Upper Arkansas River

2010 Field Analysis Summary

May 20, 2011

Basin Management Team

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I. Introduction

The Upper Arkansas subbasin has an area of approximately 2,503,000 acres, with all or parts of eleven counties: Greeley, Hamilton, Wichita, Kearny, Grant, Scott, Finney, Haskell, Gray, Hodgeman and Ford (Figure 1). The Upper Arkansas River subbasin extends from the Kansas-Colorado state line near Coolidge, Kansas east to the eastern Ford County line. The Middle Arkansas subbasin neighbors the Upper Arkansas subbasin to the east. Most of the Upper Arkansas subbasin is located within Southwest Kansas Groundwater Management District No. 3 (GMD 3), while a small portion is within the Western Kansas Groundwater Management District No.1 (GMD 1).

The climate is semiarid with long-term[1] average annual precipitation ranging from 16.2 inches at Syracuse to 22.2 inches near Dodge City, representing about a 6-inch precipitation variation from one side of the basin to the other. The range of annual precipitation in this subbasin over the period of record varies from 8 inches to 30 inches. Most of the precipitation occurs from May through August. The Arkansas River begins near the continental divide close to Leadville, Colorado. The Upper Arkansas subbasin water supply is subject to variations in snowfall and precipitation in the Colorado portion of the Arkansas River Basin.

Most irrigation in the subbasin is from the Ogallala-High Plains and alluvial aquifers, but there are also six irrigation ditches (Frontier, Amazon, South Side, Great Eastern, Farmers, and Garden City) that divert surface water from the Arkansas River from the state line east to Garden City. There are additional surface water rights between Garden City and the eastern boundary of the subbasin.

An Intensive Groundwater Use Control Area (IGUCA) has been in place along the entire alluvial corridor since 1986 (Figure 1). The IGUCA was the result of a request by GMD 3 to review information suggesting that the rate of withdrawal of groundwater equaled or exceeded the rate of recharge. This caused excessive groundwater declines that required regulation in the public interest. Provisions of the IGUCA restrict both new appropriations of water and changes to existing appropriations, set well construction requirements to prevent leakage between the alluvial and Ogallala-High Plains aquifers, require flow meter installation, and other requirements.[2]

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[1] Based on qualified precipitation data from the High Plains Regional Climate Center (http://www.hprcc.unl.edu/index.php). The average annual precipitation for period of 1948 to 2006 was determined for Syracuse (54 years used) and Dodge City (56 years used).

[2] More information on the Arkansas River Valley Intensive Groundwater Use Control Area can be found at : www.ksda.gov/appropriation/content/291/cid/1353

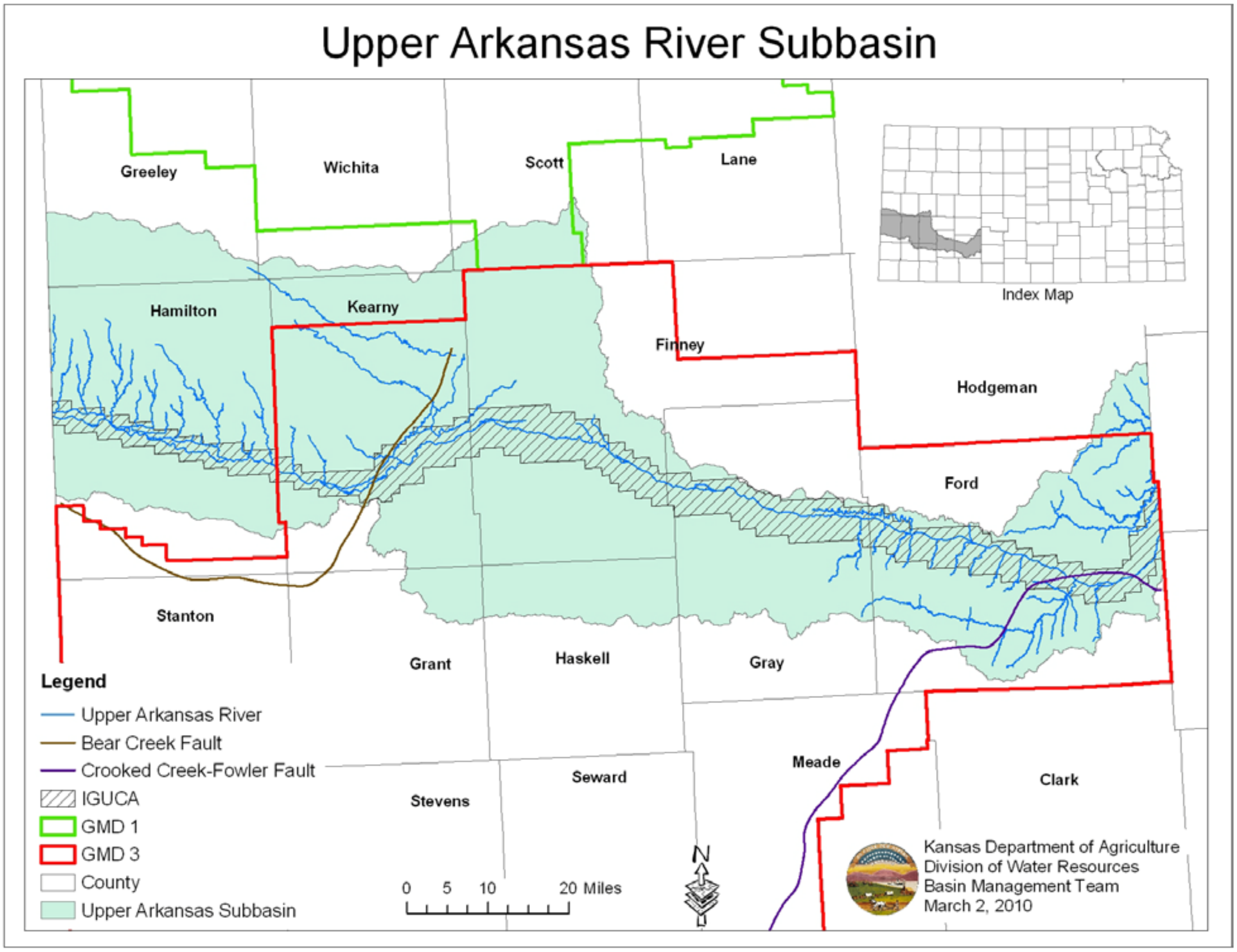

Figure 1: Upper Arkansas River Subbasin

The subbasin lies in the High Plains physiographic region and the dominant economies are agriculture and oil and natural gas production[3]. Groundwater depletion related to diversion for pumping, phreatophytes[4] and water quality degradation of alluvial groundwater from surface water flows of the Arkansas River are currently the major water issues facing the subbasin[5]. To help understand these issues, the Kansas Geological Survey (KGS) constructed a steady state model for GMD 3. The focus of the model is to learn more about aquifer storage and change through time within the Upper Arkansas subbasin.

The Kansas Department of Agriculture, Division of Water Resources (KDA-DWR) collects streamflow and groundwater level measurements, thus allowing a better understanding of the stream-aquifer interaction between the groundwater system and the Arkansas River. This report will provide background information and the most recent hydrologic data available including

[3] US Dept of Agriculture, 1973, Arkansas River Basin, Soil Science Conservation Service, Economic Research Service, State of Kansas, 306 p.
[4] Phreatophytes are deep-rooted plants (typically trees) that obtain water from the water table.
[5] Whittemore, D.O., et. al., 2000, Multi-Level Observation Well Sites of the Upper Arkansas River Corridor in Southwest Kansas, Kansas Geological Survey, Open File Report 2000-43, 59 p.

precipitation, streamflow, groundwater levels and water use in a comparative analysis to data from previous years.

II. Precipitation

Precipitation in the Upper Arkansas River subbasin historically averages 19.7 inches per year based on five precipitation stations. Figure 2 shows the annual variation in precipitation and the long term average. This chart was derived from National Climatic Data Center (NCDC) stations located at Syracuse in Hamilton County, two stations in Garden City in Finney County, Cimarron in Gray County and Bellefont in Ford County. The data was downloaded then averaged to create Figure 2.

The highest precipitation occurred in 1951 with 30.1 inches and the lowest precipitation occurred in 1956 with 8.3 inches. The wide variability in precipitation is typical of a continental climate. In 2009, precipitation was above average with 21.17 inches. Annual precipitation data for these NCDC stations is currently available through 2009.

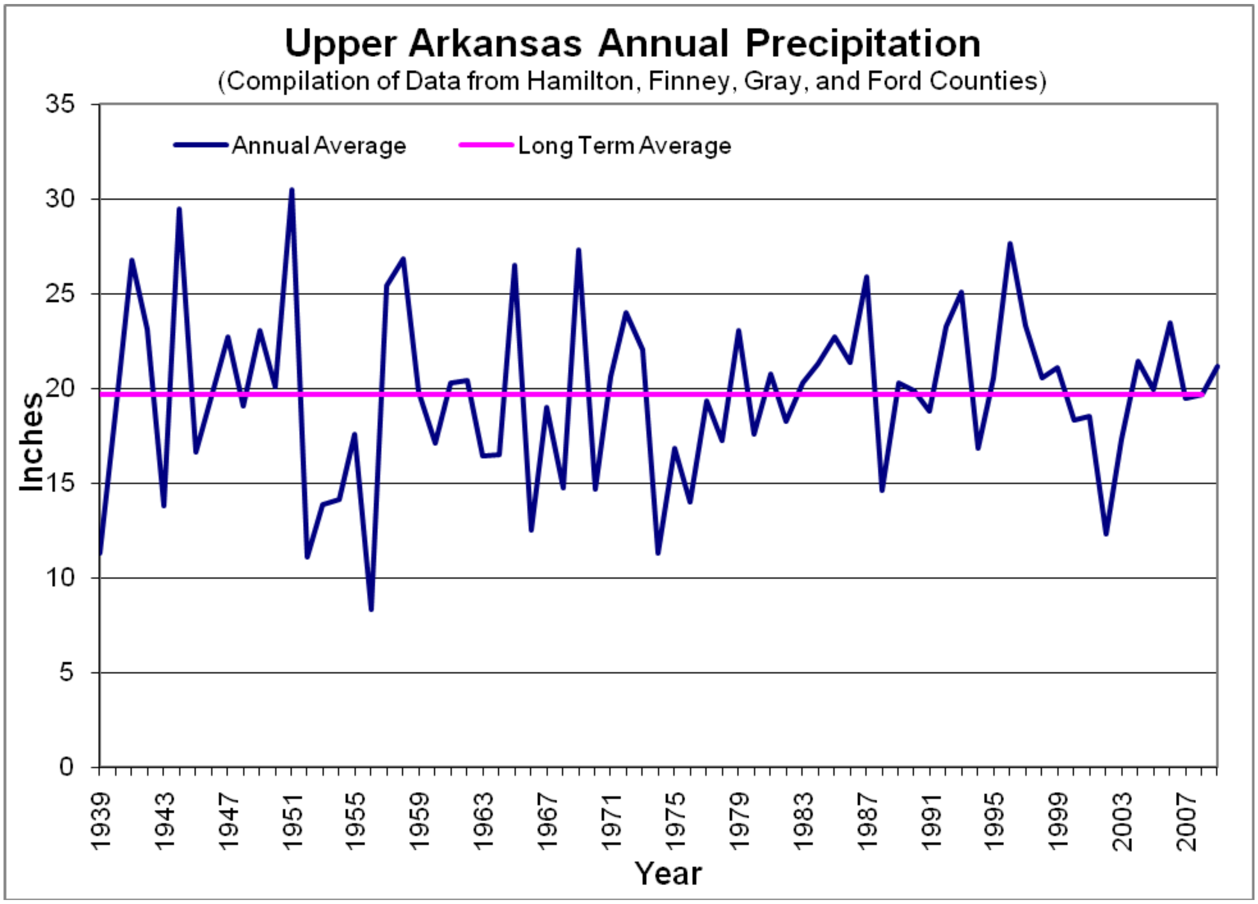

Figure 2: NCDC Annual Average Precipitation in Upper Arkansas Subbasin 1939-2009

Figure 3 charts the preliminary average monthly precipitation for 2010 and the long term average monthly precipitation for comparison. The highest precipitation occurred in July with 3.3 inches and the lowest precipitation was in December with 0.27 inches. The overall average rainfall in 2010 for the Upper Arkansas subbasin is below average with 16.8 inches.

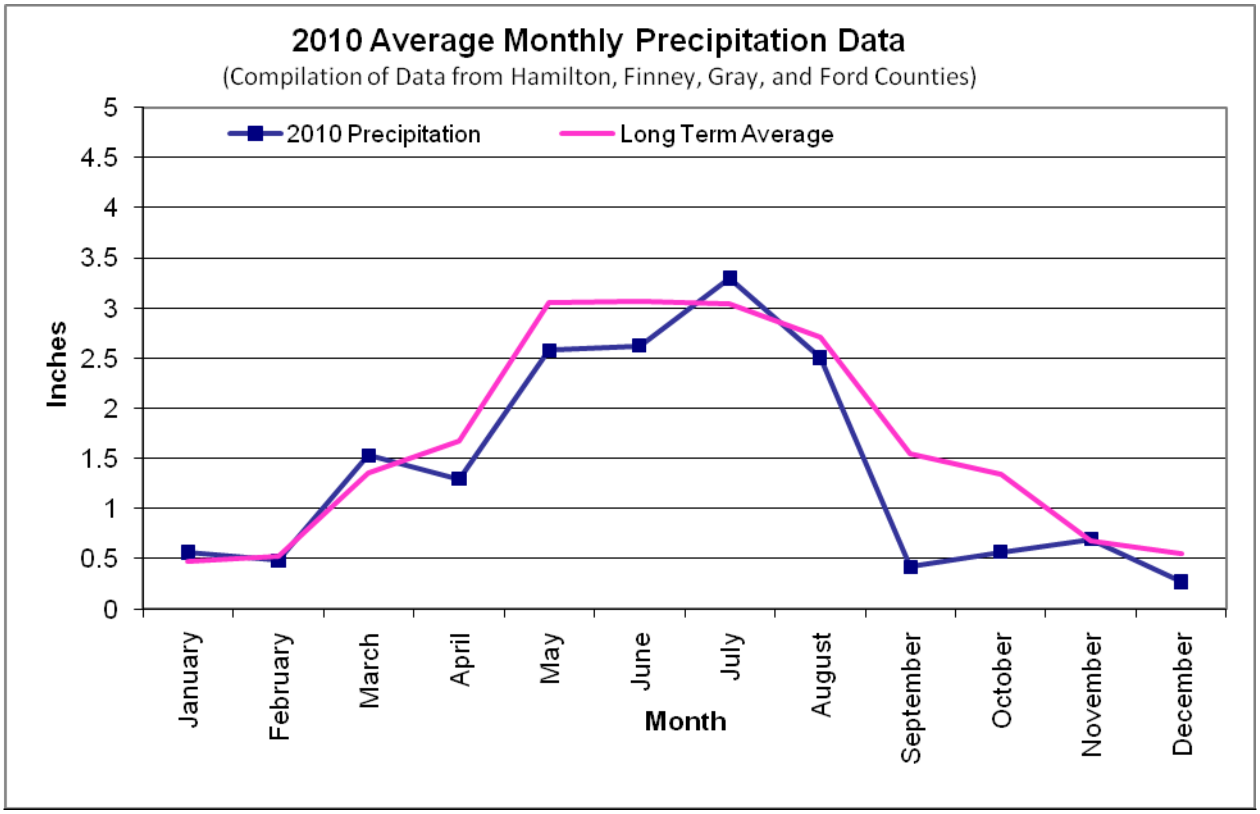

Figure 3: Monthly Average Precipitation in Upper Arkansas Subbasin for 2010

III. Surface Water

The flow in the Upper Arkansas River is influenced by the operations of an interstate compact between Colorado and Kansas ("the compact"). Under the compact, some surface water inflows are stored in John Martin Reservoir, located approximately 90 miles west of the state line, near Lamar, Colorado for use in Kansas. Water releases are coordinated with KDA-DWR and the six irrigation ditches above Garden City.

In Colorado, there are tributaries below John Martin Reservoir that contribute to surface water flows, along with irrigation return flows. In Kansas, there is only one significant tributary, Mulberry Creek, which enters the Arkansas River near Dodge City in Ford County.

Streamflow decreases in the Upper Arkansas River from west to east. The stream segment from the state line to Garden City is a losing stretch due to seepage to the alluvial aquifer system, evapotranspiration, groundwater pumping and surface water diversions. From Garden City to the eastern boundary of the Upper Arkansas subbasin, this is also a losing reach due to a lack of streamflows from above Garden City, very limited local inflows, and groundwater pumping. River water is a primary source of recharge to the alluvial aquifer system.

The USGS gages at Garden City and Dodge City show long periods of no flow. Generally, only high flows resulting from flood conditions pass Garden City but these events are rare. The last significant annual discharge seen at Garden City occurred in 2002 with 13.2 cfs. Minimum

Desirable Streamflow (MDS) is not established at any of the gages in the Upper Arkansas River subbasin.

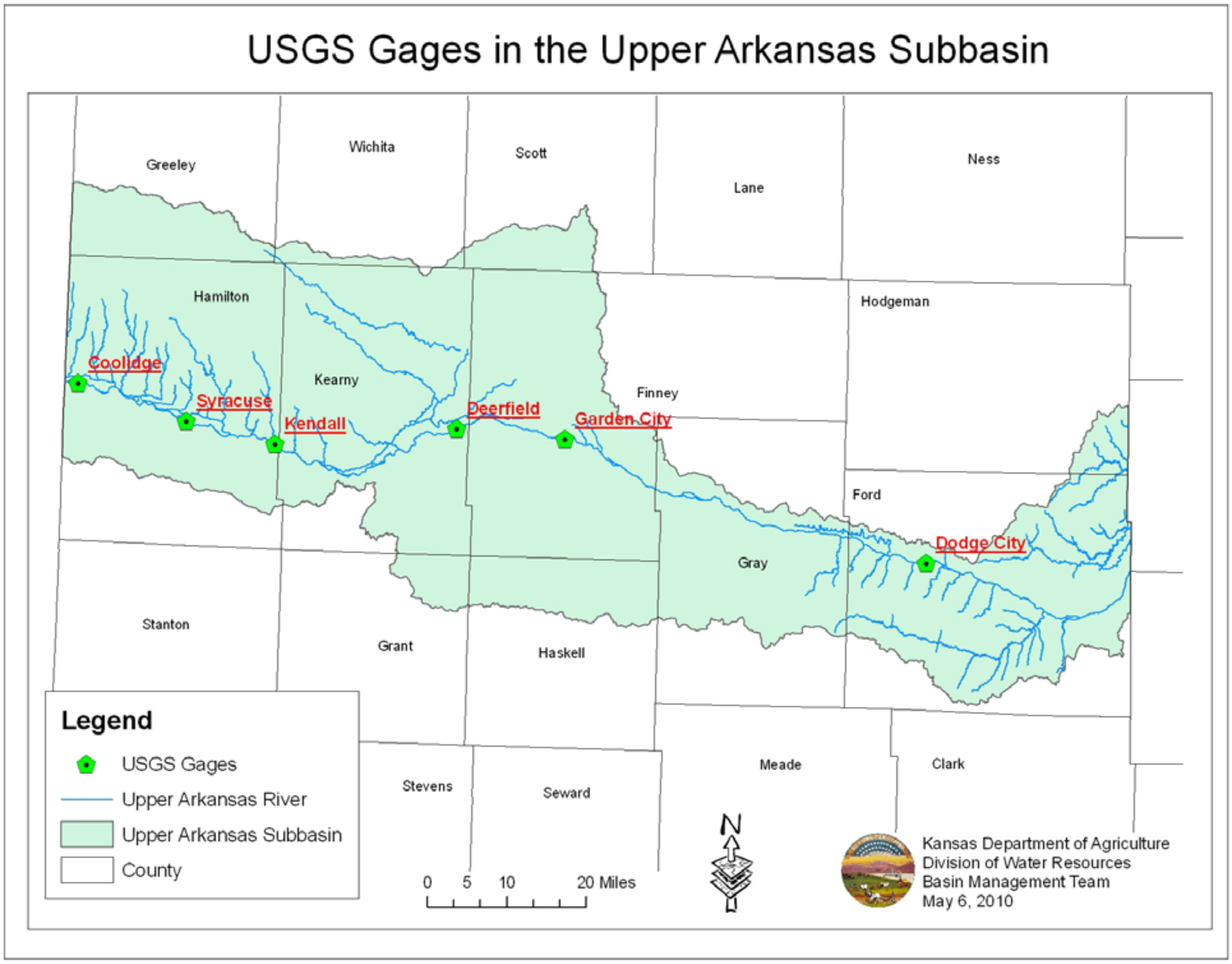

Figure 4: USGS Stream gage sites along the Upper Arkansas River valley

There are currently four active USGS streamflow gage sites (Coolidge, Syracuse, Garden City and Dodge City[6]) along the Upper Arkansas River and one active ditch gage. The locations of the six recent streamflow gages on the Arkansas River that began at the state line and continued downstream to Dodge City, Kansas are shown in Figure 4. Due to budget constraints, the Kendall and Deerfield gages were discontinued in September 2010, as well as three USGS measuring stations on four irrigation ditches (Amazon, Great Eastern, South Side and Farmers. In addition to the four river gages currently in use along the Upper Arkansas River, there have been other river gages used in the past (Table 1). On occasion, staff from KDA-DWR makes streamflow measurements at various locations in the subbasin.

[6] Dodge City is a stage only site with the Tulsa Corps of Engineers as a cooperator.

Table 1: List of gages past and present in the Upper Arkansas River valley

Gage location	Period of USGS record
Arkansas River near Coolidge	May 1903 to October 1903
	March 1921 to May 1921
	October 1950 to present
Arkansas River at Syracuse	August 1902 to September 1906
	October 1920 to present
Arkansas River at Kendall	April 1979 to 1982
	June 2000 to September 2010
Arkansas River below Amazon diversion	April 1977 to September 1982
Arkansas River at Lakin	April 1978 to September 1982
Arkansas River at Deerfield	1987 – September 1998
	October 1998 to September 2010
Arkansas River at Garden City	June 1922 to June 1970
	1980 – 1986
	October 1986 to present
Arkansas River at Dodge City	October 1902 to September 1906
	September 1944 to February 2007
	[gage is currently a stage only, but record of no flows continues to build]
Mulberry Creek near Dodge City	March 1968 to September 1990

In analyzing streamflow from 1903 to present times, the streamflow at Coolidge, Syracuse, Deerfield, Kendall, Garden City and Dodge City is included (Figure 4). Dodge City only has annual discharge data available through 2006 (stage data is still being collected, so the number of no flow days can be determined), and Kendall does not have an annual discharge record in 2000. Average annual Arkansas River flow during specified time periods for available data at each of the sites is shown in Table 2. The period of record for each gage is shown in parenthesis under gage location. Figure 5 charts the annual streamflow at each of the six USGS stream gages.

Table 2: Annual Flow on the Arkansas River at selected gaging stations

	Average annual flow (cfs)		
Gage Location	**Period of record**	**1990-1999**	**2000-2009**
Coolidge (1951-present)	212.57	311.94	147.61
Syracuse (1903-present)	283.05	302.67	135.40
Kendall (1980-1982, 2001-2010)	107.73	Not available	109.61
Deerfield (1999-2010)	107.55	Not available	53.61
Garden City (1923-1969; 1987-present)	169.31	160.95	26.08
Dodge City (1903-1906; 1945-2006)	128.68	90.39	13.23

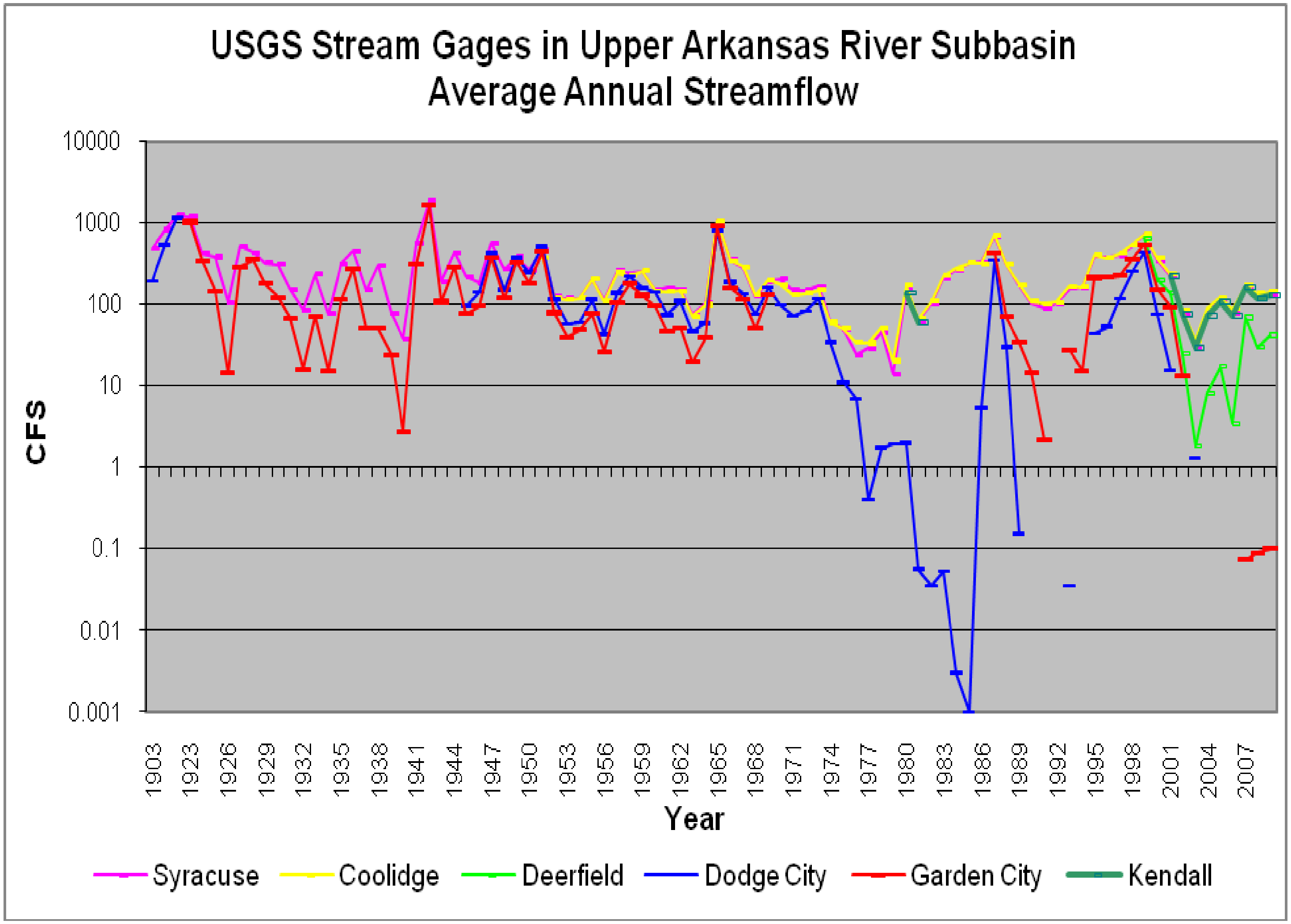

Figure 5: Streamflow at the Upper Arkansas USGS Gage stations 1903-2009

For 2010, there were a total of 109,935 acre-feet of flow recorded at the state line. This compares to a state line flow of 112,425 acre-feet in 2009. In 2010, approximately 39,817 acre-feet were released from storage accounts in John Martin Reservoir for delivery to Kansas. The six irrigation ditches diverted a total of approximately 62,489 acre-feet in 2010 (Figure 6).

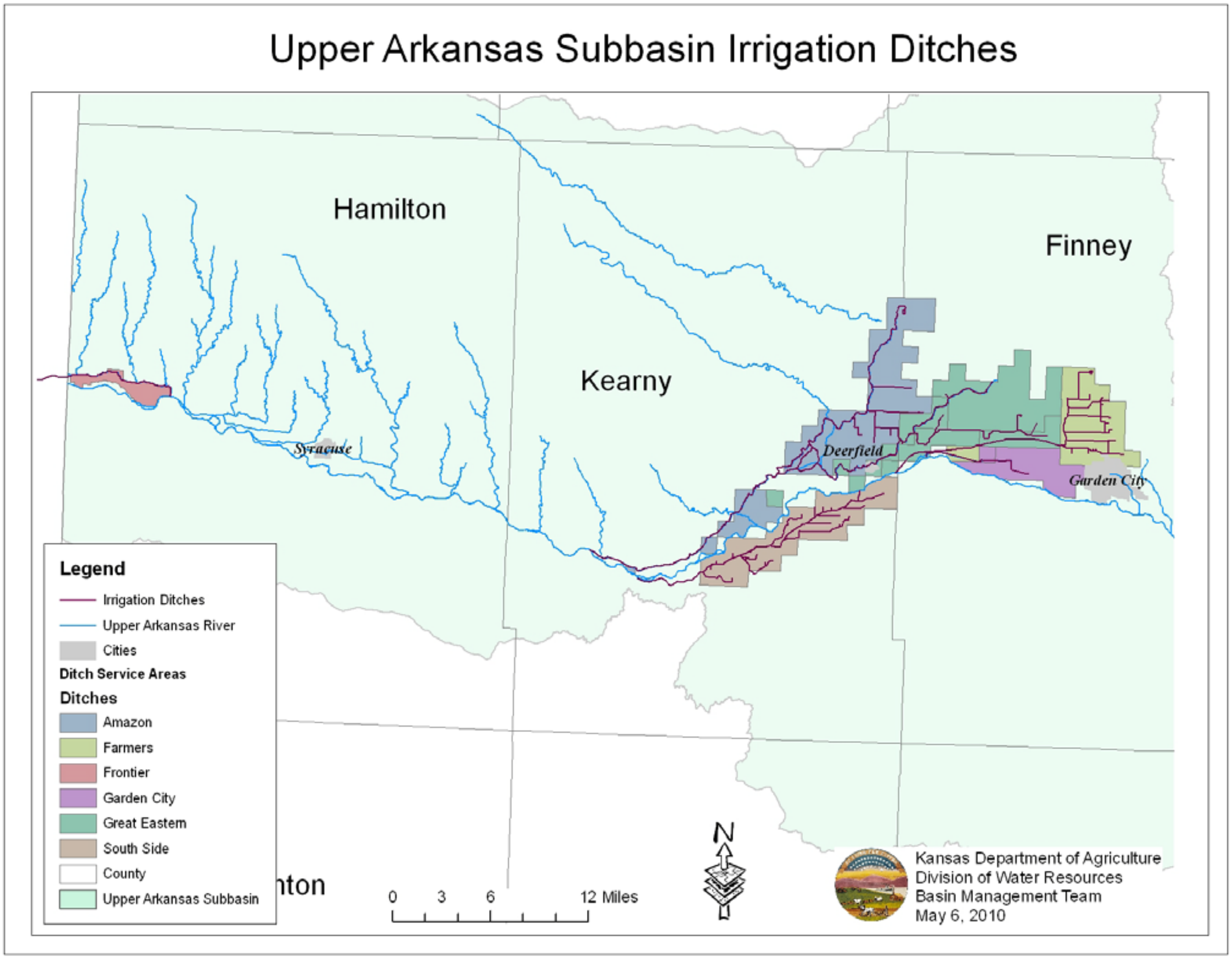

Figure 6: Upper Arkansas Subbasin Irrigation Ditches

Figure 7 represents streamflow in 2010. Garden City had some occurrences of minimal flows during 2010, due to localized runoff events. Flows at Coolidge and Syracuse are similar due in large part to the operation of the irrigation ditches.

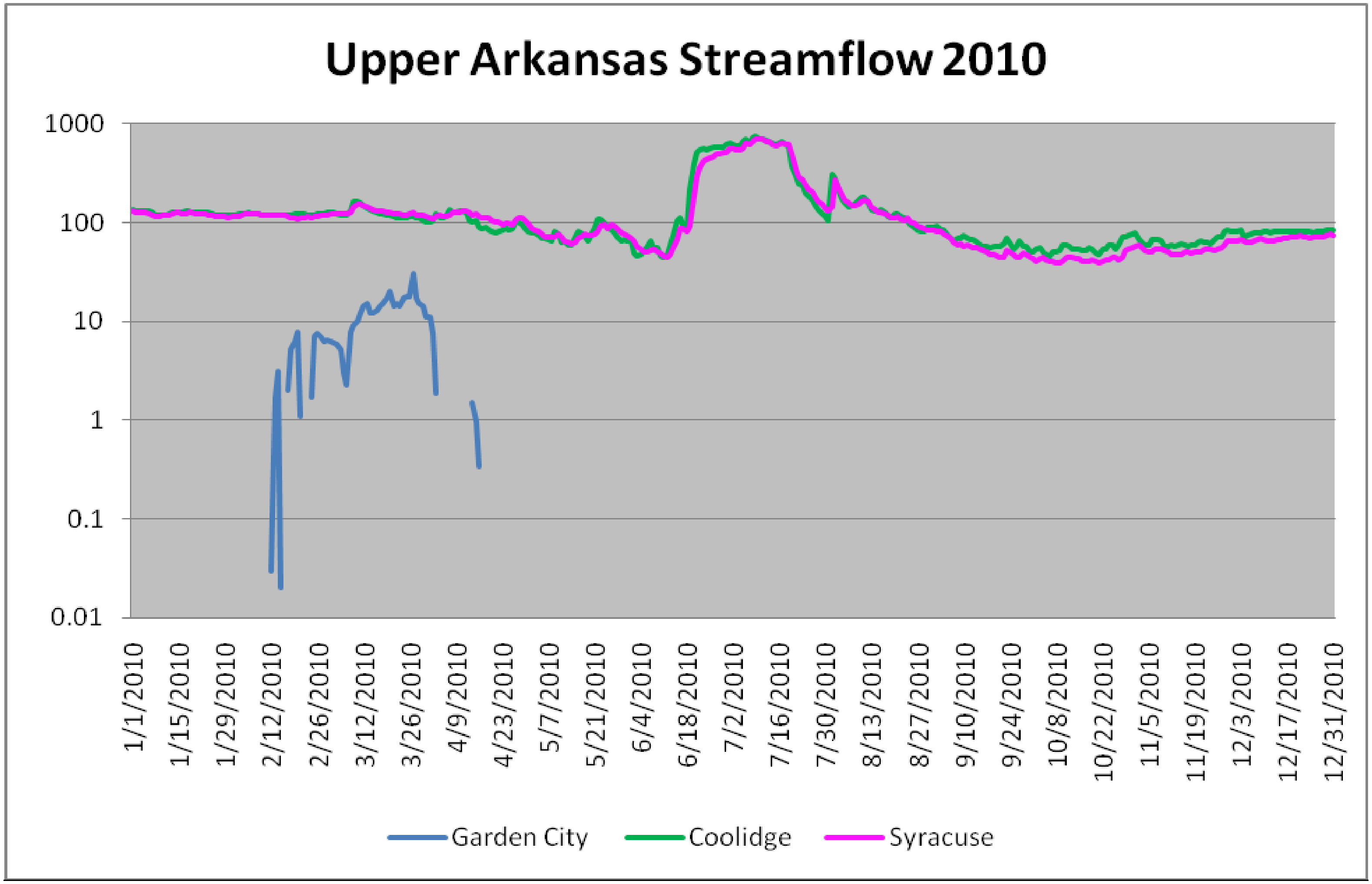

Figure 7: Streamflow along the Upper Arkansas, 2010

IV. Groundwater

The Kansas Geological Survey and the KDA-DWR cooperatively measure 100 wells in the subbasin annually. The wells are drilled into the alluvial, the Ogallala-High Plains and Dakota aquifers (Figure 8). KDA-DWR measures wells tri-annually in the winter, spring and fall.

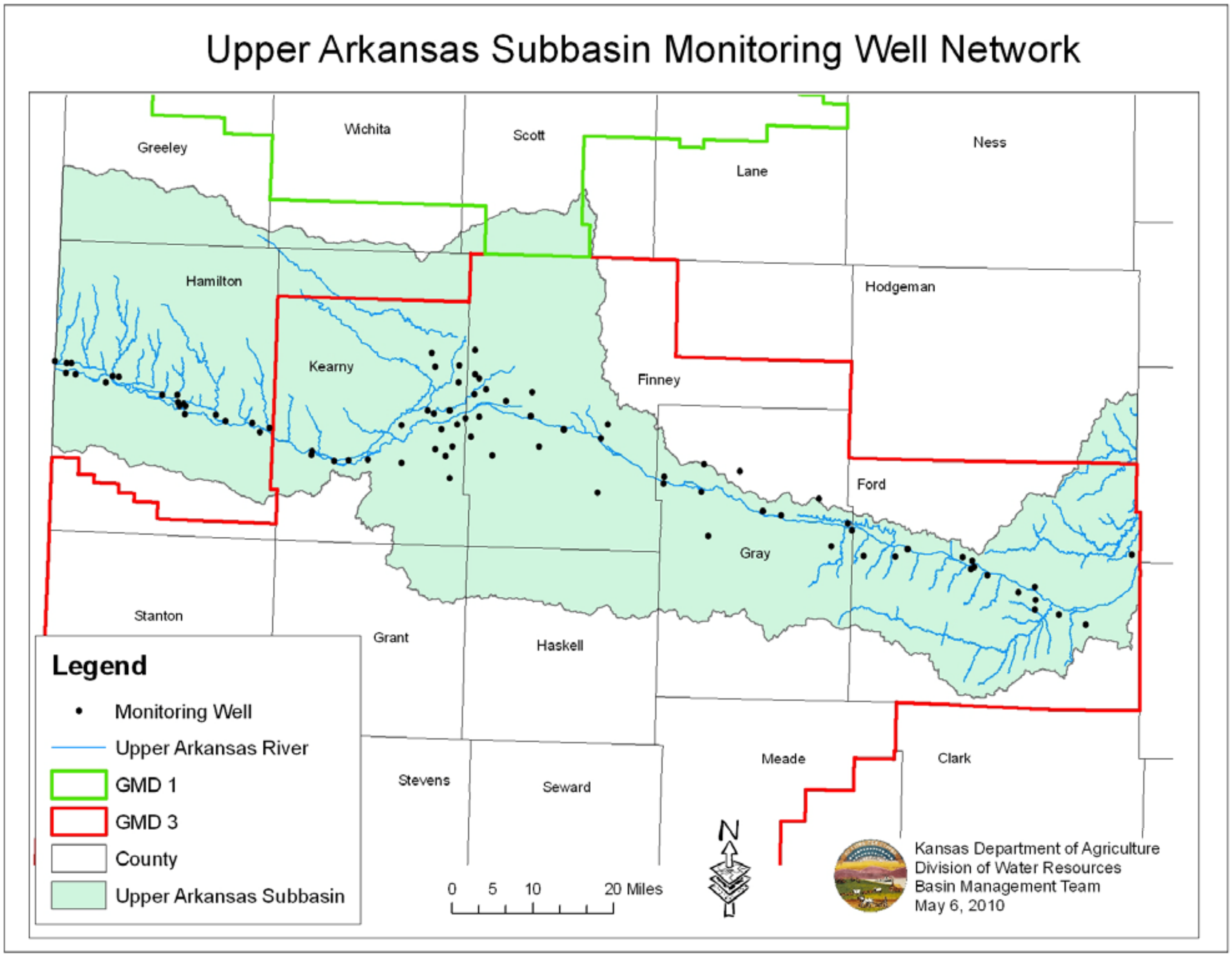

Figure 8: Upper Arkansas River Subbasin Monitoring Wells

Ongoing observation of water levels is critical to understanding fluctuations that may occur over time. Historical records from observation wells can provide a hydrologic outlook on the long-term stability or decline in an area. Pumping from the Ogallala-High Plains aquifer creates a strongly downward hydraulic gradient in the aquifer, but the leaky aquitard[7] above limits effects on the alluvial aquifer.

Wells located within the Ogallala-High Plains aquifer typically are drilled deeper than alluvial wells and in some areas of the subbasin are hydraulically connected to the alluvial aquifer system. In other areas, especially Gray County, the Ogallala-High Plains and the alluvial aquifer systems are no longer hydraulically connected.

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[7] An *aquitard* is a layer of low permeability material that restricts the flow of groundwater from one aquifer to another.

Figure 9 through Figure 17 display current and historic water level trends of the 100 monitoring wells used for this analysis. Only winter measurements, taken in December, January or February, were used in the water level hydrographs since those groundwater levels are considered to be least affected by irrigation well pumping. Legal descriptions of the monitoring wells are available in the appendix. Wells were organized by aquifer system to better demonstrate the responses in the groundwater levels in response to surface water flows. The y-axis is labeled as depth below land surface (DBLS) and is measured in feet.

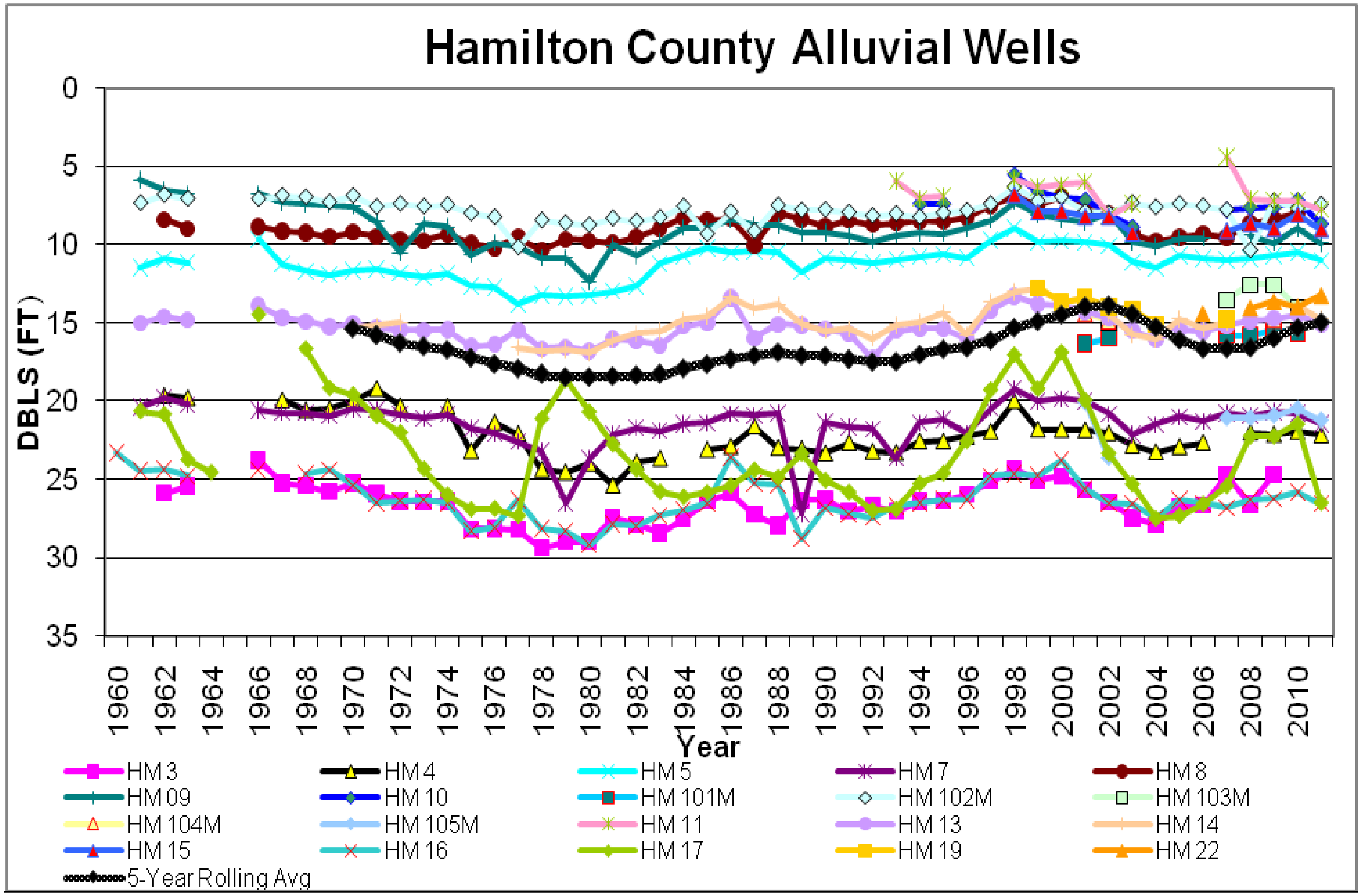

Figure 9: Alluvial groundwater levels in Hamilton County

Observation wells in Hamilton County are only in the alluvial aquifer as the Ogallala-High Plains aquifer is absent west of the Bear Creek dissolution zone. There are 20 observation wells monitored in Hamilton County. Water levels in Hamilton County appear to remain relatively stable with fluctuations in the order of approximately 5 feet (Figure 9). On average, the water levels declined from 2010 to 2011, with an average decrease of 0.84 feet. In individual wells, changes in water levels varied, decreasing as much as 5.02 feet (HM17) and increasing as much as 0.74 feet (HM22). There are a number of wells with long-term water level records. Since 1962, HM04 has experienced a net decline of 2.52 feet. Since 1961, HM07 and HM09 have had net declines of 1.07 feet and 4.05 feet, respectively, while HM05 has increased by a net 0.47 feet. The five-year rolling average shows that the water levels have remained fairly stable.

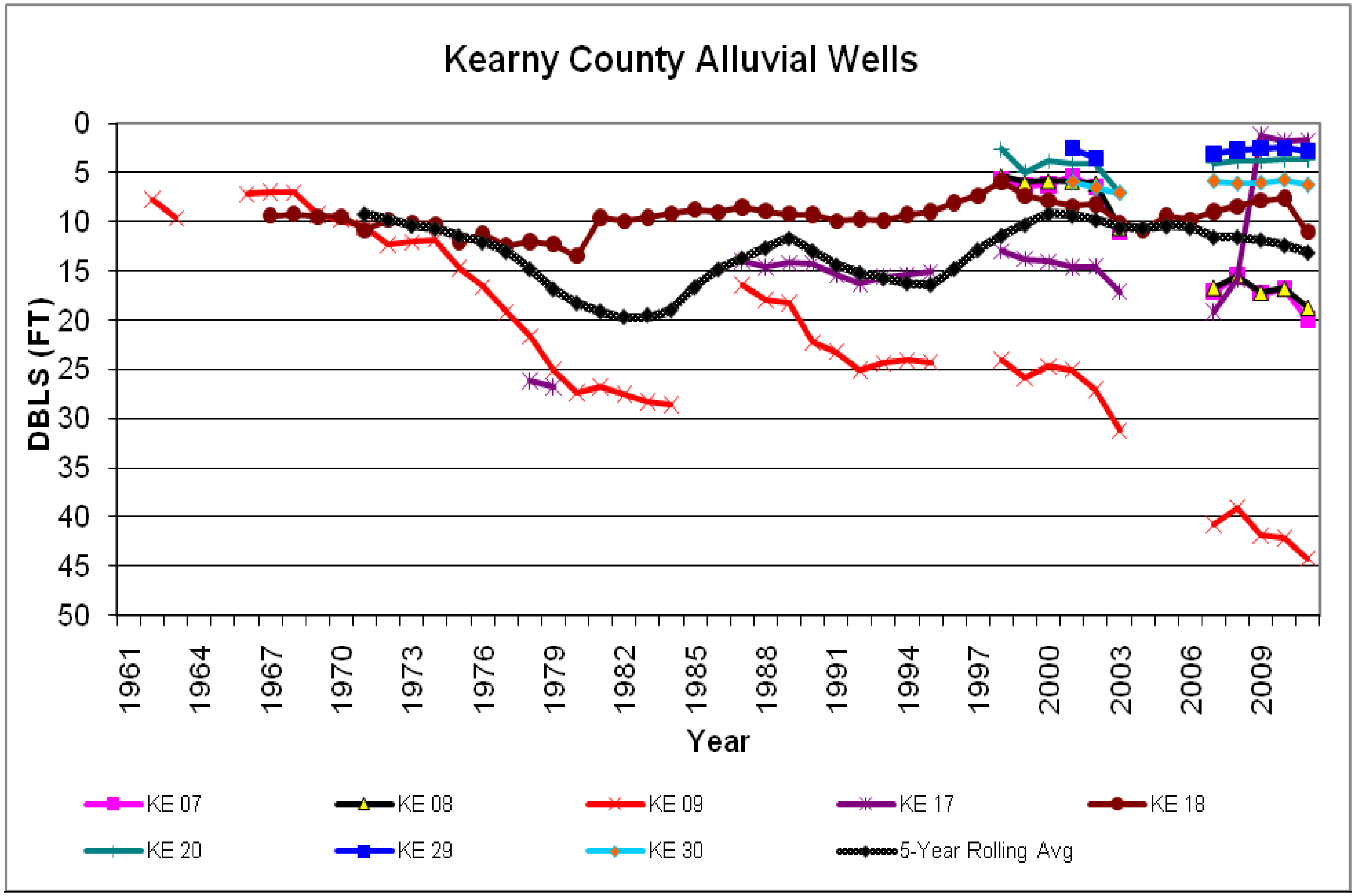

Figure 10: Alluvial groundwater levels in Kearny County

Observation wells in Kearny County are located in both the alluvial and Ogallala-High Plains aquifer. Figure 10 shows the eight alluvial observation wells in Kearny County. KE09, KE17 and KE18 have the longest record. KE09 water level measurements indicate that since 1962 the water table has experienced a net decrease of more than 35 feet in this well. Water level changes during 2010 to 2011 ranged from an increase of 0.1 feet (KE17) to a decrease of 3.12 feet (KE07). Overall, the wells experienced an average decline of 1.14 feet from 2010 to 2011. The sharp increase in water level for KE17 from 2008 to 2009 is likely attributed to the infiltration into the aquifer from use of the South Side Ditch for water transport downstream. The well is within ¼ mile from the ditch. The five-year rolling average shows fluctuations over time, with wells recently on a downward trend.

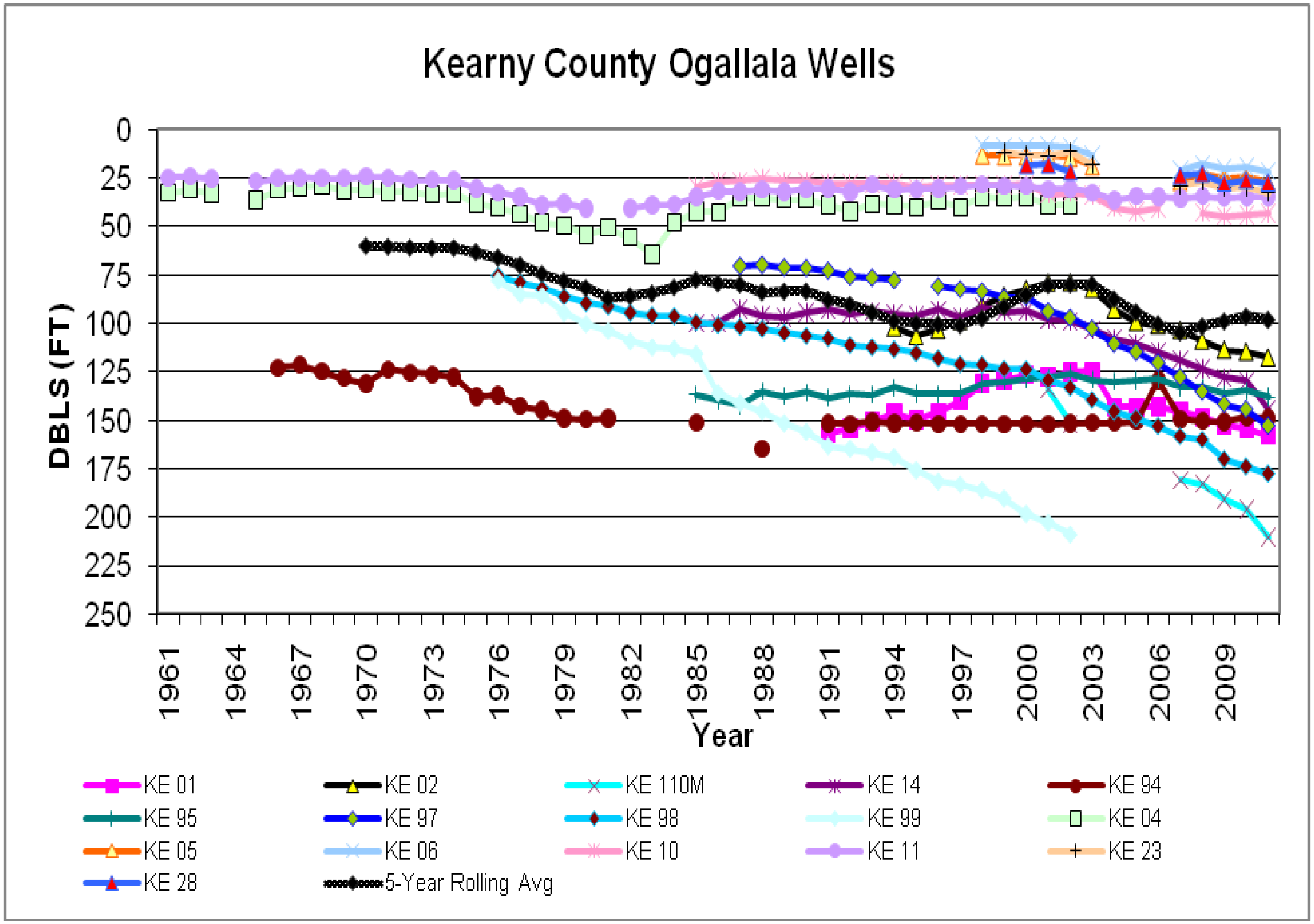

Figure 11: Ogallala-High Plains groundwater levels in Kearny County

Figure 11 shows the 16 Ogallala-High Plains wells monitored in Kearny County. The water levels from 2010 to 2011 in the Ogallala-High Plains exhibited an average decline of 4.38 feet. The water level changes ranged from a decrease of 14.49 feet (KE110M) to an increase of 0.74 feet (KE10). There are a number of wells with long-term historical records. KE94, since 1966, has declined a net of 26.3 feet, whereas KE11 since 1961 has seen a net decline of 10 feet. The five-year rolling average shows the water levels generally declining over time.

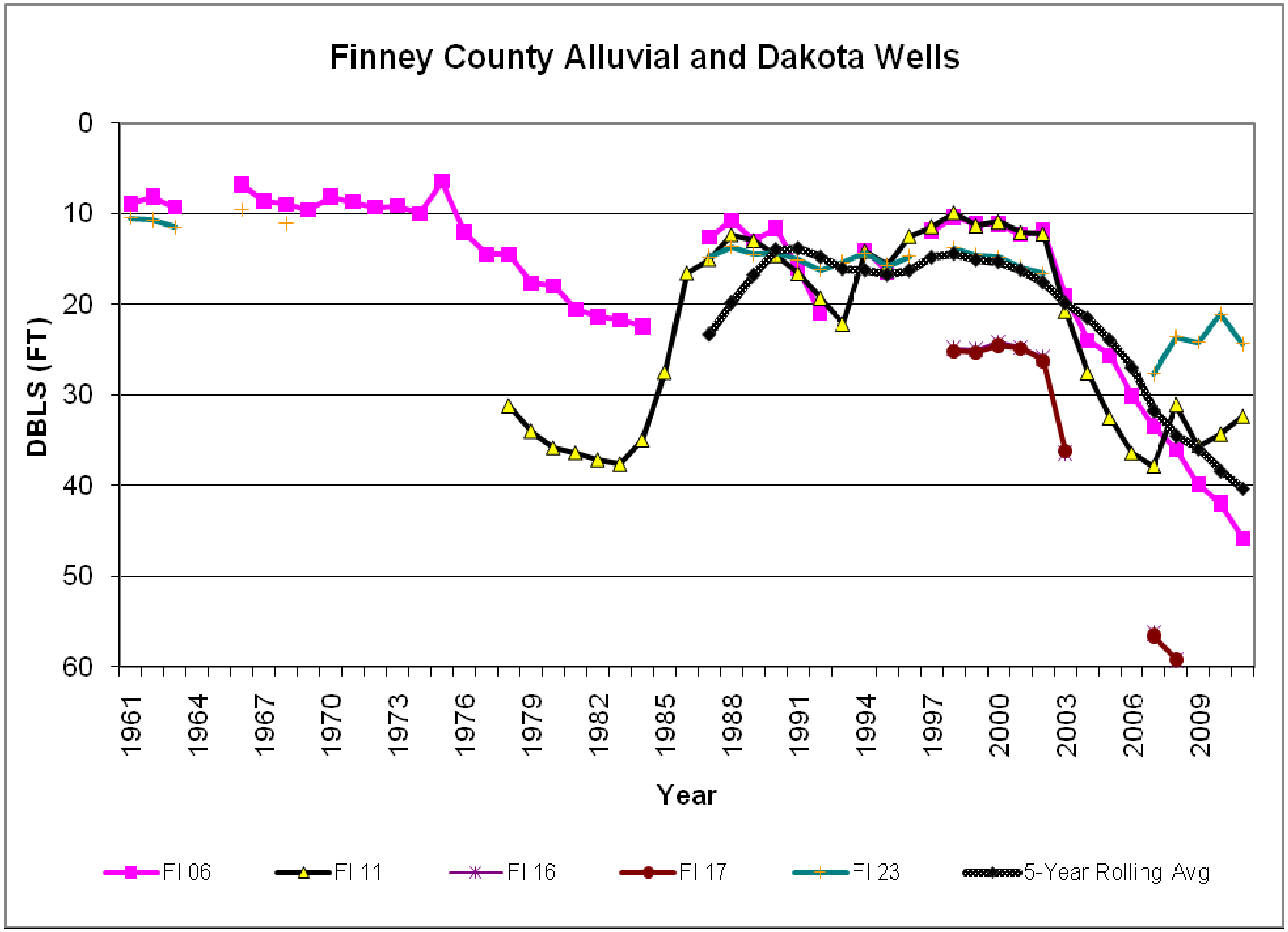

Figure 12: Alluvial groundwater wells in Finney County

Observation wells in Finney County are located in the alluvial aquifer, the Ogallala-High Plains aquifer and one well in the Dakota aquifer. Figure 12 represents the five alluvial observation wells monitored in Finney County. The alluvial water levels in Finney County experienced an overall average decrease of 1.94 feet from 2010 to 2011 and ranged from decreases of 3.8 feet (FI06) to an increase of 1.95 feet (FI11). The five-year rolling average for the alluvial wells shows an overall declining trend since the late 1990s. FI17 was dry in 2009 and no data is available in 2011.

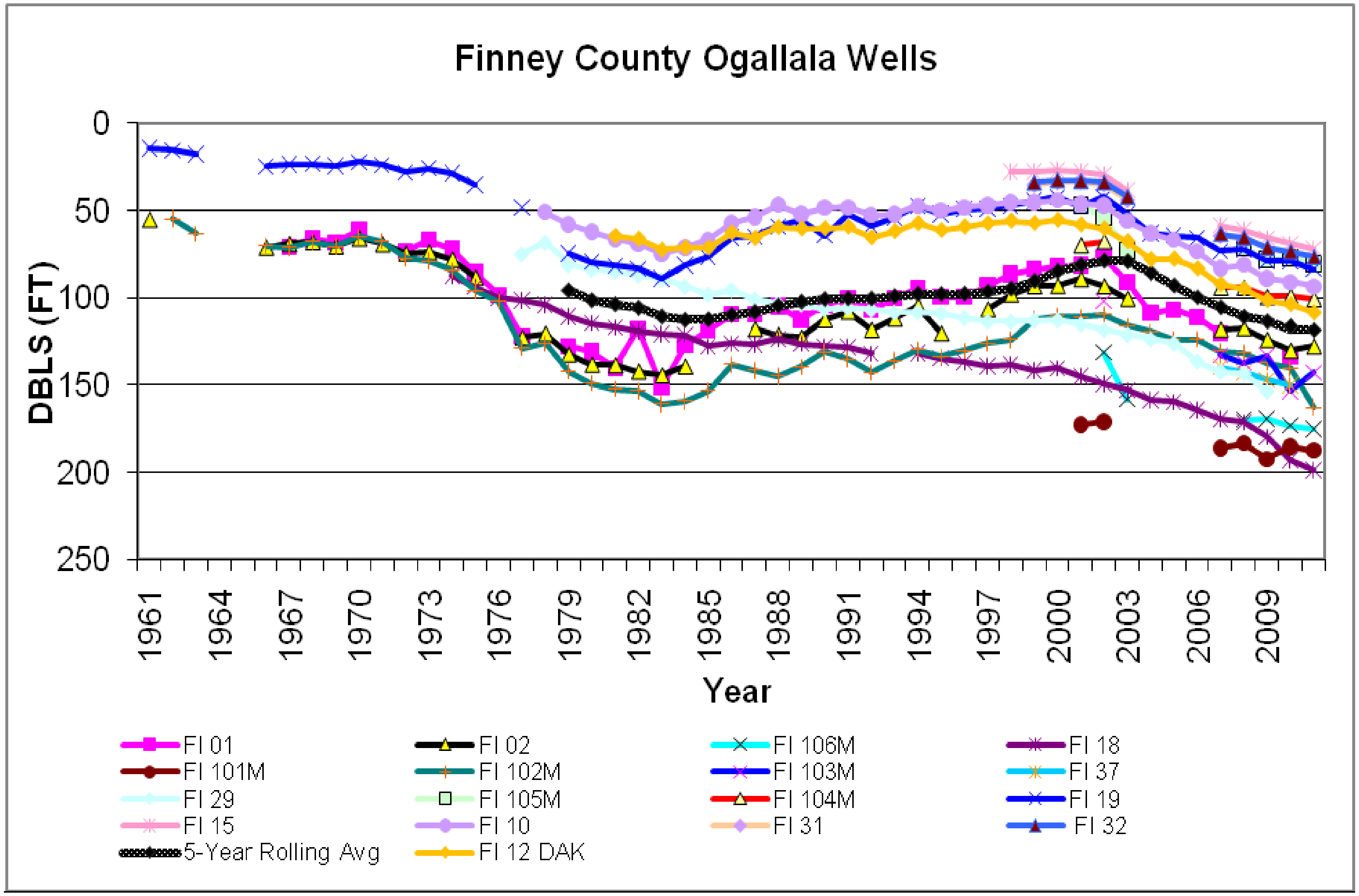

Figure 13: Ogallala-High Plains groundwater wells in Finney County

Figure 13 charts the 16 observation wells for the Ogallala – High Plains and the one Dakota well in Finney County. These monitoring wells show an average decline of about 3.28 feet from 2010 to 2011. This varied from a decline of 22.41 feet (FI102M) to an increase of 10.34 feet (FI103M). FI01 did not have measurements available in 2008, 2009, or 2011 but showed a 13.2 feet decrease from 2007 to 2010. A number of these wells have long-term water level records. Despite some increases in the early to mid 1980s, FI19, FI02 and FI102M have exhibited net declines of 69.1 feet, 73 feet and 108.08 feet, respectively over the period of record. Also in Figure 13, the Dakota well (FI12) showed a decline of 4.8 feet from 2010 to 2011 and a net decline of nearly 44 feet since 1981. The five-year rolling average shows the water levels are on a declining trend.

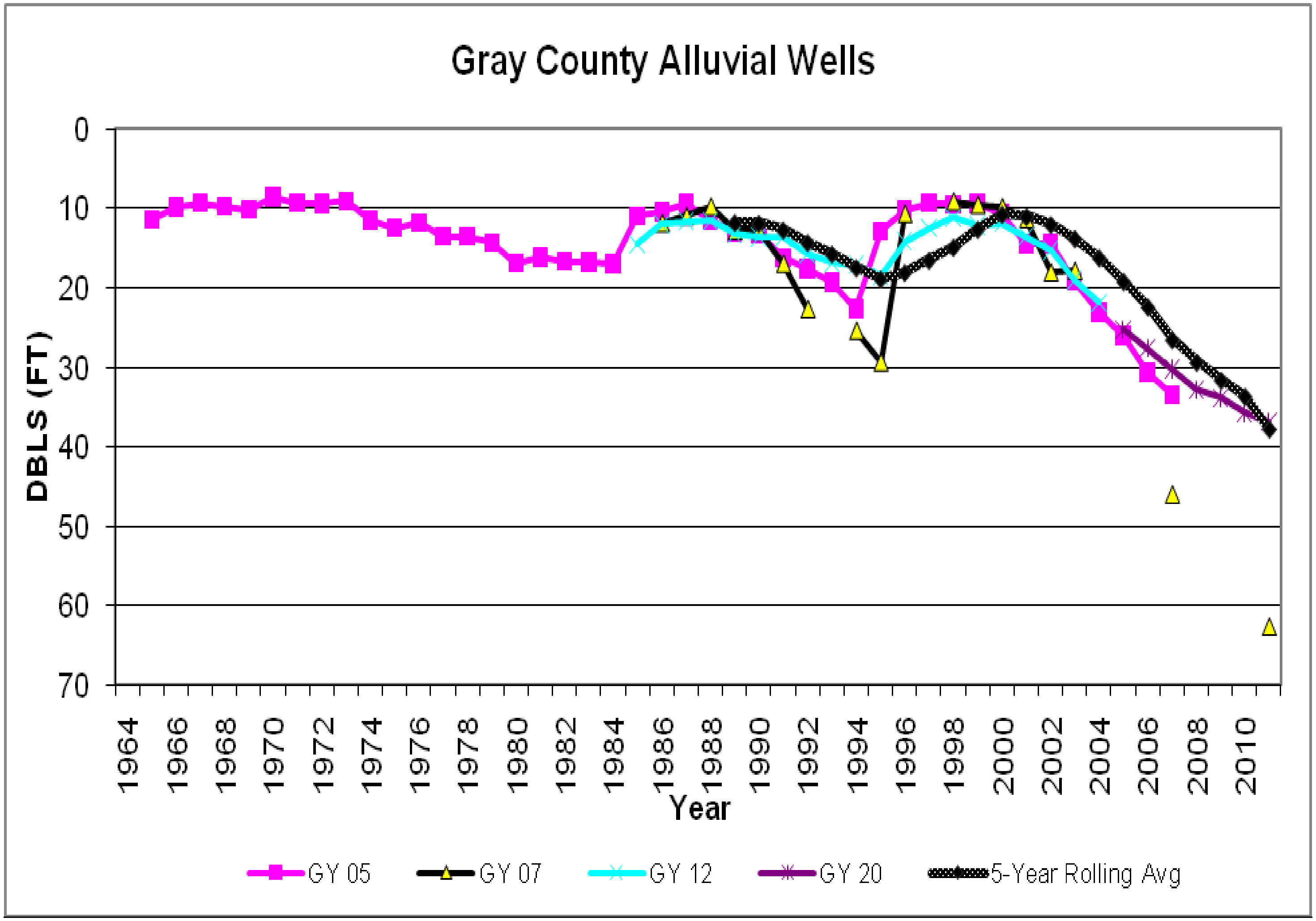

Figure 14: Alluvial groundwater levels in Gray County

Observation wells located in Gray County are in both the alluvial and Ogallala-High Plains aquifers. There are four alluvial wells monitored in Gray County (Figure 14). The water levels exhibited an average decline of 6.12 feet from 2010 to 2011. GY05 has the longest water level record in this group, and it shows that from 1965-2007 the water table has had periods of rises and falls but has declined 24 feet since 1999. In 2009, GY05 was dry and has been unable to be measured. GY07 was measured in 2011 and shows a decline of 16.63 feet since last measured in 2007. The five-year rolling average shows a sharp decline of about 27 feet since 2000.

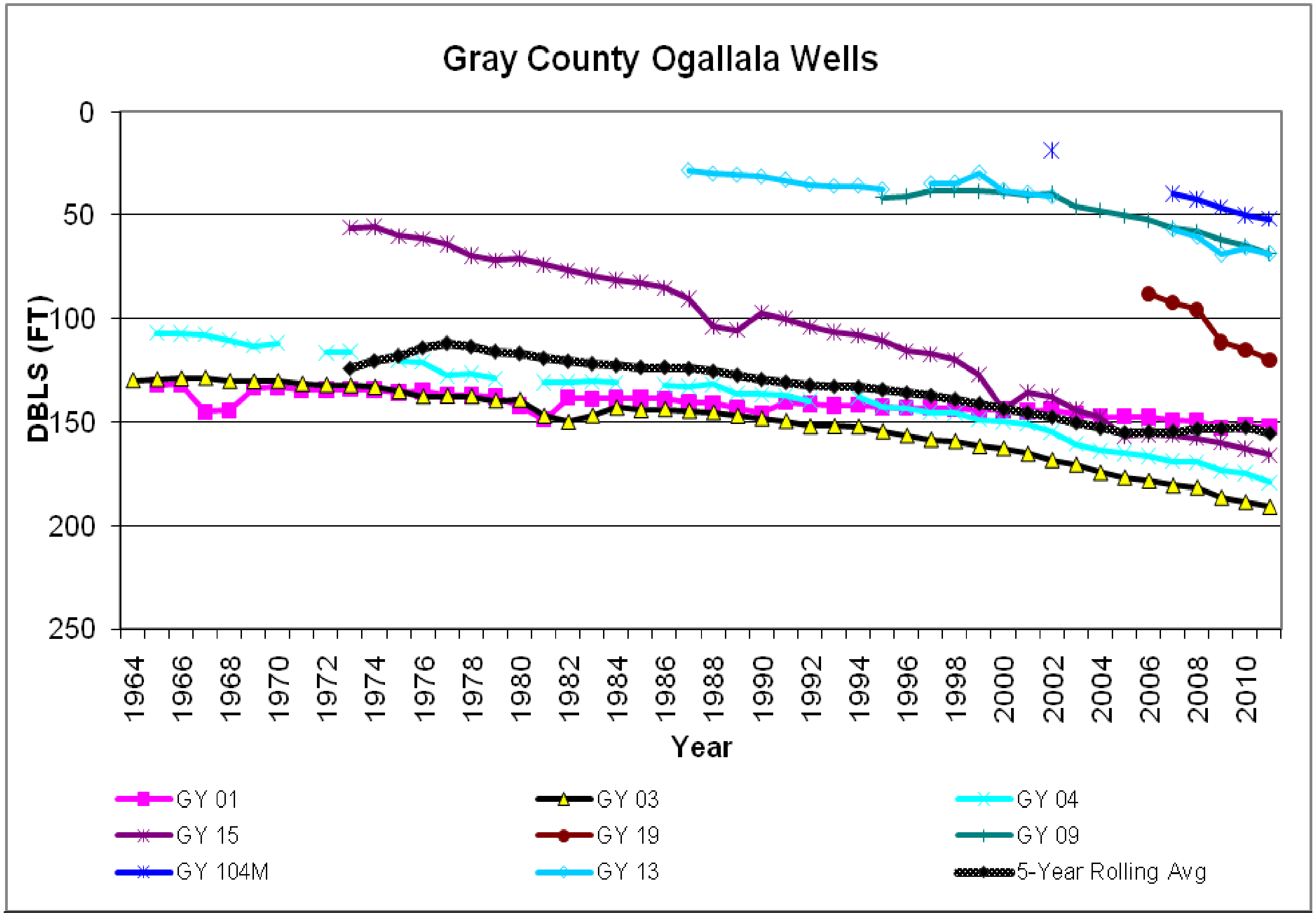

Figure 15: Ogallala-High Plains groundwater levels in Gray County

There are eight observation wells monitored in the Ogallala-High Plains aquifer in Gray County (Figure 15). All Ogallala observation wells in Gray County have shown a net decline. From 2010 to 2011, all water level changes showed a decline ranging from 0.85 feet (GY01) to 4.76 feet (GY19) with an overall average decline of 2.98 feet. There are a number of wells with long-term records. Since 1964, GY03 has experienced a net decline of 60.75 feet and since 1965 GY01 and GY04 have exhibited net declines of 20.34 feet and 72.24 feet, respectively. GY15 has shown a net decline of 109.79 feet since 1973. The five-year rolling average shows an overall declining trend.

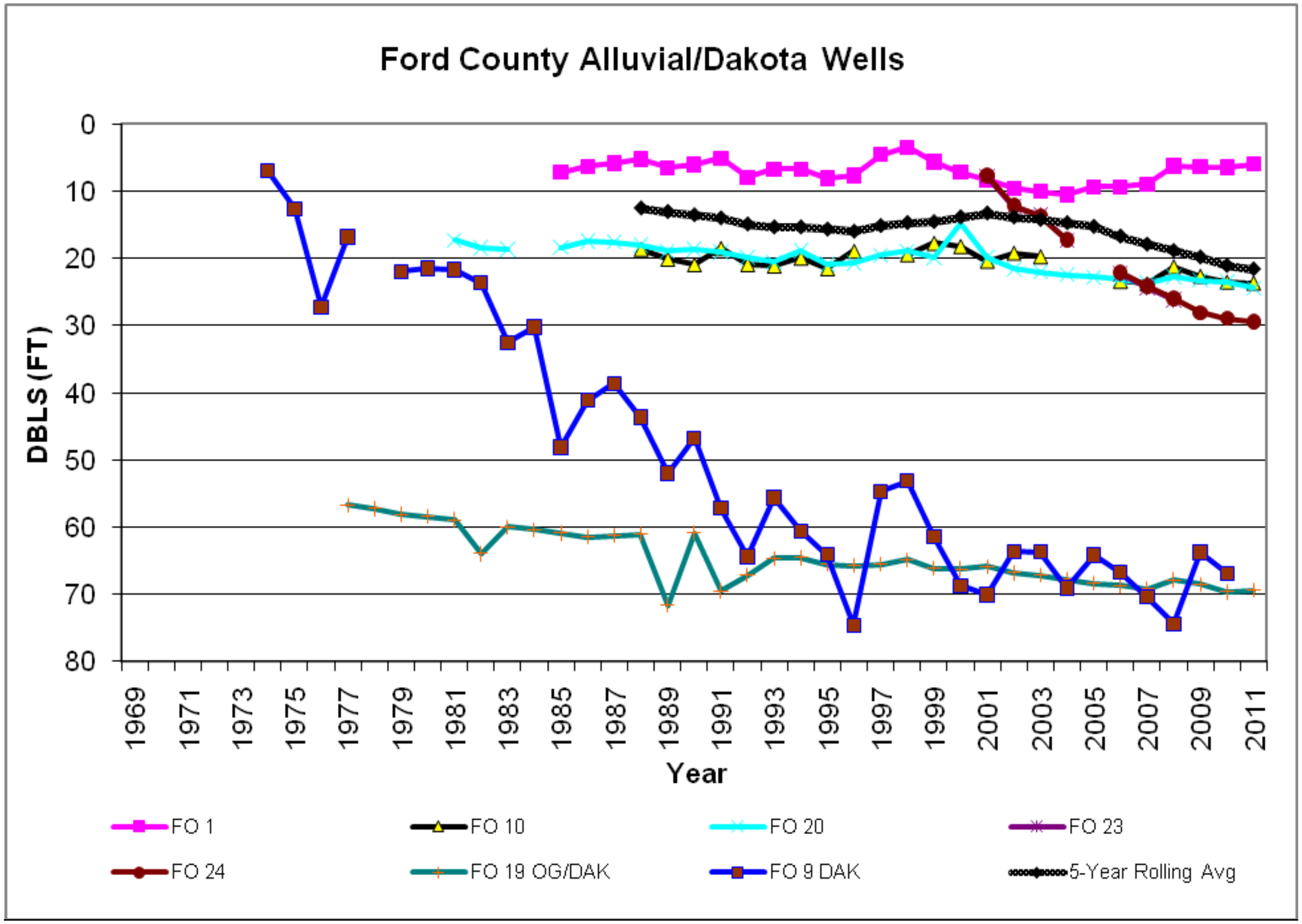

Figure 16: Alluvial, Ogallala-Dakota and Dakota groundwater levels in Ford County

Observation wells in Ford County are drilled in the alluvial, Ogallala-High Plains and Dakota aquifers. For 2011 many wells in Ford County were measured twice; in these instances an average of the two measurements was used. There are five alluvial aquifer observation wells that have shown an average decrease of 0.22 feet from 2010 to 2011 (Figure 16). This change ranged from an increase of 0.49 feet (FO1) to a decrease of 0.9 feet (FO20). The five-year rolling average for the alluvial wells shows water levels remaining stable but had a slight decline in the last several years. One well (FO19) was drilled in both the Ogallala-High Plains and Dakota aquifers, according to records, and has declined 12.64 feet since 1977. FO09, drilled in the Dakota Aquifer, shows a net decline of 59.85 feet since 1974.

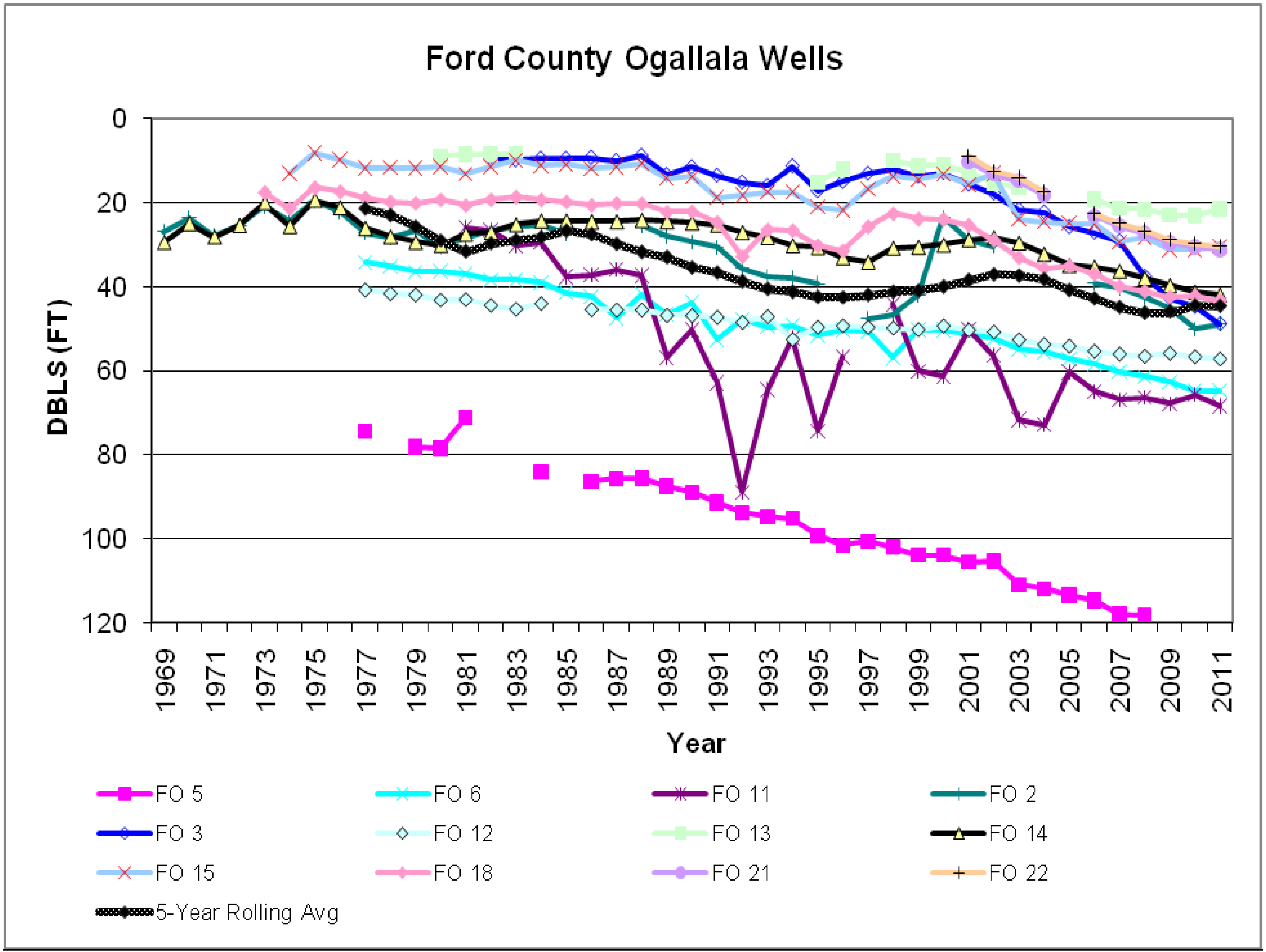

Figure 17: Ogallala-High Plains groundwater levels in Ford County

There are 15 observation wells monitored in Ford County for the Ogallala-High Plains aquifer (Figure 17). The water levels exhibited an average decline in Ford County of 0.63 feet from 2010 to 2011, ranging from an increase of 1.22 feet (FO2) to a decline of 4.08 feet (FO3). FO2 and FO14 have been monitored since 1964 and show net declines of 22.01 feet and 12.46 feet, respectively. In 2009 through 2011, FO5 has been dry. Over the period of record, the five-year rolling average shows a net decline of about 23.18 feet in water levels for the Ogallala-High Plains in Ford County.

V. Water Use

The Upper Arkansas River subbasin has a total of 4,487 water rights with an authorized quantity of 1,599,893 acre-feet. In the subbasin, eight percent of the water rights are vested, while 92 percent are appropriated. Water appropriated from groundwater sources is greater than 1.3 million acre-feet per year (Table 3). The points of diversion for these water rights are shown in Figure 18. More than one point of diversion may be associated with each water right.

Table 3: Water Rights and Authorized Quantities in the Upper Arkansas Subbasin

Source	Type	No. of Rights	Authorized Quantity
Surface	Vested	21	150,249
Ground	Vested	345	105,171
Surface	Appropriated	39	8,729
Ground	Appropriated	4,082	1,335,744

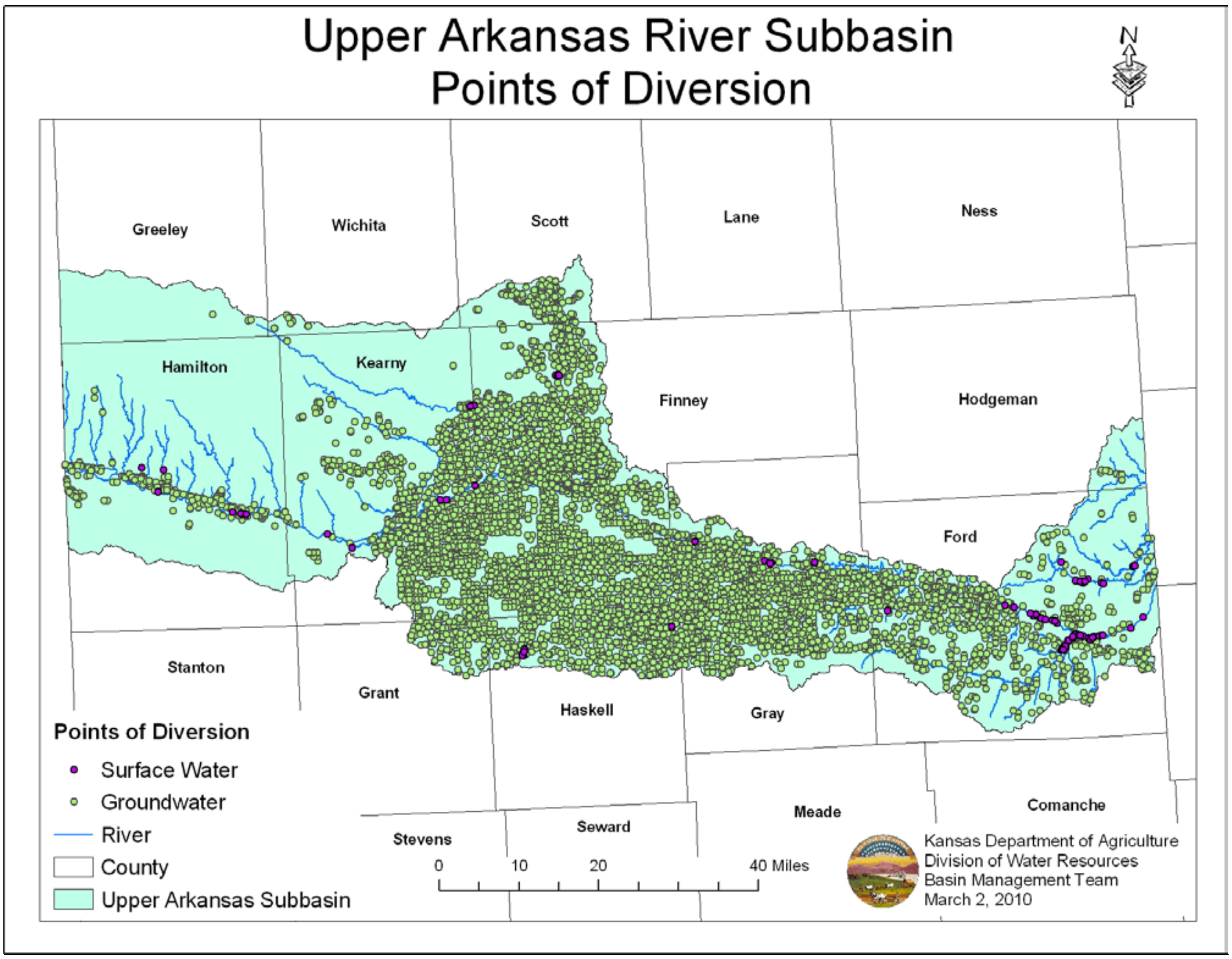

Figure 18: Upper Arkansas Subbasin Points of Diversion

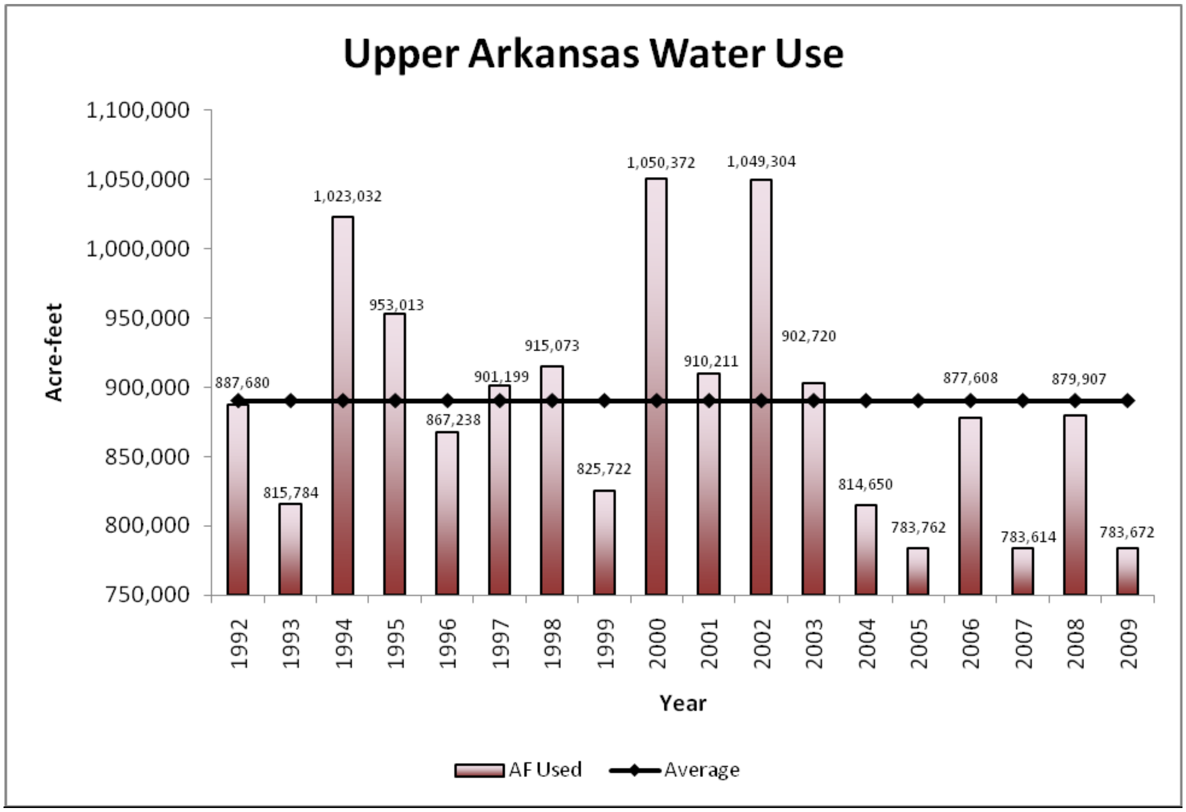

Figure 19: Upper Arkansas Subbasin Water Use 1992-2009

The water use in the Upper Arkansas subbasin ranges from 783,617 acre-feet in 2007 to 1,050,372 in 2000. The average annual water use over this span was 890,253 acre-feet (Figure 19). Water use in 2009 (the most recent year for which complete records are available) was 783,672 acre-feet. Of this total, groundwater use in 2009 was 725,199 acre-feet, which is about 93 percent of total water use in 2009 and at 50 percent of authorized quantities. In addition, surface water use in 2009 was 58,473 acre-feet, or 37 percent of authorized quantities. This analysis used all irrigation, industrial, recreation, municipal, domestic and stock water rights.

Since 1992, the Upper Arkansas subbasin averaged 20.6 inches of precipitation and 16.4 inches of irrigation pumping (Figure 20) but there is significant variability in both of those figures. Irrigators in the subbasin pump more water in drier years to compensate for the lack of precipitation. For instance, in 2002, the subbasin received 12.3 inches in precipitation and pumped 18.8 inches. Irrigation season precipitation (Figure 21) averages 14.7 inches, which is about six inches below the annual average. In 2007, the precipitation from May-October was low with 11.1 inches, but the associated irrigation was near average. This is likely due to 8.4 inches of precipitation that year that occurred outside of the irrigation season. Since 1992, the total irrigation has fluctuated with precipitation and has been on a slight downward trend.

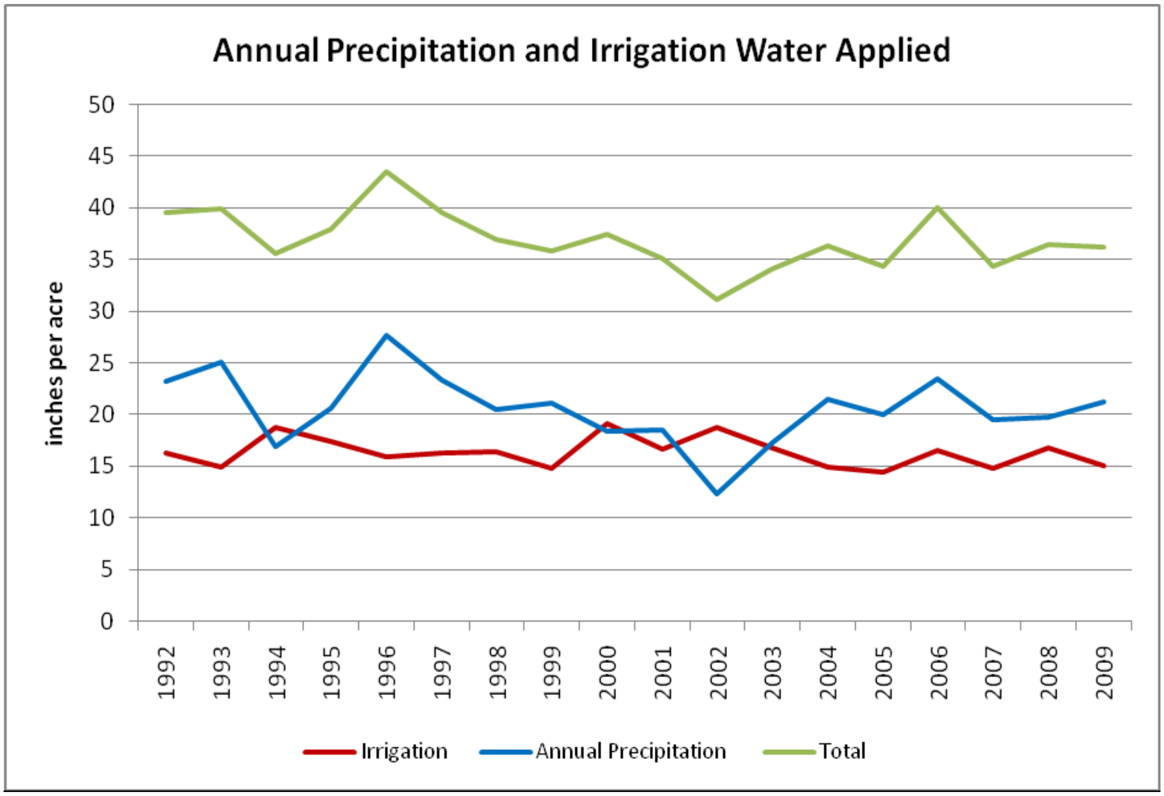

Figure 20: Annual Precipitation and Irrigation Water Applied in Upper Arkansas Subbasin

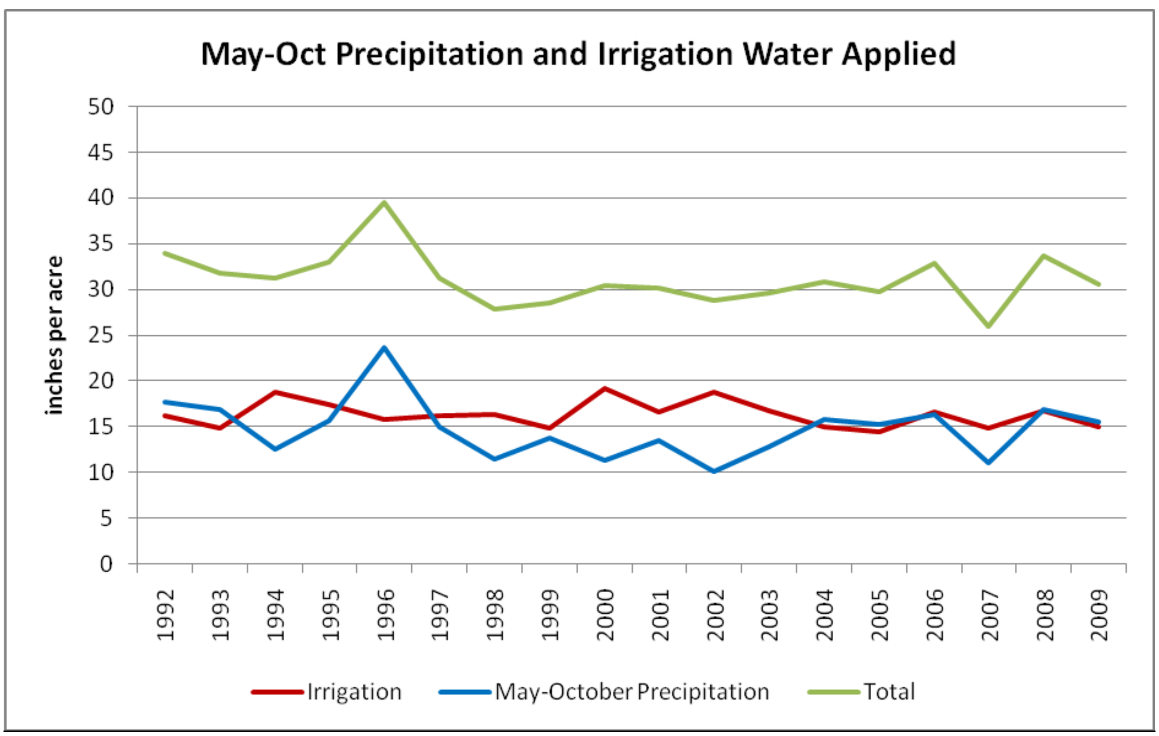

Figure 21: May-October Precipitation and Irrigation Water Applied in Upper Arkansas Subbasin

VI. Conclusions

The year 2010 appears to be a below average year for precipitation with 16.8 inches. Streamflows were somewhat less in 2010 compared to the average flow from 2000-2009. For 2010 to 2011 water levels in the alluvial aquifer on average have declined. Water levels in the Ogallala-High Plains aquifer on average also continued to decline as well as the Dakota well in Finney County. The five-year rolling averages for the subbasin show a net decline. Reported water use in 2009 was below average with 783,672 acre-feet and down from 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

Well Id	Legal	Latitude	Longitude
FI01	23S 33W 28 SWSESW	38.01825	-100.95140
FI02	23S 34W 28 SWSENE 01	38.02057	-101.05790
FI06	24S 32W 25 SWNWNW 02	37.93769	-100.79160
FI10	24S 33W 09 SWSWSE 01	37.97449	-100.95380
FI101M	23S 34W 06 NENESE	38.08995	-101.08450
FI102M	23S 34W 17 SWSWSW	38.04692	-101.08390
FI103M	23S 34W 20 NENWSW	38.03926	-101.07410
FI104M	23S 34W 32 NWSWSW	38.01099	-101.08430
FI105M	24S 34W 17 NE	37.97049	-101.07080
FI106M	24S 34W 30 SE	37.93415	-101.08900
FI107M	24S 32W 13 SESENW	37.96288	-100.77720
FI11	24S 33W 09 SWSWSE 02	37.97449	-100.95380
FI12	24S 33W 09 SWSWSE 03	37.97449	-100.95380
FI15	24S 32W 19 3	37.95171	-100.87660
FI16	24S 32W 19 4	37.95173	-100.87660
FI17	24S 32W 19 5	37.95172	-100.87650
FI18	24S 33W 34 SWNESW	37.92037	-100.93320
FI19	24S 34W 01 NWSWNW	37.99982	-101.01100
FI23	24S 34W 18 NWSWSW	37.96676	-101.10240
FI29	25S 34W 10 NENWNW	37.90164	-101.03790
FI31	24S 32W 19 1	37.95168	-100.87650
FI32	24S 32W 19 2	37.95166	-100.87660
FI37	25S 32W 35 NESWNE	37.84003	-100.79690
FO01	26S 21W 25 SWSWSW	37.74897	-99.57739
FO02	26S 24W 32 SESENE	37.73892	-99.96124
FO03	26S 26W 18 SWSWNW	37.78231	-100.21430
FO05	26S 26W 32 SESWSW	37.73704	-100.18770
FO06	26S 26W 36 SESWSW	37.73745	-100.11450
FO09	27S 23W 24 NWSWNW	37.6869	-99.79632
FO10	27S 23W 25 SWSWSW	37.66413	-99.79525

FO11	27S 23W 28 NENENE	37.67646	-99.83376
FO12	27S 23W 36 SWSWSW	37.64699	-99.79607
FO13	27S 24W 12 SWSWSW	37.70692	-99.90565
FO14	27S 24W 03 NWNWSE	37.73284	-99.93990
FO15	27S 24W 03 SWSESE	37.72116	-99.93452
FO18	27S 24W 09 NENESE	37.71824	-99.94289
FO19	28S 22W 12 SWNESW	37.6206	-99.67934
FO20	28S 22W 05 NESESE	37.63871	-99.74091
FO21	26S 25W 32 1	37.7512	-100.08740
FO22	26S 25W 32 2	37.75116	-100.08740
FO23	26S 25W 32 3	37.75111	-100.08740
FO24	26S 25W 32 4	37.75107	-100.08740
GY01	25S 27W 33 NENWNW	37.83923	-100.29120
GY03	25S 29W 07 NWSWNW	37.89606	-100.55460
GY04	25S 29W 14 NENWNW	37.88533	-100.47350
GY05	25S 30W 20 NWSWNW	37.87188	-100.64620
GY07	25S 30W 25 SESWNE	37.8463	-100.56000
GY09	26S 27W 12 SWSESE	37.79499	-100.22480
GY104M	25S 30W 19 SESESE	37.85872	-100.64660
GY12	26S 28W 06 SESENW	37.81394	-100.41870
GY13	26S 28W 10 NWNWSW	37.80766	-100.37640
GY15	26S 30W 24 SESESE	37.76631	-100.54240
GY19	26S 27W 27 SESWSW	37.7538	-100.26050
GY20	26S 28W 06 SESENW 02	37.81398	-100.41900
HM03	23S 42W 26 SESWNE	38.01848	-101.89600
HM04	23S 42W 27 SESENW	38.01925	-101.91040
HM05	23S 42W 34 SWNWNW	38.00809	-101.92600
HM07	23S 43W 23 NWSWNW	38.03961	-102.01660
HM08	23S 43W 25 SWNWSE	38.02057	-101.99540
HM09	24S 39W 19 SWNWSW	37.94723	-101.64880
HM10	24S 39W 22 SWSENE	37.94547	-101.58750
HM101M	23S 43W 23 NESW	38.03992	-102.00630
HM102M	23S 43W 26 NWSWSW	38.02289	-102.01750
HM103M	24S 40W 07 SE	37.97568	-101.74700
HM104M	24S 40W 18 NWNENW	37.971	-101.75590
HM105M	24S 39W 25 NESWSE	37.93767	-101.54790
HM11	24S 39W 26 SWSESE	37.9294	-101.56970
HM13	24S 40W 07 SWNWNW	37.97775	-101.75990
HM14	24S 40W 17 NWNWNW	37.97129	-101.74230
HM15	24S 40W 20 NWNWNW	37.95697	-101.74220
HM16	24S 40W 23 NENENW	37.95752	-101.67250
HM17	24S 41W 01 SENESE	37.99117	-101.76160
HM19	24S 41W 02 SWNWSE	37.99032	-101.79590
HM22	23S 43W 21 NENWNE 03	38.04335	-102.04390
KE01	23S 35W 12 SWSWSW	38.06175	-101.12070
KE02	23S 35W 25 NWNWNW	38.03148	-101.12060

KE04	24S 35W 09 SWSWSW	37.97382	-101.17480
KE05	24S 35W 11 SWNWSW 02	37.97984	-101.13850
KE06	24S 35W 11 SWNWSW 03	37.97986	-101.13840
KE07	24S 35W 11 SWNWSW 04	37.97988	-101.13840
KE08	24S 35W 11 SWNWSW 05	37.97989	-101.13830
KE09	24S 35W 22 SWSWSW 02	37.94499	-101.15710
KE10	24S 35W 24 NWSWNW	37.95573	-101.12060
KE11	24S 36W 23 SWNWNW 02	37.95005	-101.24800
KE110M	25S 35W 10 NESWNE	37.89774	-101.14440
KE14	25S 36W 14 NW	37.88261	-101.24430
KE17	25S 37W 12 SESESE	37.8862	-101.32230
KE18	25S 37W 15 NENWNE 02	37.8845	-101.36620
KE20	25S 37W 17 NESESW	37.88162	-101.39830
KE23	24S 35W 11 SWNWSW 01	37.97984	-101.13850
KE28	24S 35W 08 NESWSW	37.97832	-101.18880
KE29	25S 38W 11 SENENE	37.89793	-101.45000
KE30	25S 38W 11 SESENE	37.89161	-101.45000
KE94	23S 35W 05 NESWSW	38.083	-101.18460
KE95	23S 35W 16 NWNWSW	38.05813	-101.17550
KE97	25S 35W 04 NWSESE	37.90873	-101.16830
KE98	25S 35W 02 NWNENE	37.9157	-101.13020
KE99	25S 35W 26 NWNENW	37.85778	-101.13400