Chapter 5. San Joaquin Basin Water Resources Development

There are over 80 dams with a total storage capacity of over 7.7 million acre-feet on the San Joaquin, Merced, Tuolumne, and Stanislaus Rivers. Combined, these facilities have the capacity to capture and control the entire average annual yield of the rivers they dam for the primary purposes of water supply, flood control, and hydroelectric power generation. This chapter provides and overview of the history, location, capacity, and operation of the dams and diversions on these four rivers (Table 5.1).

Water resources development in the San Joaquin Basin began shortly after the discovery of gold in the Sierra Nevada in 1848 with small-scale diversions to mining districts. Larger scale water diversions did not commence until settlers began to irrigate the alluvial soils of the San Joaquin Basin for agriculture. The earliest dams were small diversion facilities that did not have the capacity to store water or significantly reduce the volume of spring snowmelt run-off. These diversion facilities were large enough, however, to significantly reduce instream flows in the late summer and early fall with implications for the cold water fisheries below them. Beginning in the early twentieth century, irrigation districts and private companies began to develop larger dams with the capacity to store water for both irrigation and hydroelectric power generation. Irrigation districts dammed the Tuolumne, Merced, and Stanislaus Rivers (at the mountain-valley transition) between 1923 and 1926, significantly altering seasonal flow patterns and blocking or impeding passage of anadromous fishes to the upper watershed. During the middle of the twentieth century dozens of dams were constructed for hydro-power, urban and agricultural water supplies, and flood control including four large flood control dams and diversions with the capacity to completely control the flow of the San Joaquin Basin rivers in most years. Today there are over 80 dams large enough to warrant regulation by the California Division of Dam Safety on the four major rivers draining the San Joaquin Basin[1]. Their total combined capacity exceeds 7.7 million acre-feet, more than 135% of the average annual yield of the rivers they dam.

[1] Other dams have also been constructed on lesser known drainages including the Fresno and Chowchilla Rivers and the streams emanating from the interior Coast Range on the western side of the San Joaquin Basin.

Table 5.1. Watershed Characteristics of the San Joaquin Basin.

	Principal Foothill Dams						All Dams in Basin[4]		
					Reservoir Capacity			Total Reservoir Capacity	
River	Dam (Reservoir)[1]	Year[1]	Drainage Area (mi^2)[1]	Annual Runoff (TAF)/yr)[2]	(TAF/ yr)[1]	% Annual Runoff	Number of Dams[1]	(TAF/yr)[3]	% Annual Runoff
San Joaquin Mainstem	Friant (Millerton)	1942	1,676	1,780	520	29%	19	1,150	64%
Merced	Exchequer	1926	1,039	989	280	28%	8	1,050	105%
	New Exchequer (Lake McClure)	1967	1,039	989	1,030	104%			
Tuolumne	Don Pedro	1923	1,541	1,740	250	14%	27	2,730	155%
	New Don Pedro	1971	1,541	1,740	2,030	116%			
Stanislaus	Melones	1926	900	1,030	110	11%	28	2,850	278%
	New Melones	1979	900	1,030	2,420	235%			

[1] Source: California Department of Water Resources (1988). Drainage area above gauges.

[2] Source: US Geological Survey (1988). Thousand acre-feet=TAF. San Joaquin River below Friant (US Geological Survey gauge #11251000) 1907 – 1987, adjusted for evaporation and storage changes in Millerton Reservoir and for diversions to Madera and Friant- Kern Canals. Merced River below Merced Falls Dam near Snelling (#11270900) 1901 – 1987, adjusted for diversion to North Side Canal and change in contents in McSwain Reservoir. Tuolumne River below La Grange Dam near La Grange (#11270900) 1970 – 1987, adjusted for diversion to North Side Canal and change in contents in Lake McClure. Stanislaus River runoff is sum of Stanislaus River below Goodwin Dam (#11302000) 1957 – 1987, Oakdale Canal (#11301000) 1914 – 1987, and South San Joaquin Canal (#11300500) 1914 – 1987, all near Knights Ferry.

[3] Source: Kondolf and Matthews (1993), and California Department of Water Resources (1988), except for New Spicer Meadows, updated based on published data of US Geological Survey.

[4] Includes only dams large enough to be regulated by the California Division of Safety of Dams, i.e. higher than 7.6 m and/or larger than 62,000m^3 in capacity (California Department of Water Resources 1988).

The era of large federally sponsored and licensed flood control dams began in 1941 with the construction of Friant Dam and its associated diversion canals. In the 1960's and 1970's the relatively small water supply dams on the Merced, Tuolumne, and Stanislaus rivers were enlarged nearly ten fold, significantly altering downstream hydrologic patterns. Friant Dam on the middle San Joaquin, New Exchequer on the Merced, New Don Pedro on the Tuolumne, and New Melones on the Stanislaus are all operated, at least in part, for flood control purposes under the authority of the Army Corps of Engineers (Corps). The Corps' water control manual specifies rule curves that govern the operation of the dams. The Corps' rule curves establish maximum controlled dam releases to prevent overbank flooding below the dams, and require that a sizeable volume of the reservoir, the flood reservation, be vacated by the beginning of the rainy season to capture the100-year flood event. The Corps, along with the California Reclamation Board, manages a system of floodways and levees below the major dams to convey the 100-year flood, which is approximately equal to the maximum controlled dam release combined with flood run-off from other smaller drainages in the Basin. Although all of the dams have outlet capacities exceeding the Corps' maximum release rules, dam operators only release more than the Corps' mandated maximum when there is a significant possibility of uncontrolled spills over the dams' spillways. The total controlled release capacity along with the Corps' maximum flow release objectives for each of the four major dams is depicted in Table 5.2.

5.1 MIDDLE AND LOWER SAN JOAQUIN RIVER

From 1910 to 1960, eight major reservoirs were constructed on the San Joaquin River and its tributaries above Friant, with a combined storage capacity of 1.15 million acre-feet, equivalent to 60% of mean annual runoff (Table 5.3 and Figure 5.1). All but Millerton Reservoir (Friant Dam) were built for hydroelectric generation. Friant Dam and its canals (Figures 5.2) are unique among major dams and diversions in the Central Valley of California in that the dam impounds a relatively small percentage of annual runoff, but the canals have an unusually large diversion capacity. The reservoir capacity of Friant Dam is 520,500 acre-feet (equivalent to 30% of mean annual runoff), but the Friant-Kern and Friant-Madera canals can divert 385,000 acre-feet in a single month (Figure 5.3). The maximum capacity of the Friant-Kern Canal is 5,300 cfs, and the maximum capacity of the Friant-Madera Canal is 1,275 cfs (Friant Water Users Authority, 1987). The combined maximum capacity of the canals is equivalent to 80 percent of the median June pre-dam flows. Between 1950 and 1989, the two canals annually diverted an average of 1.5 million acre-feet (McBain and Trush, 2002) roughly 85% of the average annual yield.

Friant Dam, and Millerton Reservoir, which it impounds, were key components of the Central Valley Project (CVP) constructed by the United States Bureau of Reclamation to irrigate the Central Valley. Water impounded at Millerton Reservoir is mostly diverted south in the Firant Kern Canal, with some water diverted north via the Friant-Madera Canal (Figure 5.2). In most years, these diversions take 95% of the river's average annual yield. A small fraction of the water is released according to a 1957 legal settlement to maintain flows (typically 250 cfs or less) during the irrigation season to support agricultural diversions by riparian water right holders in the 36-mile reach

Table 5.2. Maximum Flows in the San Joaquin Basin Tributaries.

River	Dam	Owner	Purpose(s)	Max. power generation flow capacity (cfs)	Low level or other bypass valve (cfs)	Total controlled outlet release capacity (cfs)	Maximum flood release (cfs)	Pre Dam Q1.5 (cfs)	Source
San Joaquin	Friant	Bureau of Reclamation	Flood Control, Navigation, Fire Protection	28-35	17,700	17,700	8,000	8,651	J. Cain, Natural Heritage Institute, pc 7/14/00, USACE, 2000. Post-Flood Assessment.
Merced	New Exchequer Main	Merced Irrigation District	Flood Control and Stormwater Management, Irrigation, Hydroelectric, Recreation, Fish and Wildlife, Fire Protection	3,100	9,300	12,400	6,000 (at Stevinson)	10,062	J. Vick, Stillwater Sciences, pc 7/7/00, Ted Selb, Merced Irrigation District, pc 7/13/00, USACE, 2000. Post-Flood Assessment.
Tuolumne	New Don Pedro	Turlock and Modesto Irrigation Districts	Flood Control and Stormwater Management, Irrigation, Hydroelectric, Recreation, Fish and Wildlife	5,400	9,600	15,000	9,000	8,670	J. Vick, Stillwater Sciences, pc., USACE, 2000. Post-Flood Assessment.
Stanislaus	New Melones	Bureau of Reclamation	Flood Control and Stormwater Management, Irrigation, Hydroelectric, Recreation, Fish and Wildlife	9,000	2,500	19,000	8,000 (at Orange Blossom Bridge)	5,350	G. Cawthorne, USBR New Melones Dam, pc. 3/00, Bill Sanford, USBR, pc 7/5/00, USACE, 2000. Post-Flood Assessment.

Table 5.3. San Joaquin River Dams and Cumulative Storage Capacity

A	B	C		D	E	F
Year	Dam Name	Stream	Capacity (m3)	Storage Capacity (AF) [1]	Cumulative Storage (AF)	Cum. Storage as % annual unimpaired runoff
1896	No. 1 Forebay	Trib. No Fork SJ	85,121	69	69	**0.004%**
1910	Crane Valley Storage (Bass Lk)	NF Willow Creek	55,650,000	45,410	45,479	**2.39%**
1917	Mendota Diversion	Mainstem	3,700,935	3,000	48,479	**2.55%**
1918	Huntington Lake	Big Creek	109,069,000	88,834	137,313	**7.23%**
1920	Kerckhoff Diversion	Mainstem	6,348,000	4,200	141,513	**7.45%**
1923	Big Creek #6	Mainstem	1,225,009	993	142,506	**7.50%**
1926	Florence Lake	So Fork San Joaquin	78,929,000	64,406	206,912	**10.89%**
1927	Shaver Lake	Stevenson Crk	165,441,000	135,283	342,195	**18.01%**
1942	Friant/Millerton	Mainstem	637,255,000	520,500	862,695	**45.41%**
1951	Big Creek #7	Mainstem	42,892,000	35,000	897,695	**47.25%**
1954	Vermillion Valley/Thomas Edison	Mono Creek (~8000 ft elev)	154,205,607	125,000	1,022,695	**53.83%**
1955	Portal Powerhouse Forebay	Trib Sfork SJ River	400,935	325	1,023,020	**53.84%**
1960	Mammoth Pool	Mainstem (~3,500 ft elev.)	153,186,000	123,000	1,146,020	**60.32%**
1961	Reg WW CNT OXID	Trib SJ River	3,543,028	2,872	1,148,892	**60.47%**
	TOTAL LISTED DAMS: 14			TOTAL CAPACITY:	**1,148,892** AF	
					TOTAL:	**60.5%**
					1,900,000 AF	

Note: Data on the dams within the San Joaquin River large enough to be regulated by the Division of Safety of Dams (DOSD), including the year the dam was built (col. A), watershed location (C.), and its storage capacity (D). Col. E details the cumulative storage capacity within the basin after the construction of each additional dam. Col. F expresses this cumulative storage as a percentage of total average unimpaired runoff in the basin (1.9 maf, Calfed, 2000). The total dam storage capacity in the San Joaquin basin is almost 1.15 maf, or over 60% of average annual unimpaired runoff (Adapted from Richter 2002).
[1]: Division of Safety of Dams, Bulletin 17-00, July 2000.

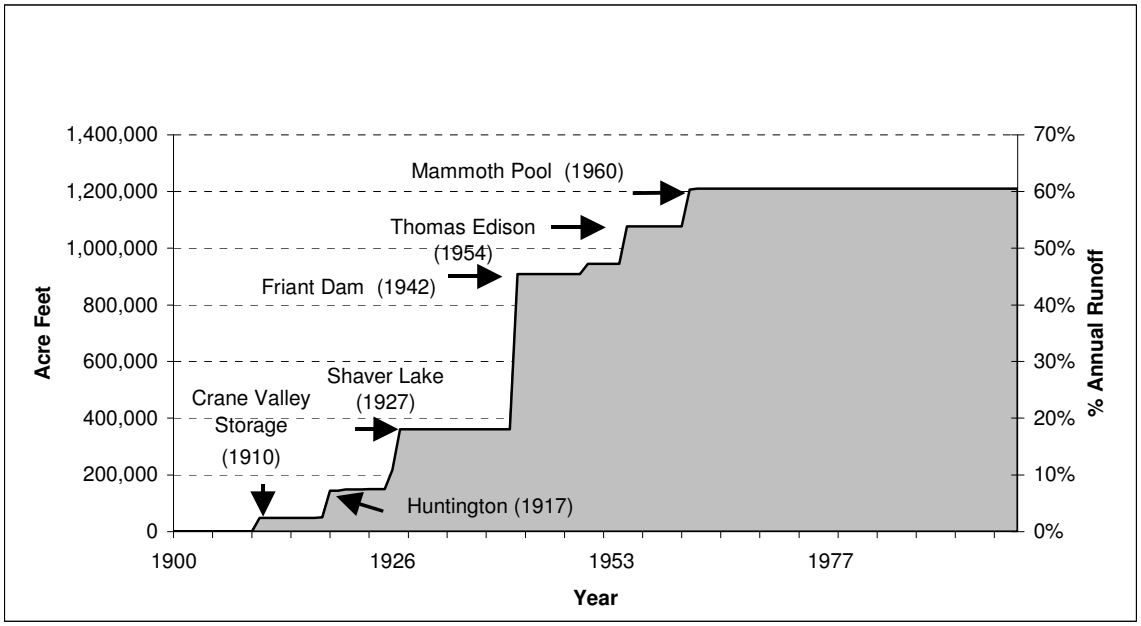

Figure 5.1. Middle San Joaquin River Dams Cumulative Storage Capacity. Incremental increase in storage capacity expressed as a percentage of mean annual runoff. The total capacity of San Joaquin River dams is 1.15 maf, relative to annual unimpaired runoff of 1.9 maf (Calfed, 2000). See Table 5.3 for details regarding calculations and data sources (Adapted from Richter 2002)

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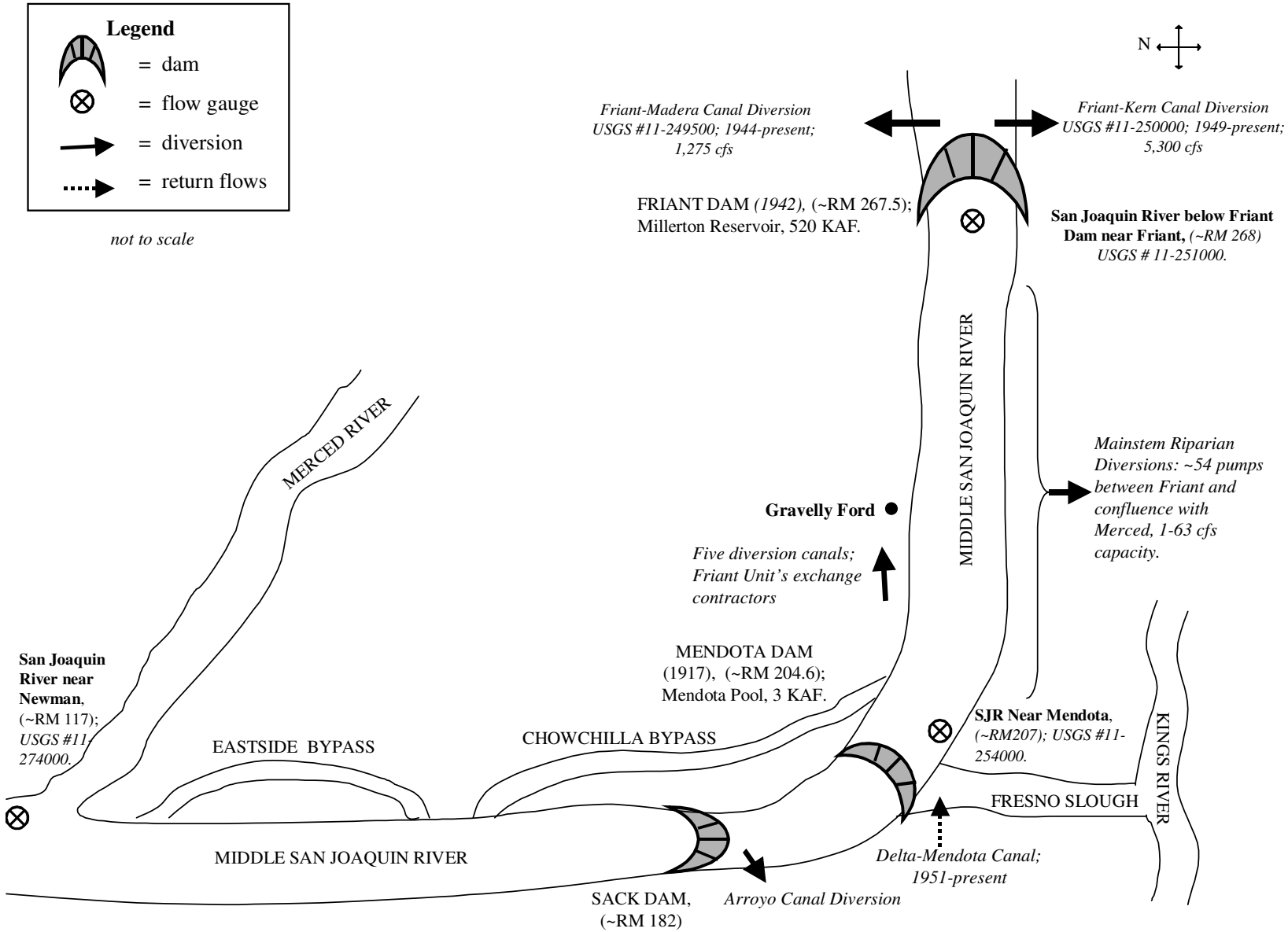

Figure 5.2. Middle San Joaquin River Dams, Diversions, and Gauges

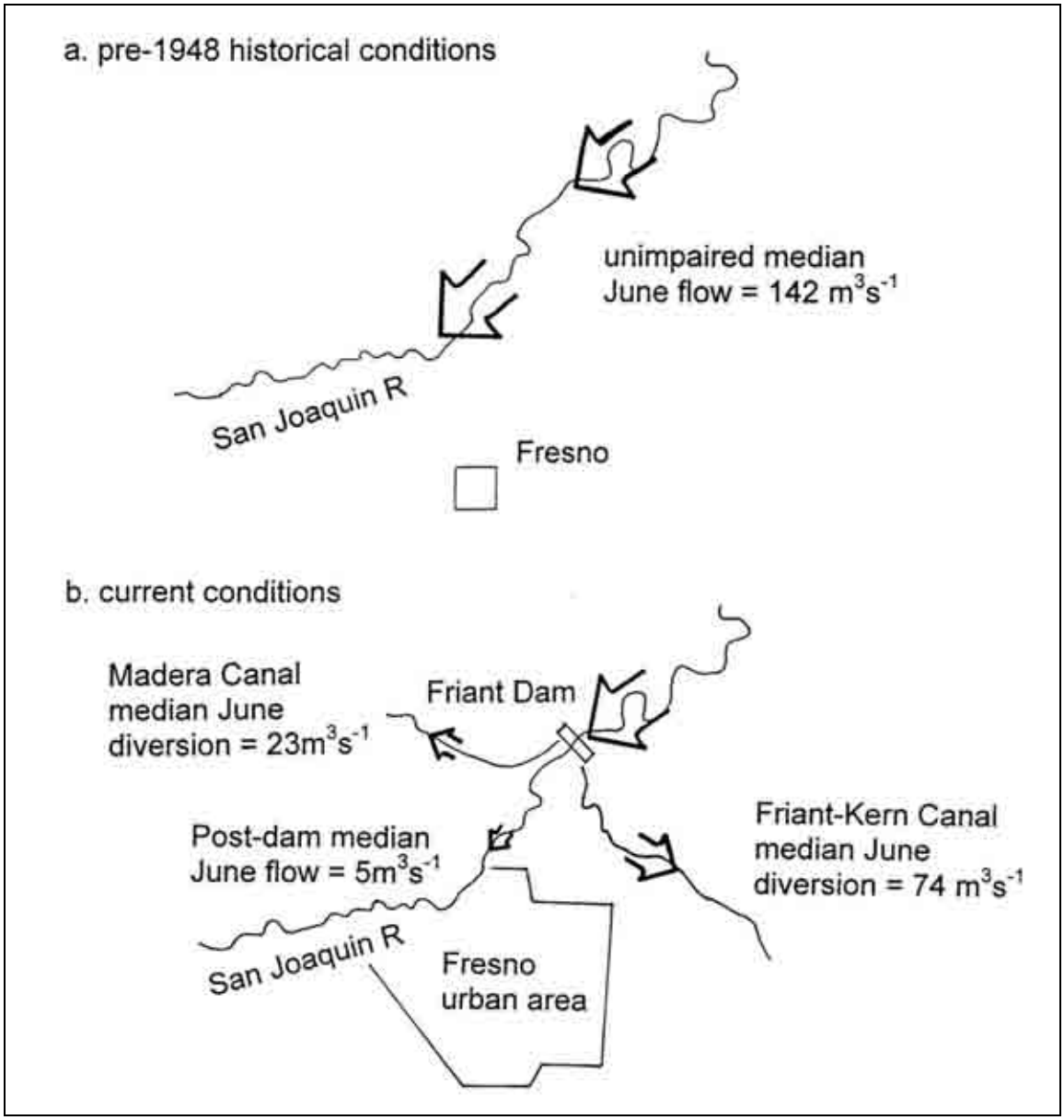

Figure 5.3. Schematic diagram showing flow split between the San Joaquin River and canals under a) pre-dam conditions and b) current conditions, with storage behind Friant and upstream dams. Unimpaired median June flow of 142 m^3s^{-1} based on wy 1908 – 1941. Median June flows in canals based on 1960 – 1997. Data from US Geological Survey published data.

downstream to the Gravelly Ford Canal. As a result, this reach of the river is wetted all year. Below Gravelly Ford, the channel is underlain by highly permeable bed material and high rates of flow losses to infiltration. This reach was allowed to dry up to avoid losing valuable surface water to groundwater infiltration.

Since construction of the CVP, riparian water rights holders downstream of Gravelly Ford have been served by the Delta-Mendota Canal, which delivers water from the Sacramento-San Joaquin Delta to the San Joaquin River at Mendota Pool (Figure 4.1 and Figure 5.2). Mendota Pool is formed behind Mendota Dam and was originally constructed in the nineteenth century to divert irrigation water from the San Joaquin River to several irrigation districts now known as the San Joaquin River Exchange Contractors (Exchange Contractors). The Exchange Contractors gave up their historic rights to the San Joaquin River in exchange for Delta water delivered via the Delta-Mendota Canal. Today, Mendota Pool has a storage capacity of 3,000 acre-feet and distributes Delta water into a system of irrigation canals. Some water is released downstream of Mendota Pool into the historical channel of the San Joaquin River for subsequent diversion into Arroyo Canal at Sack Dam, 22 miles further downstream. Below Sack Dam, the river is often dry for several miles except during flood events.

The Corps flood rules require 180,000 acre-feet of combined flood reservation in Millerton Reservoir and Mammoth Pool, an upstream reservoir, to capture winter flood events. This relatively small flood reservation is buffered by the enormous conveyance capacity of Friant's diversion canals. Corps flood control rules dictate a maximum flood control release of 8,000 cfs, but the dam has the capacity to release 16,400 cfs (Figure 5.4). The floodway below Friant Dam is designed to convey 12,000 cfs to accommodate both maximum controlled release and peak flows from Little Dry Creek, which enters the river a few miles downstream of Friant. At 12,000 cfs, the middle San Joaquin floods roads and housing associated with the Department of Fish and Game fishery. At 14,000 cfs, storm drains at the mobile home near Highway 41 back-up.

The middle San Joaquin River between Gravelly Ford and the Merced River has an unusually complex system of flood bypasses that route most flood flows around the historical channel and flood basin of the San Joaquin (Figure 5.4). Authorized by the Flood Control Act of 1944, the San Joaquin River and Tributaries Project (SJRTP) was constructed in the 1950's and 1960's and includes over 100 miles of levees and bypasses. Starting 35 miles downstream of Friant, a levee-confined floodway between Gravelly Ford and the Chowchilla bypass is designed to convey 12,000 cfs, but due to channel aggradation and levee instability may only be able to safely convey 8,000 cfs. Approximately 45 miles downstream of Friant, large flood releases are diverted into the Chowchilla and Eastside Flood bypass system which routes most of the rivers floodwaters around the historical flood basin downstream of Mendota Pool.

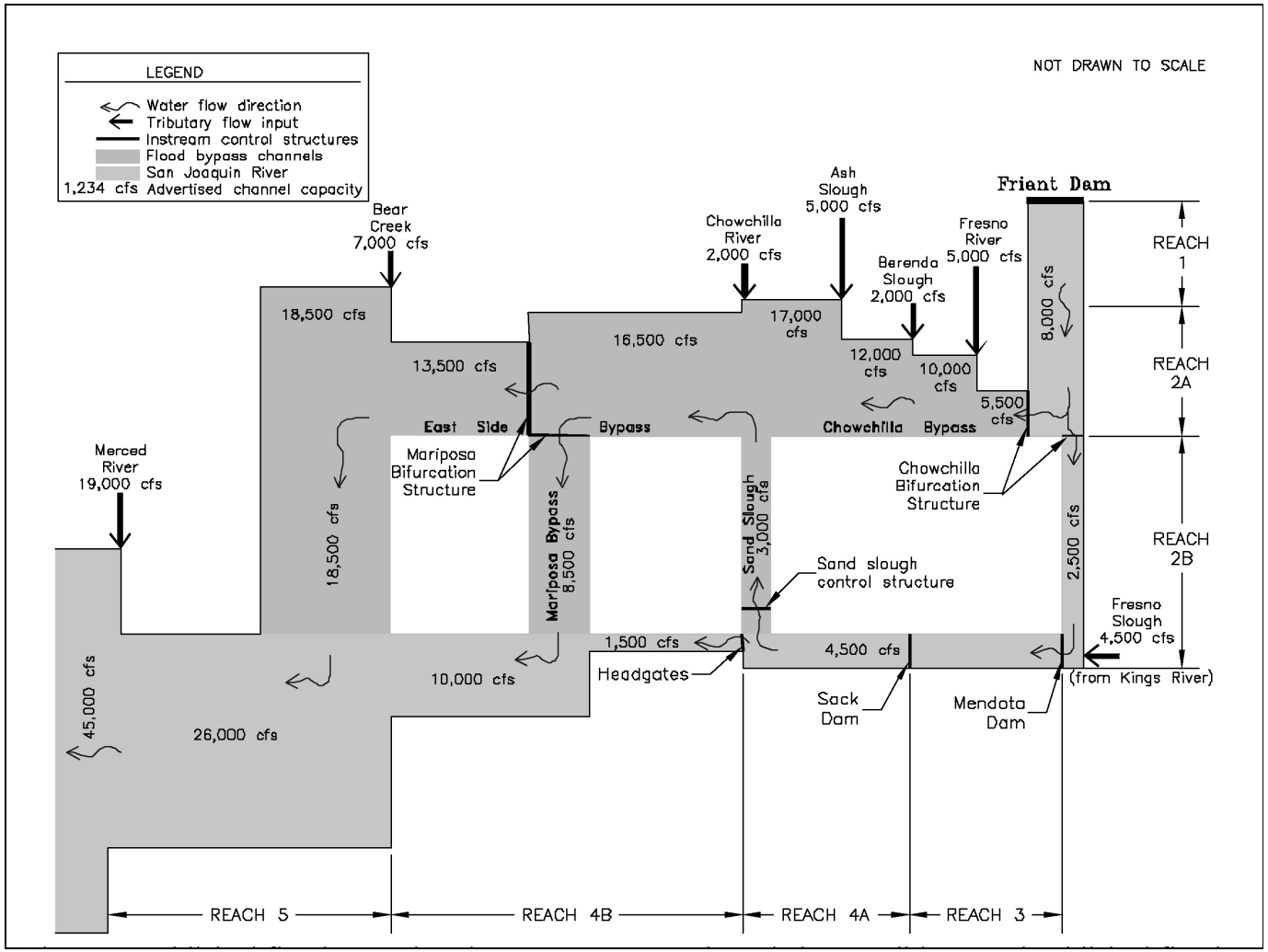

Figure 5.4. Published flood control project conveyance under existing conditions, and published flood control project operations for an example 8,000 cfs release from Friant Dam. McBain and Trush 2002

5.2 MERCED RIVER

Four principal dams control flows on the mainstem of the Merced River (Figure 5.5). Merced Falls diversion dam was constructed in 1901 by Pacific Gas and Electric Company and generates hydroelectric power and diverts flow into the Merced Irrigation District (MID) Northside Canal, which has a capacity of 90 cfs. In 1910, MID constructed Crocker Huffman Dam, which diverts flow into the Main Canal. The Main Canal has a capacity of 1,900 cfs and delivers waters to land south of the Merced River.

Exchequer Dam, the first major storage facility on the Merced River, was constructed in 1926 by the Merced Irrigation District. It stored flows during the high spring run-off period, and then released them downstream during the irrigation season for diversion into the North and Main Canals at Merced Falls and Crocker Huffman Diversion Dams. Due to its limited capacity of 281,000 acre-feet, Exchequer did not capture all of the spring run-off and did not allow for inter annual water storage.

Exchequer Dam, now known as Old Exchequer, was inundated in 1967 by Lake McClure when the Merced Irrigation District constructed New Exchequer Dam immediately downstream (Figure 5.6). New Exchequer and its downstream counterpart, McSwain Dam, are the primary components of the Merced River Development Project, which is owned by the Merced Irrigation District and licensed by the Federal Energy Regulatory Commission (FERC) (Stillwater, 2001). The Merced River Development Project provides agricultural water supply, hydroelectric power, flood control, and recreation, as well as some water to maintain minimum instream flows for fish in the Merced River and wetland habitat at the Merced National Wildlife Refuge (Stillwater, 2001). Lake McClure, the reservoir created by New Exchequer has a storage capacity of 1.032 million acre feet and enables the Merced Irrigation District to store water in wet years for use during subsequent dry years. Lake McSwain, located 6.5 miles downstream of New Exchequer Dam, has a capacity of 9,730 acre feet and is operated as a re-regulation reservoir and hydroelectric facility. Together, New Exchequer and McSwain have a combined storage capacity of 1.04 million acre-feet, which amounts to 102% of the average annual runoff from the Merced River watershed (Table 5.4 and Figure 5.7).

Figure 5.6. The Old Exchequer Dam is curved and shown in front of the New Exchequer Dam (Source: http://www.mercedid.org/_images/water_maincanal_sep02.pdf).

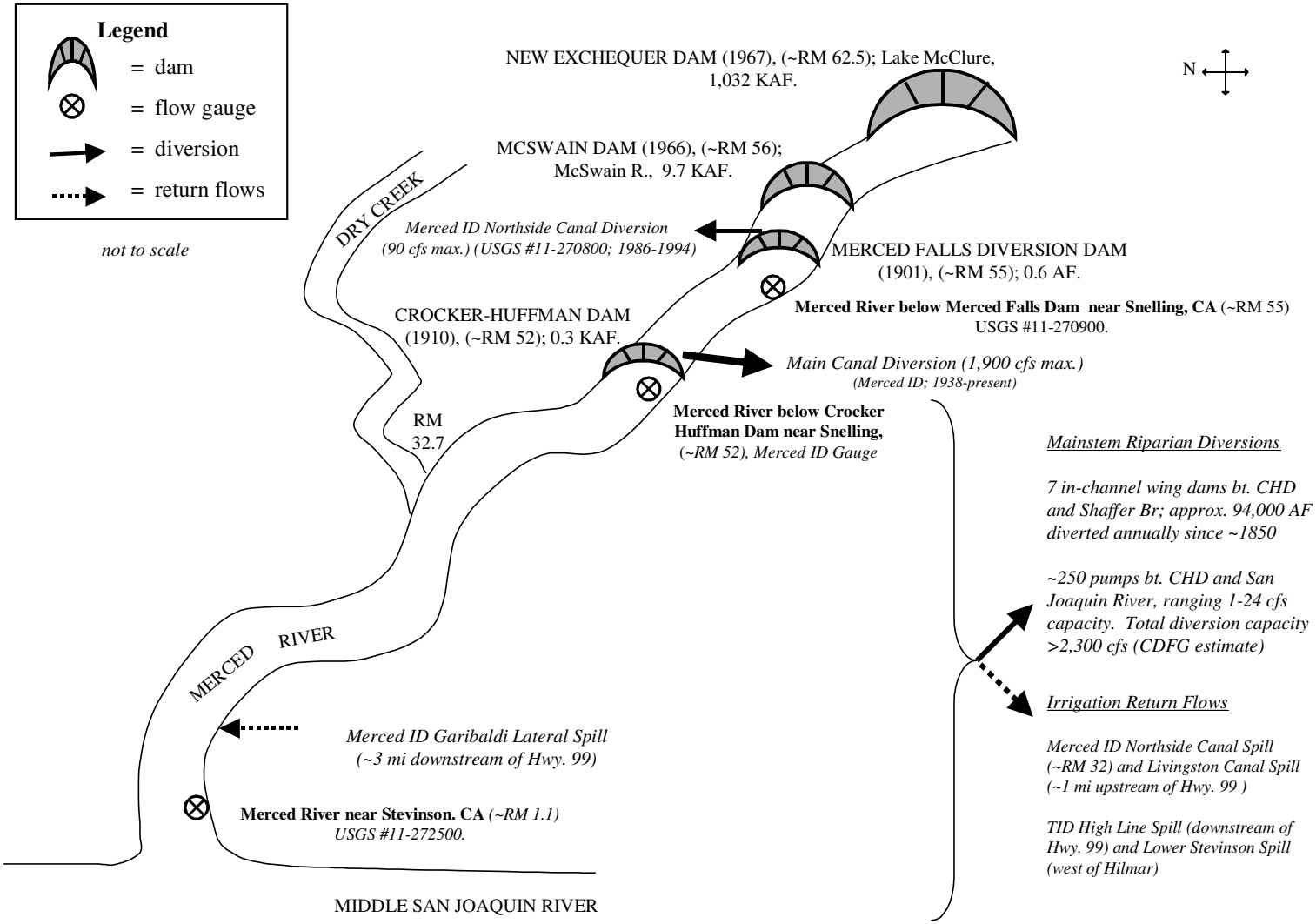

Figure 5.5. Lower Merced River Dams, Diversions, and Gauges
Data sources: USGS and CDEC web sites, CDWR DSD Bulletin17-00, Stillwater Sciences 2001

Table 5.4. Merced River Basin Dams and Cumulative Storage Capacity.

A	B	C		D	E	F
Year	Dam Name	Stream	Capacity (m3)	Storage Capacity (AF)	Cumulative Storage (AF)	Cum. Storage as % annual unimpaired runoff
1901	Merced Falls	Mainstem Merced River	765,000	620	620	**0.06%**
1910	Crocker-Huffman Diversion	Mainstem Merced River	370,000	300	920	**0.09%**
1926	Exchequer	Mainstem Merced River	347,000,000	281,280	282,200	**27.67%**
1929	Kelsey	Dry Creek (Trib)	1,230,000	1,000	283,200	**27.76%**
1956	Metzger	Dutch Creek (N. Fork)	92,500	75	283,275	**27.77%**
1957	McMahon	Maxwell Creek (Trib)	641,000	520	283,795	**27.82%**
1958	Green Valley	Smith Creek (N. Fork)	296,000	240	284,035	**27.85%**
1966	McSwain	Mainstem Merced River	12,000,000	9,727	293,762	**28.80%**
1967	New Exchequer/McClure [1]	Mainstem Merced River	1,270,000,000	1,032,000	1,044,482	**102.40%**
	TOTAL LISTED DAMS: 9 (Excheq counted twice)			TOTAL CAPACITY:	**1,044,482** AF	
					TOTAL:	**102%**
					1,020,000 AF	

Note: Data on the dams within the Merced basin large enough to be regulated by the Division of Safety of Dams (DOSD), including the year the dam was built (col. A), watershed location (C.), and its storage capacity (D). Col. E details the cumulative storage capacity within the basin after the construction of each additional dam. Col. F expresses this cumulative storage as a percentage of total average unimpaired runoff in the basin (1.02 maf, Calfed, 2000). The total dam storage capacity in the Merced basin exceeds 1.04 maf, or over 102 % of average annual unimpaired runoff. (Adapted from Richter's IHA Report) Stillwater reports Exchequer max storage capacity as 1,024,600 AF.
Source: Kondolf G.M. and Matthews, Graham, Management of Course Sediment on Regulated Rivers, Oct. 1993; Calfed, 2000; Kondolf et al, 1996, Water Resources Center Rept. 90; Division of Safety of Dams, Bulletin 17-00, July 2000.
1: Storage from Exchequer was subtracted when New Exchequer was filled.

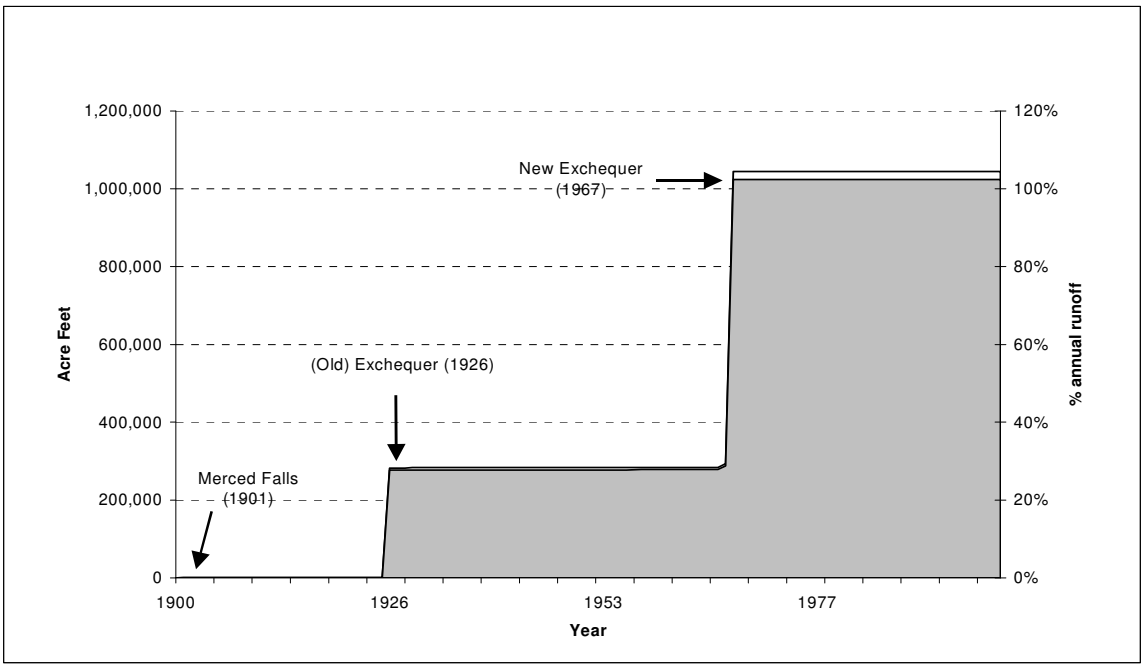

Figure 5.7: Merced River Dams Cumulative Storage Capacity. Incremental increase in storage capacity expressed as a percentage of mean annual runoff. The total capacity of Merced River dams is 1.04 maf, relative to annual unimpaired runoff of 1.02 maf (Calfed, 2000). (Adapted from Richter's IHA Report) Source: DWR, Bulletin 17-00, July 2000.

The Merced Irrigation District is required to release between 50 and 250 cfs from its facilities to satisfy the riparian water rights of the Merced River Riparian Water Users. The Merced River Riparian Water Users maintain seven major diversions between Crocker Huffman Dam and Shaffer Bridge. Downstream of Shaffer Bridge, the California Department of Fish and Game (CDFG) identified 238 diversions, generally small pumps that deliver water for agricultural purposes (Stillwater, 2001).

The Army Corps of Engineer regulates flood control operations on the New Exchequer Dam and Reservoir. According to the Corps Water Control Manual that dictates operations of the dam for flood control purposes, a maximum of 400,000 acre-feet of space is dedicated to flood control during the winter run-off season from November 1 – March 15 (Stillwater, 2001).

The Corps limits maximum reservoir releases to 6,000 cfs, measured at Stevinson gauge near the confluence with the San Joaquin. The maximum physical release from the New Exchequer outlet structure is 12,400 cfs (Table 5.2). 350,000 acre-feet of flood reservation storage is reserved for the rain flood pool between October 31 and March 15 and an additional 50,000 acre-feet is reserved for the forecasted spring snowmelt after March 1. During the floods in January 1997, flood flows released 8,000 cfs for 55 days under an emergency variance from the Corps and caused back flooding at the confluence of the San Joaquin, due to simultaneous releases at Friant Dam, and flooded agricultural lands in Stevinson and Hillman.

5.3 TUOLUMNE RIVER

There are over 25 dams on the Tuolumne with a combined storage capacity of over 2.7 million acre feet or 155% of the average annual yield, but five primary dams and several major diversions control flows on the Tuolumne River (Figure 5.8).

Local irrigation districts constructed La Grange Diversion dam in 1893 to divert water into the Turlock Irrigation District (TID) and Modesto Irrigation District (MID) main canals. Today, La Grange continues to serve as the diversion point into these canals. The MID Main canal diverts water to the north and has a capacity of 2,000 cfs and the TID Main Canal, which diverts water to the south, has a capacity of 3,400 cfs. Both canals deliver water to intermediate off-stream storage reservoirs, Modesto Reservoir and Turlock Lake, at the upper end of their canal network to regulate irrigation deliveries (FERC 1996).

The first two major storage reservoirs, Don Pedro and Hetch Hetchy, were both constructed in 1923 to increase storage and control of water for agricultural and municipal uses. The City and County of San Francisco (CCSF) constructed the 360,000 acre-foot Hetch Hetchy Dam (O'Shaughnessy Reservoir) in the upper watershed to provide a more reliable water supply. CCSF diverts 230,000 acre-feet of water directly out of river in the upper watershed for delivery via penstocks and pipelines to water users in the San Francisco Bay Area. Today, the Hetch Hetchy system also includes Lake Eleanor Dam (Lake Eleanor Reservoir) on Eleanor Creek and Cherry Valley Dam (Lake Lloyd Reservoir) on Cherry Creek, both in the upper watershed. The Hetch Hetchy

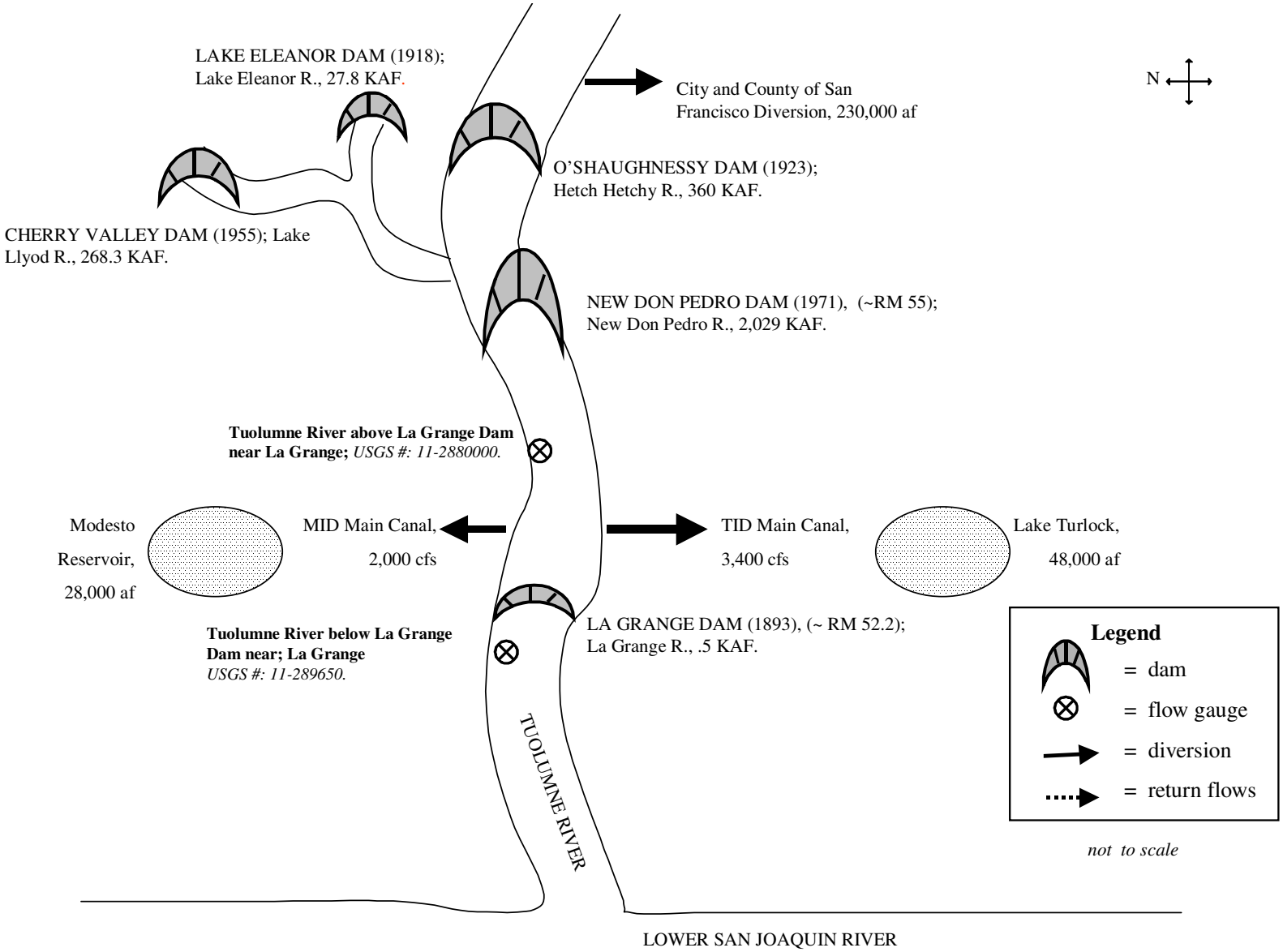

Figure 5.8. Lower Tuolumne River Dams, Diversions, and Gauges

system, which is operated in coordination with, but is not part of, the New Don Pedro Project (discussed later in this section) to meet water rights and flood control agreements.

Local irrigation districts constructed Don Pedro dam and reservoir with a capacity of 290,000. The districts utilized the increased reservoir space to capture spring flows for subsequent release and diversion at La Grange Dam, two miles downstream. In 1971, Don Pedro Dam, now know as Old Don Pedro, was inundated when New Don Pedro Dam was constructed immediately downstream of the old dam to create more reservoir storage space. New Don Pedro Dam (Figure 5.9) is the largest dam on the Tuolumne River with a storage capacity of 2.02 million acre-feet more than 110% of the average annual yield (Table 5.5 and Figure 5.10). The Merced and Turlock Irrigation Districts operate New Don Pedro Reservoir for irrigation, flood control, and hydropower generation. The New Don Pedro Powerhouse is at the base of the dam and is fed by two power tunnels (FERC, 1996). The New Don Pedro Dam, Reservoir and Powerhouse, La Grange Dam, the TID and MID diversion facilities at the La Grange Dam, the TID canal system, TID's Turlock Lake, the MID canal system, and MID's Modesto Reservoir all make up the New Don Pedro Project (NDPP) (FERC, 1996). The NDPP was constructed as a joint project between the MID, TID, CCSF and the Corps (McBain and Trush, 2001), and is owned and operated by MID and TID (FERC, 1996).

Figure 5.9. New Don Pedro Dam. http://www.tid.org/DonPedro /Default.htm

The Corps limits maximum allowable flood releases on the Tuolumne to 9,000 cfs, but the physical release capacity of the Dam outlet structure is 15,000 cfs. State and Federal agencies are working with the irrigation district to expand the floodway below the dam to safely convey 15,000 cfs. The Corps requires the district to maintain 360,000 acre-feet of flood reservation storage between November 1 and May 1 to capture the winter and spring floods.

Table 5.5. Tuolumne River Basin Dams and Cumulative Storage Capacity.

A	B	C		D	E	F
Year	Dam Name	Stream	Capacity (m3)	Storage Capacity (AF)	Cumulative Storage (AF)	Cum. Storage as % annual unimpaired runoff
1860	Kincaid	Trib. Curtis Crk.	62,000	50	50	0.003%
1860	San Diego Reservoir	Trib. Mormon Crk	49,300	40	90	0.005%
1880	Phoenix	Sullivan Creek	561,000	455	545	0.03%
1894	La Grange	Mainstem	617,000	500	1,045	0.05%
1896	Dawson Lake	Trib. Tuol. River	1,180,000	957	2,002	0.11%
1911	Modesto Reservoir	Trib. Tuol. River	35,800,000	29,020	31,021	1.63%
1912	Tuol. Log Pond	Turnback Crk	148,000	120	31,141	1.63%
1918	Lake Eleanor	Eleanor Creek	34,300,000	27,804	58,945	3.09%
1923	(Old) Don Pedro [1]	Mainstem	419,000,000	290,000	348,945	18.31%
1923	O'Shaughnessy (Hetch Hetchy) [2]	Mainstem	419,000,000	360,000	708,945	37.20%
1923	Priest	Rattlesnake Crk	2,900,000	2,351	711,296	37.32%
1925	Early Intake	Mainstem	141,000	114	711,410	37.32%
1928	Twain Harte	Trib. Sullivan Crk	159,000	129	711,539	37.33%
1930	Moccasin Lower	Moccasin Crk	623,000	505	712,044	37.36%
1931	Bigelow Lake	East Fork Cherry Crk.	580,000	470	712,514	37.38%
1931	Lower Buck Lake	Buck Meadow Crk	444,000	360	712,874	37.40%
1945	Railroad Flat #2	Trib. Dry Crk	117,000	95	712,969	37.41%
1947	Md. Cooperstown	Trib. Dry Creek	112,000	91	713,060	37.41%
1956	Cherry Valley	Cherry Creek	331,000,000	268,311	981,370	51.49%
1956	Gatzman	Trib Dry Creek	95,000	77	981,447	51.49%
1964	Brentwood Park	Trib. Sullivan Crk	98,700	80	981,527	51.50%
1969	Big Creek	Big Creek	9,440,000	7,652	989,179	51.90%
1971	Don Pedro	Mainstem	2,504,004,000	2,029,761	2,728,940	143.18%
1978	Quartz	Trib Woods Crk	1,850,000	1,500	2,730,440	143.25%
1979	Grinding Rock	Trib. Turnback Crk	290,000	235	2,730,675	143.27%
1981	Groveland	Trib. Big Creek	123,000	100	2,730,775	143.27%
Not included above:						
	Wastewater Hi Emig. Lk	No. Fk Cherry Crk	82,600			
	Kilmer	Trib. Dry creek	122,000			
	TOTAL LISTED DAMS: 27			TOTAL CAPACITY:	**2,730,777**	AF
					TOTAL:	**143%**

Note: Data on the dams within the Tuolumne basin large enough to be regulated by the Division of Safety of Dams (DOSD), including the year the dam was built (col. A), watershed location (C.), and its storage capacity (D). Col. E details the cumulative storage capacity within the basin after the construction of each additional dam. Col. F expresses this cumulative storage as a percentage of total average unimpaired runoff in the basin (1.906 MAF, McBain and Trush, 2000). (Adapted from Richter 2002).

Data source:

Kondolf G.M. and Matthews, Graham, Management of Course Sediment on Regulated Rivers, Oct. 1993;

McBain and Trush, Habitat Restoration Plan for the Lower Tuolumne River Corridor, March 2000;

Kondolf et al, 1996, Water Resources Center Rept. 90.

Division of Safety of Dams, Bulletin 17-00, July 2000.

1: Storage from Old Don Pedro was subtracted when New Don Pedro was filled.

Note: Kondolf and Matthews site Old Don Pedro as 250KAF, McBain and Trush site as 290 KAF.

2: Hetch Hetchy/O'Shaughnessy reported as 419 x $10^6 m^3$ in K&M 1993; 363KAF in M&T 2000; and 360 KAF in DSD 2000.

Hetch Hetchy originally built in 1923, with a 206,000 AF capacity, and enlarged in 1937 to 360,000 AF accd. To M&T.

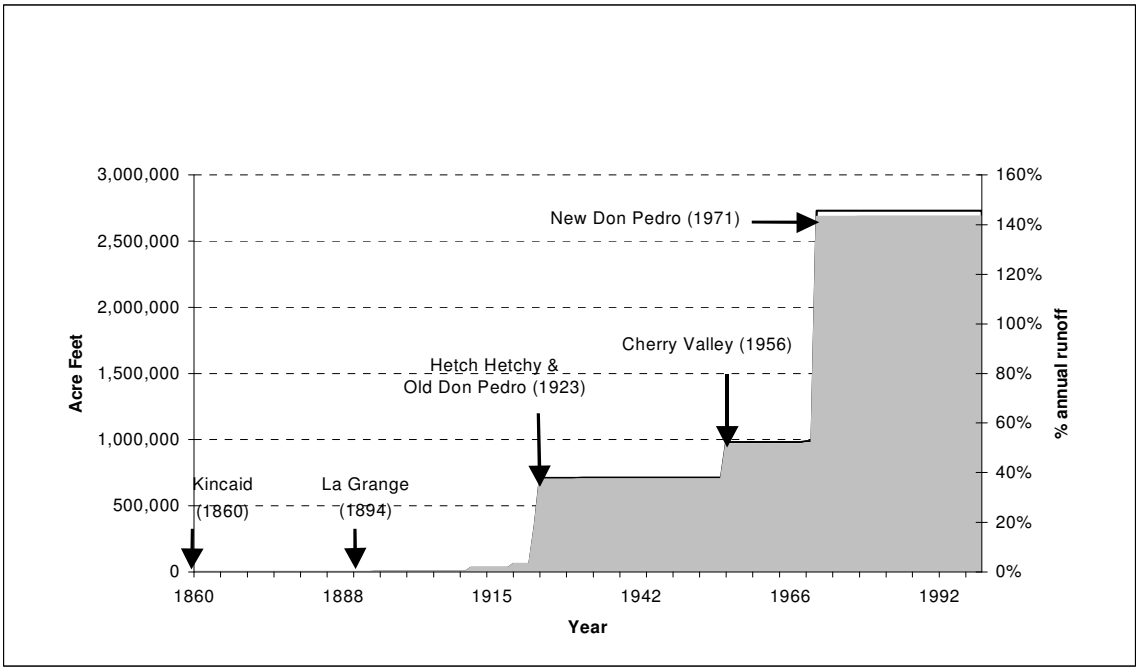

Figure 5.10. Tuolumne River Basin Dams Capacity. Incremental increase in storage capacity expressed as a percentage of mean annual runoff. The total capacity of Tuolumne River dams is 2.9 maf, relative to annual unimpaired runoff of 1.906 maf (McBain and Trush, 2000). (Adapted from Richter's IHA Report) Data Source: DWR, Bulletin 17-00, July 2000.

5.4 STANISLAUS RIVER

There are over 30 dams in the Stanislaus watershed with a combined storage capacity of 2,657,241 acre-feet, more than 220% of the average annual runoff. Daming and diversion for both mining and irrigation commenced soon after the Gold Rush. The earliest permanent dam was the original Tulloch Dam constructed in 1858 just downstream of the present dam, but it was a relatively low structure with an opening at one end, and thus may not have had a large impact on Salmon (Tudor-Goodnouogh Engineers 1959 in Yoshiyama 1996). The Oakdale Irrigation District (OID) and the San Joaquin Irrigation District (SJID) built the original 20 foot Goodwin Dam with a fishway in 1913 (Yoshiyama et al 1996) to divert water into the Oakdale and South San Joaquin Irrigation Canals. Oakdale Canal, with a capacity of 560 cfs, diverts water to the south and the South San Joaquin Canal diverts up to 1320 cfs to the north (Figure 5.11). The Goodwin Dam was apparently raised in the late fifties to serve also as a regulating reservoir for the New Tulloch Dam thus eliminating any function the old fishway may have served.

OID and SJID constructed the 156,000 acre-feet Melones Dam and reservoir 15 miles upstream of Goodwin Dam in 1926 to store spring run-off and release it downstream for diversion at Goodwin Dam. In the late 1950's the irrigation districts completed Tri-Dam project in the late 1950's consisting of Tulloch Dam between, Goodwin Dam and Melones, as well as Donnells and Beardsley Dam in the upper watershed. The irrigation districts operate the Tri-Dam Project to store spring snowmelt and release during the irrigation season for diversion at Goodwin Dam.

Melones Dam, now known as Old Melones, was replaced and inundated in 1979 when the Army Corps of Engineers constructed New Melones Dam (Figure 5.12). New Melones is the largest reservoir in the San Joaquin Basin with, and its 2,400,000 acre-feet of storage capacity is 2.4 times greater than the rivers average annual run-off (Table 5.6 and Figure 5.13). The Dam is operated and maintained by the US Bureau of Reclamation for flood control and to maintain water quality in the San Joaquin Delta.

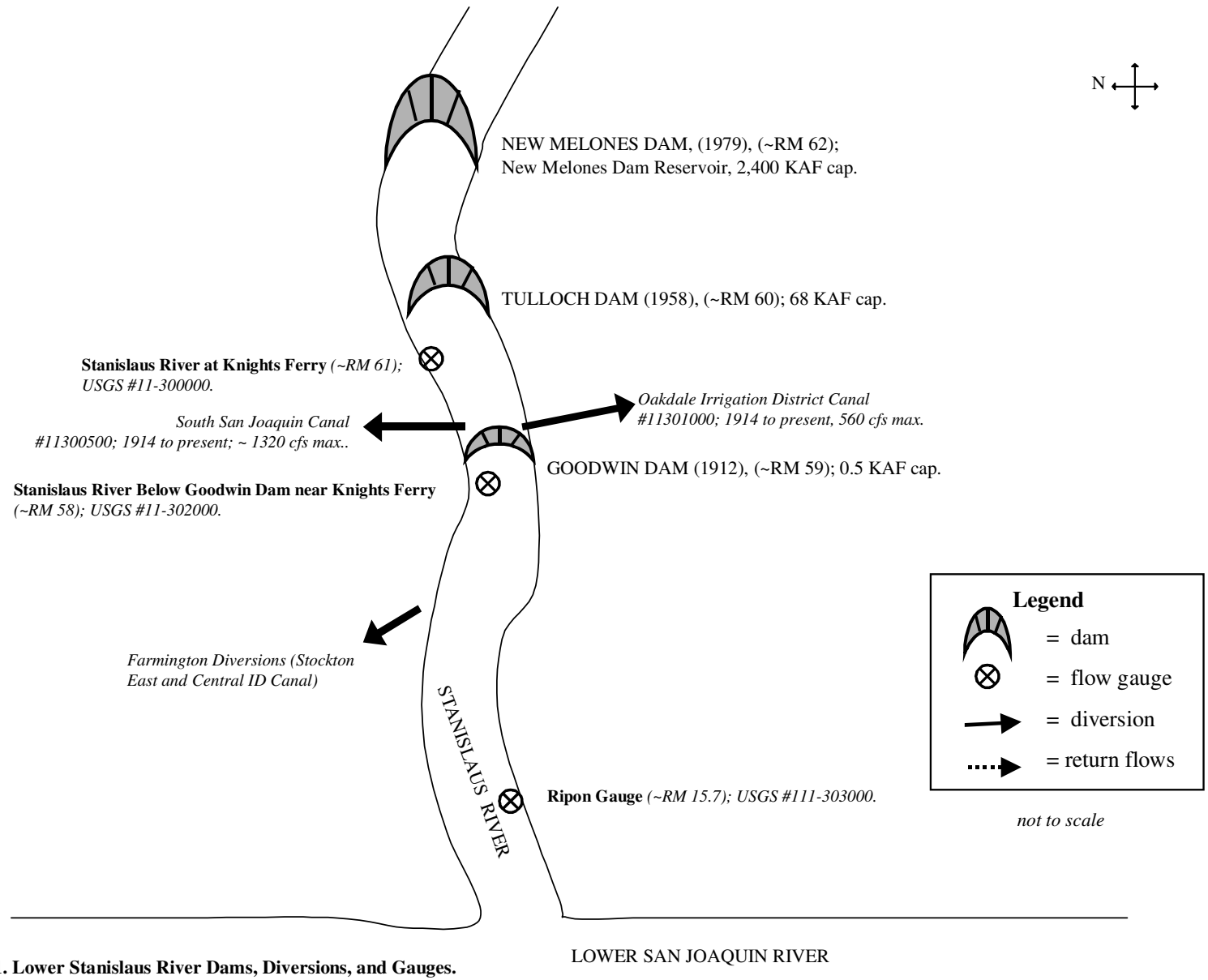

Figure 5.11. Lower Stanislaus River Dams, Diversions, and Gauges.
Data Source: Schneider 1999.

Figure 5.12. New Melones Dam and Reservoir
http://www.usbr.gov/power/data/sites/newmelon/newmelon.htm

The Corps limits the maximum flood releases to 8,000 cfs as measured at Orange Blossom Bridge. When the dam was constructed, the Corps acquired flood easements along the river to maintain a floodway that could convey up to 8,000 cfs. Despite these flood control easements, the Bureau limits flows to 1,500 cfs between March and October to prevent root damage to walnut groves during the growing season.

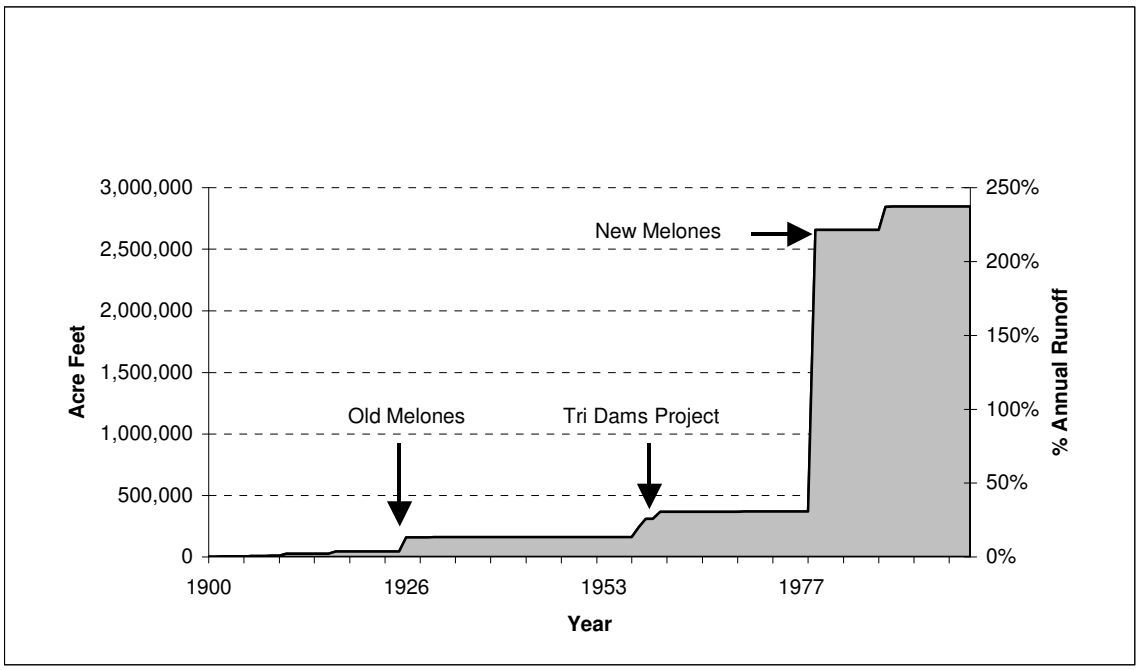

Figure 5.13. Stanislaus River Basin Dams Capacity. Incremental increase in storage capacity expressed as a percentage of mean annual runoff. Note the most noticeable jumps occur in 1926 with the construction of Old Melones Dam, 1957-8 with the Tri-Dams Project, 1979 with New Melones Dam, and 1988 with New Spicer Meadows. The total capacity of Stanislaus River dams is just under 2.85 maf, relative to annual unimpaired runoff of 1.2 maf (Calfed 2000). See Table ST1 for details regarding calculations and data sources. (Adapted from Richter's IHA Report). Data Source: DWR, Bulletin 17-93, June 1993.

Table 5.6. Stanislaus River Basin Dams and Cumulative Storage Capacity.

A	B		C		D	E	F
Year	Dam Name		Stream	Capacity (m3)	Storage Capacity (AF)	Cumulative Storage (AF)	Cum. Storage as % annual unimpaired runoff
1902	Union	NF	N Fork	2,470,000	2,000	2,000	0.2%
1905	Copperopolis	M	Penney Creek	278,000	225	2,225	0.2%
1906	Alpine	NF	Silver Creek	5,670,000	4,596	6,821	0.6%
1908	Stan FB	M	Trib Stan. River	395,000	320	7,141	0.6%
1908	Utica	NF	N Fork	2,960,000	2,399	9,541	0.8%
1910	Relief	MF	Relief Creek	18,700,000	15,158	24,699	2.1%
1912	Goodwin	M	Mainstem	617,000	500	25,199	2.1%
1916	Rodden Lake	M	Lesnini Creek	469,000	380	25,579	2.1%
1916	Main Strawberry	SF	South Fork	22,900,000	18,312	43,891	3.7%
1926	Old Melones [3]	M	Mainstem	139,000,000	112,674	156,566	13.0%
1928	Hunters	NF	Mill Creek	246,000	199	156,765	13.1%
1930	Lyons - PGE	SF	South Fork	7,680,000	6,228	162,993	13.6%
1938	McCarty	M	Trib Johnny Creek	115,000	93	163,086	13.6%
1953	Murphys Afterbay	M	Trib Angels Creek	49,300	40	163,126	13.6%
1953	Murphys Forebay	M	Trib Angels Creek	66,600	54	163,180	13.6%
1953	Fly in Acres	NF	Moran Creek	123,000	100	163,280	13.6%
1957	Beardsley	MF	Middle Fork	120,000,000	77,600	240,880	20.1%
1958	Tulloch	M	Mainstem	84,400,000	68,400	309,280	25.8%
1958	Beardsley Afterbay	MF	Middle Fork	395,000	320	309,600	25.8%
1958	Donnells	MF	Middle Fork	79,600,000	56,893	366,493	30.5%
1965	Reba	NF	Trib Bloods Creek	296,000	240	366,733	30.6%
1970	Utica	NF	No. Fork Stan	2,960,748	2,400	369,133	30.8%
1975	Forest Meadows	M	Angels Creek	133,000	108	369,241	30.8%
1975	Bear Vly Sewage Hldg	NF	Trib Bloods Creek	427,000	346	369,587	30.8%
1976	Holman	M	Trib Angels Creek	308,000	250	369,836	30.8%
1978	Leland Meadows	MF	Leland Creek	97,000	79	369,915	30.8%
1979	New Melones	M	Mainstem	2,960,000,000	2,400,000	2,657,241	221.4%
1980	Murphy's Wastewater	M	Trib Six-Mile Creek	173,000	140	2,657,381	221.4%
1983	Andrew Cademartori	M	Trib Angels Creek	175,000	142	2,657,523	221.5%
1988	North Fork Diversion	NF	No. Fork Stan	148,037	120	2,657,643	221.5%
1988	New Spicer Meadows	NF	Highland Creek	233,000,000	188,871	2,846,514	237.2%
1989	McKays Pt Div	NF	No. Fork Stan	2,590,654	2,100	2,848,614	**237.4%**
	TOTAL LISTED DAMS:	32			TOTAL CAPACITY:	**2,846,514** AF	
	(including Old Melones)					TOTAL:	**237%**

Note: Data on the dams within the Stanislaus basin large enough to be regulated by the Division of Safety of Dams (DOSD), including the y
dam was built (col. A), watershed location (C.), and its storage capacity (D). Col. E details the cumulative storage capacity within the basir
construction of each additional dam. Col. F expresses this cumulative storage as a percentage of total average unimpaired runoff in the ba
MAF, Calfed, 1999). Adapted from Richter's IHA Report.

Data source:

[1] Department of Water Resources, Bulletin17-93, Dams Within the Jurisdiction of the State of California, June 1993.

[2] CALFED Bay-Delta Program, ERPP Draft PEIS/EIR Tech. App., Vol. 2 – Ecological Management Zone Visions, 6/99.

[3] Kondolf et al, 1996, Water Resources Center Rept. 90 (for data on Old Melones Reservoir)

Note – storage from Old Melones (built in 1926) was subtracted when New Melones was filled (1979).

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