Pawnee-Buckner Subbasin

2010 Field Analysis Summary

May 16, 2011

Basin Management Team

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Table of Contents

Figures

Table

I. Introduction

The Pawnee-Buckner subbasin is located in south-central and south-western Kansas and includes portions of Scott, Edwards, Finney, Ford, Gray, Hodgeman, Lane, Ness, Pawnee, and Rush counties. The watershed encompasses approximately 2,701 square miles or 1,728,776 acres. The subbasin lies in two Groundwater Management Districts (GMDs). The Pawnee River alluvium in Pawnee County is located in Big Bend GMD #5. Gray and Ford counties and part of Finney County are located in the Southwest Kansas GMD #3 (Figure 1). The rest of the subbasin is not within a GMD.

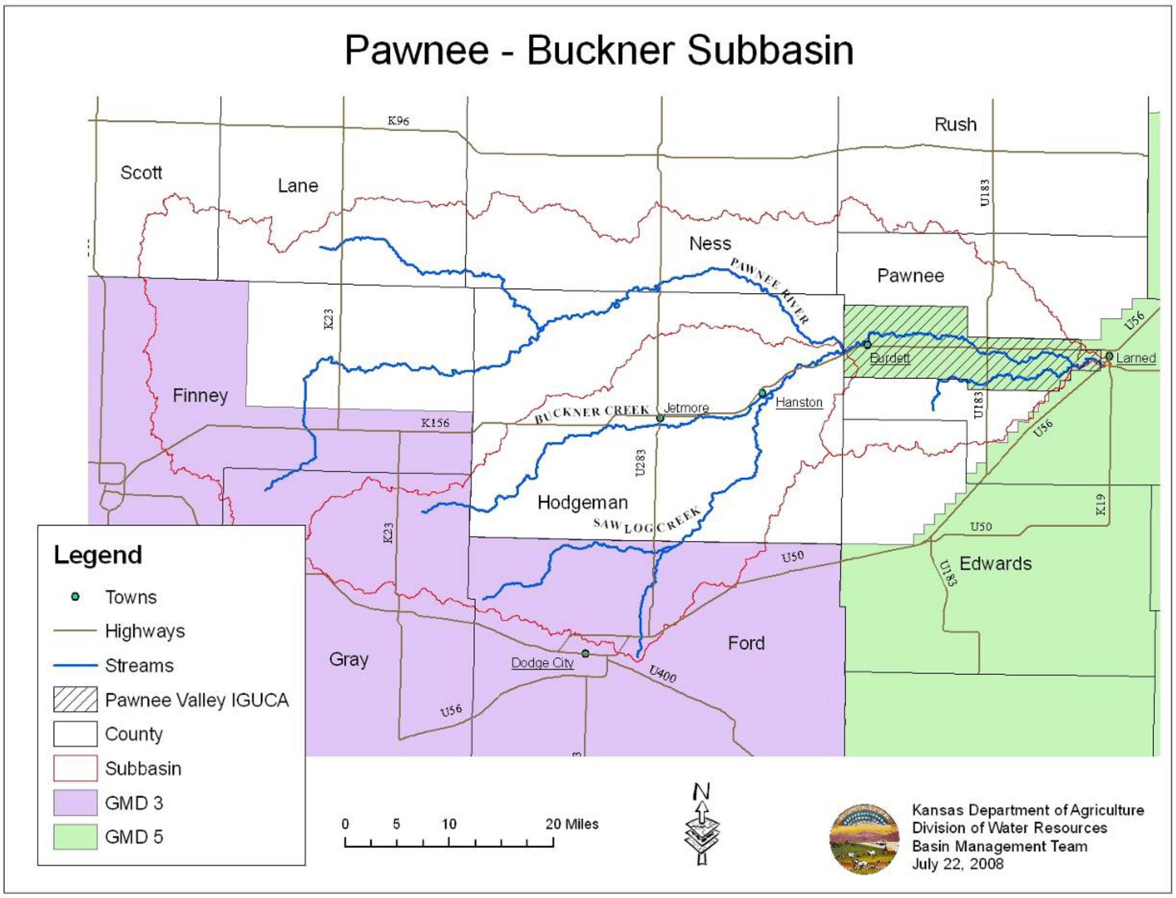

Figure 1: Pawnee-Buckner Subbasin

Three aquifer systems exist in the subbasin: alluvial, Dakota and Ogallala-High Plains. The Pawnee River Valley alluvium varies in width from three miles in parts of Pawnee County to two miles in Hodgeman and Ness counties. The alluvium thickness ranges from 65 feet to 138 feet in Pawnee County and a maximum of 100 feet in Hodgeman and Ness counties.

The Dakota aquifer is both unconfined and confined in the subbasin. The confined Dakota aquifer is present throughout the subbasin, whereas the unconfined formation is in the eastern part of Hodgeman County and continues into Pawnee County. The alluvial and Dakota aquifers are hydraulically connected in areas where the Dakota is unconfined. The Dakota discharges to both Buckner and Sawlog Creeks in southern Hodgeman County.

The Ogallala aquifer is present in the western portion of the subbasin. The Ogallala recharges and releases more slowly than the alluvial aquifer. A portion of the Ogallala aquifer known as "the Ogallala subunit" is located in south central Hodgeman County between Buckner and Sawlog Creeks. The Ogallala subunit is one of the few significant areas of the Ogallala aquifer not located within a GMD.

In order to address the supply and use of water resources in the subbasin, a working group was formed in 1994. A committee of local stakeholders submitted recommendations for long-term management strategies for the alluvial valley to the chief engineer in February 2000. The committee recommendations included dividing the subbasin into ten hydrologic subunits to address water level declines during drought conditions. The management program required amending the current Pawnee Valley IGUCA order to implement the strategies recommended to the chief engineer. Figure 2 illustrates the ten hydrologic subunits proposed by the Basin Management Team (BMT).

These management strategies and a report by BMT on proposed subunits are available on the Kansas Department of Agriculture, Division of Water Resources (KDA-DWR) website at http://www.ksda.gov/subbasin/.

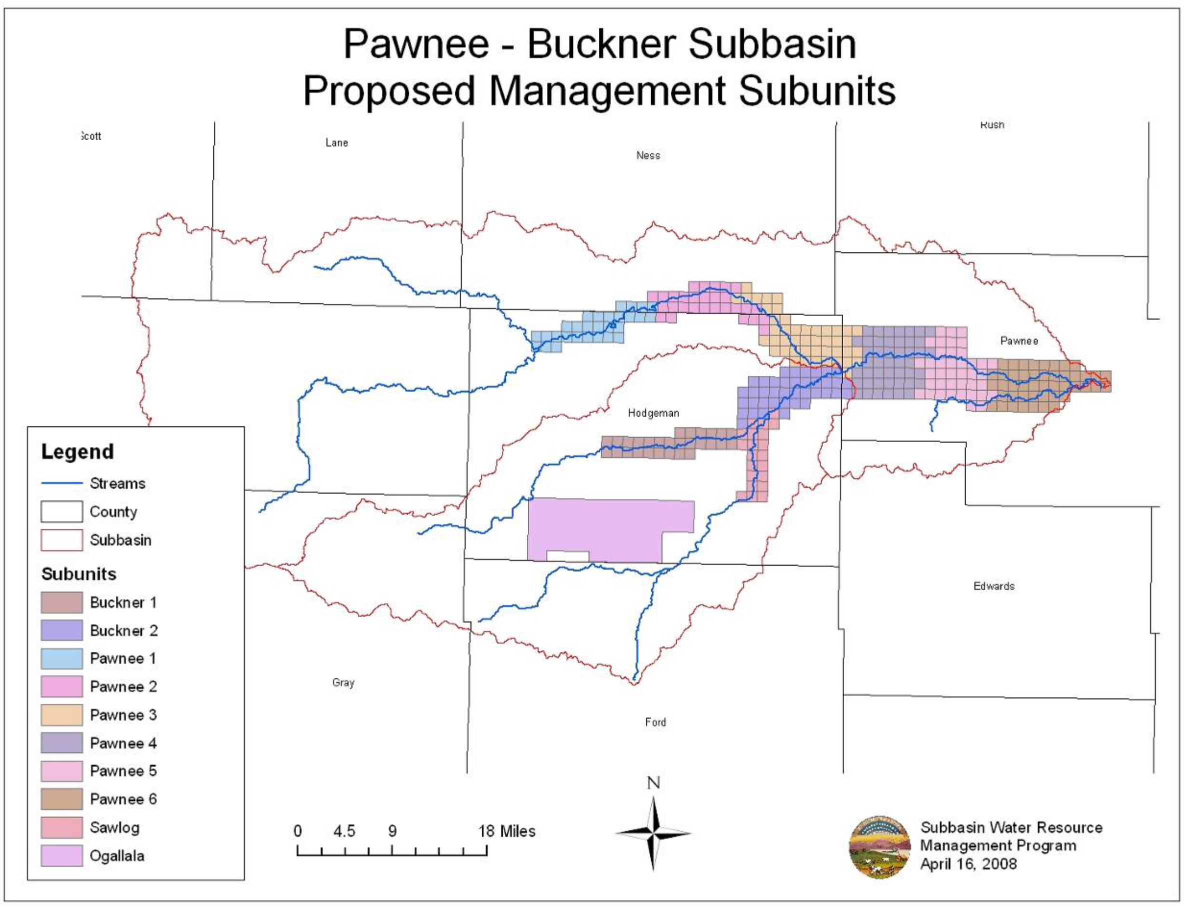

Figure 2: Pawnee-Buckner Hydrologic Subunits

II. Precipitation

Precipitation in the Pawnee-Buckner subbasin historically averages 22.8 inches per year based on five precipitation stations (historically there were three different stations at Jetmore). The graph in Figure 3 is based on averaged data from the National Climatic Data Center (NCDC) stations located in Jetmore in Hodgeman County and Larned and Burdett in Pawnee County. There have been several years with low precipitation but not in the consecutive years that characterized the drought of the 1950s. The highest annual precipitation occurred in 1993 with over 35 inches. Annual precipitation data for these NCDC stations is currently available through 2009. After dry years, 2002 and 2003, the subbasin has had above average precipitation in the period 2004-2007. In 2008, the precipitation was close to the historical annual average for the subbasin, but the subbasin had above average precipitation in 2009.

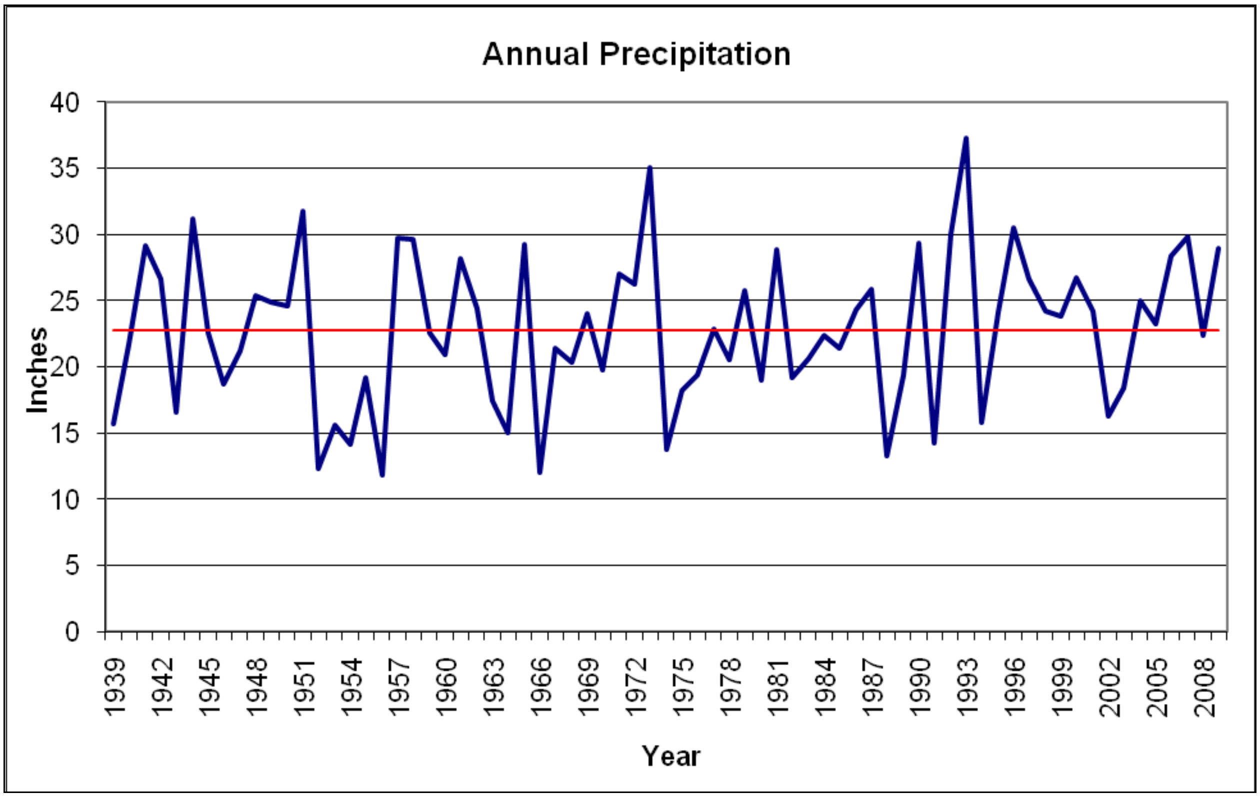

Figure 3: Average precipitation for the Pawnee-Buckner Subbasin 1939-2009

Figure 4 shows provisional 2010 monthly precipitation. This chart averages three stations, Jetmore, Burdett and Larned. June had highest precipitation with 5.65 inches while October had the least with 0.21 inches. The total precipitation in 2010 was 20.51 inches. This is less than the historical annual average of 22.8 inches.

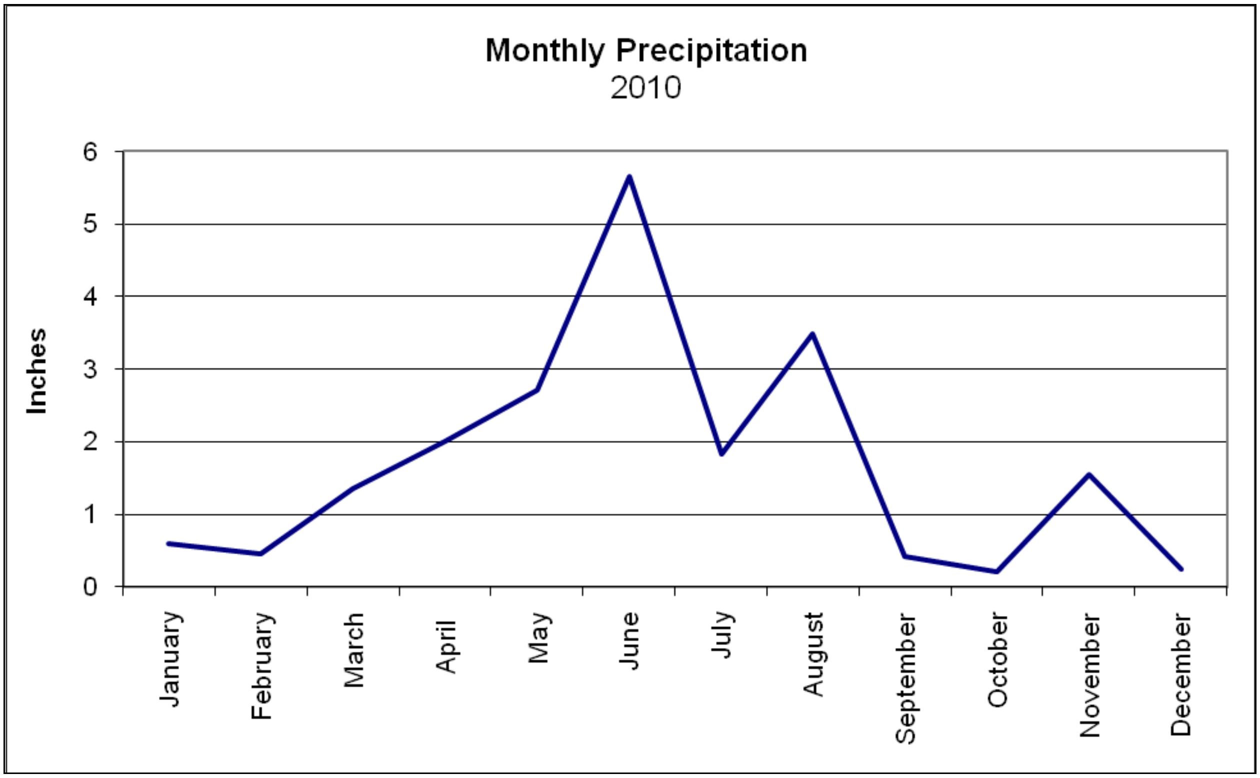

Figure 4: Monthly average precipitation for 2010

III. Surface Water

The three major stream systems in the subbasin are the Pawnee River, Buckner Creek and Sawlog Creek. The Pawnee River flows from west to east through Finney, Hodgeman, Ness and Pawnee counties and continues until it reaches its confluence with the Arkansas River near Larned, Kansas. Buckner and Sawlog Creeks originate in the southwestern portion of the subbasin in Hodgeman County. Sawlog Creek joins Buckner Creek in the eastern part of Hodgeman County. Buckner Creek then flows northeast until it reaches its confluence with the Pawnee River near the Pawnee-Hodgeman County line.

There are three historical USGS stream gaging stations in the subbasin: the Rozel gage on the Pawnee River, the Buckner Creek gage at Burdett and the Pawnee River gage at Burdett. Due to the recent construction of Horsethief Reservoir in Hodgeman County, USGS added four more streamflow gages to the network subbasin (Figure 5). Figure 6 charts the average annual streamflow for the three historical gages and Figure 7 charts the daily streamflow for all seven gages in 2010. The Burdett gage on Buckner Creek has a record that extends from 1996 to 2009. The average recorded streamflow was 15.65 cfs. The Rozel gage is missing one year of record in 1927, but otherwise has the longest record in the subbasin (1925-2009). The average recorded streamflow for Rozel was 57.82 cfs. The Burdett gage on the Pawnee River has a record that extends from 1982 to 2009. The average recorded streamflow for the Burdett gage is 9.93 cfs.

Both streamflow gages at Burdett maintained higher flows during the 1990s with Buckner Creek at 17.80 cfs and Pawnee River at 17.84 cfs. The Rozel gage averaged 44.55 cfs. Streamflows were lower from the period 2000-2009 averaging 16.55 cfs at Rozel, 7.09 cfs at Burdett on the Pawnee River and 5.91 cfs at Burdett on Buckner Creek (Figure 6).

The additional four streamflow gages are influenced by Horsethief Reservoir and therefore do not show the extremes in streamflow that the further downstream and older streamflow gages show. In 2010, the subbasin had several spikes in streamflow. The largest event was in mid-June. The Rozel gage on Pawnee River reached 1810 cfs. The precipitation events did not maintain streamflow at the lower gages as they often had no recorded streamflow (Figure 7).

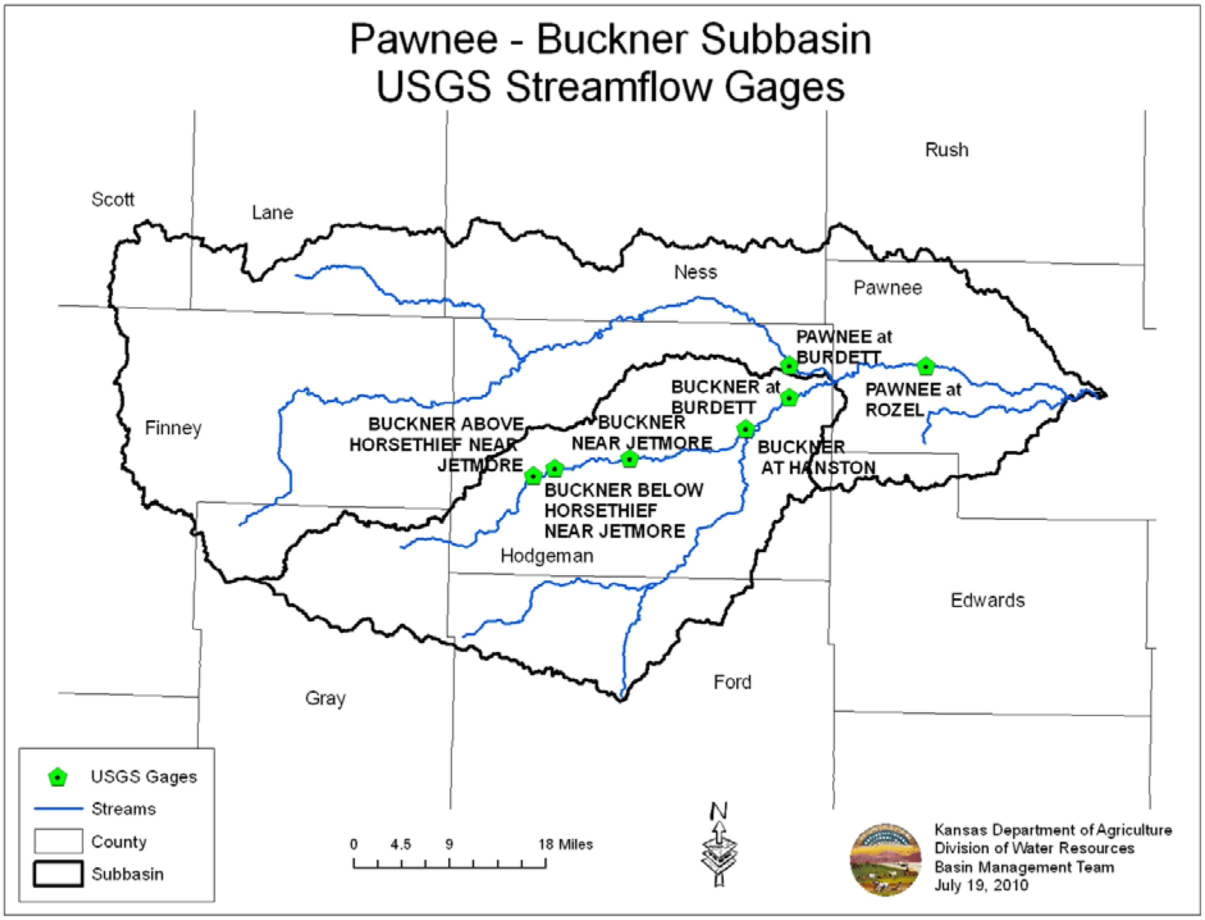

Figure 5: Pawnee-Buckner Subbasin USGS Streamflow Gages

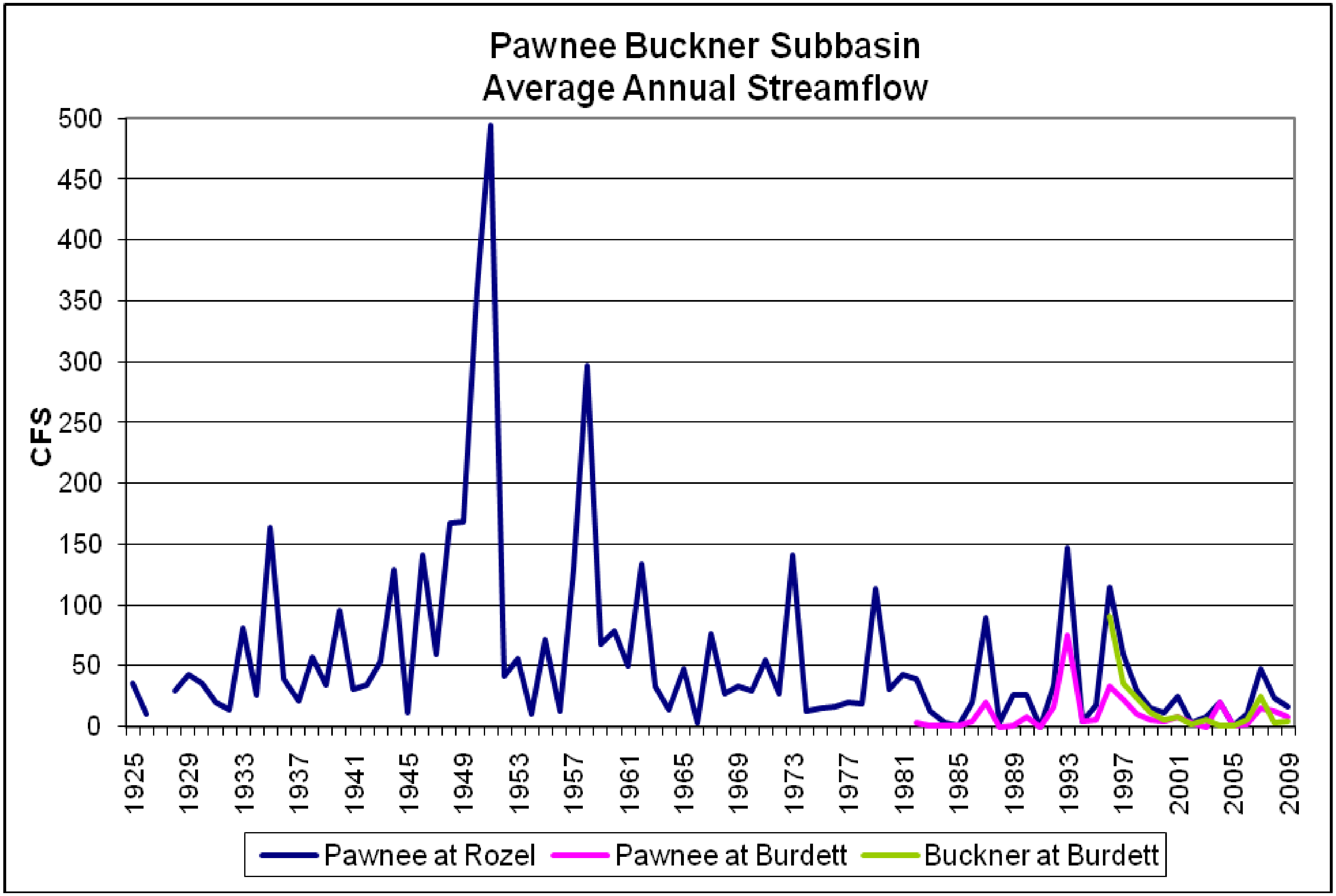

Figure 6: Average Annual Streamflow at USGS Gages 1925-2009

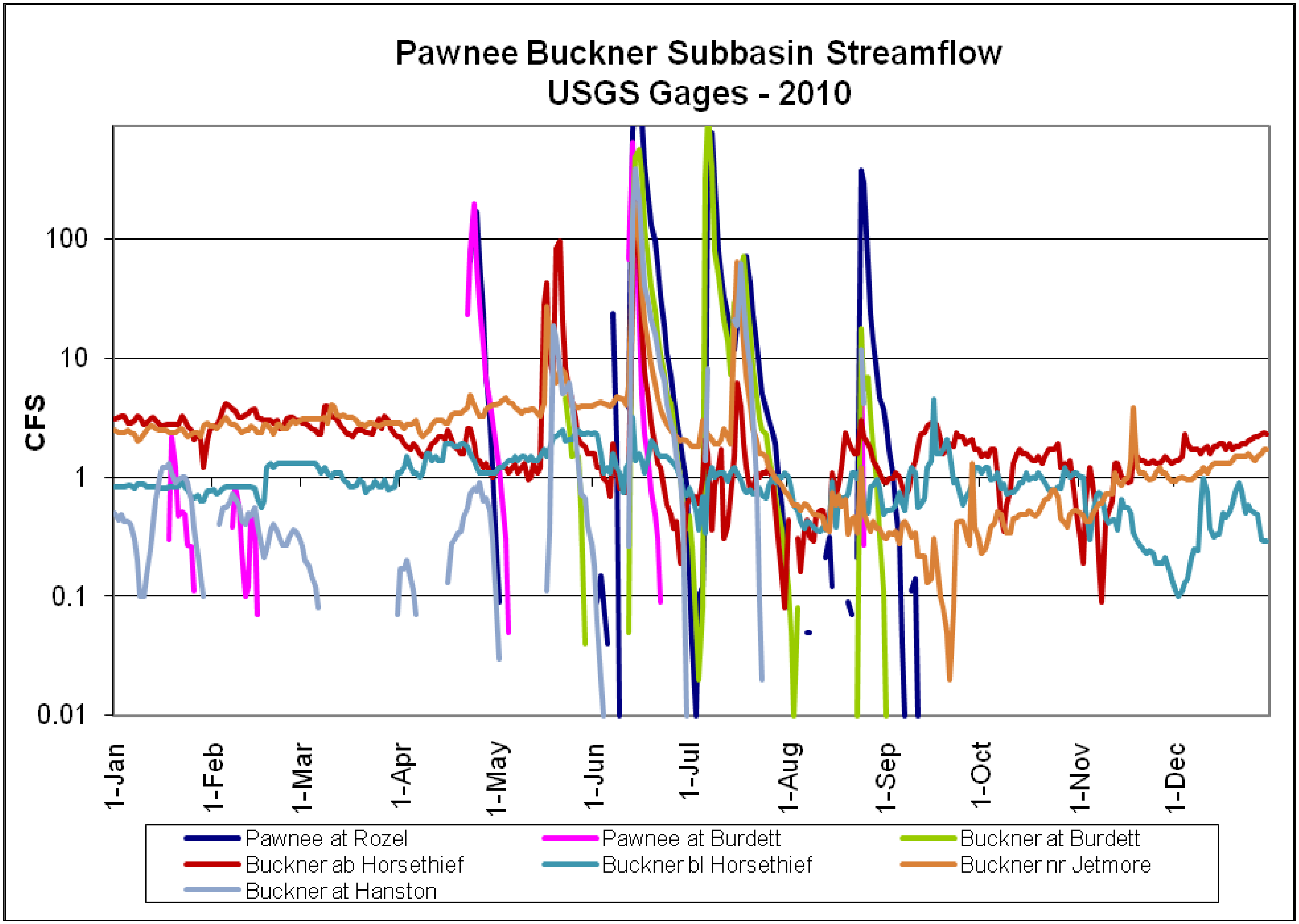

Figure 7: Daily Streamflow for 2010

IV. Groundwater

GMD #5 and KDA-DWR staff combine efforts to measure 76 wells in the Pawnee-Buckner subbasin (Figure 8). Five wells have been redrilled and have new identification numbers: HG41 to HG75, NS07 to NS76, HG24 to HG73, HG38 to HG74 and PN24 to PN97. KDA-DWR collects additional water level measurements tri-annually in the winter, spring and fall. GMD #5 measures five wells on a quarterly basis and 21 wells in January within their district in Pawnee County.

Only winter measurements, taken in December, January or February, were used for the monitoring well water level charts, since those measurements are considered to be the least influenced by groundwater pumping. Figure 9 to Figure 20 chart groundwater levels in all the monitoring wells and the five-year rolling averages.

Legal descriptions of the well locations are available in the appendix. The following graphs chart water levels in each hydrologic subunit area. The y-axis is the depth below land surface (DBLS) in feet.

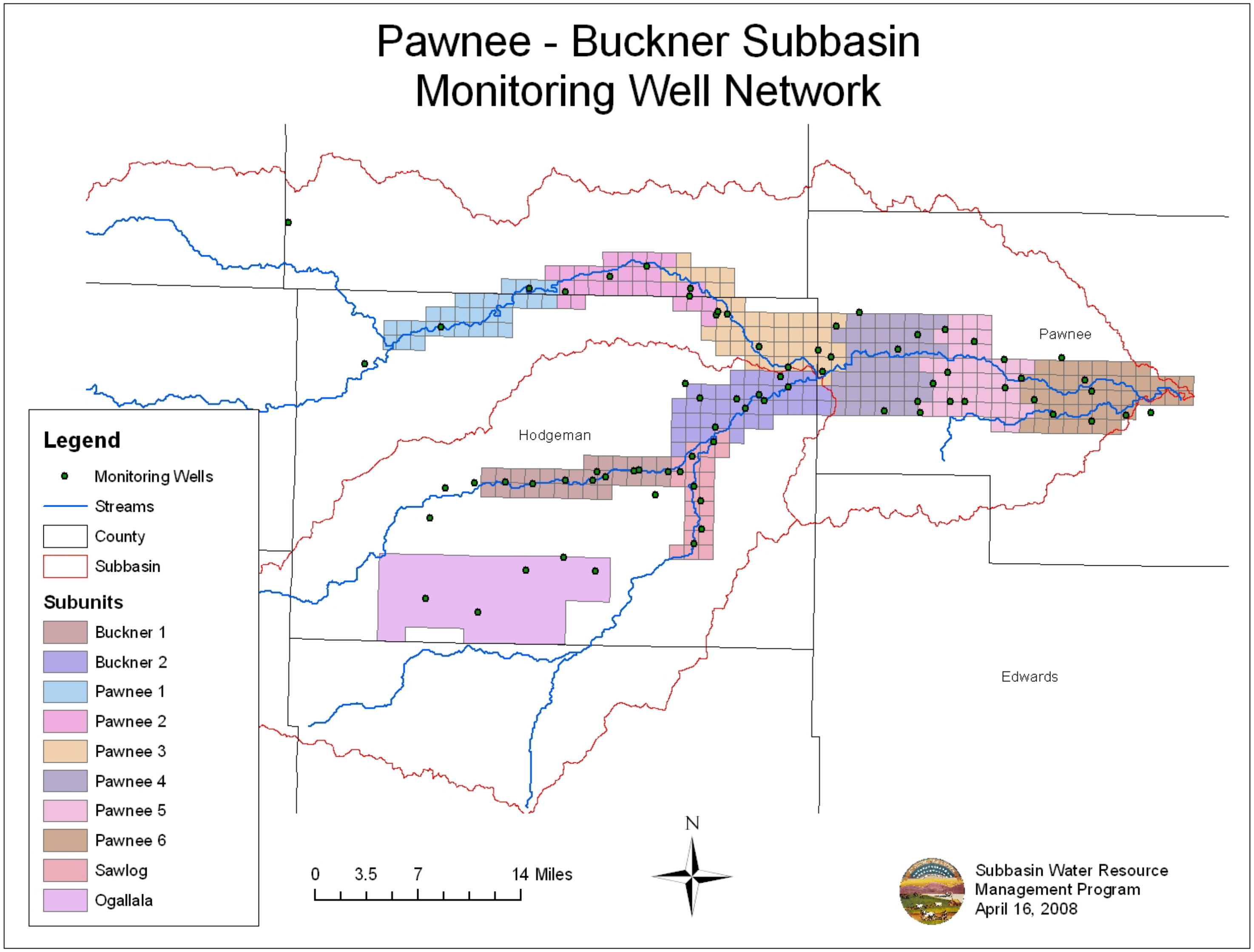

Figure 8: DWR Monitoring Wells

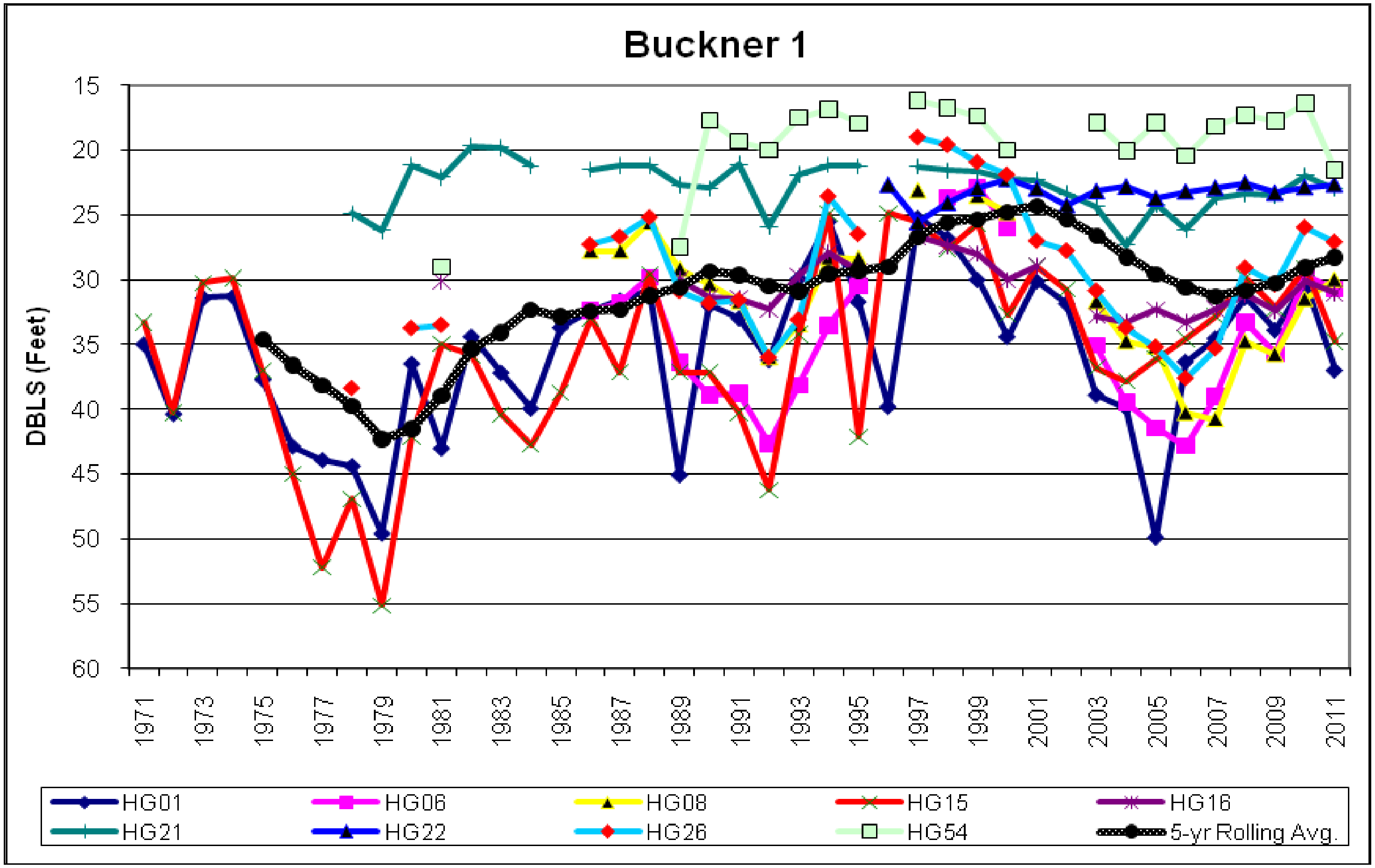

Figure 9: Monitoring well levels in Buckner 1

Buckner 1 subunit has nine monitoring wells. Water levels in these wells have shown an overall net increase of 7.0 feet over the period of record. The increase in the five-year rolling average is likely a result of the addition of monitoring wells in the 1980s. Following the 1990s, the five-year rolling average declined until 2008 when it began to increase and continued this trend in 2011. Two of the nine monitoring wells increased, but the other seven decreased. The average change in water levels from 2010 to 2011 is a decline of 2.16 feet (Figure 9).

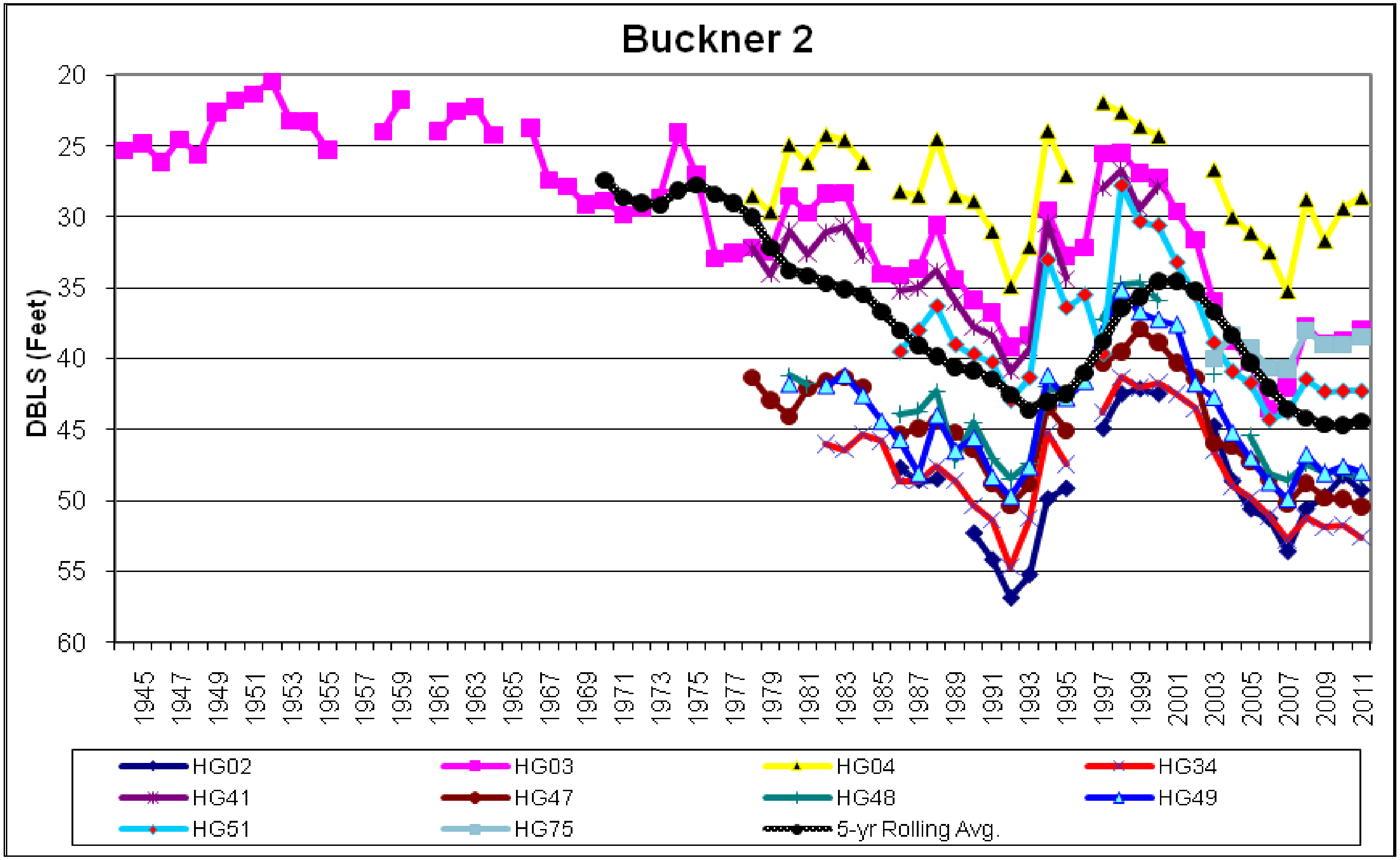

Figure 10: Monitoring well levels in Buckner 2

Buckner 2 subunit has nine monitoring wells. All the wells are in Hodgeman County. Unlike Buckner 1, the water levels show an overall downward trend. This subunit experienced a large rise in water levels during the late-1990s to early-2000s. It appears that water levels have stabilized the past three of four years. Five of the monitoring wells had declines in water levels, three increased and one was unchanged. The five-year rolling average had a slight increase in 2011 (Figure 10). HG03 has the longest record dating back to 1944 and has a net decline of 12.64 feet.

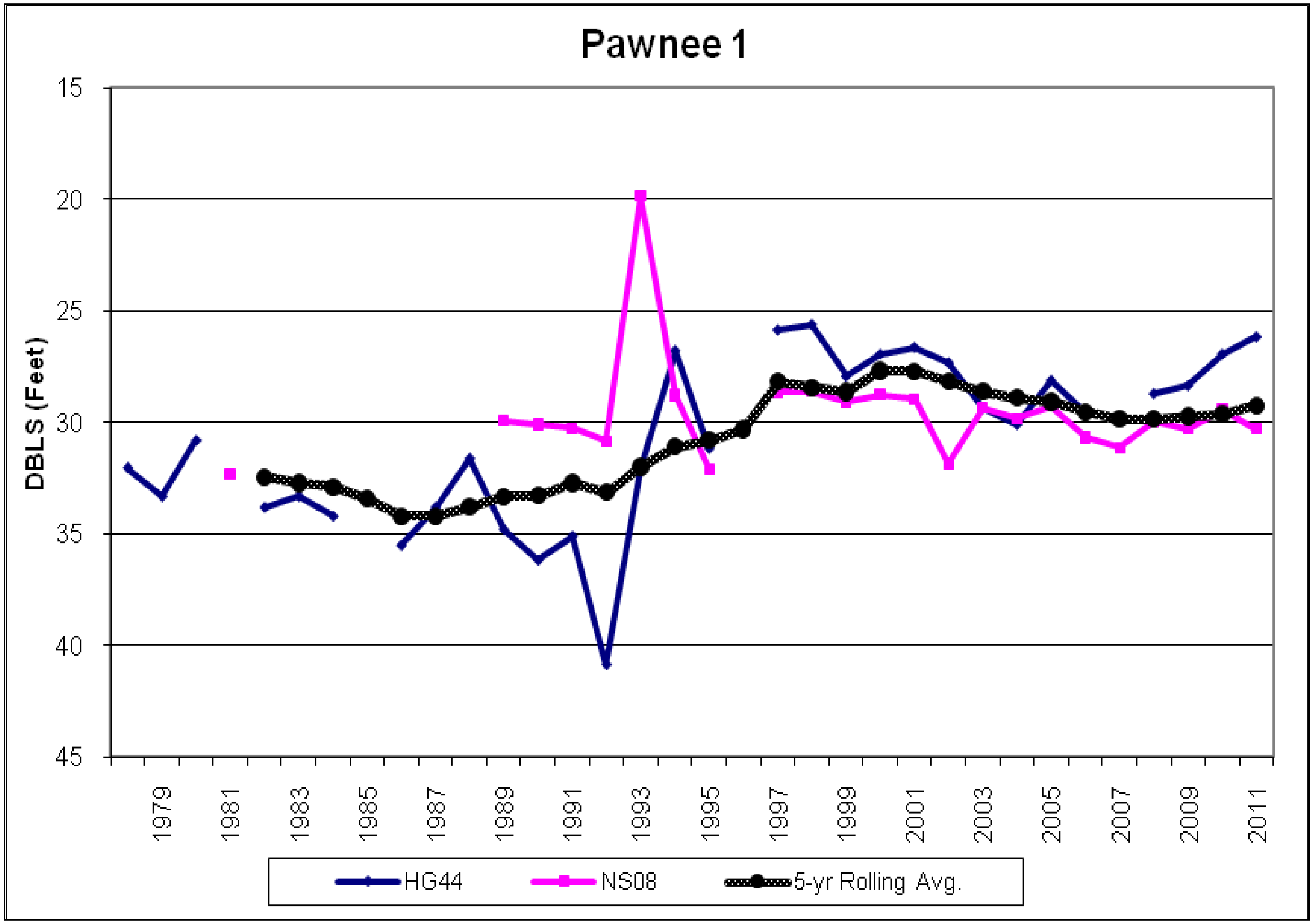

Figure 11: Monitoring well levels Pawnee 1

Pawnee 1 subunit is located furthest upstream along the Pawnee River and has two monitoring wells. In 2011, HG44 had an increase of 0.78 feet and NS08 had a decrease in water levels of 0.87 feet (Figure 11). Both wells have seen a net increase since their initial measurements (HG44, 5.87 feet and NS08, 2.01feet). The five-year rolling average had an increase of 0.38 feet in 2011 compared to 2010.

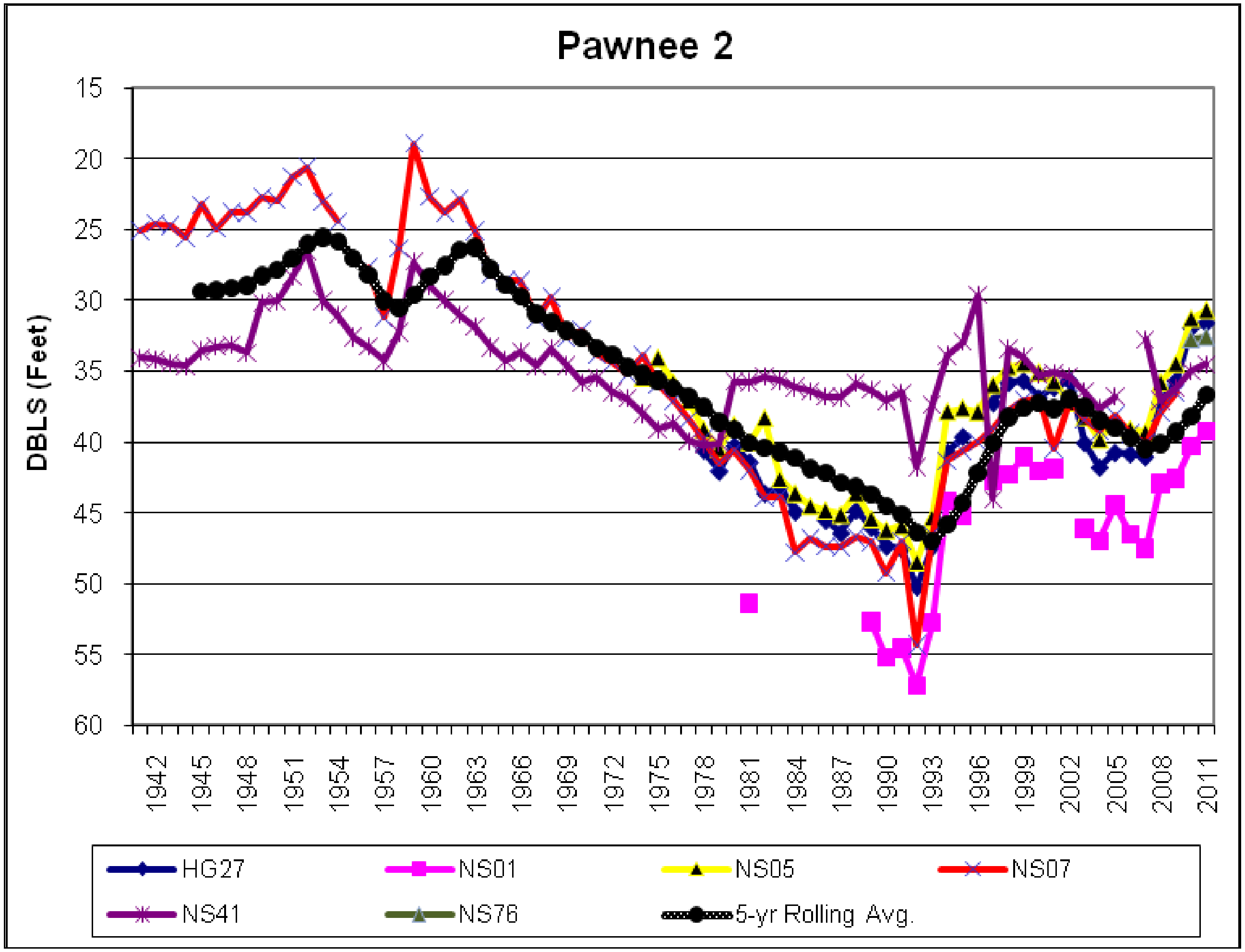

Figure 12: Monitoring well levels Pawnee 2

Pawnee 2 subunit has five monitoring wells. This subunit has an overall long-term declining trend. The five-year rolling average has exhibited a net decline of 7.73 feet since 1945 even with the recent rises in water levels (Figure 12). All five monitoring wells had an increase in water levels for an average rise of 0.52 feet.

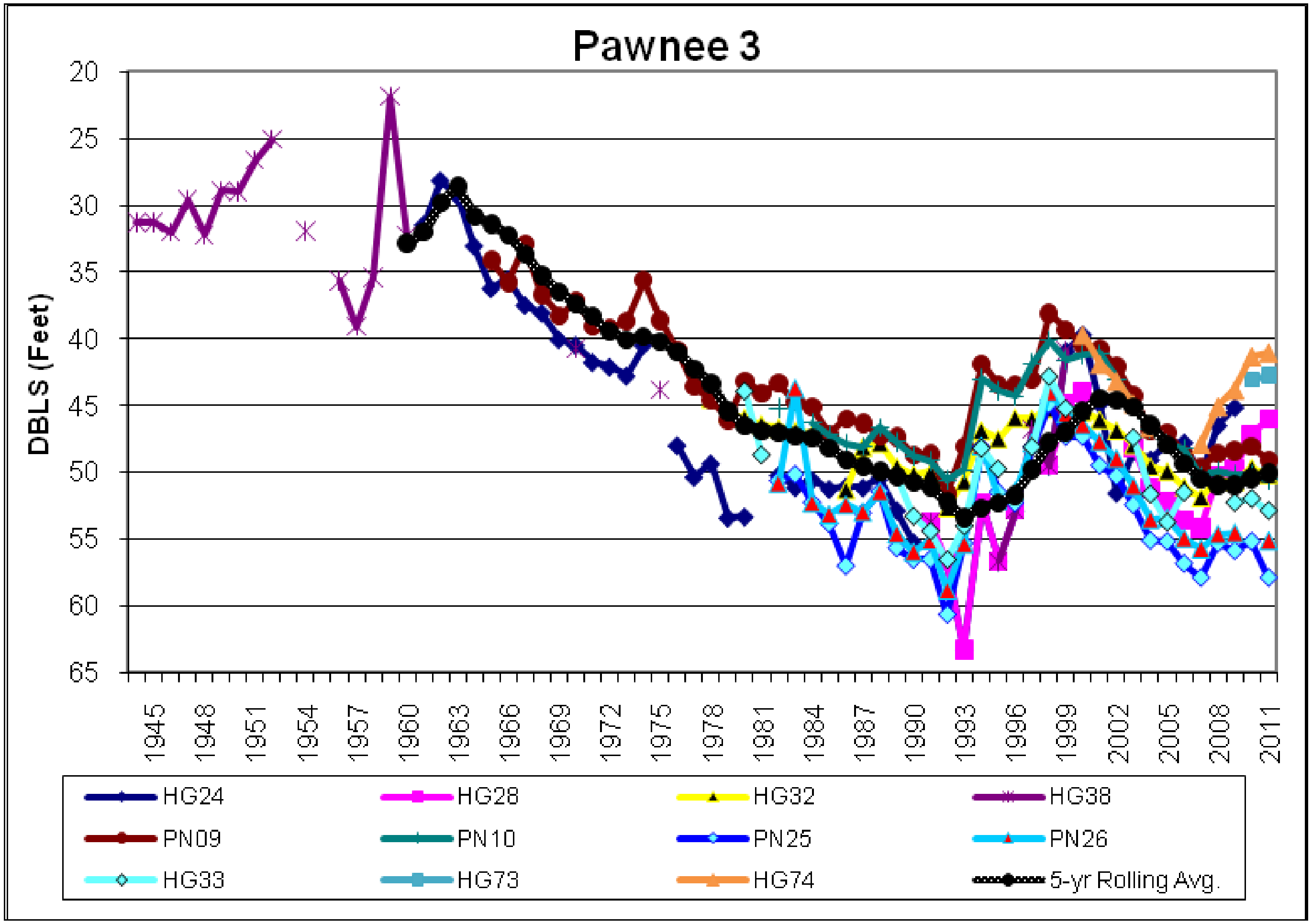

Figure 13: Monitoring well levels Pawnee 3

Pawnee 3 subunit has nine monitoring wells and similar to Pawnee 2 has seen declines. In 2011, five monitoring wells had declines in water levels. Only HG28 had the biggest rise in water levels with 1.12 feet. The five-year rolling average has also declined a net 18.2 feet even with the rise in water levels during the 1990s. Similar to Buckner 2 subunit, the five-year rolling average has stabilized the past three to four years (Figure 13).

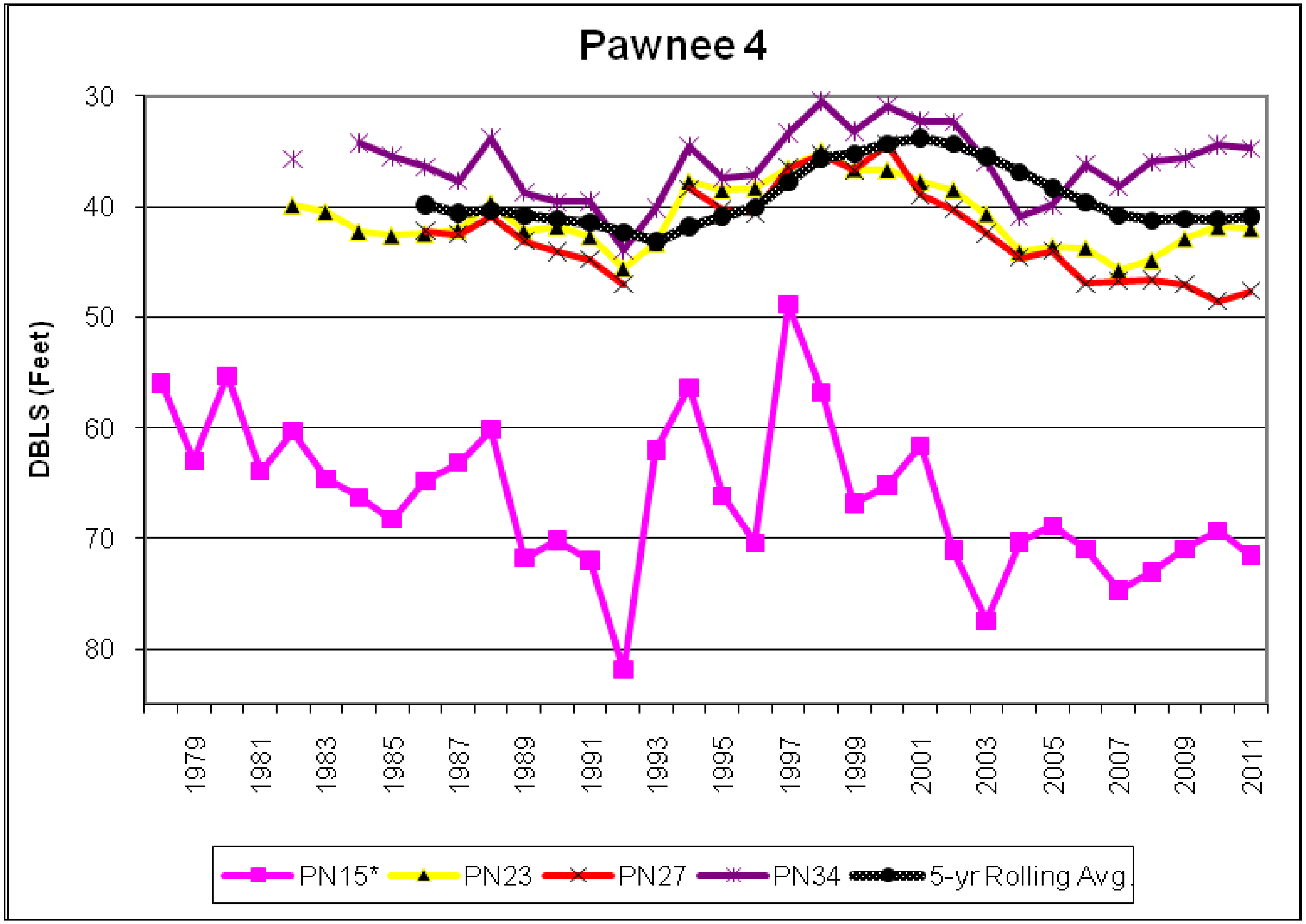

Figure 14: Monitoring well levels Pawnee 4

Pawnee 4 subunit has four monitoring wells and is located downstream of the confluence of Buckner Creek and Pawnee River. These monitoring wells show an overall decline in water levels but it is not at the magnitude of subunits Pawnee 2 and Pawnee 3. The five-year rolling average has declined 1.07 feet since 1986. Three of the four wells experienced a decline in water levels in 2011. PN15 is an unconfined Dakota well and is not included in the 5-year rolling average. It has a net water level decline of 15.55 feet since 1978 (Figure 14).

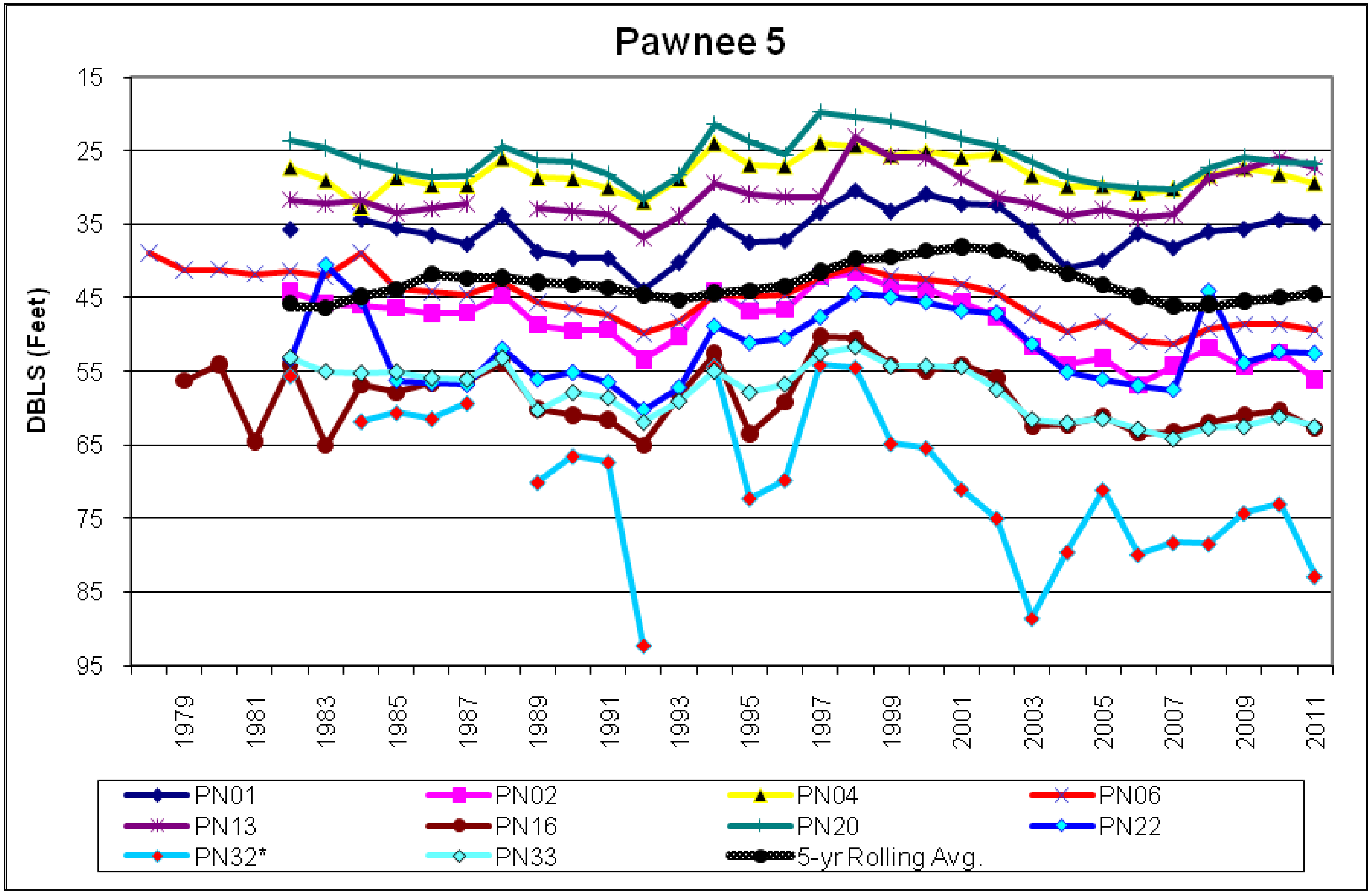

Figure 15: Monitoring well levels Pawnee 5

Pawnee 5 subunit has ten monitoring wells. Most of the wells have similar water level trends except for PN32 which is assumed to be drilled in both the alluvial and unconfined Dakota aquifer. All ten wells had a decline in water levels for 2011 (Figure 15). PN06 and PN16 have the longest record and have a net decline of 10.48 feet and 6.48 feet respectively. The five-year rolling average remains relatively stable over time.

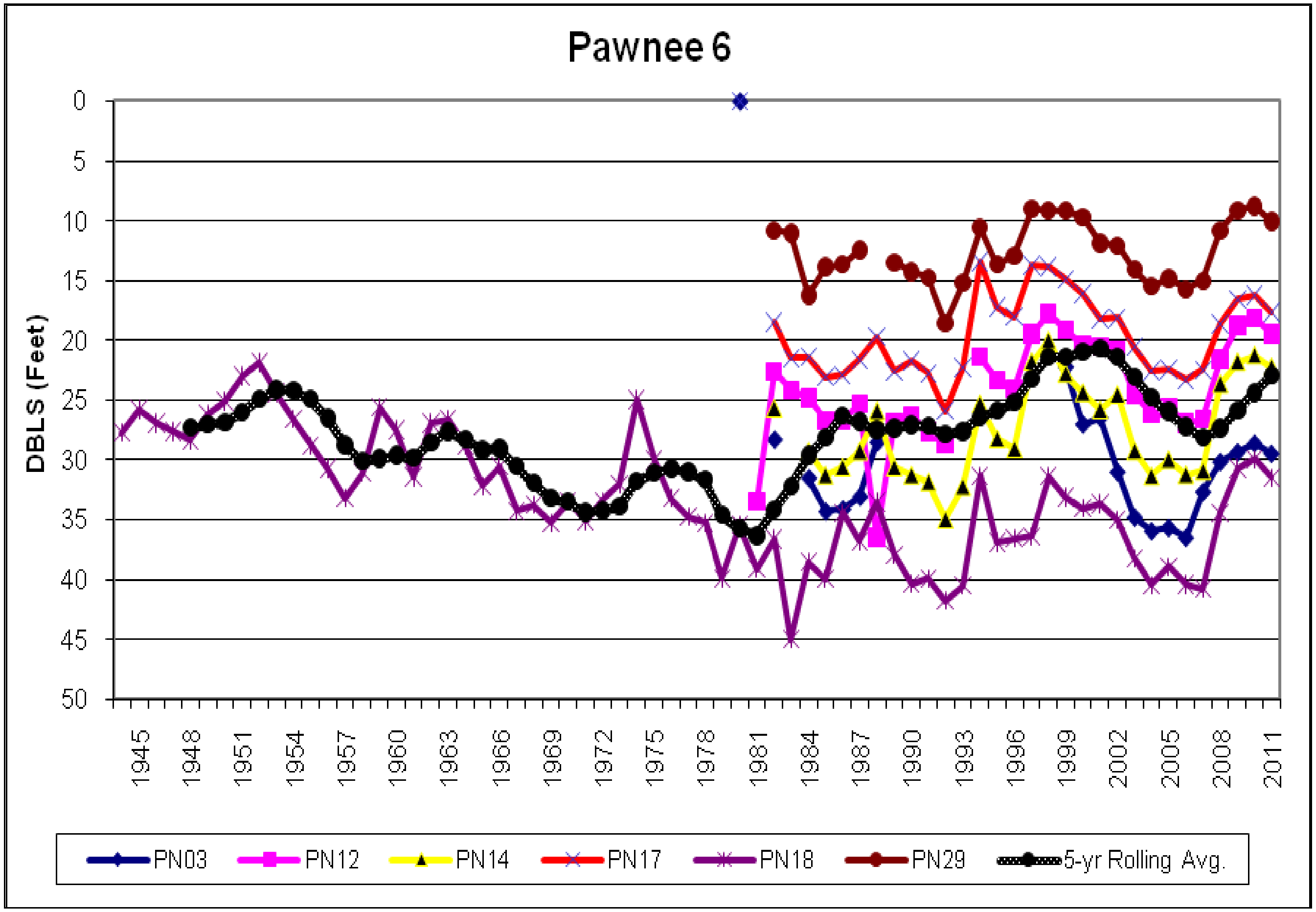

Figure 16: Monitoring well levels Pawnee 6

Pawnee 6 subunit has six monitoring wells. PN18 has a long record dating back to 1944 and has experienced a net water level decrease of 3.77 feet. The rise in the five-year rolling average in the early-1980s can likely be explained by the new wells added to the network. As in the other subunits, water levels declined after the 1990s but increased in 2008 to 2010 (Figure 16). All the monitoring wells declined in 2011 averaging 1.23 feet. Even with the decline in water levels in 2011, the five-year rolling average continued to increase in 2011.

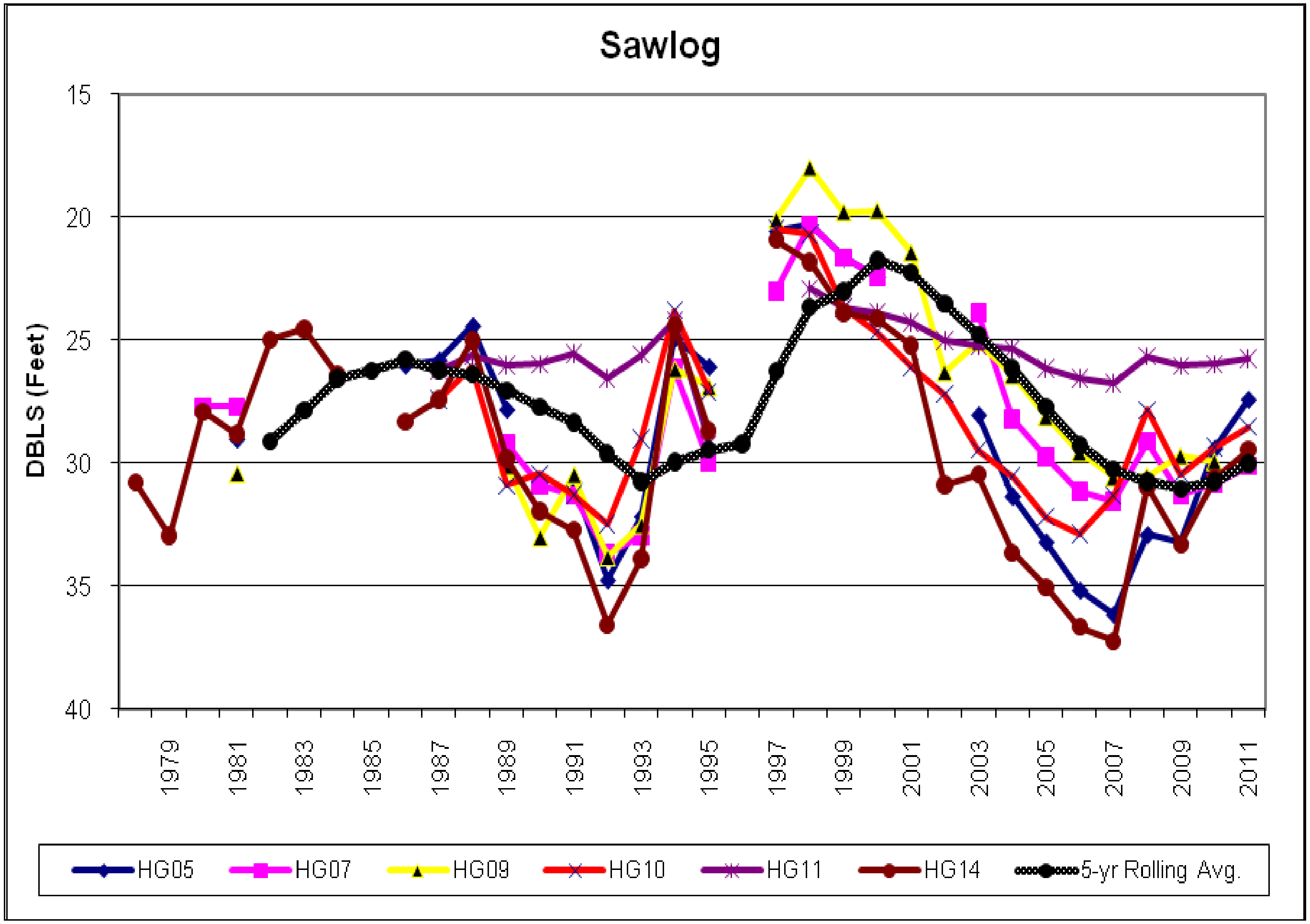

Figure 17: Monitoring well levels Sawlog

The Sawlog subunit enters Buckner Creek between Buckner 1 and Buckner 2 subunits. Sawlog has six monitoring wells. All six wells are missing records during the same years in the 1990s. This affects the five-year rolling average and individual trends. Water levels have been generally declining in the Sawlog until 2007 (Figure 17). Staff measured five of the six monitoring wells in which all had increasing water levels. The five-year rolling average continued to increase by 0.75 feet in 2011.

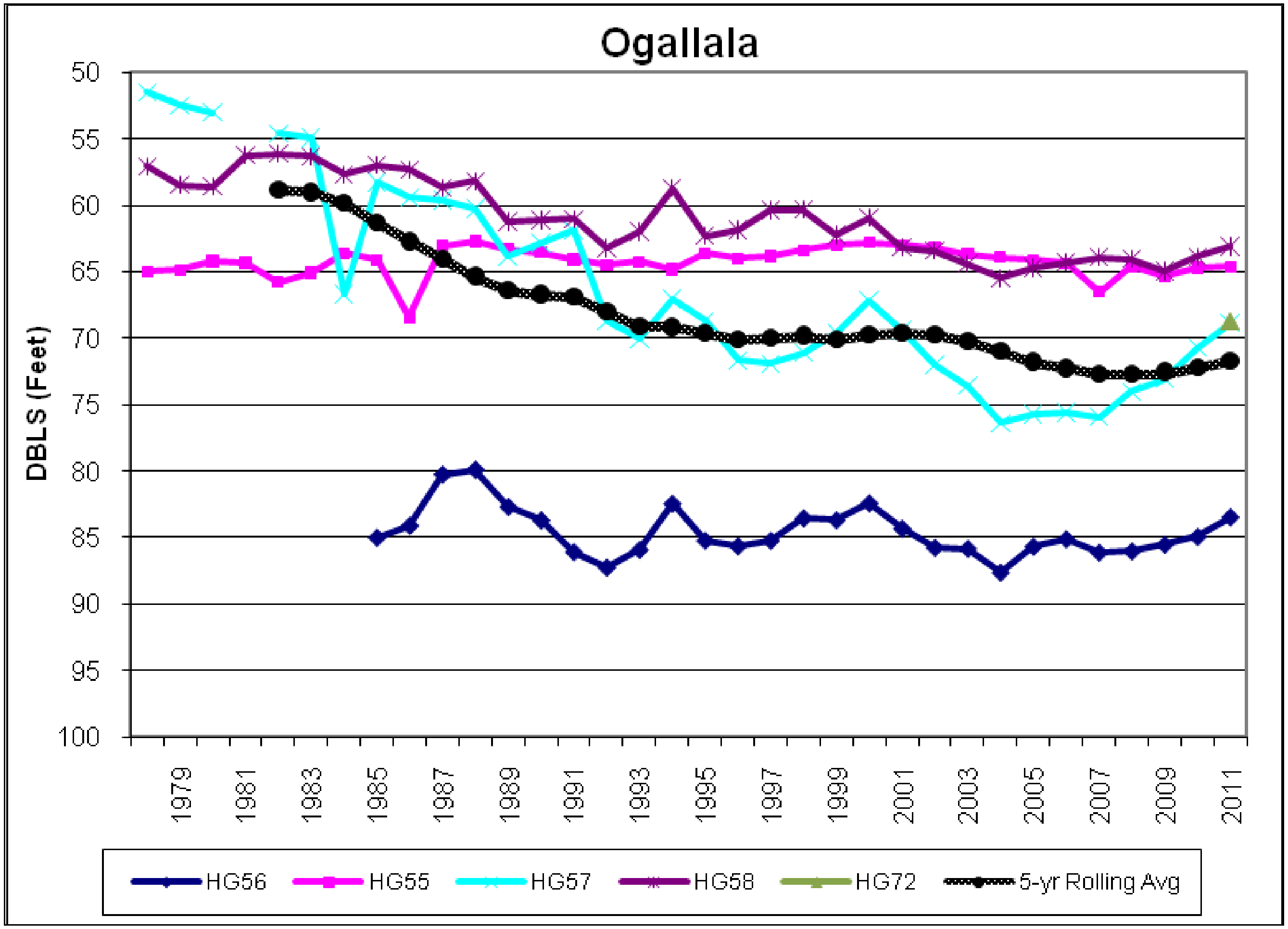

Figure 18: Monitoring well levels Ogallala

The Ogallala subunit is located in southern Hodgeman County. The subunit added another monitoring well in 2011 and now has five monitoring wells (Figure 18). HG57, HG58 and HG55 were first measured in 1978. All four of the previously measured monitoring wells had an increase in water levels. The five-year rolling average had a net decline of 12.84 feet.

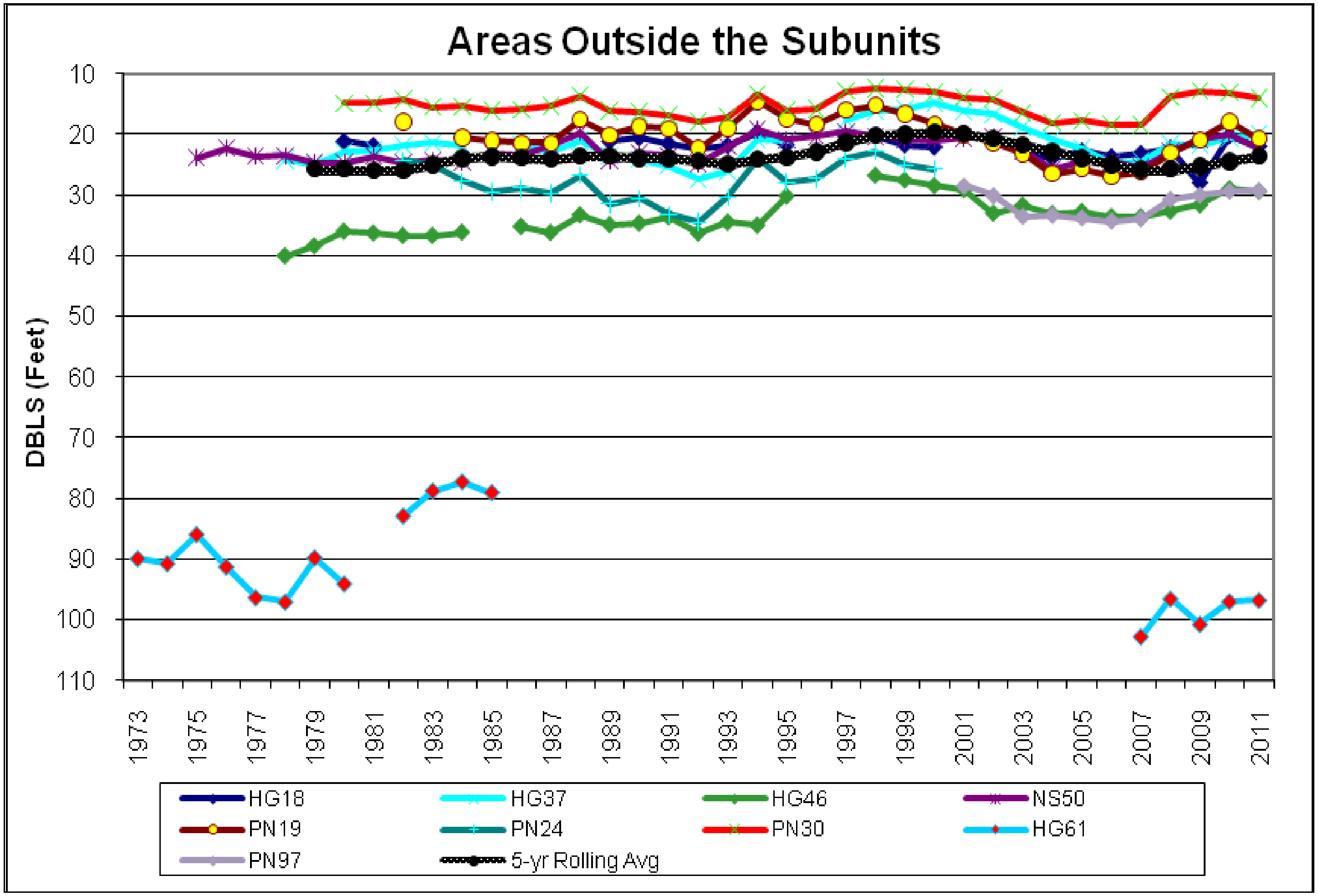

Figure 19: Monitoring well levels outside defined subunits.

Eight monitoring wells lie outside of the proposed subunits. HG61 dates back to 1973 but is missing years of data from 1985 to 2006. Five of the eight monitoring wells had a decline in water levels. The average change from 2010 to 2011 was a decline of 1.08 feet. The five-year rolling average increased in 2011 by 0.82 feet (Figure 19).

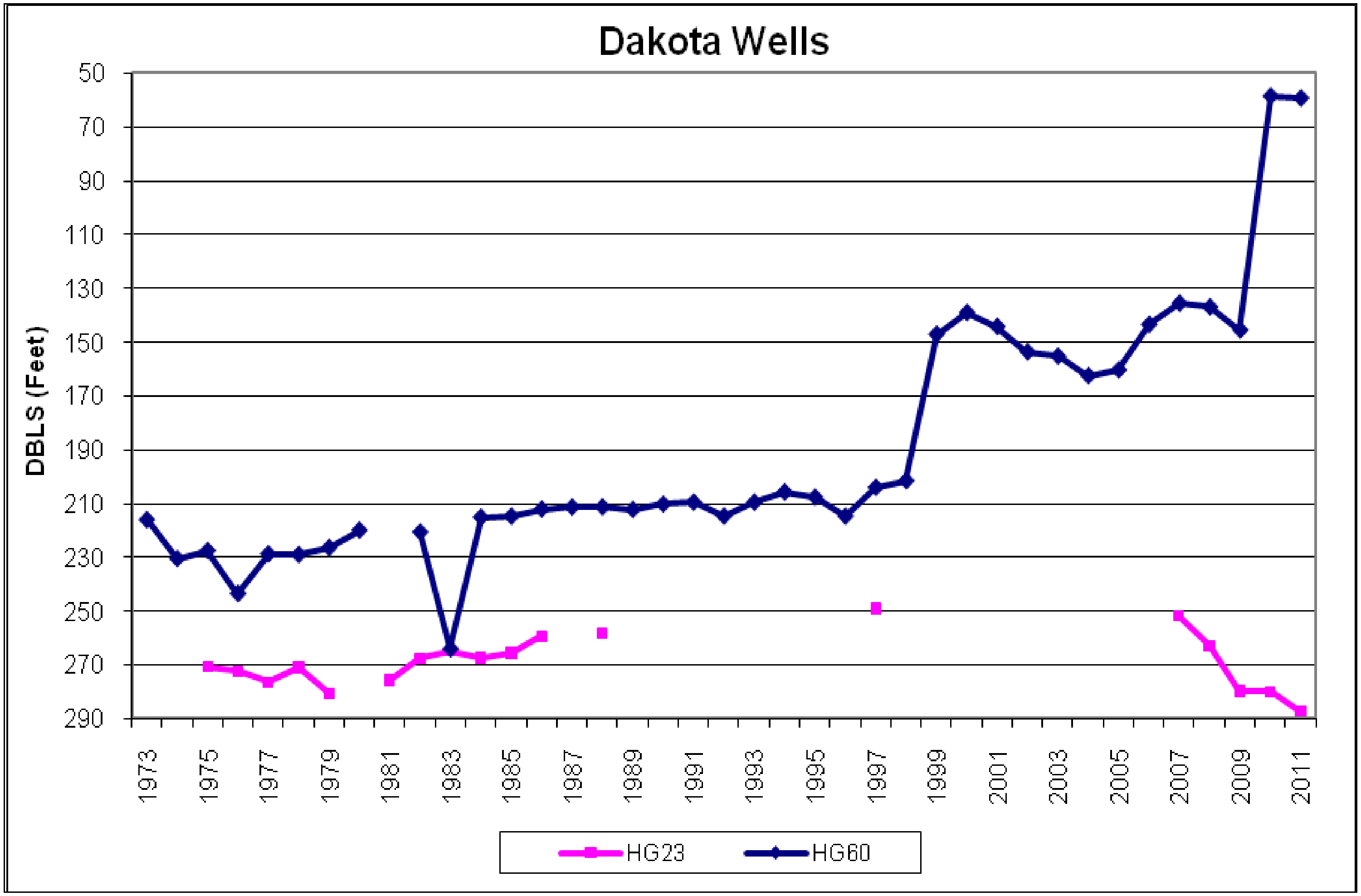

Figure 20: Monitoring well level outside defined subunits - Dakota Well

There are two wells drilled in the Dakota Aquifer. One is located outside of the proposed subunits (HG23) while the other is located within the proposed Ogallala subunit (HG60). Both wells have records dating back to the 1970s. HG23 declined nearly 20 feet in 2009 and HG60 also declined but has exhibited a net increase. In 2011, HG60 leveled off and HG23 declined (Figure 20).

V. Water Use

The Pawnee-Buckner subbasin has 1,193 water rights with an authorized quantity of 242,271 acre-feet (AF). A significant percentage of the total authorized quantity (over 10 percent) is held by vested water rights (Table 1). The following map (Figure 21) has all the surface water and groundwater points of diversion. More than one point of diversion can be associated with one water right. Forty-eight surface water points of diversion are Pawnee Watershed dams.

Table 1: Water Rights in the Pawnee-Buckner Subbasin

Type	Source	Number of Rights	Authorized Quantity
Vested	Surface Water	26	5,128
Vested	Groundwater	123	20,186
Appropriated	Surface Water	31	7,354
Appropriated	Groundwater	1,013	209,604

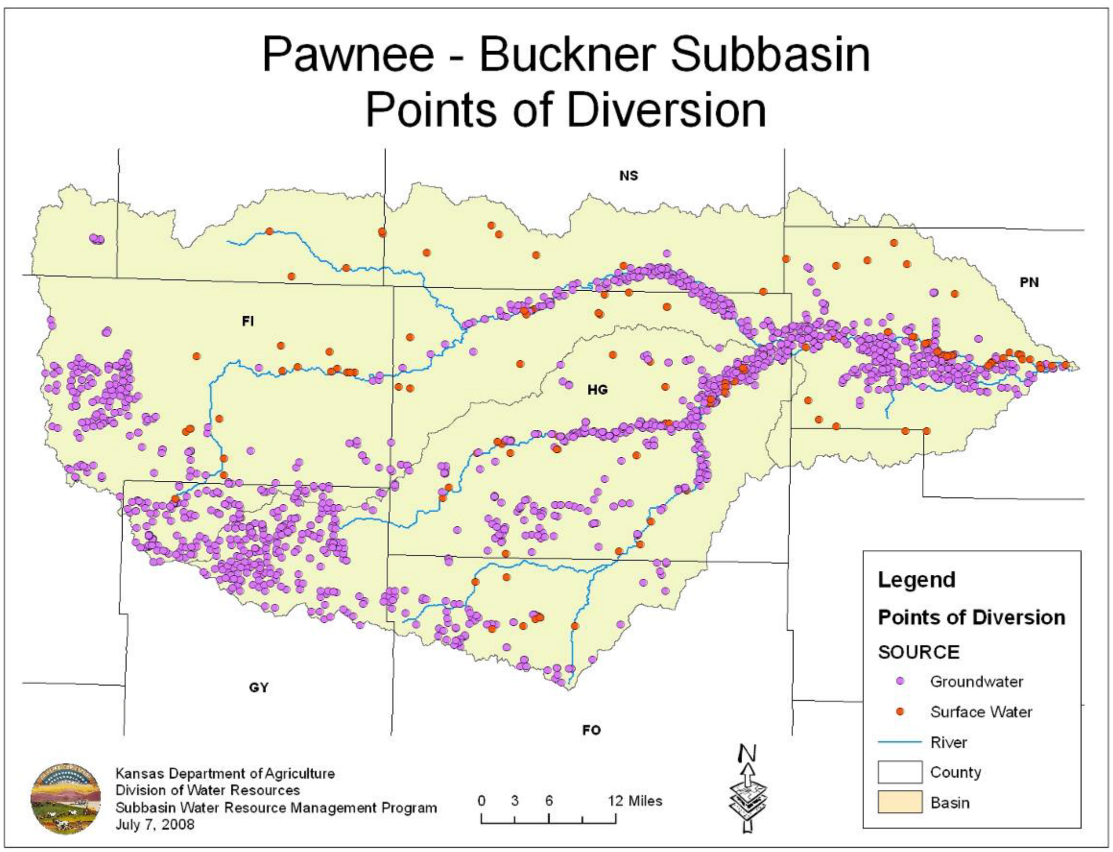

Figure 21: Pawnee-Buckner Subbasin Points of Diversion

The water use ranges from 56,820 acre-feet in 1993 to 134,971 acre-feet in 1991. The average water use over the twenty year span was 102,551 acre-feet. Water use in 2009 (the most recent year for which complete records are available) was 91,636 acre-feet. This is lower than in 2008 and below the average for the subbasin (Figure 22). Note: Some water use data reported was based on unmetered sources (rate/hrs).

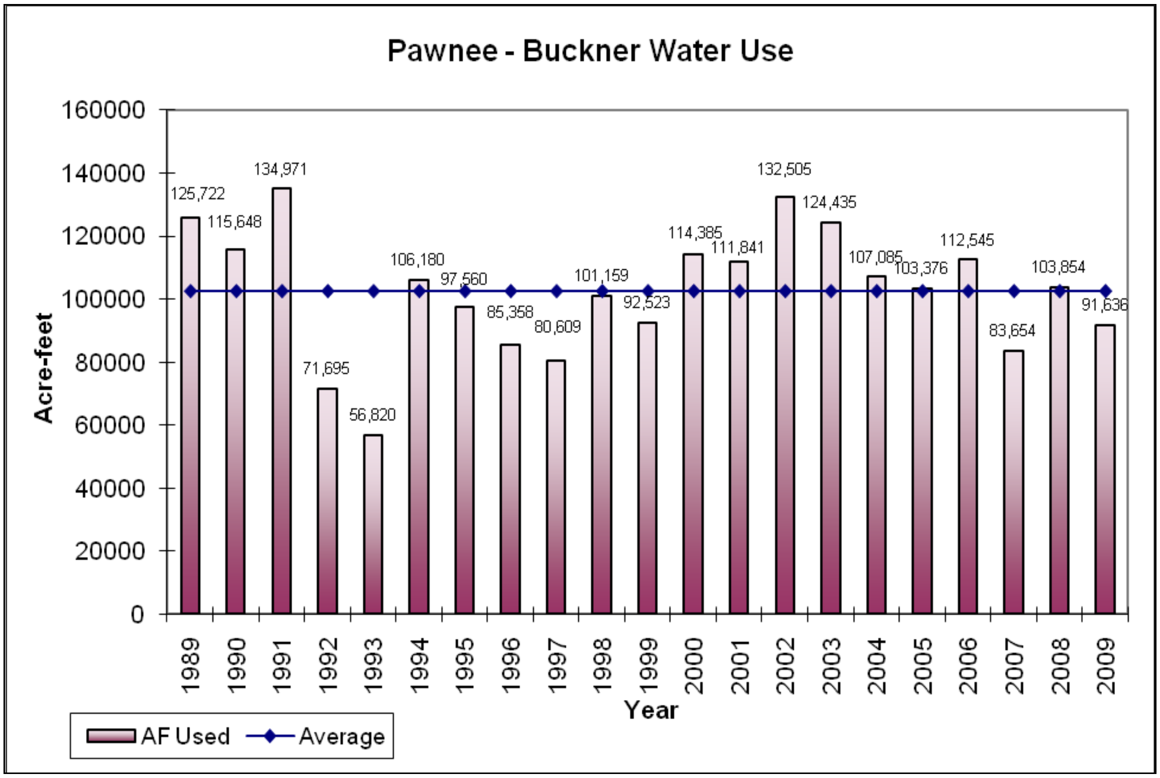

Figure 22: Ground and surface water use by year 1989-2009

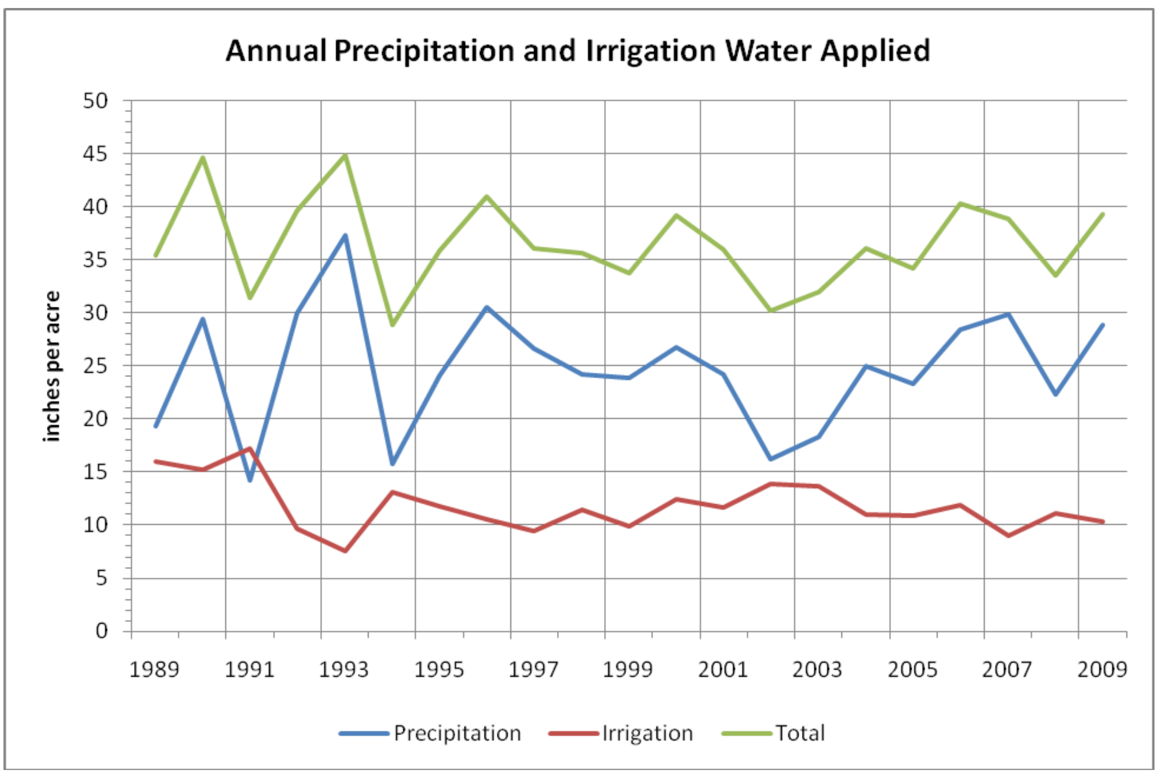

Figure 23: Annual Precipitation and Irrigation (inches per acre) 1989-2009

Figure 23 highlights the precipitation and irrigation for each year in the Pawnee-Buckner subbasin from 1989-2009. The green line is the total of precipitation and irrigation. Since precipitation increased in 2009, inches of irrigation water applied decreased, but not at the same rate. Thus, the total amount of water increased from 2008 to 2009.

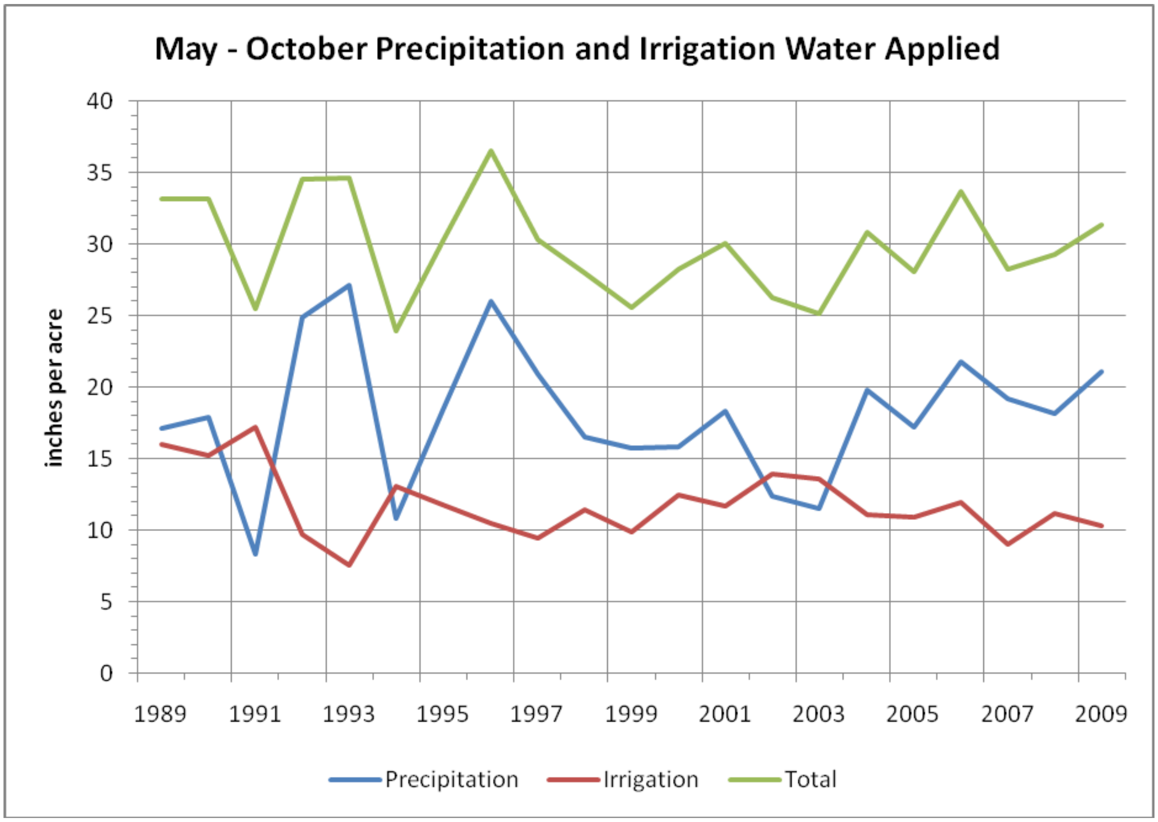

Figure 24: May-October Precipitation and Irrigation (inches per acre) 1989-2009

VI. Conclusions

Initial precipitation amounts were below average for 2010. Change in water levels varied throughout the subbasin with some priority areas seeing declines while others had increases. Water use in 2009 was less than in 2008. It is important to continue to increase our understanding of the impacts of pumping, how fast the system recovers after recharge events, and other characteristics of the hydrologic system in order to evaluate the long-term effects of water usage on this subbasin, protect property rights, and ensure the benefits of these water resources to future generations.

VII. Appendix

Wells are measured in coordination by KGS, KDA-DWR and GMD5.

Well ID	Location	Latitude	Longitude	HUC
HG01	23 23W 04 NENESE	38.085240	-99.844620	Buckner 1
HG02	22 22W 10 NENENW	38.160290	-99.716830	Buckner 2
HG03	22 22W 13 SWSWSW	38.131580	-99.696550	Buckner 2
HG04	22 22W 23 SESESE	38.117840	-99.698350	Buckner 2
HG05	22 22W 33 SESWSE	38.087430	-99.739790	Sawlog
HG06	22 23W 36 SESESW	38.087970	-99.791440	Buckner 1
HG07	23 22W 03 SESWSW	38.073110	-99.722350	Sawlog
HG08	23 22W 05 NENENW	38.087210	-99.754430	Buckner 1
HG09	23 22W 11 SWSWSW	38.058610	-99.713330	Sawlog
HG10	23 22W 23 SWSWSE	38.030260	-99.712130	Sawlog
HG11	23 22W 27 SESWSE	38.015700	-99.721310	Sawlog
HG13	23 23W03 NE01	38.080720	-99.833760	Buckner 1
HG14	22 22W 27 SESWSW	38.102470	-99.724530	Sawlog
HG15	23 23W 04 SESWNE	38.076920	-99.849150	Buckner 1
HG16	23 23W 06 SESENW	38.076310	-99.883610	Buckner 1
HG18	23 24W 07 NENWNW	38.072640	-99.997940	Outside
HG21	23 24W 11 NENWNW	38.072630	-99.924800	Buckner 1
HG22	23 24W 11 SENWNW	38.066500	-100.035300	Buckner 1
HG23	23 25W 22 SENWNW	38.036190	-100.053300	Outside
HG24	21 22W 12 NWSWNW	38.243630	-99.697670	Pawnee 3
HG26	23 23W 01 NWNENE	38.086710	-99.797910	Buckner 1
HG27	21 22W 03 NWNWNE	38.261610	-99.731320	Pawnee 2
HG28	21 22W 12 NENESW	38.244750	-99.683180	Pawnee 3
HG32	21 21W 21 NWSWSW	38.212730	-99.642990	Pawnee 3
HG33	21 21W 26 SWSWNW	38.192950	-99.606210	Pawnee 3
HG34	21 21W 34 NESWSW	38.182990	-99.615340	Buckner 2
HG37	22 22W 04 NENENE	38.174590	-99.735120	Outside
HG38	21 22W 12 NWNWNE	38.246970	-99.695260	Pawnee 3
HG41	22 21W 06 SESWSW	38.160430	-99.670300	Buckner 2
HG44	21 25W 14 NWSWNW	38.226770	-100.044300	Pawnee 1
HG46	21 26W 35 NENESW	38.188270	-100.139700	Outside
HG47	22 21W 02 NWNWSW	38.172880	-99.605980	Buckner 2
HG48	22 21W 09 NWNENE	38.159330	-99.635150	Buckner 2
HG49	22 21W 04 NWSWNW	38.164970	-99.642570	Buckner 2
HG51	22 21W 08 SWNWNE	38.151250	-99.659190	Buckner 2
HG54	23 24W 04 SESWSE	38.074040	-99.959850	Buckner 1
HG55	24 24W 20 SWSWSW	37.943420	-99.990880	Ogallala
HG56	24 25W 22 NWNENW	37.956680	-100.057400	Ogallala
HG57	24 24W 02 SWSWSW	37.986180	-99.931430	Ogallala
HG58	24 23W 03 SWSWSW	37.986650	-99.844250	Ogallala
HG60	24 23W 06 NENENW	38.000170	-99.884420	Ogallala
HG61	23 22W 07 SENENE	38.063980	-99.770800	Outside
HG72	23 26W 20 SWSWSE	38.03001	-100.199028	Ogallala
HG73	21 22W 12 NWSWNW	38.243734	-99.698387	Pawnee 3
HG74	21 22W 12 NENWNW	38.246987	-99.695664	Pawnee 3

HG75	22 21W 06 SWSWSE	38.160457	-99.670524	Buckner 2
NS01	20 23W 26 SENWSW	38.280540	-99.832180	Pawnee 2
NS05	20 22W 35 NWSWSW	38.269780	-99.730950	Pawnee 2
NS07	20 22W 20 SWSWSW	38.291080	-99.786710	Pawnee 2
NS08	20 24W 36 SWNWNW	38.266680	-99.933740	Pawnee 1
NS41	20 23W 32 SWSENE	38.263830	-99.888050	Pawnee 2
NS50	20 26W 07 NWSESW	38.328020	-100.239400	Outside
NS76	20 22W 20 SWSWSW	38.291258	-99.787055	Pawnee 2
PN01	22 18W 05 NWNWNW	38.174830	-99.332140	Pawnee 5
PN02	21 19W 33 SWNWSW	38.178620	-99.423380	Pawnee 5
PN03	21 18W 33 NWSWNW	38.184360	-99.312140	Pawnee 6
PN04	21 19W 14 SESESE	38.220550	-99.371660	Pawnee 5
PN06	21 19W 27 SWSWSW	38.190190	-99.404980	Pawnee 5
PN09	21 20W 29 NWNWNW	38.203890	-99.551760	Pawnee 3
PN10	21 20W 31 NENENW	38.189230	-99.562170	Pawnee 3
PN12	22 17W 05 NWNWSW	38.172490	-99.222800	Pawnee 6
PN13	22 19W 03 SWSWNW	38.163560	-99.295720	Pawnee 5
PN14	22 18W 11 SWSENW	38.148880	-99.270910	Pawnee 6
PN15	22 19W 07 NENENE	38.160650	-99.442040	Pawnee 4
PN16	22 19W 10 NWNWNE	38.160850	-99.401560	Pawnee 5
PN17	21 17W 31 NWSENE	38.183720	-99.232370	Pawnee 6
PN18	22 17W 18 NENESE	38.143200	-99.223180	Pawnee 6
PN19	21 18W 23 SESENW	38.206070	-99.261460	Outside
PN20	21 18W 30 NENENE	38.203300	-99.333800	Pawnee 5
PN22	21 19W 16 NENENW	38.232520	-99.409210	Pawnee 5
PN23	21 19W 18 NESESE	38.227050	-99.443650	Pawnee 4
PN24	21 20W 04 SESESE	38.248490	-99.516680	Outside
PN25	21 20W 08 SWSESW	38.234010	-99.546410	Pawnee 3
PN26	21 20W 19 SWNWNW	38.210470	-99.568660	Pawnee 3
PN27	21 20W 24 NESWSW	38.212480	-99.468450	Pawnee 4
PN29	22 17W 10 SW	38.148990	-99.179400	Pawnee 6
PN30	22 17W 12 SWNWNW	38.151680	-99.148770	Outside
PN32	22 19W 08 SW	38.149130	-99.438850	Pawnee 5
PN33	22 19W 11 NWNWNW	38.160780	-99.383300	Pawnee 5
PN34	22 20W 11 SENWSE	38.150650	-99.483990	Pawnee 4
PN97	21 20W 04 SESESE	38.247782	-99.516215	Outside