Report as of FY2006 for 2006KS50B: "Assessment of Seasonal, Pumping Induced Water Quality Changes in the Ozark Plateaus Aquifer System, Southeast Kansas and Southwest Missouri -- Year 1"

Publications

Project 2006KS50B has resulted in no reported publications as of FY2006.

Report Follows

ASSESSMENT OF SEASONAL, PUMPING-INDUCED WATER QUALITY CHANGES IN THE OZARK PLATEAUS AQUIFER SYSTEM, SOUTHEAST KANSAS AND SOUTHWEST MISSOURI

Start Date
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End Date
February 29, 2008

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Ozark Plateaus aquifer system, Springfield Plateau aquifer system, Ozark aquifer, water quality, pumping stress

Problem and Research Objectives

The Ozark Plateaus aquifer system consists of the Springfield Plateau and underlying Ozark aquifers and historically has been the single most important source of water in the Tri-State region of southeast Kansas, southwest Missouri and northeast Oklahoma. Concerns have been raised by the Kansas water agencies and the Tri-State Coalition (a multi-state organization consisting of water-related interest groups from the Tri-state region) that the available supply from the Ozark aquifer may become inadequate, rendered unusable, or require additional water treatment in the near future because of future overdevelopment. In response, the Division of Water Resources, Kansas Department of Agriculture (DWR) has instituted a moratorium on new appropriations from the aquifer system in southeast Kansas. The Southeast Kansas Ozark Aquifer Water Supply Study was also conducted by the Kansas Geological Survey to redesign a new water-level monitoring network.

Many southeast Kansas and southwest Missouri water supplies withdraw water from a 40-60-km wide transition zone in the Ozark aquifer separating low dissolved solids calcium-bicarbonate ground waters to the east from sodium chloride brines to the west (Figure 1). These supplies withdraw water using single or multi-aquifer wells. Two earlier regional studies indicated significant short and long-term changes in the chemical quality of produced water from these wells. It is unclear if the observed variability results from quality degradation in the Ozark, the Springfield Plateau, or both aquifers over the entire transition zone due to long-term use or if short-term variability in pumping stress is the dominant influence on water quality. The former implies eastward movement of poorer quality water whereas the latter implies local upconing of poorer quality water from the lower part of the aquifer. The data needed to evaluate these mechanisms is currently unavailable. Earlier studies were done in the 1970s and early 1980s and no synoptic sampling has since been carried out to assess how these changes have progressed within the transition zone in southeast Kansas and southwest Missouri.

The goal of this proposed project is to assess the influence of pumping on the temporal variability in the quality of water produced in single and multi-aquifer wells in two small areas within the Ozark aquifer transition zone in Crawford and Cherokee counties in southeast Kansas and Barton and Vernon counties in southwest Missouri. Toward this end, the first year of the project has focused on characterizing the magnitude and timing of the changes in the geochemistry of the Ozark Plateaus aquifer system relative to pumping stress at 9 sites within the transition zone in southeast Kansas. The project has also addressed the temporal aspects of water quality change within the Ozark aquifer transition in the 25 years since previous investigations were reported.

The project addresses the following Kansas Water Plan objectives:
By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala aquifer and areas specifically exempt by regulation.
By 2010, ensure that all public water suppliers have the technical, financial, and managerial capability to meet their needs and Safe Drinking Water Act requirements.
By 2010, less than 5 percent of public water suppliers will be drought vulnerable.

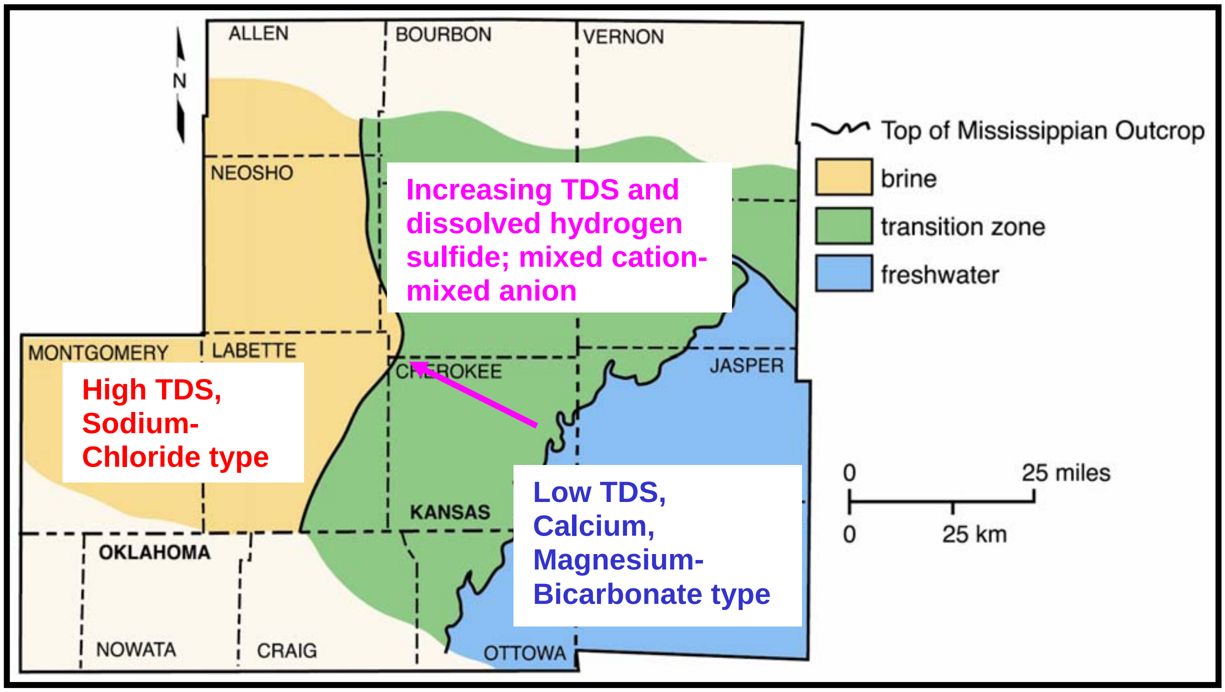


Figure 1. Extent and characterization of the three water quality provinces in the Ozark aquifer in the Tri-State region of southeast Kansas, southwest Missouri, and northeast Oklahoma. Taken from Macfarlane and Hathaway (1987).

Methodology

Well selection: In the initial plan two sets of nearby wells located within the Ozark aquifer transition zone were to be selected for water sampling. Each set was to consist of an Ozark, Springfield Plateau, and multi-aquifer well and ideally the wells in each set were to be located within a few kilometers of each other. However, difficulty was experienced in securing Springfield Plateau aquifer wells for incorporation in the study. As an alternative, nine municipal and rural water district wells located within the Ozark aquifer water-quality transition zone were selected for monthly water sample collection and water-level monitoring (Figure 2, Table 1).

Water sampling and water-level measurements: The wells were visited monthly to collect water samples and water-level data. On arrival at the well site the depth to water from surface was measured and the owner/operator was asked when the well was last pumped, if the well had not been pumping. Depth to water measurements were made with a chalked and unweighted steel tape. In October 2006 an In Situ mini-TROLL was installed in an observation in the City of Pittsburg wellfield and set to collect and store for later downloading a measurement every 15 minutes for continuous monitoring (Figure 3).

After the pump was turned on, the sampling port (tap, usually) was opened and the water was allowed to flow. As the water flowed from the sampling point, ground-water temperature and specific conductance were monitored. Samples were not collected until both parameters stabilized and at least one well volume of water had been pumped out. Ground-water temperature, specific conductance, and pH were measured on site and recorded prior to collection of a water sample. Unfiltered 1 L samples were collected in numbered Nalgene

Table 1. Water supply wells sampled for water quality during the first year of the project.

Water supply	Well Number	Aquifer	Township S	Range E	Sec.	Qualifier
Cherokee RWD 3	1	Ozark	34	24	17	SWSWSE
Columbus	4	Ozark	32	23	13	NENENW
Brock	1	Springfield Plateau	31	25	5	SWNWSE
Weir	1	Ozark Plateaus	31	24	27	NWSESW
Pittsburg	10	Ozark	30	25	28	NENESE
Girard	3	Ozark	30	24	21	NESENE
Crawford Co. RWD 1C	North well	Ozark	30	24	2	SESESE
Crawford Co. RWD 4	3	Ozark Plateaus	31	24	16	NENENE
Crawford Co. RWD 5	1	Ozark Plateaus	30	25	23	SESWSW

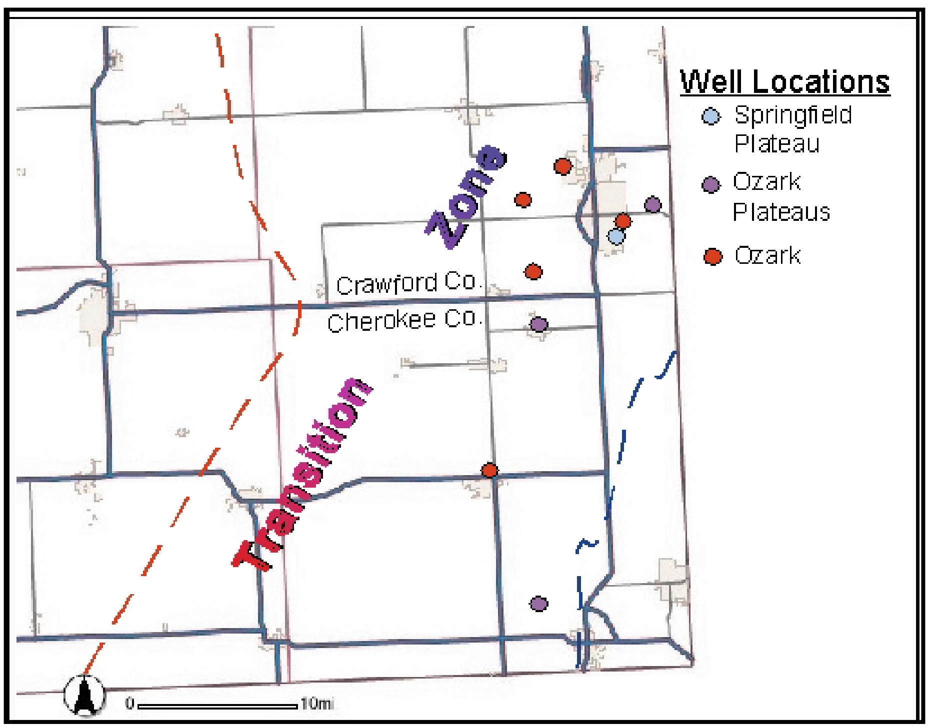


Figure 2. Distribution and construction of water supply wells sampled within the Ozark aquifer transition zone.

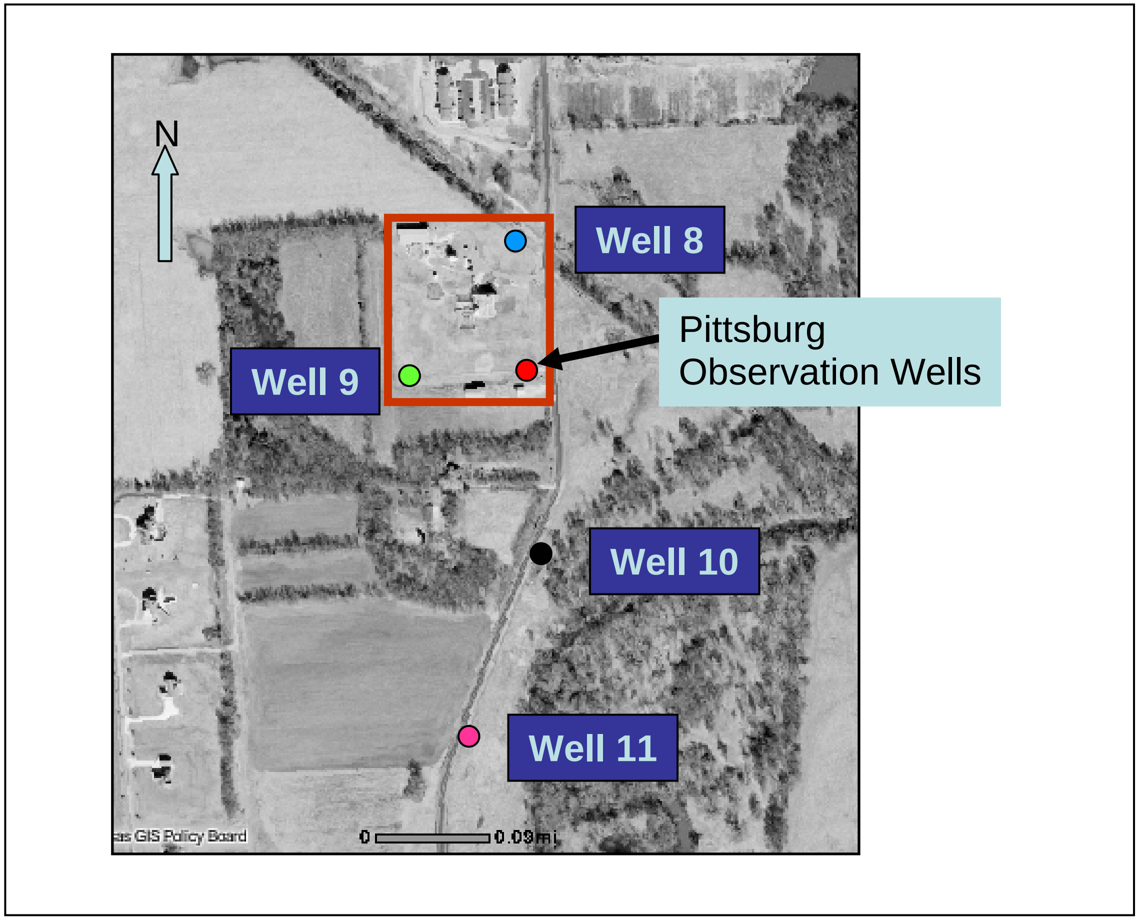


Figure 3. Layout of the City of Pittsburg wellfield with respect to the observation wells.

plastic bottles and stored on ice until their return to the KGS Analytical Services laboratory to be logged in for analysis.

Water analysis: After the samples had been logged in, they were filtered using 0.45 μm filter paper to remove suspended sediment prior to chemical analysis. Analyses were completed to determine major and selected minor constituent concentrations using standard atomic absorption and ion chromatographic techniques. pH and bicarbonate were determined in the laboratory using a titrimeter. Concentrations of dissolved silica, calcium, magnesium, sodium, potassium, strontium, and boron were determined using the ICP. Chloride and sulfate were determined using the Alpkem instrument. Fluoride was determined using an ion-specific electrode.

Pumpage data: With the exception of the City of Pittsburg, monthly pumpage data were not generally available from most supplies by the end of the first year of the project the DWR.

High-frequency specific conductance monitoring: In the project proposal, a downhole sonde was to be inserted in each monitored multi-aquifer well to monitor changes in specific conductance in the zone where waters from both aquifers mix in the well. The high-frequency specific conductance data were to be used to (1) help characterize short-term impacts of pumping on water quality associated with short-term variability (less than one month) in the amount of pumping at each site and (2) develop insight into longer-term water quality changes. This part of the project could not be completed because access to the interior of the well was limited. The probes were generally larger in diameter than that of the access hole. Furthermore, insertion was likely to be unsuccessful because of the danger of getting the sonde entangled in the pumping equipment and cables already suspended in the well. As a result this part of the project was abandoned.

Data analysis: The water chemistry data have been used to determine water types and create constituent ratio and time series plots for well sampled. Bar graphs of monthly amounts of ground water pumped from the Pittsburg wellfield were also prepared and compared to the time series water chemistry plots.

Results

The results of the first year of sampling show that the quality of produced water fluctuated in some wells but not others (Figures 4-8). Samples from City of Pittsburg well 8, Crawford Co. Consolidated Rural Water District (RWD) 1, City of Columbus well 4 and Cherokee Co. RWD 3, well 1, showed increases in chloride and a depression of the sulfate concentration in summer months relative to the samples collected during the rest of the year. Cherokee Co. RWD 3 also exhibited increases in bicarbonate and sodium, which suggests an increase in the relative amount of water being drawn into the well from the Springfield Plateau aquifer during periods of more intense pumping. The Springfield Plateau aquifer well is located within a mile of the Pittsburg wellfield. The chemical quality of the water it produces differs significantly from the water produced by the well 8 in the Pittsburg wellfield.

The chemical data from analysis of 1980 water samples from wells tapping the Ozark aquifer near the sodium-chloride type water brine zone have low sulfate to chloride ratios relative to

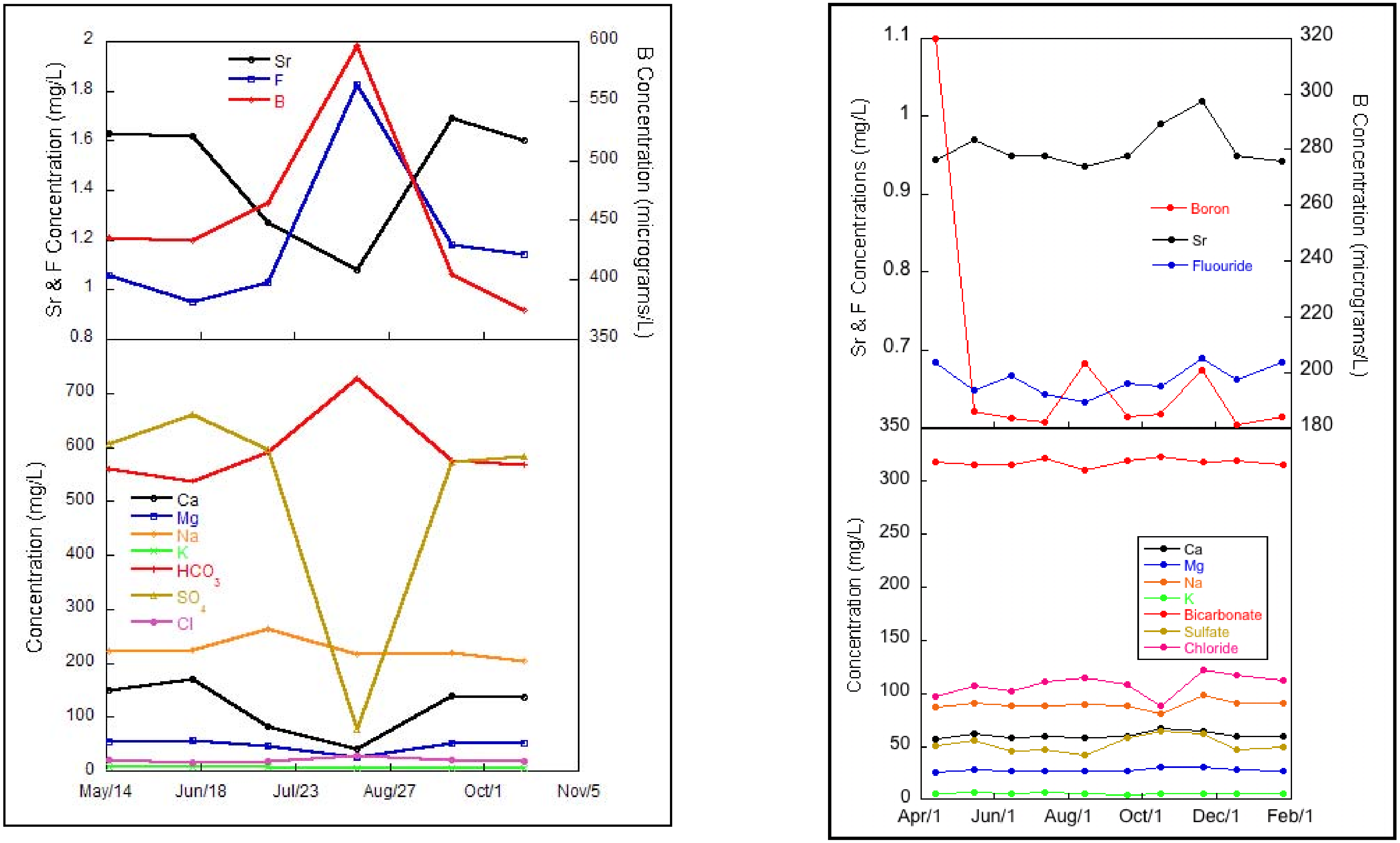
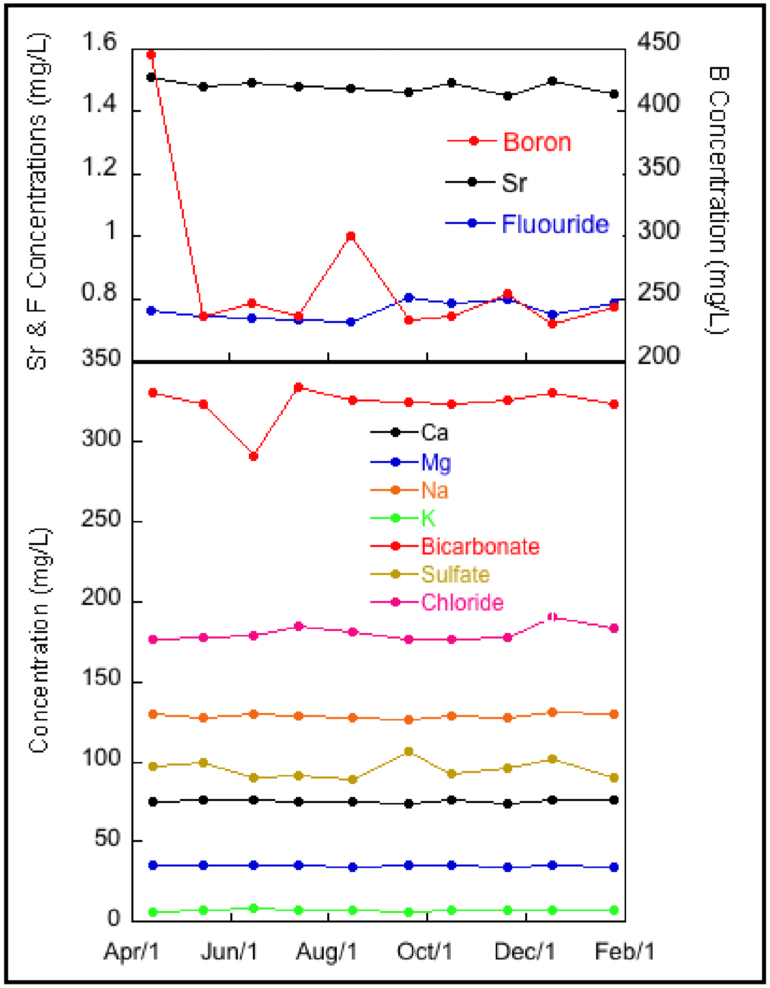


Figure 4. Monthly fluctuations in water chemistry from samples collected from the Springfield Plateau aquifer well at Pittsburg (left) and the Ozark aquifer well, the City of Pittsburg, well 8 (right).



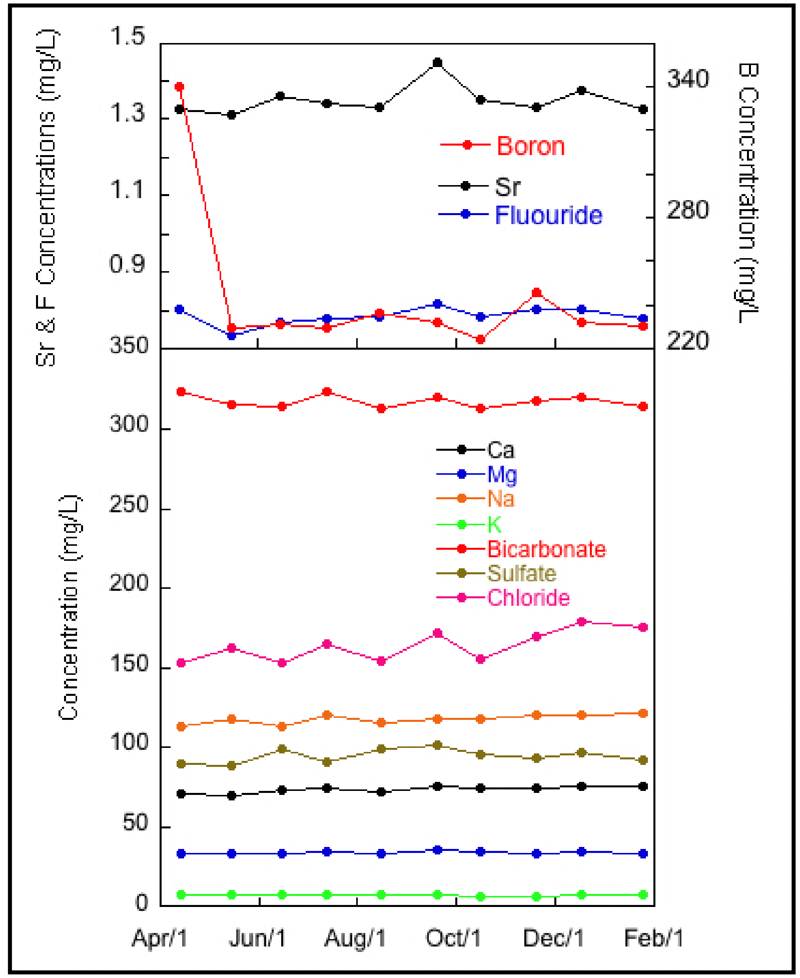


Figure 5. Monthly fluctuations in water chemistry from samples collected from Crawford Co. Consolidated RWD 1, well 1 (left) and the City of Girard, well 3 (right).

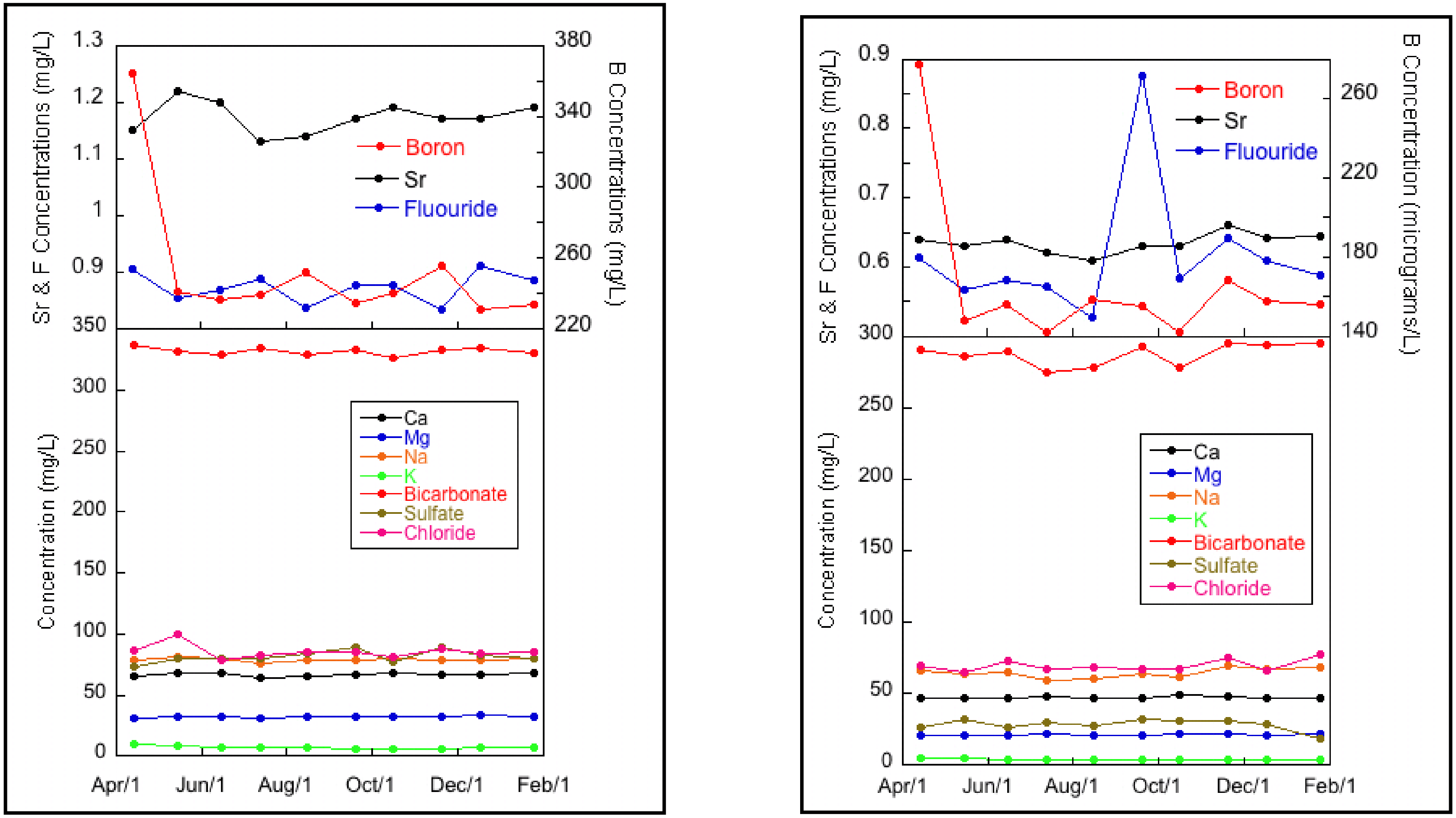


Figure 6. Monthly fluctuations in water chemistry from samples collected from Crawford Co. RWD 4, well 3 (left) and the Crawford Co. RWD 5, well 1 (right).

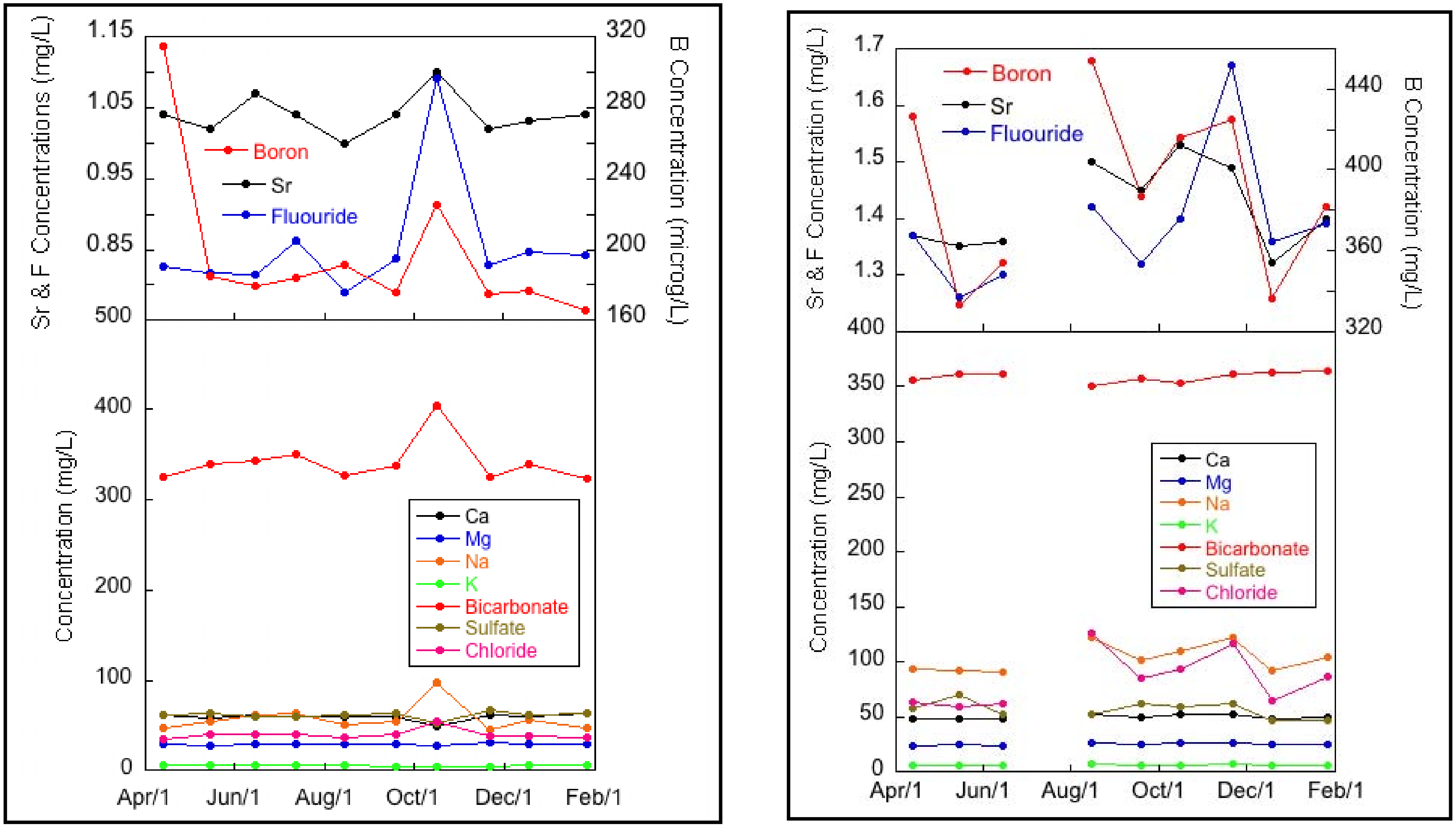


Figure 7. Monthly fluctuations in water chemistry from samples collected from the City of Weir (left) and the City of Columbus, well 4 (right).

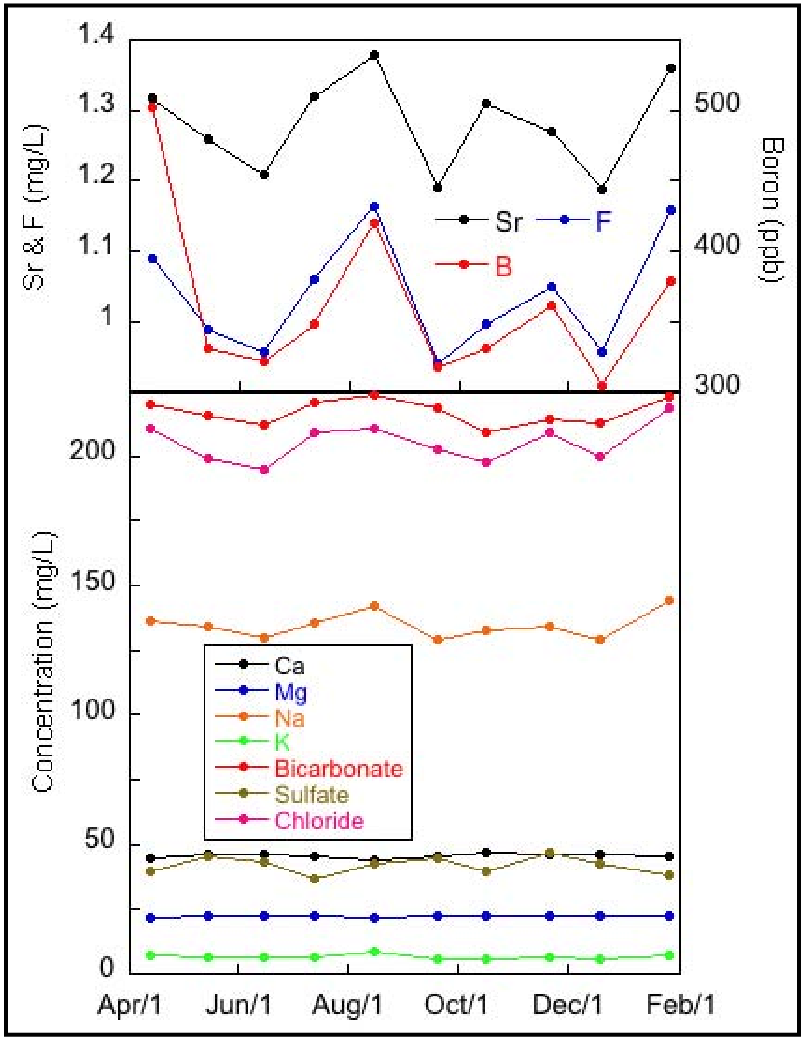


Figure 8. Monthly fluctuations in water chemistry from samples collected from Cherokee Co. RWD 3, well 1.

samples collected from wells located near the low total dissolved solids, calcium-bicarbonate type water zone (Figure 9). The samples collected from this project plot nearer the freshwater samples on the chloride vs. sulfate/chloride graph, clearly following a linear trend in log-log space. Fluctuations in the ratio of sulfate to chloride in the samples collected from the City of Pittsburg well 8 are negatively correlated with the monthly quantity of water withdrawn by all of the wells in the city's field (Figure 10). The negative correlation of the sulfate to chloride ratio and potentiometric surface elevations with monthly pumpage suggests the possibility of upconing of poorer quality ground water in response to reduced fluid pressures in the shallower parts of the Ozark aquifer when pumping from the city's wellfield is more intense.

Comparison of the water chemistry data from this project with the 1980 data indicates that water quality has markedly changed for some of the supplies sampled in this study but not others (Figures 11-14).

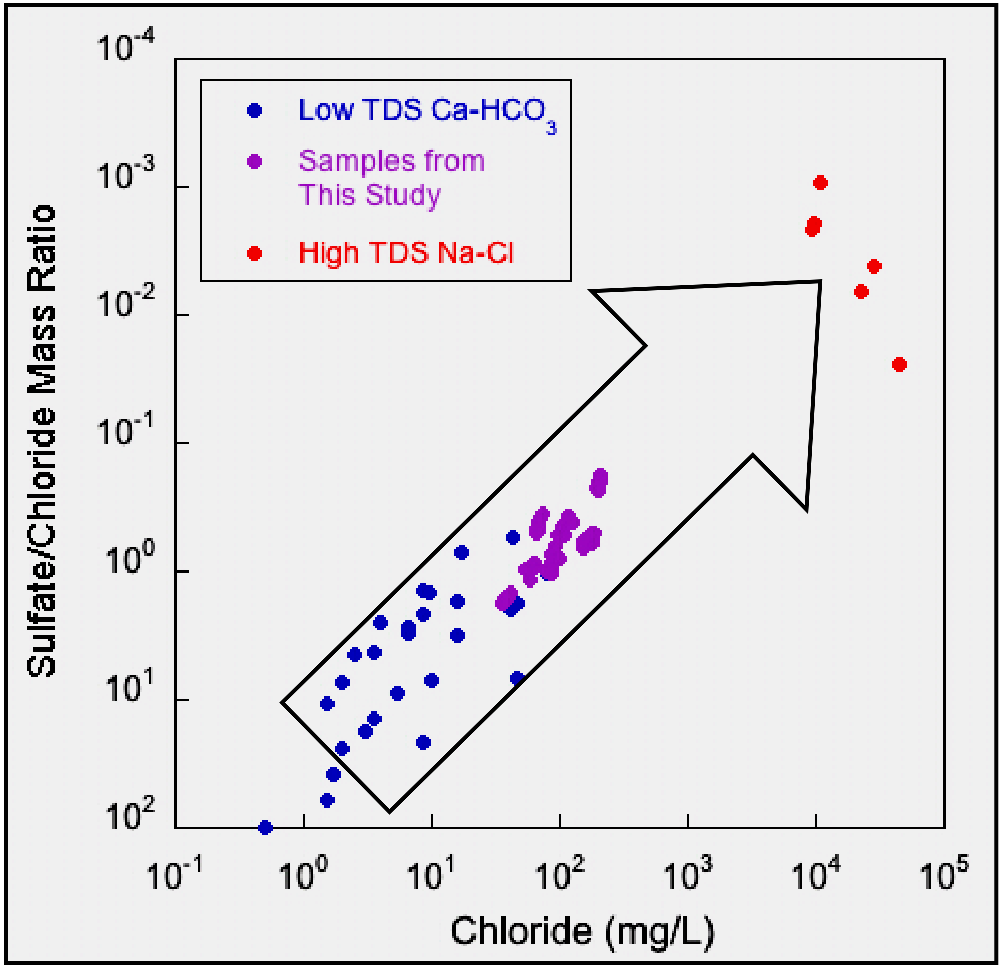


Figure 9. Chloride vs. the ratio sulfate to chloride for the 1980 samples from the low TDS calcium-bicarbonate and sodium-chloride brine portions of the Ozark aquifer and the monthly samples collected in this study.

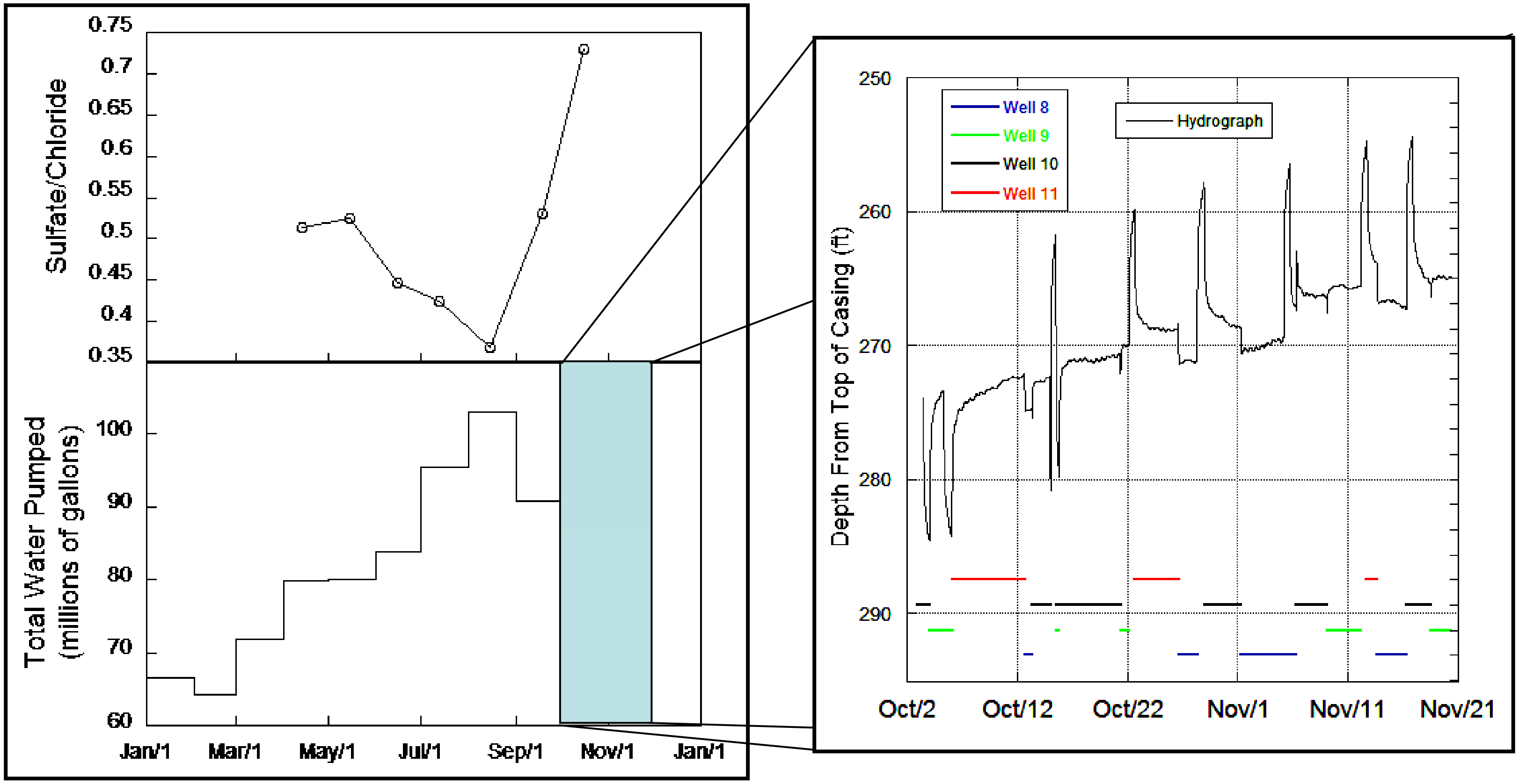


Figure 10. The ratio of sulfate to chloride in monthly water samples from the City of Pittsburg well 8 is negatively correlated with monthly pumpage from Pittsburg's wellfield. Shown on the right is the hydrograph from the Ozark aquifer monitoring well in the Pittsburg wellfield (Figure 3) derived from high-frequency monitoring.

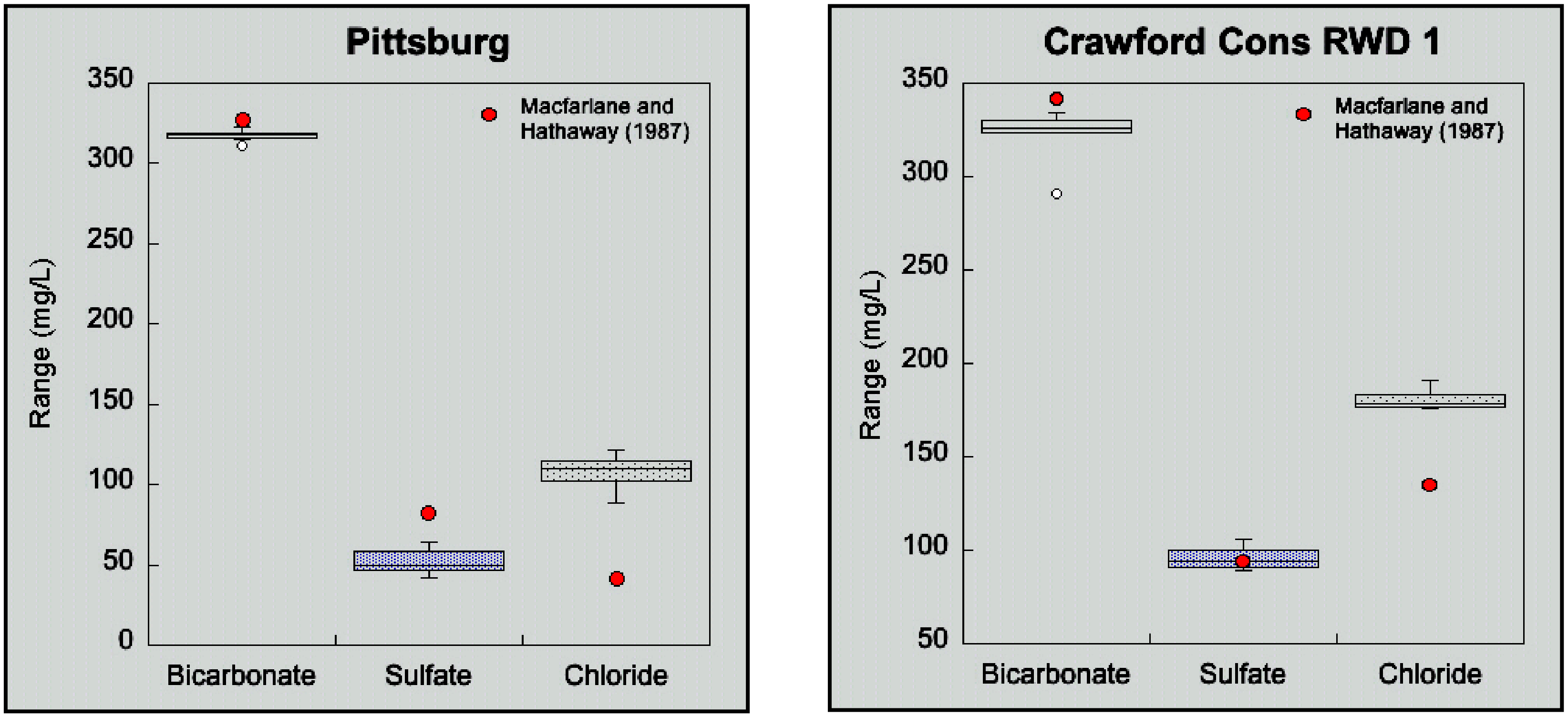


Figure 11. Comparison of the range of bicarbonate, sulfate, and chloride concentrations with 1980 values for the City of Pittsburg well 8 and Crawford Co. Consolidated RWD 1 using box plots.

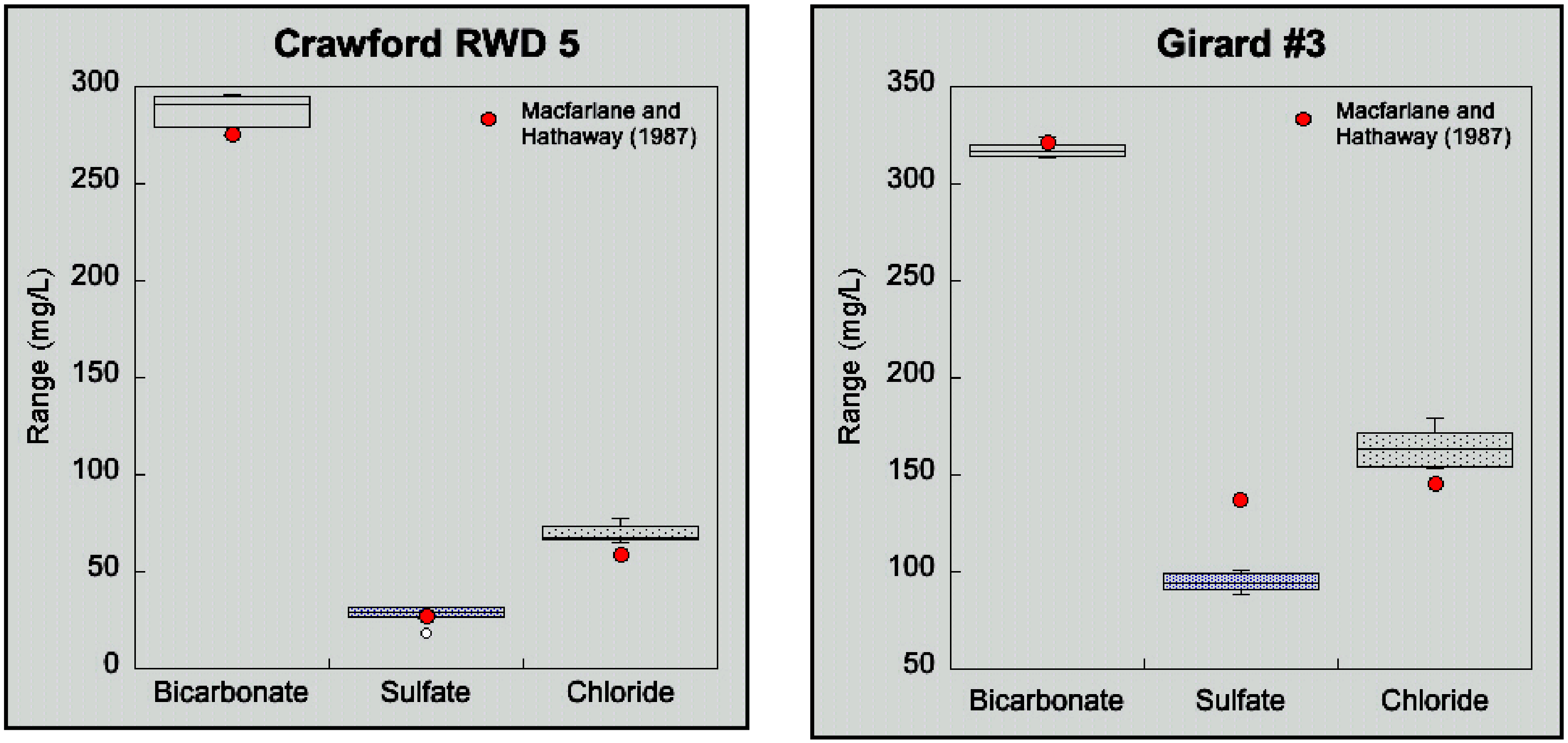


Figure 12. Comparison of the range of bicarbonate, sulfate, and chloride concentrations with 1980 values for Crawford Co. RWD #5 well 1 and the City of Girard well 3 using box plots.

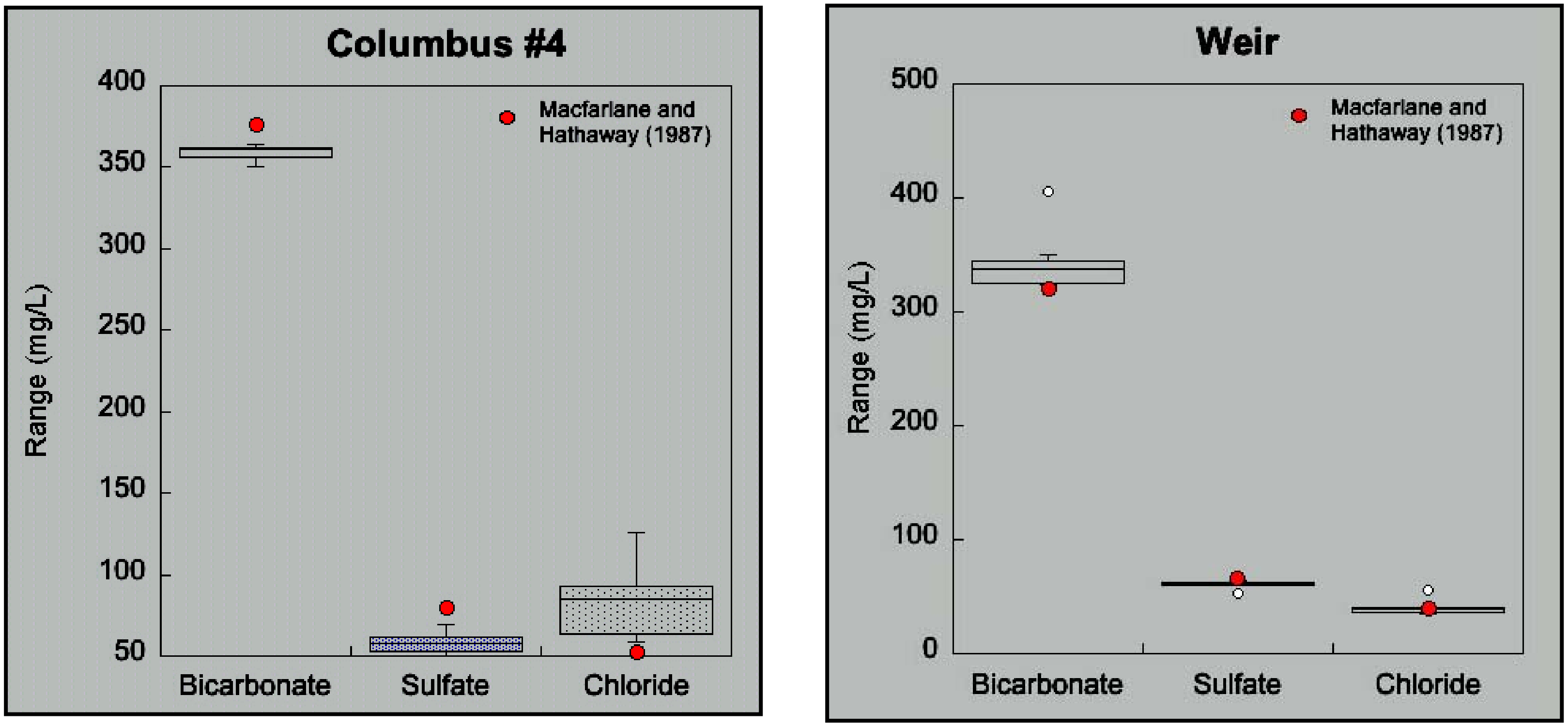


Figure 13. Comparison of the range of bicarbonate, sulfate, and chloride concentrations with 1980 values for the City of Columbus well 4 and the City of Weir using box plots.

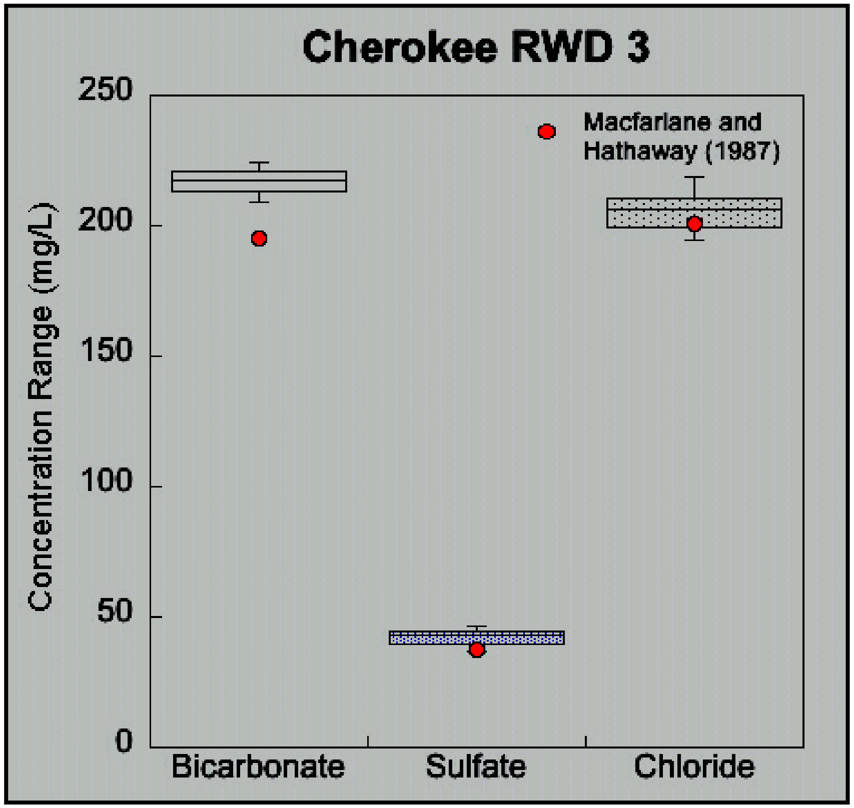


Figure 14. Comparison of the range of bicarbonate, sulfate, and chloride concentrations with 1980 values Cherokee Co. RWD 3 using box plots.

Publications and Presentations

Macfarlane, P.A., and Ghijsen, R., 2007, Assessment of seasonal pumping-induced water quality changes in the Ozark Plateaus aquifer system: Water and the Future of Kansas Conference Proceedings, Topeka, Kansas, March 15, 2007, p. 19.

Macfarlane, P.A., and Ghijsen, R., 2007, Assessment of seasonal pumping-induced water quality changes in the Ozark Plateaus aquifer system: Water and the Future of Kansas Conference, Topeka, Kansas, March 15, 2007.

Information Transfer

Project results were disseminated through and formal/informal meetings with state and local water agencies and public meetings, and with colleagues conducting the USGS Simulation of the Groundwater Flow System and Water-Quality Assessment in the Kansas Missouri and Oklahoma Tri-State Area project. Whenever possible attempts were made to discuss the results with municipalities and rural water districts in the Tri-State region.

Student Support

No students were funded by this project.