Memorandum

Subject: **San Joaquin River Hydrology**
From: **Daniel B. Steiner**
Date: **January 9, 2008**

1. Introduction

At the request of Tim O'Laughlin, Special Counsel to the San Joaquin River Group Authority, this memorandum has been prepared to describe the hydrology of the San Joaquin River in the context of the State Water Resources Control Board's special issue item "Consideration of the Pelagic Organism Decline in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary".

Described in this memorandum are the records of several parameters of the San Joaquin River Basin that are typically used to identify the annually varying hydrology of the basin, those parameters' calculated relationship to Sacramento River Basin hydrology, and the observed occurrence of smelt abundance. The data are primarily provided for the hydrologic period spanning water years 1971 through 2007. The analysis was focused upon this period since basin development (reservoir storage) during this period was generally stable, with the exception of New Melones Reservoir beginning full operation during the 1980s. This relatively stable level of development provides a 37-year period of stream flow hydrology that better represents contemporary intra- and inter-year basin operations than would an analysis that includes records prior to this period.[1]

2. Basin Wetness

Several parameters are used to describe the wetness of San Joaquin River Basin. Two such parameters are the "San Joaquin Valley Water Year Hydrologic Classification", described in SWRCB 95-1WR, May 1995, and the "San Joaquin River Unimpaired Flow at Vernalis", as described in California Central Valley Unimpaired Flow Data, Third Edition, August 1994 (updated July 3, 1995), Department of Water Resources. Table 1 illustrates the annual (water year basis) of these two parameters for the period 1971 through 2007.

The unimpaired runoff at Vernalis is a conceptual parameter representing the calculated unimpaired runoff at the San Joaquin River's major tributaries' foothill reservoirs (e.g., near New Melones Reservoir), added to runoff of the San Joaquin Valley's minor streams and valley floor, plus overflows into the San Joaquin River from the Kings River. The parameter, as computed at Vernalis, is a general indication of the surface runoff in the basin but does not include depletions within the basin. The unimpaired runoff at Vernalis has ranged from a low of 1,061,000 acre-feet in 1977 to a high of 18,928,000 acre-feet during 1983. The average unimpaired runoff was about 6,756,000 acre-feet during the period.

The annual unimpaired runoff for the period is also illustrated in Figure 1, representing the year to year variation of its occurrence. The values are also illustrated in Figure 2, representing a rank-ordered frequency of runoff during the period. Illustrated in Figure 2 is the relative ranking of the hydrologic period 1995 through 2000 and the period 2001 through 2005. Each year during those periods is noted by a year label. It is evident that the latter period was significantly drier than the earlier period.

It has been noted by Ruhl[2] that measured peak flows in the San Joaquin River since 2001 (in the context of events through 2004) have been significantly lower than during the period 1995 through 2000. And also, that monthly average flows have been consistently below the 1984 through 2004 average. By referring to data provided in Table 1, the average unimpaired runoff at Vernalis for the 1984 through 2004 period is about 5,800,000 acre-feet while the average for the 2001 through 2004 period is about

[1] New Exchequer Dam was completed in 1966 and New Don Pedro Dam was completed in 1970. New Melones Dam was completed in 1978, and filled in 1983.
[2] Summary of Delta Hydrology Data Water Years 1985-2004, Joseph Simi and Catherine Ruhl, USGS, undated.

EXHIBIT K

4,000,000 acre-feet (about 70 percent of the average value). It is reasonable to expect that some measured monthly flows at Vernalis would follow the trend of being lower coincidental with the lesser unimpaired flow. The same circumstance of lesser peak flows during the 2001-2004 period relative to the 1995 through 2000 period should also be expected given the circumstance that the 1995 through 2000 period's unimpaired flow was much greater than the latter period. The average unimpaired runoff at Vernalis for the 2001 through 2004 period was only 43 percent of the average runoff during the 1995 through 2000 period.

Table 1
Wetness Parameters for the San Joaquin River Basin – 1971-2007

Chronological				Rank-Ordered		
Water Year	SJV Index	SJV Index Classification	Unimpaired Vernalis Flow	Water Year	Unimpaired Vernalis Flow	Position Exceedence %
1971	2,885,824	Below	5,051,000	1983	18,928,000	3
1972	2,158,908	Dry	3,638,000	1995	13,572,631	5
1973	3,495,450	Above	6,939,000	1982	12,715,000	8
1974	3,903,413	Wet	7,566,000	1998	12,204,345	11
1975	3,846,306	Wet	6,547,000	2006	11,620,090	14
1976	1,568,133	Critical	2,023,000	1978	11,137,000	16
1977	838,770	Critical	1,061,000	1997	10,885,990	19
1978	4,582,803	Wet	11,137,000	1986	10,785,000	22
1979	3,668,900	Above	6,418,000	1980	10,587,000	24
1980	4,730,351	Wet	10,587,000	2005	9,801,145	27
1981	2,442,155	Dry	3,320,000	1993	8,922,000	30
1982	5,446,045	Wet	12,715,000	1984	8,063,000	32
1983	7,220,475	Wet	18,928,000	1996	7,575,440	35
1984	3,688,593	Above	8,063,000	1974	7,566,000	38
1985	2,403,226	Dry	3,715,000	1973	6,939,000	41
1986	4,305,385	Wet	10,785,000	1975	6,547,000	43
1987	1,861,362	Critical	2,160,000	1979	6,418,000	46
1988	1,476,178	Critical	2,516,000	2000	6,207,159	49
1989	1,963,675	Critical	3,618,000	1999	6,033,645	51
1990	1,514,587	Critical	2,494,000	1971	5,051,000	54
1991	1,955,459	Critical	3,315,000	2003	4,923,054	57
1992	1,557,439	Critical	2,677,000	2002	4,119,915	59
1993	4,143,494	Wet	8,922,000	2004	3,852,672	62
1994	2,042,724	Critical	2,569,077	1985	3,715,000	65
1995	5,948,085	Wet	13,572,631	1972	3,638,000	68
1996	4,119,611	Wet	7,575,440	1989	3,618,000	70
1997	4,130,304	Wet	10,885,990	1981	3,320,000	73
1998	5,655,749	Wet	12,204,345	1991	3,315,000	76
1999	3,590,923	Above	6,033,645	2001	3,257,631	78
2000	3,381,658	Above	6,207,159	1992	2,677,000	81
2001	2,198,061	Dry	3,257,631	1994	2,569,077	84
2002	2,341,004	Dry	4,119,915	1988	2,516,000	86
2003	2,813,414	Below	4,923,054	1990	2,494,000	89
2004	2,213,808	Dry	3,852,672	2007	2,489,489	92
2005	4,753,627	Wet	9,801,145	1987	2,160,000	95
2006	5,899,081	Wet	11,620,090	1976	2,023,000	97
2007	1,957,604	Critical	2,489,489	1977	1,061,000	100
Average			6,575,873			

Figure 1
San Joaquin River Unimpaired Runoff at Vernalis – 1971-2007

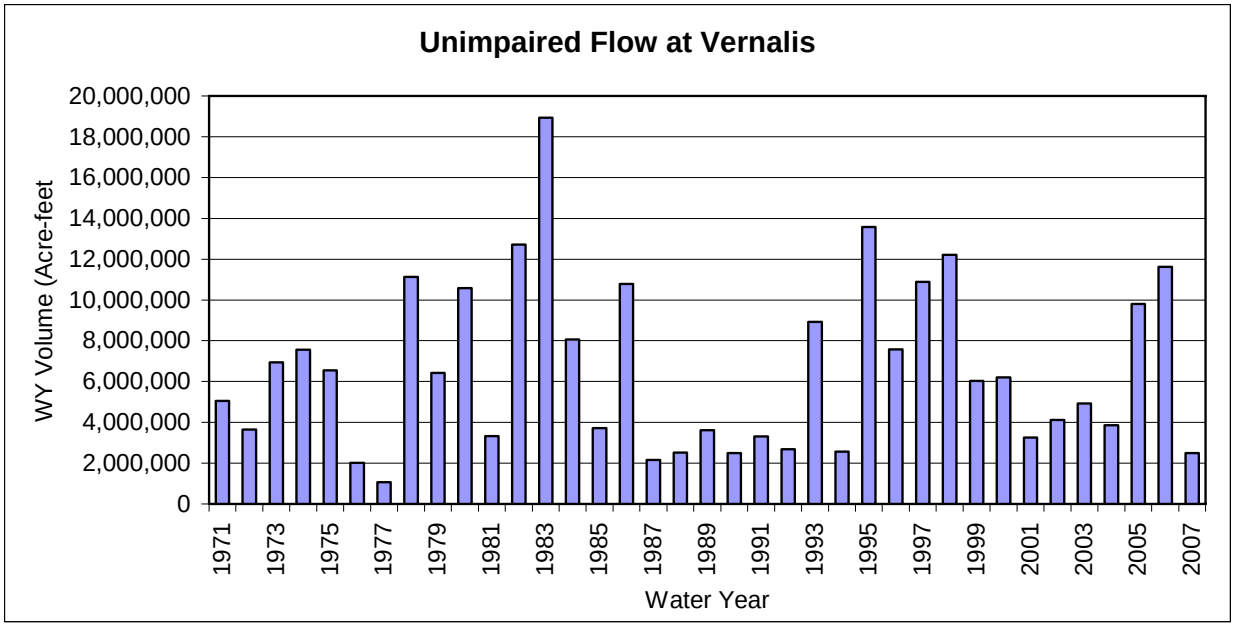
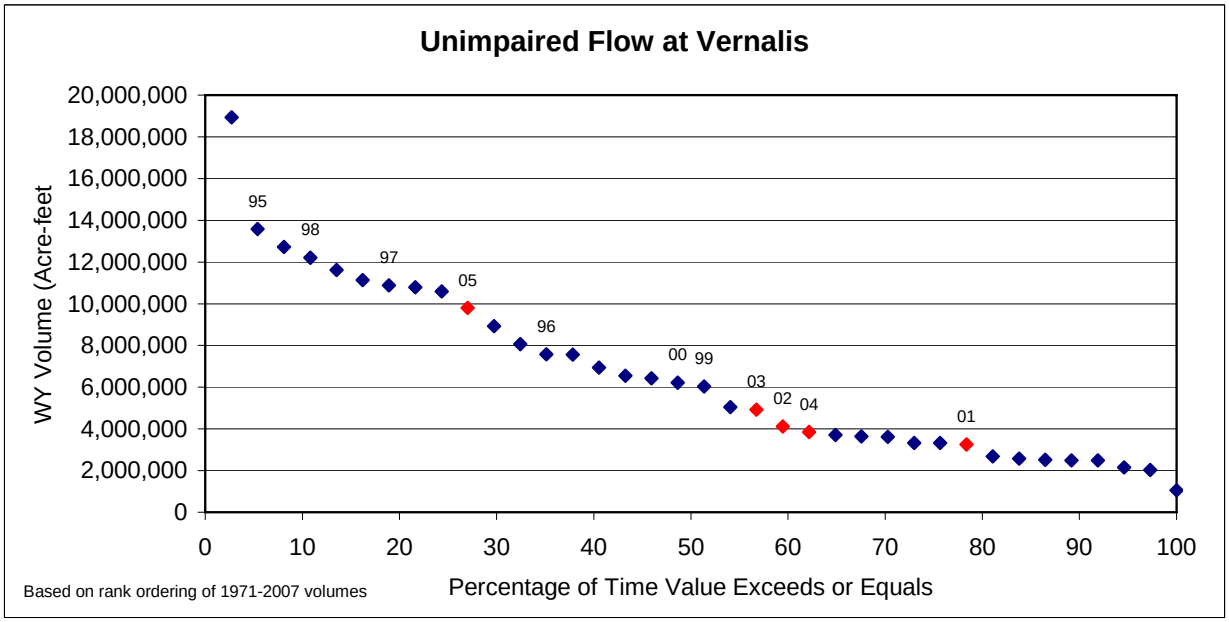
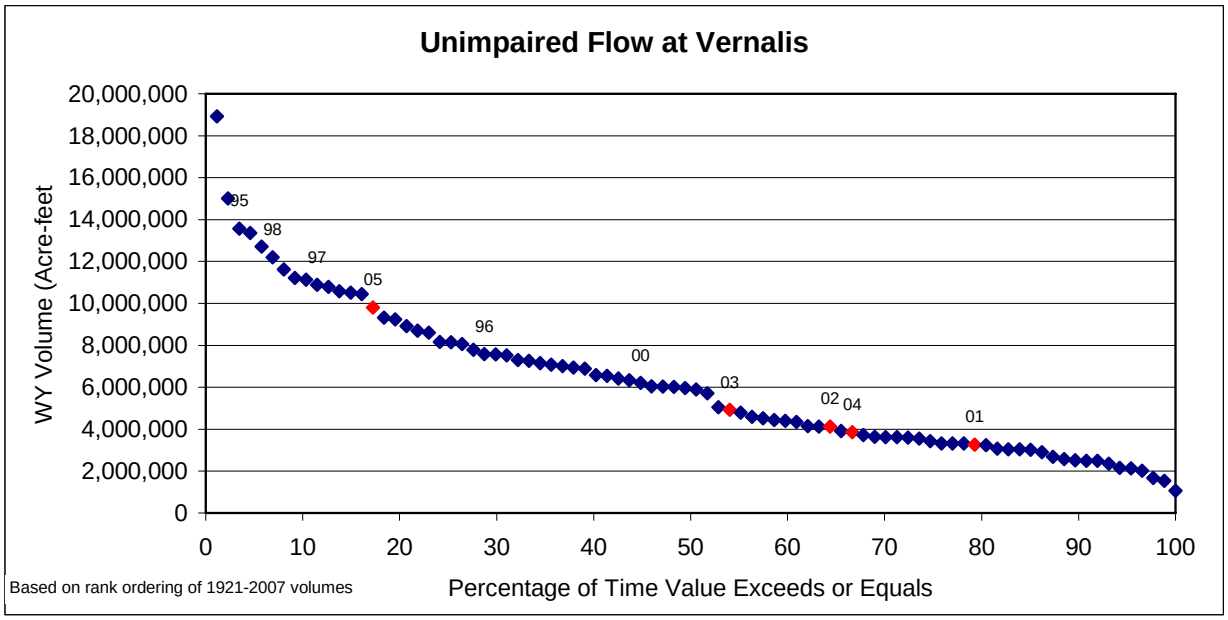


Figure 2
San Joaquin River Unimpaired Runoff at Vernalis – Rank Ordered 1971-2007



To provide a comparison of the 1971 through 2005 period with a long-term record of hydrology within the basin Figure 3 provides a rank-ordered illustration of the 1921 through 2005 unimpaired runoff at Vernalis, with the 1995 through 2005 data labeled. The 1921 through 2005 average unimpaired runoff at Vernalis is about 6,200,000 acre-feet, while the median runoff for each analysis period approximately the same 6,000,000 acre-feet.

Figure 3
San Joaquin River Unimpaired Runoff at Vernalis – Rank Ordered 1921-2007



The San Joaquin Valley Water Year Hydrologic Index is a little less of a direct indicator of annual basin wetness due to its calculation method that includes a component of the previous year's runoff. However, it is also evident from this parameter that the 1995 through 2000 period was wetter than the latter period. The years within the 1995 through 2000 period were classified as wet or above normal, while the 2001 through 2005 period had years classified as dry or below normal years, with the exception of 2005 which was classified as a wet year.

3. Stream Flow

The unimpaired runoff within the San Joaquin River Basin is affected by numerous factors including reservoir regulation and depletions. The San Joaquin River flow that enters the Delta is measured at Vernalis. Figure 4 provides an illustration of the measured flow of the San Joaquin River at Vernalis during the 1971 through 2007 period.

Flow at Vernalis ranged from a low of about 417,000 acre-feet (1977) to over 15,406,000 acre-feet (1983) with an average flow of about 3,292,000 acre-feet. During the latter part of the 1987-1992 drought, during the 4-year period 1989 through 1992 the flow at Vernalis averaged about 832,000 acre-feet per year, while during the more recent 2001 through 2004 dry period the flow averaged about 1,466,000 acre-feet per year. The rank-ordered flow at Vernalis for the 1971 through 2007 period is shown in Figure 5, with the years during the 1995 through 2005 period labeled.

Figure 4
Measured San Joaquin River Flow at Vernalis – 1971-2007

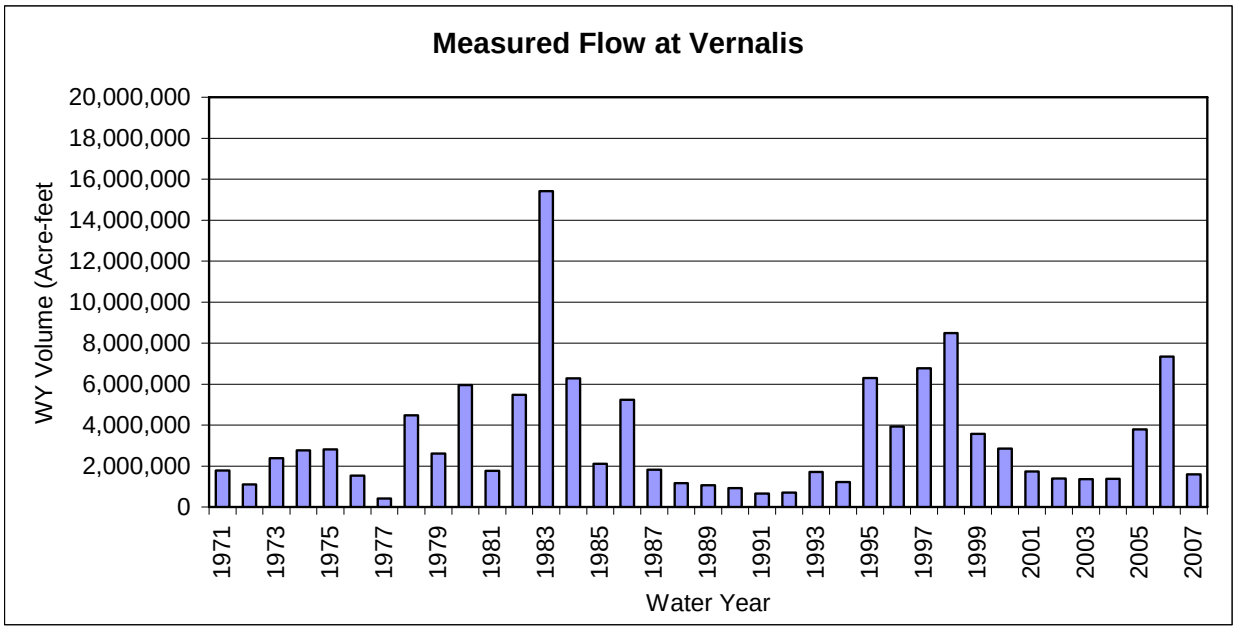
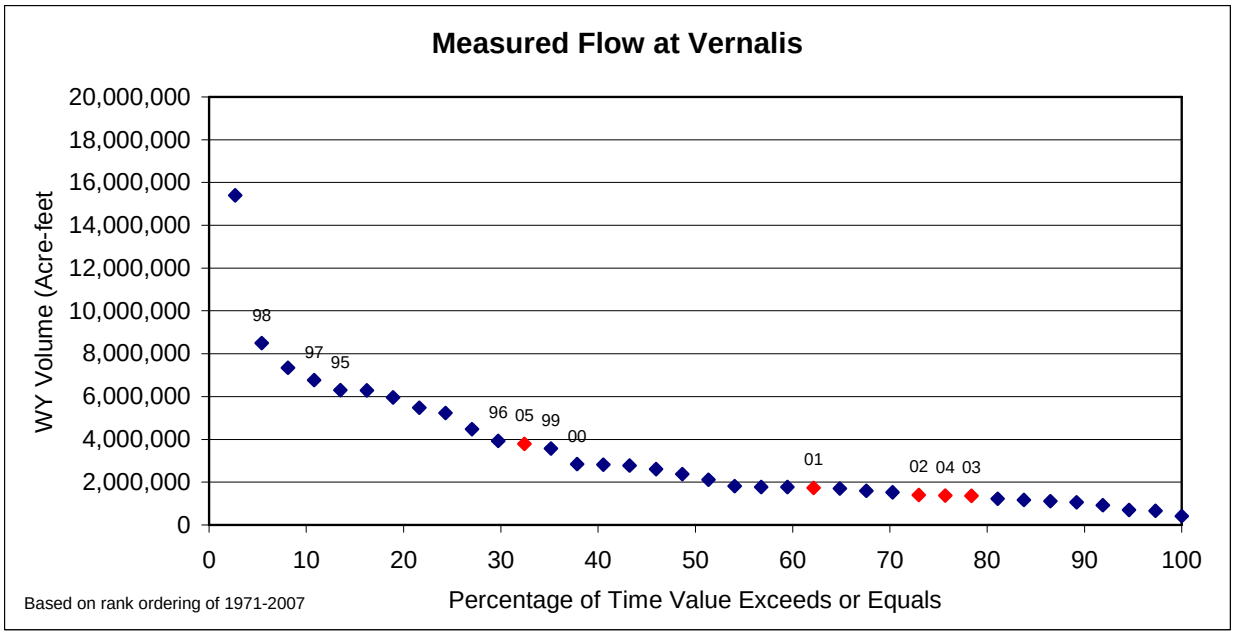


Figure 5
Measured San Joaquin River Flow at Vernalis – Rank Ordered 1971-2007



Consistent with the illustration of the unimpaired flow at Vernalis, the more recent 2001 through 2005 period exhibits less measured flow at Vernalis than the wetter 1995 through 2000 period, and there have been drier periods in recent history (1989 through 1992). Current focused protections to Delta smelt are being implemented during the January through June period. The same form of hydrology illustration for measured flow at Vernalis is shown in Figure 6 (chronological) and Figure 7 (rank-ordered).

Figure 6
Measured January – June San Joaquin River Flow at Vernalis – 1971-2007

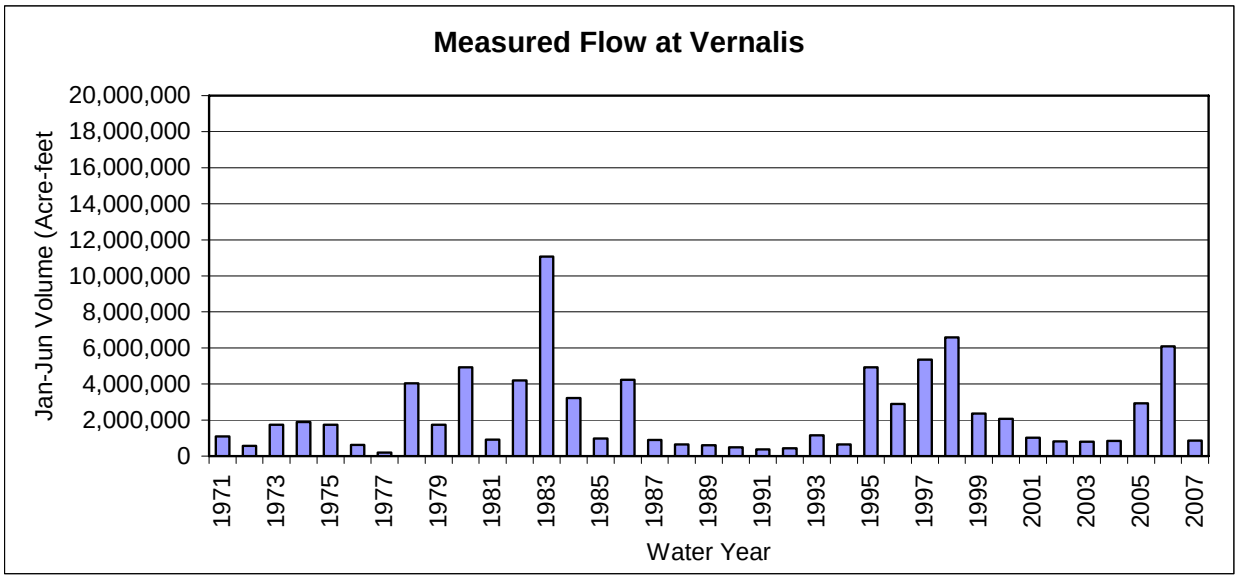
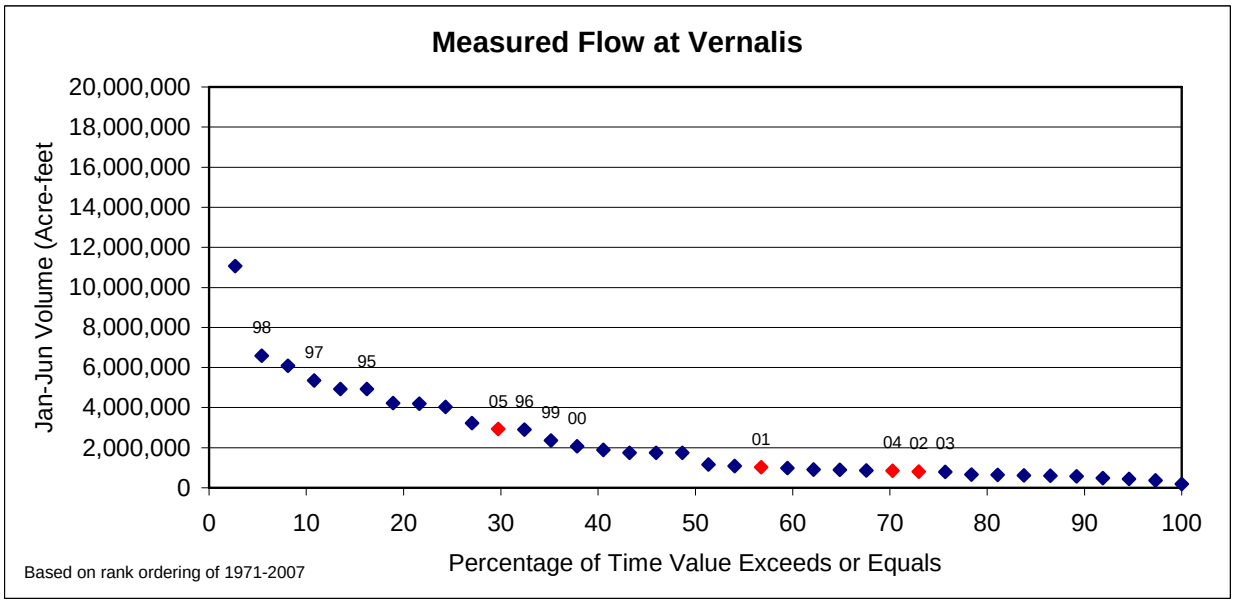


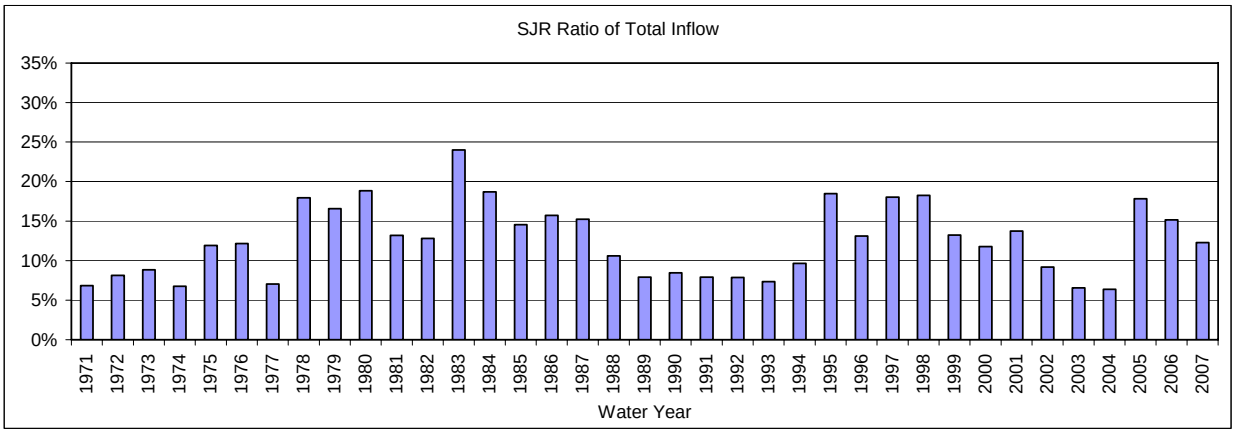
Figure 7
Measured January – June San Joaquin River Flow at Vernalis – Rank Ordered 1971-2007



Results have been stated by Ruhl[3] and others concerning the ratio of San Joaquin River entering the Delta as compared to other inflows, e.g, Sacramento River. Figure 8 shows the measured San Joaquin River flow at Vernalis as a ratio of the combined San Joaquin River flow and Sacramento River flow (including Yolo Bypass). Similar information is provided in Figure 9 for the focused period of January through June.

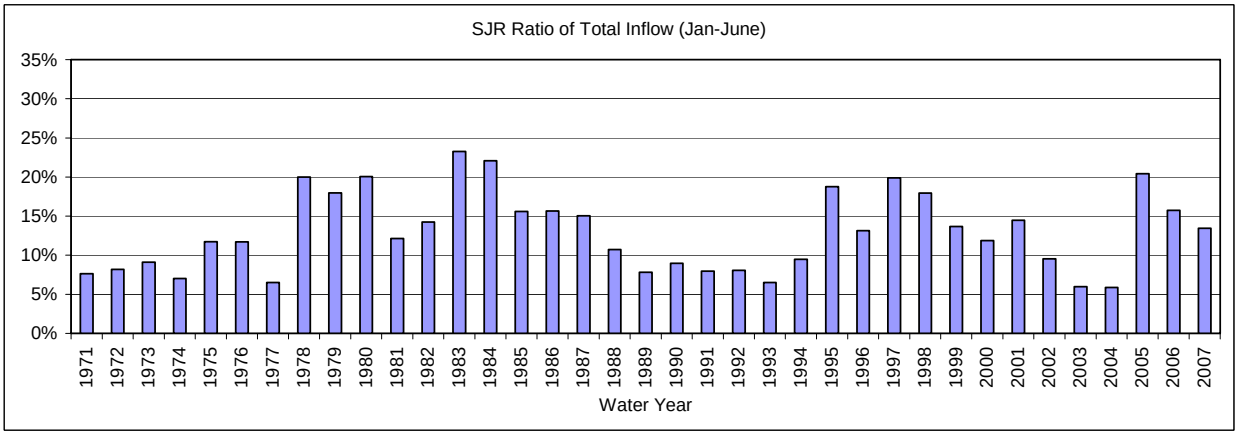
[3] Summary of Delta Hydrology Data Water Years 1985-2004, Joseph Simi and Catherine Ruhl, USGS, undated.

Figure 8
Measured Water Year San Joaquin River Flow at Vernalis as a Ratio of Total Delta Inflow*



* Total inflow defined as San Joaquin River + Sacramento River + Yolo Bypass

Figure 9
Measured January – June San Joaquin River Flow at Vernalis as a Ratio of Total Delta Inflow*



* Total inflow defined as San Joaquin River + Sacramento River + Yolo Bypass

Although illustrating a lower ratio during 2003 and 2004 than during other periods, the flow results shown above illustrate that the lower ratio is not attributable to lower San Joaquin River flows but instead due to increased Sacramento River Basin flows.

For the 1971 through 2007 period, the San Joaquin River flow has been an average 14 percent of the combined flow into the Delta on a water year basis and 15 percent of the flow during the January through June period.

4. Delta Smelt Abundance

A summary of delta smelt abundance has been reported by The Bay Institute, et al., in its petition to the State of California for the listing of delta smelt as an endangered species under the California Endangered Species Act (February 2007). Table 2 provides data extracted from that document.

Table 2
Abundance of Delta Smelt*

Year	Summer Juvenile TNS	Fall Adult FMWT	Year	Summer Juvenile TNS	Fall Adult FMWT
1971	12.5	1,303	1990	2.2	364
1972	11.1	1,265	1991	2.0	689
1973	21.3	1,145	1992	2.6	156
1974	13.0	No Data	1993	8.2	1,078
1975	12.2	697	1994	13.0	102
1976	50.6	360	1995	3.2	899
1977	25.8	481	1996	11.1	127
1978	62.5	572	1997	4.0	303
1979	13.3	No Data	1998	3.3	420
1980	15.8	1,653	1999	11.9	864
1981	19.8	374	2000	8.0	756
1982	10.7	330	2001	3.5	603
1983	2.9	132	2002	4.7	139
1984	1.2	182	2003	1.6	210
1985	0.9	110	2004	2.9	74
1986	7.9	212	2005	0.3	26
1987	1.4	280	2006	0.4	41
1988	1.2	174	2007		
1989	2.2	366			

*Extracted from The Bay Institute, et al., (February 2007)

These data have been plotted against the hydrologic parameters described above for visual inspection. Figure 10 illustrates delta smelt abundance in comparison to San Joaquin River measured flow for the January through June period, and Figure 11 illustrates delta smelt abundance in comparison to the ratio of San Joaquin River flow to total Delta inflow.

Figure 10
Measured January – June San Joaquin River Flow at Vernalis and Delta Smelt Abundance

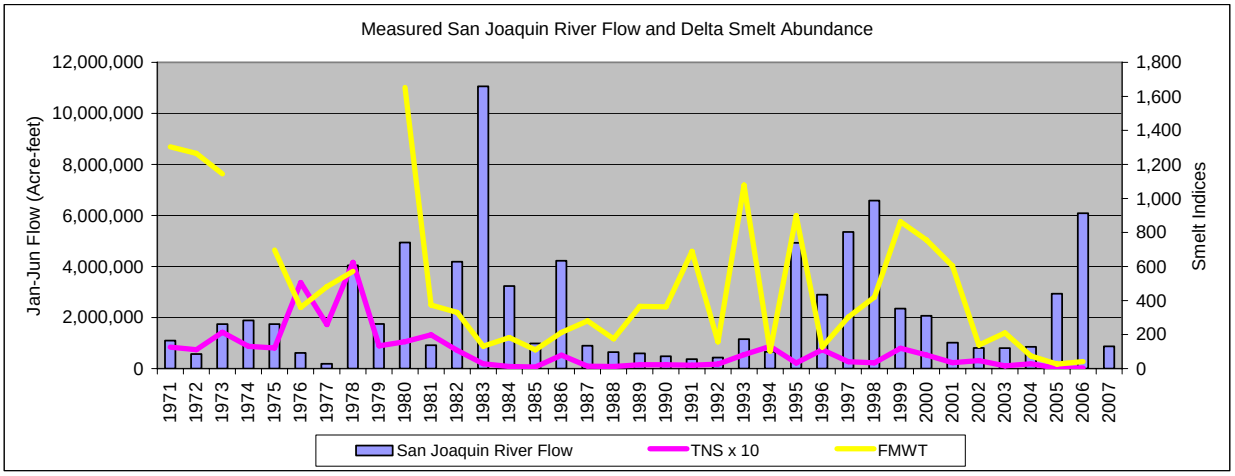
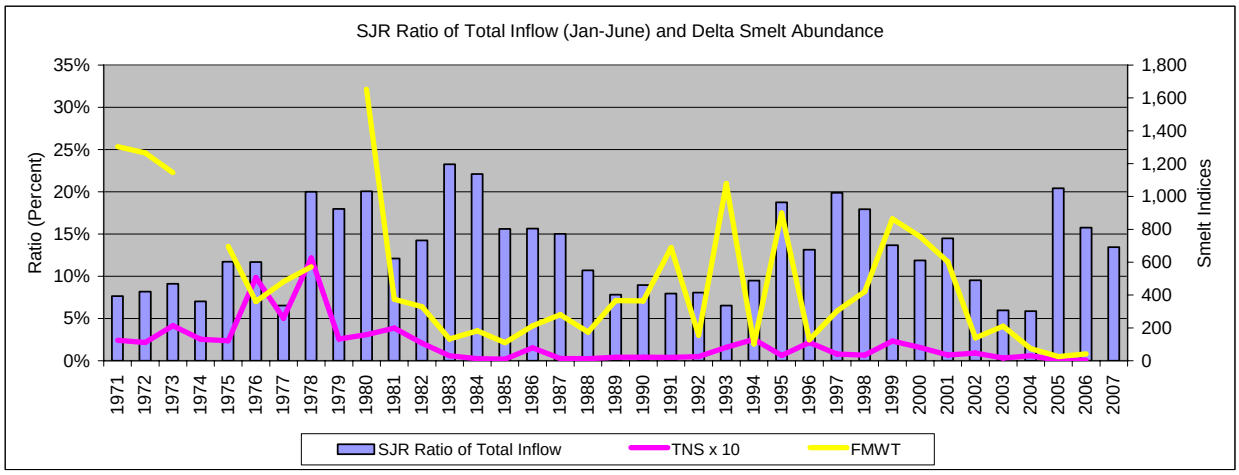


Figure 11
Measured January – June San Joaquin River Flow at Vernalis as a Ratio of Total Delta Inflow* and Smelt Abundance



* Total inflow defined as San Joaquin River + Sacramento River + Yolo Bypass

Supporting Data File
<< SJRGA_Steiner_Hydrology(January 9 2008).XLS>>

Data Sources

San Joaquin River Water Year Hydrologic Index: Calculated from DWR-CDEC Full Natural Runoff data for SNS (Stanislaus River at Goodwin), TLG (Tuolumne River at La Grange), MRC (Merced River at Merced Falls) and SJF (San Joaquin River at Friant), SWRCB 95-1WR, May 1995.

San Joaquin River Water Year Hydrologic Index Classification: Classified according to San Joaquin Valley Water Year Hydrologic Classification - SWRCB 95-1WR, May 1995.

Vernalis Unimpaired Flow: California Central Valley Unimpaired Flow Data, Third Edition, August 1994 (updated July 3, 1995), Department of Water Resources. Extended through 2007 by Daniel B. Steiner, Consulting Engineer.

Vernalis Measured Flow: Dayflow (Interagency Ecological Program) and USGS records.

Sacramento River Measured Flow: Dayflow Variable "Sac" 1971-2006 (Interagency Ecological Program), USBR CVO DOI Computation Sheet 2007.

Total Delta Exports: Dayflow Variable "CCC" + "SWP" + "CVP" 1971-2006 (Interagency Ecological Program), USBR CVO DOI Computation Sheet 2007.

Sacramento River and Yolo Bypass Measured Flow: Dayflow Variable "Sac" + "Yolo" 1971-2006 (Interagency Ecological Program), USBR CVO DOI Computation Sheet 2007.

Smelt Abundance Indices: "Petition to the State of California Fish and Game Commission and Supporting Information for Listing the Delta Smelt (Hypomesus transpacificaus) as an Endangered Species under the California Endangered Species Act", The Bay Institute, etal., February 7, 2007. Table 1.