STATUS REPORT

ARKANSAS PROTOTYPE MONITORING PROGRAM

Arkansas Department of Pollution Control & Ecology
April, 1994

TOM HUSTTER

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ABSTRACT

The Arkansas Department of Pollution Control and Ecology (ADPC&E) has established an ambient ground water quality monitoring program at various statewide locations which will enable it to gather background ground water quality data from various aquifers. The program also evaluates water quality in areas of specific interest, such as, in and around communities located in agricultural and industrial areas where water quality degradation may be related to fertilizer and pesticide use or industrial discharges. Another area of interest is the extremely complex karst region of northern Arkansas, which is extremely vulnerable to contamination. The ambient ground water quality monitoring was designed to help in water quality planning and development of ground water standards as part of the Arkansas Ground Water Protection Program. This program is funded entirely with Clean Water Act, Section 106 funds.

Water quality samples have been obtained from 100 wells and 10 springs for seven prototypes scattered statewide. These sites, sampled every three years, have lists of sampling constituents based on the types of contaminants likely to be found in their respective areas. The results of the first two or three sampling periods indicate that the overall ground water quality for these widely scattered prototypes is good with some elevated nitrate concentrations in some of the wells and high chloride concentrations in others (particularly in the Brinkley area). Since some of the protoypes are situated in an area of documented ground water contamination, they do not represent a truly ambient monitoring network. It is still too early in the investigative process to discern trends or develop conclusions based on the analytical results of relatively few monitoring sites. It is likely that more sampling sites will be necessary to provide a more accurate view of the water quality for an aquifer in a particular locality.

INTRODUCTION

The Arkansas Department of Pollution Control and Ecology initiated this program in 1985 in order to gather background ground water quality data from various aquifers in the state. Samples have been collected every three years for general water quality indicators, metals, petroleum hydrocarbons, and pesticides. Some of the prototypes have been sampled and analyzed for the third time since inception of the program. The following seven prototypes will be discussed (Figure 1):

1) Ouachita County - a recharge area of the Sparta Sand aquifer.
2) Lonoke, Lonoke County - an agricultural community in the Mississippi Delta.
3) Pine Bluff, Jefferson County - a community system in the Arkansas River Valley.
4) Omaha, Boone County - a karst area in northern Arkansas.
5) El Dorado, Union County - an industrialized urban center in the oil producing area of Arkansas.
6) Jonesboro, Craighead County - second largest city on ground water in the state and located in the middle of an agricultural region in the Arkansas Delta.
7) Brinkley, Monroe County - an agricultural community affected by saltwater intrusion of uncertain origin.

Lists of sampling constituents were compiled for the above prototypes based on the types of contaminants likely to be found in each of the respective areas. All available wells (i.e. domestic, commercial, public, irrigation, etc.) were inventoried and considered for possible use as part of a monitoring network in each area. Some wells have had to be replaced due to abandonment or inaccessibility. Table 1 is an example showing the chronological order of sampling for each prototype that follows in this report. Results of chemical analyses are listed in descending order for each sampling period beginning with the first sampling and ending with the most recent sampling.

Table 1. Example Of Prototype Data Tables

WELL NUMBER		#12	#13
NO2 +	(1986)	.65	.90
NO3 (mg/l)	(1989)	.55	.85
	(1992)	.89	.70

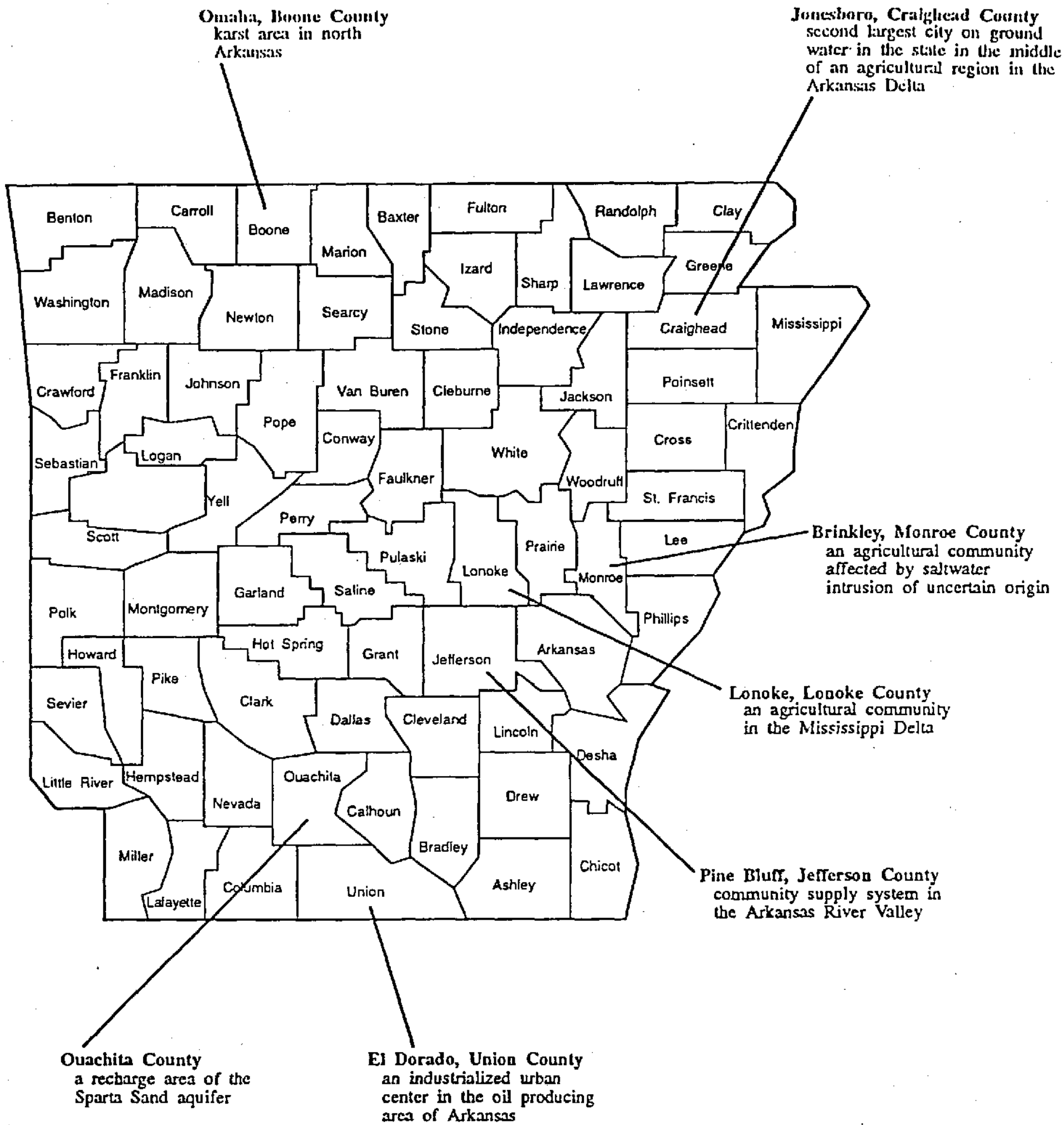


Figure 1. Arkansas Prototype Location Map

Relatively speaking, the results of the initial sampling runs for each prototype have yet to show any significant trend except in areas where there were known contamination problems and the analyses helped substantiate existing investigations done by state or federal agencies. Problems within the program include the lack of an adequate number of sites to fully delineate problems within a given area, loss of available sites, inconsistent sampling procedures, and the need for more in depth research to properly place additional sites for maximum benefit. There is a possibility that there has yet to be a sufficient amount of time allotted to each area to indicate any trends that may have developed, or that the time between sampling is long enough that relatively rapid shifts in water quality may be missed (i.e. nitrates, pesticides, etc.). This might be alleviated by decreasing the time between sampling each site, or allowing more time to pass before making any assumptions with regard to an improvement or deterioration in water quality.

GROUND WATER OCCURRENCES

Physiographically, the State of Arkansas can be divided into two provinces by a diagonal line running from the northeast to the southwest, each segment representing approximately one-half of the state. The segment northwest of this diagonal line is called the Interior Highlands Province, or the Paleozoic outcrop area of the state. This province can further be divided into the Ozark, Boston Mountains, Arkansas Valley, and Ouachita Mountains Regions (Figure 2). Mesozoic and Cenozoic sediments outcrop south and east of this line and lap upon the Paleozoic rocks and unconformably overlie them. These rocks lie within the Gulf Coastal Plain Province. The rocks representing the Cenozoic (Tertiary and Quaternary) are more extensive at the surface than the Mesozoic rocks which crop out in the southwest portion of the state (Landes, 1970). The rock types associated with each of these regions are a major factor in controlling the occurrence of ground water.

The majority of the ground water supplies in the Gulf Coastal Plain are obtained from six aquifers. These are in the Quaternary deposits (alluvium), Cockfield Formation, Sparta Sand, Wilcox Group, Nacatoch Sand, and the Tokio Formation (Bryant et al, 1985). These aquifers are part of a thick sequence of semiconsolidated sediments consisting of sands, shales, and clays, with sand representing the larger fraction (Table 2). The yields range from 300 to 2,000 gallons per minute for the formations exclusive of the Quaternary alluvial aquifer, which ranges from 1,000 to 2,000 gallons per minute (Bryant et al, 1985).

The Interior Highlands are underlain by consolidated rocks consisting of sands, shales, and carbonates of Paleozoic Age. Most of the ground water in this province occurs in fractures and joints in the sands and shales, and in solution cavities in the carbonate rocks (limestones and dolomites). Two of the most important aquifers in northern Arkansas are the Roubidoux Formation and the Gunter Sandstone (Van Buren Formation). Yields for the combined intervals range up to 500 gallons per minute (Bryant et al, 1985). Other formations that contribute ground water range in age from the Pennsylvanian through the Cambrian and are chiefly carbonate (Table 3). Paleozoic strata in the Arkansas Valley and Ouachita Region of the Interior Highlands Province produce water from fractures in sandstone and shale (Table 4). Yield is commonly in the range of 10-25 gallons per minute (Bryant et al, 1985).

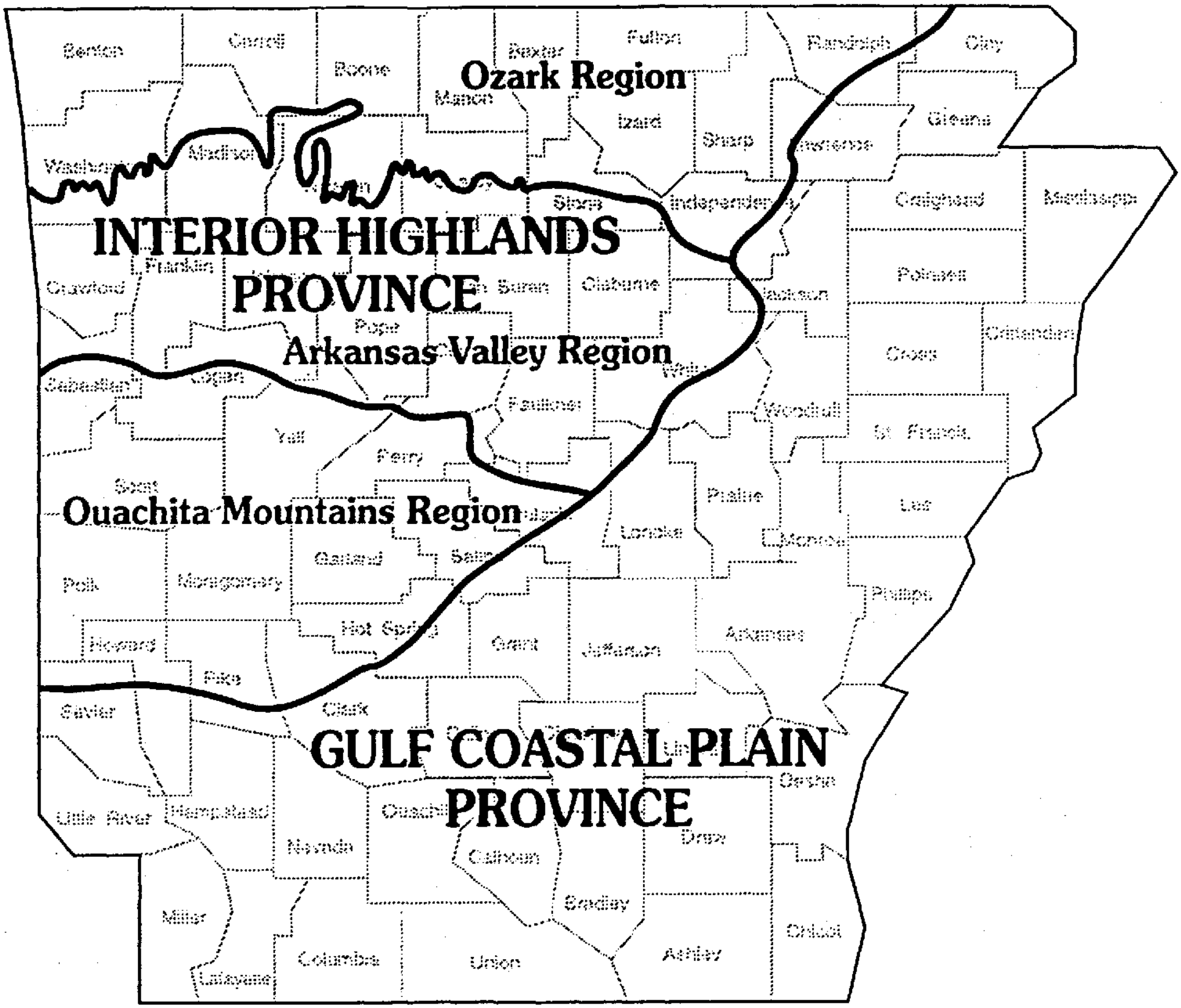


Figure 2. Physiographic Provinces Of Arkansas

Table 2. Generalized Stratigraphic Column Of The Gulf Coastal Plain Of Southern And Eastern Arkansas.

(modified from Terry and others, 1986)

ERA	SYSTEM	SERIES	GROUP	FORMATION
Cenozoic	Quaternary	Holocene & Pleistocene		Alluvium & Terrace Deposits *
	Tertiary	Eocene	Jackson	Undifferentiated
			Claiborne	Cockfield Formation *
				Cook Mountain Formation
				Sparta and Memphis Sand *
				Cane River Formation
				Carrizo Sand
			Wilcox	Undifferentiated *
		Paleocene		
			Midway	Undifferentiated
Mesozoic	Cretaceous	Upper Cretaceous		Arkadelphia Marl
				Nacatoch Sand *
				Tokio Formation *
				Undifferentiated
Paleozoic	Undifferentiated	Undifferentiated		Undifferentiated

(* denotes major aquifers)

Table 3. Generalized Stratigraphic Units In Northern Arkansas And Geohydrologic Units.

(modified from Leidy and Morris, 1990)

ERA	SYSTEM	FORMATION	GEOHYDROLOGIC UNIT
Paleozoic	Pennsylvanian	Atoka Sandstone Bloyd Shale Hale Formation	
	Mississippian	Pitkin Limestone Fayetteville Shale Batesville Sandstone Moorefield Formation	
		Boone Formation St. Joe Limestone Member	Springfield Plateau Aquifer
	Devonian	Chattanooga Shale	Ozark Confining Unit
		Clifty Limestone Penters Chert	Ozark Aquifer
	Silurian	Lafferty Limestone St. Clair Limestone Brassfield Limestone	
	Ordovician	Cason Shale Fernvale Limestone Kimmswick Limestone Plattin Limestone Joachim Dolomite St. Peter Sandstone Everton Formation Smithville Formation Powell Dolomite Cotter Dolomite Jefferson City Dolomite Roubidoux Formation Gasconade Dolomite Van Buren Formation Gunter Sandstone Member	
	Cambrian	Eminence Dolomite Potosi Dolomite	

Table 4. Generalized Stratigraphic Column Of The Arkansas Valley And Ouachita Mountain Region.

(from Haley and others, 1993)

ERA	SYSTEM	SERIES	FORMATION
Cenozoic	Quaternary	Holocene & Pleistocene	Alluvium & Terrace Deposits
Paleozoic	Pennsylvanian	Des Moinesian	Boggy Formation
			Savanna Formation
			McAlester Formation
			Hartshorne Sandstone
		Atokan	Atoka Formation
		Morrowan	Johns Valley Shale
	Mississippian & Devonian		Jackfork Sandstone
			Stanley Shale Arkansas Novaculite
	Silurian		Missouri Mountain Shale Blaylock Sandstone
	Ordovician		Polk Creek Shale Big Fork Chert Womble Shale Blakely Sandstone Mazarn Shale Crystal Mountain Sandstone Collier Shale

PROTOTYPES

Ouachita Prototype

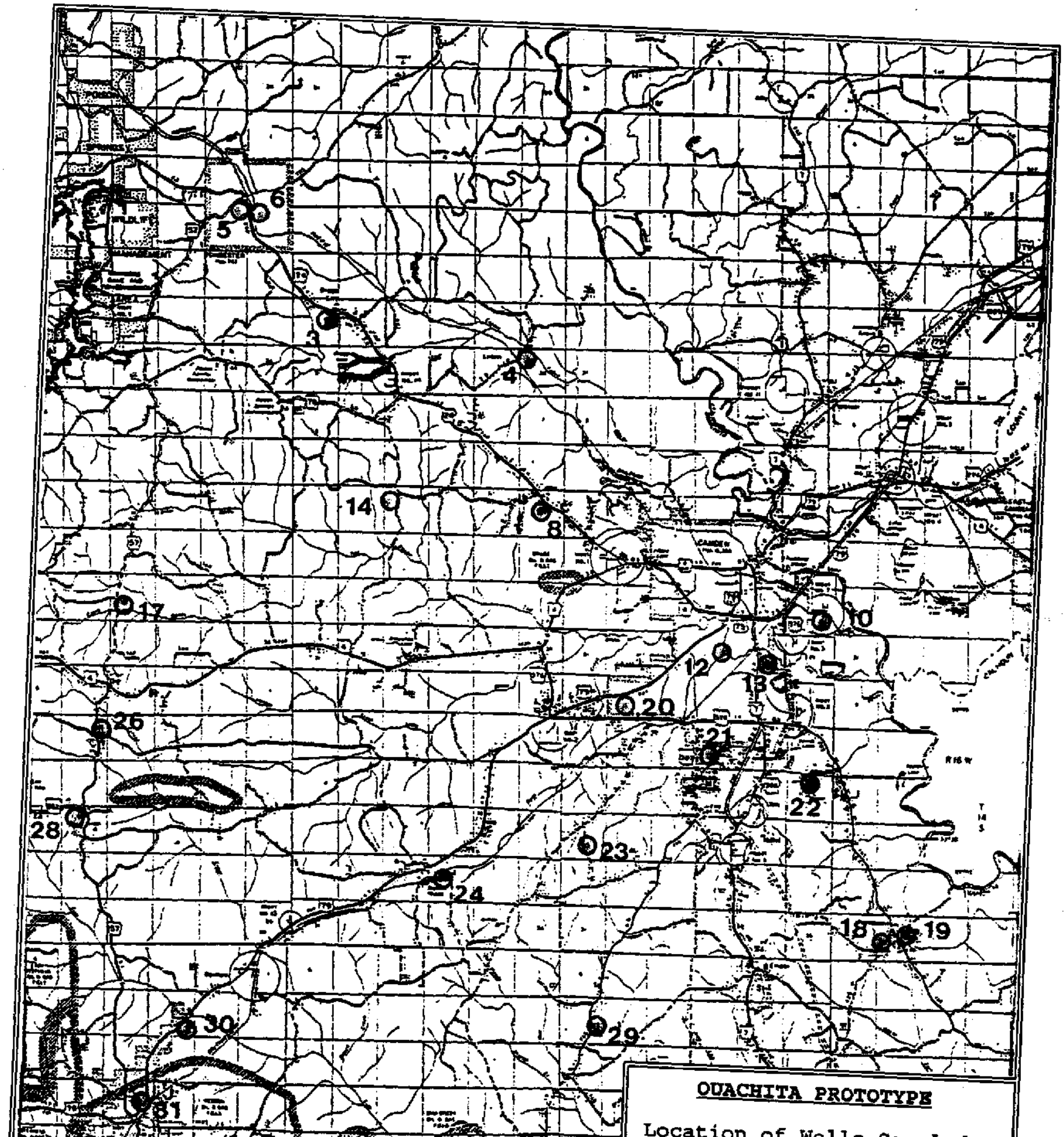
The Ouachita prototype, located in Ouachita County, southern Arkansas, encompasses approximately 350 square miles. This area is in the ~~Gulf Coastal Plain physiographic province~~, and is characterized by heavily timbered flatlands and low hills. The surface geology consists of rocks of Eocene, Pleistocene, and Recent Age (Table 2).

This prototype was selected because it is a recharge area of one of the State's most important aquifers, the ~~Sparta Sand~~. The objective of the monitoring program is to provide data about baseline water quality in the recharge area and to determine the extent of contamination from existing pollution sources in Ouachita County. This would include operations related to the timbering industry and various oil and gas related activities, particularly in the southwestern portion of the area. Sampling categories of chemical constituents included the following: **chloride, total hardness, nitrite + nitrate-N, phosphorous, sulfate, total and fecal coliform, and TOC.**

The Sparta Sand, which crops out over much of Ouachita County, consists mainly of gray, very fine to medium sand and brown and gray sandy clay. The thickness of the Sparta averages 300 feet in the outcrop area. Yields of the wells screened in the Sparta average about 300 gallons per minute (Albin, 1964). The depth of the Sparta Sand ranges from the surface to approximately 300 feet. The wells used in this study ranged from 51 feet to 370 feet in depth. Figure 3 shows the locations of the wells sampled for water quality in the Sparta aquifer. The location and description of sampled wells are listed in Table 5.

Results of the first three sampling periods initiated in the fall of 1986, 1989, and 1992 are shown in Table 6. ~~There was no serious contamination detected in the twenty-seven wells sampled.~~ Elevated nitrate levels were detected in well #33 (1.60, 1.64, and 3.33 respectively). The highest chloride value was 72.0 mg/l for well #18 which produced water from 285 feet to 300 feet. The chloride concentrations throughout the area showed no correlation whether sampled at depth or near the surface.

~~The recommendation for this prototype is expansion to the southwest in order to include more of the recharge near oil field production. Lab analyses should include chemical constituents associated with the petroleum industry.~~ Construction of detailed cross-sections may be useful (if logs are available) to help define the continuity of confining layers (some of the existing wells draw water from the Sparta at depths in excess of 300 feet and are probably confined and less susceptible to surface contamination.



OUACHITA PROTOTYPE

Location of Wells Sampled for Water Quality in the Sparta Aquifer in Ouachita County.

Figure 3

Table 5. OUACHITA PROTOTYPE - LOCATION AND DESCRIPTION OF SAMPLED WELLS

Site No.	Local Well No.	Well	Depth	Aquifer
MW103001	15S19W33BDA1	Well #34	295'	Sparta
MW103002	15S19W30DBD1	Well #33	59'	Sparta
MW103003	15S19W25ABC1	Well #32	51'	Sparta
MW103004	15S19W21DAA1	Well #31	300'	Sparta
MW103005	15S17W07ADC1	Well #29	308'	Sparta
MW103006	15S19W10DCC1	Well #30	370'	Sparta
MW103007	14S16W32BDB1	Well #19	69'	Sparta
MW103008	14S18W27BDC1	Well #24	55'	Sparta
MW103009	14S19W20BAD1	Well #28	61'	Sparta
MW103010	13S18W33CCC1	Well #16	93'	Sparta
MW103011	14S16W32CBC1	Well #18	295'	Sparta
MW103012	14S17W13ABC1	Well #22	52'	Sparta
MW103013	14S17W10CDC1	Well #21	56'	Sparta
MW103014	14S17W05CAB1	Well #20	223'	Sparta
MW103015	13S17W35DBC2	Well #13	253'	Sparta
MW103016	14S17W19DBB1	Well #23	99'	Sparta
MW103017	13S17W34DBB2	Well #12	278'	Sparta
MW103018	13S17W25DBD1	Well #10	58'	Sparta
MW103019	13S19W28CBA1	Well #17	52'	Sparta
MW103020	13S17W27BBB1	Well #8	137'	Sparta
MW103021	13S18W16BAC1	Well #14	51'	Sparta
MW103022	12S19W35BDC1	Well #7	174'	Sparta
MW103023	12S18W36BBC1	Well #4	123'	Sparta
MW103024	12S18W30ADA1	Well #3	150'	Sparta
MW103025	12S19W13BBC1	Well #5	52'	Alluvial
MW103026	12S19W14AAA1	Well #6	60'	Sparta ?
MW103027	14S19W08ADD1	Well #26	220'	Sparta

Table 6. OUACHITA PROTOTYPE

Results of the first three sampling periods initiated 12/86, 12/89, and 12/92.

WELL NO.	#34	#33	#32	#31	#29	#30	#19	#24	#28
AQFR	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt
DPTH	295'	59'	51'	300'	308'	370'	69'	55'	61'
TOT. ALK. mg/l	102 - -	13.0 - -	96.0 - -	88.0 - -	67.0 - -	59.0 - -	9.0 - -	19.0 - -	17.0 - -
NH3+ NH4 mg/l	.390 .360 .193	.040 .110 .050	.050 .100 -	.390 .050 .05K	.300 - -	.230 .05K .05K	.040 .330 .05K	.150 - -	.030 .110 .067
NO2+ NO3 mg/l	.03 .02K .05	1.60 1.64 3.33	.28 .04 -	.01K .02K .04	.01 - -	.01K .02K .04	.17 .18 .07	.14 - -	.01 .02K .10
TOC mg/l	9.2 - -	3.5 - -	14.0 - -	3.7 - -	3.7 - -	.6 - -	1.8 2.4 -	3.2 - -	.5 - -
TOT. HARD mg/l	50.0 - -	32.0 - -	98.0 - -	40.0 - -	56.0 - -	48.0 - -	22.0 22.0 -	26.0 - -	30.0 - -
CL mg/l	4.0 3.0 4.0	35.0 26.0 30.0	6.0 4.0 -	5.0 11.0 13.0	4.0 - -	5.0 10.0 10.0	20.0 21.0 6.0	5.0 - -	1.0 11.0 6.0
SO4 mg/l	7.0 10.0 10.0	7.0 20.0 5.0	1K 5.0 -	11.0 10.0 11.0	13.0 - -	16.0 14.0 14.0	10.0 11.0 19.0	2.0 - -	15.0 54.0 15.0

Table 6. QUACHITA PROTOTYPE - continued

WELL NO.	#16	#18	#22	#21	#20	#13	#23	#12	#10
AQFR	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt
DPTH	93'	295'	52'	56'	223'	253'	99'	278'	58'
TOT. ALK. mg/l	5.0 - -	131 - -	- - -	86.0 - -	104 - -	118 - -	22.0 - -	67.0 - -	14.0 - -
NH3+ NH4 mg/l	.040 .05K -	.550 .250 -	- - -	.020 .05K .05K	.500 - -	.740 .050 .05K	.100 .050 .05K	.630 - .621	.050 .160 .05K
NO2+ NO3 mg/l	.56 .20 -	.03 .27 -	- - -	.17 .08 .09	.01K - -	.01 - -	.01K .02K .02K	.02 - .02K	.02 .02K .02K
TOC mg/l	1.4 - -	9.1 - -	- - -	4.1 - -	2.9 - -	3.6 - -	1.4 - -	8.0 - -	4.6 - -
TOT. HARD mg/l	14.0 - -	64.0 - -	- - -	124 - -	22.0 - -	36.0 - -	34.0 - -	40.0 - -	36.0 - -
CL mg/l	4.0 3.0 -	72.0 72.0 -	- - -	3.0 3.0 4.0	7.0 - -	40.0 - -	3.0 4.0 4.0	4.0 - 5.0	3.0 3.0 4.0
SO4 mg/l	2.0 3.0 -	10.0 2.0 -	- - -	49.0 56.0 54.0	10.0 - -	10.0 - -	13.0 10.0 14.0	9.0 - 15.0	31.0 26.0 21.0

Table 6. <u>OUACHITA PROTOTYPE</u> continued

WELL NO.	#17	#8	#14	#7	#4	#3	#5	#6	#26
AQFR	Sprt	Sprt	Sprt	Sprt	Sprt	Sprt	Alvm	?	Sprt
DPTH	52'	137'	51'	174'	123'	150'	52'	60'	220'
TOT. ALK. mg/l	6.0 - -	20.0 - -	46.0 - -	13.0 - -	14.0 - -	9.0 - -	15.0 - -	21.0 - -	151 - -
NH3+ NH4 mg/l	.020 .05K .066	.120 - -	.030 - .050	.060 - -	.060 - .05K	.040 - -	.060 .110 -	.030 .080 .070	.400 .090 -
NO2+ NO3 mg/l	.09 .62 .27	.01 - -	.07 .02 .06	.04 .02K .02K	.01 .02K .04	.01 .02K -	.05 .27 -	.51 .05 .04	.04 .02K -
TOC mg/l	2.1 - -	2.2 - -	4.9 - 0	1.7 - -	2.5 - -	4.3 - -	1.7 - -	.7 - -	4.3 - -
TOT. HARD mg/l	12.0 - -	30.0 - -	38.0 - -	10.0 - -	14.0 - -	12.0 - -	12.0 - -	12K - -	200 - -
CL mg/l	4.0 4.0 2.0	6.0 - -	14.0 17.0 6.0	3.0 3.0 3.0	5.0 6.0 4.0	45.0 - 6.0	4.0 5.0 -	4.0 4.0 4.0	7.0 7.0 -
SO4 mg/l	11.0 3.0 1K	29.0 - -	26.0 41.0 14.0	2.0 4.0 1K	4.0 7.0 3.0	4.0 - 6.0	4.0 9.0 -	4.0 6.0 5.0	59.0 63.0 -

Lonoke Prototype

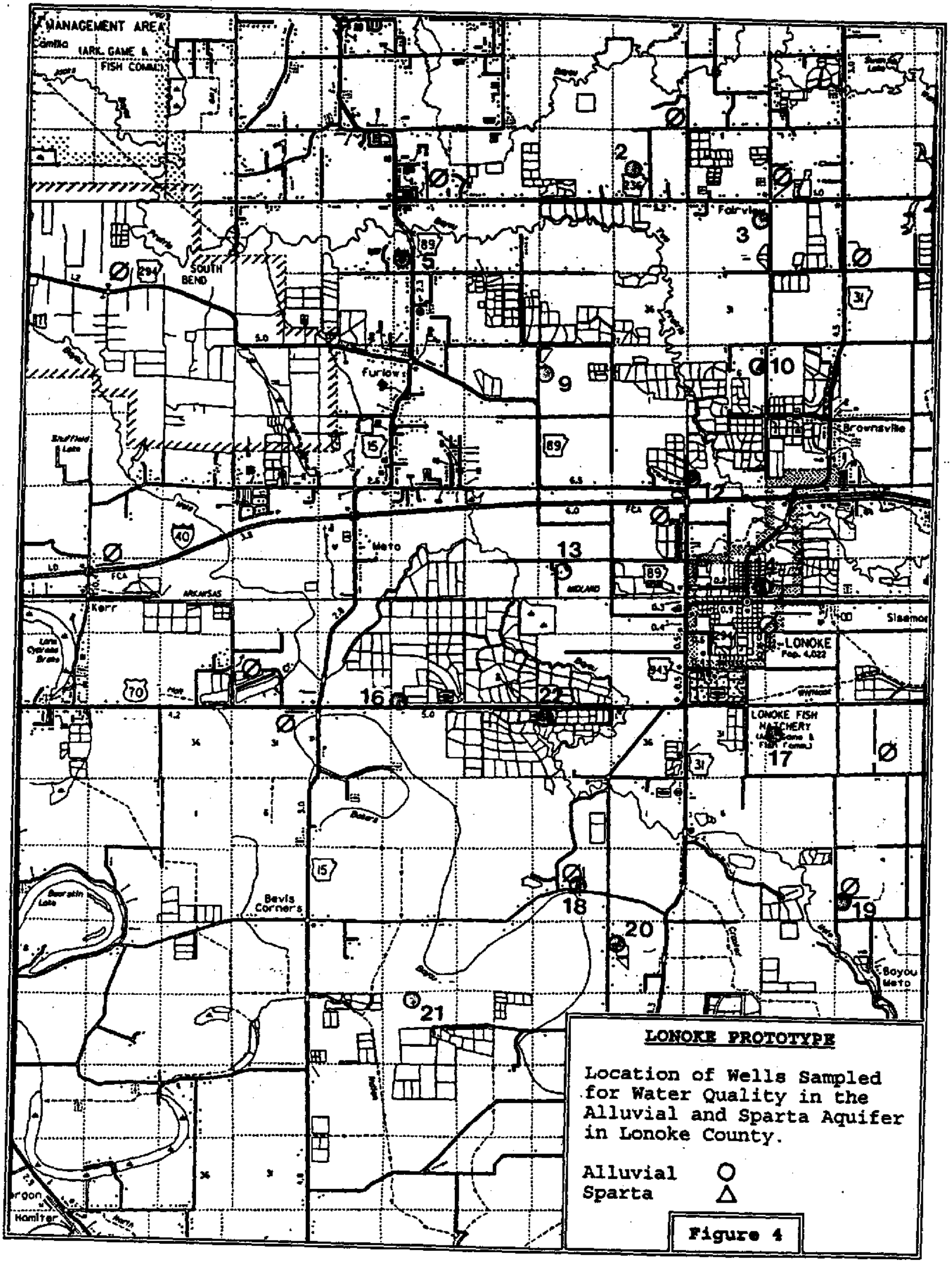
The Lonoke prototype encompasses approximately 90 square miles surrounding the town of Lonoke in central Lonoke County. Physiographically the area is located in the Gulf Coastal Plain province. According to Counts (1957), "this region consists of broad and nearly level interstream divide areas and flood plains cut from a few feet to about 25 feet below them. The bottom lands of the flood plains are characterized by numerous swamps, bayous, lakes, and abandoned stream channels." Quaternary alluvial deposits cover much of the area and may obtain a thickness in excess of 150 feet.

This prototype was selected because it represents an agricultural community in the Mississippi Delta where pesticide and fertilizer use increase the possibility of ground water contamination. The objective of the monitoring program is to determine if agricultural practices in the Lonoke, Arkansas area have resulted in ground water contamination in the alluvial aquifer with pesticide residues and nitrates associated with fertilizer application. Sources of pollution, in addition to pesticides and fertilizer, include a RCRA site, a landfill, and an unknown number of septic tanks. Sampling categories of chemical constituents included the following: chloride, total hardness, nitrite + nitrate-N, phosphorous, sulfate, Bentazon, Aciflourfen, Propanil, Molinate, 2,4-D, 2,4,5-T, Trifluralin, Fluchioralin, Alachlor, Aldicarb, Methyl Parathion, Furadan, and Metribuzin.

The Quaternary alluvial deposits unconformably overlie rocks of Tertiary age (Table 2). The alluvial deposits consists of gray to light-brown sand and sand and gravel, reddish-brown fine sand, and gray, yellow, and red silt and clay. These alluvial deposits are a very significant source of ground water used for irrigation and domestic purposes. Well yields commonly are in the range of 400 to 1,700 gallons per minute developed at depths of about 60 feet to over 150 feet (Counts, 1957). Only one well was sampled from the Sparta aquifer in this investigation. The Sparta aquifer is less than 300 feet thick and subcrops the alluvial aquifer throughout much of the study area. The Sparta consists of fine to medium sand with some interbedded clay. The yield from this aquifer is commonly in excess of 1,000 gallons per minute (Leidy and Morris, 1990).

The fifteen wells sampled in this investigation had depth ranges of 100-195 feet for the alluvial aquifer and a depth of 354 feet for the single Sparta well. Figure 4 shows the location of wells sampled for water quality in the alluvial and Sparta aquifers. The location and description of sampled wells are listed in Table 7.

Results of the first two sampling periods initiated in the late spring and summer of 1988 and 1991 are shown in Table 8. No pesticides were detected in the fourteen alluvial wells or the one Sparta well. There were no elevated chloride or nitrate levels in any of the wells. High iron and manganese concentrations, common in shallow alluvial aquifers, were detected in several wells.



LONOKE PROTOTYPE

Location of Wells Sampled for Water Quality in the Alluvial and Sparta Aquifer in Lonoke County.

Figure 4

Table 7. LONOKE PROTOTYPE - LOCATION AND DESCRIPTION OF SAMPLED WELLS

Site No.	Local Well No.	Well	Depth	Aquifer
MW085001	02N09W34AAA1	Well #22	354'	Sparta
MW085002	02N09W28CCC1	Well #16	122'	Alluvial
MW085003	02N08W31ADD1	Well #17	195'	Alluvial
MW085004	02N09W02BBC1	Well #9	157'	Alluvial
MW085005	03N09W28CCA1	Well #5	104'	Alluvial
MW085006	02N08W20BCD1	Well #14	164'	Alluvial
MW085007	02N08W07CCC1	Well #12	100'	Alluvial
MW085008	02N08W06ADA1	Well #10	160'	Alluvial
MW085009	03N09W23CCA1	Well #2	135'	Alluvial
MW085010	01N09W13BCB1	Well #20	125'	Alluvial
MW085011	01N09W21BAB1	Well #21	100'	Alluvial
MW085012	01N08W09CBC1	Well #19	150'	Alluvial
MW085013	03N08W30AAD1	Well #3	135'	Alluvial
MW085014	02N09W23BAC1	Well #13	150'	Alluvial
MW085015	01N09W11DBA1	Well #18	105'	Alluvial

Table 8. LONOKE PROTOTYPE

Results of the first two sampling periods initiated in 6/88 and 6/91.

WELL NO.	#22	#16	#17	#9	#5	#14	#12	#10
AQFR	Sprt	Alvm	Alvm	Alvm	Alvm	Alvm	Alvm	Alvm
DPTH	354'	136'	195'	157'	104'	155'	100'	160'
TOT. ALK. mg/l	192 -	307 -	243 -	98.0 -	144 -	144.0 -	135 -	111 -
NH3+ NH4 mg/l	.210 .120	.730 .740	.240 .280	.080 .110	.130 -	.120 -	.030 -	.110 -
NO2+ NO3 mg/l	.01 .05	.01 .02K	.01 .02K	.01 .02K	.01 -	.01 -	.01K -	.01K -
TOT. PHOS mg/l	- 3.0	- -	- -	- -	- -	- -	- -	- -
TOC mg/l	2.0 -	3.4 -	1.8 -	3.7 -	3.3 -	3.0 -	4.1 -	2.9 -
CA mg/l	28.0 -	91.0 -	62.0 -	14.0 -	3.0 -	24.0 -	19.0 -	14.0 -
NA mg/l	24.0 -	20.0 -	14.0 -	14.0 -	30.0 -	19.0 -	17.0 -	15.0 -

Table 8. LONOKE PROTOTYPE - continued

WELL NO.	#22	#16	#17	#9	#5	#14	#12	#10
K mg/l	4.0 -	6.0 -	5.0 -	2.0 -	.3 -	1.0 -	2.0 -	1.0 -
CL mg/l	6.0 6.0	.5 17.0	9.0 13.0	13.0 12.0	17.0 -	18.0 -	8.0 -	8.0 -
SO4 mg/l	- 3.0	- 90.0	- 25.0	14.0 13.0	3.0 -	3.0 -	5.0 -	3.0 -
AS ug/l	5K -	11.0 -	5K -	5K -	5K -	5K -	5K -	11.0 -
CR ug/l	1K -	1K -	14.0 -	1K -	1K -	1K -	60.0 -	1K -
CU ug/l	15K -	15K -	15K -	15K -	15K -	15K -	15K -	15K -
FE ug/l	3400 -	- -	2600 -	1800 -	1000 -	2000	2800 -	3800 -
PB ug/l	1K -	1K -	1K -	1K -	1.0 -	6.0 -	1K -	1K -
ZN ug/l	13.0 -	10.0 -	338 -	8.0 -	27.0 -	17.0 -	1122 -	10.0 -
MN ug/l	250 -	350 -	610 -	410 -	100K -	380 -	1380 -	810 -

Table 8. LONOKE PROTOTYPE - continued

WELL NO.	#2	#20	#21	#19	#3	#13	#18
AQFR	Alvm	Alvm	Alvm	Alvm	Alvm	Alvm	Alvm
DPTH	135'	125'	100'	150'	135'	150'	105'
TOT. ALK. mg/l	680 -	175 -	300 -	284 -	70.0 -	296 -	180 -
NH3+ NH4 mg/l	.010K -	.520 -	.500 -	.830 -	.040 -	.410 .009	.260 -
NO2+ NO3 mg/l	.21 -	.02 -	.01 -	.02 -	- -	- .02K	- -
TOT. PHOS mg/l	- -	- -	- -	- -	- -	- -	- -
TOC mg/l	2.9 -	7.5 -	9.2 -	9.6 -	2.4 -	8.3 -	4.4 -
CA mg/l	6.0 -	76.0 -	76.0 -	72.0 -	6.0 -	34.0 -	80.0 -
NA mg/l	11.0 -	13.0 -	26.0 -	43.0 -	13.0 -	15.0 -	16.0 -

Table 8. LONOKE PROTOTYPE - continued

WELL NO.	#2	#20	#21	#19	#3	#13	#18
K mg/l	.9 -	6.0 -	5.0 -	5.0 -	1.0 -	3.0 -	8.0 -
CL mg/l	6.0 -	10.0 -	33.0 -	34.0 -	9.0 -	10.0 15.0	19.0 13.0
SO4 mg/l	7.0 -	189 -	36.0 -	39.0 -	8.0 -	146 7.0	6.0 8.0
AS ug/l	5K -	5K -	5K -	9.0 -	5K -	5K -	5K -
CR ug/l	1K -	1K -	1K -	1K -	1K -	1K -	1K -
CU ug/l	15K -	15K -	40.0 -	15K -	15K -	15K -	24.0 -
FE ug/l	200K -	2100 -	8000 -	2200 -	200K -	1400 -	20000 -
PB ug/l	1K -	1K -	1.0 -	1K -	1K -	1K -	1K -
ZN ug/l	3K -	5.0 -	11.0 -	3K -	3K -	3K -	21.0 -
MN ug/l	100K -	820 -	770 -	480 -	100K -	1100 -	720 -

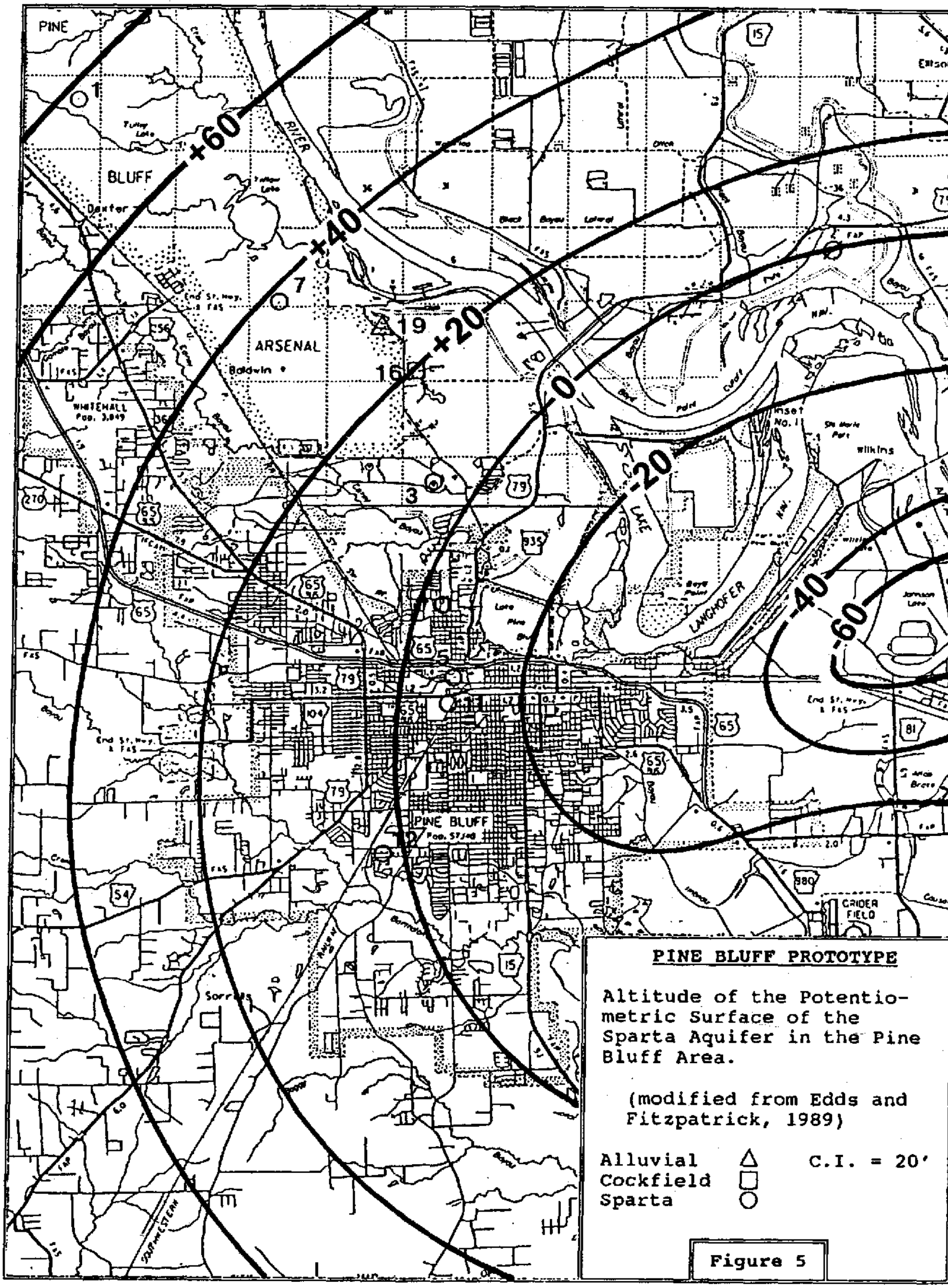
The recommendation for this prototype is to continue the program as in the past. There may be a need for replacement wells depending on the availability of previous sampling sites. The construction of cross-sections to determine if "windows" exist in the surficial clay layers would be useful (depending upon the availability of driller's logs). This could develop the need for additional monitoring sites to detect contamination possibly missed in past sampling. The physical and chemical nature of the pesticides as well as the soil type need to be considered when evaluating the pesticide's fate and transport in an area where pesticide use is widespread. It might be necessary to consider sampling pesticide mixing/loading site wells, which can contaminate the shallow aquifer when improperly managed.

Pine Bluff Prototype

The Pine Bluff prototype is located within the city of Pine Bluff in south-central Jefferson County. It lies within the Gulf Coastal Plain physiographic province. The area is dominated by the flood plain of the Arkansas River which lies immediately to the northeast of the city. The surface geology consists of clay, silt, sand, and gravel of Quaternary Age. The confining clays and silts of the Jackson Group crop out to the west of the city.

This prototype was selected because Pine Bluff is the largest community within the state using ground water to meet all its needs. The most widely used aquifer to meet community and industrial purposes is the Sparta Sand. The objective of the monitoring program is to detect any contamination upgradient of the public water supply wells and within the cone of depression developed in the Sparta aquifer caused by large-scale drawdown of public and commercial wells (Figure 5). The chief sources of contaminants entering the Sparta aquifer within the cone of depression would include a wide range of industrial, municipal, and domestic pollutants. The industrial discharges include a wide variety of wastes generated by various sources such as electroplating operations, paper mills, timber products, railways, and chemical or biochemical weapon manufacturing. Sampling categories of chemical constituents included the following: chloride, total hardness, nitrite + nitrate-N, phosphorous, sulfate, pesticides, and trace elements such as arsenic, cadmium, chromium, copper, lead, mercury, selenium, zinc, and iron.

Although the Sparta is the most widely used aquifer in the region, other aquifers provide an abundant source at shallower depths. The Quaternary alluvial and terrace deposits consists of clay, silt, sand, and gravel and generally range from 50 to 100 feet in thickness. These deposits unconformably overlie rocks of Tertiary Age (Table 2). Yields in excess of 1,000 gallons per minute are not uncommon. Water use from the alluvial aquifer in 1990 was 174.73 MGD (Holland, 1993). The Cockfield aquifer, which is overlain by the confining clays of the Jackson Group, is generally used for domestic purposes in Jefferson County. This formation is generally around 200 feet thick with yields ranging from a few gallons per minute up to 400 gallons per minute (Terry, et al, 1986). The Sparta consists of fine - to medium-grained sand in the lower portion of the unit, and beds of sand, clay, and lignite in the upper part. The thickness of the Sparta is approximately 600 feet in the Pine Bluff area. The largest use of water from the Sparta Sand is in Jefferson County (78.50 MGD in 1990) (Holland, 1993). Water yields from public water supply wells drawing from the Sparta range from 900 to 1,500 gallons per minute.



PINE BLUFF PROTOTYPE

Altitude of the Potentiometric Surface of the Sparta Aquifer in the Pine Bluff Area.

(modified from Edds and Fitzpatrick, 1989)

Alluvial △ C.I. = 20'
Cockfield □
Sparta ○

Figure 5

Nine wells were sampled for this prototype - seven from the Sparta, one from the Cockfield, and one from the alluvial aquifer. Figure 6 shows the location of wells sampled for water quality in the previously mentioned aquifers. The location and description of sampled wells are listed in Table 9. Well depths ranged from 54 feet for the alluvial aquifer to 1,085 for the Sparta aquifer.

Results of the first two sampling periods are shown in Table 10. There was no significant contamination detected in any of the seven Sparta wells. However, well #16 had a sodium concentration of 128 mg/l (first sampling) from a sample taken from the Cockfield aquifer. Well #19 had an arsenic concentration of 44 μg/l from a sample taken from the alluvial aquifer (first sampling) and nitrate concentrations of 1.7 and 1.54 mg/l, respectively. This well also had elevated chloride levels of 145 and 148 mg/l for the two sampling periods.

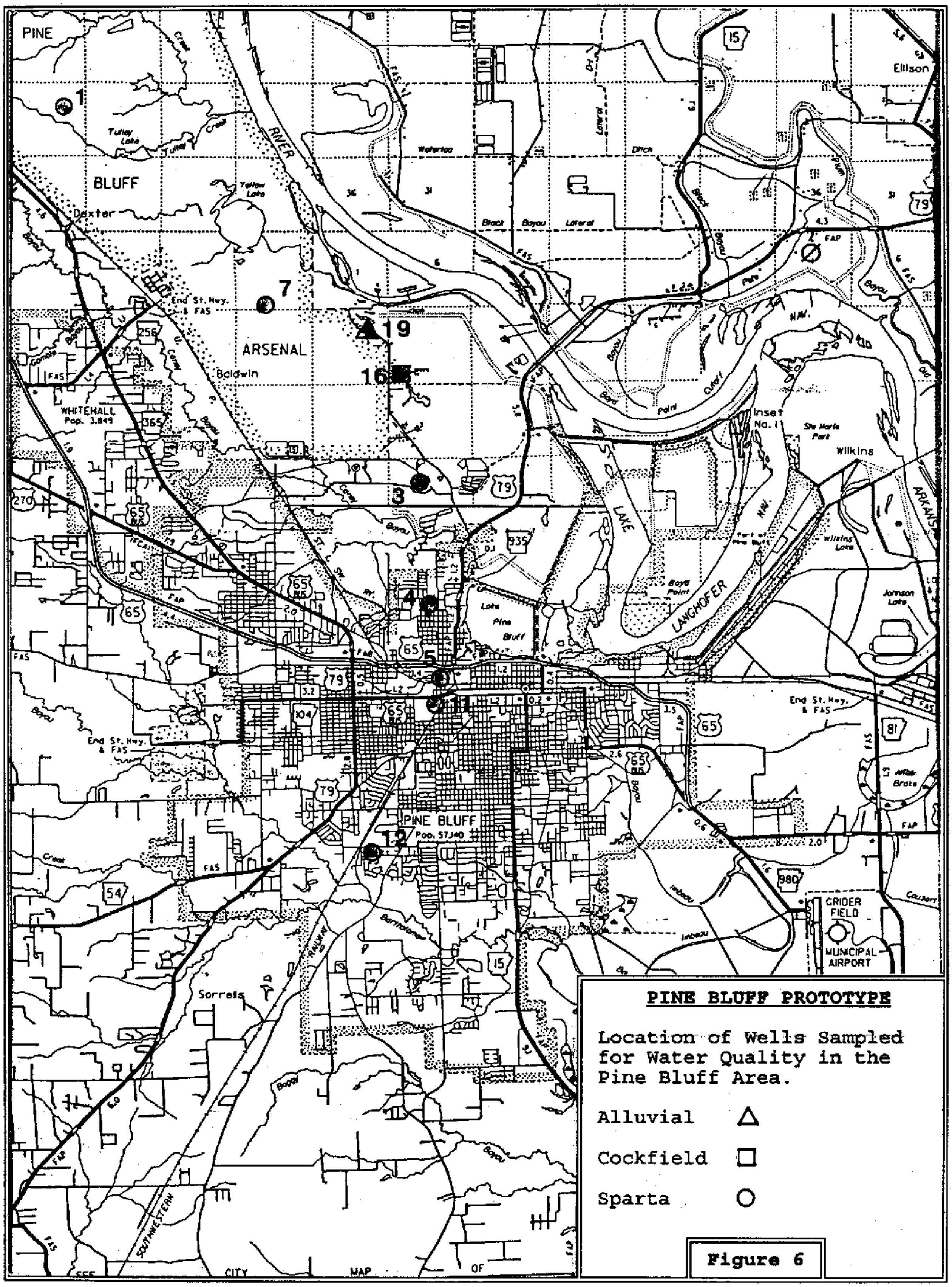
This prototype could be expanded in the Sparta, Cockfield, and alluvial aquifers as nine wells do not provide adequate representation of the area considering the size of the cone of depression and the fact that all of the wells are located just west of the center of the cone depression (Figure 5). Consideration should also be given to the influence of the Arkansas River on the alluvial aquifer.

Omaha Prototype

The Omaha prototype occupies an area of approximately 160 square miles surrounding the town of Omaha in the extreme northwestern part of Boone County. This prototype lies within the Interior Highlands physiographic province. The landscape exhibits moderate relief with elevations ranging from 700 feet above sea level in the northeastern portion of the area to 1,600 feet near the center of the area (Leidy and Morris, 1990). The surface geology consists of the cherty limestones of the Boone Formation occupying the central portion of the area with the Cotter Dolomite exposed to the northwest and northeast in the major stream tributaries.

This prototype was selected because it is in an area of increased animal production and is near a wood treatment Superfund site found to be contaminated with wood preservatives. The objective of this monitoring program is to examine the feasibility of monitoring ground water in carbonate terrains which are subject to the processes of karstification, and to describe and compare the ambient quality of the ground water in the Boone Formation and Cotter Dolomite. The chief sources of pollution are service stations, septic tanks, poultry and livestock farms, and the abandoned wood treatment plant. Sampling categories of chemical constituents included the following: chloride, total hardness, nitrite + nitrate-N, phosphorous, sulfate, pentachlorophenol, and creosote.

Table 3 shows a generalized stratigraphic column for northern Arkansas. Particular attention in this report is given to the water issuing from the Boone Formation as springs and wells drilled into the Cotter Dolomite, as these two formations are the major aquifers in the area. The wells drilled into the Cotter Dolomite may have contributions from shallow formations (i.e. Powell and Everton Formations) as there may be only a small vertical section cased with the rest of the hole open. The Boone Formation consists of fine- to coarsely-crystalline bedded limestone



PINE BLUFF PROTOTYPE

Location of Wells Sampled for Water Quality in the Pine Bluff Area.

Figure 6

Table 9. PINE BLUFF PROTOTYPE - LOCATION AND DESCRIPTION OF SELECTED WELLS

Site No.	Local Well No.	Well	Depth	Aquifer
MW069001	06S09W17CCC1	Well #12	847'	Sparta
MW069002	06S09W04BAB1	Well #11	864'	Sparta
MW069003	05S09W19BAA1	Well #3	1,275'	Sparta
MW069004	05S09W31DCA1	Well #5	859'	Sparta
MW069005	05S09W30DBA1	Well #4	792'	Sparta
MW069006	05S09W07CCC1	Well #16	265'	Cockfield
MW069007	05S10W12ADD1	Well #19	54'	Alluvial ?
MW069008	04S10W29ADC1	Well #1	651'	Sparta
MW069009	05S10W02CDD1	Well #7	1,085'	Sparta

Table 10. PINE BLUFF PROTOTYPE

Results of the first two sampling periods initiated 12/87 and 12/90.

WELL NO.	#12	#11	#3	#5	#4	#16	#19	#1	#7
AQFR	Sprt	Sprt	Sprt	Sprt	Sprt	Cckf	Alvm	Sprt	Sprt
DPTH	847'	844'	1275'	859'	792'	265'	54'	651'	1085'
TOT. ALK. mg/l	68.0 -	56.0 -	60.0 -	56.0 -	59.0 -	250 -	104 -	39.0 -	52.0 -
NH3+ NH4 mg/l	.240 -	.230 -	.190 -	.240 -	.290 -	.710 -	.020 .05K	.170 .100	.170 .190
NO2+ NO3 mg/l	.02 .02	.01 .02K	.01K -	.01 .02K	.01 -	.04 -	1.7 1.54	.10K .02K	.01K .02K
TOT. PHOS mg/l	.140 -	.110 -	.130 -	.100 -	.100 -	.130 -	.460 -	.030 -	.020 -
TOC mg/l	1.8 -	3.1 -	2.6 -	3.6 -	3.0 -	1.6 -	7.9 -	.4 -	3.0 -
TOT. HARD mg/l	32.0 -	24.0 -	36.0 -	26.0 -	26.0 -	30.0 -	182 -	18.0 -	22.0 -
CA mg/l	3.6 -	2.3 -	5.4 -	2.4 -	4.7 -	7.7 -	24.0 -	1.5 -	3.6 -

Table 10. PINE BLUFF PROTOTYPE - continued

WELL NO.	#12	#11	#3	#5	#4	#16	#19	#1	#7
NA mg/l	18.0 -	16.8 -	12.0 -	13.5 -	11.0 -	128 -	65.0 -	7.0 -	9.0 -
CL mg/l	2.0 3.0	2.0 4.0	2.0 -	3.0 3.0	2.0 -	13.0 -	145 148	3.0 6.0	3.0 6.0
SO4 mg/l	2.0 4.0	3.0 5.0	4.0 -	4.0 5.0	5.0 -	52.0 -	8.0 8.0	6.0 3.0	4.0 3.0
AS ug/l	5K -	5K -	5K -	5K -	5K -	5K -	44.0 10K	5K -	5K -
CU ug/l	15K -	22.0 -	15K -	15K -	30.0 -	15K -	15K 25K	165 -	15K 25K
FE ug/l	2100 -	2100 -	2300 -	2200 -	3400 -	400 -	8600 2100	2300 3700	2200 2100
PB ug/l	1.0 -	12.0 -	1K -	7.0 -	9.0 -	1K -	1K 2K	1.0 -	1K 2K

containing abundant quantities of gray chert, either in the form of nodules or as massive beds. The lower portion of the Boone Formation consists of a medium- to coarsely- crystalline limestone (St. Joe Limestone). Dissolution occurs along bedding planes and fracture traces creating a network of solution channels which may enlarge to form caves or collapse structures. The thickness of the Boone Formation in the Omaha area ranges from 0-100 feet (Imes, 1990). The Cotter Dolomite, which may be as much as 500 feet thick (Caplan, 1960), consists of either a massive, medium-grained, gray rock or a fine-grained earthy, white to buff rock. It may also contain minor amounts of shale, chert, and sandstone (Croneis, 1930).

Water in the Boone Formation is generally unconfined in this area with springs issuing from solution-enlarged fractures. The flow rate from the springs sampled in this study ranged from 1.5-1,400 gallons per minute (mean 137.2) for the wet season and .9-1,302 gallons per minute (mean 102.0) for the dry season. Wells drilled into the Cotter Dolomite commonly yield 5 to 10 gallons per minute (Leidy and Morris, 1990). The Cotter Dolomite may be unconfined or confined in the area.

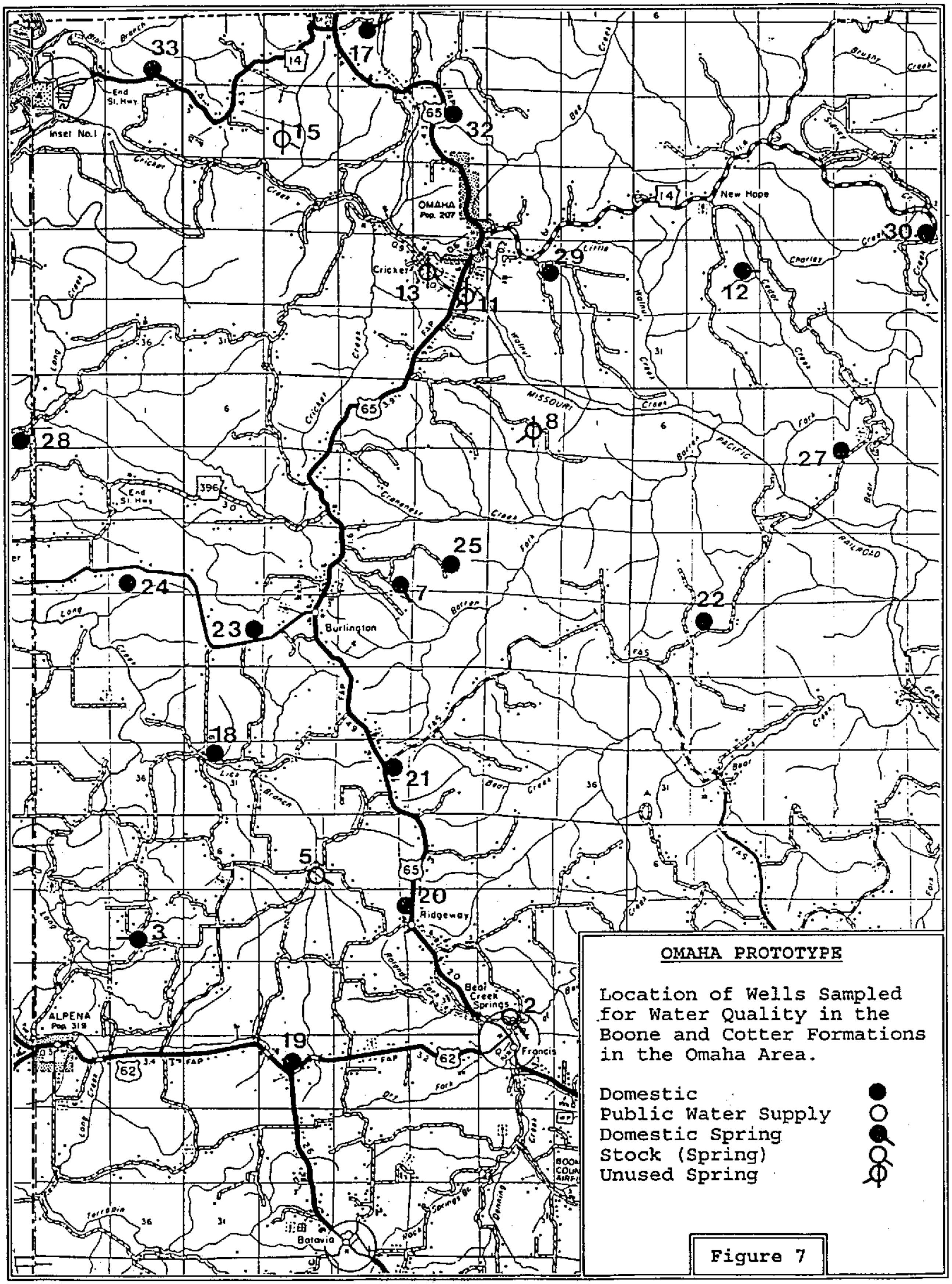
The fourteen wells sampled for water quality in the Cotter Dolomite had depths ranging from 40 feet to 675 feet. The springs sampled for water quality issued from the Boone Formation. Figure 7 shows the locations of the wells and springs sampled. The location and description of sampled wells and springs are listed in Table 11.

Results of the last two sampling periods initiated in the fall of 1989 and 1992 are listed in Table 12. The first sampling was conducted by the USGS in the spring and fall of 1987. That study included analyses for both wet and dry periods (Leidy and Morris, 1990). The analyses from the last two sampling periods indicate elevated nitrate values for springs #12 and #15 (4.75 and 6.32 mg/l, respectively). Analyses of the springs also show fecal coliform bacteria contamination for springs #2, #3, #5, and #7, and for well #22. Spring #13, located near the wood treatment plant, was also contaminated with pentachlorophenol. When comparing fecal coliform and nitrate concentrations, it can be inferred that the water quality of the Cotter Dolomite is better than that of the springs issuing from the Boone Formation.

The recommendation for this prototype is to maintain it's current status until a decision is made whether or not to increase the monitoring frequency to include wet and dry periods as was initially done during the USGS investigation. Since karst environments are hypersensitive to climatological events, it might be reasonable to increase the monitoring frequency.

El Dorado Prototype

The El Dorado prototype is located in and immediately surrounding the city of El Dorado. This city is approximately seventeen miles north of the Louisiana border in Union County and lies within the Gulf Coastal Plain physiographic province. The landscape is mostly sandy with gently rolling terrain with a vegetative cover of pine forests and pastures (Leidy and Taylor, 1992). The surface geology consists of clays and lignitic sands of the Cockfield Formation (Claiborne Group).



OMAHA PROTOTYPE
Location of Wells Sampled for Water Quality in the Boone and Cotter Formations in the Omaha Area.
Domestic
Public Water Supply
Domestic Spring
Stock (Spring)
Unused Spring
Figure 7
OMAHA Pop. 207
New Hope
Burlington
Ridgeway
Bear Creek Springs
Francis
ALPENA Pop. 319
Batavia
Inset No. 1
MISSOURI PACIFIC RAILROAD
33
17
15
32
30
29
13
11
12
8
28
27
25
24
7
22
23
18
21
5
20
3
2
19

Table 11. OMAHA PROTOTYPE - LOCATION AND DESCRIPTION OF SAMPLED SPRINGS / WELLS

Site No.	Local Well No.	Spring / Well	Depth	Aquifer
BNE002	19N21W14CDB1	Spring Site #2		Boone
BNE003	19N22W12CAB1	Spring Site #3		Boone
BNE005	19N21W05DDB1	Spring Site #5		Boone
BNE007	20N21W16DDC1	Spring Site #7		Boone
BNE008	20N21W02DBA1	Spring Site #8		Boone
BNE013	21N21W27BCB1	Spring Site #13		Boone
BNE012	21N20W29ACA1	Spring Site #12		Boone
BNE011	21N21W27DBD1	Spring Site #11		Boone
BNE015	21N21W17CAC1	Spring Site #15		Boone
BNE017	21N21W09BAD1	Spring Site #17		Boone
BNE018	20N21W31BAD1	Well #18	40’	Cotter
BNE019	19N21W20BDC1	Well #19	460’	Cotter
BNE020	19N21W10BCB1	Well #20	550’	Cotter
BNE021	20N21W33ACD1	Well #21	400’	Cotter
BNE022	20N20W20BCA1	Well #22	444’	Cotter
BNE023	20N21W19ADD1	Well #23	Unknown	Cotter
BNE024	20N22W13CBD1	Well #24	475’	Cotter
BNE025	20N21W15CAA1	Well #25	455’	Cotter
BNE027	20N20W03CCA1	Well #27	240’	Cotter
BNE028	20N22W03DDA1	Well #28	400’	Cotter
BNE029	21N21W26ADB1	Well #29	675’	Cotter
BNE030	21N20W23CDD1	Well #30	Unknown	Cotter
BNE032	21N21W15BDA1	Well #32	705’	Cotter
BNE033	21N22W12DCC1	Well #33	550’	Cotter

Table 12. OMAHA PROTOTYPE

Results of the last two sampling periods initiated in the fall of 1989 and 1992. The first sampling conducted by the USGS in the spring and fall of 1987 included both wet and dry periods and is published in WRIR 90-4066.

SPRING NUMBER	#2	#3	#5	#7	#8
AQUIFER	Boone	Boone	Boone	Boone	Boone
NH3+NH4 mg/l	.005K .070	.050K .050K	.050K .113	.050K .085	.050K -
NO2+NO3 mg/l	1.24 1.26	.94 .67	1.13 .74	1.14 1.59	1.91 -
CL mg/l	5.0 6.0	9.0 7.0	7.0 11.0	5.0 6.0	8.0 -
SO4 mg/l	3.0 6.0	8.0 4.0	3.0 2.0	4.0 4.0	25.0 -
FECAL COLIFORM /100ml	- 49.0	- 13.0	- 60L	- 54.0	- -
PCP µg/l	- -	- -	- -	- -	- -

SPRING NUMBER	#13	#12	#11	#15	#17
AQUIFER	Boone	Boone	Boone	Boone	Boone
NH3+NH4 mg/l	.150 .050K	.050K -	.120 -	.050K -	.050K -
NO2+NO3 mg/l	.13 .10	4.75 -	2.79 -	6.32 -	1.0 -
CL mg/l	7.0 5.0	6.0 -	12.0 -	8.0 -	8.0 -
SO4 mg/l	4.0 11.0	7.0 -	8.0 -	4.0 -	3.0 -
FECAL COLIFORM /100ml	- -	- -	- -	- -	- -
PCP µg/l	3023 -	- -	4.000K -	- -	- -

Table 12. OMAHA PROTOTYPE - continued

WELL NUMBER	#18	#19	#20	#21	#22	#23	#24
AQFR	Cotter	Cotter	Cotter	Cotter	Cotter	Cotter	Cotter
DEPTH	40'	460'	550'	400'	444'	Unk	475'
NH3+ NH4 mg/l	.050K .063	.050K -	.050K .068	.160 .249	.100 .050K	.050K .068	.050K .050K
NO2+ NO3 mg/l	.12 1.67	.33 -	.02K .21	.02K .02K	.02K .61	.02K .29	.12 .15
CL mg/l	4.0 4.0	5.0 -	5.0 6.0	4.0 3.0	2.0 11.0	4.0 4.0	4.0 3.0
SO4 mg/l	2.0 2.0	35.0 -	25.0 22.0	23.0 21.0	63.0 45.0	25.0 39.0	19.0 19.0
FECAL COLI. /100ml	- 19.0	- -	- 1K	- 1K	- 18.0	- 1K	- 1K

WELL NO.	#25	#27	#28	#29	#30	#32	#33
AQFR	Cotter	Cotter	Cotter	Cotter	Cotter	Cotter	Cotter
DEPTH	455'	240'	400'	675'	Unk	705'	550'
NH3+ NH4 mg/l	.050K -	.050K -	.050K -	.050K .050K	.050K -	.050K .050K	.050K .050K
NO2+ NO3 mg/l	.02K -	1.37 -	.14 -	.37 .55	- -	.02K .03	.08 .02K
CL mg/l	4.0 -	6.0 -	4.0 -	3.0 4.0	3.0 -	3.0 2.0	4.0 2.0
SO4 mg/l	46.0 -	9.0 -	17.0 -	62.0 57.0	22.0 -	42.0 45.0	14.0 29.0
FECAL COLI. /100ml	- -	- -	- -	- 1K	- -	- 1K	- 1K

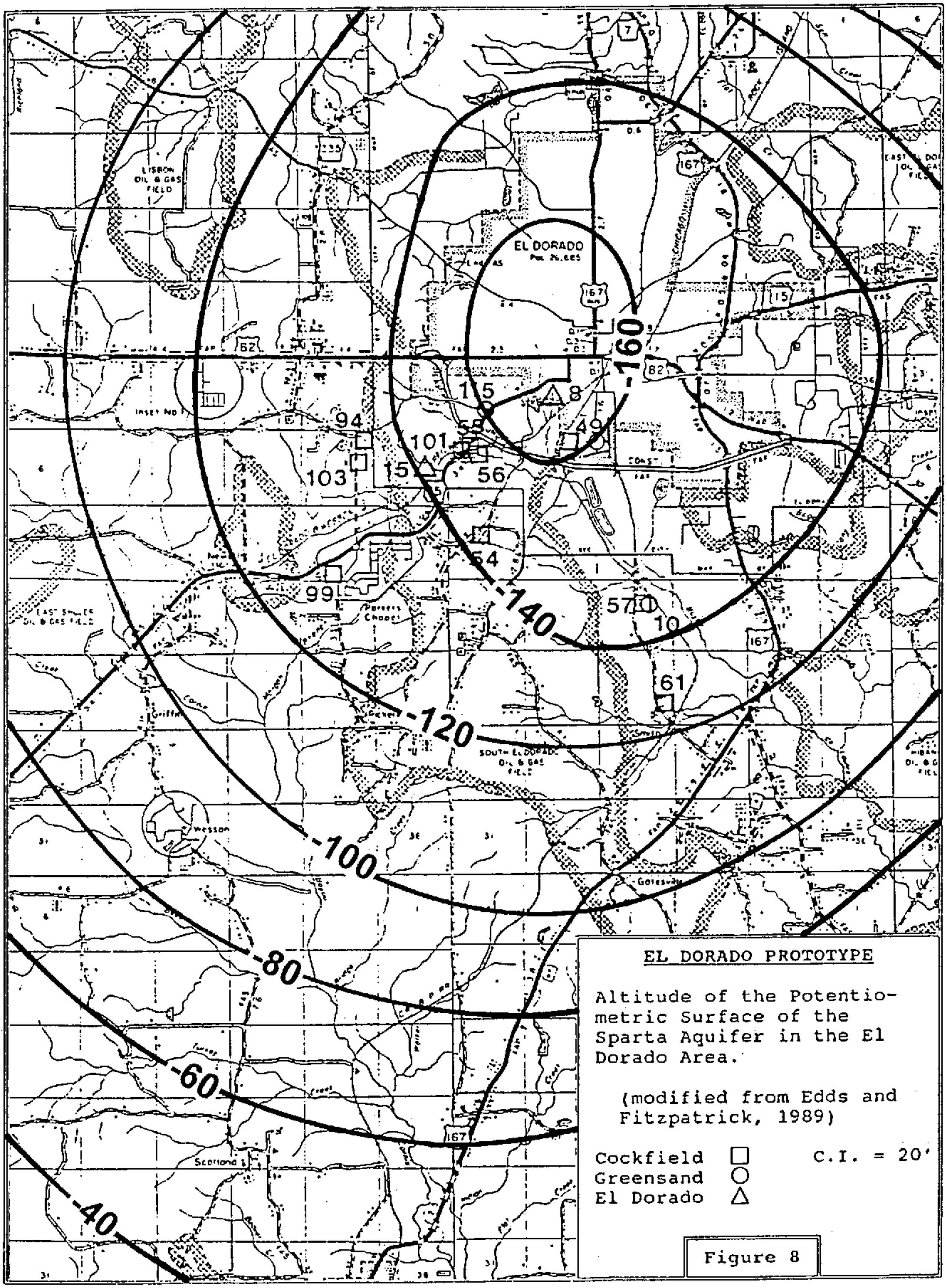
The El Dorado prototype was chosen because the city of El Dorado lies within the Bayou D'Loutre Drainage Basin which would potentially be affected by municipal and industrial discharges. The area also produces large quantities of wastes related to the petroleum industry. The objective of the program is to concentrate monitoring in an area where a large cone of depression has developed in a confined aquifer (El Dorado Sand), the surface is threatened by contamination from urban and industrial discharges into or near a stream (Bayou D'Loutre), and rural domestic users are threatened from oil industry activities. The chief sources of pollution include spent brine, saltwater, oil sludge, EDB, creosote, sewage treatment ponds, and various oil fields and their associated wastes. Sampling categories of chemical constituents included the following: chloride, total hardness, nitrite + nitrate-N, phosphorous, TOC, and trace elements such as arsenic, cadmium, chromium, copper, lead, mercury, selenium, zinc, and iron.

Table 2 shows a generalized stratigraphic column for the area of investigation. The Cockfield aquifer, which directly underlies the Quaternary alluvial and terrace deposits, consists of lignitic sand with interbedded clay. The Cockfield, used chiefly for domestic purposes in the El Dorado area, is approximately 200 feet thick (Leidy and Taylor, 1992). The Sparta Sand can be divided into an upper unit (Greensand aquifer), a middle confining unit, and a lower unit (El Dorado aquifer). The Greensand aquifer is a thinly bedded fine glauconitic sand with interbedded clay. The El Dorado aquifer is a thickly bedded medium to coarse sand (Leidy and Taylor, 1992). The Sparta Sand attains a thickness of between 400 and 500 feet in the El Dorado area (Terry et al, 1986). Yields from this aquifer may be in excess of 1,000 gallons per minute. Figure 8 shows the altitude of the potentiometric surface of the Sparta aquifer in the area of investigation. As can be seen on the map, the center of the cone of depression lies within the metropolitan area.

Broom and others (1984) theorized that the saltwater contamination in the El Dorado aquifer is coming from a graben located southeast of the city and structurally downdip (Figure 9). Normally, ground water flow is to the southeast toward the inlet of the graben but large scale withdrawal in the El Dorado area has caused the direction of flow to change locally from southeast to northwest allowing the saltwater to flow from the graben towards the center of pumping.

Fourteen wells were sampled for water quality - ten from the Cockfield, two from the Greensand, and two from the El Dorado aquifer. Figure 10 shows the location of the wells sampled. Table 13 lists the location and description of sampled wells. Depths ranged from 12 feet for the shallow Cockfield aquifer to 770 for the El Dorado aquifer.

Results of the first two sampling periods initiated in the fall of 1987 and 1990 are listed in Table 14. Samples taken from the two wells drawing from the El Dorado aquifer (Lower Sparta) and several from the Cockfield formation show elevated chloride values when compared to the other wells, but are still below the secondary maximum contaminant level of 250 mg/l. The sodium levels from the El Dorado aquifer also show somewhat high values, but there are no other analyses from this aquifer to compare. Well #103 (Cockfield) had a high nitrate level (46 mg/l) during the first sampling but was not sampled during the second period. Well #94 and #99 (both in the Cockfield) also show elevated nitrate concentrations, especially during the second sampling period. The samples taken from the Greensand aquifer (Upper Sparta) did not show any signs of contamination.

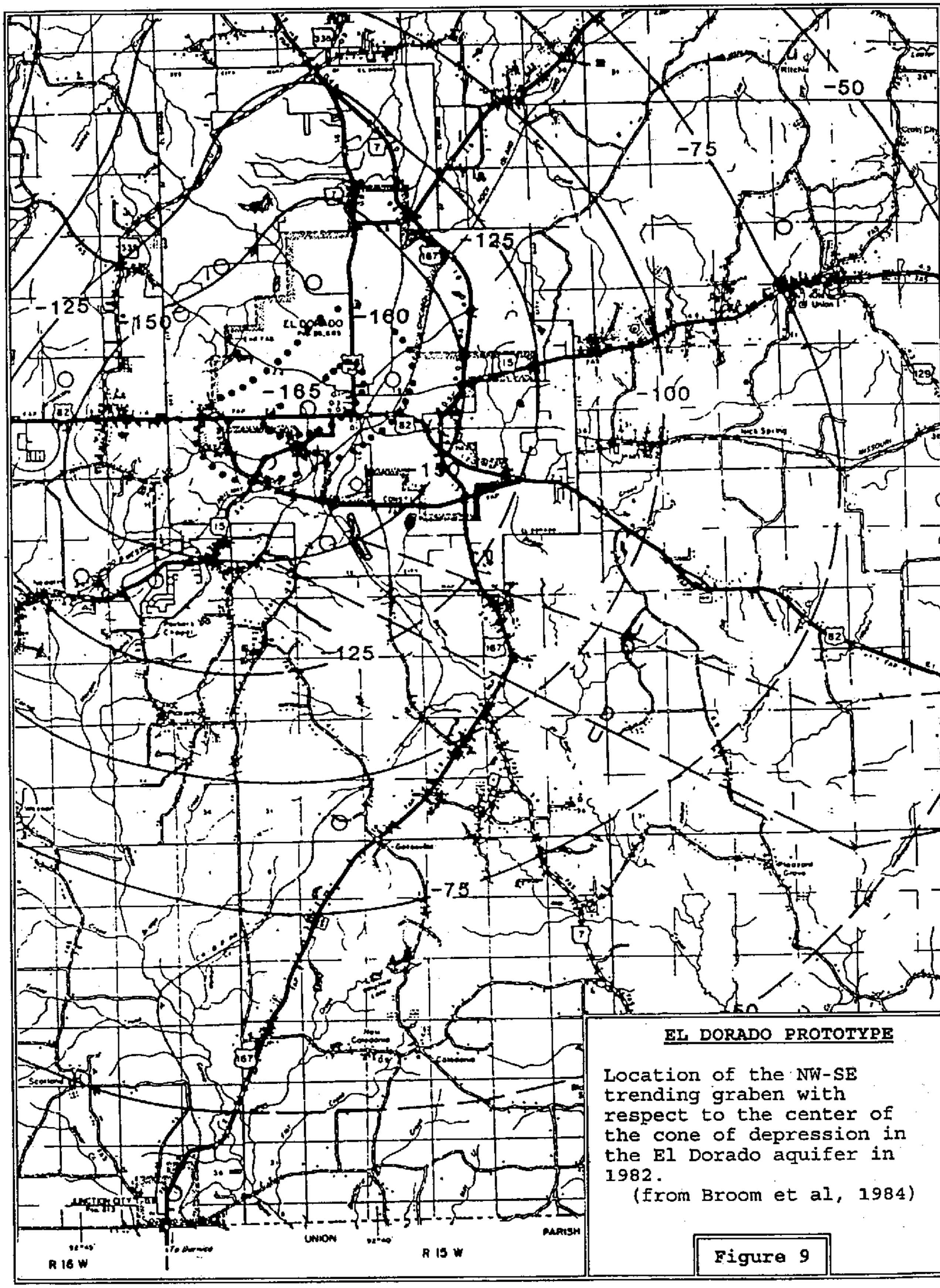


EL DORADO PROTOTYPE

Altitude of the Potentiometric Surface of the Sparta Aquifer in the El Dorado Area.

(modified from Edds and Fitzpatrick, 1989)

Figure 8



EL DORADO PROTOTYPE

Location of the NW-SE trending graben with respect to the center of the cone of depression in the El Dorado aquifer in 1982.
(from Broom et al, 1984)

Figure 9

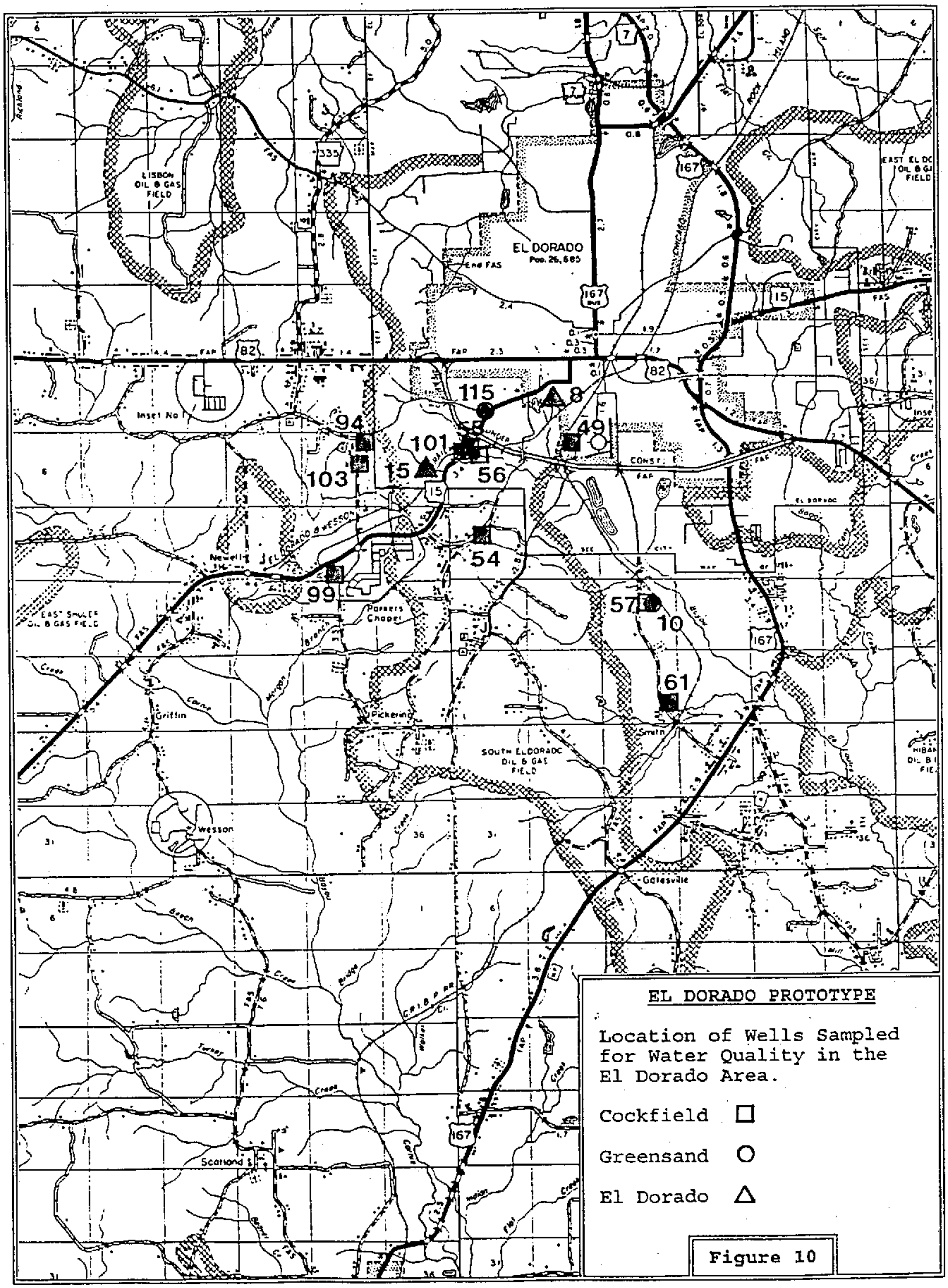

EL DORADO PROTOTYPE
Location of Wells Sampled for Water Quality in the El Dorado Area.
Cockfield
Greensand
El Dorado
Figure 10
EL DORADO
Pop. 26,685
LISBON OIL & GAS FIELD
SOUTH ELDORADO OIL & GAS FIELD
EAST SMACKOVER OIL & GAS FIELD
Newell
Parkers Chapel
Pickering
Griffin
Wesson
Smith
Gatesville
Scotland
115
8
94
101
58
49
103
15
56
54
99
57
10
61

Table 13. EL DORADO PROTOTYPE - LOCATION AND DESCRIPTION OF SAMPLED WELLS

Site No.	Local Well No.	Well	Depth	Aquifer
MW139001	18S15W21DAC1	Well #61	40'	Cockfield
MW139002	18S15W16ACB1	Well #10	295'	Greensand
MW139003	18S15W16ACB2	Well #57	24'	Cockfield
MW139004	18S16W02AAA1	Well #94	43'	Cockfield
MW139005	18S16W11CDD1	Well #99	70'	Cockfield
MW139006	18S15W07BDA1	Well #54	100'	Cockfield
MW139007	18S16W01DBC1	Well #15	770'	El Dorado
MW139008	18S15W06BDB1	Well #56	12'	Cockfield
MW139009	18S15W06BDB2	Well #55	30'	Cockfield
MW130010	18S15W06BDB3	Well #101	31'	Cockfield
MW139011	18S16W02ACA3	Well #103	27'	Cockfield
MW139012	18S15W05BBC1	Well #049	75'	Cockfield
MW139013	17S15W32BDD1	Well #008	712'	El Dorado
MW139014	17S15W31DCB1	Well #115	300'	Greensand

Table 14. EL DORADO PROTOTYPE

Results of the first two sampling periods initiated 12/87 and 12/90.

WELL NO.	#8	#10	#15	#61	#54	#55	#56
AQFR.	El Dor	Grnsd	El Dor	Cckf	Cckf	Cckf	Cckf
DEPTH	648′	295′	770′	40′	100′	30′	12′
TOT. ALK. mg/l	189 -	119 -	200 -	31.0 -	19.0 -	33.0 -	18.0 -
NH3+ NH4 mg/l	.500 -	.710 -	.510 -	.070 .050	.130 -	.070 -	.030 -
NO2+ NO3 mg/l	.01 -	.01K .02K	.01K .02K	.20 .13	.01K .02K	.51 -	.17 -
TOT. PHOS mg/l	.220 -	.120 -	.210 -	.050 -	.050 -	.050 -	.050 -
TOC mg/l	3.9 -	4.8 -	5.3 -	3.4 -	2.2 -	1.8 -	1.5 -
TOT. HARD mg/l	- -	34.0 -	- -	- -	80.0 -	130 -	102 -
CA mg/l	1.5 -	7.4 -	1.4 -	2.1 -	4.4 -	29.0 -	14.1 -
NA mg/l	98.0 -	47.0 -	128 -	10.0 -	21.0 -	- -	15.0 -
CL mg/l	33.0 -	2.0 4.0	44.0 41.0	12.0 5.0	80.0 75.0	94.0 -	85.0 -

Table 14. EL DORADO PROTOTYPE - continued

WELL NO.	#8	#10	#15	#61	#54	#55	#56
SO4 mg/l	6.0 -	5.0 4.0	15.0 18.0	6.0 7.0	8.0 9.0	4.0 -	7.0 -
AS ug/l	5K -	5K 10K	5K 10K	5K -	5K 30.0	5K -	5K -
CD ug/l	.5K -	.5K .5K	.5K .5K	.5K -	.5K .5K	.5K -	1.0 -
CR ug/l	1K -	1K 1K	1K 1K	1K -	1K 7.0	1K -	1.0 -
CU ug/l	15K -	15K 25K	15K 25K	15K -	15K 51.0	- -	29.0 -
FE ug/l	100 -	100 100	100 100K	200 -	2300 4800	1800 -	500 -
PB ug/l	3.0 -	1K 2K	2.0 2K	1.0 -	2.0 2.0	2.0 -	1K -
ZN ug/l	- -	- 15.0	- 8K	- -	- 302	- -	- -
BR mg/l	.65 -	.5K -	.89 -	.50K -	1.2 -	2.1 -	3.2 -

Table 14. EL DORADO PROTOTYPE - continued

WELL NO.	#57	#101	#94	#99	#49	#103	#115
AQFR.	Cckf	Cckf	Cckf	Cckf	Cckf	Cckf	Grnsd
DEPTH	24'	31'	43'	70'	75'	27'	300'
TOT. ALK. mg/l	20.0 -	5.0 -	33.0 -	5K -	51.0 -	68.0 -	109 -
NH3+ NH4 mg/l	.010 -	.120 -	.060 .050	.070 .050K	.130 -	.020 -	.210 -
NO2+ NO3 mg/l	.05 -	.04 -	.06 2.50	1.40 2.33	.01 -	46.0 -	.03 -
TOT. PHOS mg/l	.010 -	.090 -	.190 -	.010K -	- -	- -	- -
TOC mg/l	1.5 -	.8 -	13.3 -	1.2 -	5.8 -	7.8 -	12.3 -
TOT. HARD mg/l	40.0 -	108 -	52.0 -	14.0 -	56.0 -	190 -	88.0 -
CA mg/l	5.5 -	9.4 -	1.2 -	1K -	2.0 -	50.0 -	48.0 -
NA mg/l	7.0 -	14.0 -	- -	- -	89.0 -	8.2 -	8.3 -
CL mg/l	16.0 -	100 -	39.0 43.0	4.0 5.0	12.0 -	18.0 -	18.0 -

Table 14. <u>EL DORADO PROTOTYPE</u> - continued

WELL NO.	#57	#101	#94	#99	#49	#103	#115
SO4 mg/l	11.0 -	2.0 -	55.0 33.0	1.0 1K	1.0 -	46.0 -	3.0 -
AS ug/l	5K -	5K -	5K	5K -	5K -	5K -	5K -
CD ug/l	.5K -	.5K -	.80 -	.5K -	1.0 -	.5K -	.5K -
CR ug/l	1K -	10.0 -	1K -	1K -	18.0 -	1K -	3.0 -
CU ug/l	31.0 -	29.0 -	- -	- -	287 -	15K -	15K -
FE ug/l	200 -	10500 -	200K -	200K -	30600 -	1000K -	1000K -
PB ug/l	- -	1K -	- -	5.0 -	80.0 -	1K -	3.0 -
ZN ug/l	- -	- -	- -	- -	- -	- -	- -
BR mg/l	.5K -	2.1 -	2.4 -	.50K -	- -	- -	- -

There will need to be additional sampling sites added, as [redacted]. Most of the present monitoring sites are situated south and southwest of El Dorado and northwest of the graben mentioned as a source of saltwater contamination (Broom et al, 1984). [redacted]. The present sites in the Cockfield are too concentrated in one area. Future sites may be more spatially arranged to provide information about any possible trend. [redacted] in determining the absence of clay confining layers overlying the Cockfield aquifer.

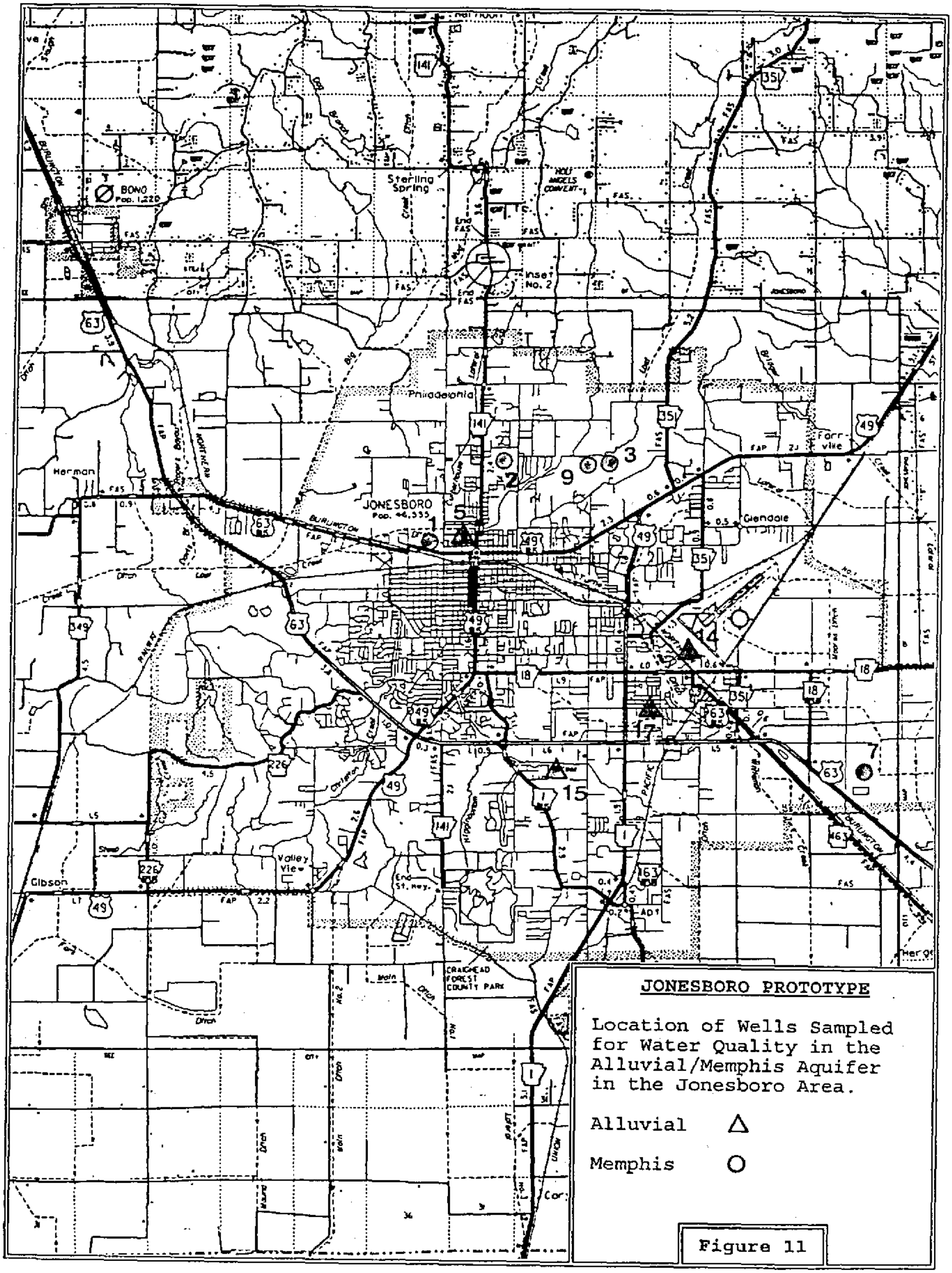
Jonesboro Protoype

The Jonesboro prototype is located within the Jonesboro metropolitan area in central Craighead County. The project area lies within the [redacted]. The city of Jonesboro lies on Crowley's Ridge, an erosional remnant of unconsolidated Eocene clay, silt, sand, and lignite capped by Pliocene sand and gravel and middle to late Pleistocene loess (Guccione and others, 1986). Local relief can be as much as 200 feet within the metropolitan area.

This prototype was selected because of the relatively large population utilizing ground water and the exposed condition of the city's public supply wells. [redacted]. The objective of the monitoring program is to provide a methodology which will protect the Jonesboro public supply wells from potential contamination stemming from landfills, storage tanks, and other potential sources on the surface upgradient from the wells. The chief sources of pollution are pesticides, halogenated solvents, and landfills. Sampling categories of chemical constituents included the following: [redacted].

A generalized stratigraphic column is listed in Table 2. The Quaternary alluvial aquifer may be as much as 100 feet thick in the immediate area and yields can be as much as 2,000 gallons per minute for wells penetrating the entire thickness of the aquifer. In many cases there may not be a confining clay separating the overlying alluvium from the Memphis Sand. The Memphis aquifer is described as a sand, fine to gravelly; principally thick-bedded, containing clay layers (Hines et al, 1972). The aquifer may yield as much as 500 gallons per minute.

The nine wells sampled in this investigation had depth ranges of 30 feet to 362 feet. Figure 11 shows the location of wells sampled for water quality in the alluvial or Memphis aquifers. The location and description of sampled wells are listed in Table 15.



JONESBORO PROTOTYPE

Location of Wells Sampled for Water Quality in the Alluvial/Memphis Aquifer in the Jonesboro Area.

Alluvial △

Memphis ○

Figure 11

Table 15. JONESBORO PROTOTYPE - LOCATION AND DESCRIPTION OF SAMPLED WELLS

Site No.	Local Well No.	Well	Depth	Aquifer
MW0310010	14N04E28BAA1	Well #17	362'	Memphis
MW0310011	14N04E28ACD1	Well #15	271'	Memphis
MW0310012	14N04E22ABD1	Well #14	350'	Memphis
MW0310013	14N03E19AAC1	Well #1	140'	Alluvial ?
MW031005	14N04E09BBA1	Well #3	80'	Alluvial
MW031006	14N04E09BBB1	Well #9	30'	Alluvial
MW031007	14N04E36ADC1	Well #7	40'	Alluvial
MW031008	14N04E07AAB1	Well #2	70'	Alluvial
MW031009	14N04E18ADD2	Well #5	180'	Memphis ?

Table 16. JONESBORO PROTOTYPE

Results of the first two sampling periods initiated 6/89 and 6/92.

WELL NO.	#17	#15	#14	#1	#3	#9	#7	#2	#5
AQFR	Mphs	Mphs	Mphs	Alvm	Alvm	Alvm	Alvm	Alvm	Mphs
DPTH	362′	271′	350′	140′	80′	30′?	40′?	70′	180′
TOT. ALK. mg/l	57.0 -	85.0 -	53.0 -	84.0 -	153 -	149 -	101 -	49.0 -	63.0 -
NH3+ NH4 mg/l	.020 -	.050 -	.060 -	.040 -	.030 .05K	.01K -	.150 .05K	.010 -	.020 -
NO2+ NO3 mg/l	.57 -	.01 -	.61 -	.01 -	18.0 12.5	.07 -	.03 .11	2.7 -	2.0 -
TOC mg/l	1.2 -	3.7 -	2.5 -	2.7 -	3.9 -	5.1 -	2.3 -	3.0 -	1.6 -
TOT. HARD mg/l	52.0 -	88.0 -	46.0 -	88.0 -	224 -	132 -	72.0 -	70.0 -	78.0 -
NA mg/l	16.0 -	- -	- -	- -	- -	- -	- -	- -	- -
CL mg/l	12.0	16.0 -	9.0 -	16.0 -	62.0 45.0	7.0 -	11.0 9.0	32.0 -	10.0 -
SO4 mg/l	5.0 -	16.0 -	5.0 -	11.0 -	12.0 20.0	7.0	3.0 2.0	8.0 -	29.0 -
FE ug/l	.3 -	- -	- -	- -	- -	- -	- -	- -	.4 -
PB ug/l	4.0 -	- -	- -	- -	- -	- -	- -	- -	- -

Results of the first two sampling periods initiated in the summer of 1989 and 1992 are listed in Table 16. Wells sampled include one public water supply well from each of the four well fields within the city limits, one industrial well, one irrigation well, and three domestic wells. Well #3 (alluvial) showed elevated nitrate concentrations (18.0 and 12.5 mg/l respectively) for the two sampling periods and also higher chloride levels (62.0 and 45.0 mg/l respectively) than the other wells sampled. Wells #2 (alluvial) and #5 (Memphis) also had elevated nitrate concentrations (2.7 and 2.0 mg/l respectively) for samples taken during the first period. These two wells were not resampled during the second period.

This prototype will need to be reviewed in closer detail to determine the extent of the overlying clay confining layer. A review of the driller's logs in the vicinity, including several from the public water supply wells indicates a surficial clay confining layer with a range in thickness of 20 feet to well over 100 feet. There is often another layer immediately below this surficial layer. The depth to the top of the Memphis aquifer, depending upon the geographic location, is variable and may indeed be less than 100 feet.

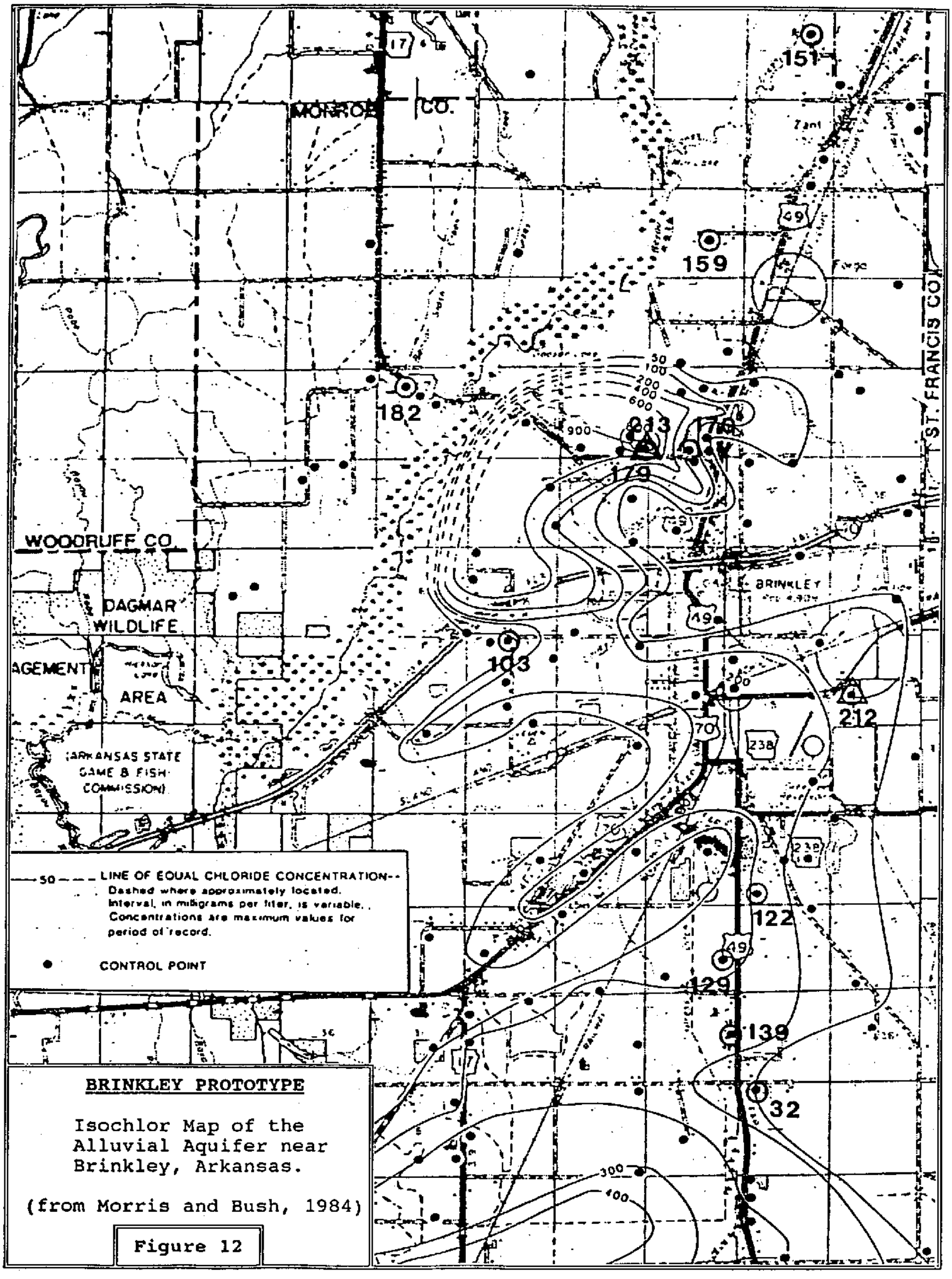
Brinkley Prototype

The Brinkley prototype encompasses approximately 56 square miles surrounding the town of Brinkley in northern Monroe County. This program area lies within the Gulf Coastal Plain physiographic province. The country is mostly farmland used for rice, cotton, and soybean production. The surface geology consists of the clay, silt, sand, and gravel of Quaternary alluvial and terrace deposits.

This prototype was selected because it represents a community in eastern Arkansas where 100 percent of the population uses ground water to meet community needs and where previous studies have shown it to be the site of a large area of contaminated ground water in what was formerly fresh water aquifers. The objective of the monitoring program is to provide a methodology which will protect the Brinkley public water supply wells from the potential expansion of the zone of saltwater through the provision of warning time in which action may be taken. Sampling categories of chemical constituents included the following: chloride, total hardness, nitrite + nitrate-N, phosphorous, sulfate, and a pesticide scan.

The Quaternary alluvial and terrace deposits, composed of clay, silt, sand, and gravel, range in thickness from about 100 feet to 160 feet. These deposits overlie the confining clays of the Jackson Group and the clays and sands of the Cockfield and Cook Mountain Formations (Table 2). The Sparta, which underlies these formations, consists of sand, clay, and silt, interbedded. The sand is fine- to medium in the upper part and fine- to coarse in the lower part, separated by a clay layer (Morris and Bush, 1984). The Sparta in this area averages approximately 400 feet in thickness. Water yields for both the Quaternary alluvial deposits and the Sparta Sand are consistent for wells drawing from these formations in the Gulf Coastal Plain province.

An investigation by Morris and Bush (1984) mapped saltwater contamination using water quality data from 217 wells in the alluvial aquifer (Figure 12). This study found that approximately 56



BRINKLEY PROTOTYPE

Isochlor Map of the Alluvial Aquifer near Brinkley, Arkansas.

(from Morris and Bush, 1984)

Figure 12

square miles of the alluvial aquifer had been contaminated by saltwater. This has been a problem since first being recognized in the late 1940's. Their investigation considered [redacted] as follows: 1) [redacted]; 2) [redacted]; and 3) [redacted] The most likely source of contamination, according to the study, was upward movement into the alluvial aquifer from the underlying Sparta aquifer through the thinned or absent Jackson confining unit.

Twelve wells were sampled for water quality - ten from the alluvial aquifer, and two from the Sparta aquifer. Figure 13 shows the location of the wells sampled in the monitoring program. The location and description of these wells are listed in Table 17. Well depths ranged from 60 feet to 140 feet for the alluvial aquifer to 420 feet for the Sparta aquifer.

Results of the first two sampling periods in the summer of 1989 and 1992 are listed in Table 18. As can be seen from the analyses, there are [redacted], including two wells in the Sparta aquifer (well #212 and #213) and one in the alluvial aquifer (#179) [redacted] Other wells, while not exceeding the SMCL for chloride, have shown [redacted]. Wells #139, #179, and #213 were not resampled during the second period. Elevated nitrate levels were seen in alluvial well #182 during the second sampling (1.04 mg/l).

There will need to be additional monitoring locations to show any trend development outside of that already mapped (Figure 12). The city wells (alluvial), which lie just to the northwest of a zone of high chloride concentration, were not included in the first two analyses although well #182 lies in close proximity to those wells. The isochlor map from the published study shows no control on the northwest flank of the zone of high chloride concentration and just southwest of the public water supply wells. Those wells not resampled during the second period will need to be replaced if they are no longer useable.

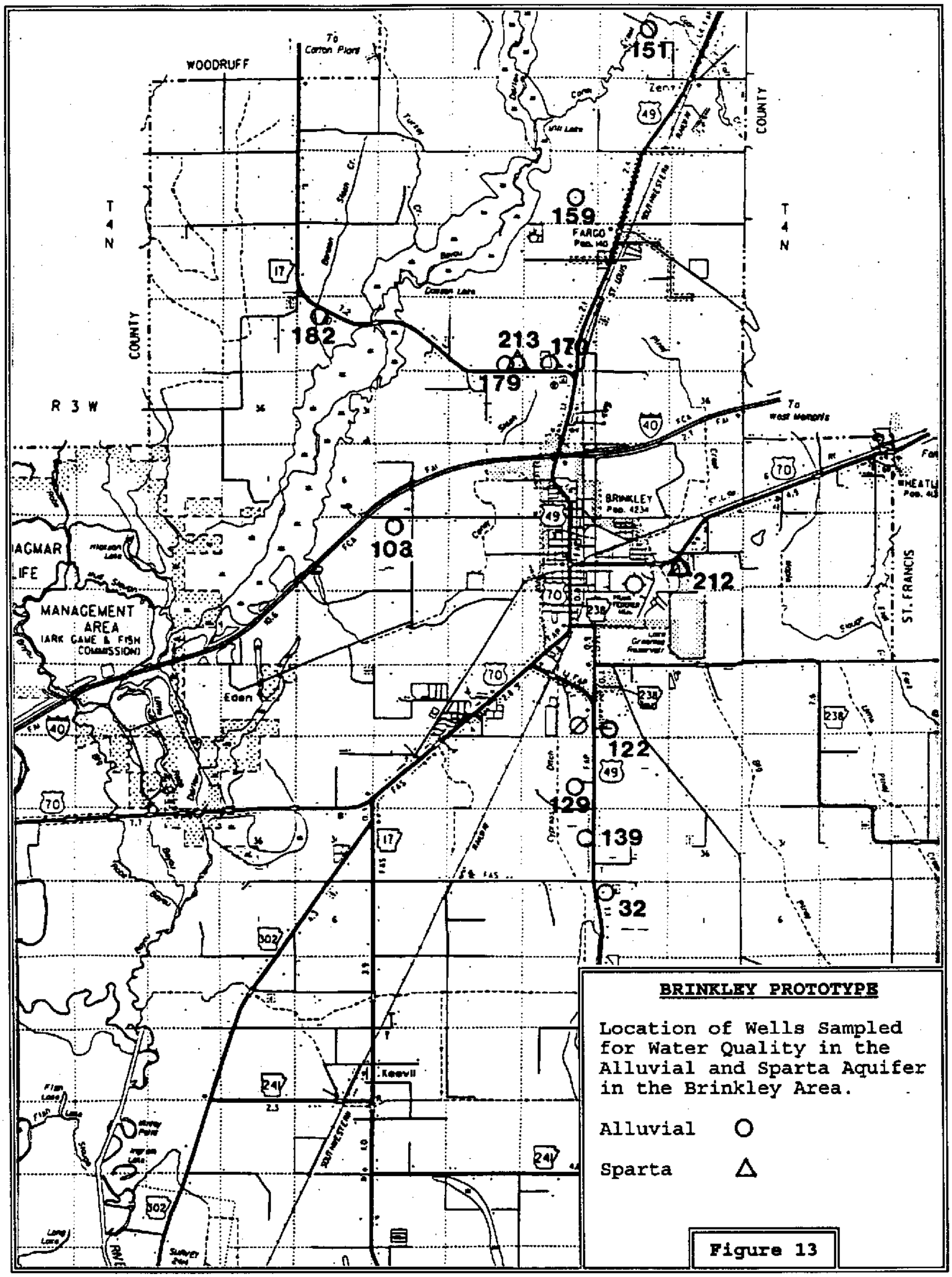

BRINKLEY PROTOTYPE
Location of Wells Sampled for Water Quality in the Alluvial and Sparta Aquifer in the Brinkley Area.
Alluvial
Sparta
Figure 13
WOODRUFF
COUNTY
ST. FRANCIS
T 4 N
R 3 W
FARGO
BRINKLEY
MANAGEMENT AREA
(ARK GAME & FISH COMMISSION)
Eden
Keevil
151
159
182
213
170
179
103
212
122
129
139
32

Table 17. <u>BRINKLEY PROTOTYPE - LOCATION AND DESCRIPTION OF SAMPLED WELLS</u>

Site No.	Local Well No.	Well	Depth	Aquifer
MW095001	02N02W02BBA1	Well #32	125'	Alluvial
MW095002	03N02W08BBA1	Well #103	Unknown	Alluvial
MW095003	03N02W12CBC1	Well #212	420'	Sparta
MW095004	03N02W23CCD1	Well #122	100'	Alluvial
MW095005	03N02W27DAC1	Well #129	90'	Alluvial
MW095006	03N02W34ADD1	Well #139	Unknown	Alluvial
MW095007	04N02W02ACA1	Well #151	84'	Alluvial
MW095008	04N02W15DBA1	Well #159	60'	Alluvial
MW095009	04N02W27CDD1	Well #170	82'	Alluvial
MW095010	04N02W28DDD3	Well #179	137'	Alluvial
MW095011	04N02W28DDD4	Well #213	408'	Sparta
MW095012	04N02W30BAC2	Well #182	140'	Alluvial

Table 18. BRINKLEY PROTOTYPE

Results of the first two sampling periods initiated 6/89 and 6/92.

WELL NO.	#32	#103	#212	#122	#129	#139	#151
AQFR	Alvm	Alvm	Sparta	Alvm	Alvm	Alvm	Unk
DEPTH	125'	Unk	420'	100'	90'	Unk	Unk
NH3+ NH4 mg/l	- .05K	.060 .420	.260 1.69	- .630	- .680	.920 -	.240 .460
NO2+ NO3 mg/l	.78 .05	.03 -	.01 .02K	.70 .02K	.79 .02K	.01 -	.01 .02K
TOTAL HARD. mg/l	340 -	416 -	52.0 -	502 -	502 -	382 -	194 -
CL mg/l	3.0 7.0	113 103	4.0 694	5.0 110	2.0 56.0	0.0 -	4.0 45.0
SO4 mg/l	- 17.0	7.0 14.0	1.0 3.0	- -	- -	34.0 -	5.0 12.0

WELL NO.	#159	#170	#179	#213	#182
AQUIFER	Alluvial	Alluvial	Alluvial	Sparta	Alluvial
DEPTH	60'	82'	137'	408'	140'
NH3+NH4 mg/l	.030 .05K	.540 .570	.950 -	1.2 -	.010 .05K
NO2+NO3 mg/l	.06 .02K	.01 .02K	.02 -	.01 -	.02 1.04
TOTAL HARDNESS mg/l	72.0 -	452 -	- -	40.0 -	74.0 -
CL mg/l	8.0 8.0	114 146	830 -	1000 -	7.0 5.0
SO4 mg/l	8.0 14.0	48.0 63.0	3.0 -	3.0 -	8.0 9.0

CONCLUSIONS

The protoypes reviewed in this summary report continue to provide useful information regarding background ground water quality conditions for various aquifers located around the state. This data can be used to assist in the development of ground water standards much like that done during the development of surface water standards (Regulation No. 2), and also for detecting significant water quality trends in a particular locality.

Most of the prototypes reviewed have an adequate number of sampling locations to effectively represent an area. However, some of the prototypes are situated in an area of documented ground water contamination and do not represent a truly ambient monitoring network. In some cases, there is a need for additional monitoring locations in order to better evaluate the ground water quality for a particular aquifer. A case in point is the relatively few sampling sites for the Greensand and El Dorado aquifers in the El Dorado prototype. The original intention was to document the water quality in the El Dorado aquifer where a large cone of depression had developed but ten of the fourteen wells sampled were from the Cockfield aquifer (used for domestic purposes). It is quite possible that there are no suitable locations available so the intent will be to continue with those that are now being used. In some areas there is widespread contamination (documented in past investigations) such as in the Brinkley area. In that particular case, it may be appropriate to expand the network of wells to be used for monitoring in order to more readily assess the extent of the problem and whether it poses a threat to the Brinkley community.

The prototype monitoring program that has been established by the Department should be maintained. However, there will need to be some modifications made in the sampling protocol in order to obtain more consistent data. Finally, there is a need to rethink the "ambient" aspect of the overall program. A monitoring network set up to address a particular contamination problem is certainly worthwhile but may not provide useful data about the overall water quality of a particular aquifer within the state. There may be a need to set up a more random network over a larger area, but one that can be handled by the staff and within the budget constraints of the Department.

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APPENDIX

ABBREVIATIONS

The following is a list of abbreviations used in the tables for the prototype monitoring program:

AQFR	=	Aquifer
DPTH	=	Depth of Well
UNK	=	Unknown

Aquifers:

Alvm	=	Alluvium
Cckf	=	Cockfield
Grnsd	=	Greensand (Upper Sparta)
El Dor	=	El Dorado (Lower Sparta)
Mphs	=	Memphis
Sprt	=	Sparta