Steady-State Simulation

The numerical model was used to simulate average (steady-state) flow conditions for the 20-year period (WY 1979-98) previously described. Steady-state conditions were numerically approximated for the steady-state simulation by using a transient simulation with one 100-year stress period using constant input flow rates. The model was more stable and closed in fewer iterations with the 100-year transient stress period than with a steady-state stress period. The potentiometric surface from the steady-state simulation established initial conditions for the transient simulation.

The first calibration criterion for the steady-state simulation was that the simulated potentiometric surfaces and hydraulic gradients generally match those of the estimated average potentiometric surfaces. The simulated steady-state potentiometric surfaces (figs. 17 and 18) generally are similar to the estimated average potentiometric surfaces (figs. 4 and 5) in comparison to both hydraulic heads and gradients, indicating satisfaction of this criterion.

A second calibration criterion included matching 95 percent of all wells to within ±50 feet of the observed hydraulic heads. This second criterion was considered adequate because 50 feet is about 7 percent of the difference between the maximum and minimum hydraulic heads of the estimated average potentiometric surfaces in the model area (total hydraulic head relief); hydraulic head relief is about 780 feet in the Ogallala aquifer and 720 feet in the Arikaree aquifer.

Simulated hydraulic heads matched observed values to within ±50 feet for 95 percent of the wells. A histogram shows the distribution of the difference between the observed and simulated hydraulic heads (residuals) (fig. 19). The fit was considerably better for the 44 State observation wells (fig. 19B) than for all wells (fig. 19A). Observation well data were weighted more heavily in calibration because of a higher degree of confidence in that data. Simulated hydraulic heads at all of the State observation wells were within ±22 feet of the observed hydraulic heads, which is about 3 percent of the total hydraulic head relief in the Ogallala and Arikaree aquifers. The residuals for 20 of these State observation wells were within ±12 feet (fig. 19B). Simulated hydraulic heads at all of the Tribal observation wells were within ±45 feet of the observed hydraulic heads, which is about 6 percent of the total hydraulic head relief in the Ogallala and Arikaree aquifers. The residuals for 15 of these Tribal observations wells were within ±20 feet (fig. 19C). The root mean square error (RMSE) for all wells was 26.8 feet. The mean error was -3.7 feet, which indicates a model bias toward overestimating head values. For the State and Tribal observation wells only, the RMSE was 21.4 feet, and the mean error was -1.6 feet. A linear regression analysis of simulated hydraulic heads and observed hydraulic heads for all wells (fig. 20) yielded an R^2 value (coefficient of determination) of 0.97.

Base flow is another important component of calibration. Base flow is sensitive to many model components besides riverbed conductance. Results of the steady-state calibration to estimated base flow are shown in table 10.

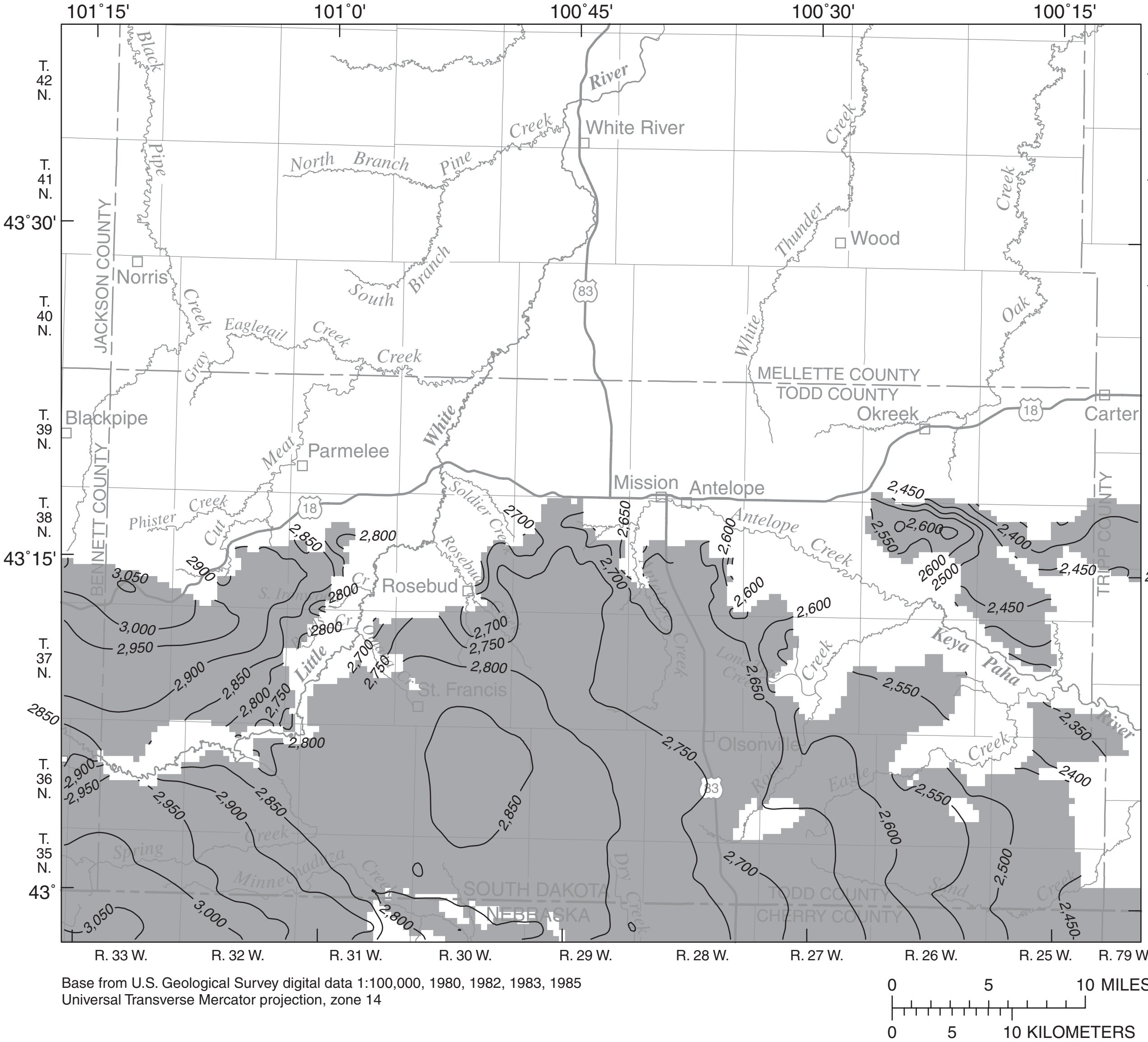
A sensitivity analysis was used to examine the response of the numerical model calibrated to the steady-state condition to changes in model parameters including horizontal and vertical hydraulic conductivity, evapotranspiration, recharge, and riverbed conductance. During each simulation when a parameter was being tested, the other parameters were set to the steady-state calibrated value. Each parameter was changed uniformly over the entire model area. The percent changes in the sum of squared weighted residuals between the simulated and observed hydraulic heads for selected changes in parameter values are shown in figure 21. The model was most sensitive to recharge and horizontal hydraulic conductivity.

The water budget for the steady-state simulation balances (inflows minus outflows) with a percent discrepancy of -0.41 (table 11). The recharge rate used for the numerical model was within the range of values listed in the conceptual model. The exact amount of irrigation well withdrawals that were estimated (table 6) was used in the numerical model. The river leakage from the aquifers into the Little White and Keya Paha Rivers calculated by the numerical model was within 3.3 cubic feet per second of the estimated base flow for each of the two rivers.

Table 10. Comparison of simulated and estimated base flow for the Little White and Keya Paha Rivers for the steady-state simulation

Stream	Base flow (cubic feet per second)		Percent error of simulated compared to estimated base flow
	Estimated[1]	Model simulated	
Little White River	49	46.79	4.5
Keya Paha River	23	19.70	14

[1]From table 5.

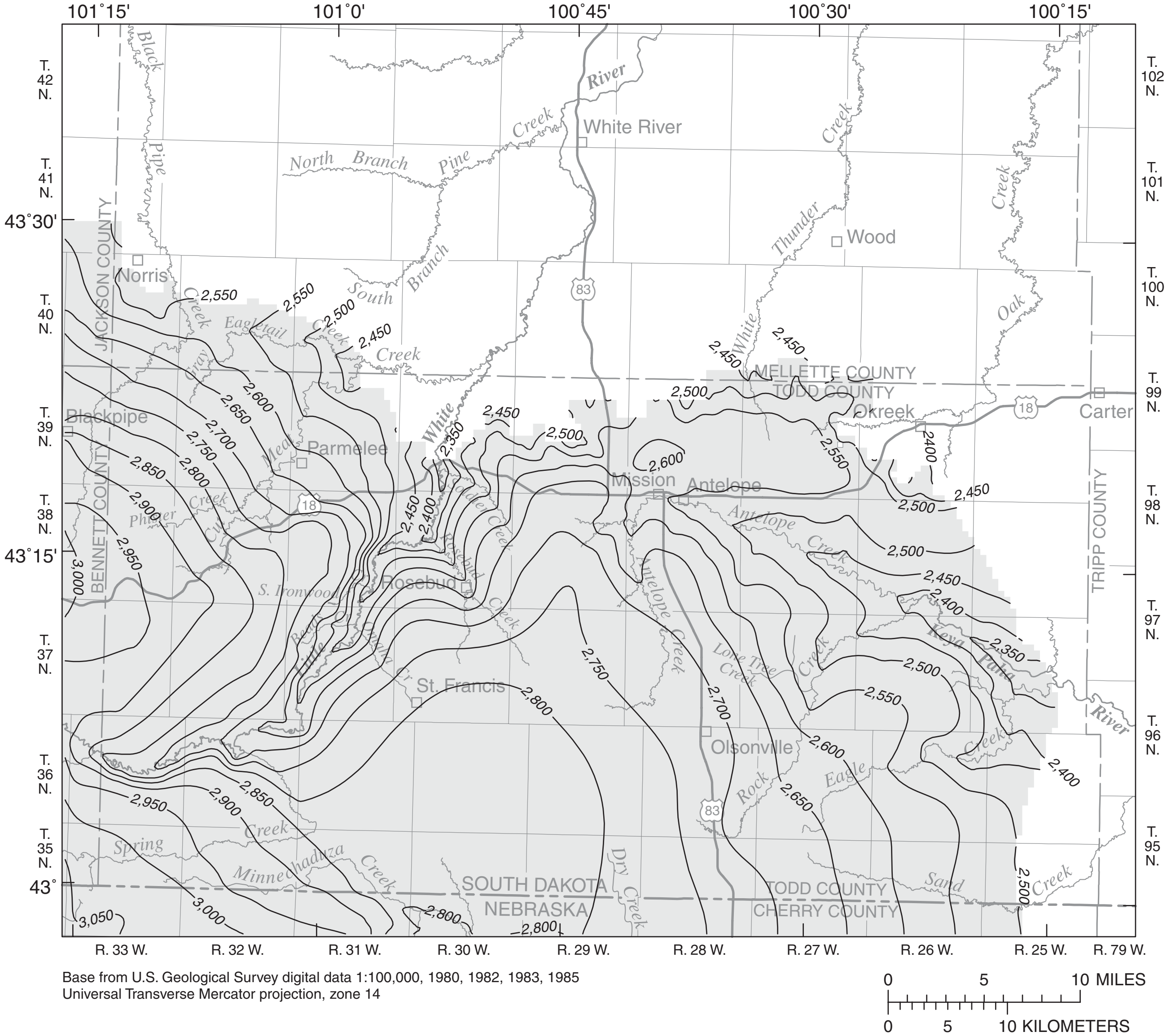


EXPLANATION

ACTIVE CELLS IN THE OGALLALA AQUIFER

—2,400— SIMULATED POTENTIOMETRIC CONTOUR—Shows average altitude at which water level would have stood in tightly cased wells, 1979-98. Contour interval is 50 feet. Datum is NGVD of 1929.

Figure 17. Potentiometric surface of the Ogallala aquifer for the steady-state simulation.



EXPLANATION

ACTIVE CELLS IN THE ARIKAREE AQUIFER

—2,800— SIMULATED POTENTIOMETRIC CONTOUR—Shows average altitude at which water level would have stood in tightly cased wells, 1979-98. Contour interval is 50 feet. Datum is NGVD of 1929.

Figure 18. Potentiometric surface of the Arikaree aquifer for the steady-state simulation.

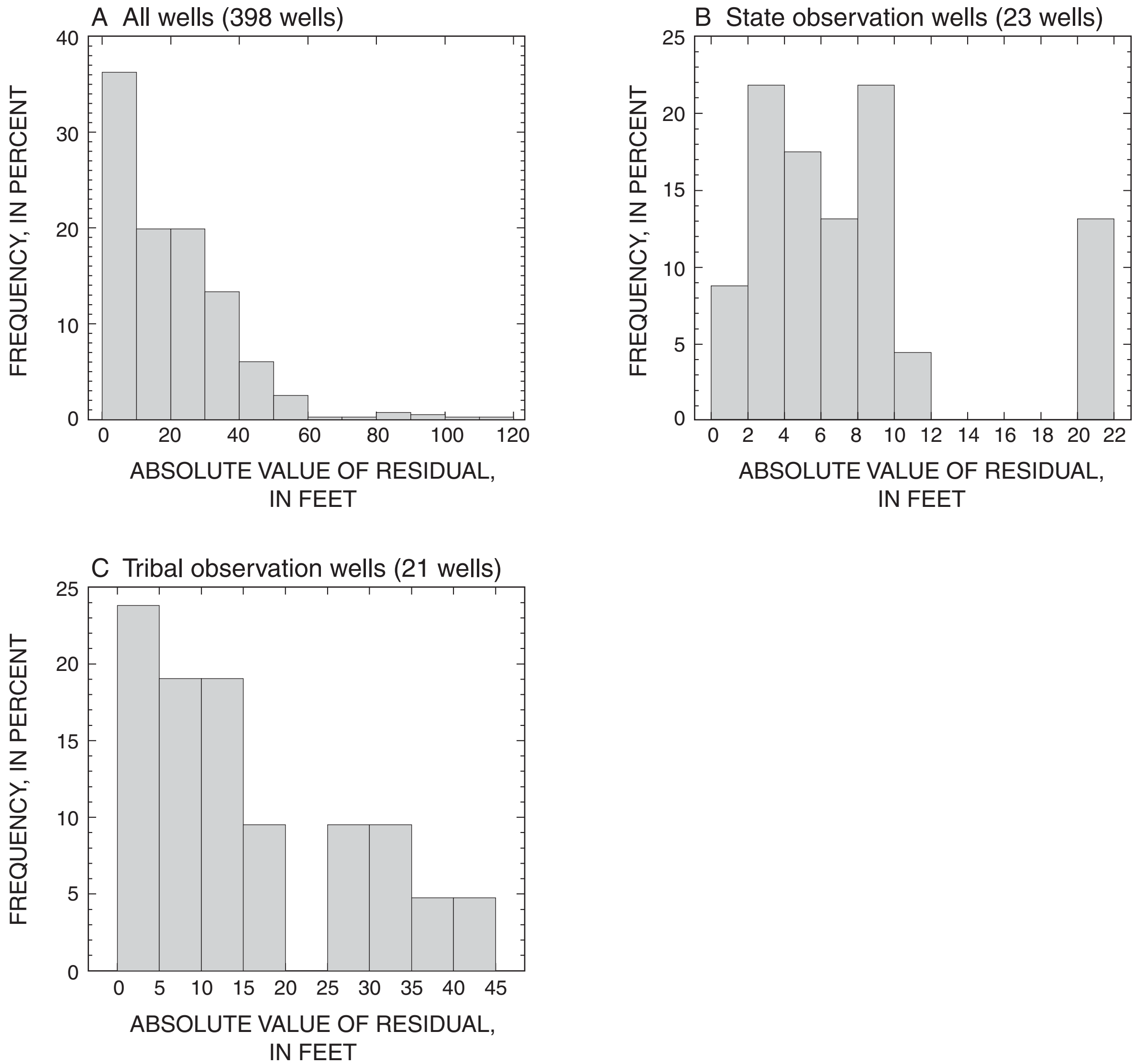


Figure 19. Histograms of residuals of estimated average observed and steady-state simulated hydraulic head in A) all wells, B) State observation wells, and C) Tribal observation wells for the Ogallala and Arikaree aquifers, water years 1979-98.

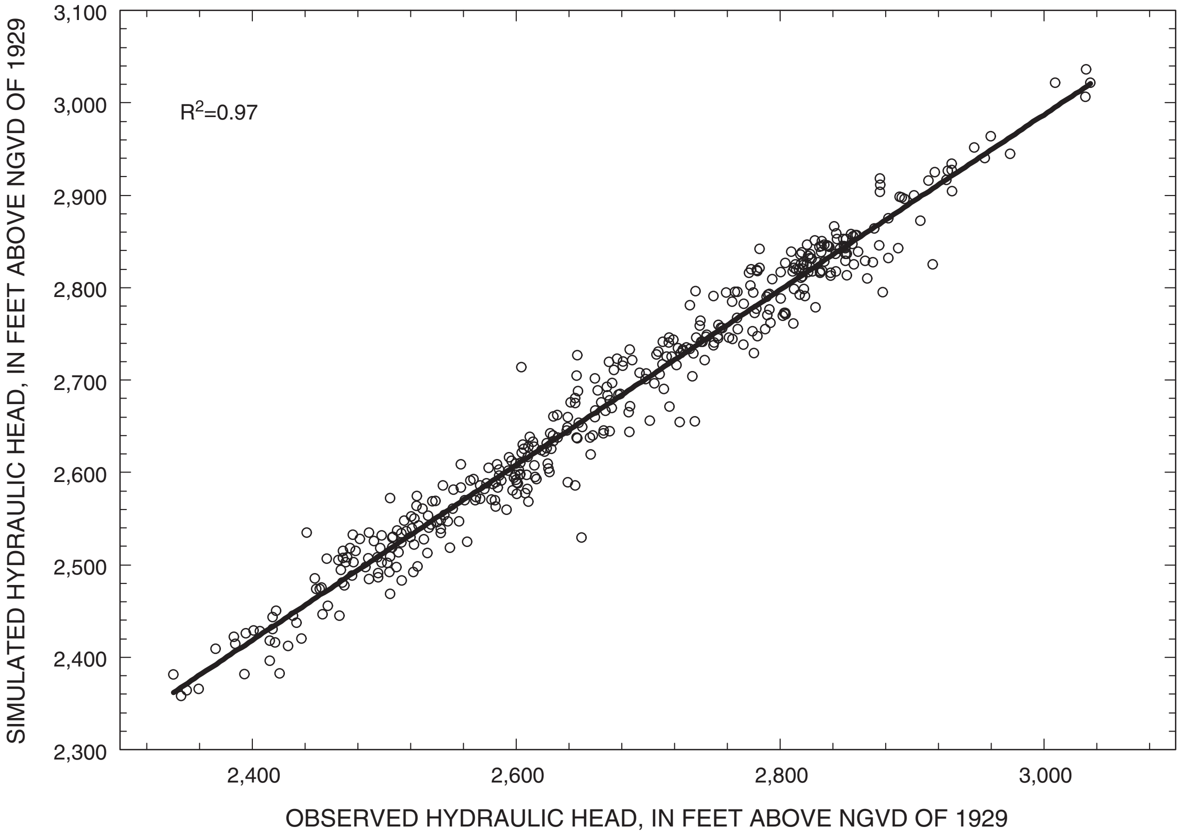


Figure 20. Linear regression of observed and simulated hydraulic heads for all wells.

Table 11. Steady-state water budget for numerical simulation compared with flow estimates for conceptual model

[--, not estimated or not applicable]

Flow component	Flow rate (cubic feet per second)	
	Numerical model	Conceptual model
Inflows		
Storage	0.52	--
Constant-head boundaries	17.90	--
River leakage	2.05	--
Recharge	266.20	111-341
Total inflows	286.67	--
Outflows		
Storage	0.74	--
Constant-head boundaries	13.16	--
Irrigation wells	11.60	11.6
Springs along northern boundary	0.50	--
Little White River	[1]46.79	[1]49
Keya Paha River	19.70	23
Other river leakage	11.50	--
Evapotranspiration	183.87	--
Total outflows	287.86	--
Inflows - outflows	-1.19	--
Percent discrepancy	-0.41	--

[1]Includes springflow contributing to base flow in river

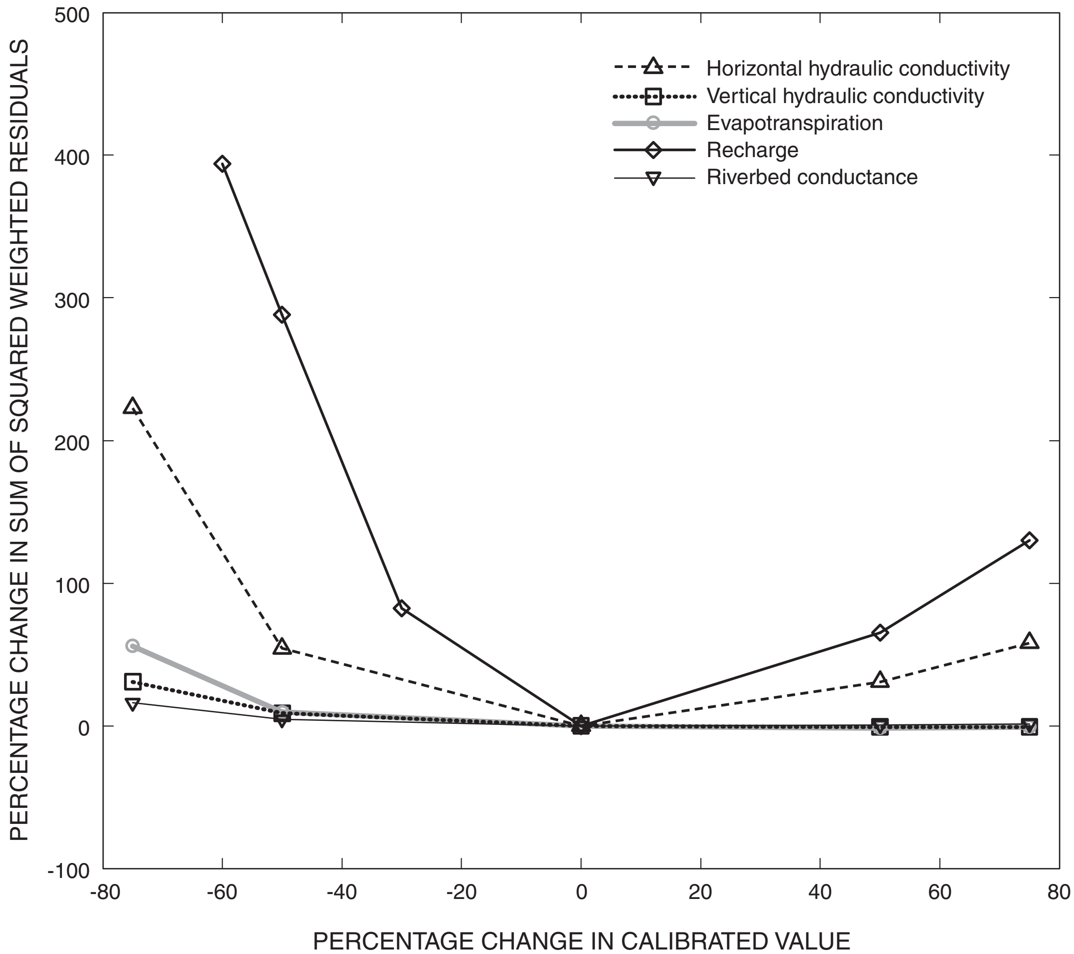


Figure 21. Results of sensitivity analysis.

Transient Simulation

Calibration criteria for the transient simulation consisted of approximately reproducing the general temporal trends of the hydrographs for the 23 State observation wells and 21 Tribal observation wells. There was no attempt to calibrate the transient simulation to match hydraulic heads in the observation wells closer than that required for the steady-state simulation (±50 feet). Therefore, a difference of up to 50 feet between the observed and simulated well hydrographs was acceptable if the general trends matched reasonably well.

Hydrographs for State and Tribal observation wells are shown in figures 22 and 23, which show that the general trends in simulated and observed hydraulic heads matched reasonably well. Basic statistics were calculated for comparison of observed and simulated hydraulic heads for observation wells (tables 12 and 13). The differences of the means of observed and simulated data were within 40 feet for all observation wells. Comparison of standard deviations, variances, and ranges for observed and simulated data are indications of how well the model simulated hydraulic head fluctuations for each well. The model overestimated hydraulic heads for 13 of the State wells and 8 of the Tribal wells. These wells have a negative number in the "Difference of observed and simulated means" column. The model underestimated hydraulic heads for 10 of the State wells and 13 of the Tribal wells. For all observation wells, the model overestimated hydraulic heads for 48 percent of the wells and underestimated hydraulic heads for 52 percent of the wells. However, the mean of the difference of observed and simulated means (tables 12 and 13) is -3.7 for State wells, -1.0 for Tribal wells, and -2.4 for all observation wells, which indicates a model bias toward overestimating hydraulic heads.

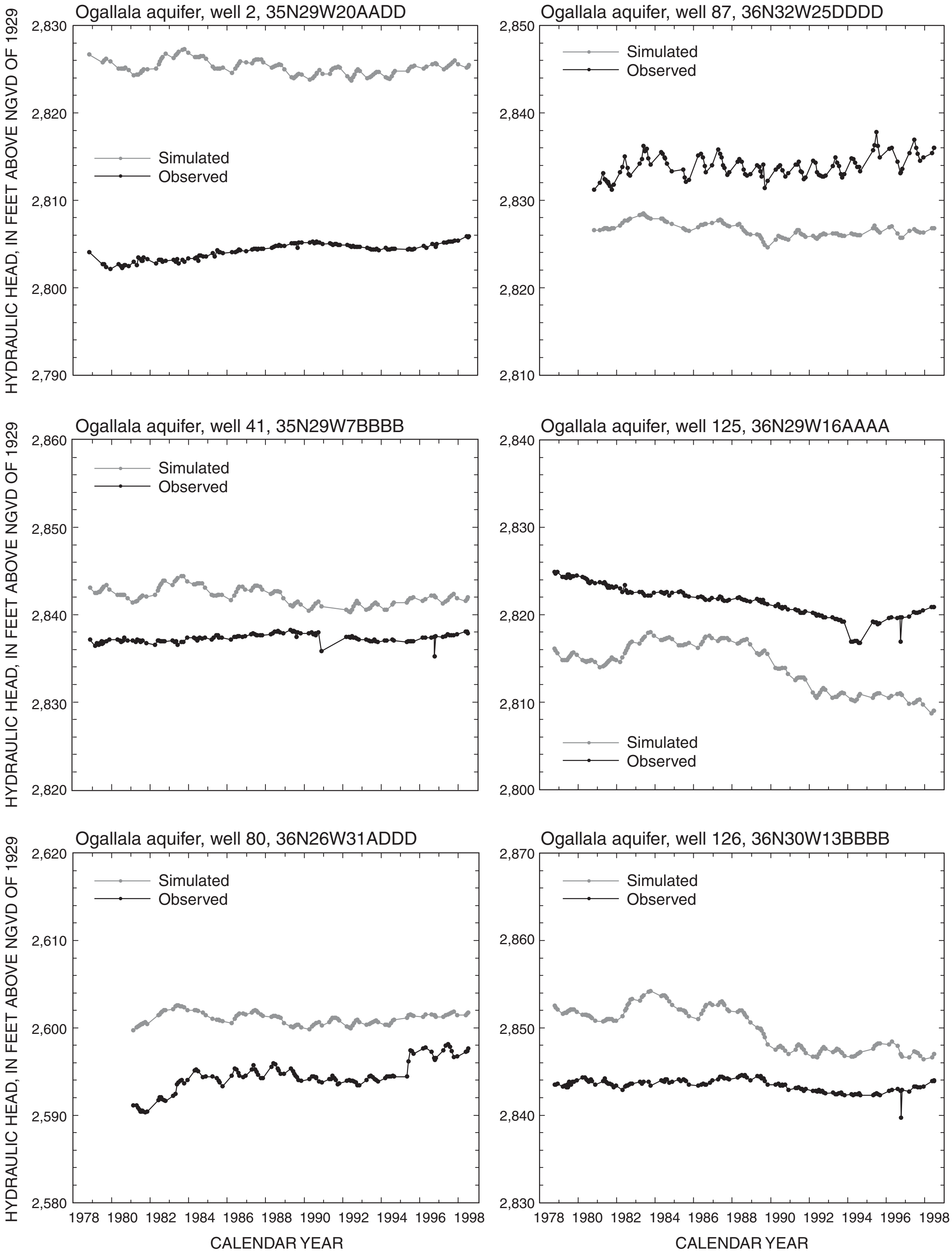


Figure 22. Hydrographs showing simulated and observed data for State observation wells.

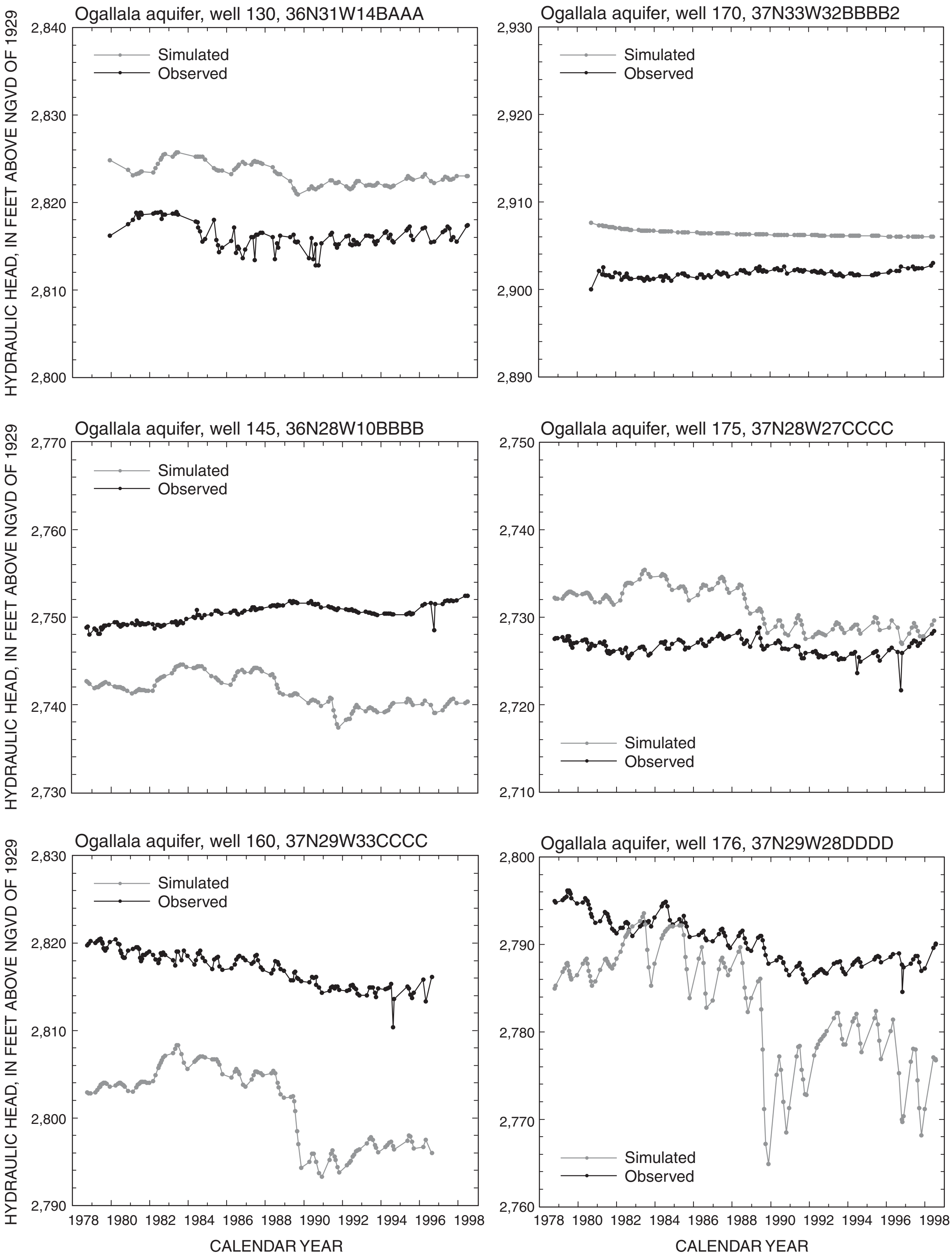


Figure 22. Hydrographs showing simulated and observed data for State observation wells.—Continued

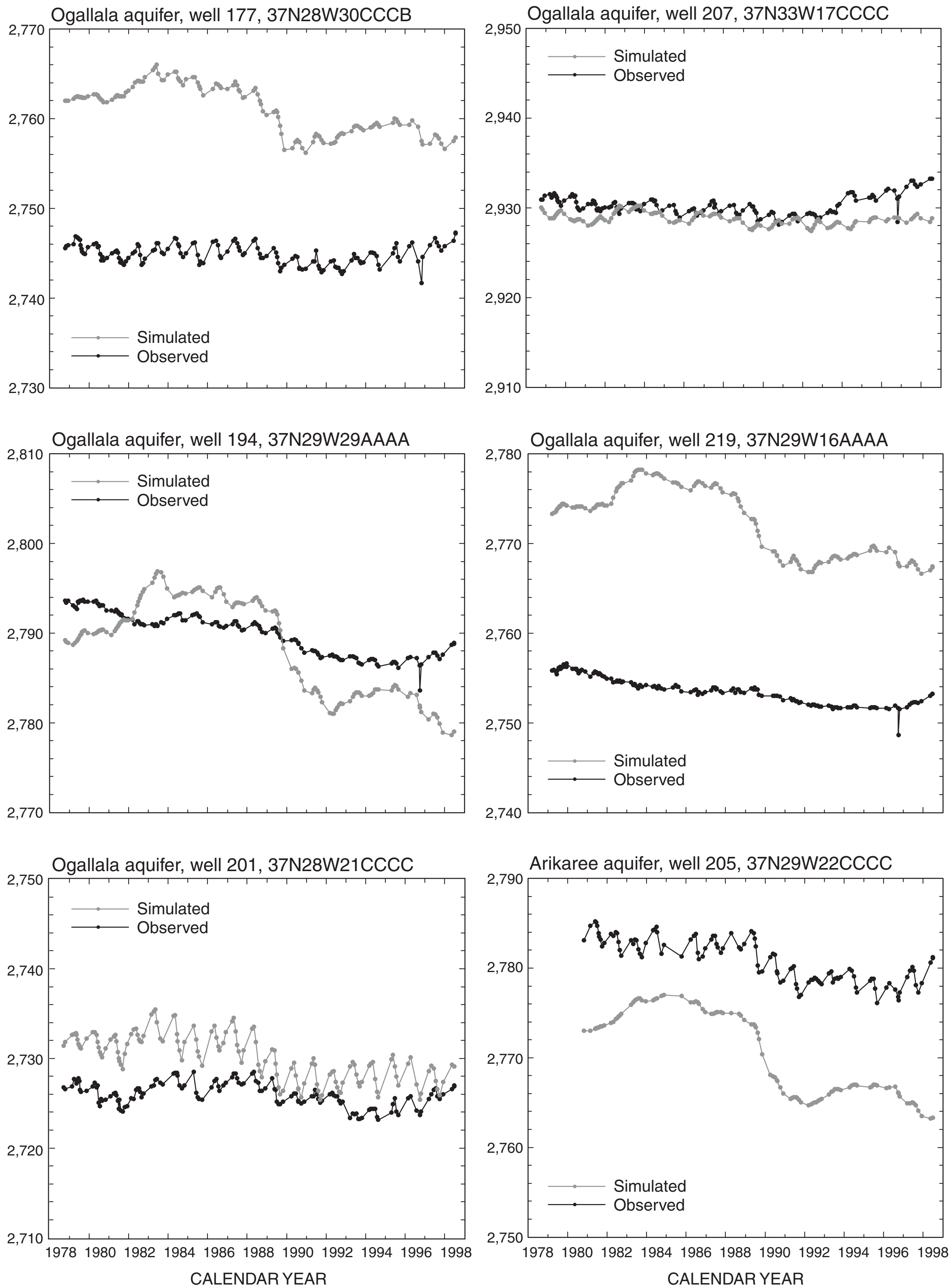


Figure 22. Hydrographs showing simulated and observed data for State observation wells.—Continued

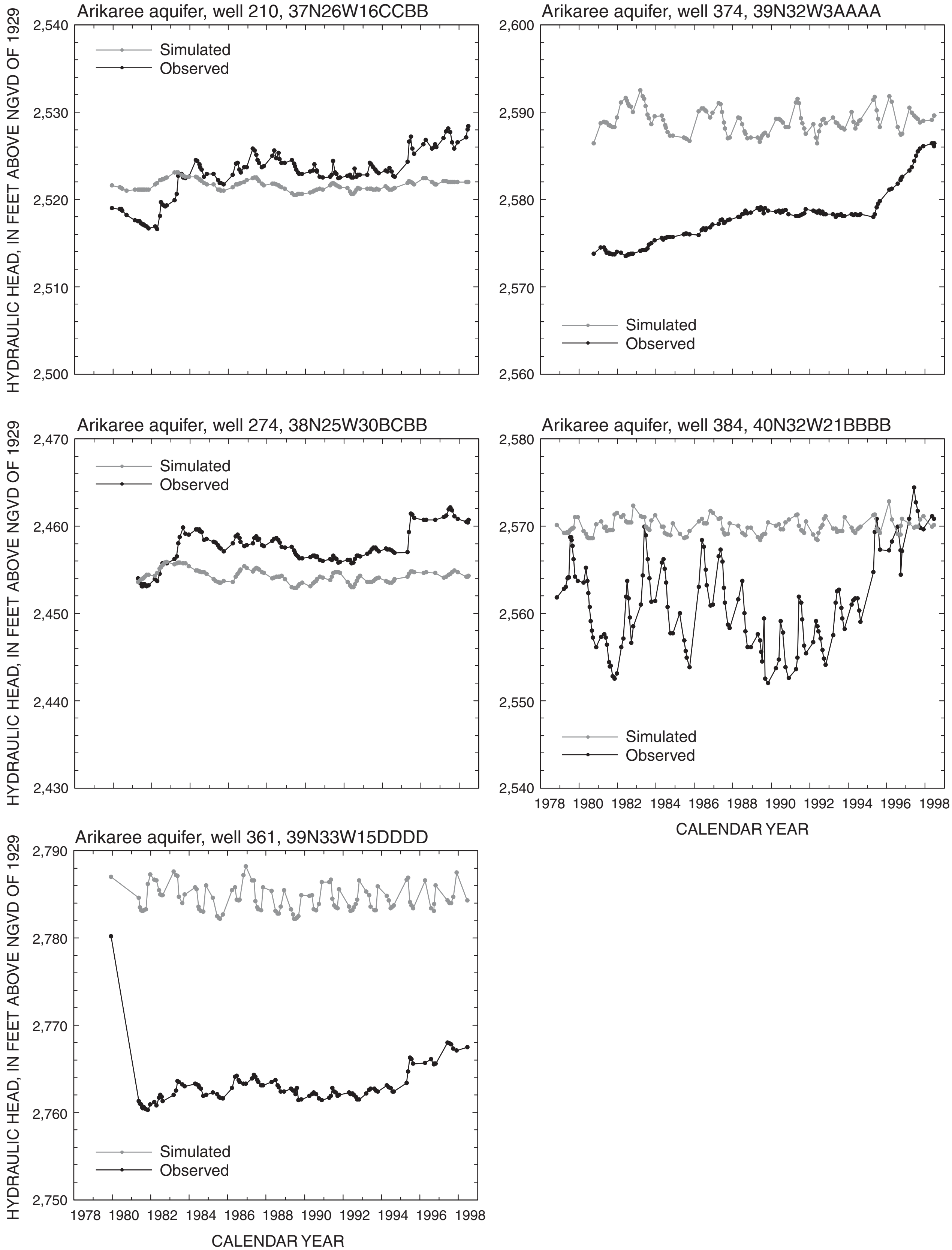


Figure 22. Hydrographs showing simulated and observed data for State observation wells.—Continued

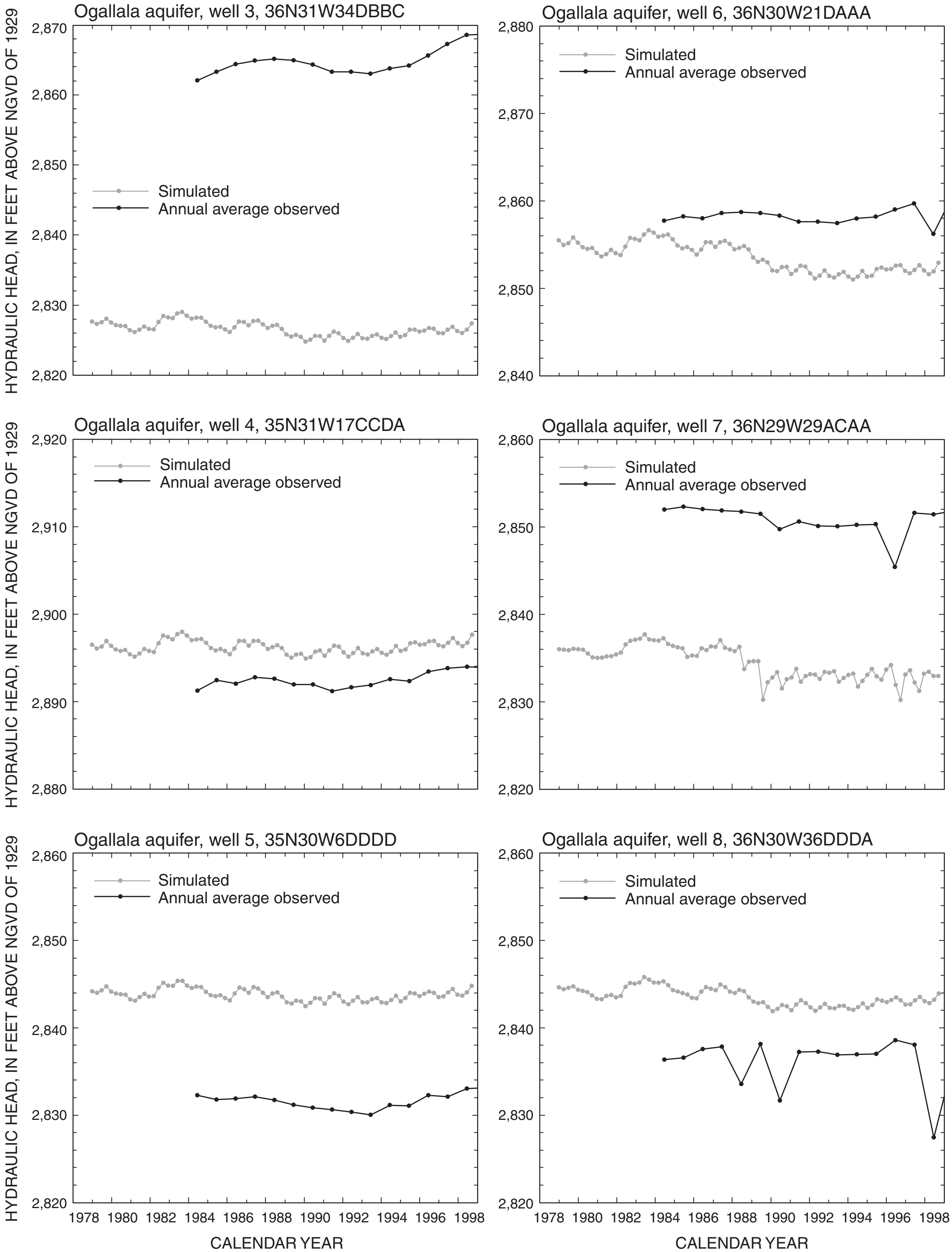


Figure 23. Hydrographs showing simulated and annual average observed data for Tribal observation wells.

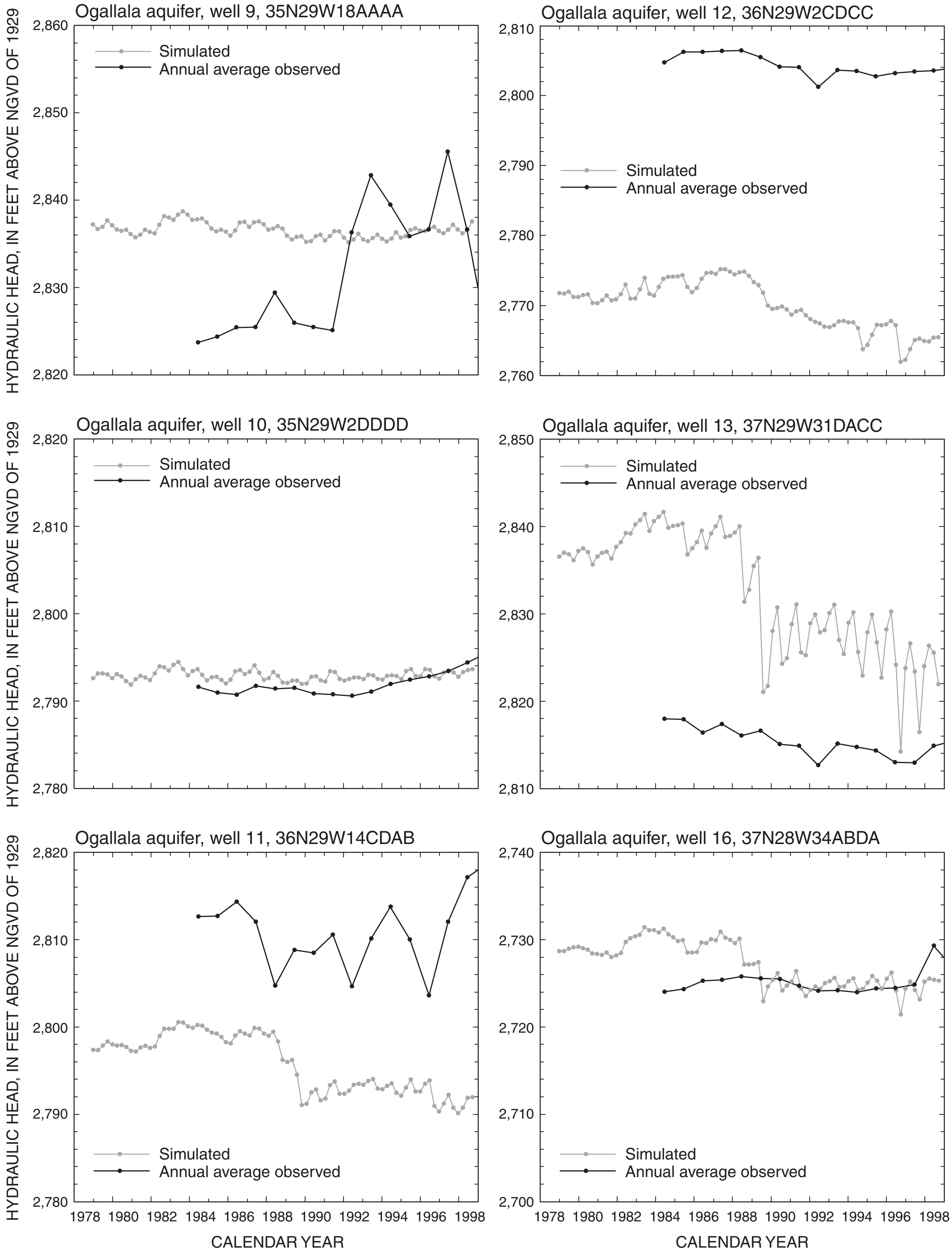


Figure 23. Hydrographs showing simulated and annual average observed data for Tribal observation wells.—Continued

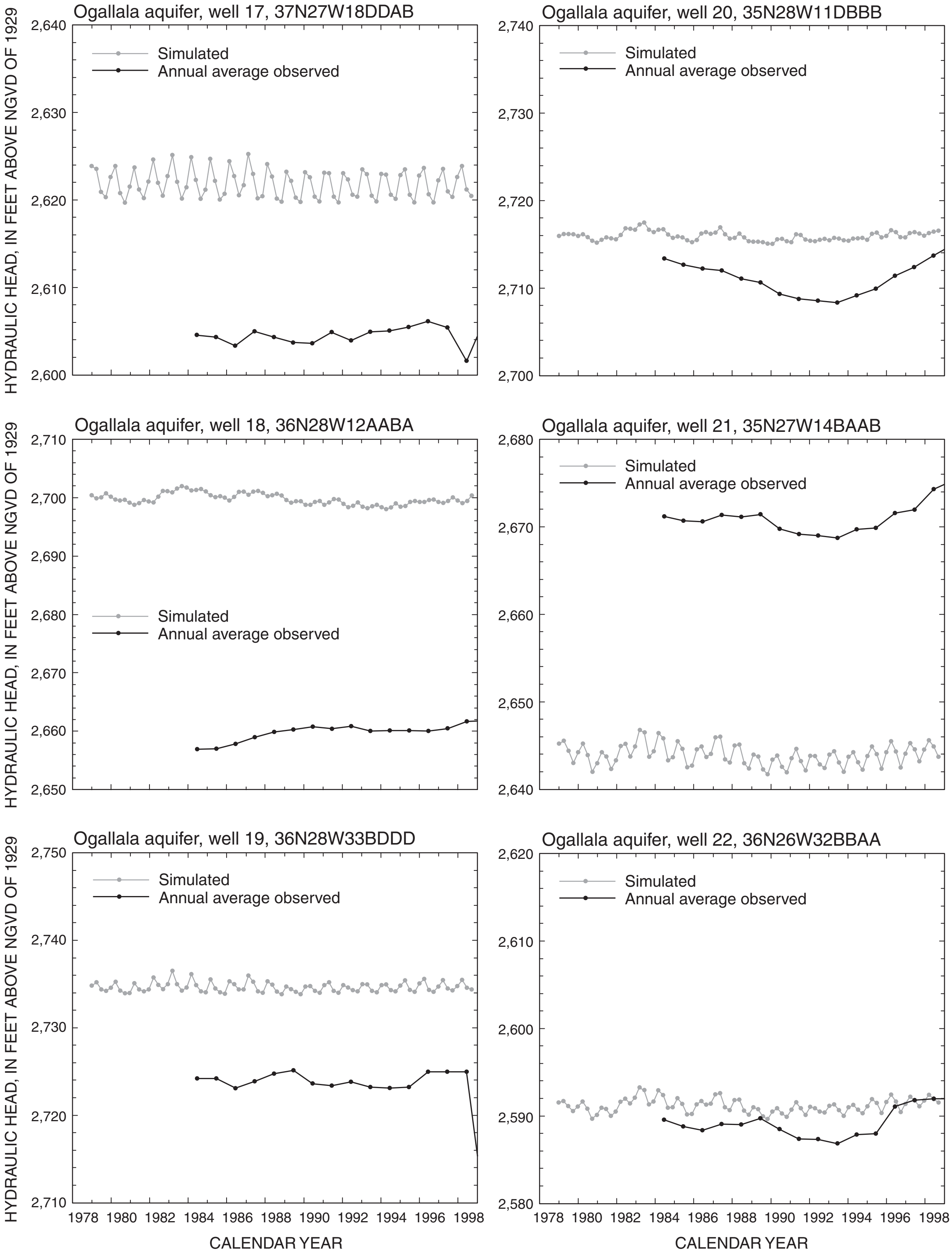


Figure 23. Hydrographs showing simulated and annual average observed data for Tribal observation wells.—Continued

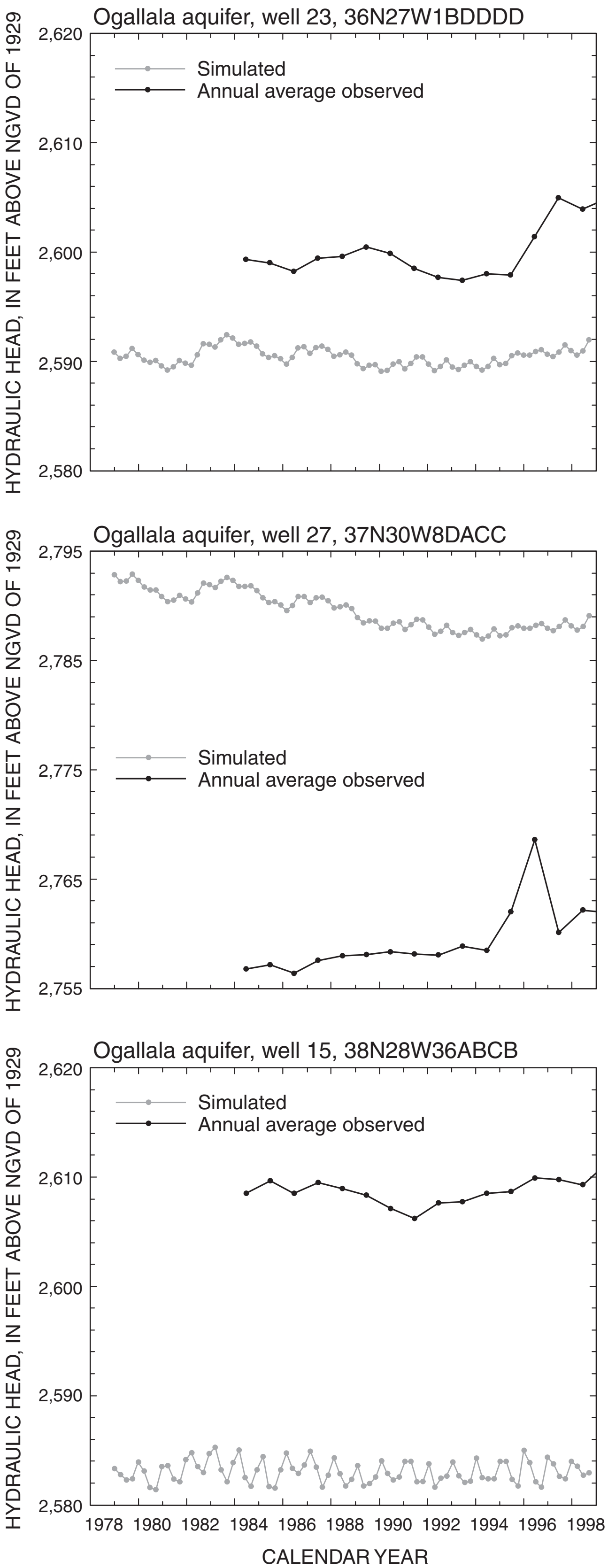


Figure 23. Hydrographs showing simulated and annual average observed data for Tribal observation wells.—Continued

Table 12. Comparison of observed and simulated hydraulic heads for State observation wells for the transient simulation

[Hydraulic heads in feet above NGVD of 1929. --, not applicable]

State well number	Data type	Mean	Standard deviation	Variance	Range	Minimum	Maximum	Difference of observed and simulated means	Average of absolute value of residuals[1]
2	Observed	2,804	0.90	0.80	4	2,802	2,806		
	Simulated	2,825	.81	.66	3	2,824	2,827	-21	20.9
41	Observed	2,837	.47	.22	3	2,835	2,838		
	Simulated	2,842	.96	.93	4	2,840	2,844	-5	4.9
80	Observed	2,594	1.81	3.26	8	2,590	2,598		
	Simulated	2,601	.69	0.47	3	2,600	2,603	-7	6.7
87	Observed	2,834	1.31	1.70	7	2,831	2,838		
	Simulated	2,827	.79	.62	4	2,825	2,829	7	7.3
125	Observed	2,822	1.90	3.60	8	2,817	2,825		
	Simulated	2,814	2.62	6.88	9	2,809	2,818	8	7.4
126	Observed	2,843	.69	.48	5	2,840	2,845		
	Simulated	2,850	2.40	5.75	8	2,846	2,854	-7	6.7
130	Observed	2,816	1.46	2.14	6	2,813	2,819		
	Simulated	2,823	1.25	1.57	5	2,821	2,826	-7	6.9
145	Observed	2,750	1.06	1.12	4	2,748	2,752		
	Simulated	2,742	1.75	3.05	8	2,737	2,745	8	8.7
160	Observed	2,817	2.04	4.17	11	2,810	2,821		
	Simulated	2,802	4.34	18.86	15	2,793	2,808	15	15.4
175	Observed	2,727	.95	.91	7	2,722	2,729		
	Simulated	2,735	2.03	4.12	8	2,731	2,739	-8	8.1
176	Observed	2,791	2.87	8.26	11	2,785	2,796		
	Simulated	2,783	6.63	43.99	29	2,765	2,794	8	7.5
177	Observed	2,745	1.09	1.20	5	2,742	2,747		
	Simulated	2,761	2.62	6.88	10	2,756	2,766	-16	16.2
194	Observed	2,790	2.38	5.68	10	2,784	2,794		
	Simulated	2,788	4.62	21.34	16	2,779	2,795	2	3.1
201	Observed	2,726	1.31	1.71	6	2,723	2,729		
	Simulated	2,733	2.43	5.89	11	2,728	2,739	-7	7.0

Table 12. Comparison of observed and simulated hydraulic heads for State observation wells for the transient simulation–Continued

[Hydraulic heads in feet above NGVD of 1929. --, not applicable]

State well number	Data type	Mean	Standard deviation	Variance	Range	Minimum	Maximum	Difference of observed and simulated means	Average of absolute value of residuals[1]
207	Observed	2,930	1.06	1.12	5	2,928	2,933		
	Simulated	2,929	.64	.41	3	2,927	2,930	1	1.6
219	Observed	2,754	1.55	2.40	8	2,749	2,757		
	Simulated	2,773	3.76	14.12	11	2,767	2,778	-19	18.9
170	Observed	2,902	.44	.20	3	2,900	2,903		
	Simulated	2,906	.36	.13	2	2,906	2,908	-4	4.6
205	Observed	2,781	2.39	5.70	9	2,776	2,785		
	Simulated	2,777	3.45	11.90	10	2,772	2,782	4	3.7
210	Observed	2,523	2.81	7.89	11	2,517	2,528		
	Simulated	2,522	.62	.38	3	2,520	2,523	1	2.7
274	Observed	2,458	2.08	4.31	9	2,453	2,462		
	Simulated	2,454	.73	.54	3	2,453	2,456	4	3.4
361	Observed	2,763	2.37	5.60	20	2,760	2,780		
	Simulated	2,784	1.48	2.20	6	2,782	2,788	-21	21.4
374	Observed	2,578	3.06	9.39	12	2,574	2,586		
	Simulated	2,589	1.38	1.92	7	2,586	2,593	-11	11.1
384	Observed	2,561	5.25	27.56	22	2,552	2,574		
	Simulated	2,570	.86	.74	5	2,568	2,573	-9	8.8
Mean	--	--	--	--	--	--	--	-3.7	8.8

[1]The residual is the difference of the observed and simulated value.

Table 13. Comparison of observed and simulated hydraulic heads for Tribal observation wells for the transient simulation

[Observed data based on annual averages. Hydraulic heads in feet above NGVD of 1929. --, not applicable]

Tribal well number	Data type	Mean	Standard deviation	Variance	Range	Minimum	Maximum	Difference of observed and simulated means
3	Observed	2,826	.89	.80	3	2,825	2,828	
	Simulated	2,865	1.67	2.79	7	2,862	2,869	-39
4	Observed	2,896	.64	.41	3	2,895	2,898	
	Simulated	2,892	.85	.71	3	2,891	2,894	4
5	Observed	2,844	.59	.34	3	2,842	2,845	
	Simulated	2,831	.82	.68	3	2,830	2,833	13
6	Observed	2,853	1.52	2.30	5	2,851	2,856	
	Simulated	2,858	.80	.64	4	2,856	2,860	-5
7	Observed	2,834	1.75	3.05	7	2,830	2,837	
	Simulated	2,851	1.69	2.87	7	2,845	2,852	-17
8	Observed	2,843	.90	.81	3	2,842	2,845	
	Simulated	2,836	2.98	8.90	12	2,827	2,839	7
9	Observed	2,836	.73	.54	3	2,835	2,838	
	Simulated	2,832	7.45	55.56	22	2,824	2,846	4
10	Observed	2,793	.51	.26	2	2,792	2,794	
	Simulated	2,792	1.11	1.23	3	2,791	2,794	1
11	Observed	2,795	3.29	10.83	10	2,790	2,800	
	Simulated	2,810	3.83	14.65	13	2,804	2,817	-15
12	Observed	2,770	3.83	14.70	13	2,762	2,775	
	Simulated	2,804	1.54	2.38	5	2,801	2,806	-34
13	Observed	2,831	6.93	47.99	28	2,814	2,842	
	Simulated	2,815	1.71	2.94	5	2,813	2,818	16
16	Observed	2,726	2.50	6.24	10	2,721	2,731	
	Simulated	2,725	1.32	1.75	5	2,724	2,729	1
17	Observed	2,622	1.58	2.49	5	2,620	2,625	
	Simulated	2,604	1.09	1.18	4	2,602	2,606	18
18	Observed	2,700	.90	.81	3	2,698	2,701	
	Simulated	2,660	1.40	1.97	5	2,657	2,662	40
19	Observed	2,735	.55	.30	2	2,734	2,736	
	Simulated	2,724	.77	.59	2	2,723	2,725	11
20	Observed	2,716	.45	.21	2	2,715	2,717	
	Simulated	2,711	1.81	3.28	6	2,708	2,714	5

Table 13. Comparison of observed and simulated hydraulic heads for Tribal observation wells for the transient simulation–Continued

[Observed data based on annual averages. Hydraulic heads in feet above NGVD of 1929. --, not applicable]

Tribal well number	Data type	Mean	Standard deviation	Variance	Range	Minimum	Maximum	Difference of observed and simulated means
21	Observed	2,644	1.15	1.31	4	2,642	2,646	
	Simulated	2,671	1.43	2.04	5	2,669	2,674	-27
22	Observed	2,591	.76	.58	3	2,590	2,593	
	Simulated	2,589	1.58	2.50	5	2,587	2,592	2
23	Observed	2,590	.75	.56	3	2,589	2,592	
	Simulated	2,600	2.21	4.89	8	2,597	2,605	-10
27	Observed	2,789	1.34	1.78	5	2,787	2,792	
	Simulated	2,759	3.08	9.50	13	2,756	2,769	30
15	Observed	2,583	0.98	0.96	3	2,582	2,585	
	Simulated	2,609	1.04	1.09	4	2,606	2,610	-26
Mean	--	--	--	--	--	--	--	-1.0

The simulated base flow from ground-water discharge for the Ogallala and Arikaree aquifers had less fluctuation between stress periods than did the estimated base flow (fig. 24), which corresponds with the data in table 5. This may represent limitations of either base-flow estimates or the model or both. The average simulated base flow was within 8 percent of the average of estimated values for the Little White River and within 13 percent for the Keya Paha River (table 14). The simulated base flow for the Little White River included springs within the Little White River Basin above Soldier Creek, which were assumed to contribute base flow to the river.

Table 14. Comparison of average simulated and estimated base flow for the Little White and Keya Paha Rivers for the transient-state simulation, water years 1979-98

Stream	Base flow (cubic feet per second)		Percent error of simulated to estimated base flow
	Estimated[1]	Model simulation	
Little White River	49	45	8
Keya Paha River	23	20	13

[1]From table 5.

Model Limitations

The numerical model adequately simulates flow in the Ogallala and Arikaree aquifers in the study area for the purposes and objectives of this study; however, water managers should be aware of the model's limitations. There are uncertainties in many model input parameters, most importantly recharge, evapotranspiration, and horizontal and vertical hydraulic conductivity. Although these parameters had a major influence on model results, extensive data were not available. The combination of parameter values used in this model were based on many considerations. The parameter values were chosen within the general ranges of previously published values, and therefore, the model's accuracy is dependent, in part, on the accuracy of those estimates. Calibration of the model possibly could be improved by breaking down further the spatial discretization of some parameters, such as hydraulic conductivity or recharge; however, without more field data, finer discretization was not justifiable. In this case, a simpler model adequately represented the system. The degree of discretization and the parameter values chosen for this model were a balance between that based on calibration and that based on available parameter data; however, combinations of parameter values other than that used in this model also may give satisfactory results.

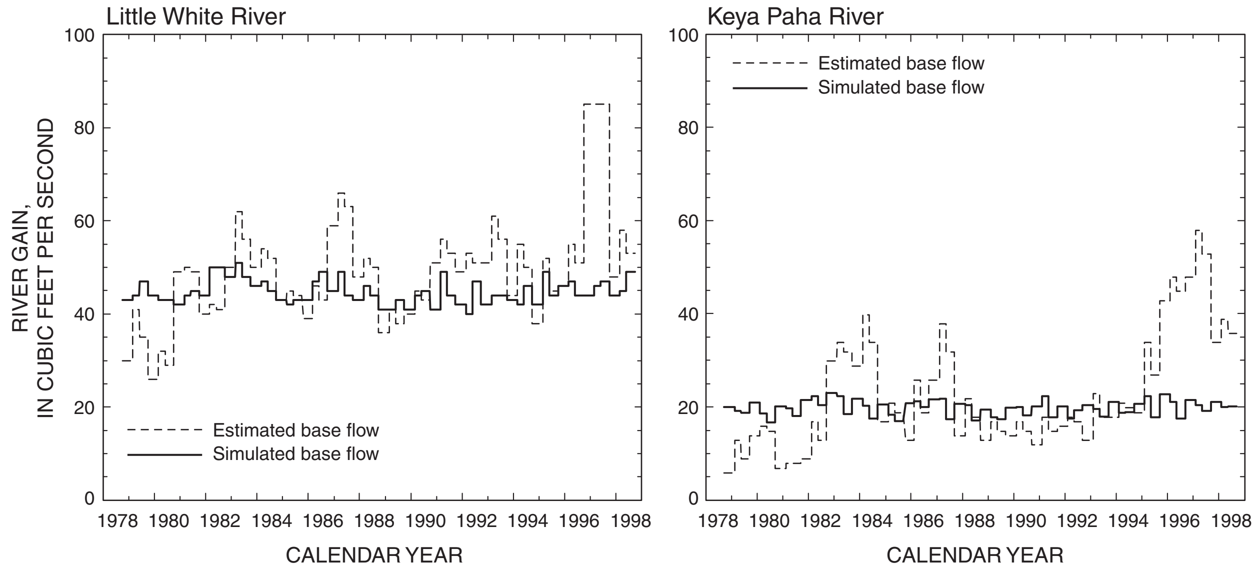


Figure 24. Comparison of estimated and simulated base flow for the Little White and Keya Paha Rivers.

This numerical model is suitable as a tool to help understand the flow system, to confirm that previous estimates of aquifer properties are reasonable, and to estimate aquifer properties in areas without data. Limitations of the model should be taken into account when applying the model to water management. With additional data, further refinement of the model would be possible, which could improve the accuracy of model prediction of the effects of additional stresses on the system, such as increased withdrawals or drought.

SUMMARY

The Ogallala and Arikaree aquifers are important water resources in the Rosebud Indian Reservation area and are used extensively for irrigation, municipal, and domestic water supplies. Continued or increased withdrawals from the Ogallala and Arikaree aquifers in the Rosebud Indian Reservation area have the potential to affect water levels in these aquifers. A water-resource tool was needed to evaluate management and environmental issues associated with the Ogallala and Arikaree aquifers, such as planning for source-water protection, describing potential impacts of contamination, and estimating sustainable aquifer withdrawals. To address this need, the U.S. Geological Survey (USGS) has worked in cooperation with the Rosebud Sioux Tribe to develop a numerical model to simulate ground-water flow in the Ogallala and Arikaree aquifers in the Rosebud Indian Reservation area. This report describes a conceptual model of ground-water flow in the aquifers and documents the development and calibration of a numerical model to simulate ground-water flow. Data for a twenty-year period (water years 1979 through 1998) were analyzed for the conceptual model. Steady-state and transient simulations were performed for the same 20-year period.

Areal recharge to the Ogallala and Arikaree aquifers occurs from precipitation on the outcrop areas, and regional flow enters the study area from the west. Ground water from areal recharge moves from areas of higher altitude toward streams that gain flow from the Ogallala and Arikaree aquifers. Discharge from the Ogallala and Arikaree aquifers occurs through evapotranspiration, discharge to streams, and well withdrawals. Evapotranspiration generally occurs in topographically low areas and along streams, and maximum evapotranspiration occurs when the water level is at the land surface.

Seepage runs were conducted in the study area to obtain information describing streamflow gains in the study area. Base flow was estimated at gaging stations using a hydrograph separation method. The 20-year average estimated base flow was 49 cubic feet per second for the Little White River and 23 cubic feet per second for the Keya Paha River.

Well withdrawals in the study area occur from irrigation, domestic, and stock wells. Withdrawals for domestic and stock uses were assumed to be negligible compared with irrigation use. The 20-year average estimated irrigation withdrawal was 11.6 cubic feet per second.

The conceptual model of ground-water flow was simulated with a numerical model with two aquifer layers using MODFLOW-2000. The upper layer represented the Ogallala aquifer, and the lower layer represented the Arikaree aquifer. The study area was divided into grid blocks 1,640 feet (500 meters) on a side, with 153 rows and 180 columns. Combinations of constant-head and no-flow boundaries were used to best represent boundary conditions.

Estimated horizontal hydraulic conductivity used for the numerical model ranged from 0.2 to 120 feet per day in the Ogallala aquifer and 0.1 to 5.4 feet per day in the Arikaree aquifer. A uniform vertical hydraulic conductivity value of 6.6×10^{-4} feet per day was applied to the Ogallala aquifer. Vertical hydraulic conductivity was estimated for five zones in the Arikaree aquifer and ranged from 8.6×10^{-6} to 7.2×10^{-1} feet per day.

The recharge rate for the steady-state simulation was 3.3 and 1.7 inches per year for the Ogallala and Arikaree aquifers, respectively, for a total recharge rate of 266 cubic feet per second. Discharge rates in cubic feet per second for the steady-state simulation were 184 for evapotranspiration, 46.8 and 19.7 for base flow to the Little White and Keya Paha Rivers, respectively, and 11.6 for well withdrawals from irrigation.

Model calibration was accomplished by varying the model parameters within plausible ranges to produce the best fit between simulated and observed hydraulic heads in the Ogallala and Arikaree aquifers. Steady-state simulations representing average conditions over the 20-year analysis period were analyzed to determine the optimum combination of model parameters. The potentiometric surface calculated from the steady-state simulation established initial conditions for the transient simulation. Water-level measurements were available for 354 public and private wells, 23 State observation wells, and 21 Tribal observation wells.

Calibration criteria for the steady-state simulation included: (1) generally matching the simulated potentiometric surfaces and hydraulic gradients to those of the estimated potentiometric surfaces, and (2) matching hydraulic heads at 95 percent of the wells to within ±50 feet of the observed hydraulic heads. Calibration criteria for the transient simulation included matching the general trends of the 23 State observation well hydrographs and 21 Tribal observation well hydrographs. There was no attempt to calibrate the well hydrographs closer than that required by the steady-state model (±50 feet). Results of the steady-state and transient simulations were within the calibration criteria established to meet the objectives of the study.

A sensitivity analysis was used to examine the response of the numerical model calibrated to steady-state conditions to changes in model parameters including horizontal and vertical hydraulic conductivity, evapotranspiration, recharge, and riverbed conductance, which were increased and decreased for the sensitivity analysis. The model was most sensitive to recharge and horizontal hydraulic conductivity.

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SUPPLEMENTAL INFORMATION

Table 15. Wells used for estimating potentiometric surface of the Ogallala aquifer

[Well locations are shown in figure 4. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Average hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 9)
430239100174301	35N25W 5BBAA	430242	1001731	2,518	2,509.5	--
430200100164801	35N25W 5DDD	430200	1001648	2,501	2,495.5	--
430151100173901	35N25W 8BB	430139	1001730	2,513	2,495.5	--
430023100115602	35N25W13DADD2	430023	1001156	2,443	2,433.9	--
430002100174801	35N25W20BBBC	430002	1001748	2,493	2,488.6	--
430237100241201	35N26W 5BA	430237	1002419	2,635	2,603.1	--
430126100222001	35N26W10CBBA2	430126	1002220	2,618	2,572.8	--
430033100203001	35N26W14DB	430028	1002036	2,530	2,520.4	--
430040100233901	35N26W17DAB	430033	1002349	2,583	2,576.3	--
430006100254301	35N26W19BBAC	430004	1002545	2,660	2,623.4	--
430236100274201	35N27W 2ABCC	430232	1002740	2,700	2,628.3	--
430215100273301	35N27W 2DBCC	430207	1002742	2,695	2,658.3	--
430245100292801	35N27W 3BBBB	430245	1002928	2,671	2,660.2	--
430230100320301	35N27W 6AAC	430235	1003205	2,710	2,679.1	--
430121100323001	35N27W 7CACB	430119	1003245	2,724	2,698.1	--
430115100322101	35N27W 7DACC	430115	1003208	2,731	2,705.1	--
430119100291801	35N27W10CBBB	430124	1002909	2,717	2,685.6	--
430103100280601	35N27W11CCDC	430102	1002806	2,682	2,650.5	--
430106100271403	35N27W11DD	430106	1002714	2,637	2,623.4	--
430139100264401	35N27W12B	430139	1002644	2,636	2,619.3	--
430057100275401	35N27W14BAAB	430100	1002751	2,690	2,671.0	T21
430022100270901	35N27W14DAA	430022	1002709	2,676	2,666.4	--
430039100301001	35N27W16BD	430039	1003010	2,695	2,677.8	--
430039100320801	35N27W18A	430039	1003208	2,725	2,709	--
430122100344501	35N28W11DBBB	430126	1003446	2,728	2,711.2	T20
430055100362702	35N28W15BBBD2	430055	1003627	2,754	2,744.2	--
430154100411801	35N29W 2DDDD	430156	1004118	2,800	2,792.0	T10
430156100411901	35N29W 2DDDD2	430156	1004119	2,800	2,791.2	--
430238100434801	35N29W 4AA	430238	1004348	2,830	2,810	--
430226100445203	35N29W 4BCCB3	430225	1004450	2,845	2,828.9	--
430148100471001	35N29W 7BBBB	430151	1004711	2,903	2,837.3	S41
430151100415402	35N29W11ABBB2	430151	1004154	2,800	2,779.7	--
430100100460501	35N29W18AAAA	430100	1004604	2,870	2,831.4	T9
425957100445601	35N29W20AADD	425957	1004453	2,890	2,804.3	S2
430212100524001	35N30W 5CA	430212	1005240	2,828	2,808.7	--

Table 15. Wells used for estimating potentiometric surface of the Ogallala aquifer–Continued

[Well locations are shown in figure 4. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Average hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 9)
430153100521303	35N30W 5DDCC3	430153	1005213	2,842	2,821.5	--
430217100535201	35N30W 6CABA	430217	1005352	2,873	2,833.7	--
430159100531001	35N30W 6DDDD	430153	1005309	2,853	2,831.6	T5
430139100474801	35N30W12ACBB	430139	1004748	2,935	2,875.3	--
430037100471601	35N30W13ADD	430037	1004716	2,895	2,784.8	--
430045100495701	35N30W15ACA	430045	1004957	2,880	2,850	--
430231100591501	35N31W 5AACC	430231	1005915	2,865	2,849.8	--
430120100574901	35N31W10CBBC	430120	1005749	2,823	2,817.9	--
430042100565801	35N31W15ACA	430042	1005658	2,822	2,814.7	--
430017100595101	35N31W17CCDA	430014	1005947	2,896	2,892.5	T4
430113101062401	35N32W 8D	430111	1010624	2,980	2,974.6	--
430152101054803	35N32W 9BABB3	430152	1010548	2,935	2,927.5	--
430047101025001	35N32W14A	430047	1010250	2,982	2,912.7	--
430028101111701	35N33W15DB	430028	1011117	3,060	3,035.4	--
425956101134503	35N33W20ABCC3	425956	1011345	3,050	3,032.4	--
430704100145901	36N25W10BABB	430704	1001459	2,442	2,420.8	--
430348100172001	36N25W29CDAC	430344	1001720	2,573	2,525.5	--
430315100184301	36N25W31BDCB	430315	1001843	2,552	2,530.4	--
430331100153301	36N25W33AA	430331	1001533	2,585	2,513.6	--
430454100255101	36N26W19BBC	430454	1002551	2,650	2,608.3	--
430515100225001	36N26W21AAB	430517	1002238	2,585	2,543.3	--
430310100245501	36N26W31ADDD	430312	1002455	2,620	2,594.4	S80
430335100241401	36N26W32BBAA	430337	1002431	2,619	2,589.2	T22
430246100222302	36N26W34CCC2	430246	1002223	2,634	2,607.2	--
430728100135801	36N27W 1BDDD	430735	1002632	2,627	2,600.0	T23
430721100290001	36N27W 3CA	430721	1002900	2,663	2,602.2	--
430705100304701	36N27W 5DDD	430709	1003045	2,600	2,579.4	--
430512100291801	36N27W15CC	430527	1002920	2,698	2,621.9	--
430458100300901	36N27W21BDDB	430500	1003013	2,664	2,613	--
430737100350602	36N28W 2BDAC2	430740	1003453	2,773	2,676.7	--
430719101380501	36N28W 5DACC	430718	1003804	2,818	2,782.9	--
430604100390801	36N28W 7DDB	430624	1003911	2,829	2,793.1	--
430649100364801	36N28W 9ADDA	430643	1003638	2,805	2,764.2	--
430701100363001	36N28W10BBBB	430705	1003635	2,823	2,750.3	S145
430700100344501	36N28W11ABB	430703	1003444	2,807	2,706.6	--

Table 15. Wells used for estimating potentiometric surface of the Ogallala aquifer–Continued

[Well locations are shown in figure 4. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Average hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 9)
430702100330501	36N28W12AABA	430706	1003313	2,806	2,659.8	T18
430618100330301	36N28W12DD	430620	1003310	2,675	2,668.8	--
430614100362503	36N28W15BABB3	430614	1003625	2,778	2,753	--
430601100364501	36N28W16ABCA	430607	1003705	2,805	2,779.4	--
430515100331201	36N28W24AAA	430518	1003306	2,685	2,664.8	--
430406100380701	36N28W29ACDC	430405	1003810	2,771	2,756.4	--
430403100395001	36N28W30BCDD	430403	1003950	2,820	2,800.8	--
430348100390401	36N28W30DDAB	430348	1003904	2,792	2,772.7	--
430314100392301	36N28W31ACDC	430314	1003923	2,839	2,819.1	--
430243100371701	36N28W33BDDD	430311	1003712	2,753	2,723.0	T19
430712100421301	36N29W 2CDCC	430706	1004208	2,850	2,804.3	T12
430714100445001	36N29W 4CCBC	430715	1004448	2,853	2,816.4	--
430624100461601	36N29W 7DDB	430624	1004616	2,925	2,889.7	--
430659100434901	36N29W 9AA	430659	1004349	2,845	2,777.8	--
430629100434401	36N29W 9DAD	430629	1004344	2,885	2,817.4	--
430530100422501	36N29W14CDAB	430528	1004158	2,893	2,810.8	T11
430522100411902	36N29W14DDDD2	430522	1004119	2,884	2,814.9	--
430558100430301	36N29W15ACBB	430558	1004303	2,884	2,866.4	--
430609100434201	36N29W16AAAA	430613	1004346	2,863	2,821.7	S125
430604100445201	36N29W17AADD1	430604	1004453	2,905	2,822.9	--
430603100460501	36N29W18AADD	430603	1004605	2,940	2,849.9	--
430450100453701	36N29W20CA	430450	1004537	2,868	2,845.4	--
430508100431901	36N29W22BBDD	430508	1004319	2,911	2,830.6	--
430415100451401	36N29W29ACAA	430415	1004512	2,870	2,850.8	T7
430305100455401	36N29W32CB	430305	1004554	2,835	2,823.3	--
430252100431301	36N29W34CD	430252	1004313	2,804	2,794.2	--
430302100412001	36N29W35DAD	430302	1004120	2,834	2,818.5	--
430723100512101	36N30W 4DBCB	430723	1005121	2,978	2,871.7	--
430652100484001	36N30W11ADBB	430652	1004840	2,949	2,850.5	--
430615100472701	36N30W12DDCD	430615	1004723	2,960	2,826.6	--
430610100481701	36N30W13BBBB	430613	1004820	2,916	2,843.4	S126
430518100533701	36N30W19ABB	430518	1005337	2,902	2,854.9	--
430501100504901	36N30W21DAAA	430453	1005045	2,888	2,858.3	T6
430507100483701	36N30W23ADBB	430507	1004837	2,934	2,848.4	--
430342100482901	36N30W26DDDB	430342	1004829	2,851	2,831.9	--

Table 15. Wells used for estimating potentiometric surface of the Ogallala aquifer–Continued

[Well locations are shown in figure 4. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Average hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 9)
430250100532701	36N30W31DCDA	430250	1005327	2,868	2,848.8	--
430327100512301	36N30W33BADD	430327	1005123	2,945	2,853.8	--
430334100515201	36N30W33BBB	430334	1005152	2,896	2,842.8	--
430254100515001	36N30W33CCBD	430254	1005150	2,879	2,855.7	--
430258100471401	36N30W36DDDA	430250	1004712	2,885	2,836.1	T8
430721100563001	36N31W 2CB	430721	1005630	2,934	2,784.8	--
430613101561701	36N31W14BAAA	430613	1005606	2,955	2,816.3	S130
430541100555501	36N31W14DB	430541	1005555	2,970	2,870.8	--
430555100570301	36N31W15ACAC	430555	1005703	3,005	2,915.8	--
430603101003401	36N31W18ABDD	430603	1010034	2,877	2,838.8	--
430309100570901	36N31W34DBBC	430306	1005714	2,920	2,864.8	T3
430458101042001	36N32W22CADA	430458	1010420	2,850	2,820.7	--
430426101020201	36N32W25BAA	430426	1010202	2,845	2,810.8	--
430340101012301	36N32W25DDDD	430340	1010123	2,841	2,833.9	S87
431236100172601	37N25W 4BCCA	431236	1001726	2,467	2,386.1	--
430932100262401	37N26W19DCC	430932	1002624	2,655	2,584.2	--
431027100333001	37N27W18DDAB	431035	1003306	2,609	2,604.5	T17
430909100333501	37N27W30BDDA	430909	1003335	2,722	2,662.1	--
431159100412103	37N28W 7BBBC3	431159	1004121	2,793	2,715.8	--
431021100384701	37N28W16CCDD	431024	1003845	2,744	2,714.4	--
430956100402901	37N28W19ACDD	430956	1004029	2,800	2,772.5	--
430932100390001	37N28W21CCCC	430930	1003858	2,772	2,726.6	S201
430839100373801	37N28W27CCCC	430839	1003745	2,805	2,726.6	S175
430907100401001	37N28W30ADDA	430907	1004010	2,757	2,741.5	--
430842100411301	37N28W30CCCB	430841	1004119	2,770	2,744.9	S177
430820100371401	37N28W34ABDA	430828	1003655	2,783	2,725.1	T16
430809100372401	37N28W34BDA	430725	1003715	2,800	2,740.4	--
431212100472901	37N29W 6DDBD	431212	1004727	2,868	2,739.8	--
431138100441601	37N29W10DBBB	431136	1004414	2,818	2,755.5	--
431141100422501	37N29W12BCDD	431141	1004215	2,825	2,761.5	--
431133100402201	37N29W13CBCD	431133	1004222	2,796	2,731.7	--
431109100445901	37N29W16AAAA	431112	1004457	2,852	2,753.6	S219
431100100461601	37N29W17AACD	431106	1004604	2,845	2,767.7	--
430920100444801	37N29W27BBCA	430920	1004448	2,877	2,810.4	--
430852100435001	37N29W27DACD	430850	1004348	2,825	2,768.1	--

Table 15. Wells used for estimating potentiometric surface of the Ogallala aquifer–Continued

[Well locations are shown in figure 4. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Average hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 9)
430909100452701	37N29W28ACBC	430905	1004527	2,880	2,803.4	--
430840100445601	37N29W28DDDD	430837	1004454	2,858	2,790.7	S176
430924100460601	37N29W29AAAA	430927	1004607	2,868	2,790.1	S194
430836100464301	37N29W29CDDD	430836	1004641	2,870	2,800.8	--
430755100582301	37N29W31DACC	430757	1004729	2,921	2,815.4	T13
430748100455601	37N29W33CCCC	430745	1004601	2,909	2,817.2	S160
431127100532801	37N30W 8DACC	431114	1005333	2,880	2,759.4	T27
431033100493201	37N30W13CBCD	431033	1004932	2,783	2,766.1	--
430910100490201	37N30W25ACBC	430911	1004902	2,899	2,882.2	--
430912100542301	37N30W29BCBB	430912	1005421	2,997	2,812.3	--
430848100544001	37N30W30DDBC	430842	1005437	2,980	2,778.2	--
430831100580301	37N31W25CCCB	430831	1005803	2,970	2,776.9	--
431200101034801	37N32W11ABA	431157	1010356	3,060	2,876.3	--
430907101073801	37N32W29ACB	430907	1010738	2,910	2,882.1	--
431222101093501	37N33W 1DAA	431222	1010954	3,104	3,008.8	--
431148101165001	37N33W 7ABD	431154	1011544	3,018	2,947.4	--
431156101105801	37N33W11AAB	431157	1011052	3,153	3031.6	--
431018101132301	37N33W16DCDC	431018	1011323	3,023	2,955.4	--
431018101152001	37N33W17CCCC	431018	1011520	2,998	2,930.3	S207
430929101104203	37N33W26AAAA3	430929	1011042	2,953	2,875.8	--
431432101123401	37N33W27BAA	430921	1011230	2,978	2,917.5	--
430836101152201	37N33W32BBBB	430836	1011522	2,960	2,894.8	--
430825101151801	37N33W32BBBB2	430834	1011518	2,960	2,901.8	S170
431250101163701	37N34W 1AAAA	431250	1011637	3,113	2,959.9	--
431540100154501	38N25W15DCCB	431540	1001545	2,467	2,406.2	--
431509100185901	38N25W19ADCC	431509	1001859	2,530	2,504.3	--
431327100164501	38N25W33ACD	431327	1001645	2,475	2,466.1	--
431716100212001	38N26W11AAB	431716	1002120	2,651	2,600.8	--
431532100200101	38N26W24AAAB	431532	1002001	2,503	2,467.3	--
431714100364101	38N28W20AAAD	431524	1003906	2,700	2,646.4	--
431427100375201	38N28W28ADAA	431427	1003754	2,781	2,729.1	--
431354100375201	38N28W28DDDD	431351	1003753	2,781	2,749.8	--
431435100414101	38N29W25AACB	431433	1004130	2,663	2,646.9	--
431318100532301	38N30W32DAAB	431318	1005321	2,838	2,818.3	--
431550100590501	38N31W16CABD	431550	1005905	2,747	2,743	--

Table 16. Wells used for estimating potentiometric surface of the Arikaree aquifer

[Well locations are shown in figure 5. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Adjusted hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 10)
430242100184801	35N25W 6BBA	430242	1001842	2,525	2,513.4	--
430003100174802	35N25W20BBBC3	430003	1001748	2,493	2,488.1	--
430204100212001	35N26W 3DDAB	430204	1002120	2,617	2,593.1	--
430216100252101	35N26W 6DBBA	430216	1002517	2,620	2,558.3	--
430127100230601	35N26W 9BDAD	430135	1002320	2,585	2,558.3	--
430126100221901	35N26W10CBBA3	430126	1002219	2,617	2,569.1	--
430033100234902	35N26W17DAB2	430033	1002349	2,583	2,565.4	--
430245100292701	35N27W 3BBBB4	430245	1002927	2,671	2,659.9	--
430106100271402	35N27W11DD2	430106	1002714	2,637	2,610.7	--
430000100285401	35N27W22ABBC	430003	1002855	2,679	2,668.1	--
430154100332601	35N28W 1DC	430154	1003326	2,683	2,673.1	--
430217100370801	35N28W 4ACCB	430224	1003707	2,753	2,719.4	--
430613100352901	35N28W14AAAA	430102	1003415	2,735	2,722	--
430226100445201	35N29W 4BCCB	430226	1004452	2,845	2,832.2	--
430225100445401	35N29W 5DDDA	430157	1004454	2,880	2,783.1	--
430048100450201	35N29W17AACD	430048	1004502	2,913	2,830.8	--
430014100445401	35N29W17DDDA	430014	1004454	2,878	2,850.6	--
430113100491601	35N30W11C	430113	1004916	2,910	2,824.1	--
430142100580301	35N31W 9AACD	430142	1005803	2,840	2,811.9	--
430021100543301	35N31W13D	430021	1005433	2,840	2,782.5	--
430153101054902	35N32W 9BABB5	430153	1010549	2,938	2,930.5	--
430727100170304	36N25W 5DBD	430721	1001700	2,440	2,427.6	--
430326100185001	36N25W31ABC	430326	1001819	2,597	2,549.9	--
430700100225701	36N26W 9AB	430700	1002257	2,505	2,498.3	--
430607100212101	36N26W15AAAB	430611	1002119	2,505	2,447.5	--
430528100242001	36N26W17CDD	430523	1002416	2,554	2,533.6	--
430455100241301	36N26W20CAD	430455	1002413	2,537	2,524.7	--
430424100214301	36N26W27ABBB	430427	1002147	2,588	2,545.7	--
430727100262801	36N27W 1	430727	1002628	2,650	2,597.4	--
430451100290001	36N27W22CDBA	430451	1002906	2,638	2,628.4	--
430410100261701	36N27W25ADBB	430415	1002611	2,658	2,614	--
430412100323001	36N27W30BDA	430413	1003233	2,693	2,672.6	--
430245100272401	36N27W35DCD	430246	1002730	2,673	2,646.5	--
430702100330501	36N28W12AAA	430706	1003313	2,806	2,641.6	--
430454100341801	36N28W23DAAC	430454	1003418	2,730	2,712.3	--

Table 16. Wells used for estimating potentiometric surface of the Arikaree aquifer–Continued

[Well locations are shown in figure 5. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Adjusted hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 10)
430448100332401	36N28W24ACA	430503	1003324	2,655	2,644.9	--
430627100532601	36N30W 7D	430627	1005326	2,960	2,856.3	--
430301100492101	36N30W35CBCC	430300	1004930	2,917	2,842.5	--
430630100565401	36N31W10DACD3	430630	1005654	2,958	2,736.1	--
430613100544901	36N31W12DCCD	430613	1005449	2,899	2,842.6	--
430650101021001	36N32W 1DCDC	430708	1010147	2,623	2,613.9	--
430721101032801	36N32W 2C	430721	1010328	2,660	2,666.6	--
430712101042801	36N32W 3CD	430712	1010428	2,686	2,631.4	--
430619101020501	36N32W12CD2	430619	1010205	2,895	2,733.9	--
430612101014401	36N32W12DD	430620	1010130	2,842	2,674.1	--
430537101062801	36N32W17DBD	430537	1010628	2,860	2,820.2	--
431500101133301	36N33W21BBC	430511	1011307	2,985	2,859.6	--
431254100191001	37N25W 6ABA	431254	1001910	2,410	2,372.6	--
431211100194502	37N25W 6CCC2	431211	1001945	2,369	2,346.5	--
430908100175801	37N25W29ACDD	430908	1001758	2,374	2,359.5	--
430757100183301	37N25W32CCAB	430757	1001833	2,423	2,395.5	--
431245100210801	37N26W 2ADAA	431245	1002108	2,383	2,350.5	--
431215100225801	37N26W 3CDA	431215	1002258	2,444	2,401.2	--
431020100243501	37N26W16CCBB	431020	1002435	2,530	2,522.9	S210
430931100251801	37N26W20CDD	430931	1002518	2,605	2,557	--
430932100211701	37N26W23DDCD	430932	1002117	2,538	2,495.2	--
431019100200001	37N26W24AAA	431019	1002000	2,471	2,453.3	--
430953100200001	37N26W24DAA	430953	1002000	2,451	2,418.3	--
430858100202301	37N26W25DBBD	430858	1002023	2,565	2,522.3	--
430851100210801	37N26W26DADD	430851	1002108	2,576	2,533.2	--
430756100231601	37N26W34CCAA	430756	1002316	2,540	2,521.2	--
430803100212801	37N26W35DBDA	430803	1002128	2,554	2,511.3	--
431212100280601	37N27W 1CC	431212	1002806	2,474	2,451.4	--
431245100320601	37N27W 5A	431245	1003206	2,593	2,581.7	--
431126100321001	37N27W 8D	431127	1003206	2,553	2,536.7	--
431139100311501	37N27W 9CAAA	431139	1003115	2,540	2,526.3	--
431050100274501	37N27W13BDD	431050	1002745	2,530	2,472.2	--
431051100293101	37N27W15ADD	431051	1002931	2,518	2,465.6	--
431000100325101	37N27W20BCD	431000	1003251	2,620	2,609.1	--
430938100273701	37N27W24DCB	430939	1002735	2,595	2,548.2	--

Table 16. Wells used for estimating potentiometric surface of the Arikaree aquifer–Continued

[Well locations are shown in figure 5. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Adjusted hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 10)
430926100290301	37N27W26BAB	430926	1002903	2,564	2,441.5	--
430817100312001	37N27W33BD	430817	1003120	2,620	2,603.5	--
431159100412102	37N28W 7BBBC2	431159	1004121	2,793	2,718	--
430922100410302	37N28W30BBAA2	430922	1004103	2,818	2,753.3	--
430821100373401	37N28W34BCAB	430821	1003734	2,808	2,734.4	--
431149100462301	37N29W 8AADC	431158	1004608	2,810	2,739.6	--
430959100444001	37N29W22CCCC	430929	1004453	2,882	2,780.9	S205
431238100490301	37N30W 1ACB	431240	1004858	2,740	2,693.9	--
431250100530101	37N30W 4BAA	431252	1005256	2,842	2,716.5	--
431122100551202	37N30W 7CDBA2	431124	1005506	2,770	2,604.2	--
431022100542301	37N30W17CCCB	431019	1005423	2,995	2,788.8	--
430824100522501	37N30W33ABD	430808	1005143	2,985	2,838.7	--
430800100491801	37N30W36A2	430812	1004845	2,935	2,824.5	--
431234100574401	37N31W 3ADAC	431234	1005744	2,512	2,506.3	--
431131100580701	37N31W10DBBB	431131	1005807	2,530	2,498.1	--
430920100581201	37N31W22ABCD2	431005	1005804	2,943	2,639.4	--
430838100561701	37N31W25CC	430836	1005611	3,015	2,802.3	--
430845100571903	37N31W26C3	430845	1005719	3,017	2,736.9	--
430807100591001	37N31W33DAA	430805	1005852	3,037	2,780.6	--
431030101031201	37N32W13CAD	431034	1010311	2,970	2,792.3	--
430929101104202	37N33W26AAAA2	430929	1011042	2,953	2,875.7	--
431430100195901	38N25W30BCBB	431428	1001955	2,483	2,457.6	S274
431311100193201	38N25W31CDBA	431311	1001932	2,426	2,413.6	--
431637100264101	38N26W 7CDB	431637	1002641	2,513	2,485.8	--
431554100203301	38N26W13BCCA	431604	1002101	2,608	2,504.6	--
431413100244901	38N26W29DAA	431413	1002449	2,440	2,417.5	--
431356100255401	38N26W30DAD	431405	1002558	2,420	2,387.5	--
431340100253901	38N26W32BBD	431340	1002539	2,452	2,437.4	--
431328100240901	38N26W33BDD	431328	1002409	2,424	2,413.4	--
431308100223101	38N26W34DDB	431308	1002231	2,417	2,394.5	--
431323100213501	38N26W35DBBA	431323	1002135	2,403	2,340.5	--
431736100293201	38N27W 3DAD	431736	1002932	2,526	2,474.3	--
431808100312801	38N27W 4BAB	431808	1003128	2,550	2,488.8	--
431757100323302	38N27W 5BDAB	431757	1003233	2,522	2,497	--
431650100330701	38N27W 7DAAB	431650	1003307	2,477	2,468.2	--

Table 16. Wells used for estimating potentiometric surface of the Arikaree aquifer–Continued

[Well locations are shown in figure 5. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Adjusted hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 10)
431548100314401	38N27W16CBCD	431548	1003144	2,484	2,452.7	--
431440100275301	38N27W25BABA	431440	1002753	2,448	2,415.8	--
431430100320101	38N27W28B	431430	1003201	2,518	2,506.7	--
431337100312101	38N27W33BDA	431337	1003121	2,570	2,540.5	--
431539100352401	38N28W13CCCC	431535	1003530	2,577	2,539.2	--
431625100361301	38N28W14BAAB	431625	1003613	2,589	2,529.4	--
431615100390701	38N28W17AADD	431615	1003907	2,664	2,609.6	--
431625100411801	38N28W18BBBA	431625	1004118	2,596	2,587.3	--
431512100402501	38N28W19ADCD	431509	1004029	2,673	2,638.5	--
431506100363601	38N28W23CBBB	431508	1003641	2,635	2,626.8	--
431430100371601	38N28W27ACB	431430	1003716	2,768	2,724.3	--
431347100404901	38N28W31ABBB	431347	1004049	2,666	2,645.1	--
431342100344101	38N28W36ABCB	431347	1003452	2,620	2,608.7	T15
431551100441601	38N29W15DBCD	431550	1004416	2,696	2,698.9	--
431536100472201	38N29W17BCDA	431605	1004705	2,687	2,669.5	--
431502100443801	38N29W22CAC	431500	1004426	2,730	2,686.3	--
431424100430601	38N29W26ACB	431425	1004305	2,750	2,670.5	--
431340100430401	38N29W35ACBB	431336	1004307	2,803	2,707.8	--
431809100483401	38N30W 1AAAA	431809	1004834	2,763	2,625.5	--
431740100502201	38N30W 2CAA	431737	1005027	2,640	2,492.2	--
431610100484701	38N30W13ADBB	431612	1004845	2,645	2,631.8	--
431537100504701	38N30W14CCCA	431537	1005047	2,723	2,639.4	--
431601100514301	38N30W15BDC	431601	1005143	2,650	2,649.7	--
431612100551201	38N30W18BADB	431612	1005512	2,550	2,415.7	--
431515100501701	38N30W23ACBC	431515	1005017	2,720	2,656.8	--
431255100545701	38N30W31DCCD	431254	1005439	2,872	2,701.4	--
431315100541301	38N30W32CBD	431309	1005415	2,887	2,735.7	--
431340100521405	38N30W33AA5	431408	1005206	2,840	2,624.3	--
431335100511101	38N30W34A	431335	1005111	2,600	2,572.8	--
431252100501801	38N30W35BDDB	431327	1005024	2,708	2,605.2	--
431744100561401	38N31W 1BACB2	431744	1005601	2,600	2,502.4	--
431744100583601	38N31W 3ABAB	431800	1005753	2,692	2,600.9	--
431733100585701	38N31W 4DABD2	431733	1005857	2,725	2,656	--
431623101010501	38N31W 8CCC	431623	1010105	2,787	2,732	--
431654100574302	38N31W10ADAC2	431654	1005743	2,698	2,606	--

Table 16. Wells used for estimating potentiometric surface of the Arikaree aquifer–Continued

[Well locations are shown in figure 5. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Adjusted hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 10)
431630100570201	38N31W11CDAA	431630	1005702	2,652	2,552.8	--
431520100593601	38N31W16DBAA	431555	1005907	2,710	2,688	--
431551101003901	38N31W17CAA	431551	1010039	2,880	2,878.1	--
431501101005701	38N31W20CBAA	431501	1010057	2,837	2,827.1	--
431526100563202	38N31W23AAAB2	431526	1005635	2,443	2,431.2	--
431508100562101	38N31W24BDAD	431508	1005620	2,605	2,504.8	--
431427100561201	38N31W25BBAC	431426	1005601	2,722	2,563.2	--
431259100574401	38N31W34DDAC	431259	1005744	2,502	2,477.2	--
431338100570901	38N31W35BA	431338	1005709	2,485	2,476.1	--
431738103035702	38N32W 1BAAC	431759	1010303	2,750	2,671.1	--
431740101044601	38N32W 3ADDD	431740	1010446	2,750	2,681.3	--
431637101084802	38N32W 7DCAB2	431637	1010848	2,890	2,841.3	--
431639101043102	38N32W11CBD2	431639	1010431	2,785	2,716.3	--
431554101044501	38N32W15DAAA	431554	1010445	2,805	2,782.3	--
431533101080501	38N32W17CCD	431533	1010805	3,059	2,906.7	--
431303101075401	38N32W32CDB	431303	1010754	3,032	2,926.3	--
431625101103001	38N33W12CCDC	431623	1011029	2,943	2,930.7	--
431843100263301	39N26W31BDA	431847	1002633	2,600	2,543	--
431830100250201	39N26W32DCDA	431816	1002502	2,533	2,456.9	--
432242100281201	39N27W 1CCB	432242	1002812	2,520	2,478.6	--
432316100305801	39N27W 3BBD	432316	1003058	2,500	2,468.9	--
432205100294301	39N27W10DABB	432205	1002943	2,513	2,481.7	--
432033100305601	39N27W21ADDA	432033	1003056	2,754	2,582.8	--
432009100290301	39N27W23CDBA	432009	1002903	2,651	2,609.5	--
431937100320101	39N27W29ADBD	431937	1003201	2,676	2,645	--
431815100341801	39N27W31CCC	431815	1003418	2,537	2,476.6	--
431818100324201	39N27W32CDCB2	431818	1003242	2,544	2,513.1	--
431814100302602	39N27W34CCDC2	431814	1003026	2,562	2,535.6	--
431903100282002	39N27W35AAAB2	431903	1002820	2,598	2,552.3	--
432150100381701	39N28W 9DCA	432150	1003817	2,518	2,506.3	--
432203100361301	39N28W11CAA	432203	1003613	2,535	2,509.9	--
432117100371601	39N28W15ACC	432117	1003716	2,585	2,525.1	--
432108100400001	39N28W17CBD	432103	1004006	2,683	2,615.8	--
432003100352501	39N28W24CC	432003	1003525	2,675	2,614.8	--
431907100350201	39N28W25CCD	431907	1003502	2,565	2,504.7	--

Table 16. Wells used for estimating potentiometric surface of the Arikaree aquifer–Continued

[Well locations are shown in figure 5. Hydraulic heads are estimated averages for water years 1979-98. NGVD of 1929, National Geodetic Vertical Datum of 1929. Agency code: S, State; T, Tribal. --, not applicable]

Site identification number	Local number	Latitude	Longitude	Land surface altitude (feet above NGVD of 1929)	Adjusted hydraulic head altitude (feet above NGVD of 1929)	Agency (S/T) and well number for observation wells (fig. 10)
431947100354001	39N28W26AADB	431947	1003540	2,628	2,567.9	--
431927100381501	39N28W28DBAA	431927	1003815	2,628	2,598.6	--
431949100392901	39N28W29ABAD	431949	1003929	2,634	2,624.9	--
431933100412101	39N28W30BCDB	431933	1004121	2,622	2,603.4	--
431912100410501	39N28W30CDBD	431912	1004105	2,601	2,587.4	--
431812100383901	39N28W33CDD	431812	1003839	2,563	2,520.9	--
432049100415301	39N29W13CC	432053	1004229	2,640	2,584.7	--
432025100434001	39N29W23BCD	432025	1004340	2,500	2,468.8	--
431830100450901	39N29W33DA	431830	1004509	2,657	2,628.6	--
431822100424301	39N29W35DDAB	431822	1004243	2,681	2,647.6	--
431813100413101	39N29W36DDDC	431813	1004131	2,645	2,596.7	--
432244100594502	39N31W 4CBDB2	432244	1005945	2,467	2,448.7	--
432149101005001	39N31W 8CACB	432149	1010050	2,653	2,516.8	--
432020101010901	39N31W19ACDA2	432020	1010127	2,625	2,544.9	--
431903100561701	39N31W25CCCA	431902	1005615	2,558	2,470.9	--
431933101010501	39N31W29BCB	431933	1010105	2,640	2,585.9	--
431823101005201	39N31W32CBDB	431823	1010052	2,685	2,646	--
431813100571001	39N31W35CDBD	431813	1005710	2,620	2,533.9	--
432310101045501	39N32W 3AAAA	432320	1010441	2,610	2,577.9	S374
432205101032201	39N32W11ACDA	432205	1010322	2,595	2,584.8	--
432131101034001	39N32W14AAA	432131	1010340	2,634	2,599.9	--
432131101053001	39N32W15BAB	432131	1010528	2,678	2,638.9	--
431922101032201	39N32W25CBAB	431922	1010322	2,705	2,626	--
431913101084001	39N32W30DBDC	431913	1010840	2,820	2,767.9	--
431820101045002	39N32W34DADC2	431820	1010450	2,781	2,646.2	--
432044101115201	39N33W15DDDD	432044	1011152	2,800	2,763.7	S361
432416100315601	40N27W32AAA	432412	1003200	2,478	2,470.1	--
432540101092202	40N32W19BCC2	432540	1010922	2,595	2,569.8	--
432515101071701	40N32W20DDBB	432518	1010737	2,597	2,586.4	--
432554101065601	40N32W21BBBB	432557	1010703	2,576	2,561.3	S384
432530101024801	40N32W24CBB	432530	1010319	2,568	2,543.3	--
432453101075601	40N32W29BCAB	432452	1010803	2,618	2,599.7	--
432654101130401	40N33W 9DDDA	432654	1011304	2,570	2,515.6	--
432545101102701	40N33W24BBDD	432545	1011027	2,548	2,523.1	--
432446101131104	40N33W28AD	432446	1011311	2,740	2,686.1	--
432407101131201	40N33W33AAB	432407	1011312	2,742	2,686.4	--