Bernalillo County
Environmental Health Department

North Albuquerque Acres Groundwater Quality Assessment

March 2002

Report

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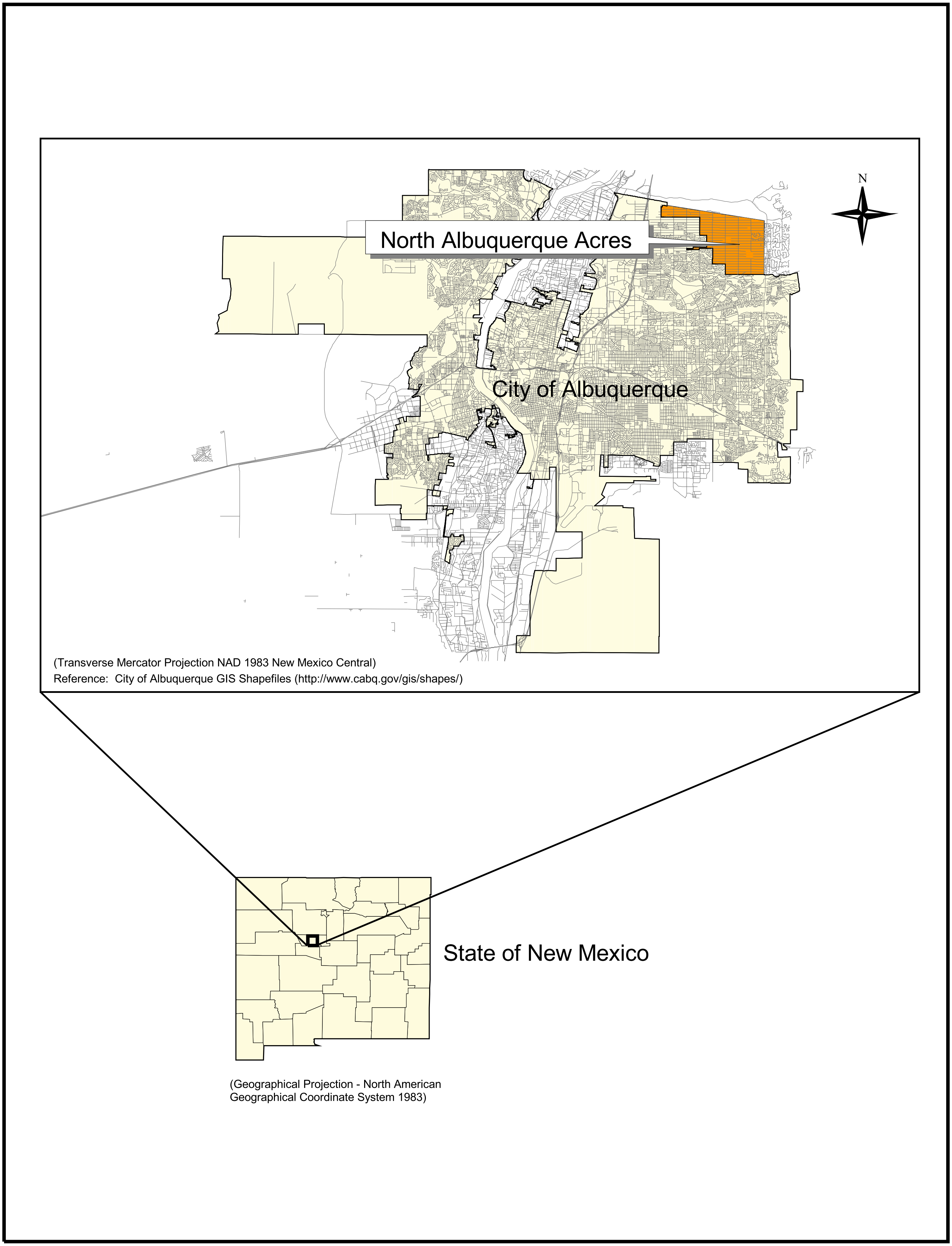

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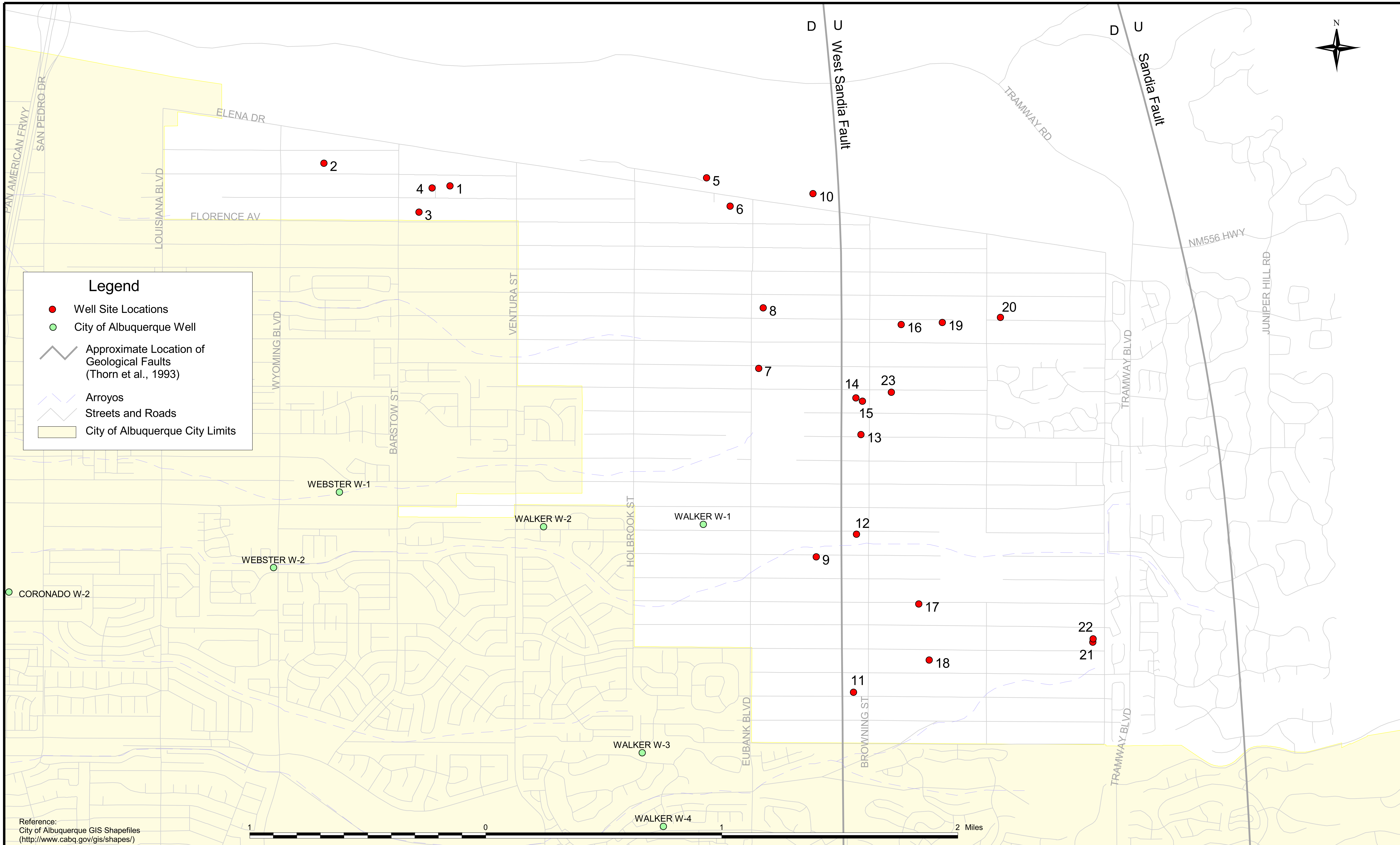
North Albuquerque Acres, Bernalillo County, New Mexico
Location of North Albuquerque Acres
Figure 1



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North Albuquerque Acres, Bernalillo County, New Mexico
Site Map
Figure 2

Section 2 Introduction

The NAA is a rapidly growing community at the base of the Sandia Mountains in Bernalillo County, New Mexico. Currently, all residents in the area use on-site wastewater disposal systems (septic systems) to treat wastewater. To what degree the operation of these systems is affecting groundwater quality is unknown and was identified as a possible threat to groundwater quality in the Albuquerque/Bernalillo County Ground-Water Protection Policy and Action Plan (GPPAP) (Edwin et al, 1990).

The principal threats to groundwater quality are bacteriological and nitrate contamination. Bacteria are present in domestic septage. Nitrates are produced from septic tank effluent as a result of nitrification of ammonia (requires aerobic conditions), which is produced from urea, in a process known as ammonification. Nitrates are a major water quality concern in areas where onsite disposal systems are prevalent. The nitrate molecule carries a negative charge and therefore does not sorb to negatively charged soil particles; this enables nitrate to migrate rapidly in subsurface environments.

NAA is located on the eastern margin of the Albuquerque Basin on piedmont-slope alluvium of the Sandia Mountains (Figure 1). Elevations vary greatly across the study area and individual sampling locations ranged from 5,388 feet to 6,038 feet. Groundwater occurs under unconfined conditions. The Santa Fe Group (late Oligocene to middle Pleistocene) is the principal aquifer in the NAA. The wells in the study area are generally completed within the Upper Santa Fe Group, deposited during the late Miocene to early Pleistocene (5 to 1 Ma) and consist of coarse grained alluvial deposits. Generally, the highest horizontal hydraulic conductivities occur in the stable axial channel deposits of the ancestral Rio Grande placed during the deposition of the Upper Santa Fe Group, just east of the NAA (Thorn et al., 1993). The Sandia and West Sandia faults are major structural controls on the depth to groundwater in the area.

2.1 Sampling Methods

Groundwater samples were collected at locations listed in Table 2. Sample collection taps were identified prior to any treatment systems or storage systems, when possible. To ensure that representative samples were collected, the wells were purged by running water from the sampling tap for 10 to 30 minutes prior to sampling. Samples were collected after temperature, conductivity, pH, and dissolved oxygen had stabilized to less than 10% variation. Ten sample containers were filled at each site and were placed on ice for delivery to the laboratory. The sample containers and method of preservation are described in Table 3.

Table 3 Sampling Protocol

Sample Type	Quantity/Size/Material	Preservation
TOC	2/125 mL/Amber Glass	H_2SO_4
Ca,Mg,K,Na,As	1/250 mL/Plastic	HNO_3
NO_3,NH_3,TKN	1/1000 mL/Plastic	H_2SO_4
NO_2,Cl,SO_4,Alk Grp.	1/1000 mL/Plastic	none
Bacteriological	3/125 mL/Plastic	Sodium Thiosulfate
Chlorine	2/60 mL/Clear Glass	None (no headspace)

As part of the groundwater quality analyses of the wells were sampled and analyzed for the following constituents:

Table 4 Analytes and Methods

Constituent	Test Method	Constituent	Test Method
Nitrate	EPA Method 300.0	Calcium	EPA Method 300.0
Ammonia	EPA Method 350.2	Chloride	EPA Method 300.0
TKN	EPA Method 351.3	Chlorine	4500-Cl B
Sodium	EPA Method 300.0	Sulfate	EPA Method 300.0
Potassium	EPA Method 6010	Bicarbonate	EPA Method 310.1
Magnesium	EPA Method 6010	Carbonate	EPA Method 310.1
TOC	EPA Method 415.1	Total Coliform	MMO/MUG
E. Coliform	MMO/MUG	Arsenic	EPA Method 6010
Fecal Coliform	SM922D		

Section 3
General Groundwater Chemistry

The main goals of the water quality analyses were to evaluate the impact of on-site wastewater disposal systems, characterize the hydrochemical facies and collect arsenic concentration data for comparison to new water quality standards for that element. A summary of the results of the groundwater chemistry analyses is presented in Table 5. All laboratory results and QA/QC procedures are included in Appendix B.

Assuming background concentrations for nitrate are below the method detection limits, the presence of nitrate in 19 of the 23 wells sampled suggests that on-site septic systems are degrading water quality in the NAA. The average nitrate concentration of the wells in which it was detected was 1.03 mg/L, and the maximum nitrate concentration was 2.3 mg/L (site 22), both of which are well below the groundwater standard of 10 mg/L, as established by the New Mexico Water Quality Control Commission (NMWQCC). These values are consistent with the results of previous studies just east of NAA in the Sandia Heights area (Hall, 1999).

The results of these two studies suggest that the quantity of nitrate reaching groundwater is limited, as a result of the thickness of the vadose zone in the area. It seems likely that nitrate is undergoing denitrification during transport in anaerobic microzones of the soil column. Under anaerobic conditions nitrate is the most thermodynamically favorable electron acceptor and is used by a number of facultative bacteria in respiration (e.g., Pseudomonas sp.) (Chapelle, 2001), the end product of which is nitrogen gas (N_2). This assumes there is a suitable organic carbon source as approximately 1 mg/l of organic carbon is required for each mg of nitrate nitrogen to be denitrified. Anaerobic microenvironments could develop in the retained water between soil particles, particularly in low hydraulic conductivity zones that impede downward percolation. Because of all of the water samples collected were well oxygenated, it can be assumed that all nitrate reaching the groundwater will remain as nitrate and is available to migrate downgradient.

The bacteriological water quality was good throughout the NAA as no Escherichia coli sp. (E. Coliform) or fecal coliforms were present in any water samples above laboratory detection limits. However, several of the initial samples (Site 5 and 20) analyzed using the membrane filter test for total coliform were overgrown with bacteria, and should be re-sampled and analyzed for total coliforms using the MMO-MUG Test. The bacteriological water quality data are summarized in Table 6.

Table 5. General Groundwater Chemistry

Site and Location	Nitrate mg/L	Nitrite mg/L	Ammonia mg/L	TKN mg/L	Sodium mg/L	Potassium mg/L	Magnesium mg/L	Calcium mg/L	Chloride mg/L	Chlorine mg/L	Sulfate mg/L	Bicarbonate mg/L	Carbonate mg/L	Alkalinity mg/L	TOC mg/L	Arsenic ug/L	Ph pH units
1.8600 Beverly Hills Ave.	<0.5	<0.01	<0.3	<0.50	28	2.0	3.4	44	14	<0.05	39	130	<1.0	130	<0.5	14	7.8
2. 7921 Beverly Hills Ave.	<0.5	<0.01	<0.3	<0.50	47	7.0	5.2	20	9.4	<0.05	36	140	<1.0	140	<0.5	46	7.9
3. 8401 Florence Ave.	<0.5	<0.01	<0.3	<0.50	33	4.6	5.7	30	22	<0.05	32	130	<1.0	130	<0.5	21	7.9
4. 8501 San Diego Ct.	<0.5	<0.01	<0.3	<0.50	30	1.9	3.4	35	15	<0.05	33	120	<1.0	120	<0.05	11	7.9
5. 9905 Desert Mt. Rd	0.7	<0.01	<0.3	<0.50	27	1.6	7.3	43	7.7	<0.05	27	180	<1.0	180	<0.5	2.4	7.7
6. 10200 Elena Dr.	0.7	<0.01	<0.3	<0.50	23	1.4	5.0	48	5.4	<0.05	22	170	<1.0	170	<0.5	4.7	7.8
7. 10420 Signal Ave.	0.8	<0.01	<0.3	<0.50	22	1.1	2.9	35	5.3	<0.05	18	140	<1.0	140	<0.5	<2.0	7.8
8. 10421 Oakland Ave	1.2	<0.01	<0.3	<0.50	19	110	0.05	0.3	6.2	<0.05	22	150	<1.0	150	<0.5	<2.0	7.8
9. 10710 San Bernardino	0.8	<0.01	<0.3	<0.50	18	1.3	3.8	44	5.1	<0.05	17	150	<1.0	150	<0.5	<2.0	7.7
10. 10801 Elena Dr.	1.4	<0.01	<0.3	<0.50	26	1.0	4.7	42	7.0	<0.05	26	150	<1.0	150	<0.5	<2.0	7.8
11. 11009 Del Rey Ave.	0.7	<0.01	<0.3	<0.50	19	0.98	3.3	43	5.7	<0.05	19	140	<1.0	140	<0.5	<2.0	7.9
12. 11110 Palomas Ave.	0.7	<0.01	<0.3	<0.50	17	1.0	3.7	47	5.2	<0.05	18	150	<1.0	150	<0.5	<2.0	7.7
13. 11101 Anaheim Ave.	0.8	<0.01	<0.3	<0.50	3.6	130	<0.05	<0.1	4.9	<0.05	17	150	<1.0	150	<0.5	<2.0	7.9
14. 11100 Wilshire Ave.	0.7	<0.01	<0.3	<0.50	17	1.2	3.8	46	5.1	<0.05	18	160	<1.0	160	<0.5	<2.0	7.8
15. 11120 Wilshire Ave.	0.8	<0.01	<0.3	<0.50	17	1.2	3.9	44	5.0	<0.05	17	160	<1.0	160	<0.5	<2.0	7.7
16. 11304 Oakland Ave.	0.8	<0.01	<0.3	<0.50	16	1.1	4.4	47	4.7	<0.05	15	160	<1.0	160	<0.5	<2.0	7.7
17. 11424 Pino Ave.	1.6	<0.01	<0.3	<0.50	15	1.1	4.2	50	5.3	<0.05	17	150	<1.0	150	<0.5	<2.0	7.8
18. 11601 San Rafael Ave.	0.9	<0.01	<0.3	<0.50	16	1.1	3.4	42	5.1	<0.05	17	150	<1.0	150	<0.5	<2.0	7.7
19. 11600 Oakland	0.9	<0.01	<0.3	<0.50	16	1.3	4.6	48	4.8	<0.05	16	170	<1.0	170	<0.5	<2.0	7.7
20. 11905 Oakland	1.1	<0.01	<0.3	<0.50	21	0.85	4.4	37	5.3	<0.05	16	140	<1.0	140	<0.5	<2.0	7.7
21. 12501 Corondado Ave.	1.9	<0.01	<0.3	<0.50	14	1.2	8.2	66	5.7	<0.05	28	200	<1.0	200	0.6	<2.0	7.5

Table 5. General Groundwater Chemistry

Site and Location	Nitrate mg/L	Nitrite mg/L	Ammonia mg/L	TKN mg/L	Sodium mg/L	Potassium mg/L	Magnesium mg/L	Calcium mg/L	Chloride mg/L	Chlorine mg/L	Sulfate mg/L	Bicarbonate mg/L	Carbonate mg/L	Alkalinity mg/L	TOC mg/L	Arsenic ug/L	Ph pH units
22. 12500 San Francisco	2.3	<0.01	<0.3	<0.50	14	1.2	6.6	64	5.3	<0.05	21	190	<1.0	190	<0.5	<2.0	7.7
23. 11212 Wilshire Ave.	0.8	<0.01	<0.3	<0.50	16	1.3	3.8	48	5.1	<0.05	17	160	<1.0	160	<0.5	<2.0	7.7
MCL	10	1							250		250					10	6.5-8.5
MRL	0.5	0.01	0.3	0.5	0.1	0.05	0.05	0.1	2.0	0.05	5.0	1.0	1.0	1.0	0.5	2.0	

** Current Arsenic standard is 50 ppb, the new standard will be 10 ppb

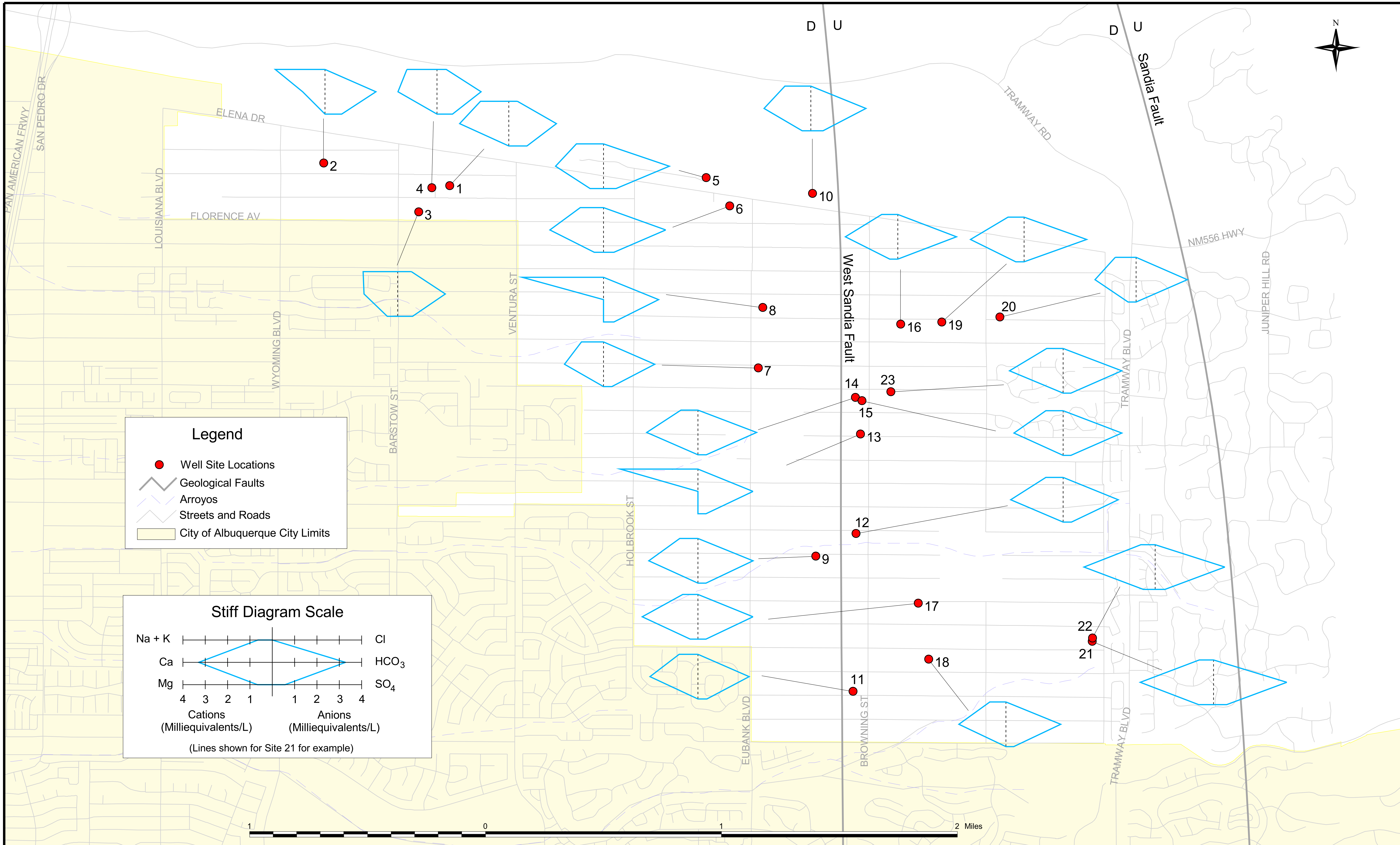
Table 6. Bacteriological Water Quality

Site and Location	Total Coliform col/100 ml	Fecal Coliform col/100 ml	E.Coliform col/100 ml
1. 8600 Beverly Hills Ave.	Absent	<1/100	<1/100
2. 7921 Beverly Hills Ave.	Absent	<1/100	<1/100
3. 8401 Florence Ave.	Absent	<1/100	<1/100
4. 8501 San Diego Ct.	Absent	<1/100	<1/100
5. 9905 Desert Mt. Rd	Present*	<1/100	<1/100
6. 10200 Elena Dr.	Absent	<1/100	<1/100
7. 10420 Signal Ave.	Absent	<1/100	<1/100
8. 10421 Oakland Ave	Absent	<1/100	<1/100
9. 10710 San Bernardino	Absent	<1/100	<1/100
10. 10801 Elena Dr.	Absent	<1/100	<1/100
11. 11009 Del Rey Ave.	Absent	<1/100	<1/100
12. 11110 Palomas Ave.	Absent	<1/100	<1/100
13. 11101 Anaheim Ave.	Absent	<1/100	<1/100
14. 11100 Wilshire Ave.	Absent	<1/100	<1/100
15. 11120 Wilshire Ave.	Absent	<1/100	<1/100
16. 11304 Oakland Ave.	Absent	<1/100	<1/100
17. 11424 Pino Ave.	Absent	<1/100	<1/100
18. 11601 San Rafael Ave.	Absent	<1/100	<1/100
19. 11600 Oakland	Absent	<1/100	<1/100
20. 11905 Oakland	Present*	<1/100	<1/100
21. 12501 Corondado Ave.	Absent	<1/100	<1/100
22. 12500 San Francisco	Absent	<1/100	<1/100
23. 11212 Wilshire Ave.	Absent	<1/100	<1/100

* TNTC of noncoliforms, well should be resampled and analyzed using the MMO-MUG Test

A graphical representation of the general water chemistry is summarized by the stiff diagrams superimposed over the site locations presented in Figure 2. These data clearly indicate that the water chemistry is generally consistent across NAA. In order to determine the hydrochemical facies, the water quality data were also plotted on trilinear diagrams (Figures 4 through 8). Hydrochemical facies are classified based on the dominant ions in the facies, which in turn are result of the lithology, solution kinetics and flow patterns of the aquifer (Fetter, 1988). The ionic chemistry indicates that the waters were of the calcium and bicarbonate types.

The exceptions are the samples collected from sites 8 and 13, which had very different cation chemistry. These samples were of the potassium type and bicarbonate type



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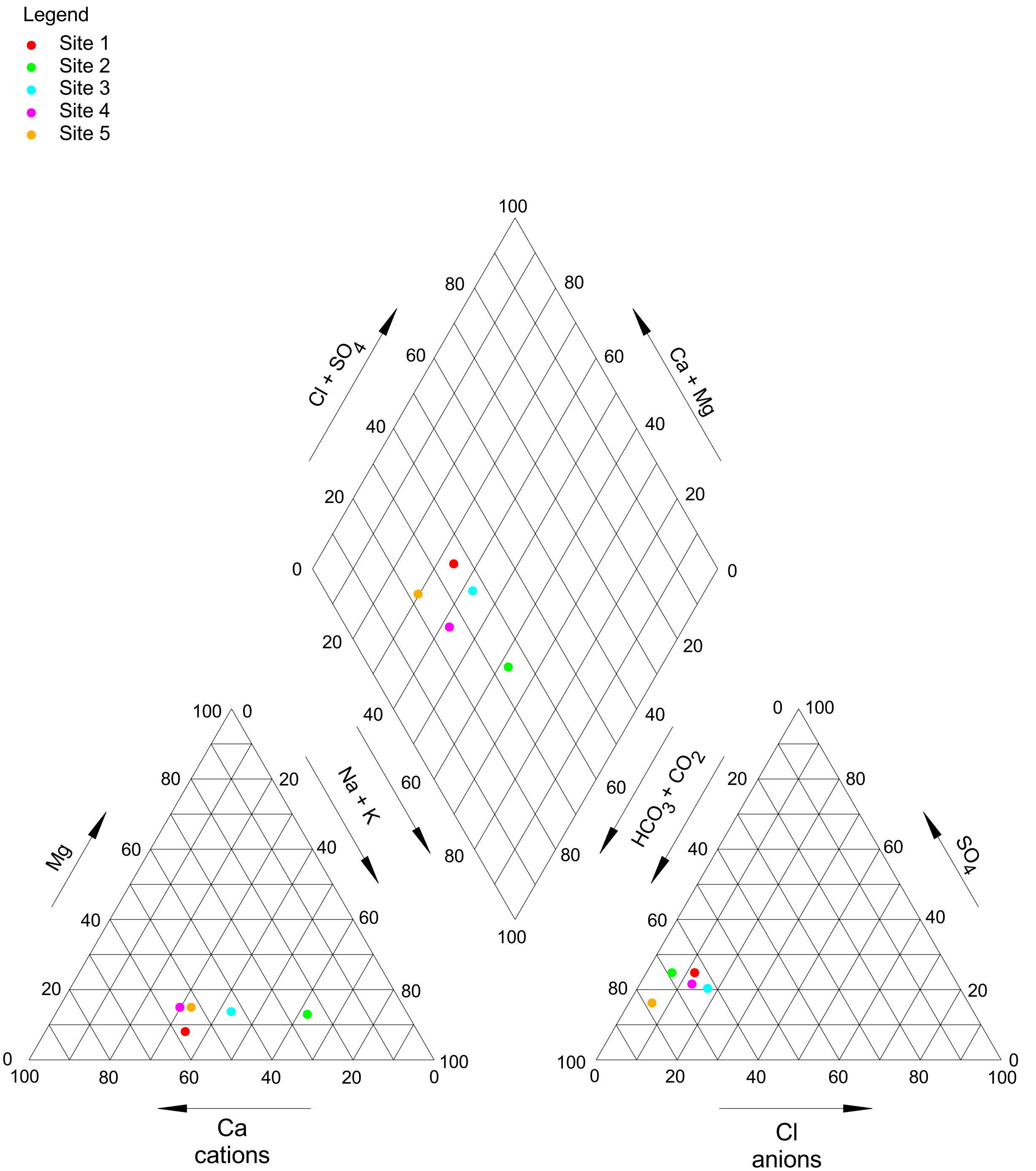
North Albuquerque Acres, Bernalillo County, New Mexico
Groundwater Chemistry
Figure 3



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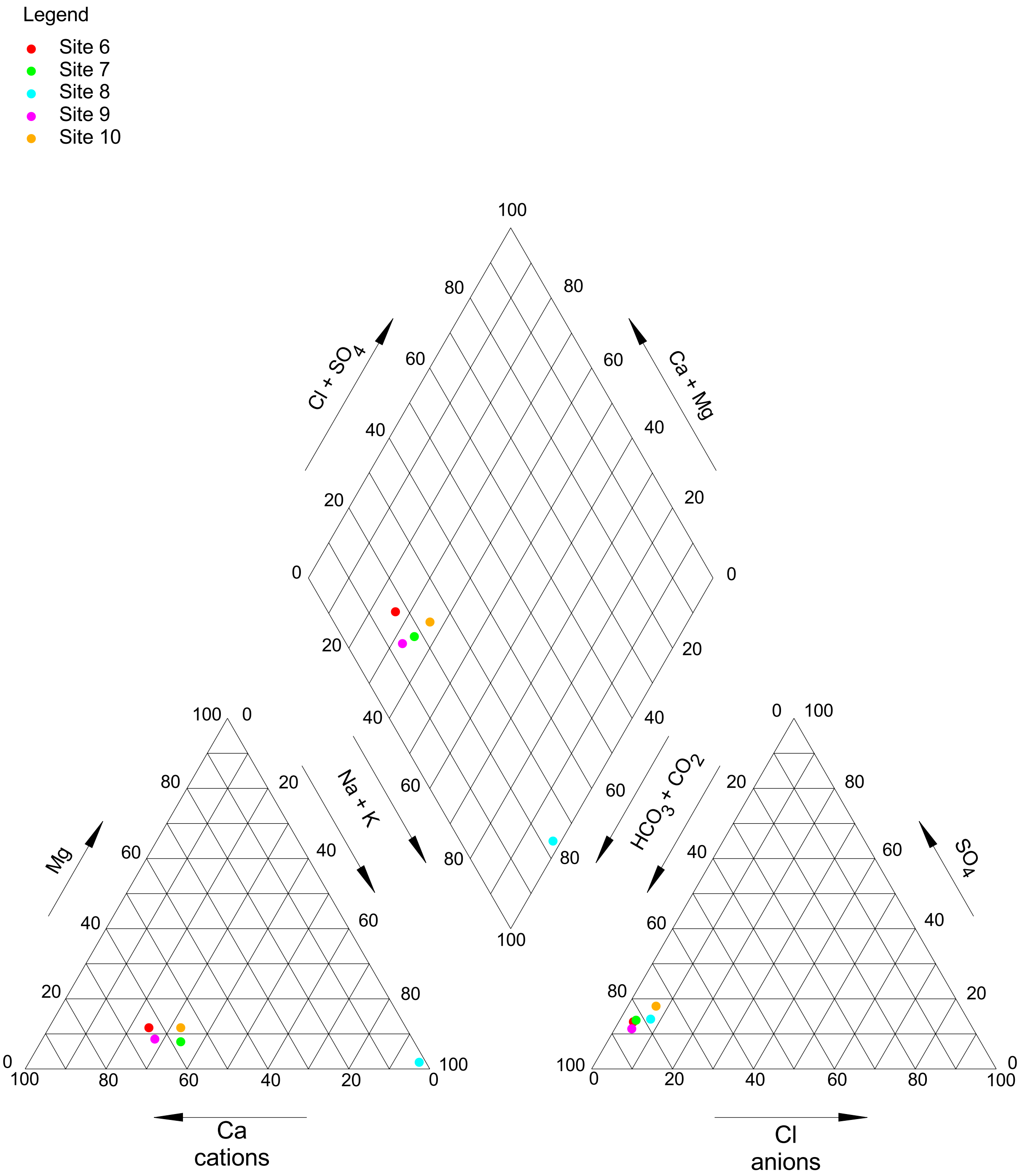
North Albuquerque Acres, Bernalillo County, New Mexico
Trilinear Diagram of Water Chemistry - Sites 1-6
Figure 4



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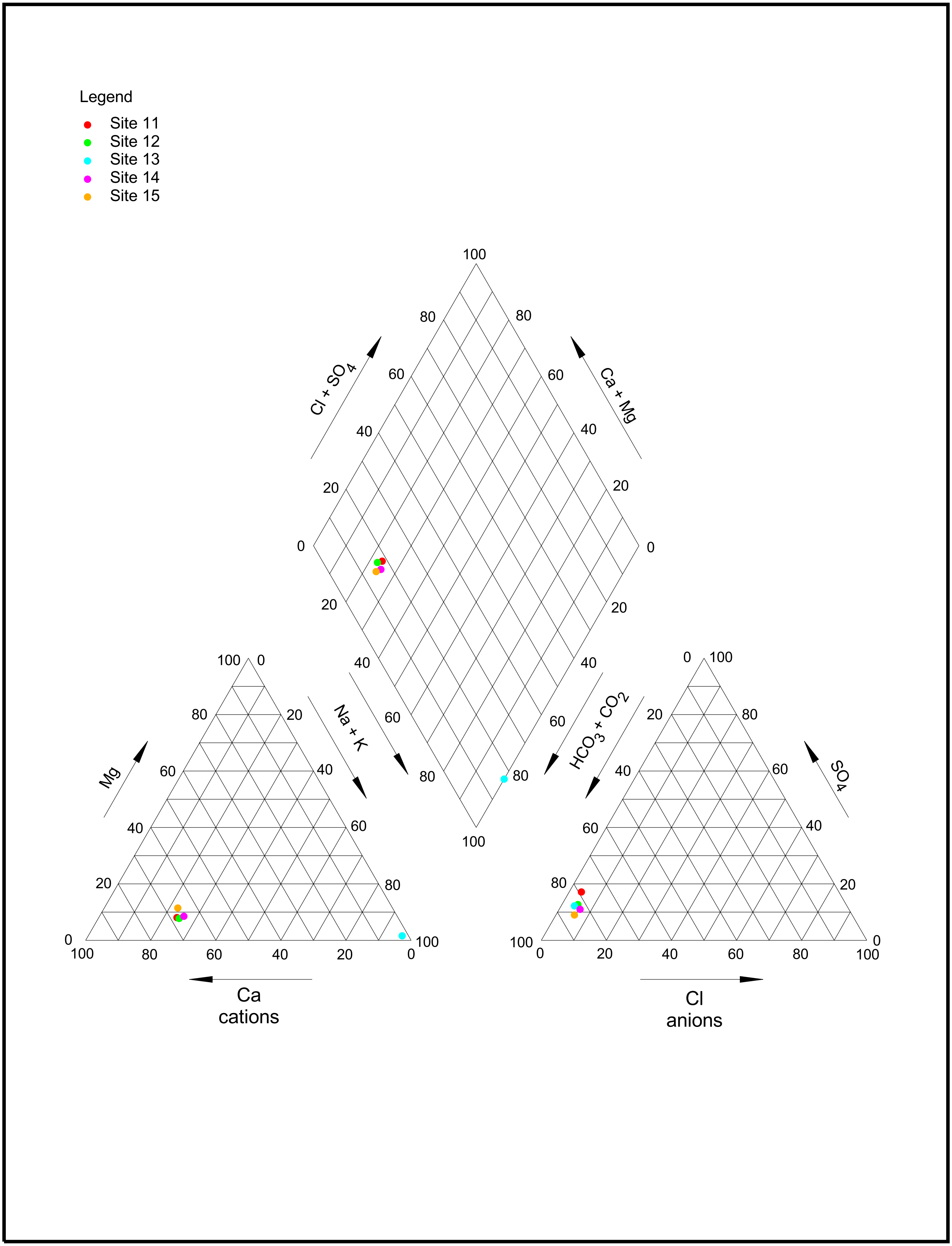
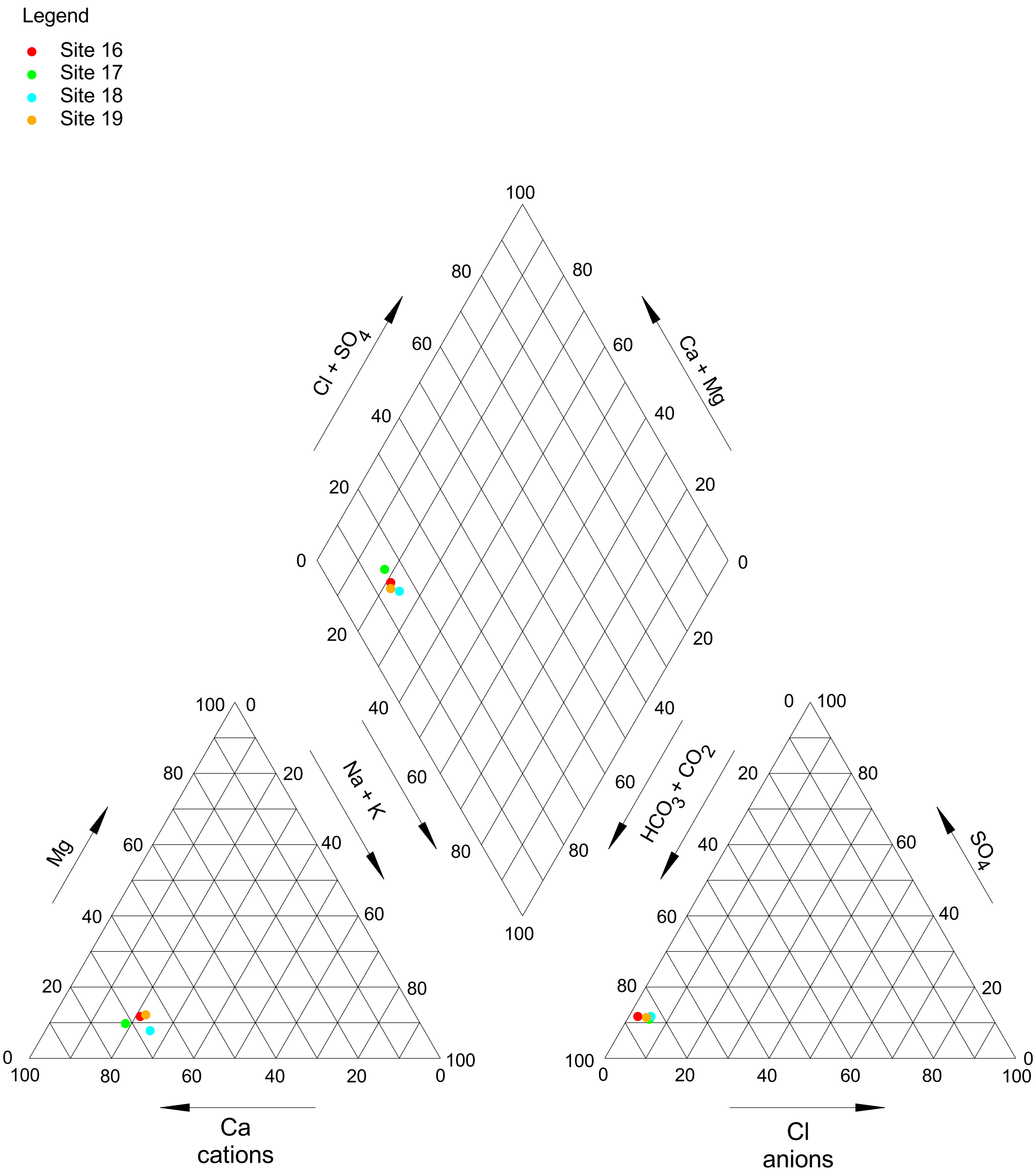
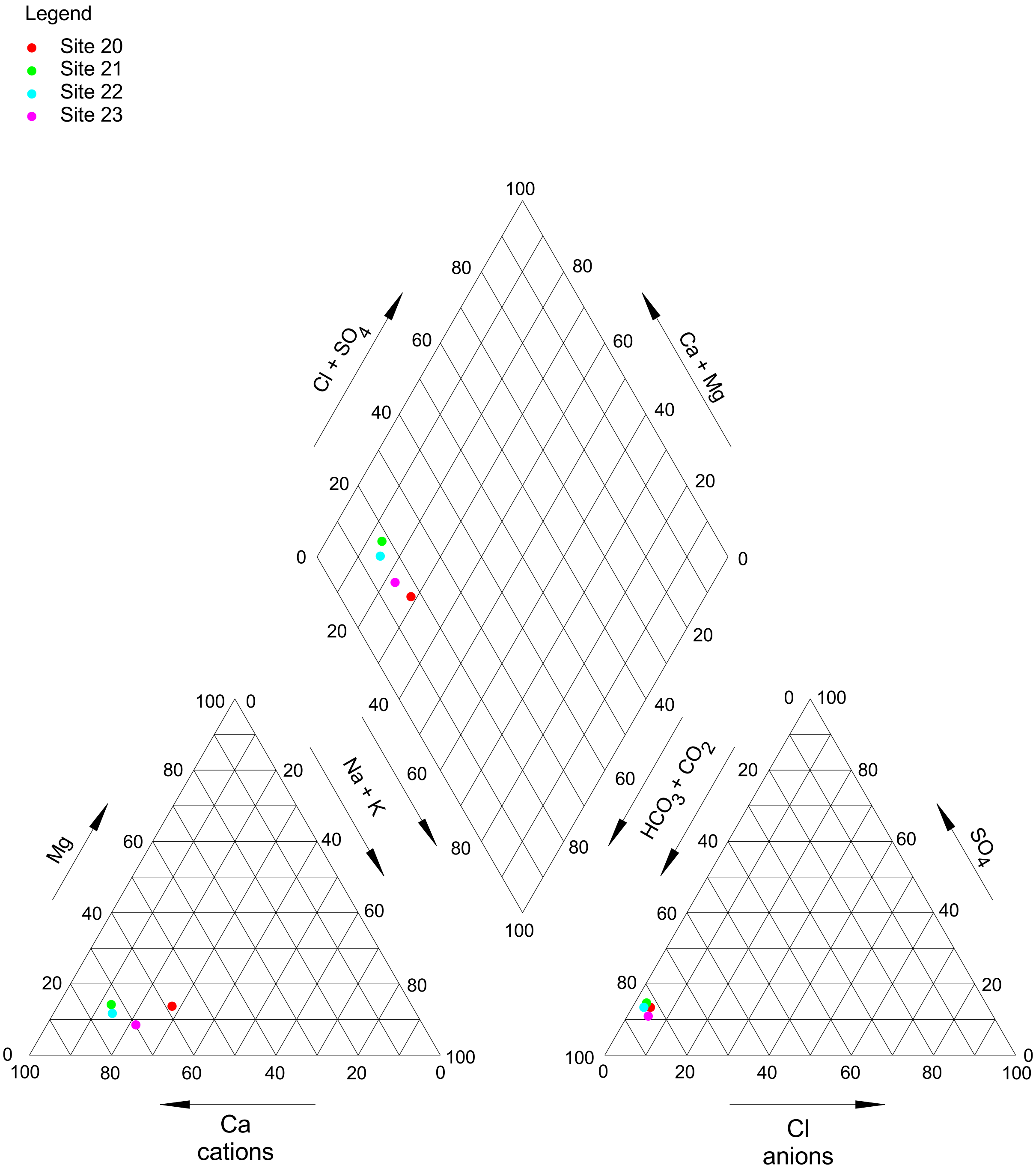
North Albuquerque Acres, Bernalillo County, New Mexico
Trilinear Diagram of Water Chemistry - Sites 6-10
Figure 5



North Albuquerque Acres, Bernalillo County, New Mexico
Trilinear Diagram of Water Chemistry - Sites 11-15
Figure 6



North Albuquerque Acres, Bernalillo County, New Mexico
Trilinear Diagram of Water Chemistry - Sites 16-19
Figure 7



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North Albuquerque Acres, Bernalillo County, New Mexico
Trilinear Diagram of Water Chemistry - Sites 20-23
Figure 8

hydrochemical facies. It should be noted that many of the cation-anion balances were off by greater than 5% and as much as 8.2%. The typical acceptable analytical error is <5%. Therefore, it seems likely that there are anions that are major components of the water chemistry and were not part of the analyses. A summary of the Cation/Anion balance in milliequivalents per liter is provided in Table 7.

Six samples contained arsenic values above the laboratory detection limit of 2 µg/L. The highest of these was 46 µg/L (Site 2) and the average value of samples containing arsenic was 16 µg/L. Four wells exceeded the new EPA arsenic standard of 10 µg/L. These wells (Sites 1 through 4) are all clustered in the northwest corner of the study area (Figure 1). The reason for the high arsenic values in this area is not known. However, it may be that these wells are within the eastern limit of the stable axial channel deposits of the ancestral Rio Grande which could contain sediments with elevated arsenic levels.

Table 7. Cation and AnionBalance (meq/L)

Site and Location	Sodium mg/L	Potassium mg/L	Magnesium mg/L	Calcium mg/L	Chloride mg/L	Sulfate mg/L	Bicarbonate mg/L	Sodium meg/L	Potassium meg/L	Sodium + Potassium meg/L	Magnesium meg/L	Calcium meg/L	Chloride meg/L	Bicarbonate meg/L	Sulfate meg/L	SUMzmc SUMzma-	% from neutral	Total Cations meg/L	Total Anions meg/L
1.8600 Beverly Hills Ave.	28	2	3.4	44	14	39	130	1.22	0.05	1.27	0.28	2.20	0.39	2.13	0.81	0.41	5.75	3.74	3.34
2. 7921 Beverly Hills Ave.	47	7	5.2	20	9.4	36	140	2.04	0.18	2.22	0.43	1.00	0.27	2.29	0.75	0.34	4.89	3.65	3.31
3. 8401 Florence Ave.	33	4.6	5.7	30	22	32	130	1.44	0.12	1.55	0.47	1.50	0.62	2.13	0.67	0.10	1.47	3.52	3.42
4. 8501 San Diego Ct.	30	1.9	3.4	35	15	33	120	1.30	0.05	1.35	0.28	1.75	0.42	1.97	0.69	0.30	4.69	3.38	3.08
5. 9905 Desert Mt. Rd	27	1.6	7.3	43	7.7	27	180	1.17	0.04	1.22	0.60	2.15	0.22	2.95	0.56	0.23	3.02	3.96	3.73
6. 10200 Elena Dr.	23	1.4	5	48	5.4	22	170	1.00	0.04	1.04	0.41	2.40	0.15	2.79	0.46	0.45	6.17	3.84	3.40
7. 10420 Signal Ave.	22	1.1	2.9	35	5.3	18	140	0.96	0.03	0.99	0.24	1.75	0.15	2.29	0.37	0.15	2.62	2.97	2.82
8. 10421 Oakland Ave	19	110	0.05	0.3	6.2	22	150	0.83	2.81	3.64	0.00	0.01	0.17	2.46	0.46	0.57	8.41	3.66	3.09
9. 10710 San Bernardino	18	1.3	3.8	44	5.1	17	150	0.78	0.03	0.82	0.31	2.20	0.14	2.46	0.35	0.37	5.87	3.32	2.96
10. 10801 Elena Dr.	26	1	4.7	42	7	26	150	1.13	0.03	1.16	0.39	2.10	0.20	2.46	0.54	0.44	6.47	3.64	3.20
11. 11009 Del Rey Ave.	19	0.98	3.3	43	5.7	19	140	0.83	0.03	0.85	0.27	2.15	0.16	2.29	0.40	0.42	6.83	3.27	2.85
12. 11110 Palomas Ave.	17	1	3.7	47	5.2	18	150	0.74	0.03	0.77	0.30	2.35	0.15	2.46	0.37	0.44	6.80	3.41	2.98
13. 11101 Anaheim Ave.	3.6	130	<0.05	<0.1	4.9	17	150	0.16	3.32	3.48	0.00	0.00	0.14	2.46	0.35	0.53	8.26	3.48	2.95
14. 11100 Wilshire Ave.	17	1.2	3.8	46	5.1	18	160	0.74	0.03	0.77	0.31	2.30	0.14	2.62	0.37	0.24	3.64	3.38	3.14
15. 11120 Wilshire Ave.	17	1.2	3.9	44	5	17	160	0.74	0.03	0.77	0.32	2.20	0.14	2.62	0.35	0.17	2.65	3.29	3.12
16. 11304 Oakland Ave.	16	1.1	4.4	47	4.7	15	160	0.70	0.03	0.72	0.36	2.35	0.13	2.62	0.31	0.36	5.61	3.43	3.07
17. 11424 Pino Ave.	15	1.1	4.2	50	5.3	17	150	0.65	0.03	0.68	0.35	2.50	0.15	2.46	0.35	0.56	8.63	3.52	2.96
18. 11601 San Rafael Ave.	16	1.1	3.4	42	5.1	17	150	0.70	0.03	0.72	0.28	2.10	0.14	2.46	0.35	0.14	2.37	3.10	2.96
19. 11600 Oakland	16	1.3	4.6	48	4.8	16	170	0.70	0.03	0.73	0.38	2.40	0.14	2.79	0.33	0.25	3.68	3.50	3.25
20. 11905 Oakland	21	0.85	4.4	37	5.3	16	140	0.91	0.02	0.94	0.36	1.85	0.15	2.29	0.33	0.37	6.19	3.14	2.78
21. 12501 Corondado Ave.	14	1.2	8.2	66	5.7	28	200	0.61	0.03	0.64	0.67	3.29	0.16	3.28	0.58	0.59	6.80	4.61	4.02
22. 12500 San Francisco	14	1.2	6.6	64	5.3	21	190	0.61	0.03	0.64	0.54	3.19	0.15	3.11	0.44	0.68	8.37	4.38	3.70
23. 11212 Wilshire Ave.	16	1.3	3.8	48	5.1	17	160	0.70	0.03	0.73	0.31	2.40	0.14	2.62	0.35	0.32	4.84	3.44	3.12

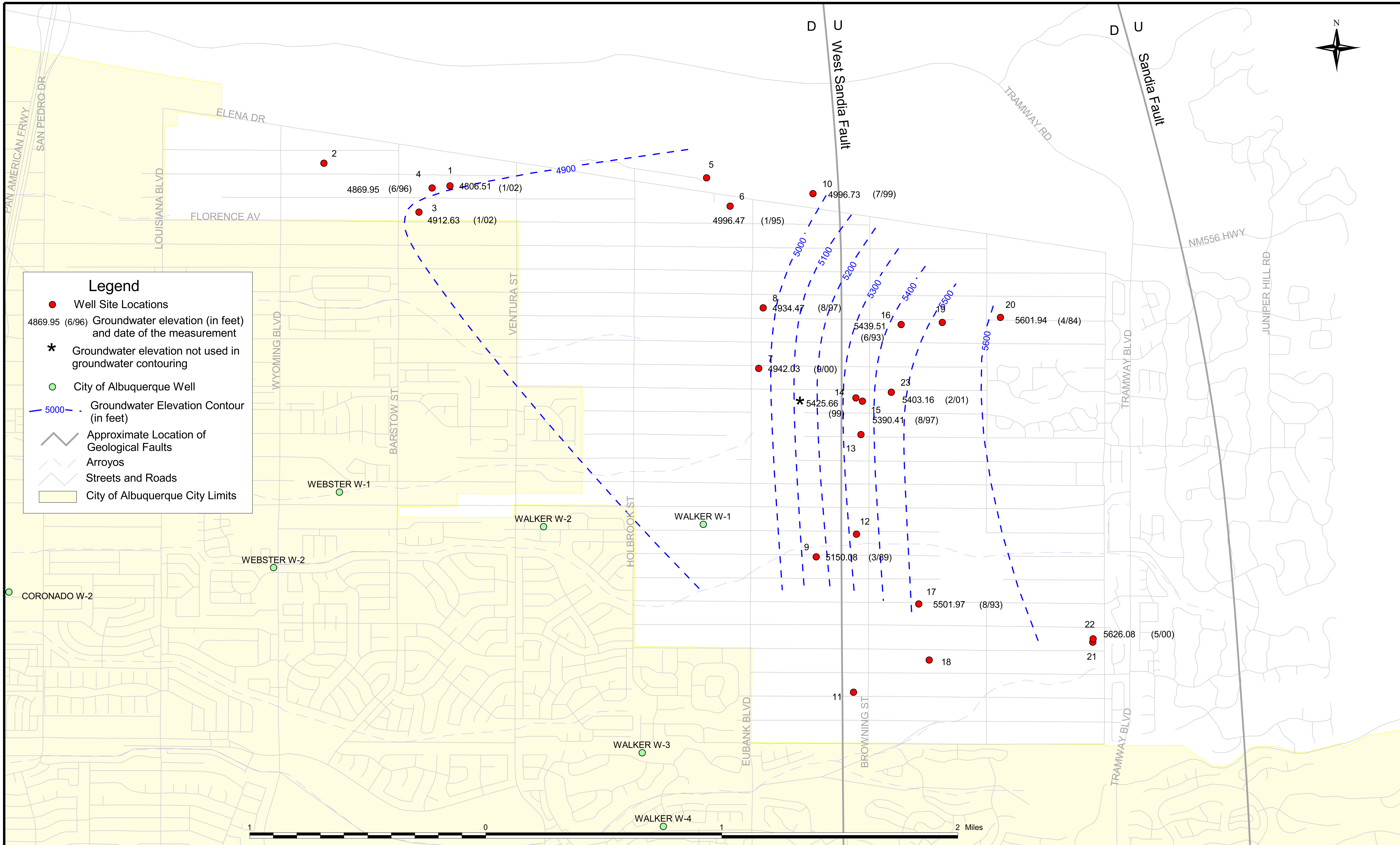
Note: meq/L = (mmol of solute * valence state)/(1 Liter of solution)

Section 4
Hydrogeologic Analysis

As part of this study, depth to groundwater measurements were made whenever possible and top of casing elevations were collected using a Starlink Invicta® 2105 APS receiver. However, due to the presence of the pumps, pumping, and power cords and the small diameter (generally 4 in.) of the wells, only three measurements were successfully made. These data were augmented with the depth to groundwater measurements collected upon completion of the wells and prior to the installation of the pumps, recorded on the Office of the State Engineer (OSE) well records (Appendix C) in order to generate a groundwater gradient map (Figure 9). Groundwater flow is generally to the west; however, flow in the southwestern portion of the study area appears to hydraulically influenced by the pumping of the City of Albuquerque Webster and Walker well fields. The calculated hydraulic gradient across the study area is approximately 0.04 ft/ft. However, much of the drop in water table elevation occurs across the west Sandia Fault where groundwater elevation are at least 350 feet lower on the down thrown side of the fault. The depth to groundwater in the study area ranges from 355 ft. to 830 ft. with an average depth to groundwater of approximately 576 feet below surface grade (bsg). The location, elevation and depth to groundwater data are included in Appendix D.

The average well yield of the study wells based on estimates recorded on the OSE well records was 17 gallons/minute (gpm). CDM did not locate data on aquifer testing performed on wells in the NAA. However, values are available for the Webster well field (City of Albuquerque) located just outside the boundaries of the study area (Figure 9). The Webster well field is completed through both the Upper and Middle Santa Fe Group. The transmissivity of the two Webster wells (Webster 1 & 2) were estimated as 42,080 ft^2/day and 19,970 ft^2/day (Thorn et al., 1993), respectively. The hydraulic conductivity can then be estimated by dividing the transmissivity by the screen lengths (725 and 726 ft.) to obtain values of 58 ft/day and 28 ft/day.

No geologic cross-section could be generated based on the lithology descriptions on the OSE well logs. Because the borehole logs are generated by a variety of individuals, the inconsistency of the descriptions are such that no correlations could be made. It should be noted that only seventeen of the twenty-three well logs could be located. The names of all participants were entered into the OSE database, however some of the residents did not register as having water rights and therefore no well log was available under these residents' name. It seems likely that many of the well logs are filled under the names of the original property owners.



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CDM

North Albuquerque Acres, Bernalillo County, New Mexico
Groundwater Contours
Figure 9

Section 5
Conclusions and Recommendations

In general, water quality in the NAA is good. None of the collected samples exceeded NMWQCC groundwater standards for any of the tested analytes. The general chemistry is very consistent across the study area and the waters are of the calcium and bicarbonate hydrochemical facies. Groundwater is encountered at an average depth of 576 feet bsg and generally flows west at a gradient of 0.04 ft/ft. Based on the nitrate data it appears that most of the nitrate is being denitrified in the thick vadose zone or the that solute front has not reached the groundwater in most places. Four samples exceed the new, but not currently implemented, EPA arsenic standard of 10 μg/l. These four samples were spatially confined to the northwest corner of the study area.

Given that several samples were in excess of two times the new arsenic standard, CDM recommends that the BCEHD conduct additional sampling of domestic wells in the area to delineate the extent of the elevated arsenic in groundwater. At the conclusion of the additional sampling BCEHD will be able to make recommendations to residents regarding point of use treatment systems. Additionally, these data would be valuable in determining locations for potential water supply wells if Bernalillo County decides to install utilities in the NAA.

In order to gain an understanding of the overall fate of nitrates in the subsurface, the fate and transport processes in the vadose zone must be examined further. CDM suggests that a plan be developed in which several boreholes using direct push technologies are advanced and continuously sampled and analyzed at 5 or 10 foot intervals for ammonia, TKN, nitrate, nitrite and nitrogen gas. This could be accomplished using systems such as the Vertek Cone Penetrometer (CPT) systems that have up to 40 ton push capacities and should be able to achieve the necessary depth of penetration. The data obtained in such an investigation would yield a nitrate concentration vs. depth profile. This profile would provide valuable insight as to the fate and transport of nitrate in the subsurface.

Data from a vadose zone nitrate study could then be used to modify and extend the groundwater model for the Sandia Heights (Hall, 1999) to include the North Albuquerque Acres. Additionally, a regularly scheduled groundwater monitoring program should be developed in order to determine whether nitrate concentrations are increasing. CDM suggests that at least five of the sites used in this study be sampled for nitrate and bacteriological quality on an annual basis.

Section 6
References

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Appendix A
Field Notes

Appendix B
Lab Reports

Appendix C
OSE Records

Appendix D
Location and Elevation Data