Appendix C

Water Balance Analysis Methodology, Assumptions, and Tables

Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014–2038

Final
January 2013

WATER BALANCE ANALYSIS METHODOLOGY, ASSUMPTIONS, AND TABLES

1.0 INTRODUCTION

Appendix A of the *Final Environmental Impact Statement / Environmental Impact Report for the 10-Year Water Transfer Program* (USBR and Exchange Contractors, 2004) was a water balance analysis of the application of up to 130,000 acre-feet to agricultural uses during years 2005-2014 in nine water districts and the Friant Division of the Central Valley Project (CVP): Plain View Water District (now Byron-Bethany Irrigation District), Westlands Water District, Panoche Water District, Pacheco Water District, San Luis Water District, Del Puerto Water District, Patterson Irrigation District, San Benito County Water District, Santa Clara Valley Water District (Santa Clara Vly WD), and Friant Division as a whole. The results of the water balance were used to demonstrate that the irrigation demand could potentially exceed the existing water supply. This appendix supports the current 25-Year Water Transfer Program EIS/EIR and includes the above districts as well as Kern County Water Agency (Kern Co WA) and Pajaro Valley Water Management Agency (Pajaro Vly WMA).

The USBR has prepared a Water Needs Assessment (WNA) for water districts that use CVP water for agriculture (and municipal and industrial uses) (USBR, 2011). The WNA was developed for a year with normal hydrologic conditions. The water balance was previously performed for a wet year and a dry year in the December 2004 analysis. In order to obtain an approximate estimate for a normal year that can be compared to the values in the WNA, the monthly precipitation and evapotranspiration values used in the December 2004 analysis for the wet and dry years were averaged and the water balance was re-calculated. The resulting crop water requirement and effective precipitation (calculated per acre) were compared to the corresponding values in the WNA (calculated per acre, based on the reported average irrigated acres) to obtain a scaling factor. The scaling factors were used to adjust the wet-year and dry-year values in order to obtain revised values based on the WNA without having to adjust the crop mix and completely revise the water balance. New water balance analyses were prepared for Pajaro Vly WMA and Kern Co WA as a whole. Since the USBR had prepared a WNA for Pajaro Vly WMA, scaling factors were used to adjust the values obtained in the water balance for Pajaro Vly WMA. However, a WNA was not available for Kern Co WA, so the results of the water balance analysis were used directly. The net irrigation requirement was calculated for each district and compared to the contract water supply.

This appendix describes the method used to update the net irrigation requirement for the districts included in the December 2004 analysis based on the WNA. It also describes the method used in the water balance analysis from December 2004 and describes the inputs and results obtained in the current water balance analyses for Kern Co WA and Pajaro Vly WMA.

The water balance was used to determine the crop water requirements for districts that could potentially receive water from the San Joaquin River Exchange Contractors Water Authority (SJRECWA) under the proposed water transfer program. The maximum range in potential need

for additional water was determined by calculating the irrigation requirement remaining after applying contracted CVP (and SWP for Santa Clara Vly WD and Kern Co WA) deliveries during wet and dry years.

2.0 WATER BALANCE METHODOLOGY

The net irrigation requirement for a unit area is the amount of water that must be supplied by irrigation to satisfy evapotranspiration, leaching, and miscellaneous water requirements not provided by either water stored in the soil or precipitation that enters the soil (Jensen et al. 1990). In this analysis, the net irrigation requirement was estimated using the following equation (the miscellaneous water uses were considered insignificant):

$$NET_{irr} = ET_{crop} - PPT_{eff} - \Delta SW + LCH$$

where,

NET_{irr} = Net irrigation water requirement for the period considered (in);
ET_{crop} = Total water used in evapotranspiration (in);
PPT_{eff} = Effective rainfall (in);
ΔSW = Change in soil water during the period (in);
LCH = Water required for leaching (in).

Each term is described in more detail below.

Evapotranspiration

The total evapotranspiration, ET_{crop}, for a particular crop is expressed as:

$$ET_{crop} = k_c \cdot ET_o$$

where,

k_c = Crop coefficient (unitless);
ET_o = Reference evapotranspiration (in).

The term ET_{crop} is also referred to as the consumptive use. The crop coefficients were generally obtained from the UC Leaflets 21427, 21428, and 21454. Table 1 lists the source of the crop coefficients used for each crop, as well as adjustments, if any, made based on personal communication with Joel Zander (USBR 2000). The daily crop coefficients corresponding to particular growth and development stages were calculated for each crop. The monthly k_c is then obtained by averaging the daily k_c values within each month. Table 2 consists of the resulting monthly k_c values. Values of zero are shown for months that are outside of the growing season (after harvest or when transpiration has ceased and before the next planting date).

The monthly reference evapotranspiration was obtained from stations maintained by the California Irrigation Management Information System (CIMIS). Precipitation data at

representative stations within the project area were reviewed to select representative wet and dry years. A review of annual precipitation from 1989 through 2010 showed that, for most of the stations, the total annual precipitation was the lowest for calendar year 1989 and the highest for calendar year 1998. Calendar year 1989 was used for dry year hydrology and 1998 was used for wet year hydrology. ETo data was compiled for these same years from the nearest CIMIS station with available data. The station assumed to have representative ETo data for a particular district is shown in Table 3. Table 4 shows the monthly ETo data used in a wet year, and Table 5 shows the monthly ETo data used in a dry year. As a way to develop hydrology comparable to the normal year hydrology used in the WNA, the monthly ETo values for the wet and dry years were averaged, with the results shown in Table 6.

2.1 Effective Rainfall

Effective precipitation is the sum of precipitation intercepted by living or dry vegetation, precipitation that stagnates on soil and evaporates, precipitation lost by evaporation during plant growth, and precipitation that contributes to leaching or facilitates other agricultural operations (Dastane 1974). Effective precipitation does not include precipitation lost to surface runoff, precipitation lost to deep percolation below the root zone, or moisture remaining in the soil after the crop harvest and which is not useful for the next crop (Dastane 1974).

For this analysis, effective precipitation was based on a method developed by the USDA-Soil Conservation Service (SCS). The SCS method uses the relation (USDA-SCS 1970):

$$r_e = (0.70917 \cdot r_t^{0.82416} - 0.11556) \cdot (10^{0.02426.u}) \cdot f$$

where,

r_e = average effective monthly rainfall (in);
r_t = average monthly rainfall (in);
u = average monthly consumptive use (in); and
f = correction factor for application depth different from 3 inches, and where

$$f = (0.531747 + 0.295164 \cdot D - 0.057697 \cdot D^2 + 0.003804 \cdot D^3)$$

where D is the net depth of application during irrigation (in).

The allowable depletion is the amount of soil water that can be used by plants without suffering yield loss due to water stress (Univ. of Calif. 1993). To simplify the analysis, the allowable depletion for each water district was assumed to be 3 inches. In the current analysis, the net depth of application during irrigation is approximated by the allowable depletion.

For all districts except for Kern Co WA, the monthly precipitation data were obtained from stations in the National Climatic Data Center (NCDC) database. For Kern Co WA, monthly precipitation data from three stations were averaged to determine the representative precipitation for the entire district. In addition to the NCDC Bakersfield AP and Wasco stations, the Greenlee's Pasture station, which is operated by Wheeler Ridge Maricopa Water Storage District, was also included. As mentioned above for evapotranspiration, calendar year 1998 was assumed to be representative of wet year precipitation and calendar year 1989 was used to

represent dry year precipitation. The NCDC station assumed to have representative precipitation data for a particular district is shown in Table 3. Table 7 shows the monthly precipitation data used in the wet year scenario, and Table 8 shows the monthly precipitation data used in the dry year scenario. As a way to develop hydrology comparable to the normal year hydrology used in the WNA, the monthly precipitation values for the wet and dry years were averaged, with the results shown in Table 9.

2.2 Carryover Soil Moisture

The soil moisture at the beginning of the year was assumed to be equal to the allowable depletion, or 3 inches. The carryover soil moisture was calculated by adding the effective precipitation to the previous month's soil moisture and subtracting the consumptive use. It was assumed that the carryover soil moisture could not be less than half the allowable depletion.

2.3 Leaching

In this study, the leaching requirement is set to be 5 percent of the total amount of irrigation water.

2.4 Irrigation Efficiency

Due to unavoidable losses, no field application of irrigation water can be 100 percent efficient. Thus, more water than is needed to satisfy net irrigation requirements must be applied. In this study, a 77 percent irrigation efficiency was assumed for all districts except Kern Co WA. A 75 percent irrigation efficiency was applied for Kern Co WA, which is consistent with the irrigation efficiency estimated in the *Water Supply Report: 2008* (Kern Co WA, 2008).

2.5 Gross Irrigation Demand

By taking into account the irrigation efficiency, the gross field irrigation requirements (NET_{gross}) may be estimated as:

$$NET_{gross} = \alpha \cdot NET_{irr}$$

where α is the irrigation efficiency.

2.6 Irrigation Deliveries

In order to provide a range for the potential need for water from the SJRECWA, it was assumed that in the wet year scenario, the districts would receive 100% of their CVP (and SWP for Santa Clara Vly WD and Kern Co WA) contracts for agricultural use. In the dry year scenario, it was assumed that the districts would only receive 25% of their total CVP contracts for agricultural use. This assumption is based on a review of historical CVP water supply allocations. In 1977, agricultural contractors received 25% of their supply, urban contractors received 25 to 50% and the Friant water users only received 25% of the Class 1 supply.

2.7 Crop Mix

The historical irrigated crop acreage used in the water balance was obtained from the USBR for districts in the CVP Friant Division, as well as Del Puerto Water District (WD), Pacheco WD, Panoche WD, Patterson Irrigation District (ID), Plain View WD (now Byron-Bethany Irrigation District), San Benito County WD, San Luis WD, and Westlands WD. For Santa Clara Valley WD, the irrigated acreage was obtained from the Santa Clara County Department of Agriculture crop report for 2002. For Pajaro Vly WMA, the irrigated acreage was based on values for 2006 obtained from the district (Pajaro Vly WMA, 2011). For Kern Co WA, the irrigated acreage was obtained from the 2008 Water Supply Report (Kern Co WA, 2008). The determination of the crop mix assumed to be representative of existing conditions was made using the above data sources, as described in Table 10. Table 11 shows the acreage per district of each crop type included in the water balance.

3.0 WATER BALANCE RESULTS

The water balance was used to determine the effective precipitation and the existing irrigation requirement for ten separate agricultural districts, as well as the Friant Division and Kern Co WA as a whole. Tables 12 through 14 summarize the results. Table 12 shows the results for the wet-year scenario, Table 13 shows the results in the dry-year scenario, and Table 14 shows the results using the average of the wet- and dry-year hydrology. The following sections describe how the results from the water balance were used to estimate wet-year and dry-year irrigation requirements based on the WNA.

4.0 REVISIONS TO WATER NEEDS ASSESSMENT

The WNA prepared by the USBR was developed for a year with normal hydrologic conditions. The results of the water balance analysis determined using the average of the hydrology for wet and dry years were compared to components in the WNA. Table 15 shows the comparison and the resulting scaling factors. Values from the WNA were converted to inches per acre from the values provided in acre-feet, based on the irrigated acreage [reference number 21 in the WNA definitions (USBR, 2011)].

Scaling factors were determined for the following two components:

- Effective precipitation [reference number 17 in the WNA definitions (USBR, 2011)].
- The crop water requirement component that included extra water for leaching but not irrigation efficiency [reference number 15 in the WNA definitions (USBR, 2011)].

The gross irrigation requirement determined in the water balance (see Table 14) was multiplied by the irrigation efficiency used in the water balance to obtain the crop water requirement that includes leaching but not irrigation efficiency. The scaling factors (effective precipitation ratio and crop water requirement ratio) shown in Table 15 were based on dividing the value from the water balance by the value from the WNA.

To obtain the modified effective precipitation, the monthly effective precipitation values determined from the water balance for the wet and dry years were divided by the associated scaling factors determined for each month. To obtain the modified crop water requirement, the monthly values for gross irrigation requirement determined from the water balance (see Tables

12 and 13) were multiplied by the irrigation efficiency used in the water balance (77%) to obtain the irrigation demand that includes leaching but not irrigation efficiency, and then the values were divided by the monthly scaling factors for the crop water requirement.

Table 16 shows the adjusted values based on the WNA for a wet year. Table 17 shows the adjusted values based on the WNA for a dry year. Tables 16 and 17 show values for all the districts except for Kern Co WA, which was not included in the WNA. The results for the member districts of the Friant Division are included in Tables 16 and 17.

The total agricultural water demand was compared to the contract water supply in Table 18. The contract amounts have been adjusted so that only the agricultural supply (excluding any municipal and industrial use) is shown. In Table 18, the demand for Kern Co WA calculated using the water balance has been included, and the demand was summarized for the Friant Division as a whole. It was assumed that for a wet year, districts would receive 100% of their CVP (and/or SWP for Santa Clara Vly WD and Kern Co WA) contract water supply and that the Friant Division would receive 100% of both Class 1 and Class 2 deliveries. For a dry year, it was assumed that districts would receive 25% of their contract water supply, with the Friant division receiving no Class 2 deliveries and 25% of Class 1 deliveries.

For a wet year, the results show that the Friant Division, Kern Co WA, Pajaro Vly WMA, Patterson ID, and Westlands WD have combined deficits in supply water totaling nearly 2 million acre-feet. For a dry year, the results show that all districts have supply water deficits with a combined total of approximately 8.6 million acre-feet.

5.0 LIMITATIONS

This report was developed using data provided by USBR as well as data from other sources (e.g. Kern Co WA). While URS attempted to assess the validity of the provided data, the scope of work did not include independent verification of any data such as existing crop acreage, effective precipitation or consumptive use.

These data and other key inputs and assumptions listed substantially affect the results presented in this report. These inputs, although thought to be reasonable and appropriate, may not prove to be true or correct. The results presented in this report are conditioned upon these inputs and assumptions.

The conclusions and opinions presented in this report were developed with the standard of care commonly used as state-of-the practice in the profession. No other warranties are included, either express or implied, regarding the professional opinions presented in this report.

6.0 REFERENCES

Dastane, N.G. 1974. Effective rainfall in irrigated agriculture. FAO Irrigation and Drainage Paper No. 25, FAO, Rome, Italy.

Jensen, C.T., R.D. Burman, and R.G. Allen (edt). 1990. *Evapotranspiration and Irrigation Water Requirements*. American Society of Civil Engineers. New York, New York.

Kern County Water Agency. 2008. *Water Supply Report: 2008*.

Pajaro Valley Water Management Agency. 2011. Pajaro Valley Land Use from file "LandUseStats_2006.xls." Email Communication to Jeanne Gambino, Water Resources Engineer, URS from Brian Lockwood, Staff Hydrologist. July 1.

Santa Clara Valley Water District, 2011. State Water Project information accessed from http://www.valleywater.org/Services/StateWaterProject.aspx on August 5.

United States Bureau of Reclamation (USBR). 2000. Adjustments to Crop Seasons. Personal Communication to Jeanne Gambino, Water Resources Engineer, URS from Joel Zander, Regional Ag Engineer. April 17.

USBR and San Joaquin River Exchange Contractors Water Authority (Exchange Contractors). 2004. Final Environmental Impact Statement / Environmental Impact Report for the 10-Year Water Transfer Program. December.

USBR. 2011. *Water Needs Assessment for Contract Renewals* and *Background explanation for Water Needs Assessment*. Downloaded from http://www.usbr.gov/mp/cvp/mandi/docs/index.html on April 26.

USBR – South-Central California Area Office (SCCAO), Email to URS and Cardno ENTRIX from Erma Clowers, Repayment Specialist, with attached file "Revised 08-01-11 SJREC Trfr Program Table Analysis.xlsx" with Central Valley Project water supply contract allocations. August 1.

United States Department of Agriculture - Soil Conservation Service (USDA). 1970. Irrigation Water Requirements. USDA-SCS Technical Release No. 21. 88 pp

University of California. 1989. *Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc) for Trees and Vines*. Leaflet 21428, Cooperative Extension, Division of Agriculture and Natural Resources.

University of California. 1993. Cooperative Extension Irrigation Course, Tule Lake, California.

University of California. 1994. *Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc) for Agronomic Crops, Grasses, and Vegetable Crops*. Leaflet 21427, Cooperative Extension, Division of Agriculture and Natural Resources.

Table 1
Sources for Crop Coefficients

Crop Name	Location	kc Source	Notes/Adjustments
Alfalfa	San Joaquin Vly	UC Publication 3396	constant Kc averaged over entire year
Almonds	Central Vly	UC Leaflet 21428	used kc values for deciduous orchards, c associated with leafout date 2/26, but used a leafout date of 2/20 and assumed kc values cut in half from 7/20 to 8/20.
Barley	San Joaquin Vly	UC Leaflet 21454	small grains planted 11/1 except used season end date of 5/1
Beans	San Joaquin Vly	UC Leaflet 21427	planted 5/1
Cereals, other (use barley)	San Joaquin Vly	UC Leaflet 21454	small grains planted 11/1
Citrus	Central Vly	UC Leaflet 21428	assumed a constant Kc for entire year
Corn	San Joaquin Vly	UC Leaflet 21427	planted 4/1
Cotton	San Joaquin Vly	UC Leaflet 21427	kc values and growth dates associated with a plant date of 4/16, but used a plant date of 4/10 and season end date of 10/1
Deciduous Orchard, c	Central Vly	UC Leaflet 21428	leafout date 3/1 (From UC Leaflet 21428, Deciduous Orchard, c refers to "peaches, apricots, pears, plums, almonds and pecans without a cover crop.")
Deciduous Orchard, d	Central Vly	UC Leaflet 21428	leafout date 3/1 (From UC Leaflet 21428, Deciduous Orchard, d refers to "apples, cherries, and walnuts without a cover crop.") "other nuts" were included with Deciduous Orchard, d.
Garlic/Onions	San Joaquin Vly	estimated from UC Leaflet 21427	used onions w/ A date of 10/15, B date of 11/15, C date of 01/01, E date of 05/15. Kc values were based on onions planted 9/16, however Kc1 was taken to be the average of 0.18 and 0.27 (values corresponding to A date of 09/16 and 11/16). Percent of season to date D used was 0.72.
Grain Sorghum (Milo)	San Joaquin Vly	UC Leaflet 21427	planted 5/1
Melons	San Joaquin Vly	UC Leaflet 21427	plant date of 3/16, except used season end date of 6/30
Misc. Truck/Field Crops (High)	San Joaquin Vly	UC Leaflet 21427	corn planted 4/1
Misc. Truck/Field Crops (Low)	Imperial Vly	UC Leaflet 21454	lettuce planted 8/31
Misc. Truck/Field Crops (Med)			avg. of misc. (High) and misc. (Low)
Nursery/Lettuce	Imperial Vly	UC Leaflet 21454	lettuce planted 8/31
Olives	Central Vly	UC Leaflet 21428	leafout date 3/31
Pasture (Improved)	Statewide	UC Leaflet 21427	constant kc shown for grazed pasture
Potatoes	San Joaquin Vly	UC Leaflet 21427	planted 3/1
Rice	San Joaquin Vly	UC Leaflet 21427	planted 4/1
Sugar Beets	San Joaquin Vly	UC Leaflet 21427	planted 3/16
Tomatoes (canning)	San Joaquin Vly	UC Leaflet 21427	planted 5/1
Tomatoes (fresh market)	San Joaquin Vly	UC Leaflet 21454	tomatoes planted 3/23
Vineyard/Berries (use Grapes)	San Joaquin Vly	UC Leaflet 21454	leafout date 3/15
Wheat	San Joaquin Vly	UC Leaflet 21454	small grains planted 11/1 except used season end date of 6/1

Note: Acreage for crops not listed may have been grouped with other crops having similar crop coefficients.

Table 2
Monthly Crop Coefficients (Kc)

Month	Alfalfa Monthly Average Kc	Almonds Monthly Average Kc	Barley Monthly Average Kc	Beans Monthly Average Kc	Cereal (use Barley) Monthly Average Kc	Citrus Monthly Average Kc	Corn Monthly Average Kc	Cotton Monthly Average Kc	Deciduous Orchard, c Monthly Average Kc	Deciduous Orchard, d Monthly Average Kc	Garlic/ Onions Monthly Average Kc	Grain Sorghum (Milo) Monthly Average Kc	Melons Monthly Average Kc
Jan	0.95	0.00	0.98	0.00	0.98	0.65	0.00	0.00	0.00	0.00	1.15	0.00	0.00
Feb	0.95	0.18	1.20	0.00	1.20	0.65	0.00	0.00	0.00	0.00	1.15	0.00	0.00
Mar	0.95	0.62	1.14	0.00	1.14	0.65	0.00	0.00	0.58	0.60	1.13	0.00	0.09
Apr	0.95	0.71	0.78	0.00	0.78	0.65	0.20	0.11	0.70	0.75	0.96	0.00	0.26
May	0.95	0.80	0.24	0.28	0.24	0.65	0.60	0.22	0.82	0.91	0.40	0.16	0.90
Jun	0.95	0.89	0.00	1.08	0.00	0.65	1.11	0.75	0.87	0.97	0.00	0.51	0.63
Jul	0.95	0.74	0.00	0.98	0.00	0.65	0.99	1.17	0.87	0.97	0.00	1.04	0.00
Aug	0.95	0.62	0.00	0.25	0.00	0.65	0.59	1.05	0.87	0.97	0.00	0.81	0.00
Sep	0.95	0.80	0.00	0.00	0.00	0.65	0.00	0.62	0.83	0.95	0.00	0.00	0.00
Oct	0.95	0.62	0.00	0.00	0.00	0.65	0.00	0.01	0.71	0.88	0.12	0.00	0.00
Nov	0.95	0.02	0.25	0.00	0.25	0.65	0.00	0.00	0.00	0.00	0.30	0.00	0.00
Dec	0.95	0.00	0.36	0.00	0.36	0.65	0.00	0.00	0.00	0.00	0.84	0.00	0.00

Month	Misc. (High) (use Corn) Monthly Average Kc	Misc. (Low) (use 8/31 Lettuce) Monthly Average Kc	Misc. (Med) (use avg. of High and Low) Monthly Average Kc	Nursery/ Lettuce Monthly Average Kc	Olives Monthly Average Kc	Pasture (Improved) Monthly Average Kc	Potatoes Monthly Average Kc	Rice Monthly Average Kc	Sugarbeets Monthly Average Kc	Tomatoes (canning) Monthly Average Kc	Tomatoes (fresh market) Monthly Average Kc	Vineyard/ Berries (use Grapes) Monthly Average Kc	Wheat Monthly Average Kc
Jan	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.98
Feb	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	1.20
Mar	0.00	0.00	0.00	0.00	0.02	0.90	0.58	0.00	0.08	0.00	0.02	0.17	1.20
Apr	0.20	0.00	0.10	0.00	0.62	0.90	1.01	0.95	0.27	0.00	0.08	0.46	1.09
May	0.60	0.00	0.30	0.00	0.71	0.90	1.19	1.14	0.75	0.27	0.64	0.64	0.74
Jun	1.11	0.00	0.56	0.00	0.78	0.90	0.71	1.25	1.10	0.62	1.00	0.80	0.24
Jul	0.99	0.00	0.49	0.00	0.80	0.90	0.00	1.17	1.09	1.04	0.90	0.82	0.00
Aug	0.59	0.13	0.36	0.13	0.80	0.90	0.00	1.02	1.02	0.99	0.05	0.70	0.00
Sep	0.00	0.21	0.10	0.21	0.80	0.90	0.00	0.00	0.48	0.38	0.00	0.00	0.00
Oct	0.00	0.71	0.35	0.71	0.80	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	1.01	0.50	1.01	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Dec	0.00	0.48	0.24	0.48	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.36

Table 3
Weather Stations Used for Reference Evapotranspiration and Precipitation Data

District	CIMIS Station with Representative Eto for Wet Year	CIMIS Station with Representative Eto for Dry Year	NCDC Station with Representative Precipitation for Wet and Dry Year Scenarios
Del Puerto WD	Modesto	Modesto	Modesto
Kern Co WA	Average from Arvin-Edison, Blackwells Corner, and Shafter/USDA	Average from Blackwells Corner, Shafter/USDA, and Tehachapi	Average from Bakersfield AP, Greenlee's Pasture[1], and Wasco
Pacheco WD	Panoche	Firebaugh/Telles	Los Banos
Pajaro Vly WMA	Pajaro	Pajaro	Watsonville Waterworks
Panoche WD	Firebaugh/Telles	Firebaugh/Telles	Los Banos
Patterson ID	Modesto	Modesto	Newman
Plain View WD (now Byron-Bethany ID)	Manteca	Manteca	Modesto
San Benito Co WD	San Benito	San Benito	Hollister
San Luis WD	Los Banos	Los Banos	Los Banos
Santa Clara Vly WD	San Jose	San Jose	Gilroy
Westlands WD	Westlands	Mendota/Murietta USDA	Five Points 5 SSW
Friant Division Districts			
Arvin-Edison WSD	Arvin-Edison	Tehachapi	Bakersfield AP
Chowchilla WD	Los Banos	Los Banos	Madera
Delano-Earlimart ID	Famoso	McFarland/Kern Farms	Delano
Exeter ID	Visalia	Visalia	Visalia
Fresno ID	Fresno State	Fresno State	Fresno Yosemite Intl
Garfield WD	Fresno State	Fresno State	Fresno Yosemite Intl
Gravelly Ford WD	Firebaugh/Telles	Firebaugh/Telles	Madera
International WD	Fresno State	Fresno State	Fresno Yosemite Intl
Ivanhoe ID	Visalia	Visalia	Visalia
Lewis Creek WD	Visalia	Visalia	Lindsay
Lindmore ID	Visalia	Visalia	Lindsay
Lindsay-Strathmore ID	Visalia	Visalia	Lindsay
Lower Tule River ID	Visalia	Visalia	Porterville
Madera ID	Fresno State	Fresno State	Madera
Orange Cove ID	Parlier	Parlier	Lemon Cove
Porterville ID	Visalia	Visalia	Porterville
Saucelito ID	Visalia	Visalia	Porterville
Shafter-Wasco ID	Shafter/USDA	Shafter/USDA	Wasco
Southern San Joaquin MUD	Famoso	McFarland/Kern Farms	Wasco
Stone Corral ID	Lindcove	Visalia	Lemon Cove
Tea Pot Dome WD	Visalia	Visalia	Porterville
Terra Bella ID	Visalia	Visalia	Porterville
Tulare ID	Visalia	Visalia	Visalia

[1]Precipitation data at Greenlee's Pasture is maintained by Wheeler Ridge-Maricopa Water Storage District.

Table 4
Wet Year (1998) Total Monthly Reference Evapotranspiration (in)

CIMIS Station No.	CIMIS Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
125	Arvin-Edison	1.47	1.56	3.56	5.03	5.57	7.48	9	8.46	5.63	3.91	1.86	1.5	**55.0**
54	Blackwells Corner	1.51	1.5	3.23	4.58	4.76	6.73	7.9	7.48	5.32	3.57	1.3	1.2	**49.1**
138	Famoso	1.26	1.23	3.18	4.59	4.76	6.26	7.97	7.32	4.92	3.20	1.50	1.18	**47.4**
7	Firebaugh/Telles	0.89	1.43	3.24	5.04	5.57	7.45	8.77	7.78	5.42	3.82	1.78	1.43	**52.6**
80	Fresno State	0.97	1.30	2.95	4.55	5.63	6.80	8.55	7.70	5.21	3.57	1.79	1.25	**50.3**
5, 54, 125	KCWA Average	1.44	1.50	3.35	4.83	5.29	7.09	8.35	7.78	5.38	3.72	1.65	1.34	**51.7**
21	Kettleman	1.20	1.47	3.26	4.85	5.16	6.96	8.84	8.45	5.67	4.17	1.90	1.37	**53.3**
86	Lindcove	1.20	1.30	2.86	4.25	4.54	6.21	8.02	7.40	4.89	3.30	1.53	1.14	**46.6**
56	Los Banos	0.90	1.42	3.24	4.81	5.75	7.39	8.52	7.78	5.33	3.53	1.62	1.33	**51.6**
70	Manteca	0.70	1.21	3.08	4.21	4.51	6.58	7.93	7.19	4.75	3.38	1.56	1.25	**46.4**
71	Modesto	0.69	1.22	3.15	4.49	4.75	6.55	7.42	6.72	4.51	3.19	1.47	1.26	**45.4**
129	Pajaro	1.37	1.49	3.06	4.50	4.90	4.46	5.16	4.95	3.56	3.29	1.70	1.74	**40.2**
124	Panoche	0.94	1.54	3.33	5.02	5.55	7.58	8.75	7.73	5.42	3.87	1.89	1.47	**53.1**
39	Parlier	0.88	1.30	2.81	4.52	5.26	6.74	8.35	7.41	5.07	3.38	1.57	1.19	**48.5**
126	San Benito	1.27	1.39	2.85	4.26	4.51	5.26	6.91	6.82	4.73	3.48	1.75	1.51	**44.7**
69	San Jose	1.29	1.31	3.22	4.47	3.90	5.52	6.77	6.53	4.48	3.55	1.57	1.44	**44.1**
5	Shafter/USDA	1.35	1.45	3.25	4.89	5.55	7.07	8.16	7.41	5.20	3.68	1.79	1.33	**51.1**
33	Visalia	0.92	1.22	2.60	4.34	4.99	6.35	7.48	6.96	4.60	3.07	1.31	1.13	**45.0**
105	Westlands	0.91	1.34	3.01	5.01	5.60	7.25	8.55	8.07	5.41	3.90	1.81	1.39	**52.3**
	Average	**1.11**	**1.38**	**3.12**	**4.64**	**5.08**	**6.62**	**7.97**	**7.37**	**5.03**	**3.56**	**1.65**	**1.34**	**48.9**

Table 5
Dry Year (1989) Total Monthly Reference Evapotranspiration (in)

CIMIS Station No.	CIMIS Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
54	Blackwells Corner	1.34	1.79	3.87	5.61	7.43	8.06	8.29	8.03	5.51	3.82	2.27	1.44	**57.5**
7	Firebaugh/Telles	1.49	1.71	3.82	5.75	7.84	8.61	8.98	7.42	5.12	3.96	2.00	1.04	**57.7**
80	Fresno State	1.09	1.53	2.92	4.79	6.77	8.19	8.97	7.30	5.02	3.47	1.77	0.78	**52.6**
5, 54, 59	KCWA Average	1.98	2.20	4.22	6.20	7.33	8.29	8.96	7.88	5.70	4.09	2.88	2.16	**61.9**
21	Kettleman	1.34	1.94	4.46	6.53	7.95	8.98	9.88	8.44	5.72	4.40	2.38	1.07	**63.1**
56	Los Banos	1.63	2.35	4.32	5.56	7.64	8.71	9.36	8.14	5.37	3.90	2.01	0.76	**59.8**
70	Manteca	0.92	1.63	2.68	4.34	6.04	6.55	8.12	6.69	4.88	3.51	1.87	1.29	**48.5**
31	McFarland/Kern Farms	1.14	1.75	3.79	6.12	7.36	8.07	8.30	7.28	5.16	3.79	2.12	1.24	**56.1**
40	Mendota/Murietta USDA	1.78	2.58	4.83	7.11	8.47	8.93	9.49	7.77	5.29	4.10	2.18	1.12	**63.7**
71	Modesto	1.66	2.25	3.66	5.80	8.21	8.02	8.69	6.72	4.24	2.86	1.57	0.58	**54.3**
129	Pajaro	2.01	1.76	3.49	4.08	4.47	4.94	4.78	4.40	3.59	2.93	1.79	1.48	**39.7**
39	Parlier	1.13	1.66	2.97	5.29	6.89	8.10	8.42	6.92	4.73	3.27	1.81	0.93	**52.1**
126	San Benito	1.31	1.63	2.83	4.57	5.62	6.45	6.75	5.74	4.48	3.87	1.96	1.89	**47.1**
69	San Jose	1.85	2.05	3.17	5.00	6.17	6.97	7.96	6.95	5.25	3.69	2.42	1.89	**53.4**
5	Shafter/USDA	1.91	2.27	4.34	5.89	7.22	7.99	8.31	7.47	5.39	4.10	2.31	1.27	**58.5**
59	Tehachapi	2.70	2.53	4.45	7.11	7.35	8.82	10.29	8.13	6.21	4.34	4.07	3.76	**69.8**
33	Visalia	0.99	1.69	3.38	5.73	7.11	8.06	8.30	7.01	4.80	3.44	1.77	0.86	**53.1**
	Average	**1.55**	**1.96**	**3.72**	**5.62**	**7.05**	**7.87**	**8.46**	**7.19**	**5.09**	**3.74**	**2.19**	**1.39**	**55.8**

Note: All stations used 1989 ETo from CIMIS except Pajaro, which used 2007, and San Benito, which used 1999.

Table 6
Average of Dry Year (1989) and Wet Year (1998) Total Monthly Reference Evapotranspiration (in)

CIMIS Station No.	CIMIS Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
54	Blackwells Corner	1.43	1.65	3.55	5.10	6.10	7.40	8.10	7.76	5.42	3.70	1.79	1.32	**53.3**
7	Firebaugh/Telles	1.19	1.57	3.53	5.40	6.71	8.03	8.88	7.60	5.27	3.89	1.89	1.24	**55.2**
7, 124	Firebaugh/Telles and Panoche	1.22	1.63	3.58	5.39	6.70	8.10	8.87	7.58	5.27	3.92	1.95	1.26	**55.4**
80	Fresno State	1.03	1.42	2.94	4.67	6.20	7.50	8.76	7.50	5.12	3.52	1.78	1.02	**51.4**
5, 54, 59, 125	KCWA Average	1.71	1.85	3.78	5.52	6.31	7.69	8.66	7.83	5.54	3.90	2.27	1.75	**56.8**
21	Kettleman	1.27	1.71	3.86	5.69	6.56	7.97	9.36	8.45	5.70	4.29	2.14	1.22	**58.2**
56	Los Banos	1.27	1.89	3.78	5.19	6.70	8.05	8.94	7.96	5.35	3.72	1.82	1.05	**55.7**
70	Manteca	0.81	1.42	2.88	4.28	5.28	6.57	8.03	6.94	4.82	3.45	1.72	1.27	**47.4**
31, 138	McFarland/Kern Farms and Famoso	1.20	1.49	3.49	5.36	6.06	7.17	8.14	7.30	5.04	3.50	1.81	1.21	**51.7**
40	Mendota/Murietta USDA and Westlands	1.35	1.96	3.92	6.06	7.04	8.09	9.02	7.92	5.35	4.00	2.00	1.26	**58.0**
71	Modesto	1.18	1.74	3.41	5.15	6.48	7.29	8.06	6.72	4.38	3.03	1.52	0.92	**49.8**
129	Pajaro	1.69	1.63	3.28	4.29	4.69	4.70	4.97	4.68	3.58	3.11	1.75	1.61	**40.0**
39	Parlier	1.01	1.48	2.89	4.91	6.08	7.42	8.39	7.17	4.90	3.33	1.69	1.06	**50.3**
126	San Benito	1.29	1.51	2.84	4.42	5.07	5.86	6.83	6.28	4.61	3.68	1.86	1.70	**45.9**
69	San Jose	1.57	1.68	3.20	4.74	5.04	6.25	7.37	6.74	4.87	3.62	2.00	1.67	**48.7**
5	Shafter/USDA	1.63	1.86	3.80	5.39	6.39	7.53	8.24	7.44	5.30	3.89	2.05	1.30	**54.8**
59, 125	Tehachapi and Arvin-Edison	2.09	2.05	4.01	6.07	6.46	8.15	9.65	8.30	5.92	4.13	2.97	2.63	**62.4**
33	Visalia	0.96	1.46	2.99	5.04	6.05	7.21	7.89	6.99	4.70	3.26	1.54	1.00	**49.1**
33, 86	Visalia and Lindcove	1.10	1.50	3.12	4.99	5.83	7.14	8.16	7.21	4.85	3.37	1.65	1.00	**49.9**
	Average	**1.31**	**1.66**	**3.41**	**5.14**	**6.09**	**7.27**	**8.22**	**7.28**	**5.05**	**3.65**	**1.90**	**1.34**	**52.3**

Table 7
Wet Year (1998) Total Monthly Precipitation (in)

NCDC Station ID	NCDC Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
442	Bakersfield AP	1.32	5.36	2.19	0.87	1.33	0.37	0	0	0.31	0.24	0.46	0.55	**13.0**
2012	Corcoran Irrig Dist	1.80	4.54	2.97	0.95	1.38	0.41	0	0	0.02	0.60	0.79	0.33	**13.8**
2346	Delano	1.58	5.54	2.73	0.58	2.34	0.80	0	0	0.02	0.44	0.93	0.27	**15.2**
3083	Five Points 5 SSW	1.09	4.86	1.45	1.29	1.77	0.45	0	0	0.53	0.36	1.08	0.00	**12.9**
3257	Fresno Yosemite Intl	3.40	4.89	3.44	1.26	1.37	1.93	0	0	0.15	0.16	0.43	0.62	**17.7**
3417	Gilroy	6.88	13.18	2.33	1.77	1.53	0.04	0.02	0	0.00	0.55	2.51	1.98	**30.8**
--	Greenlee's Pasture	1.22	5.32	3.30	1.83	1.34	0.10	0	0	0.58	0.16	1.34	0.68	**15.9**
4025	Hollister	4.84	10.54	3.14	1.96	1.83	0.09	0	0	0.08	0.54	1.83	1.00	**25.9**
442, 9452, --	KCWA Average	1.25	5.49	2.74	1.18	1.49	0.82	0.00	0.00	0.32	0.31	0.96	0.51	**15.1**
4890	Lemon Cove	4.24	6.43	4.96	4.17	1.57	0.67	0	0	0.05	0.23	1.36	1.07	**24.8**
4957	Lindsay	3.74	5.84	5.15	2.63	1.33	0.37	0	0	0.05	0.44	0.82	0.97	**21.3**
5118	Los Banos	3.41	8.08	2.08	1.16	3.87	0.43	0	0	0.00	0.66	0.94	0.45	**21.1**
5233	Madera	4.22	5.69	4.26	2.03	1.38	0.74	0	0	0.88	0.19	0.34	0.95	**20.7**
5738	Modesto	3.82	8.80	1.52	1.09	3.95	0.18	0	0	0.00	1.36	1.86	0.69	**23.3**
6168	Newman	4.17	9.38	1.86	1.00	3.97	0.02	0	0	0.02	0.87	1.22	0.39	**22.9**
7077	Porterville	2.99	5.93	4.13	2.23	1.34	0.46	0	0	0.05	0.43	1.08	1.02	**19.7**
9367	Visalia	3.53	4.62	4.09	2.03	1.60	1.25	0	0	0.99	0.26	0.95	0.62	**19.9**
9452	Wasco	1.20	5.78	2.72	0.84	1.79	2.00	0	0	0.06	0.52	1.08	0.30	**16.3**
9473	Watsonville Waterworks	10.23	15.99	3.84	3.01	2.46	0.00	0	0	0.15	0.61	2.95	1.89	**41.1**
	Average	**3.4**	**7.2**	**3.1**	**1.7**	**2.0**	**0.6**	**0.0**	**0.0**	**0.2**	**0.5**	**1.2**	**0.8**	**20.6**

Note: Greenlee's Pasture data from Wheeler Ridge Maricopa WSD.

Table 8
Dry Year (1989) Total Monthly Precipitation (in)

NCDC Station ID	NCDC Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
442	Bakersfield AP	0.16	0.81	0.86	0	0.45	0	0	0	0.49	0.04	0.07	0	**2.9**
2012	Corcoran Irrig Dist	0.29	1.09	1.24	0.04	0.36	0	0	0	0.4	0.13	0.07	0	**3.6**
2346	Delano	0.19	1.34	0.46	0	0.55	0	0	0	0.21	0.04	0	0	**2.8**
3083	Five Points 5 SSW	0.23	1.01	0.26	0	0.07	0	0	0	0.89	0.05	0.44	0	**3.0**
3257	Fresno Yosemite Intl	0.48	1.18	2.25	0.05	0.89	0	0	0.03	1.11	0.42	0.5	0	**6.9**
3417	Gilroy	1.34	1.01	3.63	0.23	0.15	0.11	0	0	1.56	0.1	1.15	0.01	**9.3**
--	Greenlee's Pasture	0.8	0.84	0.73	0.01	0.14	0	0	0	0.49	0.4	0.05	0.38	**3.8**
4025	Hollister	0.78	0.92	1.79	0.3	0.19	0	0	0.08	1.12	0.8	0.88	0.01	**6.9**
442, 9452, --	KCWA Average	0.41	1.01	0.80	0.00	0.29	0.00	0.00	0.00	0.42	0.16	0.05	0.13	**3.3**
4890	Lemon Cove	0.51	1.87	2.9	0.26	0.46	0	0	0	1.14	0.17	0.57	0	**7.9**
4957	Lindsay	0.34	2.03	2.57	0.23	0.3	0	0	0	0.65	0.22	0.52	0.02	**6.9**
5118	Los Banos	0.6	0.93	0.64	0.39	0	0	0	0.12	1.42	0.85	0.28	0.01	**5.2**
5233	Madera	0.4	1.2	2.13	0.17	0.11	0	0	0.03	0.94	0	0.54	0	**5.5**
5738	Modesto	0.54	0.99	2.09	0.11	0.04	0	0	0.08	1.5	0.99	0.7	0.01	**7.1**
6168	Newman	0.42	1.21	0.83	0.05	0	0	0	0	1.81	0.42	0.35	0	**5.1**
7077	Porterville	0.26	1.76	2.03	0.34	0.27	0	0	0	0	0.22	0.37	0	**5.3**
9367	Visalia	0.18	1.4	1.94	0.08	0.29	0	0	0	0.56	0.1	0.4	0	**5.0**
9452	Wasco	0.26	1.37	0.8	0	0.27	0	0	0	0.29	0.04	0.03	0	**3.1**
9473	Watsonville Waterworks	1.56	1.22	4.75	0.65	0.1	0	0	0.04	0.86	1.38	1.73	0.03	**12.3**
	Average	**0.5**	**1.2**	**1.7**	**0.2**	**0.3**	**0.0**	**0.0**	**0.0**	**0.8**	**0.3**	**0.5**	**0.0**	**5.6**

Note: No data available in Nov 1989 for Modesto, so used precipitation from Turlock #2. Greenlee's Pasture data from Wheeler Ridge Maricopa WSD.

Table 9
Average of Dry Year (1989) and Wet Year (1998) Total Monthly Precipitation (in)

NCDC Station ID	NCDC Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
442	Bakersfield AP	0.74	3.09	1.53	0.44	0.89	0.19	0.00	0.00	0.40	0.14	0.27	0.28	**7.9**
2012	Corcoran Irrig Dist	1.05	2.82	2.11	0.50	0.87	0.21	0.00	0.00	0.21	0.37	0.43	0.17	**8.7**
2346	Delano	0.89	3.44	1.60	0.29	1.45	0.40	0.00	0.00	0.12	0.24	0.47	0.14	**9.0**
3083	Five Points 5 SSW	0.66	2.94	0.86	0.65	0.92	0.23	0.00	0.00	0.71	0.21	0.76	0.00	**7.9**
3257	Fresno Yosemite Intl	1.94	3.04	2.85	0.66	1.13	0.97	0.00	0.02	0.63	0.29	0.47	0.31	**12.3**
3417	Gilroy	4.11	7.10	2.98	1.00	0.84	0.08	0.01	0.00	0.78	0.33	1.83	1.00	**20.0**
--	Greenlee's Pasture	1.01	3.08	2.02	0.92	0.74	0.05	0.00	0.00	0.54	0.28	0.70	0.53	**9.9**
4025	Hollister	2.81	5.73	2.47	1.13	1.01	0.05	0.00	0.04	0.60	0.67	1.36	0.51	**16.4**
442, 9452, --	KCWA Average	0.83	3.25	1.77	0.59	0.89	0.41	0.00	0.00	0.37	0.23	0.51	0.32	**9.2**
4890	Lemon Cove	2.38	4.15	3.93	2.22	1.02	0.34	0.00	0.00	0.60	0.20	0.97	0.54	**16.3**
4957	Lindsay	2.04	3.94	3.86	1.43	0.82	0.19	0.00	0.00	0.35	0.33	0.67	0.50	**14.1**
5118	Los Banos	2.01	4.51	1.36	0.78	1.94	0.22	0.00	0.06	0.71	0.76	0.61	0.23	**13.2**
5233	Madera	2.31	3.45	3.20	1.10	0.75	0.37	0.00	0.02	0.91	0.10	0.44	0.48	**13.1**
5738	Modesto	2.18	4.90	1.81	0.60	2.00	0.09	0.00	0.04	0.75	1.18	1.28	0.35	**15.2**
6168	Newman	2.30	5.30	1.35	0.53	1.99	0.01	0.00	0.00	0.92	0.65	0.79	0.20	**14.0**
7077	Porterville	1.63	3.85	3.08	1.29	0.81	0.23	0.00	0.00	0.03	0.33	0.73	0.51	**12.5**
9367	Visalia	1.86	3.01	3.02	1.06	0.95	0.63	0.00	0.00	0.78	0.18	0.68	0.31	**12.4**
9452	Wasco	0.73	3.58	1.76	0.42	1.03	1.00	0.00	0.00	0.18	0.28	0.56	0.15	**9.7**
9473	Watsonville Waterworks	5.90	8.61	4.30	1.83	1.28	0.00	0.00	0.02	0.51	1.00	2.34	0.96	**26.7**
	Average	**2.0**	**4.2**	**2.4**	**0.9**	**1.1**	**0.3**	**0.0**	**0.0**	**0.5**	**0.4**	**0.8**	**0.4**	**13.1**

Note: No data available in Nov 1989 for Modesto, so used precipitation from Turlock #2. Greenlee's Pasture data from Wheeler Ridge Maricopa WSD.

Table 10
Sources of Irrigated Acreage in Water Balance Analysis

District	Source of Irrigated Acreage	Total Irrigated Acreage Reported to the USBR[1]
Del Puerto WD	Average of irrigated acreage from USBR (1979-93, 95, 96, 99)	39,986
Friant Division	1995 USBR data, except Terra Bella, which used average of irrigated acreage from USBR (1979-92, 94, 96, 97)	850,348
Kern Co WA	KCWA Water Supply Report: 2008	780,793
Pacheco WD	Crop mix based on average of USBR data (1985-94, 99) with total acreage of 4900 (based on reported total acreage in March 2000 Final EA/IS Table 3.4-4)	4,900
Pajaro Vly WMA	Pajaro Vly WMA land use circa 2006 from email communication with Brian Locke, PVWMA, with attached file "LandUseStats_2006.xlsx" received 7/1/2011.	27,820
Panoche WD	Average of irrigated acreage from USBR (1979-93,99)	35,073
Patterson ID	1999 USBR data	13,316
Plain View WD	1995 USBR data	4,120
San Benito Co WD	2002 USBR data	29,119
San Luis WD	Average of irrigated acreage from USBR (1979-96, 99)	45,758
Santa Clara Vly WD	2002 Crop Report from Santa Clara County Department of Agriculture	25,677
Westlands WD	1995 USBR data	529,050
	Total:	**2,385,961**

[1]Except as noted for Kern Co WA, Pajaro Vly WMA, Santa Clara Vly WD and San Benito Co WD.

Table 11
Crop Acreage by District

District	Alfalfa	Almonds	Barley	Beans	Cereals, other (use barley)	Citrus	Corn	Cotton	Deciduous Orchard, c	Deciduous Orchard, d	Garlic/ Onions	Grain Sorghum (Milo)	Melons
Del Puerto WD	3,781	8,701	391	5,982	707	232	354	356	4,312	3,437	96	454	2,441
Friant Division	75,471	76,410	6,195	8,130	24,308	96,935	56,467	126,416	51,192	45,544		1,826	471
Kern Co WA	100,279	159,540	70,342	8,400		58,339	43,847	59,965	27,501	75,987	5,136		3,668
Pacheco WD	165		111	35	195		169	1,994					884
Pajaro Vly WMA	7,790					199				3,143		125	
Panoche WD	2,070	136	702	1,337	892		653	14,686	127	201	187	551	2,830
Patterson WD	3,637	331		1,494	1,001		1,470		1,980	224			17
Plain View WD (now Byron-Bethany ID)	972	84	115	760	936		60		289	158			
San Benito Co WD					4,205				64	6,221			
San Luis WD	2,657	2,766	1,797	1,499	604	269	595	16,350	1,860	378	341		5,417
Santa Clara Vly WD	568				4,242		1,285		608	1,177	568		734
Westlands WD	3,815	13,877	5,423	13,172	9,487	234	114	268,706	973	6,830	8,516		23,524

District	Misc. Truck/ Field Crops (High)	Misc. Truck/ Field Crops (Low)	Misc. Truck/ Field Crops (Med)	Nursery/Lettuce	Olives	Pasture (Improved)	Potatoes	Rice	Sugar Beets	Tomatoes (canning)	Tomatoes (fresh market)	Vineyard/ Berries (use Grapes)	Wheat	Total Crop Acreage
Del Puerto WD	235	1,236	1,771	53		596			433	2,881	321	66	1,152	**39,986**
Friant Division	574	26,557	2,381	1,056	12,184	12,975	16,537		2,316	512		188,768	17,124	**850,348**
Kern Co WA		20,703	377	5,665		6,135	11,951		665	21,077		101,216		**780,793**
Pacheco WD	194	269	103	273						409			100	**4,900**
Pajaro Vly WMA			10,716	2,161		761						2,925		**27,820**
Panoche WD	571	603	1,386	252		60		265	656	4,035	760	275	1,836	**35,073**
Patterson WD	73	140	247			647			54	1,738	263			**13,316**
Plain View WD (now Byron-Bethany ID)		363		2		89			154		138			**4,120**
San Benito Co WD			13,094			1,801						3,734		**29,119**
San Luis WD	1,645	894	1,752	253		244			1,633	2,413	543	1,096	752	**45,758**
Santa Clara Vly WD		4,128	1,194	4,303		3,890				623	414	1,943		**25,677**
Westlands WD	7,560	30,552	2,887	19,148	487	604	75		5,485	83,693	4,375	6,179	13,334	**529,050**
													Total:	**2,385,961**

Note: Acreage for crops not listed may have been grouped with other crops having similar crop coefficients.

Table 12
Water Balance Analysis Results
Scenario 1: Hydrology for a Wet Calendar Year

Water District	Total Area (acres)	Weighted Average Annual Effective Precipitation (in)	Weighted Average Annual Crop Evapotranspiration (in)	Weighted Average Annual Gross Irrigation Requirement[1] (in)	Annual Gross Irrigation Requirement (ac-ft)
Del Puerto WD	39,986	4.6	25.8	26.7	89,046
Friant Division[3]	850,348	4.8	28.5	30.1	2,132,194
Kern Co WA	780,793	4.9	30.9	34.0	2,214,815
Pacheco WD	4,900	3.2	22.2	23.7	9,683
Pajaro Vly WMA	27,820	6.6	22.0	18.9	43,760
Panoche WD	35,073	3.5	25.6	28.0	81,829
Patterson ID	13,316	4.9	29.0	30.4	33,775
Plain View WD (now Byron-Bethany ID)	4,120	5.2	24.4	23.8	8,176
San Benito Co WD	29,119	4.6	20.4	19.4	47,055
San Luis WD	45,758	3.9	26.0	28.0	106,893
Santa Clara Vly WD	25,677	4.7	17.7	15.7	33,510
Westlands WD	529,050	2.6	24.8	28.0	1,235,869
Total	**2,385,961**				**6,036,604**

Table 13
Water Balance Analysis Results
Scenario 2: Hydrology for a Dry Calendar Year

Water District	Total Area (acres)	Weighted Average Annual Effective Precipitation (in)	Weighted Average Annual Crop Evapotranspiration (in)	Weighted Average Annual Gross Irrigation Requirement[1] (in)	Annual Gross Irrigation Requirement (ac-ft)
Del Puerto WD	39,986	2.3	31.0	36.9	123,069
Friant Division[4]	850,348	1.7	32.5	39.6	2,805,384
Kern Co WA	780,793	1.2	36.1	46.2	3,004,860
Pacheco WD	4,900	1.2	23.9	28.7	11,719
Pajaro Vly WMA	27,820	4.2	21.5	20.7	47,928
Panoche WD	35,073	1.3	27.6	33.6	98,335
Patterson ID	13,316	1.8	34.8	42.6	47,265
Plain View WD (now Byron-Bethany ID)	4,120	2.5	25.5	28.6	9,812
San Benito Co WD	29,119	2.2	21.4	23.6	57,266
San Luis WD	45,758	1.5	29.6	36.2	138,157
Santa Clara Vly WD	25,677	2.9	21.5	22.4	47,908
Westlands WD	529,050	0.7	28.1	35.2	1,552,933
Total	**2,385,961**				**7,944,637**

[1]Irrigation demand was increased by 5% to account for leaching, with an additional increase to account for the irrigation efficiency (all districts were assigned an irrigation efficiency of 77%, except Kern Co WA, which had 75%).

Table 14
Water Balance Analysis Results
Scenario 3: Average of Hydrology for Wet and Dry Calendar Years

Water District	Total Area (acres)	Weighted Average Annual Effective Precipitation (in)	Weighted Average Annual Crop Evapotranspiration (in)	Weighted Average Annual Gross Irrigation Requirement[1] (in)	Annual Gross Irrigation Requirement (ac-ft)
Del Puerto WD	39,986	4.1	28.4	31.0	103,208
Friant Division[3]	850,348	3.6	30.5	34.4	2,434,309
Kern Co WA	780,793	3.4	33.5	39.6	2,578,324
Pacheco WD	4,900	2.7	23.0	25.5	10,400
Pajaro Vly WMA	27,820	5.9	21.8	19.2	44,406
Panoche WD	35,073	3.0	26.6	29.9	87,517
Patterson ID	13,316	4.3	31.9	35.2	39,059
Plain View WD (now Byron-Bethany ID)	4,120	4.7	25.0	25.1	8,613
San Benito Co WD	29,119	4.0	20.9	20.8	50,486
San Luis WD	45,758	3.3	27.8	31.3	119,349
Santa Clara Vly WD	25,677	4.6	19.6	18.2	38,961
Westlands WD	529,050	1.8	26.4	31.4	1,383,921
Total	**2,385,961**				**6,898,551**

[1]Irrigation demand was increased by 5% to account for leaching, with an additional increase to account for the irrigation efficiency (all districts were assigned an irrigation efficiency of 77%, except Kern Co WA, which had 75%).

Table 15
Comparison of Water Balance (WB) Analysis and Values from Water Needs Assessment (WNA) for a Normal Year

Water District	Total Area in WNA (acres)	Total Area in WB (acres)	Effective Precipitation from WNA (in)	Effective Precipitation from WB (in)	WNA Crop Water Requirement[1] (in)	WB Crop Water Requirement[1] (in)	Effective Precipitation Ratio (WB/WNA)	Crop Water Requirement[1] Ratio (WB/WNA)
Del Puerto WD	40,819	39,986	2.4	4.1	32.8	23.8	1.7	0.7
Kern Co WA	--	780,793		3.4				
Pacheco WD	3,972	4,900	6.1	2.7	25.2	19.6	0.4	0.8
Pajaro Vly WMA	43,563	27,820	6.0	5.9	18.2	14.7	1.0	0.8
Panoche WD	36,197	35,073	3.6	3.0	27.0	23.1	0.8	0.9
Patterson ID	13,469	13,316	2.5	4.3	33.5	27.1	1.7	0.8
Plain View WD (now Byron-Bethany ID)	5,594	4,120	4.5	4.7	35.3	19.3	1.0	0.5
San Benito Co WD	22,926	29,119	6.0	4.0	23.1	16.0	0.7	0.7
San Luis WD	47,924	45,758	8.3	3.3	26.2	24.1	0.4	0.9
Santa Clara Vly WD	26,177	25,677	4.8	4.6	22.6	14.0	0.9	0.6
Westlands WD	545,847	529,050	3.6	1.8	27.9	24.2	0.5	0.9
Friant Division Districts								
Arvin-Edison WSD	129,340	102,700	2.9	2.39	30.1	29.5	0.8	1.0
Chowchilla WD	63,637	56,133	2.9	4.34	36.1	31.7	1.5	0.9
Delano-Earlimart ID	50,971	45,518	1.5	2.42	33.9	25.6	1.6	0.8
Exeter ID	12,670	11,288	2.2	5.92	32.4	25.4	2.7	0.8
Fresno ID	163,218	159,547	4.8	3.74	31.9	25.2	0.8	0.8
Garfield WD		1,415	not available	5.43	not available	26.4	1.0	1.0
Gravelly Ford WD	8,498	8,442	1.2	3.25	28.8	27.1	2.6	0.9
International WD		627	not available	6.42	not available	26.3	1.0	1.0
Ivanhoe ID	10,514	10,526	1.7	6.20	35.2	25.2	3.6	0.7
Lewis Creek WD		631	not available	2.43	not available	25.9	1.0	1.0
Lindmore ID	24,167	23,752	2.7	4.58	32.6	25.6	1.7	0.8
Lindsay-Strathmore ID	12,700	11,852	8.4	5.62	29.4	25.0	0.7	0.8
Lower Tule River ID	110,875	98,824	1.6	3.49	37.5	25.8	2.2	0.7
Madera ID	107,658	99,837	2.6	2.94	43.2	25.0	1.1	0.6
Orange Cove ID	28,000	23,976	5.7	6.55	33.6	25.1	1.2	0.7
Porterville ID	13,250	13,291	1.8	3.54	34.3	25.2	2.0	0.7
Saucelito ID	17,702	19,217	2.2	3.15	32.2	23.0	1.4	0.7
Shafter-Wasco ID	32,504	29,233	2.3	3.26	37.6	29.4	1.4	0.8
Southern San Joaquin MUD	49,045	46,052	1.0	3.29	35.8	27.4	3.2	0.8
Stone Corral ID	5,163	5,297	2.8	5.93	36.9	26.1	2.1	0.7
Tea Pot Dome WD	3,128	2,948	6.6	5.45	30.3	25.3	0.8	0.8
Terra Bella ID	10,068	11,927	1.6	5.19	34.3	25.3	3.3	0.7
Tulare ID	75,582	67,315	6.0	4.04	30.3	24.8	0.7	0.8

[1]Includes leaching but not irrigation efficiency.

Table 16
Revised Water Needs Assessment for a Wet Calendar Year

Water District	(a) Total Area in WNA (acres)	(b) Conveyance Losses in WNA (ac-ft)	(c) Modified Effective Precipitation (in)	(d) Modified Crop Water Requirement[1] (in)	(e) = (c)/(12 in/ft)*(a) Modified Effective Precipitation (ac-ft)	(f) = (d)/(12 in/ft)*(a) Modified Crop Water Requirement[1] (ac-ft)	(g) Irrigation Efficiency from WNA	(h) = [(f) - (e)]/(g) Net Crop Water Requirement (ac-ft)	(i) = (h) + (b) Total Agricultural Demand (ac-ft)
Del Puerto WD	40,819	6,420	2.7	28.3	9,204	96,239	0.75	116,046	122,466
Friant Division	931,363	72,693	--	--	329,240	2,341,019	--	2,617,291	2,689,984
Kern Co WA	--	--	--	--	--	--	--	--	--
Pacheco WD	3,972	1,235	7.2	23.5	2,377	7,764	0.75	7,182	8,417
Pajaro Vly WMA	43,563	5,130	6.6	18.0	24,089	65,253	0.85	48,428	53,558
Panoche WD	36,197	7,903	4.1	25.2	12,515	76,150	0.75	84,846	92,749
Patterson ID	13,469	725	2.8	28.9	3,170	32,476	0.75	39,074	39,799
Plain View WD (now Byron-Bethany ID)	5,594	0	5.1	33.5	2,358	15,616	0.75	17,676	17,676
San Benito Co WD	22,926	2,000	7.0	21.5	13,303	41,133	0.75	37,107	39,107
San Luis WD	47,924	1,906	9.8	23.5	39,232	93,734	0.75	72,669	74,575
Santa Clara Vly WD	26,177	0	5.0	19.4	10,911	42,329	0.75	41,890	41,890
Westlands WD	545,847	319	5.2	24.9	235,367	1,133,326	0.75	1,197,278	1,197,597
Total	**1,717,851**	**98,331**	**--**	**--**	**681,767**	**3,945,038**	**--**	**4,279,489**	**4,377,820**
Friant Division Districts									
Arvin-Edison WSD	129,340	13,485	4.2	26.0	44,873	280,253	0.78	301,770	315,255
Chowchilla WD	63,637	13,255	3.6	31.8	19,211	168,828	0.75	199,489	212,744
Delano-Earlimart ID	50,971	2,918	2.3	29.0	9,747	123,032	0.80	141,606	144,524
Exeter ID	12,670	100	2.8	26.7	2,968	28,151	0.75	33,577	33,677
Fresno ID	163,218	8,000	6.1	29.4	82,875	399,603	0.75	422,304	430,304
Garfield WD[2]	1,415	0	6.4	24.6	750	2,898	0.77	2,791	2,791
Gravelly Ford WD	8,498	1,948	1.8	25.7	1,240	18,200	0.74	22,918	24,866
International WD[2]	627	0	7.4	24.5	386	1,281	0.77	1,162	1,162
Ivanhoe ID	10,514	0	2.2	28.9	1,921	25,344	0.75	31,231	31,231
Lewis Creek WD[2]	631	0	3.4	22.5	181	1,181	0.77	1,299	1,299
Lindmore ID	24,167	200	3.2	28.1	6,463	56,604	0.78	64,284	64,484
Lindsay-Strathmore ID	12,700	490	10.0	25.1	10,552	26,602	0.75	21,400	21,890
Lower Tule River ID	110,875	730	2.0	32.4	18,648	299,166	0.78	359,639	360,369
Madera ID	107,658	25,080	3.7	39.0	33,390	349,827	0.78	405,689	430,769
Orange Cove ID	28,000	0	7.0	30.0	16,384	70,070	0.75	71,582	71,582
Porterville ID	13,250	0	2.3	29.4	2,492	32,464	0.75	39,964	39,964
Saucelito ID	17,702	1,000	2.8	27.6	4,195	40,680	0.80	45,606	46,606
Shafter-Wasco ID	32,504	0	3.7	32.8	10,009	88,741	0.75	104,976	104,976
Southern San Joaquin MUD	49,045	2,500	1.6	29.9	6,532	122,175	0.78	148,260	150,760
Stone Corral ID	5,163	0	3.4	32.0	1,473	13,773	0.83	14,819	14,819
Tea Pot Dome WD	3,128	12	8.3	25.6	2,151	6,684	0.75	6,043	6,055
Terra Bella ID	10,068	0	2.0	29.0	1,647	24,366	0.75	30,293	30,293
Tulare ID	75,582	2,975	8.1	25.6	51,151	161,093	0.75	146,589	149,564
Total for Friant Division	**931,363**	**72,693**	--	--	**329,240**	**2,341,019**	--	**2,617,291**	**2,689,984**

[1]Includes leaching but not irrigation efficiency.
[2]Since values from WNA were unavailable, used acreage from water balance, assumed conveyance losses of 0 acre-feet, and used irrigation efficiency from water balance.

Table 17
Revised Water Needs Assessment for a Dry Calendar Year

Water District	(a) Total Area in WNA (acres)	(b) Conveyance Losses in WNA (ac-ft)	(c) Modified Effective Precipitation (in)	(d) Modified Crop Water Requirement[1] (in)	(e) = (c)/(12 in/ft)*(a) Modified Effective Precipitation (ac-ft)	(f) = (d)/(12 in/ft)*(a) Modified Crop Water Requirement[1] (ac-ft)	(g) Irrigation Efficiency from WNA	(h) = [(f) - (e)]/(g) Net Crop Water Requirement (ac-ft)	(i) = (h) + (b) Total Agricultural Demand (ac-ft)
Del Puerto WD	40,819	6,420	1.4	39.1	4,627	133,011	0.75	171,179	177,599
Friant Division	931,363	72,693	--	--	118,794	3,077,365	--	3,851,124	3,923,817
Kern Co WA	--	--	--	--	--	--	--	--	--
Pacheco WD	3,972	1,235	2.7	28.4	897	9,397	0.75	11,333	12,568
Pajaro Vly WMA	43,563	5,130	4.3	19.7	15,465	71,468	0.85	65,886	71,016
Panoche WD	36,197	7,903	1.5	30.3	4,628	91,510	0.75	115,843	123,746
Patterson ID	13,469	725	1.1	40.5	1,200	45,447	0.75	58,996	59,721
Plain View WD (now Byron-Bethany ID)	5,594	0	2.5	40.2	1,147	18,740	0.75	23,458	23,458
San Benito Co WD	22,926	2,000	3.4	26.2	6,416	50,060	0.75	58,191	60,191
San Luis WD	47,924	1,906	3.7	30.3	14,733	121,148	0.75	141,888	143,794
Santa Clara Vly WD	26,177	0	3.0	27.7	6,614	60,514	0.75	71,867	71,867
Westlands WD	545,847	319	1.3	31.3	60,448	1,424,083	0.75	1,818,180	1,818,499
Total	**1,717,851**	**98,331**	**--**	**--**	**234,968**	**5,102,745**	**--**	**6,387,946**	**6,486,277**
Friant Division Districts									
Arvin-Edison WSD	129,340	13,485	1.3	34.7	14,456	373,470	0.78	460,274	473,759
Chowchilla WD	63,637	13,255	1.3	41.8	6,761	221,870	0.75	286,813	300,068
Delano-Earlimart ID	50,971	2,918	0.5	39.4	2,135	167,395	0.80	206,574	209,492
Exeter ID	12,670	100	1.0	40.3	1,024	42,510	0.75	55,315	55,415
Fresno ID	163,218	8,000	2.9	35.1	39,158	477,705	0.75	584,730	592,730
Garfield WD[2]	1,415	0	3.6	29.3	422	3,457	0.77	3,942	3,942
Gravelly Ford WD	8,498	1,948	0.5	32.5	376	23,044	0.74	30,632	32,580
International WD[2]	627	0	4.5	29.1	233	1,521	0.77	1,672	1,672
Ivanhoe ID	10,514	0	0.8	44.0	675	38,595	0.75	50,559	50,559
Lewis Creek WD[2]	631	0	1.1	29.6	59	1,556	0.77	1,945	1,945
Lindmore ID	24,167	200	1.6	38.2	3,184	76,928	0.78	94,543	94,743
Lindsay-Strathmore ID	12,700	490	5.3	35.0	5,591	37,009	0.75	41,891	42,381
Lower Tule River ID	110,875	730	0.7	44.1	6,186	407,113	0.78	514,009	514,739
Madera ID	107,658	25,080	1.0	48.1	9,235	431,950	0.78	541,942	567,022
Orange Cove ID	28,000	0	3.6	38.3	8,452	89,354	0.75	107,869	107,869
Porterville ID	13,250	0	0.8	40.4	895	44,600	0.75	58,274	58,274
Saucelito ID	17,702	1,000	1.0	37.9	1,456	55,968	0.80	68,140	69,140
Shafter-Wasco ID	32,504	0	0.7	43.1	1,852	116,675	0.75	153,097	153,097
Southern San Joaquin MUD	49,045	2,500	0.3	42.4	1,283	173,265	0.78	220,490	222,990
Stone Corral ID	5,163	0	1.8	43.0	761	18,504	0.83	21,377	21,377
Tea Pot Dome WD	3,128	12	3.5	36.6	903	9,549	0.75	11,528	11,540
Terra Bella ID	10,068	0	0.8	41.4	677	34,726	0.75	45,399	45,399
Tulare ID	75,582	2,975	2.1	36.6	13,020	230,601	0.75	290,108	293,083
Total for Friant Division	**931,363**	**72,693**	**--**	**--**	**118,794**	**3,077,365**	**--**	**3,851,124**	**3,923,817**

[1]Includes leaching but not irrigation efficiency.

[2]Since values from WNA were unavailable, used acreage from water balance, assumed conveyance losses of 0 acre-feet, and used irrigation efficiency from water balance.

Table 18
Seasonal Irrigation Water Deficits for Existing Conditions

Water District	Wet Year with 100 Percent Contract Water Supply			Dry Year with 25 Percent Contract Water Supply		
	Contract Water for Agricultural Use[1] (ac-ft)	Annual Gross Irrigation Requirement (ac-ft)	Annual Irrigation Water Deficit (ac-ft)	Contract Water for Agricultural Use (ac-ft)	Annual Gross Irrigation Requirement (ac-ft)	Annual Irrigation Water Deficit (ac-ft)
Del Puerto WD	140,210	122,466	0	35,053	177,599	142,547
Friant Division (Class 1)[2,3]	735,750			183,938		
Friant Division (Class 2)[2,3]	1,401,475			0		
Friant Division (Total)	2,137,225	2,689,984	552,759	183,938	3,923,817	3,739,880
Kern Co WA	862,730	2,214,815	1,352,085	215,683	3,004,860	2,789,177
Pacheco WD	10,071	8,417	0	2,518	12,568	10,050
Pajaro Vly WMA	6,260	53,558	47,298	1,565	71,016	69,451
Panoche WD	93,935	92,749	0	23,484	123,746	100,262
Patterson ID	22,500	39,799	17,299	5,625	59,721	54,096
Plain View WD (now Byron-Bethany ID)	19,893	17,676	0	4,973	23,458	18,485
San Benito Co WD	40,780	39,107	0	10,195	60,191	49,996
San Luis WD	124,263	74,575	0	31,066	143,794	112,728
Santa Clara Vly WD (CVP)	103,033			25,758		
Santa Clara Vly WD (SWP)	70,000			17,500		
Santa Clara Vly WD (Total)	173,033	41,890	0	43,258	71,867	28,609
Westlands WD	1,183,653	1,197,597	13,944	295,913	1,818,499	1,522,585
Total	**4,814,553**	**6,592,635**	**1,983,385**	**853,270**	**9,491,136**	**8,637,867**

[1]See Table 2-2 of EIR for more detail on the contract water amounts obtained from the following sources (USBR-SCCAO, 2011; KCWA, 2008; SCVWD, 2011).

[2]The Friant Division was assumed to receive 100 percent of both Class 1 and Class 2 deliveries in a wet year, although unlikely to occur.

[3]The Friant Division was assumed to receive no Class 2 deliveries and 25 percent of Class 1 deliveries in a dry year.