Special Publication SJ 89-SP3

GROUND WATER QUALITY RECONNAISSANCE OF THE BULL CREEK WILDLIFE MANAGEMENT AREA

OSCEOLA COUNTY, FLORIDA

St. Johns River Water Management District
Palatka, Florida

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INTRODUCTION

On October 31, 1988, the South Brevard Water Authority (Authority) requested the St. Johns River Management District (District) assist the Authority in the evaluation of the water supply potential of the Bull Creek Wildlife Management Area.

Pursuant to the request from the Authority, on November 16, 1988, the District and the Authority entered into an agreement, providing for the performance of a groundwater quality reconnaissance study of the Floridan aquifer on the Bull Creek Wildlife Management Area. A copy of the agreement is included in Appendix A.

The agreement sets forth several tasks to be performed by the District in order to provide baseline hydrogeological data. These tasks included the construction and geophysical logging of Floridan aquifer observation wells, collection and analysis of water samples, performance of specific capacity tests on the observation wells, and preparation of a descriptive report.

This report contains the results of the work performed pursuant to the November 16, 1988, agreement. The report is organized into sections describing well construction, hydrogeology, and water quality for the study area. Results of the specific capacity tests, lithologic logs, and geophysical logs for each well are indexed by well number (tabs one through five) in the well data section. The information contained in this report will be valuable in determining the appropriate steps necessary to further evaluate the water supply potential of the Bull Creek Wildlife Management Area.

The Bull Creek Wildlife Management Area consists of 22,206 acres of land which is owned by the St. Johns River Management District. This parcel of land is located near Deer Park in eastern Osceola County, directly south of U.S. 192 (Figure 1). The property is managed by the Florida Game and Freshwater Fish Commission as a public hunting area.

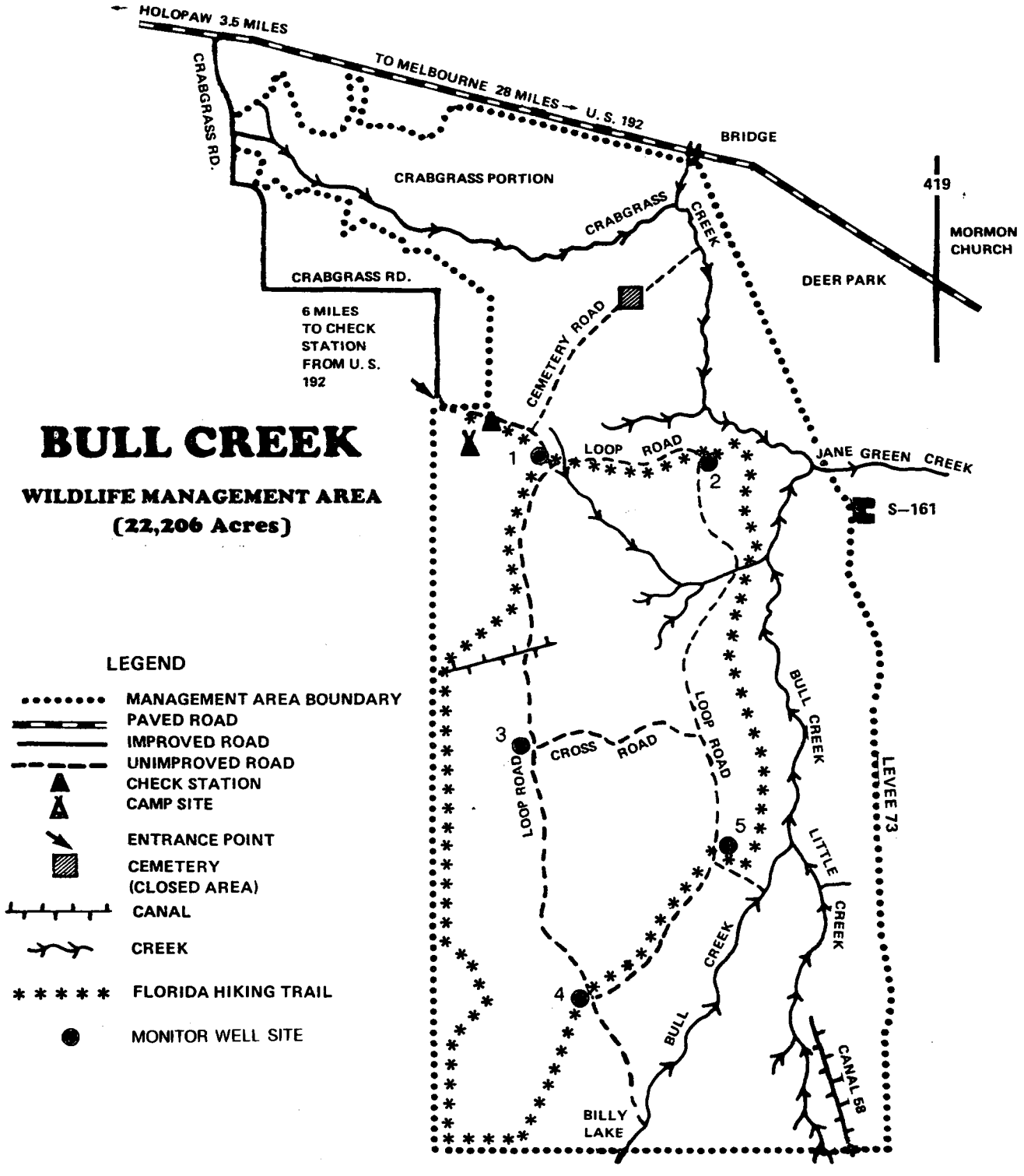


Figure 1. Location and boundaries of the Bull Creek Wildlife Management Area

CONSTRUCTION OF OBSERVATION WELLS

Five observation wells are located around the perimeter of the loop road in the Bull Creek Wildlife Management Area at the locations indicated on Figure 2. A sixth well is located on the east side of Crabgrass Road, just north of Crabgrass Creek, in the extreme northwest portion of the property. The wells were constructed using standard mud and air rotary drilling methods. In each well, a 12-inch diameter bore hole was drilled to approximately 140 feet below land surface. Eight-inch diameter PVC casing was set in the bore hole and cemented to land surface. This portion of each well cases off undifferentiated materials, primarily sand and shell, overlying the Hawthorn Group.

Subsequent to installation of the eight-inch diameter PVC casing, a seven and seven-eighths inch diameter bore hole was drilled through the Hawthorn Group into the top of the Floridan aquifer. In wells 1 through 5, approximately 240 feet of 4-inch diameter PVC casing was set in each bore hole and cemented to land surface. The sixth well has 370 feet of four-inch casing.

After penetrating the top of the Floridan aquifer, the wells were drilled by the reverse air rotary method. Each well was completed with a three and seven-eighths inch diameter bore hole. Total depth of the wells varies between 380 and 780 feet below land surface. The open hole section of each well is designed to monitor the Upper Floridan aquifer.

Throughout drilling, lithologic samples were collected at twenty-foot intervals. A complete description of the lithologic samples from the open hole section of each well is included in the well data section of this report. During reverse air drilling, field measurements of conductivity and temperature were made every twenty feet. Water quality samples were also collected during this phase of drilling. Upon completion of drilling, each observation well was geophysically logged. The logs are included in the well data section of this report.

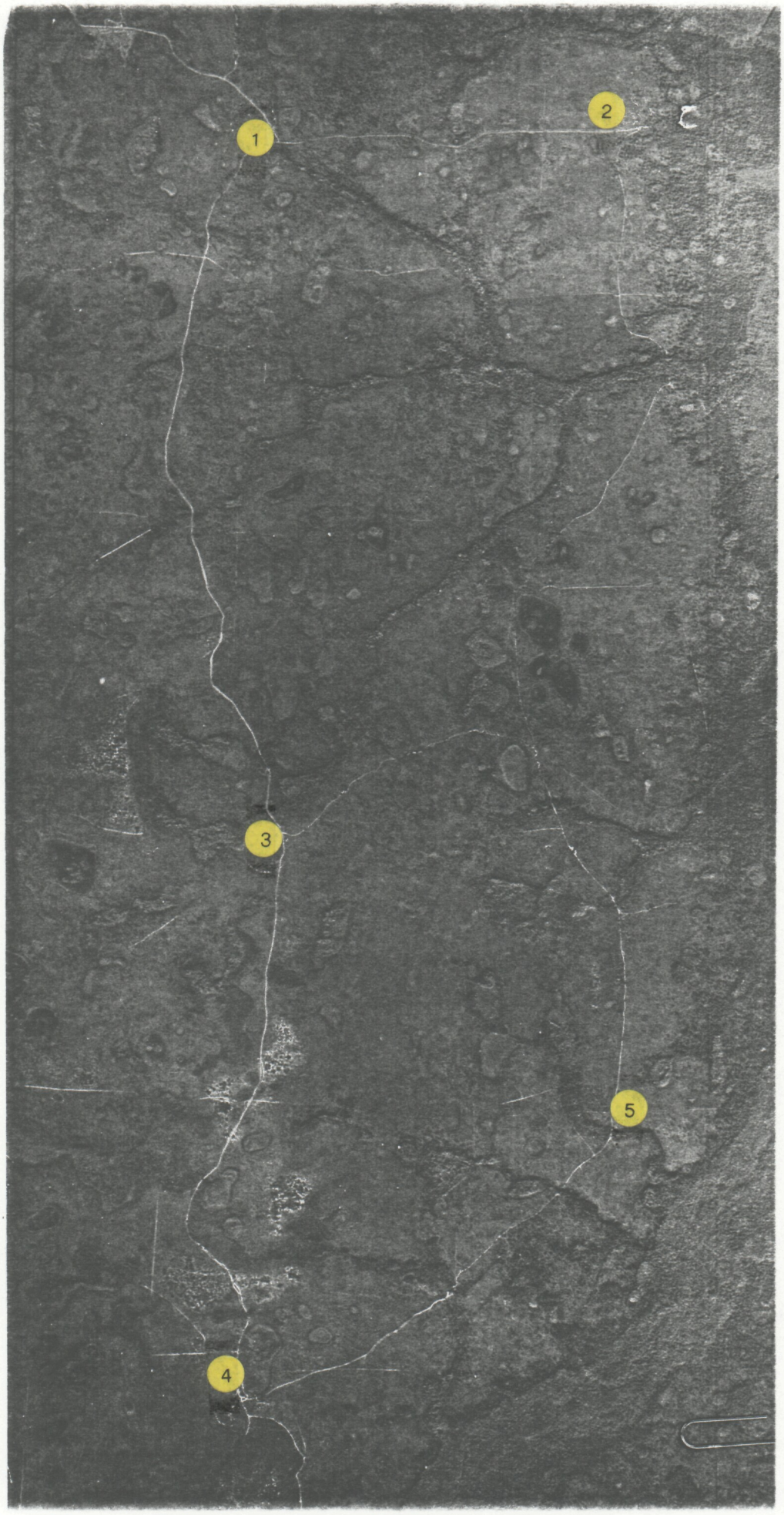


Figure 2. Location of observation wells

HYDROGEOLOGY

The surficial deposits at the Bull Creek Wildlife Management Area consist of sand, silt, and shell extending from land surface to a depth of about 100 feet below land surface. A predominantly shell zone is present throughout the Bull Creek Wildlife Management Area at depths of between 30 feet and 100 feet below land surface. The shell zone is permeable and is the source of domestic water supplies in the area.

Underlying the surficial deposits are the sediments of the Miocene age Hawthorn Group. The Hawthorn consists primarily of highly phosphatic clays with lesser amounts of silt, sand, and limestone. Thickness of the Hawthorn ranges from 80 to 100 feet in wells 1 through 5 to 200 feet in well 6

Limestones of Eocene age underlie the Hawthorn Group. In wells 1 through 5, the top of the Ocala Limestone ranges from 200 to 240 feet below land surface and has an average thickness of 135 feet. In these wells the contact between the Avon Park Limestone and the Ocala Limestone ranges from 320 to 380 feet below land surface as indicated by the drill cuttings and geophysical logs. The two limestone units are generally considered to be the Upper Floridan aquifer. In a significant departure from what was encountered in the other observation wells, the Ocala limestone does not appear to be present at well 6. The entire open hole section of the well appears to be open to the Avon Park Limestone. The well terminates in extremely hard dolomite that has little or no primary porosity.

Water in the Upper Floridan aquifer at the Bull Creek Wildlife Management Area is under artesian pressure. In April 1989, static water levels ranged from five and one-half feet above land surface in Well 2 to more than 23 feet below land surface in Well 4. The movement of water into the open bore hole as shown by the flow meter logs indicates the upper 20 to 40 feet of the Ocala Limestone contributes a major portion of the total flow.

Pump tests were conducted at each observation well. The tests were conducted with either a four-inch centrifugal or four-inch submersible pump. Each well was pumped for a period of one hour at a constant rate in order to determine the specific capacity. A step-drawdown test was also conducted on wells 1 and 6 in order to determine the specific capacity at various pumping rates.

Following a method described by Brown the specific capacity data was used to estimate the transmissivity. For the analysis, a storage coefficient of 2.0×10^{-4} and a pumping period of one day was assumed. Estimated transmissivity values for the wells vary between 10,000 and 50,000 gallons per day per foot as

depicted in Figure 3. Complete specific capacity test data for each well is included in the well data section.

A specific capacity test run on well 6 with a four-inch submersible pump yielded a result of five gallons per minute per foot of drawdown. Using Brown's method, transmissivity is estimated to be 13,000 gallons per day per foot. Estimated specific capacity and transmissivity values from well 6 are within the range of values determined for the other observation wells. However, it should be noted that the estimated transmissivity values for all wells are conservative and may underestimate actual values. Well losses are believed to account for a substantial portion of the drawdown observed in the pumped wells and actual drawdown in the aquifer is most likely less than that measured in the well.

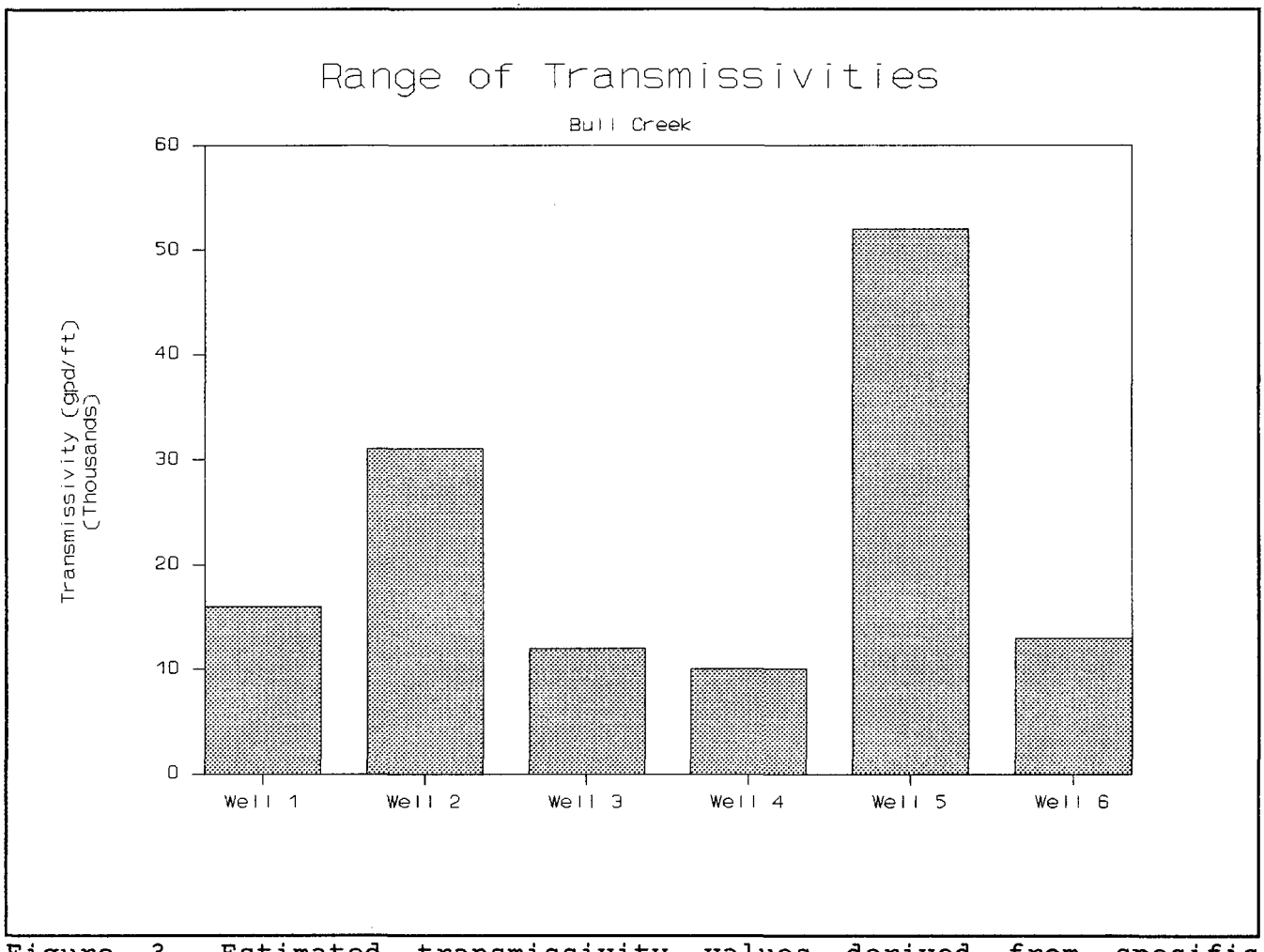


Figure 3. Estimated transmissivity values derived from specific capacity tests.

WATER QUALITY

Detailed water quality information, specifically chloride concentration of the Upper Floridan aquifer within the Bull Creek Wildlife Management Area, was not available prior to this study. Figure 4 represents the most current information available from the computer files of the U.S. Geological Survey through 1988. This data was computer plotted to generate a map of chloride concentration for the study area.

In order to better define the horizontal and vertical variation in the quality of the ground water, water samples were collected during the reverse air drilling phase of the six upper Floridan aquifer observations wells. The samples were analyzed for Cl^- SO_4, alkalinity, Na, K, Ca, Mg, Fe, Sr, SiO_2, total dissolved solids (TDS), hardness, and conductivity. (Table 1). Samples were also collected during the specific capacity test and later sampled with a downhole sampler. Table 1 summarizes the water quality analysis.

Geochemical pattern analyses (Piper, 1944; Frazee, 1982) performed using the results of the water quality analyses (Figure 5) of the drill stem samples (Wells 2 and 6) indicated that ground water in the Upper Floridan aquifer in the northeastern and northwestern portions of the property has water quality characteristics similar to connate and relic sea water. The analysis of water collected from the southern portion of the property (Wells 4 and 5) also has characteristics similar to connate water. The quality of water collected from depths greater than 280 feet below land surface in Wells 1 and 3 in the western portion of the property has characteristics typical of a mixture of fresh and connate water, often referred to as transitional water. The analyses of water collected at depths less than 280 feet below land surface in Well 3 indicates the presence of fresh recharge water. Calcium and bicarbonate are the dominant ions in recharge waters (Well 3). In connate and relic seawater, sodium, chloride, and sulfate become the dominant ions (Wells 2, 4, 5, 6). Transitional waters (Well 1) have compositions between fresh recharge and connate water, and result from various mixtures of the two.

The water quality analyses indicate that water quality in the Floridan aquifer at the Bull Creek Wildlife Management Area improves in a narrow band along the western boundary of the property. Chloride concentrations in excess of 250 mg/l are present in the eastern and extreme northwestern portions of the property, but decrease to about 100 mg/l in the western portion (Figure 6).

Additional diagrams of the water quality for each well are included in Appendix B.

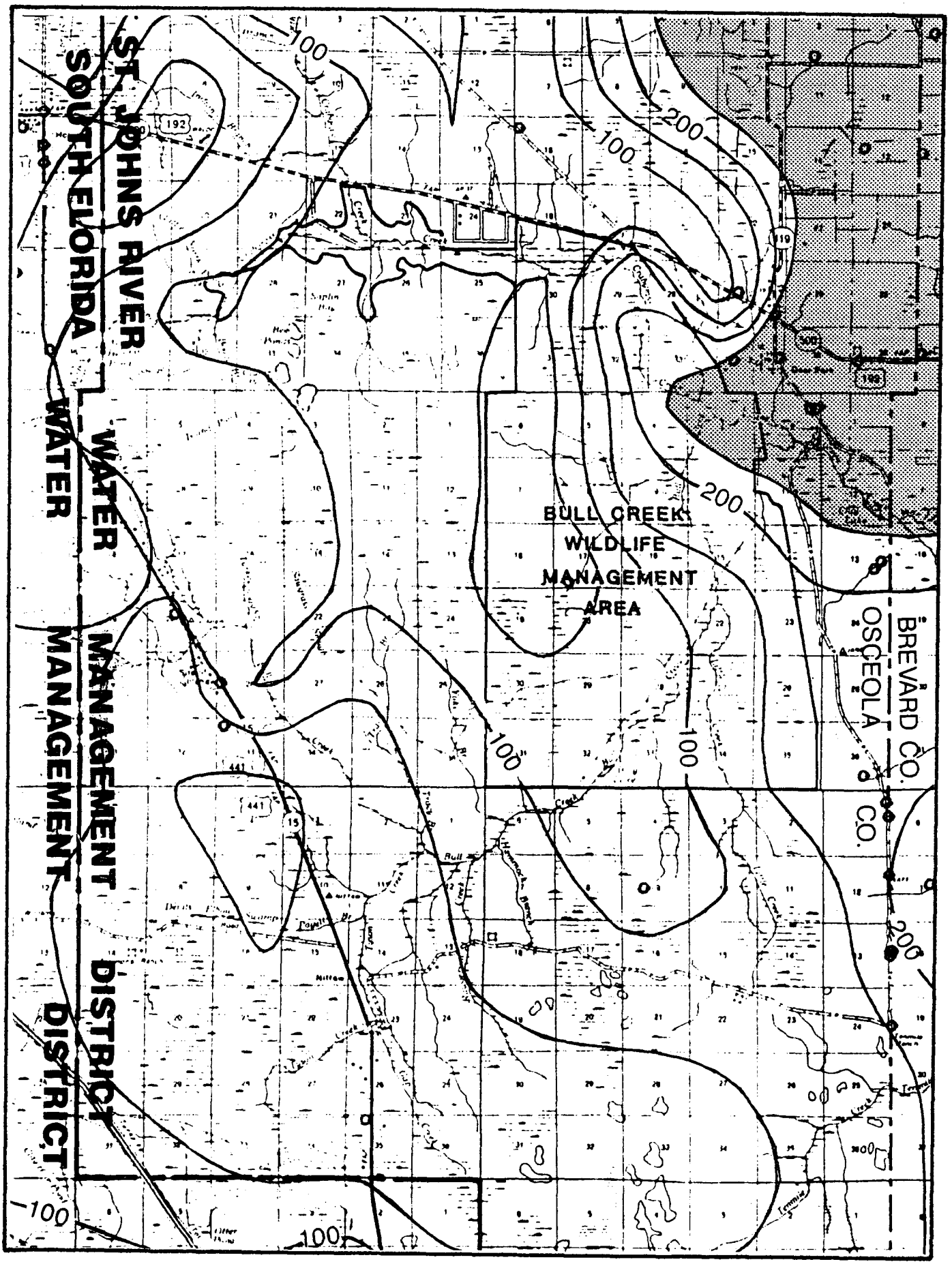


Figure 4. Chloride content of water in the Upper Floridan aquifer plotted from data available through 1988

Table 1. Geochemical analyses for wells at Bull Creek

Sample	Sample #	Depth	Concentration (mg/l) Cl	SO_4	*ALK	HCO_3	Na	K	Ca	Mg	Fe	Sr	Si_2O	TDS	Hardness (mg/L)	Cond (umhos/cm)
Bull Creek #1		240	78	31			41	6.6	18	9.6	<.05	0.35	34	460		
		240[4]	89	7	204	249								400		
		260	83	22			41	3.9	51	12	.116	0.60	51	369		
		280	89	55			44	5.8	21	4.4	.071	0.34	41	286		
		360	88	25									56	303		
	1	480	90	31	164	200	47	2.8	50	14	<.05	1.09	-	372		-
	2	600	86	17	123	150	48	3.2	31	11.2	<.05	0.80	58	297		-
		600[4]	90	6	259	316								372		
(pumping)			94	6	201	245	47	2.5	60	15.2	-		62	368	216	
Bull Creek #2		220[4]	313	55	111	135								638		
	3	240	419	73	228	278	220	8.8	54	29.6	<.05	4.29	31	765		1500
	4	380	328	64	147	179	144	4.4	61	34	.182	4.38	26	665		1290
(pumping)			333	70	110	134	144	4.7	58	32	-		32	604	278	
Bull Creek #3		240[4]	78	4	193	235								348		
	5	260	59	5	230	281	25	2.9	40	34	<.05	2.36	116	341		543
		270[4]	74	4	215	262								362		
	6	280	71	2	230	281	37	2.5	58	28	.063	1.47	97	377		-
		385	40	5												
		390	78	4	219	267								402		
	7	400	78	4	196	239	41	6.2	54	25	3.42	1.24	85	385		-
(pumping)			75	6	203	248	39	2.8	72	24.8	-		96	378	236	

			Concentration (mg/l)													
Sample	Sample #	Depth	Cl	SO_4	*ALK	HCO_3	Na	K	Ca	Mg	Fe	Sr	S_iO_2	TDS	Hardness (mg/L)	Cond (umhos/cm)
Bull Creek #4		250[1]	149	34												
		2	168	31												
		3	225	47	154	188								606		
	8	280	211	54	73	89	104	4.6	51	14	<.05	0.96	50	521		620
		4	225	42	171	209								528		
		385	201	43												
		3	234	53	112	137								532		
		390[4]	193	34	158	193								482		
	9	400	239	58	110	134	108	8.2	68	1.2	<.05	1.44	38	499		644
(pumping)			235	44	132	161	100	5.2	72	14.4	-		35	336	240	
Bull Creek #5		260	300	58	98	120							27	588		1070
		270[4]	216	54	130	159								528		
		300	296	52	93	113							40	597		971
	A	300	298	57	47	57	132	10	71	10.8			23	574	170	
		380[4]	207	47	126	154								488		
	B	400	269	54	113	138	116	5.7	55	22.4			37	561	226	
(pumping)			282	51	122	149	128	3.6	76	17.2	-		33	644	268	

			Concentration (mg/l)												Hardness	Cond
Sample	Sample #	Depth	Cl	SO_4	*ALK	HCO_3	Na	K	Ca	Mg	Fe	Sr	S_iO_2	TDS	(mg/L)	(umhos/cm)
Bull Creek #6	C	400	109	46	47	57	56	14	31	30		4.12	24	296	92	
	D	420	242	47	83	101	108	10	33	30		2.54	60	645	204	
		460	225		142	173							45	555	258	
	E	560[5]	307	61	126	154	172	7.6	61	7		2.23	36		186	1150
	F	700[6]	373	69	94	115	120	7.2	31	30.4		2.49	35		278	1400
		770[7]	336	62	119	145	142	6.6	58	31.2			36			1180

*Concentration expressed as mg/l of $CaCO_3$

[1]Date = 4/5/89 time = 1520 hours

[2]Date = 4/6/89 time = 1130 hours

[3]Date = 4/20/89 Down Hole Sample

[4]Date = 4/24/89 Down Hole Sample

[5]Ph = 8.7

[6]Ph = 8.2

[7]Ph = 7.9 Down Hole Sample

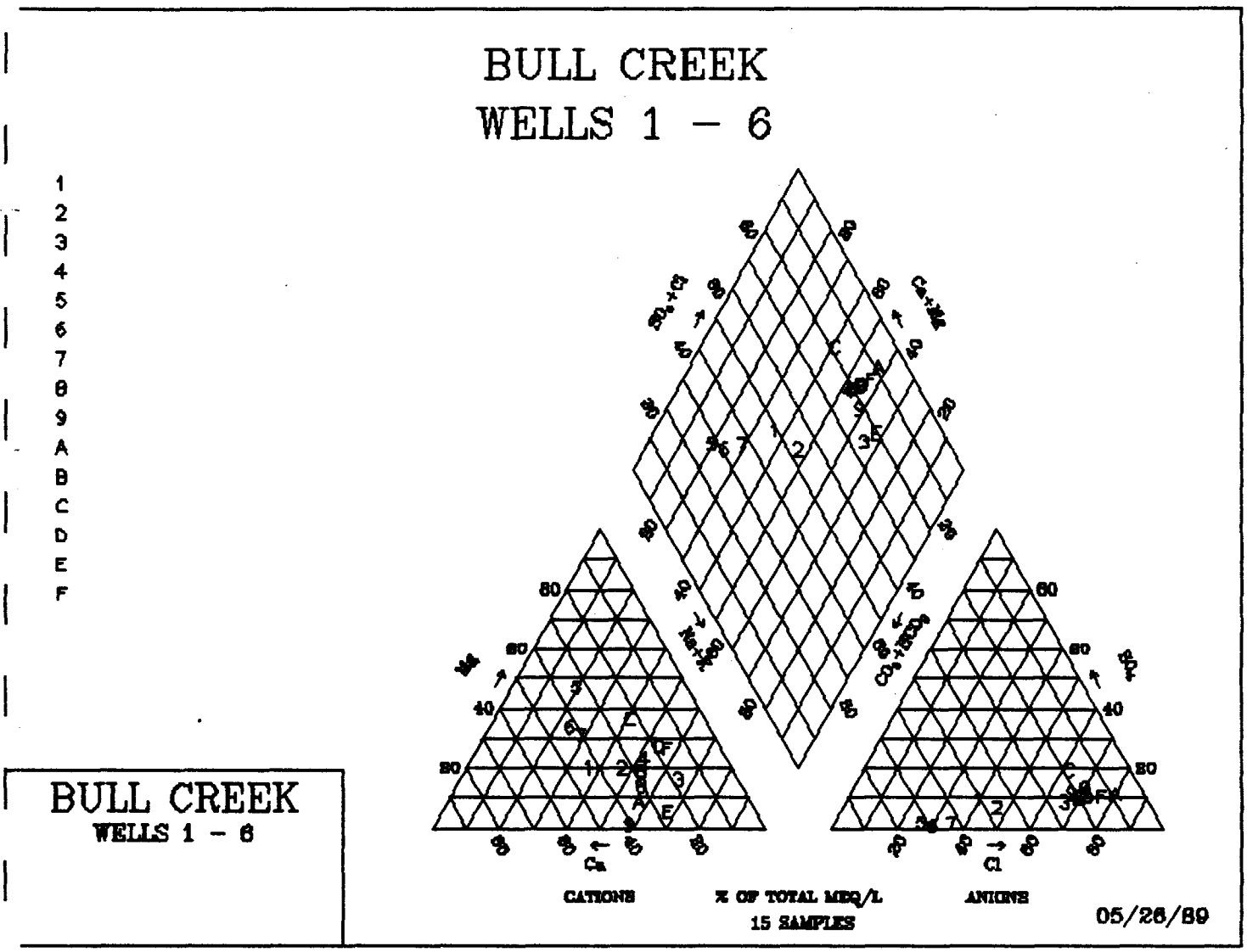


Figure 5. Piper trilinear diagram of water quality analysis of drill stem samples

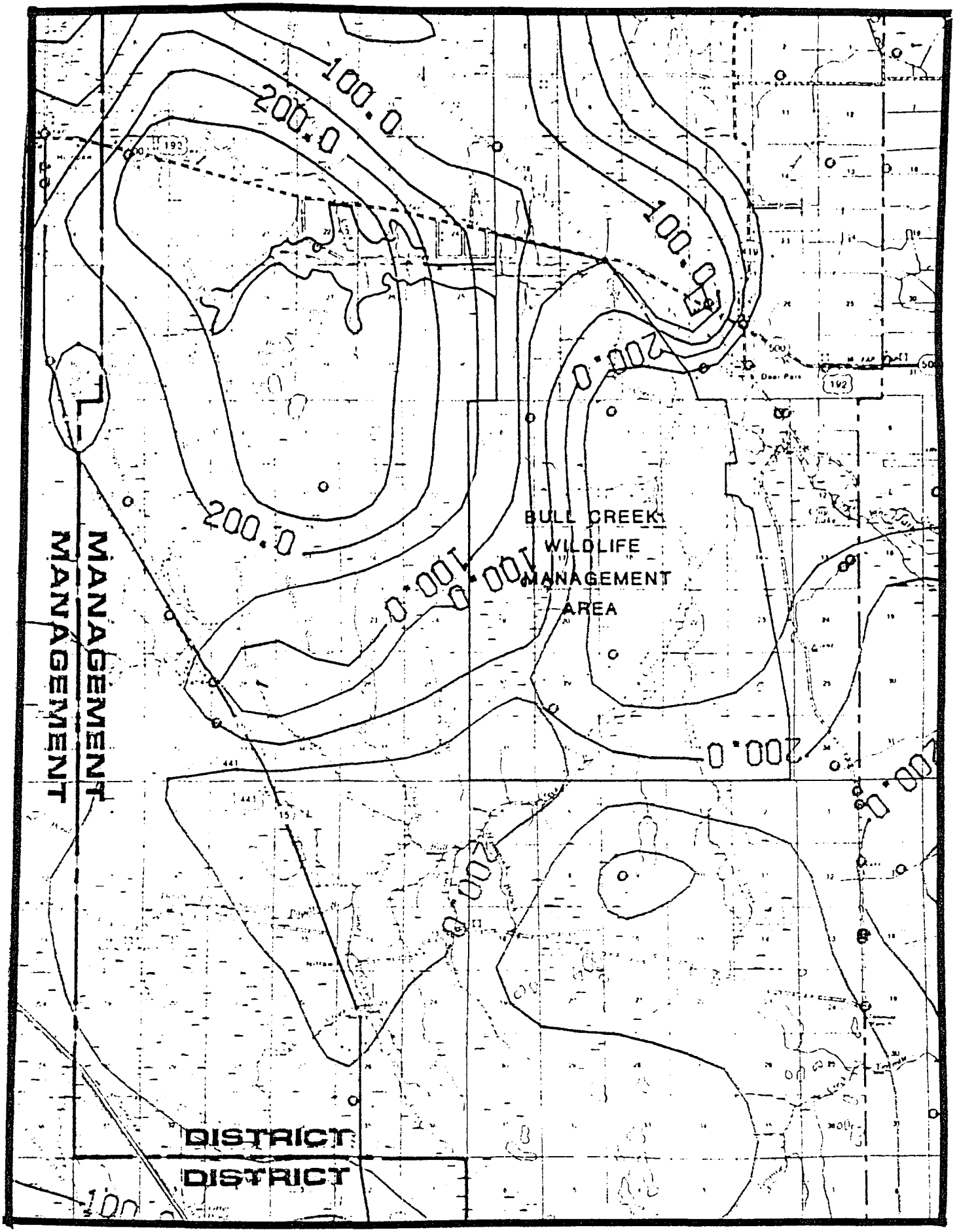


Figure 6. Chloride content of the Upper Floridan aquifer as modified by the addition of the data collected at Bull Creek

SUMMARY AND CONCLUSIONS

The St. Johns River Water Management District and the South Brevard Water Authority cooperated in the performance of a water quality reconnaissance study of the Floridan aquifer at the Bull Creek Wildlife Management Area. This study was performed pursuant to a November 16, 1988 agreement between the District and the Authority.

The surficial aquifer within the Bull Creek Wildlife Management Area is composed of sand, silt, and shell and is the source of domestic water supply in the area. This aquifer could supplement Upper Floridan aquifer withdrawals, but its water supply potential cannot be accurately assessed without additional testing.

Wells constructed as part of this study penetrated the Ocala and Avon Park Limestones. The limestones together are generally considered to be the Upper Floridan aquifer. Flowmeter logs of wells 1 through 5 show that a major portion of the water contributed to the open bore hole is derived from the upper 20 to 40 feet of the Ocala Limestone. The Ocala limestone does not appear to be present at well 6 and the well is only open to the Avon Park Limestone. Values of transmissivity for the upper 200 feet of aquifer penetrated were calculated from specific capacity tests. These values ranged from 10,000 gallons per day per foot to 50,000 gallons per day per foot.

Water quality analysis of samples collected from the observation wells illustrate with greater detail the location of the 250 milligrams per liter chloride isochlor in comparison to previous data presented. Geochemical analysis indicates the Upper Floridan aquifer in the northwest and eastern portions of the property contains relic seawater and connate waters. The Upper Floridan aquifer in a narrow band along the western boundary of the property contains transitional and fresh recharge waters. Generally, water quality improves in a westerly direction across the Bull Creek Wildlife Management Area, but deteriorates with depth below land surface in all portions of the property.

REFERENCES

Brown, R. H. 1963. Estimating the transmissibility of an artesian aquifer from the specific capacity of a well, in Bental, Ray, Methods of determining permeability, transmissibility, and drawdown. Geological Survey Water Supply Paper 1536-I, p. 336-338.

Frazee, J. M., Jr. 1982. Geochemical pattern analysis: Method of describing the southeastern limestone regional aquifer system. In Studies of the Hydrogeology of the Southeastern United States: 1981, B. F. Beck. Special Publications: Number 1, Georgia Southwestern College, Americus, Georgia.

Piper, A. M. 1944. A graphic procedure in the geochemical interpretation of water analyses. Trans. Amer. Geophys. Union 25, pp. 914-923.

SITE - BULL CREEK

WELL NO. 1

DEPTH INTERVAL	LITHOLOGY DESCRIPTION
	In Ocala Limestone
300-320	Limestone, pelletal-skeletal (90% grains), very small forams, bryozoa, mollusc, loosely consolidated, good interparticular porosity, light brown color.
320-340	Limestone, pelletal-skeletal, as texture above, abundant echinoids, light-medium brown color.
340-360	Limestone, micritic-skeletal (25% grains), well consolidated, abundant Coskinolina and echinoids, fair interparticular porosity, medium-light brown color.
	Avon Park (?)
360-380	Limestone, skeletal-micritic (60% grains), calcarenite, dolomitic in places, great influx of individual forams (Dictyoconus Americanus(?), Coskinolina elongata, Quinqueloculina, etc.), micrite grains, poorly lithified, good interparticulate and moldic porosity, light-medium brown color
380-400	Limestone, as above but less Dictyoconus - more mullusks. CEMENT
400-420	Limestone, detrital-skeletal (90% grains), calcarenite, few Dictyoconus cookei, very dolomitic, detrital grains are mostly unidentifiable but are probably micritic and small skeletal, poorly lithified, good interparticulate porosity, light brown color, sandy and organic in places.
420-440	Limestone, detrital-skeletal (90% grains), as above but finer grain fraction, large (>9mm) echinoids.
440-460	A) Limestone, micritic-detrital (50% grains), appearance of lepidocyclina, fairly well lithified, poor intergranular porosity, light brown color, Dictyoconus cookei, Lituonella floridana.
	B) Dolomite, skeletal-pelletal (90% grains), well lithified, unidentified skeletal grains, good moldic porosity, dark gray-brown color.
460-480	Limestone, micritic (25% grains), few skeletal and detrital grains, poorly lithified, poor moldic porosity, light gray-brown color.
480-500	Limestone, micritic-detrital-skeletal (50% grains), medium-coarse grain fraction, poorly lithified, good intergranular and moldic porosity, light gray-brown color, organic stain.

500-520 Limestone, micritic-detrital-skeletal (50% grains), as above, few Lepidocyclina, Dictyoconus gunteri(?).

520-540 A) Limestone, as above

B) Limestone, skeletal (90% grains), foraminiferal hash, loosely consolidated, some skeletal fragments, coarse grain size, very good intergranular and moldic porosity, light-medium gray-brown color, carbonaceous material. Lepidocyclina, Valvulina cushman.

540-560 A) Limestone, micritic (10% skeletal grains), well lithified, small un identified forams, no visible porosity, medium-dark gray-brown color.

B) Limestone, skeletal (90% grains), loosely consolidated, good interparticular porosity, light brown color.

560-580 Limestone, skeletal-pelletal (75% grains), calcarenite, fine-medium grain size, good interparticular porosity, light-medium brown color.

580-600 Limestone, micritic-skeletal (50% grains), well lithified, abundant small forams (Quinqueloculina, Spiroloculina, etc.), few large (12-15 mm) echinoids, fair interparticulate of moldic porosity, light-medium brown color, dark brown organic stain.

Specific Capacity Test Data

Project: Bull Creek Wildlife Management Area

Well #1 Pumping Rate (gpm) 100
Pump Type: 4" submersible
Static: 12.97
Datum: Top of 4" casing

Elapsed Time (min.)	Water level (ft.)	Draw-down (ft.)	Specific Capacity (gpm/ft)
0	12.97	0.00	NA
1	25.95	12.98	7.7
2	25.95	12.98	7.7
4	25.95	12.98	7.7
6	25.97	13.00	7.7
8	26.07	15.27	6.6
10	26.02	15.22	6.6
15	26.02	15.22	6.6
20	26.02	15.22	6.6
25	26.05	15.25	6.6
30	26.10	15.30	6.5
35	26.42	15.62	6.4
40	26.42	15.62	6.4
45	26.42	15.62	6.4
50	26.40	15.60	6.4
55	26.40	15.60	6.4
60	26.40	15.60	6.4

Estimated Transmissivity: 16,448 gpd/ft

Sensitivity Analysis

	Specific Capacity gpm/ft	Transmissivity gpd/ft
50%	3.2	8000
60%	3.8	10000
70%	4.5	12000
80%	5.1	13000
90%	5.8	15000
100%	6.4	16000
110%	7.0	18000
120%	7.7	20000
130%	8.3	21000
140%	9.0	23000
150%	9.6	25000

SITE - BULL CREEK

WELL NO. 2

DEPTH INTERVAL	LITHOLOGY DESCRIPTION
	In Ocala Limestone
200-220	A) Limestone, skeletal, fossiliferous hash (90% grains), small forams (Spiroloculina, Quinqueloculina, Lepidocyclina, etc.), well lithified, good intergranular porosity, light brown-buff color, some phosphatic flecks.
	B) Siltstone, phosphatic, medium gray color.
220-240	Limestone, skeletal-micritic (60% grains), as above but more micrite, well lithified, fair intergranular porosity, light brown-buff color.
240-260	Limestone, skeletal-micritic (50% grains), as above but less well sorted, coarser grain fraction.
260-280	Limestone, micritic-skeletal (40% grains), as above but finer grain fraction, fair intergranular and moldic porosity, organic staining, light-medium brown color.
280-300	Limestone, micritic-skeletal (50% grains), as above.
300-320	Limestone, skeletal-pelletal-micritic (50% grains), skeletal-pelletal hash, poorly sorted grain fraction, fair moldic and intergranular porosity.
	Avon Park (?)
320-340	Limestone, skeletal (90% grains), abundance of individual (>1mm) forams (Coskinolina Quinqueloculina, Dictyoconus, etc.) good interparticular porosity, light-medium brown color.
340-360	Limestone, skeletal (90% grains), as above - abundant Coskinolina, Dictyoconus, etc.).
360-380	Dolostone, skeletal-pelletal (75% grains), very fine grained texture, no individual forams, fairly well lithified, good pinpoint moldic and intercrystalline porosity, medium brown color.
380	Dolostone, micritic-pelletal (40% grains), well lithified, fair moldic porosity, medium-dark, brown color.

Specific Capacity Test Data

Project: Bull Creek Wildlife Management Area

Well #2 Pumping Rate (gpm) 151
Pump Type: 4" centrifugal
Static: 0.50
Datum: Top of 4" casing

	Elapsed Time (min.)	Water level (ft.)	Draw-down (ft.)	Specific Capacity (gpm/ft)
	0	0.50	0.00	NA
	1	NA	NA	NA
	2	13.35	12.85	11.7
	4	NA	NA	NA
	6	NA	NA	NA
*	8	10.62	12.29	12.3
	10	10.62	12.29	12.3
	15	10.75	12.42	12.2
	20	10.75	12.42	12.2
	25	10.75	12.42	12.2
	30	10.75	12.42	12.2
	40	10.75	12.42	12.2
	50	10.75	12.42	12.2
	60	10.75	12.42	12.2

* Note: Static water level is above land surface. Additional casing, added as a temporary stand pipe, was removed at this point in the test.

Estimated Transmissivity: 31,353 gpd/ft

Sensitivity Analysis

	Specific Capacity gpm/ft.	Transmissivity gpd/ft
50%	6.1	16000
60%	7.3	19000
70%	8.5	22000
80%	9.8	25000
90%	11.0	28000
100%	12.2	31000
110%	13.4	34000
120%	14.6	38000
130%	15.9	41000
140%	17.1	44000
150%	18.3	47000

SITE - BULL CREEK

WELL NO. 3

DEPTH INTERVAL	LITHOLOGY DESCRIPTION
	In Hawthorn
150-160	Claystone and siltstone, very phosphatic (fine grain size) phosphate nodules (2-3 mm), medium-dark gray-black color.
160-170	Phosphate, claystone, siltstone, as above.
170-190	Limestone, micritic-detrital (40% grains), very phosphatic in places, well lithified, no visible porosity, light-medium gray color.
	Ocala Limestone
190-240	Samples missing.
240-260	Limestone, skeletal (95% grains), rock composed almost entirely of individual Lepidocyclina, Nummulites, etc., light-medium gray-brown color.
260-280	Limestone, micritic-skeletal (50% grains), calcarenite, few identifiable Nummulites, poorly lithified, good moldic and intergranular porosity, light gray-brown color.
280-300	Limestone, skeletal-micritic (75% grains), calcarenite, poorly lithified, very good interparticulate porosity, light gray-brown color.
300-320	Limestone, skeletal-micritic (75% grains), as above but pieces of bryozoan evident.
320-340	Limestone, detrital-micritic (60% grains), very fine grain size, calcarenite, well lithified, fair interparticle porosity, light gray-brown color.
340-360	Limestone, micritic-skeletal (25% grains), very fine grain size, occasional Nummulites and Lepidocyclina, poor interparticle porosity, light gray-brown color.
360-380	Limestone, skeletal-micritic (50% grains), very fine grain size, well lithified, fair interparticular and moldic porosity, light gray-brown color.
380-400	Limestone, skeletal-micritic (60% grains), as above but coarser grain size, good moldic and interparticular porosity, light-medium brown color, Dictyoconus cookei (?).

Specific Capacity Test Data

Project: Bull Creek Wildlife Management Area

Well #3 Pumping Rate (gpm) 100
Pump Type: 4" submersible
Static: 18.22
Datum: Top of 4" casing

Elapsed Time (min.)	Water level (ft.)	Draw-down (ft.)	Specific Capacity (gpm/ft)
0	18.22	0.00	NA
1	NA	NA	NA
2	NA	NA	NA
4	NA	NA	NA
6	NA	NA	NA
8	NA	NA	NA
10	39.70	21.48	4.7
15	39.75	21.53	4.6
20	39.75	21.53	4.6
25	39.78	21.56	4.6
30	39.80	21.58	4.6
40	39.68	21.46	4.7
50	39.65	21.43	4.7
60	39.65	21.43	4.7

Estimated Transmissivity: 12,079 gpd/ft

Sensitivity Analysis

	Specific Capacity gpm/ft	Transmissivity gpd/ft
50%	2.4	6000
60%	2.8	7000
70%	3.3	8000
80%	3.8	10000
90%	4.2	11000
100%	4.7	12000
110%	5.2	13000
120%	5.6	14000
130%	6.1	16000
140%	6.6	17000
150%	7.1	18000

SITE - BULL CREEK

WELL NO. 4

DEPTH INTERVAL	LITHOLOGY DESCRIPTION
	In Ocala Limestone
240	Limestone, skeletal-micritic (50% grains), very abundant Lepidocyclina and Nummulites, very sandy and phosphatic in places, poorly lithified, very good interparticular porosity, light-medium brown-gray color.
240-260	Limestone, skeletal-micritic (75% grains), fossiliferous hash, calcarenite, Lepidocyclina, good interparticulate and moldic porosity, light brown-tan color.
260-280	Limestone, fossiliferous hash, as above.
280-300	Limestone, fossiliferous hash, as above.
300-320	Limestone, fossiliferous hash, as above but more micritic in places, first appearance of Dictyoconus cookei
320-340	Limestone, micritic (>10% grains), some very small pelletal grains, medium-dark brown color, very well lithified.
340-360	Limestone, micritic-skeletal-pelletal (25% grains), well lithified, poor interparticular and moldic porosity, light gray-brown color.
360-380	Limestone, micritic-skeletal-pelletal (40% grains), as above but very organic stained, light-medium gray-brown color.
	Avon Park (?)
380-400	Limestone, skeletal (90% grains), numerous individual forams (Dictyoconus Americanus(?), Textularia, Quinqueloculina, Coskinolina elongata, etc.), light gray-brown color.

Specific Capacity Test Data

Project: Bull Creek Wildlife Management Area

Well #4 Pumping Rate (gpm) 97
Pump Type: 4" submersible
Static: 23.87
Datum: Top of 4" casing

Elapsed Time (min.)	Water level (ft.)	Draw-down (ft.)	Specific Capacity (gpm/ft)
0	23.87	0.00	NA
1	NA	NA	NA
2	45.50	21.63	4.5
4	45.45	21.58	4.5
6	45.42	21.55	4.5
8	45.35	23.65	4.1
10	45.77	24.07	4.0
15	46.02	24.32	4.0
20	46.10	24.40	4.0
25	46.40	24.70	3.9
30	46.23	24.53	4.0
40	45.87	24.17	4.0
45	46.00	24.30	4.0
50	45.95	24.25	4.0
60	46.10	24.40	4.0

Estimated Transmissivity: 10,280 gpd/ft

Sensitivity Analysis

	Specific Capacity gpm/ft	Transmissivity gpd/ft
50%	2.0	5000
60%	2.4	6000
70%	2.8	7000
80%	3.2	8000
90%	3.6	9000
100%	4.0	10000
110%	4.4	11000
120%	4.8	12000
130%	5.2	13000
140%	5.6	14000
150%	6.0	15000

SITE - BULL CREEK

WELL NO. 5

DEPTH INTERVAL	LITHOLOGY DESCRIPTION
	In Ocala Limestone
225-240	Limestone, skeletal-micritic (75% grains), fossiliferous hash, calcarenite, small forams (Quinqueloculina, Spiroloculina, Lepidocyclina, etc.) fairly well lithified, fair-good interparticular porosity, light gray-brown color.
240-260	Limestone, fossiliferous hash, as above but less porous
260-280	A) Limestone, fossiliferous hash as above.
	B) Limestone, micritic (>10% grains), well lithified, no visible porosity, light-medium gray-brown color.
280-300	Limestone, skeletal-micritic (50% grains), poorly sorted grain fraction, fairly well lithified, poor interparticular porosity, light-medium gray-brown color.
300-320	Limestone, skeletal-micritic (50% grains), as above
320-340	Limestone, skeletal-micritic (75% grains), coarser grain fraction than above, dolomitic, few Dictyoconus cookei, fairly well lithified, good pinpoint vuggy and interparticular porosity, medium-light brown-gray color with streaks of dark gray lithology as before, brown organic staining.
	Avon Park (?)
340-360	Limestone, skeletal (90% grains), very numerous individual forams - mostly Dictyoconus Americanus (?) and Coskinolina elongata - few Quinqueloculina, poorly lithified, light-medium brown-gray color.
360-380	Limestone, skeletal (80% grains), as above but fewer individual forams, medium-light brown-gray color.
380-400	Limestone, micritic-skeletal (50% grains), numerous Bryozoan fragments, echinoid fragments, Coskinolina elongata, interbedded micritic layers, poor interparticular porosity, medium-light brown color.

"fines" - almost entirely individual forams (Textularia, Quinqueloculina, Fabularia, Coskinolina elongata, Cribrobulimina, etc.), light-medium brown color.

Specific Capacity Test Data

Project: Bull Creek Wildlife Management Area

Well #5 Pumping Rate (gpm) 165
Pump Type: 4" centrifugal
Static: 0.29
Datum: Top of 4" casing

Elapsed Time (min.)	Water level (ft.)	Draw-down (ft.)	Specific Capacity (gpm/ft)
0	0.29	0.00	NA
1	8.00	7.71	21.5
2	8.10	7.81	21.2
4	8.23	7.94	20.8
6	8.28	7.99	20.7
8	8.32	8.03	20.6
10	8.32	8.03	20.6
15	8.32	8.03	20.6
20	8.34	8.05	20.5
25	8.35	8.06	20.5
30	8.37	8.08	20.5
40	8.42	8.13	20.3
50	8.42	8.13	20.3
60	8.42	8.13	20.3

Estimated Transmissivity: 52,170 gpd/ft

Sensitivity Analysis

	Specific Capacity gpm/ft	Transmissivity gpd/ft
50%	10.2	26000
60%	12.2	31000
70%	14.2	37000
80%	16.2	42000
90%	18.3	47000
100%	20.3	52000
110%	22.3	57000
120%	24.4	63000
130%	26.4	68000
140%	28.4	73000
150%	30.5	78000

Note: Analysis assumes S = 0.0002
Duration of pump test one day.

SITE - BULL CREEK

WELL NO. 6

DEPTH INTERVAL	LITHOLOGY DESCRIPTION
0-10	Silt, very sandy, very organic, dark brown color.
10-20	Silt, as above.
20-30	Silt, very shelly, sandy, dark gray color.
30-40	Silt, as above.
40-50	Silt, as above.
50-60	Silt, as above.
60-70	Coquina, silty, unconsolidated shell hash.
70-80	Silt, very shelly, very sandy, dark gray color.
80-90	Silt, very sandy, medium gray color.
90-100	Clay, very silty, medium gray blue color.
100-110	Clay, as above, but abundant shell fragments.
110-120	Clay, as above.
120-130	Clay, as above, but silty.
130-140	Silt, shelly, abundant individual quartz (2 mm) granules, medium gray blue color.
140-150	Silt, as above.
150-160	Coquina, silty, unconsolidated shell hash.
160-170	Silt, shelly, abundant individual quartz (2 mm) granules, medium dark gray blue color, medium grain size phosphate.
170-180	Silt, as above, but more consolidated silt fragments.
180-190	Siltstone, shelly, sandy, phosphatic, calcareous, medium dark gray color.
190-200	Siltstone, very phosphatic (medium coarse grain size) in places, calcareous, tan color, fairly well lithified.
200-210	Siltstone, as above, but less sorted phosphate.

210-220 Siltstone, as above, but light medium gray color.

220-230 Siltstone, as above, medium light gray color.

230-240 Phosphate, medium grain coarse pebble size, dark gray black color.
Siltstone, buff color.

240-250 Phosphate, as above, but silty.

250-260 Siltstone, sandy, phosphatic, medium gray brown color, well lithified.
Phosphate, as above.

260-270 Siltstone, as above, but clayey, shelly.

270-280 Siltstone, as above, clayey.

280-290 Siltstone, as above, clayey.

290-300 Siltstone, as above, clayey.

300-310 Siltstone, as above, clayey.

310-320 Siltstone, as above, clayey.

320-330 Silt, clayey, medium brown gray color.

330-340 Silt, as above.

340-350 Silt, as above.

350-360 Limestone, micritic-skeletal (50% grains), calcarenite, phosphatic (medium coarse grain size), fairly well lithified, light brown color.

360-370 Limestone, as above, but with only 15% grains.

370-380 Limestone, skeletal-micritic (60% grains), calcarenite, good intergranular porosity, fairly well lithified, tan light brown color.

380-400 Limestone, skeletal-micritic (75% grains), calcarenite, Spiroloculina, Quinqueloculina, fragments of echinoids, fairly well lithified, fair to good intergranular and intragranular porosity, tan light brown color.

400-420 Limestone, skeletal-micritic, as above, tan color.
Dolostone, skeletal-micritic (75% grains) microcrystalline, well lithified, no visible porosity, medium brown color.

420-440 Limestone, detrital-skeletal-micritic (75% grains),

calcarenite, fairly well lithified, fair to good intergranular porosity, light medium brown color.

440-460 Limestone, skeletal-micritic (60% grains), few individual Dictyoconus americanus, Coskinolina, Lituonella, echinoid fragments, fairly well lithified, fair intergranular porosity, tan light brown color. Dolostone, micritic (10% grains), well lithified, medium brown color.

460-480 Limestone, skeletal (90% grains), almost entirely individual forams: Dictyoconus, Coskinolina, Lituonella, etc., light medium brown color.

480-500 Limestone, skeletal-micritic, as above, but more micrite, light medium brown color.

500-520 Limestone, detrital-micritic-skeletal (50% grains), calcarenite, few forams as above, fair to good intergranular and moldic porosity, light medium brown color.

520-540 Limestone, skeletal-micritic (75% grains - coarse grain size), numerous small unidentified forams, good intergranular porosity, light medium brown color.

540-560 Limestone, skeletal-micritic, as above, but 60% grains.

560-580 Limestone, skeletal-detrital-micritic (50% grains), Quinqueloculina, Spiroloculina, etc., fairly well lithified calcarenite, fair intragranular and intergranular porosity, light medium brown color.

580-600 Limestone, as above.

600-620 Limestone, as above.

620-640 Limestone, as above, fair intragranular porosity, medium light brown gray color.

640-660 Limestone, as above, good intragranular and intergranular porosity.

660-680 Limestone, as above, Quinqueloculina, good intragranular and intergranular porosity.

680-700 Limestone, skeletal (90% grains), abundant small,individual, ovoid forams (medium grain size), friable, medium brown color.

700-720 Limestone, micrite (10% grains), well lithified, no visible porosity, dark brown color.

720-740 Limestone, micrite (10% grains), as above. Splotchy dark brown to very dark brown color.

740-760 Limestone, micritic (15% grains), as above, but scattered pin point vugs, dolomitic, splotchy dark to very dark brown color.

760-780 Dolostone, micritic (10% grains), fairly well lithified, fair intercrystalline and moldic porosity, medium brown color, dark organic staining.

Project: Bull Creek Wildlife Management Area

Well 6 Pumping Rate (gpm) 97
Pump Type: 4" submersible
Static: 4.75
Datum: Top of 4" casing

Elapsed Time (min.)	Water level (ft.)	Draw-down (ft.)	Specific Capacity (gpm/ft)
0	24.25	19.50	NA
5	24.32	19.57	4.9
10	24.32	19.57	4.9
15	24.35	19.60	4.9
25	24.30	19.55	5.0
35	24.32	19.57	4.9
45	24.32	19.57	4.9
55	24.60	19.85	5.3
60	24.60	19.85	5.3

Step Drawdown Test

Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)
37	3.45	10.7
56	7.45	7.5
97	19.50	5.0

AGREEMENT BETWEEN THE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

AND THE

SOUTH BREVARD WATER AUTHORITY

THIS AGREEMENT is entered into on this 16th day of November 1988 between the ST. JOHNS RIVER WATER MANAGEMENT DISTRICT, hereinafter referred to as the "District", and the SOUTH BREVARD WATER AUTHORITY, hereinafter referred to as the "Authority".

WHEREAS, the District is a governmental entity created and empowered by Chapter 373 Florida Statutes and charged with the responsibility to research and investigate all aspects of water use; and more specifically to assist water supply authorities in meeting water supply needs, and

WHEREAS, the Authority is a duly created water supply authority which in order to carry out its responsibility for supplying a safe and reliable source of drinking water for the citizens within its boundaries is in need of technical assistance from the District.

NOW, THEREFORE, in consideration of the conveyance of good and valuable consideration as described below, the District and the Authority agree to the terms and conditions as set forth herein.

1. A ground water quality reconnaissance study will be conducted in the eastern Osceola County area on property within and owned by the St. Johns River Water Management District. Said property is known as the Bull Creek Wildlife Management Area.
2. Both parties acknowledge that time is of the essence for the work performed pursuant to this Agreement. This Agreement shall be effective upon full execution by each of the parties.
3. The District will do the following:
   a. Construct up to six Floridan Aquifer observation wells within the Bull Creek Wildlife Management Area at the locations identified in Exhibit A.

The exact locations will be determined following site visits.

b. Geophysically log each of the observation wells, to include but not be limited to, caliper, gamma, conductivity, electric, temperature, and flow logs.

c. Collect and analyze water quality samples for primary chemical constituents including TDS, HCO_3, Cl, SO_4 Ca, Mg, Na, K, Fe, Sr and Silica.

d. Perform specific capacity tests on each well.

e. Evaluate the data collected in connection with a, b, c and d above and prepare a descriptive report to be presented to the Authority within 120 days of the full execution of this Agreement.

f. Provide to the Authority, upon request of the Authority, copies of any information, including information in raw form, collected pursuant to this Agreement.

4. The Authority or its duly designated representatives shall have the right to collect duplicate water quality samples.

5. The Authority agrees to reimburse the District for the actual cost of the construction of the observation wells including direct and indirect costs for the District's staff support, drilling equipment and crew, geophysical logging, per diem, materials, laboratory services, and administrative overhead, the total amount of which shall not exceed $87,000.00 as listed in Exhibit B.

6. Final use or disposition of the wells shall be decided jointly by the Authority and the District at the completion of the work performed pursuant to this Agreement.

7. Performance under this agreement is subject to the availability of funds.

8. The Executive Director of the District or his designee shall act as the District's Project Manager. The

Authority hereby designates Mr. Robert J. Massarelli as its Project Manager.

9. The Authority agrees to indemnify and save harmless the District for any and all liability claims, damages, expenses, proceedings, and causes of action of every kind and nature arising out of any act or omission of the Authority in carrying out this Agreement. The District agrees to indemnify and save harmless the Authority for any and all liability claims, damages, expenses, proceedings, and causes of action of every kind and nature arising out of any act or omission of the District in carrying out this Agreement.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the date and year first stated above.

Signed, sealed and delivered
IN THE PRESENCE OF:

WITNESSES:

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

By: _____

Attest: _____

SOUTH BREVARD WATER AUTHORITY

By: _____
Joe H. Wickham 11-7-88

Attest: _____
Robert J. Massarelli

_____
Wayne Flowers, SJRWMD
Approved as to Form and Legality

EXHIBIT A

BULL CREEK

WILDLIFE MANAGEMENT AREA

(22,206 Acres)

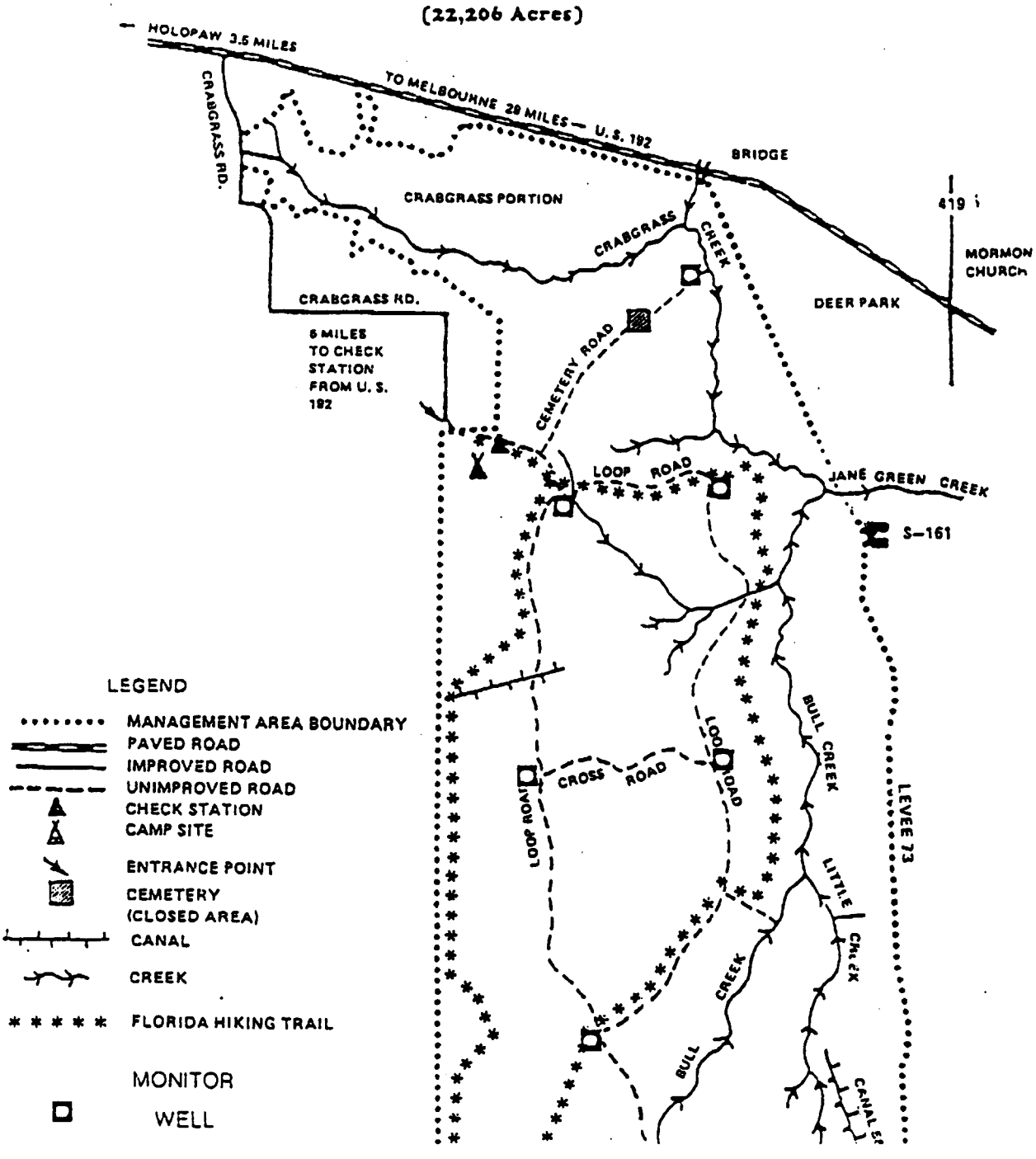


EXHIBIT B

Estimated Schedule of District Costs

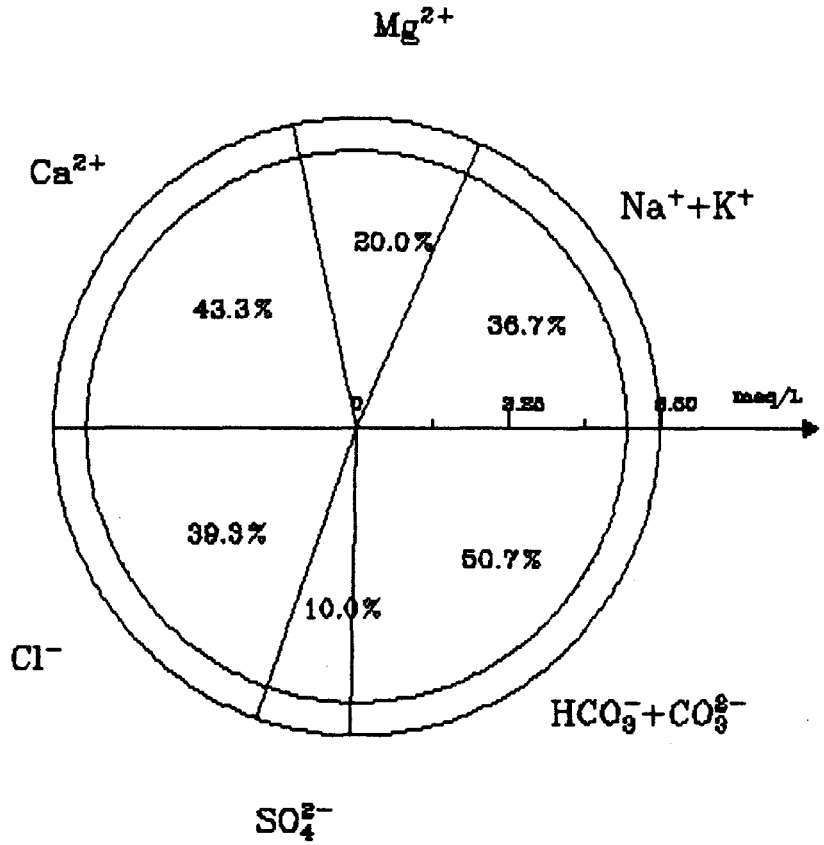
1)	Staff Support (based on current salaries of involved staff, exclusive of two-man drilling crew)	$ 7,922.00
2)	Drilling Equipment and Crew (based on rate of $125/hours)	40,000.00
3)	Travel - Per Diem (based on current state rates)	5,000.00
4)	Construction Materials (based on actual costs)	10,000.00
5)	Geophysical Logging (based on a rate of $2,000/well)	12,000.00
6)	Laboratory Services (based on a rate of $56.08/sample)	2,019.00
	Sub-Total	$76,941.00
7)	Administrative Overhead (based on a 12% rate)	9,233.00
	Estimated Project Total	$86,174.00

APPENDIX B

Composition and stiff diagrams for samples collected from the drill-stem and during the specific capacity tests (Table 1). Both diagrams indicate the dominant ion compositions. The radii of the circles on the composition diagrams are equivalent to the total anion and cation concentrations in meg/l. The closer the circles are together the better the charge balance. The charge imbalance for all samples is less the 20%.

BULL CREEK 1
480 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	2.1	
Mg^{2+}	1.1	
Ca^{2+}	2.4	
Cl^{-}		2.5
SO_4^{2-}		.6
$HCO_3^{-}+CO_3^{2-}$		3.2
	5.76	6.46

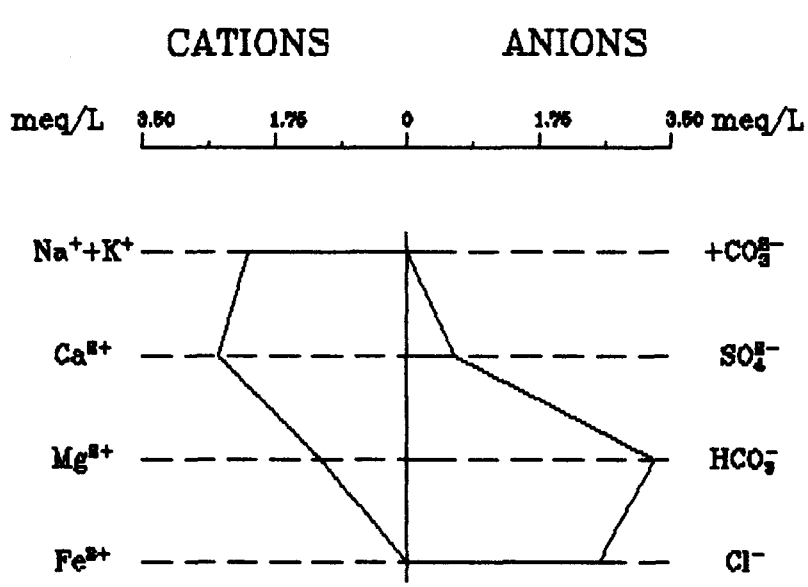


BULL CREEK
WELL 1
DEPTH = 480 FT

04/17/89

BULL CREEK 1
480 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	3.13	
Mg^{2+}	1.15	
Ca^{2+}	3.49	
Fe^{2+}	.00	
Cl^{-}		2.54
SO_4^{2-}		.65
$HCO_3^{-}+CO_3^{2-}$		3.28
	5.76	6.46

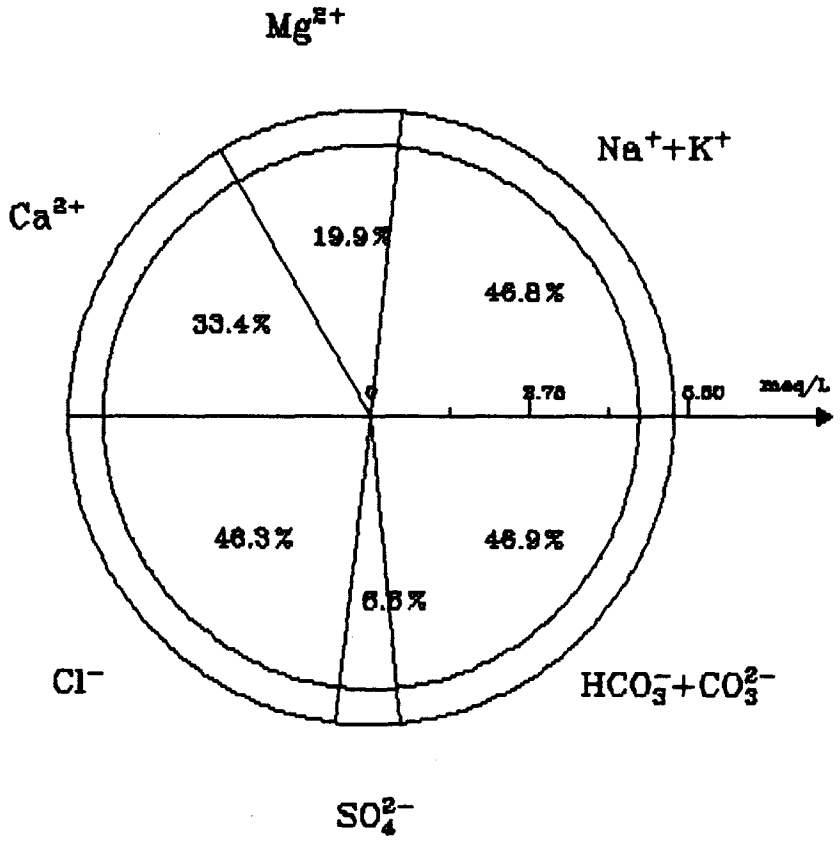


BULL CREEK
WELL 1
DEPTH = 480 FT

04/17/89

BULL CREEK 1
600 FT

Ion	meq/L	meq/L
$Na^+ + K^+$	3.1	
Mg^{2+}	.9	
Ca^{2+}	1.5	
Cl^-		3.4
SO_4^{2-}		.3
$HCO_3^- + CO_3^{2-}$		2.4
	4.64	5.24

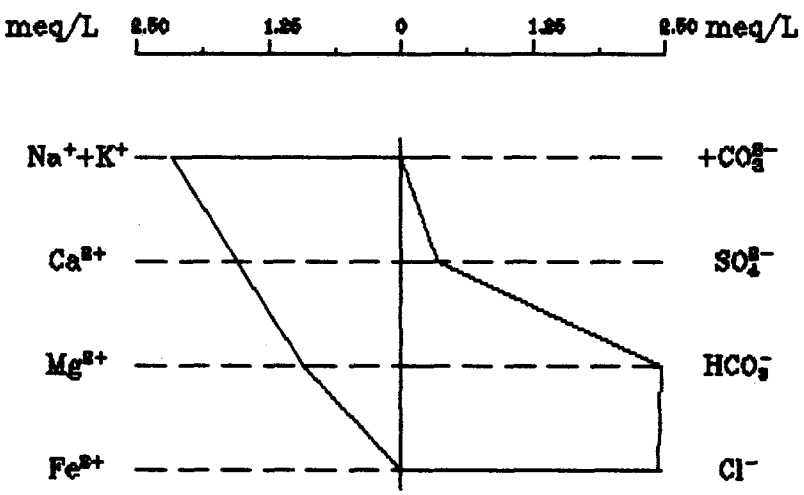


BULL CREEK
WELL 1
DEPTH = 600 FT

04/17/89

BULL CREEK 1
600 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	2.17	
Mg^{2+}	.52	
Ca^{2+}	1.55	
Fe^{2+}	.00	
Cl^{-}		2.43
SO_4^{2-}		.35
$HCO_3^{-}+CO_3^{2-}$		2.46
	4.64	5.24

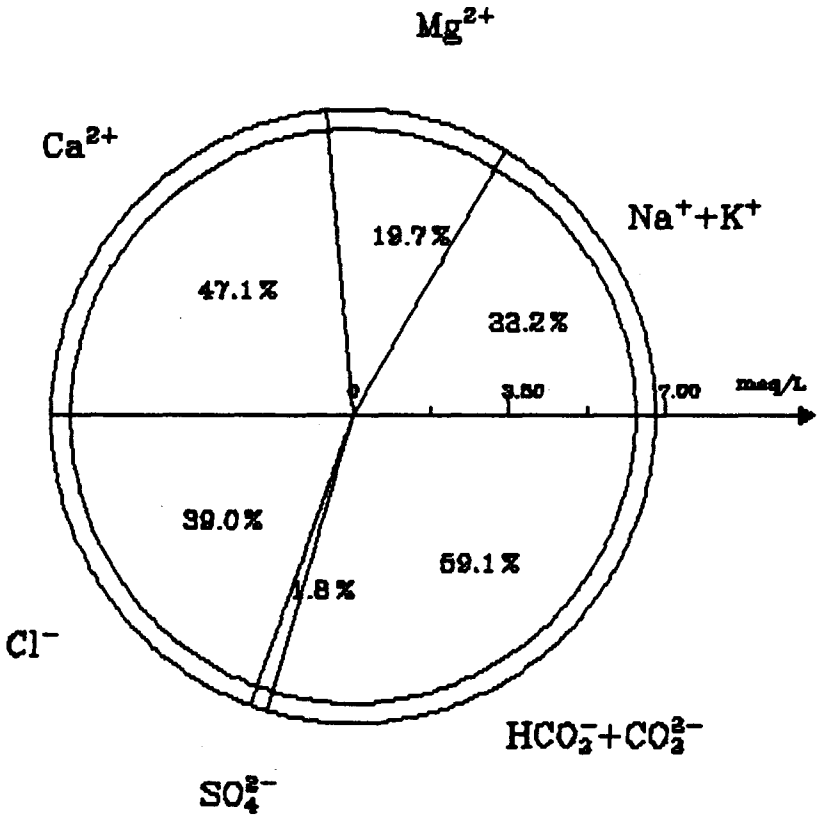


BULL CREEK
WELL 1
DEPTH = 600 FT

04/17/89

BULL CREEK 1
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	2.1	
Mg^{2+}	1.8	
Ca^{2+}	2.9	
Cl^{-}		2.6
SO_4^{2-}		.1
$HCO_3^{-}+CO_3^{2-}$		4.0
	6.35	6.79

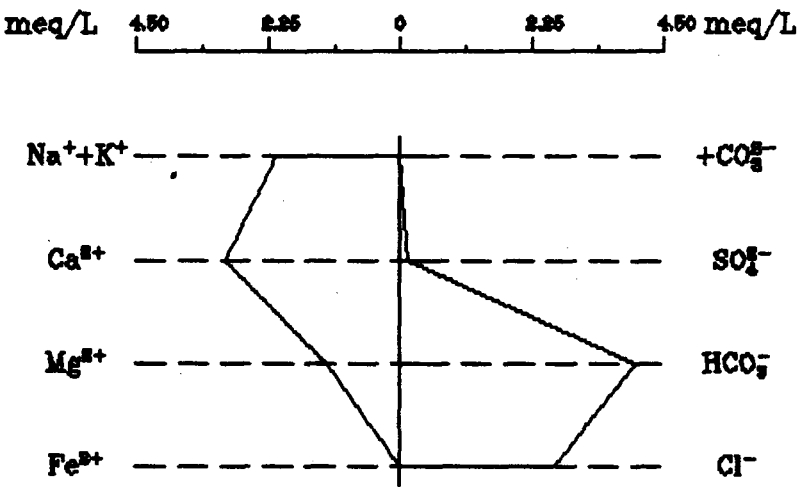


BULL CREEK
WELL 1
PUMPING

04/27/89

BULL CREEK 1
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	2.11	
Mg^{2+}	1.36	
Ca^{2+}	2.99	
Fe^{2+}	.00	
Cl^{-}		2.65
SO_4^{2-}		.12
$HCO_3^{-}+CO_3^{2-}$		4.02
	6.35	6.79

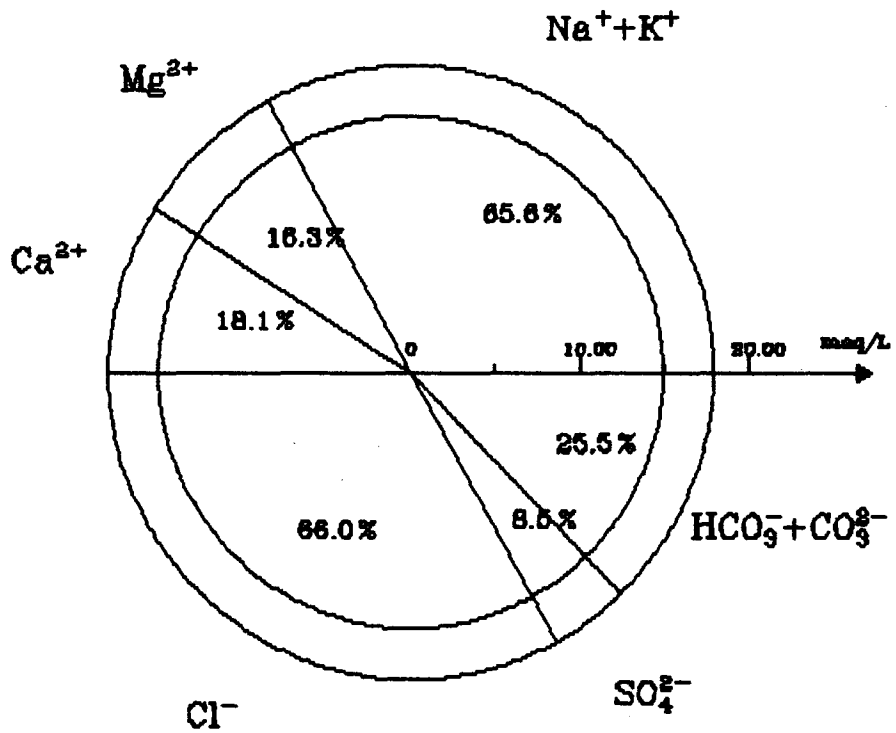


BULL CREEK
WELL 1
PUMPING

04/27/89

BULL CREEK 2
240 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	9.8	
Mg^{2+}	3.4	
Ca^{2+}	3.6	
Cl^{-}		11.8
SO_4^{2-}		1.5
$HCO_3^{-}+CO_3^{2-}$		4.5
	14.92	17.90

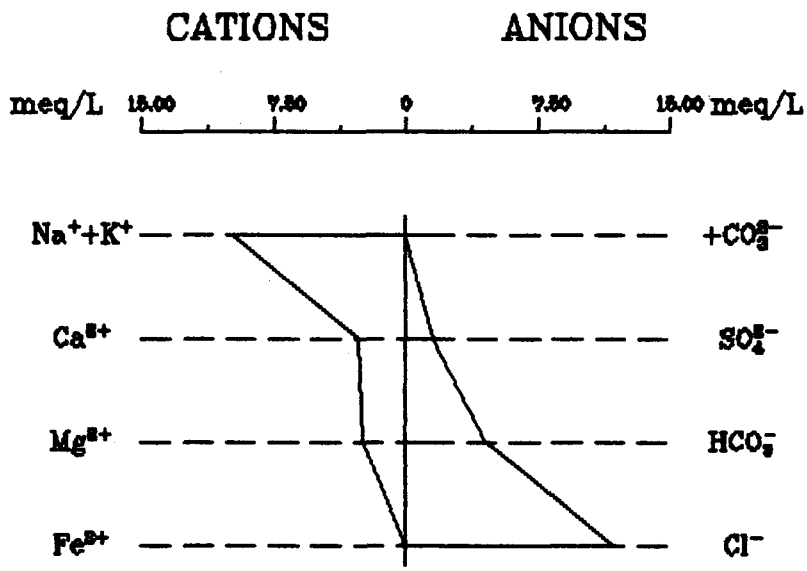


BULL CREEK
WELL 2
DEPTH = 240 FT

04/17/89

BULL CREEK 2
240 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	9.80	
Mg^{2+}	2.43	
Ca^{2+}	3.69	
Fe^{2+}	.00	
Cl^{-}		11.82
SO_4^{2-}		1.52
$HCO_3^{-}+CO_3^{2-}$		4.56
	14.93	17.90

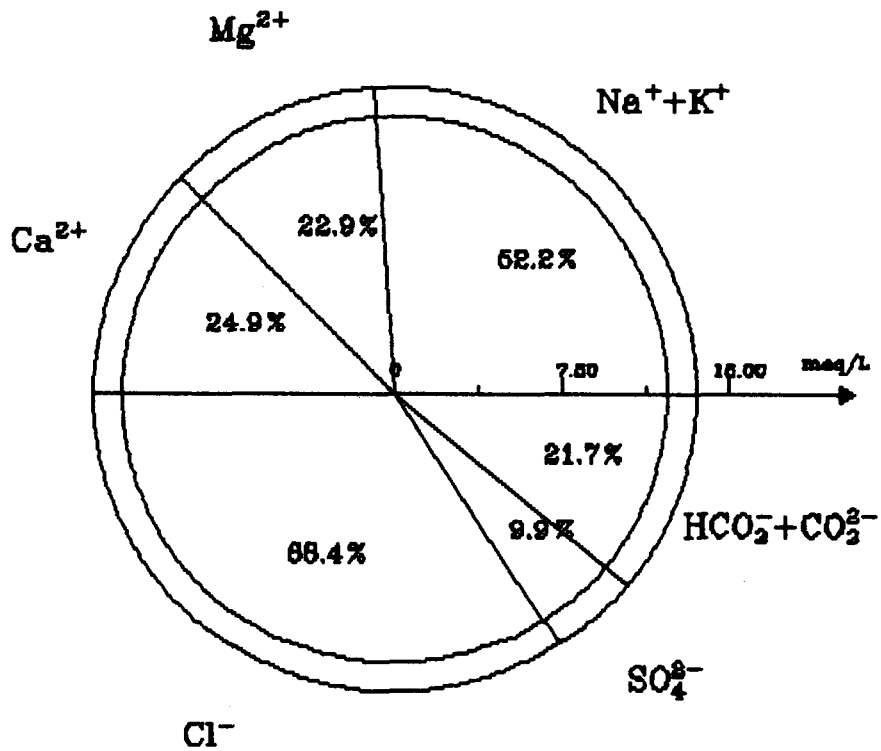


BULL CREEK
WELL 2
DEPTH = 240 FT

04/17/89

BULL CREEK 2
380 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	6.3	
Mg^{2+}	2.6	
Ca^{2+}	3.0	
Cl^{-}		9.2
SO_4^{2-}		1.3
$HCO_3^{-}+CO_3^{2-}$		2.9
	12.22	13.52

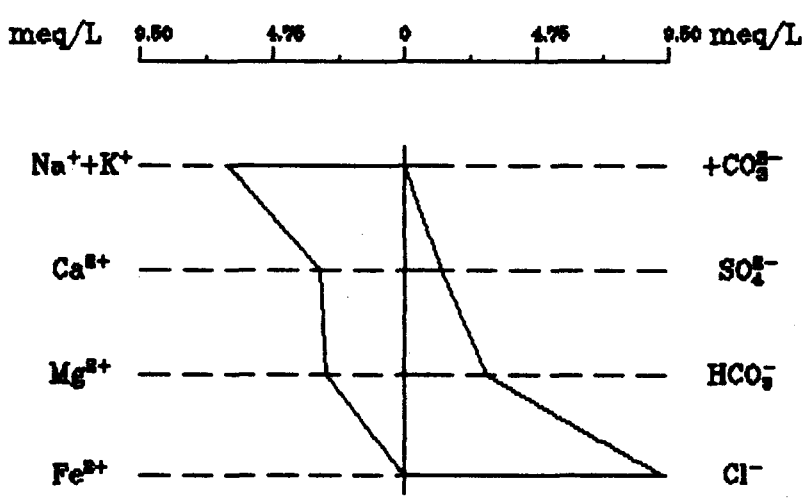


BULL CREEK
WELL 2
DEPTH = 380 FT

04/17/89

BULL CREEK 2
380 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	6.38	
Mg^{2+}	2.60	
Ca^{2+}	3.04	
Fe^{2+}	.01	
Cl^{-}		9.25
SO_4^{2-}		1.33
$HCO_3^{-}+CO_3^{2-}$		2.93
	12.22	13.52

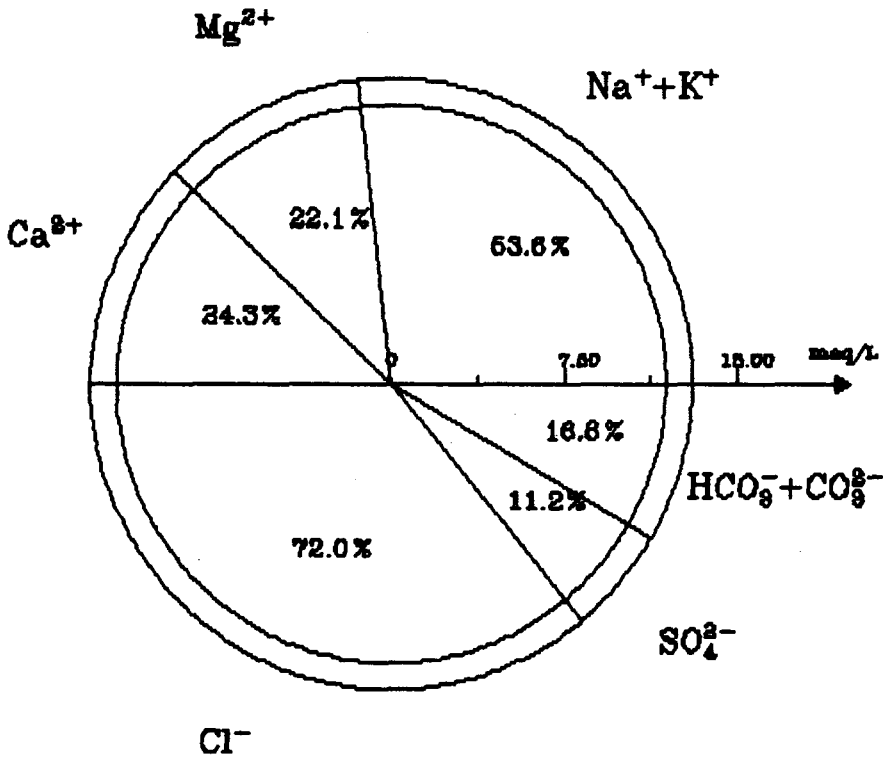


BULL CREEK
WELL 2
DEPTH = 380 FT

04/17/89

BULL CREEK 2
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	6.3	
Mg^{2+}	2.6	
Ca^{2+}	2.8	
Cl^{-}		9.3
SO_4^{2-}		1.4
$HCO_3^{-}+CO_3^{2-}$		2.2
	11.91	13.05

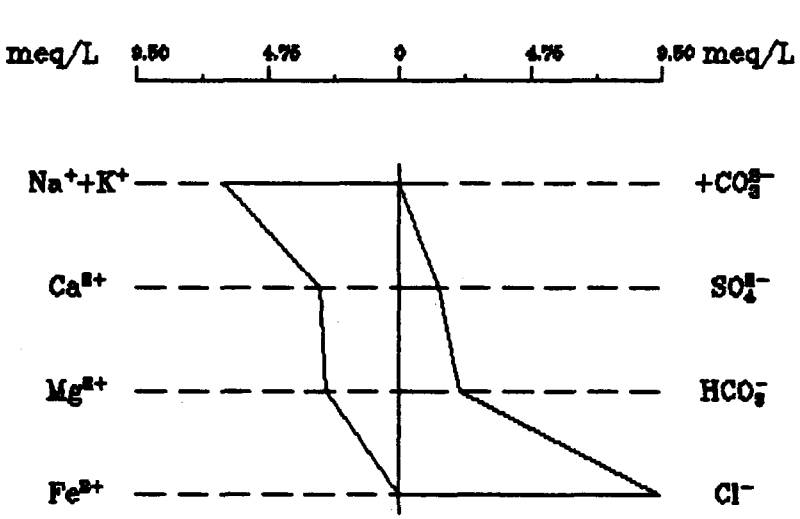


BULL CREEK
WELL 2
PUMPING

04/27/89

BULL CREEK 2
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	6.38	
Mg^{2+}	2.63	
Ca^{2+}	2.89	
Fe^{2+}	.00	
Cl^{-}		9.39
SO_4^{2-}		1.46
$HCO_3^{-}+CO_3^{2-}$		2.20
	11.91	13.05

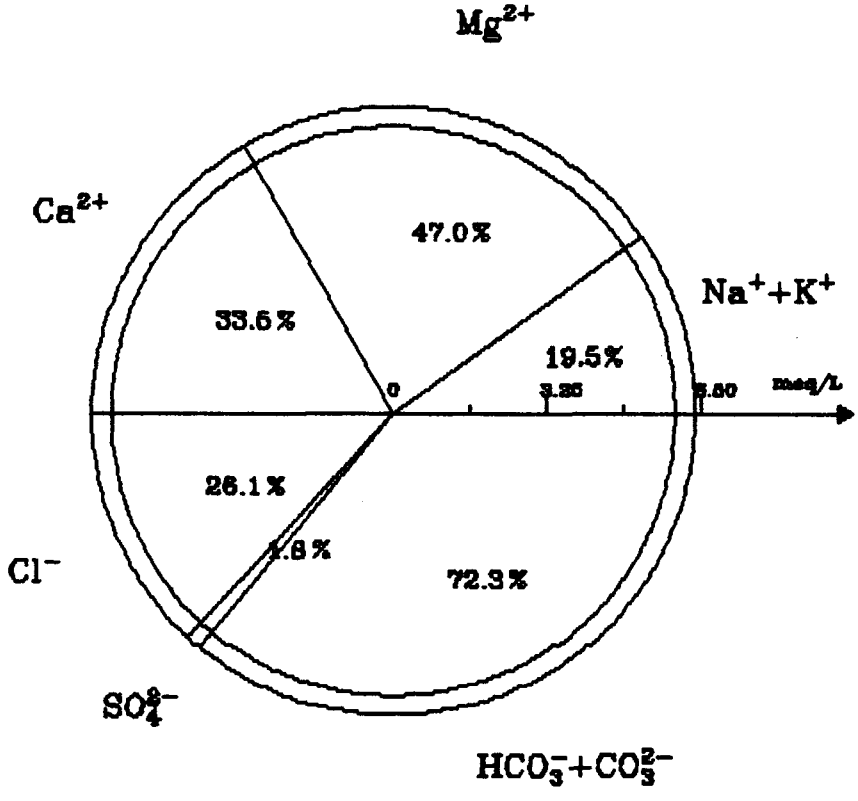


BULL CREEK
WELL 2
PUMPING

04/27/89

BULL CREEK 3
260 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	1.1	
Mg^{2+}	3.6	
Ca^{2+}	2.0	
Cl^{-}		1.6
SO_4^{2-}		.1
$HCO_3^{-}+CO_3^{2-}$		4.6
	5.95	6.37

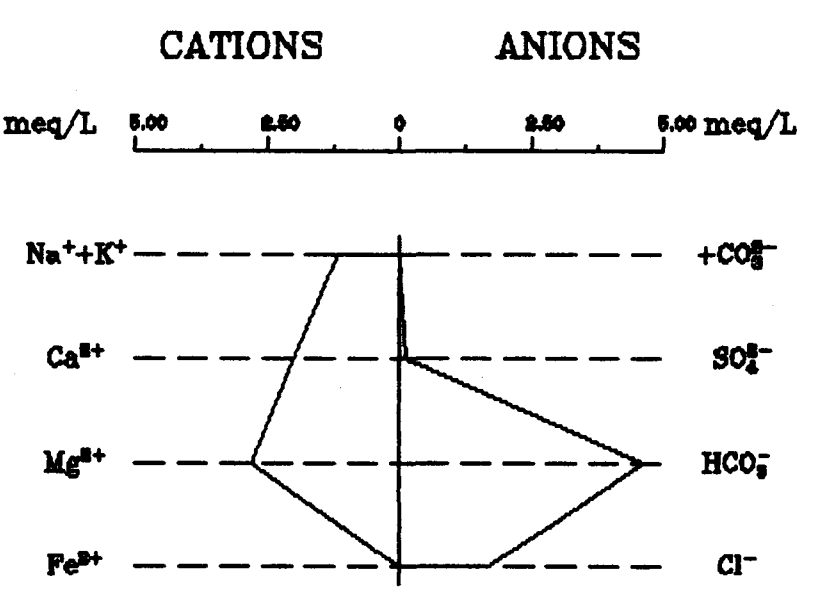


BULL CREEK
WELL 3
DEPTH = 260 FT

04/17/89

BULL CREEK 3
260 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	1.16	
Mg^{2+}	3.60	
Ca^{2+}	3.00	
Fe^{2+}	.00	
Cl^{-}		1.66
SO_4^{2-}		.10
$HCO_3^{-}+CO_3^{2-}$		4.61
	5.96	6.37

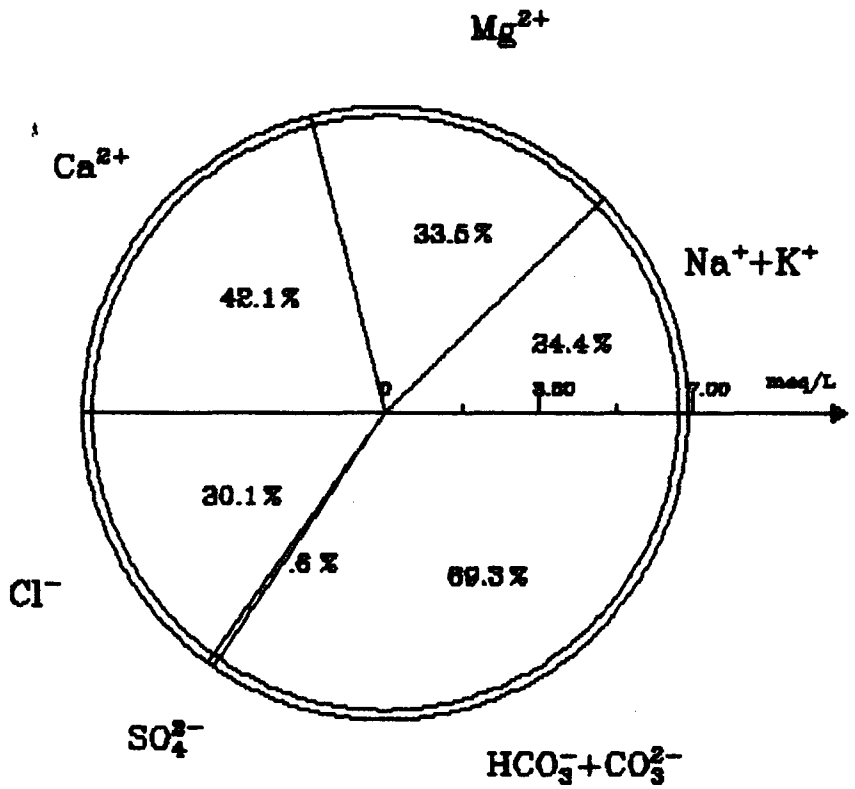


BULL CREEK
WELL 3
DEPTH = 260 FT

04/17/89

BULL CREEK 3
280 FT

Ion	meq/L	meq/L
$Na^+ + K^+$	1.6	
Mg^{2+}	2.3	
Ca^{2+}	2.8	
Cl^-		2.0
SO_4^{2-}		.0
$HCO_3^- + CO_3^{2-}$		4.6
	6.67	6.65

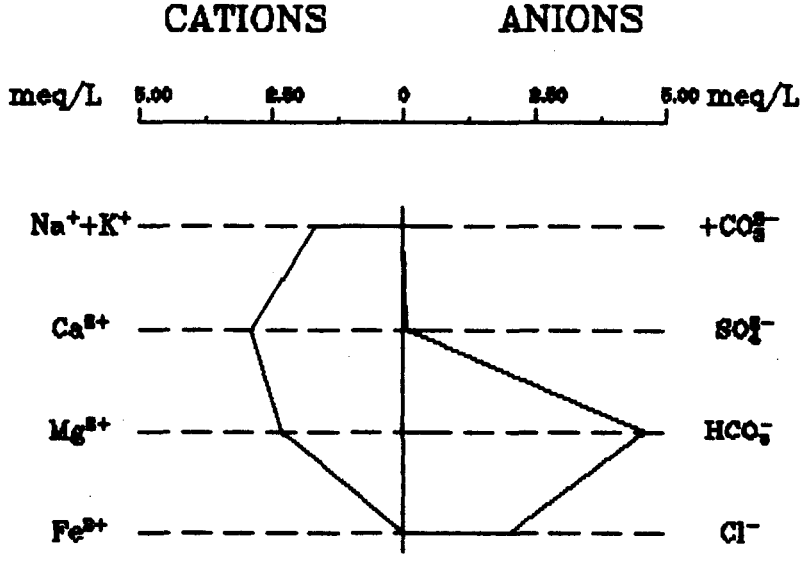


BULL CREEK
WELL 3
DEPTH = 280 FT

04/17/89

BULL CREEK 3
280 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	1.67	
Mg^{2+}	2.30	
Ca^{2+}	2.69	
Fe^{2+}	.00	
Cl^{-}		2.00
SO_4^{2-}		.04
$HCO_3^{-}+CO_3^{2-}$		4.61
	6.67	6.65

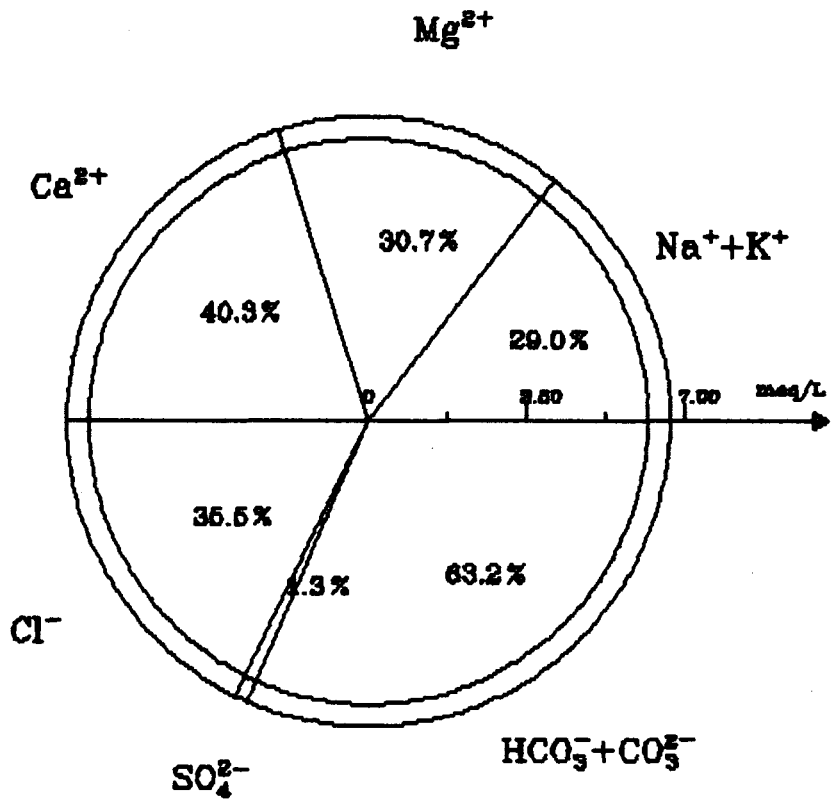


BULL CREEK
WELL 3
DEPTH = 280 FT

04/17/89

BULL CREEK 3
400 FT

Ion	meq/L	meq/L
$Na^+ + K^+$	1.9	
Mg^{2+}	2.0	
Ca^{2+}	2.6	
Cl^-		2.2
SO_4^{2-}		.0
$HCO_3^- + CO_3^{2-}$		3.9
	6.69	6.20

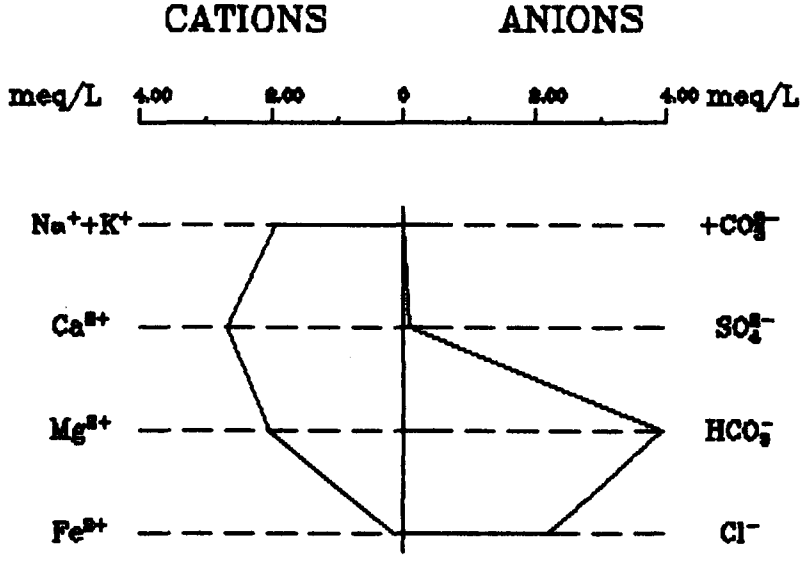


BULL CREEK
WELL 3
DEPTH = 400 FT

04/17/89

BULL CREEK 3
400 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	1.94	
Mg^{2+}	2.06	
Ca^{2+}	2.69	
Fe^{2+}	.12	
Cl^{-}		2.20
SO_4^{2-}		.08
$HCO_3^{-}+CO_3^{2-}$		3.92
	6.62	6.20

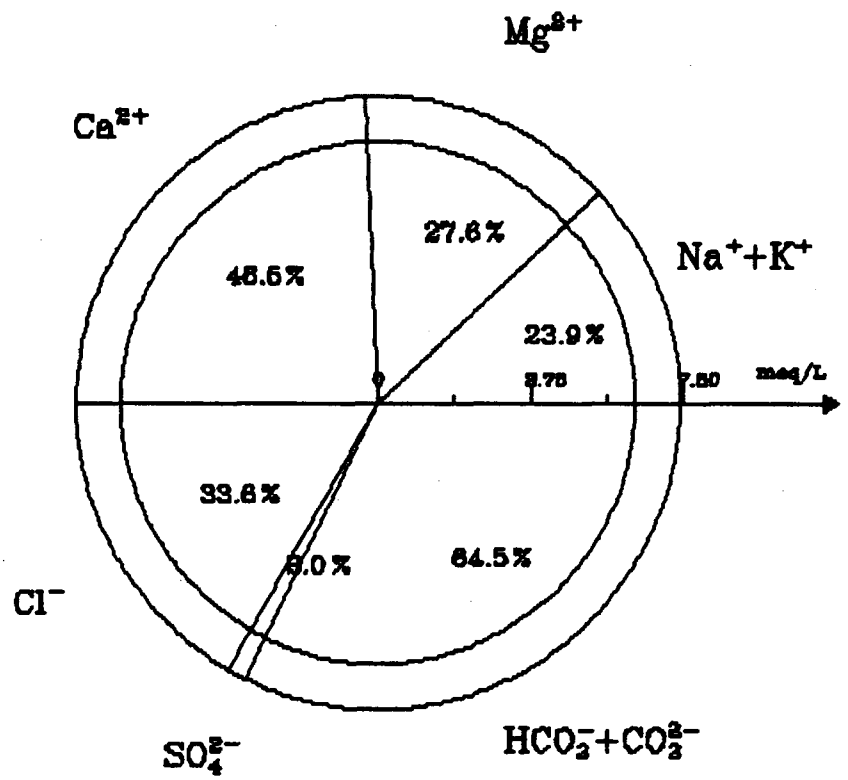


BULL CREEK
WELL 3
DEPTH = 400 FT

04/17/89

BULL CREEK 3
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	1.7	
Mg^{2+}	2.0	
Ca^{2+}	3.5	
Cl^{-}		2.1
SO_4^{2-}		.1
$HCO_3^{-}+CO_3^{2-}$		4.0
	7.40	6.31

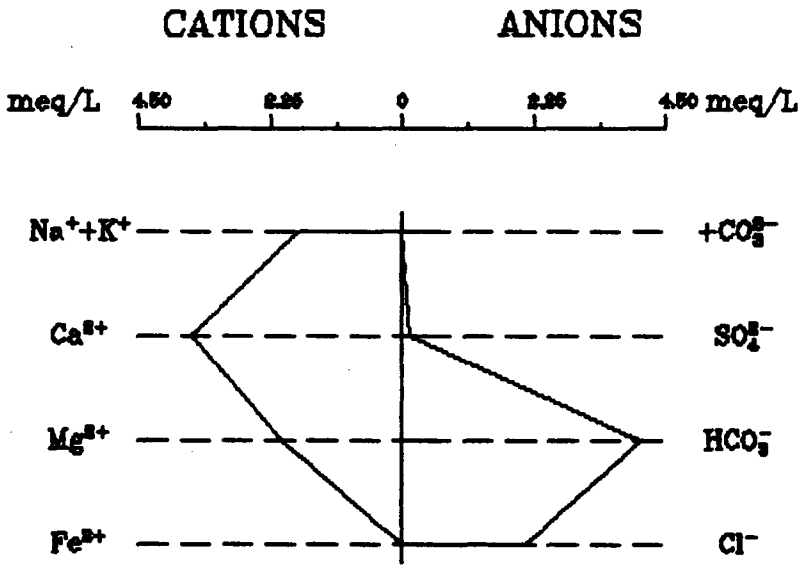


BULL CREEK
WELL 3
PUMPING

04/27/89

BULL CREEK 3
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	1.77	
Mg^{2+}	3.04	
Ca^{2+}	3.59	
Fe^{2+}	.00	
Cl^{-}		2.12
SO_4^{2-}		.12
$HCO_3^{-}+CO_3^{2-}$		4.06
	7.40	6.31

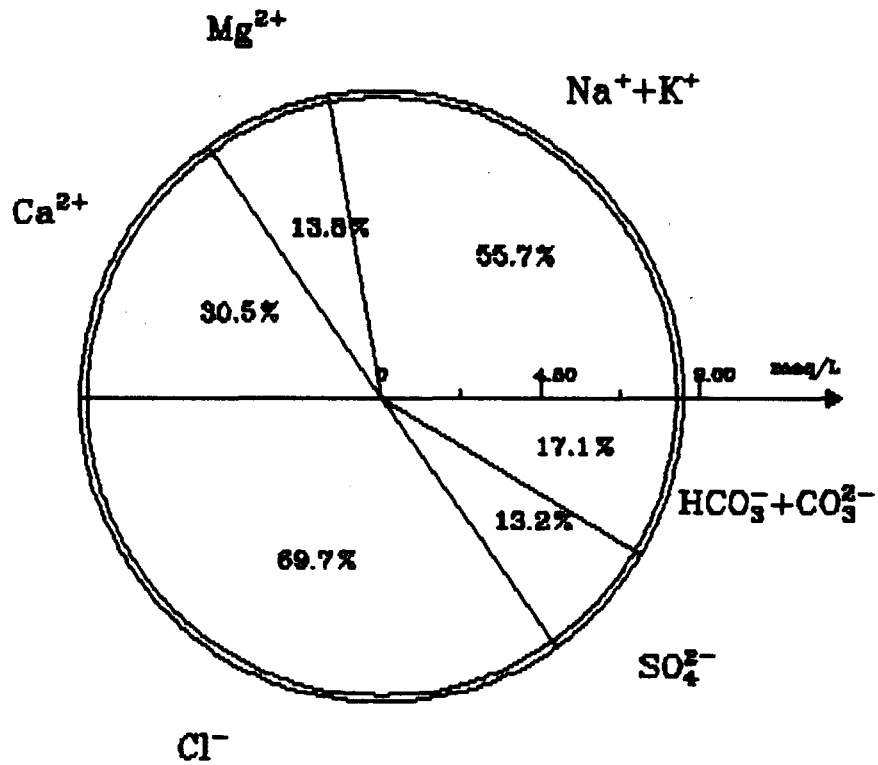


BULL CREEK
WELL 3
PUMPING

04/27/89

BULL CREEK 4
280 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	4.6	
Mg^{2+}	1.1	
Ca^{2+}	2.6	
Cl^{-}		5.9
SO_4^{2-}		1.1
$HCO_3^{-}+CO_3^{2-}$		1.4
	8.34	8.54

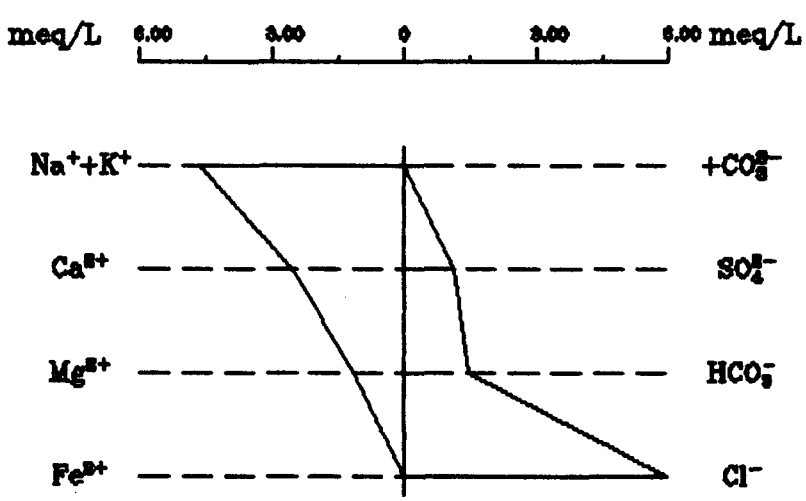


BULL CREEK
WELL 4
DEPTH = 280 FT

04/17/89

BULL CREEK 4
280 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	4.64	
Mg^{2+}	1.15	
Ca^{2+}	2.54	
Fe^{2+}	.00	
Cl^{-}		5.95
SO_4^{2-}		1.12
$HCO_3^{-}+CO_3^{2-}$		1.46
	8.34	8.54

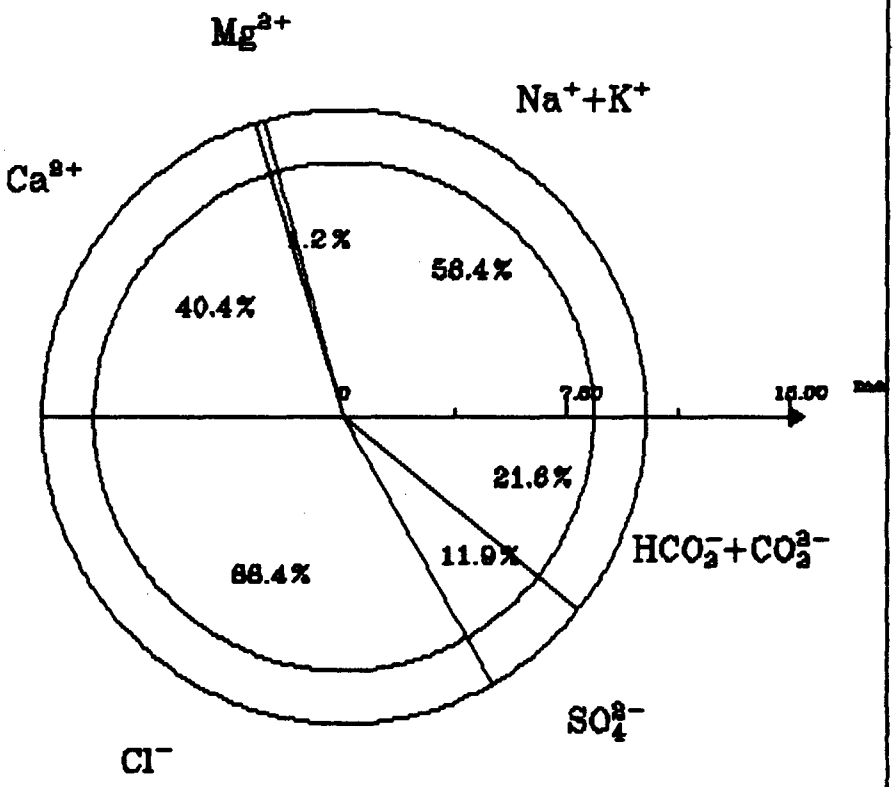


BULL CREEK
WELL 4
DEPTH = 280 FT

04/17/89

BULL CREEK 4
400 FT

Ion	meq/L	meq/L
$Na^+ + K^+$	4.9	
Mg^{2+}	.1	
Ca^{2+}	3.3	
Cl^-		6.7
SO_4^{2-}		1.2
$HCO_3^- + CO_3^{2-}$		2.2
	8.40	10.15

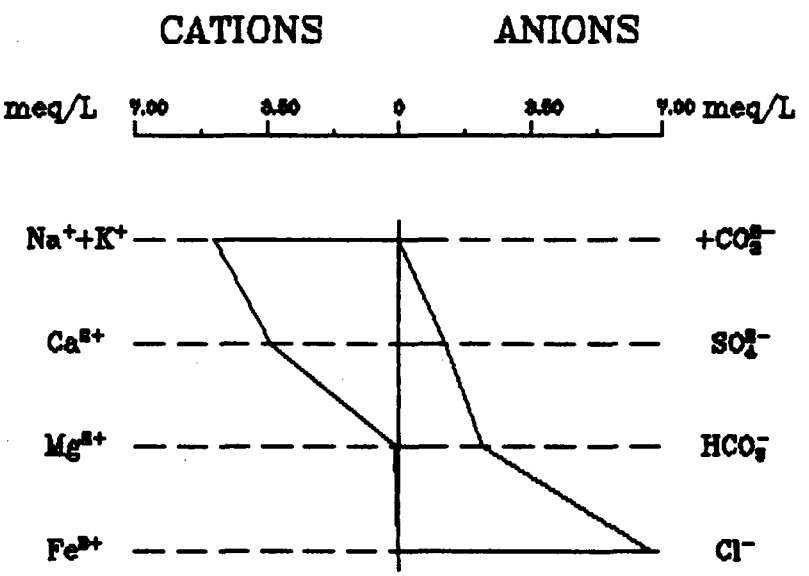


BULL CREEK
WELL 4
DEPTH = 400 FT

04/27/89

BULL CREEK 4
400 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	4.91	
Mg^{2+}	.10	
Ca^{2+}	3.39	
Fe^{2+}	.00	
Cl^{-}		6.74
SO_4^{2-}		1.21
$HCO_3^{-}+CO_3^{2-}$		2.20
	8.40	10.15

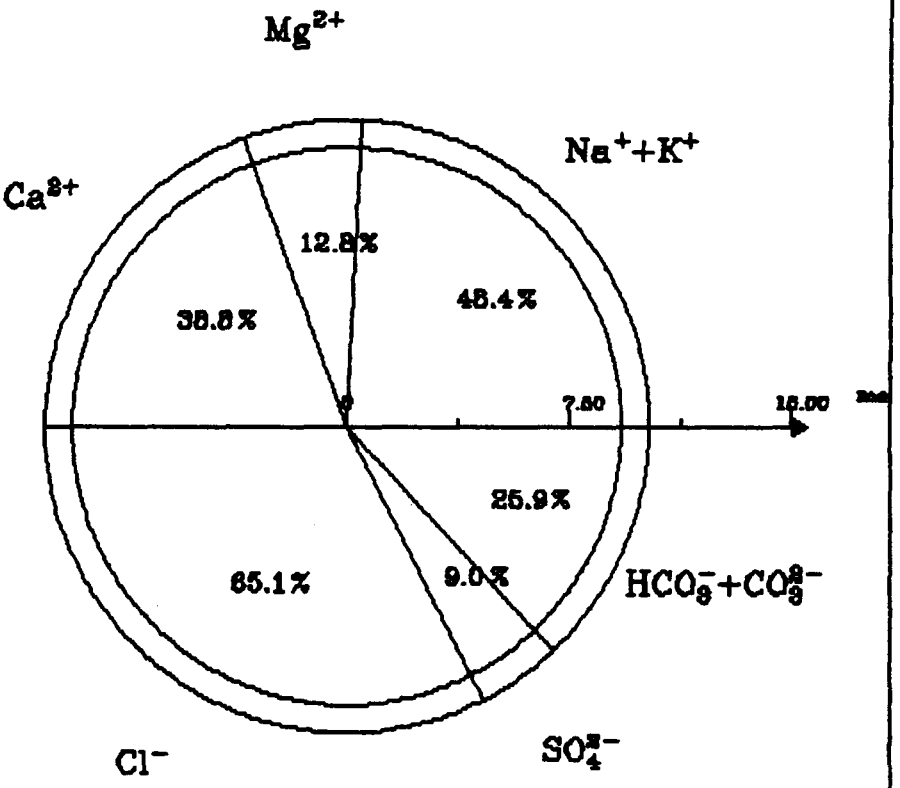


BULL CREEK
WELL 4
DEPTH = 400 FT

04/27/89

BULL CREEK 4
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	4.4	
Mg^{2+}	1.1	
Ca^{2+}	3.5	
Cl^{-}		5.6
SO_4^{2-}		.9
$HCO_3^{-}+CO_3^{2-}$		2.6
	9.26	10.16

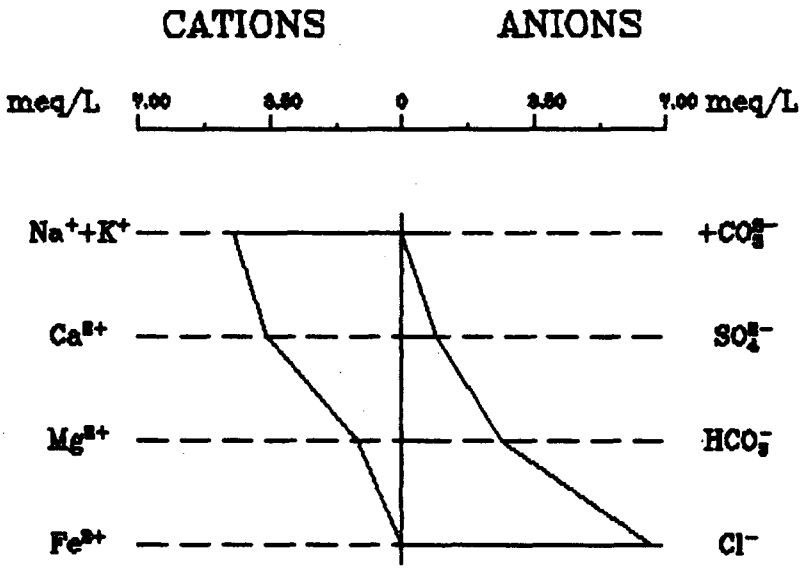


BULL CREEK
WELL 4
PUMPING

04/27/89

BULL CREEK 4
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	4.45	
Mg^{2+}	1.15	
Ca^{2+}	3.59	
Fe^{2+}	.00	
Cl^{-}		6.63
SO_4^{2-}		.92
$HCO_3^{-}+CO_3^{2-}$		2.64
	9.26	10.18

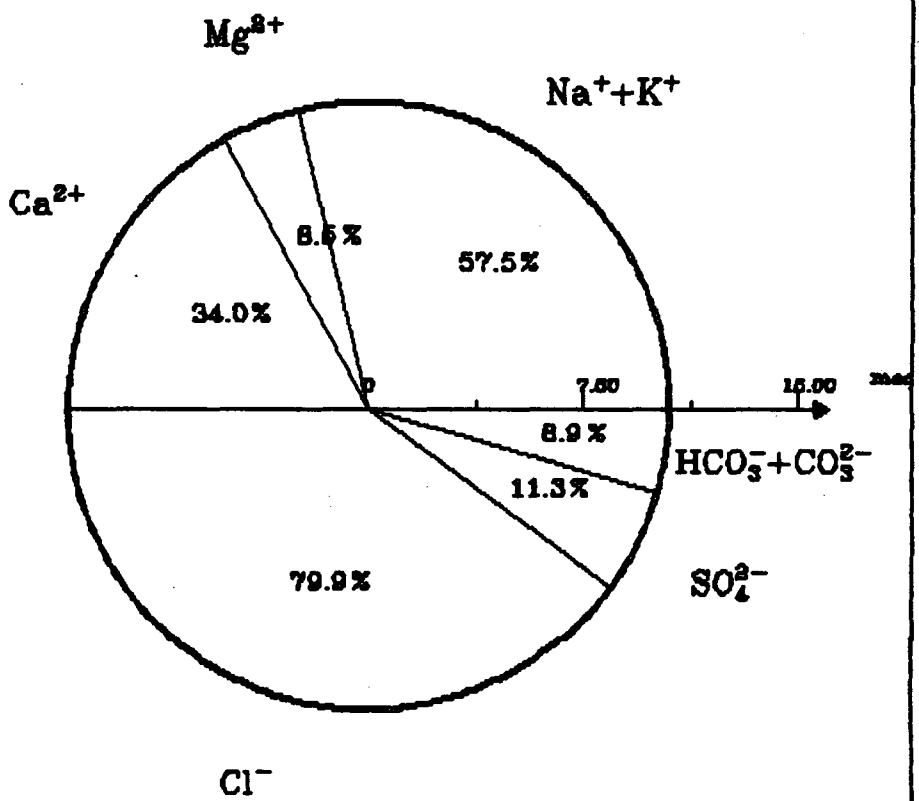


BULL CREEK
WELL 4
PUMPING

04/27/89

BULL CREEK 5
300 FT

Ion	meq/L	meq/L
$Na^+ + K^+$	6.0	
Mg^{2+}	.5	
Ca^{2+}	3.5	
Cl^-		8.4
SO_4^{2-}		1.1
$HCO_3^- + CO_3^{2-}$		.9
	10.43	10.53

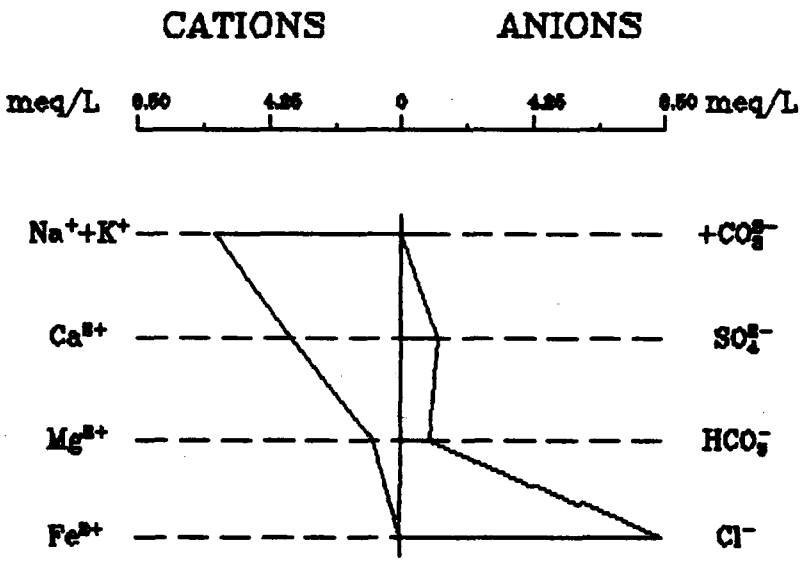


BULL CREEK
WELL 5
DEPTH = 300 FT

04/27/89

BULL CREEK 5
300 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	6.00	
Mg^{2+}	.89	
Ca^{2+}	3.54	
Fe^{2+}	.00	
Cl^{-}		8.41
SO_4^{2-}		1.19
$HCO_3^{-}+CO_3^{2-}$		.93
	10.43	10.53

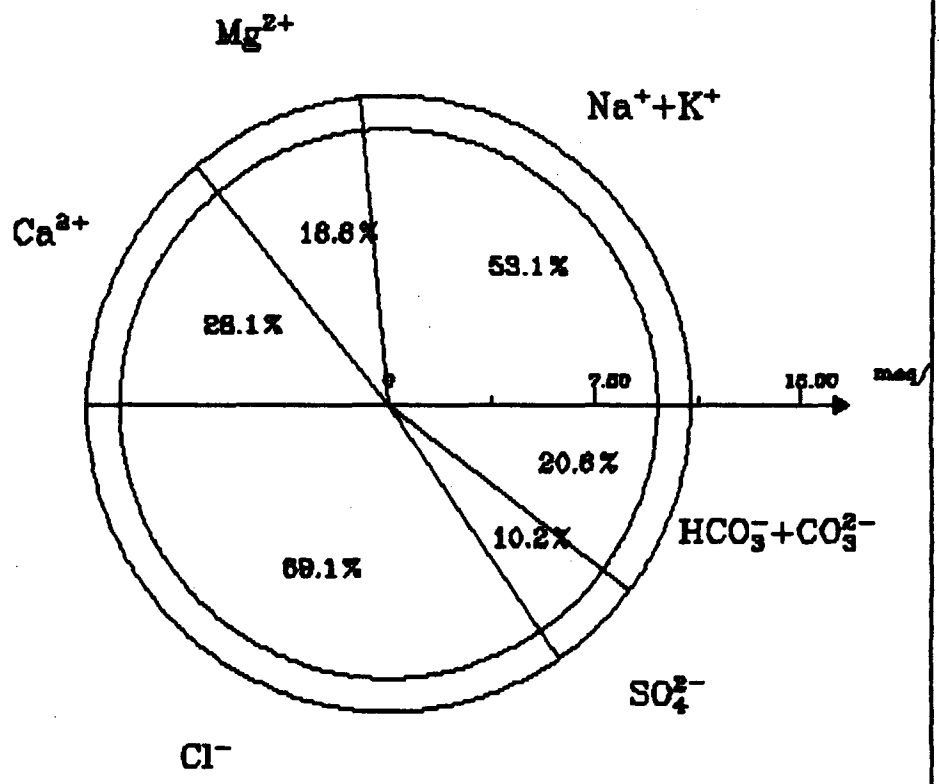


BULL CREEK
WELL 5
DEPTH = 300 FT

04/27/89

BULL CREEK 5
400 FT

Ion	meq/L	meq/L
$Na^+ + K^+$	5.1	
Mg^{2+}	1.5	
Ca^{2+}	3.7	
Cl^-		7.5
SO_4^{2-}		1.1
$HCO_3^- + CO_3^{2-}$		2.2
	9.78	10.97

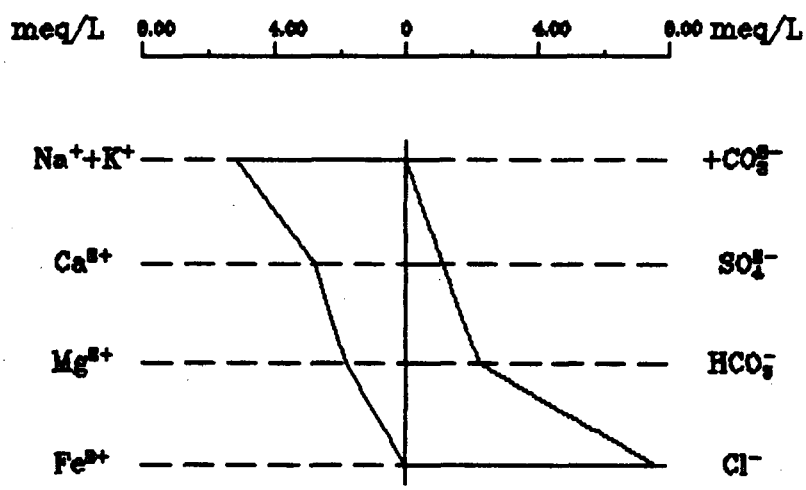


BULL CREEK
WELL 5
DEPTH = 400 FT

04/27/89

BULL CREEK 5
400 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	5.19	
Mg^{2+}	1.84	
Ca^{2+}	2.74	
Fe^{2+}	.00	
Cl^{-}		7.59
SO_4^{2-}		1.12
$HCO_3^{-}+CO_3^{2-}$		2.26
	9.78	10.97

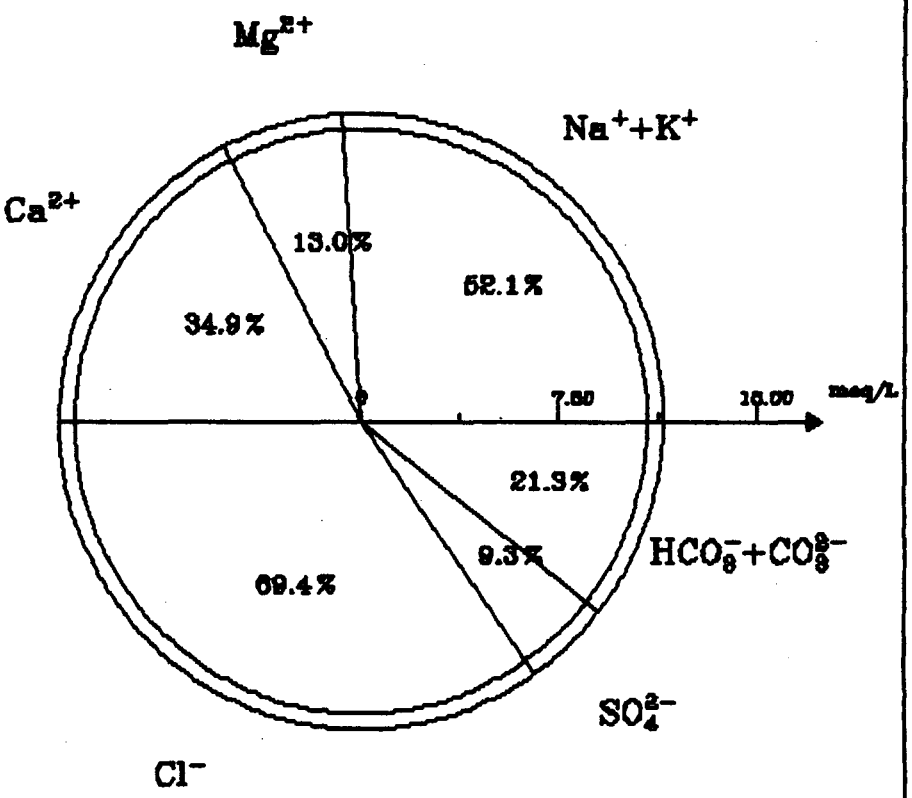


BULL CREEK
WELL 5
DEPTH = 400 FT

04/27/89

BULL CREEK 5
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	6.6	
Mg^{2+}	1.4	
Ca^{2+}	3.7	
Cl^{-}		7.9
SO_4^{2-}		1.0
$HCO_3^{-}+CO_3^{2-}$		2.4
	10.67	11.46

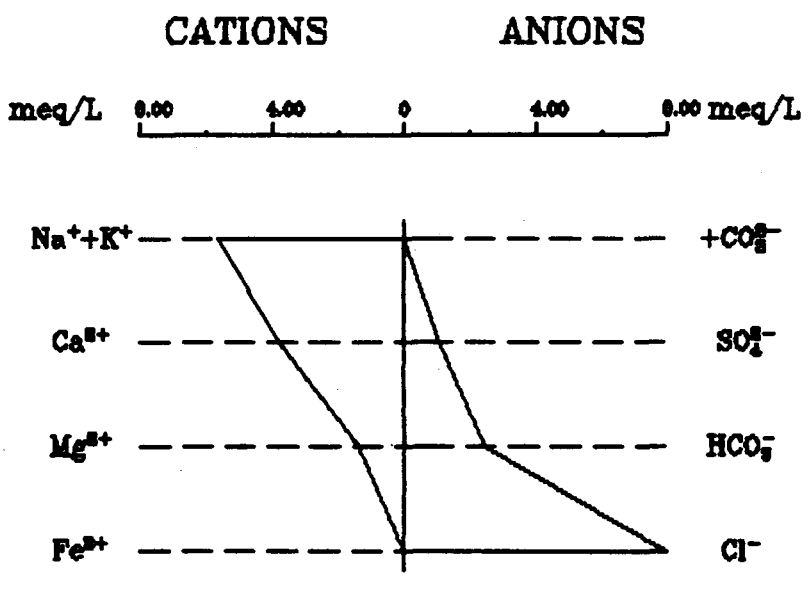


BULL CREEK
WELL 5
PUMPING

04/27/89

BULL CREEK 5
PUMPING

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	5.66	
Mg^{2+}	1.41	
Ca^{2+}	3.79	
Fe^{2+}	.00	
Cl^{-}		7.96
SO_4^{2-}		1.06
$HCO_3^{-}+CO_3^{2-}$		2.44
	10.87	11.46

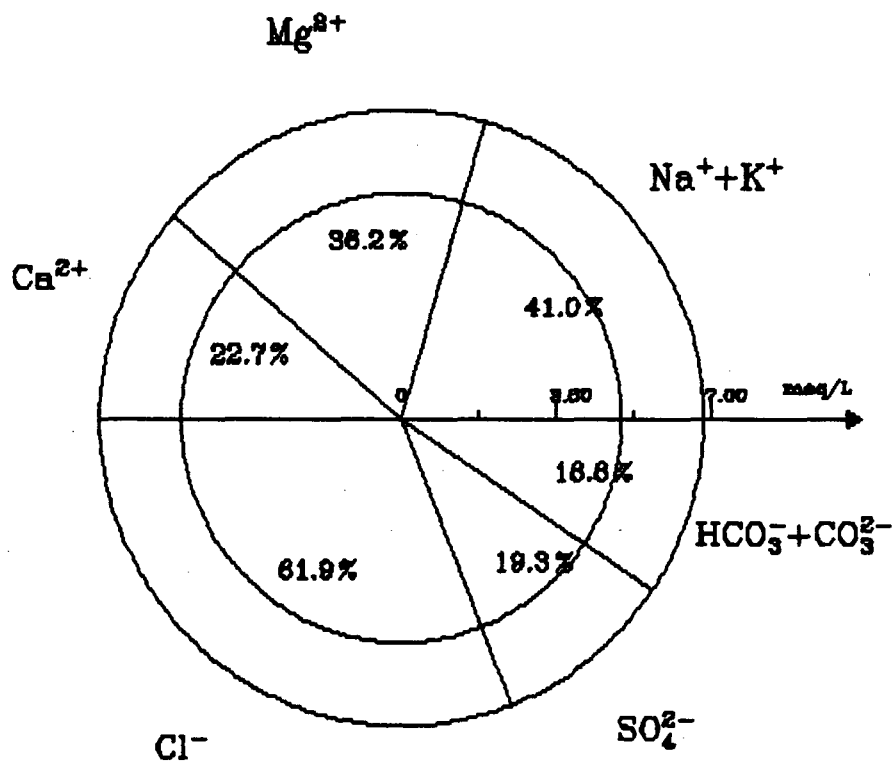


BULL CREEK
WELL 5
PUMPING

04/27/89

BULL CREEK 6
400 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	2.7	
Mg^{2+}	2.4	
Ca^{2+}	1.5	
Cl^{-}		3.0
SO_4^{2-}		.9
$HCO_3^{-}+CO_3^{2-}$		.9
	6.61	4.97

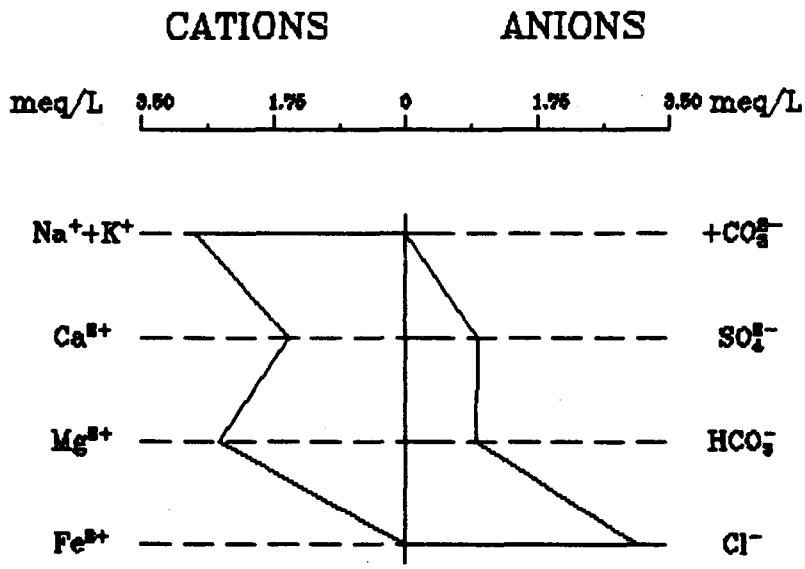


BULL CREEK
WELL 6
DEPTH = 400 FT

05/26/89

BULL CREEK 6
400 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	2.79	
Mg^{2+}	2.47	
Ca^{2+}	1.55	
Fe^{2+}	.00	
Cl^{-}		3.07
SO_4^{2-}		.96
$HCO_3^{-}+CO_3^{2-}$		.93
	6.81	4.97

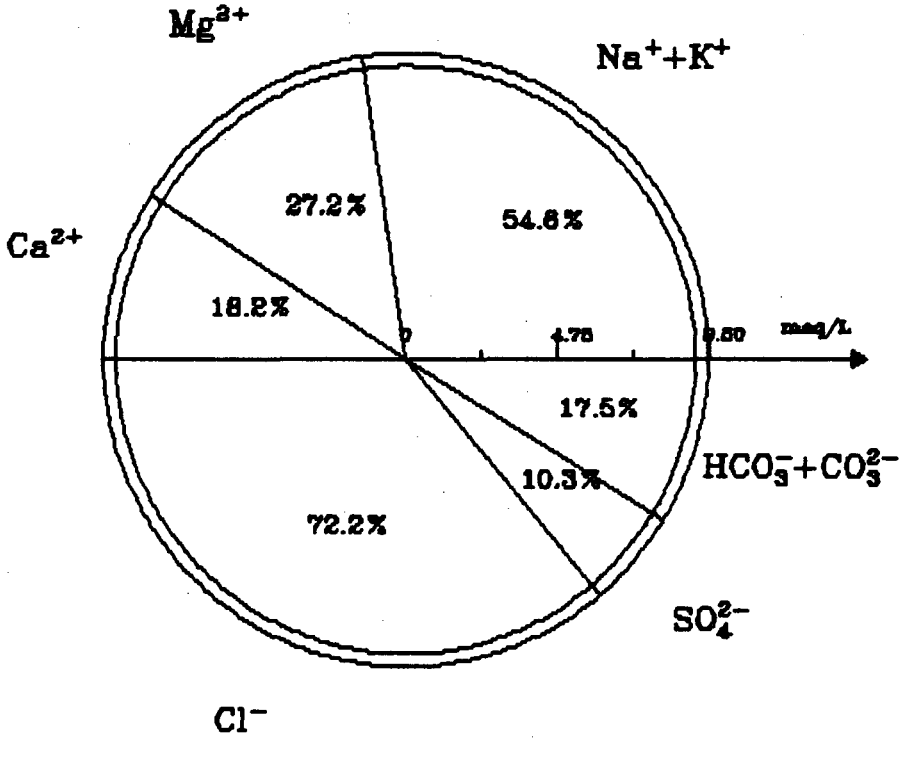


BULL CREEK
WELL 6
DEPTH = 400 FT

05/26/89

BULL CREEK 6
420 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	4.9	
Mg^{2+}	3.4	
Ca^{2+}	1.6	
Cl^{-}		6.8
SO_4^{2-}		.9
$HCO_3^{-}+CO_3^{2-}$		1.6
	9.07	9.46

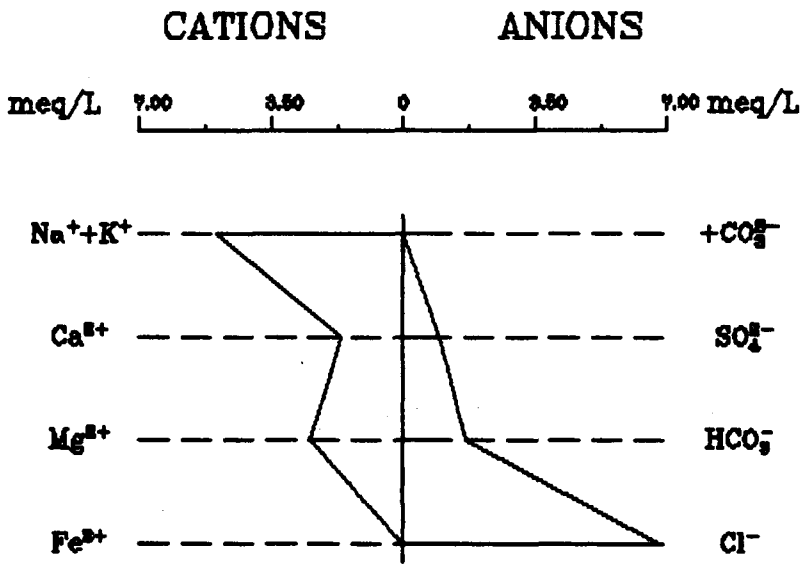


BULL CREEK
WELL 6
DEPTH = 420 FT

05/26/89

BULL CREEK 6
420 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	4.95	
Mg^{2+}	2.47	
Ca^{2+}	1.65	
Fe^{2+}	.00	
Cl^{-}		6.83
SO_4^{2-}		.98
$HCO_3^{-}+CO_3^{2-}$		1.66
	9.07	9.46

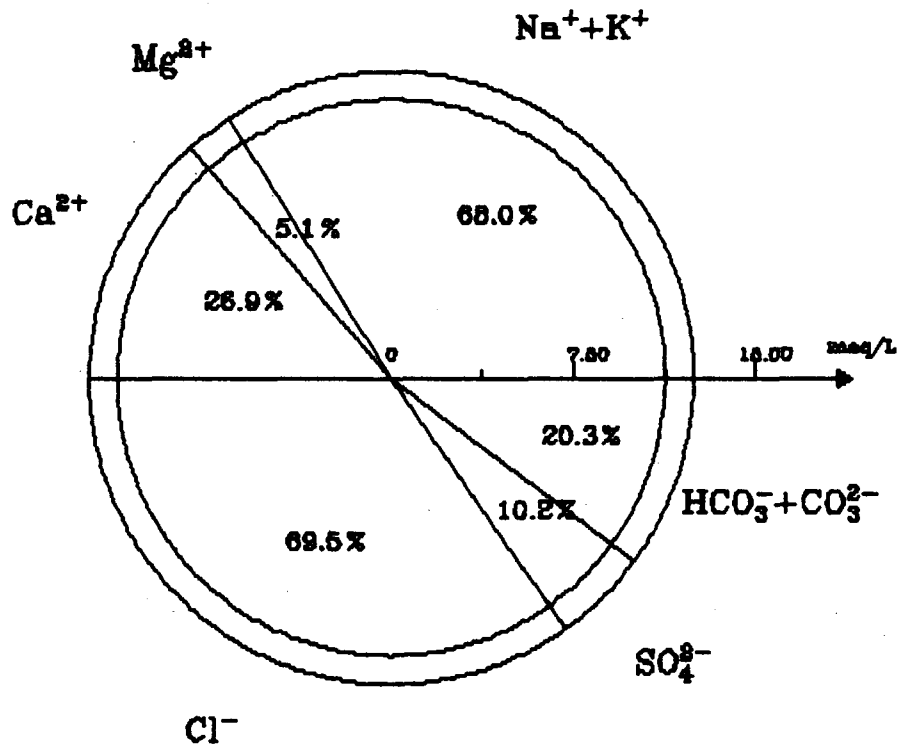


BULL CREEK
WELL 6
DEPTH = 420 FT

05/26/89

BULL CREEK 6
560 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	7.6	
Mg^{2+}	.5	
Ca^{2+}	3.0	
Cl^{-}		5.5
SO_4^{2-}		1.2
$HCO_3^{-}+CO_3^{2-}$		2.5
	11.30	12.45

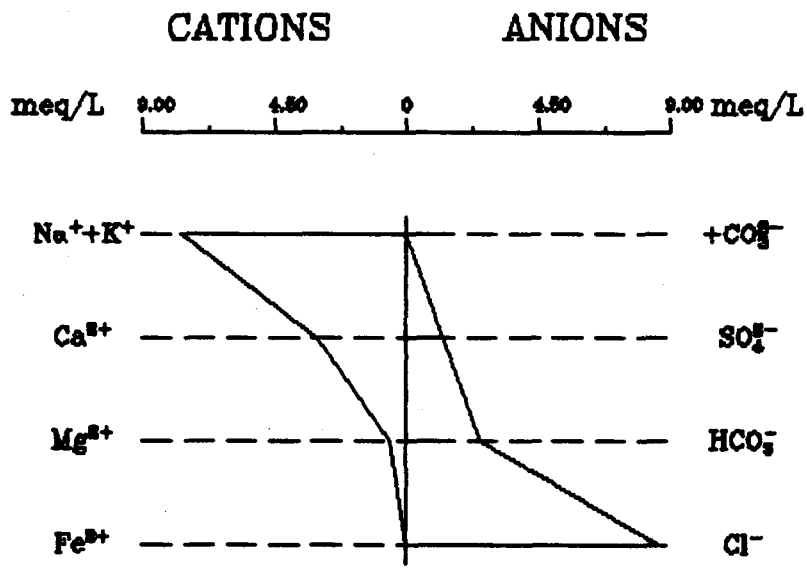


BULL CREEK
WELL 6
DEPTH = 560 FT

05/26/89

BULL CREEK 6
560 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	7.68	
Mg^{2+}	.55	
Ca^{2+}	3.04	
Fe^{2+}	.00	
Cl^{-}		8.66
SO_4^{2-}		1.27
$HCO_3^{-}+CO_3^{2-}$		2.52
	11.30	12.45

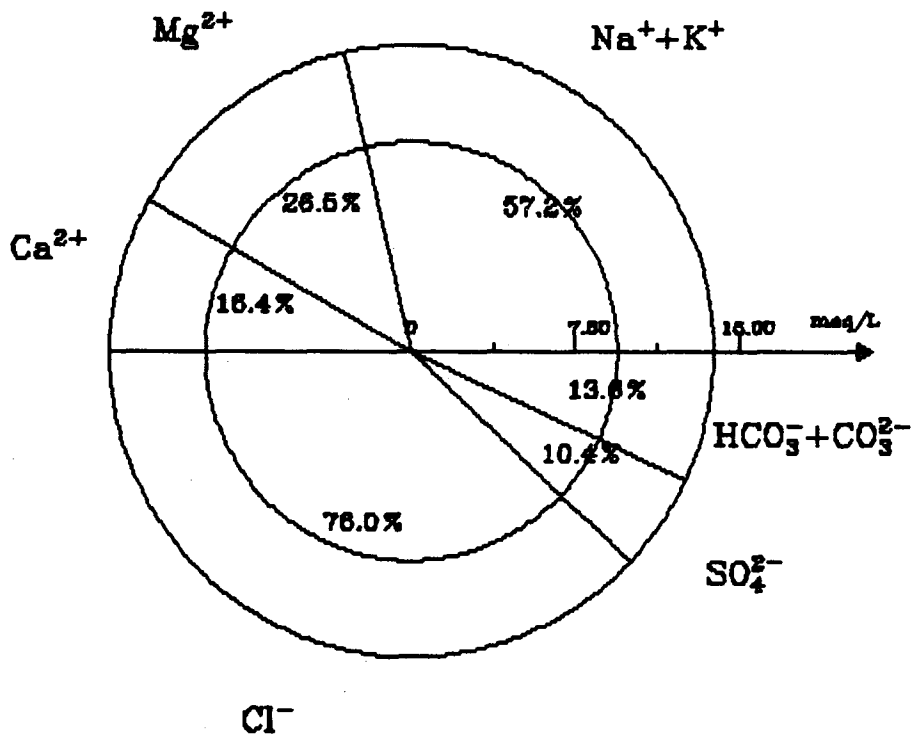


BULL CREEK
WELL 6
DEPTH = 560 FT

05/26/89

BULL CREEK 6
700 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	6.4	
Mg^{2+}	3.5	
Ca^{2+}	1.5	
Cl^{-}		10.5
SO_4^{2-}		1.4
$HCO_3^{-}+CO_3^{2-}$		1.8
	9.45	13.84

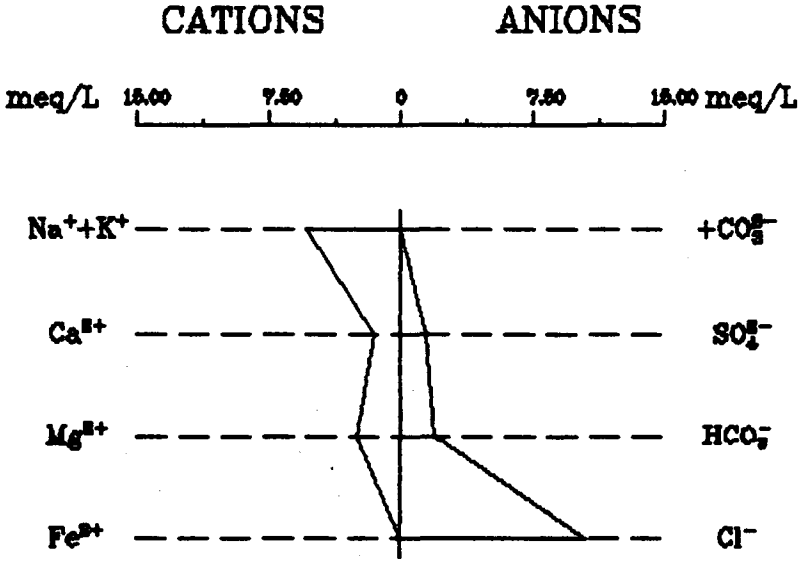


BULL CREEK
WELL 6
DEPTH = 700 FT

05/26/89

BULL CREEK 6
700 FT

Ion	meq/L	meq/L
$Na^{+}+K^{+}$	5.40	
Mg^{2+}	2.50	
Ca^{2+}	1.55	
Fe^{2+}	.00	
Cl^{-}		10.52
SO_4^{2-}		1.44
$HCO_3^{-}+CO_3^{2-}$		1.88
	9.45	13.84

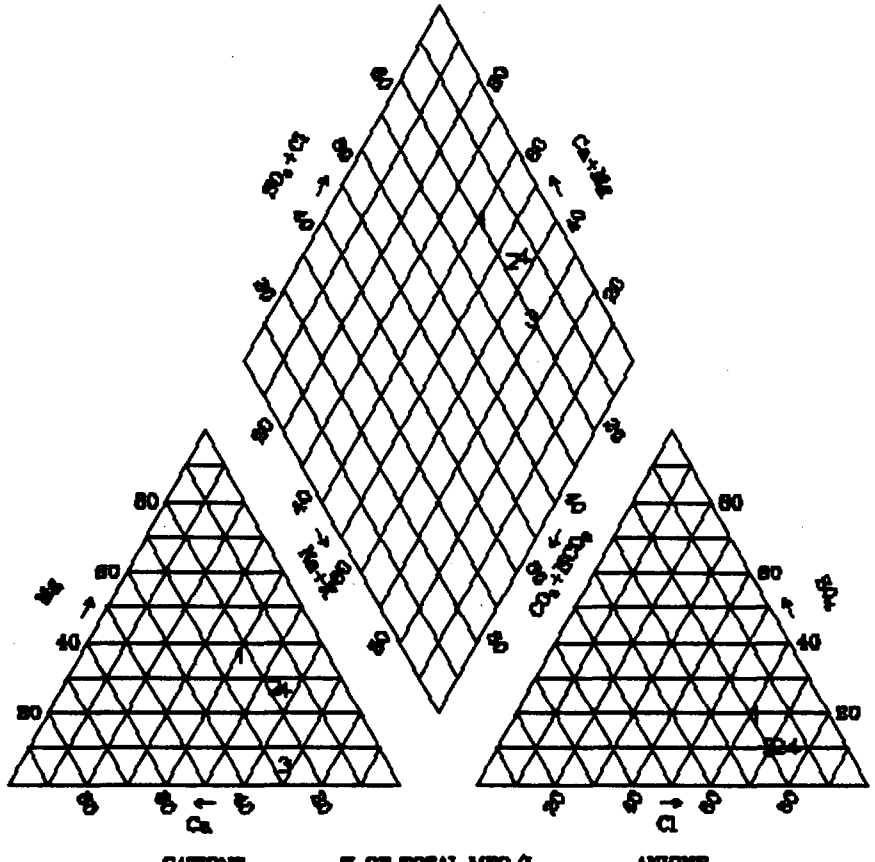


BULL CREEK
WELL 6
DEPTH = 700 FT

05/26/89

BULL CREEK
WELL 6

1
2
3
4



05/26/89

BULL CREEK
WELL 6