STATE OF ARKANSAS

ARKANSAS GEOLOGICAL COMMISSION
William V. Bush, State Geologist

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WATER RESOURCES CIRCULAR NO. 17

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Roubidoux Formation and Gunter Sandstone Member of the Gasconade Formation,

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Abstract

The Roubidoux Formation and the Gunter Sandstone Member of the Gasconade Formation, both of Early Ordovician age, are important aquifers in the Ozark Plateau region of northern Arkansas. These units are composed of sand-stone and dolostone. They are the preferred aquifers in this region of Arkansas because they yield relatively high volumes of potable water and are deep enough to avoid surface water infiltration.

The two units are exposed in Missouri, but are present only in the subsurface in northern Arkansas. Because they dip to the south at 0.5 to 2.0 degrees (46 to 184 feet per mile), their depth increases to 3,000 feet or more in the Boston Mountains area. South of the Boston Mountains, the Roubidoux Formation was encountered at a depth of greater than 19,000 feet in one well included in the study.

Well yields in the Roubidoux Formation and Gunter Sandstone Member are affected by the following factors: depth of penetration of the well bore into the water-producing unit, total thickness, relative proportion of sandstone to dolo-stone, degree of cementation of sandstone, and secondary porosity/permeability from recrystallization of the dolostone.

Chemically the water is of good quality—a magnesium-bicarbonate type with generally low chloride content. Some wells in the northwestern portion of the study area have relatively high chloride concentrations, but are still within accept-ed standards for potable water.

The impact on water quality and yield due to increased usage of potable water from these units has not been determined.

## Introduction

The Roubidoux Formation and the Gunter Sandstone Member of the Gasconade Formation are used extens-ively as sources of ground water for the public, commerce, industry, and rural water districts. Recently, deeper wells to the Roubidoux were required in order to meet increased agricultural water needs. In properly completed wells, these units receive no surface contamination because of their depth. Consequently, the Ark-ansas Department of Health has instruct-ed many public water-supply utilities in northern Arkansas to convert from shal-low wells and springs that are susceptible to contamination and utilize the Roubi-doux and/or Gunter.

This report summarizes geologic and hydrologic data available for the

Roubidoux and Gunter Sandstone in northern Arkansas. It involved gathering and studying drill cuttings; preparing and interpreting both geologic and drilling logs to determine stratigraphic relations; and researching and tabulating water levels and yields reported by other workers. Well cuttings and strip logs were evaluated for a total of 71 wells. Finally, digital models, utilizing Surfer Surface Mapping System™ (version 6.02) by Golden Software, Inc., were built in which the data set was gridded by the Kriging method to allow extrapolation for contours drawn for geologic and hydrogeologic maps.

Several ground-water investigations of the Ozark Plateaus province have been conducted: Durfor and Becker (1964), Lamonds (1972), MacDonald et al. (1977), Imes (1990a, b), Smith and Imes (1991), Christenson et al.(1994), Imes and Emmett (1994), Bell et al. (1996), and Jorgensen et al. (1996). Regional stratigraphic studies were conducted by Heller (1954), Knight (1954), Sheldon (1954), Caplan (1957, 1960), Snyder (1976), Thompson (1991, 1995), and McFarland (1998).

The area of investigation is bounded by Missouri on the north, Oklahoma on the west, the boundary between the Interior Highlands and the Gulf Coastal Plain provinces on the east, and the Arkansas Baseline (a line separating north Townships from south Townships) on the south, and includes northern and central Arkansas (figure 1). The investigation focuses on the Ozark Plateaus province of Arkansas because hydrologic data exist for only Baxter, Benton, Boone, Carroll, Fulton, Izard, Lawrence, Madison, Marion, Newton, Randolph, Searcy, Sharp, Stone, and Washington Counties. Limited geologic information is included for the southern portion of the study area.

The study area is located in the Interior Highlands of Arkansas, which is topographically higher and more rugged than the Gulf Coastal Plain. The Interior Highlands occupies about 48 percent of Arkansas and is divided into three major physiographic regions: the Ozark Plateaus, Arkansas Valley, and Ouachita Mountains (figure 2).

The Ozark Plateaus province is subdivided into the Salem Plateau, the Springfield Plateau, and the Boston Mountains. The Salem Plateau extends southward from Missouri and is topographically the most subdued. It is underlain dominantly by Ordovician dolostones and interbedded sandstones. The Springfield Plateau lies between the Salem Plateau and the Boston Mountains. It is intermediate in elevation and ruggedness, and is generally underlain by a sequence of limestone and chert of Mississippian age. The Boston Mountains are the southernmost and most rugged portion of the region. The mountains are capped by sandstones and shales of Pennsylvanian age (Howard et al., 1997).

The Ozark Plateaus province of Arkansas has a temperate climate and ranges from 42 to 48 inches of annual precipitation (figure 3a; Imes and Emmett, 1994). Estimated mean annual evapotranspiration rates are 30 to 35 inches (Adamski et al., 1995). The recharge area for the Roubidoux Formation and Gunter Sandstone Member is in southern Missouri, where the mean annual recharge ranges from 5 to 15 inches per year (figure 3b; Jorgensen et al., 1996).

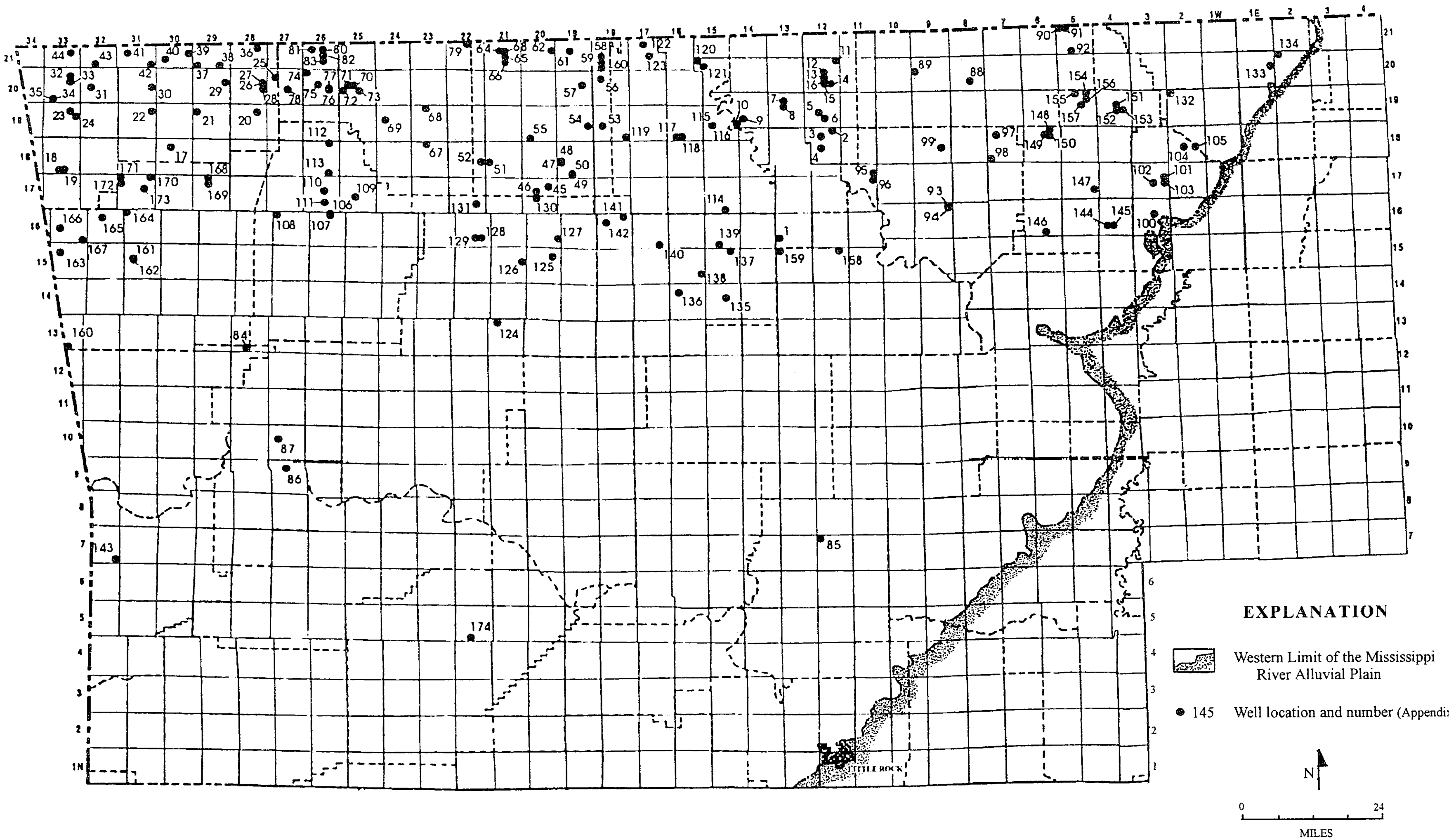



**Figure 1. Location of wells included in this study.**

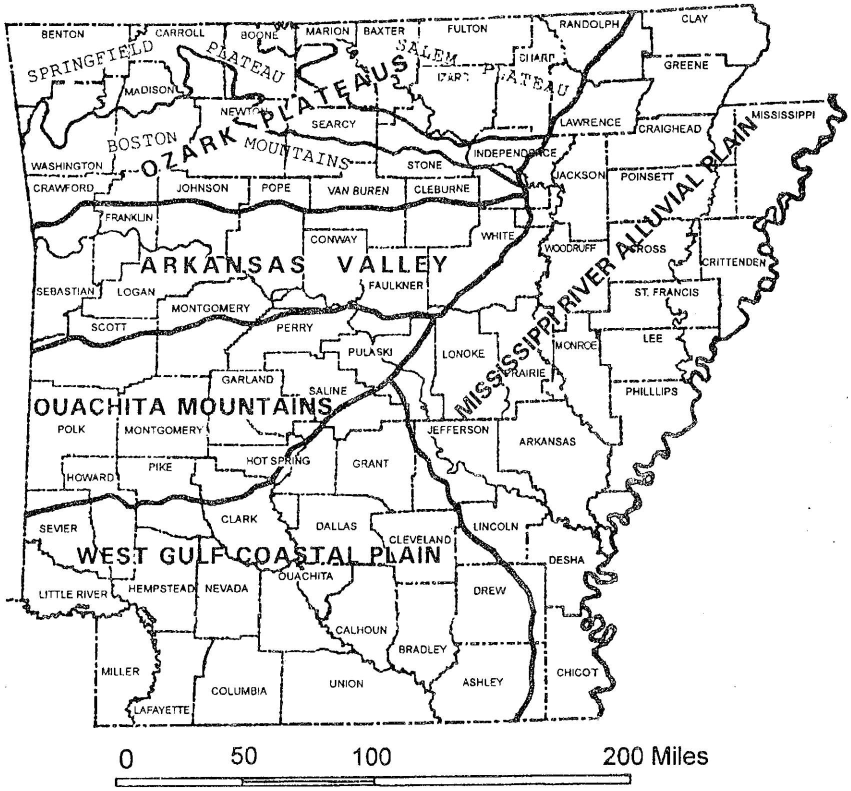
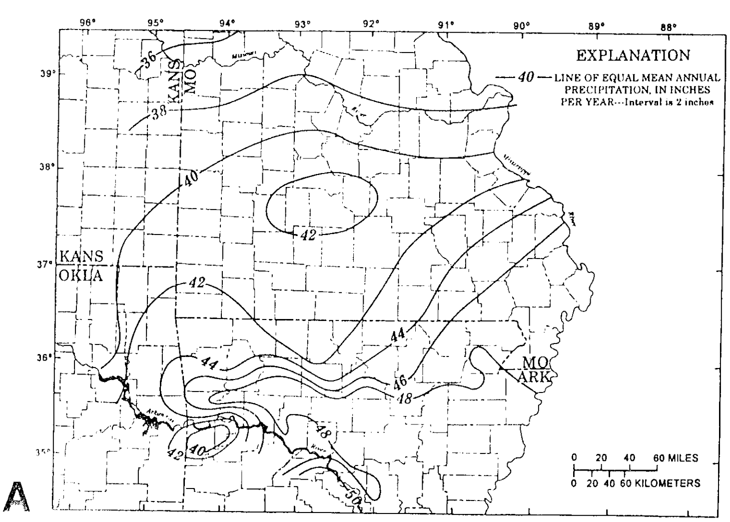



**Figure 2. Physiographic provinces of Arkansas**
(Modified from Howard, Colton, and Prior, 1997)



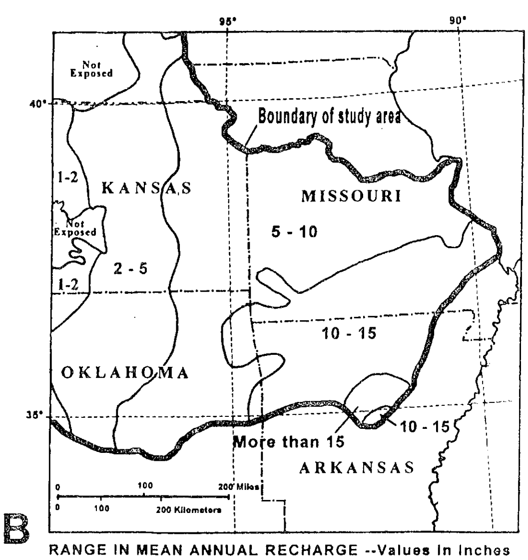




**Figure 3A. Mean annual precipitation of the Ozark Plateaus region.** (Data from Imes and Emmett, 1994, figure 4)

**Figure 3B. Mean annual recharge of the Ozark Plateaus region.** (Data from Jorgensen et al., 1996, figure 5)

| Period | | Formation | Hydrologic Unit |
|---|---|---|---|
| CARBONIFEROUS | PENNSYLVANIAN | Atoka | Boston Mountains/Western Interior Plains Confining Unit |
| | | Bloyd | |
| | | Hale – Prairie Grove | |
| | | Hale – Cane Hill | |
| | MISSISSIPPIAN | Pitkin | |
| | | Fayetteville | |
| | | Batesville | |
| | | Moorefield | |
| | | Boone | Springfield Plateau Aquifer |
| | | St. Joe | |
| DEVONIAN | | Chattanooga | Ozark Confining Unit |
| | | Clifty | Ozark Aquifer |
| | | Penters | |
| SILURIAN | | Lafferty | |
| | | St Clair | |
| | | Cason – Brassfield | |
| ORDOVICIAN | Late | Cason | |
| | | Fernvale | |
| | Middle | Kimmswick | |
| | | Plattin | |
| | | Joachim | |
| | | St. Peter | |
| | | Everton | |
| | Early | Powell | |
| | | Cotter | |
| | | Jefferson City | |
| | | Roubidoux | |
| | | Gasconade | |
| | | Gunter | |
| CAMBRIAN | | Eminence | |
| | | Potosi | |
| | | Derby-Doerun-Davis | St. Francois Confining Unit |
| | | Bonneterre | St. Francois Aquifer |
| | | Lamotte | |
| PRECAMBRIAN | | Igneous rocks | Basement Confining Unit |

**FIGURE 4. Correlation chart of Arkansas formations and Ozark Plateaus hydrologic units.** No relative thickness is implied by this chart.

## Geology

The Ozark region is a broad structural and sedimentary platform surrounding the Precambrian igneous rocks that compose the St. Francois Mountains in southeastern Missouri. In Arkansas, the Precambrian igneous basement is buried by the overlying sedimentary rocks of Late Cambrian through Early Pennsylvanian age, which form the Ozark Plateaus province. The Roubidoux Formation and Gunter Sandstone Member of the Gasconade Formation are Early Ordovician in age (figure 4, modified from J. D. McFarland, 1998, and USGS Water Resources Division data).

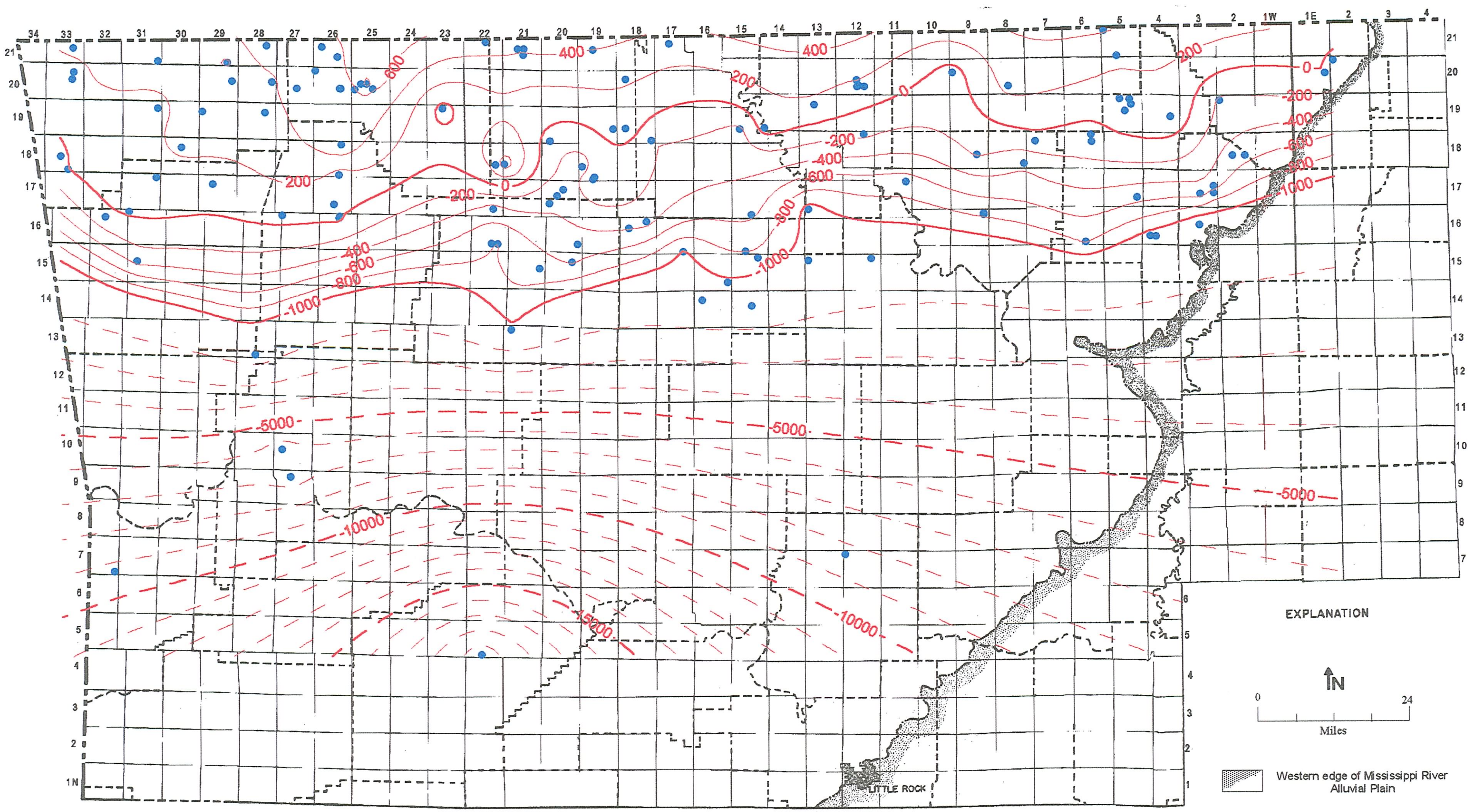
The Roubidoux unconformably overlies the Gasconade and is composed of cherty dolostone, dolomitic sandstone, and scattered sandstone intervals. The dolostone of the Roubidoux is finely- to coarsely-crystalline and light gray to brown in color. The formation's thickness ranges from 130 to 260 feet in the area where hydrologic data is available and thickens to the southeast in Conway, Faulkner, and White Counties to over 300 feet. The formation is thinnest in Benton and Washington Counties. Local variation in thickness is apparently due to irregularities on the surface on which it was deposited (MacDonald et al., 1977). Outcrops are present in a broad area in southeastern Missouri. The Roubidoux is conformably overlain by the Jefferson City Dolomite (MacDonald et al., 1977).

The Gasconade unconformably overlies the Late Cambrian Eminence Formation (figure 4). It is predominantly a light brownish-gray, cherty dolostone. Except in Howell, Oregon, and Ozark Counties in southeastern Missouri (T. L. Thompson, personal communication), the Gasconade contains a persistent sandstone unit in its lowermost part that is designated the Gunter Sandstone Member. The upper portion of the formation is dominantly medium-crystalline dolostone and contains relatively small amounts of chert. The part of the formation below the "upper" portion and above the Gunter Sandstone Member is generally coarsely crystalline and may contain up to 50 percent chert by volume. The Gasconade ranges in thickness from 300 to 600 feet in northern Arkansas. Outcrops are present in a broad area in southeastern Missouri.

The Gunter Sandstone Member of the Gasconade is composed of quartzose sandstone and sandy dolostone, except in those counties in Missouri mentioned above where it consists of a few thin sand beds or "floating" sand grains in the dolostone succession. In Arkansas, the Gunter is a recognizable and persistent subsurface unit, which lies unconformably above the Eminence Formation. It ranges in thickness from 20 to over 100 feet and averages about 30 feet. The area of greatest thickness includes southern Boone and northern Newton Counties and has been attributed to irregularities in the underlying Eminence Formation (Caplan, 1960). Gunter outcrops are confined to a narrow belt in southeastern Missouri.

The restricted number of wells drilled to and through the Roubidoux and Gunter limits subsurface investigations in northern Arkansas. Caplan (1960) and Lamonds (1972) both used 28 wells as data points to construct contour maps on selected formations. MacDonald et al. (1977) used 48 wells in a study of the Roubidoux and Gasconade Formations. The data set of this report contains 174 wells, although no map uses all wells in the data set. Previous investigators evaluated lithology, electric and gamma logs, and insoluble residue patterns to delineate the tops of formations, and thus formation thickness. The presence, tops, and thickness of the Roubidoux and the Gunter for the additional wells studied for this report (Appendix) were evaluated by examination of well cuttings. In the predominantly dolostone sequence, the presence or absence of sand grains, sandstone, and sandy cherts was used to define the upper and lower contacts of both aquifers. Well distribution is influenced by local area needs for water supply. Northwest Arkansas has a greater density of water wells drilled to these aquifers than the remainder of the Ozark Plateaus province (figure 1).

The elevations of the top of the Roubidoux and Gunter relative to mean sea level are shown by contour lines in Figures 5 and 6, respectively. Given a specific well site elevation, depth to the upper contacts of the units may be calculated. The contour maps show a general southerly dip for both aquifers. The dip increases near the -1000-foot elevation on the Roubidoux Formation (figure 5 ) and the -1500-foot elevation on the Gunter Sandstone (figure 6). Sharp bends in the contours may be related to local structures, such as displacement across faults, as shown in Boone, Newton, and Searcy Counties (figures 7a and 7b). Well and chemical data are too sparse to evaluate possible effects of regional post-lithification structure (faulting) plotted on Figures 7a and 7b. However, both surface mapping and inferred subsurface faulting suggest a general lack of faulting influence on the aquifers in northern Carroll, Boone, and Marion Counties and in Fulton, Randolph, Sharp, and Izard Counties. Additional subsurface mapping during this




# Figure 5. Structure contour map of the top of the Roubidoux Formation

The blue dots mark the locations of the wells used to construct this map. The contour interval is 200 feet above -1000 feet and 1000 feet below -1000. This map was created in Surfer Surface Mapping System (Version 6.02) software from Golden Software, Inc. The data set was grided for contouring by the Kriging method (with a linear variogram) utilizing an extrapolated grid density of 288 lines east-west and 144 lines north-south.

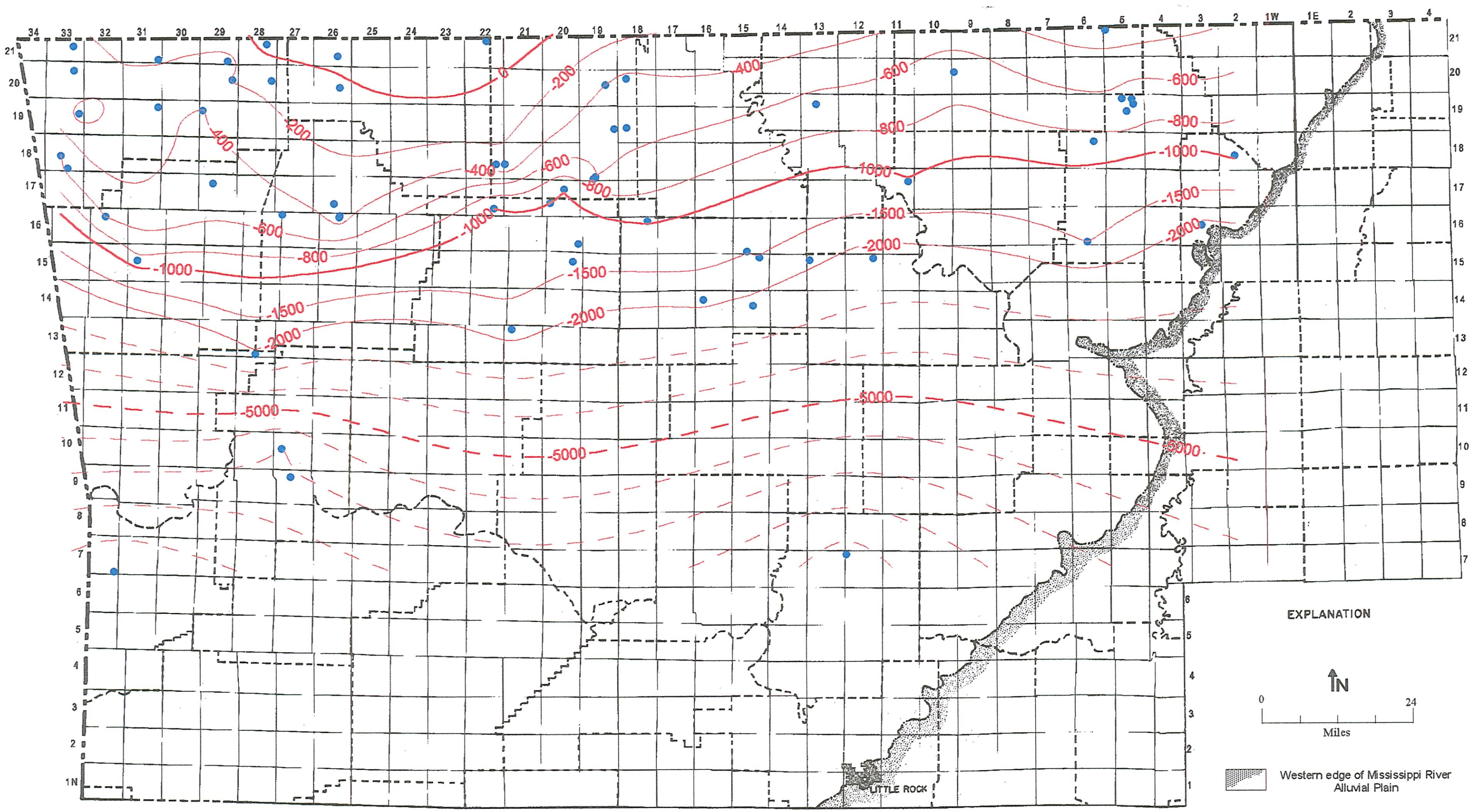



**Figure 6. Structure contour map of the top of the Gunter Sandstone Member of the Gasconade Formation**

The blue dots mark the locations of the wells used to construct this map. The contour interval is 200 feet above -1000 feet, 500 feet between -1000 and -2000 feet, and 1000 feet below -2000 feet. The map was created in Surfer Surface Mapping System (Version 6.02) software from Golden Software, Inc. The data set was grided for contouring by the Kriging method (with a linear variogram) utilizing an extrapolated grid density of 288 lines east-west and 144 lines north-south.

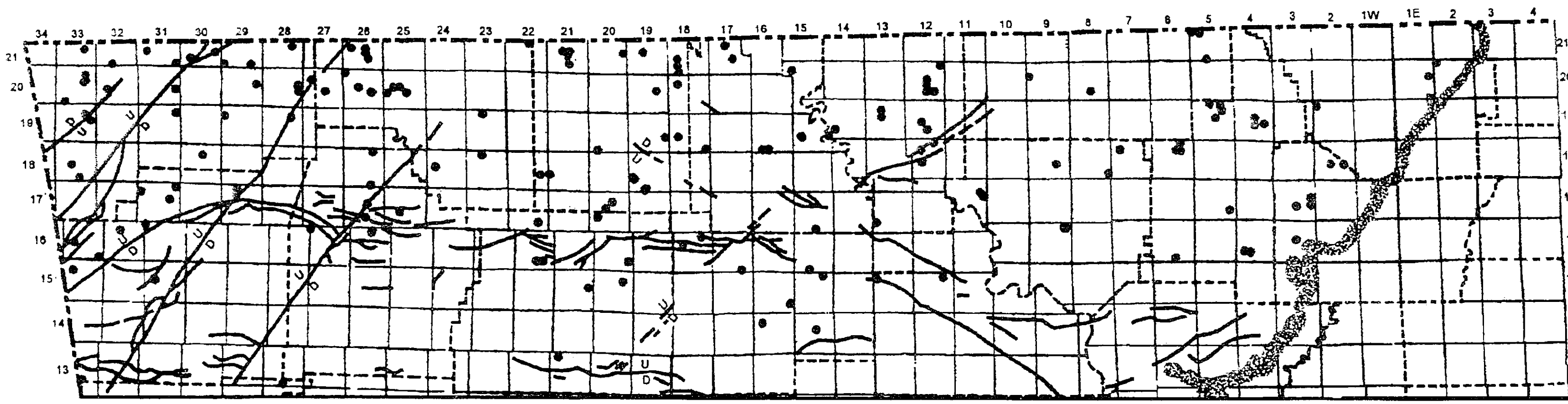


**Figure 7A. Surface faults of northern Arkansas.** (Data from Haley, et al., 1993.)

EXPLANATION

Western Limit of the Mississippi River Alluvial Plain

U/D Relative direction of fault displacement

N

0 24

MILES

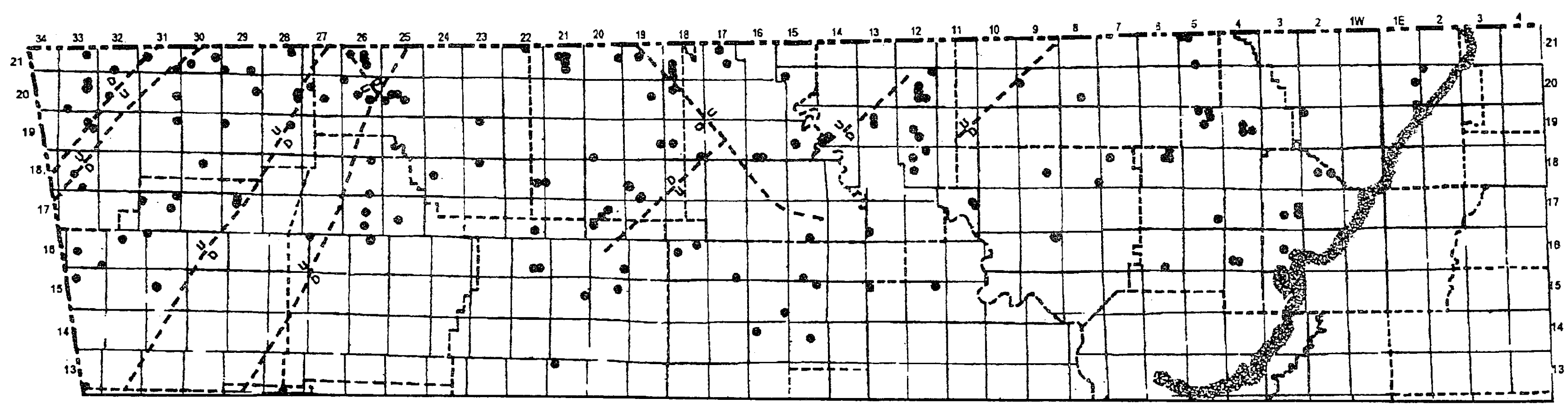


**Figure 7B. Inferred faults that may influence the Roubidoux - Gunter Strata.**
(Data from Plate 2, MacDonald, et al., 1977.)

project was deemed not feasible due to an insufficient number of wells. Broad structural highs in western Carroll and Benton Counties (figures 5 and 6) are caused by irregularities in the Precambrian basement (MacDonald et al., 1977). Smaller structural highs and lows in the Ozark Plateaus province may indicate local solution, compaction, and subsidence.

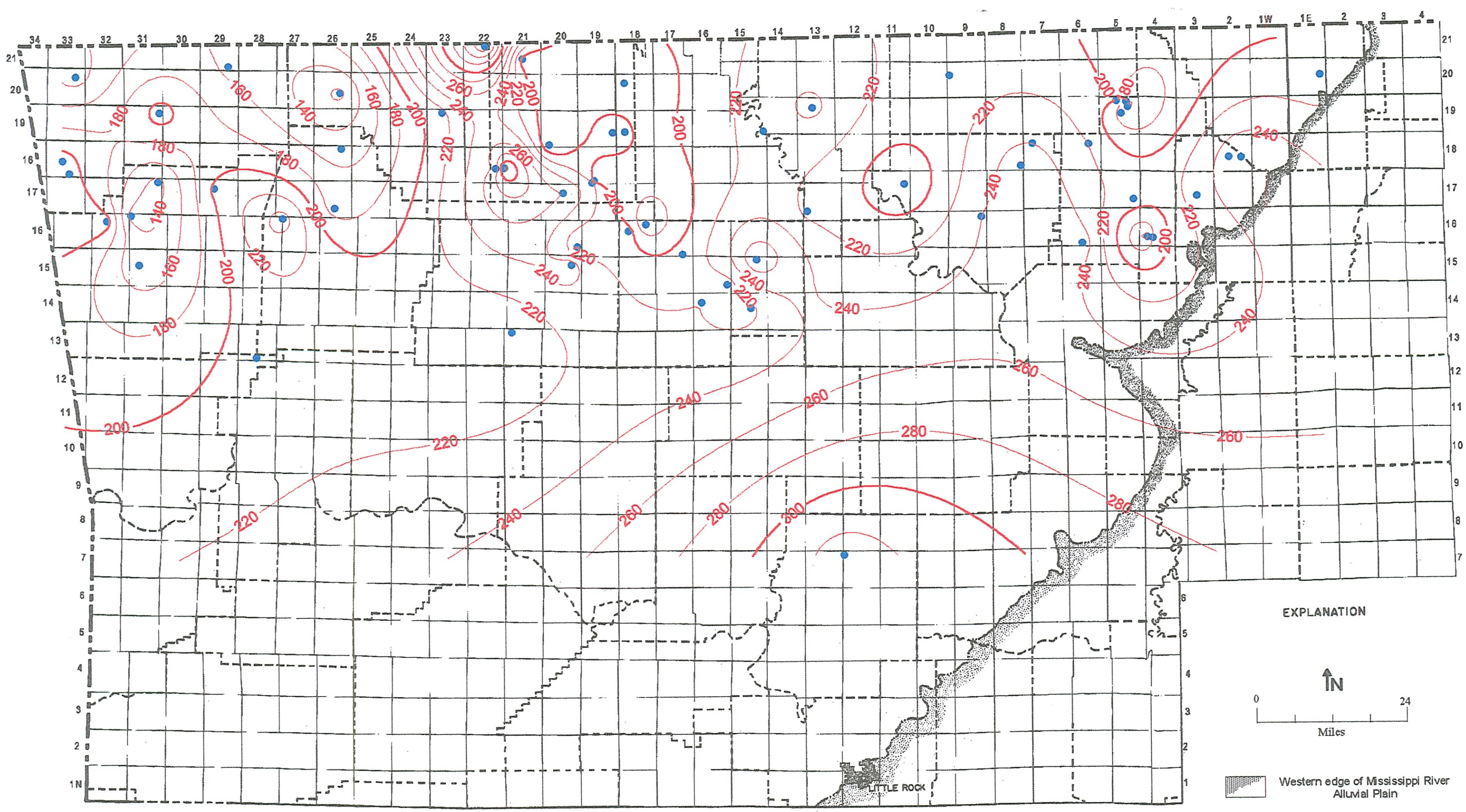
Only wells where the top and bottom of the aquifer could be located were used to produce isopach (thickness) maps of the units (figures 8 and 9). These maps may be used to evaluate the depth and thickness of the major water-producing units. Unconformities at the base of the Roubidoux and Gunter may affect their thickness (MacDonald et al., 1977). The apparent thickness of the Roubidoux as indicated by this investigation (figure 8) seems to vary only over broad areas.

**Hydrogeology**

This report used water levels and well yields as the principal parameters for hydrogeologic evaluation, with a focus on the areal distribution of these parameters. According to the U. S. Geological Survey (Imes and Emmett, 1994), the Roubidoux Formation and Gunter Sandstone member comprise only a small part of the Ozark Aquifer (figure 4). In Missouri, many other Lower Ordovician formations produce ground water. Recharge is largely from the outcrop areas in southern Missouri (figure 3b) and water flow follows the regional dip of the sedimentary units toward the south. Some Missouri wells drilled into the Roubidoux and Gunter utilize an unknown percentage of the recharge before it can reach Arkansas.

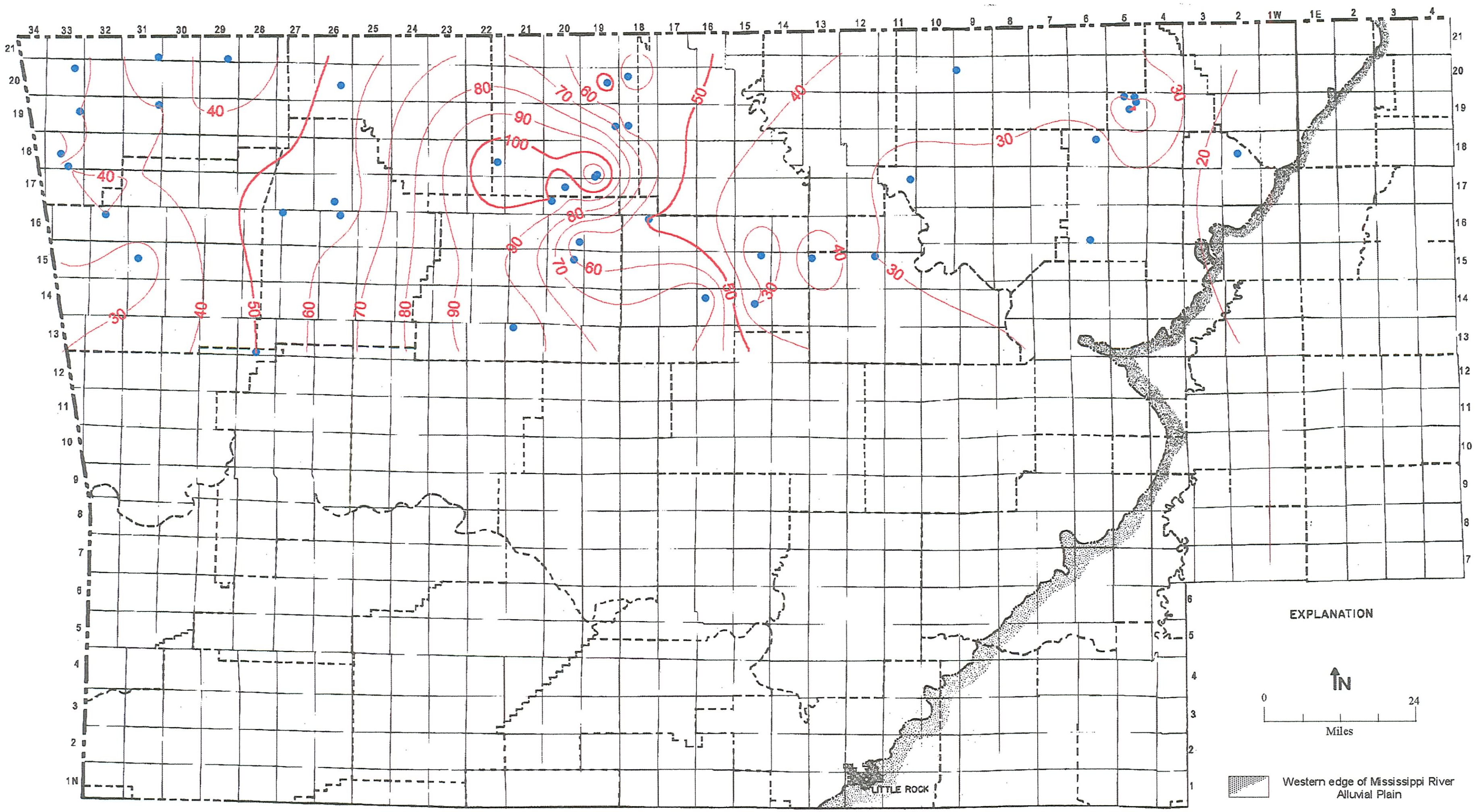
In Arkansas, water in the Roubidoux and Gunter is confined between impervious strata and is under hydrostatic pressure from a column of water extending upward to the recharge area. Under these conditions, water in a well will rise to a level above the top of the highest water-producing unit if the well is not being over pumped. Ideally the amount of rise is measured during a test period when the well is not being pumped. This is the static water level. Elevations of static water level are shown in Figure 10. The map does not represent a true potentiometric surface for either of the aquifers, but it may be used as a guide to estimate the minimum depth for pump installation.

Well yields in the Roubidoux and Gunter are affected by the following factors: depth of penetration of the well bore into the water-producing unit, total thickness, relative proportion of sandstone to dolostone, degree of cementation of sandstone, and secondary porosity/ permeability from recrystallization of the dolostone. Well yields from the Roubidoux in Arkansas ranges from 20 to 600 gallons per minute (GPM) (Figure 11). The wide range in yield may be caused by several factors: 1) some wells penetrate the entire section of the Roubidoux, while others do not; 2) local variation in the porosity and permeability due to differing cementation and the presence or absence of clay in the unit; 3) variable thickness of the Roubidoux; or 4) proximity to faults. When insufficient yield is obtained from the Roubidoux, wells are drilled into the underlying Gunter. Well yields in the Gunter Sandstone are usually combined for both aquifers (figure 12). Wells producing from both units range in yields from 26 to 502 gpm.




## Figure 8. Isopach (thickness) map of the Roubidoux Formation

The blue dots mark the locations of the wells used to construct this map. The contour interval is 20 feet. The map was created in Surfer Surface Mapping System (Version 6.02) software from Golden Software, Inc. The data set was grided for contouring by the Kriging method (with a linear variogram) utilizing an extrapolated grid density of 288 lines east-west and 144 lines north-south.




# Figure 9. Isopach (thickness) map of the Gunter Sandstone Member of the Gasconade Formation

The blue dots mark the locations of the wells used to construct this map. The contour interval is 10 feet. The map was created in Surfer Surface Mapping System (Version 6.02) software from Golden Software, Inc. The data set was grided for contouring by the Kriging method (with a linear variogram) utilizing an extrapolated grid density of 288 lines east-west and 144 lines north-south.

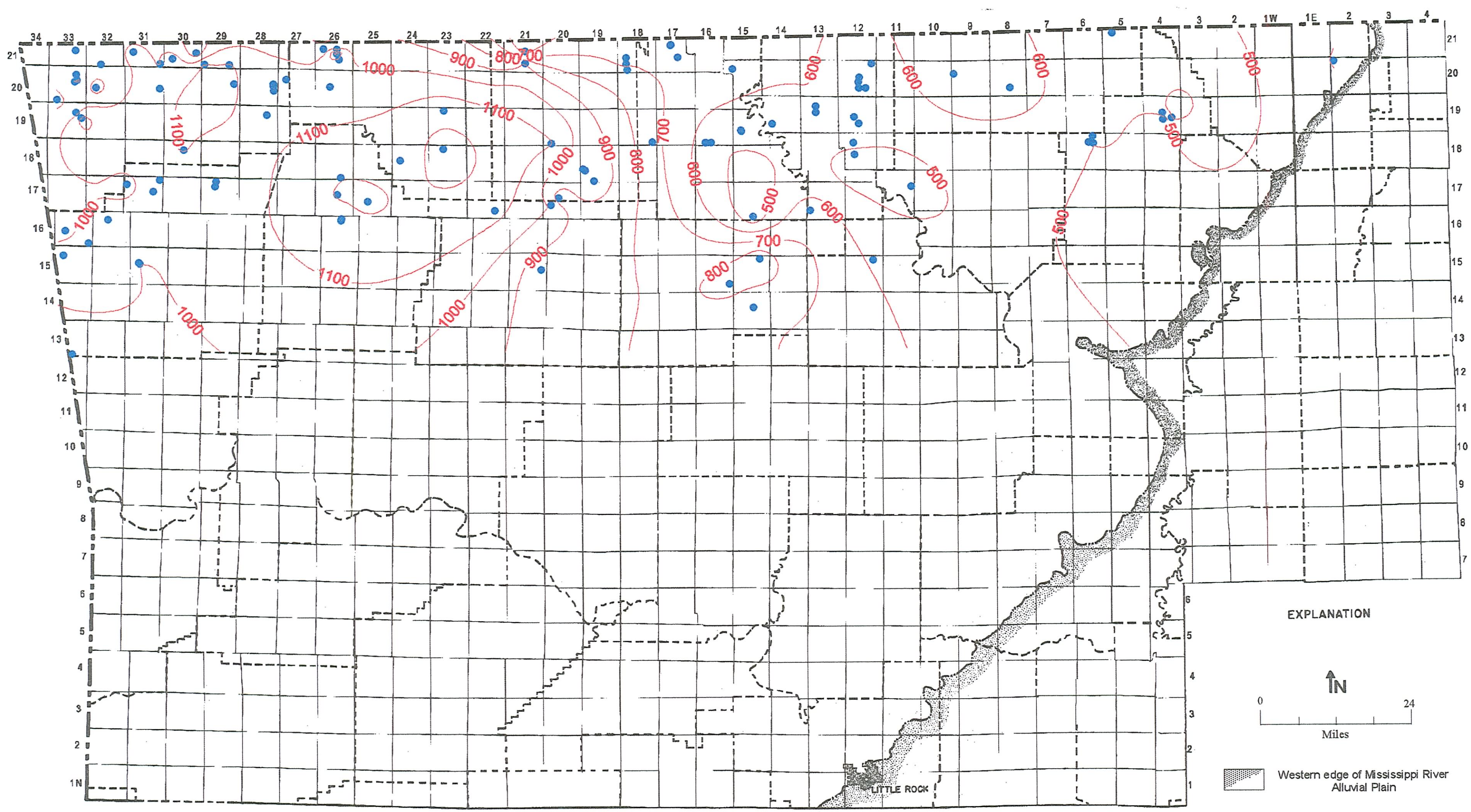



**Figure 10. Elevation (feet above sea level) of the static water level in selected water wells.**

The blue dots mark the locations of the wells used to construct this map. The contour interval is 100 feet. The map was created in Surfer Surface Mapping System (Version 6.02) software from Golden Software, Inc. The data set was grided for contouring by the Kriging method (with a linear variogram) utilizing an extrapolated grid density of 288 lines east-west and 144 lines north-south.

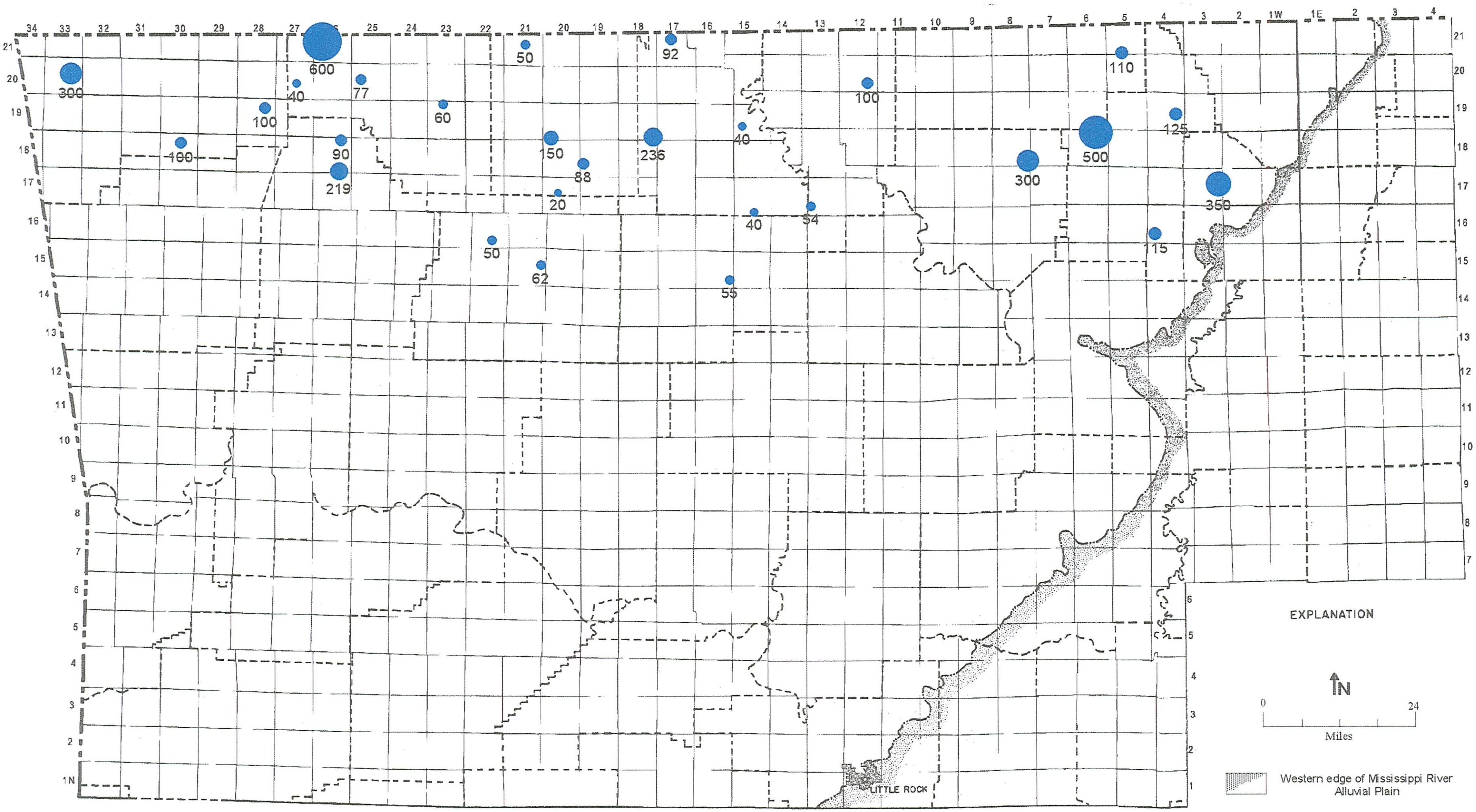



**Figure 11. Yields (gpm) of selected water wells producing from the Roubidoux Formation**

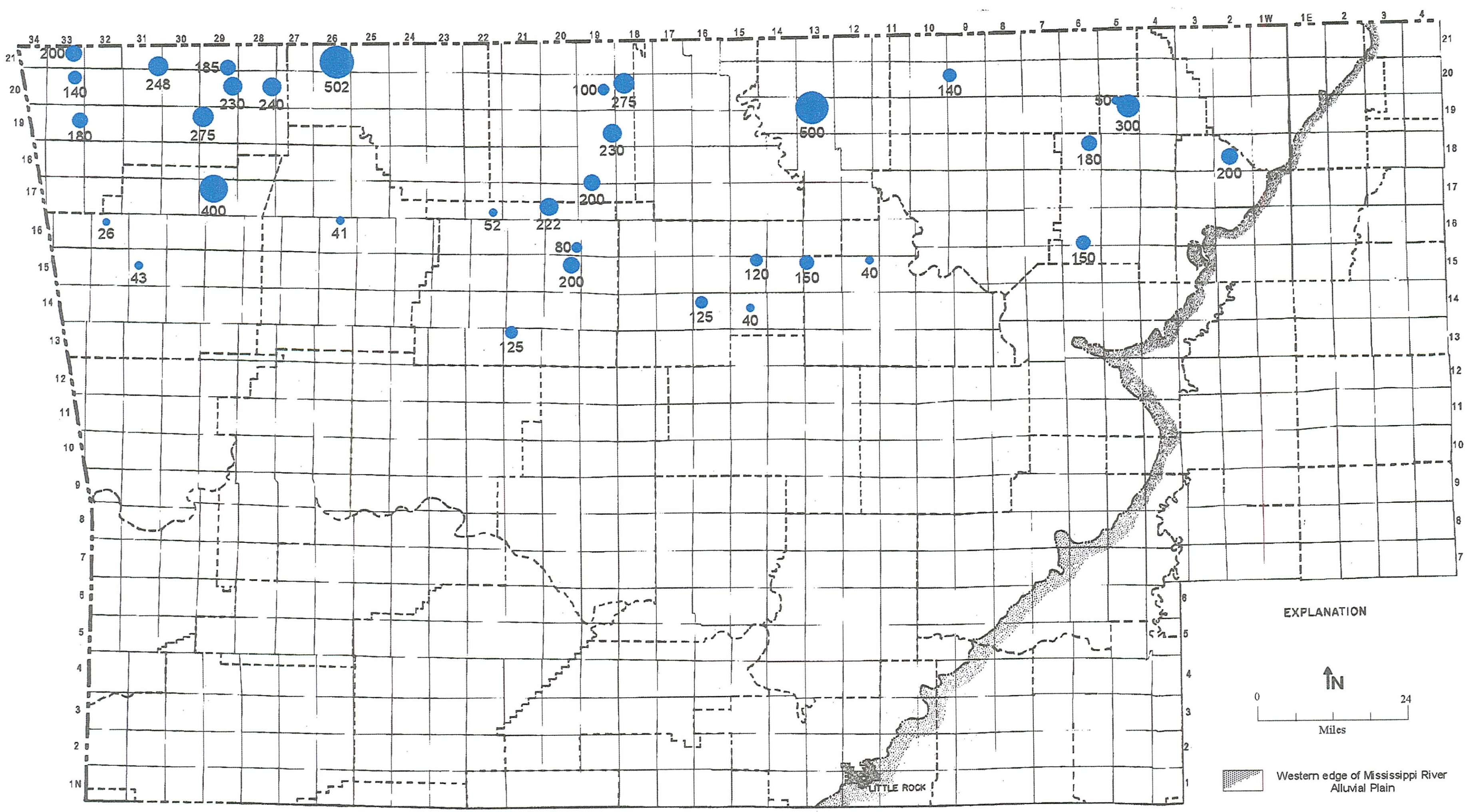



Figure 12. Yields (gpm) of selected water wells producing from both the Roubidoux Formation and the Gunter Sandstone Member

**Water Quality**

A set of water chemistry data is presented in the Appendix. Water quality is defined by the National Drinking Water Standards, which is based on the maximum concentrations of constituents considered to be safe in drinking water. Table 1 shows selected National Secondary Drinking Water Standards (NSDWS) as set by the U. S. Environmental Protection Agency and adopted by the Arkansas Department of Health. The Arkansas Department of Health requires treatment of ground water that does not meet these standards.

| | |
|---|---|
| pH | 6.5-8.5 |
| Total Dissolved Solids | 500 mg/L |
| Chloride | 250 mg/L |
| Iron | 0.3 mg/L |
| Sulfate | 250 mg/L |

**Table 1.** Selected National Secondary Drinking Water Standards (source: Arkansas Department of Health)

Christenson et al. (1994) report the presence of brine in the Roubidoux Formation in western northeast Oklahoma and an intermediate zone of mixing of the fresh water and brine. The southern end of the mixed zone trends east toward Arkansas. Jorgensen et al. (1996) show a zone of high chloride concentration in Oklahoma entering Arkansas from the west in the vicinity of Fort Smith and trending east across the Arkansas Valley region.

Only a few water wells have been drilled to the Roubidoux south of Township 14 North. One of these, the Nail-Swain #1 well (124, Appendix), was relatively high in chloride and contained a high value of fluoride (16.3 mg/L). The NSDWS for fluoride is 4 mg/L. South of the Boston Mountains in the northern Arkansas Valley, most wells reaching the Roubidoux were drilled as test holes for oil or gas production. No specific water analyses are available for these wells, but they were reported to contain brine. No evaluation of possible zones of mixed waters in the Roubidoux and Gunter on the southern margin of the Arkansas Ozark Plateaus (similar to that documented in Oklahoma ) is possible due to insufficient data. If deeper wells are drilled in the extreme southern Ozark Plateaus province, they probably will encounter higher chloride concentrations and increasing water salinity. The combination of increasing salinity southward across the Ozark Plateaus and increased drilling costs may limit the southward extent of drilling to the Roubidoux and Gunter in search of potable water. At present, this limit has not been defined.

**Water Analyses**

Chemical analyses of waters from the Roubidoux Formation and Gunter Sandstone Member of the Gasconade Formation are tabulated in the Appendix. No analyses exist for water solely from the Gunter, but instead represent the mixing of waters from both formations.

Sources of Water Data

Water analyses in this report are primarily from the U. S. Geological Survey. Some of the wells were sampled several times over a multi-year span, while others were sampled only once. Where multiple samples were available, the earliest analyses were used. This approach creates a uniform data set and minimizes the effects of water-quality changes due to pumping over time. When earlier analyses were incomplete, the earliest analysis was used. Additional analyses were obtained from MacDonald et al. (1977) and the Arkansas Department of Health.

Chemical Data

Despite numerous studies, the chemical data set on wells completed in the Roubidoux and Gunter is relatively small. Due to cost and physical limitations, most analytical work has been conducted on municipal wells and much less on commercial and privately owned wells. If the well yield is sufficient, only a small portion of the Roubidoux may be penetrated. If well yield is insufficient, the drilling will often be extended to the Gunter. Only 60 wells in the study area have extensive water analyses. Of these wells, only 28 represent water from the Roubidoux. Most of the data set (32 wells) consists of analyses of the mixed formation waters produced from both aquifers. In either case, it is possible that the samples are mixed due to infiltration of waters from units higher in the section.

An interpretation of chemical data in the Appendix should be done with caution due to the sparseness of the data compared to the areal extent of the study area. In many instances, only one analytical value is available for a given well. Several wells have multiple analyses which show changes in water chemistry with pumping over time. Initial analyses may represent highly localized ground water conditions in a given formation or contaminants from the drilling and pump-setting stages of well development. The general trend of water chemistry of wells analyzed periodically over time indicates an improvement in the water quality as defined by the National Drinking Water Standards.

Temperature, pH, and total alkalinity were measured in the field. All other chemical data are laboratory analyses and/or calculated values (G. Stanton, personal communication). Data collected in the field may be subject to variations in test procedures by the many workers involved during the period of investigation (1950-1995). Ideally, for instance, the pH and temperature are measured on a sample from a well after sufficient pumping removes 3 times the well's storage capacity (G. Stanton, personal communication). However, this procedure may not have been followed by every analyst at every well.

Laboratory analyses may also change over time due to evolving methodologies and techniques as well as changes in the well. The use of more sensitive analytical equipment has resulted in the lowering of detection limits of many water-soluble chemical constituents.

Chemical data with 3 decimals (0.00X) may not be accurate because of uncertainty with the third decimal (Hem, 1992), but was the only analysis available when included in the Appendix. Many of the chemical analyses listed in the Appendix were not originally expressed past the second decimal. A value of <0.003 or 0.001 should only be interpreted as indicating very low, but detectable values. In most cases, these values represent the detection limits of the analytical method (G. Stanton, personal communication). Accuracy of analytical results for major constituents of water is $\pm 2$ to $\pm 10$ percent (Hem, 1992). This indicates a difference of 2 to 10 percent between the reported result and the true sample concentration at the time of analysis. Concentrations greater than 100 mg/L are generally accurate to within ±5 percent. Precipitation on the collection container wall after sample collection may alter water chemistry. Consequently, the chemical data in the Appendix should be interpreted as a best approximation of the true value.

Temperature

Temperature of ground water normally increases with depth due to the geothermal gradient. Shallow ground-water temperature (shallow wells and springs) usually reflects the average yearly temperature of the region. In the study area, shallow ground-water temperature is 18.2° C (65° F), based on the average of 27 springs in the study area. In general, the temperature increases about 1° C for each 100 meters (1.8° F for each 328 feet) in depth in north Arkansas. The following temperatures at given depths were reported on a temperature log run by Southeast Region Logger Service for the USGS on the Nail-Swain #1 well in Newton County: 22° C at 354 meters (71.6° F at 1160 feet), 23° C at 451 meters (73.4° F at 1480 feet), 24° C at 518 meters (75.2° F at 1700 feet), 25° C at 628 meters (77° F at 2060 feet), 26° C at 726 meters (78.8° F at 2380 feet), 28° C at 902 meters (82.4° F at 2959 feet), 29° C at 1018 meters (84.2° F at 3340 feet), 30.8° C at 1183 meters (87.4° F at 3880 feet).

## Results

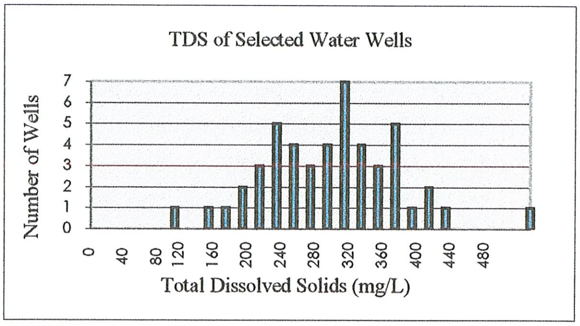
Total Dissolved Solids

The total concentration of dissolved material in water is ordinarily determined from the weight of the dry residue remaining after evaporation of the volatile portion of a specified volume of the water sample. This value is called the total dissolved solids (TDS). If the concentration of the major ions have been determined, the TDS may be calculated by summing the constituents. One flaw with the evaporative method is that water is retained by some residue types. However, the residue left by evaporation can usually be used to verify a calculated value. In the Appendix, the TDS concentrations were determined by summation of the constituents.

TDS concentrations (figure 13) range from 93 to 685 mg/L with a mean of 278 mg/L. Only one value was above the NSDWS of 500 mg/L TDS. The highest concentration was from the Nail-Swain #1 well (well 124) in Newton County, the southernmost water well reaching the Roubidoux Formation and Gunter Sandstone. A map plot of selected wells for TDS (figure 14) shows no significant pattern to the concentration distribution.

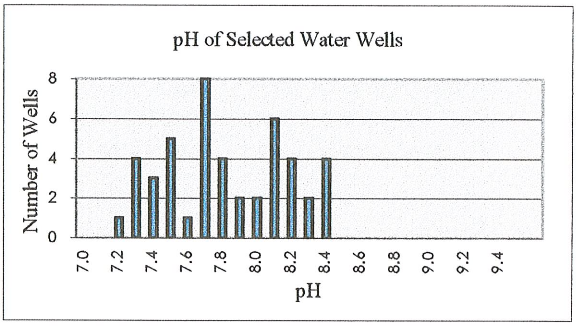
pH

The pH of water is the measure of its acidity or alkalinity. A pH value indicates concentrations of $H^+$ and $OH^-$ in solution. The pH of natural waters may vary widely from acid (<7.0) to alkaline (>7.0). The pH is influenced by mineral dissolution in the formation(s) in which water resides, elevated concentrations of $CO_2$ in the soils through which the water originally passed, and the source of the water (atmospheric, formational, or brines). Acidic rainwater reacts with carbonate rocks upon entry into the subsurface in the recharge area in southern Missouri, resulting in slight alkalinity. Additionally, the carbonate cements of the Roubidoux and Gunter may further alter the ground water chemistry. Once the water reaches a near neutral pH, then adsorption



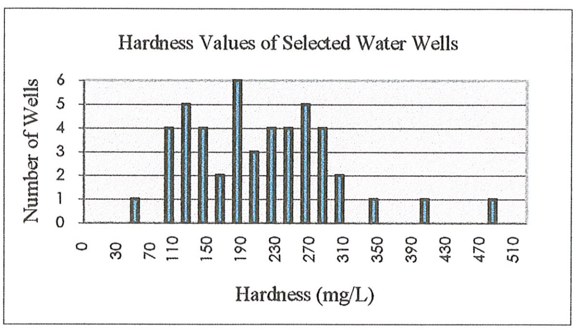

**TDS**

| | |
|---|---|
| No. samples | 48 |
| Max. | 685 |
| Min. | 93 |
| Mean | 278.56 |
| Standard deviation | 93.04 |



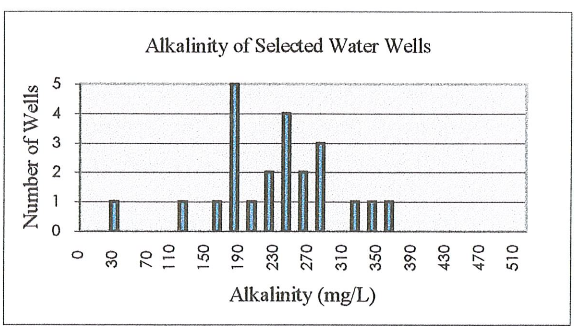

**pH**

| | |
|---|---|
| No. samples | 46 |
| Max. | 8.4 |
| Min. | 7.2 |
| Mean | 7.82 |
| Standard deviation | 0.35 |



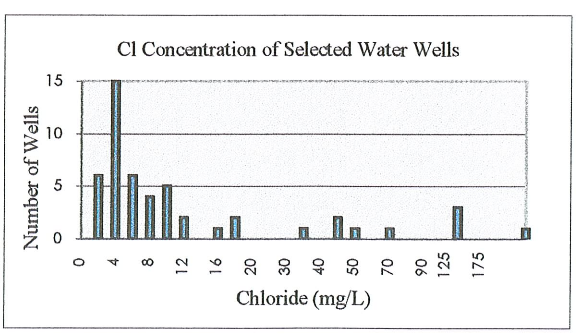

**Hardness**

| | |
|---|---|
| No. samples | 47 |
| Max. | 470 |
| Min. | 51 |
| Mean | 200.83 |
| Standard deviation | 84.12 |



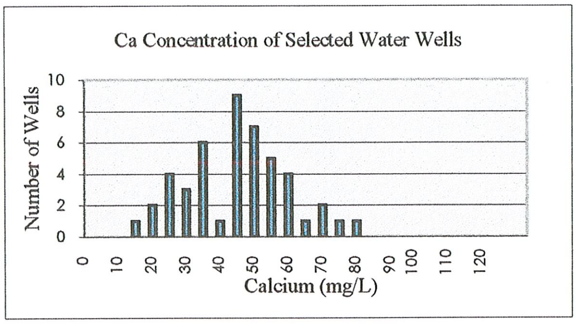

**Alkalinity**

| | |
|---|---|
| No. samples | 23 |
| Max. | 354 |
| Min. | 38 |
| Mean | 219.00 |
| Standard deviation | 71.06 |

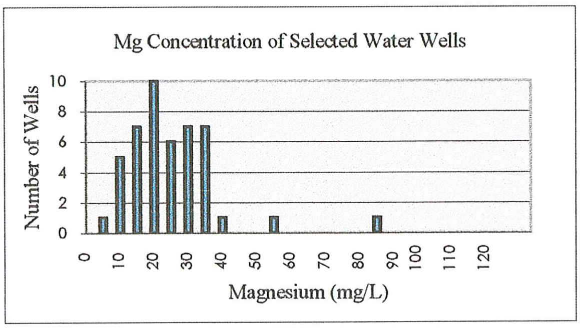



**Cl**

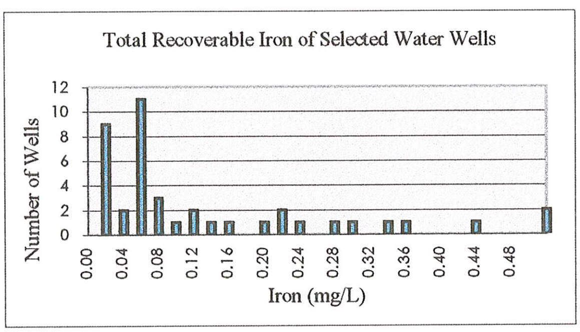
| | |
|---|---|
| No. samples | 50 |
| Max. | 240 |
| Min. | 1.4 |
| Mean | 21.04 |
| Standard deviation | 42.38 |



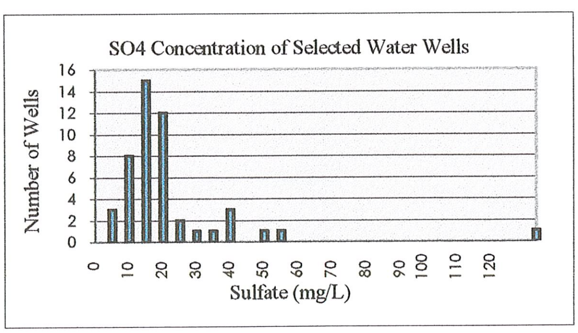

| **Ca** | |
|---|---|
| No. samples | 47 |
| Max. | 79 |
| Min. | 11 |
| Mean | 43.55 |
| Standard deviation | 15.30 |




| **Mg** | |
|---|---|
| No. samples | 46 |
| Max. | 83 |
| Min. | 1 |
| Mean | 23.06 |
| Standard deviation | 13.47 |




| **Recoverable Iron** | |
|---|---|
| No. samples | 41 |
| Max. | 3.6 |
| Min. | 0.001 |
| Mean | 0.214 |
| Standard deviation | 0.574 |




| **SO4** | |
|---|---|
| No. samples | 48 |
| Max. | 131 |
| Min. | 0.4 |
| Mean | 19.12 |
| Standard deviation | 19.95 |

**Figure 13. Histograms of data from selected wells.**

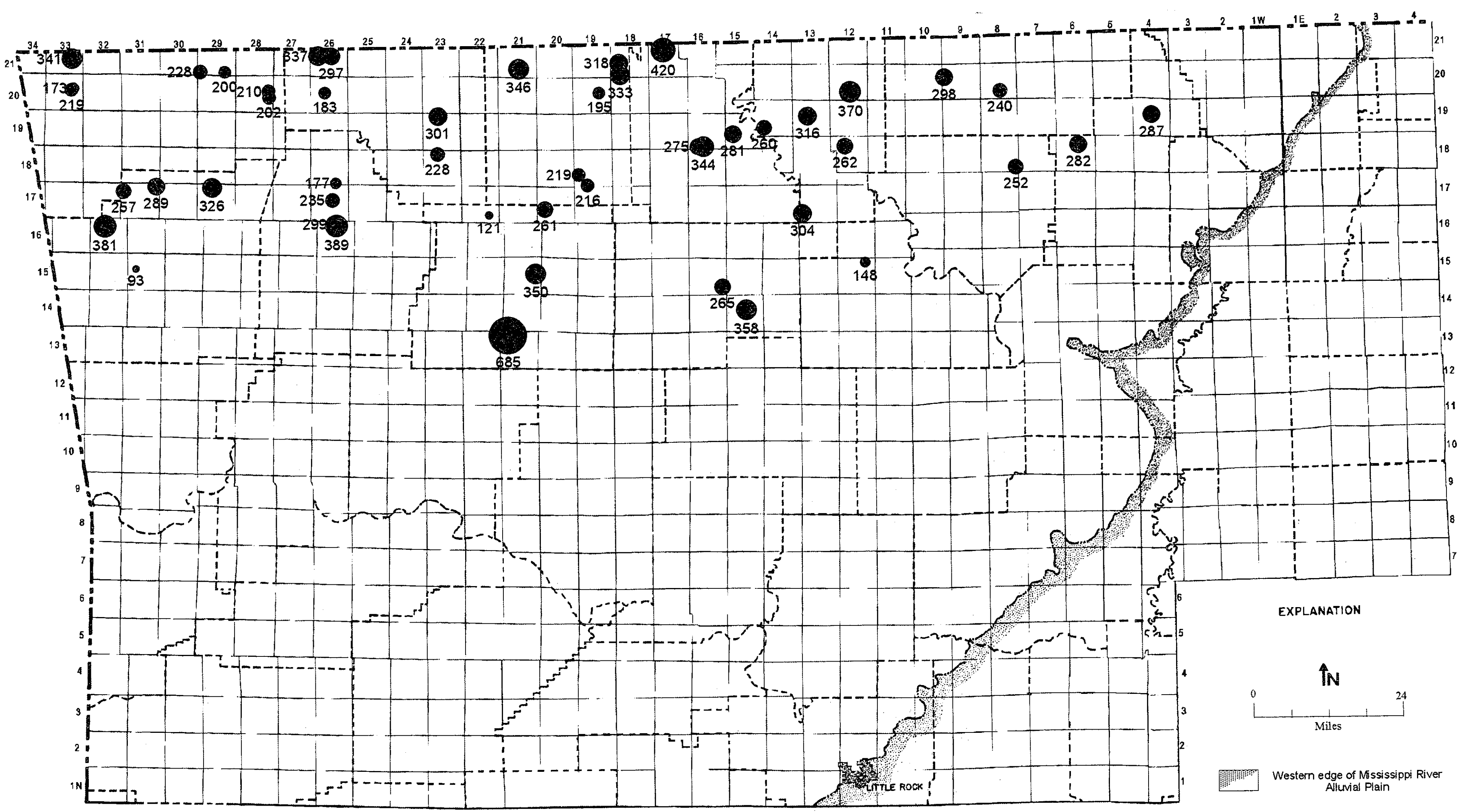



**Figure 14. Total dissolved solids (TDS) of selected water wells**

of certain dissolved ions on grain surfaces may occur because of negative charges on grain surfaces (Hem, 1992). Some effects on ground water chemistry may only be local.

The slightly alkaline pH values of the water data (7.2 to 8.4) are typical for carbonate-sourced ground water and are within the NSDWS for pH (table 1). The histogram for pH (figure 13) shows a mean of 7.82.

Hardness

The term "hardness", although commonly used, is difficult to define. In the past, hardness was evaluated by effects observed in the use of soap or with encrustations left by some types of water after heating. If reaction with soap was only considered, then hardness represents the soap-consuming capacity of water. Since most of the effect observed with soap comes from the presence of calcium and magnesium, hardness is now generally defined in terms of these elements alone, with possible interferences (American Society for Testing and Materials, 1964, p. 391). The modern method for analysis of hardness, developed in the 1940's, utilizes individual instrumental element analysis and is much more reliable than the soap method. Since hardness is caused by the presence of several elements, a convention is used to express concentrations in quantitative terms. Usually, hardness values are reported as equivalent concentrations of calcium carbonate. The term "total hardness" is calculated by taking the sums of calcium and magnesium concentrations (expressed as mg/L) and multiplying by 50. As a result, a practical definition of hardness becomes "the effect of alkaline-earth cations" (Hem, 1992). The hardness range has been classified by Durfor and Becker (1964):

0-60 mg/L – Soft
61-120 mg/L – Moderately hard
121-180 mg/L – Hard
Greater than 180 mg/L – Very hard

In domestic water, hardness is not objectionable until it reaches a concentration of about 100 mg/L. Where waters have been in contact with limestone or gypsum, hardnesses of 200 to 300 mg/L or greater may occur.

Hardness concentrations in this study range from 51 to 470 mg/L with a mean of 201 mg/L (figure 13). About one half of the water samples from the Roubidoux Formation and Gunter Sandstone are moderately hard to very hard. The highest concentration reported is from the City of Lead Hill well (well 60) in Boone County.

Alkalinity

The alkalinity of a solution is its capacity to react with and neutralize acid and is influenced by carbon dioxide ($CO_2$) content. Alkalinity is a calculated parameter accomplished through a field procedure that uses titration. Acid is added to the water sample until the solution's pH reaches a predetermined pH value. Natural waters attain alkalinity during water-rock interaction. Alkalinity usually indicates only bicarbonate and carbonate concentration, given in mg/L. The sources of $CO_2$ species in both surface and ground water are: 1) the $CO_2$ gas fraction in the atmosphere; 2) the $CO_2$ gas fraction in atmospheric gases in soil; and 3) gases in the zone below the soil horizon and above the water table (vadose zone). Carbon dioxide in ground water may be increased during respiration of vegetation and oxidation of organic matter (Hem, 1992).

Alkalinity concentrations (figure 13) range from 38 to 354 mg/L with a mean of 219 mg/L. The highest concentration reported is from the Corps of Engineers well (well 120) in Marion County.

Chloride

Chlorine is the most common of the halogen elements and may exist in some minerals (such as halite) and as a gas. It is readily soluble in water where it exists as $Cl^-$ (chloride). Chloride is present in all natural ground waters derived from rainfall, but with low concentrations. Both sodium and chloride are present in high concentrations in brines and sea water, resulting in salinity.

The data set presented in this study meets the NSDWS maximum limit for chloride of 250 mg/L (Table 1). Chloride concentration (figure 13) ranges from 1.4 to 240 mg/L with a mean of 21 mg/L. The data set is positively skewed toward values less than 12 mg/L. The highest concentration reported is from the Hugh W. Webb well (well 37) in Benton County, although it is well within the NSDWS (table 1). A plot of the chloride concentration of selected wells (figure 15) shows higher chloride concentrations in the western portion of the study area.

Calcium

Calcium is the most abundant of the alkaline-earth metals. It is a major constituent of many rock-forming minerals and a major component of the total dissolved solids in most natural waters. The most common calcium-bearing minerals in sedimentary rocks are calcite and aragonite (calcium carbonate), dolomite (calcium magnesium carbonate), and gypsum (calcium sulfate hydrate). In sandstones and other detrital rocks, calcium carbonate is common as a cement or as a partial filling of interstices between grains. Calcium is also present in the form of adsorbed ions on negatively charged mineral surfaces in soils, sediments, and rocks. Carbonate rocks (limestone/dolostone) in the recharge area and carbonate cements in the formations all influence calcium concentration. The dominant source providing calcium to the ground water in the Roubidoux and Gunter is unknown, but it is likely the carbonate-dominated section of rocks composing the recharge area in southern Missouri.

The concentrations of calcium range from 11 to 79 mg/L with a mean of 44 mg/L (figure 13).

Magnesium

Calcium and magnesium contribute similarly to the hardness of water. However, magnesium ions are considerably smaller than sodium or calcium, which leads to precipitation of magnesium compounds. The source of magnesium in ground water is commonly the mineral dolomite, which composes sedimentary beds of dolostone. Magnesium also occurs in high concentrations in most limestones. Dissolution of both dolostones and limestones releases magnesium into solution, but the process is not readily reversible. Therefore, the magnesium concentration increases along the flow path of groundwater undergoing such processes, until a high Mg:Ca ratio is achieved. The general characteristics of ground water from dolomitic terrain indicate that saturation relative to $CaCO_3$ also occurs in these waters. The dominant source providing magnesium to

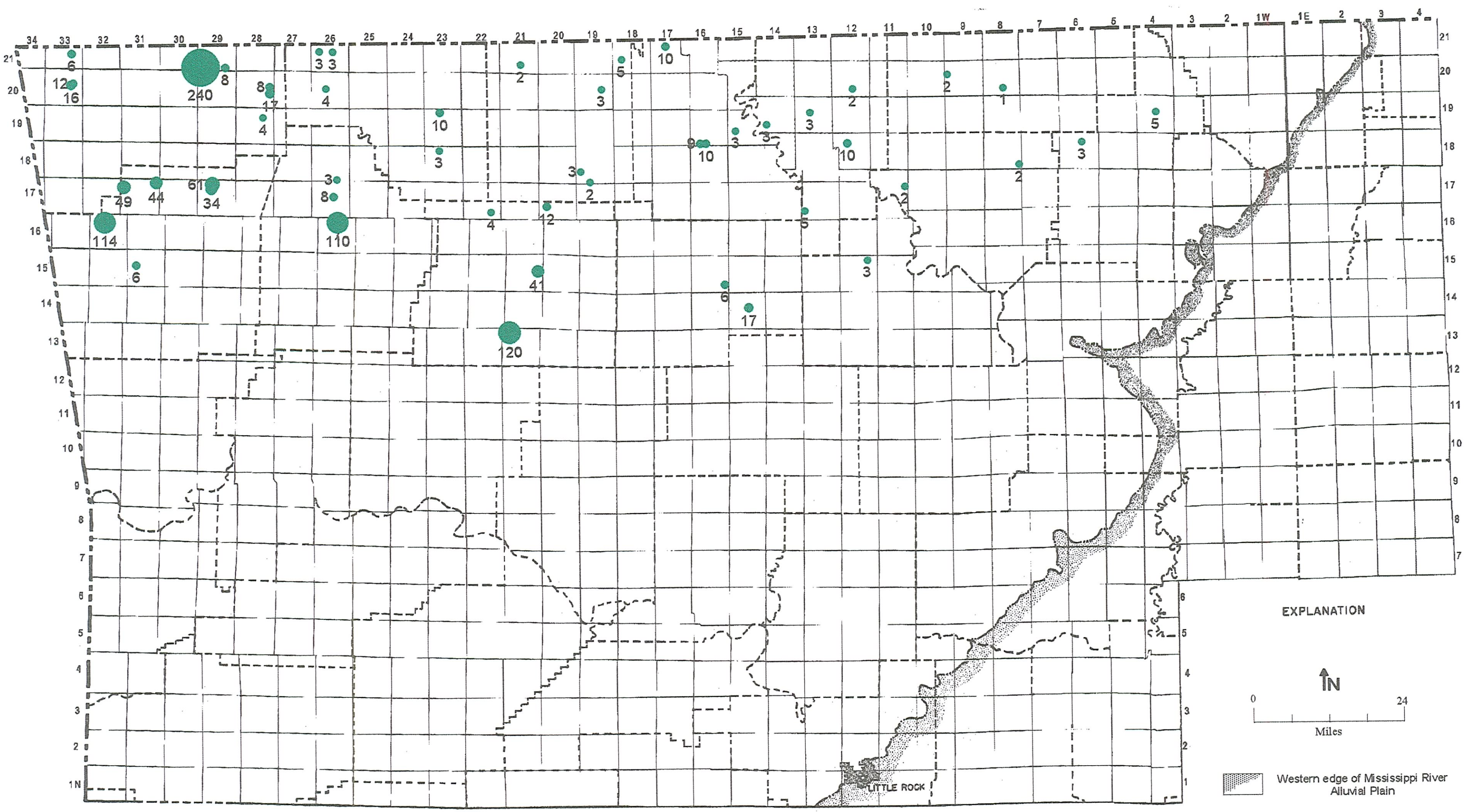



**Figure 15. Chloride concentration (mg/L) of selected water wells**

ground water in the Roubidoux and Gunter is unknown, but is likely the carbonate-dominated section of rocks in the recharge area of southern Missouri.

The concentrations of magnesium in this study range from 1 to 83 mg/L with a mean of 23 mg/L (figure 13).

Iron

Total iron concentration in this study was originally calculated in micrograms/liter by the USGS analysts. Their values were converted to milligrams/liter (mg/L) because chemical constituent concentrations listed in the National Drinking Water Standards are given in mg/L, as are the concentrations reported in the Appendix.

Dissolved iron in ground water comes from the dissolution of iron-bearing minerals during water-rock interaction. Soluble iron-bearing minerals in sedimentary rocks are pyrite or marcasite (iron sulfide), limonite (iron hydroxide), or hematite or goethite (iron oxides). Iron may exist in water in both the ferric or ferrous state. If the system contains sufficient oxygen, ferrous iron is oxidized to ferric iron.

Concentrations reported represent total recoverable iron. The NSDWS for iron is 0.3 mg/L. In general, water quality for both the Roubidoux and Gunter meets these standards; only 4 wells in the data set were above 0.3 mg/L. Iron concentration ranged from 0.001 to 3.6 mg/L with a mean of 0.214 mg/L (figure 13). The histogram shows a positive skewness of values above 0.110. When iron concentrations are above 0.3 mg/L, municipal water treatment facilities can remove the iron by treatment.

Sulfate

The presence of sulfur in the form of hydrogen sulfide ($H_2S$) gas in ground water creates a "rotten egg" odor. The presence of sulfate ($SO_4$) does not create an odor, but results in "soft water". Soft water creates difficulty in the removal of soap film. Sulfate in ground water comes from the dissolution of sulfur-bearing minerals, such as pyrite-marcasite (iron sulfide), gypsum (calcium sulfate), or glauberite (sodium calcium sulfate). Additionally, sulfur is released during aerobic bacterial action on organic matter in unconsolidated sediments and sedimentary rocks above the water table in an oxygen-rich environment. After being released, sulfur may readily oxidize to sulfate or, in the presence of hydrogen, be converted to $H_2S$.

All the analyses in the study's data set meet the NSDWS maximum limit for sulfate of 250 mg/L (Table 1). Sulfate concentrations range from 0.4 to 131 mg/L with a mean of 19 mg/L (figure 13). The histogram displays a positive skewness for higher concentrations, but all values are within the drinking water standard.

## Acknowledgments

The authors are indebted to many people for their cooperation and assistance in providing information concerning geology and hydrogeology of the Roubidoux Formation and the Gunter Sandstone Member of the Gasconade Formation. The cooperation of the U. S. Geological Survey -Water Resources Division and the Arkansas Department of Health was crucial in providing hydrologic and water chemistry information, without which this study could not have been completed. Outside reviews of the manuscript by G. W. Colton, Dr. D. L. Zachry, and D. A. Freiwald improved the content and focus of the report markedly. Special assistance from Susan Young, Cartography Supervisor of the Arkansas Geological Commission, is greatly appreciated.

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# Appendix

## Water Wells Used in the Compilation of This Report

The Elev. is the surface elevation at the well head. TD is the total depth of the well. The Rbx Top and Gtr Top list the elevations of the top of the Roubidoux Formation and the Gunter Sandstone Member of the Gasconade Formation respectively. Rbx Thick and Gtr Thick list thickness values for the Roubidoux and Gunter respectively. WL is the elevation of the static water level in the well. Yield is the reported production of the well in gallons per minute (gpm). TDS (total dissolved solids), Alkal (alkalinity), Cl, Ca, Mg, Fe, and $SO_4$ are expressed as milligrams per liter (mg/L).

| Well | County | Well Name | Location | Elev. | TD | Rbx Top | Rbx Thick | Gtr Top | Gtr Thick | W L | Yield | TDS | pH | Hard-ness | Alkal | Cl | Ca | Mg | Fe | SO4 | Temp (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Baxter | Big Flat #1 | T16N,R13W, Sec30 | 1300 | 2603 | -1080 | 215 | | | 660 | 54 | 304 | 7.7 | 180 | 270 | 4.5 | 30.0 | 19.0 | 0.050 | 52.0 | |
| 2 | Baxter | Norfork Dam | T18N,R12W, Sec02 | 640 | 910 | -160 | | | | | | | | | | | | | | | |
| 3 | Baxter | Salesville | T18N,R12W,Sec09 | 725 | 835 | | | | | 595 | 170 | 262 | | 210 | 198 | 10.0 | 51.0 | 21.0 | 0.350 | 7.0 | |
| 4 | Baxter | Norfork | T18N,R12W,Sec21 | 500 | 1507 | | | | | 409 | 122 | | | | | | | | | | |
| 5 | Baxter | Corps Engs. | T19N,R12W,Sec21 | 662 | 652 | | | | | 565 | 45 | | | | | | | | | | |
| 6 | Baxter | Corps Engs. | T19N,R12W,Sec27 | 645 | 652 | | | | | 569 | 110 | | | | | | | | | | |
| 7 | Baxter | Mtn Home #3 | T19N,R13W,Sec09 | 809 | 1562 | 154 | 245 | -671 | | 601 | 500 | | | | | | | | | | |
| 8 | Baxter | Mtn Home #1 | T19N,R13W,Sec16 | 740 | 1540 | | | | | 564 | 185 | 316 | 7.7 | 290 | | 3.0 | 60.0 | 35.0 | 3.600 | 14.0 | |
| 9 | Baxter | Cty of Cotter #2 | T19N,R14W,Sec29 | 720 | 1625 | | | | | 543 | 400 | 260 | 7.5 | 260 | | 2.8 | 50.0 | 33.0 | | 14.0 | 19.0 |
| 10 | Baxter | Cty of Cotter | T19N,R14W,Sec31 | 800 | 1090 | 80 | 230 | | | | | | | | | | | | | | |
| 11 | Baxter | Gamaliel Land | T20N,R12W,Sec01 | 705 | 606 | | | | | 570 | 110 | | | | | | | | | | |
| 12 | Baxter | Corps Engs. | T20N,R12W,Sec15 | 652 | 511 | | | | | 557 | 100 | | | | | | | | | | |
| 13 | Baxter | Bidwell Point | T20N,R12W,Sec22 | 650 | 547 | 210 | | | | 566 | | | | | | | | | | | |
| 14 | Baxter | Henderson #1 | T20N,R12W,Sec26 | 605 | 510 | 135 | | | | 536 | 100 | | | | | | | | | | |
| 15 | Baxter | Panther Bay #1 | T20N,R12W,Sec27 | 665 | 550 | 120 | | | | 546 | 100 | 370 | 8.0 | 400 | 38 | 2.0 | 75.0 | 52.0 | 0.300 | 13.0 | |
| 16 | Baxter | Panther Bay #2 | T20N,R12W,Sec27 | 600 | 490 | 120 | | | | | 145 | | | | | | | | | | |
| 17 | Benton | Billy Acres Sbd | T18N,R30W,Sec09 | 1295 | 1160 | 235 | | | | 1104 | 100 | | | | | | | | | | |
| 18 | Benton | EW Curry #1 | T18N,R33W,Sec33 | 1138 | 2236 | -52 | 210 | -607 | 15 | | | | | | | | | | | | |
| 19 | Benton | Ozark Prod.1 | T18N,R33W,Sec34 | 1190 | 2222 | -5 | 205 | -550 | 40 | | | | | | | | | | | | |
| 20 | Benton | Rocky Branch #1 | T19N,R28W,Sec11 | 1260 | 1030 | 280 | | | | 1068 | 100 | | 8.1 | 110 | 262 | 4.0 | 43.0 | 1.0 | 0.040 | 18.0 | |

| Well | County | Well Name | Location | Elev. | TD | Rbx Top | Rbx Thick | Gtr Top | Gtr Thick | W L | Yield | TDS | pH | Hard-ness | Alkal | Cl | Ca | Mg | Fe | SO4 | Temp (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Benton | Cty of Rogers | T19N,R29W,Sec07 | 1220 | 1659 | 350 | | -405 | | 1080 | 275 | | | | | | | | | | |
| 22 | Benton | Mlsp-Grdy Jns1 | T19N,R31W,Sec12 | 1273 | 2338 | 143 | 210 | -372 | 40 | | | | | | | | | | | | |
| 23 | Benton | Decatur | T19N,R33W,Sec11 | 1200 | 1720 | | | | | 942 | 350 | | | | | | | | | | |
| 24 | Benton | Cty of Decatur | T19N,R33W,Sec13 | 1275 | 1450 | | | -140 | 30 | 1139 | 180 | | | | | | | | | | |
| 25 | Benton | Mor Loch | T20N,R27W,Sec08 | 1295 | 1875 | | | | | 1056 | 20 | | | | | | | | | | |
| 26 | Benton | Lst Brdge Vil #1 | T20N,R28W,Sec13 | 1380 | 1626 | 360 | | -145 | | 1039 | 240 | 210 | 7.9 | 170 | | 7.5 | 37.0 | 18.0 | 0.050 | 16.0 | 19.5 |
| 27 | Benton | Corps Engs. | T20N,R28W,Sec13 | 1438 | 1037 | | | | | 1031 | 70 | | | | | | | | | | |
| 28 | Benton | Lst Brdg Village | T20N,R28W,Sec24 | 1380 | 1150 | | | | | 1028 | 300 | 202 | 8.4 | 190 | 160 | 17.0 | 43.0 | 21.0 | 0.050 | 13.0 | |
| 29 | Benton | Avoca Water D #1 | T20N,R29W,Sec13 | 1432 | 1968 | 310 | | -190 | | 1107 | 230 | | | | | | | | | | |
| 30 | Benton | Jebco Inc | T20N,R31W,Sec24 | 1120 | 1100 | | | | | 1066 | 120 | | | | | | | | | | |
| 31 | Benton | JE Farriester | T20N,R32W,Sec20 | 1220 | 1170 | | | | | 854 | 40 | | | | | | | | | | |
| 32 | Benton | Cty of Gravette2 | T20N,R33W,Sec11 | 1210 | 1600 | 139 | 130 | -361 | 25 | 960 | 140 | | | | | | | | | | |
| 33 | Benton | Cty of Gravette3 | T20N,R33W,Sec14 | 1230 | 1614 | 195 | | | | 1000 | 300 | 219 | 8.2 | | | 16.0 | | | | 8.0 | |
| 34 | Benton | Cty of Gravette1 | T20N,R33W,Sec14 | 1200 | 1603 | | | | | 1030 | 125 | 173 | 7.4 | 110 | | 12.0 | 25.0 | 11.0 | | 14.0 | |
| 35 | Benton | Monte Shaha | T20N,R33W,Sec32 | 1165 | 1133 | | | | | 873 | 8 | | | | | | | | | | |
| 36 | Benton | Gateway #1 | T21N,R28W,Sec14 | 1615 | 1610 | 555 | | 65 | | | | | | | | | | | | | |
| 37 | Benton | Hugh W Webb | T21N,R29W,Sec31 | 1300 | 1274 | | | | | 1115 | 50 | 228 | | 190 | 175 | 240.0 | 42.0 | 20.0 | 0.020 | 11.0 | |
| 38 | Benton | Pea Ridge NPS | T21N,R29W,Sec35 | 1406 | 1769 | 171 | 155 | -259 | 30 | 1108 | 185 | 200 | 7.8 | 180 | 170 | 8.0 | 42.0 | 19.0 | 0.270 | 14.0 | 20.0 |
| 39 | Benton | Bella Vista | T21N,R30W,Sec24 | 1220 | 2000 | | | | | 825 | 319 | | | | | | | | | | |
| 40 | Benton | Bella Vista | T21N,R30W,Sec29 | 1260 | 1985 | | | | | 1048 | 299 | | | | | | | | | | |
| 41 | Benton | Bella Vista | T21N,R31W,Sec20 | 1242 | 1115 | | | | | 1025 | 50 | | | | | | | | | | |
| 42 | Benton | Lambeth Bella V | T21N,R31W,Sec36 | 1260 | 2000 | 290 | | -180 | 50 | 995 | 248 | | | | | | | | | | |
| 43 | Benton | Don Tyson | T21N,R32W,Sec33 | 1280 | 1156 | | | | | 938 | 60 | | | | | | | | | | |
| 44 | Benton | Sulpher Sprgs #1 | T21N,R33W,Sec23 | 1036 | 1442 | 240 | | -260 | | 917 | 200 | 341 | 7.8 | 260 | 222 | 5.5 | 64.0 | 26.0 | 0.230 | 39.0 | |
| 45 | Boone | Krooked Creek | T17N,R20W,Sec11 | 1245 | 2370 | -275 | 260 | -995 | 90 | | | | | | | | | | | | |
| 46 | Boone | Big Rck Cdy Mtn | T17N,R20W,Sec16 | 1250 | 1800 | -380 | | | | 850 | 20 | | | | | | | | | | |
| 47 | Boone | Cty of Bellefont | T18N,R19W,Sec19 | 1150 | 1649 | | | | | 1010 | 96 | 219 | 8.1 | 160 | 170 | 2.5 | 33.0 | 20.0 | 0.050 | 18.0 | |
| 48 | Boone | AHTD | T18N,R19W,Sec19 | 1050 | 2000 | -320 | | | | 926 | 88 | | | | | | | | | | |
| 49 | Boone | Valley Sprg Mt 1 | T18N,R19W,Sec33 | 1300 | 2055 | -20 | 230 | -710 | 120 | 967 | 200 | 216 | 7.7 | 190 | 170 | 1.5 | 41.0 | 22.0 | 0.050 | 20.0 | 19.5 |

| Well | County | Well Name | Location | Elev. | TD | Rbx Top | Rbx Thick | Gtr Top | Gtr Thick | W L | Yield | TDS | pH | Hard-ness | Alkal | Cl | Ca | Mg | Fe | SO4 | Temp (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | Boone | Valley Sprg Mt 2 | T18N,R19W,Sec33 | 1330 | 2050 | 10 | 190 | -600 | 120 | | 225 | | | | | | | | | | |
| 51 | Boone | Barrett #1 | T18N,R21W,Sec19 | 1470 | 2246 | 520 | 330 | -250 | | | | | | | | | | | | | |
| 52 | Boone | RHEA Bryan1 | T18N,R22W,Sec24 | 1894 | 2343 | 274 | 265 | -326 | 110 | | | | | | | | | | | | |
| 53 | Boone | Prowett #1 | T19N,R18W,Sec20 | 920 | 2646 | 123 | 203 | -545 | 54 | | | | | | | | | | | | |
| 54 | Boone | Cty of Bergman 2 | T19N,R19W,Sec24 | 1400 | 2090 | 70 | 220 | -570 | 70 | | 230 | | | | | | | | | | |
| 55 | Boone | Lindsey Const #1 | T19N,R20W,Sec32 | 1187 | 1505 | -113 | 180 | | | 1107 | 150 | | | | | | | | | | |
| 56 | Boone | City of Lead Hill | T20N,R18W,Sec08 | 895 | 1420 | 225 | 180 | -435 | 67 | | 275 | | | | | | | | | | |
| 57 | Boone | Paul Epps 7A | T20N,R19W,Sec14 | 760 | 2412 | | | -403 | 44 | | 100 | 195 | 7.7 | 180 | 179 | 2.8 | 41.0 | 20.0 | 1.100 | 7.7 | 16.0 |
| 58 | Boone | H W Dietz | T21N,R18W,Sec20 | 830 | 604 | | | | | 673 | | 318 | 8.1 | 250 | | 5.0 | 49.0 | 30.0 | 0.070 | 20.0 | |
| 59 | Boone | H W Dietz | T21N,R18W,Sec29 | 750 | 703 | | | | | 664 | 650 | | | | | | | | | | |
| 60 | Boone | Cty of Lead Hill | T21N,R18W,Sec32 | 840 | 602 | | | | | 741 | | 333 | 7.3 | 470 | | | 50.0 | 83.0 | 0.430 | 11.0 | |
| 61 | Boone | Tucker Hollow R | T21N,R19W,Sec16 | 700 | | 400 | | | | | | | | | | | | | | | |
| 62 | Boone | Corps Engs | T21N,R20W,Sec13 | 710 | 348 | | | | | | 35 | | | | | | | | | | |
| 63 | Boone | Unknown | T21N,R21W,Sec15 | 1340 | 847 | 530 | | | | 525 | 50 | | | | | | | | | | |
| 64 | Boone | Rivera St Line P | T21N,R21W,Sec16 | 1290 | 868 | 480 | | | | | 35 | | | | | | | | | | |
| 65 | Boone | Omaha #2 | T21N,R21W,Sec22 | 1300 | 1340 | 310 | 190 | | | | 115 | | | | | | | | | | |
| 66 | Boone | Cty of Omaha | T21N,R21W,Sec27 | 1357 | 1315 | | | | | 907 | 52 | 346 | 8.1 | 210 | | 2.0 | 45.0 | 25.0 | 0.070 | 40.0 | |
| 67 | Carroll | Howard Collins | T18N,R23W,Sec04 | 1310 | 1032 | | | | | 1238 | | 228 | 7.5 | 220 | 211 | 2.7 | 48.0 | 25.0 | 0.010 | 13.0 | 16.0 |
| 68 | Carroll | Cty of Grn Fores | T19N,R23W,Sec04 | 1350 | 1587 | -66 | 215 | | | 1164 | 60 | 301 | 8.0 | 250 | 228 | 10.0 | 54.0 | 28.0 | 0.150 | 32.0 | |
| 69 | Carroll | W J Schell | T19N,R24W,Sec17 | 1410 | 1314 | | | | | 1146 | 150 | | | | | | | | | | |
| 70 | Carroll | Riverside Res. | T20N,R25W,Sec16 | 1287 | 506 | 897 | | | | | | | | | | | | | | | |
| 71 | Carroll | Usrey Mobil Pk | T20N,R25W,Sec17 | 1160 | 560 | 690 | | | | | 77 | | | | | | | | | | |
| 72 | Carroll | Longview Realty | T20N,R25W,Sec19 | 1420 | 890 | 580 | | | | | 100 | | | | | | | | | | |
| 73 | Carroll | Osage Mobil Pk | T20N,R25W,Sec22 | 1200 | 780 | 610 | | | | | | | | | | | | | | | |
| 74 | Carroll | Riverlake OutDor | T20N,R26W,Sec06 | 1420 | 1003 | 460 | | | | | | | | | | | | | | | |
| 75 | Carroll | Eureka Sprgs | T20N,R26W,Sec16 | 1200 | 1332 | | | | | 1022 | 500 | 183 | 8.2 | 170 | | 4.0 | 34.0 | 16.0 | | 18.0 | |
| 76 | Carroll | Cty of Eureka Sp | T20N,R26W,Sec23 | 1334 | 1713 | 519 | 115 | -31 | 55 | | | | | | | | | | | | |
| 77 | Carroll | Cty of Eureka Sp | T20N,R26W,Sec23 | 1330 | 902 | 490 | | | | | | | | | | | | | | | |
| 78 | Carroll | Greencliff Subd | T20N,R27W,Sec22 | 1350 | 870 | 550 | | | | | 40 | | | | | | | | | | |

| Well | County | Well Name | Location | Elev. | TD | Rbx Top | Rbx Thick | Gtr Top | Gtr Thick | W L | Yield | TDS | pH | Hard-ness | Alkal | Cl | Ca | Mg | Fe | SO4 | Temp (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79 | Carroll | Branson RV Pk | T21N,R22W,Sec10 | 1164 | 1200 | 504 | 380 | 124 | | | | | | | | | | | | | |
| 80 | Carroll | Holiday Isl #2 | T21N,R26W,Sec15 | 1102 | 1122 | | | | | 967 | 500 | 297 | 8.4 | 230 | | 2.8 | 48.0 | 27.0 | 0.050 | 11.0 | 19.0 |
| 81 | Carroll | Holiday Isl #1 | T21N,R26W,Sec17 | 1010 | 1058 | 495 | | | | 924 | 600 | 337 | 8.3 | 280 | 260 | 2.8 | 58.0 | 34.0 | 0.050 | 11.0 | 17.5 |
| 82 | Carroll | Holiday Isl | T21N,R26W,Sec22 | 1500 | 1184 | | | | | 1354 | 500 | | | | | | | | | | |
| 83 | Carroll | Holiday Isl #4 | T21N,R26W,Sec27 | 1520 | 1880 | 560 | | 40 | | 1000 | 502 | | | | | | | | | | |
| 84 | Crawford | USA #1 | T13N,R28W,Sec33 | 1420 | 4090 | -1510 | 210 | -2075 | 50 | | | | | | | | | | | | |
| 85 | Faulkner | ARGO Edgmon #1 | T07N,R12W,Sec06 | 486 | 12160 | -8314 | 330 | -9384 | | | | | | | | | | | | | |
| 86 | Franklin | ARKLA Harding #1 | T09N,R27W,Sec09 | 472 | 7898 | -6528 | | -7068 | | | | | | | | | | | | | |
| 87 | Franklin | Tnco Conaster 1 | T10N,R27W,Sec17 | 454 | 8270 | -6426 | | -7031 | | | | | | | | | | | | | |
| 88 | Fulton | Cty of Salem | T20N,R08W,Sec27 | 660 | 1282 | 255 | | | | 632 | | 240 | 7.3 | 240 | 245 | 1.4 | 50.0 | 28.0 | 0.020 | 1.8 | 17.0 |
| 89 | Fulton | Cty of Viola1 | T20N,R09W,Sec18 | 800 | 1600 | -80 | 210 | -750 | 40 | 674 | 140 | 298 | 7.3 | 220 | 272 | 1.5 | 45.0 | 26.0 | 0.200 | 1.6 | 16.0 |
| 90 | Fulton | Mammoth Spgs | T21N,R05W,Sec07 | 575 | 1340 | 415 | | -305 | | | | | | | | | | | | | |
| 91 | Fulton | Mammoth Spgs | T21N,R05W,Sec08 | 580 | 363 | | | | | 506 | 445 | | | | | | | | | | |
| 92 | Fulton | Rvr Side Resort | T21N,R05W,Sec33 | 490 | 370 | 240 | | | | | 110 | | | | | | | | | | |
| 93 | Izard | Cty of Melborne1 | T16N,R09W,Sec01 | 580 | 1446 | -750 | | | | | | | | | | | | | | | |
| 94 | Izard | Cty of Melborne2 | T16N,R09W,Sec01 | 754 | 1807 | -776 | 240 | | | | | | | | | | | | | | |
| 95 | Izard | Clco Rck #6 | T17N,R11W,Sec12 | 776 | 2134 | -684 | 180 | -1024 | 25 | | | | | | | | | | | | |
| 96 | Izard | Cty of Clco Rck | T17N,R11W,Sec13 | 541 | 1729 | | | | | 464 | | | | | | 2.3 | | | | | 17.5 |
| 97 | Izard | Horsebend #4 | T18N,R07W,Sec08 | 840 | 1406 | -70 | 240 | | | | | | | | | | | | | | |
| 98 | Izard | Franklin2 | T18N,R07W,Sec31 | 670 | 1300 | -360 | 250 | | | | 300 | 252 | 8.4 | 270 | | 2.0 | 55.0 | 33.0 | 0.340 | 13.0 | |
| 99 | Izard | Oxford #1 | T18N,R09W,Sec23 | 800 | 1070 | -180 | | | | | | | | | | | | | | | |
| 100 | Lawrence | Thatcher #1 | T16N,R03W,Sec15 | 300 | 2640 | -1209 | | -2081 | | | | | | | | | | | | | |
| 101 | Lawrence | Lawrence Co. RWA | T17N,R03W,Sec13 | 500 | 1010 | -500 | | | | | 350 | | | | | | | | | | |
| 102 | Lawrence | Guthrie #1 | T17N,R03W,Sec22 | 380 | 1390 | -520 | 230 | | | | | | | | | | | | | | |
| 103 | Lawrence | Smithville #1 | T17N,R03W,Sec24 | 450 | 1400 | -690 | | | | | | | | | | | | | | | |
| 104 | Lawrence | Imboden #1 | T18N,R02W,Sec21 | 390 | 1740 | -510 | 250 | -960 | 10 | | 200 | | | | | | | | | | |
| 105 | Lawrence | Imboden #2 | T18N,R02W,Sec23 | 340 | 1260 | -540 | 260 | | | | | | | | | | | | | | |
| 106 | Madison | Huntsville #2 | T16N,R26W,Sec03 | 1670 | 3288 | 0 | | -355 | | 1160 | 41 | 299 | 7.8 | 51 | 237 | 6.9 | 11.0 | 5.7 | 0.140 | 0.4 | 20.5 |
| 107 | Madison | Huntsville #1 | T16N,R26W,Sec03 | 1670 | 3290 | 30 | | -325 | 55 | 1160 | 41 | 389 | 7.2 | 130 | | 110.0 | 30.0 | 15.0 | 0.002 | 49.0 | |

| Well | County | Well Name | Location | Elev. | TD | Rbx Top | Rbx Thick | Gtr Top | Gtr Thick | W L | Yield | TDS | pH | Hard-ness | Alkal | Cl | Ca | Mg | Fe | SO4 | Temp (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 108 | Madison | Bank #1 | T16N,R27W,Sec06 | 1545 | 2515 | 59 | 250 | -505 | 60 | | | | | | | | | | | | |
| 109 | Madison | Max B Hoeme | T17N,R25W,Sec21 | 1900 | 2290 | | | | | 1221 | 200 | | | | | | | | | | |
| 110 | Madison | Gal BG Noark | T17N,R26W,Sec15 | 1400 | 1120 | | | | | 1207 | 100 | 235 | 8.1 | 140 | | 7.7 | 31.0 | 14.0 | | 14.0 | |
| 111 | Madison | #1 Swift-Madison | T17N,R26W,Sec27 | 1436 | 2350 | 76 | 170 | -364 | 50 | | | | | | | | | | | | |
| 112 | Madison | Ozark Science Ct | T18N,R26W,Sec02 | 1374 | 1110 | 544 | 150 | | | | 90 | | | | | | | | | | |
| 113 | Madison | Madison Co. WA | T18N,R26W,Sec35 | 1558 | 1970 | 130 | | | | 1196 | 219 | 177 | 8.1 | 160 | | 3.0 | 34.0 | 19.0 | 0.210 | 20.0 | |
| 114 | Marion | Buffalo Point | T17N,R15W,Sec34 | 545 | 1300 | -565 | | | | 425 | 40 | | | | | | | | | | |
| 115 | Marion | Flippin Water #2 | T19N,R15W,Sec20 | 650 | 1150 | -240 | | | | 530 | 40 | | | | | | | | | | |
| 116 | Marion | Cty of Flippin | T19N,R15W,Sec20 | 630 | 900 | | | | | 544 | 30 | 281 | 7.8 | 290 | 337 | 2.5 | 58.0 | 35.0 | 0.050 | 18.0 | |
| 117 | Marion | Cty of Summit | T19N,R16W,Sec32 | 950 | 1524 | | | | | 561 | 61 | 275 | 7.7 | 280 | | 9.2 | 58.0 | 33.0 | 0.050 | 7.0 | |
| 118 | Marion | Cty of Yellville | T19N,R16W,Sec33 | 840 | 753 | | | | | 515 | 60 | 344 | 7.4 | 340 | | 9.8 | 70.0 | 39.0 | 0.090 | 23.0 | |
| 119 | Marion | Town of Pyatt #1 | T19N,R18W,Sec36 | 758 | 1392 | -187 | | | | 732 | 236 | | | | | | | | | | |
| 120 | Marion | Corps Engs | T20N,R15W,Sec06 | 725 | 506 | | | | | 690 | 100 | 420 | 7.7 | | 354 | 10.0 | 79.0 | | 0.001 | | |
| 121 | Marion | Brown Oil | T20N,R15W,Sec08 | 775 | 775 | | | | | 649 | 75 | | | | | | | | | | |
| 122 | Marion | Buck Creek Park | T21N,R17W,Sec09 | 720 | 525 | 300 | | | | 610 | 92 | | | | | | | | | | |
| 123 | Marion | Corps Engs | T21N,R17W,Sec22 | 755 | 525 | | | | | 687 | 100 | | | | | | | | | | |
| 124 | Newton | Nail-Swain #1 | T13N,R21W,Sec05 | 2060 | 3900 | -1060 | 200 | -1720 | 100 | | 125 | 685 | 7.4 | 112 | | 120.0 | | | 0.030 | 131.0 | |
| 125 | Newton | Piercetown | T15N,R20W,Sec11 | 980 | 2520 | -580 | 250 | -1430 | 60 | | 200 | | | | | | | | | | |
| 126 | Newton | Mockingbird Hill | T15N,R21W,Sec13 | 2135 | 3142 | -705 | | | | 839 | 62 | 350 | 8.3 | 140 | | 41.0 | 32.0 | 14.0 | 0.110 | 37.0 | |
| 127 | Newton | Hasty #1 | T16N,R20W,Sec25 | 1230 | 2590 | -510 | 200 | -1220 | 50 | | 80 | | | | | | | | | | |
| 128 | Newton | Mt Sherman #2 | T16N,R22W,Sec26 | 2105 | 3080 | -805 | | | | | 58 | | | | | | | | | | |
| 129 | Newton | Mt Sherman #1 | T16N,R22W,Sec27 | 2240 | 3288 | -785 | | | | | 50 | | | | | | | | | | |
| 130 | Newton | Marble Falls #1 | T17N,R20W,Sec21 | 1344 | 2580 | -356 | | -1006 | 100 | 996 | 222 | 261 | 7.5 | 230 | | 12.0 | 54.0 | 23.0 | 0.050 | 17.0 | |
| 131 | Newton | Cty of Compton 1 | T17N,R22W,Sec26 | 2110 | 3215 | -475 | | -1010 | | 1135 | 52 | 121 | 7.3 | 97 | 116 | 3.6 | 24.0 | 9.1 | 0.070 | 28.0 | 24.0 |
| 132 | Randolph | Ravenden Sprgs | T19N,R02W,Sec06 | 480 | 875 | -230 | | | | | | | | | | | | | | | |
| 133 | Randolph | LB Adams #1 | T20N,R01E,Sec13 | 400 | 925 | -5 | 205 | | | | | | | | | | | | | | |
| 134 | Randolph | Cty of Maynard 1 | T20N,R02E,Sec06 | 485 | 900 | -55 | | | | 395 | | | | | | | | | | | |
| 135 | Searcy | Cty of Leslie #1 | T14N,R15W,Sec15 | 1060 | 3535 | -1400 | 215 | -2190 | 30 | 708 | 40 | 358 | 7.7 | 180 | 320 | 17.0 | 44.0 | 18.0 | 0.190 | 17.0 | 15.0 |
| 136 | Searcy | Marshall (S Mtn) | T14N,R16W,Sec08 | 880 | 3700 | -1270 | 220 | -1850 | 80 | | 125 | | | | | | | | | | |

| Well | County | Well Name | Location | Elev. | TD | Rbx Top | Rbx Thick | Gtr Top | Gtr Thick | W L | Yield | TDS | pH | Hard-ness | Alkal | Cl | Ca | Mg | Fe | SO4 | Temp (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 137 | Searcy | Morning Star 2 | T15N,R15W,Sec02 | 1110 | 2690 | -850 | 280 | -1510 | 20 | 881 | 120 | | | | | | | | | | |
| 138 | Searcy | Marshall #3 | T15N,R16W,Sec25 | 1045 | 2415 | -1045 | 210 | | | 840 | 55 | 265 | 7.5 | 230 | 239 | 5.5 | 67.0 | 16.0 | 0.010 | 16.0 | 15.5 |
| 139 | Searcy | Morning Star 1 | T16N,R15W,Sec33 | 1240 | 2900 | -800 | | -1490 | | | | | | | | | | | | | |
| 140 | Searcy | Tyler Bend #1 | T16N,R17W,Sec35 | 768 | 2200 | -1022 | 210 | | | | | | | | | | | | | | |
| 141 | Searcy | Wylie Moore 1 | T16N,R18W,Sec02 | 1150 | 3123 | -333 | 161 | -980 | 49 | | | | | | | | | | | | |
| 142 | Searcy | Pndl-Glbt WA 2 | T16N,R18W,Sec08 | 1250 | 1910 | -390 | 210 | | | | | | | | | | | | | | |
| 143 | Sebastian | Shell Oil #1 | T07N,R32W,Sec36 | 505 | 10924 | -9290 | | -9860 | | | | | | | | | | | | | |
| 144 | Sharp | Calamine-Grauge1 | T16N,R04W,Sec28 | 395 | 1900 | -1105 | 190 | | | | 190 | | | | | | | | | | |
| 145 | Sharp | Grange-Calamine2 | T16N,R04W,Sec29 | 460 | 1850 | -1080 | 150 | | | | 115 | | | | | | | | | | |
| 146 | Sharp | Sidney | T16N,R06W,Sec34 | 742 | 2700 | -778 | 250 | -1488 | 30 | | 150 | | | | | | | | | | |
| 147 | Sharp | Grange-Calamine3 | T17N,R05W,Sec25 | 488 | 1580 | -542 | 210 | | | | | | | | | | | | | | |
| 148 | Sharp | Baxter Lab. #1 | T18N,R06W,Sec02 | 600 | 1250 | -100 | | | | 578 | 500 | | | | | | | | | | |
| 149 | Sharp | Ash Flat | T18N,R06W,Sec10 | 655 | 1525 | | | | | 527 | 180 | 262 | | 280 | | 3.0 | 52.0 | 30.0 | | 16.0 | 17.0 |
| 150 | Sharp | Cty of Ash Flat1 | T18N,R06W,Sec11 | 650 | 1545 | -100 | 220 | -870 | 25 | 502 | 180 | | | | | | | | | | |
| 151 | Sharp | Ozark Acres3 | T19N,R04W,Sec15 | 590 | 611 | | | | | 574 | 120 | 287 | 7.9 | 260 | | 5.0 | 46.0 | 32.0 | 0.010 | 11.0 | 16.5 |
| 152 | Sharp | Ozark Acres | T19N,R04W,Sec22 | 473 | 940 | | | | | 407 | 125 | | | | | | | | | | |
| 153 | Sharp | Ozark Acres #1 | T19N,R04W,Sec23 | 680 | 940 | 160 | | | | 614 | 125 | | | | | | | | | | |
| 154 | Sharp | Hardy #2 | T19N,R05W,Sec02 | 570 | 1590 | 120 | 160 | -730 | 30 | | | | | | | | | | | | |
| 155 | Sharp | Highland #2 | T19N,R05W,Sec04 | 682 | 1425 | 102 | 200 | -648 | 40 | | 50 | | | | | | | | | | |
| 156 | Sharp | Hardy #1 | T19N,R05W,Sec11 | 375 | 1180 | 85 | 160 | -745 | 50 | | 300 | | | | | | | | | | |
| 157 | Sharp | Highland #2A | T19N,R05W,Sec15 | 623 | 1370 | 143 | 170 | -667 | 50 | | 150 | | | | | | | | | | |
| 158 | Stone | Twn of Fifty-six | T15N,R12W,Sec02 | 985 | 3426 | -1295 | | -2285 | 30 | 586 | 40 | 148 | 8.4 | 130 | | 2.5 | 28.0 | 15.0 | 0.110 | 22.0 | 20.0 |
| 159 | Stone | Big Flat #2 | T15N,R13W,Sec06 | 1130 | 3105 | -1130 | | -1860 | 50 | | 150 | | | | | | | | | | |
| 160 | Washington | Jim Rush | T13N,R33W,Sec34 | 1700 | 2439 | | | | | 940 | 40 | | | | | | | | | | |
| 161 | Washington | JW Grissom 1 | T15N,R31W,Sec17 | 1140 | 2097 | -342 | 143 | -860 | 25 | 990 | 43 | | | | | | | | | | |
| 162 | Washington | Holcomb D | T15N,R31W,Sec17 | 1200 | 2097 | | | | | 1073 | 60 | 93 | 8.2 | 93 | | 5.8 | 19.0 | 11.0 | 0.020 | 8.0 | |
| 163 | Washington | Ramsey Berlin | T15N,R33W,Sec08 | 1175 | 1563 | | | | | 1060 | 20 | | | | | | | | | | |
| 164 | Washington | Walker #1 | T16N,R31W,Sec06 | 1220 | 1525 | 20 | 132 | | | | | | | | | | | | | | |
| 165 | Washington | Wedington | T16N,R32W,Sec09 | 1135 | 1815 | -70 | 210 | -595 | 40 | 1034 | 26 | 381 | 7.6 | 118 | | 114.0 | 32.8 | 8.5 | 0.060 | 7.0 | |

| Well | County | Well Name | Location | Elev. | TD | Rbx Top | Rbx Thick | Gtr Top | Gtr Thick | W L | Yield | TDS | pH | Hard-ness | Alkal | Cl | Ca | Mg | Fe | SO4 | Temp (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 166 | Washington | Jim Cash | T16N,R33W,Sec20 | 1125 | 1402 | | | | | 955 | 30 | | | | | | | | | | |
| 167 | Washington | Tyson Foods | T16N,R33W,Sec36 | 1510 | 1806 | | | | | 1071 | 20 | | | | | | | | | | |
| 168 | Washington | RW White River | T17N,R29W,Sec04 | 1420 | 2080 | | | | | 1005 | 300 | 326 | 7.5 | 94 | 204 | 61.0 | 22.0 | 9.6 | <.003 | 8.3 | 21.0 |
| 169 | Washington | RDC White River | T17N,R29W,Sec09 | 1481 | 2071 | 64 | 204 | -528 | | 1066 | 400 | | | | | 34.0 | | | | | 20.5 |
| 170 | Washington | St. Joseph Crch | T17N,R31W,Sec01 | 1320 | 1416 | | | | | 1065 | | 289 | 7.7 | 84 | | 44.0 | 17.0 | 10.0 | | 6.0 | |
| 171 | Washington | Cty of Tontitown | T17N,R31W,Sec06 | 1320 | 1416 | 104 | 134 | | | | | | | | | | | | | | |
| 172 | Washington | Casey Raymond | T17N,R31W,Sec07 | 1000 | 1505 | | | | | 971 | | 257 | 8.2 | 110 | | 49.0 | 25.0 | 11.0 | | 11.0 | |
| 173 | Washington | Bobby Pianalto | T17N,R31W,Sec14 | 1288 | 1591 | | | | | 1047 | 200 | | | | | | | | | | |
| 174 | Yell | OXY USA Dnvl 4 | T05N,R22W,Sec33 | 848 | 20661 | -19602 | | | | | | | | | | | | | | | |