained in this report and that to the best of my knowledge and belief such information is true, complete, and accurate.

This Agency is authorized to require this information under Illinois Revised Statutes, 1979, Chapter 111 1/2, Section 1042. Disclosure of this information is required. Failure to do so may result in a civil penalty, up to \$10,000.00 per day of violation or a fine up to \$25,000.00 per day of violation and imprisonment.