Contractor / Water Right Holder	Contract Type	Annual Demand (AF)
West Side ID	CVP Ag	7,500
Davis WD	CVP Ag	5,400
Del Puerto WD	CVP Ag	12,060
Hospital WD	CVP Ag	34,105
Kern Canyon WD	CVP Ag	7,700
Salado WD	CVP Ag	9,130
Sunflower WD	CVP Ag	16,625
West Stanislaus WD	CVP Ag	50,000
Mustang WD	CVP Ag	14,680
Orestimba WD	CVP Ag	15,860
Patterson WD	CVP Ag	16,500
Foothill WD	CVP Ag	10,840
Quinto WD	CVP Ag	8,620
Romero WD	CVP Ag	5,190
Centinella WD	CVP Ag	2,500
City of Tracy	CVP M&I	10,000
Patterson WD Water Rights	WR	6,000
Project Losses	Loss	18,500
CVP Ag		262,310
CVP M&I		10,000
CVP Exchange		0
CVP Refuge		0
Water Right		6,000
CVP Losses		18,500
CVP Total		**290,810**
TOTAL		**296,810**

Table 3-32: West Side Demands (Main Stem Diversions)

Riparian Water Users	Annual Demand (AF)
From Merced River to Tuolumne River	Varies – See Appendix A
From Tuolumne River to Stanislaus River	Varies – See Appendix A

Unlike other water demands on the west side, San Joaquin River west bank riparian demands are not tied to contract amounts. These demands are more similar to east side diversion requirements which vary according to hydrologic conditions within the basin. However, unlike east side demands, west bank riparian diversion requirements were not determined as part of a water budget analysis, but were correlated to corresponding east bank riparian demands using historical data.

4. Accretions/Depletions

Accretions for the San Joaquin River and its major tributaries were estimated by performing a mass-balance for each major river reach. Well established gages (with long periods of record) were used to define upstream and downstream flow points for the mass-balance calculations.

The objective was to establish an accretion/depletion (rainfall runoff/seepage) estimate that does not include the effect of development. Therefore, estimated or recorded historical diversions were added to stream flow and estimated or recorded historical return flows were subtracted. This procedure removes the effects of development on surface inflows and diversions; however, it does not remove the changes in stream-groundwater interaction resulting from development. That component can be addressed when the groundwater modeling portion of the hydrology is complete.

The accretion/depletion mass-balance accounted for water entering and leaving river reaches using the following formula:

Accretion / Depletion =

+ *Downstream River gage*
- *Upstream River gage*
+ *Diversions*
- *Return flow*

The remaining result of this equation was a value equal to the precipitation runoff and historical stream-groundwater interaction, and gage errors. The value is absent of return flows and diversions which will be simulated by CALSIM II.

Land use changes cause a change in rainfall runoff relationships during the passage of time. The previously described accretion/depletion values required adjustment so that rainfall runoff was appropriate for the projected (then current) level of development. The adjustment was designed to modify river accretion/depletion to reflect increases or decreases in runoff resulting from land use changes over time. Output from the DWR CU model is used to estimate this change through the following equation:

Runoff adjustment =

(Projected replaced native vegetation CU - Projected CU of precipitation by crops)
minus
(Historical replaced native vegetation CU - Historical CU of precipitation by crops)

Groundwater

Groundwater is an extremely important component of San Joaquin River Basin hydrology and is the most difficult to simulate. Groundwater conditions affect the stream-groundwater interaction (stream gains and loss). An attempt was made to disaggregate the stream-groundwater interaction from the accretion/depletion values previously described. Existing information from CVGSM in terms of the stream-groundwater interaction appeared to grossly misrepresent the magnitude and direction of flow into or out of the stream reaches. Since the development of a revised groundwater model has not been performed, the accretion/depletion calculation remains an aggregated value of precipitation runoff and stream-groundwater interaction. CALSIM II does not dynamically model the interaction within the Basin of groundwater with streamflow.

In the context of water supply within CALSIM II, groundwater is assumed to provide a water source for demands not met from surface supplies.

Description of Accretions by Reach

River accretions/depletions for key reaches of each tributary are described in this section. The stream gages used in the estimation procedures are also described.

Calaveras River

For the purposes of defining river accretions and depletions, the Calaveras River was identified as having two significant reaches: from New Hogan Dam to Bellota and from Bellota to the San Joaquin River confluence. A description of accretion/depletion estimates for both of these reaches follows.

New Hogan Dam to Bellota

Both accretions (rainfall runoff) and depletions (seepage) were estimated for the Calaveras River reach from New Hogan Dam to Bellota. Monthly rainfall runoff from 1922-1998 was calculated based on available data. The data available to estimate the rainfall runoff were:

- New Hogan release (1961-present)
- Calaveras River at Jenny Lind (1922-1966)
- Cosgrove Creek near Valley Springs, Ca (1930-1969)
- Precipitation (three station average of Galt - B03301, Lodi - B05032, and Oakdale - B06303)

During the time period 1961-1966, there were two coincidental river gage records to calculate accretions. These records can only be used to estimate accretions from New Hogan to Jenny Lind. Based on previous work performed (by MBK Engineers; approximately 1968 and 1980) and verified with the latest available data, rainfall runoff from New Hogan to Jenny Lind can be estimated as 1.4 times

the Cosgrove Creek (near Valley Springs, California) USGS recorded gage flow. Cosgrove Creek flows were extended from 1967 to 1998 using a monthly regression with precipitation, and then multiplying by 1.4 to estimate runoff from New Hogan to Jenny Lind. To estimate the accretions from New Hogan to Bellota, the New Hogan to Jenny Lind accretions were multiplied by a drainage area ratio of 1.5. These accretions are input to CALSIM II as a DSS time series.

Due to insufficient data, depletions (from seepage) were not able to be calculated. CALSIM II assumes a constant 13 cfs depletion for this reach.

Bellota to San Joaquin River Confluence

Accretions and depletions on the Calaveras River below Bellota could not be calculated because of insufficient data. Depletions were assumed to be a constant 6.5 cfs, but no assumption was made for accretions.

Stanislaus River

The Stanislaus River accretions/depletions were estimated for three reaches:

- New Melones Reservoir to Tulloch Reservoir
- Tulloch Reservoir to Goodwin Dam
- Goodwin Dam to Ripon

New Melones Reservoir to Tulloch Reservoir

Accretions for the reach between Melones and Tulloch were estimated to be 20 percent of the unimpaired runoff of the Calaveras River at Jenny Lind. This relationship was developed by DWR planning staff, is based on relative drainage area, and is documented in DWR's September 1995 publication on "Central Valley Future Water Supplies for Use in DWRSIM".

Tulloch Reservoir to Goodwin Dam

Accretions/depletions from Tulloch Reservoir to Goodwin Dam were estimated to be 1.5 percent of the unimpaired runoff of the Calaveras River at Jenny Lind. This relationship was developed by DWR planning staff, is based on relative drainage area, and is documented in DWR's September 1995 publication on "Central Valley Future Water Supplies for Use in DWRSIM".

Goodwin Dam to Ripon

Accretions/depletions for the reach between Goodwin Dam and Ripon were calculated by the following equation.

Accretions/depletions =

	Stanislaus River flow at Ripon
+	*River diversions*
-	*Modesto ID return flows*
-	*Stanislaus River flow below Goodwin*

where,

Stanislaus River flow at Ripon

- Stanislaus River flow at Ripon for 1922-1940 is estimated based on a regression with Goodwin flow, and 1941-1998 is from the USGS record.
- Stanislaus River flow at Ripon for 1922-1940
  = 1.01 * (Stanislaus River flow below Goodwin Dam
  - River Diversions between Goodwin Dam and Ripon
  + Modesto ID return flow upstream from Ripon)
  + 9,684 AF
  (R Squared = 0.99)

Stanislaus River flow below Goodwin Dam

- 1922-1933 Stanislaus River at Knights Ferry
- 1933-1957 Stanislaus River below New Melones plus New Melones Reservoir to Tulloch Reservoir accretions/depletions plus Tulloch Reservoir to Goodwin Dam accretions/depletions minus Oakdale ID and South San Joaquin ID Diversions
- 1957-1999 USGS

Stanislaus River Diversions

- River diversions are from DWR Bulletin 23 and Bulletin 130, SWAM model data, and estimations. Monthly diversion data from DWR bulletins are available for the diversion season from about 1930 through 1958, and year-round from 1959 through 1970. Annual SWAM model data are available from 1970 through 1994. Diversions during the irrigation season from 1922 through 1929 are approximated based on averages from 1932 through 1940 and winter diversions are approximated using average diversions from 1958 through 1970. Annual SWAM data is distributed on a monthly pattern using average monthly diversions from 1958 through 1970. Ten percent of the Stanislaus River diversions are assumed to occur above Ripon and 90 percent between Ripon and the San Joaquin River, based on DWR Bulletin 130 data.

Tuolumne River

Accretions/depletions for the lower Tuolumne River were represented for one reach between LaGrange Dam and Modesto, determined by the following equation:

Accretions /depletions =

Tuolumne River flow at Modesto
\+ *River Diversions*
\- *Turlock ID return flow to Tuolumne River above Modesto*
\- *Modesto ID return flow to Tuolumne River above Modesto*
\- *Tuolumne River below LaGrange*

where,

Tuolumne River flow at Modesto

- Tuolumne River flow at Modesto for 1922-1940 is estimated based on a regression with the Tuolumne City gage, and 1940-1998 is from the USGS record
- Tuolumne River flow at Modesto for 1922-1940
  = 1.03 * (Tuolumne River below LaGrange
  – River Diversions + Turlock ID and Modesto ID return flow between Modesto and Tuolumne City) + 16804 AF

Tuolumne River Diversions

- River diversions are from DWR Bulletin 23 and Bulletin 130, SWAM model data, and estimations. Monthly diversion data from DWR bulletins are available for the diversion season from about 1930 through 1958 and year-round from 1959 through 1970. Annual SWAM model data are available from 1970 through 1994. Diversions during the irrigation season from 1922 through 1929 are approximated based on averages from 1932 through 1940 and winter diversions are approximated using average diversions from 1958 through 1970. Annual SWAM data is distributed on a monthly pattern using average monthly diversions from 1958 through 1970. Based on DWR Bulletin 130, 24 percent of Tuolumne River diversions occur above the Modesto gage, 33 percent occur between Modesto and Tuolumne City, and 43 percent occur below Tuolumne City.

Tuolumne River below LaGrange

- Tuolumne River below LaGrange for 1922-1970 is calculated using Tuolumne River above LaGrange minus Modesto ID and Turlock ID diversions, and 1970-1998 taken from the USGS record.

Merced River

The Merced River accretions/depletions were described for three reaches:

- Exchequer to Crocker-Huffman Dam
- Crocker-Huffman to Cressey
- Cressey to Stevinson

Merced River Accretion from Exchequer to Crocker-Huffman Dam

Accretions/depletions for the Merced River from Exchequer to Crocker-Huffman Dam were determined by the following equation:

Accretions/depletions =

Merced River below Crocker-Huffman Dam
\+ *Merced ID Main Canal Diversion*
\+ *Merced ID North Canal Diversion*
\- *Merced River below Exchequer*

where,

Merced River below Crocker-Huffman Dam

- Merced River below Crocker-Huffman Dam for 1922-1939 is estimated based on a regression with the Merced Falls gage, and 1939-1998 records were provided by Merced ID.
- Merced River above Crocker-Huffman Dam 1922-1939
  = 0.952 * (Merced River below falls + Merced ID Main Canal) + 1666 AF
  (R Square = 0.985)

Flow below Crocker-Huffman Dam is calculated by subtracting Merced ID Main Canal.

Merced ID diversions

- Merced ID Main Canal and North Canal diversions were provided by Merced ID

Merced River below Exchequer

- Merced River below Exchequer for 1922-1964 is estimated based on a regression with Merced Falls gage, 1965-1999 taken from USGS record
- Merced River below Exchequer 1922-1964
  = 0.994 * (Merced River below falls + Merced ID North Canal) + 417 AF
  (R Square = 0.998)

Merced River Accretion from Crocker-Huffman Dam to Cressey

Accretions/depletions between Crocker-Huffman Dam and Cressey were determined by the following equation:

Accretions/depletions =
Merced River at Cressey
\+ *River Diversions*
\- *Merced River below Crocker-Huffman Dam*

where,

Merced River at Cressey

- Merced River at Cressey for 1922-1941 is estimated based on a regression, and 1942-1998 from DWR records
- Merced River at Cressey for 1922-1941
  = 1.13 * (Merced River below falls + Merced ID Main Canal + river diversions) + 1023.7 AF
  (R Square = 0.962)

Merced River Diversions

- River diversions are from DWR Bulletin 23 and Bulletin 130, SWAM model data, and estimations. Monthly diversion data from DWR bulletins are available for the diversion season from about 1930 through 1958 and year round from 1959 through 1970. Annual SWAM model data are available from 1970 through 1994. Diversions during the irrigation season from 1922-1929 are approximated based on averages from 1930-1940, and winter diversion are approximated using average diversions from 1960-1963. Annual SWAM data is distributed on a monthly pattern using average monthly diversions from 1968-1970. This 3 year period was selected based on the construction of New Exchequer. The Merced River diversions are distributed to river reaches based on diversion records for 1966-1970; 78 percent of the total diversion is assumed to occur above Cressey, 17 percent between Cressey and Stevinson, and 5 percent below Stevinson.

Merced River Accretion from Cressey to Stevinson

Accretions/depletions between Cressey and Stevinson were determined by the following equation:

Accretions/depletions =

	Merced River at Stevinson
+	*River diversions*
-	*Merced ID return flows in Livingston Lateral*
-	*Turlock ID Return flows*
-	*Merced River at Cressey*

where,

Merced River at Stevinson

- Merced River at Stevinson for 1922-1940 is estimated based on a regression with the Livingston gage, and 1941-1998 taken from USGS records
- Merced River at Stevinson for 1922-1940
  = 0.962 * (Merced River at Livingston) + 2991 AF
  (R Square = 0.999)

Merced ID flow to Merced River

- Merced ID flow to the Merced River from the Livingston lateral for 1926-1999 is provided by Merced ID, and 1922-1926 is estimated using averages.

San Joaquin River Main Stem

San Joaquin River main stem accretions/depletions encompass the river reach from Vernalis to the confluence of the Merced River. San Joaquin River flow at Vernalis and Newman are the only available long-term (1922-1998) flow records

in this reach. The accretions/depletions for this reach also include the accretions/depletions of the lower Stanislaus River below Ripon and the lower Tuolumne River below Modesto.

The San Joaquin River Basin has experienced numerous physical changes from 1922 through 1998. Both reservoir construction on San Joaquin River tributaries and levee construction in the valley floor have changed the Basin's flow characteristics. Flooding in the valley floor was more severe before the construction of upstream reservoirs, which resulted in difficulties measuring flows throughout the valley. Also, as levees were constructed in the valley, flood flows that typically bypassed stream gages would remain in stream channels more often, allowing more accurate flow measurements. These changes have had a significant effect on the estimate of accretions/depletions along the San Joaquin River.

Annual San Joaquin River accretions/depletions were initially developed using a mass-balance approach. The results are presented in Figure 4-1. An initial mass-balance estimate of accretions/depletions for this river reach indicates the river was losing water during the 1920s. However, this finding does not seem reasonable as the Vernalis stream flow gage was not in place until about 1929, and flows at Vernalis before this date were roughly estimated based on Stanislaus River at Ripon, Tuolumne River at Modesto, and San Joaquin River at Newman (1957 Joint Hydrology Study) records. From approximately 1930 to 1970, there were several reservoirs built and levees that were constructed, and the trend was an increase in annual accretions/depletions. After about 1970, the annual accretions/depletions are highly correlated to San Joaquin River Basin precipitation and wetness.

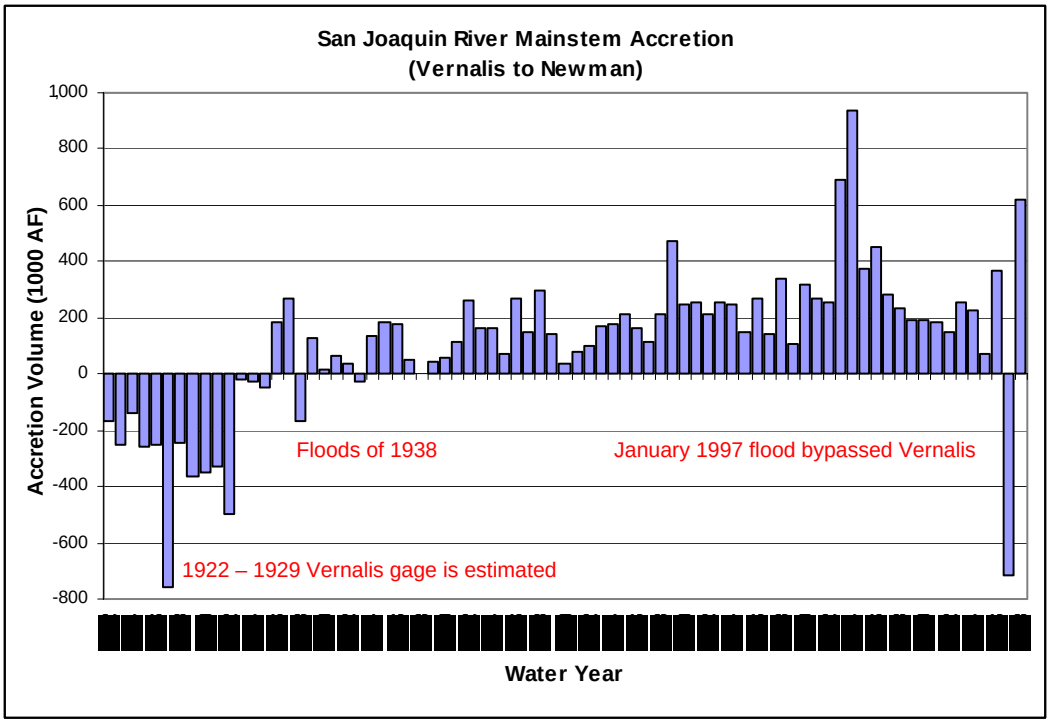

Figure 4-1: Annual San Joaquin River Main Stem Accretion from Vernalis to Newman (Based on Mass-Balance Only)

Since a goal of the hydrology development was to develop recent projected level accretions/depletions, and that the accretions/depletions apparent from a mass-balance of recorded flow seemed for some periods to be unreasonable, a synthetic record of the river's gains and losses for the period prior to 1970 was developed. San Joaquin River main stem accretions/depletions prior to 1970 were estimated based on relationships between: 1) gains/losses that occurred after 1970 and, 2) precipitation and flows entering the main stem of the San Joaquin River. Figure 4-2 illustrates the estimated annual accretions/depletions using regression equations for years prior to 1970 and a strict mass-balance approach for after 1970.

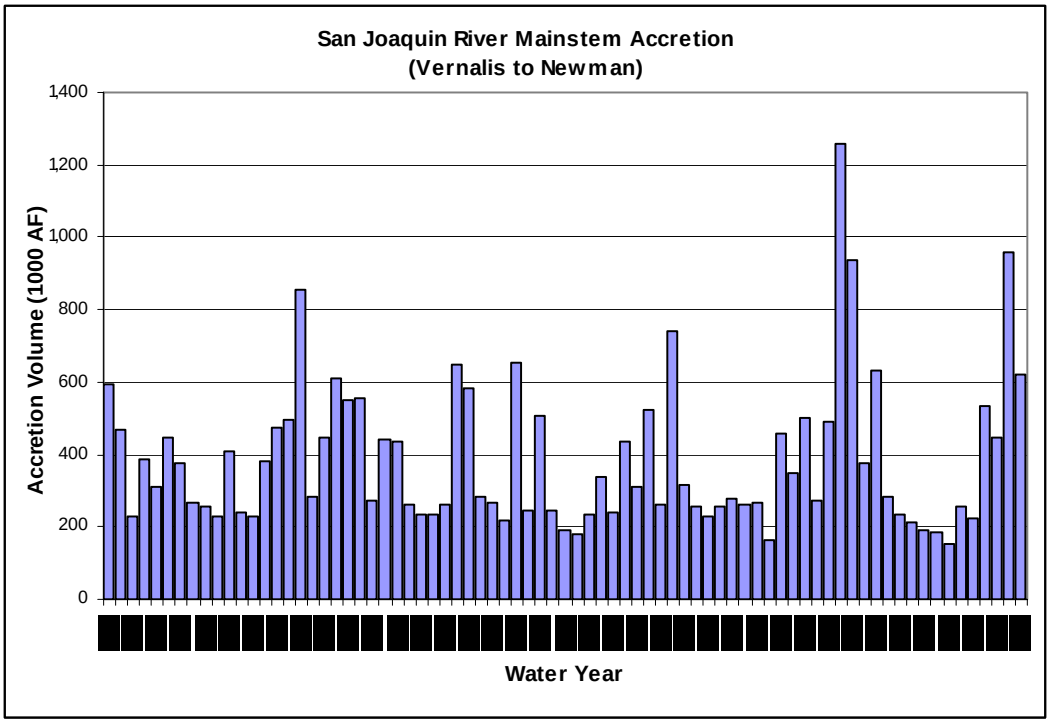

Figure 4-2: Annual San Joaquin River Main Stem Accretion from Vernalis to Newman (Based on Mass-Balance and Regression Analysis)

The San Joaquin River main stem accretions/depletions estimates for the 1970-1998 period were determined by the following equation:

Newman to Vernalis accretions/depletions =

	San Joaquin River at Vernalis
-	*Stanislaus River at Ripon*
-	*Tuolumne River at Modesto*
-	*San Joaquin River at Newman*
-	*Merced River Slough*
+	*San Joaquin River diversions*
+	*Stanislaus River diversions downstream from Ripon*
-	*Return flow from San Joaquin River Diversions*
-	*Turlock ID return flow*
-	*Modesto ID return flow*
-	*Return flow from the west side of the San Joaquin Valley*
+	*Runoff adjustment*

where,

<u>*San Joaquin River at Vernalis*</u>

- San Joaquin River at Vernalis for 1922-1923 and 1925-1929 is from DWR planning data and 1924, 1930-1998 is from USGS records.

<u>*San Joaquin River at Newman*</u>

- San Joaquin River at Newman is from USGS records.

Merced River Slough

- Merced River Slough for 1922-1941 and for 1973-1998 is based on a regression with Merced River at Stevinson, and 1942-1972 is from USGS records.
- Merced River Slough for 1942-1972
  = 0.189 * (Merced River at Stevinson) - 3680 AF
  (R Square = 0.626)

San Joaquin River Diversions

- River diversions are from DWR Bulletin 23 and Bulletin 130, SWAM model data, and estimations. Monthly diversion data from DWR bulletins are available during for the diversion season from about 1930 through 1958, and year-round from 1959 through 1970. Annual SWAM model data are available from 1970 through 1994. Diversions during the irrigation season from 1922-1929 are approximated based on averages from 1932-1940 and winter diversions are approximated using average diversions from 1958-1970. Annual SWAM data is distributed on a monthly pattern using average monthly diversions from 1958-1970.

Return flow from San Joaquin River Diversions

- Return flows from San Joaquin River diversions are assumed to be 30 percent of diversions.

Modesto ID and Turlock ID Return Flows

- These return flows are documented in the discussion of their respective district operations.

Return flow from the west side of the San Joaquin Valley

- Return flows from the west side of the San Joaquin Valley are estimated as 30 percent of contractual deliveries (surrogate of total water supply) to Delta-Mendota Canal contractors.

Table 4-1 contains the coefficients used for estimating San Joaquin River accretions/depletions for 1922 through 1970, and during the months after 1970 when the record appeared to indicate flood flow bypassed stream gages. DSA 49 precipitation for the current month and previous month are two coefficients used. Upstream flow in the Stanislaus River at Ripon, Tuolumne River at Modesto, and San Joaquin River at Newman in the current and previous months are also used. October accretions were not able to be calculated based on these coefficients; therefore, the average of September and November accretions/depletions are used for October.

Table 4-1: Coefficients used for estimating San Joaquin River Basin Accretions/Depletions

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Intercept		7,669	12,575	0	0	0	13,109	13,852	21,036	16,656	18,702	17,814
Previous Month Precipitation		0	0	0	0	0	0	0	0	0	0	0
Current Month Precipitation		0	0	0	0	0	0	0	0	20,780	0	0
Previous Month Upstream Flow		0.127	0	0.166	0.063	0.067	0	0	0.02	0	0	0.078
Current Month Upstream Flow		0	0.068	0	0.025	0.054	0.053	0.075	0	0.11	0.1	0

Water quality calculations and New Melones Reservoir operation procedures within CALSIM II require the determination of flow and water quality in the San Joaquin River upstream of the Stanislaus River confluence. This upstream location is indicative of the Maze Boulevard crossing of the San Joaquin River. The division of the San Joaquin River accretions/depletions above and below this site is estimated as follows:

Vernalis to Maze

- 5 percent of Vernalis to Newman

Maze to Newman

- 95 percent of Vernalis to Newman

San Joaquin River Drainage Area Upstream from Merced River

Above Fremont Ford (representing the drainage upstream of the confluence with the Merced River), the San Joaquin River drainage area covers approximately 8,247 square miles. More than 16 riparian diversions have been identified between Gravelly Ford and Fremont Ford by DWR (Bulletin 130-68). These diversions averaged 728,900 AF per year between 1922 and 1980 (Reclamation et al., 1990). Most of these diversions are at or below Mendota Pool and are currently supplied by water from the Delta-Mendota Canal.

Historically, the San Joaquin River (between Gravelly Ford and Fremont Ford) received inflow from several large tributaries, including the Fresno and Chowchilla Rivers. Currently, most of the flow in the Fresno and Chowchilla Rivers is diverted, reaching only the San Joaquin River during flooding events. The rest of the time, flow in this reach of the San Joaquin River consists primarily of imported Delta water via the Delta-Mendota Canal, which is released from the Mendota Pool for subsequent diversion, agricultural returns, and releases from

wildlife areas. Between Sack Dam and the Salt Slough confluence, an approximate reach length of 54 miles, there is usually slight or no flow. Mud and Salt Sloughs contribute irrigation return flows to the lower end of this reach.

Accretions/depletions for the San Joaquin River drainage area upstream from Merced River include accretions for the Fresno River, Chowchilla River, and the San Joaquin River from Friant to Gravelly Ford, the Mendota Pool area, and minor streams upstream from the Merced River. Accretions/depletions were calculated for these river reaches.

San Joaquin River Upstream Accretions/Depletions

Due to the lack of available records, only a single composite estimate of accretions/depletions for the area upstream of the Merced River was made. This estimate was determined by the following equation:

San Joaquin River drainage area accretions upstream from Merced River =

	San Joaquin River at Newman
+	*Merced River Slough*
+	*Merced River at Stevinson*
-	*Chowchilla River below Buchanan Dam*
-	*Fresno River below Hidden Dam*
-	*San Joaquin River below Friant*
-	*Madera Canal at Head*
-	*James Bypass flow to Mendota Pool*
-	*Delta Mendota Canal flow to Mendota Pool*
+	*San Joaquin River diversions from Friant to Gravelly Ford*
+	*Mendota Pool diversions*
+	*Madera ID diversions*
+	*Chowchilla WD diversions*
-	*Return flows*
+	*Runoff Adjustment*
-	*Seepage estimates for Chowchilla River, Fresno River, San Joaquin River from Friant to Gravelly Ford, San Joaquin River at Gravelly Ford to Mendota Pool, and Mendota Pool*

where,

Chowchilla River below Buchanan Dam

- Chowchilla River below Buchanan Dam for 1922-1923 and 1931-1998 is from USGS records and 1924-1930 is from DWR planning data.

San Joaquin River below Friant

- Flow for the San Joaquin River below Friant is from USGS records.

Madera Canal at Head

- Flow for the Madera Canal at Head is from USGS records.

James Bypass flow to Mendota Pool

- James Bypass flow to Mendota Pool for 1922-1927 is from DWR planning data, 1928-1977 is from DWR records, and 1978-1998 is from USGS records.

Delta Mendota Canal flow to Mendota Pool

- Delta-Mendota Canal flow to Mendota Pool is from USBR reports of operation, and DWR Bulletin 130 when USBR reports were unavailable.

Mendota Pool diversions

- Mendota Pool diversions for 1922-1949 are estimated based on San Joaquin River flow at Friant, San Joaquin River losses and diversion above Mendota Pool, James Bypass flow, and average diversions from 1950-1998. Diversions from 1950-1999 are from DWR Bulletin 23 and Bulletin 130, DWR San Joaquin Division records (1949-1981), and USBR records (1982-1999)

Madera ID diversions

- Madera ID diversions from 1922-1939 are estimated based on a 200 cfs water right and water availability, and 1939-2000 records provided by Madera ID

Chowchilla WD diversions

- Chowchilla WD diversions are estimated based on Madera Canal delivery and flow in the Chowchilla River. Maximum monthly diversions, determined by recent operations, limit the use of springtime flows.

Fresno River Accretions

Flow data prior to 1951 is unavailable for the lower Fresno River; therefore, the Fresno River accretions/depletions estimate was used to estimate seepage only. Precipitation runoff was included in the accretions/depletions calculation for the entire San Joaquin River drainage upstream from the confluence of the Merced River. Fresno River accretions/depletions for 1952-1998 were calculated using the following equation:

Fresno River accretion from Hidden to gage 8 miles west of Madera =

	Fresno River flow 8 Miles west of Madera
+	*Madera ID Main Canal diversion*
-	*Fresno River below Hidden Dam*
-	*Madera Canal release for Madera ID diversion*
-	*Madera Canal flood release to Fresno River*

where,

Fresno River below Hidden Dam

- Hidden Dam release for 1922-1941 is estimated from a regression with Fresno River at Knowles, flow for 1942-1998 is from USGS records.
- Hidden Dam release for 1922-1941
  = 1.51 * Fresno River at Knowles
  (R Squared = 0.96)

Fresno River flow 8 Miles west of Madera

- Fresno River flow 8 Miles west of Madera, Madera ID Main Canal diversion, Hidden Dam release, Madera Canal release for Madera ID diversion, and Madera Canal flood release to Fresno River data were all provided by Madera ID.

Chowchilla River Accretions

An accretions/depletions estimate for the lower Chowchilla River, Ash Slough, and Berenda Slough was not possible because flow data is unavailable. Precipitation runoff was included in the accretion calculation for the entire San Joaquin River drainage upstream from the confluence of the Merced River. Seepage estimates were extracted from a DWR operation study of Chowchilla WD and Buchanan Dam. Seepage was estimated as 4,200 AF per month, or the sum of release from Buchanan Dam and Madera Canal release to the Chowchilla River, whichever was less.

San Joaquin River from Friant Dam to Gravelly Ford

Since the completion of Friant Dam in 1941, the majority of the annual flow of the San Joaquin River at the dam has been diverted to the Friant-Kern and Madera Canals. Average monthly releases from Friant Dam to the San Joaquin River since 1941 have included releases to satisfy water rights and contractual obligations above Gravelly Ford and flood control releases. Approximately 20 small diversions are located between Friant Dam and Gravelly Ford (DWR Bulletin 130).

Flow data for the San Joaquin River at Gravelly Ford is unavailable before 1974; therefore, the accretions/depletions estimate for 1974-1998 was used to estimate seepage for the reach. Precipitation runoff was included in the accretions/depletions calculation for the entire San Joaquin River drainage upstream from the confluence of the Merced River. The accretions/depletions (seepage) for the reach were estimated by the following equation:

San Joaquin River Accretion from Friant to Gravelly Ford 1974-1998 =
San Joaquin River at Gravelly Ford
\+ *River Diversions*
\- *San Joaquin River below Friant Dam*

where,

San Joaquin River below Friant Dam

- From USGS records.

San Joaquin River at Gravelly Ford

- From USBR records.

San Joaquin River Diversions

- River diversions are from DWR Bulletin 23 and Bulletin 130, SWAM model data, and estimations. Monthly diversion data from DWR Bulletins are available about 1949 through 1970. Annual SWAM model data are available from 1970 through 1994. Diversions from 1922-1949 are approximated based on averages from 1950-1970. Annual SWAM data is distributed on a monthly pattern using average monthly diversions from 1950-1970.

San Joaquin River from Gravelly Ford to Mendota Pool

The San Joaquin River reach between Gravelly Ford and Mendota Pool was estimated to lose up to 200 cfs of the available flow at Gravelly Ford. This estimate is consistent with information acquired from pilot projects recently performed on the San Joaquin River.

Salt Slough and Mud Slough

Salt Slough and Mud Slough primarily convey agricultural and wildlife area drainage water to the San Joaquin River. During the winter and spring, flows in the sloughs consist primarily of a combination of subsurface agricultural drainage, precipitation runoff, and surface runoff discharges from agricultural areas and wildlife areas. Summer and fall flows consist primarily of agricultural tail water, irrigation district spill water, and subsurface agricultural drainage. Following the closure of Kesterson Reservoir and the San Luis Drain in 1985, some amount of agricultural subsurface drainage from water users on the west side of the San Joaquin Valley is routed to Mud Slough (north) into the San Joaquin River.

The Salt Slough and Mud Slough systems are modeled in CALSIM II as a combined stream network. As a component of its connection to the San Joaquin River, a base flow is assumed for the streams. Flow from the Grasslands Bypass Project is explicitly modeled in CALSIM II.

5. Rim Basin Flows

San Joaquin watershed "rim basins" consist of watersheds in the Sierra Nevada Mountains and foothills that drain into the San Joaquin Valley floor. Rim basins are represented in CALSIM II as inflows at specific locations. For the San Joaquin River portion of CALSIM II, rim basins typically flow into reservoirs, and are input into CALSIM II as:

- San Joaquin River inflow to Millerton Lake
- Fresno River inflow to Hensley Lake
- Chowchilla River inflow to Eastman Lake
- Merced River inflow to Lake McClure
- Tuolumne River inflow to Don Pedro Reservoir
- Stanislaus River inflow to New Melones Reservoir
- Littlejohns Creek flow into Central San Joaquin WCD
- Calaveras River inflow to New Hogan Reservoir
- Kings River flow to James Bypass

San Joaquin River Inflow to Millerton Lake

Above Friant Dam, the San Joaquin River drains an area of approximately 1,676 square miles and has an average annual unimpaired runoff of 1.7 million AF. The median historical unimpaired annual runoff is 1.4 million AF, with a range of 0.4 to 4.6 million AF. Several reservoirs in the upper portion of the San Joaquin River watershed, including Mammoth Pool and Shaver Lake, are primarily used for hydroelectric power generation and have a combined storage capacity of approximately 620,000 AF. The operation of these reservoirs affects the inflow to Millerton Lake.

Millerton Lake inflow is derived from the modeling output of the "Base Plan" that used the Upper San Joaquin River Basin Model (USAN), which simulates current San Joaquin River operations from headwaters to Millerton Lake. USAN is a daily time step model and its Millerton Lake inflow data have been converted to monthly average values for CALSIM II.

Fresno River Inflow to Hensley Lake

The Fresno River is a tributary to the San Joaquin River that drains a watershed of approximately 237 square miles in foothills of the Sierra Nevada. Because of the relatively low elevation of the watershed, most of the flow in the Fresno River results from rainfall.

Historically, the Fresno River has behaved as an ephemeral stream with large winter flood flows and near zero summertime flows. The Fresno River ultimately discharges into the East Side Bypass. Fresno River inflow to Hensley Lake is estimated as the flow below Hidden Dam, adjusted for change in contents and evaporation in Hensley Lake.

Chowchilla River Inflow to Eastman Lake

The Chowchilla River, a tributary to the San Joaquin River, drains a watershed of approximately 236 square miles in the Sierra Nevada. Because of the relatively low elevation of the watershed, most of the flow in the Chowchilla River results from rainfall.

Historically, the Chowchilla River has behaved as an ephemeral stream with large winter flood flows and near zero summertime flows. The Chowchilla River ultimately discharges into the East Side Bypass. Chowchilla River inflow to Eastman Lake is estimated as the flow below Buchanan Dam, adjusted for change in contents and evaporation in Eastman Lake.

Merced River Inflow to Lake McClure

The Merced River originates in the Sierra Nevada, and drains an area of approximately 1,273 square miles east of the San Joaquin River. Portions of the upper Merced watershed drain national parklands. The average unimpaired runoff in the Basin is approximately 1 million AF per year (AF/year). The median historical unimpaired annual runoff is 0.8 million AF, with a range of 0.2 to 2.8 million AF.

Merced River inflow to Lake McClure is estimated as the flow below Exchequer Dam, adjusted for change in contents and evaporation in Lake McClure.

Tuolumne River Inflow to New Don Pedro Reservoir

The Tuolumne River originates in the Sierra Nevada and drains a watershed of approximately 1,540 square miles. The Tuolumne River is the largest tributary to the San Joaquin River with an annual average unimpaired runoff of approximately 1.95 million AF. The median historical unimpaired annual runoff is 1.8 million AF, with a range of 0.4 to 4.6 million AF.

Flow in the Tuolumne River upstream of New Don Pedro Reservoir is significantly influenced by the operations of the City and County of San Francisco’s Hetch Hetchy Water and Power Project. Inflow to New Don Pedro Reservoir is included in CALSIM II as a time series data set that has been provided by San Francisco. The data is the result of a simulation of long-term

project operations with current facilities. Inflow data for 1922-1996 is simulated by San Francisco's modeling. Data after 1996 is equal to actual computed inflow to New Don Pedro Reservoir.

Stanislaus River Inflow to New Melones Reservoir

The Stanislaus River originates in the Sierra Nevada and drains a watershed of approximately 900 square miles. The average unimpaired runoff in the Basin is approximately 1.2 million AF/year; the median historical unimpaired annual runoff is 1.1 million AF, with a range of 0.2 to 3.0 million AF. Snowmelt contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of May and June. Basin runoff is affected by upstream reservoirs.

Inflow to New Melones Reservoir is a times series representing a combination of planning study inflows and actual recorded inflow for recent years developed by Reclamation.

Littlejohns Creek Inflow to Central San Joaquin Water Conservation District

Littlejohns Creek flows into Central San Joaquin WCD and provides a source of water for district irrigation. A record of full natural flow on Littlejohns Creek was available from the 2001 San Joaquin County Water Management Plan (prepared by Camp Dresser & McKee) and was incorporated into CALSIM II as a monthly time series.

Calaveras River Inflow to New Hogan Reservoir

The Calaveras River originates in the Sierra Nevada, drains an area of approximately 363 square miles, and enters the San Joaquin River near the City of Stockton. The Calaveras River watershed is almost entirely below the effective average snowfall level (5,000 feet), and receives nearly all of its flow from rainfall. As a result, nearly all of the annual flow occurs between November and April. The median historical unimpaired annual runoff is 130,000 AF, with a range of 8,000 to 600,000 AF. Seepage from the north fork of the Stanislaus River also enters the Basin from diversion canals and reservoirs. In the late summer/early fall, a portion of the river in the valley is commonly subject to periods of low or no flow for numerous days or weeks.

Inflow to New Hogan for 1922 through 1963 is estimated as the Calaveras River flow at Jenny Lind, plus estimated accretions from New Hogan to Jenny Lind adjusted for change in contents of Old Hogan Reservoir and evaporation. The U.S. Army Corps of Engineers (COE) data is used from 1963 to 1998.

Kings River to James Bypass

James Bypass flow to Mendota Pool was provided by DWR planning staff. The flow is equal to historical for the period after Pine Flat Dam was constructed. Flows prior to construction of Pine Flat were estimated by DWR planning staff.

6. Regulations and Agreements

Minimum in-stream flow requirements and agreements governing in-stream flows that have an effect on San Joaquin River hydrology and operations are described in this section.

San Joaquin River below Friant Dam

Other than flood control releases, the release from Friant Dam to the San Joaquin River is normally limited to that amount necessary to maintain diversions by riparian and contractor users below Friant Dam to a location near Gravelly Ford. Water diverted to the fish hatchery below Friant Dam and returned to the river partially serves that purpose. Review of historical operation records provides guidance in estimating the minimum downstream release. From an analysis of the historical record (1990-1994) for periods when no flood control releases were made, an annual release of 116,700 AF was estimated to be the current minimum release necessary to meet downstream diversions (including seepage). Table 6-1 illustrates the assumed monthly distribution of this release requirement.

Table 6-1: Estimated Millerton Lake Minimum River Release Requirement (1,000 AF)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10.1	7.4	6.7	4.5	5.0	6.6	9.0	10.9	12.9	14.4	15.7	13.4

Total: 116,700 AF

Fresno River

Flow in the Fresno River must be maintained at a level sufficient to satisfy water right holder diversions downstream from Madera ID. This requirement is zero during dryer years; however, in wetter years the required flow is about 4,000-5,000 AF/year. The actual flow that must be released from Hensley Lake is determined through complicated daily accounting of Fresno River flows and Hensley Lake storage. For the purpose of CALSIM II simulation, the schedule outlined in Table 6-2 is assumed:

Table 6-2: Required flow below Madera ID diversion (1,000 AF)

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Normal	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	4.0
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Merced River

Due to a water rights agreement known as the Cowell Agreement, the Merced ID must make available below Crocker-Huffman Diversion Dam an amount of water that can then be diverted from the Merced River at a number of private ditches between Crocker-Huffman Diversion Dam and Shaffer Bridge. Two additional riparian diversions not covered under the Cowell Agreement exist off of the Merced Falls pool. The Merced River also has flow requirements as set forth by the Federal Energy Regulatory Commission (FERC) and the Davis-Grunsky contract between the State of California and Merced ID.

In order to satisfy the flow requirements and the Cowell Agreement, the district operates to a target flow below Crocker-Huffman Diversion Dam equal to the Cowell Agreement entitlement plus the FERC/Davis-Grunsky flow requirements. The flow below Crocker-Huffman Diversion Dam must equal the greater of the Davis-Grunsky and FERC flows, plus the Cowell Agreement entitlement. The flow requirement and Cowell Agreement entitlements are listed in Table 6-3, and are implemented in CALSIM II.

Table 6-3: Merced River Minimum Flow Requirements (cfs)

Month	Davis Grunsky Crocker-Huffman Dam to Shaffer Bridge	FERC At Shaffer Bridge		Cowell Agreement Entitlement
		Normal Year [1]	Dry Year [2]	
Oct 1-15	0	25	15	50 [3]
Oct 16-31	0	75	60	50 [3]
Nov	180-220	100	75	50 [3]
Dec	180-220	100	75	50 [3]
Jan	180-220	75	60	50 [3]
Feb	180-220	75	60	50 [3]
Mar	180-220	75	60	100
Apr	0	75	60	175
May	0	75	60	225
Jun	0	25	15	250 [4]
Jul	0	25	15	225 [4]
Aug	0	25	15	175 [4]
Sep	0	25	15	150 [4]

[1] Normal year as defined by FERC license: Forecasted April through July inflow to Lake McClure is equal to or greater than 450,000 AF, as published in DWR May 1 Bulletin 120.
[2] Dry year as defined by FERC license: Forecasted April through July inflow to Lake McClure is less than 450,000 AF, as published in DWR May 1 Bulletin 120.
[3] Entitlement is equal to 50 cfs or the natural flow of the Merced River (inflow to Lake McClure), whichever is less.
[4] If the natural flow of the Merced River falls below 1,200 cfs in the month of June, the entitlement flows are reduced accordingly from that day: 225 cfs flow for next 31 days; 175 cfs flow for next 31 days; 150 cfs for next 30 days; 50 cfs for the remainder of September

Tuolumne River

Minimum flows for the Tuolumne River are required by the FERC license for the New Don Pedro Project. The FERC license identifies ten year type classifications for the Tuolumne River, of which only seven have distinctly different minimum flow schedules.

Table 6-4: Tuolumne River FERC Flow Requirement Classification

Year Type Classification	San Joaquin Basin 60-20-20 Index (1000 AF)
Critical and Below	<1500
Median Critical	1500
Intermediate Critical/Dry	2000
Median Dry	2200
Intermediate Dry/Below Normal	2400
Median Below Normal	2700
Intermediate Below Normal/ Above Normal	3100
Median Above Normal	3100
Intermediate Above Normal/ Wet	3100
Median Wet/ Maximum	3100

For each year type classification, a basic schedule of flows is identified for the break point for the year type. For example, if the San Joaquin Basin Index is 1,550 thousand acre-feet (TAF) the year is classified as Median Critical and its basic schedule is a volume of 103,000 AF. The FERC license requires an interpolation of schedules within year type classifications. Therefore, the annual FERC requirement for this example is a linearly interpolated volume between the Median Critical schedule (103,000 AF) and the Intermediate Critical/Dry schedule (117,016 AF).

For CALSIM II modeling purposes, the amount of water determined from the interpolation (e.g., above 103,000 AF) is assumed to be added to the basic schedule during the out migration pulse flow period. The flow schedules are implemented on an April through following March flow year. CALSIM II inputs the flow requirements through time series data.

Table 6-5: Tuolumne River Minimum Flow Schedules

	Critical and Below	Median Critical	Intermediate Critical/ Dry	Median Dry	Intermediate Dry/ Below Normal	Median Below Normal	Intermediate Below Normal/ Above Normal and Above

	Critical and Below	Median Critical	Intermediate Critical/ Dry	Median Dry	Intermediate Dry/ Below Normal	Median Below Normal	Intermediate Below Normal/ Above Normal and Above
Annual Volume (AF)	94,000	103,000	117,016	127,507	142,502	165,002	300,923
October 1 – 15	100	100	150	150	180	200	300
Attraction Pulse Flow (AF)	None	None	None	None	1,676	1,736	5,950
October 16-May 31	150	150	150	150	180	175	300
Out migration Pulse Flow (AF)	11,091	20,091	32,619	37,060	35,920	60,027	89,882
June 1 – September 30	50	50	50	75	75	75	250

Note: Units are in average monthly cfs unless otherwise noted.

Stanislaus River

1997 New Melones Interim Plan of Operations

The New Melones Interim Plan of Operations (IPO) documents a stakeholder-based allocation of supply to four purposes: fishery, water quality, Bay-Delta flow, and water supply. In this discussion, fishery refers to flow requirements of the 1987 Reclamation, Department of Fish and Game (DFG) Agreement and prescriptive use of Central Valley Project Improvement Act (CVPIA) 3406(b)(2); water quality refers to State Water Resources Control Board (SWRCB) Decision 1641 (D-1641) salinity objectives at Vernalis; Bay-Delta flow refers to D-1641 flow requirements at Vernalis (not including pulse flows during the April 15 - May 16 period, “Vernalis Adaptive Management Plan”); and water supply refers to CVP contractors, Stockton East WD and Central San Joaquin WCD.

Table 6-6 below identifies the allocation of annual water supply to each of the purposes. The allocations are linearly interpolated based on the value of the end-of-February New Melones Storage, plus the March - September forecast of inflow to the reservoir. Water is provided to Oakdale ID and South San Joaquin ID in accordance with their settlement with Reclamation (water year basis). Required releases to the Stanislaus River below Goodwin Dam are accounted in the following order: 1) releases up to the amount of the fishery pattern are debited from the annual fishery allocation; 2) releases up to the amount of the D-1641 Bay-Delta flow requirement, excluding the amount of fishery release, are debited from the annual Bay-Delta flow allocation; and 3) releases up to the amount of the Vernalis water quality requirement, excluding the amount of fishery and Bay-

Delta flow allocations, are debited from the annual Vernalis water quality allocation.

Table 6-6: New Melones Interim Plan of Operation Allocations (1,000 AF)

New Melones Storage Plus Inflow		Fishery		Vernalis Water Quality		Bay-Delta		CVP Contractors	
From	To	From	To	From	To	From	To	From	To
0	1,400	0	98	0	70	0	0	0	0
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90

Additional releases are made to the Stanislaus River below Goodwin Dam if necessary, to meet the Decision 1422 (D-1422) dissolved oxygen content objective. Those releases are defined in CALSIM II by a surrogate flow requirement. Releases from Goodwin Dam to the Stanislaus River (except for flood control) do not exceed 1,500 cfs.

Deliveries to the Oakdale ID and South San Joaquin ID are limited by the following equation:

Oakdale ID/South San Joaquin ID Maximum Diversion

- Annual volume equals 600 TAF unless water year inflow is less than 600 TAF.
- When less than 600 TAF the following formula is applied:

  Entitlement = Inflow + (600 – Inflow) / 3

The districts are assumed to each have entitlement to one-half of the water determined available.

1987 Reclamation, Department of Fish and Game Agreement, and U.S. Fish and Wildlife Service Discretionary Use of CVPIA 3406(b)(2)

Depending on the fishery allocation (0 - 467 TAF/Yr) under the New Melones IPO, the fishery release volume at Goodwin Dam is managed under the base and pulse flow schedules shown in Table 6-7 below. Values are interpolated between the seven discrete schedules. Fishery releases are based on the 1987 Reclamation-DFG agreement and U.S. Fish and Wildlife Service (FWS) discretionary use of the CVPIA 3406(b)(2) account to support release goals established by the Anadromous Fish Restoration Program (AFRP).

Table 6-7: Stanislaus River Minimum and Pulse Flow Schedules

Annual Fishery Allocation (TAF)	0	98.4	243.3	253.8	310.3	410.2	466.8
Minimum Flow Schedules (cfs)							
January	0	125	250	275	300	350	400
February	0	125	250	275	300	350	400
March	0	125	250	275	300	350	400
April	0	250	300	300	900	1500	1500
May	0	250	300	300	900	1500	1500
June	0	0	200	200	250	800	1500
July	0	0	200	200	250	300	300
August	0	0	200	200	250	300	300
September	0	0	200	200	250	300	300
October	0	110	200	250	250	350	350
November	0	200	250	275	300	350	400
December	0	200	250	275	300	350	400
Pulse Flow Schedules (cfs)							
Apr 15 – May 16	0	500	1500	1500	1500	1500	1500

State Water Resources Control Board Decision 1422

CALSIM II has neither the ability to predict or adjust operations for dissolved oxygen within the Stanislaus River. D-1422 requires that water be released from New Melones to maintain the dissolved oxygen concentration in the Stanislaus River at a value of at least 7 mg/l as measured near Ripon. As a surrogate, specific volumes of release are made from Goodwin Dam as required, to meet this criterion. The surrogate volumes are shown in Table 6-8 below.

Table 6-8: Surrogate Dissolved Oxygen Release Volumes (1,000 AF)

Month	Release Volume
June	13.2
July	16.2
August	16.4
September	14.3

State Water Resources Control Board Decision 1641 – Vernalis Water Quality and Flow

The salinity objective near Vernalis was originally defined in SWRCB D-1422. SWRCB D-1641 provisions have revised this requirement. CALSIM II calculates the salinity concentration at Vernalis by evaluating the blended flows and their associated assumed salinity concentrations that reach Vernalis. D-1641 requires salinity near Vernalis to be less than 0.7 electrical conductivity (EC) for April - August and less than 1.0 EC September - March. Releases are made from New Melones, as required, up to the allocation provided by the New Melones IPO, to meet this criterion.

D-1641 also requires the flow at Vernalis to be maintained during the February through June period. The flow requirement is based on the required location of

"X2" and the San Joaquin Basin Index according to Table 6-9. The objectives of the Vernalis Adaptive Management Plan (VAMP - see below) become the flow objective during the period April 15 through May 16. Releases are made from New Melones, as required, but are limited by the Bay-Delta allocation determined by the New Melones IPO.

Table 6-9: Bay-Delta Vernalis Flow Objectives (average monthly cfs)

San Joaquin Basin Index	X2 Required West of Chipps	X2 Required East of Chipps
Wet	3420	2130
Above Normal	3420	2130
Below Normal	2280	1420
Dry	2280	1420
Critical	1140	710

San Joaquin River

The San Joaquin River Agreement (SJRA) provides for the acquisition of water by the Department of the Interior (Interior) from certain San Joaquin River Group Authority (SJRGA) members for use as a pulse flow at Vernalis during April and May, and the acquisition of other water for use during other times of the year. The water is needed to support the VAMP during the pulse flow period and to assist Interior in meeting the Anadromous Fish Restoration Plan, Bay-Delta flow objectives and the FWS Biological Opinion for Delta Smelt. As part of the VAMP, the CVP and State Water Project (SWP) exports during the VAMP test period (April/May) will be managed to specified levels.

Four components of water are provided by certain SJRGA members: Merced ID, Turlock ID, Modesto ID, Oakdale ID, South San Joaquin ID and the San Joaquin River Exchange Contractors Water Authority (Exchange Contractors).

- Up to 110,000 AF/year towards meeting the VAMP flow target. Water provided under this component is divided among the SJRGA members. This water is to only be used during the VAMP 31-day test flow period;
- Additional water from Merced ID (12,500 AF) during October of all years. This flow is provided above the "existing flow" in the Merced River during October.
- Additional water from Oakdale ID (15,000 AF) every year to be available to Reclamation. In addition to this water, any of the (up to) 11,000 AF of Oakdale ID VAMP water not provided towards meeting the VAMP flow target is also available to Reclamation;
- Additional water from willing SJRGA members above the 110,000 AF to achieve full "double-step" flow targets.

The VAMP flow target is determined by a series of procedures and conditions based on the flow at Vernalis which would occur in the absence of the SJRA ("existing flow"), and the San Joaquin Valley Water Year Hydrologic Classification. The SJRA provides a VAMP flow target that will be incrementally larger than the existing flow at Vernalis consistent with Table 6-10.

Table 6-10: VAMP Flow Targets (cfs)

Existing Flow at Vernalis			VAMP Test Flow Target
0	To	1,999	2,000 [1]
2,000	To	3,199	3,200
3,200	To	4,449	4,450
4,450	To	5,699	5,700
5,700	To	7,000	7,000

[1] For the purpose of determining water to be provided by the SJRGA's members only. The VAMP Test Flow Target is 3,200 cfs.

The SJRA assigns a numeric adjunct (60-20-20 Indicator) to the San Joaquin Valley Water Year Hydrologic Classification: a wet year is assigned the numeric value of 5, an above normal year is assigned the numeric value of 4, a below normal year is assigned the numeric value of 3, a dry year is assigned the numeric value of 2, and a critical year is assigned the numeric value of 1. In any year when the sum of the current year's 60-20-20 indicator and previous year's 60-20-20 indicator is seven (7) or greater, the 31-day flow target will be the flow target one level higher than that established by Table 6-10 above (e.g., if the existing flow is 3,500 cfs then the flow target will be 5,700 cfs). This condition is referred to as a "double-step".

The SJRA also provides for relaxation of this obligation during sequential dry-year periods. During years when the sum of the current year's 60-20-20 Indicator and the previous two years' 60-20-20 Indicator is four (4) or less (a sequence of dry and critical years), the SJRGA members will not be required to provide water above the existing flow.

The agreement assumes that the Stanislaus River is operated in accordance with the New Melones IPO (see Section 6, page 75) and that releases under the plan are included in the "existing" flow at Vernalis.

The SJRGA has executed a "Division Agreement" which specifies the amount and order of the individual contributions of water by its members. The division of flow to provide up to 110,000 AF of water for VAMP is shown in Table 6-11 below.

Table 6-11: Division of VAMP Pulse Flow Water (AF)

Entity (in order of providing flow)	First 50,000 AF	Next 23,000 AF	Next 17,000 AF	Next 20,000 AF	Totals
Merced ID	25,000	11,500	8,500	10,000	55,000

Entity (in order of providing flow)	First 50,000 AF	Next 23,000 AF	Next 17,000 AF	Next 20,000 AF	Totals
Oakdale ID/South San Joaquin ID	10,000	4,600	3,400	4,000	22,000
Exchange Contractors	5,000	2,300	1,700	2,000	11,000
Modesto ID/Turlock ID	10,000	4,600	3,400	4,000	22,000

An additional 12.5 TAF of water above “existing” flow in the Merced River is provided by Merced ID in October of all years. Also, an additional 15.0 TAF of water and up to 11.0 TAF of any unused Oakdale ID VAMP water is made available to Reclamation by Oakdale ID. The additional 15.0 TAF of water from Oakdale ID is released in October above any flow that is already occurring under the IPO. Oakdale ID VAMP water not used during the VAMP period is released to the Stanislaus River evenly distributed among November and December. Releases needed for VAMP flow objectives in excess of 110,000 AF are not provided in the modeling.

7. East Side Tributary Operations

This section describes San Joaquin Basin east side tributary operations as implemented in CALSIM II. Included in this section is a description of major reservoirs, their losses, and their flood control parameters. Also included is a description of district and non-district operations for meeting demands; specifically, CALSIM II protocols for determining water supply availability, deliveries, distribution losses, and return flows.

San Joaquin River below Friant Dam

CALSIM II incorporates a dynamic operation of CVP Friant Division water diversions and operations. Canal diversions vary from year to year based on an annually variable water supply. The monthly distribution of an annual diversion is based on the historical delivery practices of the contractors. Minimum required releases below Friant Dam for riparian and contractor users are modeled as a constant annual requirement, consistent with recent records of operations.

Flood control operations for Millerton Lake and the lower San Joaquin River are based on the rain-flood space reservation requirements specified by the COE. The flood control operation during the snowmelt runoff period recognizes the competing objectives of water supply and flood control. The operation attempts to maximize water supply carry-over storage (into summer) while reducing the potential for downstream flooding.

Several fixed parameters and simulated inputs are included in the Benchmark model. These inputs and parameters represent attributes of Friant Division facilities or hydrology that do not vary.

Millerton Lake

Millerton Lake was formed by the completion of Friant Dam on the Upper San Joaquin River in 1942. The dam and reservoir are located 25 miles northeast of Fresno, California. Friant Dam is a concrete gravity structure that stands 319 feet high with a crest length of 3,488 feet, and Millerton Lake has a gross pool capacity of 520,528 AF. The dam and reservoir provide flood control, conservation storage, diversions to the Madera and Friant-Kern Canals, and recreational uses. Friant water is delivered to approximately one million acres of agricultural lands within Fresno, Kern, Madera, and Tulare Counties. (From Reclamation's *dataweb* website.)

Inflow

Information relating to San Joaquin River inflow to Millerton Lake can be seen in Section 5, page 68.

Reservoir Losses

Millerton Lake losses are assumed to only be evaporative in CALSIM II. The monthly evaporation volume is determined by multiplying evaporation rate estimates by the reservoir's water surface area, which is determined using the area-capacity relationship described in Table 7-1. The table was developed from data shown in the *Report on Reservoir Regulation for Flood Control, Friant Dam and Millerton Lake, San Joaquin River, California*, Department of the Army, December 1955, Revised August 1980. Water surface acreage is approximated by linearly interpolating between storage values.

Table 7-1: Millerton Lake Storage-Area Relationship

Storage (TAF)	0	60	100	140	190	250	310	380	450	530
Area (Acres)	0	1,205	1,749	2,200	2,685	3,190	3,637	4,103	4,524	4,963

Monthly evaporation rates were estimated by DWR and input into CALSIM II as a time series. Attachment 1 provides more information on development of the Millerton Lake evaporation rates.

Flood Control Rules

Flood control is an important aspect of Friant Division operations, and is guided by objectives included in the *Report on Reservoir Regulation for Flood Control, Friant Dam and Millerton Lake San Joaquin River, California*, Department of the Army, December 1955, Revised August 1980. According these guidelines, at any given time Millerton Lake storage is identified to be within one of three zones: within the conservation space, when flood releases are not required; within the rain-flood space, when water stored in this space (including credit for available storage space in Mammoth Pool) will be released as rapidly as possible without exceeding 8,000 cfs below Little Dry Creek, or 6,500 cfs at the Mendota gage; or within the conditional space, when releases are required in excess of irrigation demand, and are determined based on forecasted runoff, available upstream space and forecasted irrigation demand.

The required rain-flood space is a fixed end-of-month constraint as identified in Table 7-2. During the heaviest precipitation months of November through January, 170,000 AF of reserved space is maintained. The amount of space required in Millerton Lake (in excess of 85,000 AF) is reduced by the amount of available space in Mammoth Pool. When necessary, CALSIM II logic creates a release to the San Joaquin River that is sufficient to keep storage from encroaching into the required rain-flood space. CALSIM II does not constrain releases in consideration of the downstream flow objectives.

Table 7-2: Millerton Lake Rain-flood Space (1,000 AF)*

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
85	170	170	170	42	0	0	0	0	0	0	0

* Space in excess of 85,000 AF can be replaced by an equal amount in Mammoth Pool

During the conditional space time period (modeled February through June), an algorithm is used to simulate the management of flood volumes over the entire period. The release necessary to operate within the conditional flood control space is determined for each month between February and May. This is done by making a forecast of the quantity of water anticipated to be spilled by the end of June.

The forecast requires an estimate of the available water supply, project deliveries, lake evaporation and minimum river releases through the end of June. The water supply forecast uses perfect foresight to predict the amount of Millerton inflow that will occur through the end of June. The deliveries, evaporation, and minimum river releases through the end of June are estimated. Using the water supply forecast, delivery forecast, current storage, and end of June full reservoir storage target (520,000 AF), the projected volume of spill through the end of June is computed. The projected spill volume is then distributed on a release schedule which is consistent with historical reservoir flood control operation.

Large projected spills are spread out over several months to surrogate the avoidance of large flows late in the season, while the release of small projected spill volumes is deferred until their release is necessary in May or June. The flood control release made for a given month is the greater of the computed rain-flood release or the conditional space release.

The management (shaping) of river releases for operation within the conditional space is determined by user input matrices that establish river releases based on the forecast of spill volumes. A different matrix is used for each month of forecast from February through May. The matrix for a subsequent month only differs from the previous month's matrix by the amount of flow volume that is determined to be passed during the previous month. The algorithm is not operative during June as it is assumed that Millerton Lake has an objective to fill by the end of June, and any required spill in excess of minimum releases will be determined by the balance of operations during the month.

Central Valley Project Friant Division

Friant Division canal diversions are not dependent on land use-based water demands. To model land use-based diversions for the Friant Division would require significant additional analyses that take into account the operation of other water resource supplies within the Tulare Lake Basin. The water diversions developed for CALSIM II mimic recent historical operations.

Water Supply Availability and Delivery Protocols

Delivery Patterns

A review of the historical record of water deliveries from the Friant Division was conducted. The record of those deliveries is contained in a database maintained by Reclamation. The protocol of the database attempts to categorize the different classifications of water deliveries made through the Friant Division. The review found several anomalies within the data, some of which could be explained by changing practices of classification (or institutional changes in classifications) and others that were apparently data entry errors or multiple accountings. Although questionable or possibly misinterpreted data were a problem, the review provided significant insight regarding the relationship between water supply availability and water delivery patterns for the Friant Division.

Most salient to the analysis are the data concerning monthly deliveries from the Friant-Kern Canal and the Madera Canal as water supply availability changes during a year. The data and analysis allowed development of a water delivery function (based on water supply availability at Millerton Lake) that is responsive to both flood control operations and other considerations within the Basin that affect the delivery of water from the Friant Division, such as water availability from tributaries within the Tulare Lake Basin. Analysis also provided a coarse division of water deliveries between Class 1, Class 2, and other water classifications.

There is substantial variability in the monthly distribution of deliveries year-to-year. Analysis shows that definite trends occur between the total availability of water to Friant Division contractors and the pattern in which deliveries are taken. Most significantly affecting the pattern is the availability of Class 2 water. The availability of Class 2 water proportionately concentrates deliveries during the spring-time and also affects the pattern that Class 1 deliveries are made to contractors that have both Class 1 and Class 2 supplies. During years with Class 2 water available, contractors with both Class 1 and Class 2 supplies will tend to shift their delivery of Class 1 supplies to later in the year, thus extending the period of deliveries.

The model's water delivery function distributes a forecasted volume of water supply into monthly deliveries to the Friant-Kern and Madera Canals. Key to this distribution is the relationship between monthly deliveries and water supply availability. The model determines a forecasted volume of water availability. With that determination, the pattern of total water deliveries and the pattern of Class 1 deliveries are established. The product of the pattern and the water supply (limited by contract maximums) results in the monthly delivery of water. Inferred by the difference between the total delivery and the Class 1 delivery is Class 2 delivery.

From the many years of record, certain years of data were selected to develop guidance for establishing a water availability/delivery distribution pattern relationship. Years during which only Class 1 water was available provided an indication of the delivery pattern associated with limited water supplies, those

years when no Class 2 supply was available. The pattern is used to distribute a water supply that equals or is less than 800,000 AF (a full Class 1 supply). A second group of years was selected to represent the delivery patterns of Class 1 and total deliveries during years when the available water supply was near full Class1 and Class 2 allocations without exceeding a full Class 2 allocation (years when "Other" water may influence the delivery of Class 2 deliveries). Intermediate patterns between these two bounds of patterns were established to transition from the availability of only Class 1 supplies to the availability of full Class 1 and Class 2 supplies. The following figures illustrate the range of patterns used to distribute deliveries from the canals.

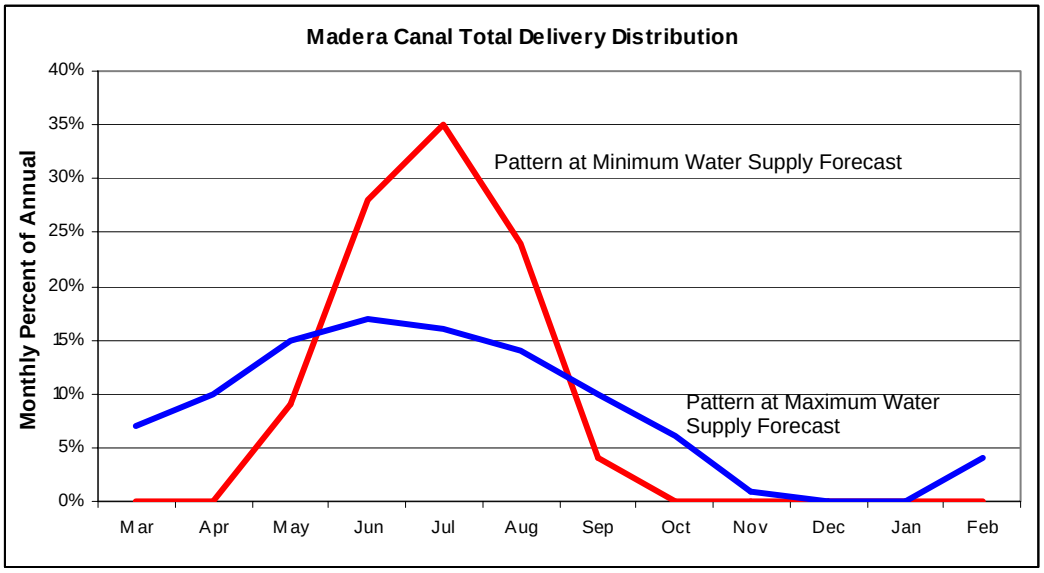

Figure 7-1: Total Madera Canal Delivery Pattern

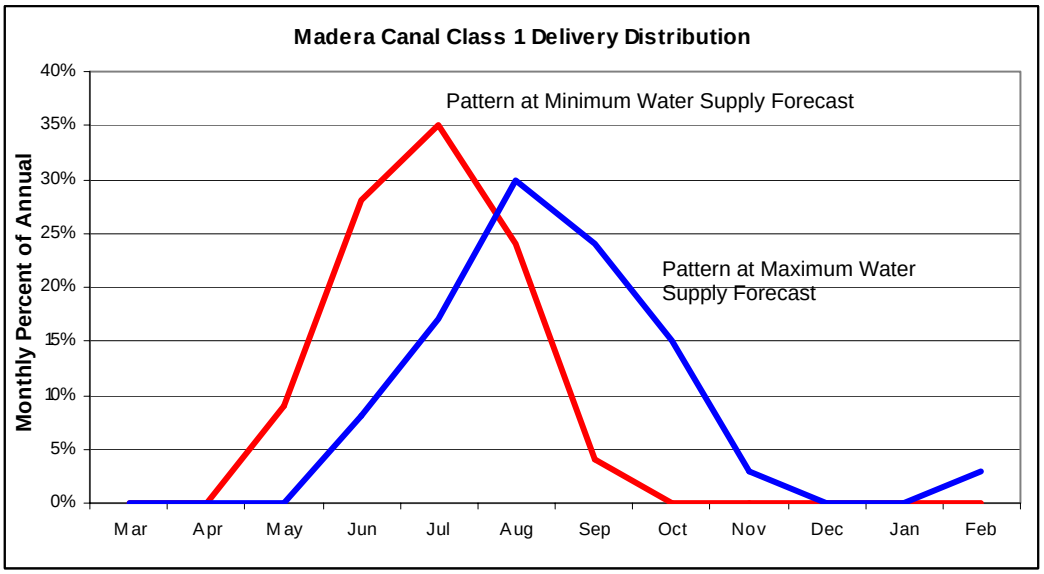

Figure 7-2: Madera Canal Class 1 Delivery Pattern

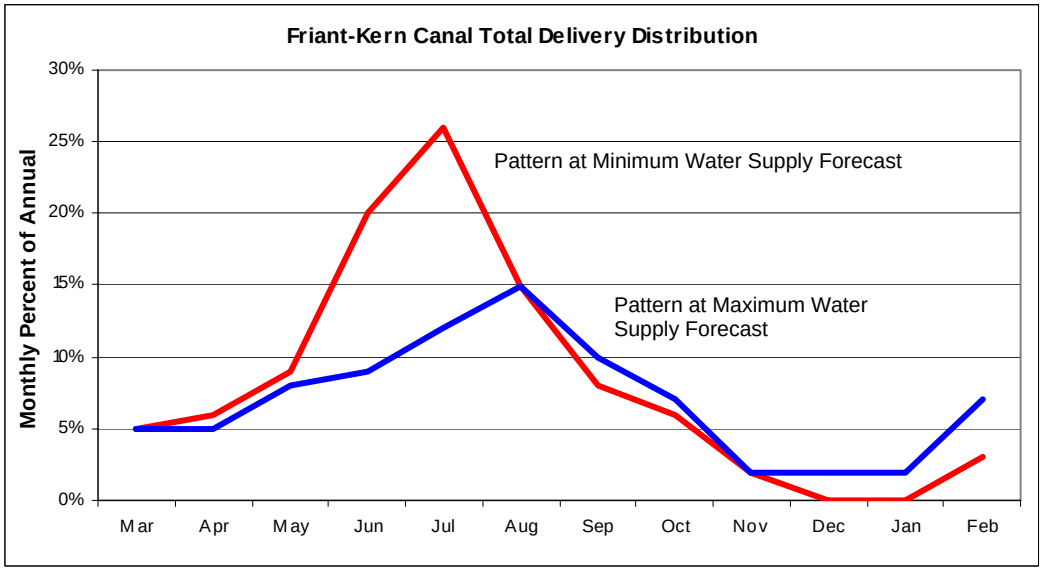

Figure 7-3: Total Friant-Kern Canal Delivery Pattern

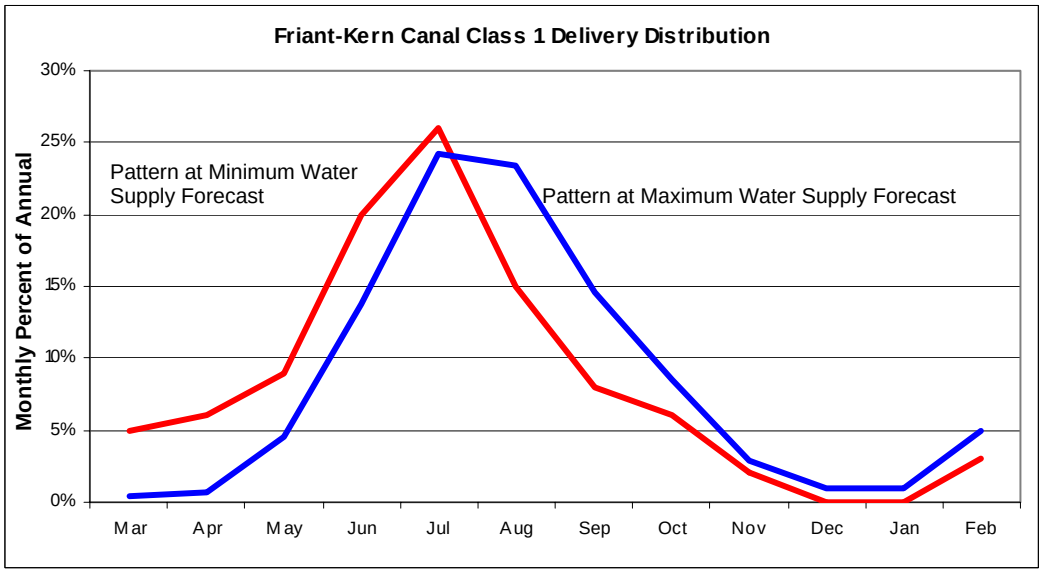

Figure 7-4: Friant-Kern Canal Class 1 Delivery Pattern

Delivery Adjustments

There are two adjustments made to deliveries after initial allocations are made with the delivery logic. One is based on wetness in the Tulare Lake Basin and the other is based on flood control releases from Friant. Deliveries from the Friant-Kern canal are reduced when there is abundant surplus in the Tulare Lake Basin tributaries and Tulare Lake Basin water users are receiving flood flows from their local tributary projects. Conversely, deliveries to both the Friant-Kern and Madera Canals are increased when spills from Friant can be delivered. The model assumes an increased demand for water when Friant is spilling. The demand for surplus is a user defined input to the model. The increased flood flow demand

logic will not occur during months when the Tulare Lake Basin tributary logic reduces deliveries.

Procedural Delivery Logic

Annual water deliveries for the Friant Division are determined in March of each year and updated monthly through June. The allocation is estimated by summing the total water available from storage and inflow and subtracting requirements and losses. The remainder is the water available for delivery. The following equation is used to estimate water delivery at any point during the allocation season.

Water available for delivery =

	Sum of current month through September Millerton inflow
+	*Beginning of month Millerton Storage*
-	*Millerton target (end of September) carryover storage*
-	*Average current month through September evaporation*
-	*Minimum Friant release to SJR for current month through September*
-	*Losses for current month through September*

Water is allocated to Class 1 and Class 2 deliveries based on the annual volume of available water. If the annual volume is less than the full Class 1 contract amount, Class 1 is set to the annual volume of available water. If the annual volume is greater than the Class 1 contract amount, Class 1 is set to full contract amount and the remainder is allocated to Class 2, up to the full Class 2 contract amount.

The monthly delivery patterns are based on the total annual volume of delivery. Lookup tables in the model contain the monthly delivery patterns. Four lookup tables are used to determine monthly patterns for total delivery to the Friant-Kern and Madera Canals and Class 1 delivery to the Friant-Kern and Madera Canals. Monthly Class 2 delivery is the difference between total deliveries and Class 1 deliveries. The deliveries determined using this logic is based solely on water supply availability at Friant without consideration of wetness in the Friant service area and delivery of flood control releases. The adjustments for these factors are made subsequently in the model.

Distribution Losses Protocol

Canal losses were developed through a comparison of historical water deliveries and canal diversions. Using the same selective analytical process of evaluating certain years and months of diversion and delivery data, an estimate of monthly un-accounted for diversions (losses) was developed. When diversions are occurring within the model, losses become an additional diversion requirement of the Madera and Friant-Kern Canals. The estimated losses for the two canals are shown in Table 7-3 and Table 7-4 below.

Table 7-3: Friant-Kern Canal Losses (1,000 AF)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
5	4	1	1	2	3	4	5	6	7	7	6

Table 7-4: Madera Canal Losses (1,000 AF)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	2	3	4	3	0

Return Flow Protocol

Friant Division deliveries to the Friant-Kern and Madera Canals do not have any directly associated return flows.

Mendota Pool

Operations at Mendota Pool are discussed in detail in Section 8, page 124.

Fresno River

The only regulating reservoir on the Fresno River is Hensley Lake (formed by Hidden Dam), which was completed and operational in 1975. Hidden Dam is operated by the COE and releases are coordinated with Reclamation operations at Friant Dam. Madera Canal, which conveys water northwest from Friant Dam, crosses the Fresno River approximately three miles downstream from Hidden Dam. Deliveries from Madera Canal to CVP contractors are made via the Fresno River, as are flood spills during flood control operations.

Hensley Lake

Hensley Lake is operated to protect the Fresno River from flood damage and provide water supply for irrigation. The maximum storage is 90,000 AF, and dead storage is 5,000 AF. The operation of Hensley Lake is governed by the diversion requirement of Madera ID, with consideration given to water supplied by the Friant system. Both the pattern and quantity of water supplied from Friant influences the operation of Hensley Lake. Operational rules for Hensley Lake are developed to best use water supply from both water supply sources.

Inflow

For information related to Hensley Lake inflow, refer to Section 5, page 68.

Reservoir Losses

In CALSIM II, Hensley Lake losses are assumed only to be evaporative. Evaporation is estimated by multiplying a predefined (time series) evaporation rate by the reservoir surface area. Attachment 1 provides details on the development of the Hensley Lake evaporation rate time series.

Flood Control Rules

The Fresno River Basin is a rain-fed basin with little or no snowmelt. Although actual storage limits are conditional, CALSIM II assumes that end-of-month

allowable storage is static for each year. Table 7-5 describes the maximum allowable end-of-month storage for flood control used in the model.

Table 7-5: Maximum Allowable Storage at Hensley Lake (1,000 AF)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
46	25	27	33	40	50	75	90	90	90	90	69

Madera Irrigation District

Madera ID is situated north of the San Joaquin River and adjacent to the Fresno River. Madera ID relies on Millerton Lake water supplies (via the Madera Canal) and from Hensley Lake and the Fresno River. There are approximately 106,000 acres of irrigated land within Madera ID boundaries. Although Madera ID does not own and operate groundwater wells, there is significant reliance on groundwater pumping from private wells to satisfy irrigation demands within the district.

Water Supply Availability Protocol

The protocol for water management in modeling Madera ID operations in CALSIM II is:

1. Utilize groundwater pumping (amount estimated to be the minimum utilized regardless of the availability of surface supplies)
2. Millerton Lake surface supply
3. Fresno River surface supply
4. Supply remainder of demand with additional groundwater pumping

The Madera Canal delivery is dependant on the water supply available from Millerton Lake. When there is water available from Millerton Lake, Madera ID will use it to the extent possible and reduce use from other sources. CALSIM II determines the supply from Millerton Lake available to Madera ID then adjusts the operation of Hensley Lake to satisfy Madera ID demands.

The amount of water available from Hensley Lake and the Fresno River is estimated using a water supply forecast. The forecast and allocation of available supplies attempts to make surface deliveries on a pattern such that shortages do not exceed the existing ability of pumping groundwater within the district.

An April 1 forecast is made to determine the available supply in Hensley Lake and the Fresno River. In most years there is not enough surface water available to satisfy Madera ID demands; therefore, water supply available in Hensley Lake will be fully utilized in all but wet years. The carryover target for Hensley Lake for Madera ID is 15,000 AF in normal years and 8,000 AF in dry years.

April 1st Forecast

Supply =

April 1st storage in Hensley Lake
\+ *April 1st to September 30th inflow to Hensley Lake*
\- *carryover storage target*
\- *downstream requirements*
\- *Fresno River seepage*
\- *evaporation*

Demand =
Madera ID diversion requirement (not including M&I demands)
\- *minimum private groundwater pumping*

Delivery Protocol

When Madera ID surface water supplies are greater than the demand for surface water, full deliveries are made. When the supply is less than the demand, the available surface supply is delivered, and the residual demand is met through groundwater pumping. CALSIM II also includes a protocol that limits releases from Hidden Dam for Madera ID to the capacity of the Madera ID main canal, which is 200 cfs.

Distribution Losses Protocol

Annual distribution system loss assumptions for Madera ID were determined as part of the district's water budget, outlined in Section 3 (page 26). Distribution losses are assumed to be 30 percent of the surface diversion in dry years and 40 percent in normal years.

Return Flow Protocol

Madera ID return flows are assumed to be constant from year-to-year, varying by year-type and are returned to the Fresno River. However, returns only occur when there is an irrigation demand (i.e., when CUAW is greater than zero). The return flow estimates were determined as part of the district's water budget analysis, also discussed in Section 3. The Madera ID annual volume of return flow and its monthly distribution is shown in Table 3-2.

Non-District Lands East of Madera Irrigation District and Chowchilla Water District

The non-district demand area located directly east of Madera ID and Chowchilla WD extends as far east as the valley floor boundary. The San Joaquin River below Friant Dam and the Chowchilla River establish the southernmost and northernmost boundaries, respectively. Borders for this area are very similar to those of DAU 214; the main difference between this area and DAU 214 is that this area excludes all Madera ID lands whereas DAU 214 includes some Madera ID lands.

Water Supply Availability Protocol

In CALSIM II, non-district lands east of Madera ID and Chowchilla WD rely solely on groundwater pumping to meet agricultural water demands. Because

CALSIM II does not dynamically model groundwater-surface water interaction there is no protocol to reduce groundwater supplies.

Delivery Protocol

There is no surface water delivery to this area. Groundwater pumping is allowed by the model to completely satisfy the diversion requirement for every month in the simulation period.

Distribution Losses Protocol

CALSIM II does not have an explicit assumption or protocol for defining distribution system losses for this area.

Return Flow Protocol

Because there are no surface water deliveries to this demand area, there is no return flow assumption or protocol. This demand area has no effect on tributary operations.

Non-District Lands West of Madera Irrigation District and Chowchilla Water District

The non-district area west of Chowchilla WD and Madera ID is bounded on the west and south by the San Joaquin River. It includes Gravelly Ford and Clayton Water Districts. Boundaries for this area coincide with DAU 215, but the area does not include Columbia Canal Company.

Water Supply Availability Protocol

The CALSIM II diversion requirement for non-district lands west of Madera ID and Chowchilla WD is met through both surface water and groundwater. This area has three sources of surface water: 1) San Joaquin River delivery to Gravelly Ford WD, 2) Chowchilla Bypass delivery, 3) surface returns from Chowchilla WD. There is no explicit protocol to reduce supplies to water users in the area.

Delivery Protocol

Diversion requirements are first met through Chowchilla WD return flows. These returns are small and do not contribute greatly to meeting agricultural demands. San Joaquin River delivery to Gravelly Ford WD is the second priority in meeting agricultural demands for this area. Table 7-6 describes the San Joaquin River diversions and losses from Friant Dam to Gravelly Ford.

Table 7-6: Friant Dam Release for Down Stream Diversions and Losses (AF)

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
All Years	2,640	3,600	4,360	5,160	5,760	6,280	5,360	4,040	2,960	2,680	1,800	2,000	46,640

After Gravelly Ford WD deliveries, Chowchilla Bypass may contribute up to 10 percent of the area's CUAW. Any demand not satisfied by these three surface water sources is met through groundwater pumping.

Distribution Losses Protocol

CALSIM II does not have an explicit assumption or protocol for defining distribution system losses for this area.

Return Flow Protocol

Return flows are calculated using an assumed 75 percent surface water irrigation efficiency. The calculation for non-district return flow is:

$$\textit{Return Flow} = \textit{Surface water delivery} * [1 - (1 + NRL) * IE]$$

Where NRL is the non-recoverable loss (10%) and IE is the irrigation efficiency (75%). There are no return flows associated with groundwater deliveries.

Flows leaving non-district lands west of Madera ID and Chowchilla WD are returned to the Chowchilla River.

Chowchilla River

The only regulating reservoir on the Chowchilla River is Eastman Lake (formed by Buchanan Dam), which was completed and operational in 1976. Buchanan Dam is operated by the COE and releases are coordinated with Reclamation operations at Friant Dam. Generally, direct diversions from the Chowchilla River are supplemented by supplies from the Madera Canal. Releases from Buchanan Dam help meet the supplemental water demand and reduce the need for water from the Madera Canal. During flood control operations, Madera Canal spills can be released down Ash and Berenda Sloughs, approximately 10 miles downstream of Buchanan Dam.

Eastman Lake

Eastman Lake is operated to protect the Chowchilla River from flood damage and to provide water supply for irrigation. The maximum storage is 150,000 AF, and dead storage is 10,000 AF.

Inflow

For information related to Eastman Lake inflow, refer to Section 5, page 69.

Reservoir Losses

In CALSIM II, Eastman Lake losses are assumed only to be evaporative. Evaporation is estimated by multiplying a predefined (time series) evaporation rate by the reservoir surface area. Attachment 1 provides details on the development of the Eastman Lake evaporation rate time series.

Flood Control Rules

The Chowchilla River Basin is a rain-fed basin with little or no snowmelt. Although actual storage limits are conditional, CALSIM II assumes that end-of-

month allowable storage is static each year. Table 7-7 describes the maximum allowable end-of-month storage for flood control used in the model.

Table 7-7: Maximum Allowable Storage at Eastman Lake (1,000 AF)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
120	105	105	112	117	125	140	150	150	150	150	135

Chowchilla Water District

Chowchilla WD is situated adjacent to the Chowchilla River. The district relies on surface water delivery from Millerton Lake via the Madera Canal and from Eastman Lake and the Chowchilla River. There are approximately 68,000 acres of irrigated land within Chowchilla WD boundaries.

Water Supply Availability Protocol

The protocol for water management in modeling Madera ID operations in CALSIM II is:

1. Utilize groundwater pumping (amount estimated to be the minimum utilized regardless of the availability of surface supplies)
2. Millerton Lake surface water supply
3. Fresno River surface supply
4. Supply remainder of demand with additional groundwater pumping

Madera Canal delivery is dependant on the water supply available from Millerton Lake. When there is water available from Millerton Lake, Chowchilla WD will use it to the extent possible and reduce use from other sources. CALSIM II determines the supply from Millerton Lake available to Chowchilla WD then adjusts the operation of Eastman Lake to satisfy Chowchilla WD demands.

The amount of water available from Eastman Lake and the Chowchilla River is estimated using a water supply forecast. The forecast and allocation of available supplies attempts to make surface deliveries on a pattern such that shortages do not exceed the existing ability of pumping groundwater within the district.

An April 1 forecast is made to determine available supply in Eastman Lake and the Chowchilla River. Carryover target for Chowchilla WD is about 80,000 AF in wetter years, 40,000 AF in normal type years and 10,000 AF in dry years.

April 1st Forecast

Supply =

	April 1st storage in Eastman Lake
+	*April 1st to September 30th inflow to Eastman Lake*
-	*carryover storage target*
-	*downstream requirements*
-	*Chowchilla River seepage*

- *evaporation*

Demand =

Chowchilla WD diversion requirement (not including M&I demands)

- *minimum private groundwater pumping*

Delivery Protocol

When Chowchilla WD surface water supplies are greater than the demand for surface water, full deliveries are made from the available supplies. When the supply is less than the demand, the available supply is delivered, and the residual demand is met through groundwater pumping.

Distribution Losses Protocol

Chowchilla WD distribution losses are assumed to be 35% of the surface water diversion (refer to Section 3, page 29).

Return Flow Protocol

As discussed in Section 3, there are no data available regarding flows leaving Chowchilla WD. For lack of better information, Chowchilla WD return flows are assumed to be equivalent to Madera ID returns in CALSIM II. Chowchilla WD splits the return flows to the Chowchilla Bypass and to non-project service areas. Return flow quantities are based on water year type and month.

Merced River

Agricultural development in the Merced River watershed began in the 1850s, and significant changes have been made to the hydrologic system since that time. The enlarged New Exchequer Dam forming Lake McClure was completed in 1967 and regulates releases to the lower Merced River. New Exchequer Dam is owned and operated by Merced ID for power production, irrigation, and flood control.

Releases from Lake McClure pass through a series of power plants and are re-regulated at McSwain Reservoir, which serves as an afterbay to New Exchequer Dam. Below McSwain Dam, water is diverted to Merced ID's Northside Canal at the Pacific Gas & Electric (PG&E) Merced Falls Dam for delivery to 4,100 acres of land within the district (USGS, 1992). The Crocker-Huffman Dam, Merced ID's main diversion point located downstream of the Merced Falls Dam near the town of Snelling, diverts water into the Main Canal.

Lake McClure

Lake McClure is operated to protect the Merced River from flood damage, generate hydroelectric power, provide water supply for irrigation and downstream uses, and provide in-stream flow for the Merced River. The maximum storage is 1,024,600 AF, dead storage is 3,000 AF, and the minimum pool district water supply storage is 115,000 AF.

Inflow

For information related to Lake McClure inflow, refer to Section 5, page 69.

Reservoir Losses

In CALSIM II, Lake McClure losses are assumed only to be evaporative. Evaporation is estimated by multiplying a predefined (time series) evaporation rate by the reservoir surface area. Attachment 1 provides details on the development of the Lake McClure evaporation rate time series.

Flood Control Rules

The model operates to satisfy minimum flow requirements but ignores the maximum allowable flow objective at Cressey (6,000 cfs). In actual operations, encroachment into the flood control space in Lake McClure has been more acceptable than exceeding flows of 6,000 cfs in the Merced River below Crocker-Huffman. This operation criterion is important in daily operations for flood protection, but has a minimal impact on monthly planning model operations. Flood control constraints included in CALSIM II are detailed below.

Lake McClure/New Exchequer Dam Flood Control Storage Limits

Rain Flood Space

The Lake McClure allowable storage based on rain flood considerations for flood control is described as follows:

- June 16 to August 31 – 1024.6 TAF
- September 1 to October 31 – Linear reduction from 1024.6 TAF to 674.6 TAF
- November 1 to March 15 – 674.6 TAF
- March 16 to June 15 – Linear increase from 674.6 TAF to 1024.6 TAF

Conditional Space (snow melt flood space)

During the months of March through July, depending on the forecasted runoff and demands, the allowable storage may fall anywhere between the above-defined rain flood space and the following maximum conditional space. Although this space may be required in actual operations, it is not incorporated in CALSIM II.

- March 1 to March 31 – Linear reduction from 674.6 TAF to 624.6 TAF
- April 1 to May 15 – 624.6 TAF
- May 16 to July 31 – Linear increase from 624.6 TAF to 1024.6 TAF

Table 7-8 summarizes the flood control storage limits implemented into CALSIM II, in terms of end-of-month storages.

Table 7-8: Maximum End-of-Month Storage for Flood Control (1,000 AF)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
674.6	674.6	674.6	674.6	674.6	735.0	845.0	970.0	1024.6	1024.6	1024.6	850.0

Merced Irrigation District

Merced ID provides water to both district growers and sphere-of-influence water users, including El Nido ID, Le Grand-Athlone Water District, and individual growers near district boundaries. In all, more than 110,000 acres of land are irrigated using more than 320,000 AF of water annually. Merced ID operates Lake McClure to satisfy district, Merced NWR, Stevinson Water District (Stevinson WD), and sphere-of-influence water demands, as well as to satisfy Merced River downstream flow requirements.

The operation of Lake McClure is determined by the diversion requirement developed from the water budget. In most years there is enough water from runoff to the Merced River and storage in Lake McClure to satisfy Merced ID demands, supply the Merced NWR, and deliver water to Stevinson WD and areas within the Merced ID sphere-of-influence. During water short years, surface deliveries within Merced ID may be reduced. In those years, no water is available to lands within the sphere-of-influence. The allocation of water supply and the operation of Lake McClure are developed based on water supply forecasts and regulatory requirements.

Water Supply Availability Protocol

In CALSIM II modeling, a water supply forecast in the spring of each year determines if shortages in deliveries will occur. If it is determined that Merced ID will experience a water supply shortage, surface deliveries will be reduced. The forecast and allocation of available supplies attempts to make surface deliveries on a pattern such that shortages do not exceed the existing ability of Merced ID to pump groundwater.

A forecast in the April time step is used to balance available supply and demands to determine if surface deliveries can be satisfied.

April 1st Forecast

Supply =

	April 1st storage in Lake McClure
+	*April 1st to September 30th inflow to Lake McClure*
-	*required Merced River in-stream flow*
-	*releases for downstream water users*
+	*stream accretion from Exchequer to Crocker-Huffman Dam*
-	*carryover storage*

Demand =

	Merced ID diversion requirement (not including M&I demands)
+	*Merced NWR demand*
-	*district groundwater pumping*
-	*minimum private groundwater pumping*
+	*delivery to Stevinson WD*

+ *delivery to areas in Merced ID sphere-of-influence*

Delivery Protocol

If the surface water supply is greater than the demand for surface water, full surface water deliveries are made. If the supply is less than the demand, a reduction in delivery will occur. The first reduction in delivery will be made to areas outside the Merced ID boundary. If cutting deliveries to these areas is not sufficient, deliveries within the district will be reduced until the delivery is commensurate with supply, and the residual demand will be made up through groundwater pumping.

When storage in Lake McClure falls below 115,000 AF, releases can only be used for in-stream flows and deliveries to the Merced NWR. Merced ID is not allowed to release from storage under these circumstances. During periods of low storage CALSIM II determines how much water Merced ID can divert each month while storage remains above 115,000 AF.

Distribution Losses Protocol

Merced ID canal distribution loss is 150 TAF per year distributed April through October on a Merced ID irrigation demand pattern (see also Section 3, page 30).

Return Flow Protocol

In addition to deliveries made outside the Merced ID boundary, Merced ID is required to release water to Stevinson WD. Operational spills leaving the Merced ID west boundary are used to satisfy this requirement. In some cases operational spills are sufficient to satisfy the requirement, although many times additional releases must be made. Table 7-9 contains the flow entitlement for Stevinson WD for a normal water year:

Table 7-9: Stevinson WD Entitlements – Normal Year

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
Daily CFS	0	0	0	54.44	81.66	81.66	81.66	81.66	54.44	0	0	0	
Monthly AF	0	0	0	3,239	5,021	4,859	5,021	5,021	3,239	0	0	0	26,401.5

Note: To reach the annual entitlement amount the average daily CFS for April through September should not be less than 72.74 CFS.

When surface water deliveries to Merced ID are reduced due to lack of Merced River supply, flows to Stevinson WD can be reduced based on inflow to Lake McClure. In that event, the percent reduction in flow to Stevinson WD is consistent with the percent reduction in surface water supplied to Merced ID.

Return flows by Merced ID are also made back to the Merced River above Cressey. The quantity of return flow is determined by water year type and month, and only occurs when there is an irrigation demand (see Table 3-4).

Other Related Information

Minimum flows on the Merced River are stipulated by FERC at Shaffer Bridge and are based on projected inflow to Lake McClure Reservoir. Normal and above normal water year types are defined as inflow at or above 450 TAF. Dry water year types are inflows below 450 TAF. A time series of target minimum flows based on these two water year type levels and month is incorporated in CALSIM II.

Merced National Wildlife Refuge

The Merced NWR is the oldest refuge in the San Luis National Wildlife Refuge Complex. The refuge totals more than 8,200 acres and is the "primary wintering area for the largest flock of lesser sandhill cranes and Ross' geese in the Pacific Flyway." Additionally, the Merced NWR is a critical use area for a large variety of waterfowl and shorebirds. (From U.S. Fish and Wildlife Service – Pacific Region website)

Water Supply Availability Protocol

Merced NWR is supplied 15 TAF annually from Merced ID. There is no protocol to reduce the refuge water supply based on hydrologic or Lake McClure storage conditions. Lake McClure releases for Merced NWR are allowed even when the reservoir content falls below the 115,000 AF minimum operating target.

Delivery Protocol

Merced ID deliveries to the Merced NWR are limited by a 45 cfs conveyance capacity. Surface water deliveries are made to the refuge until either the refuge demand is met or until deliveries reach the 45 cfs conveyance limit.

Distribution Losses Protocol

CALSIM II does not have an explicit assumption or protocol for defining distribution system losses for this area.

Return Flow Protocol

The Merced NWR operation in CALSIM II does not include a protocol for return flow back to the stream network.

Non-District Lands East of Merced Irrigation District

The non-district demand area located east of Merced ID extends as far east as the valley floor boundary. The area is bounded to the north by the Merced River and by the Chowchilla River to the south. These boundaries are very similar to DAU 211 boundaries, but areas within DAU 211 that fall within Merced ID are not included.

Water Supply Availability Protocol

As depicted in CALSIM II, non-district lands east of Merced ID rely solely on groundwater pumping to meet agricultural water demands. Because CALSIM II

does not dynamically model groundwater-surface water interaction, groundwater supplies are only restricted by demand.

Delivery Protocol

There is no surface water delivery to this area. Groundwater pumping is set up in the model to completely satisfy the diversion requirement for every month in the simulation period.

Distribution Losses Protocol

CALSIM II does not have an explicit assumption or protocol for defining distribution system losses for this area.

Return Flow Protocol

Because there are no surface water deliveries to this demand area, there is no return flow assumption or protocol. This demand area has no effect on tributary operations.

Non-District Lands West of Merced Irrigation District

The non-district[10] demand area located west of Merced ID generally lies between the Merced and Chowchilla Rivers and extends to the San Joaquin River. It includes Plainsburg and El Nido Irrigation Districts, as well as La Grande-Athlone, Turner Island, and Stevinson Water Districts. Boundaries for this area are similar to DAU 212, but do not include areas that fall within Merced ID. Non-district areas within DAU 210 are included in this area.

This area uses a combination of groundwater and limited surface water to satisfy crop irrigation requirements. Merced ID has an agreement to supply water to Stevinson Water District; this water is supplied through Merced ID laterals as operational spills. Merced ID also supplies water to its sphere-of-influence water users including El Nido Irrigation District (El Nido ID) through its El Nido canal, La Grande-Athlone Water District, and individual growers.

Water Supply Availability Protocol

Merced ID releases water to non-district lands west of it borders. Two separate surface water allocations are made for this area. Allocations for Stevinson WD are made first, according to the logic outlined previously in this section (page 96). Allocations for El Nido ID are then made based on the Lake McClure April forecast. El Nido ID is allocated Lake McClure water if the available supply is above Merced ID and Stevinson WD surface water demands, up to a maximum of 40 TAF. If the available surface supply based on the Lake McClure April forecast is not sufficient to meet Merced ID and Stevinson WD demands, the El Nido ID allocation is 0 TAF.

[10] The term “non-district” as used here may be construed a misnomer. There are actually districted lands within the boundaries of this demand area. However, these districts are relatively small and have a small, if any, affect on upstream reservoir operations.

Delivery Protocol

Surface water deliveries from Merced ID to Stevinson WD and El Nido ID contribute to meeting the demand area's aggregate diversion requirement. Allocations for both Stevinson WD and El Nido ID are distributed April through September. The distribution of Stevinson WD surface water is shown in Table 7-9 above; the El Nido allocation is distributed April through September on a CUAW pattern.

When surface water supply from Merced ID is not sufficient to meet the area's diversion requirement, groundwater pumping satisfies the remaining demand.

Distribution Losses Protocol

CALSIM II does not have an explicit assumption or protocol for defining distribution system losses for this area.

Return Flow Protocol

Return flows are calculated using an assumed 75 percent surface water irrigation efficiency. The calculation for non-district return flow is:

$$\textit{Return Flow} = \textit{Surface water delivery} * [1 - (1 + NRL) * IE]$$

Where NRL is the non-recoverable loss (10%) and IE is the irrigation efficiency (75%). There are no return flows associated with groundwater deliveries.

Flows leaving non-district lands west of Merced ID are returned to the San Joaquin River below Salt Slough.

Non-District Riparian Lands Adjacent to the Merced River

The non-district riparian demand area adjacent to the Merced River relies on Merced River diversions to satisfy irrigation requirements. This area is bounded by Merced ID on the south and Turlock ID on the north.

Water Supply Availability Protocol

There is no protocol in CALSIM II to determine or reduce the availability of Merced River water for non-district riparian diverters adjacent to the Merced River.

Delivery Protocol

CALSIM II places a higher priority on riparian water diversions than Merced ID diversions. Riparian deliveries are made until demands are satisfied; there are no other operational criteria to constrain this area's river diversions.

Distribution Losses Protocol

CALSIM II does not have an explicit assumption or protocol for defining distribution system losses for this area.