FIELD SCALE STUDY RESULTS FOR THE BENEFICIAL USE OF COAL ASH AS FILL MATERIAL IN SATURATED CONDITIONS
VARRA COAL ASH BURIAL PROJECT
WELD COUNTY, COLORADO

FINAL REPORT

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By

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DISCLAIMER

ABSTRACT

The Varra Coal Ash Project (Varra Project) is an on-going study to determine the feasibility of using coal ash to reclaim flooded, gravel mine quarries in Weld County, Colorado. The use of coal ash as fill in saturated environments is discouraged by most regulatory agencies, and there are few studies documenting the affects of coal ash in wet systems. Nearly four years were required to obtain the required permits for conducting this field scale study to assess potential impacts of large-scale coal ash reclamation on groundwater resources.

The field scale study consisted of placing 400 tons of two types of class F coal ash in a trench excavated to seven feet below the water table at the Varra gravel quarry near Longmont, Colorado. The trench was immediately adjacent to the quarry pond proposed for reclamation. The State of Colorado and Weld County approved the permits required to conduct the field study, based on column leaching studies and local surface and groundwater investigation results and safeguards implemented for the project.

The trench was divided into two ash cells measuring 10 feet in width, 45 feet in length and 11 feet in depth. A 15-foot native soil divider was left between the ash cells. Twelve groundwater monitoring wells were installed up, cross and downgradient of the ash deposit. Two monitoring wells were installed within the trench to monitor water quality of the pore waters within the ash. Groundwater monitoring wells were placed downgradient of the coal ash trench at a spacing of 10, 25, 45, 50 (point of compliance (POC) distance) and 120 feet. Groundwater monitoring was conducted weekly for the first month, monthly to the end of the first quarter and quarterly till project termination. Surface and groundwater samples were analyzed for 29 elements and ions such as alkalinity, chloride, fluoride, nitrate, nitrite and sulfate.

Analytical data generated from the field study indicate that the leaching characteristics of coal ash used in this study are relatively benign. The most mobile and prevalent constituent of concern appears to be boron. Molybdenum, sulfate, selenium chloride and fluoride had elevated concentrations in water samples obtained from the ash; however the levels associated with these elements or ions dropped to below regulatory or background levels within a month of ash placement.

Drinking water standards were not exceeded at point of compliance wells 50 feet downgradient of the trench. With the exception of boron and nitrite, water quality samples obtained from the ash for the last sampling event met drinking water standards. These data indicate that large-scale ash reclamation may be feasible at this location.

INTRODUCTION

This report documents the results of a field scale study intended to evaluate the feasibility of using coal ash as fill material in saturated conditions. The field study consisted of placing 400 tons of two types of class F coal ash within the water table and evaluating the affects on water quality and the local hydrology. Groundwater samples were obtained from 12 groundwater monitoring wells on a periodic basis and analyzed for 29 elements and ions such as alkalinity, chloride, fluoride, nitrate, nitrite and sulfate. The results of the field study will be used to evaluate the feasibility of a large-scale reclamation. Site conditions are depicted on Figure 1. The study area is an active gravel quarry near Longmont, Colorado and surrounding land use consists of agricultural, rural residential, commercial and open-cut gravel quarry operations.

As a precursor to the field scale test, bench scale testing was requested by the Colorado Department of Public Health and Environment (CDPH&E). Five different leaching experiments were conducted in order to evaluate coal ash leaching potentials. Two of the leaching experiments compared element and compound water quality for different pH ranges relative to effluent pore volume. However, the data generated from the different leaching tests were not comparable to each other or to water quality standards. It was recommended by various members of the CDPH&E that additional leaching tests be performed that would simulate, to the extent possible, conditions that would be encountered at the Varra property. A modified form of ASTM D 4874-95 Standard Test Method for Leaching Solid Material in Column Apparatus was used to simulate field conditions. Testing results were submitted as part of a permit application to conduct the pilot study. Based on the results of the column leaching tests, the field scale project was approved by the State and Weld County.

EXECUTIVE SUMMARY

The Varra Coal Ash Burial Project is a field scale study to evaluate the feasibility of large-scale reclamation using coal ash. This project was accomplished by obtaining the required permits in combination with conducting bench scale leaching tests and a small-scale ash burial and water quality monitoring program. This project directly or indirectly addressed all of the Combustion Byproducts Recycling Consortium (CBRC), Western Region research priorities, under which funding for this project was granted.

Varra Companies obtained the required permits to conduct the field scale study consisting of placing 400 tons of two types of coal ash in an unlined saturated trench. The primary permits were a Certificate of Designation permit (CD) and a Use by Special Review permit. Numerous other permits were also required. The permitting process was initiated in April 1998 and successfully terminated in October 2001. The lack of information regarding the use of coal ash in wet systems and the uncertainty of which regulatory agency had statutory oversight created a lengthy and costly permitting process. This project is the first successfully permitted project of its kind in Colorado and represents a case study where coal combustion byproducts (CCBs) were successfully used in a wet environment. This project has successfully promoted the use of CCBs to local and state governmental agencies for nontraditional uses.

Blended ashes were used in the field scale study and will be used in the proposed large-scale reclamation as well. The initial premise of this project was that as long as the mass loading of elements from the ash is small relative to the volume of water bypassing the ash deposit, it may be possible to safely deposit ashes of any composition in saturated environments. This project successfully demonstrates the use of blended ashes in nontraditional uses. As mentioned, the use of ash for the reclamation of ponds as used in this project is more dependant on local hydrology and the physical characteristics of the ash being placed in saturated conditions. The physical and chemical properties of FGD ash, which was used in this project, appears to have enhanced the desired properties of ash in wet systems by providing calcium which precipitates in the form of calcite and indurates the ash – increasing its load bearing capacity. In addition, class F ashes, as used in this project, are typically higher in carbon content than class C or bottom ash.

This project also directly addressed the issue of possible water quality impacts resulting from mine land reclamation. The results of this study showed negligible water quality impacts over a limited areal extent. No drinking water standards were exceeded at the point of compliance (50 feet downgradient of the trench) and only minimal affects were documented within 25 feet downgradient of the trench. Changes to local hydrology were as expected. Most encouraging of all were the dramatic elemental concentration reductions within the ash deposit over a short duration. The permeability of the ash is such that geochemical reactions are reducing elemental concentrations. The calculated travel time for water to pass through the trench is 370 days and as such reductions in elemental concentrations cannot be attributed to flushing or simple dilution. These data indicate that elements or ions of concern will be reduced within ash deposits at this location.

EXPERIMENTAL

Surface water samples were collected from the pond proposed for reclamation (immediately adjacent to the coal ash trench) between May 1999 and August 2002. The samples were obtained to establish background water quality and assess any impacts of coal ash burial in groundwater. All samples were filtered to 0.45 microns and analyzed for eight major ions and 29 elements.

Between September 2001 and February 2002, twelve soil borings were drilled with a truck mounted, hollow stem power auger. The soil borings were advanced to between 8 and 17 feet below ground surface (bgs). Soil sampling was conducted in accordance with ASTM:D 1586-87. Using this method representative soil samples were obtained by advancing a two-inch outside diameter split barrel sampler ahead of the auger bit. Local soil lithology descriptions were recorded during drilling activities. As the samples were obtained in the field, they were examined and described in accordance with ASTM:D 2488-84. In general, soil conditions consist of two to five feet of fine-grained alluvial deposits of brown clay, silt, and fine-grained sands, which are underlain by six feet of gravel with sand. Bedrock, which consists of a dense, dark gray shale (Pierre Shale) underlies the sand and gravel deposits. Figure 2 depicts soil conditions based on boring log data.

All of the twelve soil borings drilled at the site were completed as two-inch diameter groundwater monitoring wells. All monitoring wells were constructed with 0.01-inch factory slotted PVC well screen with a blank PVC riser. All monitoring wells were completed within 4”x 4” above grade monuments. The depth of the wells varied between 8 and 15 feet bgs.

The material that the water table is located in can be described as sand with gravel with the depth to water varying between 1.5 and 13 feet below grade. The Pierre Shale underlies the unconsolidated alluvial deposits and extends to beyond the depths explored during this project. The depth to the Pierre Shale within the study area ranges between 8 feet and 15 feet below ground surface. Over the entire site, the saturated thickness of the aquifer averages 5.61 feet. The groundwater flow direction within the study area is from north to south and is reflective of local topography. The hydraulic gradient varied between 0.0095 and 0.025 ft/ft, during the report period. Figure 3 depicts groundwater contours for February 2002 and Figure 3a depicts groundwater contours for May 2002.

Two slug tests were utilized to determine the hydraulic conductivity of the upper portion of the aquifer and one slug test was performed in the coal ash trench. Water level measurements and times were recorded using an InSitu Troll SP4000 pressure transducer. The test results will be input into standardized software, utilizing the Bouwer Rice Method, to determine hydraulic conductivity of the aquifer. Hydraulic conductivity values (K) for the aquifer varied over an order of magnitude, ranging from 20 to 203 feet/day. The hydraulic conductivity of the coal ash was calculated to be 1.22 feet per day. Using Darcy's Law the average groundwater flow rate for the aquifer was calculated to be 2.5 feet per day. The seepage velocity within the coal ash was 0.027 feet per day (using an effective porosity of 0.27 and 0.40 for the aquifer and ash, respectively).

On February 14 and 15, 2002 a 100-foot by 10-foot trench was excavated to 11 feet bgs using a Hitachi track driven loader. The ash was placed in two cells measuring 10 feet in width, 45 feet in length and 11 feet in depth. A 15-foot native soil divider was left between the ash cells. Concurrent with the excavation, 200 tons of class F coal ash with gypsum and 200 tons of coal ash with sodium were transported to the site, mixed and placed in the excavation. Mixing was performed by use of a front-end loader and a track driven excavator was used to compact the ash after

placement. The trenches were filled to ground surface with ash and a two-foot native soil cover was placed over the ash to preclude wind or water erosion.

Water quality samples were collected from site monitoring wells on a periodic basis in order to evaluate possible changes in water quality. The sampling frequency was weekly for the first month, biweekly for the second month, monthly to the end of the first quarter and then quarterly until project termination.

All samples were filtered to 0.45 microns prior to analysis. Samples were analyzed for alkalinity as bicarbonate and carbonate, chloride, fluoride, nitrate, nitrite, and sulfate along with other metals aluminum, antimony, arsenic, barium, beryllium, boron, calcium, cadmium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorous, potassium, selenium, silver, sodium, thallium, titanium, uranium, vanadium and zinc. Elements were analyzed with a Perkin-Elmer Optima 2000 ICP/AES. Ions were analyzed with a Dionex LC90 ion chromatograph. Field parameters such as pH, conductivity and temperature were measured with a HyDAC digital conductivity, pH and temperature meter. Analytical procedures for water and soil sample collection and analysis were performed in accordance with USEPA guidelines described in SW 846 (Test Methods for Evaluating Solid Waste/Physical/Chemical Methods, 3rd ed.).

RESULTS AND DISCUSSION

Surface water samples were obtained to document surface water quality of the gravel pond adjacent to the coal ash trench. Six samples were obtained between February 22 and May 13, 2002. A total of 12 samples were obtained for analyses between May 1999 and August 2002. All samples were obtained at the location depicted on Figure 1. The samples were analyzed for all constituents of concern identified for this project. Elemental analytical results are presented in Table 1. Major ions results are presented in Table 2.

A review of Table 1 and 2 shows that all surface water samples (identified as Pond) exceeded the standard for sulfate. Pond samples exceeded the standard for iron, lead, manganese, and nitrate for one sampling event prior to coal ash placement. The primary standard for selenium was exceeded on three sampling events. However, the elevated selenium levels are considered to be naturally occurring as sampling was conducted prior to and concurrent with coal ash placement. The anticipated travel time from the coal ash trench to the Pond sample point is on the order of 56 days, assuming no retardation or dilution effects. All of the pond samples that exceeded the selenium standard were obtained prior to the 56-day trench to pond travel time. At the time of this writing, no surface water quality issues can be associated with coal ash placement.

Groundwater quality samples were collected from all monitoring wells at the same sample frequency identified for surface water samples. The samples were submitted a contract laboratory and analyzed to determine constituents identified previously. The laboratory results are summarized in Table 1 and Table 2**.**

A review of Table 1 and Table 2 shows that all wells not completed within the coal ash trench exceeded the standard for sulfate during every sampling event, with the levels varying between 600 and 1,961 mg/L. Nitrate levels varied between 4.8 and 36 mg/L and every well located outside the ash trench exceeded the 10 mg/L standard.

The nitrite standard was exceeded in monitoring wells MW-5 and MW-6 on sampling events one and four, respectively. With the exception of one well, all wells exceeded the standard at least once for manganese and selenium during the project. Manganese levels varied between not detected and 1.73 mg/L. Selenium varied between 0.005 and 0.151 mg/L. The average pH of groundwater in non-ash wells was 7.4.

Monitoring wells MW-11 and MW-12 were located within the coal ash trench (ash wells). The ash wells had sulfate concentrations that closely approximated wells installed outside the trench. The ash wells also had elevated nitrate concentrations; however, with time nitrate concentrations declined and nitrite concentrations increased, with a mean concentration of 3.46 mg/L. The mean boron concentration in the ash wells was 20 mg/L with all other wells having a mean concentration of 0.69 mg/L. Significant increases in molybdenum and selenium were observed in the ash wells; however, concentrations of both elements decreased to background levels within two months of the ash placement. Chloride and fluoride concentrations were elevated in samples obtained from the ash wells with levels exceeding both standards on occasion. The mean pH of groundwater in the trench was 9.8 with a range minimum and maximum of 7.4 and 11.9, respectively. Table 3 presents selected water quality comparison of ash and nonash wells.

CONCLUSION

As expected, the coal ash trench acted as an impermeable barrier and diverted groundwater between and around the coal ash cells. The change in hydraulic head in the vicinity of the trench was on the order of 0.43 to 0.52 feet. The hydraulic conductivity of the ash was calculated to be 1.22 feet per day, which is between one and two orders of magnitude less than the permeability of the surrounding aquifer. Other than the change in hydraulic head at the trench, no other hydrogeologic effects were noted.

As previously documented in the column leaching studies, the most mobile elements in the coal ashes used in this study were boron, molybdenum and selenium. Sulfate is also mobile; however, background sulfate levels are very high and any contribution from the coal ash cannot be determined. In the column study, molybdenum and selenium levels dropped off sharply with passing pore volumes and reduction in pH, while boron levels appeared to be less affected by pH changes. To date, these trends are occurring in samples obtained from the coal ash trench as well. Analytical data document concentration spikes and reductions for the mentioned constituents, which appears to be the result of geochemical processes.

An unexpected occurrence, which was not observed in the column study, is the reduction of nitrate to nitrite within the ash. Nitrite was detected at elevated levels within the trench and above background levels in downgradient wells MW-5 and MW-6. A water quality graph for MW-5 (attachment) depicts boron, nitrite and selenium. There appears to be a direct correlation between nitrite and boron concentrations.

Water quality monitoring documented high (above regulatory standards) natural levels of manganese, selenium, sulfate and nitrate. Weld County established the downstream point of compliance at 50 feet downgradient from the trench. Wells were installed downstream of the trench at 10 (MW-6), 25 (MW-5), 40 (MW-2) and 50 feet (MW-4 and MW-7). Monitoring wells MW-7 and MW-4 are points of compliance and have not been affected by the presence of coal ash within the water table. Wells MW-6 and MW-5 had apparent impacts as a result of the ash placement. Nitrite levels in samples obtained from MW-5 were in excess of the 1.0 mg/L standard in four of six sampling events. The standard for boron was exceeded on one occasion. At the time of this writing, both boron and nitrite have declining levels. The nitrite standard was exceeded in samples obtained from MW-6 on one occasion (the first sampling event). Boron levels in samples obtained from MW-6 exceeded the 5 mg/l standard during the last sample event.

The potential of using coal ash for a large-scale reclamation appears promising as field and analytical data indicate limited impacts from the coal ash placement. Concentrations for all of the elements or compounds of concern have dramatically decreased within and outside the ash deposit within a relatively short period of time. Boron, pH, and selenium levels have reduced to below regulatory limits in samples obtained from MW-12 and both ash cells have exhibited sharp reductions in elemental concentrations to date. The seepage velocity within the ash is on the order of ten feet per year and the concentration reductions within the ash cannot be attributed to flushing or simple dilution. If this trend occurs in much larger scale deposits, then using coal ash to reclaim saturated quarries appears viable.

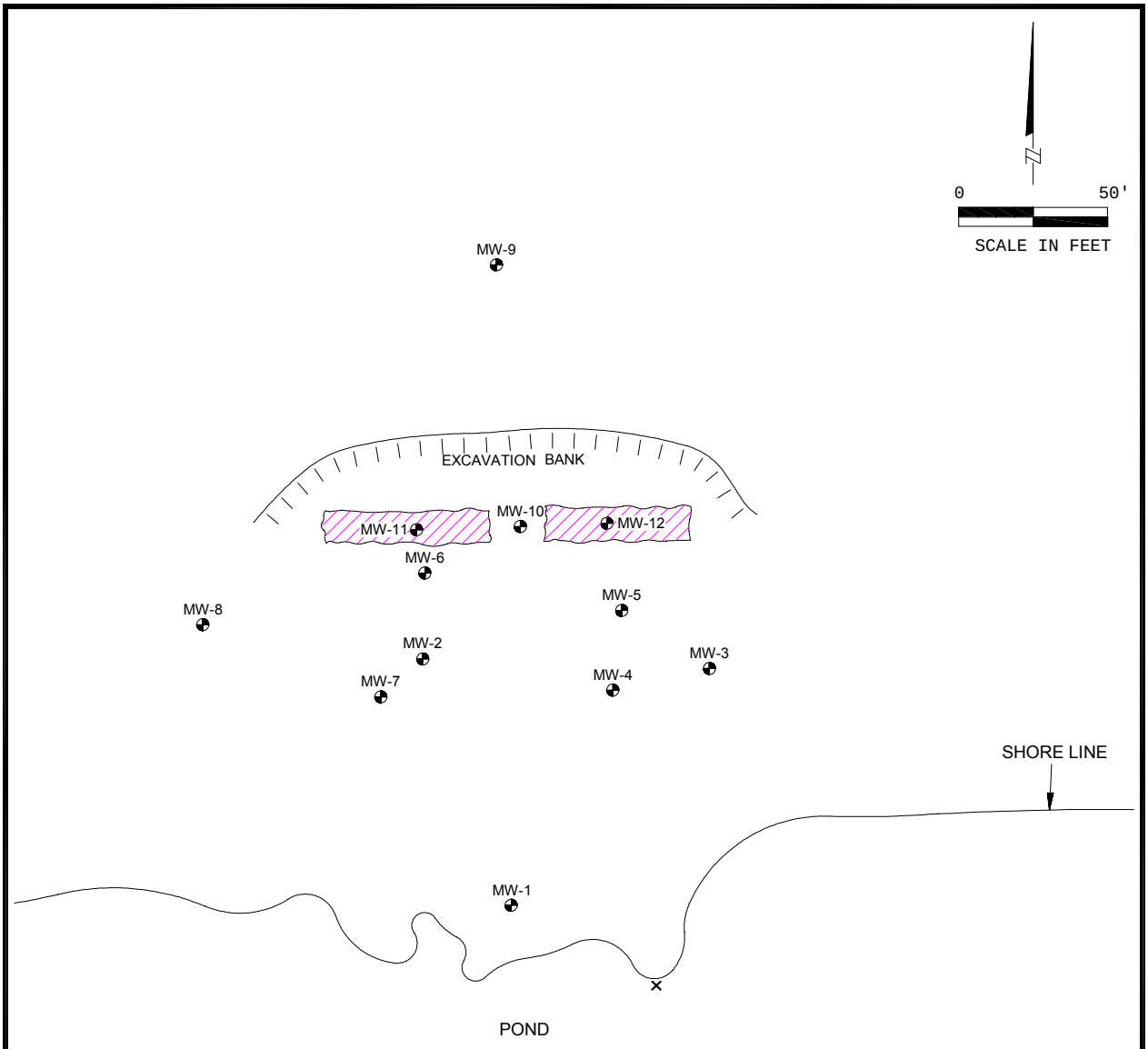
REFERENCES

ASTM D1586, Standard Test Method for Penetration Test and Split Barrel Sampling of Soils, Vol. 04.08.

ASTM D2488, Description and Identification of Soils (Visual-Manual Procedure, Vol. 04.08.

U.S. EPA, 1990, Test Methods for Evaluation Solid Waste: Physical/Chemical Methods (SW 846), Vol. 1C, 3rd. Ed.

FIGURES



LEGEND

MW-1 MONITORING WELL LOCATION

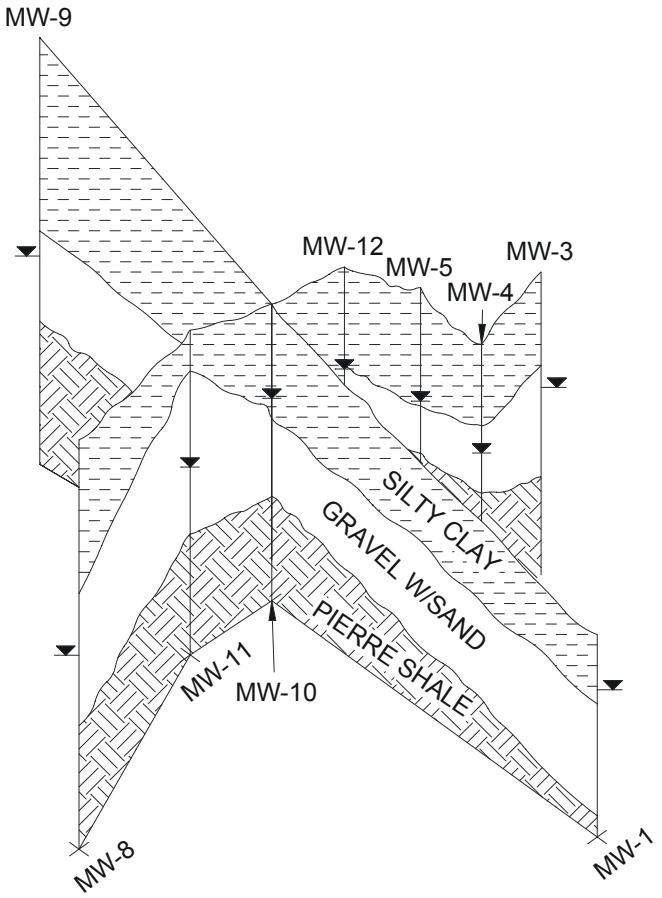
× SURFACE WATER SAMPLE LOCATION

COAL ASH TRENCH

FIGURE 1

SITE CONDITION MAP
VARRA COAL ASH PROJECT
LONGMONT, COLORADO

PROJECT NO. 1-135-	PREPARED BY RACAD	CGRS
DATE 06/20/02	REVIEWED BY	COLORADO GROUNDWATER RESOURCE SERVICES



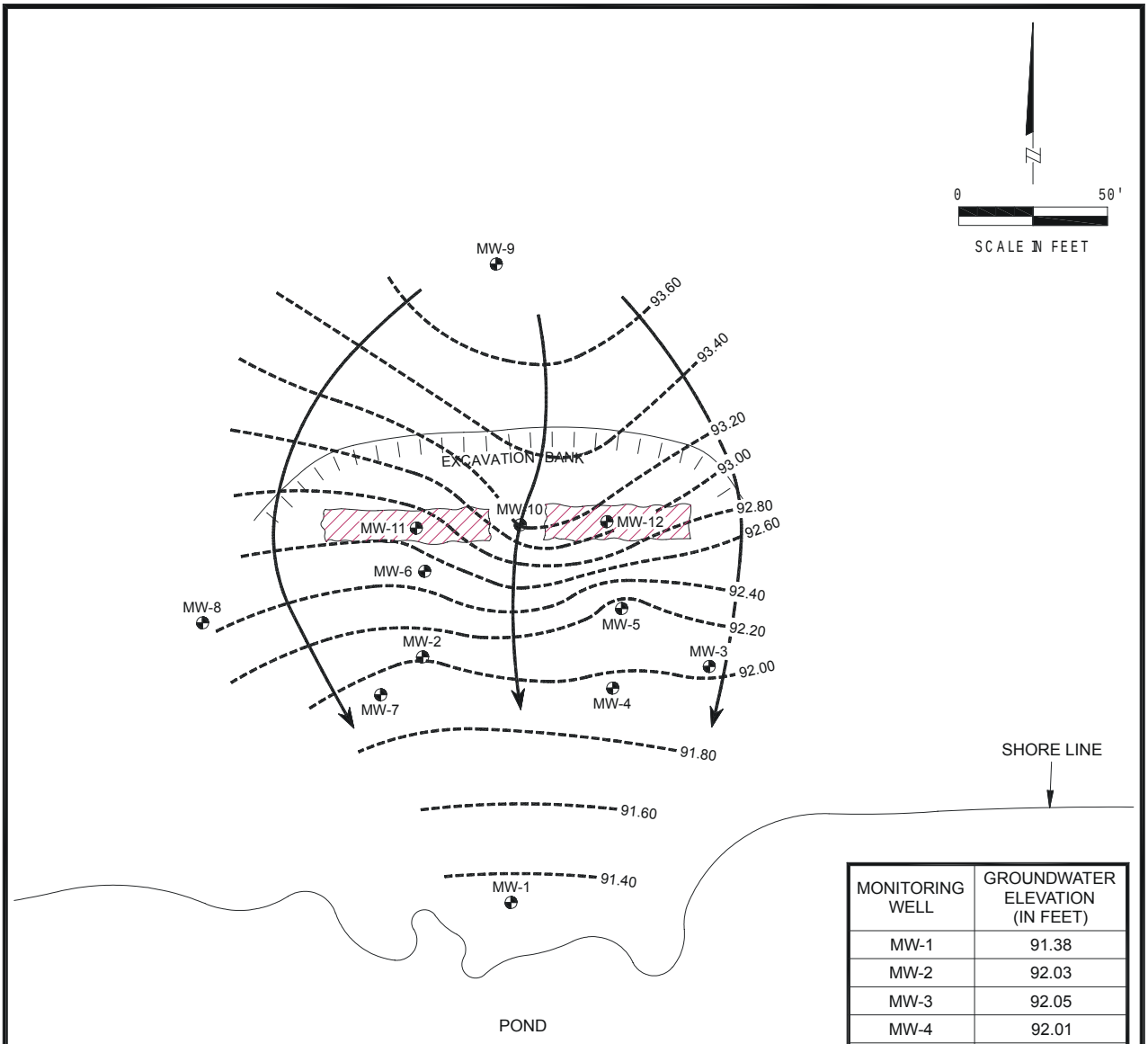
LEGEND

WATER TABLE SURFACE

FIGURE 2

FENCE DIAGRAM
VARRA COAL ASH PROJECT
LONGMONT, COLORADO

PROJECT NO.	PREPARED BY	CGRS
1-135-2755aa	RACAD	COLORADO GROUNDWATER RESOURCE SERVICES
DATE	REVIEWED BY	
06/20/02		



MONITORING WELL	GROUNDWATER ELEVATION (IN FEET)
MW-1	91.38
MW-2	92.03
MW-3	92.05
MW-4	92.01
MW-5	92.10
MW-6	92.51
MW-7	91.94
MW-8	92.44
MW-9	93.79
MW-10	93.24
MW-11	92.72
MW-12	93.12

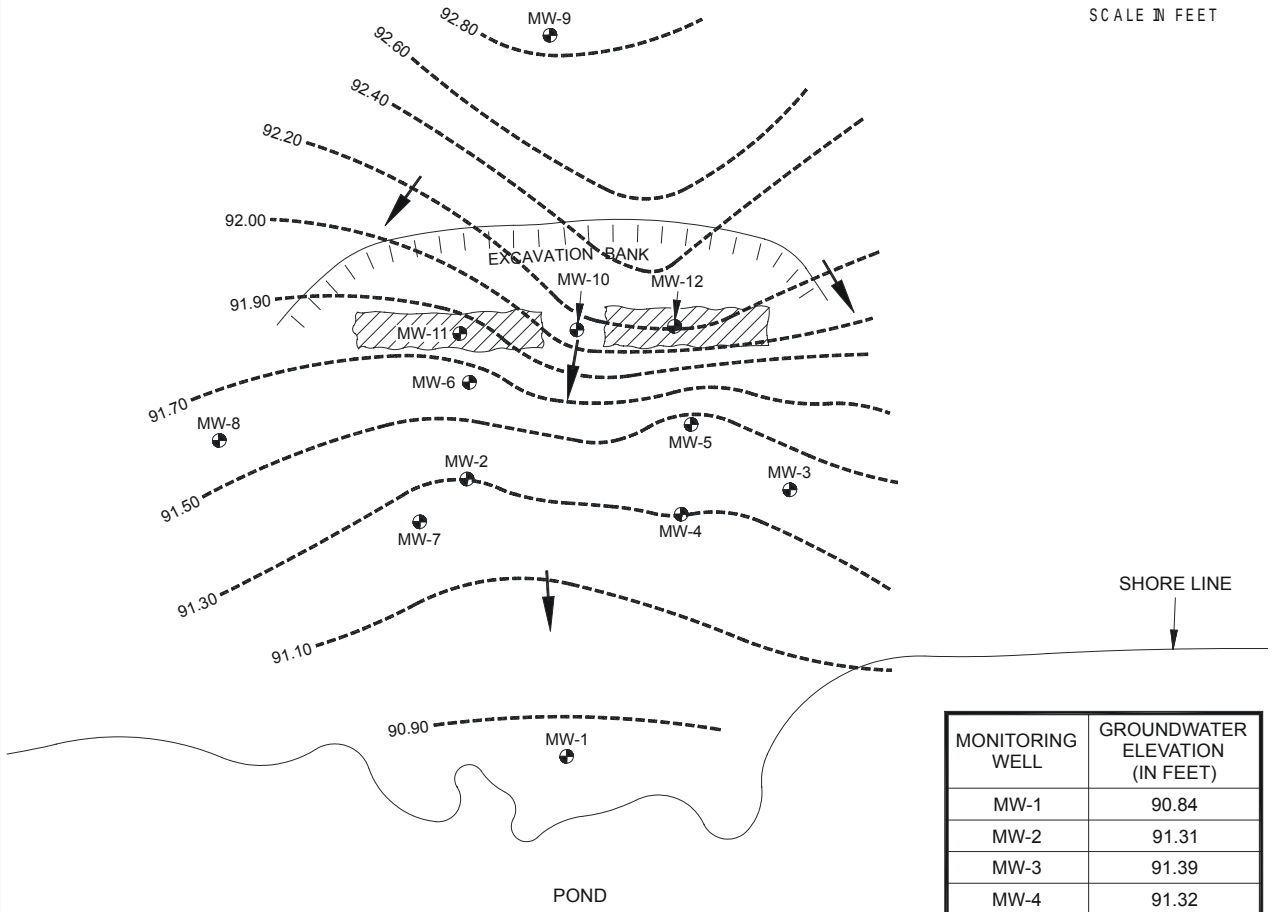
LEGEND

- MW-1 — MONITORING WELL LOCATION
- INFERRED GROUNDWATER CONTOURS (CONTOUR INTERVAL = .20 FT.)
- INFERRED FLOW DIRECTION
- STREAM LINES
- COAL ASH TRENCH

FIGURE 3

WATER TABLE CONTOUR MAP
FEBRUARY 22, 2002
VARRA COAL ASH PROJECT
LONGMONT, COLORADO

PROJECT NO.	PREPARED BY	CGRS
1-135-2755aa	RACAD	COLORADO GROUNDWATER RESOURCE SERVICES
DATE	REVIEWED BY	
06/20/02		



MONITORING WELL	GROUNDWATER ELEVATION (IN FEET)
MW-1	90.84
MW-2	91.31
MW-3	91.39
MW-4	91.32
MW-5	91.41
MW-6	91.65
MW-7	91.24
MW-8	91.63
MW-9	92.85
MW-10	92.28
MW-11	91.85
MW-12	92.40

LEGEND

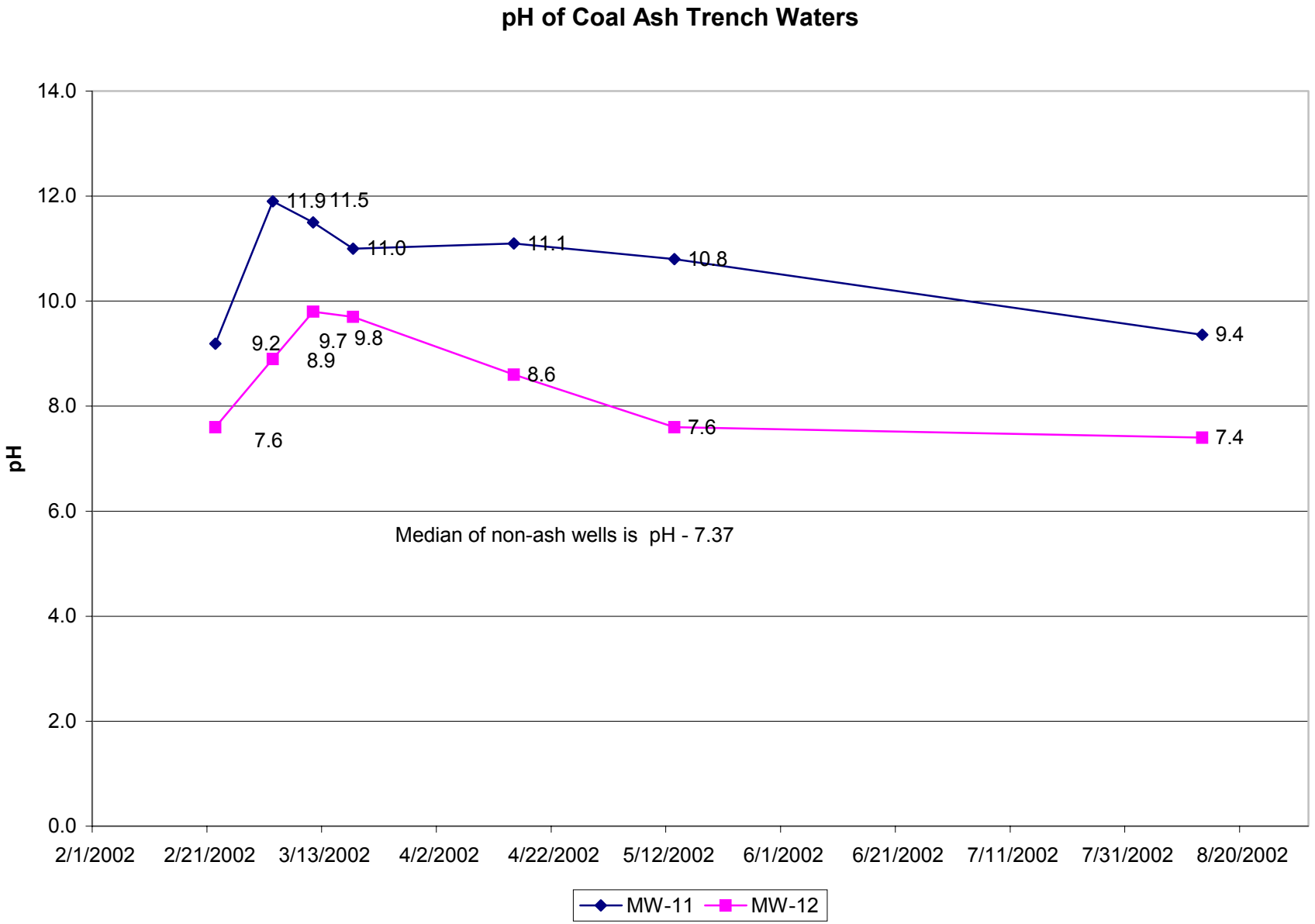
- MW-1 — MONITORING WELL LOCATION
- INFERRED GROUNDWATER CONTOURS (CONTOUR INTERVAL = .20 FT.)
- INFERRED FLOW DIRECTION
- COAL ASH TRENCH

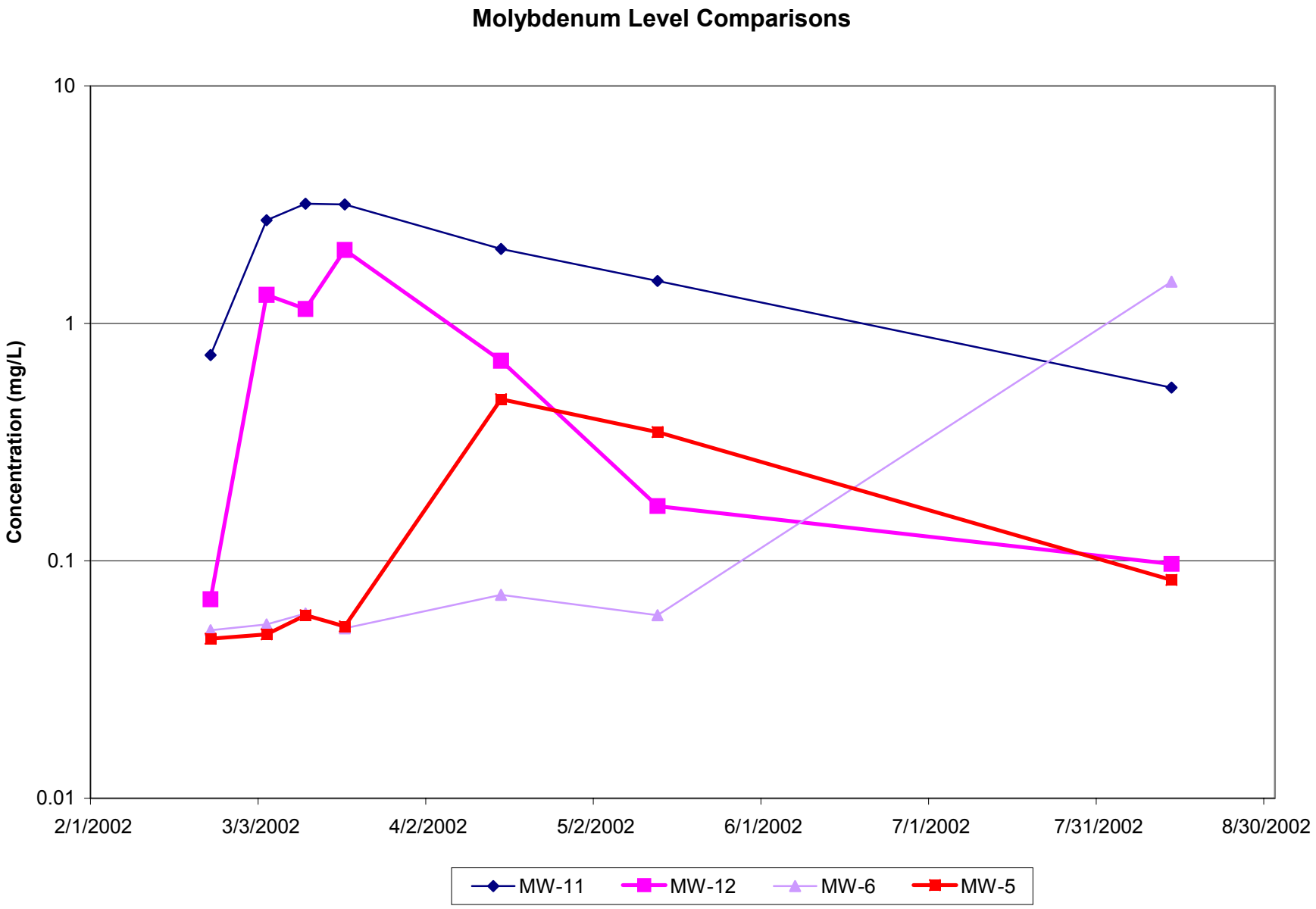
FIGURE 3A

WATER TABLE CONTOUR MAP
MAY 13, 2002
VARRA COAL ASH PROJECT
LONGMONT, COLORADO

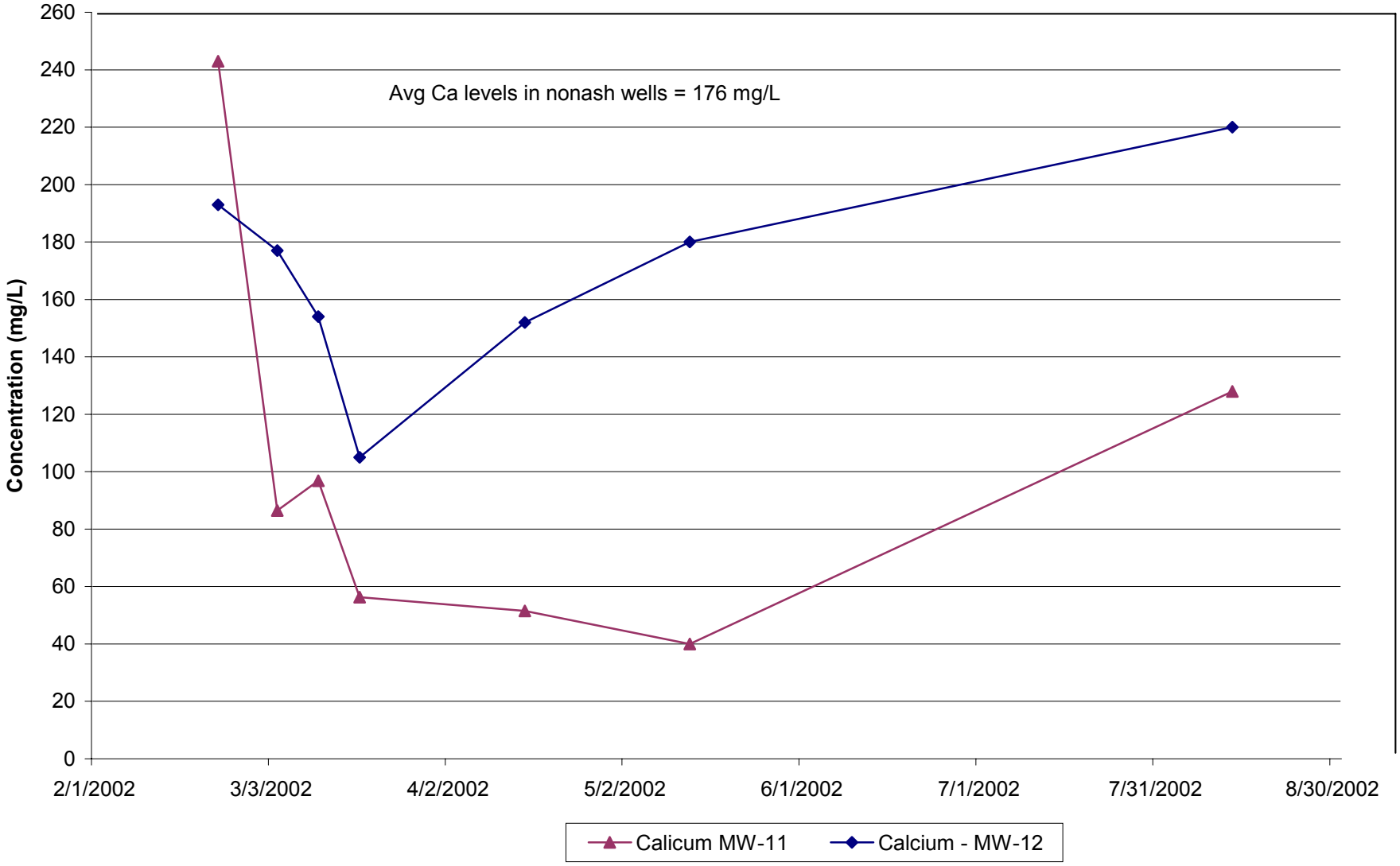
PROJECT NO.	PREPARED BY	CGRS
1-135-2755aa	RACAD	COLORADO GROUNDWATER RESOURCE SERVICES
DATE	REVIEWED BY	
06/20/02		

GRAPHS

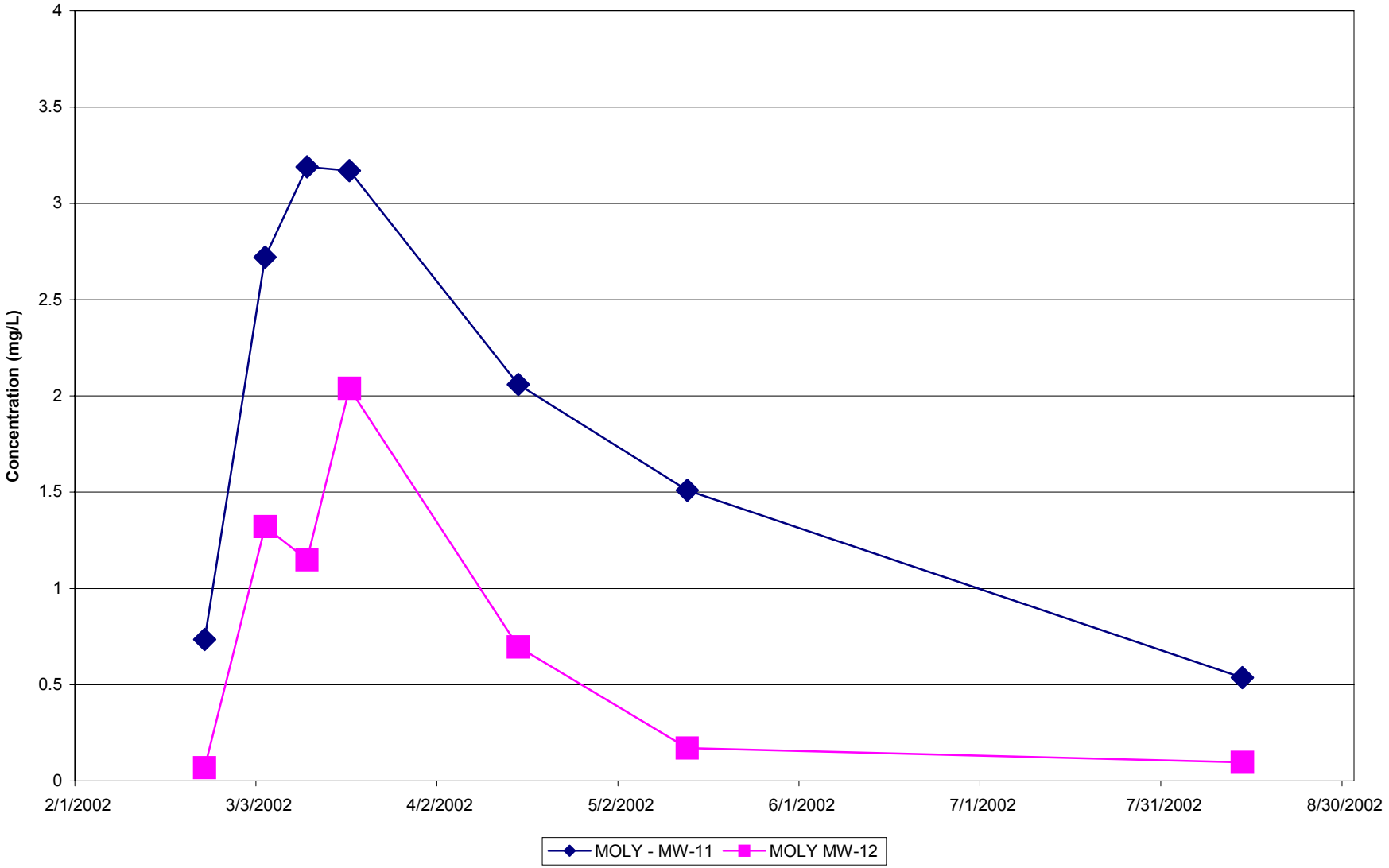

pH of Coal Ash Trench Waters
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
pH
11.9
11.5
11.0
11.1
10.8
9.4
9.2
9.7
9.8
8.9
8.6
7.6
7.6
7.4
Median of non-ash wells is pH - 7.37
2/1/2002
2/21/2002
3/13/2002
4/2/2002
4/22/2002
5/12/2002
6/1/2002
6/21/2002
7/11/2002
7/31/2002
8/20/2002
MW-11
MW-12


Molybdenum Level Comparisons
Concentration (mg/L)
10
1
0.1
0.01
2/1/2002
3/3/2002
4/2/2002
5/2/2002
6/1/2002
7/1/2002
7/31/2002
8/30/2002
MW-11
MW-12
MW-6
MW-5

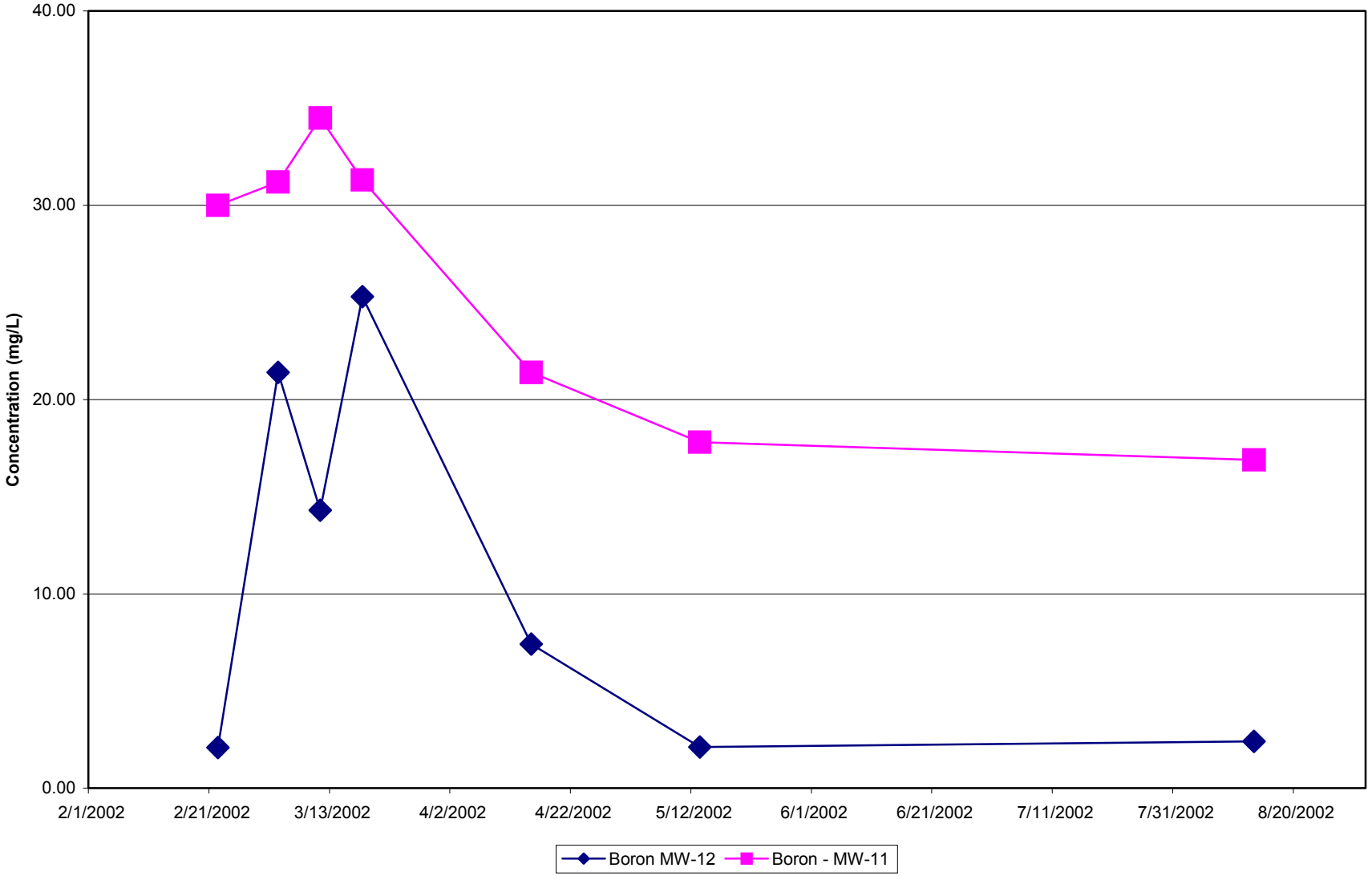
Calcium Levels in Ash Wells



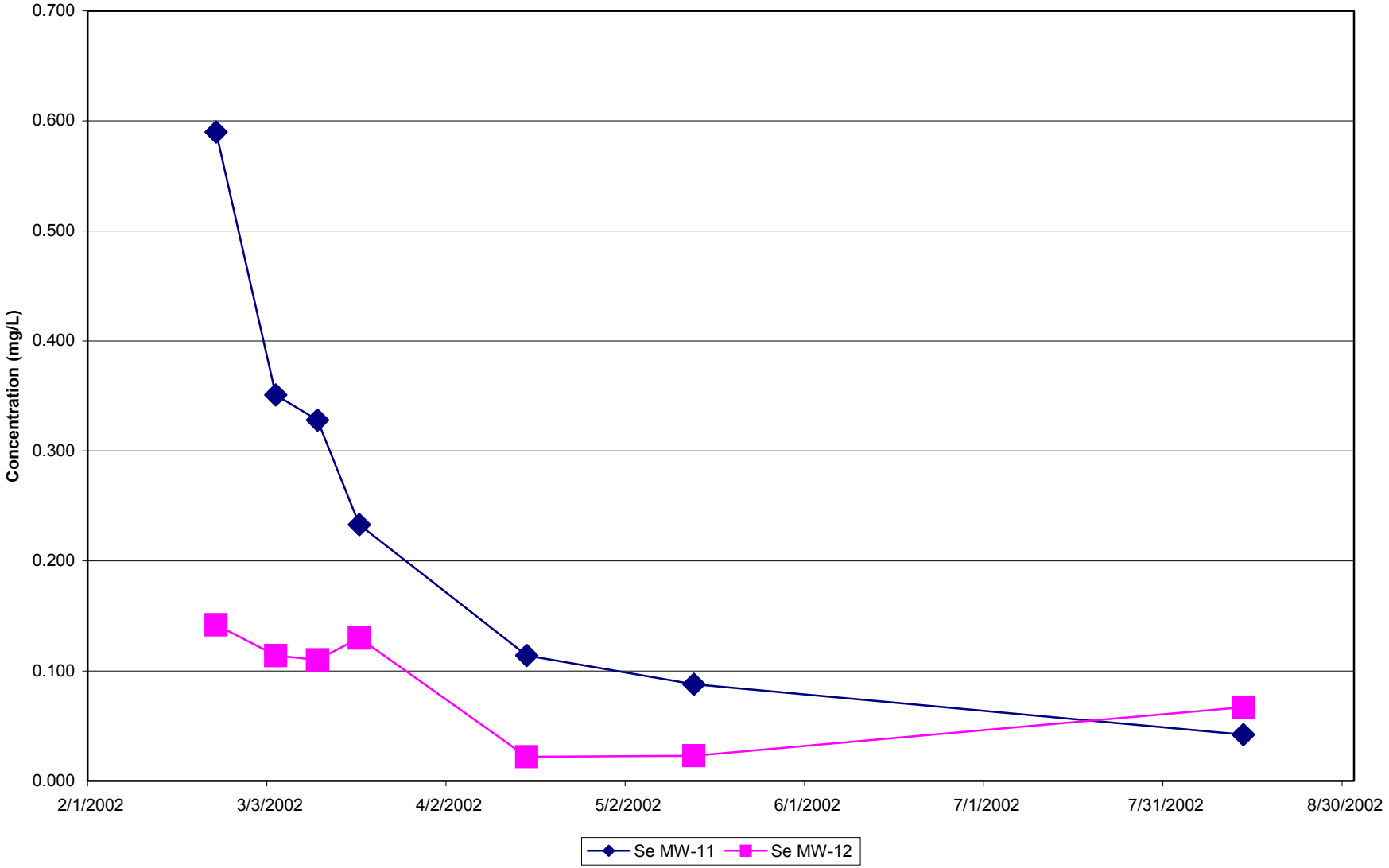
Molybdenum Levels in Ash Wells

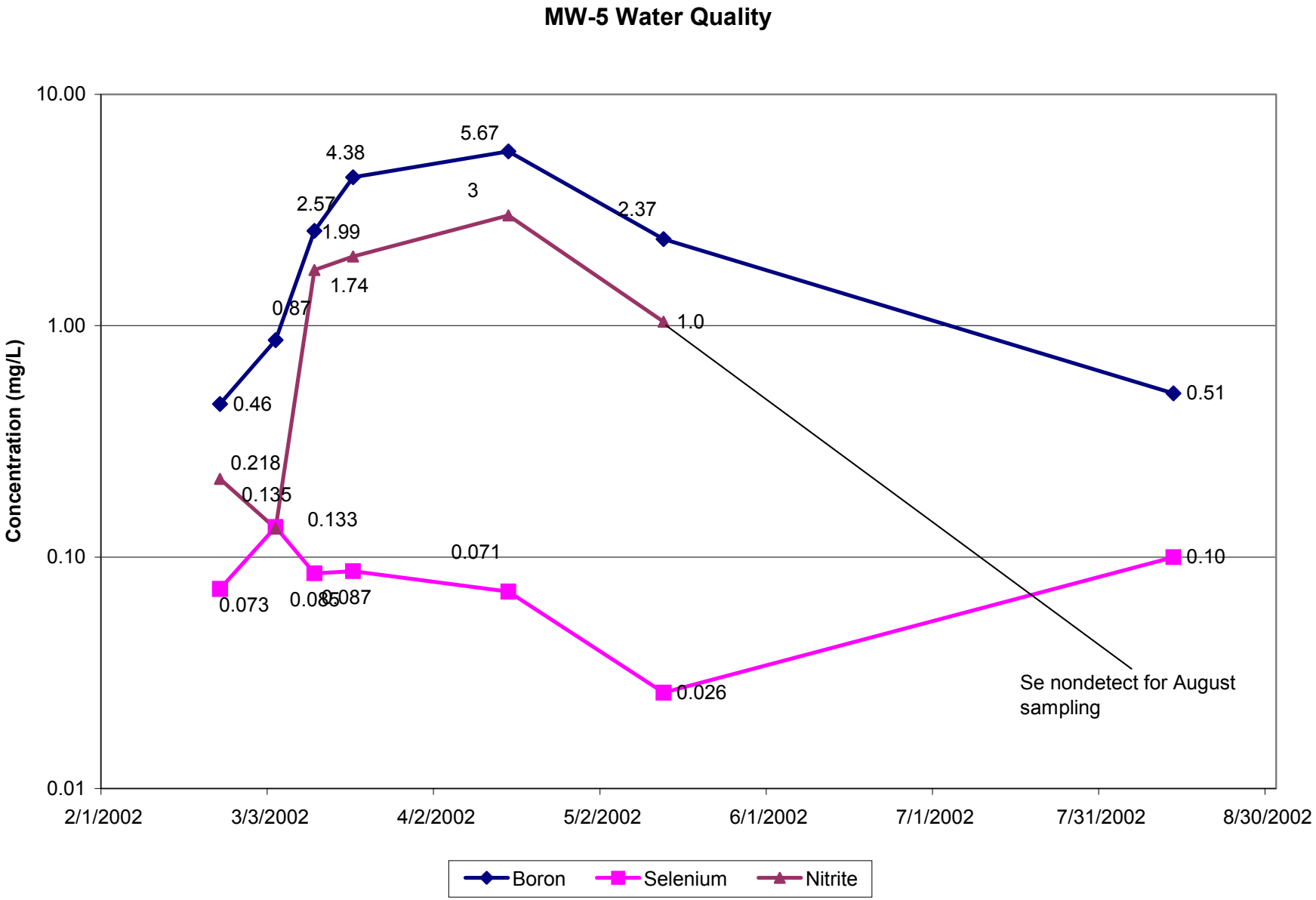


Boron Levels in Ash Wells



Selenium in Ash Wells




MW-5 Water Quality
Concentration (mg/L)
10.00
1.00
0.10
0.01
2/1/2002
3/3/2002
4/2/2002
5/2/2002
6/1/2002
7/1/2002
7/31/2002
8/30/2002
0.46
0.87
2.57
4.38
5.67
2.37
0.51
0.218
0.135
1.74
3
1.99
1.0
0.073
0.133
0.085
0.087
0.071
0.026
0.10
Se nondetect for August sampling
Boron
Selenium
Nitrite

TABLES

TABLE 1
Analytical Results
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

Sample ID	Sample Date	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Mo	Ni	P	K	Se	Ag	Na	Ti	Tl	V	Zn	Hg	U
MW-1	10/5/2001	7.4	<0.02	<0.006	<0.005	0.022	<0.003	0.33	<0.001	139	<0.004	0.002	<0.003	<0.007	<0.003	0.050	179	0.045	0.045	<0.005	0.198	5.35	**0.029**	<0.002	174	<0.01	<0.005	<0.003	<0.002	<0.0002	<0.015
	2/22/2002	7.7	<0.02	<0.006	<0.005	0.043	<0.003	0.34	<0.001	149	<0.004	<0.002	<0.003	<0.007	<0.003	0.043	175	0.035	0.30	<0.005	0.184	4.83	**0.082**	<0.002	192	<0.01	<0.005	<0.003	0.012	<0.0002	0.032
	3/4/2002	7.5	<0.02	<0.006	<0.005	0.014	<0.003	0.40	<0.001	166	<0.004	<0.002	<0.003	<0.007	<0.003	0.044	206	0.016	0.059	<0.005	0.194	5.18	**0.145**	<0.002	213	<0.01	<0.005	<0.003	<0.002	<0.0002	0.019
	3/11/2002	7.3	<0.02	<0.006	<0.005	0.016	<0.003	0.52	<0.001	160	<0.004	<0.002	<0.003	<0.007	<0.003	0.043	195	0.013	0.053	<0.005	0.193	5.32	**0.098**	<0.002	205	<0.01	<0.005	<0.003	<0.002	<0.0002	0.028
	3/18/2002	7.6	<0.02	<0.006	<0.005	0.014	<0.003	0.71	<0.001	170	<0.004	<0.002	<0.003	<0.007	<0.003	0.062	196	0.009	0.044	<0.005	0.174	7.05	**0.098**	<0.002	225	<0.01	<0.005	<0.003	<0.002	<0.0002	0.024
	4/15/2002	7.4	<0.02	<0.006	<0.005	0.023	<0.003	1.14	<0.001	170	<0.004	<0.002	<0.003	<0.007	<0.003	0.046	205	<0.001	0.049	<0.005	0.214	5.43	<0.005	<0.002	229	<0.01	<0.005	<0.003	0.01	<0.0002	0.037
	5/13/2002	7.4	<0.02	<0.006	<0.005	0.024	<0.003	1.31	0.002	174	<0.004	<0.002	<0.003	<0.007	0.006	0.085	199	0.002	0.068	<0.005	0.205	9.46	**0.039**	<0.002	245	<0.01	<0.005	<0.003	0.011	<0.0002	0.02
	8/13/2002	7.1	<0.02	<0.006	<0.005	0.027	<0.003	1.14	<0.001	207	<0.004	<0.002	<0.003	<0.007	<0.003	0.082	243	<0.001	0.099	<0.005	0.171	6.68	**0.098**	<0.002	270	<0.01	<0.005	<0.003	<0.002	<0.002	0.028
MW-2	11/9/2001	7.3	<0.02	<0.006	<0.005	0.041	<0.003	0.35	<0.001	157	<0.004	<0.002	<0.003	<0.007	<0.003	0.045	184	**0.218**	0.040	<0.005	0.236	6	**0.094**	<0.002	181	<0.01	<0.005	<0.003	0.11	<0.0002	0.029
	2/22/2002	7.5	<0.02	<0.006	<0.005	0.057	<0.003	0.41	<0.001	155	<0.004	<0.002	<0.003	<0.007	<0.003	0.008	172	<0.001	0.033	<0.005	0.179	4.78	**0.083**	<0.002	182	<0.01	<0.005	<0.003	0.01	<0.0002	0.038
	3/4/2002	7.4	<0.02	<0.006	<0.005	0.029	<0.003	0.50	<0.001	176	<0.004	<0.002	<0.003	<0.007	<0.003	0.041	201	<0.001	0.056	<0.005	0.189	5.28	**0.144**	<0.002	204	<0.01	<0.005	<0.003	<0.002	<0.0002	0.019
	3/11/2002	7.5	<0.02	<0.006	<0.005	0.031	<0.003	0.57	<0.001	170	<0.004	<0.002	<0.003	<0.007	<0.003	0.041	195	<0.001	0.054	<0.005	0.185	5.23	**0.104**	<0.002	201	<0.01	<0.005	<0.003	<0.002	<0.0002	0.029
	3/18/2002	7.5	<0.02	<0.006	<0.005	0.030	<0.003	0.77	<0.001	174	<0.004	<0.002	<0.003	0.11	<0.003	0.068	196	<0.001	0.064	<0.005	0.176	6.56	**0.105**	<0.002	217	<0.01	<0.005	<0.003	<0.002	<0.0002	0.027
	4/15/2002	7.3	<0.02	<0.006	<0.005	0.034	<0.003	0.76	<0.001	174	<0.004	<0.002	<0.003	<0.007	0.004	0.043	204	<0.001	0.055	<0.005	0.211	5.10	**0.015**	<0.002	221	<0.01	<0.005	<0.003	<0.002	<0.0002	0.042
	5/13/2002	7.4	<0.02	<0.006	<0.005	0.032	<0.003	0.64	<0.001	177	<0.004	<0.002	<0.003	<0.007	0.007	0.047	199	<0.001	0.047	<0.005	0.205	6.60	**0.034**	<0.002	214	<0.01	<0.005	<0.003	0.01	<0.0002	0.024
	8/13/2002	7.2	<0.02	<0.006	<0.005	0.034	<0.003	0.95	<0.001	210	<0.004	<0.002	<0.003	<0.007	<0.003	0.058	242	<0.001	0.074	<0.005	0.163	5.83	**0.107**	<0.002	243	<0.01	<0.005	<0.003	<0.002	<0.002	0.033
MW-3	10/5/2001	7.5	<0.02	<0.006	<0.005	0.037	<0.003	0.35	<0.001	152	<0.004	<0.002	<0.003	<0.007	<0.003	0.053	176	**1.73**	0.096	<0.005	0.17	8.8	**0.027**	<0.002	190	<0.01	<0.005	<0.003	<0.002	<0.0002	0.0190
	2/22/2002	7.5	<0.02	<0.006	<0.005	0.045	<0.003	0.43	<0.001	164	<0.004	<0.002	<0.003	<0.007	<0.003	0.430	183	**0.105**	0.033	<0.005	0.155	5.11	**0.079**	<0.002	214	<0.01	<0.005	<0.003	0.015	<0.0002	0.040
	3/4/2002	7.4	<0.02	<0.006	<0.005	0.017	<0.003	0.32	<0.001	160	<0.004	<0.002	<0.003	<0.007	0.004	0.042	193	**0.11**	0.056	<0.005	0.187	4.97	**0.145**	<0.002	208	<0.01	<0.005	<0.003	<0.002	<0.0002	0.018
	3/11/2002	7.2	<0.02	<0.006	<0.005	0.019	<0.003	0.33	<0.001	170	<0.004	<0.002	<0.003	<0.007	<0.003	0.040	197	**0.104**	0.056	<0.005	0.186	5.24	**0.101**	<0.002	211	<0.01	<0.005	<0.003	<0.002	<0.0002	0.027
	3/18/2002	7.6	<0.02	<0.006	<0.005	0.019	<0.003	0.35	<0.001	178	<0.004	<0.002	<0.003	0.127	<0.003	0.043	208	**0.097**	0.051	<0.005	0.171	6.0	**0.107**	<0.002	224	<0.01	<0.005	<0.003	<0.002	<0.0002	0.031
	4/15/2002	7.4	0.027	<0.006	<0.005	0.029	<0.003	0.40	<0.001	216	<0.004	<0.002	<0.003	<0.007	<0.003	0.045	265	**0.088**	0.059	<0.005	0.213	5.8	**0.022**	<0.002	256	<0.01	<0.005	<0.003	<0.002	<0.0002	0.043
	5/13/2002	7.3	0.027	<0.006	<0.005	0.030	<0.003	0.32	<0.001	222	<0.004	<0.002	<0.003	<0.007	0.006	0.048	269	**0.054**	0.057	<0.005	0.208	7.2	**0.031**	<0.002	262	<0.01	<0.005	<0.003	<0.002	<0.0002	0.024
	8/13/2002	7.1	<0.02	<0.006	<0.005	0.025	<0.003	0.44	<0.001	225	<0.004	<0.002	<0.003	<0.007	<0.003	0.054	266	**0.03**	0.071	<0.005	0.147	6.0	**0.105**	<0.002	261	<0.01	<0.005	<0.003	<0.002	<0.002	0.035
MW-4	2/22/2002	7.5	<0.02	<0.006	<0.005	0.061	<0.003	0.42	<0.001	152	<0.004	<0.002	<0.003	<0.007	<0.003	0.043	175	**0.281**	0.041	<0.005	0.138	6.3	**0.073**	<0.002	198	<0.01	<0.005	<0.003	0.02	<0.0002	0.042
	3/4/2002	7.5	<0.02	<0.006	<0.005	0.017	<0.003	0.32	<0.001	168	<0.004	<0.002	<0.003	<0.007	<0.003	0.044	204	**0.393**	0.052	<0.005	0.165	5.94	**0.144**	<0.002	218	<0.01	<0.005	<0.003	<0.002	<0.0002	0.021
	3/11/2002	7.2	<0.02	<0.006	<0.005	0.016	<0.003	0.32	<0.001	172	<0.004	<0.002	<0.003	<0.007	<0.003	0.045	206	**0.307**	0.058	<0.005	0.164	5.84	**0.099**	<0.002	217	<0.01	<0.005	<0.003	<0.002	<0.0002	0.028
	3/18/2002	7.6	<0.02	<0.006	<0.005	0.015	<0.003	0.32	<0.001	167	<0.004	<0.002	<0.003	0.062	<0.003	0.045	199	**0.235**	0.050	<0.005	0.154	5.77	**0.097**	<0.002	216	<0.01	<0.005	<0.003	<0.002	<0.0002	0.028
	4/15/2002	7.4	<0.02	<0.006	<0.005	0.018	<0.003	0.41	<0.001	197	<0.004	<0.002	<0.003	<0.007	0.005	0.046	248	**0.14**	0.054	<0.005	0.197	5.64	**0.011**	<0.002	253	<0.01	<0.005	<0.003	<0.002	<0.0002	0.044
	5/13/2002	7.4	<0.02	<0.006	<0.005	0.02	<0.003	0.32	<0.001	209	<0.004	<0.002	<0.003	<0.007	<0.003	0.050	254	**0.126**	0.058	<0.005	0.2	6.37	**0.026**	<0.002	251	<0.01	<0.005	<0.003	<0.002	<0.0002	0.025
	8/13/2002	7.1	<0.02	<0.006	<0.005	0.016	<0.003	0.44	<0.001	214	<0.004	<0.002	<0.003	<0.007	<0.003	0.055	257	**0.076**	0.070	<0.005	0.14	6.12	**0.099**	<0.002	251	<0.01	<0.005	<0.003	<0.002	<0.002	0.036
MW-5	2/22/2002	7.5	<0.02	<0.006	<0.005	0.063	<0.003	0.46	<0.001	150	<0.004	0.003	<0.003	<0.007	<0.003	0.045	178	**0.464**	0.047	<0.005	0.141	5.60	**0.073**	<0.002	191	<0.01	<0.005	0.005	0.015	<0.0002	0.043
	3/4/2002	7.8	<0.02	<0.006	<0.005	0.021	<0.003	0.87	<0.001	168	<0.004	<0.002	<0.003	<0.007	<0.003	0.049	214	**0.242**	0.049	<0.005	0.164	5.97	**0.135**	<0.002	217	<0.01	<0.005	<0.003	<0.002	<0.0002	0.021
	3/11/2002	7.2	<0.02	<0.006	<0.005	0.021	<0.003	2.57	<0.001	152	<0.004	<0.002	<0.003	<0.007	<0.003	0.043	188	**0.198**	0.059	<0.005	0.167	5.00	**0.085**	<0.002	195	<0.01	<0.005	<0.003	<0.002	<0.0002	0.026
	3/18/2002	7.6	<0.02	<0.006	<0.005	0.022	<0.003	4.38	<0.001	174	<0.004	<0.002	<0.003	0.063	<0.003	0.052	212	**0.214**	0.053	<0.005	0.157	6.28	**0.087**	<0.002	238	<0.01	<0.005	<0.003	<0.002	<0.0002	0.021
	4/15/2002	7.5	<0.02	<0.006	<0.005	0.024	<0.003	5.67	<0.001	168	<0.004	0.003	<0.003	<0.007	0.004	0.096	205	**0.913**	0.479	<0.005	0.154	5.63	**0.071**	<0.002	307	<0.01	<0.005	<0.003	<0.002	<0.0002	0.043
	5/13/2002	7.5	<0.02	<0.006	<0.005	0.029	<0.003	**2.37**	<0.001	179	<0.004	0.003	<0.003	<0.007	<0.003	0.123	223	**0.807**	0.349	<0.005	0.175	5.84	**0.026**	<0.002	289	<0.01	<0.005	<0.003	<0.002	<0.0002	0.031
	8/13/2002	7.2	<0.02	<0.006	<0.005	0.022	<0.003	0.51	<0.001	208	<0.004	<0.002	<0.003	<0.007	<0.003	0.059	251	**0.171**	0.083	<0.005	0.147	6.27	**0.10**	<0.002	253	<0.01	<0.005	<0.003	<0.002	<0.002	0.038

TABLE 1
Analytical Results
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

Sample ID	Sample Date	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Mo	Ni	P	K	Se	Ag	Na	Ti	Tl	V	Zn	Hg	U
MW-6	2/22/2002	7.1	<0.02	<0.006	<0.005	0.077	<0.003	0.46	<0.001	175	<0.004	<0.002	<0.003	<0.007	<0.003	0.044	182	**0.404**	0.051	<0.005	0.146	6.77	**0.081**	<0.002	204	<0.01	<0.005	<0.003	0.015	<0.0002	0.041
	3/5/2002	7.2	<0.02	<0.006	<0.005	0.033	<0.003	0.91	<0.001	198	<0.004	<0.002	<0.003	<0.007	<0.003	0.041	197	**0.195**	0.054	<0.005	0.179	6.45	**0.135**	<0.002	206	<0.01	<0.005	<0.003	<0.002	<0.0002	0.02
	3/11/2002	7.7	<0.02	<0.006	<0.005	0.035	<0.003	1.04	<0.001	179	<0.004	<0.002	<0.003	<0.007	<0.003	0.043	197	**0.101**	0.06	<0.005	0.17	5.87	**0.093**	<0.002	209	<0.01	<0.005	<0.003	<0.002	<0.0002	0.032
	3/18/2002	7.7	<0.02	<0.006	<0.005	0.035	<0.003	1.08	<0.001	177	<0.004	<0.002	<0.003	<0.007	<0.003	0.046	191	0.035	0.052	<0.005	0.174	5.57	**0.095**	<0.002	213	<0.01	<0.005	<0.003	<0.002	<0.0002	0.026
	4/15/2002	7.5	<0.02	<0.006	<0.005	0.037	<0.003	0.86	<0.001	179	<0.004	<0.002	<0.003	<0.007	0.005	0.051	202	<0.001	0.072	<0.005	0.21	5.04	**0.013**	<0.002	229	<0.01	<0.005	<0.003	<0.002	<0.0002	0.043
	5/13/2002	7.4	<0.02	<0.006	<0.005	0.036	<0.003	0.53	<0.001	176	<0.004	<0.002	<0.003	<0.007	0.005	0.049	201	0.014	0.059	0.045	0.221	5.33	**0.023**	<0.002	220	<0.01	<0.005	<0.003	<0.002	<0.0002	0.025
	8/13/2002	8.2	0.02	<0.006	<0.005	0.029	<0.003	12.60	<0.001	133	<0.004	<0.002	<0.003	<0.007	<0.003	0.680	137	1.14	1.5	<0.005	0.16	10.9	**0.093**	<0.002	509	<0.01	<0.005	<0.003	<0.002	<0.002	0.029
MW-7	2/22/2002	7.1	<0.02	<0.006	<0.005	0.077	<0.003	0.42	<0.001	163	<0.004	<0.002	<0.003	0.037	<0.003	0.044	173	**0.14**	0.047	<0.005	0.158	7.3	**0.071**	<0.002	190	<0.01	<0.005	0.004	0.017	<0.0002	0.042
	3/4/2002	7.5	<0.02	<0.006	<0.005	0.032	<0.003	0.34	<0.001	178	<0.004	<0.002	<0.003	<0.007	<0.003	0.043	204	**0.533**	0.056	<0.005	0.165	6.53	**0.142**	<0.002	201	<0.01	<0.005	<0.003	<0.002	<0.0002	0.021
	3/11/2002	7.4	<0.02	<0.006	<0.005	0.028	<0.003	0.42	<0.001	170	<0.004	<0.002	<0.003	<0.007	<0.003	0.040	191	**0.209**	0.057	<0.005	0.177	5.73	**0.094**	<0.002	193	<0.01	<0.005	<0.003	<0.002	<0.0002	0.031
	3/18/2002	7.5	<0.02	<0.006	<0.005	0.027	<0.003	0.44	<0.001	173	<0.004	<0.002	<0.003	<0.007	<0.003	0.041	194	**0.213**	0.045	<0.005	0.159	5.9	**0.099**	<0.002	201	<0.01	<0.005	<0.003	<0.002	<0.0002	0.027
	4/15/2002	7.3	<0.02	<0.006	<0.005	0.029	<0.003	0.67	<0.001	174	<0.004	<0.002	<0.003	<0.007	0.006	0.039	204	**0.102**	0.055	<0.005	0.194	5.38	0.013	<0.002	210	<0.01	<0.005	<0.003	<0.002	<0.0002	0.044
	5/13/2002	7.3	<0.02	<0.006	<0.005	0.028	<0.003	0.58	<0.001	173	<0.004	<0.002	<0.003	<0.007	0.006	0.044	199	**0.044**	0.054	<0.005	0.197	5.8	**0.027**	<0.002	210	<0.01	<0.005	<0.003	<0.002	<0.0002	0.026
	8/13/2002	7.1	<0.02	<0.006	<0.005	0.032	<0.003	0.74	<0.001	219	<0.004	<0.002	<0.003	<0.007	<0.003	0.058	247	0.078	0.083	<0.005	0.147	6.38	**0.10**	<0.002	243	<0.01	<0.005	<0.003	<0.002	<0.002	0.037
MW-8	2/22/2002	7.4	<0.02	<0.006	<0.005	0.059	<0.003	0.33	<0.001	162	<0.004	<0.002	<0.003	0.039	<0.003	0.033	148	**0.328**	0.033	<0.005	0.148	6.4	**0.054**	<0.002	139	<0.01	<0.005	0.004	0.017	0.00022	0.038
	3/4/2002	7.4	<0.02	<0.006	<0.005	0.024	<0.003	0.26	<0.001	174	<0.004	<0.002	<0.003	<0.007	<0.003	0.038	178	**0.187**	0.042	<0.005	0.166	5.94	**0.149**	<0.002	159	<0.01	<0.005	<0.003	<0.002	<0.0002	0.018
	3/11/2002	7.1	<0.02	<0.006	<0.005	0.025	<0.003	0.28	<0.001	173	<0.004	<0.002	<0.003	<0.007	<0.003	0.037	168	**0.138**	0.049	<0.005	0.153	5.87	**0.101**	<0.002	154	<0.01	<0.005	<0.003	<0.002	<0.0002	0.029
	3/18/2002	7.6	<0.02	<0.006	<0.005	0.026	<0.003	0.30	<0.001	181	<0.004	<0.002	<0.003	<0.007	<0.003	0.037	177	**0.096**	0.049	<0.005	0.158	6.35	**0.099**	<0.002	169	<0.01	<0.005	<0.003	<0.002	<0.0002	0.03
	4/15/2002	7.2	<0.02	<0.006	<0.005	0.029	<0.003	0.37	<0.001	182	<0.004	<0.002	<0.003	<0.007	<0.003	0.036	186	**0.047**	0.053	<0.005	0.183	6.03	**0.01**	<0.002	182	<0.01	<0.005	<0.003	<0.002	<0.0002	0.038
	5/13/2002	7.3	<0.02	<0.006	<0.005	0.028	<0.003	0.31	<0.001	181	<0.004	<0.002	<0.003	<0.007	<0.003	0.041	187	0.027	0.047	<0.005	0.189	5.92	**0.033**	<0.002	184	<0.01	<0.005	<0.003	<0.002	<0.0002	0.024
	8/13/2002	7.0	<0.02	<0.006	<0.005	0.024	<0.003	0.48	<0.001	189	<0.004	<0.002	<0.003	<0.007	<0.003	0.047	206	0.06	0.067	<0.005	0.129	6.38	**0.06**	<0.002	194	<0.01	<0.005	<0.003	<0.002	<0.002	0.037
MW-9	2/22/2002	7.0	<0.02	<0.006	<0.005	0.074	<0.003	0.40	<0.001	166	<0.004	<0.002	<0.003	0.052	<0.003	0.038	160	**0.063**	0.037	<0.005	0.154	8.29	**0.055**	<0.002	170	<0.01	<0.005	0.004	0.014	0.00022	0.039
	3/4/2002	7.5	<0.02	<0.006	<0.005	0.036	<0.003	0.28	<0.001	179	<0.004	<0.002	<0.003	<0.007	<0.003	0.041	189	0.027	0.043	<0.005	0.174	5.95	**0.151**	<0.002	182	<0.01	<0.005	<0.003	<0.002	<0.0002	0.018
	3/11/2002	7.2	<0.02	<0.006	<0.005	0.037	<0.003	0.33	<0.001	168	<0.004	<0.002	<0.003	<0.007	<0.003	0.039	175	0.026	0.05	<0.005	0.158	5.7	**0.102**	<0.002	169	<0.01	<0.005	<0.003	<0.002	<0.0002	0.037
	3/18/2002	7.4	<0.02	<0.006	<0.005	0.037	<0.003	0.31	<0.001	179	<0.004	<0.002	<0.003	<0.007	<0.003	0.040	179	0.012	0.049	<0.005	0.166	6.08	**0.102**	<0.002	181	<0.01	<0.005	<0.003	<0.002	<0.0002	0.024
	4/15/2002	7.1	<0.02	<0.006	<0.005	0.039	<0.003	0.38	<0.001	179	<0.004	<0.002	<0.003	<0.007	<0.003	0.037	190	0.009	0.05	<0.005	0.205	5.94	**0.024**	<0.002	197	<0.01	<0.005	<0.003	<0.002	<0.0002	0.04
	5/13/2002	7.4	<0.02	<0.006	<0.005	0.037	<0.003	0.32	<0.001	178	<0.004	<0.002	<0.003	<0.007	<0.003	0.042	197	0.002	0.05	<0.005	0.206	5.72	**0.028**	<0.002	194	<0.01	<0.005	<0.003	<0.002	<0.0002	0.027
	8/13/2002	7.0	<0.02	<0.006	<0.005	0.029	<0.003	0.49	<0.001	186	<0.004	<0.002	<0.003	<0.007	<0.003	0.049	211	0.087	0.065	<0.005	0.138	6.18	**0.122**	<0.002	207	<0.01	<0.005	<0.003	<0.002	<0.002	0.032
MW-10	2/22/2002	7.0	<0.02	<0.006	<0.005	0.09	<0.003	0.43	<0.001	159	<0.004	0.004	<0.003	<0.007	<0.003	0.040	170	**1.03**	0.045	<0.005	0.148	9.2	**0.062**	<0.002	197	<0.01	<0.005	<0.003	0.014	0.00022	0.049
	3/4/2002	7.2	<0.02	<0.006	<0.005	0.031	<0.003	0.32	<0.001	168	<0.004	<0.002	<0.003	<0.007	<0.003	0.041	200	**0.076**	0.045	<0.005	0.176	5.06	**0.146**	<0.002	213	<0.01	<0.005	<0.003	<0.002	<0.0002	0.025
	3/11/2002	7.7	<0.02	<0.006	<0.005	0.031	<0.003	0.34	<0.001	166	<0.004	<0.002	<0.003	<0.007	0.003	0.040	190	0.047	0.052	<0.005	0.184	4.95	**0.102**	<0.002	205	<0.01	<0.005	<0.003	<0.002	<0.0002	0.033
	3/18/2002	7.7	<0.02	<0.006	<0.005	0.033	<0.003	0.34	<0.001	173	<0.004	<0.002	<0.003	<0.007	<0.003	0.040	193	**0.064**	0.052	<0.005	0.171	5.54	**0.098**	<0.002	215	<0.01	<0.005	<0.003	<0.002	<0.0002	0.029
	4/15/2002	7.5	<0.02	<0.006	<0.005	0.034	<0.003	0.35	<0.001	179	<0.004	<0.002	<0.003	<0.007	<0.003	0.040	217	**0.012**	0.052	<0.005	0.217	5.16	**0.013**	<0.002	288	<0.01	<0.005	<0.003	<0.002	<0.0002	0.037
	5/13/2002	7.6	<0.02	<0.006	<0.005	0.031	<0.003	0.31	<0.001	175	<0.004	<0.002	<0.003	<0.007	0.008	0.041	209	0.004	0.056	<0.005	0.218	4.97	**0.03**	<0.002	221	<0.01	<0.005	<0.003	<0.002	<0.0002	0.027
	8/13/2002	7.1	<0.02	<0.006	<0.005	0.033	<0.003	0.48	<0.001	223	<0.004	<0.002	<0.003	<0.007	<0.003	0.051	260	<0.001	0.079	<0.005	0.157	5.37	**0.107**	<0.002	252	<0.01	<0.005	<0.003	<0.002	<0.002	0.041
MW-11	2/22/2002	9.2	0.059	<0.006	<0.005	0.16	<0.003	**30.00**	<0.001	243	<0.004	<0.002	<0.003	<0.007	<0.003	0.479	110	0.005	0.735	<0.005	0.136	17.9	**0.590**	<0.002	391	<0.01	<0.005	0.016	<0.002	0.00022	0.03
	3/4/2002	11.9	0.097	<0.006	<0.005	0.137	<0.003	**31.20**	<0.001	86.5	<0.004	<0.002	<0.003	<0.007	<0.003	2.2	46.5	<0.001	2.72	<0.005	0.186	55.8	**0.351**	<0.002	986	<0.01	<0.005	0.19	<0.002	<0.0002	0.005
	3/11/2002	11.5	0.143	<0.006	<0.005	0.242	<0.003	**34.50**	<0.001	96.8	<0.004	<0.002	<0.003	<0.007	<0.003	2.5	29.3	<0.001	3.19	<0.005	0.185	60.4	**0.328**	<0.002	1050	<0.01	<0.005	0.258	<0.002	<0.0002	0.005
	3/18/2002	11.0	0.090	<0.006	<0.005	0.259	<0.003	**31.30**	<0.001	56.3	<0.004	<0.002	<0.003	<0.007	<0.003	2.71	12.4	<0.001	3.17	<0.005	<0.05	63.1	**0.233**	<0.002	982	<0.01	<0.005	0.304	<0.002	<0.0002	<0.015
	4/15/2002	11.1	0.232	<0.006	<0.005	0.191	<0.003	**21.40**	<0.001	51.5	<0.004	<0.002	<0.003	<0.007	<0.003	1.83	0.522	<0.001	2.06	<0.005	<0.05	42.6	**0.114**	<0.002	499	<0.01	<0.005	0.3	<0.002	<0.0002	<0.015
	5/13/2002	10.8	2.280	<0.006	<0.005	0.159	<0.003	**17.80**	0.004	40.0	<0.004	<0.002	<0.003	<0.007	<0.003	1.51	1.56	<0.001	1.51	<0.005	<0.05	32	**0.088**	<0.002	439	<0.01	<0.005	0.29	<0.002	<0.0002	<0.015
	8/13/2002	9.4	2.500	<0.006	<0.005	0.317	<0.003	**16.90**	<0.001	128.0	<0.004	<0.002	<0.003	<0.007	<0.003	0.815	5.99	<0.001	0.537	<0.005	<0.05	25.0	**0.042**	<0.002	314	<0.01	<0.005	0.149	<0.002	<0.002	0.0040

TABLE 1
Analytical Results
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

Sample ID	Sample Date	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Mo	Ni	P	K	Se	Ag	Na	Ti	Tl	V	Zn	Hg	U
MW-12	2/22/2002	7.6	<0.02	<0.006	<0.005	0.126	<0.003	2.09	<0.001	193	<0.004	<0.002	<0.003	<0.007	<0.003	0.065	180	**0.107**	0.069	<0.005	0.385	6.52	**0.142**	<0.002	224	<0.01	<0.005	0.006	0.016	0.00022	0.033
	3/4/2002	8.9	0.108	<0.006	<0.005	0.166	<0.003	**21.40**	<0.001	177	<0.004	<0.002	<0.003	<0.007	<0.003	0.845	106	0.048	1.32	<0.005	0.22	24.9	**0.114**	<0.002	536	<0.01	<0.005	0.095	<0.002	<0.0002	0.009
	3/11/2002	9.8	0.158	<0.006	<0.005	0.15	<0.003	**14.30**	<0.001	154	<0.004	<0.002	<0.003	<0.007	<0.003	0.688	127	0.045	1.15	<0.005	0.323	20.9	**0.110**	<0.002	467	<0.01	<0.005	0.098	<0.002	<0.0002	0.016
	3/18/2002	9.7	0.774	<0.006	<0.005	0.11	<0.003	**25.30**	<0.001	105	<0.004	<0.002	<0.003	<0.007	<0.003	1.29	65	0.041	2.04	<0.005	<0.05	32.5	**0.130**	<0.002	637	<0.01	<0.005	0.221	<0.002	<0.0002	<0.015
	4/15/2002	8.6	0.164	<0.006	<0.005	0.12	<0.003	**7.42**	<0.001	152	<0.004	<0.002	<0.003	<0.007	<0.003	0.506	147	0.092	0.70	<0.005	0.248	17.6	**0.022**	<0.002	384	<0.01	<0.005	0.073	<0.002	<0.0002	0.0220
	5/13/2002	7.6	<0.02	<0.006	<0.005	0.00	<0.003	2.11	<0.001	180	<0.004	<0.002	<0.003	<0.007	<0.003	0.129	187	**0.080**	0.17	<0.005	0.292	8.3	**0.023**	<0.002	250	<0.01	<0.005	0.015	<0.002	<0.0002	0.0180
	8/13/2002	7.4	0.02	<0.006	<0.005	0.038	<0.003	2.40	<0.001	220	<0.004	<0.002	<0.003	<0.007	<0.003	0.074	206	**0.174**	0.10	<0.005	0.206	7.1	**0.067**	<0.002	245	<0.01	<0.005	<0.003	<0.002	<0.002	0.0270
Pond Water	5/26/1999	7.6	2.60	<0.006	<0.1	0.09	<0.004	0.21	<0.005	110	<0.01	<0.01	<0.01	**1.80**	**0.052**	0.200	53	**0.58**	<0.01	<0.004	NA	<5	<.1	<0.01	120	0.078	<0.002	<0.01	<0.02	0.00022	NA
	12/20/1999	8.3	<0.05	<0.006	<0.003	0.032	<0.004	0.44	<0.005	210	<0.01	<0.01	<0.01	<0.006	<0.002	0.057	290	<0.005	NA	<0.004	0.19	6.4	<.01	<0.01	300	NA	<0.002	<0.01	<0.02	<0.0002	NA
	2/28/2000	8.2	<0.05	<0.003	<0.003	<0.02	<0.004	0.66	<0.005	170	<0.01	<0.01	<0.01	<0.01	<0.002	0.059	450	<0.005	<0.01	<0.004	<0.05	9.3	<0.005	<0.01	410	<0.01	<0.002	<0.01	<0.02	<0.0002	0.041
	4/4/2000	8.2	0.056	<0.003	<0.003	0.980	<0.003	0.38	<0.004	179	<0.01	<0.01	<0.01	<0.01	<0.002	0.060	440	<0.005	<0.01	<0.04	0.09	10.0	<0.005	<0.01	460	<0.01	<0.002	<0.01	<0.02	<0.0002	0.047
	11/9/2001	8.4	<0.02	<0.006	<0.005	0.025	<0.003	0.88	<0.001	125	<0.004	<0.002	<0.003	<0.007	<0.003	0.070	444	0.017	0.075	<0.005	0.061	11.9	**0.045**	<0.002	495	<0.01	<0.005	<0.003	0.02	<0.0002	0.043
	2/22/2002	8.2	<0.02	<0.006	<0.005	0.050	<0.003	1.02	<0.001	128	<0.004	<0.002	<0.003	<0.007	<0.003	0.062	375	<0.001	0.076	<0.005	0.14	9.9	**0.049**	<0.002	425	<0.01	<0.005	0.01	<0.002	<0.0002	0.052
	3/4/2002	8.3	<0.02	<0.006	<0.005	0.012	<0.003	0.82	<0.001	142	<0.004	<0.002	<0.003	<0.007	<0.003	0.057	368	0.015	0.077	<0.005	0.16	9.1	**0.099**	<0.002	388	<0.01	<0.005	<0.003	<0.002	<0.0002	0.029
	3/11/2002	7.8	<0.02	<0.006	<0.005	0.010	<0.003	0.91	<0.001	148	<0.004	<0.002	<0.003	<0.007	<0.003	0.071	460	0.003	0.115	<0.005	0.16	11.9	**0.054**	<0.002	498	<0.01	<0.005	<0.003	<0.002	<0.0002	0.041
	3/18/2002	8.6	<0.02	<0.006	<0.005	0.011	<0.003	0.99	<0.001	154	<0.004	<0.002	<0.003	<0.007	<0.003	0.069	449	0.012	0.089	<0.005	0.149	12.8	**0.068**	<0.002	500	<0.01	<0.005	<0.003	<0.002	<0.0002	0.037
	4/15/2002	8.6	<0.02	<0.006	<0.005	0.012	<0.003	0.79	<0.001	152	<0.004	<0.002	<0.003	<0.007	0.009	0.065	443	<0.001	0.098	<0.005	0.183	10.9	**0.006**	<0.002	491	<0.01	<0.005	<0.003	<0.002	<0.0002	0.047
	5/13/2002	8.4	<0.02	<0.006	<0.005	0.002	<0.003	0.87	<0.001	138	<0.004	<0.002	<0.003	0.05	<0.003	0.071	479	0.006	0.12	<0.005	0.194	17.7	0.007	<0.002	519	<0.01	<0.005	<0.003	<0.002	<0.0002	0.043
	8/13/2002	8.42	<0.02	<0.006	<0.005	0.011	<0.003	1.40	<0.001	129	<0.004	<0.002	<0.003	<0.007	<0.003	0.100	692	<0.001	0.18	<0.005	0.142	17.5	**0.037**	<0.002	749	<0.01	<0.005	<0.003	<0.002	<0.002	0.057
Standards			5.0	0.006	0.050	2.0	0.004	0.75/5.0	0.005	no std.	0.100	0.050	.20/1.0	0.30/5.0	0.050	2.50	no std.	0.050	no std.	0.200	no std.	no std.	0.05/0.02	0.050	no std.	no std.	0.002	0.10	2.0	0.002	no std.
			A	P	P	P	P	A	P		P	A	A/S	S/A	P	A	n/a	S		P			P/A	P			P	A	A	P	

Notes: NA = Not Analyzed A - Agricultural Standard P - Primary Drinking Water Standard S - Secondary Drinking Water Standard All values reported in milligrams per liter (mg/L)

NA = Not Analyzed
A - Agricultural Standard
P - Primary Drinking Water Standard
S - Secondary Drinking Water Standard
All values reported in milligrams per liter (mg/L)

TABLE 2
Analytical Results
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

Sample ID	Date	pH	Total Alkalanity	Alkalinity as Bicarbonate	Alkalinity as Carbonate	Alkalinity as Hydroxide	Chloride	Fluoride	Sulfate	Nitrate	Nitrite
MW-1	10/5/2001	7.4	408	408	<1	<1	47.3	1.4	**1020**	8	0.01
	2/22/2002	7.7	549	549	<1	<1	47	1.4	**600**	**34**	0.008
	3/4/2002	7.5	536	536	<1	<1	58	1.3	**1160**	**24**	0.007
	3/11/2002	7.3	536	536	<1	<1	58.5	1.4	**1240**	**15**	<0.005
	3/18/2002	7.6	536	536	<1	<1	59.3	1.03	**1484**	**22**	<0.07
	4/15/2002	7.4	500	500	<1	<1	77.4	1.01	**1207**	**24**	<0.07
	5/13/2002	7.4	500	500	<1	<1	89.2	1.2	**1300**	**24**	<0.1
	8/13/2002	7.05	549	549	<1	<1	74	0.81	**1390**	**19.4**	<0.05
MW-2	11/9/2001	7.3	463	463	<1	<1	41.8	1.5	**900**	5	<0.005
	2/22/2002	7.5	512	512	<1	<1	43	1.3	**800**	**31**	<0.005
	3/4/2002	7.4	512	512	<1	<1	57	0.1	**1180**	**22**	0.008
	3/11/2002	7.5	524	524	<1	<1	59.4	1.7	**1180**	**22**	<0.005
	3/18/2002	7.5	512	512	<1	<1	51.1	0.93	**1337**	**22**	<0.07
	4/15/2002	7.3	512	512	<1	<1	60.8	0.98	**1197**	**26**	<0.07
	5/13/2002	7.4	500	500	<1	<1	57.9	0.85	**1240**	**24**	<0.1
	8/13/2002	7.2	500	500	<1	<1	59.7	0.89	**1493**	**19.6**	<0.05
MW-3	10/5/2001	7.5	451	451	<1	<1	45.5	1.5	**1160**	6	0.058
	2/22/2002	7.5	512	512	<1	<1	43	1.3	**850**	**35**	0.332
	3/4/2002	7.4	524	524	<1	<1	53	1.4	**1180**	**33**	0.025
	3/11/2002	7.2	524	524	<1	<1	55.8	1.3	**1220**	**18**	0.027
	3/18/2002	7.6	524	524	<1	<1	50.6	0.92	**1358**	**16**	<0.07
	4/15/2002	7.4	500	500	<1	<1	69.5	0.93	**1556**	**12**	<0.07
	5/13/2002	7.3	463	463	<1	<1	62.7	0.75	**1840**	**10**	<0.1
	8/13/2002	7.1	536	536	<1	<1	55.2	0.82	**1961**	**18.9**	<0.05
MW-4	2/22/2002	7.5	549	549	<1	<1	43	1.5	**800**	**27**	0.065
	3/4/2002	7.5	524	524	<1	<1	51	1.3	**1160**	**22**	0.129
	3/11/2002	7.2	536	536	<1	<1	46.6	1.7	**1200**	**13**	0.073
	3/18/2002	7.6	524	524	<1	<1	56.1	0.98	**1511**	**17**	<0.07
	4/15/2002	7.4	488	488	<1	<1	65.1	0.96	**1415**	**14**	<0.07
	5/13/2002	7.4	488	488	<1	<1	64.1	0.78	**1640**	**11**	<0.1
	8/13/2002	7.1	634	634	<1	<1	53.5	0.81	**1513**	**19**	<0.05

TABLE 2
Analytical Results
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

Sample ID	Date	pH	Total Alkalanity	Alkalinity as Bicarbonate	Alkalinity as Carbonate	Alkalinity as Hydroxide	Chloride	Fluoride	Sulfate	Nitrate	Nitrite
MW-5	2/22/2002	7.5	537	537	<1	<1	43	1.4	**800**	**27**	0.218
	3/4/2002	7.8	512	512	<1	<1	57	1.3	**1180**	**20**	0.133
	3/11/2002	7.2	488	488	<1	<1	80.5	1.7	**1240**	**23**	**1.74**
	3/18/2002	7.6	463	463	<1	<1	122.3	0.99	**1292**	**11**	**1.99**
	4/15/2002	7.5	475	475	<1	<1	184.7	1.11	**1283**	**13**	**3**
	5/13/2002	7.5	500	500	<1	<1	105	1.01	**1440**	**9**	**1.0**
	8/13/2002	7.2	549	549	<1	<1	52.3	0.9	**1375**	**19**	<0.05
MW-6	2/22/2002	7.1	537	537	<1	<1	56	1.4	**800**	**36**	**3.52**
	3/4/2002	7.2	512	512	<1	<1	48	1.6	**1120**	**22**	0.102
	3/11/2002	7.7	536	536	<1	<1	53	1.4	**1160**	**16**	0.03
	3/18/2002	7.7	512	512	<1	<1	52.5	0.95	**1260**	**22**	<0.07
	4/15/2002	7.5	524	524	<1	<1	65.5	1	**1181**	**26**	<0.07
	5/13/2002	7.4	512	512	<1	<1	58.7	0.77	**1180**	**25**	<0.1
	8/13/2002	8.2	378	378	<1	<1	196	3	**1316**	**5**	<0.05
MW-7	2/22/2002	7.1	537	537	<1	<1	42	1.4	**800**	**27**	0.006
	3/4/2002	7.5	536	536	<1	<1	50	1.1	**1060**	**31**	0.175
	3/11/2002	7.4	536	536	<1	<1	54.9	1.5	**1140**	**20**	0.021
	3/18/2002	7.5	524	524	<1	<1	48.5	0.92	**1222**	**19**	<0.07
	4/15/2002	7.3	561	561	<1	<1	63	0.97	**1186**	**25**	<0.07
	5/13/2002	7.3	512	512	<1	<1	57.2	0.71	**1160**	**23**	<0.1
	8/13/2002	7.1	536	536	<1	<1	52	0.71	**1348**	**18.3**	<0.05
MW-8	2/22/2002	7.4	524	524	<1	<1	32	1.2	**600**	**22**	0.026
	3/4/2002	7.4	549	549	<1	<1	45	1.3	**940**	**16**	0.018
	3/11/2002	7.1	524	524	<1	<1	38.4	1.5	**980**	**17**	<0.005
	3/18/2002	7.6	524	524	<1	<1	42.7	0.89	**1102**	**15**	<0.07
	4/15/2002	7.2	536	536	<1	<1	58.6	0.9	**1119**	**23**	<0.07
	5/13/2002	7.3	524	524	<1	<1	50.1	0.61	**1080**	**19**	<0.1
	8/13/2002	7.0	610	610	<1	<1	38.3	0.62	**1098**	**9.7**	<0.05

TABLE 2
Analytical Results
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

Sample ID	Date	pH	Total Alkalanity	Alkalinity as Bicarbonate	Alkalinity as Carbonate	Alkalinity as Hydroxide	Chloride	Fluoride	Sulfate	Nitrate	Nitrite
MW-9	2/22/2002	7.0	537	537	<1	<1	42	1.3	**800**	**35**	0.198
	3/4/2002	7.5	536	536	<1	<1	49	1	**1040**	**18**	0.076
	3/11/2002	7.2	524	524	<1	<1	51.2	1.5	**1040**	**16**	0.009
	3/18/2002	7.4	524	524	<1	<1	47.3	0.88	**1180**	**21**	<0.07
	4/15/2002	7.1	549	549	<1	<1	58.2	0.88	**1159**	**24**	<0.07
	5/13/2002	7.4	536	536	<1	<1	51.4	0.67	**980**	**19**	<0.1
	8/13/2002	7.0	610	610	<1	<1	42.5	0.56	**1097**	**12**	<0.05
MW-10	2/22/2002	7.0	549	549	<1	<1	47	1.4	**750**	**36**	0.34
	3/4/2002	7.2	536	536	<1	<1	53	1.1	**1140**	**32**	0.01
	3/11/2002	7.7	524	524	<1	<1	51.2	1.7	**1040**	**24**	<0.005
	3/18/2002	7.7	524	524	<1	<1	50.6	0.9	**1260**	**23**	<0.07
	4/15/2002	7.5	549	549	<1	<1	64.9	0.93	**1248**	**24**	<0.07
	5/13/2002	7.6	512	512	<1	<1	58.8	0.82	**1220**	**23**	<0.1
	8/13/2002	1.1	512	512	<1	<1	56	0.92	**1504**	**22.4**	<0.05
MW-11	2/22/2002	9.2	121	61	60	<1	151	**5.0**	**1200**	**22**	**2.0**
	3/4/2002	11.9	234	36	198	<1	**427**	2	**1500**	4	**2.1**
	3/11/2002	11.5	362	158	204	<1	**543**	**7**	**1440**	4	**4.1**
	3/18/2002	11.0	228	24	204	<1	**444**	1.98	**1435**	8	**5.0**
	4/15/2002	11.1	252	48	204	<1	147	1.67	**767**	**14**	**4.1**
	5/13/2002	10.8	217	73	144	<1	119	1.86	**360**	**14**	**2.2**
	8/13/2002	9.4	132	24	108	<1	68.6	1.4	**681**	**14.2**	**1.4**
MW-12	2/22/2002	7.6	488	488	<1	<1	53	1.7	**900**	**15**	**3.4**
	3/4/2002	8.9	243	171	72	<1	234	**2.2**	**1420**	**14**	**4.2**
	3/11/2002	9.8	389	341	48	<1	194	**7**	**1340**	**10**	**3.2**
	3/18/2002	9.7	291	171	120	<1	**370**	**3.16**	**1862**	7	**7.2**
	4/15/2002	8.6	376	316	60	<1	155	**1.49**	**1349**	2	**3.1**
	5/13/2002	7.6	475	475	<1	<1	74	0.88	**1380**	1	0.8
	8/13/2002	7.4	475	475	<1	<1	56.2	0.86	**1298**	0.89	<0.05

TABLE 2
Analytical Results
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

Sample ID	Date	pH	Total Alkalanity	Alkalinity as Bicarbonate	Alkalinity as Carbonate	Alkalinity as Hydroxide	Chloride	Fluoride	Sulfate	Nitrate	Nitrite
Pond Water	5/26/1999	7.6	NA	NA	<5	NA	59	0.76	**320**	9.8	<0.10
	12/20/1999	8.3	470	470	<5	<5	66	0.89	**1500**	**17**	<0.20
	2/28/2000	8.2	280	280	<5	<5	78	0.93	**2800**	0.91	0.79
	4/5/2000	8.2	290	290	<5	<5	77	0.98	**2700**	N/A	N/A
	11/9/2001	8.4	274	238	36	<1	80.9	1.70	**2400**	1.3	0.019
	2/22/2002	8.2	378	378	<1	<1	78	1.80	**2100**	13	0.039
	3/4/2002	8.3	414	414	<1	<1	75	1.40	**2320**	7	0.045
	3/11/2002	7.8	341	305	36	<1	82.3	**2.00**	**2200**	17	0.33
	3/18/2002	8.6	292	244	48	<1	86.8	1.15	**2941**	1.59	<0.07
	4/15/2002	8.6	292	244	48	<1	100.5	1.16	**2298**	2.04	<0.07
	5/13/2002	8.4	304	256	48	<1	106	0.90	**2700**	0.24	<0.1
	8/13/2002	8.4	279	219	60	<1	147	1.2	**3735**	0.16	<0.05
Standards			no std.	no std.	no std.	no std.	250	2.0	250	10	1
							S	A	P	P	P

Notes:
NA = Not Analyzed
A - Agricultural Standard
P - Primary Drinking Water Standard
S - Secondary Drinking Water Standard
All values reported in milligrams per liter (mg/L)

TABLE 3
Analytical Comparisons
Ash - Non-Ash Wells
Varra Coal Ash Project
Weld County, Colorado
CGRS No. 1-135-2755

	Non-Ash Wells			Ash Wells		
	Mean	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
pH	7.37	6.95	8.16	9.60	7.4	11.9
Selinium	0.07	0.005	0.151	0.16	0.022	0.59
Boron	0.84	0.257	12.6	18.43	2.09	34.5
Molybdenum	0.08	0.033	1.5	1.39	0.069	3.19
Sulfate	1178.20	600	1961	1209.42	360	1861.9
Calcium	176.43	133	225	134.50	40	243
Nitrate	20.56	4.8	36	9.21	0.66	22