

Technical Memorandum

SGMA Readiness Project

Subject: Eastern San Joaquin Water Resources Model
Agricultural and Urban Demand Estimates (Task 2 Deliverable)

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1 Introduction

The purpose of this Technical Memorandum is to document the data and information used in analyzing land surface processes, to briefly discuss the analytical tools used, and to present estimates of the agricultural and urban water use in the Eastern San Joaquin Groundwater Subbasin (ESJ Subbasin) as part of the development of the Eastern San Joaquin Water Resources Model (ESJWRM).

The IWFDM Demand Calculator (IDC) (Dogrul et al., 2017) is used to estimate the agricultural and urban water use in the ESJ Subbasin portion of ESJWRM. IDC, the stand-alone version of the Integrated Water Flow Model's (IWFDM) root zone component, calculates agricultural and urban water demands with major inputs including climate conditions, soil parameters, and land use types and distribution. The hydrologic period of the ESJWRM spans from October 1994 through September 2015 and covers water years 1995 through 2015.

The ESJWRM boundaries include the ESJ Subbasin (primary model area), as well as the Cosumnes Subbasin to the north and the Modesto Subbasin to the south. The model network is a Finite Element based grid that contains 16,054 elements and 15,302 nodes. The model elements are grouped into 20 model subregions that are used to organize input data for the model and to report standard model output water budgets (Figure 1). These subregions are aggregated into 8 larger units (model subareas) used to output model results for basin-scale planning (Figure 2). ESJ Subbasin, the primary model area, is made up of 18 subregions and is the focus of this Technical Memorandum.

2 Technical Review and Oversight

The development of the ESJWRM, including the development and calibration of IDC, is taking place in an open and transparent process. The Eastern San Joaquin County Groundwater Basin Authority (GBA) was the organizational structure for model development coordination before the creation of the Eastern San Joaquin Groundwater Authority (GWA). The GBA's Ad Hoc Technical Review Committee was the forum to review model input data and assumptions, as well as calibration results. The monthly committee meetings were open to all interested parties and generally consisted of technical representatives from local agencies, consultants with knowledge of the area, representatives for neighboring groundwater subbasins, DWR staff, and San Joaquin County personnel.

Local agencies with consistent representation included San Joaquin County, Woodbridge Irrigation District, City of Lodi, North San Joaquin Water Conservation District, Lockeford Community Services District, Calaveras County Water District, City of Stockton, Cal Water, Stockton East Water District, City of

Lathrop, City of Manteca, South San Joaquin Irrigation District, City of Escalon, Oakdale Irrigation District, and Stanislaus County.

3 Land Use

Spatial land use data was used to develop land use and crop acreages for each model element. Model element acreages were then aggregated by subregion for reporting and verification purposes.

The Department of Water Resources (DWR) conducts periodic land use surveys for each county that include over 70 different crop categories, as well as urban and native vegetation (DWR, 1993-2000). DWR land use surveys by county were merged and assumed to represent water year 1995 in the model. The surveys used include:

1. San Joaquin County (1996)
2. Sacramento County (1993)
3. Amador County (1997)
4. Calaveras County (2000)
5. Stanislaus County (1996)

Data for water years 2007 through 2015 are from the United States Department of Agriculture's remote sensing CropScape data (USDA NASS, 2007-2015). CropScape includes 256 land use categories that come from annual satellite imagery collected during the growing season on 30 meter by 30 meter pixels. Based on reports on the CropScape website, the level of accuracy for this data is about 85-97% for crop-specific land cover categories. Although this level of accuracy is high, the accuracy varies depending on many factors, including the time of the satellite image, growing season timing, cloud cover, type of crop, and maturity state of the crop.

DWR retained LandIQ, LLC to develop a statewide assessment of agricultural land use in summer 2014. LandIQ used remote sensing methods to collect and process the data, which was then ground truthed for a reported overall accuracy of 96.6% (DWR, 2014). In ESJWRM, this data was broadly used as verification of CropScape 2014 data and, in a few specific cases, as replacement or enhancement of the CropScape data.

Local data and knowledge was also utilized to refine and correct, as needed, the cropping acreages developed based on the DWR land use surveys and CropScape years. ESJWRM includes 23 irrigated crop categories and 4 general land use categories. The irrigated crop categories were combined into 6 high-level groupings of crops with similar water use or irrigation practices. Table 1 lists the land use categories.

To fill the gap between 1995 and 2007, all land use and crop categories were interpolated at the spatial resolution level of the model element. Thus, the geographic distribution of interpolated land use and cropping patterns are honored. Adjustments were made, as needed, at the element level to ensure that the land use and cropping pattern trends over time are reflective of local data. These adjustments were mostly based on local knowledge and information received from various entities, including irrigation districts, water districts, and municipalities.

Figure 3 and Figure 4 show the spatial distribution of the major land use categories in the ESJ Subbasin. Figure 5 shows the annual trends of land use categories in the ESJ Subbasin.

Figure 6, Figure 7, and Figure 8 show the spatial distribution of the irrigated crops for 1995, 2014, and 2015. Figure 9a-9m show the annual cropping patterns, by high level categories, for the ESJ Subbasin and those major model input subregions that are not predominantly urban centers (i.e., all subregions in the primary model area except subregions 3, 6, 9, 10, 12, and 16).

Table 1: Land Use Categories

Land Use Type	Model Category	Grouped Categories
Irrigated Crops	Almonds Cherries Citrus & Subtropical Other Orchard Pistachios Walnuts	Fruit and Nut Trees
	Vineyards	Vineyards
	Alfalfa Pasture	Alfalfa and Irrigated Pasture
	Grain	Grain
	Corn Cotton Dry Beans Field Crops Safflower Sugar Beets	Field Crops
	Cucurbits Onion & Garlic Potatoes Tomato Fresh Tomato Processing Truck Crops	Truck Crops
	Rice	Rice
	Urban Landscape Water Surface Riparian Vegetation Native Vegetation	
Other Land Use		

4 Urban Demand

IDC calculates urban demand based on per capita water use, population, and the breakdown of indoor versus outdoor water use by month. Figure 10 shows the annual population trends for each urban center. Figure 11 shows the annual per capita water use values of these urban centers used in the calculation of urban water demand. Figure 12a-12g show the model estimated annual urban demand for predominantly urban subregions and the total ESJ Subbasin area.

Population and per capita water use for the major urban areas were largely provided directly by the urban areas or were contained in Urban Water Management Plans (UWMPs). Additional annual population, including an estimate for rural urban areas, came from the United States Census Bureau and the California Department of Finance. Monthly per capita water use, commonly reported in gallons per capita per day (GPCD), was generally estimated for each urban entity using the annual population and monthly urban water use (provided by cities based on water delivery records). To estimate the urban water demand of rural domestic water areas, the average major urban area GPCD was combined with the estimated rural population.

It was assumed that an annual average of 60% of urban water was used indoors and 40% was used outdoors. The monthly fractions entered into the model had the majority of urban water demand due to indoor activities from November through March and up to a maximum of 60% of urban water used outdoors for the remainder of the year.

The indoor/outdoor breakdown received concurrence from the urban water providers who attended the Ad Hoc Technical Review Committee meetings. Population and per capita water use data were reviewed by the major urban areas and confirmed at the meetings (pers. comm. Kathryn Garcia, Andrew Richle, Michael Bolzowski, Greg Gibson, and Elba Mijango).

5 Agricultural Demand

IDC estimates agricultural water demand based on model input data for evapotranspiration (ET), monthly precipitation, return and reuse fractions, irrigation period, land use and cropping acreages, and soil properties (e.g., hydraulic conductivity, pore size distribution index, etc.). This data was compiled, analyzed, synthesized, and processed for input in ESJWRM.

The ET requirement is based on a variety of sources, including locally-developed data for the South San Joaquin Irrigation District and the Oakdale Irrigation District Agricultural Water Management Plans (AWMPs) (SJJID, 2015; OID, 2016) and averages for DWR's CIMIS (California Irrigation Management Information System) Zone 12 developed using the METRIC methodology, which is a remote-sensing based technology to estimate crop actual ET. Based on discussions with locals (pers. comm. Jennifer Spaletta and Bryan Thoreson), deficit irrigation of vineyards was simulated in ESJWRM with reference to the growing season ET values in the Lodi area (Prichard). Figure 13 shows the range in annual evapotranspiration rates from the various sources for the 27 model land use categories.

Monthly rainfall data was derived from the PRISM (OSU, 1970-2015) database and mapped to the model element in order to preserve the spatial distribution of the monthly rainfall over the model hydrologic period of 1995 through 2015. Figure 14 shows the annual rainfall in the model area and the cumulative departure from mean, which is an indication of long-term rainfall trends in the area.

The soil properties included in the model for each element are field capacity, wilting point, total porosity, hydraulic conductivity, and pore size distribution index. The soil survey geographic (SSURGO) database was downloaded first from the Web Soil Survey and any gaps in data were filled in using the General Soil Map of the United States (STATSGO2). These spatial datasets were averaged over each model element using IWFm's Soil Data Builder with GIS tool available at http://baydeltaoffice.water.ca.gov/modeling/hydrology/IWFm/SupportTools/index_SupportTools.cfm.

IDC was used to simulate the monthly agricultural demand estimates for each model element. The IDC model was calibrated to agricultural water use values reported by irrigation districts in their AWMPs and then checked against local data with input from irrigation district representatives and consultants (pers. comm. Doug Heberle, Jennifer Spaletta, Tom Flinn, Peter Martin, Cathy Lee, Manuel Verduzco, Sam Bologna, Bryan Thoreson, Emily Sheldon, Eric Thorburn, and Byron Clark). ESJWRM as a whole will undergo a more rigorous calibration process comparing model streamflow and groundwater levels to actual observed data.

The calibrated IDC was used to estimate monthly agricultural water demand at each model element during the model hydrologic period. The element-level estimates were then aggregated to report the information for each model subregion. Figure 15a-15n show the agricultural water demand, unit agricultural water use, and unit evapotranspiration of applied water (ETAW) estimates by the total ESJ Subbasin area and the subregions with irrigation districts who participated in the IDC development and calibration process.

The IDC model will be integrated with the comprehensive IWFm model, ESJWRM, to simulate the surface water and groundwater conditions in the ESJ Subbasin.

6 References

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- United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). Cropland Data Layers. Downloaded 2007-2015. USDA-NASS, Washington, DC. <https://nassgeodata.gmu.edu/CropScape/>.

Figure 1: Model Subregions

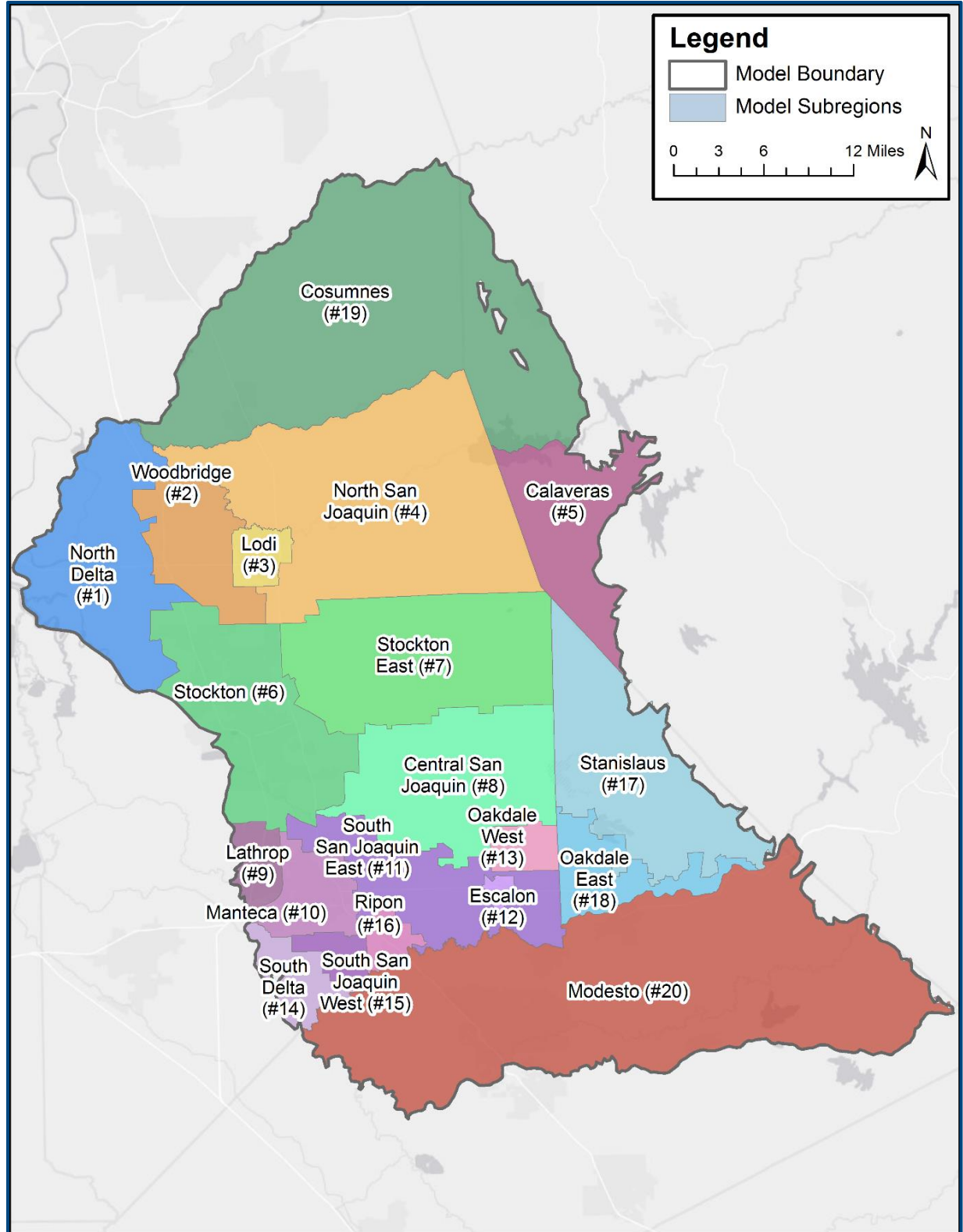


Figure 2: Model Subareas with Eastern San Joaquin Subbasin

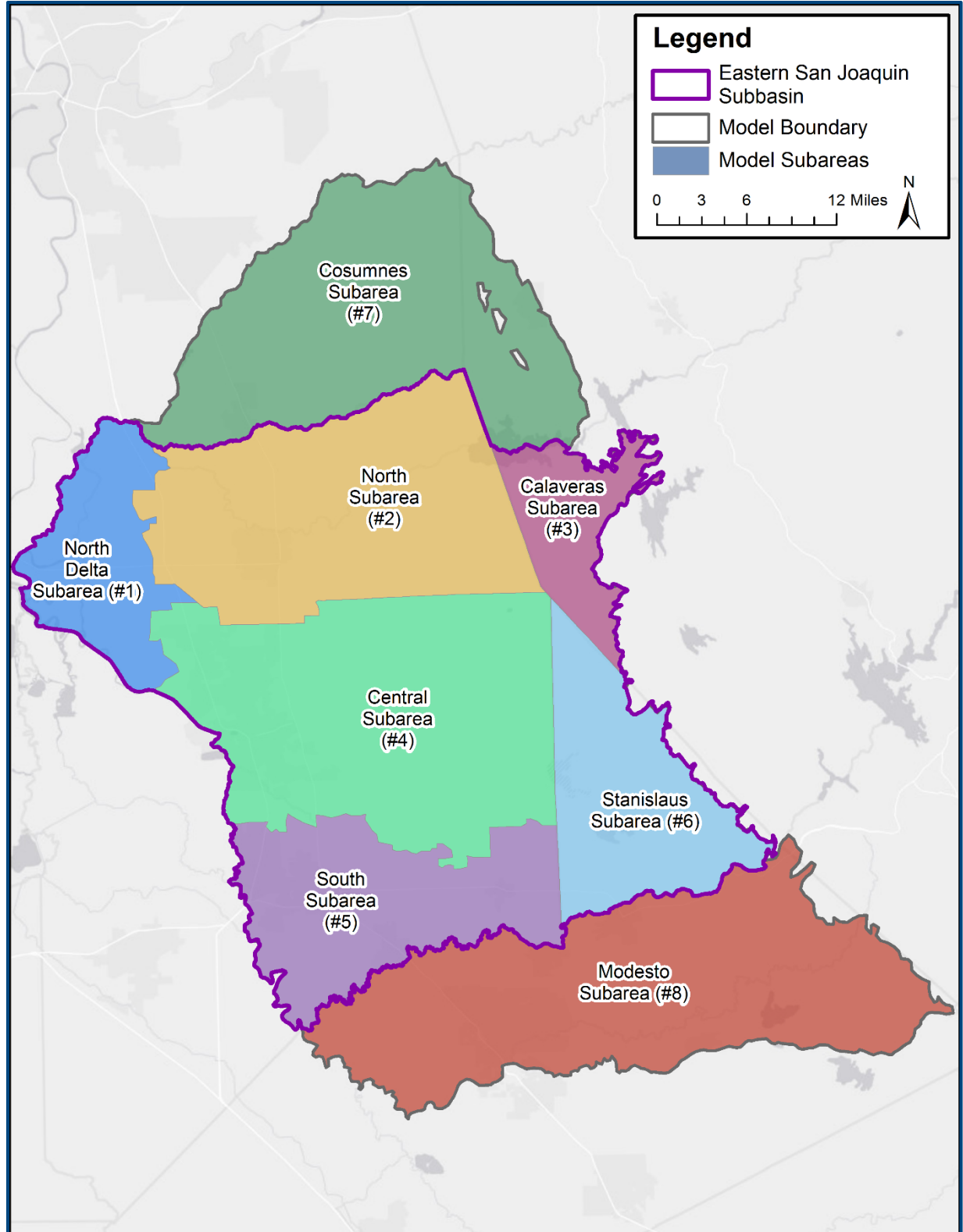


Figure 3: General Land Use in 1995 DWR Land Use Survey

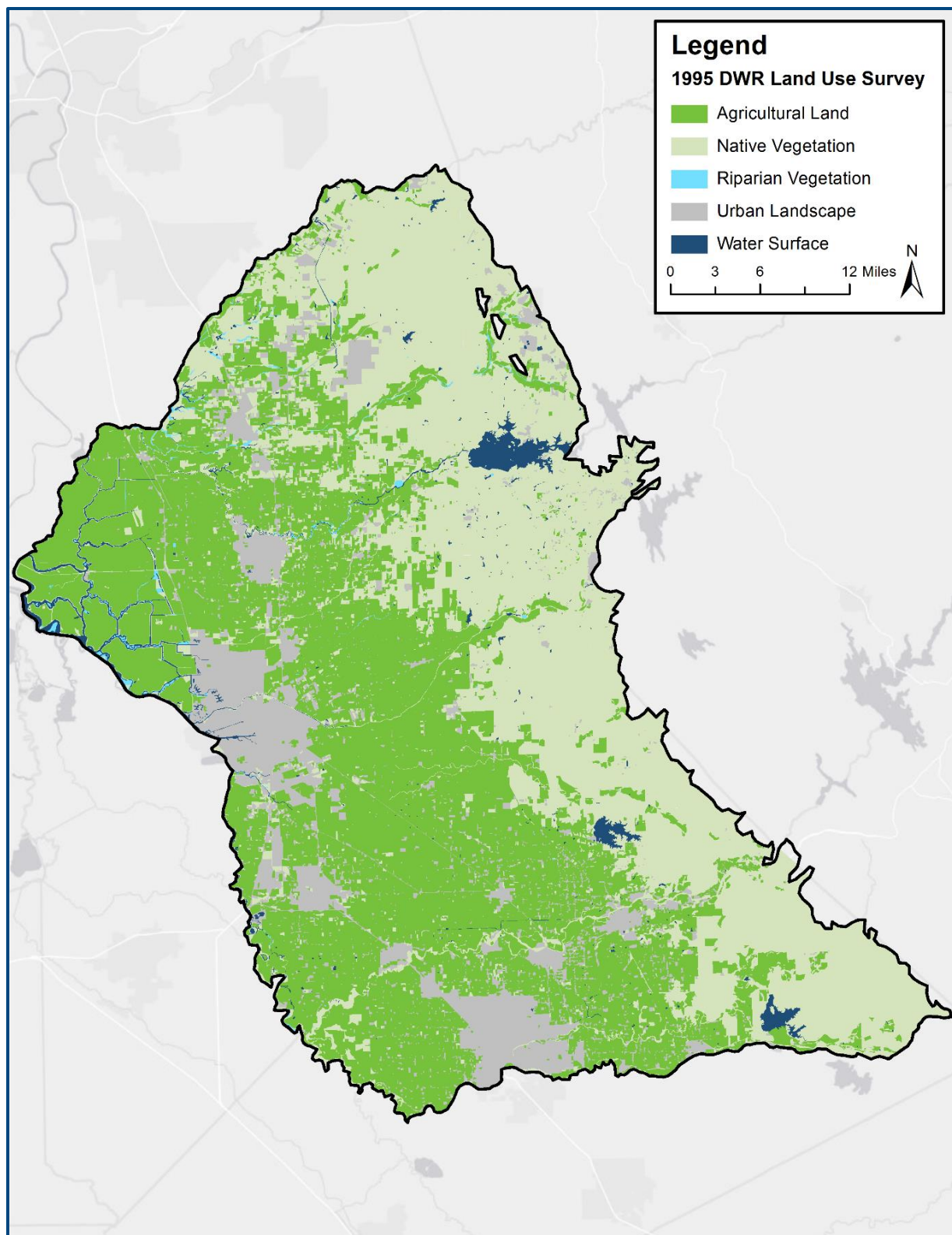


Figure 4: General Land Use in 2015 CropScape

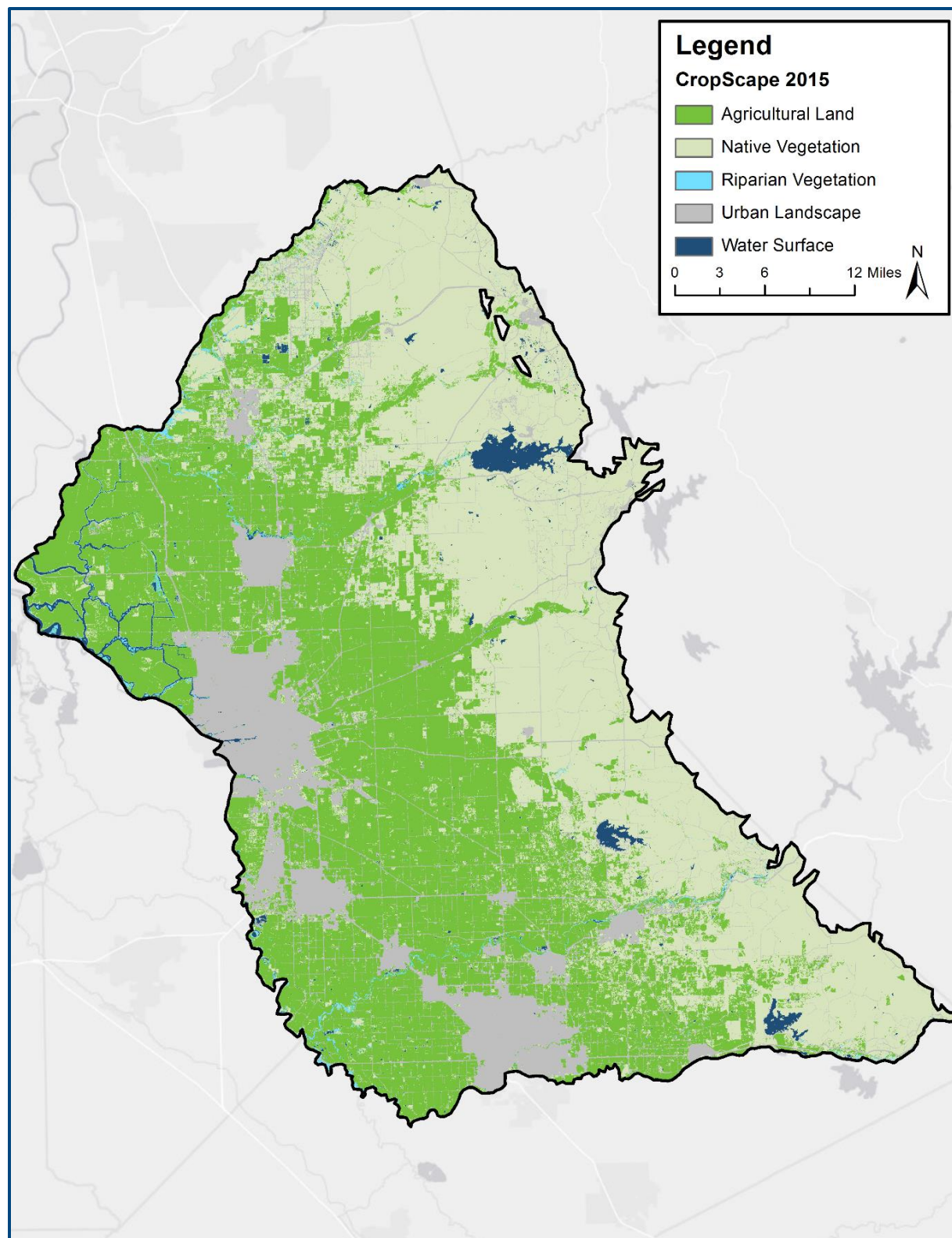


Figure 5: Eastern San Joaquin Subbasin General Land Use Acreages

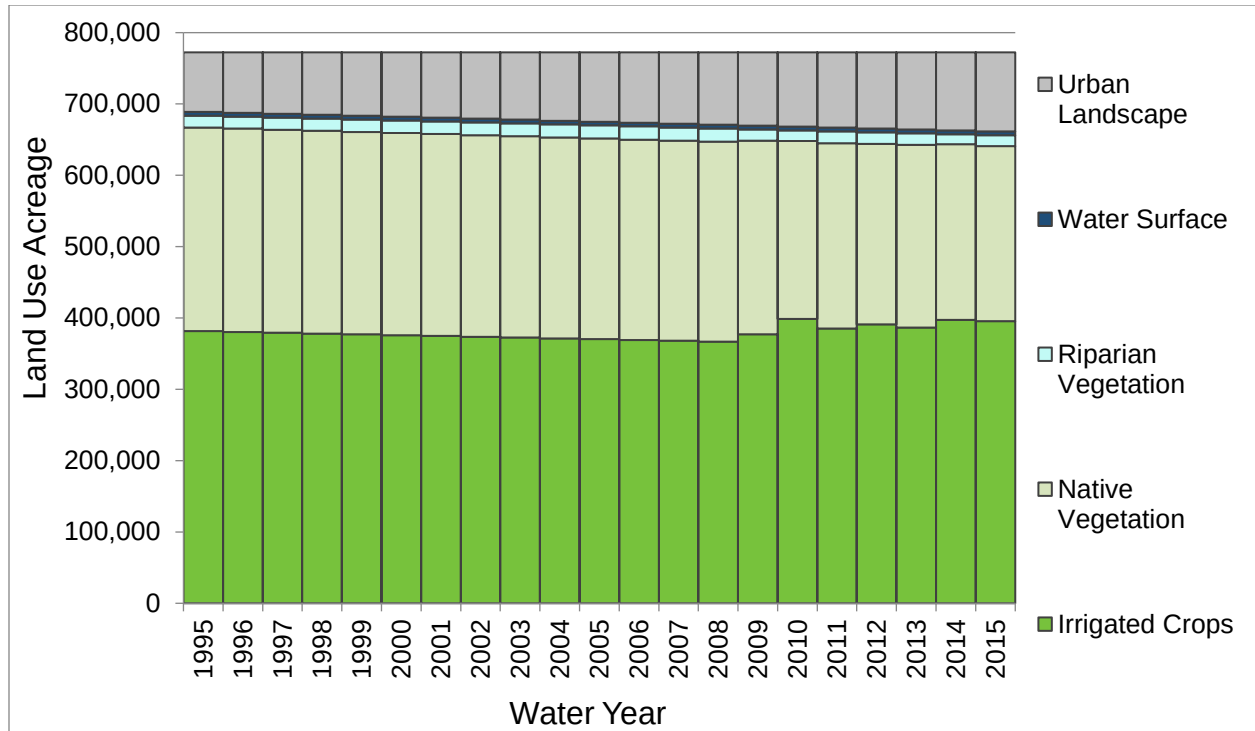


Figure 6: Cropping Pattern in 1995 DWR Land Use Survey

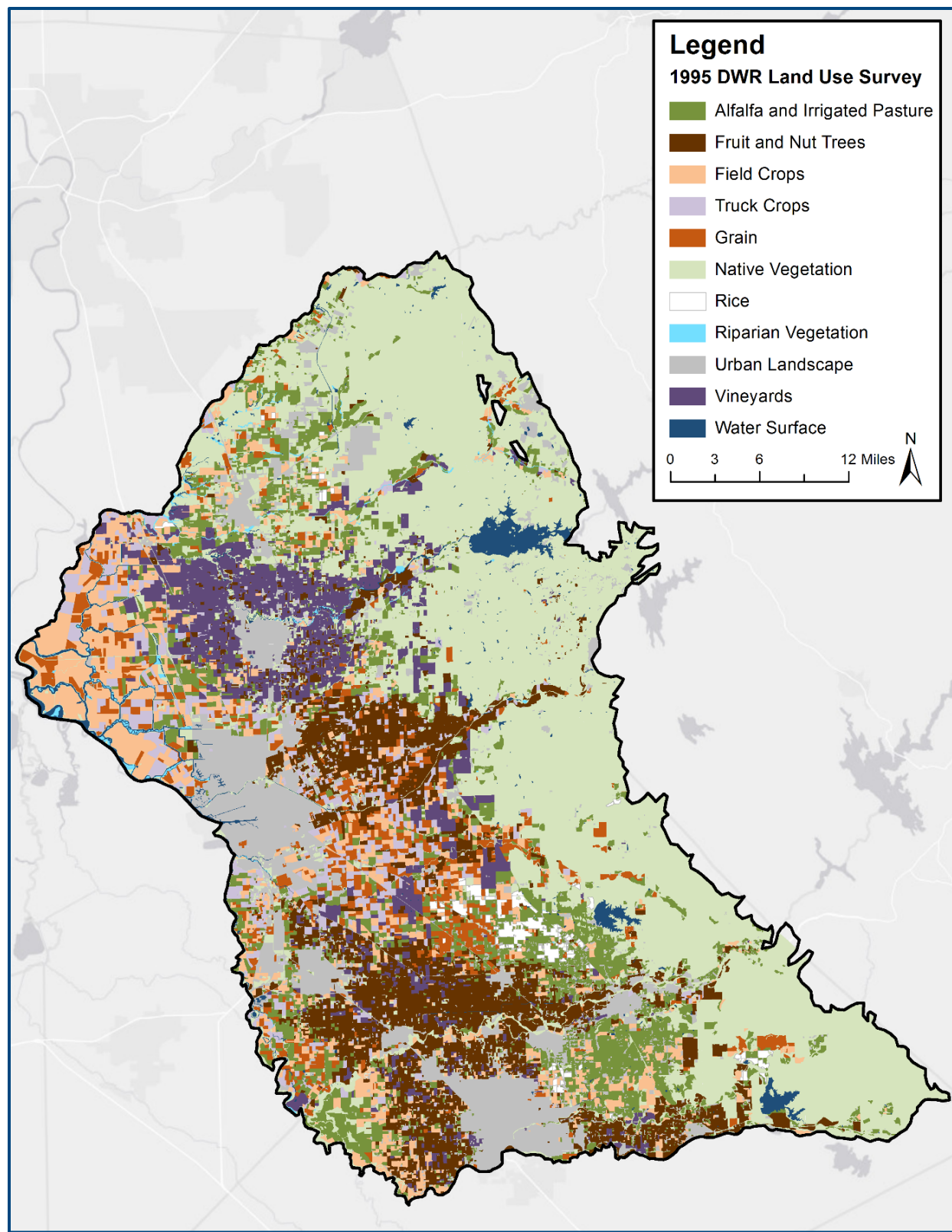


Figure 7: Cropping Pattern in 2014 LandIQ

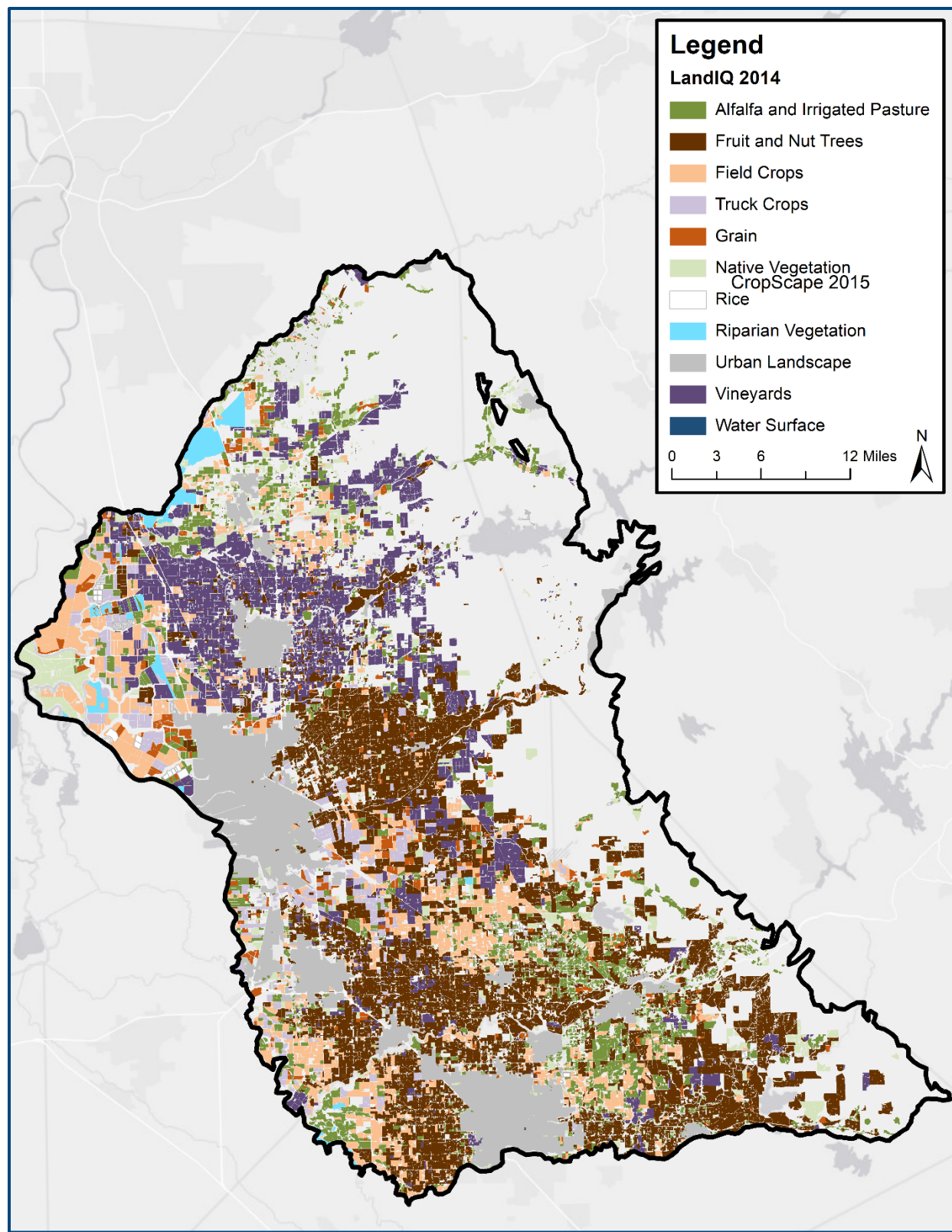


Figure 8: Cropping Pattern in 2015 CropScape

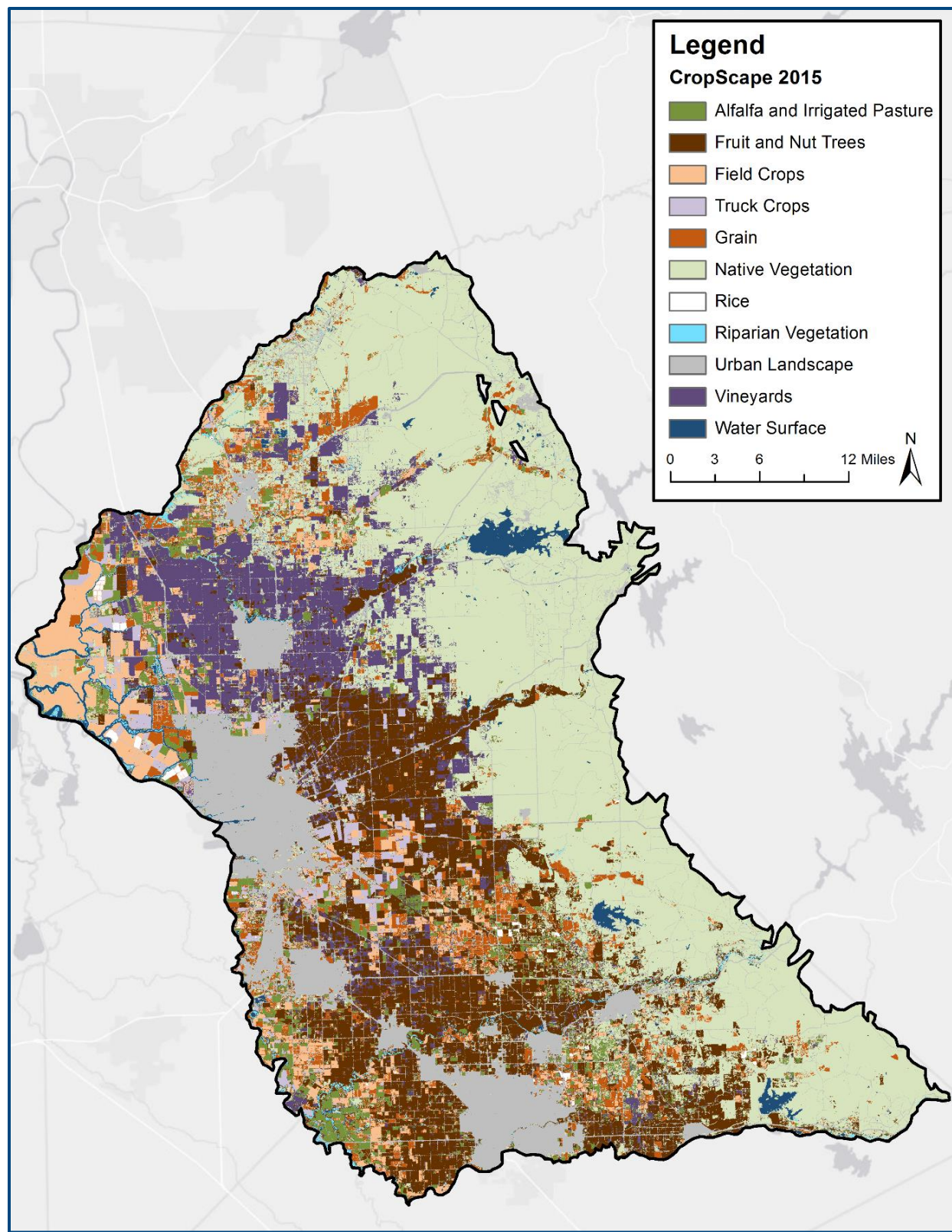


Figure 9a: Irrigated Crop Acreages- Eastern San Joaquin Subbasin

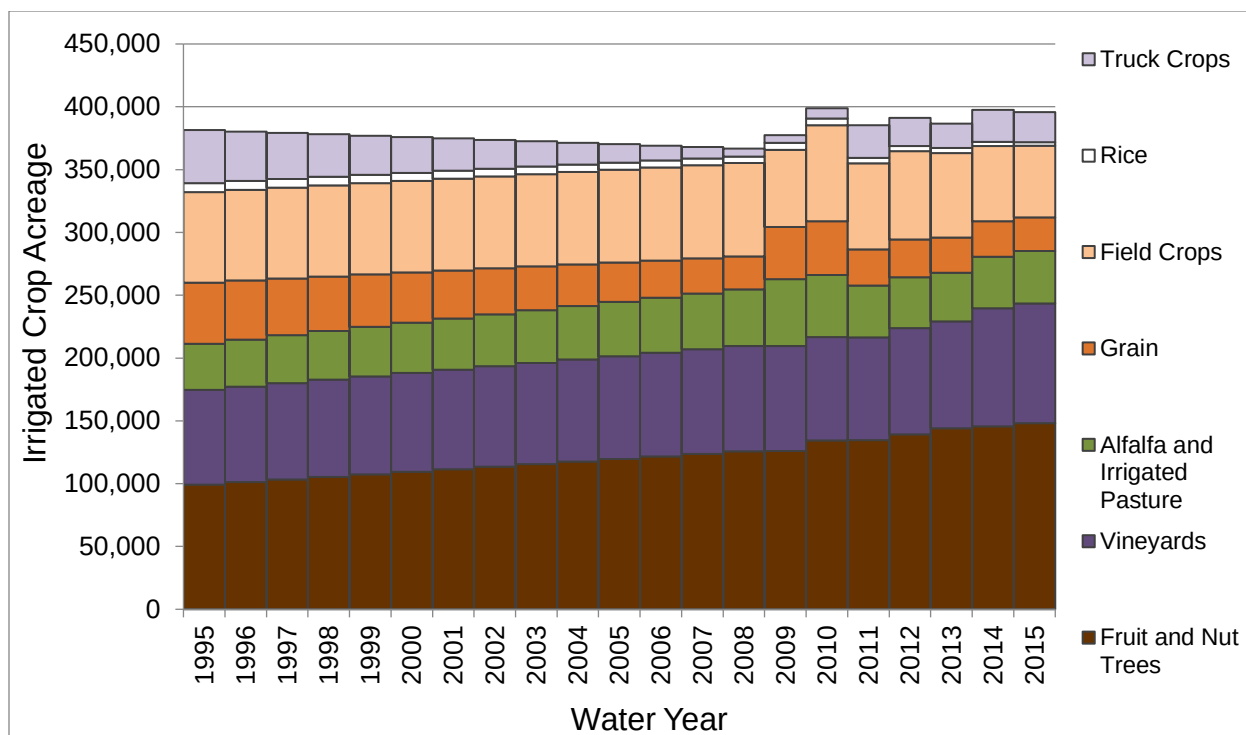


Figure 9b: Irrigated Crop Acreages- Subregion 1 (North Delta Subregion)

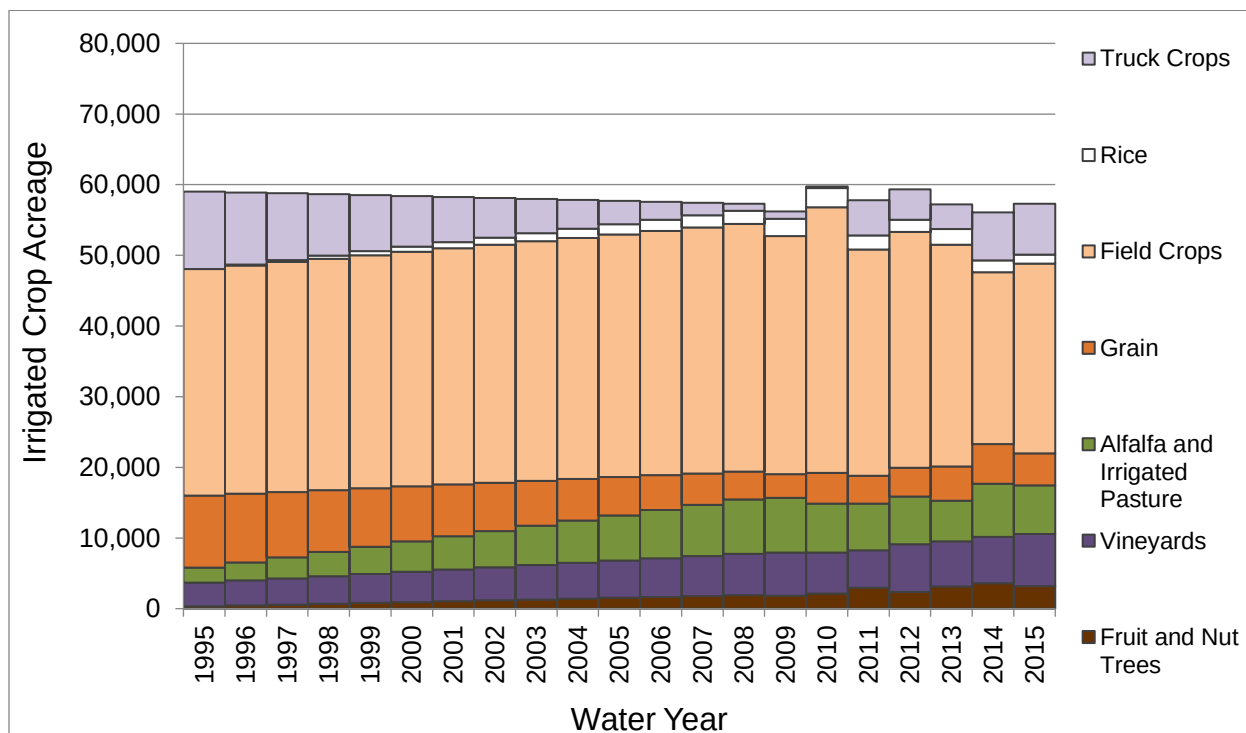


Figure 9c: Irrigated Crop Acreages- Subregion 2 (Woodbridge Subregion)

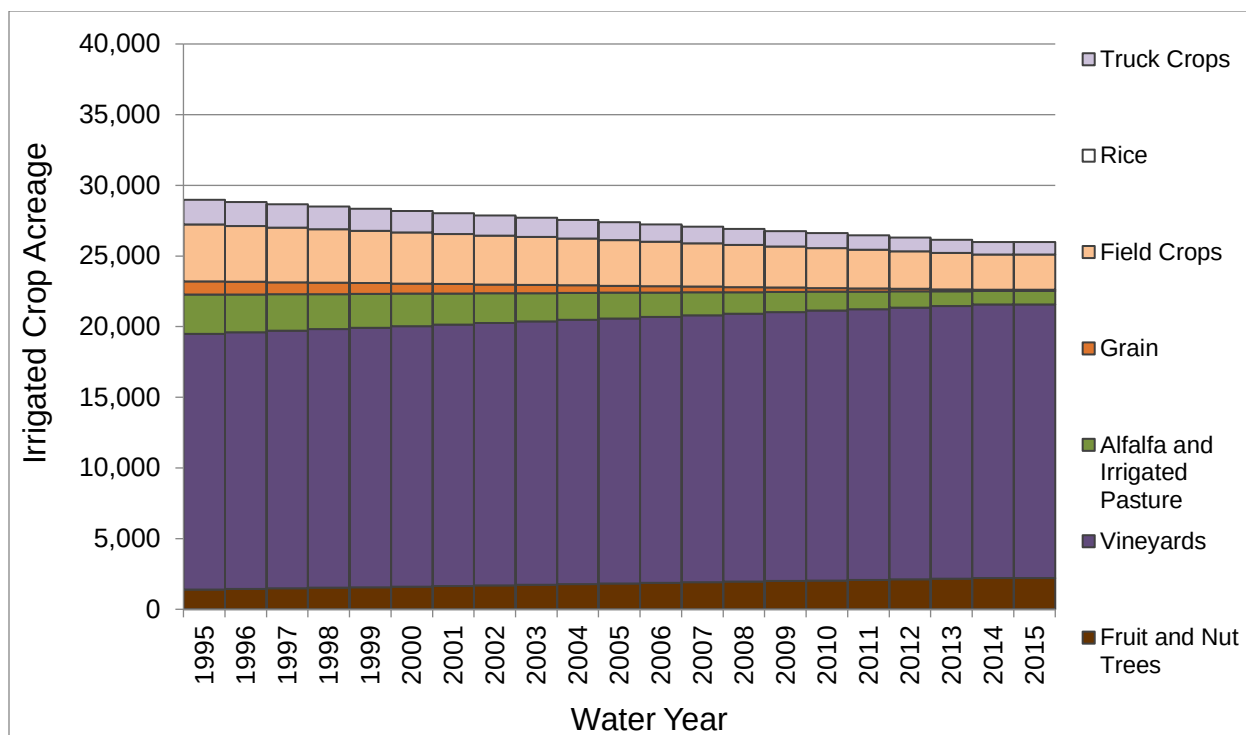


Figure 9d: Irrigated Crop Acreages- Subregion 4 (North San Joaquin Subregion)

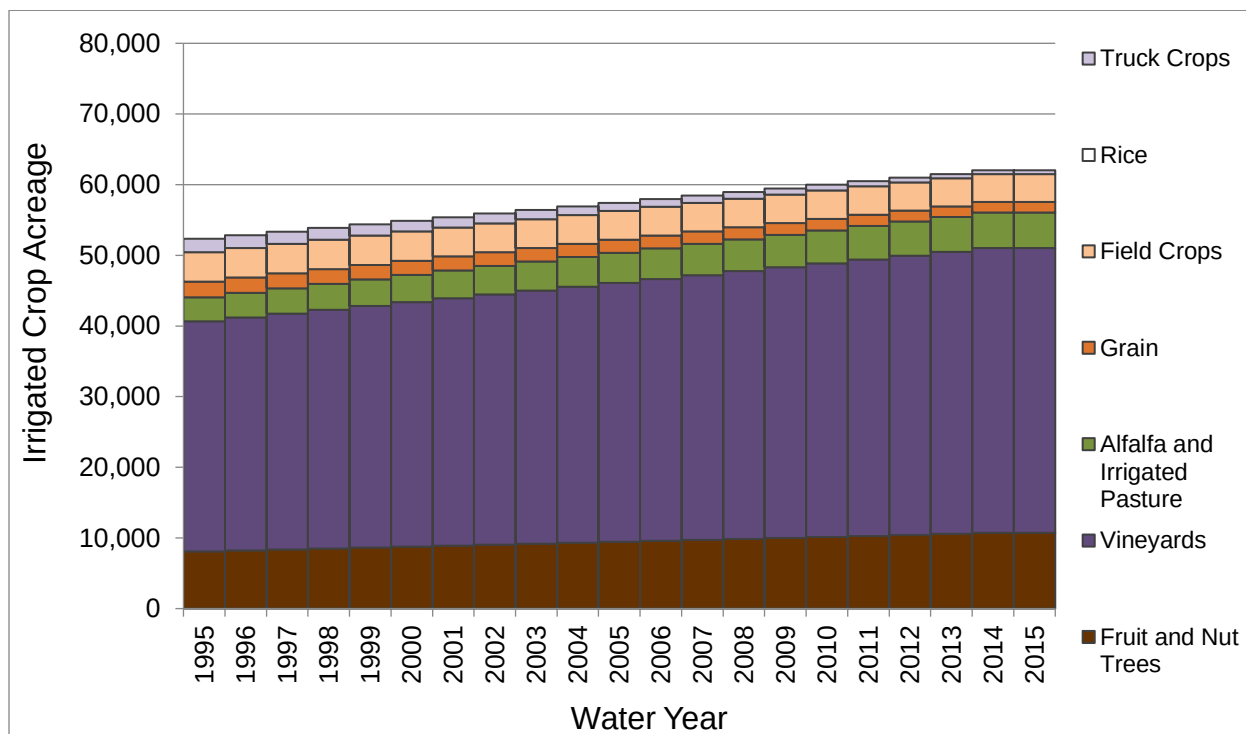


Figure 9e: Irrigated Crop Acreages- Subregion 5 (Calaveras Subregion)

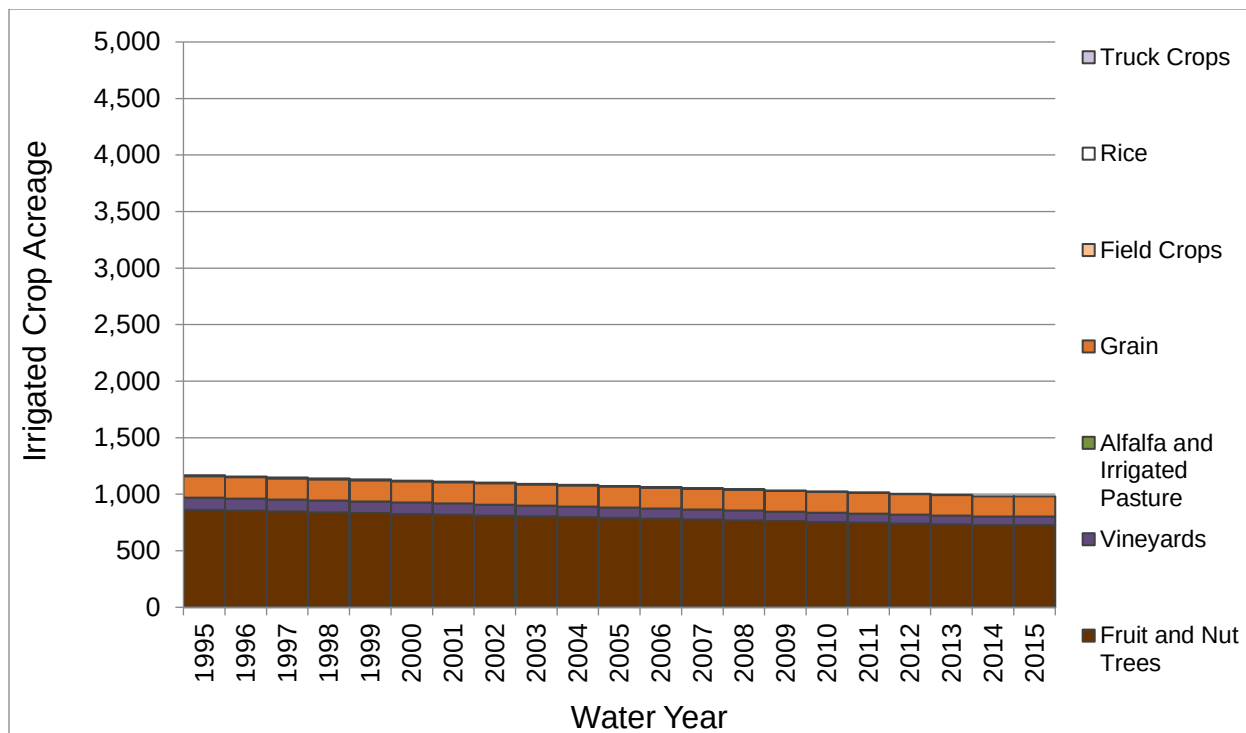


Figure 9f: Irrigated Crop Acreages- Subregion 7 (Stockton East Subregion)

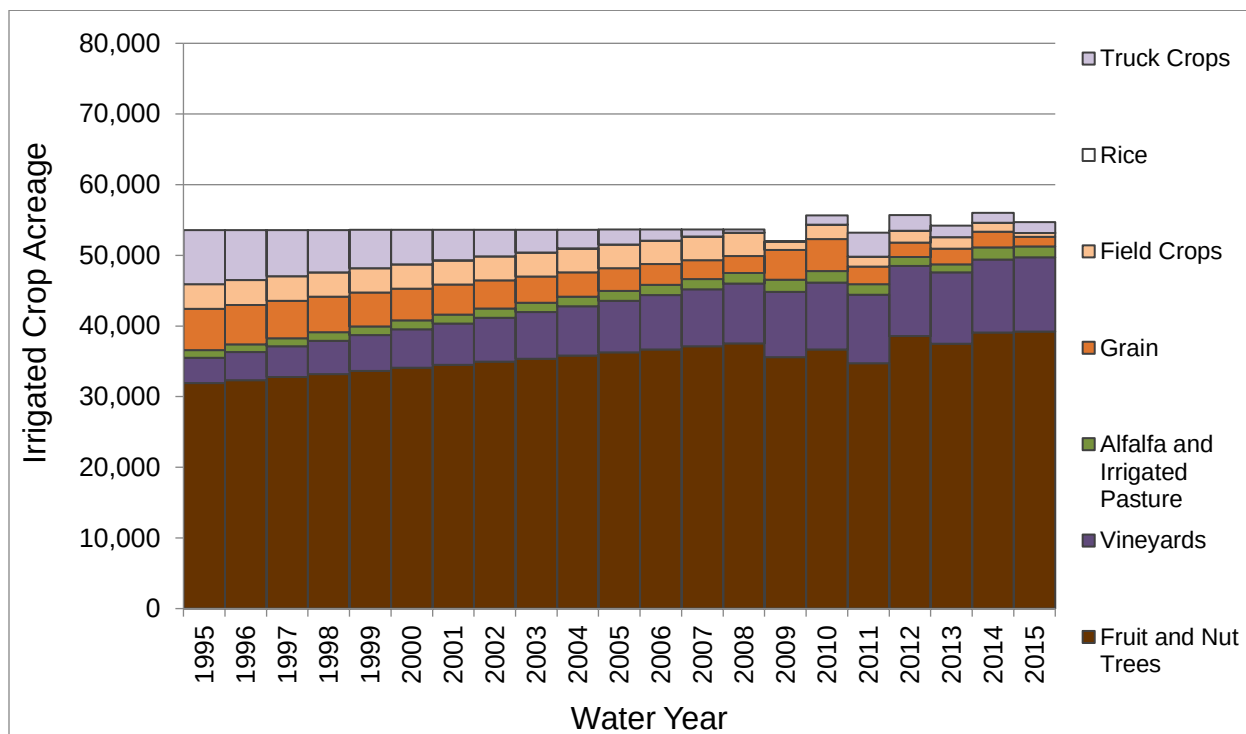


Figure 9g: Irrigated Crop Acreages- Subregion 8 (Central San Joaquin Subregion)

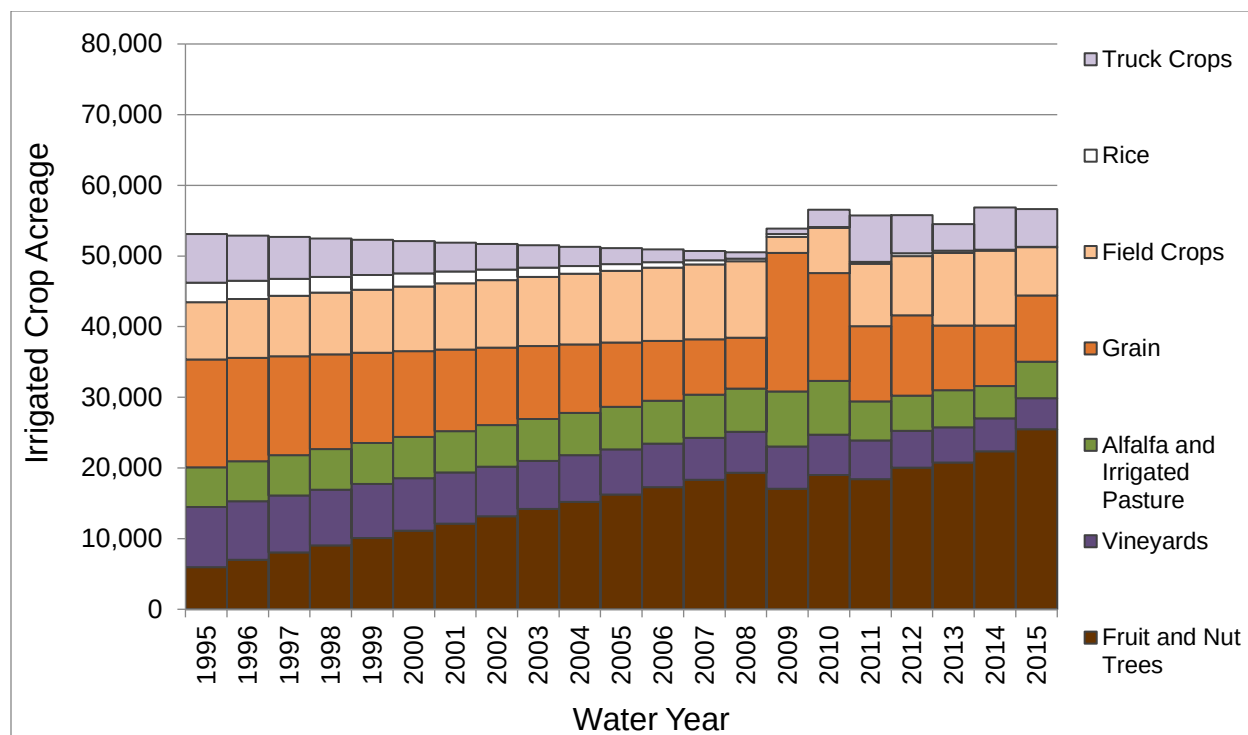


Figure 9h: Irrigated Crop Acreages- Subregion 11 (South San Joaquin East Subregion)

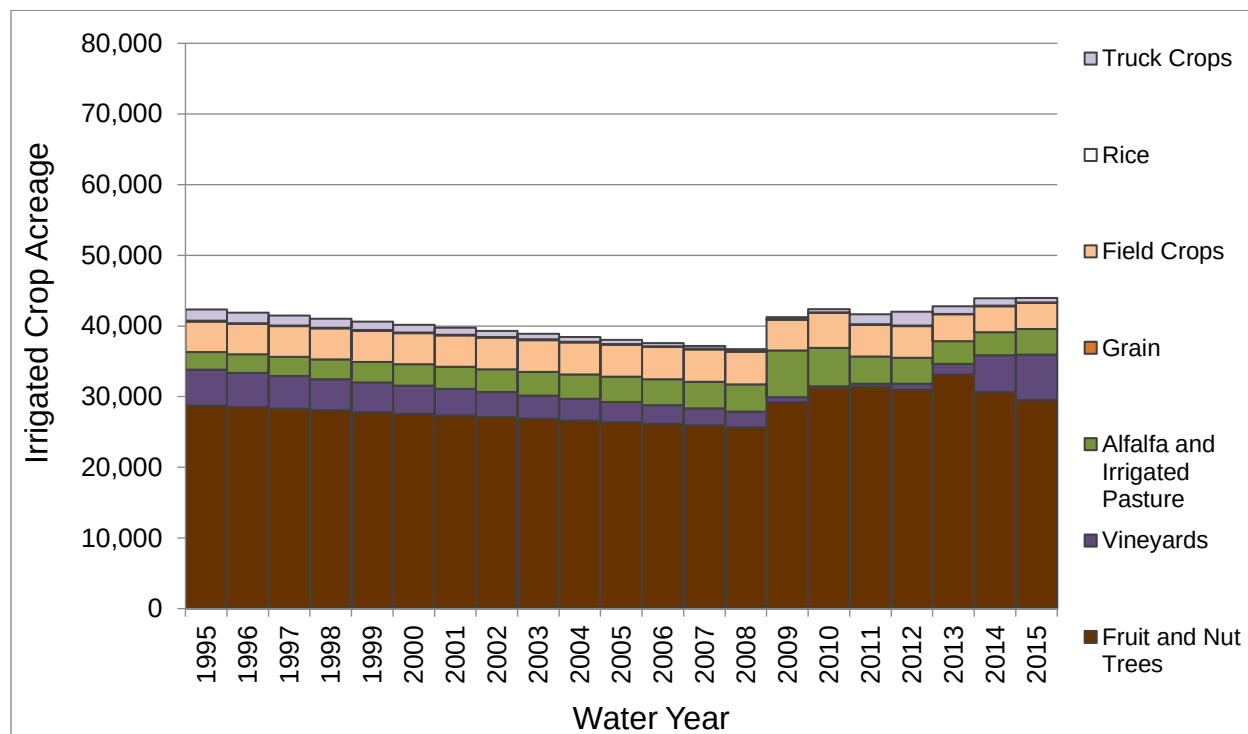


Figure 9i: Irrigated Crop Acreages- Subregion 13 (Oakdale West Subregion)

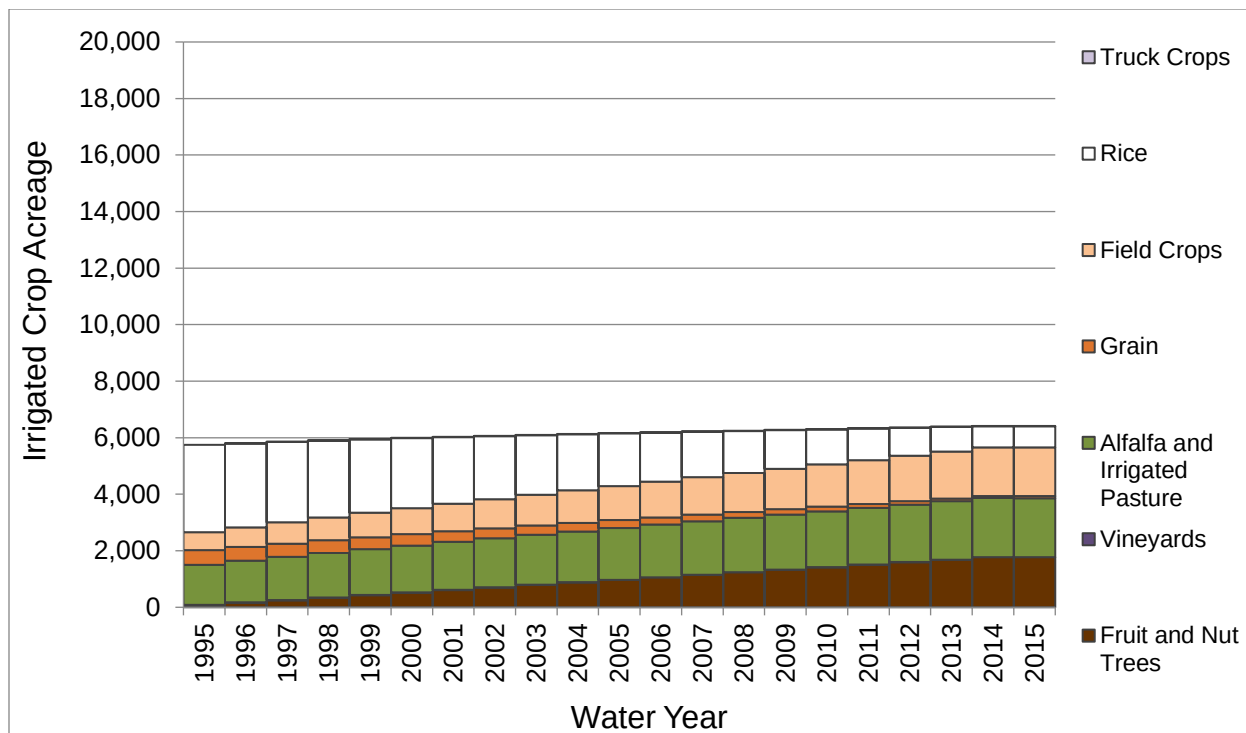


Figure 9j: Irrigated Crop Acreages- Subregion 14 (South Delta Subregion)

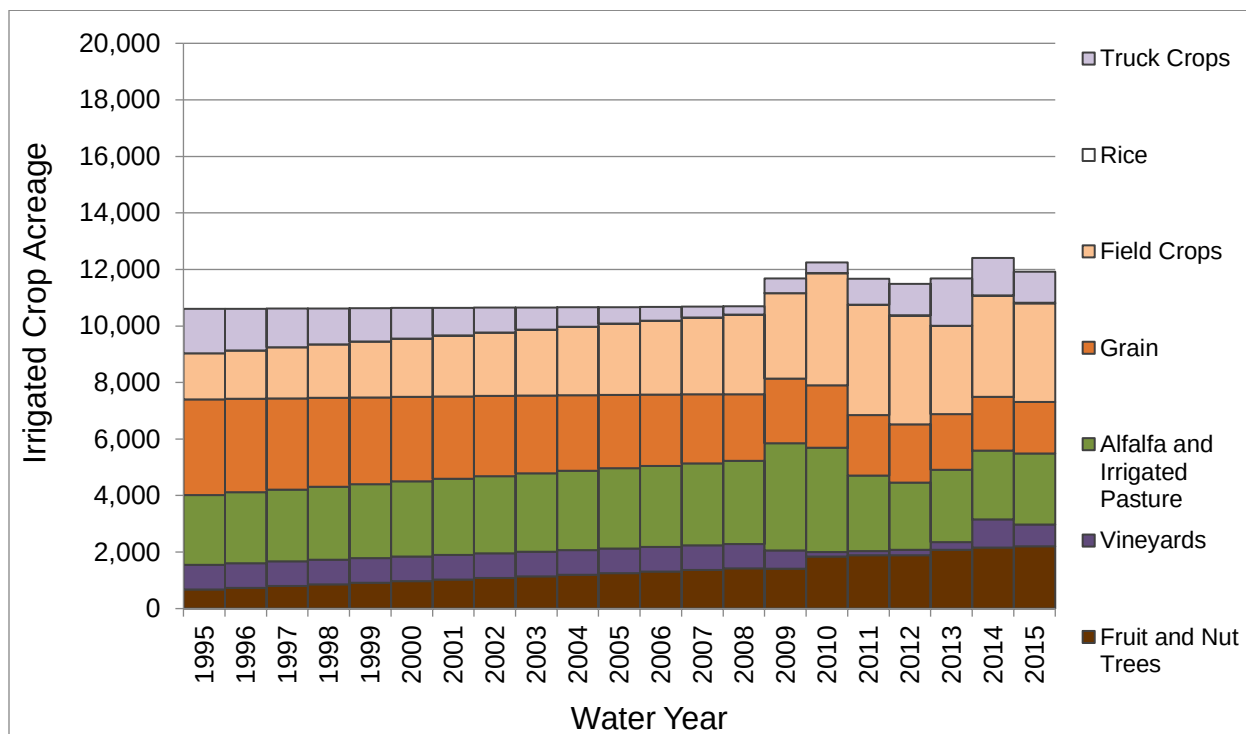


Figure 9k: Irrigated Crop Acreages- Subregion 15 (South San Joaquin West Subregion)

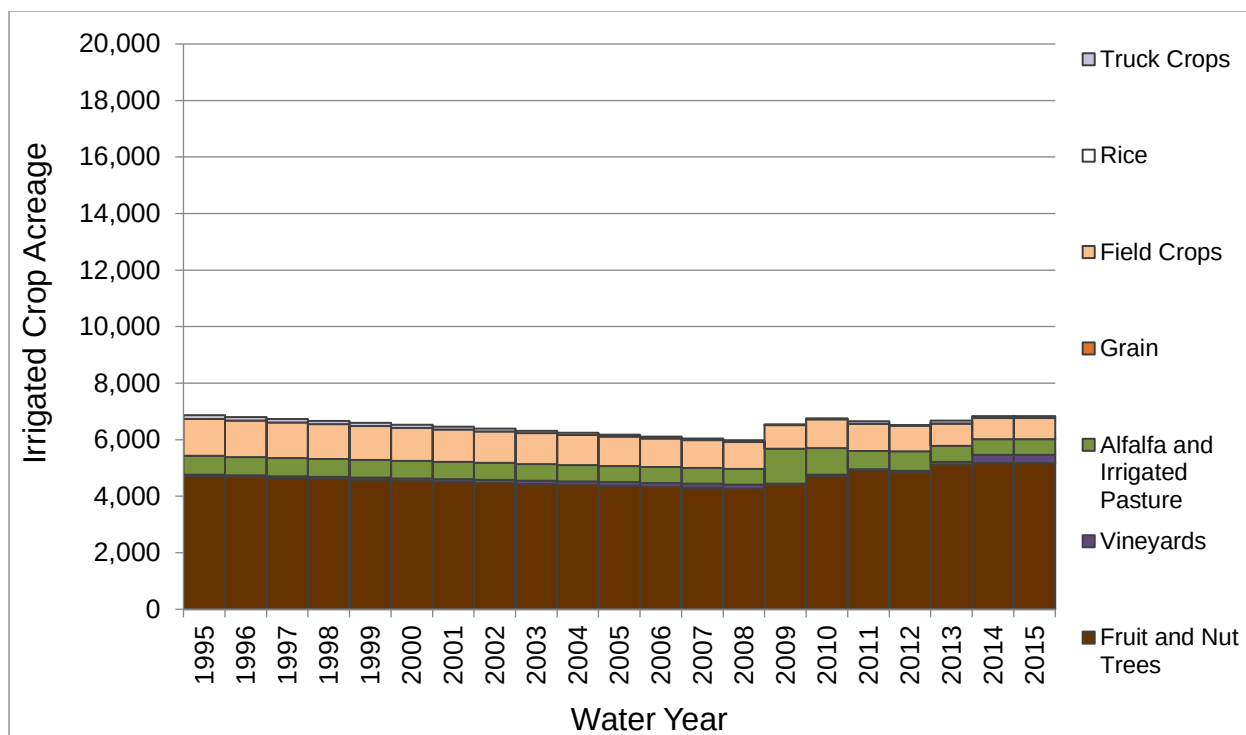


Figure 9l: Irrigated Crop Acreages- Subregion 17 (Stanislaus Subregion)

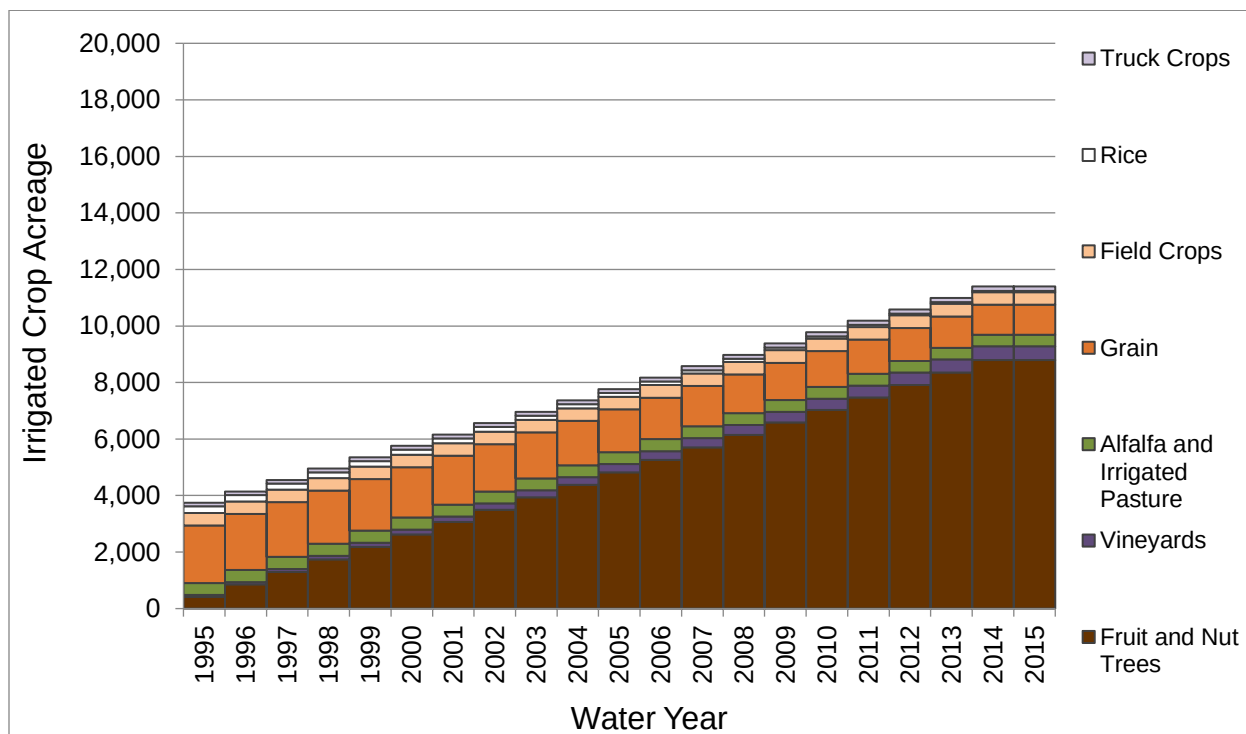


Figure 9m: Irrigated Crop Acreages- Subregion 18 (Oakdale East Subregion)

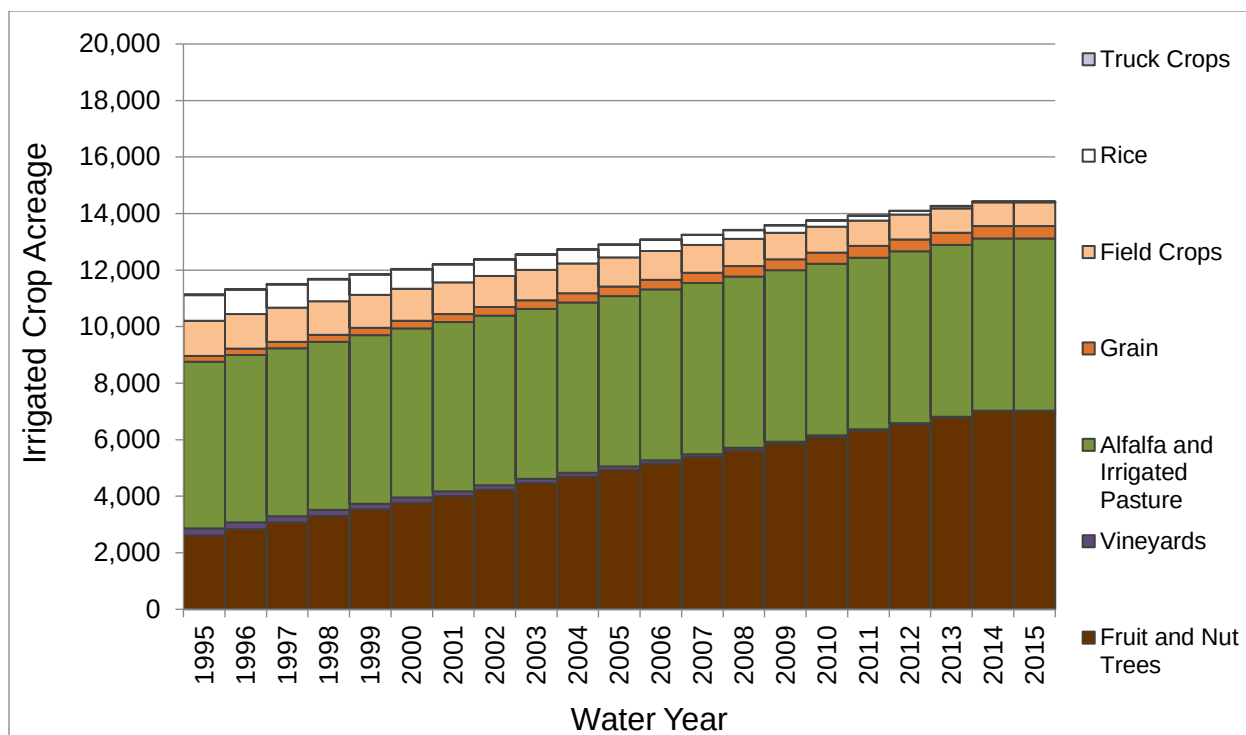


Figure 10: Urban Population Centers in Eastern San Joaquin Subbasin

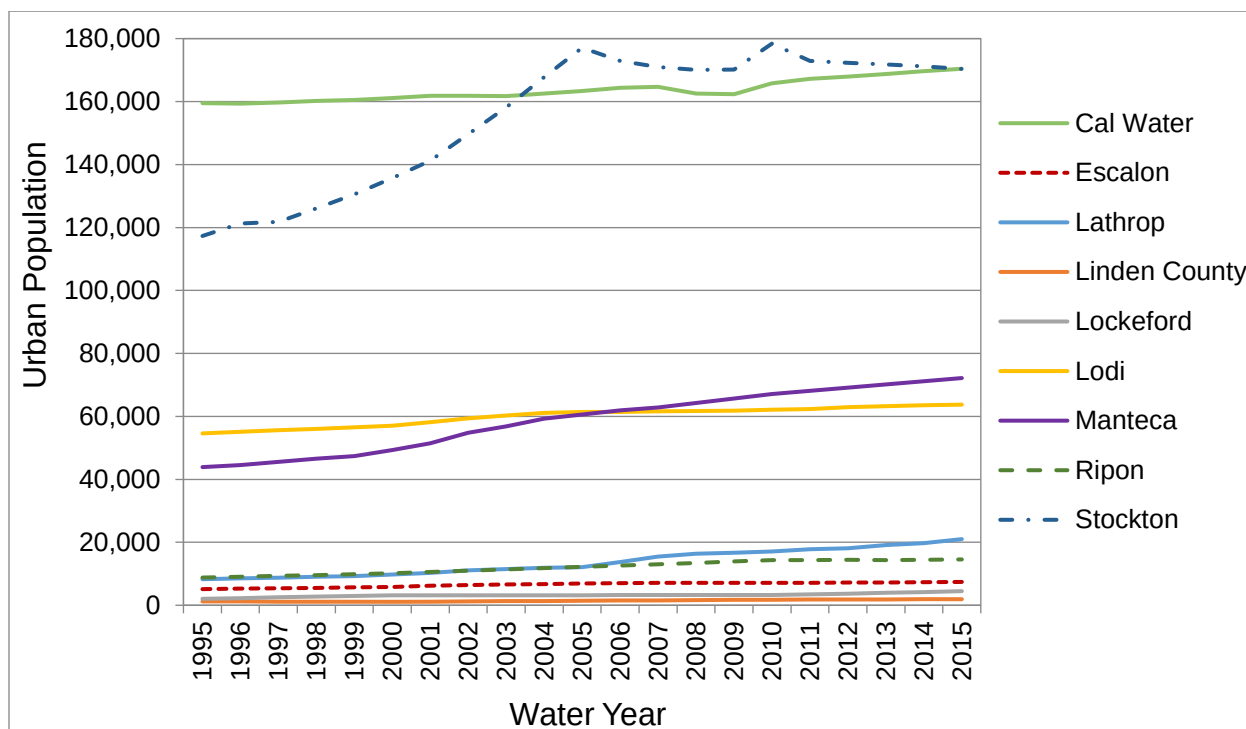


Figure 11: Urban Per Capita Water Use in Eastern San Joaquin Subbasin

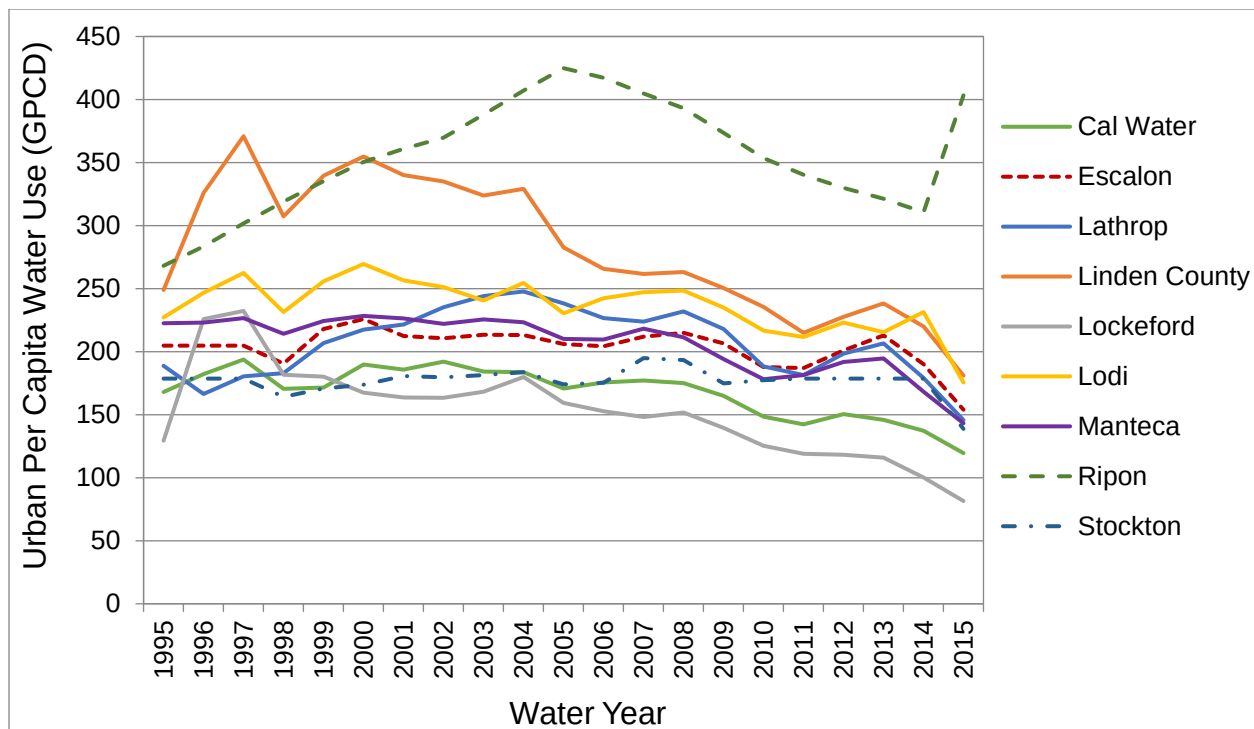


Figure 12a: Urban Demand- Eastern San Joaquin Subbasin

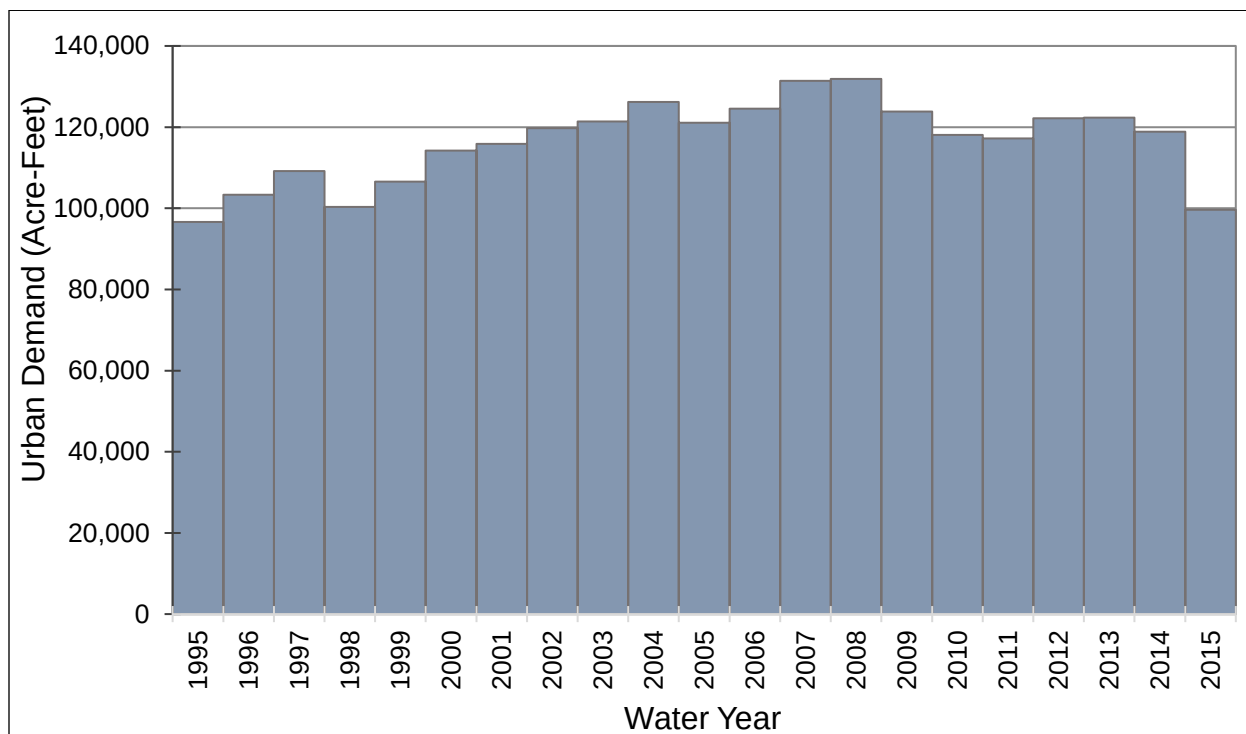


Figure 12b: Urban Demand- Subregion 3 (Lodi Subregion)

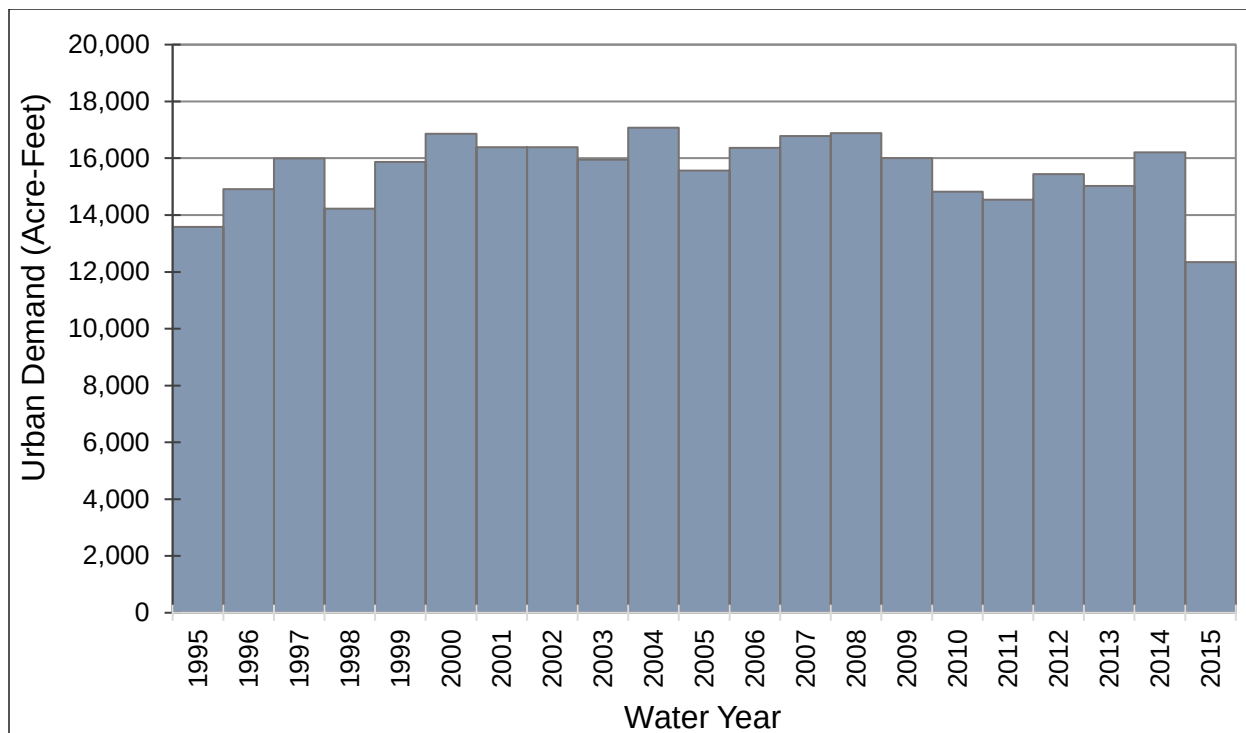


Figure 12c: Urban Demand- Subregion 6 (Stockton Subregion)

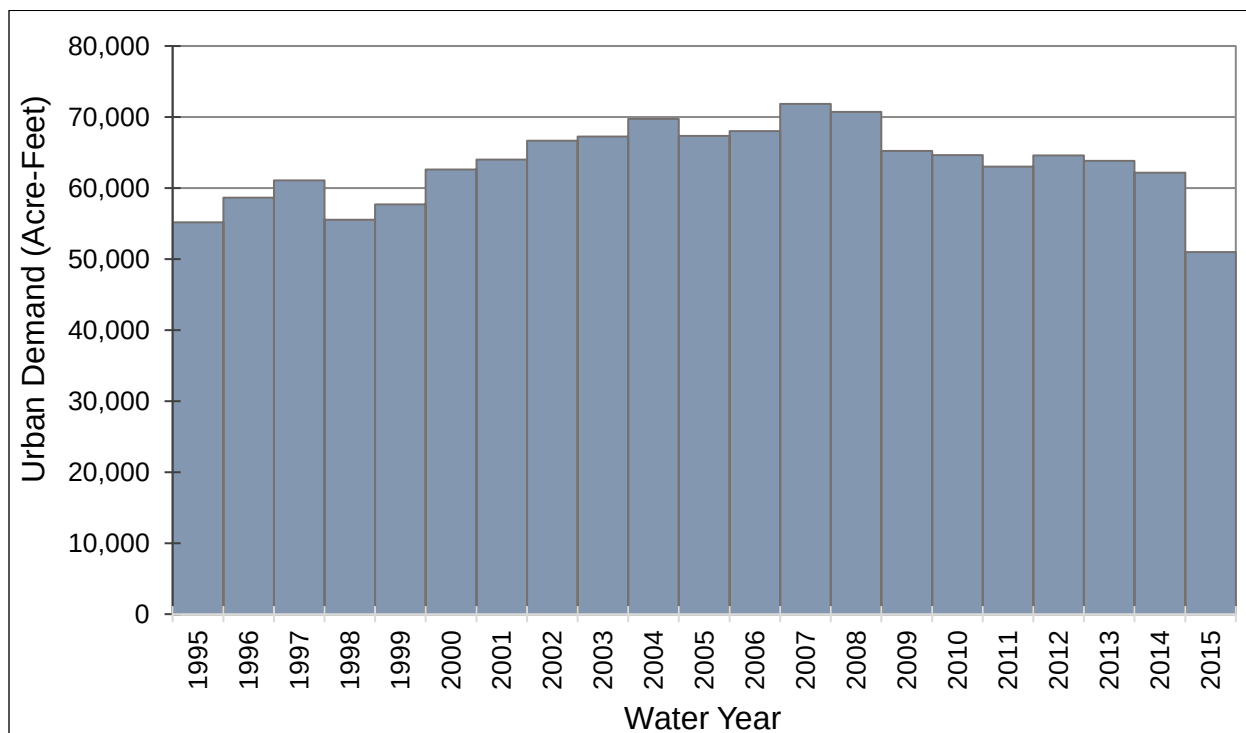


Figure 12d: Urban Demand- Subregion 9 (Lathrop Subregion)

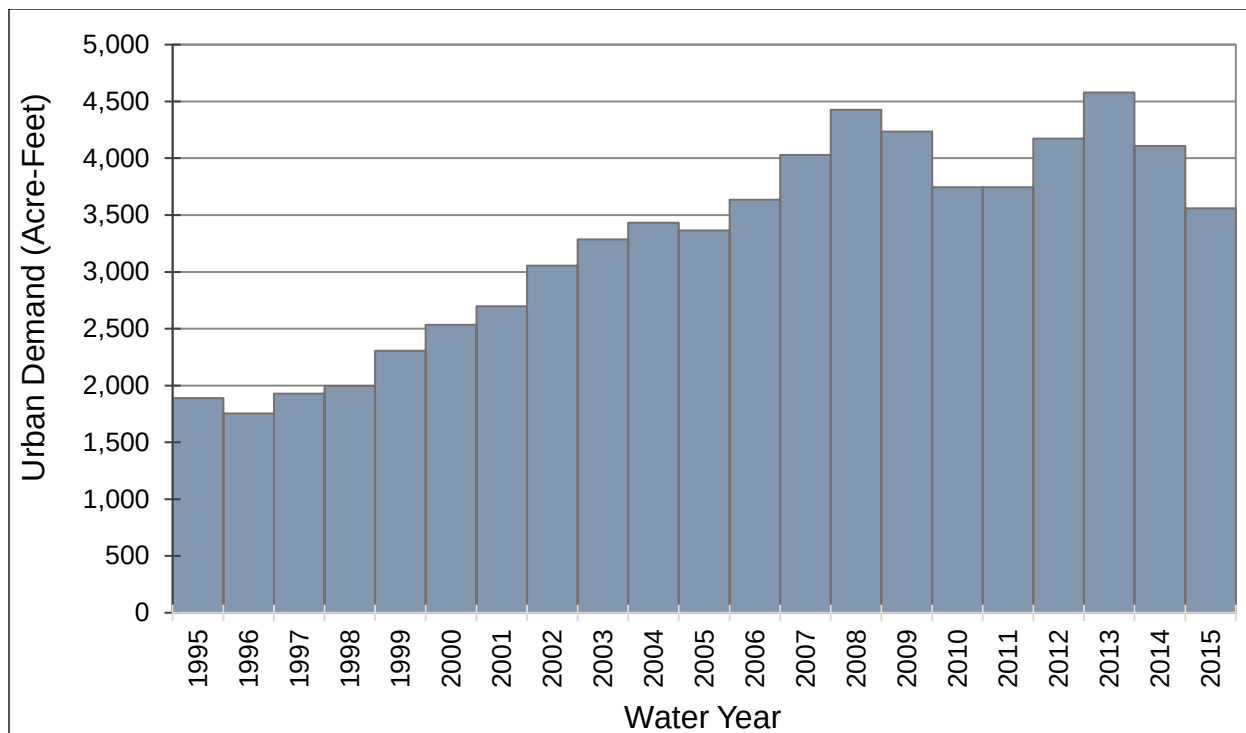


Figure 12e: Urban Demand- Subregion 10 (Manteca Subregion)

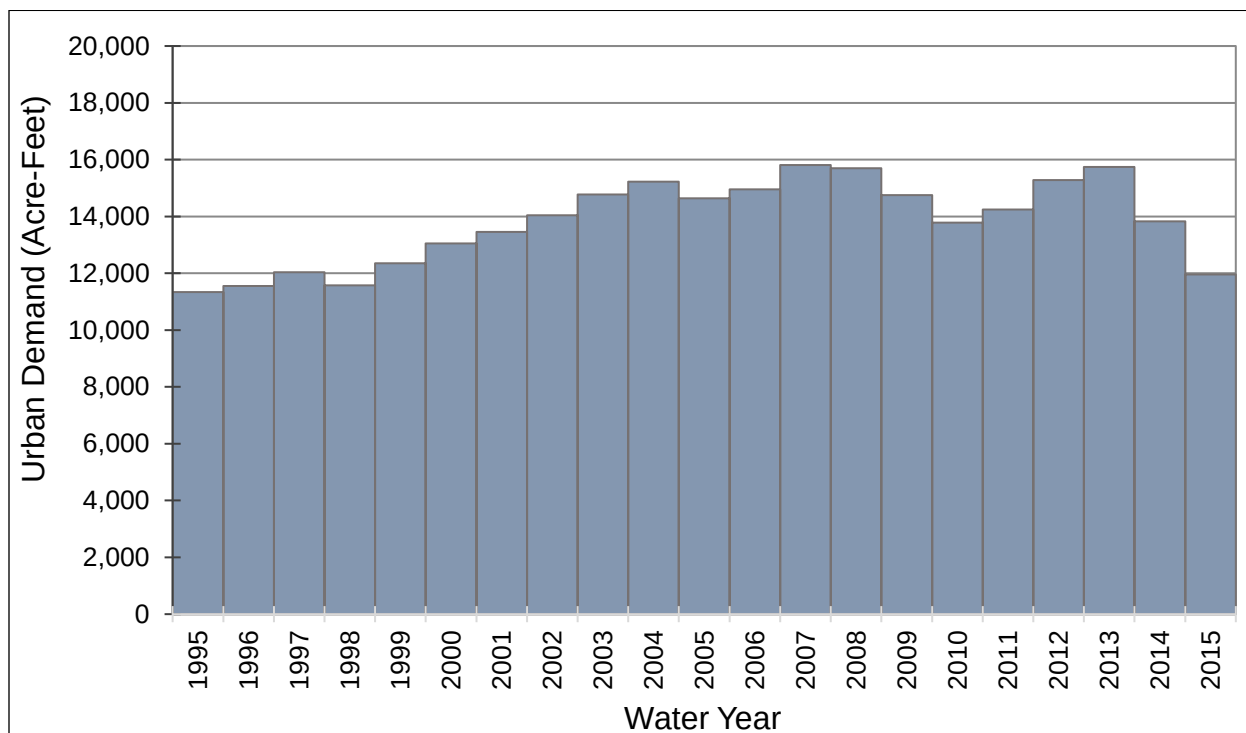


Figure 12f: Urban Demand- Subregion 12 (Escalon Subregion)

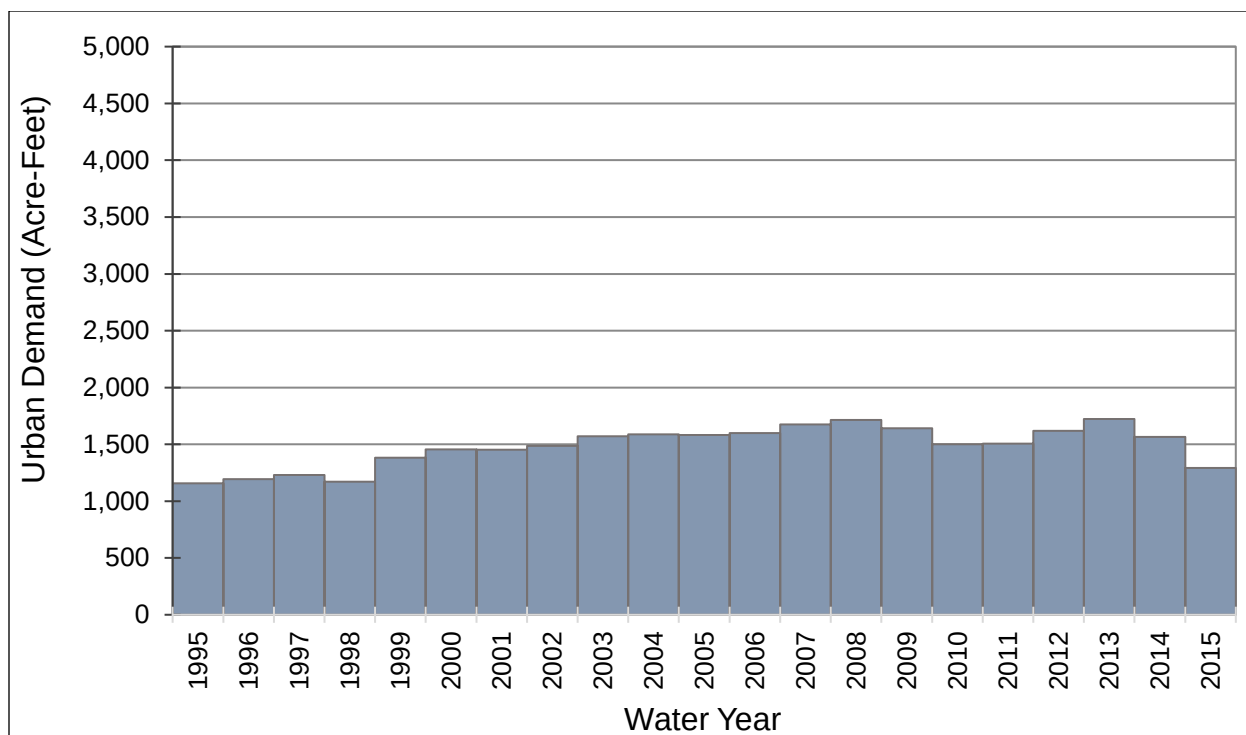


Figure 12g: Urban Demand- Subregion 16 (Ripon Subregion)

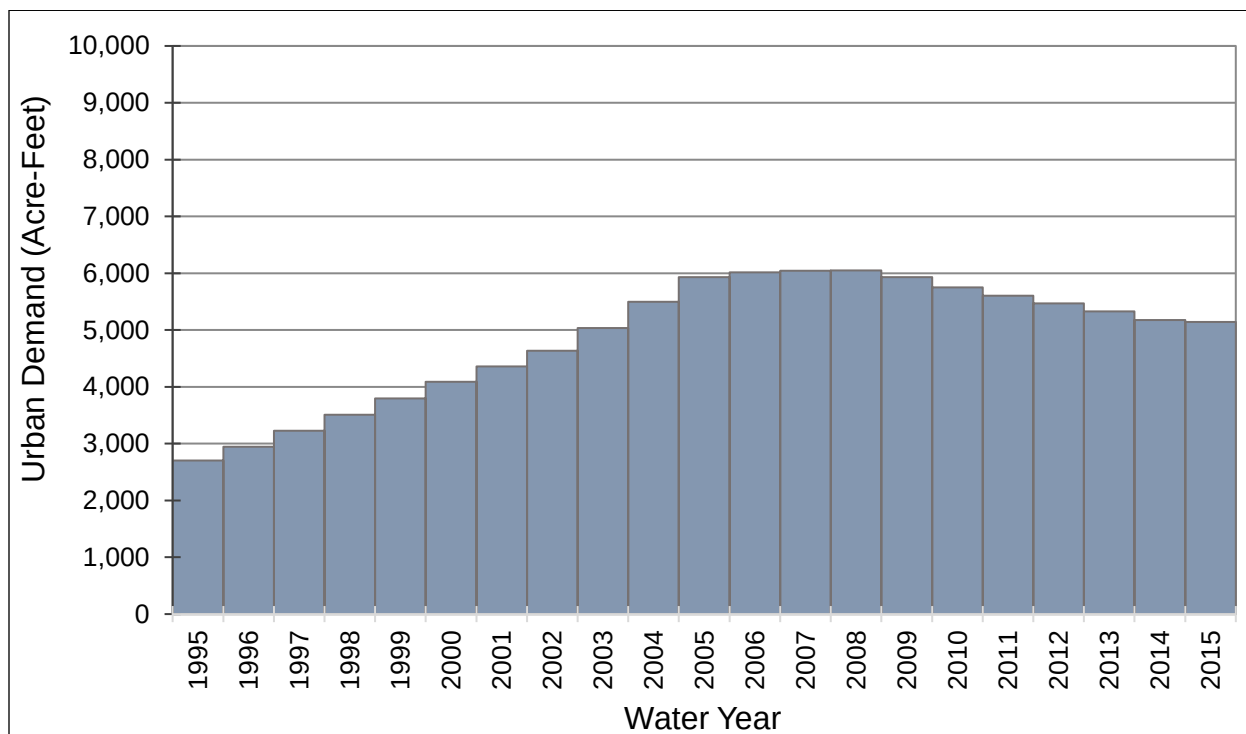


Figure 13: Annual Crop Evapotranspiration

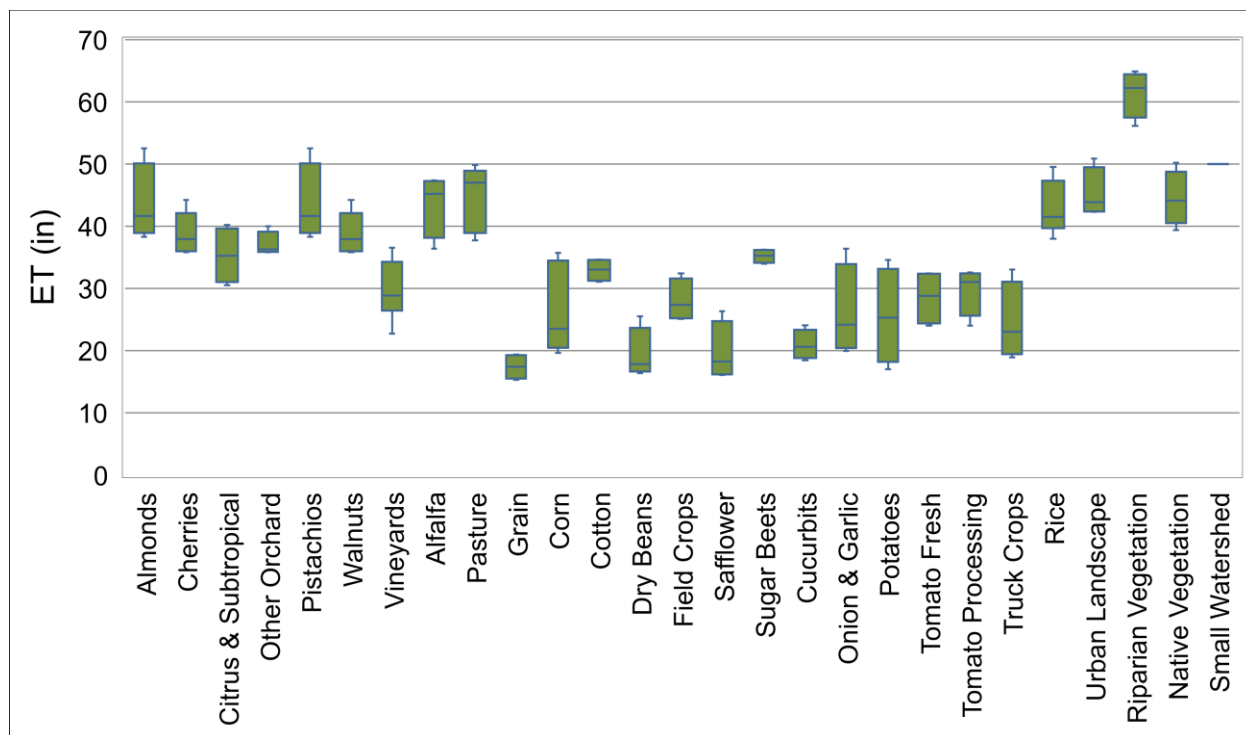


Figure 14: Annual Precipitation

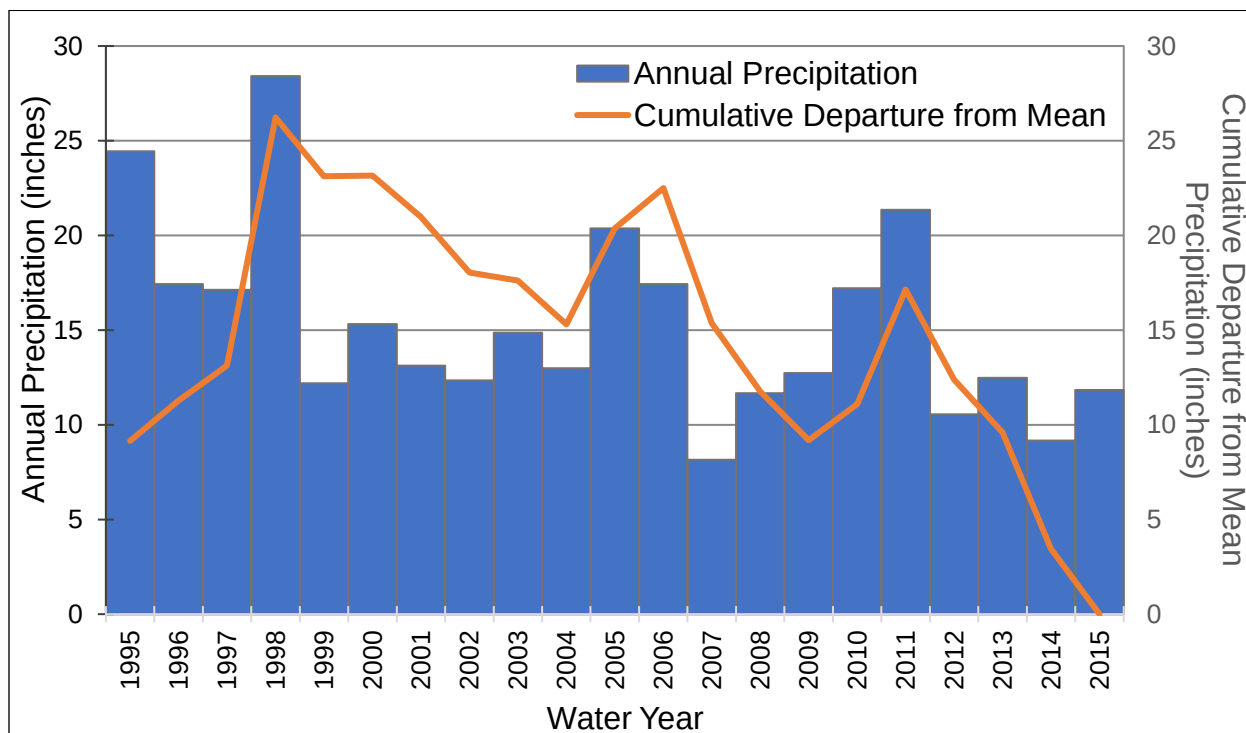


Figure 15a: Agricultural Demand- Eastern San Joaquin Subbasin

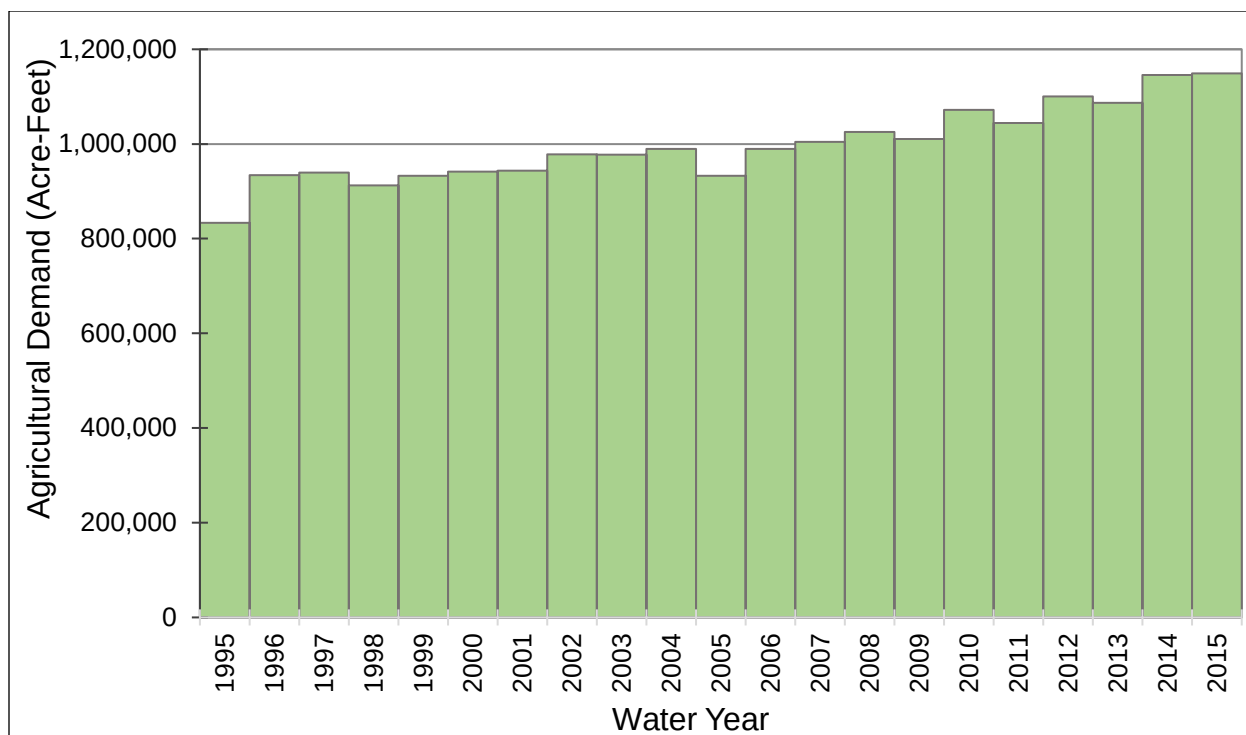


Figure 15b: Unit Agricultural Water Use and ETAW- Eastern San Joaquin Subbasin

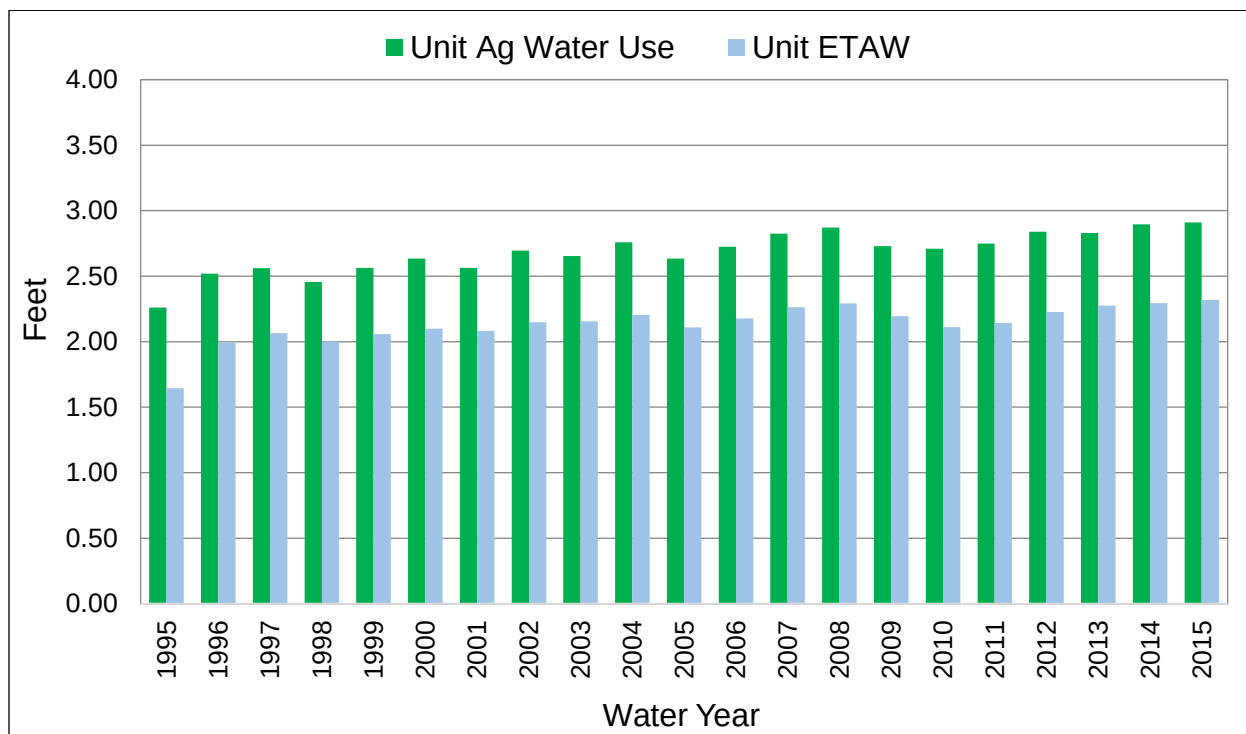


Figure 15c: Agricultural Demand- Subregion 2 (Woodbridge Subregion)

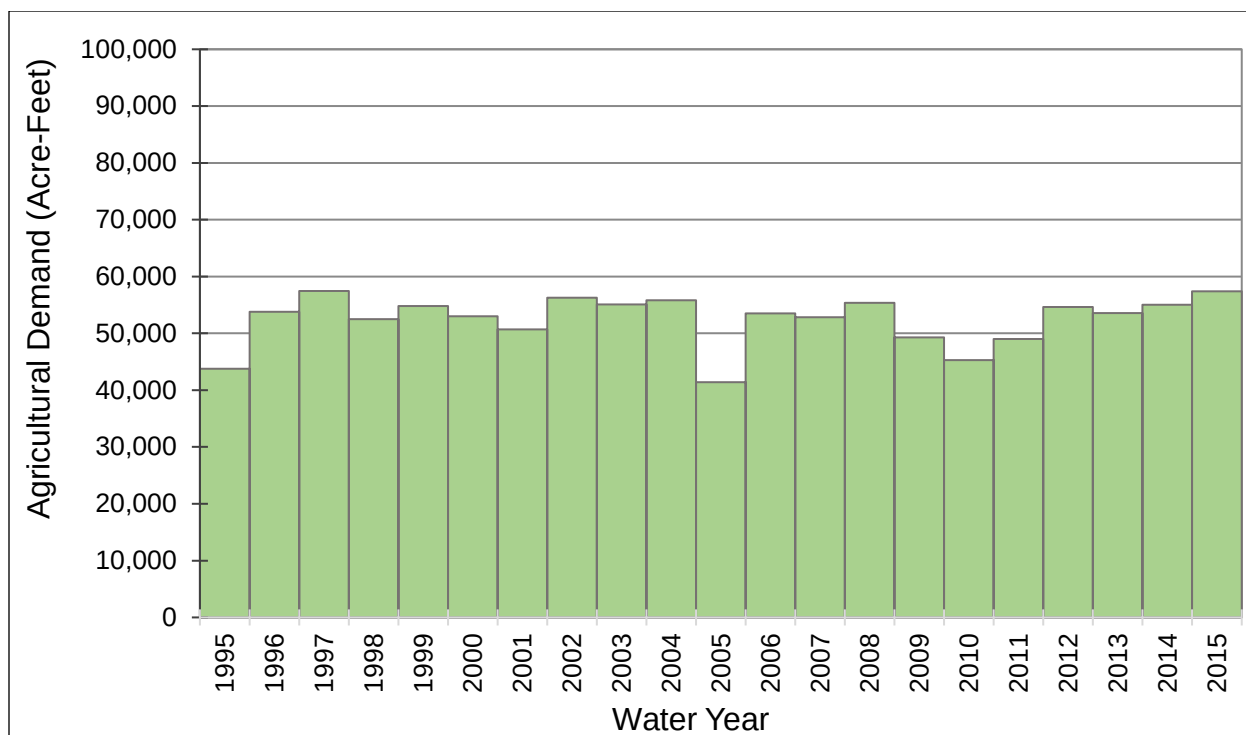


Figure 15d: Unit Agricultural Water Use and ETAW- Subregion 2 (Woodbridge Subregion)

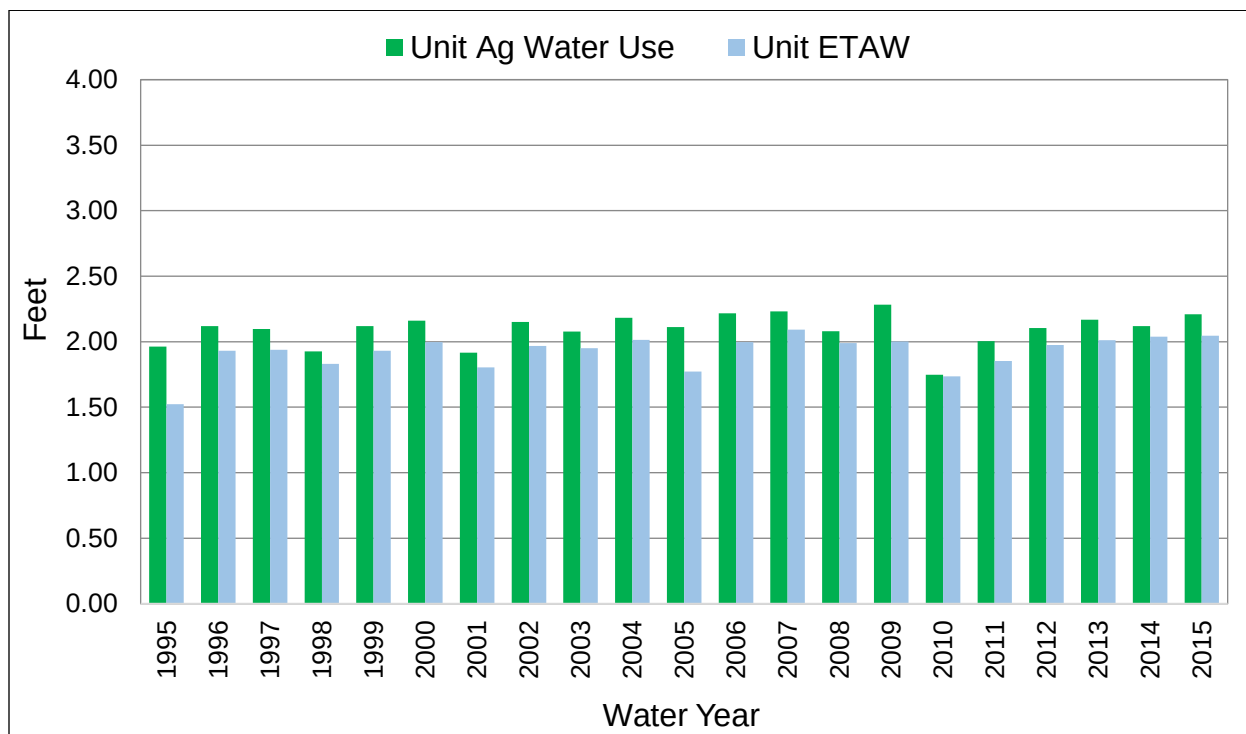


Figure 15e: Agricultural Demand- Subregion 4 (North San Joaquin Subregion)

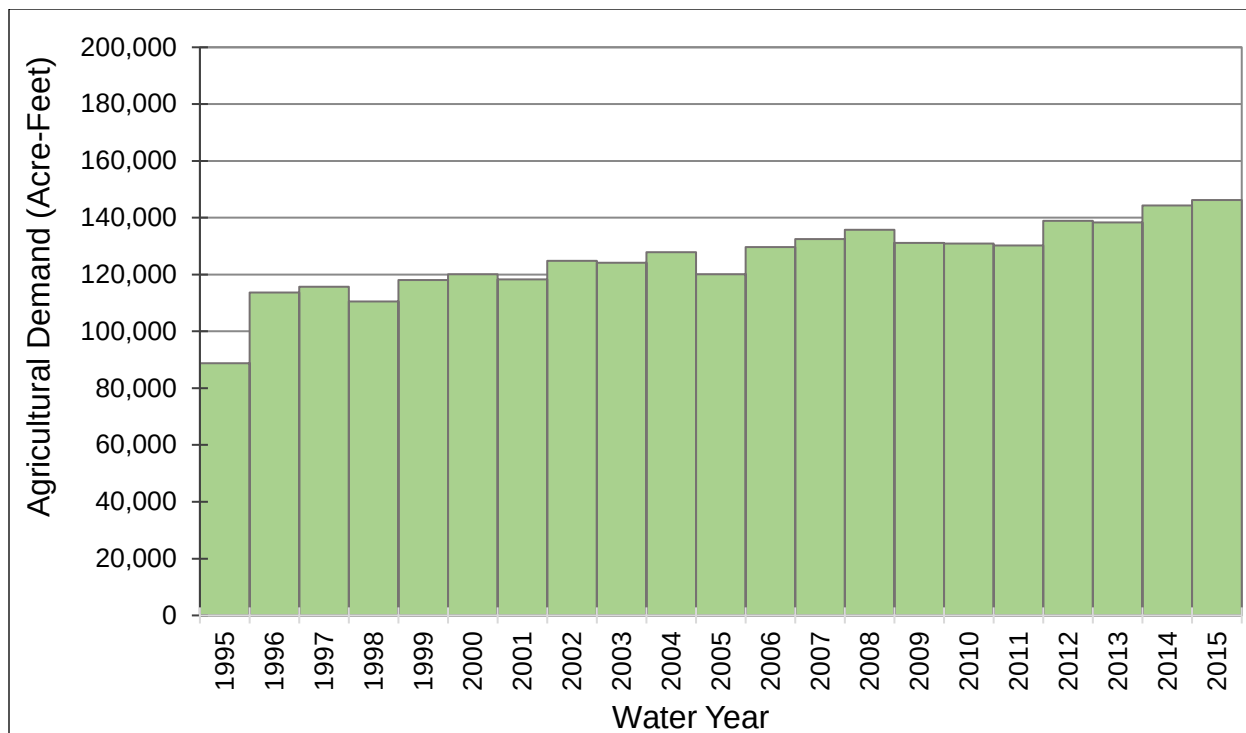


Figure 15f: Unit Agricultural Water Use and ETAW- Subregion 4 (North San Joaquin Subregion)

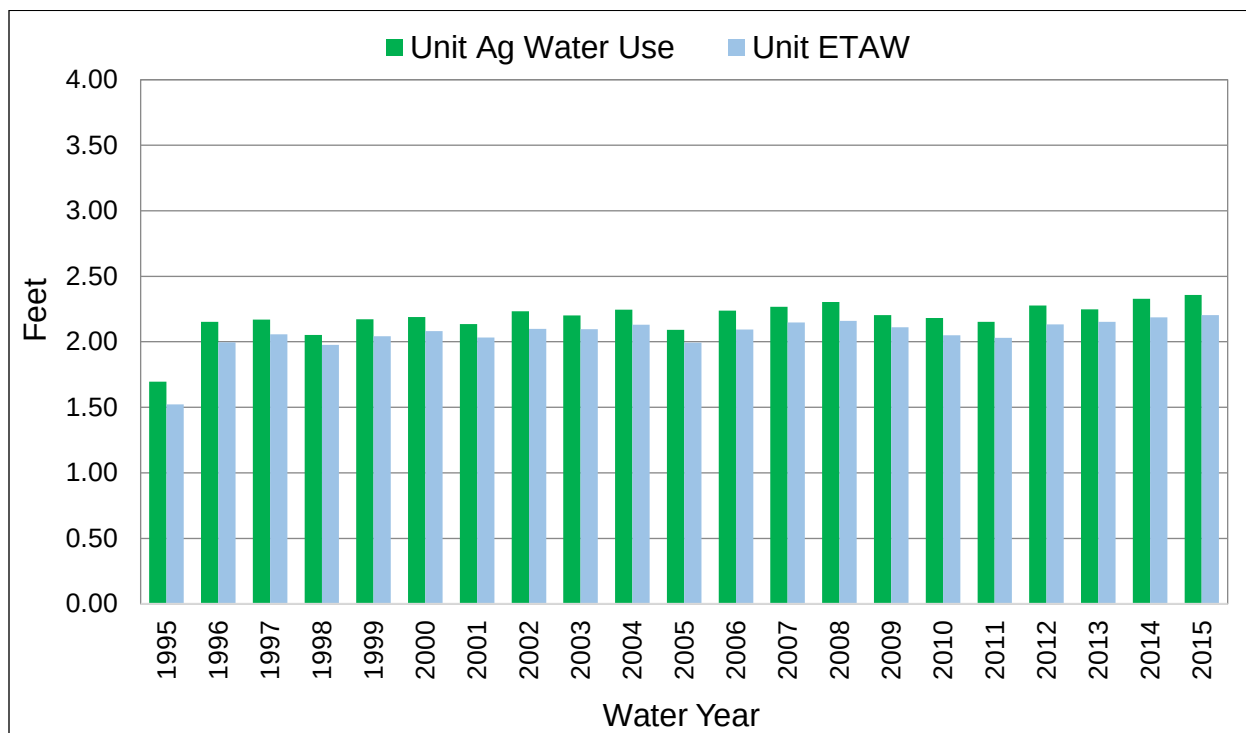


Figure 15g: Agricultural Demand- Subregion 7 (Stockton East Subregion)

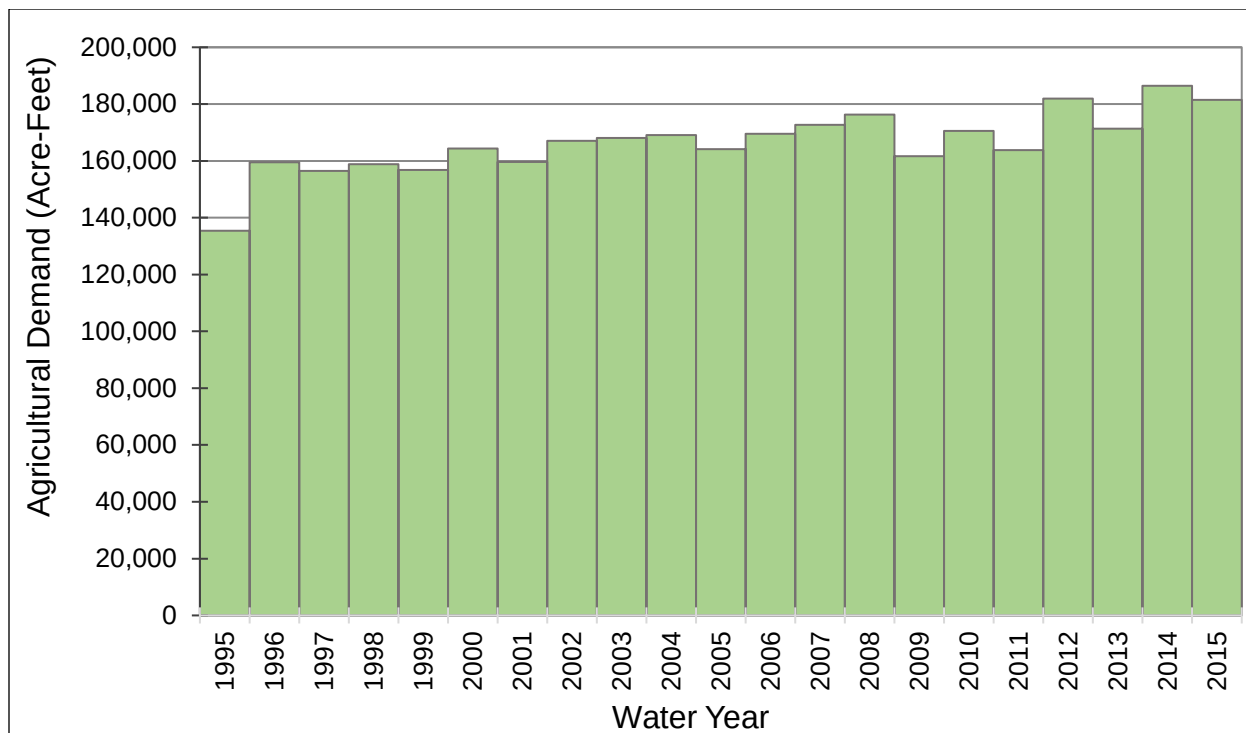


Figure 15h: Unit Agricultural Water Use and ETAW- Subregion 7 (Stockton East Subregion)

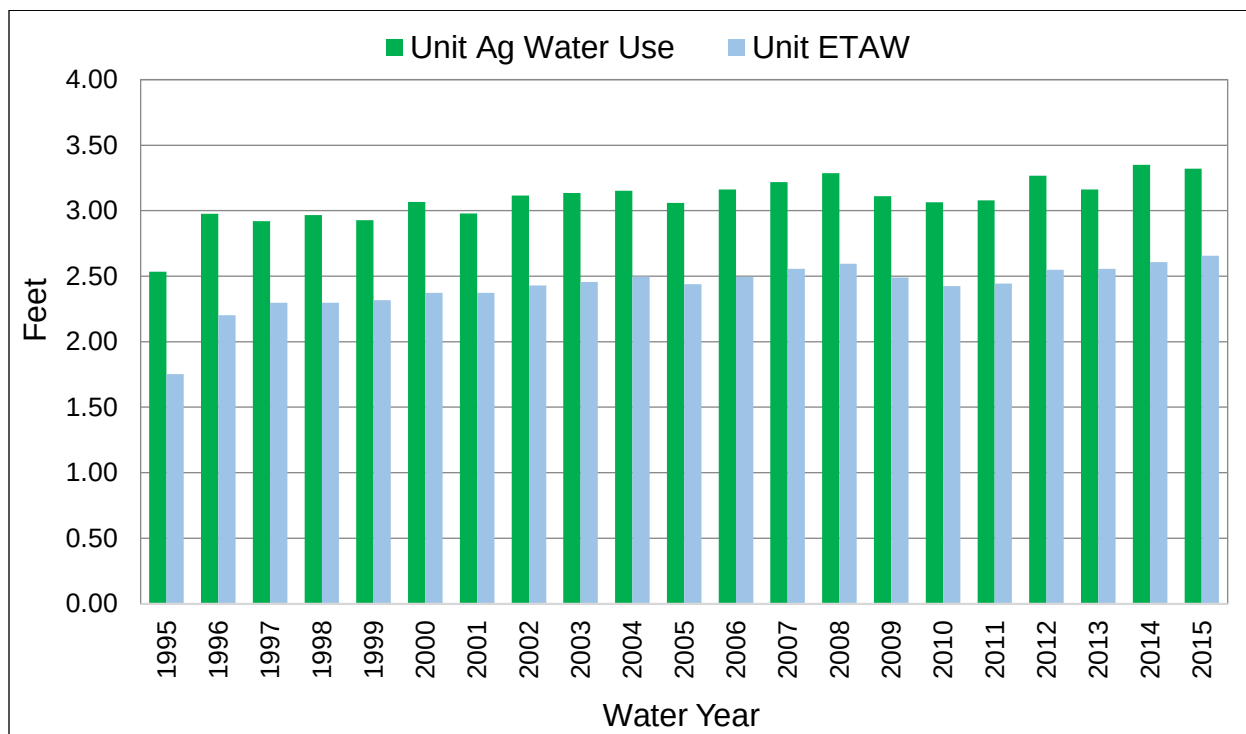


Figure 15i: Agricultural Demand- Subregion 11 (South San Joaquin East Subregion)

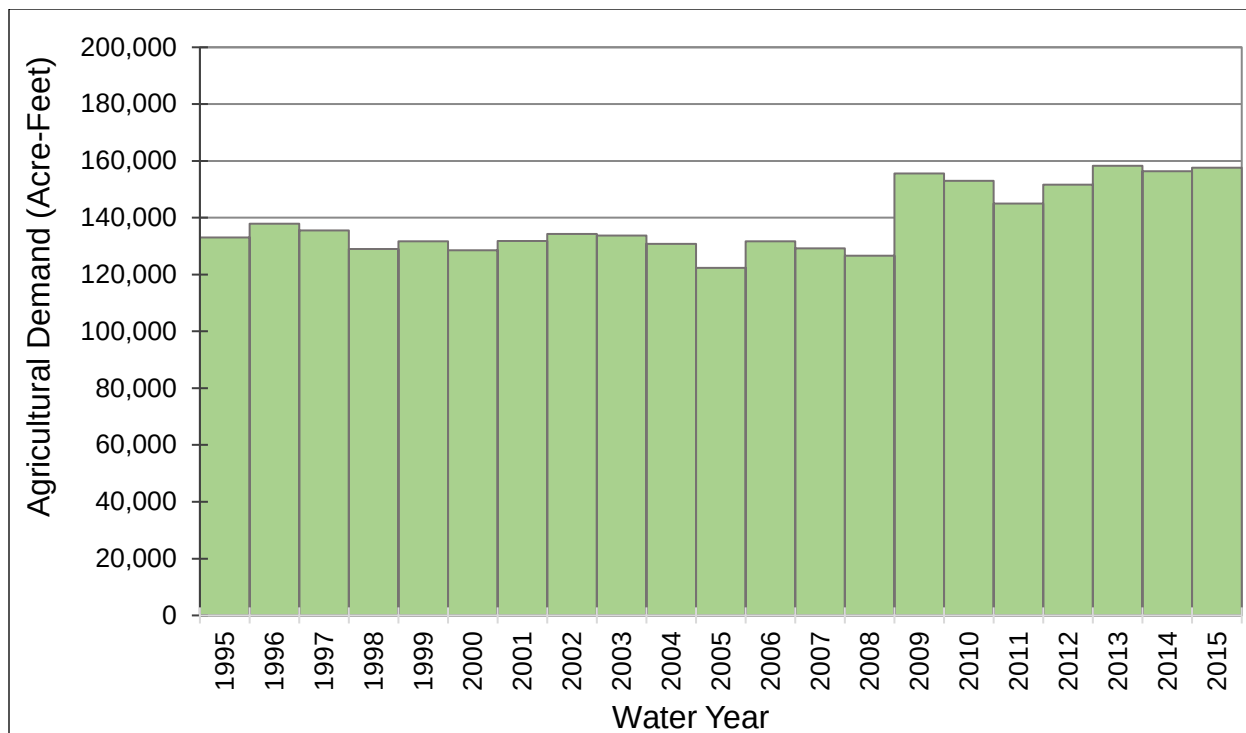


Figure 15j: Unit Agricultural Water Use and ETAW- Subregion 11 (South San Joaquin East Subregion)

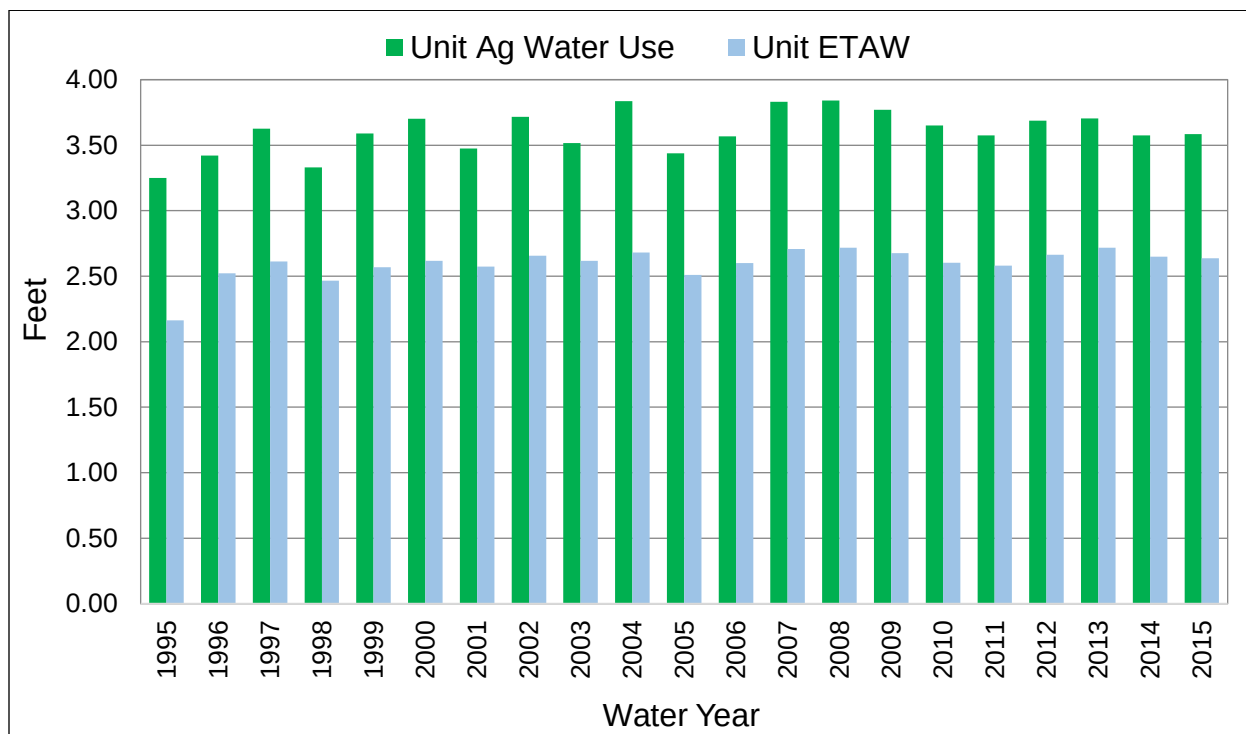


Figure 15k: Agricultural Demand- Subregion 13 (Oakdale West Subregion)

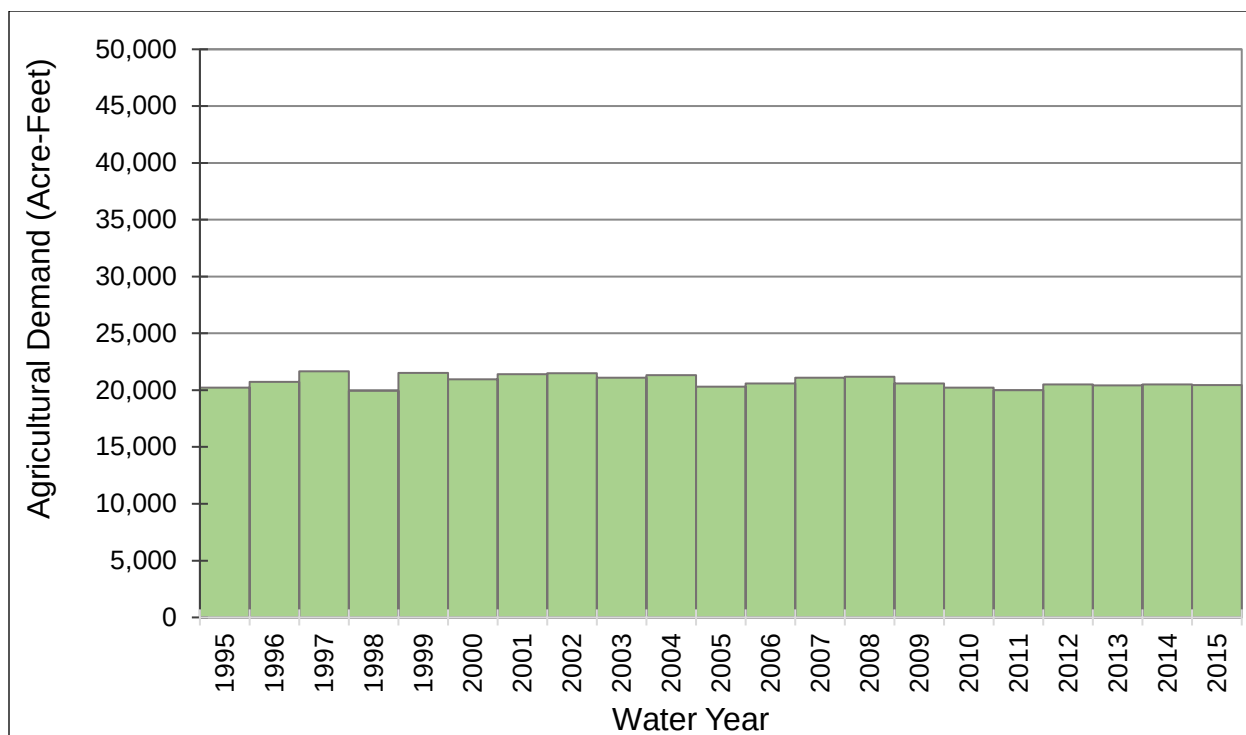


Figure 15l: Unit Agricultural Water Use and ETAW- Subregion 13 (Oakdale West Subregion)

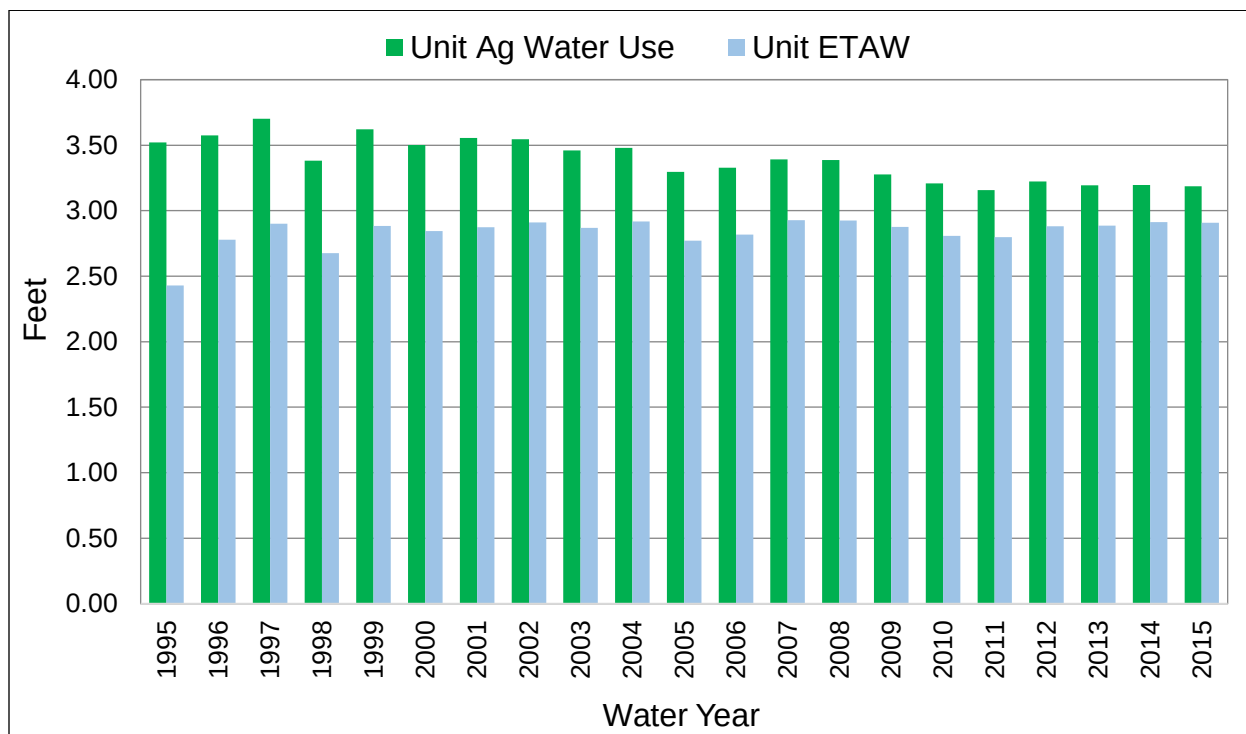


Figure 15m: Agricultural Demand- Subregion 18 (Oakdale East Subregion)

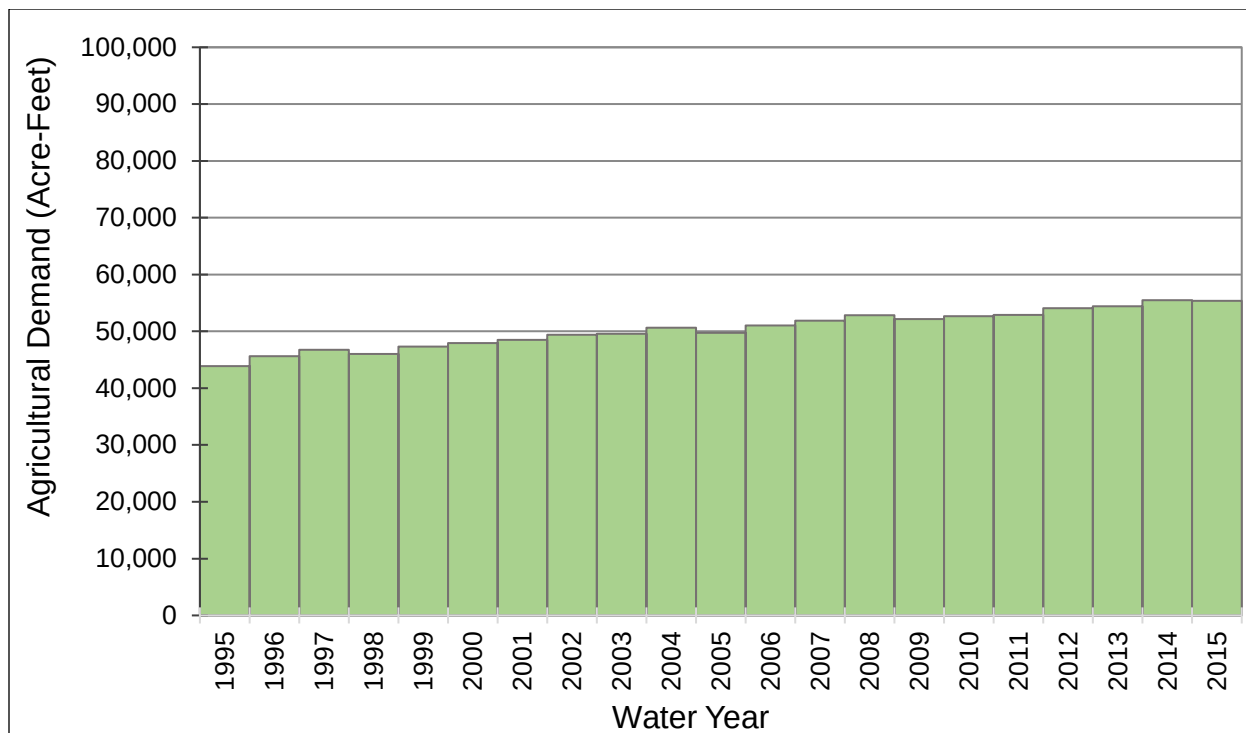


Figure 15n: Unit Agricultural Water Use and ETAW- Subregion 18 (Oakdale East Subregion)

