Ozark Plateau

2008 Field Analysis Summary

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I. Introduction

The Ozark Plateau is a four-state region located primarily in southern Missouri and northern Arkansas, and includes smaller areas in northwest Oklahoma and southeast Kansas (Figure 1). The Ozark Plateau consists of four physiographic regions: the Springfield Plateau, Salem Plateau, Saint Francois Mountains and Boston Mountains. Of these four regions only a small portion of the Springfield Plateau extends into the far southeastern corner of Kansas. Under this corner of Kansas lies the Ozark Plateau aquifer.

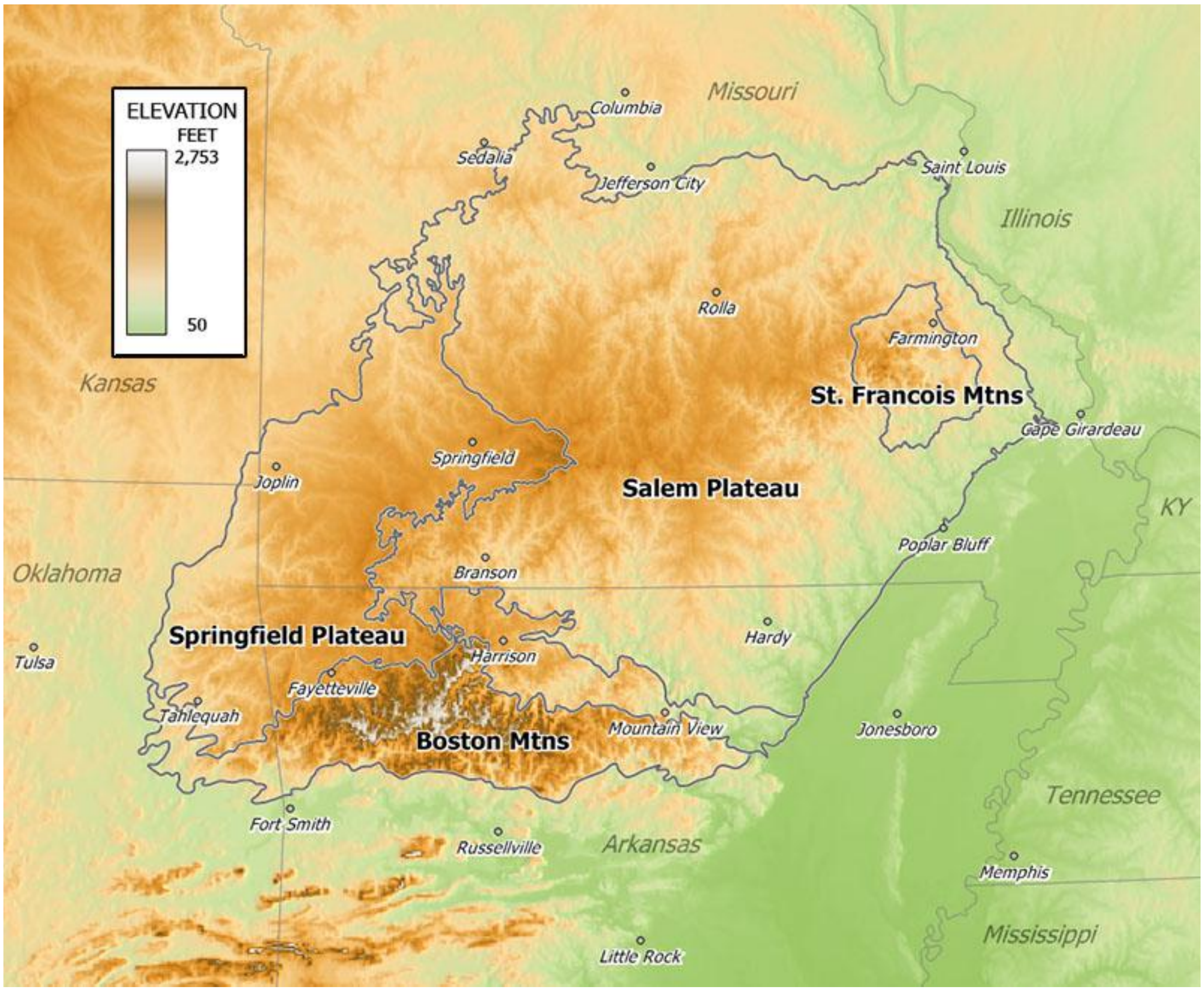

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Figure 1: Ozark Plateau

The Ozark Plateau aquifer is an important source of water for the quad-state region of southeast Kansas, southwest Missouri, northeastern Oklahoma and a small portion of northwest Arkansas. The Ozark Plateau aquifer consists of two aquifers, a deep aquifer and a shallower aquifer, both with discontinuous confining layers. The upper aquifer is the Springfield Plateau aquifer, the lower is the Ozark aquifer (Figure 2).

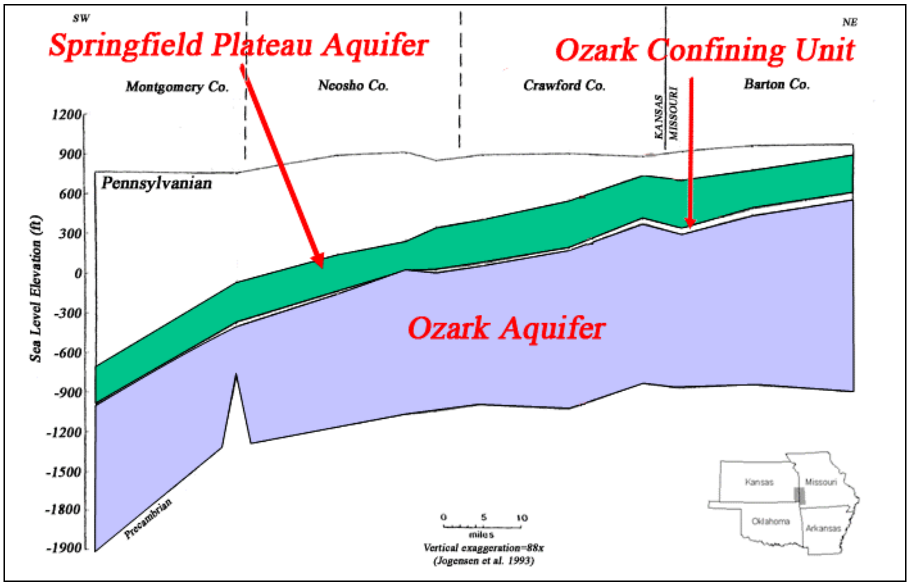

Figure 2: Ozark and Springfield Plateau Aquifers

Figure taken from Kansas Geological Survey Open File Report 2007-20 *The Southeast Kansas Ozark Aquifer Water Supply Program*.

The Springfield Plateau aquifer contains fresh water in southwest Missouri and northeast Oklahoma, where it is shallow and can produce water sufficient for domestic purposes. Water quality of the Springfield Plateau aquifer in Kansas is poor and may be unfit for domestic use due to the prior extensive lead and ore mining in the area. Mining shafts have allowed contaminated water to move from the surface into the aquifer.

The Ozark aquifer contains usable water in southeast Kansas and is the source for most of the groundwater supplied to area municipalities and rural water districts. At the bottom of the Ozark aquifer is a brine layer (salt water) that is moving west to east across Kansas. There is concern that significant groundwater pumping in areas could potentially cause upwelling of brines within the aquifer and adversely impact water quality.

Due to uncertainty about the available water supply in the Ozark aquifer, as well as water quality concerns, in 2004 the Kansas Department of Agriculture's Division of Water Resources (KDA-DWR) established a moratorium on new appropriations from the aquifer in Kansas, except for some specified exceptions. The moratorium referenced a study of the Springfield Plateau aquifer and Ozark aquifer to be completed by December 31, 2010 (K.A.R. 5-3-29). The study by the U.S. Geological Survey (USGS), with state and local involvement, has been ongoing for several years and is anticipated to be completed in 2009. (http://ks.water.usgs.gov/Kansas/studies/OzarkAquifer/index.html).

In 2004, a groundwater well monitoring network was re-established for the Ozark aquifer moratorium area. The network consists of 24 wells that are screened within the Springfield Plateau aquifer, the Ozark aquifer, or both aquifers (referred to as the Ozark Plateau aquifer), and are measured on a quarterly basis. Also, in order to detect the potential eastward movement of salt water, a network consisting of 12 wells has been established from which water quality samples are taken quarterly. Lastly, three continuous monitoring wells have been drilled. Two of the monitoring wells are located in the Ozark aquifer at McCune and Pittsburg and one is located in the Springfield Plateau aquifer, also located at Pittsburg. All three wells have transducers installed and are equipped with satellite telemetry capabilities.

II. Precipitation

Precipitation in the Ozark Plateau area in Kansas averages 41 inches (in.) per year based on six precipitation stations. Figure 3 shows the annual variation in precipitation. This chart was derived from National Climatic Data Center (NCDC) stations located in Columbus (Cherokee County), Erie (Neosho County), Fort Scott (Bourbon County), Moran (Allen County), Parsons (Labette County) and Pittsburg (Crawford County). The data is downloaded then averaged to create the following chart. The highest precipitation total occurred in 1985 with 59 in. The lowest precipitation occurred in 1963 with 22 in. In 2007, the precipitation total was 53 in., which is above average. Annual precipitation data for these NCDC stations is currently available through 2007.

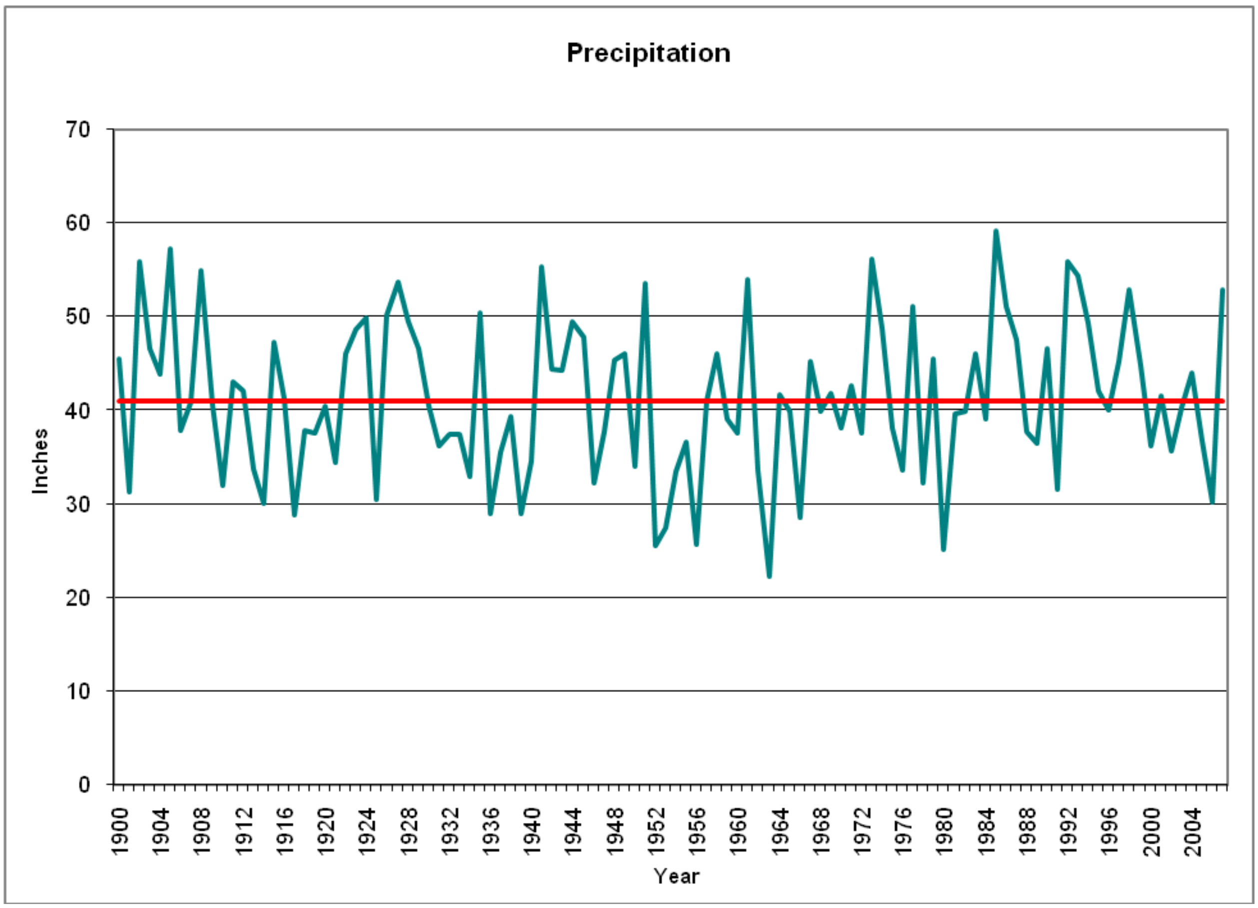

Figure 3: Average Ozark Precipitation 1900-2007

Figure 4 shows the preliminary monthly precipitation for 2008. With these measurements the subbasin experienced an average of 54 inches in 2008. This is 13 in. above the annual average. June had the highest average with 10.47 in. while January had the lowest precipitation average with 0.91 in.

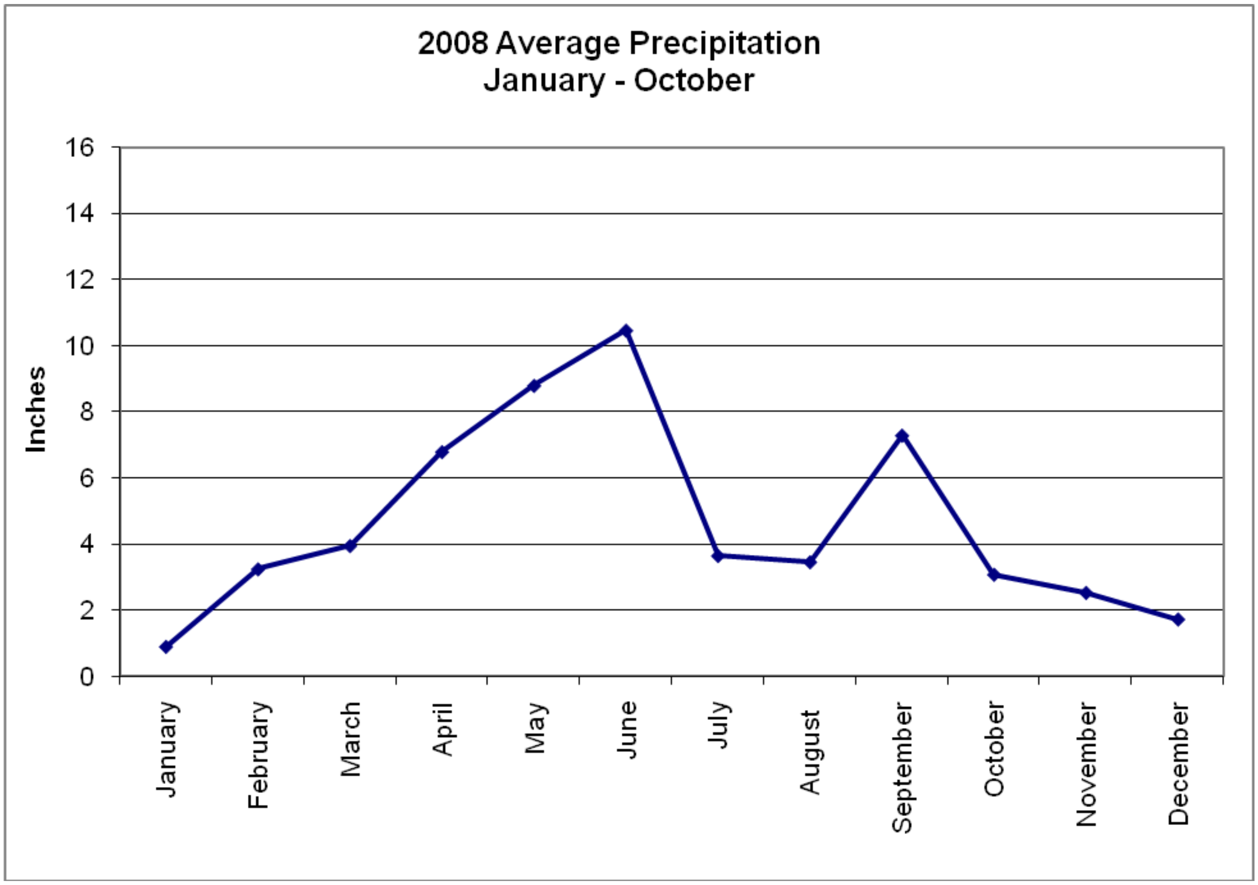

Figure 4: 2008 Monthly Average Precipitation

III. Surface Water

The Neosho River and the Spring River are the two major river systems that cut through the regulation area boundary of the Ozark Plateau aquifer (Figure 5). The lower Neosho River flows through Neosho and Labette counties, and briefly flows through the southwest corner of Cherokee County before flowing out of Kansas into Oklahoma. The Spring River enters Kansas from Missouri on the eastern side of Cherokee County, flows through Cherokee County, and exits the state at the southern part of the county into Oklahoma. Both river systems are monitored by the USGS and have streamflow gages positioned near Parsons, Kansas on the lower Neosho River and near Quapaw, Oklahoma on the Spring River (Figure 5).

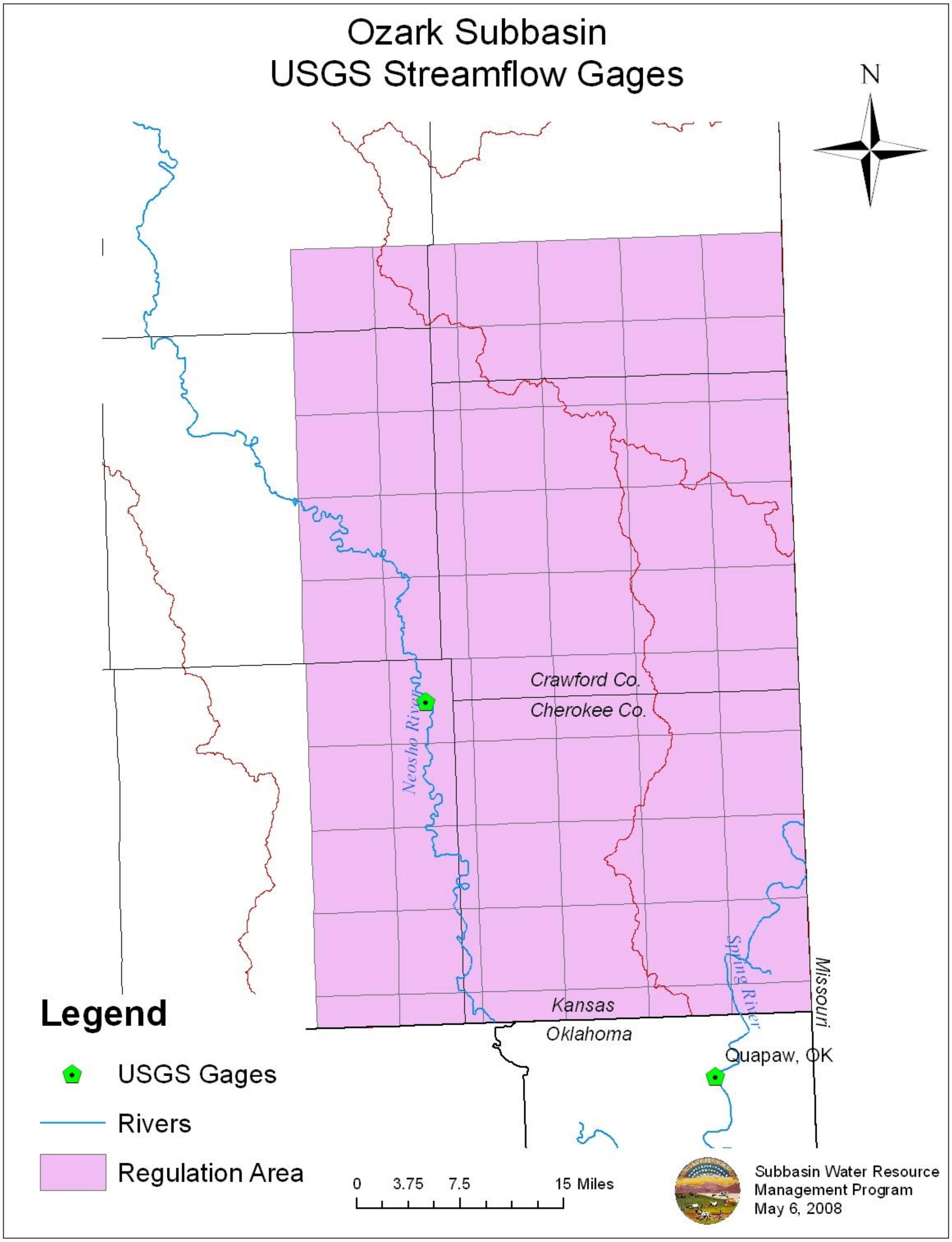

Figure 5: Neosho River and Spring River USGS streamflow gage

Figure 6 was derived from the Parsons, Kansas and Quapaw, Oklahoma USGS gages and demonstrates how flow can vary each year. Following the 1951 flood the Neosho River reached periods of little to no flow during the subsequent drought.

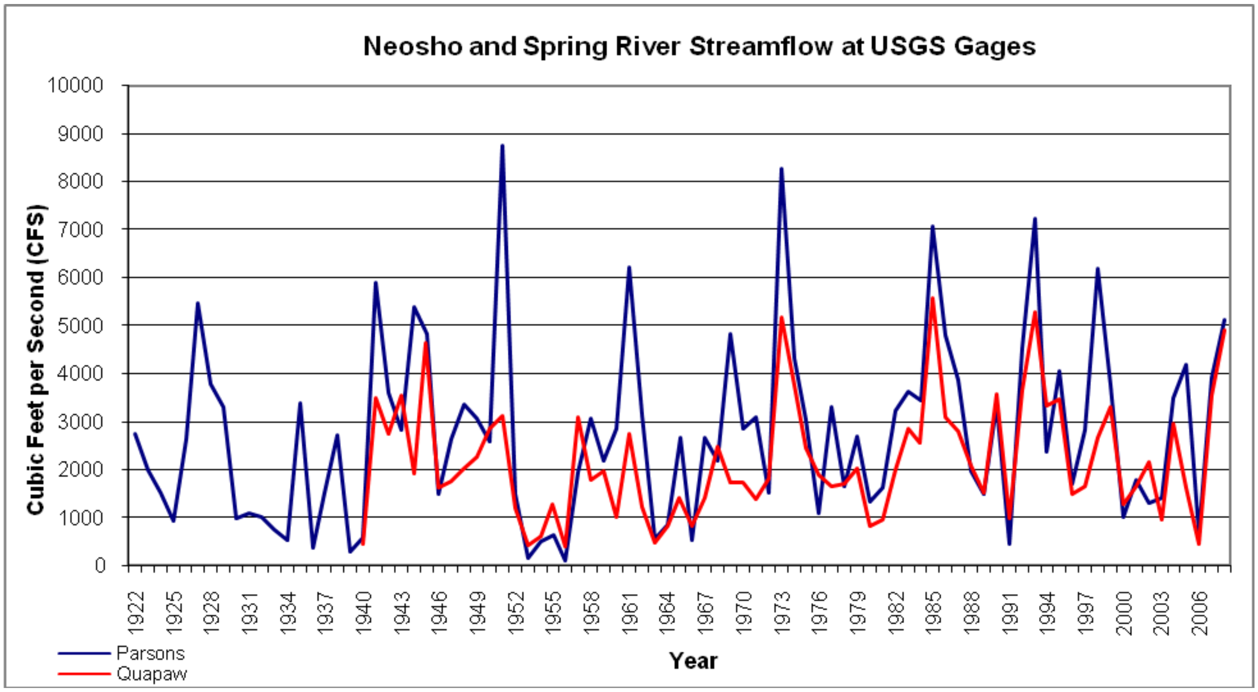

Figure 6: Streamflow at USGS Gages 1921-2008

In 1984, the Kansas legislature amended the Kansas Water Appropriation Act to establish Minimum Desirable Streamflows (MDS) on certain watercourses in Kansas. The statutory provision provided for the establishment of MDS flow criteria to be designated on a number of Kansas streams prior to a 1990 deadline. MDS flow criteria was established on the Neosho and Spring Rivers at specific USGS streamflow gages. Table 1 represents the MDS values for the lower Neosho River and the Spring River USGS streamflow gages.

Figure 7 shows the streamflow measurements for 2008, which were above MDS levels. The lower Neosho River gage is located near Parsons, Kansas and is used in administering MDS between the Iola, Kansas USGS gage and the Parsons, Kansas USGS gage. The Spring River gage near Quapaw, Oklahoma is used in administration of MDS at Baxter Springs, Kansas. The MDS values for the Neosho River near Parsons in parenthesis in Table 1 represent the spawning flows that are managed if the reservoir is in flood pool.

Table 1: Minimal Desirable Streamflow (MDS)

River	Gage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Neosho	**Parsons**	50	50	50	50 (100)	50 (300)	50 (300)	50	50	50	50	50	50
Spring	**Quapaw**	175	200	250	300	450	350	200	160	120	120	150	175

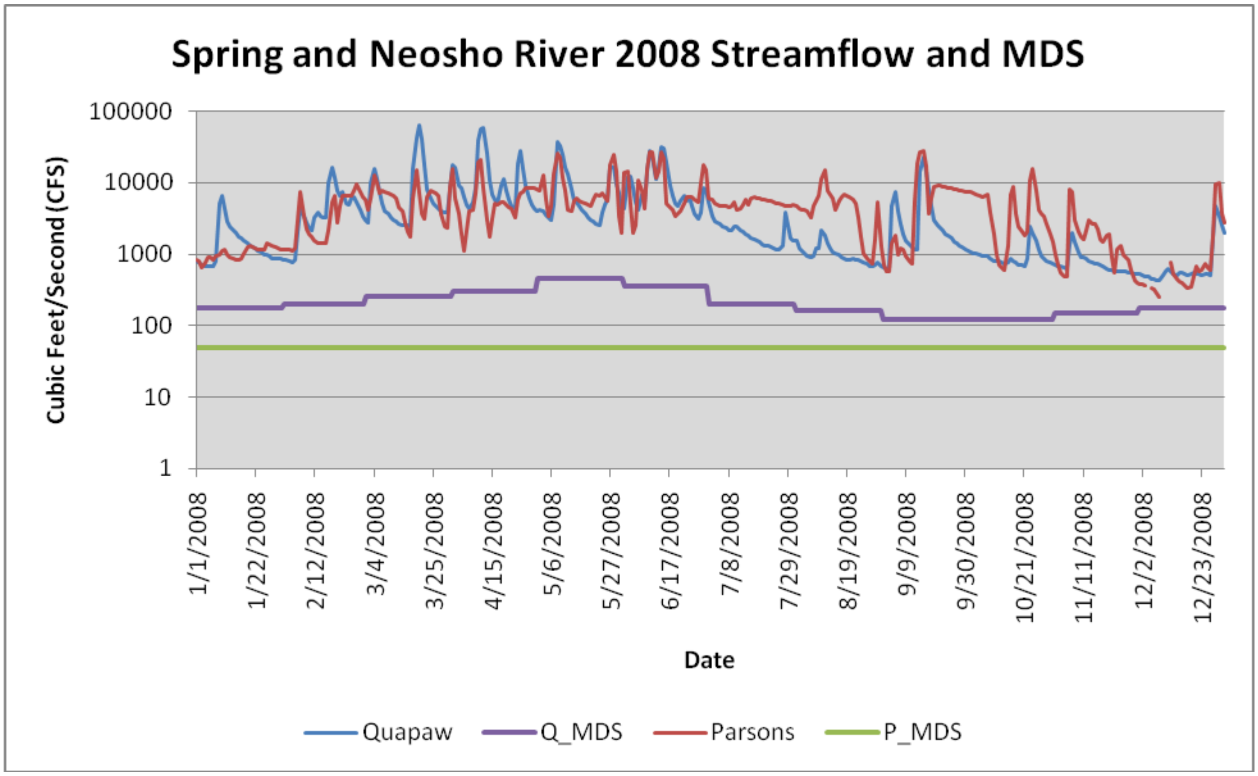

Figure 7: Daily Streamflow and MDS for 2008

Figure 8 charts the potential days in which MDS criteria are not met at the lower Neosho River gage and Spring River gage. Since MDS was established in 1984, the frequency of streamflow below the MDS criteria has been less at the Quapaw gage than at the Parsons gage. This is partly due to the fact that streamflows on the lower Neosho River are affected by operations of three federal reservoirs located within the basin (Marion, Council Grove, and John Redmond Reservoirs). The lower Neosho has a greater potential for flows below MDS criteria for consecutive years, resulting in the administration of MDS on the Neosho River in 2002, 2003, 2006, and 2007. MDS administration occurred for the first time on the Spring River in 2006.

The Parsons gage on the Neosho River has a longer record dating back to 1922, while recording on the Spring River at the Quapaw gage started in 1940. Over the periods of record, the average streamflow at the Parsons gage on the Neosho River was 2,762 cfs and 2,212 cfs at the Quapaw gage on the Spring River. During the 1990s, the Parsons gage had reduced flows and averaged 1,994 cfs. On the other hand, the Quapaw gage averaged 2,948 cfs during the 1990s. The Parsons gage is averaging higher streamflows at 2,543 cfs than the Quapaw gage at 2,177 cfs from 2000 to 2008.

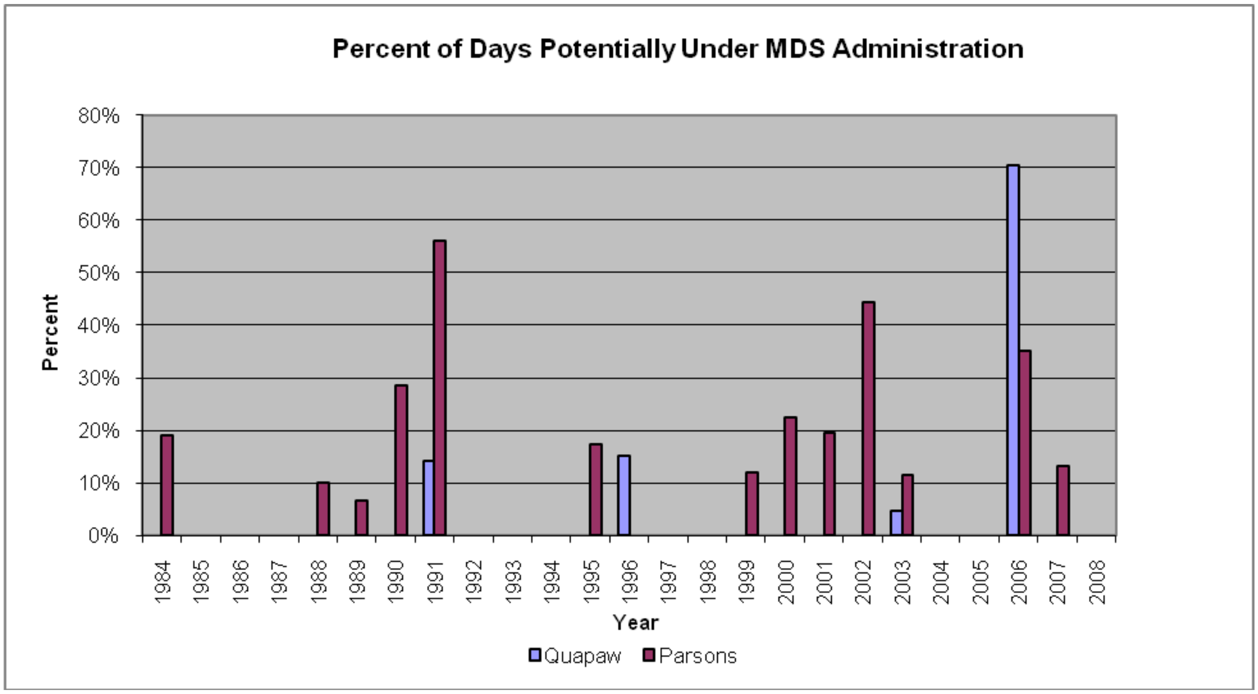

Figure 8: Percent of days potential MDS is not met at USGS gages

IV. Groundwater

In the Ozark Plateau region there are two aquifer sources in which groundwater level measurements are taken: the Ozark aquifer and the Springfield Plateau aquifer. The Springfield Plateau aquifer is of poor quality water and not used much for domestic purposes. Monitoring wells used in this report are located in the Ozark aquifer and what we refer to as the Ozark Plateau aquifer (wells believed to be screened in both the Ozark and the Springfield aquifers). There are no known monitoring wells solely screened in the Springfield Plateau aquifer besides the dedicated observation well at Pittsburg, Kansas. For this fieldwork summary, groundwater data was grouped by aquifer source and geographic location. The monitoring well network is shown in Figure 9. Figures 10 through 13 chart the groundwater levels in the Ozark and the Ozark Plateau aquifer by location. Well depths and water level trends vary between individual wells, which are partly due to the majority of the well network consisting of active municipal wells.

There is little historical water level data to compare to current water levels. In the future, five-year rolling averages will be prepared. The KDA-DWR measures a total of 27 wells in the Ozark Plateau region. Generally, winter (December, January and February) measurements are used for the Subbasin Water Resource Management Program field analysis summary as this is a period in which irrigation wells are usually not pumping and recovery of the water table is occurring. Historically, in this area, spring, summer and fall were the common times to measure groundwater level data. Since the wells monitored are mostly municipal wells that pump year-round, capturing a period of recovery would be difficult. In reviewing the data, fall measurements (September, October, and November) seemed to be the most consistent time in which groundwater levels were taken; therefore, they were used for this analysis. Legal descriptions and names for monitoring wells are available in the appendix.

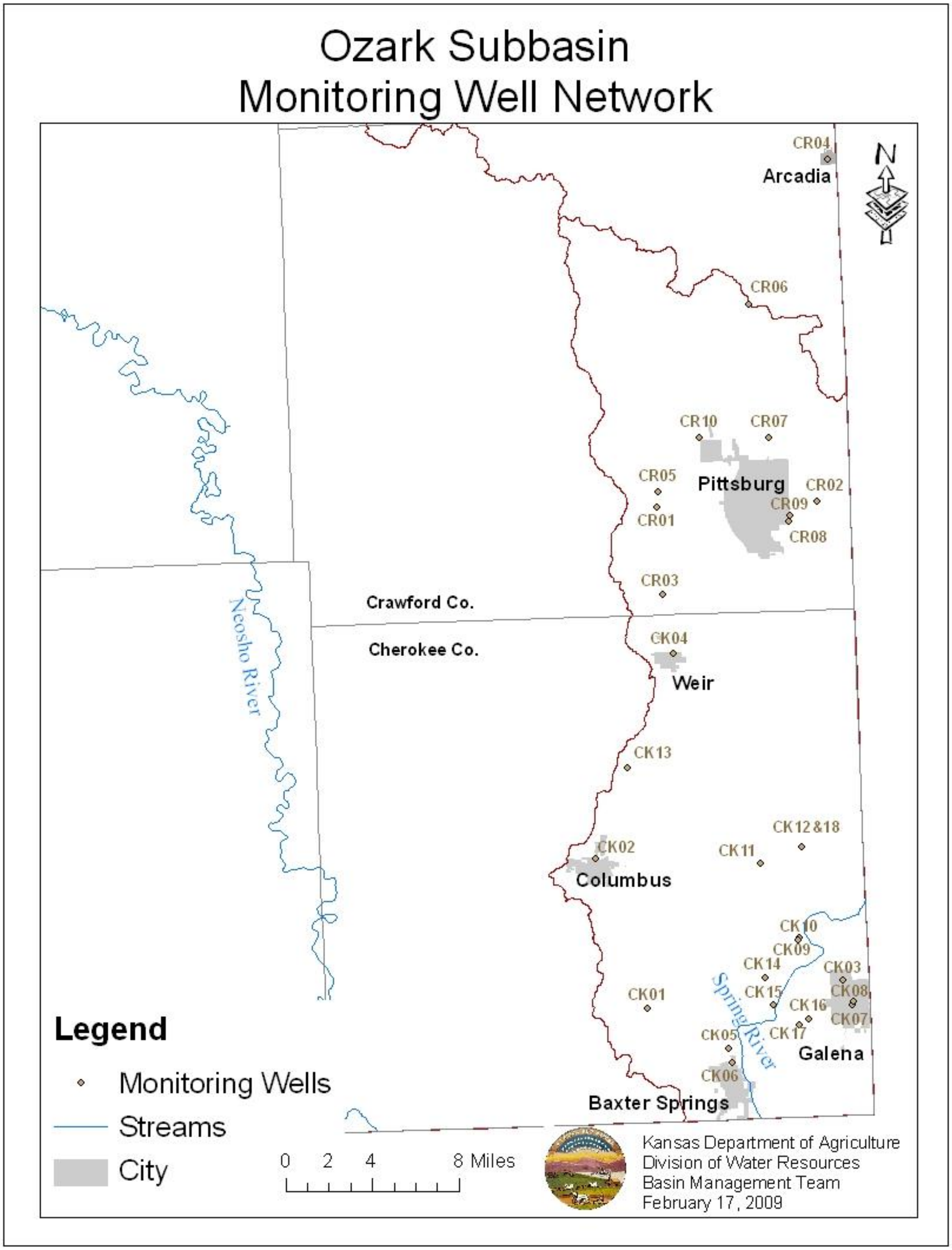

Figure 9: Ozark Monitoring Wells

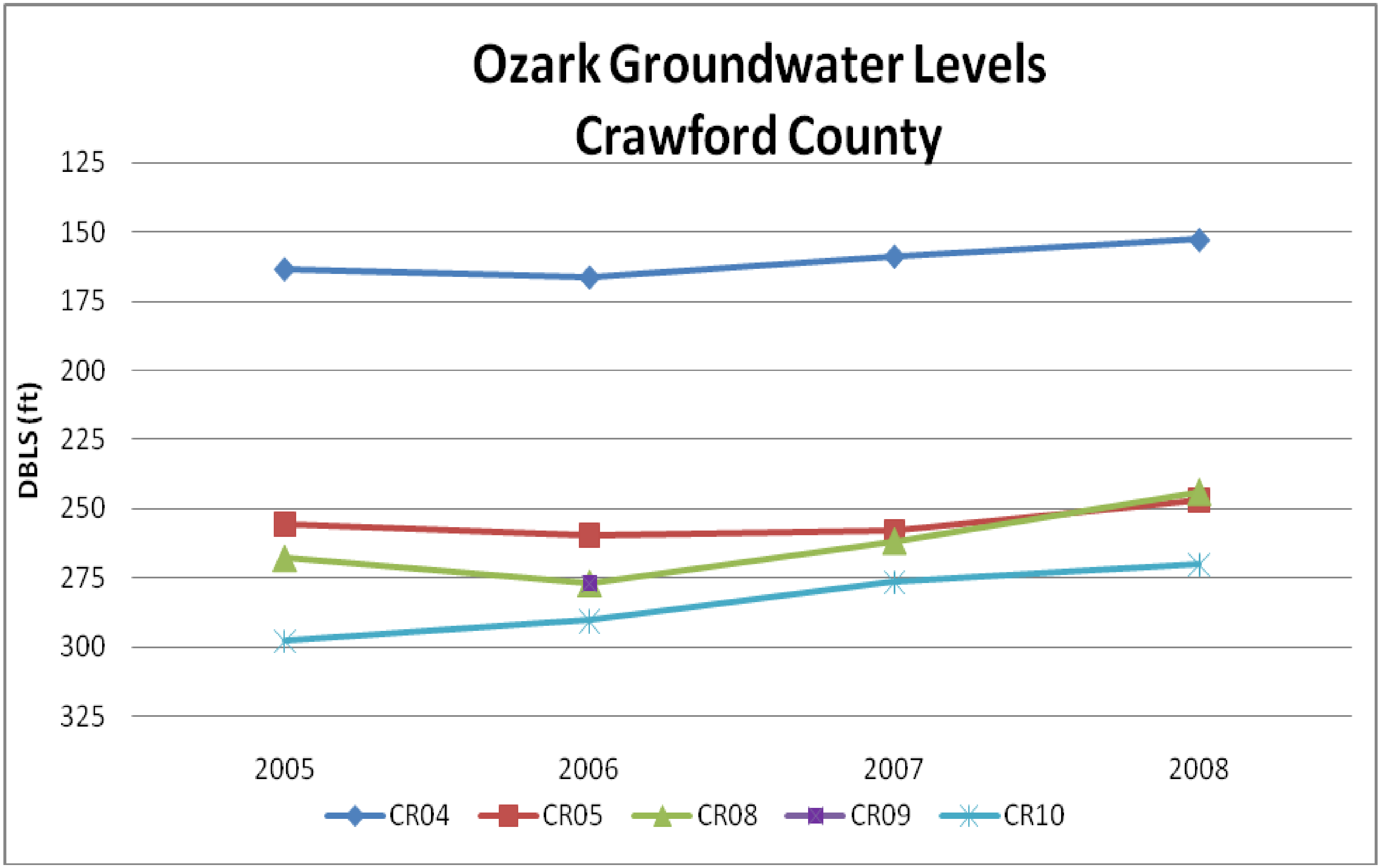

Figure 10: Groundwater levels for the Ozark aquifer in Crawford County

In the Ozark aquifer, there are 20 monitoring wells, which are identified by the Kansas Geological Survey well ID numbers as shown in Figures 10-13. Figure 10 shows that the groundwater levels for the Ozark aquifer in Crawford County overall had decreased an average of 2 feet from 2005 to 2006 but have increased about 20 feet from 2006 to 2008.

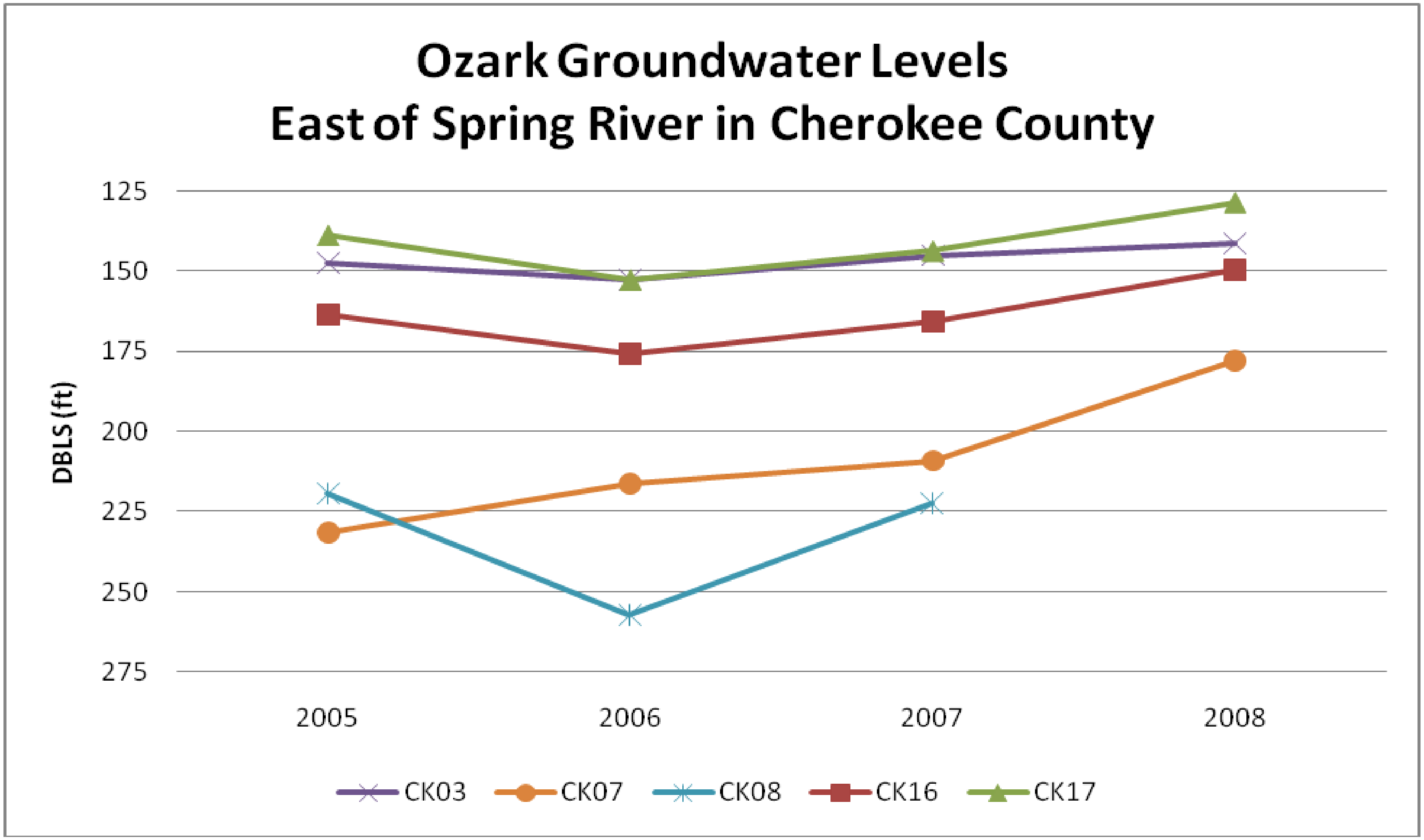

Figure 11: Ozark groundwater levels East of the Spring River in Cherokee County

Figure 11 shows groundwater levels in Cherokee County that are East of the Spring River. From 2005 to 2006 average water levels declined about 11 ft. However, from 2006 to 2008 overall water levels recovered an average of 25 ft. CK08 declined about 38 feet from 2005 to 2006 but recovered 35 feet from 2006 to 2007. Since CK08 is a pumping well, the data may represent pumping levels as opposed to a static water level. CK08 was obstructed and could not be measured in 2008.

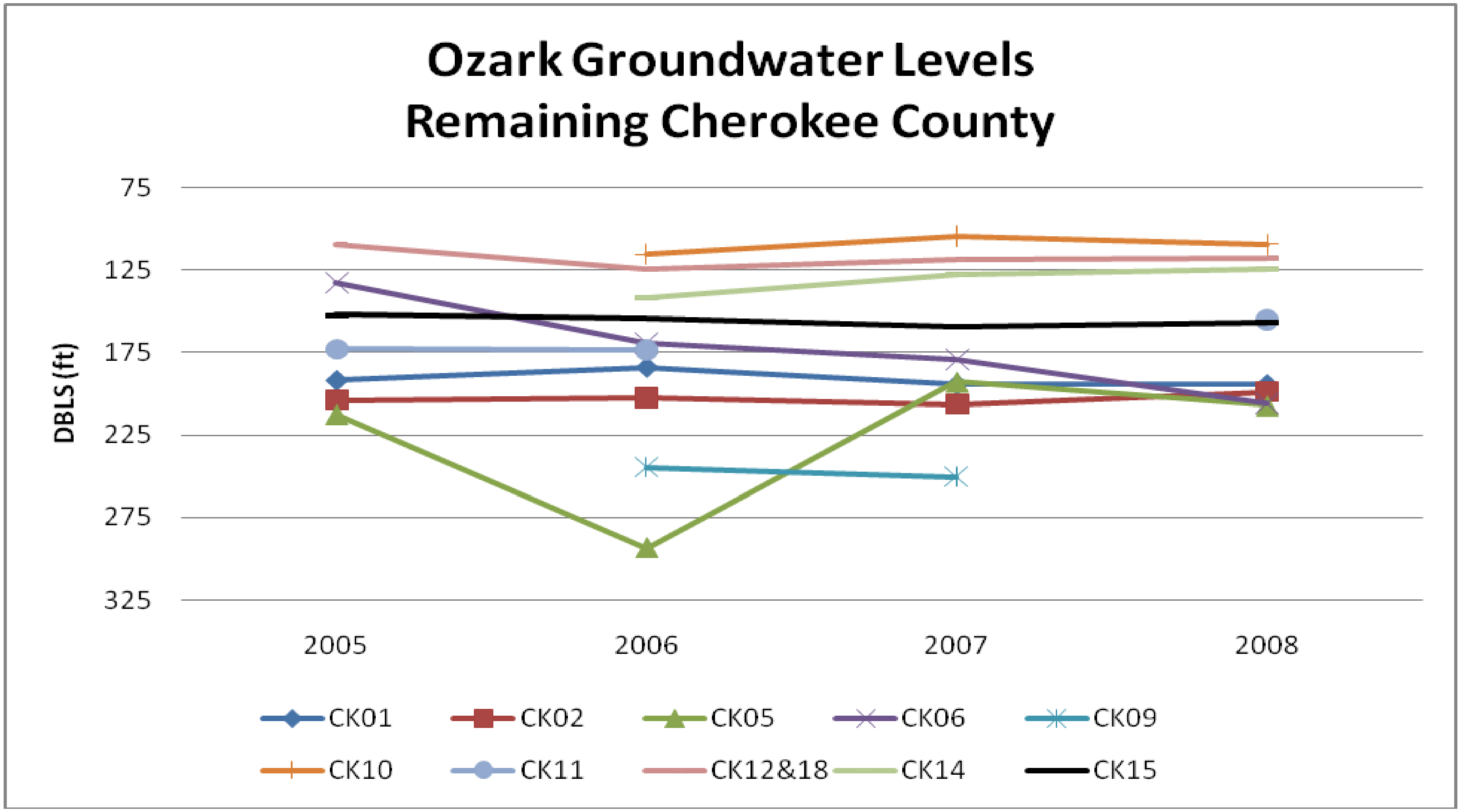

Figure 12: Ozark groundwater levels for remaining Cherokee County wells (non-east) of the Spring River

Figure 12 shows the Ozark groundwater levels for the remaining wells in Cherokee County that are not east of the Spring River. Overall, from 2005 to 2006 the wells declined an average of 21 feet and recovered an average of 10 feet from 2006 to 2007. From 2007 to 2008 overall well levels declined an average of 4 ft. CK05 declined about 37 feet from 2005 to 2006, recovered about 100 feet from 2006 to 2007, and then declined about 14 feet from 2007 to 2008. CK05 has declined approximately 81 ft from 1987 to 2008. CK12/CK18 has shown similar trends to CK05 and have declined about 41 ft from 1975-2008. Since these are pumping wells, some data is representative of pumping levels instead of static water levels. CK09 was pumping and could not be measured in 2008.

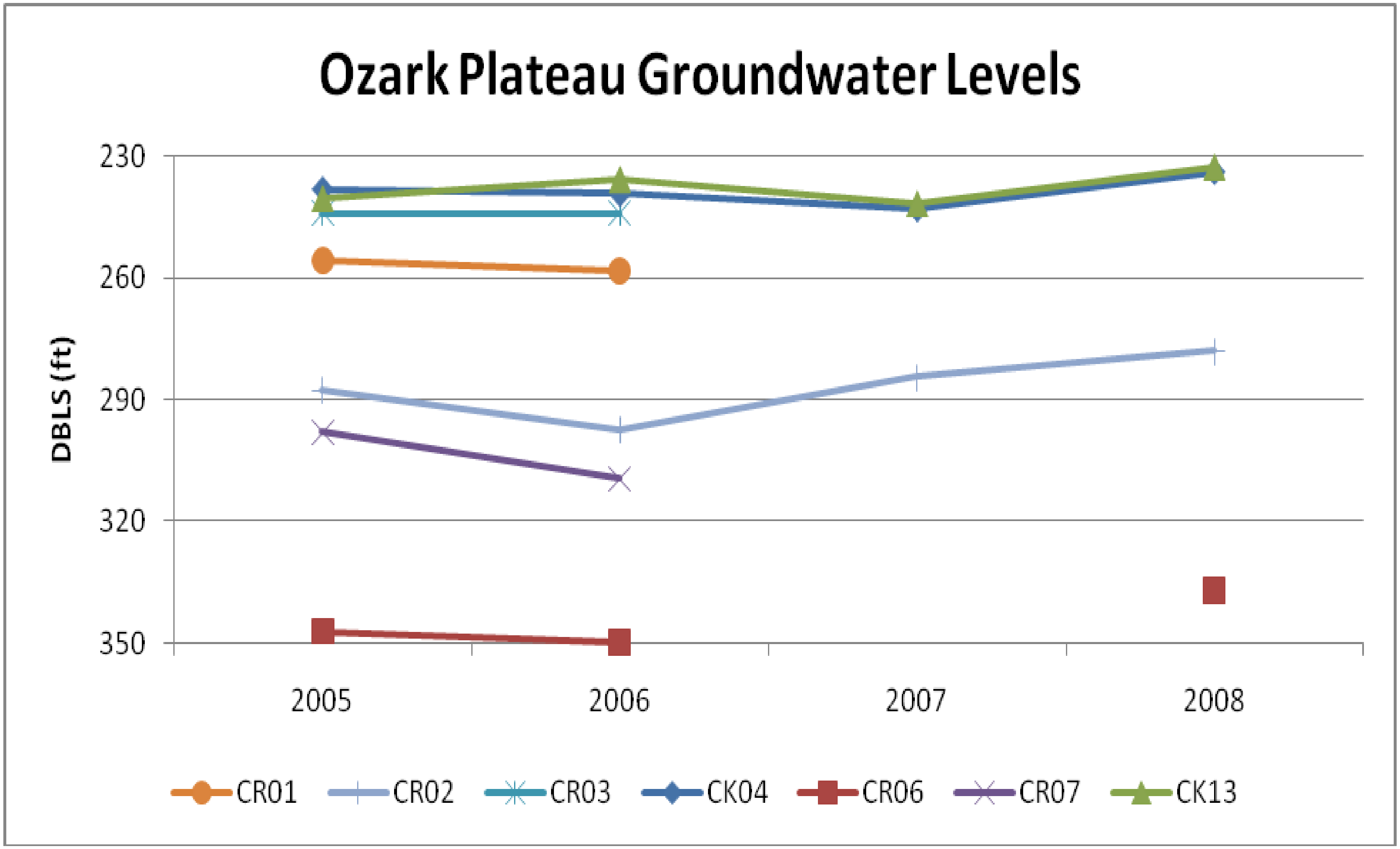

Figure 13: Groundwater levels in the Ozark Plateau aquifer

In the Ozark Plateau aquifer there are seven monitoring wells (Figure 13). Overall from 2005 to 2006 water levels declined by about 3 feet but increased nearly 10 feet from 2006 to 2008. CR07 has not been measured for the past two years due to sludge. CR01 and CR03 are no longer part of the monitoring network, and will not be included in subsequent reports.

V. Water Quality

Figure 14 to 17 chart salinity and conductivity values in the Ozark aquifer and Ozark Plateau aquifer from March 2007 to December 2008. Figure 14 and 15 show salinity levels have remained fairly consistent throughout the network. Figure 14 charts a range in salinity from 200 to 600 parts per million (ppm) in the Ozark aquifer, while the Ozark Plateau aquifer (Figure 15) has a range from 300 to 600 ppm. The U.S. Environmental Protection Agency's (EPA) secondary drinking water standard for chloride is 250 ppm.

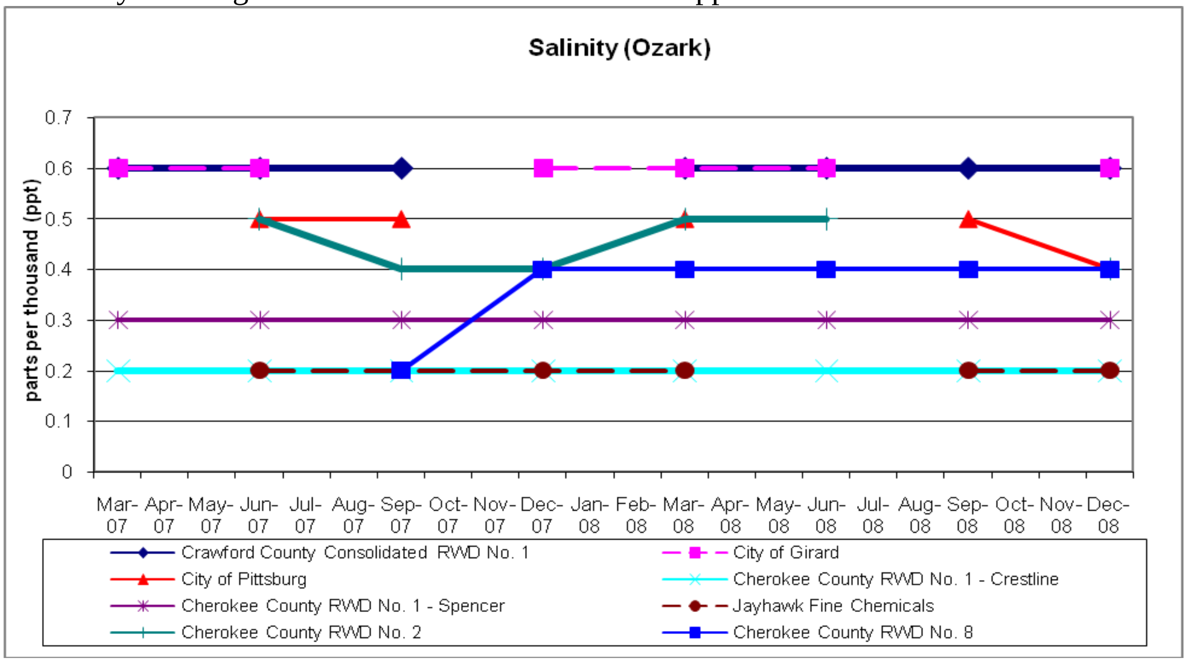

Figure 14: Ozark Aquifer Salinity

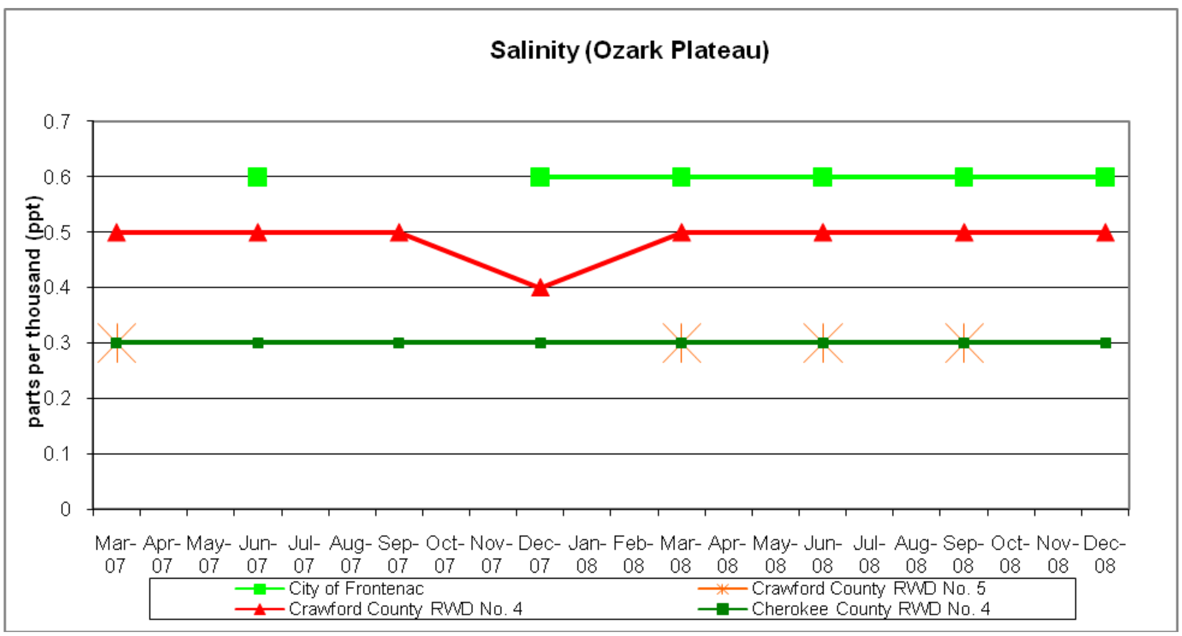

Figure 15: Ozark Plateau Aquifer Salinity

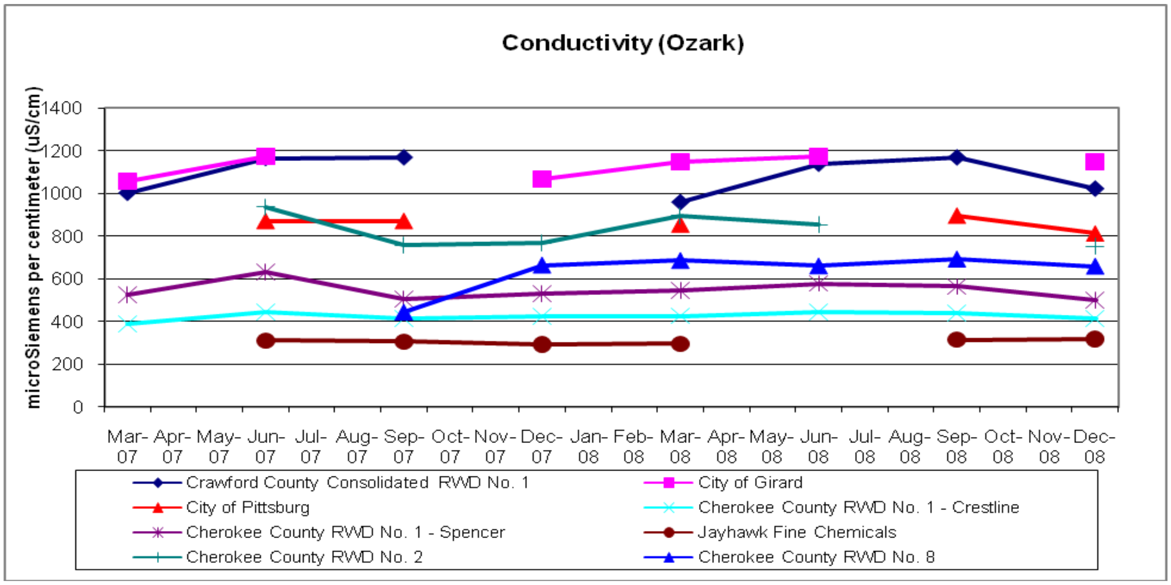

Figure 16: Ozark Aquifer Conductivity

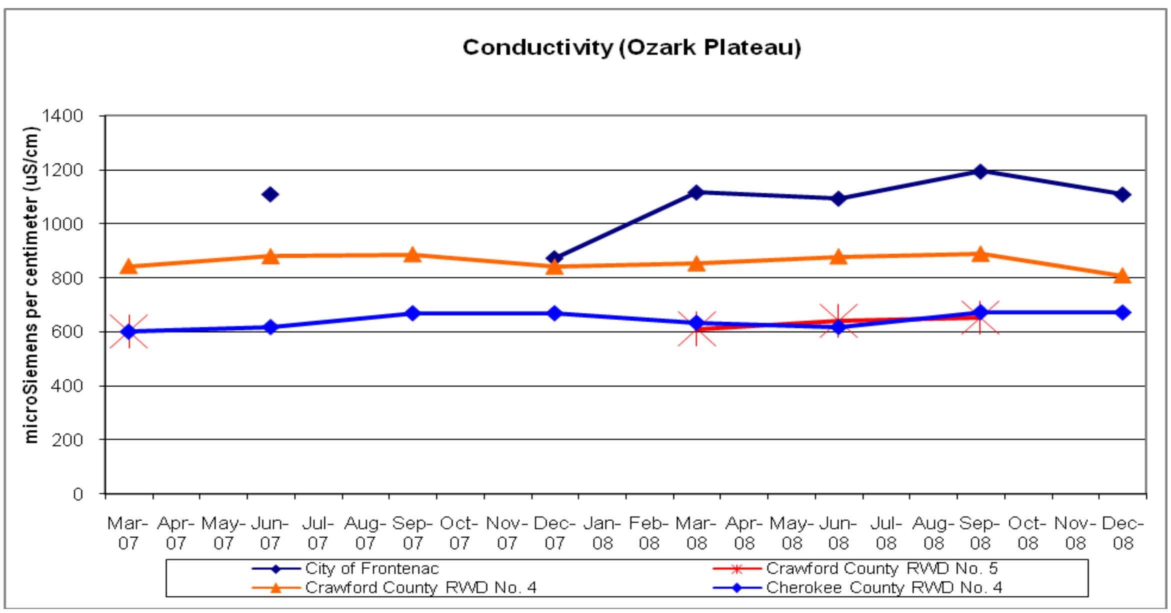

Figure 17: Ozark Plateau Aquifer Conductivity

Figure 16 and 17 chart conductivity values for the Ozark aquifer and the Ozark Plateau aquifer. As with the salinity values, conductivity values remain fairly consistent with a range in the Ozark aquifer of 200 micosiemens/centimeter (µS/cm) to 1200 µS/cm (Figure 16) and a range in Ozark Plateau aquifer from 600 µS/cm to 1200 µS/cm (Figure 17). The electrical conductivity of water is directly related to the concentration of dissolved solids in the water. However, in order to determine the relationship laboratory tests are needed to correlate conductivity with total dissolved solids. The EPA secondary drinking water standard for total dissolved solids is 500 ppm; without knowing the correlation factor for these groundwater sources it is unknown at this time whether the range of conductivity measured in these aquifers is above or below the secondary drinking water standard.

VI. Water Use

The portion of the Neosho River basin and Spring River basin within the Ozark Plateau moratorium region has a total of 219 water rights with an authorized quantity of 257,614 acre-feet. These water right numbers are for the following counties: Neosho, Crawford, Labette and Cherokee. The source of supply is groundwater for 95 water rights, or 43% of the total rights (Table 2). This analysis includes all water rights authorized for irrigation, municipal, recreation, industrial, domestic and stock water uses and includes moratorium term permits within the Ozark Plateau moratorium region.

Table 2: Water Rights in the Neosho and Spring River Subbasin[1]

Type	Source	Number of Rights	Authorized Quantity
Vested	Surface Water	12	156,960AF
Appropriated	Surface Water	112	88,341 AF
Vested	Groundwater	14	2,111 AF
Appropriated	Groundwater	81	10,202AF
Total		**219**	**257,614 AF**

The points of diversion associated with these water rights are shown in Figure 18. One water right may have multiple points of diversion. In the Neosho River basin, some municipal and industrial users obtain some of their water supply from federal reservoirs through Water Marketing contracts. Since Marketing Program contracts do not require water appropriation permits, diversions under contract are not reflected in Table 2. Additionally, all municipal and industrial users who divert surface water in the Neosho River basin are required to be members of the Cottonwood and Neosho River Basins Water Assurance District No. 3, which supports diversions of its members from a dedicated pool in Assurance reservoirs.

[1] The authorized acre-feet of usage for surface water include the amount of water that is diverted within the Spring River basin for industrial use by the Empire District Electric Company. Operations at the plant are largely flow-through cooling and a large portion of this water is discharged back into the Spring River. The Empire District Electric Company has three water rights; one of these rights is vested and the other two are appropriated. The total combined maximum authorized acre-feet for this company's rights totals to 177,794 acre-feet.

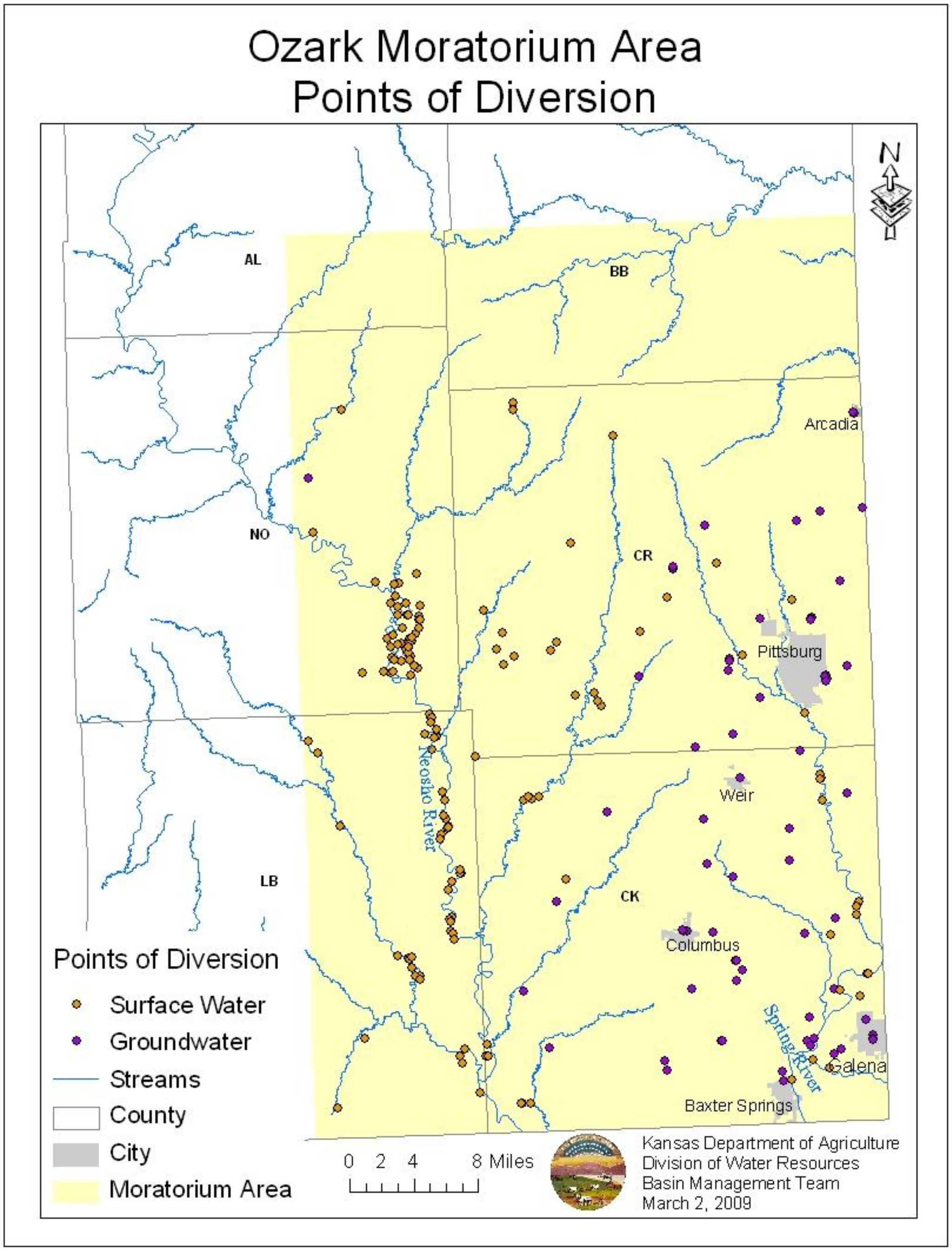

Figure 18: Points of Diversion within the Ozark Moratorium Area

Moratorium area water use tends to fluctuate per year largely due to varying surface water diversions within the Spring River basin used in cooling for the Empire District Electric Company. Usage ranges from 113,601 acre-feet in 2003 to 130,149 acre-feet in 1996. The total average water use over the twenty-year span was 122,767 acre-feet (Figure 19). Groundwater usage averages 7,859 acre-feet per year from 1990-2007, which is at 64% of authorized quantities. Average Spring River basin surface water use is 108,498 acre-feet, which is 48% of authorized quantities, whereas Neosho River basin surface water use is 6,393 acre-feet, or 32% of authorized quantities.

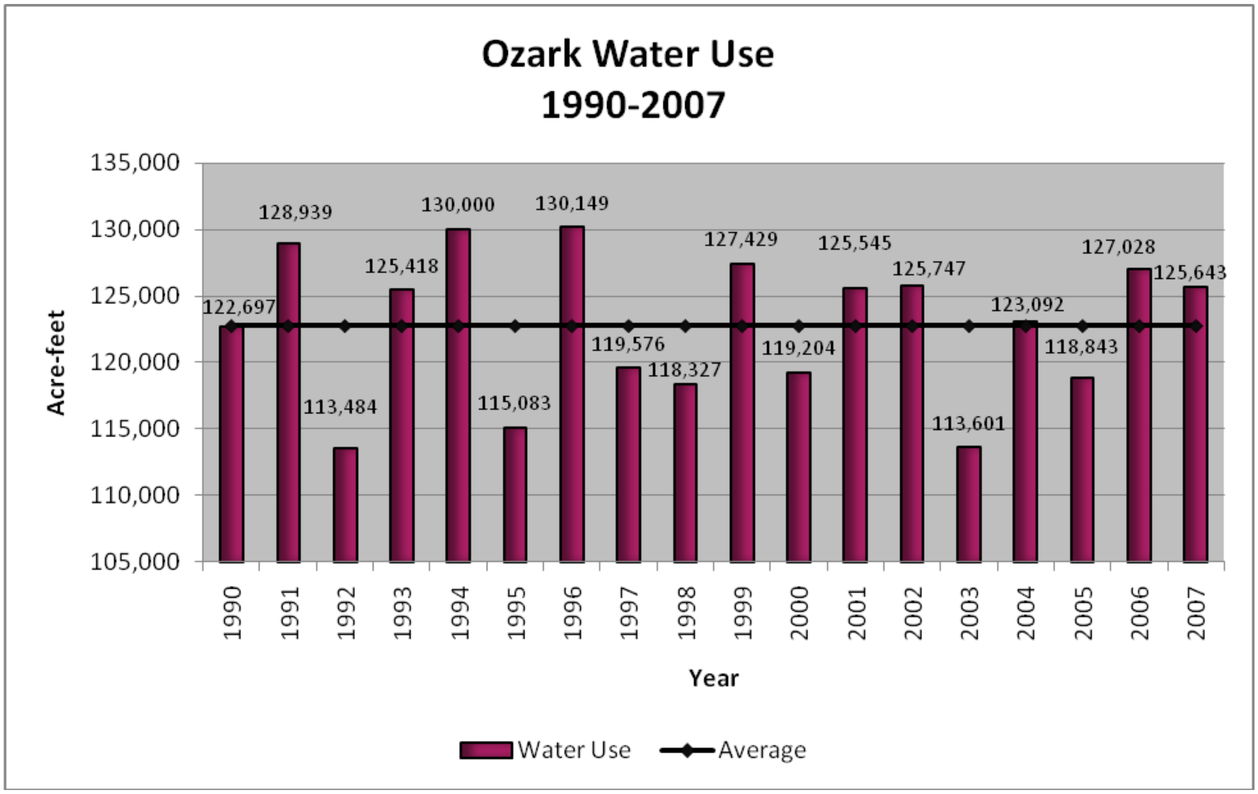

Figure 19: Ground and Surface water use 1990-2007

VII. Conclusions

In conclusion, precipitation in the regulated boundary area during 2007 averaged 53 in. and preliminary 2008 data averaged 54 in., which are well above the normal average of 41 in. per year. Groundwater usage was 6,724 acre-feet in 2007, which has declined 1,567 acre-feet since 1999. Total surface water use was 118,919 acre-feet in 2007, which is above average. With above average precipitation in 2007 and 2008, streamflow levels improved and remained above MDS levels for 2008. Salinity and conductivity levels for both the Ozark aquifer and Ozark Plateau aquifer remained consistent from March 2007 to December 2008. In general the Ozark aquifer and the Ozark Plateau aquifer water levels have increased from 2007 to 2008. However, when looking at the geographic location of the wells, it seems that the wells in Cherokee County located generally to the west or north of the Spring River have experienced more historical declines and have had an overall decrease of 4 ft from 2007 to 2008 (Figure 12). With the release of the groundwater model later this year, water quantity, recharge, and water movement should be better understood. Continued monitoring of hydrologic conditions and their response to climate variations is important for evaluating the long-term effects of water usage on this subbasin and protection of property rights. It is important to understand recharge and the impacts of pumping and other factors on the hydrologic system.

VIII. Appendix

Name	Well ID	Aquifer	Legal	Latitude	Longitude
Cherokee Co. RWD 2	CK14	Ozark	34S25E08SWNWSW	37.0930	-94.7040
Cherokee Co. RWD 9	CK15	Ozark	34S25E20NWNENW	37.0741	-94.6983
Cherokee Co. RWD 8	CK16	Ozark	34S25E21NWNESE	37.0640	-94.6690
Cherokee Co. RWD 8	CK17	Ozark	34S25E28NWNWNW	37.0600	-94.6770
Galena	CK07	Ozark	34S25E23SENENE	37.0720	-94.6320
Galena	CK08	Ozark	34S25E13SWSWSW	37.0750	-94.6310
Galena	CK03	Ozark	34S25E14NWNWNE	37.0890	-94.6390
Baxter Springs	CK05	Ozark	34S24E36NENWNW	37.0460	-94.7370
Baxter Springs	CK06	Ozark	34S24E36NWNWSW	37.0370	-94.7350
Cherokee RWD 3	CK01	Ozark	34S24E17SWSWSE	37.0750	-94.8040
Jayhawk Fine Chemicals	CK09	Ozark	34S24E04NENWNE	37.1190	-94.6740
Jayhawk Fine Chemicals	CK10	Ozark	34S25E04NENWNE	37.1170	-94.6750
Cherokee RWD 1	CK11	Ozark	33S25E18NENESE	37.1700	-94.7050
Cherokee RWD 1	CK12&18	Ozark	33S25E09SENESE	37.1800	-94.6690
Columbus	CK02	Ozark	32S23E13NENENW	37.1770	-94.8430
Cherokee Co. RWD 4	CK13	Ozark Plateaus	32S24E29NWNWNW	37.2370	-94.8130
Weir	CK04	Ozark Plateaus	31S24E27NWSESW	37.3130	-94.7710
Arma	CR06	Ozark Plateaus	29S25E05SESESW	37.5446	-94.6962
Frontenac	CR07	Ozark Plateaus	20S25E04NESWSW	37.4550	-94.6840
Girard	CR05	Ozark	30S24E21NESENE	37.4218	-94.7784
Arcadia	CR04	Ozark	28S25E01NESWNE	37.6404	-94.6250
Crawford Co. RWD 1C	CR10	Ozark	30S24E02SESESE	37.4568	-94.7419
Pittsburg DWR	CR09	Ozark	30S25E28NENESE	37.4021	-94.6685
Pittsburg	CR08	Ozark	20S25E28SESESE	37.3980	-94.6700
Crawford Co. RWD 4	CR01	Ozark Plateaus	30S24E28NENENE	37.4110	-94.7800
Crawford Co. RWD 4	CR03	Ozark Plateaus	31S24E16NENENE	37.3530	-94.7780
Crawford Co. RWD 5	CR02	Ozark Plateaus	30S25E23SESWSW	37.4111	-94.6449