Santa Fe River Studies

August 2009

Stream Flow

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This is one of a series of scientifically-based studies designed to provide the technical background information for decision makers and the community in evaluating management options for the Santa Fe River. The series covers the following topics: stream flow, storm flow, reservoir storage, ecosystem watershed yield analysis, stream flow losses, stream-aquifer interaction, and fate of reservoir releases. For more information on the series, please contact Claudia Borchert at 505-955-4203 or ciborchert@santafenm.gov

Santa Fe River Studies: Stream Flow

With headwaters high in the Sangre de Cristo Mountains, the Santa Fe River flows to the west providing approximately 40 percent of the water supply for the City of Santa Fe. The river also provides water for acequias and supports riparian habitat. Analysis of stream flow records at different locations is fundamental to assess the historical availability of stream flow for meeting 1) the City's water demand and 2) potential releases for improving riparian habitat through town. The records of flow in the Santa Fe River are reviewed and summarized here to provide basic statistics for water planning.

Stream gages measure water level elevation and, combined with a rating curve specific to the gage location, the flow in the stream can be estimated. In the vicinity of the City of Santa Fe, the Santa Fe River is currently gaged over a 10.3 mile reach and in five locations from above McClure Reservoir downstream through town to Ricardo Road, just upstream of Frenchy's Park (Figure 1). This report summarizes available data and statistics for the five gages. The Santa Fe River has one of the oldest gages in the State of New Mexico; *Santa Fe near Santa Fe*, which the USGS has maintained since February 1913. Figure 2 shows the annual measured flow for the period of record at this gage.

The gage *above McClure Reservoir* has been operated by the water utility for the City of Santa Fe since the 1980s and equipped with a recording device by the USGS in 1998. Three gages below the reservoirs were installed in 1998. The stage height is also measured daily at McClure and Nichols Reservoirs to quantify changes in storage. The historical record varies for the seven gages in the vicinity of Santa Fe as summarized in Table 1.

The Santa Fe River has also been gaged downstream of La Bajada in two locations, which are not part of this analysis. At gage site *Santa Fe River above Cochiti Lake (08317200)* records are available from 1970 to 1999 and 2005 to present. The Santa Fe River was also gaged several miles upstream of the *above Cochiti Lake gage* at a site just downstream of La Bajada from Oct 1996 to Dec 1997 by the USGS (Thomas, et al 2000).

Figure 1. Santa Fe River stream gage locations

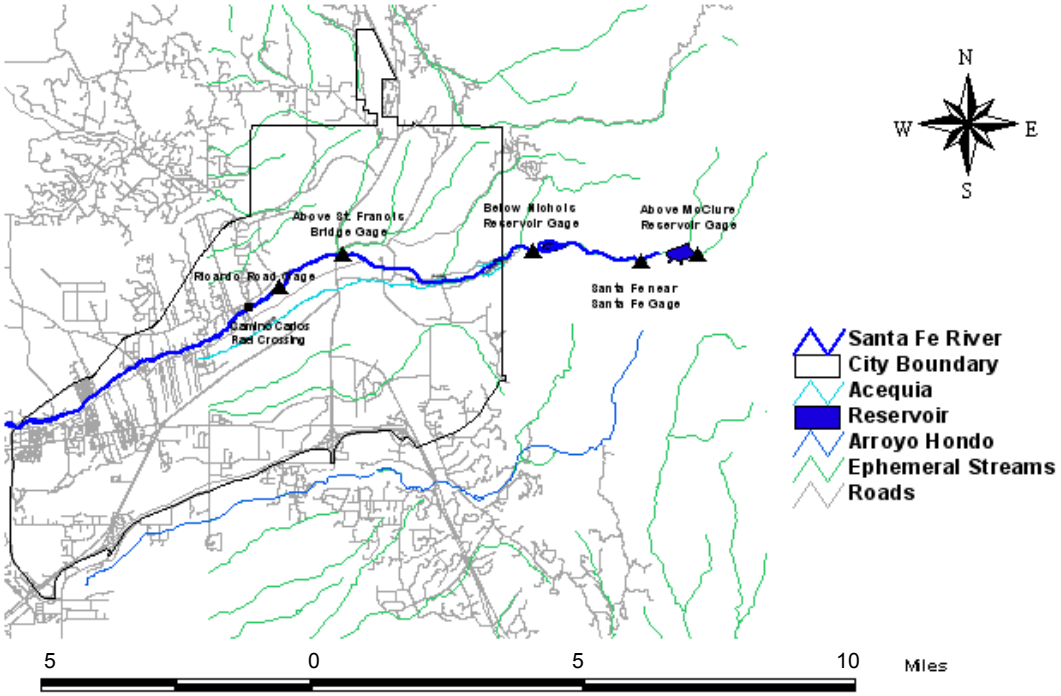
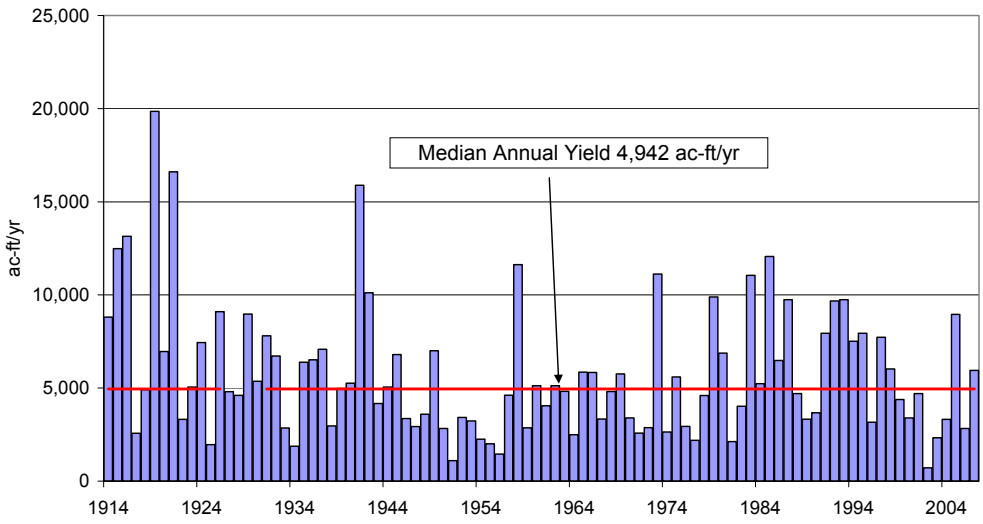


Table 1. Stream flow and reservoir level gages on the Santa Fe River from the Upper Watershed through the town of Santa Fe.

Gage	Gage Number	Period of Record	Gap in record	Comments
Above McClure	08315479 (18-inch flume) 08315480 (8-ft flume)	07/01/1998 – 12/31/2007	USGS estimated flow during the period of record when flumes were inundated by McClure Reservoir. Computed estimates of inflow available for 1966-2006 (mean daily), 1943-2003 (monthly), 1998-present mean daily flow	See Appendix A for discussion of estimated flow prior to 1998.
McClure Reservoir	08315500	9/1929 – 12/31/2007	Prior to 1947 no recording device was used and numerous gaps exist	Early record has month end readings
Santa Fe near Santa Fe	08316000	02/01/1913-12/31/2007	11/01/1927 - 02/29/1928; 12/01/1928 - 03/31/1929; 07/01/1929 - 07/31/1929; 12/01/1929 - 01/31/1930;	Mean daily flow
Nichols Reservoir	08316500	3/1943 – 12/31/2007	Prior to 1965 month end readings only	
Below Nichols	08316505	05/22/1998 – 12/31/2007	10/01/1999 -12/31/1999; 07/31/2003 - 09/15/2003	Instantaneous 15 minute records
Above St Francis	08316530	10/01/1998 – 12/31/2007	10/01/1999 - 02/31/1999	Instantaneous 15 minute records
Ricardo	08316535	10/01/1998-12/31/2007	10/01/1999 - 02/23/2000	Instantaneous 15 minute records

Figure 2. Annual flow *Santa Fe near Santa Fe* (08316000) 1914-2009.



Note: To estimate annual flow for the years 1927 to 1930 that are missing primarily winter months, the mean monthly flow for the period of record was added to the annual diversion for each missing month.

Mean Daily Flow for Historical Record at Santa Fe River Gages

The continuous period of record that coincides for all stream gages is for calendar years 2001 through 2007. The annual yield and available records for each gage are reported in the following section.

Santa Fe River above McClure Reservoir near Santa Fe (08315479 and 08315480)

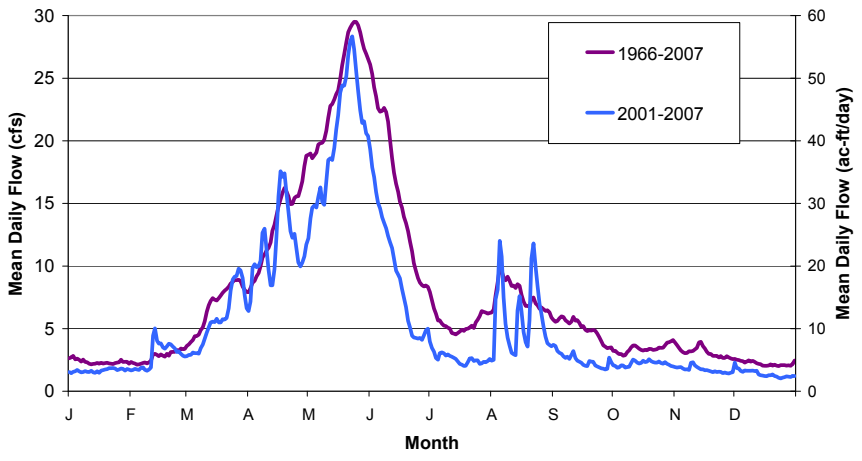
The median annual yield for the *Santa Fe River above McClure Reservoir near Santa Fe* gage (*above McClure*) for the long-term record of 1943 through 2007 is 4,656 ac-ft. Mean daily flow data at the *above McClure* gage are available from 1966 through 2007. Mean daily flow data from the period of record and from 2001 through 2007 that are available for all gages are shown in Figure 3. The long-term record is composed of the calculated estimates from 1966 through 2000 (see explanation below) and gage records from 2001 to 2007. The recent short-term record mean daily flow averages about 74 percent of the long-term record.

The flow into McClure reservoir at the *above McClure* gage is measured at two flumes, an 18-inch (08315479) and an 8-foot (08315480). The flumes have been measured weekly by Sangre de Cristo Water Company (SDCW) staff since at least 1981 and the flumes were instrumented with a continuous recorder by the United States Geological Survey (USGS) in 1998 to measure gage height every 15 minutes (USGS 2008). In 1995 the height of McClure dam was raised resulting in the inundation of the flumes when the reservoir is full.

Jack Veenhuis (2008) utilized McClure reservoir stage records and flow at the gage between the two reservoirs to calculate the daily inflow into McClure prior to 1998. The flow into McClure is approximated by subtracting the amount of water released from storage in McClure Reservoir from the flow recorded at the *Santa Fe near Santa Fe* gage. Negative numbers can be generated with this calculation when the estimated flow at the *Santa Fe near Santa Fe* gage is less than the amount of water estimated to come out of storage, which may occur if evaporation is significant or when flows have significant measurement error. Veenhuis removed negative numbers from the calculated estimates. An overestimation of the flow at the *above McClure* gage could also be calculated if tributary inflow between the two gage sites is significant. Details of the calculated estimates are provided in Appendix A.

An analysis prepared for the City by Camp Dresser & McKee (CDM) also calculated the average daily inflow at the *above McClure* gage from January 1, 1990 to January 26, 1999 and monthly inflows from 1943 to 2003 (Rehring, 2008). A comparison of the Veenhuis method with the CDM method shows nearly the exact same daily inflow values as shown in Appendix A, Figure A-4.

Figure 3. Recent and long-term mean daily inflow at the *above McClure Reservoir gage* on the Santa Fe River (08315479 and 08315480).



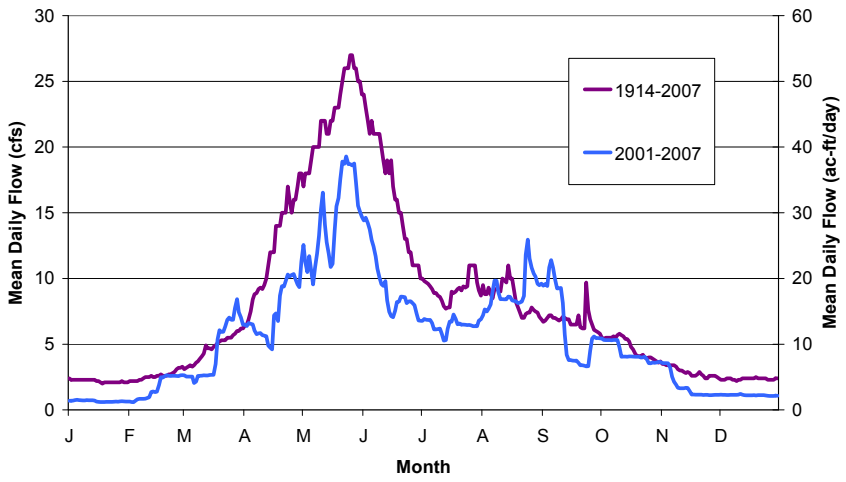
Santa Fe near Santa Fe Gage (08316000)

The median annual yield is 4,942 ac-ft for the *Santa Fe near Santa Fe* gage for the period of record 1914-2007. The *Santa Fe near Santa Fe* gage is located between McClure and Nichols Reservoirs and was installed in February of 1913, prior to the construction of either reservoir. McClure was built in 1926 (raised in 1935, 1947 and 1995) and thus, after that time the flow at this gage is

controlled by releases from McClure Reservoir which has a capacity of 3,257 ac-ft. Stage height is measured by a continuous recorder every 15 minutes and the USGS reports mean daily flow.

The mean daily flow for *Santa Fe near Santa Fe* from 1914 to 2007 is compared to the recent period of record in Figure 4. The average mean daily flow over the recent period of record is 72 percent of the long-term period of record.

Figure 4. Mean daily flow for *Santa Fe River near Santa Fe* gage for recent and long-term records (08316000).



Santa Fe River below Nichols Reservoir Gage (08316505)

Figure 5 shows the mean daily flow at the *Santa Fe River below Nichols Reservoir gage (below Nichols*) for the period of record 2001-2007. The river at this location flows primarily during spring runoff and during the late summer, with peaks reaching about 20 cfs. The river in this reach averages less than 1 cfs for more than six months of the year.

The flow at the *below Nichols* gage is impacted by the inflow to McClure Reservoir, the change in storage of both McClure and Nichols Reservoirs and the diversions from the City of Santa Fe Water Treatment Plant and Acequia Llano. The diversions from the Cerro Gordo Acequia and Acequia Madre on the Santa Fe River occur downstream of the gage and thus do not impact the measured flow.

The *below Nichols* gage was installed in 1998 by the USGS who also maintained the gage until September of 1999 when Watershed West took over the gage operation under the City of Santa Fe's direction. Data are available from May of 1998 to September of 1999 and from January 2000 to December 2007. Data for 2006 and 2007 are provisional. Gage height is measured by a continuous recorder every 15 minutes.

Santa Fe River above St. Francis Bridge Gage (08316530)

Figure 6 shows the mean daily flow for the continuous period of record 2001-2007. As with the *below Nichols* gage, flow at this gage occur primarily during spring runoff and during the late summer. Average annual peaks are 13 cfs, lower than the 20 cfs peaks *below Nichols*. The river in this reach also flows, on average less than 1 cfs five months of the year.

The *above St. Francis Bridge* gage was installed in 1998 and operated by the USGS from October 1998 through September 1999. Watershed West took over operation of the gage beginning in January 2000. Data for 2006 and 2007 are provisional. Gage height is measured by a continuous recorder every 15 minutes.

Figure 5. Mean daily flow Santa Fe River *below Nichols Reservoir* gage 2001-2007 (08316505).

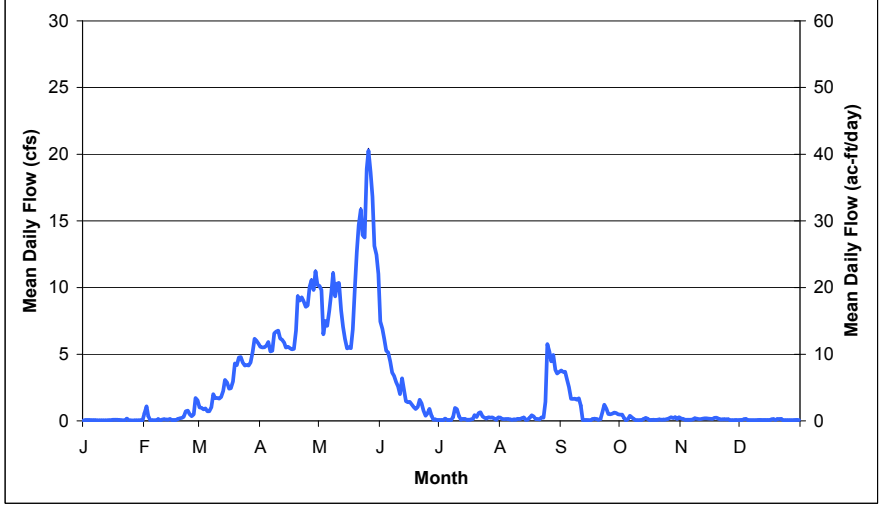
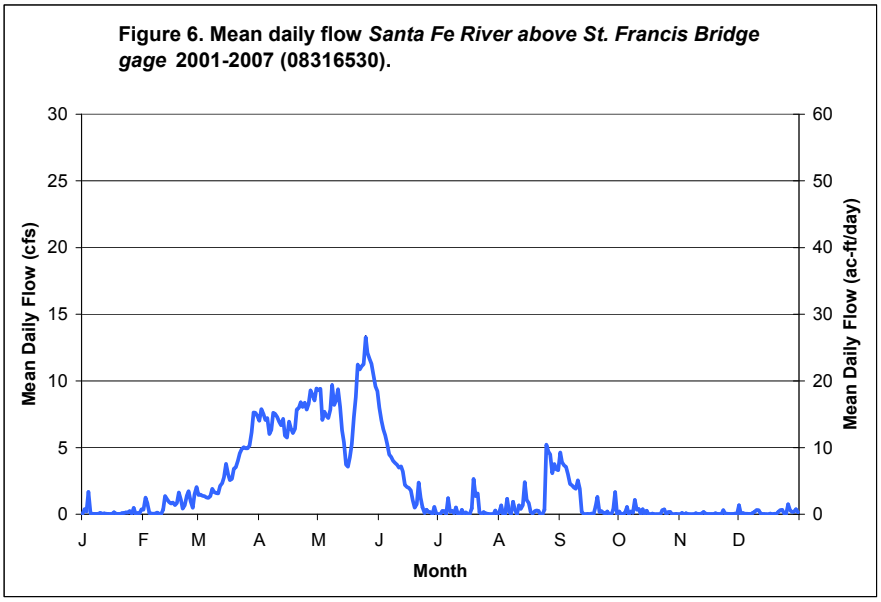


Figure 6. Mean daily flow *Santa Fe River above St. Francis Bridge gage* 2001-2007 (08316530).

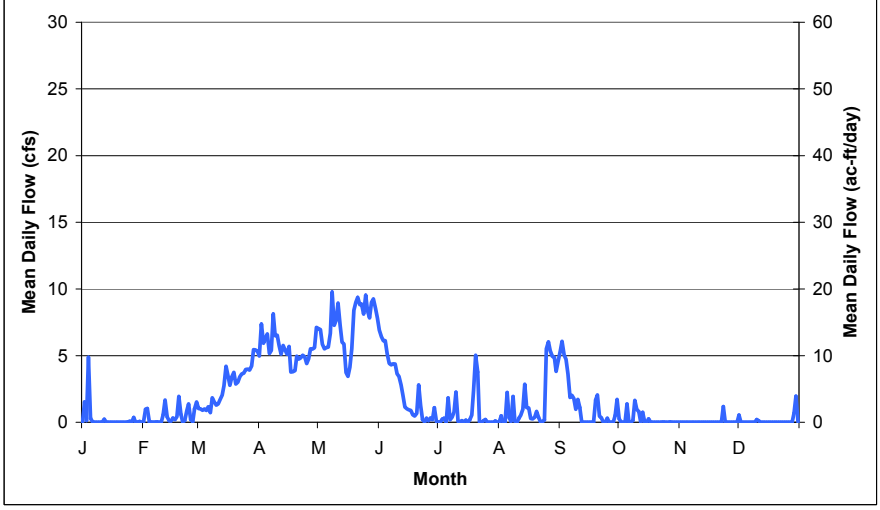


Santa Fe River at Ricardo Road Gage (08316535)

Figure 7 shows the mean daily flow at the *Santa Fe River at Ricardo Road* gage (*Ricardo*) for the continuous period of record 2001-2007. Flow at this gage occurs primarily during the spring and summer. Average annual peaks reach roughly 10 cfs. While the river in this reach flows less than 1 cfs five months of the year, it is more impacted by storm flows throughout the year than both the below Nichols and St. Francis reaches.

The *Ricardo* gage was installed in 1998 and operated by the USGS from October 1998 to September 1999. Watershed West began operating the gage on February 23, 2000. Data for 2006 and 2007 are provisional. Gage height is measured by a continuous recorder every 15 minutes.

Figure 7. Mean daily flow for *Santa Fe River at Ricardo Road* gage 2001-2007 (08316535).



Combined Mean Daily Flow and Mean Monthly Flow

The calendar years 2001 through 2007 provide the only coinciding record for daily stream flow data available for all five gages. Peak mean daily flow in all gages is during spring runoff in late May and early June (Figure 8). Monsoon rains provide a smaller peak of mean daily flow in August. Instantaneous flows can reach about 1,000 cfs during the monsoons at the *Ricardo* gage.

For the first half of the year, the mean monthly flow is highest at the upstream gage and is progressively less at the downstream gages (Figure 9). Diversions from the WTP and acequias contribute to the decrease in stream flow from the *Santa Fe near Santa Fe* gage to the gages below Nichols Reservoir. Seepage losses and evapotranspiration also reduce the stream flow. After spring runoff has subsided and water is released from storage out of McClure, the flow at the *Santa Fe near Santa Fe* gage is greater than at the *above McClure* gage. Monthly flow at the *Ricardo* gage is higher than the *St. Francis* gage in July and August when monsoon flows contribute to the flow at the *Ricardo* gage. The annual average flow is shown in Table 2.

Table 2. Summary of mean annual flow rates for 2001-2007 for the five gages on the Santa Fe River.

Santa Fe River Gage	Mean Flow Rate 2001-2007
	cfs
Above McClure Reservoir	5.76
Santa Fe near Santa Fe	5.70
Below Nichols Reservoir	2.26
Above St. Francis	2.20
Ricardo	1.91

Figure 8. Mean daily flow for five gages on the Santa Fe River 2001-2007.

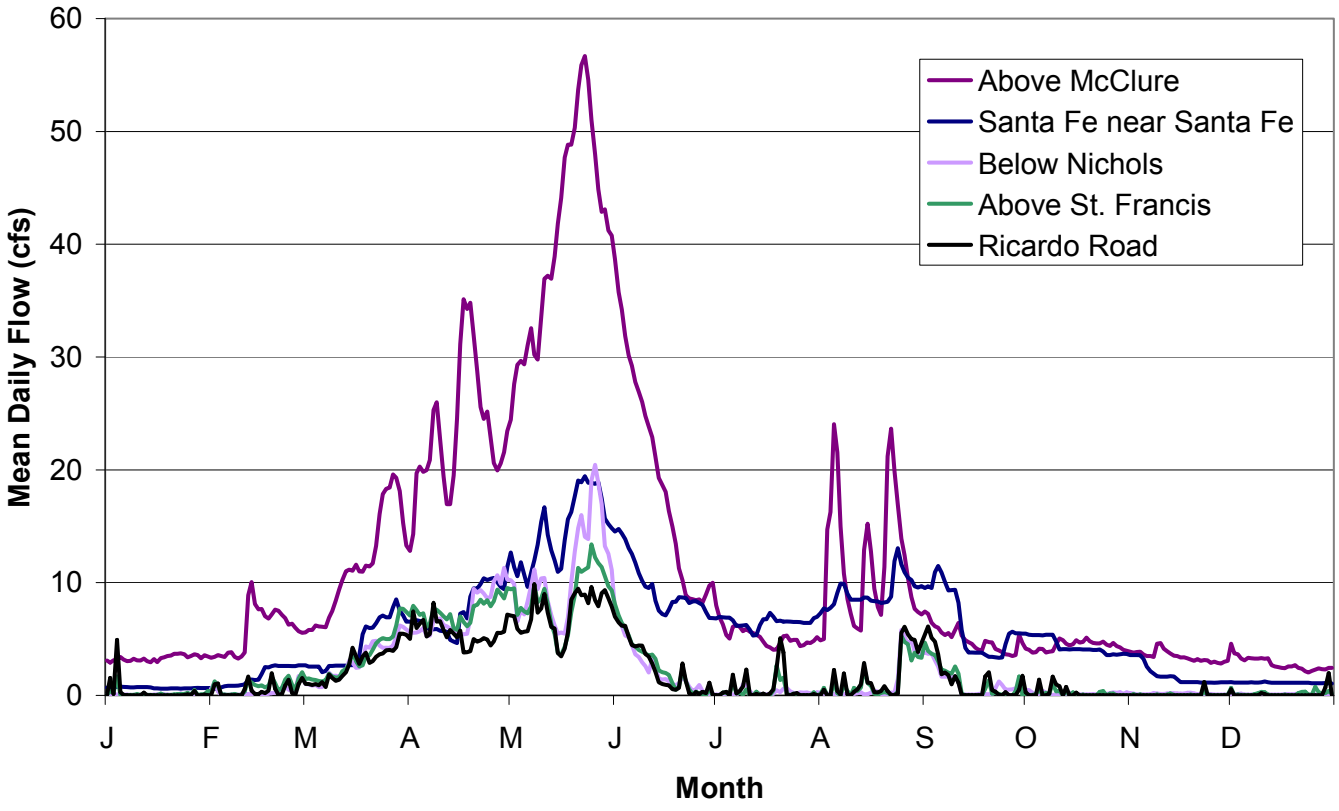
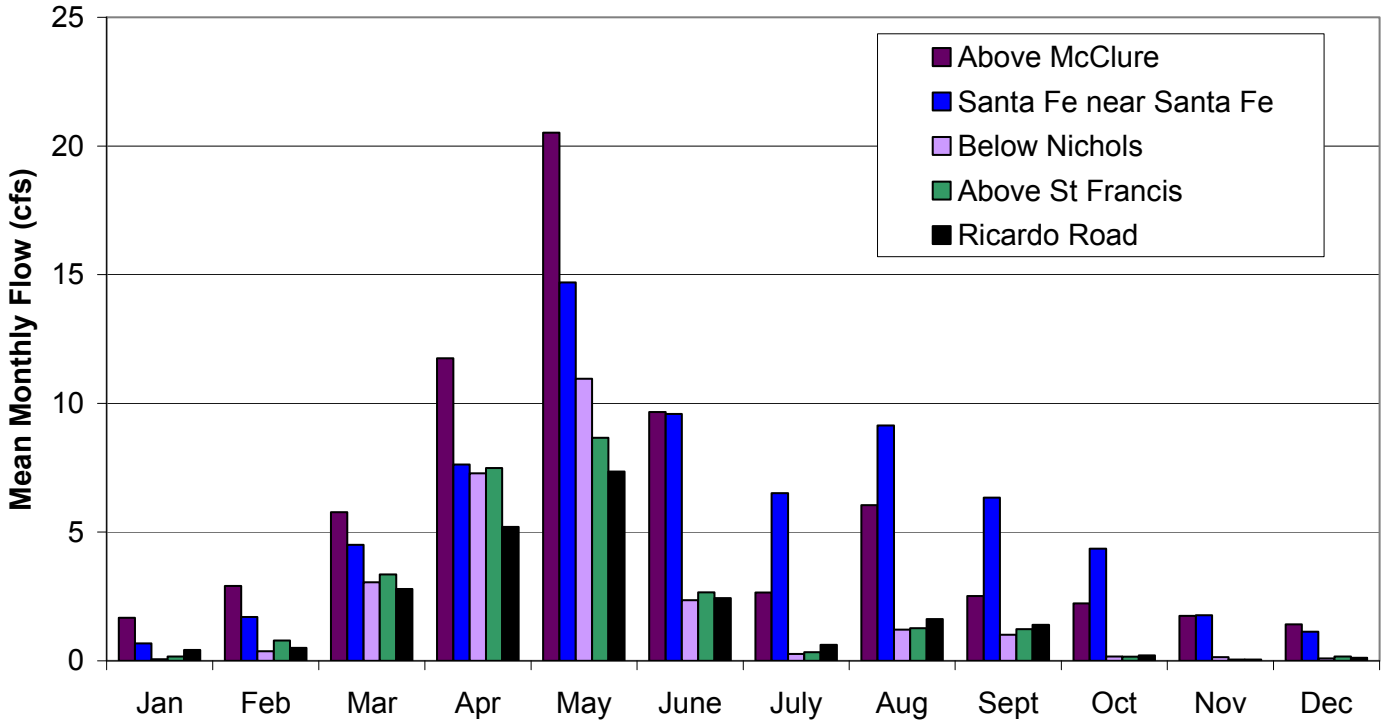


Figure 9. Mean monthly flow for five gages on the Santa Fe River 2001-2007.



Annual Stream Gage Statistics

The annual flow in the Santa Fe River varies in response to high mountain winter precipitation, summer thunderstorms and diversions. A statistical analysis of the stream gage data was developed for each of the gages for the most recent period of record that is available for all five gages and for the longer period of record that is available for the two most upstream gages. Table 3 summarizes the mean and median annual flow for three different periods of record for the five stream gage locations on the Santa Fe River. The annual mean and median are shown for the recent period of consistent record (2001-2007) and the available long-term data on the *above McClure* gage and the longest record (1914-2007) for the gage between the two reservoirs, *Santa Fe near Santa Fe*. Because there is for only 7 years of data available for the gages below the reservoirs, a comparison of the statistics for this recent period of record to the available long-term average is shown in Table 3. The recent period of record on the gage between the two reservoirs (*Santa Fe near Santa Fe*), shows that the mean annual flow for the short-term record is only 72 percent of the long-term record (1914-2007) and the median annual flow is 67 percent of the long-term value, indicating that the most recent period of record is much drier than the long-term average.

Figure 10. Annual stream flow and precipitation 2001-2007.

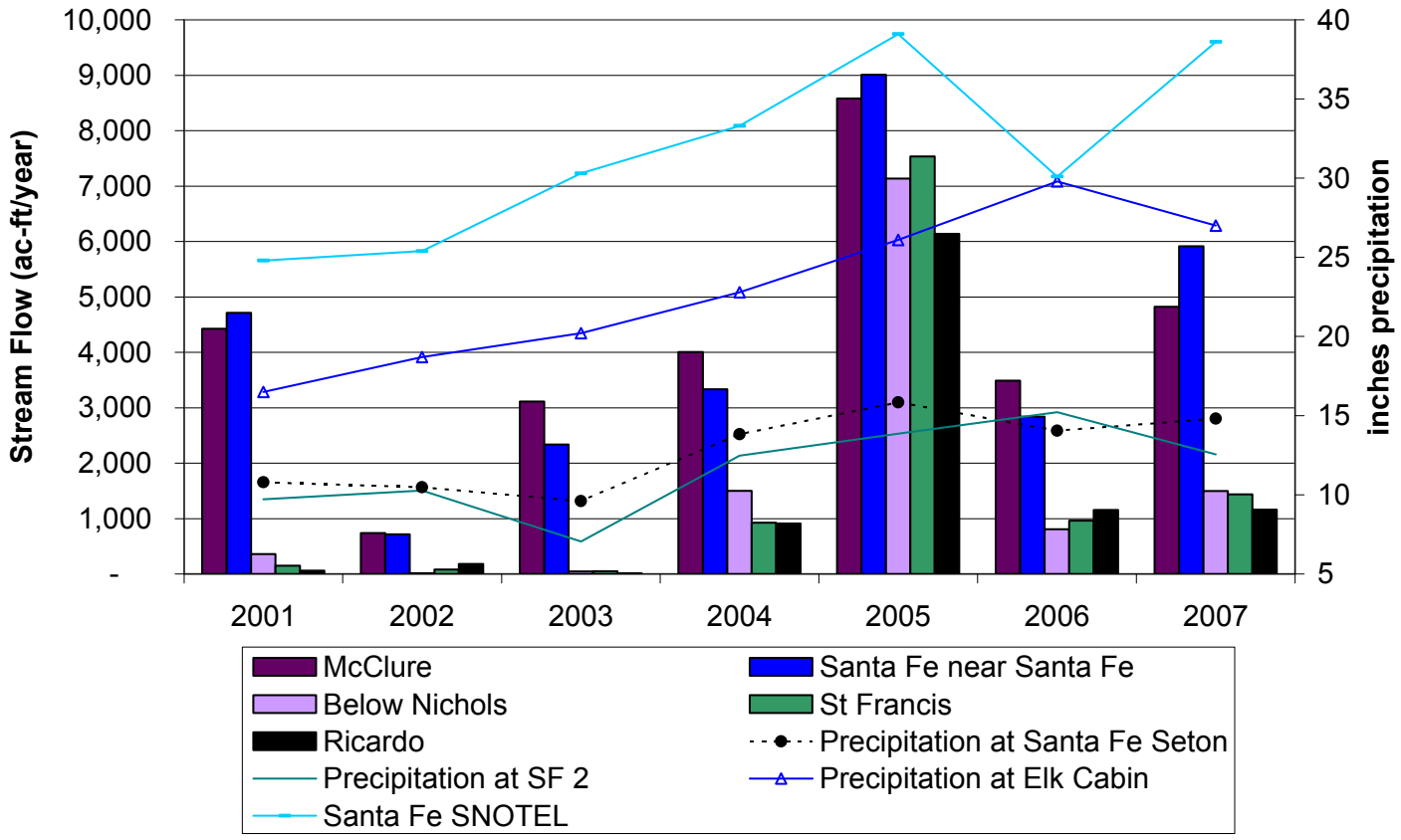


Table 3. Summary of mean and median annual flow for different periods of record available on the five Santa Fe River gages.

Stream Gage	Annual Flow					
	2001-2007		1943-2007		1914-2007	
	Mean	Median	Mean	Median	Mean	Median
	ac-ft/yr	ac-ft/yr	ac-ft/yr	ac-ft/yr	ac-ft/yr	ac-ft/yr
Above McClure Reservoir	4,167	4,003	5,075	4,656	NA	NA
Santa Fe near Santa Fe	4,130	3,331	5,058	4,599	5,770	4,942
Below Nichols	1,622	815	NA	NA	NA	NA
Above St. Francis	1,593	935	NA	NA	NA	NA
Ricardo	1,402	914	NA	NA	NA	NA

Annual yield (Table 4 and Figure 10) is directly correlated to annual precipitation. In 2005, the precipitation at the Santa Fe SNOTEL station at 12,000 ft was 39 inches and the flow at the *above McClure* gage was 8,500 ac-ft. Compare this to 2002 when precipitation was only 25 inches (64 percent of the precipitation 2005) and flow in the Santa Fe River at the *above McClure* gage was 739 ac-ft (9 percent of the flow in 2005).

Table 4. Annual stream flow, water treatment plant diversions and precipitation 2001-2007.

Stream Gage	Calendar Year						
	2001	2002	2003	2004	2005	2006	2007
	Stream Flow						
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Above McClure Reservoir	4,425	739	3,113	4,003	8,578	3,490	4,821
Santa Fe near Santa Fe	4,713	717	2,334	3,331	9,007	2,840	5,965
Water Treatment Plant Diversions	4,981	703	2,152	2,855	4,592	2,085	4,985
Below Nichols Reservoir	357	14	41	1,499	7,132	815	1,496
Above St Francis	150	82	51	935	7532	963	1,435
Ricardo	61	180	8	914	6,292	1,196	1,160

Precipitation Station	Elevation	Precipitation						
	feet	inches	inches	inches	inches	inches	inches	inches
Santa Fe SNOTEL	11,445	24.8	25.4	30.3	33.3	39.1	30.1	38.6
Elk Cabin SNOTEL	8,210	16.5	18.7	20.2	22.8	26.1	29.8	27
Santa Fe Seton	7,000	10.8	10.5	9.6	13.8	15.8	14.1	14.8
Santa Fe 2	6,720	9.7	10.3	7.0	12.5	13.9	15.2	12.6

Estimated Annual and Mean Daily Yields

The consistent period of record available for all gages (2001-2007) represents a relatively dry period of record (67 percent of the median for the period 1914-2007 at *Santa Fe near Santa Fe* gage). For planning purposes, a longer period of record is more desirable in that it reflects a greater range of climatic variability. In order to estimate the probabilities of wet, average and dry year yields under current infrastructure and management constraints, the annual and daily yields from gages with short-term records were recalculated using the longer period of record and the inherent variability observed at the *Santa Fe near Santa Fe* gage.

Two extrapolation methods using the long-term record at *Santa Fe near Santa Fe* were attempted and both present difficulties due to the complexity of the system. The first method utilized the annual probabilities of the long-term record at Santa Fe near Santa Fe in relation to the short-term record and translated that relationship to the other gages with a shorter record. The second method utilized the daily probabilities of flow at the *Santa Fe near Santa Fe* gage and subtracted the demands on the system to estimate what would flow downstream to the gages below Nichols. The first method may be appropriate for estimating the probabilities of flow at the *above McClure* gage, and the second method

may be the best for estimating flows below Nichols Reservoir.

Annual Yields Adjusted to Long-Term Record

Annual hydrographs representing drought, median and wet years for each of the five gage locations were developed by utilizing the statistics available for the long-term record of *Santa Fe near Santa Fe*. A drought year is based on the 20th percentile flow (P20); the flow would be less than this amount one out of every 5-years. A wet year is based on the 80th percentile flow (P80); the flow rate would be greater than the P80 once out of every 5 years. The median (50th percentile flow or P50) would be greater one out of 2 years.

Using the relationship of the P20, P50, and P80 values at the *Santa Fe near Santa Fe* gage over the long-term record to the median for the short-term record, statistics were developed for the gages with a short-term record. Table 5 summarizes the median for each period of record, and the estimated P20, P50 and P80 annual values for each of the gages.

Table 5. Stream flow statistics for *Santa Fe near Santa Fe* 1914-2007 and estimated statistics for gages without a long-term record (Extrapolation Method 1).

Santa Fe River Gage	Median Annual Flow (2001-2007)	Estimated Long-Term statistics 1914-2007		
		P20th	P50th (Median)	P80th
	ac-ft/yr	ac-ft/yr	ac-ft/yr	ac-ft/yr
Above McClure [a]	4,003	*2,894*	*5,003*	*8,040*
Santa Fe near Santa Fe [b]	**3,331**	**2,859**	**4,942**	**7,942**
Percent of SF nr SF probability to median (1914-2007)	*NA*	*58%*	*100%*	*161%*
Percent of SF nr SF probability to annual short-term median (2001-2007)	*NA*	*86%*	*148%*	*238%*
Below Nichols [c]	815	*700*	*1,209*	*1,943*
Above St Francis [c]	935	*800*	*1,388*	*2,230*
Ricardo [c]	914	*780*	*1,356*	*2,178*

[a] Estimated probabilities from relation of P20, P50 and P80 to median for the *Santa Fe near Santa Fe* gaged long-term (1914-2007) record to 1943-2007 record for above McClure. Median for 1943-2007 is 93% of median for 1914-2007 at *Santa Fe near Santa Fe* gage.

[b] Based on 1914-2007 annual flow records (from USGS)

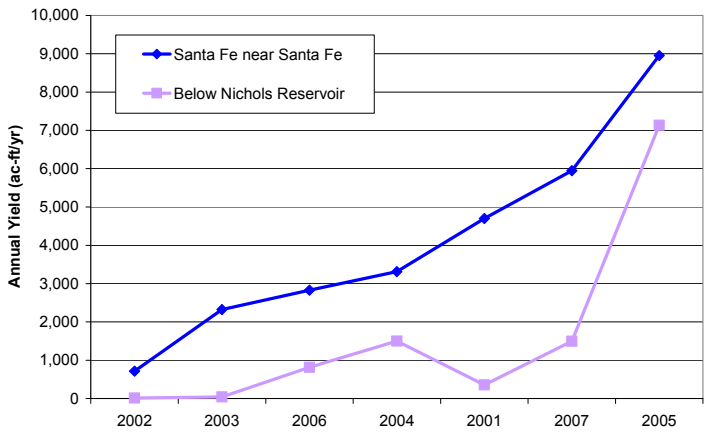
[c] Estimated probabilities from relation of P20, P50 and P80 to median from *Santa Fe near Santa Fe* long-term record to short-term record

Italics indicate value calculated based on statistics at *Santa Fe near Santa Fe* gage.

The probability distribution for the *Santa Fe near Santa Fe* gage was obtained from the using USGS annual flow records and USGS calculated daily probability values (USGS 2008). An attempt to create the drought, median and wet year hydrographs for each of the gages without a long-term record was performed based on the relation of the short-term record to the long-term record at the *Santa Fe near Santa Fe* gage. Specifically, the median (50th percentile) value at the *Santa Fe near Santa Fe* gage for the long-term record (4,942 ac-ft/yr) is 148 percent of the short-term record (3,331 ac-ft/yr) as shown in Table 5. The 20th percentile flow of the long-term record is 86 percent, the mean is 173 percent and the 80th percentile flow is 238 percent of the short-term record (2001-2007).

This method has three important caveats. The first is that the substantial diversions of the water treatment plant and acequias create a poor correlation between the flows at the *Santa Fe near Santa Fe* gage and the flows downstream of Nichols Reservoir. Figure 11 shows the flow at the Santa Fe near Santa Fe gage and the *below Nichols* gage sorted from lowest to highest annual

Figure 11. Distribution of flows from high to low on the Santa Fe River



yields, showing the poor correlation between the two gages, particularly at low flows. Secondly, the farther downstream the gage, the more it is impacted by storm flows from paved urban areas. And lastly, the period of record 2001-2007 does not represent future conditions because the water treatment plant was undergoing construction during this period and thus, diversions were less than usual. The average WTP diversions over this period was 3,200 ac-ft/yr or about 1,800 ac-ft less than the water right.

Daily Yields Adjusted to Long-Term Record

Another approach to estimating the potential yield based on the long-term record is to use the mean daily flow statistics for the *Santa Fe near Santa Fe* gage and subtract the MDF from the water treatment plant in a year when the full water right was diverted and adjusting for the change in storage from Nichols Reservoir. Figure 12 shows a comparison of the gaged flow at the *below Nichols* gage and the calculated flow (Santa Fe near Santa Fe gage minus water treatment plant diversions plus the amount out of storage in Nichols reservoir). The measured flow is more than the calculated flow, particularly during spring runoff and monsoon season, and only slightly less in June. The underestimate during spring runoff may be due to significant contribution from snow melt on the tributaries entering the Santa Fe River between the *Santa Fe near Santa Fe* gage and the *below Nichols* gage. Such inflow would result in more water going into storage (thus a negative storage value) that is from inflow below the *Santa Fe near Santa Fe* gage. The overestimate in June may be due to evapotranspiration during the hottest driest month of the year and diversions from Acequia Llano.

Using the daily values for the P20, P50 and P80 (Figure 13) developed for the long-term record at the *Santa Fe near Santa Fe* gage and subtracting the mean daily diversions of the water treatment plant in a year when the full (5,040 ac-ft) water right was diverted, the annual yield for *below Nichols* can be estimated for dry, median and wet years (Figure 14). This method of estimating the statistics for *below Nichols gage* produces lower yields in the dry and median years and much more water in a wet year than the first method. Table 6 shows the P20 and P50 annual yields at the *below Nichols* gage.

Figure 12. Calculated and gaged mean daily flow for Santa Fe River below Nichols gage

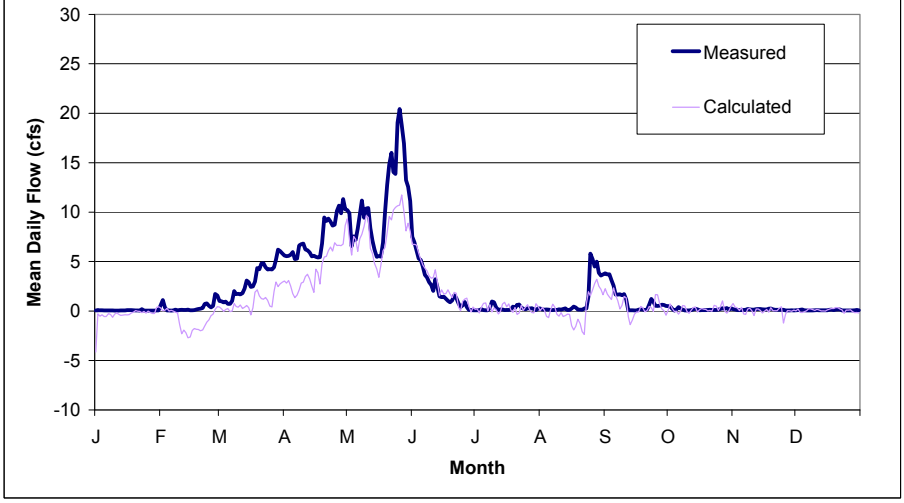


Figure 13. Probability of mean daily flow at the *Santa Fe near Santa Fe* gage based on the period of record 1914-2007 (USGS, 2008).

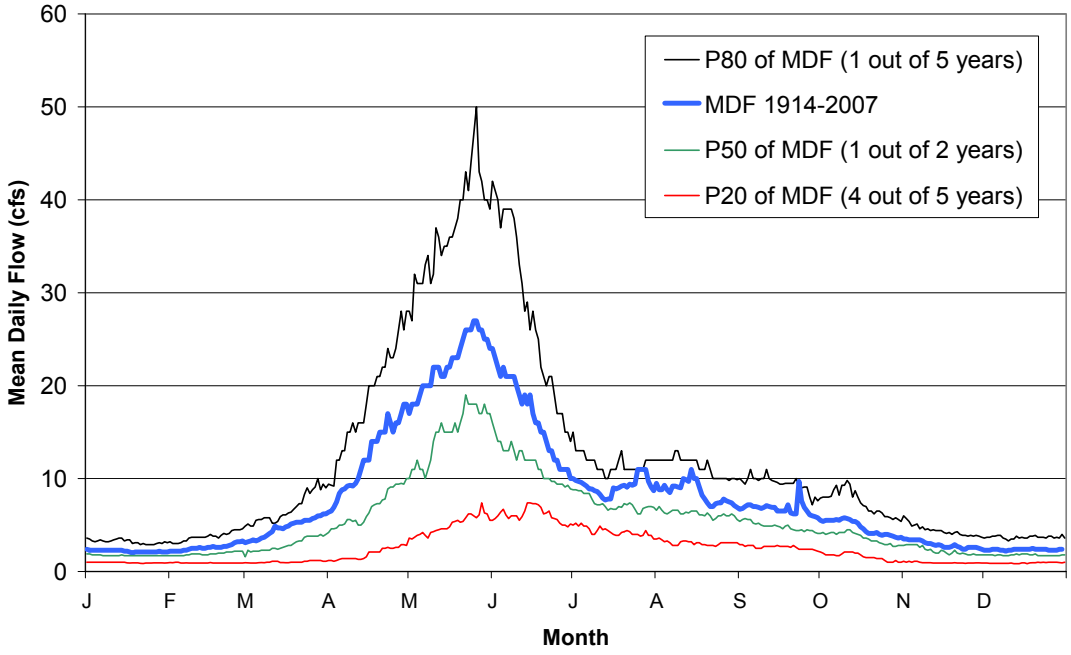
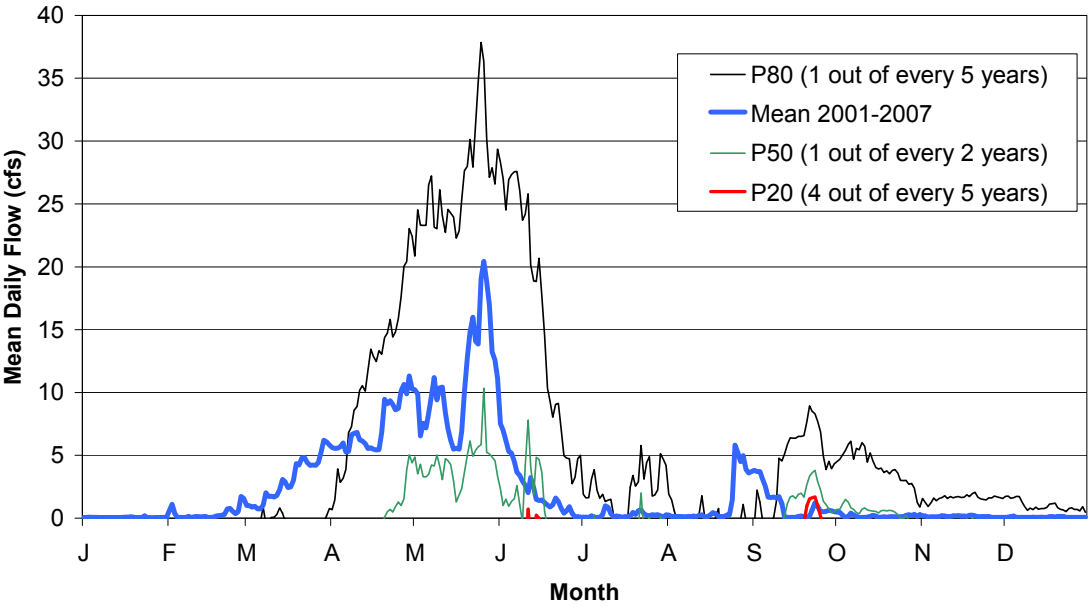


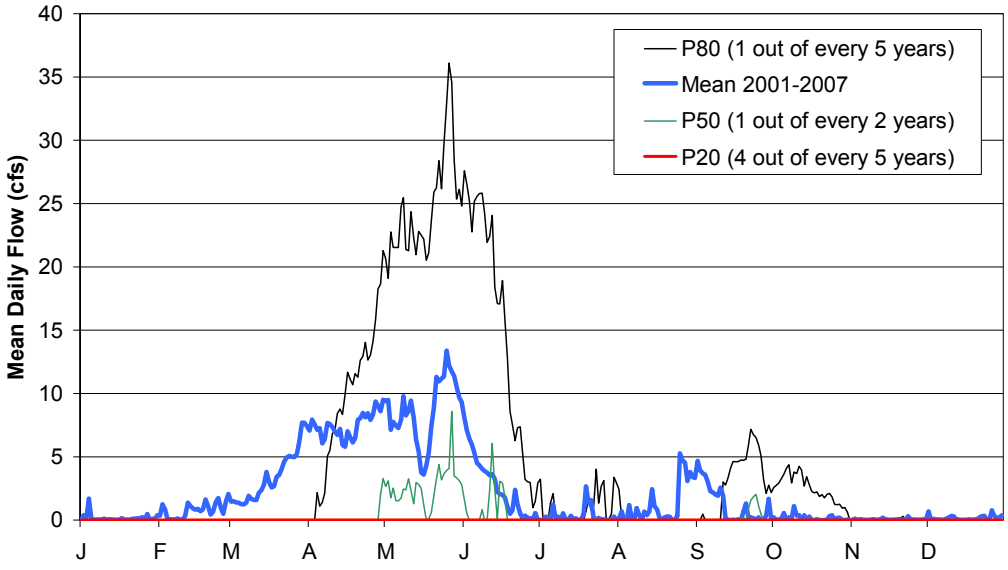
Figure 14. Estimated probability of mean daily flow at the *below Nichols Reservoir* gage adjusted to the long-term record.



Note: Probabilities based on Santa Fe near Santa Fe gage plus mean daily flow out of storage in Nichols Reservoir minus the mean daily flow of the water treatment plant in 2007

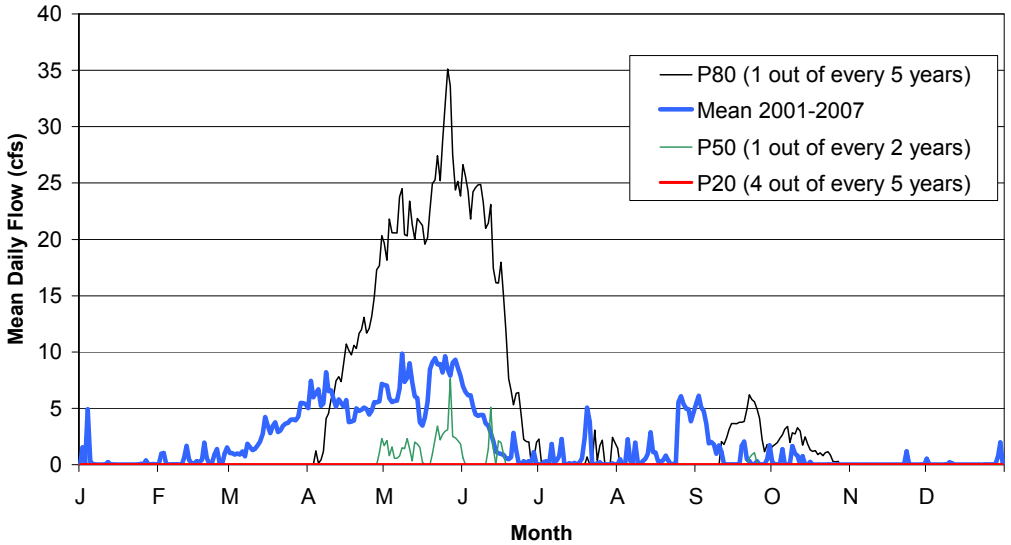
To estimate the flow at the *above St. Francis* and *Ricardo* gages (Figures 15 and 16), the seepage losses between Nichols Reservoir and the downstream gages were subtracted from the mean daily flow calculated for the *below Nichols* gage. The seepage losses are discussed in a separate report in this series titled Stream Losses.

Figure 15. Estimated probability of mean daily flow at the *above St. Francis* gage adjusted to the long-term record.



Note: Probabilities based on Santa Fe near Santa Fe gage plus mean daily flow out of storage in Nichols Reservoir minus the mean daily flow of the water treatment plant in 2007 minus seepage losses between Nichols and St. Francis

Figure 16. Estimated probability of mean daily flow at the *Ricardo Road* gage adjusted to the long-term record



Note: Probabilities based on Santa Fe near Santa Fe gage plus mean daily flow out of storage in Nichols Reservoir minus the mean daily flow of the water treatment plant in 2007 minus seepage losses between Nichols Reservoir and Ricardo Road.

Table 6. Estimated annual flow at three gages below Nichols Reservoir based on *Santa Fe River near Santa Fe* 1914-2007 and mean daily flow of the water treatment plant and change in storage (Extrapolation Method 2).

Santa Fe River Gage	Median Annual Flow (2001-2007)	Estimated Long-Term statistics 1914-2007		
		P20th	P50th (Median)	P80th
	ac-ft/yr	ac-ft/yr	ac-ft/yr	ac-ft/yr
Santa Fe near Santa Fe	**3,331**	**2,859**	**4,942**	**7,942**
Below Nichols	815	*16*	*500*	*4,100*
Above St Francis	935	*0*	*234*	*3,360*
Ricardo	914	*0*	*148*	*3,076*

In a dry year, the mean daily flow peaks are predicted to be zero, whereas in the calculated median year (one out of every two years), mean daily flow is at about 0.69, 0.32 and 0.20 cfs for the three gages; *below Nichols*, *St. Francis* and *Ricardo* respectively. In a wet year, mean daily flow would be about 5.7 cfs at the *below Nichols* gage, 4.6 cfs at the *St. Francis* gage and 4.2 cfs at *Ricardo*. In all scenarios at each of the three gages, the mean daily flow can be near zero in winter months. This method does not consider the contribution of storm runoff below Nichols Reservoir.

Estimated Maximum and Minimum Flows

Annual maximum and minimum flow for the five gage locations are shown in Table 7 for both the available record. The instantaneous peak flows are discussed in another paper in this series titled Storm Flows. The maximum observed flow at the *Santa Fe near Santa Fe* gage was 19,832 ac-ft/yr in 1919 (a year with almost 21 inches of precipitation was recorded in Santa Fe, the third wettest year on record from 1868 to 2007). High annual flows at the *below Nichols* gage were over 7,000 ac-ft in 2005. The maximum flow at the *below Nichols* gage could be nearly 15,000 ac-ft if the peak observed in 1919 is revisited and the full water right of 5,040 ac-ft is diverted by the City of Santa Fe and 54 ac-ft is diverted by Acequia Llano. The driest year for inflow into McClure was in 2002, when just over 700 ac-ft/yr flowed at the *above McClure* gage. In that year, only 14 ac-ft was recorded passing the *below Nichols* gage.

Table 7. Historic maximum and minimum annual flows for each gage in the Santa Fe River.

Santa Fe River Stream Gage	Observed Annual Extreme Flows		
	Min	Max	Min /Max
	ac-ft/yr		year
Above McClure	739	12,375	2002/1985
Santa Fe near Santa Fe	707	19,832	2002/1919
Percent of short-term (2001-2007) mean	*17%*	*482%*	---
Below Nichols	14	7,132	2002/2005
Above St Francis	51	7,532	2003/2005
Ricardo	8	6,292	2003/2005

Conclusions

The five gages on the Santa Fe River from above the reservoirs through town provide useful information about the variability of the stream system. The period of record that is coincides between the 5 gages is relatively short (7 years), and was drier than the long-term record available for one gage that has a 94-year record. The gaging data are necessary to understand the dynamics of the system for demand management on the water treatment side, and also for assessing options for maintaining riparian habitat below the reservoirs.

Stream flow generally decreases from above McClure Reservoir downstream. Flow below the

reservoirs is impacted, proportionally greater during low flow years, by the City of Santa Fe's water treatment plant diversions, and minor diversions by acequias. Storm runoff in town contributes to the otherwise losing reach of the Santa Fe River, with annual yields roughly the same at the three gages in town. Annual median flow into the Santa Fe River above the reservoirs is about 5,000 ac-ft/yr; whereas the estimated median flows below the reservoirs are 1,200 to 1,400 ac-ft/yr.

References

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Thomas, Carole L., Amy E. Stewart, and Jim Constantz. 2000. Determination of Infiltration and Percolation Rates Along A Reach of the Santa Fe River Near La Bajada, New Mexico. USGS Water-Resources Investigations Report 00-4141)

USGS. 2008. http://nwis.waterdata.usgs.gov/nm/nwis/dvstat/ accessed on March 3, 2008.

Veenhuis, Jack. 2008. Spreadsheet provided by Claudia Borchert, City of Santa Fe. September 2008.

Appendix A. Modeled Estimates of Inflow to McClure Reservoirs

The Veenhuis model estimates are shown with the weekly data measured by Sangre de Cristo Water Company and with USGS data in Figures A-1 and A-2. The apparent oscillation in stream flow is an artifact of the model approach. The data were smoothed to eliminate this oscillation using a 4-day running average as shown in Figure A-3. The 4-day period was a compromise between losing the peak daily flow and reducing the noise in the modeled estimates.

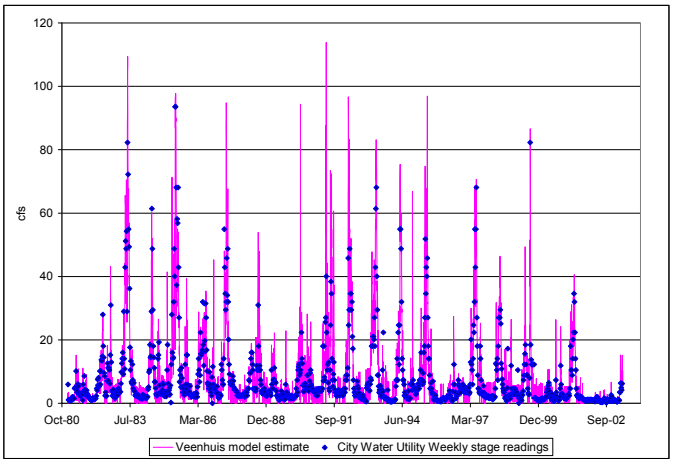

Figure A-1. Modeled on the Santa Fe River at the *above McClure Reservoir* gage and inflow based on weekly readings of flume levels 1981 to 2002.

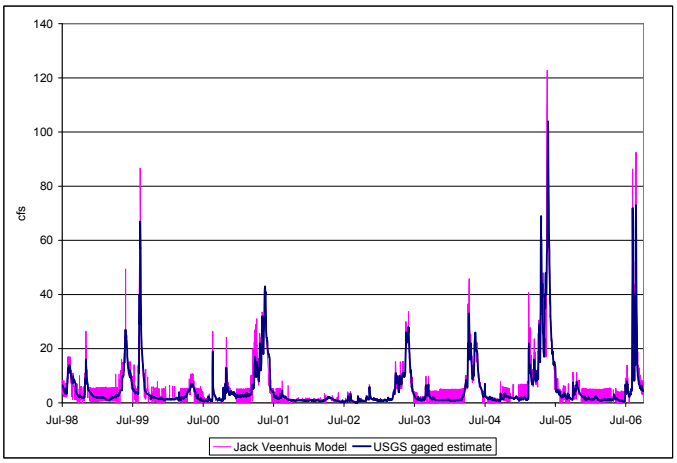

Figure A-2. Model estimated inflow on the Santa Fe River at the *above McClure Reservoir gage* and USGS gage records from 1998-2006.

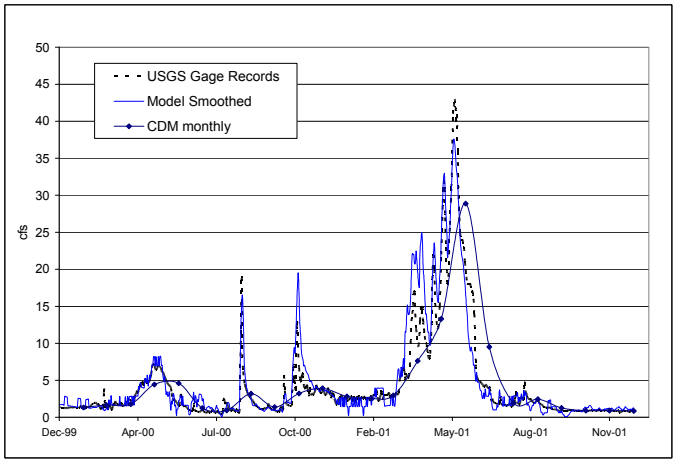

Figure A-3. Comparison of USGS gaged inflow to Model estimated flow smoothed over a 4-day moving average.

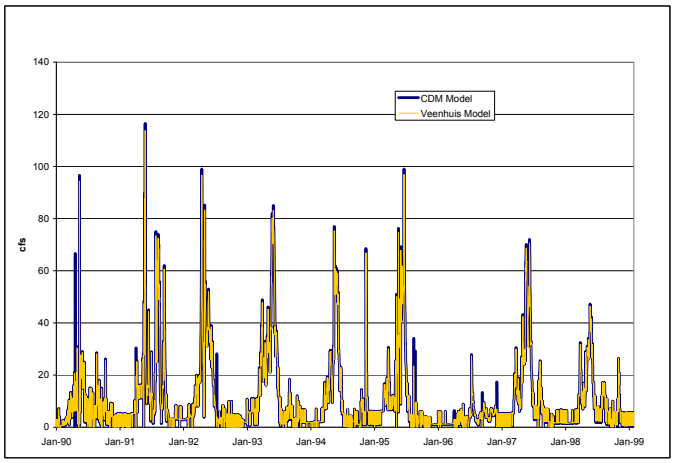

Figure A-4. Comparison of modeled inflow in the Santa Fe River at the *above McClure Reservoir* gage from CDM and Veenhuis.