Ground Water Chemical Characterization of Morrison Spring, Florida
Water Resources Special Report 06-02

PREPARED BY:

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT

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GROUND WATER CHEMICAL CHARACTERIZATION OF MORRISON SPRING, FLORIDA

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Acknowledgements

Introduction

In 2001, the Florida Legislature funded the first phase of the Florida Springs Initiative (FSI) to study and preserve the quality of Florida's springs. The Florida Department of Environmental Protection (FDEP), administrator of FSI funding, contracted with the Northwest Florida Water Management District (NWFWMD) to monitor first magnitude springs within the District, delineate springsheds, and perform other research regarding springs water quality and distribution. The 2005 Florida Legislature continued funding and FDEP requested project proposals for additional work. The NWFWMD proposed completion of a ground water chemical characterization of the Morrison Spring basin in an effort to aid in delineation of the spring basin. This study was performed under FDEP contract GW245 (July 2005) during the period of September 2005 through June 2006.

Two primary goals formed the foundation for this study. The first was to apply statistical methods (principle component analysis and hierarchical cluster analysis) for characterizing spring basin water quality developed in other areas of the state to Morrison Spring and the St. Marks River Rise. Previous works by Dalton and Upchurch (1978), Jones, et al (1996), and Barrios and DeFosset (2005) demonstrated the effectiveness of the statistical analysis of common ions in identifying intra-basin relationships and geochemical facies for Floridan Aquifer springs. The second objective was to apply these same statistical methods towards the delineation of the spring basin boundary and/or the identification of the principle contribution area(s) within the spring basin boundary.

Morrison Spring Characterization Study Area and Hydrogeology

Morrison Spring, a second magnitude spring located in east-central Walton County, is one of the more significant discrete contributors to the flow of the Choctawhatchee River. Based on a known record of eight spring discharge measurements, Morrison Spring contributes an approximate median discharge of 60 ft³/sec to that of the Choctawhatchee River. Over the period of record, Morrison Spring discharge has ranged from 47 to 89 ft³/sec. Regional scale potentiometric surface maps suggest that the springshed contributing to Morrison Spring lies within an area to the northwest encompassing southwest Holmes County and east-central to northeast Walton County. Within this general area, three second or third magnitude springs exist: Ponce de Leon Spring, Vortex Spring, and Holmes Blue Spring.

The focus area for this study (Figure 1) is located at the western edge of the Dougherty Karst Plain District. The Floridan Aquifer in the study area includes Eocene to Miocene age carbonate formations. According to Florida Geological Survey core descriptions from Walton, Holmes, and Washington counties, the elevation at the top of the aquifer and its thickness can vary considerably. In the northern sections of the study area, a combination of structural and geomorphic processes has limited the Floridan Aquifer to the Eocene Ocala Formation with a known thickness not exceeding 120 ft. South and west of these northern reaches, Oligocene formations and the Miocene Chattahoochee Formation are incorporated into the Floridan with known thicknesses increasing to as much as 265 feet.

The Floridan Aquifer is recharged by rainfall through the leaky confinement of a thin and inconsistent Intermediate System. As with the general thickness trend of the Floridan Aquifer in the area, the Intermediate System composed of the Alum Bluff Formation thickens to the south and west. The potentiometric surface suggests that ground water recharge to the aquifer moves regionally in a northwest to southeast direction. In the study area, the potentiometric surface elevations range from 180 to 30 ft above sea level. Due to suspected changes in aquifer transmissivities (Miller, 1986), the gradient of the potentiometric surface is particularly steep between 180 and 70 ft above sea level. Below 70 feet the gradient of the potentiometric surface decreases noticeably.

Ground water moving through the Floridan Aquifer in this area discharges in several manners. The springs mentioned, Morrison Spring, Ponce de Leon Spring, Vortex Spring, and Holmes Blue Spring, serve as the most distinct points of ground water discharge in the area. Recent specific conductance measurements taken by NWFWMD staff during base flow conditions demonstrate that the Floridan Aquifer also discharges to stretches of West Pittman Creek, Reedy Creek, Sandy Creek, and Bruce Creek. Additionally, Choctawhatchee River discharge measurements taken by District staff during base flow conditions reveal that significant Floridan Aquifer discharge not accounted for at discrete surface water locales occurs along the river bottom.
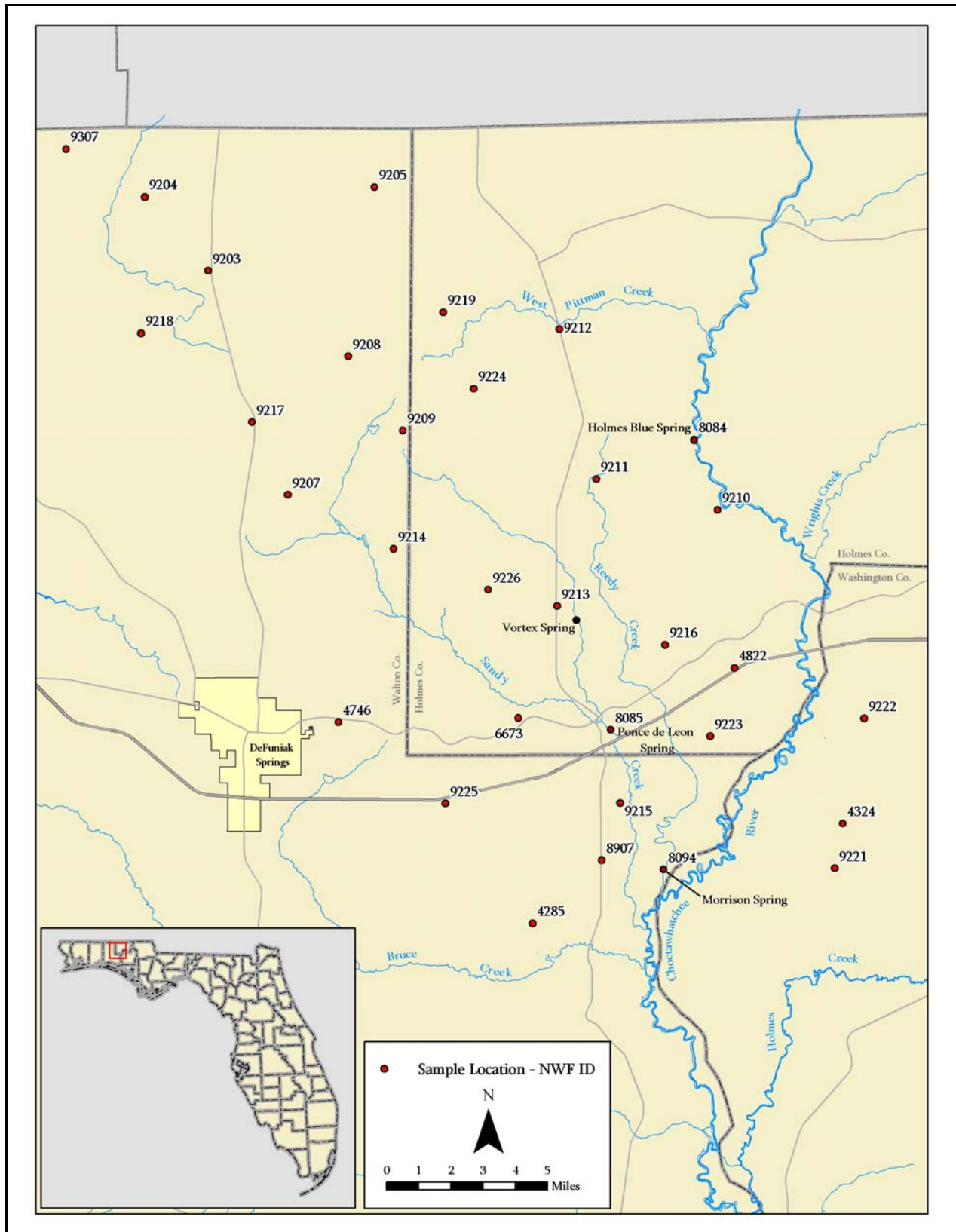
Figure 1. Study area and sample locations

Data Collection and Analysis Methods

Sample sites (Figure 1) were selected from the NWFWMD Well Inventory and Construction Permitting databases and conformed to the following requirements: wells must possess an open hole or screened interval entirely within the Floridan Aquifer, wells with in-place plumbing must be functioning with a sample withdrawal site located before any filtration equipment, and site location allows for adequate coverage of the study area. A total of thirty-four ground water samples were collected from wells and karst features throughout the above described area during the fall quarter of 2005. Water quality sampling was conducted in accordance with FDEP standard operating procedures listed under DEP-SOP-002/02 (revised 6/28/2004). Lab samples and equipment blanks were submitted to the FDEP Central Chemistry Lab for analysis. Field parameters and laboratory analyses are summarized in Table 1.

Due to unexpected shallow sampling depths at two locations, thirty two of the thirty four water chemistry samples were utilized for the Morrison Spring chemical characterization. Site information and well construction data for the thirty two samples are provided in Appendix A. Field and laboratory results are provided in Appendix B. Individual parameter concentration gradients for the study area are plotted in Figures 2-5.

Table 1 – Statistical Summary of Water Quality Data

Variable	Reported Unit	n	Mean	Median	St. Dev.	Skewness	Kurtosis
Water Temperature	°C	34.0	20.7	20.7	0.74	0.32	-0.73
Specific Conductance	μS/cm	34.0	226	219	79.09	0.08	3.25
Dissolved Oxygen	mg/L	34.0	3.17	2.26	2.66	0.8	-0.29
pH	su	34.0	7.3	7.5	0.81	-3.42	11.62
Alkalinity, Total	mg/L	34.0	106.96	105.50	39.89	-0.16	3.43
Ammonia	mg/L	34.0	0.023	0.010	0.03	3.22	10.63
Ammonia + Organic N	mg/L	34.0	0.121	0.080	0.10	4.56	23.64
Nitrate + Nitrite, Total	mg/L	34.0	0.180	0.010	0.40	3.27	10.81
Phosphorus, Total	mg/L	34.0	0.035	0.022	0.05	4.21	19.92
Orthophosphate, Dissolved	mg/L	34.0	0.023	0.018	0.03	2.54	7.25
TOC	mg/L	34.0	1.08	1.00	0.28	3.75	13.23
Calcium, Total	mg/L	34.0	34.6	32.0	16.73	1.02	3.26
Magnesium, Total	mg/L	34.0	8.6	8.4	4.92	0.19	-0.33
Sodium, Total	mg/L	34.0	2.23	1.82	1.51	4.39	21.82
Potassium, Total	mg/L	34.0	0.77	0.58	0.62	2.39	7.94
Chloride, Total	mg/L	34.0	3.0	2.4	2.16	3.58	14.36
Sulfate, Total	mg/L	34.0	4.76	4.40	4.97	2.32	7.62
Fluoride, Total	mg/L	34.0	0.087	0.084	0.03	0.71	-0.20
Silica, Total	mg/L	34.0	11.4	10.0	6.01	3.86	18.33
Iron, Total	μg/L	34.0	359.9	96.5	632.78	2.86	8.70
TDS	mg/L	34.0	121	120	43.31	0.71	2.88
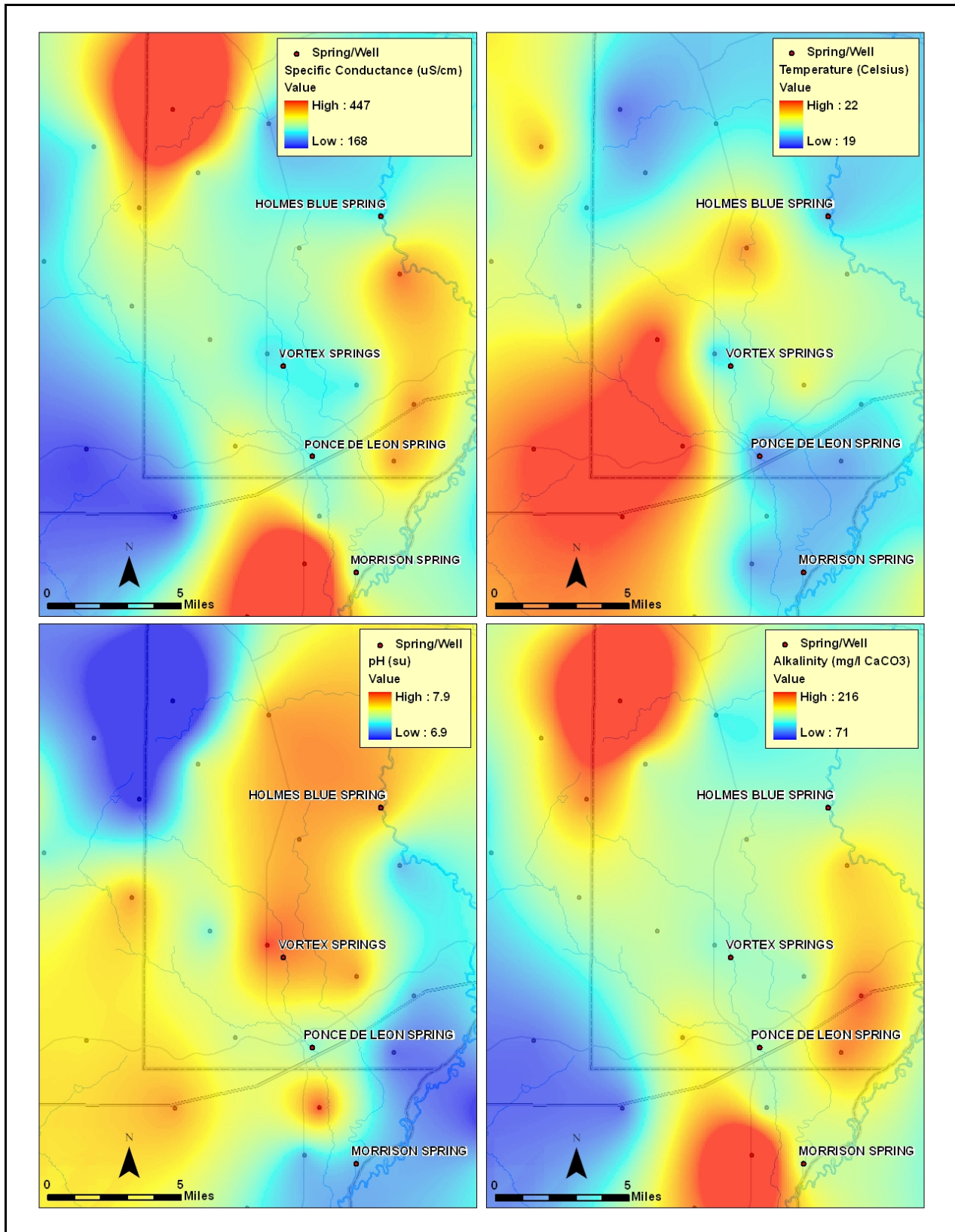
Figure 2. Parameter trends (specific conductance, temperature, pH, alkalinity)
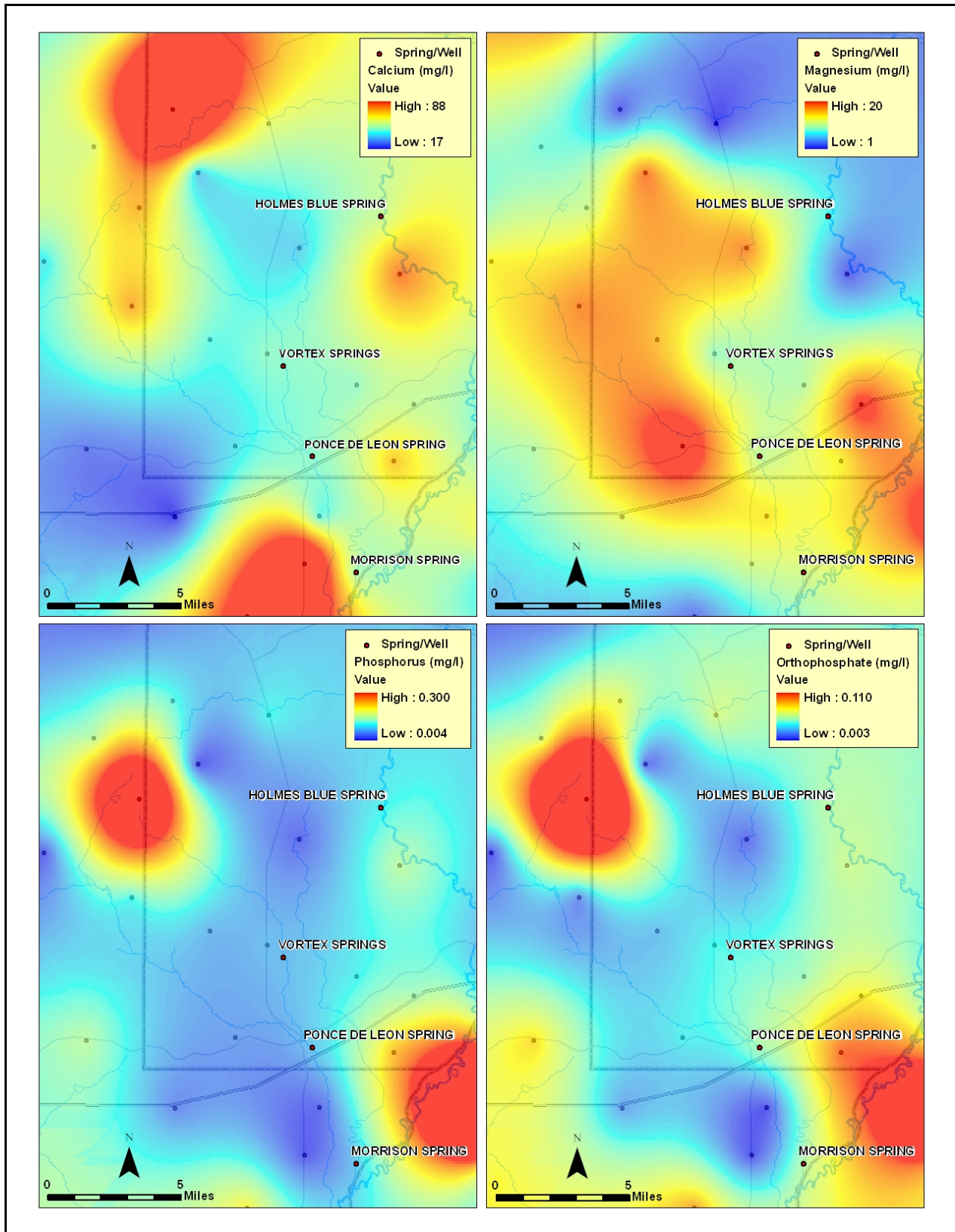
Figure 3. Parameter trends (calcium, magnesium, phosphorus, orthophosphate)
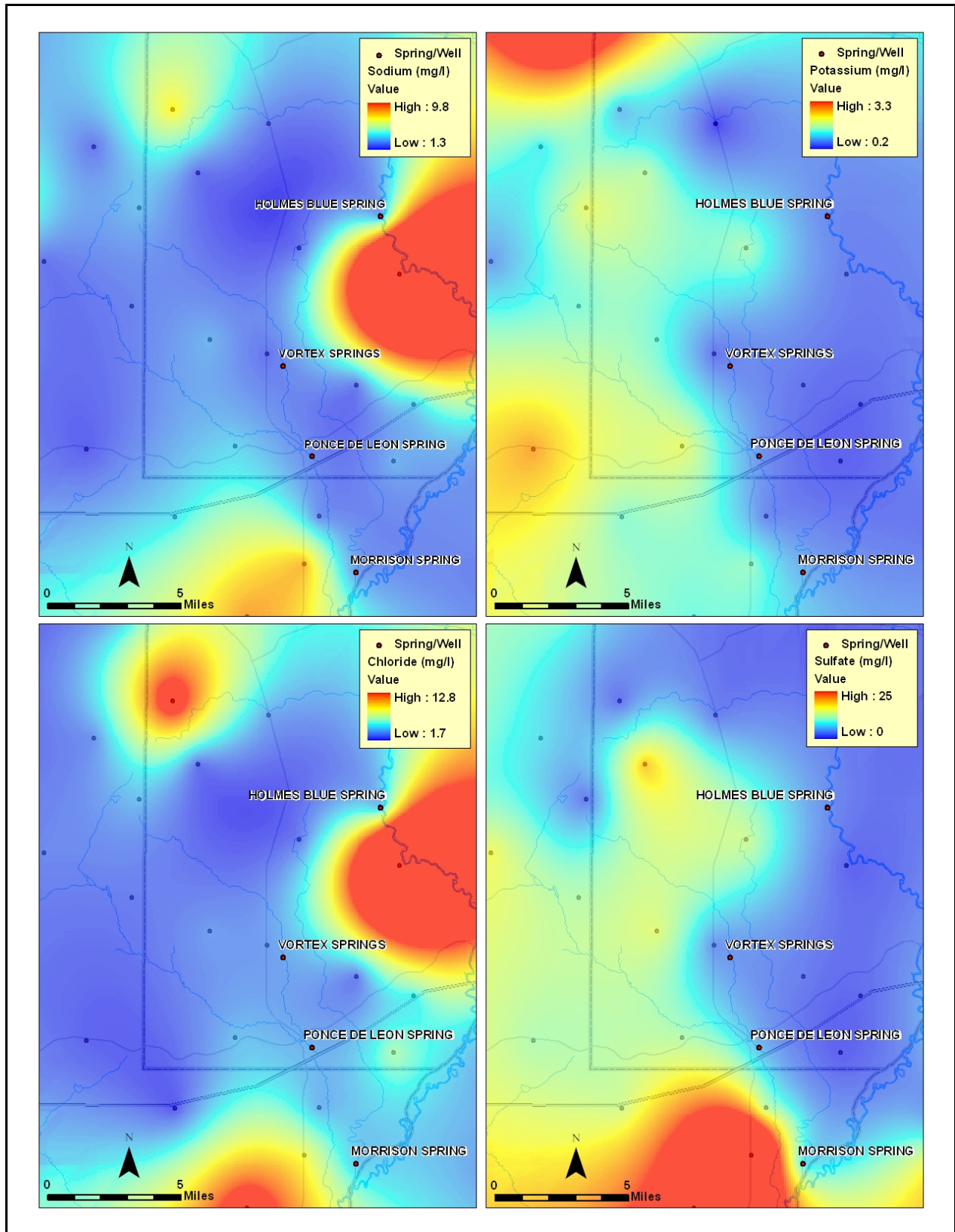
Figure 4. Parameter trends (sodium, potassium, chloride, sulfate)
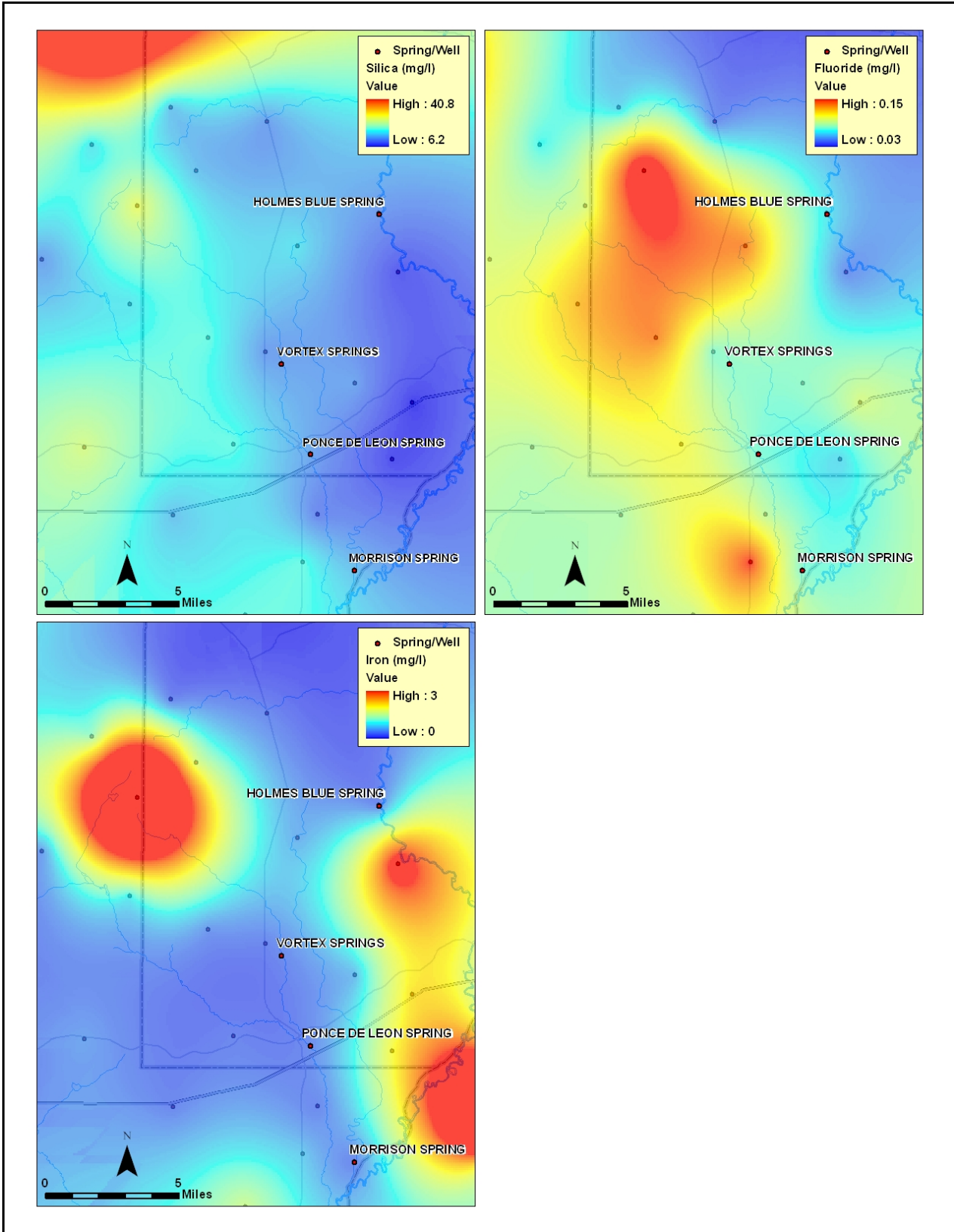
Figure 5. Parameter trends (silica, fluoride, iron)

Floridan Aquifer Potentiometric Surface

Water level measurements were collected from thirty-two wells visited for this investigation. The elevation of the Floridan Aquifer potentiometric surface was determined by subtracting the depth to water at the measurement location from the land surface elevation. The Floridan Aquifer potentiometric surface presented in Figure 6 displays the regional flow pattern in the study area – as flow through the aquifer is generally normal to isopotential contours.

A similar, less detailed surface was used to approximate a groundwater contribution area for Morrison Spring for the purposes of sample site selection. Relative to the spring, the groundwater basin was assumed to trend to the north-northwest. A more numerous and expansive set of surveyed water level measurements would be required to more precisely define the spring basin boundary.
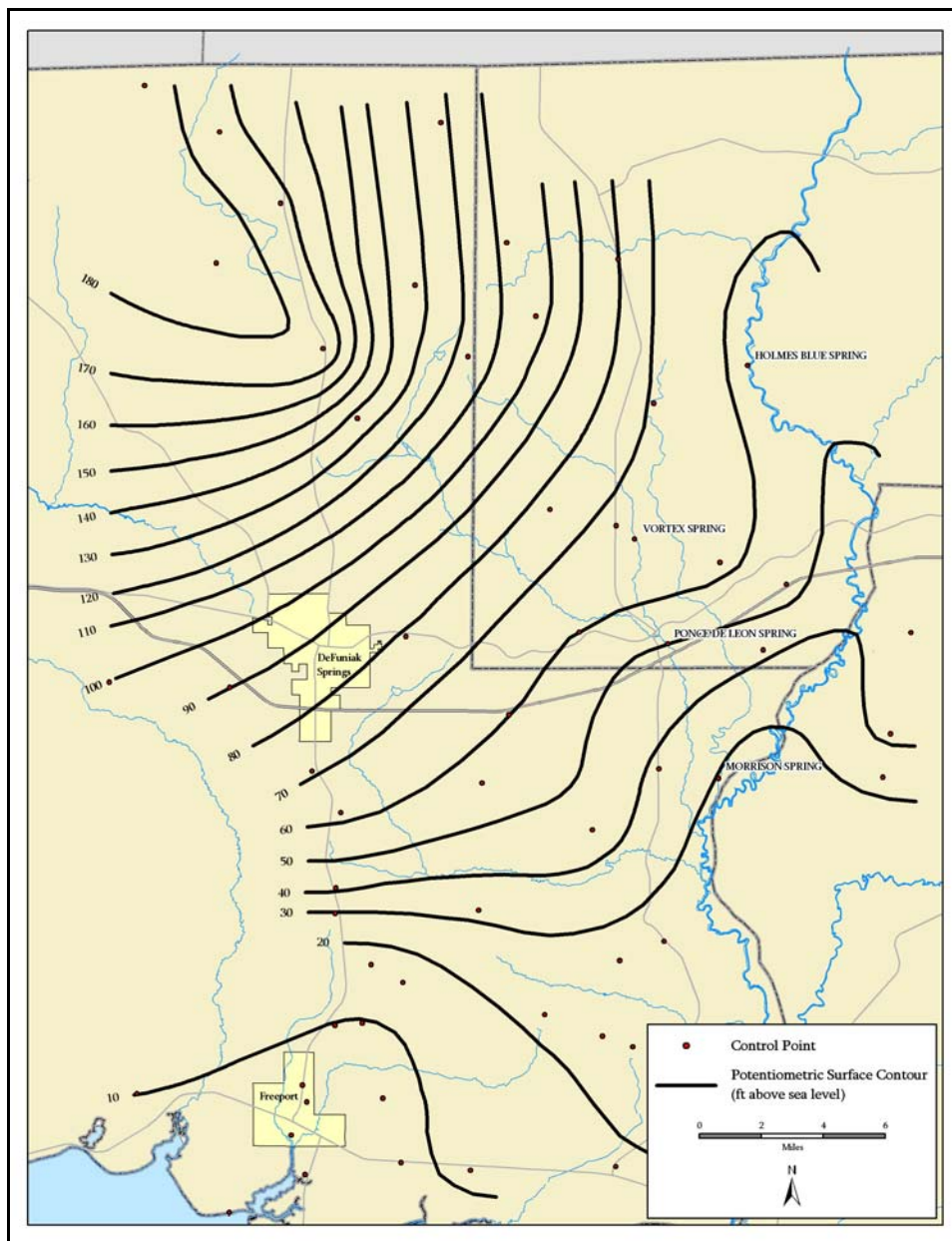
Figure 6. Regional potentiometric surface map

Morrison Spring Chemical Characterization

The calculated charge balance error for the Morrison Spring dataset ranges from 6.5 to 42 percent with a mean and median value of 13.5 and 11.5 percent respectively. Under ideal conditions, all components of the water chemistry can be sampled and identified and the resulting charge balance error will be zero. Usually a charge balance error less than five percent is acceptable.

Principle Component Analysis

Once the water chemistry results were received, the samples were checked for consistency with Floridan Aquifer characteristics and reviewed for entry errors. Nitrate + nitrite, ammonia, ammonia + organic nitrogen, and TOC (parameters with significant results below the laboratory method detection limit) were removed to eliminate an artificial influence on variance within the population. For the balance of the parameters, results below the method detection limit were assigned the detection limit value. Dissolved oxygen was also excluded due to a lack of confidence that measured field values were representative of Floridan Aquifer dissolved oxygen concentrations. Factors related to well construction and well plumbing could result in artificially increased dissolved oxygen concentrations. The water quality results from two well sites were removed from the analysis due to water level and chemical data indicating a casing interval wholly or partially intersecting the Intermediate Aquifer System. In order to allow the comparison of parameters with different units and widely ranging scales, all reported values were converted into units of standard deviation.

The Principle Component Analysis (PCA) method is used to group the parameters into common components, or root causes of variability, within the sample population. The PCA is also useful in assisting with the clustering of similar samples and determination of the dominant chemical processes in the study area. The PCA used for this study was conducted in Microsoft Excel using methods established by Darlington (2004), Arsham (2006), Tyne, et al (2004) and Dalton and Upchurch (1978). Matrix and linear algebra operations for Excel were completed with the MATRIX.XLA add-in created by the Foxes Team at Calcolo Numerico (Volpi 2006). After standardization of the water quality variables, a correlation matrix was generated for the data set. The Jacobian eigenvalue and eigenvector matrices were then created. Components with eigenvalues satisfying Kaiser's criterion (eigenvalue >1) were retained and the associated eigenvectors were transformed into component loading coefficients. Varimax rotation was not needed to concentrate variables within a single component. Component scores were then calculated for each sampling location by adding the products of the component loading coefficient and the standardized value for each variable

The PCA for the dataset resulted in three principle components derived from the original data, together accounting for 74 percent of the variability within the sample population. Individual component loading coefficients are listed in Table 2. An elevated positive or negative component loading indicates a positive or negative correlation for the variable with that component. The communality represents the percent variance for any single parameter explained by the three components.

As indicated by the component loading coefficients in Table 2, component I is primarily influenced by the variables calcium, specific conductance, alkalinity, TDS, pH, chloride, and sodium. As shown in Figure 7, areas of higher scores for component I are located along the Choctawhatchee River and in the northern portion of the study area. These areas generally correspond with concentrations of the individual variables elevated above their respective mean values. The first five variables listed indicate that the component is a measure of the availability and contact with soluble solids (Hem 1992). When these parameters are observed to be near the population mean, the respective site is considered to assume a character of standard carbonate water. Elevated levels of carbonate related parameters such as calcium may be expected due to the varying degree of solubility that a carbonate unit can possess on a regional scale.

The few samples with accompanying elevated levels of sodium and chloride could signify the presence of connate water in this section of the aquifer. Given the marine depositional environment of these carbonates it would not be unexpected to find elevated sodium and chloride content in these relic waters. One source of this water could be the Claiborne Group. The fact that many of the samples with elevated concentrations are located along the Choctawhatchee River suggests that the upward gradient to the river that exists in the Floridan Aquifer could encourage the migration of more mineralized water into the non saline component of the aquifer. Although the sodium and chloride concentrations and Cl/Na ratio do not suggest highly mineralized connate waters, it is possible that although migrating to this portion of the aquifer, concentrations may be diluted by the fresh water component of the aquifer.

Component II is primarily influenced by the variables total phosphorus, orthophosphate, iron, and sulfate; sulfate having an inverse relationship to the other parameters in the component. As indicated in Figure 7, high values of component II are found in areas similar to those for component I; along the Choctawhatchee River and in the northern portion of the study area. The more elevated component II values generally correspond to areas with the lowest sulfate values, the highest iron concentrations, and phosphorus and orthophosphate values above the population mean. Conversely, minimal component II values define waters with some of the

higher sulfate concentrations among the population and phosphorus and orthophosphate concentrations below that of the population mean. Iron concentrations in areas with depressed component II values appear to fall on either side of the population median value. Component II could reveal those areas with an appreciable thickness of phosphatic Miocene sediments. Component II could also suggest a localized nature to gypsum deposits in these sediments as evidenced by the varied sulfate concentrations.

Component III (Figure 7) is primarily influenced by potassium, magnesium, silica, and fluoride. According to Florida Geological Survey core descriptions, the higher component III scores occur in areas where Oligocene carbonate formations exist. In these areas, individual parameter concentrations within this component are generally elevated above their respective mean values. The more depressed component III values tend to apply to sampling locations exposed to Oligocene and Eocene formations. The distribution of component III scores coincides with the structure of the Floridan Aquifer within the study area. From east to west the sediments comprising the Floridan Aquifer thicken and plunge, resulting in a transition of ground water withdrawal from Eocene formations to Oligocene formations. The parameters in this component are most associated with the mineralogy of Oligocene formations; specifically dolomite and glauconite.

<p align="center">Table 2 - Component Loading Coefficients</p>

| Variable	I	II	III	Communality (%)
Specific Conductance	**0.890**	-0.304	0.128	90
pH	**-0.647**	-0.267	-0.397	65
Alkalinity, Total	**0.873**	-0.226	0.128	83
Phosphorus, Total	0.224	**0.865**	0.298	89
Orthophosphate, Dissolved	0.327	**0.842**	0.198	85
Calcium, Total	**0.920**	-0.050	0.028	85
Magnesium, Total	-0.322	0.185	**0.669**	59
Sodium, Total	**0.646**	-0.071	-0.267	49
Potassium, Total	-0.136	-0.370	**0.701**	65
Chloride, Total	**0.775**	-0.019	-0.356	73
Sulfate, Total	0.127	**-0.593**	0.324	47
Fluoride, Total	-0.181	-0.357	**0.572**	49
Silica, Total	-0.104	-0.306	**0.655**	53
Iron, Total	0.288	**0.808**	0.376	88
TDS	**0.870**	-0.358	0.162	91
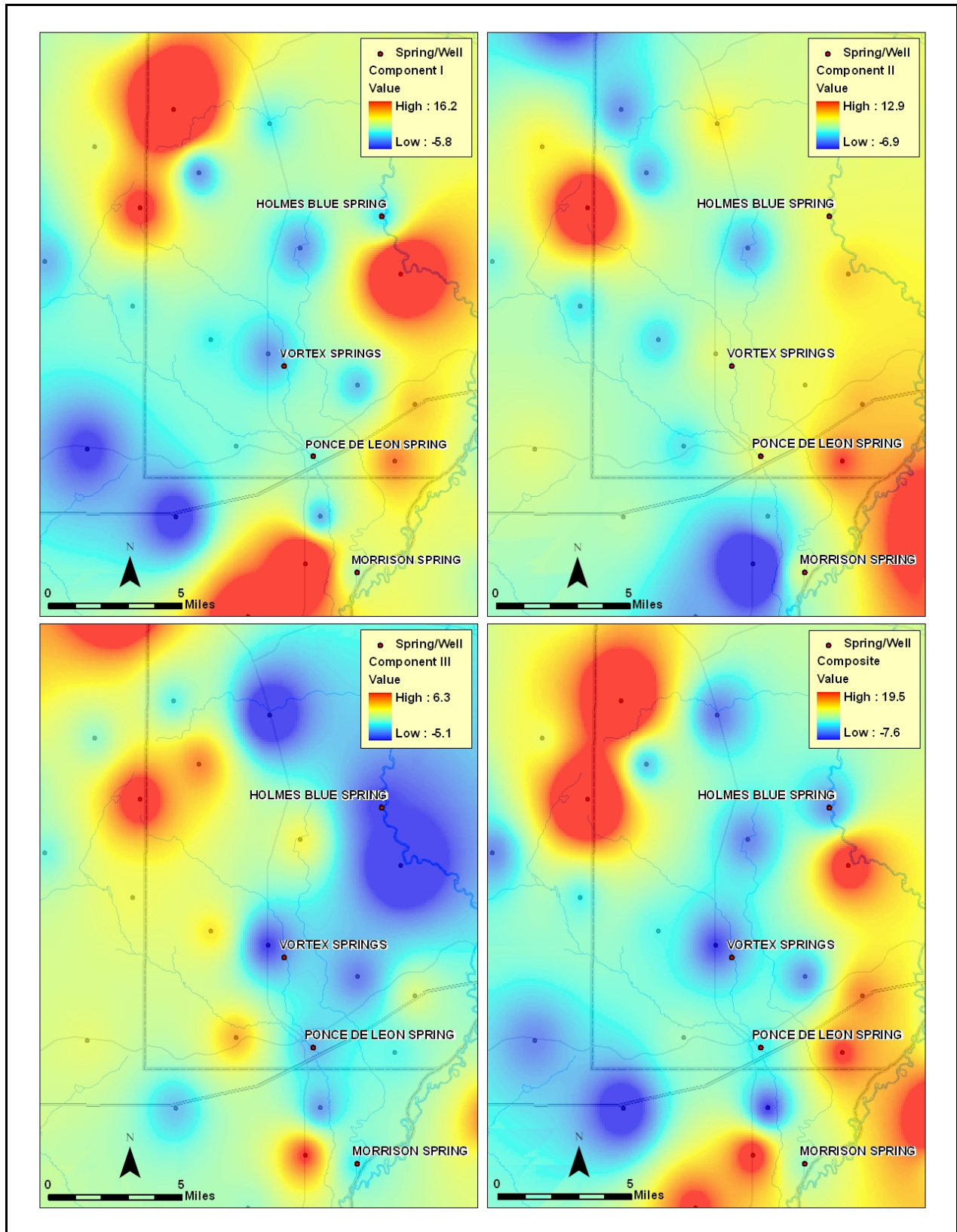
Figure 7. Distribution of principal components

<u>Hierarchical Cluster Analysis</u>

Hierarchical cluster analysis has traditionally been used as an exploratory method to formulate an initial understanding of a dataset by grouping objects to form a structure that reveals the degree of similarity or dissimilarity between samples. In hydrological investigations, hierarchical clustering is used along with component or factor analysis to acquire a spatial understanding of the geochemical and/or anthropogenic processes influencing the chemical character of water throughout a study area.

Hierarchical clustering involves determination of similarity/dissimilarity by algorithms and linkage of groups once the degree of similarity is determined. The approach of the combined application of principal component analysis and hierarchical clustering has differed between various studies. The method of Suk and Lee (1999) appears to be the most applicable to the current study. Particular to hierarchical clustering, Suk and Lee utilized factor scores to complete the cluster analysis. The clustering was completed with the software SYSTAT 11. It was determined that using Pearson's distance determination and the average linkage method, produces a structure that best organizes the water samples into clusters of common chemical character.

The hierarchical structure resulted in the identification of six clusters (Figure 8). As a means of visualizing sample similarity/dissimilarity determined by the clustering, radial diagrams were constructed for each sample using the component scores as determined by the PCA. Examples of the general chemical character of each cluster are shown in Figure 9. The spatial relationship of the clusters can be seen in Figure 10.

Component III is the predominate determiner of the chemical character of samples in cluster 1. Components I and II have a relatively minimal influence on the water type demonstrated by this cluster. Due to the relative importance of the components it can be suggested that water in these areas are receiving ground water that has been or is flowing largely through the portion of the Floridan Aquifer comprised of dolomitic and/or glauconitic Oligocene carbonates.

In cluster 2, although component III is influential to the chemical character of the group, component II shares an equal influence in determining water type. The apparent mixture of waters suggests that flow through a portion of the Floridan Aquifer comprised of Oligocene carbonates has also received recharge waters that have passed through the semi confining Miocene sediments.

Interaction with Miocene sediments is suggested to determine the chemical character of waters in cluster 3. Components I and III both have a minor influence on the samples in this cluster. The predominance of component II suggests that water in these areas has recharged the ground water system through the semi confining Miocene sediments.

Cluster 4 is defined by a mixture of waters whose chemical character is determined by components I and II. Waters grouped into this cluster have recharged the ground water system through Miocene sediments. However, there is a significant imprint of a carbonate water character as determined by the presence of component I. The lack of component III may suggest that these waters either have not been exposed to Oligocene carbonates or the Oligocene carbonates they have been exposed to do not share a common mineralogy as those discussed earlier.

Samples belonging to clusters 5 and 6 demonstrate an influence by component I to a degree unique among the sample population. Although this suggests a native Floridan Aquifer character, those samples possessing a particularly pronounced component I score may be associated with connate waters given the relatively high concentration of sodium and chloride. These two clusters differ in that cluster 5 chemical character is more influenced by component II than cluster 6. It would be expected that due to their respective spatial clustering, there is a greater presence of Miocene sediments in the vicinity of cluster 5 than cluster 6.
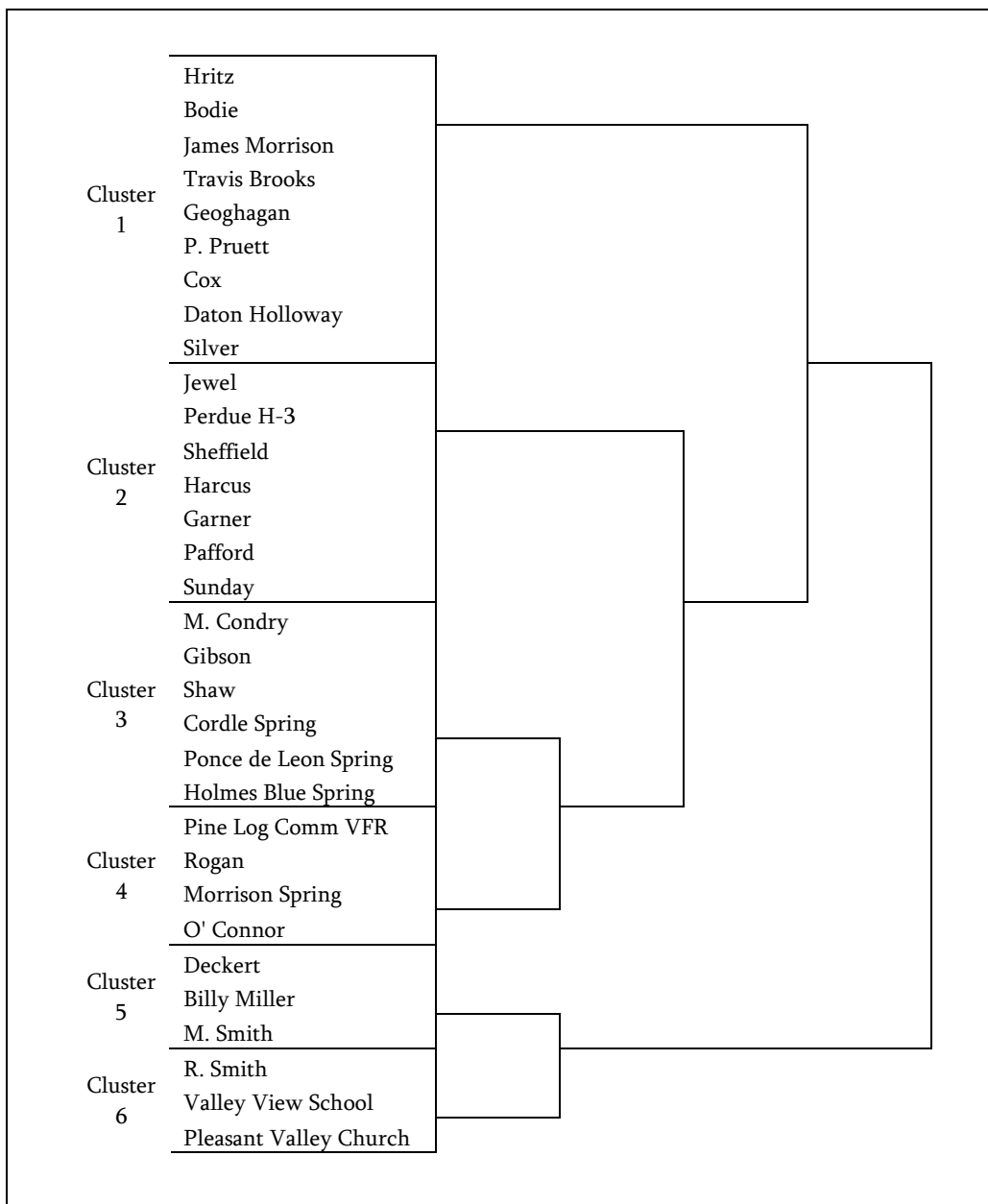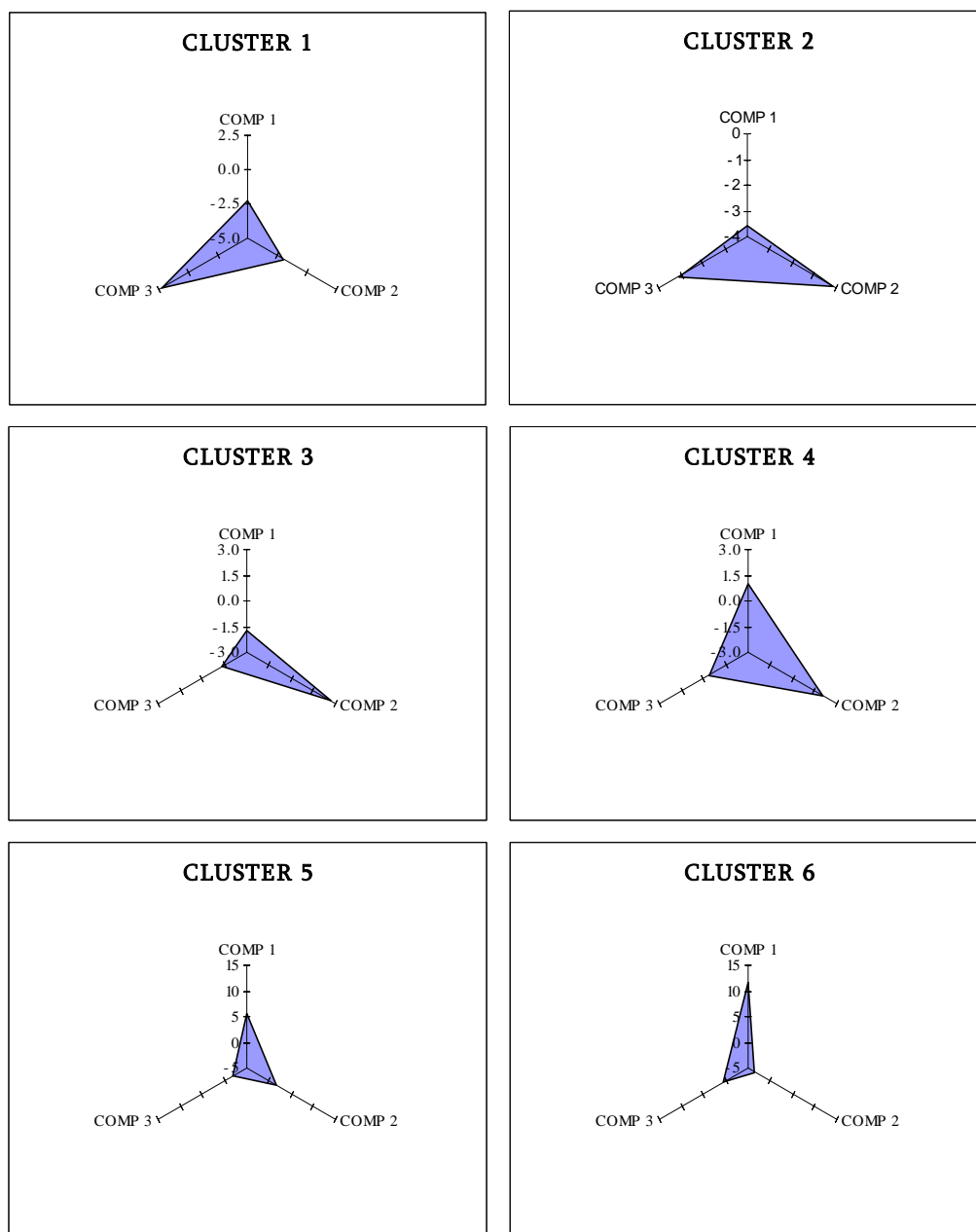
Figure 8. Results of hierarchical clustering analysis

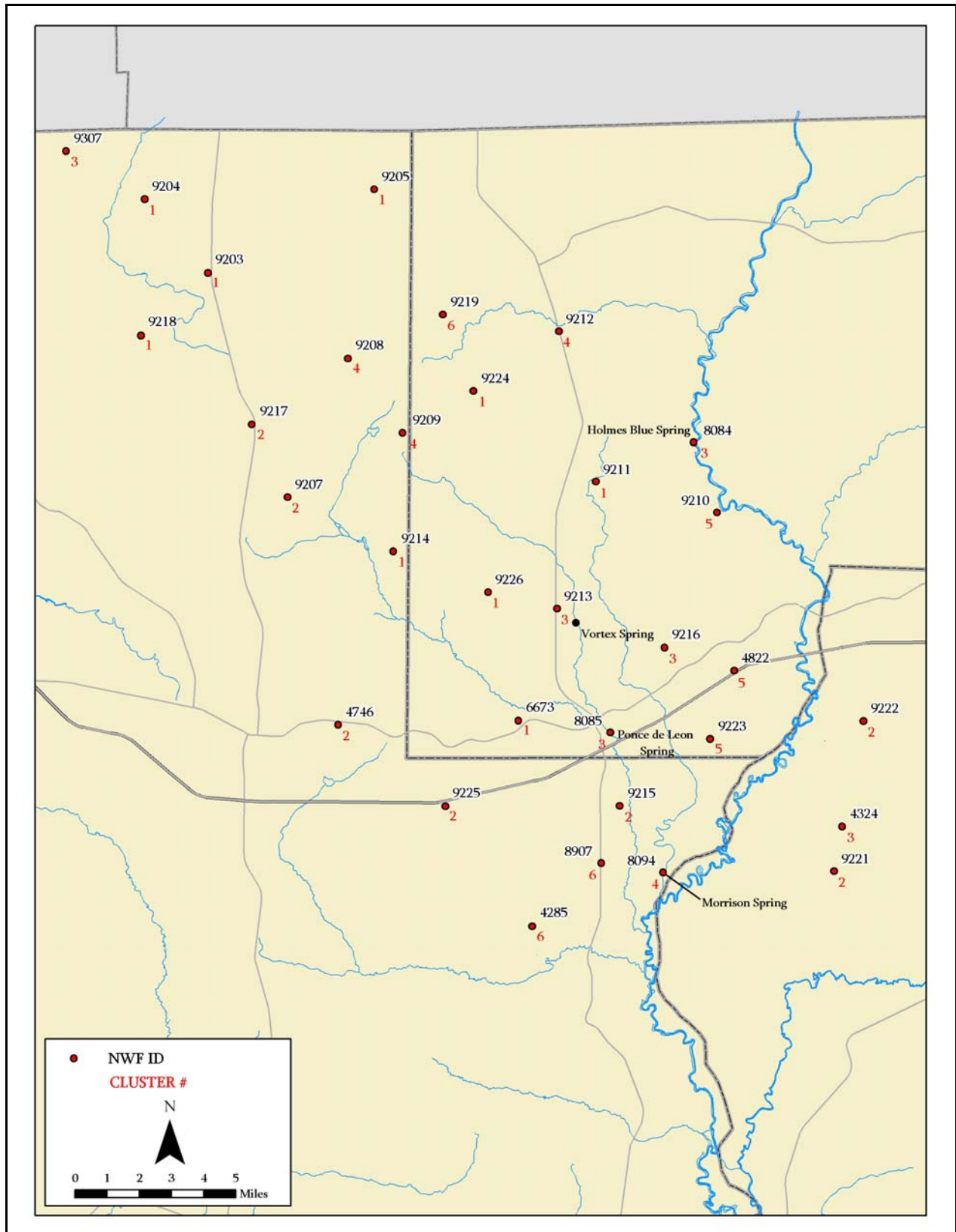Figure 9. Radial diagrams of the average component scores of each cluster

Figure 10. Spatial relationship of clusters in study area

Conclusions

1. The principle component analysis of the Morrison Spring chemical characterization water quality data determined three components explain a majority of the variance within the sample population.

2. The principle components appear to represent lithologic and stratigraphic influences upon the chemical composition of Floridan Aquifer water in the area of Morrison Spring. It should be noted that similar studies on three first magnitude springs in the NWFWMD have yielded one component that was considered the result of anthropogenic influence. The analysis of the Morrison Spring sample population did not produce such a component. Given this result coupled with the slight nitrate-nitrite concentrations (often considered an indicator of human impact) across the sample population, it appears there has been a minimal anthropogenic impact on the ground water quality in the area of Morrison Spring.

3. The components appear to suggest a relative depth of flow within the Floridan Aquifer contributing to springs in the area. With increasing depth component II represents a Miocene lithology, component III represents an Oligocene lithology, and component I represents Oligocene to Eocene lithologies. As can be seen in each spring's radial diagram, with increasing spring discharge, the more each component is represented in its chemical character. This suggests that with increasing discharge a deeper aspect of the flow regime is incorporated into a spring's basin. Given each component's shared representation at Morrison Spring, it appears that the area contributing to Morrison Spring could represent a thick flow system through the Floridan Aquifer incorporating a more varied lithology than that of other springs in the area.
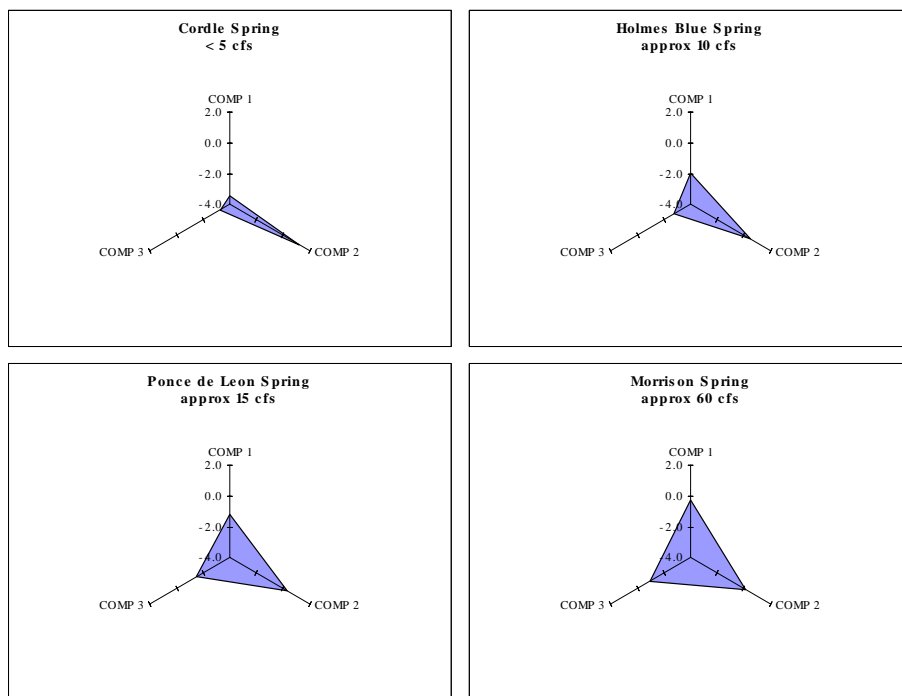
4. The Pearson's distance determination and average linkage method produced clusters whose individual samples share common chemical character and a reasonable common spatial relationship. The mapped clusters serve as a composite view of the water types determined by the three components.

5. Although the method utilized for this study did not result in the determination of a definitive ground water basin boundary for Morrison Spring, the use of both the potentiometric surface and water chemistry trends allowed for a reasonable estimation of the area contributing to the spring (Figure 11). A more thoroughly understood potentiometrically derived ground water basin prior to determining sample location may have aided the study's efforts.

6. The potentiometric surface in the area believed to contribute to Morrison Spring has an unusually steep gradient when compared to that of other large springs in the District. Elevations decrease approximately 120 ft over the entirety of the basin. As a matter of comparison, three of the first magnitude springs in NWFWMD have potentiometric differences of

only 30-50 ft (2-4 ft/mi) over the length of their basins. In the vicinity of Morrison Spring, the gradient transitions from approximately 10 ft/mi in the northern portion of the basin to 5 ft/mi in the lower portions of the basin. A change in transmissivity caused by the varied lithology and stratigraphy is believed the likely culprit for such a change in potentiometric gradient.
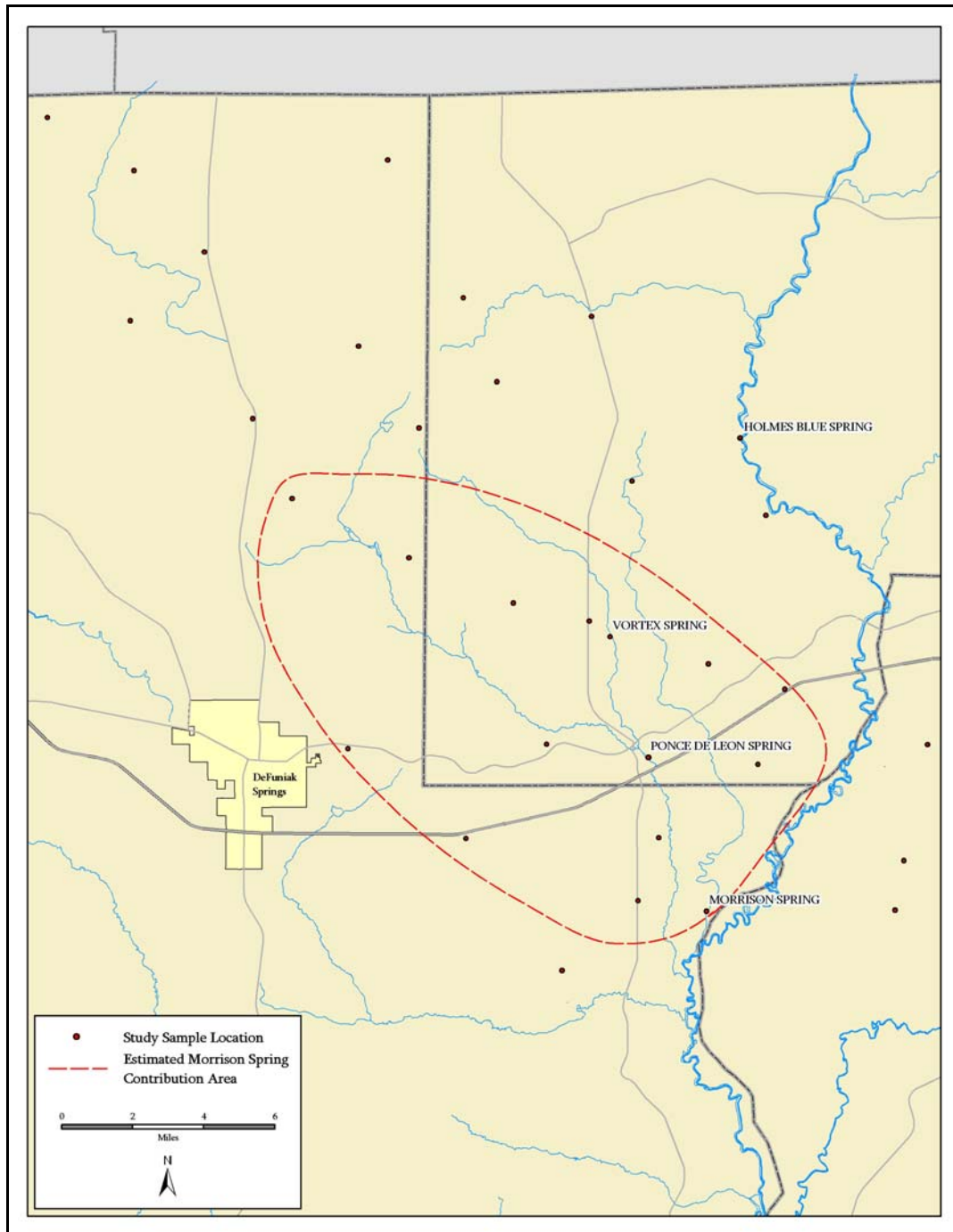
Figure 11. Estimated Morrison Spring contribution area

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APPENDIX A

Well Construction Data

NWF ID	SITE ID	SITE NAME	LATITUDE	LONGITUDE	HORIZONTAL DATUM	ELEVATION (ft msl)	VERTICAL DATUM	WELL DEPTH (ft lsd)	CASING DEPTH (ft lsd)	DIAMETER (in)
9203	305547086082101	James Morrison	30.929776009	-86.139297830	WGS 84	280	NGVD 29	240	140	4
9204	305748086102001	Daton Holloway	30.963376344	-86.172280678	WGS 84	210	NGVD 29	380	250	4
9205	305800086030601	Hritz	30.966924817	-86.051822139	WGS 84	125	NGVD 29	250	145	4
9207	304942086055501	Jewel	30.828350570	-86.098550771	WGS 84	240	NGVD 29	170	150	4
9208	305326086035901	O' Connor	30.890638680	-86.066489113	WGS 84	290	NGVD 29	420	246	4
9209	305124086021701	Rogan	30.856991764	-86.038086932	WGS 84	220	NGVD 29	160	145	4
9210	304910085522601	M. Smith	30.819791233	-85.873957890	WGS 84	80	NGVD 29	100	65	4
9211	305003085561401	Silver	30.834246410	-85.937201667	WGS 84	130	NGVD 29	340	240	4
9212	305407085572001	Pine Log Community VFR	30.902030402	-85.955821478	WGS 84	95	NGVD 29	120	65	4
9213	304637085572901	Gibson	30.776992670	-85.958238348	WGS 84	90	NGVD 29	200	140	4
9214	304813086023601	Geoghagan	30.803621098	-86.043498986	WGS 84	230	NGVD 29	290	200	4
9215	304117085553401	Garner	30.688136711	-85.926365759	WGS 84	70	NGVD 29	160	80	4
9216	304533085540701	Shaw	30.759280060	-85.902047428	WGS 84	70	NGVD 29	100	90	4
9217	305140086070101	Sunday-Hayes Rd	30.861257975	-86.116942837	WGS 84	275	NGVD 29	270	160	4
9218	305406086102801	Bodie	30.901900333	-86.174689390	WGS 84	270	NGVD 29	340	168	4
9219	305436086005901	R. Smith	30.910176719	-86.016530365	WGS 84	170	NGVD 29	240	190	4
4285	303803085582201	Valley View School	30.634180357	-85.972662303	WGS 84	73	NGVD 29	147	100	4
8907	303944085561001	Pleasant Valley Church	30.662443467	-85.936254463	WGS 84	75	NGVD 29	270	100	4
4324	303820085482001	M. Condry	30.677878540	-85.810226259	WGS 84	61	NGVD 29	220	180	4
9221	303927085485201	Pafford	30.657595107	-85.814677803	WGS 84	70	NGVD 29	300	240	4
9222	304330085475401	Harcus	30.725279259	-85.798529583	WGS 84	75	NGVD 29	340	240	4
8094	303928085541401	Morrison Spring	30.657928610	-85.903931670	WGS 84	30	NGVD 29	Spring		
8085	304316085555101	Ponce de Leon Springs	30.721219960	-85.930851286	WGS 84	50	NGVD 29	Spring		
4746	304330086042101	Perdue H-3	30.725823031	-86.073016018	WGS 84	210	NGVD 29	320	220	6
9226	304705085593801	P. Pruett	30.784745583	-85.994129509	WGS 84	243	NGVD 29	357	195	4
9223	304307085524401	Deckert	30.717881504	-85.878897720	WGS 84	65	NGVD 29	100	60	4
9224	305232086000301	Cox	30.875650319	-86.000840407	WGS 84	190	NGVD 29	440	315	4
9225	304120086010601	Sheffield	30.688618530	-86.017487786	WGS 84	210	NGVD 29	220	211	4
6673	304337085584401	Travis Brooks	30.726986840	-85.978974690	WGS 84	130	NGVD 29	250		4
4822	304456085515801	Billy Miller	30.748614701	-85.865907074	WGS 84	62	NGVD 29	165	81	4
8084	305104085530901	Holmes Blue Spring	30.851631422	-85.885846908	WGS 84	55	NGVD 29	Spring		
9307	305907086124701	Cordle Spring	30.985333330	-86.213200000	WGS 84	185	NGVD 29	Spring		

APPENDIX B

Field and Laboratory Results

NWF ID	SITE NAME	DATE COLLECTED	Temp (°C)	Sp Cond (µS/cm)	DO	pH (su)	Alkalinity	NH_3	NH_3+ Organic N	NO_3+ NO_2	P	PO_4	TOC	Ca	Mg	Na	K	Cl	SO_4	F	Si	Fe	TDS
9203	James Morrison	11/14/05 12:04 PM	20.9	221	1.31	7.3	104	0.01 U	0.08 U	0.004 U	0.011	0.007 I	1 U	31.2	10.1	1.8	0.95	1.8	6.1	0.14	16	0.142	123
9204	Daton Holloway	11/14/05 1:32 PM	21.7	209	5.04	7.4	102	0.01 U	0.08 U	0.006 I	0.016	0.004 U	1 U	25.8	16.2	1.63	1.5	1.7	5.8	0.12	19	0.729	116
9205	Hritz	11/14/05 3:08 PM	20.9	255	0.87	7.4	109	0.047	0.08 U	0.004 U	0.004 U	0.004 U	1 U	29.9	13.9	2.22	3.3	2	5	0.071 I	41	0.046	154
9207	Jewel	11/15/05 12:25 PM	20.9	209	0.88	7.5	98	0.01 U	0.16 U	0.004 U	0.007 I	0.004 I	1 U	28.3	10.3	1.54	0.48	2.2	7.4	0.089 I	8.9	0.052	108
9208	O' Connor	11/15/05 3:57 PM	21.4	222	3.13	7.3	124	0.01 U	0.16 U	0.004 U	0.039	0.027	1 U	37.5	6.2	1.56	0.73	2.3	3.3	0.068 I	11	0.307	128
9209	Rogan	11/15/05 5:42 PM	20.29	271	0.2	7.2	140	0.16	0.22 I	0.02	0.14	0.11	1 U	46	8.1	2.04	1.2	2.7	0.84	0.088 I	16	2.21	151
9210	M. Smith	11/16/05 12:18 PM	20.7	297	2.27	7.4	130	0.042	0.08 U	0.004 U	0.039	0.026	1 U	50.2	1.8	9.95	0.37	13	0.27 I	0.05 U	6.7	1.01	154
9211	Silver	11/16/05 1:31 PM	21.6	234	2.24	7.8	111	0.01 U	0.08 U	0.004 U	0.008 I	0.006 I	1 U	27	13.2	1.55	0.95	2.1	6.1	0.12	11	0.088	117
9212	Pine Log Community VFR	11/16/05 2:39 PM	20.3	195	7.15	7.8	97	0.017 I	0.08 U	0.33	0.028	0.027	1 U	38.4	1.3	1.6	0.21	2.5	0.91	0.05 U	8.9	0.014 I	115
9213	Gibson	11/16/05 4:56 PM	20.2	209	6	7.9	102	0.01 U	0.08 U	0.24	0.02	0.018	1 U	32.1	6.8	1.54	0.34	2.4	1.5	0.074 I	8.8	0.005 U	97
9214	Geoghagan	11/17/05 1:10 PM	20.7	233	1.11	7.8	112	0.01 U	0.16 U	0.033	0.028	0.009 I	1 U	46.7	13.1	1.64	0.83	2.1	5.4	0.11	11	0.206	129
9215	Garner	11/17/05 3:19 PM	20.4	229	4.82	7.9	107	0.01 U	0.16 U	0.5	0.008 I	0.004 U	1 U	30.1	10.6	1.73	0.4	2.6	5.8	0.083 I	8.1	0.0088 I	121
9216	Shaw	11/17/05 4:34 PM	21	215	5.73	7.8	105	0.01 U	0.16 U	0.19	0.027	0.022	1 U	32.3	7.6	1.59	0.34	2.1	0.91	0.075 I	9.1	0.11	111
9217	Sunday-Hayes Rd	11/21/05 12:43 PM	20.2	182	4.42	7.7	86	0.017 I	0.08 U	0.024	0.036	0.03	1 U	38.1	5.3	2.89	0.75	2.1	4.1	0.095 I	13	0.387	103
9218	Bodie	11/21/05 2:18 PM	19.6	215	1.76	7.6	96	0.01 U	0.08 U	0.006 I	0.017	0.013	1 U	34.6	7	2.27	1.8	1.8	10	0.14	15	0.069	127
9219	R. Smith	11/21/05 3:39 PM	19.8	451	7.76	6.9	218	0.01 U	0.08 U	1.5	0.03	0.03	1 U	88.9	1.9	3.49	0.58	7.1	0.65	0.063 I	10	0.005 U	245
4285	Valley View School	11/22/05 1:51 PM	21.1	324	1.03	7.5	141	0.01 U	0.08 U	0.004 U	0.052	0.04	1 U	59.7	2.3	3.98	0.8	7	15	0.086 I	12	0.405	184
8907	Pleasant Valley Church	11/22/05 3:08 PM	20	400	0.75	7.4	192	0.01 U	0.08 U	0.004 U	0.006 I	0.004 U	1 U	72.5	8.5	3.83	0.89	4.5	25	0.13	12	0.141	235
4324	M. Condry	11/30/05 2:36 PM	20.2	193	1.23	7.1	95	0.04	0.08 U	0.004 U	0.3	0.11	1 U	46.3	19.7	1.89	0.31	2.6	0.46 I	0.084 I	8.1	2.88	92
9221	Pafford	11/30/05 4:06 PM	21.1	214	0.59	7.5	97	0.01 U	0.08 U	0.004 U	0.038	0.036	1 U	27	9.6	1.56	0.43	2.3	9.1	0.084 I	8.5	0.424	118
9222	Harcus	11/30/05 5:43 PM	20.9	178	5.07	7.6	84	0.01 U	0.08 U	0.12	0.008 I	0.006 I	1 U	22	8.4	1.47	0.53	2	4.7	0.087 I	9.1	0.012 I	84
8094	Morrison Spring	12/1/05 2:11 PM	20.1	231	3.09	7.4	111	0.01 U	0.08 U	0.16	0.021	0.024	1 U	33.7	8.4	1.83	0.55	2.8	3.4	0.073 I	10	0.005 U	128
8085	Ponce de Leon Springs	12/1/05 4:35 PM	19.9	217	4.26	7.5	106	0.01 U	0.08 U	0.25	0.021	0.023	1 U	31.8	7.9	1.69	0.46	2.6	2.5	0.073 I	9.2	0.02 I	122
4746	Perdue H-3	12/6/05 1:23 PM	21.9	170	0.35	7.7	77	0.01 U	0.16 U	0.004 U	0.039	0.035	1 U	21.2	7.5	1.42	1.6	1.9	5.3	0.081 I	15	0.069	91
9226	P. Pruett	12/6/05 3:44 PM	22	234	1.97	7.5	110	0.01 U	0.16 U	0.059	0.019	0.013	1 U	30	11.7	1.96	0.82	2.4	6.7	0.12	12	0.041	121
9223	Deckert	12/6/05 5:38 PM	20	284	1.3	7.3	141	0.12	0.65	0.004 U	0.061	0.045	2.1 I	44.7	10.2	1.95	0.27	3.7	0.2 U	0.063 I	6.4	0.53	136
9224	Cox	12/8/05 12:52 PM	20.1	238	1.24	7.6	111	0.01 U	0.08 U	0.004 U	0.006 I	0.006 I	1 U	26.5	13.6	1.52	1	2	9.2	0.15	10	0.441	97
9225	Sheffield	12/8/05 2:51 PM	21.9	169	0.09	7.8	77	0.01 U	0.08 U	0.004 U	0.013	0.011	1 U	17.9	9.3	2.25	0.85	1.8	6.2	0.08 I	10	0.0061 I	79
6673	Travis Brooks	12/8/05 4:07 PM	22.1	257	3.4	7.6	125	0.01 U	0.08 U	0.018	0.016	0.017	1 U	28.1	17.5	2.16	1.2	2.7	5.4	0.097 I	12	0.005 U	123
4822	Billy Miller	12/8/05 5:27 PM	20.3	287	0.06	7.4	146	0.067	0.094 I	0.004 U	0.036	0.033	1.3 I	35	15.5	2.12	0.29	3.1	0.4 I	0.088 I	6.2	0.59	148
8084	Holmes Blue Spring	12/13/05 2:10 PM	20.05	214	6.01	7.8	103	0.01 U	0.16 U	0.52	0.027	0.024	1 U	35.5	5.8	1.85	0.4	2.7	1.3	0.066 I	8.7	0.0086 I	107
9307	Cordle Spring	12/15/05 4:18 PM	19.3	168	4.25	7.6	78	0.01 U	0.092 I	0.260	0.022	0.017	2.2 I	27.4	4.0	1.56	0.28	2.6	1.80	0.052 I	8.6	0.105	100

All values in mg/L unless noted

U=result at or below method detection limit

I=result between method detection limit and practical quantification limit