Chapter 8
Economic Analysis and Other Considerations

8.1 Introduction

Under the Porter-Cologne Water Quality Control Act (Porter-Cologne Act), the State Water Board is required to consider several factors, including economic considerations, when establishing water quality objectives for the reasonable protection of beneficial uses (Wat. Code, § 13241). The need for economic analysis associated with State Water Board actions is also required by Water Code section 13141, which states: "prior to implementation of any agricultural water quality control program, an estimate of the total cost of such a program, together with an identification of potential sources of financing, shall be indicated in any regional water quality control plan (Wat. Code, § 13141). The other factors identified in section 13241 of the Porter-Cologne Act are discussed here and elsewhere in this Staff Report, including but not limited to relevant sections in Chapter 2, *Hydrology and Water Supply*, Chapter 6, *Changes in Hydrology and Water Supply*, Chapter 7, *Environmental Analysis*, and Chapter 9, *Proposed Voluntary Agreements*.

The CEQA environmental analysis also must take into account a reasonable range of environmental, economic, and technical factors (Cal. Code Regs., tit. 23, § 3777, subd. (c)). Under CEQA, economic and social changes are not treated as significant effects on the environment. However, physical changes to the environment as a result of economic and social changes may be significant. Economic and social changes also may be used to determine the significance of physical changes caused by the economic or social change (Cal. Code Regs., tit. 14, § 15064, subd. (e)).

This chapter analyzes the economic effects of changes in hydrology and water supply under the proposed Plan amendments on agricultural and municipal use.[1] Chapter 6, *Changes in Hydrology and Water Supply*, summarizes the Sacramento Water Allocation Model (SacWAM) results for changes in hydrology and water supply under various percent of unimpaired flow scenarios. Modeling results are presented in ranges of potential instream flows in increments of 10 percent, from 35 up to 75 percent unimpaired flow (referred to as numbered flow scenarios, such as *35 scenario*, *45 scenario*). As discussed in Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*, the proposed Plan amendments would establish a new numeric inflow objective for the Sacramento River, its tributaries, and the Delta eastside tributaries (the Consumnes, Mokelumne, and Calaveras Rivers) that would require 55 percent unimpaired flow, with an adaptive range from 45 to 65 percent unimpaired flow. Section 7.2, *Alternatives Description*, describes the other project alternatives evaluated in this Staff Report, including a Low Flow Alternative (Alternative 2), High Flow Alternative (Alternative 3), and a Proposed Voluntary Agreements Alternative (Alternative 6). The Low Flow Alternative is similar to the proposed Plan amendments, but the new numeric inflow objective for the Sacramento/Delta tributaries would require between 35 and 45 percent unimpaired flow. The High Flow Alternative is similar to the proposed Plan amendments, but the new numeric inflow objective for the Sacramento/Delta tributaries would require between 65 and 75 percent unimpaired flow. Economic effects due to potential changes in

[1] For the purposes of this document, a reference to *municipal use* includes domestic and industrial uses unless otherwise specified. The terms *urban* and *municipal and industrial* (*M&I)* are also sometimes used to reference municipal type uses.

hydrology and water supply under the Low Flow Alternative and High Flow Alternative are summarized in Section 7.24, *Alternatives Analysis*.

In 2022, when this draft Staff Report was nearing completion, the State Water Board received a memorandum of understanding (MOU) for proposed Voluntary Agreements (VAs) for updating the Bay-Delta Plan from various users in the watershed, including the California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation), as well as the California Department of Fish and Wildlife, California Natural Resources Agency, and California Environmental Protection Agency. As discussed in Section 7.2, *Alternatives Description*, and Chapter 9, *Proposed Voluntary Agreements*, the State Water Board is considering the proposed VAs as an alternative that could provide a possible path forward for updating the Bay-Delta Plan. The economic effects due to potential changes in hydrology and water supply under the proposed VAs are discussed in Chapter 9, *Proposed Voluntary Agreements*.

This chapter includes a discussion of other economic considerations applicable to all project alternatives, including the estimated costs of methods of compliance and response actions that may result from the project. The evaluation of actions that may be taken in response to changes in water supply includes groundwater use and other water management actions, which include groundwater storage and recovery/conjunctive management efforts, water transfers, water recycling, and conservation measures. The chapter identifies example funding sources that could assist water users in conserving or more efficiently using water supplies. This chapter also discusses costs for habitat restoration and other ecosystem projects that would contribute to the overall goal of improving conditions for fish and wildlife in the Sacramento/Delta watershed, and costs associated with construction of new or modified facilities and infrastructure to supplement or conserve surface water supplies. This chapter also discusses economic benefits associated with the proposed Plan amendments, including beneficial economic effects from fisheries and ecosystem services.

Generally, the area considered in this chapter corresponds to the study area, as defined in Chapter 2, *Hydrology and Water Supply*. Figure 2.8-1a in Chapter 2 shows the location of the study area in California, which is divided into seven geographic regions based on geography and water supply, including the Sacramento River watershed, Delta eastside tributaries, Delta, San Joaquin Valley, San Francisco Bay Area (Bay Area), Central Coast, and Southern California. However, geographic locations may vary where appropriate by topic, depending on the issue being evaluated, the temporal and geographic distribution of that resource, and the geographic extent of potential effects on regional and state economies. For example, the Sacramento River watershed, Delta, and Delta eastside tributaries are collectively referred to in this Staff Report as the *Sacramento/Delta watershed* or *Sacramento/Delta*, and some data in this section are presented for the State of California as a whole.

8.2 Economic Profile

California's economy would be the world's fifth largest if it was a country, with over $3 trillion gross product in 2020 (California State Assembly 2023). Dominant sectors include finance, insurance, and real estate; trade; science and technology; media; and tourism. With close to 40 million people, California is the most populous U.S. state, and is home to some of the most valuable companies in the world, such as Apple. Economic activity is focused along coastal cities, including Los Angeles (media, tourism, and trade) and San Francisco (technology, tourism, and trade), and agriculture in the interior areas of the state. Table 8.2-1 provides an overview of the California economy as Gross

Domestic Product (GDP) by industry, as presented by the California State Assembly using 2020 data from the U.S. Bureau of Economic Analysis.

Table 8.2-1. California Gross Domestic Product by Industry Category, 2020

Category	2020 GDP (in millions)	Percent of GDP
Agriculture, Forestry, Fishing and Hunting	$46,819	1.5%
Other Services	$51,441	1.7%
Arts, Entertainment, Recreation, Accommodation, and Food Services	$101,479	3.3%
Construction	$120,390	4.0%
Educational and Health Services	$225,942	7.5%
Information	$317,647	10.5%
Government and Government Enterprises	$350,350	11.6%
Manufacturing	$356,436	11.8%
Professional and Business Services	$427,122	14.2%
Trade, Transportation, and Utilities	$436,369	14.5%
Finance, Insurance, Real Estate, Rental, and Leasing	$573,193	19.0%

Source: U.S. Bureau of Economic Analysis, as cited by California State Assembly 2023.
GDP = gross domestic product

While agriculture makes up a relatively small portion of the state's GDP, California leads all states in the value of sales from agricultural production. The role of agriculture in the state's economy varies among the geographic regions of the study area in terms of both jobs and output (product sales). This is demonstrated in Table 8.2-2, which displays data on agriculture related jobs and output by geographic region, and for the state as a whole. Agriculture accounts for 2 percent of the state's economic activity and provides 3 percent of its jobs. But agriculture's role in the economy varies among the geographic regions, with agriculture related jobs and sales constituting a larger portion of the regional economy in some areas. As shown in Table 8.2-2, agriculture constitutes 15 percent of the economy in the San Joaquin Valley.

Table 8.2-2. Agriculture in the California Economy

	Agriculture		All Sectors		Agriculture: Percent of Total	
Region	Jobs	Sales	Jobs	Sales	Jobs	Sales
Sacramento/Delta	80	$10,578	2,072	$310,392	4%	3%
San Joaquin Valley	228	$35,411	1,493	$238,456	15%	15%
San Francisco Bay Area	23	$3,010	3,181	$757,982	1%	0%
Central Coast	35	$4,361	465	$67,691	8%	6%
Southern California	111	$10,958	12,771	$2,187,054	1%	1%
California	582	$82,789	22,625	$4,076,095	3%	2%

Source: ^IMPLAN 2017.
Jobs are in thousands; Sales are in millions of dollars. Agriculture includes direct production plus support services, including migrant labor.

Table 8.2-3 identifies the counties included in the economic profile, as organized by geographic region in the study area. The boundaries of the geographic regions do not fully align with county boundaries. In some cases, portions of a county are located within multiple geographic regions, or portions of a county are located outside of the study area. These counties are denoted with an asterisk (*) in the table below. This section also summarizes municipal, industrial, and agricultural water use in the regions.

Table 8.2-3. Counties Included in the Economic Profile for the Geographic Regions

Sacramento River Watershed		Delta Eastside Tributaries	Delta
Butte	Plumas	Alpine	Contra Costa*
Colusa	Sacramento*	Amador	Sacramento*
El Dorado*	Shasta	Calaveras	San Joaquin*
Glenn	Sierra	El Dorado*	Solano*
Lake	Siskiyou*	Sacramento*	Yolo*
Lassen*	Solano*	San Joaquin*	
Modoc*	Sutter		
Napa*	Tehama		
Nevada	Yolo*		
Placer	Yuba		
San Francisco Bay Area	San Joaquin Valley	Central Coast	Southern California
Alameda	Fresno	Monterey	Imperial
Contra Costa*	Kern	San Benito	Inyo
Marin	Kings	San Luis Obispo	Los Angeles
Napa*	Madera	Santa Barbara	Mono
San Francisco	Mariposa	Santa Cruz	Orange
San Mateo	Merced		Riverside
Santa Clara	San Joaquin*		San Bernardino
Solano*	Stanislaus		San Diego
Sonoma*	Tulare		Ventura
	Tuolumne		

* Portion of county falls within the indicated geographic region.

Unless otherwise noted, the data presented in this section generally reflect county-level information that are grouped to most closely align with the boundaries of each geographic region in the study area. The geographic scope of the economic analysis generally covers entire counties rather than being divided by watershed boundaries or delivery service areas, but also generally correlates with the geographic regions defined in Chapter 2, *Hydrology and Water Supply*. An entire county is included in the analysis even if portions of the county do not provide or receive Sacramento/Delta water supply because economic data are nearly always organized on a county-level basis. Some data are available at a finer scale, such as population totals and population estimates available at the Census County Division level presented in Section 8.2.1, *Population – Current and Future*. The Census County Division level data is grouped to most closely align with the boundaries of each geographic region.

The study area reflects the diversity of California as a whole, including its water use. The counties in the study area include the populous and urbanized counties (e.g., Los Angeles, Santa Clara, Sacramento), those with both significant agricultural land and urban areas (e.g., San Joaquin, Fresno), and many that are rural with a large agricultural base (e.g., Glenn, Sutter, Kings, Merced).

The Sacramento/Delta watershed includes the Sacramento metropolitan area and several other cities, but the majority of the counties in the Sacramento/Delta watershed are sparsely populated (Figure 2.8-2). The remaining four geographic regions include the high-technology manufacturing center of the Bay Area, the agricultural area of the San Joaquin Valley, the less-urbanized Central Coast, and the highly urbanized areas of Southern California.

8.2.1 Population—Current and Future

Recent population levels and estimated population growth for California and for the geographic regions of the study area are shown in Table 8.2-4. The table shows population in 2010 and 2016 for each area based on data from the U.S. Census Bureau (^2017), including 2010 population totals and 2016 population estimates at the Census County Division level. A Census County Division is a subdivision of a county. The population of the state as a whole grew by more than 2 million, or 5.5 percent, from 2010 to 2016, but as shown in Table 8.2-4, the growth was not evenly distributed, as some regions grew much faster and others much slower than the state as a whole.

Table 8.2-5 presents population projections for the state of California and the geographic regions of the study area. These projections were prepared at the county level by the California Department of Finance Demographic Research Unit and are presented for July 2025 and July 2030. (Because the state provides estimates at the county level, the regions shown in Table 8.2-5 are approximate relative to the more refined estimates within Table 8.2-4; that is, the proportional share of each county's population that is contained within a region based on the 2016 estimate in Table 8.2-4 is applied to projected population within each region within Table 8.2-5.)

Table 8.2-4. Population Estimates for the State of California and Geographic Regions of the Study Area, 2010–2016

	Population Estimate		2010 to 2016 Population Change	
Population Area	April 1, 2010	July 1, 2016	Population Change	Percent Change
State of California	37,254,518	39,296,476	2,041,958	5.5
Sacramento River Watershed	2,803,517	2,910,072	106,555	3.8
Delta Eastside Tributaries	444,626	451,712	7,086	1.6
Delta	735,572	774,282	38,710	5.3
San Francisco Bay Area	6,507,165	6,993,837	486,672	7.5
San Joaquin Valley	3,483,447	3,646,099	162,652	4.7
Central Coast	1,426,227	1,499,472	73,245	5.1
Southern California	21,179,935	22,233,325	1,053,390	5.0

Source: ^U.S. Census Bureau 2017.
The estimates are based on the 2010 U.S. Census and reflect changes to the April 1, 2010, population due to the Count Question Resolution program and geographic program revisions. All geographic boundaries for the 2016 population estimates series except statistical area delineations are as of January 1, 2016. For population estimates methodology statements, see ^U.S. Census Bureau 2017.

Table 8.2-5. Population Projections for State of California and Geographic Regions of the Study Area

Population Area	July 1, 2025, Projection	July 1, 2030, Projection
State of California	42,326,397	43,939,250
Sacramento River Watershed	3,172,118	3,332,794
Delta Eastside Tributaries	495,259	521,710
Delta	867,513	919,883
San Francisco Bay Area	7,574,305	7,906,311
San Joaquin Valley	4,073,114	4,314,771
Central Coast	1,597,076	1,648,244
Southern California	23,717,834	24,442,704

8.2.2 Employment and Income

Total personal income (per capita) and median household income, poverty rates, and unemployment rates are commonly used economic indicators of social well-being. Table 8.2-6 presents comparative statistics for California and the United States based on information from the U.S. Census Bureau (^2017).

Table 8.2-6. Income, Poverty Rates, and Unemployment Rate, 2015

	United States	California
Per capita income ($/year)	$29,979	$31,587
Median household income ($/year)	$55,575	$64,500
Poverty rate (percent)	14.7%	15.3%
Unemployment rate (percent)	6.3%	7.3%

Source: ^U.S. Census Bureau 2017.

8.2.3 Municipal Water Use

Most of California's population receives municipal water supply provided by urban water agencies or suppliers (SWRCB 2023b, p. 41). Urban water suppliers are either publicly or privately owned, and provide water for more than 3,000 customers or supply more than 3,000 acre-feet of water annually. (Wat. Code, § 10617.) Urban water suppliers are generally responsible for acquiring and developing water supply and providing water supply to end users. This may require creating and managing water storage and conveyance systems, water treatment, constructing and maintaining pipelines and distribution infrastructure, and planning for and implementing systems that ensure that water is delivered to customers on an as-needed and uninterrupted basis.

Municipal water costs and water rates have been rising faster than the rate of inflation since at least the year 2000. Investment recovery costs have combined with declining water and sewer use, from drought, reduced economic activity, and increased conservation, such that revenues are not rising as fast as costs (Hanak et al. 2014, p. 28). In California's urban areas (especially San Diego, Los Angeles, and San Francisco), monthly water bills have risen two to three times the rate of inflation (Hanak et al. 2014).

The SWP provides municipal water supplies to multiple communities in the Sacramento/Delta watershed and other locations in California, and agricultural water to irrigation districts primarily in Kern County. The water contractors pay rates that cover both major operating costs and capital debt repayment. The CVP also provides Sacramento/Delta supply to water users in the Sacramento/Delta watershed and other locations in California primarily for agricultural irrigation, but some CVP supplies are provided for municipal uses. Table 8.2-7 summarizes the average water costs for municipal SWP and CVP water contractors. The table provides the volume-weighted average annual cost of water by CVP and SWP delivery regions for all contractors, based on allocation, contract volume, and fixed and variable costs. As shown, SWP costs vary widely by region, ranging from $80 per acre-foot per year (AF/yr) in the Sacramento River watershed, to $658 in the Central Coast region. CVP water costs range from $21 to $77 per AF/yr.

Table 8.2-7. CVP and SWP Average Municipal Water Delivery Costs ($ per acre-foot per year), 2018

Region	CVP	SWP
Sacramento River Watershed	$42	$80
San Francisco Bay Area	$62	$300
San Joaquin Valley		
San Joaquin River	$32	$238
Tulare Lake	$77	$126
Central Coast	$21	$658
Southern California	-	$510

Source: Table adapted from review and assembly of historical CVP and SWP contract and delivery data.

Table 8.2-8 and the discussion that follows summarize municipal water use by subcategories for the state as a whole and current goals for water conservation by sector, based on information from the *California Water Plan Update 2013*.

Table 8.2-8. Statewide Municipal Water Uses

Water Use Category	Percent of Total Municipal Water Use	Per Capita Water Use (GPCD)	Volume of Water (MAF)
Residential landscape	34	79	3.0
Large landscape	10	24	0.9
Indoor residential	31	71	2.7
Commercial, institutional, and industrial	20	48	1.7
Other	5	—	0.5
Total	**100**		**8.8**

Source: ^DWR 2014.
Numbers based on an average of the years 1998 through 2005.
GPCD = gallons per capita per day; MAF = million acre-feet

- The *California Water Plan Update 2013* identified factors contributing to the high use of water for residential landscape irrigation, including a shift in population to the interior regions of California, which are not only hotter but tend to have larger residential landscapes; use of cool-season grasses and other plants that have high water requirements; inefficient irrigation systems; and a general overwatering of residential landscapes.

- Large landscapes (i.e., commercial, industrial, institutional [CII] landscapes) are served by dedicated water meters, which provide accurate measures of water to compare to landscape water budgets and also allow users to detect leaks in the irrigation system. The state is targeting a 15 percent reduction in water use in this sector of urban water (^2013 Water Plan V2).
- Indoor residential use includes water delivered through toilets, clothes washers, showers, faucets, and dishwashers. Because of the water conservation potential of more efficient indoor fixtures, the state estimates that a 15-gallon per capita per day (GPCD) reduction in indoor water use is feasible (^2013 Water Plan V2).
- The CII segment of urban water use covers a wide range of uses and is thus difficult to describe in general terms. Use of recycled municipal water and reuse of process water can reduce water demand in industrial facilities. Actions in other (non-industrial) parts of the CII segment are also possible, e.g., replacement of older fixtures and equipment. The state is targeting a 10 percent reduction in water use for the CII segment's water users (^2013 Water Plan V2).

The Water Conservation Bill of 2009 (SB X7-7) required the state to reduce urban water consumption by 20 percent by the year 2020 and encouraged both urban and agricultural water providers to implement conservation strategies, monitor water usage, and report data to DWR. California met the SB X7-7 targets and between 2000 and 2013, average statewide per capita water use decreased from 199 to 164 GPCD. After release of the California Water Plan Update 2013, severe drought conditions resulted in additional conservation regulations. During the drought, the State Water Board adopted an emergency regulation under Water Code section 1058.5 that, among other things, required a mandatory 25 percent statewide reduction in potable urban water use. Conservation generally exceeded requirements, and led to further decrease in municipal water use (SWRCB 2017). Since then, municipal water use in California reached 137 GPCD in 2020, and further dropped to 130 GPCD by the end of 2022 when state and local emergency drought actions again took effect (SWRCB 2023a, p. 11).

Larger urban water suppliers minimize risk and ensure reliability of supply by developing diversified water supply portfolios. This method focuses on creating a reserve of multiple sources of water supply—stored surface water, groundwater wells, water recycling, conservation, and exchanges or transfers of water—that avoids the reliability risks of dependence on one or a few sources of water. If one supply source is reduced (e.g., by drought) then other sources can be used to make up for the loss and avoid reductions in service.

Urban water suppliers for larger communities tend to have more opportunities for diversified portfolios than small communities. However, in either circumstance, there tend to be primary and secondary supplies, with locally developed supply sources as both least expensive and first priority options.

8.2.4 Industrial Water Use

Table 8.2-9 provides county-level information on industrial water use based on U.S. Geological Survey data for 2010. Table 8.2-9 provides information on self-supplied groundwater and surface water, as well as water deliveries provided by public suppliers, for industrial water use in the counties within the study area. Based on the information provided in Table 8.2-9, self-supplied water for industrial use is nearly all from groundwater, as only three counties (Amador, Butte, and Lake) receive any self-supplied industrial water use from surface water sources. Industrial users that receive deliveries from public supply are supplied by public wholesale and retail water providers, which is roughly 40 percent of industrial use, and utilize surface water to the extent that it is a part of their providers' portfolio.[2] Industrial water use from public supplies is discussed in Section 8.2.3, *Municipal Water Use*.

Table 8.2-9. Industrial Water Use in California, 2010 (million gallons per day)

County	Industrial Total Self-Supplied Withdrawals, Groundwater	Industrial Total Self-Supplied Withdrawals, Surface Water	Industrial Deliveries from Public Supply	Industrial Total
Alameda	0.90	0	19.77	20.67
Alpine	0	0	0	0
Amador	0.21	0.20	0.08	0.49
Butte	3.17	0.85	0.76	4.78
Calaveras	0.17	0	0	0.17
Colusa	0.84	0	0.10	0.94
Contra Costa	3.34	0	34.02	37.36
El Dorado	0.89	0	0.38	1.27
Fresno	10.51	0	12.95	23.46
Glenn	0.27	0	0.03	0.30
Imperial	1.20	0	1.75	2.95
Inyo	0.09	0	0	0.09
Kern	2.46	0	28.04	30.50
Kings	3.08	0	1.01	4.09
Lake	0.88	0.08	0.01	0.97
Lassen	0	0	0.54	0.54
Los Angeles	103.27	0	56.12	159.39
Madera	4.57	0	0	4.57
Marin	0.28	0	0.01	0.29
Mariposa	0	0	0	0
Merced	5.63	0	4.42	10.05
Modoc	0	0	0.09	0.09
Mono	0.03	0	0	0.03
Monterey	2.16	0	1.56	3.72
Napa	7.55	0	0.01	7.56
Nevada	0.08	0	0.08	0.16
Orange	18.11	0	17.82	35.93
Placer	2.01	0	1.14	3.15
Plumas	1.35	0	0	1.35
Riverside	5.26	0	12.05	17.31
Sacramento	16.91	0	5.73	22.64
San Benito	4.02	0	0.61	4.63

[2] From Table 8.2-9, total industrial deliveries from public supply as a share of the total is 258.22 million gallons per day /653.39 million gallons per day = 39.4 percent.

County	Industrial Total Self-Supplied Withdrawals, Groundwater	Industrial Total Self-Supplied Withdrawals, Surface Water	Industrial Deliveries from Public Supply	Industrial Total
San Bernardino	46.01	0	9.26	55.27
San Diego	1.82	0	3.93	5.75
San Francisco	0	0	2.10	2.10
San Joaquin	22.88	0	4.52	27.40
San Luis Obispo	3.96	0	0.16	4.12
San Mateo	0.26	0	2.37	2.63
Santa Barbara	6.36	0	0.71	7.07
Santa Clara	12.48	0	10.10	22.58
Santa Cruz	6.96	0	1.96	8.02
Shasta	15.16	0	1.21	16.37
Sierra	0.45	0	0	0.45
Siskiyou	2.29	0	0.08	2.37
Solano	6.08	0	2.60	8.68
Sonoma	14.77	0	1.07	15.84
Stanislaus	16.03	0	6.39	22.42
Sutter	8.58	0	1.76	10.34
Tehama	1.79	0	0.53	2.32
Tulare	16.07	0	3.02	19.09
Tuolumne	1.53	0	0	1.53
Ventura	10.21	0	7.10	17.31
Yolo	0.79	0	0.26	1.05
Yuba	1.22	0	0.01	1.23
Total	**394.94**	**1.13**	**258.22**	**653.39**

Self-supplied industrial groundwater use is predominant in the large urban manufacturing areas, including Los Angeles, San Bernardino, and (to a lesser extent) Orange Counties. Other areas with moderate self-supplied industrial groundwater use include San Joaquin, Stanislaus, Tulare, and Sacramento Counties. These are areas with a large presence of water-using food manufacturing plants. Santa Clara County, with high technology chip manufacturing and related industries, also uses a larger amount of self-supplied industrial groundwater compared to other locations. Groundwater is also used for industrial purposes in several other counties.

Recent data shows that manufacturing provided about 5 percent of overall employment and less than 10 percent of employee compensation (^IMPLAN 2017). Information on the primary manufacturing sectors within California is summarized in Table 8.2-10. The top two employment categories for California manufacturing industries are computer and electronic product manufacturing, and food manufacturing.

Table 8.2-10. Primary Manufacturing Sectors in California, 2015

Manufacturing Sector	Employment (jobs)	Percent of Total Manufacturing Employment	Percent of Total Manufacturing Labor Income
Computer and electronic product manufacturing	244,066	18	33
Food manufacturing	188,934	14	8
Fabricated metal product manufacturing	139,444	10	7
Transportation equipment manufacturing	117,682	9	10
Machinery manufacturing	78,127	6	6
Textiles and apparel manufacturing	77,406	6	2
Chemical manufacturing	75,081	5	9

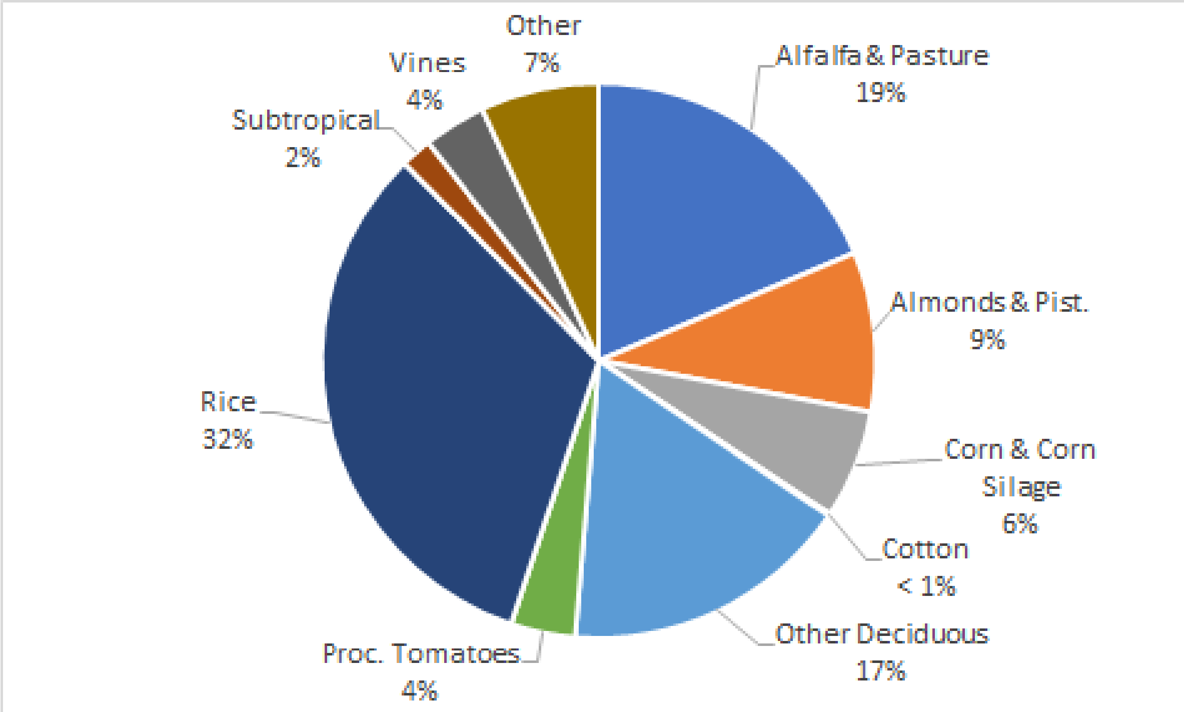
Source: ^IMPLAN 2017.

8.2.5 Agricultural Water Use

Agriculture is dependent on the complex distribution infrastructure that stores, manages, and transports water from its original sources to its users. Agricultural water users rely on a variety of water sources to meet crop water demands. Some agricultural water users use surface water supplies delivered under SWP, CVP, and other contracts. Some agricultural water users rely on water provided by agricultural water suppliers (i.e., water districts, water conservation districts, water management districts, irrigation districts). Once diverted, the water supply is routed through conveyance facilities to growers. Some agricultural water users rely on local surface water sources, and some agricultural water users rely on groundwater to meet all or a portion of their water demands. Groundwater use generally increases during dry years to offset limited surface water availability. Some agricultural producers may also purchase water from other users to maintain crop production during dry years.

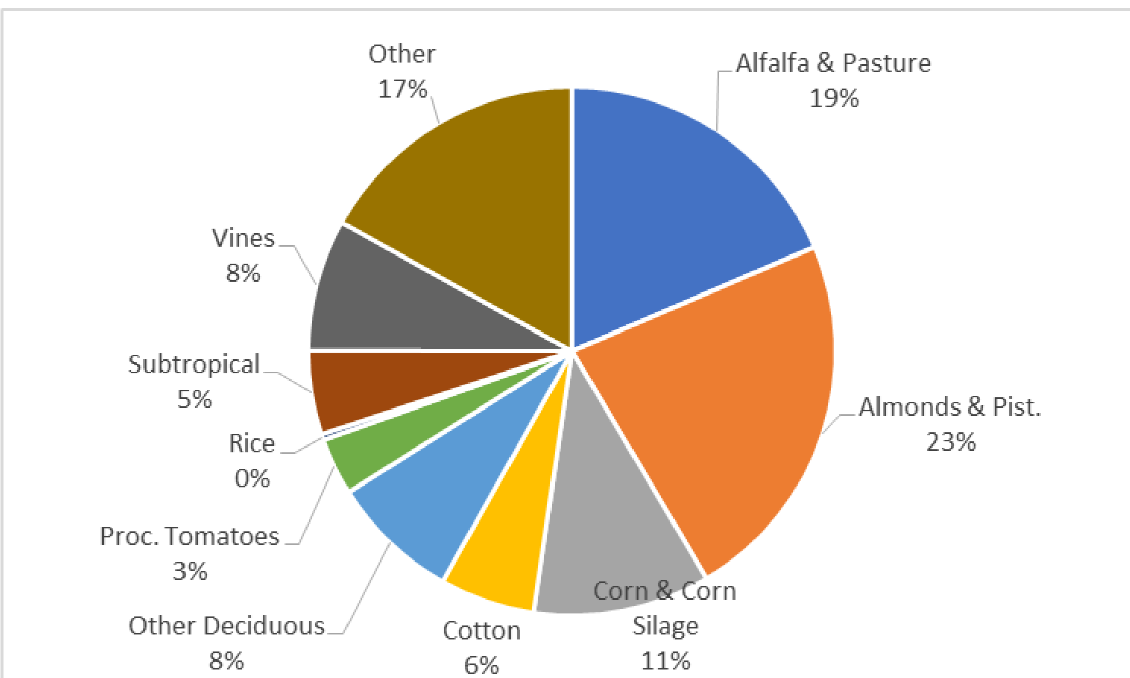
Most of the agricultural water use in the state is within the Sacramento/Delta watershed and San Joaquin Valley regions. Figures 8.2-1 and 8.2-2 show the fraction of the estimated total agricultural water use by crop category within these regions.[3] In the Sacramento/Delta watershed, these figures indicate that of the total volume of water used for agricultural production, approximately 32 percent is applied to rice, 19 percent to alfalfa and pasture, 17 percent to other deciduous, 9 percent to almonds and pistachios, and 23 percent to other crop categories (subtropical, vines, corn and corn silage, cotton, processing tomatoes, and other). In the San Joaquin Valley, of the total volume of water used for agricultural production, approximately 23 percent is applied to almonds and pistachios, 19 percent to alfalfa and pasture, 11 percent to corn and corn silage, and 47 percent to other crop categories (cotton, other deciduous, processing tomatoes, rice, subtropical, vines, and other).

[3] Crop water use estimates presented here were developed using 2010 land use data developed by DWR. The 2010 land use data were combined with 2010 applied water requirements in the Sacramento River watershed, Delta eastside tributaries, and Delta estimated by SacWAM and 2010 applied water requirements estimated by DWR for the San Joaquin Valley. Estimated water use does not include transmission losses and return flow, which are reflected in water supply estimates elsewhere in the Staff Report (see e.g., Chapter 6, *Changes in Hydrology and Water Supply*, Table 6.4-2).



Sources: Adapted from DWR (2010) land use data and SacWAM water requirement data.

Figure 8.2-1. Estimated Annual Water Use by Crop Category, Sacramento/Delta



Source: Adapted from DWR (2010) land use data and SacWAM water requirement data.

Figure 8.2-2. Estimated Annual Water Use by Crop Category, San Joaquin Valley

Agricultural water costs vary by water source and hydrologic conditions. For example, water provided by the CVP is subsidized by the federal government (Wichelns 2010, p. 14). In contrast, SWP water users must repay the construction investment, interest, and annual costs of operation and investment annually, regardless of agricultural conditions (Wichelns 2010, p. 17). Another price variable is the water distribution agencies' policies on charging for service and distribution, including operations and maintenance, which could include costs of accessing groundwater for those irrigation districts that include groundwater as part of their water supply portfolio (Wichelns 2010, pp. 16–17). Surface water prices can vary substantially across regions, and within a region if some water users divert water under senior water rights and claims, and others purchase water from a water supplier (Wichelns 2010, p. 8).

Table 8.2-11 summarizes the average surface water costs for CVP and SWP agricultural water users, organized according to the hydrologic regions defined in the California Water Plan. The table provides the volume-weighted average annual cost of water by region across all contractors, based on allocation, contract volume, contract type, and fixed and variable costs. As shown, neither the CVP nor SWP directly deliver agricultural water to the South Coast Hydrologic Region (located in the Southern California geographic region). All agricultural contractors within the SWP are located within the Tulare Lake hydrologic region (located in the San Joaquin Valley geographic region) where the average water cost is $127 per AF/yr. CVP water costs are somewhat lower and range from $57 to $95 per AF/yr. Average water costs were developed by applying the fixed cost components of Project water charges to the water volume assigned to each contractor. Variable costs were added by multiplying the variable cost components by the average annual historical water allocation for agricultural contractors within the CVP and SWP. For the SWP, the average historical allocation has been approximately 60 percent of the water volume assigned to each contractor. Within the CVP, average annual allocations range from approximately 27 to 84 percent for Class 2 and Class 1 contractors within the Friant Division, respectively.

Table 8.2-11. CVP and SWP Average Agricultural Water Costs ($ per acre-foot per year)

Hydrologic Region	CVP	SWP
Sacramento River	$58	-
San Francisco Bay	$57	-
San Joaquin River	$94	-
Tulare Lake	$95	$127
Central Coast	$61	-
South Coast	-	-

Source: Table adapted from review and assembly of historical CVP and SWP contract and delivery data.
- = not applicable; CVP = Central Valley Project; SWP = State Water Project

8.2.6 Farming-Dependent Industries

Table 8.2-12 summarizes the economic characteristics of farming-dependent sectors that provide agricultural services or process agricultural crops or commodities or which rely directly on irrigated cropland within the Sacramento/Delta. Employment figures include full-time, part-time, and seasonal jobs. Table 8.2-13 provides similar information for the San Joaquin Valley. This information is relevant for the agricultural economic analysis presented later in this chapter.

Table 8.2-12. Economic Characteristics of Selected Farming-Dependent Sectors in the Sacramento/Delta, 2015

Sector	Jobs (thousand)	Output (Sales) ($ million)	Employee Compensation ($ million)
Agricultural Services			
Support activities for agriculture and forestry	21.9	1,444.7	803.9
Fertilizer and pesticide manufacturing and mixing	0.6	953.9	59.7
Food Processing			
Fluid milk manufacturing	0.1	79.6	9.7
Cheese manufacturing	0.4	500.5	36.2
Flour milling	0.3	368.5	19.7
Rice milling	1.3	1,139.8	86.4
Wet corn milling	0.4	730.1	32.0
Canned fruits and vegetables manufacturing	2.7	1,357.0	150.6
Dehydrated food products manufacturing	0.6	261.1	32.5
Bread and bakery product, except frozen, manufacturing	4.6	604.8	160.1
Roasted nuts and peanut butter manufacturing	1.9	1,389.0	126.2
All other food processing [a]	5.2	3,419.3	320.7
Other Farming-Dependent Businesses			
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	4.2	546.6	12.1
Dairy cattle and milk production	1.6	846.2	34.3
Wineries	3.8	1,264.3	194.9

Source: ^IMPLAN 2017.

[a] May not involve or utilize raw products grown or produced in the Sacramento/Delta.

Table 8.2-13. Economic Characteristics of Selected Farming-Dependent Sectors in the San Joaquin Valley, 2015

Sector	Jobs (thousands)	Output (Sales) ($ million)	Employee Compensation ($ million)
Agricultural Services			
Support activities for agriculture and forestry	123.7	7,244.2	3,898.7
Fertilizer and pesticide manufacturing and mixing	0.6	873.0	55.9
Food Processing			
Fluid milk manufacturing	2.4	2,104.4	212.3
Cheese manufacturing	4.3	4,854.1	350.2
Frozen fruits, juices, and vegetables manufacturing	2.5	1,076.9	129.7
Canned fruits and vegetables manufacturing	8.6	4,321.9	532.8
Dehydrated food products manufacturing	1.7	726.3	72.4
Roasted nuts and peanut butter manufacturing	3.3	2,386.7	193.7
Dry, condensed, and evaporated dairy product manufacturing	0.5	865.5	40.9
Ice cream and frozen dessert manufacturing	1.3	580.1	101.7
Animal, except poultry, slaughtering	2.7	1,985.7	137.4
Bread and bakery product, except frozen, manufacturing	3.3	397.1	80.6
All other food processing [a]	20.7	11,375.9	983.2
Other Farming-Dependent Businesses			
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	3.8	1,704.7	29.2
Dairy cattle and milk production	13.2	7,264.6	314.4
Wineries	5.3	1,968.4	502.8

Source: ^IMPLAN 2017.
[a] May not involve or utilize raw products grown or produced in the San Joaquin Valley region.

Agricultural Services

Agricultural support service businesses are strongly influenced by changes to farms and their crops. *Agricultural services* include the following.

- Fertilizer and chemical dealers and custom appliers
- Irrigation equipment suppliers
- Farm equipment dealers
- Tractor and equipment maintenance and repair facilities
- Financial service providers
- Insurance agents
- Custom harvesters
- Trucking companies
- Labor contractors
- Migrant farm workers

Many businesses that provide supplies or services to farming may not be included in the above tables, either because they serve a broader clientele and therefore do not self-identify as agricultural service businesses or are otherwise classified.

The role of and dependency upon farming inputs supplied by the services sector varies by crop, just as there are differences in requirements for fertilizer, pesticides, harvest labor needs, equipment, and supplies. The variation in crop types means that decreases in production of lower net revenue crops (e.g., alfalfa, grain) would likely reduce demand for services by a smaller proportion than it would for higher net revenue crops (e.g., fruit and nut orchards, vegetables), since they require fewer input services. Similarly, a shift in production from lower net revenue to higher net revenue crops could result in a net increase in demand for agricultural services. Nevertheless, some reduction or displacement among individual businesses or services within the broader agricultural services sector is possible with any change in overall farmed acreage or cropping pattern.

Food Processing

Food and agricultural product processing is a component of California's economy, both in rural and urban areas of the state. The food and agricultural product processing sector uses raw farm outputs and converts them into food and fiber products sold domestically and internationally. However, not all of the food and beverage processing sector is connected to California agriculture, as a considerable share of the sector's raw materials either originate elsewhere or do not involve agricultural output (e.g., beverages such as carbonated drinks, fish processors). Food processing associated with crops or commodities is described in the subsections that follow.

Based on the information presented in the tables above, in the Sacramento/Delta, bread and bakery product manufacturing is the largest individual food processing employer category, followed by canning of fruits and vegetables. Roasted nut and peanut butter manufacturing and rice milling are also large employers. In the San Joaquin Valley, canning of fruits and vegetables is the largest individual food processing employer category among food-processing industries, followed by cheese manufacturing, roasted nut and peanut butter manufacturing, and bread and bakery product manufacturing.

Rice Milling

With approximately 500,000 acres in production, California ranks as the second-largest rice-growing state in the United States, after Arkansas. California is the only U.S. producer of the high-quality japonica rice. The sticky, moist characteristics of japonica varieties make them particularly suited for Mediterranean and Asian cuisines (^UC AIC 1994; USA Rice 2017). As a result, a substantial share of this crop (45–55 percent annually) is exported to Japan, South Korea, and elsewhere (Rice Growers of America 2017). The majority of rice in California is grown in the Sacramento Valley.

Rice processors are involved in multiple aspects of preparing rice for market, including hulling, cleaning, milling (removing the bran), drying, packaging, transport, and marketing. By the early 1990s, milling capacity was 42 million hundredweight statewide, with cooperatives owning about half (^UC AIC 1994, pp. 6, 9). As a result of cooperative ownership, growers control significant amounts of both production and processing.

Wheat and Other Small Grains

Winter wheat is grown across California. Yolo County in the Sacramento Valley produces a large quantity of winter wheat. Much of California's average annual wheat production (1.1 million tons) is used within the state for both human and animal consumption. Approximately 25 percent of the wheat is exported to other countries (California Wheat Commission 2017). A large proportion of non-export hard red wheat is used for milling into bread flour or general purpose flour. California is a *wheat deficit* state, consuming more wheat than it grows. Consequently, California mills wheat imported from other states to meet the demand. California mills collectively had the largest wheat milling capacity in the country in the last few years. Including durum mills, which are located primarily in the Imperial Valley, California grinds approximately 1.8–1.9 million tons of wheat per year (California Wheat Commission 2017).

A fairly large percentage of California's wheat grain production is used to feed livestock and dairy cows, depending on the price of competing grains. Because of the sizable dairy industry, a large percentage of California's wheat crop never enters the grain market. From 2012 to 2014, an average of 60 percent of the common wheat planted in California was used for silage, green chop, forage, or hay. California still must import millions of tons of feed stuffs into the state to meet the needs of the livestock industry (California Wheat Commission 2017).

Barley is grown for forage or used in malt production in breweries. Oats are grown in California almost exclusively as forage for livestock, and dairies use oats alone or in combination with other legumes to add protein to feed. Triticale is grown as forage for dairies (Jackson et al. 2006, pp. 3–4).

The most common class of wheat grown in the San Joaquin Valley is fall-sown hard red spring wheat, with a smaller amount of hard white wheat and durum; other small grains such as barley, oat, and triticale are also grown. Most wheat is grown in rotation with field and vegetable crops, including tomatoes, cotton, and alfalfa (Geisseler and Horwath 2014; Jackson et al. 2006, p. 2).

Grain Corn

In California, field corn is grown for grain and silage. The total area planted for both purposes was about 520,000 acres in 2014. Of that area, 95,000 acres were harvested for grain. Leading counties in grain corn production were Sacramento, Glenn, Solano, and Sutter in 2014, all of which are in the Sacramento Valley (UCANR 2015). Grain corn may be processed through corn mills for livestock feed, human consumption, and industrial products. Food products made from corn include starch, sweeteners, and oil. Industrial products include industrial alcohol and fuel ethanol. California grain corn acreage tends to fluctuate in response to market conditions, either substituting a different crop or harvesting corn as silage (UCANR 2015). For silage crops, the entire corn plant is generally harvested and hauled directly to dairies where it is stored in pits for curing and eventually feeding to cows.

Processing Tomatoes

Over 100,000 acres of processing tomatoes are grown in the Sacramento River watershed and Delta, concentrated in Colusa, San Joaquin, Solano, Sutter, and Yolo Counties. Over 180,000 acres of processing tomatoes are grown in the San Joaquin Valley, concentrated in Fresno, Kings, and Merced Counties. Tomatoes grown for processing are manufactured into paste and resold as a raw ingredient in other foods. Many firms also manufacture pulp-based products, such as stewed, whole-peeled, and diced tomatoes. Bulk items can be remanufactured into sauces, ketchup, salsas, soups, and other foods. Several small processors produce dried tomato products (Hartz et al. 2008). California accounts for approximately 94 percent of the area harvested for processing tomatoes in the United States (ERS 2017).

Growers typically contract with specific processors to grow processing tomatoes. Processing tomatoes are generally delivered to market within a 2-week period, with that time period set by the processor (Hartz et al. 2008). Because of the bulk density of the ripe product, processing plants are located near production areas.

Vegetable Processing

Vegetable processors purchase raw produce and process vegetables for packaging as frozen, canned, or dehydrated forms, or combined with other ingredients in prepared (cooked) form. Vegetable processors are located in both the Sacramento and San Joaquin Valleys.

Cucumbers, cantaloupes, watermelons, summer and winter squash, and pumpkins are all members of the cucurbit family. The majority of these crops are grown in the San Joaquin Valley. Onions and garlic are also important crops there. A large portion of the farm product enters the fresh market with minimal additional processing beyond field packing, cooling, warehousing, and distribution. A smaller share is utilized in prepared foods or frozen.

Cotton Ginning

California produces two types of cotton—upland and Pima. Cotton is grown primarily in the San Joaquin Valley, but some acreage is also grown near the Colorado River, and a small amount in the Sacramento Valley. California's production of Pima cotton represents over 90 percent of the total U.S. Pima cotton production (CCGGA 2023). Although cotton acreage peaked at about 1.2 to 1.4 million acres during the late 1970s and early 1980s, other crops supplanted cotton due to relative profitability, drought, and pest problems. Acreage is now in the range of 200,000–400,000 acres (CCGGA 2023; Geisseler and Horwath 2013).

There are about 30 cotton gins in the state that process cotton for lint, cottonseed, oil, and other products. Lint is used both domestically and exported for textile goods production. Cottonseed is retained, with 95 percent sold as dairy feed and the remainder further processed for oil. Crushed cottonseed meal and cake is used for fertilizers and feed for cattle, sheep, horses, pigs, fish, and shrimp (CCGGA 2023).

Nut Processing

Almonds, walnuts, and pistachios are major crops in the study area, and nut processors can be found throughout in locations that are central to production areas and transportation outlets.

Almonds are among the top three highest-net revenue crops in the Sacramento Valley, and orchards represent a substantial share of farmed acreage. Processing is a significant and substantial component of getting almonds to consumers. Nuts are harvested from orchards and transported to almond-processing facilities, where the almonds are hulled and shelled. Almonds may then be processed into different forms (e.g., blanched, roasted, sliced, slivered, diced, ground) for ingredient or direct (snacking) use.

Most walnuts are now produced in three main areas of the San Joaquin and Sacramento Valleys, with more than half of the acreage located in San Joaquin, Stanislaus, Tulare, Butte, and Sutter

Counties. California growers produce 99 percent of the commercial U.S. supply (Geisseler and Horwath 2016). Harvested nuts are taken to a huller that removes the green hulls from the shell with wet scrubbers and are dried in gas dryers. When dry, the nuts are ready for storage or processing. Processors typically buy walnuts in-shell and then crack, grade, and package or further process for export (about a third of the crop) or domestic consumption.

Fruit Processing

California accounts for over half of the harvested fruit acreage in the country, and much of the deciduous fruit is grown in the study area. Peaches, plums, nectarines, cherries, apricots, and other tree fruits are grown in the Sacramento Valley. Types of processors include canneries, dehydrated fruit processors, and fresh and frozen packaged or prepared foods. The San Joaquin Valley is also a dominant producer of many varieties of fruit, especially peaches, nectarines, and cherries, and is the location of a number of fruit processors.

Fresh fruits are harvested into bins for immediate cold storage. At the processor end, fruit bins are transferred to receiving bins, and conveyed through processing machines to be washed, cut, blanched, and peeled and/or pitted. The fruit may be frozen into packages and stored for shipment. Canned fruit may include syrup or other additives before it is filled into cans, after which lids are applied. The cans are then cooked, labeled, cased, and stored pending shipment.

Wine Grapes

California has three types of wineries: wineries producing their own wine brands, wineries/production facilities contracted to produce wines for other companies, and companies marketing their own wine brand, but not producing the wine itself (John Dunham & Associates 2016). Wineries are a large industry in the Sacramento/Delta watershed. As shown in Table 8.2-12, wineries provide almost 4,000 jobs in the Sacramento/Delta watershed, with compensation of nearly $200 million annually. Numerous wineries are also located in the San Joaquin Valley, employing approximately 5,000 people, with compensation of over $500 million annually (Table 8.2-13).

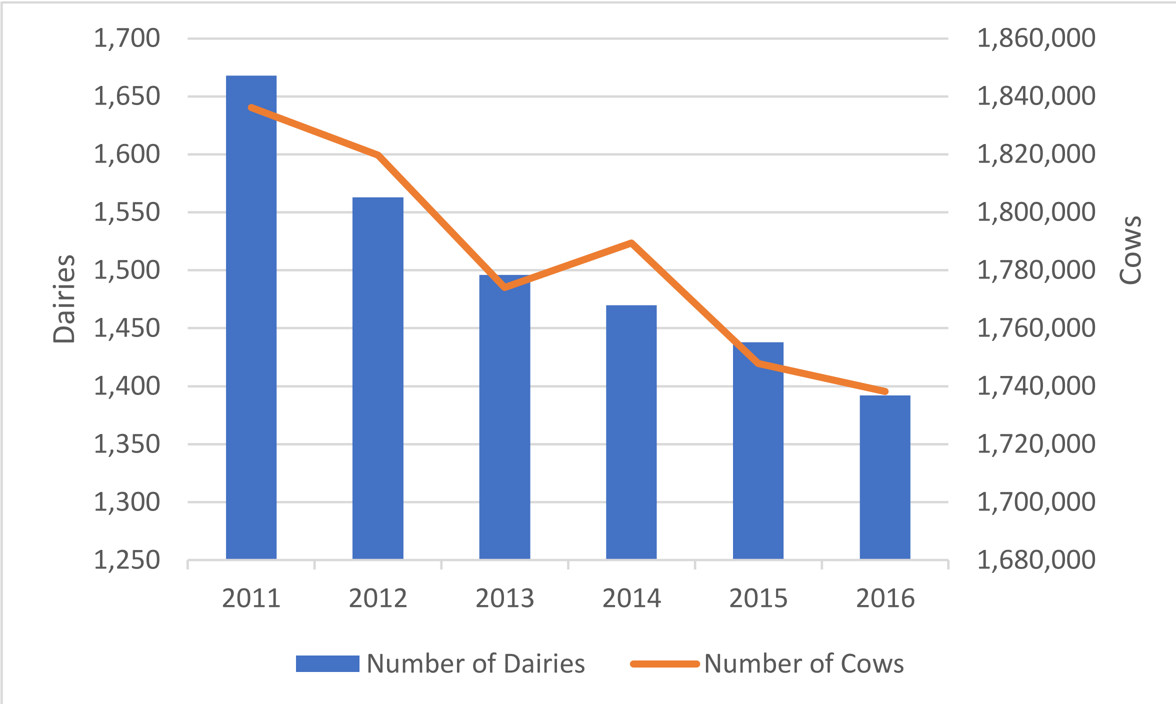
Livestock

Dairies

Dairies represent a unique category of agricultural operations with a substantial dependency upon irrigated cropland for feedstock. Dairies primarily rely on the following feed crops: silage (typically corn that has been preserved through partial fermentation and is stored in a wet condition); forage (typically alfalfa that has been stored in bales at a low moisture content to prevent spoilage); grain based concentrates (such as dried field corn and wheat); other feed (which may include distiller’s grains, almond hulls, cotton seed, citrus pulp, and other feed items); and supplements for feed rations (vitamins and minerals to ensure animal health). The exact mix of a feed ration and its source is up to the individual dairy operator and changes depending on market conditions.

Figure 8.2-3 provides a recent summary of the number of dairies and dairy cows in California, which declined from 2011 to 2016. The large decline was attributable to a number of factors. In general, dairy operations face urbanization pressures, especially in Southern California, and many dairies have moved to other states where land prices are lower and competition for land is less pronounced.

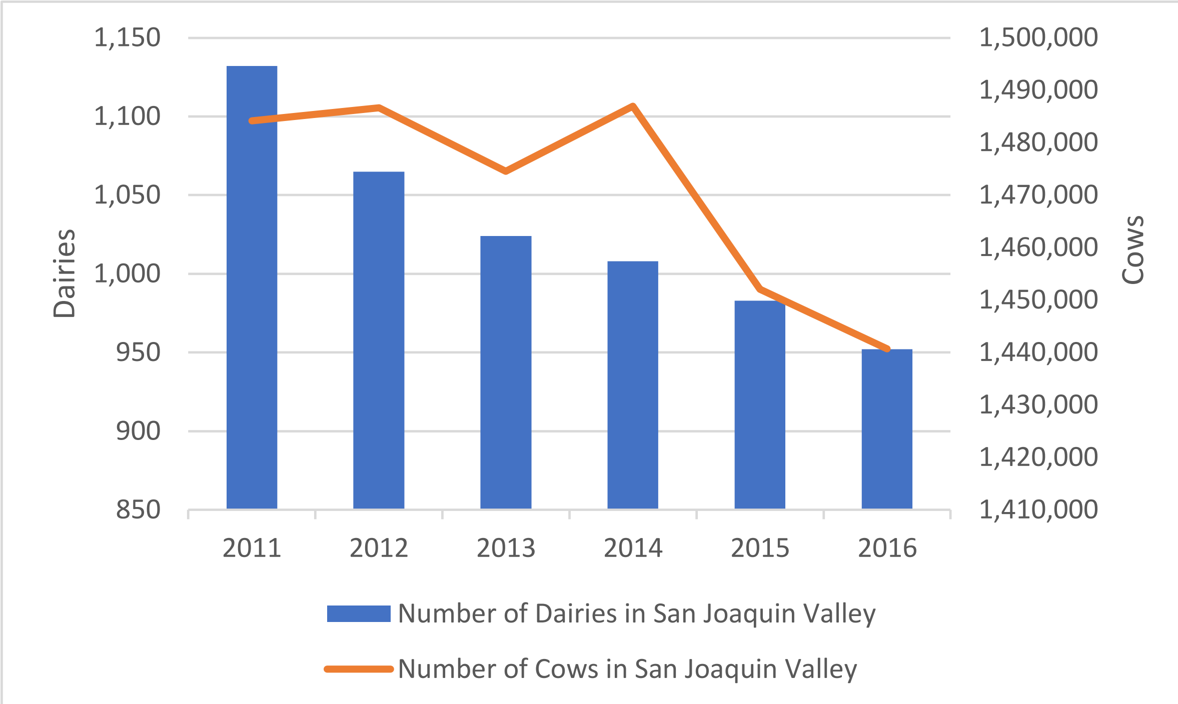
Several small to midsize operations have been sold in consolidations or moved out of state (CDFA 2016, p. 86).



Sources: CDFA 2011–2016.

Figure 8.2-3. Number of Dairies and Dairy Cows, California (2011–2016)

Figure 8.2-4 provides a recent summary (2011–2016) of the number of dairies and dairy cows in the San Joaquin Valley, which represent about 75 percent of the state's dairy cows (CDFA 2015). The decline in the number of dairies in the region from 2011 to 2016 is attributable in part to a trend toward consolidation. The number of dairy cows also declined during this period. The 2012–2016 drought affected water costs and allocations, thus limiting local feed as water was used for more lucrative crops. Increased milk production in other states, lower milk prices, and loss of feed acreage to almonds and other nuts were contributing factors (CDFA 2016, p. 86).



Sources: CDFA 2011–2016.

Figure 8.2-4. Number of Dairies and Dairy Cows in the San Joaquin Valley (2011–2016)

A significant portion of the grain acreage grown in the San Joaquin Valley is used for silage, green chop, forage, and hay, in service to the dairy industry (California Wheat Commission 2017). Despite the 2012–2016 drought, the acreage devoted to production of corn silage remained relatively stable during the 2011–2016 period because many corn growers are directly associated with dairies. Tulare, Merced, Stanislaus, San Joaquin, and Kings Counties were the top five producing silage counties (UCANR 2015).

In addition to having the majority of California's dairy farms, the San Joaquin Valley has the state's highest production of alfalfa. Nevertheless, the region is a net importer of feedstock, obtaining alfalfa from other regions in California, as well as other nearby states. Alfalfa production in the region also remained fairly uniform during the 2011–2016 period. In the future, plantings of alfalfa are anticipated to decline in Kings, Kern, Tulare, and Fresno Counties, due to competition from other crops, especially tree nuts. This will increase reliance by dairies on alfalfa hay coming from out of state (Hoyt Report, as cited by Blake 2017). In addition, there is a small but increasing export market for alfalfa and other hay to China and the Middle East, and that is increasing competition, and prices, for feed (Putnam et al. 2013).

Beef Cattle

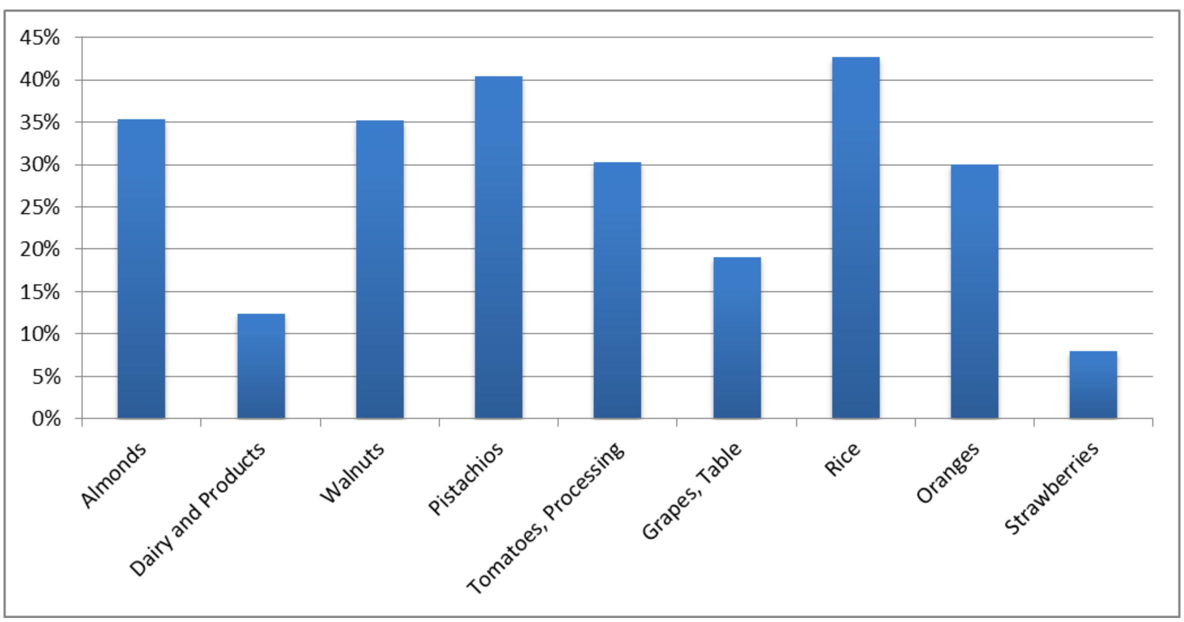
Cattle are raised in every county in the state except San Francisco. Ranching operations are generally classified into four types. Small (less than 50 animals) and medium-sized operations (from 75 to 200 cows) are generally supplemented with revenue from other enterprises or from off-ranch sources. Large ranches (over 200 cows), where cattle production is the primary enterprise, and cattle ranches of varying sizes that are part of a larger diversified operation with farming and other businesses can be profitable business enterprises, although they generally do not return a profit every year as cattle prices and weather varies (Forero et al. 2017).

Cow-calf operations rely on forage as the primary feed component, including rangeland and irrigated pasture. Stocker operations rely on grazing, but stocker cattle are typically moved to feedlots at the end of the grazing season. Feedlots combine many cattle in a concentrated area, and the cattle are fed directly with feed grains, byproducts (e.g., rice bran, almond hulls, cottonseed), and hay. Feedlots are located in both the Sacramento Valley and San Joaquin Valley.

To a large extent, the dairy and beef industries use common inputs such as feed, supplies, and support services, so effects on the dairy industry could also affect the beef cattle industry. The dairy industry is also a significant supplier of animals for the beef industry. It sells live animals for fattening and slaughter, as well as animal feed such as byproducts from milk processing.

8.2.7 Exports of Agricultural Commodities

California producers have well-established export markets for a significant portion of their commodities. Many commodities produced in California are exported directly to other countries; Figure 8.2-5 shows the percentage of certain commodities that were exported during 2011–2016. These commodities include fruits, nuts, dairy products, processing tomatoes, and rice, all of which are all produced in the study area. For example, as shown in the figure below, exports of rice averaged 42 percent by value during 2011–2016, and more than a third of almonds and walnuts are exported to other countries.



Source: Derived from CDFA data, 2011–2016.

Figure 8.2-5. Percentage of Commodities Exported, by Value, California (2011–2016)

Many factors influence the amount of agricultural commodities that are exported, including relative domestic and export prices, market contracts, and even individual growers and processors that may have established market relationships with export countries in disproportionate levels.

8.2.8 Sacramento/Delta Watershed Regional Profile

Regional economic data for population, employment, and income in the Sacramento/Delta watershed are provided in this section. For the purposes of this economic profile, data for the three regions are presented as a combined group. However, some distinctions among the regions are presented here, and as distinct areas later within the results sections of this chapter.

8.2.8.1 Population

As shown in Section 8.2.1, *Population – Current and Future*, the population in the Sacramento/Delta watershed grew at a slower rate compared to California as a whole from 2010 to 2016, but is projected to grow at a faster rate compared to California as a whole in the future.

Several counties in and near the Sacramento metropolitan area have experienced population growth in recent years, such as Sacramento, Placer, and Yolo Counties. Sacramento County has been growing at a rate of about 1.0 percent a year with net migration accounting for more than 40 percent of this growth. That growth rate is anticipated to continue in the near term but with net migration accounting for almost half of the growth (^California Economic Forecast 2017). Placer County's population grew in the 2011 to 2016 period by 1.1 percent, mostly from net migration. The population in Yolo County grew 1.3 percent in the same period. Population growth in both Placer and Yolo Counties is expected to increase in the near term, with almost 90 percent of that growth coming from net migration (^California Economic Forecast 2017).

In contrast to the growing urban areas surrounding Sacramento, 7 (Lake, Lassen, Modoc, Nevada, Plumas, Sierra, Siskiyou) of the 20 counties in the Sacramento River watershed have been identified in the California Economic Forecast report as "vulnerable counties," meaning population growth rates have been minimal or negative, and other associated economic indicators (e.g., job growth, income growth) are also weak (^California Economic Forecast 2017).

The Delta eastside tributaries region contains population areas of Lodi, eastern Stockton, southern El Dorado and Sacramento Counties, as well as the sparsely populated Sierra Nevada foothills of Alpine, Amador, and Calaveras Counties. The region's growth was very slow (at 1.6 percent) from 2010 to 2015, and the foothill counties were identified as "vulnerable" (^California Economic Forecast 2017). However, future rapid growth is anticipated in this region as a whole, led by San Joaquin County as one of the fastest growing counties in the state (^California Economic Forecast 2017).

The Delta region includes five counties, including most of Stockton, south and west Sacramento suburbs, and east Contra Costa County communities. Past growth has been highest of the three regions, and mirrors that of the state. However, future population growth is anticipated to be at a much higher rate than for the state, as driven by in-migration and demand for low cost housing in suburban areas characteristic of the region (^California Economic Forecast 2017).

8.2.8.2 Socioeconomic Profile

Employment and Income

As shown in Table 8.2-14, based on information from IMPLAN (^2017), total employment in the Sacramento/Delta watershed in 2015 was approximately 2.1 million jobs, and annual payroll (employee compensation) associated with these jobs was approximately $104 billion. Among selected industry sector groups that have a relatively high proportion of water use, employment is about 172,000, and payroll approximately $9 billion. A complete table of all sectors is presented in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

Table 8.2-14. Sacramento/Delta Watershed Employment and Annual Payroll for Selected Sectors, 2015

Sector Group	Employment (jobs)	Annual Payroll $ (thousands)
Agriculture	48,643	1,000,485
Other natural resources	31,164	997,133
Utilities	9,014	1,385,435
Food manufacturing and processing	17,353	974,138
Other nondurables manufacturing	19,069	1,134,190
Durables manufacturing	46,642	3,547,713
Subtotal	171,886	9,039,095
Total – all sectors	2,071,898	103,894,066

Source: ^IMPLAN 2017.

Based on data from IMPLAN presented in Appendix A4, the government and miscellaneous category is the largest employer and has the highest payroll. Nearly 367,000 persons are employed in government (federal, state, and local), and payroll is nearly $36 billion annually. Health and educational services is second in terms of employment at nearly 275,000 persons, with a payroll of over $14 billion. Retail trade; finance, insurance, and real estate; and professional services round out the top five employment sectors in terms of the number of jobs. However, professional services and finance, insurance, and real estate have the third and fourth largest payroll, respectively.

Industries

Table 8.2-15 shows a breakout by specific kinds of manufacturing activity.

Table 8.2-15. Employment and Payroll for Selected Manufacturing Sectors in the Sacramento/Delta, 2015

Manufacturing Sector	Employment (jobs)	Share (%) of Manufacturing Employment	Share (%) of Manufacturing Payroll
Food manufacturing and processing	17,353	21	17
Wood product manufacturing	8,222	10	7
Fabricated metal product manufacturing	8,131	10	8
Computer and electronic product manufacturing	6,991	8	20
Beverage product manufacturing	6,398	8	6
Nonmetallic mineral product manufacturing	5,117	6	6
Transportation equipment manufacturing	4,300	5	7

Source: ^IMPLAN 2017.

As shown in Table 8.2-15, food manufacturing and processing is the largest employer group among manufacturing sectors. Bread and bakery products, fruit and vegetable canning, roasted nut manufacturing, and rice milling are the most significant components of the food manufacturing and processing sector.

Fabricated metal product manufacturing is a highly diversified sector which includes machine shops, sheet metal work, and fabricated structural metal manufacturing. Computer and electronics jobs, while contributing less of the overall share of manufacturing jobs, pay more than other kinds of manufacturing employment.

8.2.9 San Francisco Bay Area Regional Profile

8.2.9.1 Population

Population in Bay Area counties in 2016 was approximately 7.0 million persons, or 17.8 percent of the state's population. The Bay Area has experienced a higher-than-statewide growth rate in recent years that is expected to continue in the future. The above-average growth has been attributed in part to high levels of net migration. In Santa Clara County, which includes Silicon Valley, 40 percent of the population growth between 2011 and 2016 was attributed to migration for employment opportunities in this area. In Alameda and Contra Costa Counties, the second and third largest counties in the group, over half the population growth in this period was attributed to net migration. Some of the net migration in both locations was from people leaving higher priced housing markets and some was from people moving into the area for its strong job market. In the near future, employment growth, although still strong relative to other regions, is expected to be more moderate in this area than in the recent past (^California Economic Forecast 2017).

Between 2011 and 2016, the population in San Francisco County grew 1.2 percent per year, mostly from net migration with people moving into the area for high paying jobs, but this growth rate is expected to slow in the near term. The population in San Mateo Country grew at a similar rate, but is also expected to grow at a slower rate in the near term (^California Economic Forecast, 2017).

Sonoma, Solano, Marin, and Napa Counties all grew at less than 1.0 percent per year during the 2011 to 2016 period with migration contributing a significant share of this growth. Growth rates in these counties will continue to be moderate in the near term with migration contributing 60 percent or more of this growth (^California Economic Forecast, 2017).

8.2.9.2 Socioeconomic Profile

Employment and Income

Table 8.2-16 shows total employment and payroll in the Bay Area based on information from IMPLAN (^2017), as well as employment and payroll for industry sector groups that have a relatively high proportion of water use. A complete table of all sectors is presented in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

Table 8.2-16. San Francisco Bay Area Employment and Annual Payroll for Selected Sectors, 2015

Sector	Employment (jobs)	Annual Payroll $ (thousands)
Agriculture	19,454	479,049
Other natural resources	19,054	639,728
Utilities	16,064	2,927,093
Food manufacturing and processing	33,918	1,858,208
Other nondurables manufacturing	82,316	10,209,024
Durables manufacturing	244,246	39,760,697
Subtotal	415,051	55,873,799
Total for San Francisco Bay Area—all sectors	5,169,137	418,074,532

Source: ^IMPLAN 2017.

Based on the data presented in Appendix A4, in terms of employment, professional services is the largest category and also has the highest payroll. More than 841,000 persons are employed in the category, and payroll is nearly $102 billion annually. Health and educational services is second in employment at 670,000 persons, with a payroll of nearly $40 billion. Government is fourth in employment at 467,000 persons but is second in payroll at $49 billion. Finance, insurance, and real estate; and retail trade round out the top five employment sectors.

Industries

Table 8.2-17 shows a breakout by specific kinds of manufacturing activity.

The manufacturing sector in Bay Area counties is dominated by the computer and electronic manufacturing sector. Of the 132,060 jobs in that sector, about a third are in electronic computer manufacturing and about a quarter are in semiconductor manufacturing.

Food manufacturing and processing is in a distant second place relative to the computer sector in employment. Within the third largest sector, beverage product manufacturing, 85 percent of jobs are associated with wineries. Chemical manufacturing is largely associated with pharmaceutical preparation manufacturing. Automobile and truck manufacturing and guided missile and space vehicle manufacturing contribute the most jobs within fabricated product manufacturing. Within machinery manufacturing, more than 40 percent of the jobs are associated with manufacturing semiconductor machinery.

Table 8.2-17. Employment and Payroll for Selected Manufacturing Sectors in the San Francisco Bay Area, 2015

Manufacturing Sector	Employment (jobs)	Share (%) of Manufacturing Employment	Share (%) of Manufacturing Payroll
Computer and electronic product manufacturing	132,060	37	55
Food manufacturing and processing	33,918	9	4
Beverage product manufacturing	25,488	7	4
Chemical manufacturing	24,829	7	11
Fabricated product manufacturing	23,962	7	3
Machinery manufacturing	21,349	6	6

Source: ^IMPLAN 2017.

8.2.10 San Joaquin Valley Regional Profile

8.2.10.1 Population

According to the U.S. Census, the population in the San Joaquin Valley in 2016 was approximately 3.6 million persons, or 9.3 percent of the state's population. Although population growth within the San Joaquin Valley has been slightly lower than the state overall in recent years, future growth is expected to be considerably faster than the state as a whole.

In recent years most of the population growth in this region has been from natural increases (births). Fresno County, the largest county in this group, had a low rate of net migration between 2011 and 2016. While the populations of Kern, Madera, Merced, and Tulare Counties grew in this same time period, all four had negative net migration. Kings County lost population during the 2011–2016 period due to out-migration. In contrast, Stanislaus County grew both from natural increase (births) but also from net migration of more than 1,600 people each year during this period (^California Economic Forecast 2017).

Mariposa and Tuolumne counties are both considered to be "vulnerable:" population growth rates have been minimal or negative, and other associated economic indicators (e.g., job growth, income growth) are also weak (^California Economic Forecast 2017).

In the near future, population growth in Kings, Madera, Merced, and Tulare Counties is expected to increase and net migration is expected to be close to zero or positive. Population growth in Fresno, Kern, and Stanislaus Counties is expected to continue with growth rates and migration patterns similar to recent years.

8.2.10.2 Socioeconomic Profile

Employment and Income

Table 8.2-18 shows total employment and payroll in the San Joaquin Valley region based on information from IMPLAN (^2017), as well as employment and payroll for industry sector groups that have a relatively high proportion of water use. A complete table of all sectors is presented in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

Table 8.2-18. San Joaquin Valley Employment and Payroll for Selected Sectors, 2015

Sector	Employment (jobs)	Annual Payroll $ (thousands)
Agriculture	99,883	3,049,025
Other natural resources	143,810	5,912,928
Utilities	5,527	863,603
Food manufacturing and processing	51,377	2,834,755
Other nondurables manufacturing	20,267	1,573,142
Durables manufacturing	29,032	1,828,287
Subtotal	349,898	16,061,740
Total for San Joaquin Valley –all sectors	1,589,728	70,779,186

Source: ^IMPLAN 2017.

Based on information presented in Appendix A4, government is the largest category in terms of employment (245,000 jobs) and has the highest payroll ($20 billion). Health and educational services is the second largest category in terms of employment at more than 190,000 jobs, with a payroll of $9 billion. Retail trade and other natural resources are third and fourth largest categories in terms of employment at more than 140,000 jobs each; “other natural resources” includes support services for agriculture, including migrant farm labor.

Industries

Based on information from IMPLAN (^2017), there are about 101,000 manufacturing jobs (including food processing) in the San Joaquin Valley region, generating about $6 billion in payroll. Manufacturing sectors represent a little over 6 percent of total employment in this area but 9 percent of the payroll. Table 8.2-19 shows a breakout by specific kinds of manufacturing activity.

Table 8.2-19 shows that the manufacturing sector in the San Joaquin Valley is dominated by the food processing industry. The three biggest segments of that industry in this area are poultry processing, canned fruits and vegetables, and cheese manufacturing, which together account for over 40 percent of the jobs. Wineries account for about three-quarters of the jobs in the beverage sector. Within the machinery manufacturing sector, over a third of the jobs are associated with making farm machinery.

Table 8.2-19. Employment and Payroll for Selected Manufacturing Sectors in the San Joaquin Valley, 2015

Manufacturing Sector	Employment (jobs)	Share (%) of Manufacturing Employment	Share (%) of Manufacturing Payroll
Food manufacturing and processing	51,377	51	45
Fabricated metal product manufacturing	7,061	7	7
Beverage product manufacturing	6,943	7	10
Machine manufacturing	6,604	7	7

Source: ^IMPLAN 2017.

8.2.11 Central Coast Regional Profile

8.2.11.1 Population

The population in the Central Coast in 2016 was approximately 1.5 million persons, or just 3.8 percent of the state's population. In recent years, the population in the Central Coast has grown at a slightly lower rate compared to the state overall, and this trend is expected to continue in the future. The population in Santa Barbara County grew about 1.1 percent per year in the 2011 to 2016 period with a positive migration rate of 1,900 people per year (^California Economic Forecast 2017). The population in Monterey County grew by about 1.0 percent per year between 2011 and 2016; most of this growth was from new births. The population in Santa Cruz County grew at an average annual rate of 0.8 percent between 2011 and 2016, with high levels of in-migration. The population in San Luis Obispo County was 0.6 percent in recent years. Population growth in San Benito County in recent years was primarily due to natural growth (new births) (^California Economic Forecast 2017).

8.2.11.2 Socioeconomic Profile

Employment and Income

Table 8.2-20 shows total employment and payroll in the Central Coast region based on information from IMPLAN (^2017), as well as employment and payroll for industry sector groups that have a relatively high proportion of water use. A complete table of all sectors is presented in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

Table 8.2-20. Central Coast Employment and Annual Payroll for Selected Sectors, 2015

Sector	Employment (jobs)	Annual Payroll $ (thousands)
Agriculture	46,416	1,388,642
Other natural resources	54,094	2,399,252
Utilities	2,632	487,450
Food manufacturing and processing	7,851	304,640
Other nondurables manufacturing	12,034	677,095
Durables manufacturing	19,894	1,610,592
Subtotal	142,922	6,867,671
Total for Central Coast – all sectors	868,440	39,450,403

Source: ^IMPLAN 2017.

Government is the largest employment category (119,000 jobs) and at $11 billion also has the highest payroll. Health and educational services is second largest employment category at 97,000 jobs, with a payroll of nearly $5 billion. Accommodations and food services; retail trade; and professional services round out the top five employment sectors. However, professional services, retail trade, and "other natural resources" (mostly wineries) round out the top five payroll sectors.

Industries

Table 8.2-21 shows a breakout by specific kinds of manufacturing activity based on information from IMPLAN (^2017).

Although the food manufacturing and processing sector is largest employment category in the Central Coast region, the beverage product manufacturing sector (the second largest employment category) has the largest individual employment sector: wineries. The third largest sector, computer, and electronic product manufacturing, primarily includes search, detection, and navigation instruments manufacturing; manufacturing of laboratory equipment; and semiconductor fabrication.

The economic importance of the transportation industry in the Central Coast is largely due to aircraft manufacturing, airplane parts manufacturing, and manufacturing associated with the defense and space industries.

Table 8.2-21. Employment and Payroll for Selected Manufacturing Sectors in the Central Coast, 2015

Manufacturing Sector	Employment (jobs)	Share (%) of Manufacturing Employment	Share (%) of Manufacturing Payroll
Food manufacturing and processing	7,851	20	12
Beverage product manufacturing	5,627	14	11
Computer and electronic product manufacturing	5,359	13	25
Fabricated metal product manufacturing	3,369	8	7
Chemical manufacturing	2,636	7	8
Transportation equipment manufacturing	2,356	6	8

Source: ^IMPLAN 2017.

8.2.12 Southern California Regional Profile

8.2.12.1 Population

Southern California is the most populous region in California. Counties in the Southern California region had approximately 22.2 million persons in 2016, or 56.6 percent of the state's population. While California's population grew by 5.5 percent from 2010 to July 2016, the population in Southern California grew at a slightly slower rate of 5.0 percent over the same time period.

The population in Los Angeles County, the most populous county in this region, grew primarily from natural increase (births) during the 2011 to 2016 period. Net migration was negative. In the near term, the population in Los Angeles County is expected to grow at a slightly slower pace than recent years, with births rather than migration being the driver of this growth (^California Economic Forecast 2017).

The population in San Diego County, the second most populous county in this region, grew at a faster rate than Los Angeles County in the 2011 to 2016 period but with net migration primarily contributing that growth. San Diego County is projected to increase employment in the near term, but population growth is expected to slow slightly with a reduction in migration (^California Economic Forecast 2017).

The population in Orange County, the third most populous county in this region, grew by 0.9 percent per year between 2011 and 2016, much of it driven by net migration. Net migration rates are expected to decrease from recent levels and population growth is also expected to moderate (^California Economic Forecast 2017).

The population in Riverside County grew at a faster rate than the three largest counties (Los Angeles, San Diego, and Orange Counties) in recent years, and the county's population growth is expected to continue at this pace in the near term. Net migration was significant in recent years and is expected to remain high in the near future, with net migration contributing almost half of the population growth (^California Economic Forecast 2017).

San Bernardino County's population grew at 0.8 percent in recent years, with the growth attributed to natural increase (births). The county's population is expected to grow slightly faster in the near term, with low but positive migration.

Ventura County population growth was slower than any of the larger counties and growth attributed to natural increase (births). It is expected that slow population growth and negative migration will continue in the near term.

Imperial, Inyo, and Mono are the three least-populated counties in the Southern California region. Each had low average annual growth rate (1.0 percent or less) in the 2011 to 2016 period, with net migration that was negative or near zero. In the near-term future, some modest growth is anticipated with some reversal in migration patterns (^California Economic Forecast 2017).

8.2.12.2 Socioeconomic Profile

Employment and Income

Table 8.2-22 shows total employment and payroll in the Southern California region based on information from IMPLAN (^2017), as well as employment and payroll for industry sector groups that have a relatively high proportion of water use, which account for about 16 percent of the region's total payroll based on information from IMPLAN (^2017). A complete table of all sectors is presented in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

Based on information presented in Appendix A4, in terms of employment, health and educational services is the largest category with 1.663 million jobs and a payroll of $76 billion. However, government is the second largest category in terms of employment (1.394 million jobs) but has the highest payroll in the region ($131 billion). Professional services (1.382 million jobs) is the third largest category in terms of employment. Finance, insurance, and real estate; and retail trade round out the top five employment sectors (Appendix A4).

Table 8.2-22. Southern California Employment and Annual Payroll for Selected Sectors, 2015

Sector	Employment (jobs)	Annual Payroll $ (thousands)
Agriculture	50,884	1,340,043
Other natural resources	60,349	2,5213,286
Utilities	43,059	6,903,213
Food manufacturing and processing	77,299	4,68,965
Other nondurables manufacturing	221,229	15,268,294
Durables manufacturing	488,411	43,148,567
Subtotal	941,233	73,342,369
Total for Southern California – all sectors	12,791,403	679,330,285

Source: ^IMPLAN 2017.

Industries

Based on information from IMPLAN (^2017), there are nearly 787,000 manufacturing jobs in the Southern California region, generating about $63 billion in payroll. Manufacturing sectors represent a little over 6 percent of total employment in Southern California but 9 percent of the payroll in the region. Table 8.2-23 shows a breakout by specific kinds of manufacturing activity.

Table 8.2-23. Employment and Payroll for Selected Manufacturing Sectors in Southern California, 2015

Manufacturing Sector	Employment (jobs)	Share (%) of Manufacturing Employment	Share (%) of Manufacturing Payroll
Computer and electronic product manufacturing	97,423	12	19
Fabricated metal product manufacturing	96,494	12	10
Transportation equipment manufacturing	91,860	12	16
Food product manufacturing and processing	77,299	10	7
Textiles and apparel manufacturing	67,568	9	5
Machinery manufacturing	44,058	6	6
Chemical manufacturing	43,068	5	8
Printing and related services	97,423	12	19
Plastics and rubber product manufacturing	96,494	12	10

Source: ^IMPLAN 2017.

Computer and electronic product manufacturing is the largest of the manufacturing sectors in this area. With respect to jobs, search, detection, and navigation instruments manufacturing and semiconductors are the two largest categories in this manufacturing group.

The economic importance of the transportation industry in this region is largely due to jobs in aircraft manufacturing, airplane parts manufacturing, and manufacturing associated with the defense and space industries.

In the food manufacturing sector, more than a third of the jobs are in bakery and bread products manufacturing. Canned and frozen fruit and vegetable processing and dairy and meat processing are also important parts of this segment.

8.3 Costs Associated with Other Water Management Actions

In response to reduced Sacramento/Delta surface water supplies, water users may choose to modify their water supply portfolios by increasing the use of other sources of water and maximizing the use of existing water supplies. These other water management actions include groundwater storage and recovery, water transfers, water recycling, and water conservation. A description of these other water management actions, including state-wide trends and regional observations, is provided in Section 6.6, *Other Water Management Actions*.

This section describes the potential costs for implementation and operation and maintenance of other water management actions. This cost information informs the analysis of the estimated economic costs to replace reduced Sacramento/Delta supply for agricultural regions that are not analyzed by the SWAP model, and the economic costs to affected municipal and industrial suppliers to secure reliable water supplies. Costs for construction of new and modified facilities are discussed below in Section 8.8, *Costs Associated with New or Modified Facilities*.

8.3.1 Groundwater Use

Section 2.8, *Existing Water Supply*, provides information on estimated average annual groundwater supply by geographic region and section. The information presented in Section 2.8 shows that groundwater use provides a substantial portion of the total water supply used in the study area. However, the water supply summaries presented in Section 2.8 demonstrate regional differences in water supply portfolios. Some regions, such as the Central Coast, depend primarily on groundwater, while other regions, such as the Bay Area, depend primarily on surface water supplies.

Groundwater pumping costs can vary depending upon the condition and size of the aquifer, the depth of the wells, pumping yield, and pump size. Recent studies indicate groundwater pumping operations and maintenance costs can vary from approximately $100 to $1,000 per AF, but are typically less than $200 per AF (McCann et al. 2018; Perrone and Rhode 2016). A study in Los Angeles County of the full cost of pumping, treatment, conveyance, and delivery found an estimated total cost to be $739 per AF (Porse et al. 2018, Table 3, p. 293). The cost of drilling a new municipal well can vary considerably, with costs dependent upon size, well depth, pumping yield, and attendant infrastructure for storing pumped water. The analysis of municipal water supply options (see Section 8.5, *Municipal Water Supply Economic Effects*) includes a range of groundwater pumping costs that generally reflect regional differences, based upon representative costs derived from M&I modeling conducted for Reclamation (Reclamation 2013).

8.3.2 Groundwater Storage and Recovery

Groundwater storage and recovery (also known as *managed groundwater recharge* or *groundwater banking*) involves storage of water for later recovery by intentionally recharging groundwater basins when excess surface water or other water sources are available, for example, during years of above-average surface water supply or through storing recycled water or stormwater in groundwater basins for future use. Groundwater storage and recovery is also part of conjunctive management or use that involves coordinated management of surface water and groundwater resources to maximize the availability and reliability of water supplies in a region.

Several groundwater storage and recovery approaches are used to actively recharge groundwater basins, such as stormwater capture. This approach is used in certain urban areas. Under this approach, stormwater is collected and conveyed to detention and spreading basins in recharge areas for later withdrawal and use. Costs are generally incurred to capture and store stormwater, as well as to extract that water from the aquifer and treat it to drinking water standards. Total cost of a stormwater capture system can vary based on required well depth and the quality of receiving water that must be treated. Recent estimates for a larger scale (over 6,000 AF) system are approximately $590 per AF (Cooley and Phurisamban 2016, p. 9; Cooley et al. 2019, p. 5), with estimates ranging from $500 to $1,500 per AF depending on scale (McCann et al. 2018). A separate study of groundwater recharge projects found a cost range of $90 to $1,100 per AF for most projects, with a median cost of $390 per AF (in 2014 dollars) (Choy et al. 2014). A recent study focused on stormwater capture found the median cost of urban projects to be $1,180 per AF (Diringer et al. 2020, Table 2, p. 9).

Excess surface water deliveries in years of abundance can also be used in groundwater banking. For example, a number of CVP and SWP contractors have entered into long-term agreements with the operators of the Kern Water Bank. As discussed in Section 6.6, *Other Water Management Actions*, many water agencies are actively evaluating groundwater storage expansion options, including groundwater banking; agencies include the Semitropic Water Storage District, Sacramento and San Joaquin Counties, Orange County Water District, and Eastern Municipal Water District.

Agricultural lands can also function as recharge systems with controlled floodwater-based replenishment. Fallowed or idled agricultural lands can serve as outlets and spreading areas for floodwaters that percolates to the shallow aquifer, from which it can be pumped and used during the irrigation season. These activities can help to maintain groundwater levels, which can reduce groundwater pumping costs.

8.3.3 Water Transfers

Water transfers, which include exchanges and purchases of water, are an important component of water resource management in California. The extensive network of water conveyance infrastructure developed through state, federal, and locally funded projects, most notably the CVP and SWP, is used to facilitate water transfers. Water can be transferred from a seller to a buyer through networks of rivers, canals, aqueducts, and pipelines. Although the SWP and CVP are the most extensive storage and conveyance projects involved in transfers, many major local and regional water suppliers are involved in transfers, especially in-basin transfers.

Section 6.6, *Other Water Management Actions*, provides information on both temporary and permanent transfers that have occurred in recent decades. Information from the Public Policy Institute of California (PPIC) on both temporary and permanent transfers shows that water transfer volumes have grown in California in recent decades.

The market price for transferred water can vary widely and is affected by available seller supply and buyer need, supply reliability, transaction volume, duration of lease, location of both seller and buyer, and available transport infrastructure. (WestWater Research, unpublished data.)A buyer's end use is a key determinant of purchase price. Municipal purchasers generally pay higher prices to acquire water than other users. Refuge and agricultural buyers have generally acquired water at the lowest cost. However, during the severe drought in 2014–2015, agricultural buyers paid a premium above municipal buyers to prevent the loss of established tree crops. (WestWater Research, unpublished data.)

An analysis of transactions demonstrates some regional differences in terms of observed market prices. In the Sacramento River watershed, historical prices (dating to 2007) averaged around $100/AF, but were over $500/AF in 2014 and 2015. In contrast, water prices for users south of the Delta were observed to be higher than prices observed within the Sacramento Valley. From 2007 through 2013, average prices ranged between $150/AF and $250/AF but were generally higher during drier years. For example, in 2014, prices rose to an average of $779/AF. In the Southern California region, average prices generally ranged between $200/AF and $300/AF, with fluctuations in years with single-year transfers. (WestWater Research, unpublished data.)

Forecasting future water prices is complex, requiring knowledge and information regarding supply alternatives, future demand and market conditions, and behavior of willing sellers and buyers in response to market prices. The analyses in this chapter assume that there could be greater demand pressure in the water transfer market such that future prices may be higher than recent historical trends. For the purposes of the municipal water supply economic effects analysis presented in Section 8.5, future transfer prices are assumed to be $500 per AF for transfers to the Bay Area, $500 per AF for transfers to the Central Coast, $500 per AF for transactions to and within the San Joaquin Valley region, and $750 per AF for transfers to the Southern California region.

8.3.4 Water Recycling

Recycled water use can be used in water scarce areas of the state to supplement or replace existing water supplies. The state has been active in developing legislation, adopting resolutions and policies, setting goals for recycled water use, and funding recycled water projects.

Recycled water is primarily municipal wastewater that has been treated in a wastewater facility and complies with existing water regulations for a specific beneficial use. It is generated by treating domestic wastewater to make the water suitable for a direct beneficial use that would not otherwise occur. There are different required levels of treatment corresponding to the proposed use of the recycled water. Use of recycled water is part of the state's larger strategy to develop more resilient water supplies and increase regional self-reliance. Recycled water use can help reduce local water scarcity and can be a cost-effective solution for bringing supply and demand into a better balance. The California Legislature has expressed its intent that the state undertake all possible steps to encourage development of water recycling facilities so that recycled water may be made available to help meet the state's growing water needs. (Wat. Code, § 13512.)

Recycled water is used for both potable and non-potable (e.g., landscape and agricultural irrigation) uses. Non-potable recycling ranges in cost from $1,500 to $2,100 per AF, according to a recent study (Cooley and Phurisamban 2016, p. 12). Approximately $950 per AF of this cost is associated with the installation of "purple pipe" systems to distribute the water. For this reason, expanding an existing reuse facility may result in a somewhat lower facility cost but only a modest savings overall if additional pipeline is needed. A large-scale indirect potable reuse project (more than 10,000 AF/yr) is similar in cost at $1,600 to $2,000 per AF, and a smaller-scale project can average about $2,300 per AF (Cooley and Phurisamban 2016, p. 12). Although the treatment cost is higher for an indirect potable facility, the distribution pipeline cost is much less since a separate conveyance system is not required. A study in Los Angeles County estimated the total cost of a full indirect potable reuse system to range from $1,551 to $2,641 per AF. This includes sewage collection, disinfection, and tertiary treatment; conveyance; spreading and infiltration; pumping; treatment; and delivery (Porse et al. 2018, Table 3, p. 293).

8.3.5 Desalination

Desalination is the removal of salts from saline waters to produce water suitable for human consumption or irrigation. Existing facilities in California desalinate sea water for coastal communities and brackish groundwater for inland water users, many of which have provided high-quality water to their customers for more than 10 years. While construction and operational costs for desalination remain high in comparison with other water supplies, technologies have improved over time and are becoming more cost-effective (especially in regions with access to brackish water), leading some communities (especially in the Central Coast) to reconsider previously deferred desalination plants.

In California, desalinated water is not a common drinking water supply by volume. For many geographic areas within the state, desalination is impractical because of a lack of suitable saline source water and is not economically feasible because more cost-effective water supply alternatives are available. However, desalination technologies continue to improve; they are becoming more cost effective and are being used in the Central Coast and Southern California regions. Seawater desalination, with a median cost of $2,100 per AF for large projects and $2,800 per AF for smaller projects, is currently among the most expensive water supply options. Brackish water desalination is much less expensive, at median prices of $1,100 to $1,600 per AF, due to lower energy and treatment costs (Cooley and Phurisamban 2016, p. 14). Desalinated water requires three to ten times more energy than recycled water (Reinhart 2023).

8.3.6 Water Conservation and Water Efficiency Measures

Water conservation is often considered the fastest, easiest, and most cost-effective way to extend existing supplies. Through voluntary and required actions, water users statewide have made significant investments to manage demand through improved water use efficiency and water conservation measures. The degree to which water conservation and efficiency are established in a particular region can reduce the environmental impacts and economic effects from reduced Sacramento/Delta supply. The subsections below discuss agricultural and municipal water conservation in more detail.

8.3.6.1 Agricultural Demand Management Measures

Agricultural water use efficiency is often expressed as "net water savings," or the reduction of irrecoverable flows, rather than applied water reductions. Applied water is often reused multiple times on the same farm or in the same region. Reuse of applied water is the main reason why the quantity of saved water in the agricultural setting is much smaller than in the urban setting. Often, increased water use efficiency, along with other management practices, allow for an increase in crop yield without increasing the amount of irrigation water. For the same amount of water used, an increase in crop yield translates into increased water productivity. Management practices to improve agricultural water use efficiency can include advances in irrigation technology, fertilizer technology, crop selection, and genetically modified crop development.

Multiple existing and historical financial assistance program could be leveraged to support agricultural water conservation efforts. Examples of public financing include grant funds; single purpose appropriations from federal, state, and/or local legislative bodies; and bond indebtedness and loans from government institutions.

Traditionally when agricultural water conservation is implemented, saved water has remained in control of the growers by increasing yields on the same crops, exchanging to more profitable but higher water-using crops, spreading to other irrigated lands (even if not to expanding the irrigated footprint, which is usually prohibited when farmers use public cost-share funds), or reducing use of supplemental groundwater later in the season. In some circumstances, saved water may be used in long-term or permanent water transfers.

The strategy to improve agricultural efficiency focuses on improvements in technology and management of water at different scales—on farms, at the irrigation district level, and on a regional scale. The following agricultural conservation measures may be implemented.

- Measures implemented by irrigators (i.e., farmers), such as installations of drip or low flow sprinklers.

- Measures implemented by irrigation districts to improve efficiencies of water conveyance, such as lining open canals or adding pipelines.
- Measures implemented at a regional level, such as re-use of agricultural drainage water.

The cost of agricultural water conservation measures vary by scale and scope, but typically are implemented on a multi-farm, irrigation district, or regional basis, and funded through a combination of government (federal and/or state) funds and local contributions. The conserved water is retained by the water users for supply enhancement, unless there is an explicit transfer mechanism specified (for example, the IID-MWD project discussed previously). The following projects are examples of projects related to on-farm irrigation efficiency, improved water transport, and agricultural water re-use, and their associated costs.

- **Los Angeles—Ventura County: Agricultural Water Use Efficiency Program**. A project implemented by Ventura County to analyze and implement irrigation system improvements for increased agricultural efficiencies. Cost: $1.7 million. Nearly 100 percent of the funding from Proposition 84, Integrated Regional Management funds (CNRA 2017a).
- **Upper Pit River Watershed: Ash Valley Ranch**. Irrigation infrastructure project intended to improve efficiency of water conveyance on a cattle ranch, includes piping of an open irrigation ditch and upgrades to two pumps. Cost: $471,251, with 75 percent paid by Proposition 84 and 25 percent by local contributions. The project qualified under disadvantaged community (DAC) assistance (CNRA 2017b).
- **Upper Pit River Watershed: South Fork Irrigation District**. Project includes installation of new piping and open conveyance to upgrade the irrigation water distribution system. Cost: $272,225, with 79 percent paid by Proposition 84 and 21 percent paid by local contributions. The project qualified under DAC assistance (CNRA 2017c).
- **Westside—San Joaquin: Reuse of Agricultural Water**. A project pursued by the San Luis and Delta Mendota Water Agency to upgrade the irrigation distribution system in order to reclaim and recirculate 5,000 AF/yr of agricultural drainage water and replace intertie pumps to increase capacity. Cost: $3.6 million, with 42 percent federal contribution, 41 percent local contribution, and 17 percent from Proposition 84. The project qualified under DAC assistance (CNRA 2017d).

8.3.6.2 Municipal Demand Management Measures

A variety of factors affect residential per capita water use, including climate characteristics, population growth, population density, socioeconomic measures such as income level and lot size, and water prices (SWRCB 2015). However, a comparison of per capita use across hydrologic regions in California demonstrates that water use varies widely by location without influencing that area’s potential for growth. Table 8.3-1 compares August water use by DWR hydrologic region from 2013 through 2017. For example, comparisons between the Tulare Lake and San Joaquin River hydrologic regions, which have similar climates, show a difference of 17 to 40 GPCD each year; comparisons between the San Joaquin River and Colorado River hydrologic regions show a difference of approximately 50 GPCD each year.

Table 8.3-1. Residential Daily Use by DWR Hydrologic Region during August (GPCD), 2013–2017

DWR Hydrologic Region	2013	2014	2015	2016	2017
Central Coast	107.3	90.6	76.4	80.2	84.5
Colorado River	243.4	222.1	171.8	195.9	201.7
North Coast	87.3	81.9	75.7	81.6	77.2
North Lahontan	160.9	131.2	117.7	144.0	137.8
Sacramento River	214.8	176.3	147.3	179.9	187.5
San Francisco Bay	103.2	90.7	72.3	82.0	87.6
San Joaquin River	180.7	171.3	131.5	149.5	154.1
South Coast	123.2	112.3	94.8	103.4	105.2
South Lahontan	190.4	178.6	148.3	147.4	149.1
Tulare Lake	224.1	188.9	164.0	187.6	194.3
Statewide R-GPCD	137.7	122.7	102.2	113.8	117.3

Source: SWRCB Fact Sheet, "August 2017 Statewide Conservation Data."
DWR = California Department of Water Resources; GPCD = gallons per capita per day; R-GPCD = residential gallons per capita per day

The costs of water conservation can vary considerably by user (e.g., residential, commercial, or municipal) and the measures implemented. Nonetheless, a recent study found that urban water conservation and efficiency are the most cost-effective ways to meet current and future water needs, as compared to developing alternative water supplies. In fact, many measures have a negative cost: they save the customer more money over their lifetime than they cost to implement (Cooley and Phurisamban 2016, p. 19).

Residential water efficiency measures include high-efficiency toilets, showerheads, clothes washers, dishwashers, landscape conversions, and household leak repairs. Non-residential measures apply to commercial, industrial, and institutional facilities. They include similar water use improvements, including high-efficiency toilets, urinals, faucets, and showerheads, but extends to restaurant equipment (e.g., food steamers, ice machines, waterless woks), commercial clothes washers, steam sterilizers, and pre-rinse sprayers. Landscape conversion is also a significant efficiency measure. A recent study contained estimates of cost savings by measure. Residential landscape conversion could result in net cost savings of $2,600 to $4,500 per AF, which occurs from reduced water, fertilizer applications, and other maintenance costs. It also would be the water conservation measure that provides the greatest reduction in water use statewide. Clothes washers ($190 to $760 in cost savings per AF) and toilets ($190 to $630 saved) are the next highest savings measures by volume. Showerhead conversion would save $2,800 to $3,000 per AF (Cooley and Phurisamban 2016, pp. 15–17).

8.4 Agricultural Water Supply Economic Effects

This section analyzes the potential economic effects on California's agricultural economy from changes in water supply under the proposed Plan amendments.

Section 7.4, *Agriculture and Forest Resources,* provides information on existing agricultural use and production. As discussed in Section 7.4, the proposed Plan amendments could result in conversion of farmland as a result of reduced Sacramento/Delta water supplies and lowered groundwater levels, which could affect flexibility for water districts that rely on conjunctive use to manage their supplies.

Most of the irrigated agriculture in the study area is located on the valley floor portion of the Sacramento/Delta and the San Joaquin Valley. For these areas, growers' responses to changes in water supply are estimated using the Statewide Agricultural Production (SWAP) model. The SWAP model is a regional agricultural and economic optimization model, originally developed at the University of California, Davis, that estimates growers' responses to changes in water supply by determining the cropping pattern that maximizes the net returns to agricultural production for 28 production regions: Regions 1 through 9 are in the Sacramento/Delta, and Regions 10 through 21C are in the San Joaquin Valley.

Using the SWAP model, this analysis estimates the direct economic effects of potential changes in water supply on production of irrigated crops with a range of possible outcomes based on assumptions related to availability of groundwater to offset reductions. In addition, this analysis estimates how changes in agricultural production could affect total industry output (sales), income, and employment throughout the regional economy. This occurs as purchases, expenditures, and income are recirculated through the economy as a multiplier effect. The analysis of regional economic effects is primarily conducted using the IMPLAN model (described in more detail below).

Economic effects on agriculture are measured in terms of the change in revenue for agricultural producers. The change to agricultural production and consequent changes in crop revenue and farm income is considered a direct economic effect of potential changes in Sacramento/Delta supply. This serves as a driver for secondary, indirect effects in the regional and state economy that are described in more detail in the sections below.

Potential impacts on irrigated agricultural production in other parts of the study area that are not modeled in SWAP are estimated using the California Sub-Regional Agricultural Analysis (CASRAA) model that emulates the same optimization process that is used in the SWAP model.

8.4.1 Approach to Analysis

This section contains a description of the overall approach to analyzing a representation of the agricultural response to reductions in Sacramento/Delta supply under different flow scenarios. Three primary components are required to provide a reasonable representation of agricultural effects: (1) use of economic modeling to estimate potential response(s) of agricultural producers under baseline conditions and flow scenarios; (2) consideration of a range of replacement groundwater pumping under baseline conditions and flow scenarios; and (3) effects of different water year conditions that farmers typically encounter—average and dry. These components are discussed in detail below.

8.4.1.1 SWAP Model

SWAP is an economic decision model designed to estimate potential effects on cropping patterns and agriculture revenue. It is an economic optimization model that makes the most profitable adjustments to water supply and other changes (Reclamation 2012). The model has been peer reviewed and applied to numerous policy analyses and impact studies over the last two decades (Reclamation 2012; Medellín-Azuara et al. 2016). SWAP is frequently used to estimate changes in California agricultural production due to changes in water resource availability (see Appendix A3, *Agricultural Economic Effects: SWAP Methodology and Modeling Results*). Surface water supply reductions could affect agricultural production primarily by reducing crop production revenue as a result of crop substitution, deficit irrigation, or permanent fallowing of cropland. The potential changes in irrigated cropland and potential effects on agricultural resources are presented in Section 7.4, *Agriculture and Forest Resources*.

The SWAP model estimates the cropping pattern that maximizes the net returns to agricultural production subject to resource constraints, technical production relationships, and market conditions (Reclamation 2012). It incorporates information on the availability of water supplies within a SWAP modeled region, such as SWP and CVP deliveries, local surface water supplies, and groundwater in its analysis. As conditions change within a SWAP modeled region (e.g., the quantity of available SWP and CVP water supply decreases or the cost of groundwater pumping increases), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. SWAP estimates that land will be fallowed when that is the most cost-effective response to changes in resource conditions. Farmers are assumed to face competitive markets in which no single farmer can influence crop prices. This competitive market is simulated by maximizing the sum of consumer and producer surplus subject to production costs, market conditions, and available resources (Reclamation 2012). Constraints can be imposed to simulate restrictions on how much adjustment is possible or how fast an adjustment can realistically occur. Constraints were applied to the SWAP model runs for this analysis and are detailed in Appendix A3, *Agricultural Economic Effects: SWAP Methodology and Modeling Results*.

An optimization model, such as SWAP, can over-adjust and minimize costs associated with detrimental changes or, similarly, maximize benefits associated with positive changes. To account for this possibility, two bookends related to reduced Sacramento/Delta surface water supplies are included: *maximum replacement groundwater pumping*, and *no replacement groundwater pumping*. Under maximum replacement groundwater pumping, it was assumed that growers could use groundwater in addition to local water supplies to offset some or all Sacramento/Delta supply reductions. Importantly, this is not a directive that farmers and ranchers should or would replace Sacramento/Delta reductions with groundwater pumping, especially in light of requirements to achieve sustainability in basins subject to the Sustainable Groundwater Management Act (SGMA), but a good faith attempt to capture the potential maximum impacts on the groundwater basin from replacement pumping. For no replacement groundwater pumping, it was assumed that groundwater would not be available to replace reductions in surface water availability beyond current use under the baseline condition. Similarly, this is not an assumption about groundwater demand management in any particular basin, for example under SGMA, but a good faith attempt to model the potential lower limit of groundwater pumping. In this way, the analysis captures the breadth of likely responses, which would be somewhere in between—meaning that water users likely would increase groundwater pumping to replace some amount of the reduced surface water supplies, but not at volumes sufficient to replace all of the reduced surface water supplies. Additional discussion is provided below. Information regarding the two SWAP bookends are provided below. Additional details are provided in Appendix A3, *Agricultural Economic Effects: SWAP Methodology and Modeling Results*.

- Maximum replacement groundwater pumping: the analysis within each SWAP region assumes maximum substitute pumping. Under maximum replacement groundwater pumping, it is assumed that groundwater would replace Sacramento/Delta surface water supply reductions when economically feasible to do so, and subject to existing groundwater infrastructure limits. Within the Sacramento River watershed and Delta eastside tributaries regions, the annual groundwater pumping limit was set equal to the maximum annual pumping in the SacWAM baseline condition. This maximum typically corresponds to water year 1977, an extreme drought year. For all other SWAP regions (i.e., the San Joaquin Valley), SWAP's default groundwater pumping limits were used.

- No replacement groundwater pumping: the analysis within each SWAP region assumes groundwater is limited to the SWAP estimated pumping levels for average water years under the baseline condition. The model does not allow additional groundwater pumping to replace Sacramento/Delta surface water supply reductions, beyond current use under the baseline condition.

The agricultural production regions modeled in SWAP include the valley floor of the Sacramento/Delta, and the San Joaquin Valley. Figure A3-2 in Appendix A3, *Agricultural Economic Effects: SWAP Methodology and Modeling Results*, depicts the SWAP production region boundaries. The Sacramento/Delta comprise SWAP production regions 1 through 9 while the San Joaquin Valley includes SWAP regions 10 through 21.

SWAP provides a point-in-time comparison between two conditions, which is consistent with the customary approach to conducting economic and environmental impact analysis. SWAP provides information on changes in gross revenues, agricultural production, irrigated acreage, crop mix, and water use, in addition to other parameters. Primary SWAP model outputs include estimated changes in gross and net revenues associated with the flow scenarios.

SWAP accounts for risk and variability in two ways. First, the calibration procedure for SWAP is designed to reproduce an observed crop mix, so to the extent that crop mix incorporates risk spreading and risk aversion, the calibrated SWAP model baseline condition will also incorporate risk spreading and aversion. Second, variability in water delivery, prices, yields, or other parameters, can be evaluated by running the model over a sequence of conditions or over a set of conditions that characterize a distribution, such as a set of water year conditions, as was done in the current analysis by evaluating two water year conditions.

The cost and availability of groundwater has an important effect on how SWAP responds to changes in surface water deliveries. The SWAP model calculates the total costs of groundwater pumping on a SWAP region-basis. Pumping costs are calculated by region and are based on depth to groundwater and power rates. SWAP is not a groundwater model, and, therefore, does not estimate changes in pumping lifts and unit pumping costs resulting from increased pumping at lower aquifer depths. As a result, unit pumping costs for each SWAP region are fixed because depths are not changed and therefore are not varied in the analysis.

The SWAP model is calibrated based upon a 2010 baseline, when DWR land use survey data were most recently available at the geographic scale (Detailed Analysis Units [DAU]) used by the SWAP model. However, cropping patterns have changed over time when compared with the SWAP baseline year of 2010; in particular, there has been an increase in acreage of tree crops, such as almonds, and a reduction in acreage of alfalfa.

The SWAP model allows for some efficiency improvements and deficit irrigation. However, it does not capture the full set of other water management actions that agricultural producers may pursue in response to reduced water supplies, such as groundwater storage and recovery, use of recycled water, and water transfers. This combination of factors is an indicator that the SWAP model results should be considered an indicator of the change in crop acreage and agricultural economic effects that could occur under the proposed Plan amendments and other flow scenarios, but the actual outcome on crop acreage and revenue may vary to some degree from the model results.

The evaluation of agricultural economic effects involves using changes in Sacramento/Delta supply results from SacWAM as inputs to SWAP. Estimates of changes in Sacramento/Delta supply to growers within the Sacramento/Delta are provided by SacWAM in sufficient detail that the output can be directly mapped into the SWAP production regions. SacWAM also provides estimates of the amounts of Sacramento/Delta water exported to the other regions, including the San Joaquin Valley, in larger aggregations based on conveyance facilities. Information from water contracts and water management plans were used to disaggregate these estimates to individual SWP and CVP contractor levels and smaller subareas for analysis purposes. Further details are provided in Appendix A3*, Agricultural Economic Analysis: SWAP Methodology and Modeling Results*. In this way, changes in agricultural water deliveries, the use of water, and the crop acreage and crop mix in the other regions can be analyzed.

This section discusses SWAP model results for baseline and the five unimpaired flow scenarios (35, 45, 55, 65, and 75 percent unimpaired flow). The output that is generated for each of the model runs includes cropping acreage by category of crop, total revenue, net revenue (profit), and amount of irrigation water used by source of supply. The output details are generated for each SWAP zone which, when combined geographically, provide totals for: (1) the Sacramento/Delta watershed; and (2) the San Joaquin Valley region.

8.4.1.2 CASRAA Model

The CASRAA (California Sub-Regional Agricultural Analysis) model is used to estimate agricultural economic effects in the Bay Area, Central Coast, and Southern California regions. This analytical model is a spreadsheet tool that uses an approach similar to that used by the SWAP model to determine cropping patterns and water use. SacWAM results for changes in hydrology under the unimpaired flow scenarios as inputs to the CASRAA model.

Appendix A1a Attachment, *California Subregional Agricultural Analysis*, details how the CASRAA process was implemented in regions outside areas modeled by SWAP to estimate water supply changes to irrigation in due to changes in Sacramento/Delta supply, and effects on crop acreage and crop revenues. The general approach to CASRAA involves four primary components:

1. Estimate change in agricultural surface water supply.
2. Select crops most likely to be affected by the water supply reduction.
3. Estimate reduction in crop acres.
4. Apply University of California Extension Service crop budgets to estimate reduction in gross and net crop revenues.

The CASRAA analysis assumes that growers would not increase groundwater pumping in response to reduced Sacramento/Delta surface water supplies (no replacement groundwater pumping condition), which may overestimate the agricultural economic effects. As discussed above, water users likely would increase groundwater pumping to replace some amount of the reduced surface water diversions, but not at volumes sufficient to replace all the reduced surface water supplies.

This section primarily presents model results for changes in crop revenues under the percent unimpaired flow scenarios. Section 7.4, *Agriculture and Forest Resources,* presents the corresponding change in crop acreage.

8.4.1.3 IMPLAN Model

As explained in more detail below in Section 8.4.3, *Regional Economic Effects*, the regional agricultural economic analysis relies on the IMPLAN Input-Output modeling system. IMPLAN is a widely-used, proprietary data and modeling software system. SWAP model results for crop revenues and expenditures are used as inputs to IMPLAN to analyze regional economic effects for the Sacramento/Delta and statewide.

8.4.1.4 Water Year Types and Flow Scenarios

SWAP model runs were completed for each of the unimpaired flow scenarios (35, 45, 55, 65, and 75 percent unimpaired flow), for average and dry hydrologic conditions. The *average water year* is calculated as the straight average for all water year types. *Dry water years* are represented as the probability weighted average of dry and critical water year types. The change in agricultural production or crop revenue from the baseline condition represents the estimated economic effect associated with each flow scenario.

The SWAP model runs use pre-determined surface water supply input values from SacWAM output. For example, the SWAP 35 scenario includes the surface water deliveries that would occur under the SacWAM 35 percent unimpaired flow scenario, and the agricultural crop acreage and production levels as estimated by the SWAP model.

Tables 8.4-1 and 8.4-2 provide the average and dry year total surface water inputs used in the SWAP modeling of the flow scenarios. The values shown in these tables represent the total surface water supply (imported and local), summed over all the SWAP zones in the Sacramento/Delta and San Joaquin Valley, respectively, that is estimated to be available for irrigation at the field level. For SWAP zones that receive Sacramento/Delta supply, SacWAM results were postprocessed to remove conveyance losses. Appendix A3, *Agricultural Economic Analysis: SWAP Methodology and Modeling Results*, provides more details on the approach used.

Table 8.4-1. Total Surface Water Supply for Agriculture in the SWAP Zones of the Sacramento River Watershed, Delta Eastside Tributaries, and Delta Regions, Average and Dry Water Year Types, SWAP Model Inputs for Baseline and Flow Scenarios (thousand acre-feet per year)

SWAP Water Year Type	Baseline	35	45	55	65	75
Average year	4,858	4,690	4,598	4,389	4,008	3,448
Dry year	4,649	4,289	4,129	3,788	3,403	2,917

Source: Appendix A3, Agricultural Economic Analysis: SWAP Methodology and Modeling Results

Table 8.4-2. Total Surface Water Supply for Agriculture in the SWAP Zones of the San Joaquin Valley Region, Average and Dry Water Year Types, SWAP Model Inputs for Baseline and Flow Scenarios (thousand acre-feet per year)

SWAP Water Year Type	Baseline	35	45	55	65	75
Average year	8,466	8,421	8,302	8,083	7,638	7,267
Dry year	7,596	7,528	7,348	7,061	6,736	6,373

Source: Appendix A3, Agricultural Economic Analysis: SWAP Methodology and Modeling Results

The CASRAA model runs were also completed for each of the unimpaired flow scenarios, for average and dry year hydrologic conditions.

8.4.2 Agricultural Economic Effects

This section provides model results for changes in crop revenue, and discusses associated effects on the economies of various agricultural sectors under each flow scenario (35, 45, 55, 65, and 75 percent unimpaired flow). Discussion is provided for the Sacramento/Delta and other regions in the study area. This section also analyzes economic effects on farming-dependent industries, including food processors, followed by regional economic or distributional effects.

Changes in agricultural production could also result in additional economic effects that affect total industry output (sales), income, and employment. These effects are discussed and evaluated in Section 8.4.3, *Regional Economic Effects*, for the Sacramento/Delta and statewide.

8.4.2.1 Sacramento/Delta

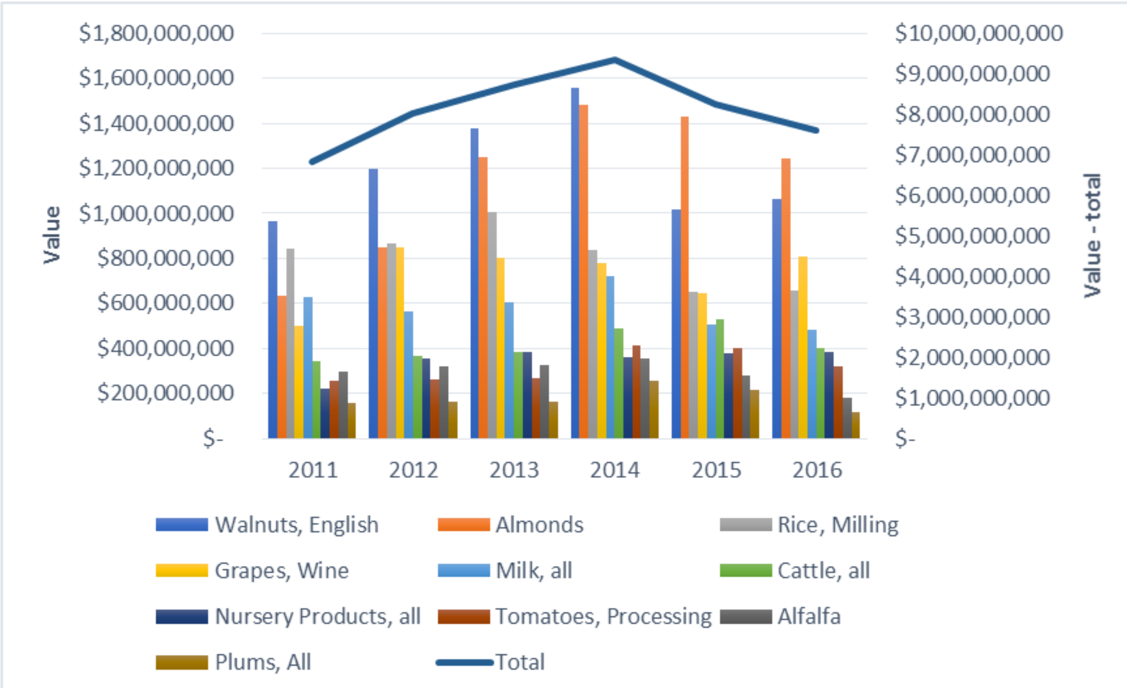
Table 8.4-3 shows the top-producing commodities by revenue. Walnuts, almonds, and rice provided the highest commodity revenue over the period of 2011–2016.

Table 8.4-3. Top-Producing Commodities in the Sacramento/Delta, by Production Revenue, 2011–2016 average

Crop	Revenue
Walnuts, English	$1,196,255,833
Almonds	$1,148,675,000
Rice, Milling	$809,279,500
Grapes, Wine	$731,375,667
Milk, all	$584,721,700
Cattle, all	$419,048,450
Nursery Products, all	$347,175,667
Tomatoes, Processing	$319,649,333
Alfalfa	$293,643,167
Plums, all	$177,956,542
Total—all commodities	**$8,135,031,374**

Sources: CDFA 2011–2016.

Figure 8.4-1 shows the revenue during the 2011–2016 period for the top commodities and all commodities combined. As the figure demonstrates, revenues can vary considerably from year to year due to market conditions.



Sources: CDFA 2011–2016.

Figure 8.4-1. Top-Producing Commodities and Total of All Commodities, Sacramento/Delta, by Revenue (2011–2016)

Crop revenues are the product of crop acres, crop yield, and crop price and represent the revenues that accrue to farming operations from the sale of crops.

Table 8.4-4 presents the modeled total estimated agricultural crop revenues for the baseline and each flow scenario for an average water year, with no replacement groundwater pumping. Figure 8.4-2 presents the corresponding change in revenue by crop category. Table 8.4-5 presents the modeled total estimated agricultural crop revenues for the baseline and each flow scenario for an average water year, with maximum replacement groundwater pumping. The results indicate that crop revenues would generally decrease with increasing flow scenarios. The results also show that a large portion of the reduction in crop revenues is associated with a decline in the production of rice, alfalfa and pasture, and almonds and pistachios. For each of the 35, 45, and 55 scenarios, SWAP predicts that wheat and field crops may experience an increase in crop revenue, a reflection of some crop shifting from higher to lower water-using crops. At higher flow levels in particular, additional effects occur to deciduous orchard growers (including walnuts), processing tomatoes, and corn.

As discussed above, it is uncertain how all water users may respond to reduced Sacramento/Delta supply regarding groundwater pumping. Modeling higher groundwater replacement pumping by farmers and ranchers assumes more water is available for agriculture, which reduces associated effects on crop revenues. The model results presented for the flow scenarios with maximum replacement groundwater pumping show a smaller effect on crop production and revenue because some of the reduced surface water supply would be replaced by groundwater. The model results presented for the flow scenarios with no replacement groundwater pumping show a greater effect on crop production and revenue because the availability of groundwater to replace reduced surface water supply would be limited.

A similar comparison can be made of estimated crop revenues from the baseline and flow scenarios for a dry water year. Table 8.4-6 presents the modeled total estimated agricultural crop revenues for baseline and each flow scenario for a dry water year, with no replacement groundwater pumping. Figure 8.4-3 presents the corresponding change in revenue by crop category. Table 8.4-7 presents the modeled total estimated agricultural crop revenues for baseline and each flow scenario for a dry water year, with maximum replacement groundwater pumping. These results show the same general trends as observed for the average year modeling results.

Tables 8.4-4 through 8.4-7 also display the percent reduction in overall crop revenue from baseline for each flow scenario. Overall, the percent reduction in crop revenues are greater under the higher flow scenarios than the lower flow scenarios. The percent reduction in crop revenues are also higher with no replacement groundwater pumping than with maximum replacement groundwater pumping. The percent reduction in crop revenues are also generally higher under the dry year model run than the average year model run.

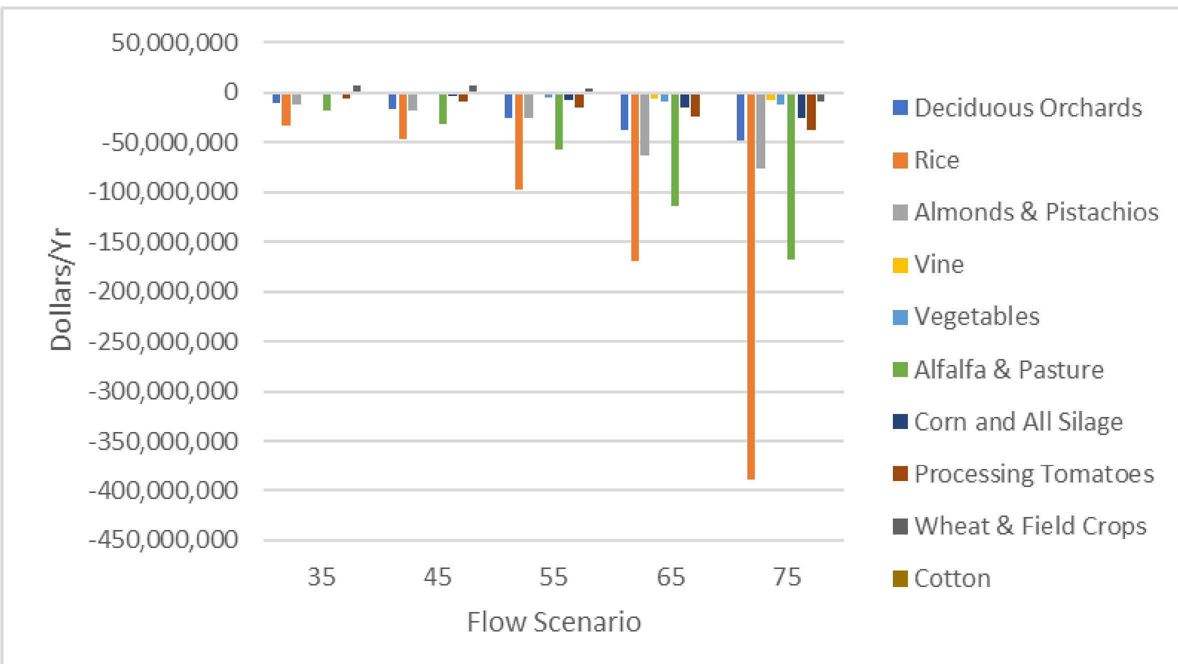


Figure 8.4-2. Changes in Crop Revenue, Sacramento/Delta, SWAP Model Analysis, Average Year, No Replacement Groundwater Pumping

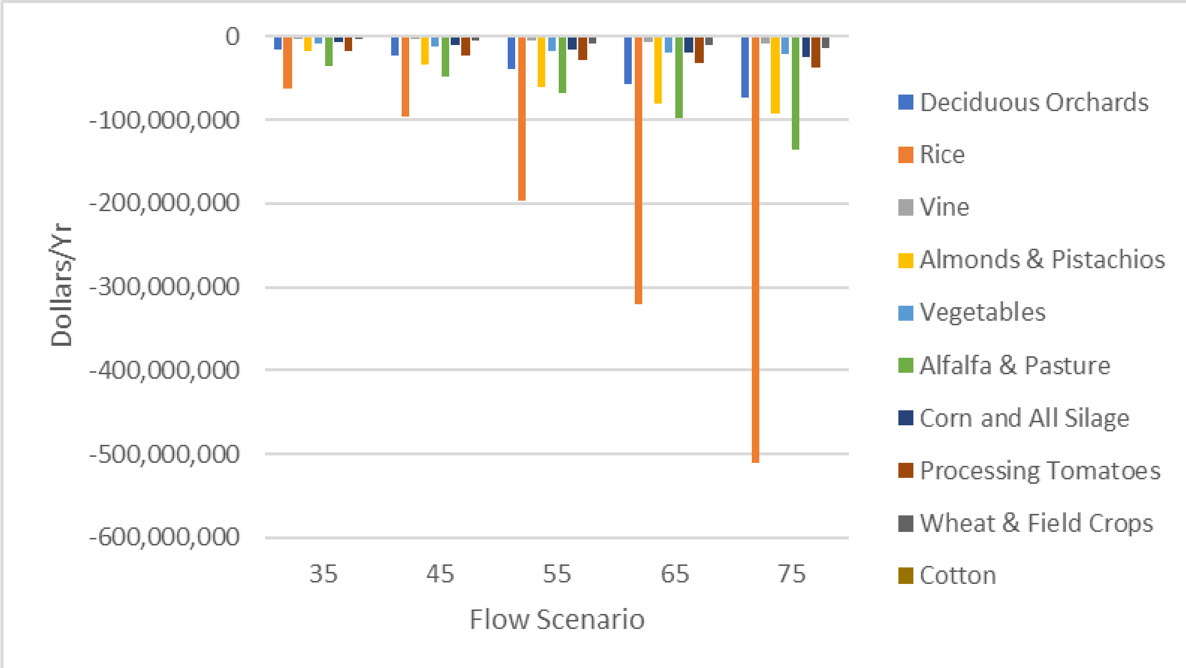


Figure 8.4-3. Changes in Crop Revenue, Sacramento/Delta, SWAP Model Analysis, Dry Year, No Replacement Groundwater Pumping

Table 8.4-4. Average Year: Crop Revenue in the Sacramento/Delta, SWAP Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	3,650,086,900	3,639,537,900	3,633,741,500	3,624,897,500	3,612,965,300	3,601,453,300
Rice	1,495,391,700	1,462,803,200	1,449,250,700	1,397,927,700	1,325,716,300	1,106,853,700
Almonds & Pistachios	932,906,100	921,364,000	914,617,200	906,827,400	870,091,600	856,981,200
Vine	930,289,500	930,251,000	929,660,000	927,926,600	924,433,100	923,196,700
Vegetables	786,069,400	787,027,200	785,169,900	781,957,600	777,170,000	773,425,700
Alfalfa & Pasture	571,085,500	552,952,200	539,357,000	513,887,600	457,074,800	403,419,300
Corn and All Silage	438,058,400	436,335,600	434,438,700	430,417,100	422,660,300	412,083,300
Processing Tomatoes	383,723,000	376,811,500	374,240,600	368,351,700	359,007,300	346,311,100
Wheat & Field Crops	195,275,400	203,021,200	202,036,800	199,685,900	193,724,400	185,321,000
Cotton	10,566,600	10,526,800	10,470,600	10,356,600	10,103,900	9,991,500
Total	9,393,452,700	9,320,630,500	9,272,983,100	9,162,235,800	8,952,947,100	8,619,036,700
Change from existing		-0.8%	-1.3%	-2.5%	-4.7%	-8.2%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under no replacement groundwater pumping conditions.

Table 8.4-5. Average Year: Crop Revenue in the Sacramento/Delta, SWAP Model Analysis, Maximum Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	3,650,086,900	3,648,960,400	3,648,308,300	3,647,477,900	3,644,629,800	3,640,890,500
Rice	1,495,391,700	1,486,311,700	1,483,269,300	1,471,212,200	1,450,021,800	1,326,998,000
Almonds & Pistachios	932,906,100	932,356,500	932,135,000	931,641,600	919,546,700	911,330,800
Vine	930,289,500	930,289,400	930,289,400	930,289,400	929,792,900	929,578,700
Vegetables	786,069,400	786,735,900	785,925,600	784,714,600	783,824,800	780,582,200
Alfalfa & Pasture	571,085,500	570,131,500	569,708,300	568,802,100	561,860,300	545,728,000
Corn and All Silage	438,058,400	438,127,300	437,707,300	436,348,000	434,354,300	429,793,300
Processing Tomatoes	383,723,000	379,743,900	378,767,200	375,578,700	372,015,200	366,092,200
Wheat & Field Crops	195,275,400	197,547,700	197,189,600	196,134,600	195,698,500	192,096,800
Cotton	10,566,600	10,558,300	10,549,300	10,531,400	10,460,500	10,277,600
Total	9,393,452,700	9,380,762,600	9,373,849,400	9,352,730,700	9,302,204,900	9,133,368,000
Change from existing		-0.1%	-0.2%	-0.4%	-1.0%	-2.8%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under maximum replacement groundwater pumping conditions.

Table 8.4-6. Dry Year: Crop Revenue in the Sacramento/Delta, SWAP Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	3,634,821,500	3,619,850,300	3,612,420,600	3,596,079,000	3,578,034,300	3,561,321,200
Rice	1,487,715,100	1,425,296,800	1,391,943,100	1,290,579,900	1,168,001,800	977,766,500
Vine	924,005,100	921,356,900	920,535,800	919,049,200	917,407,300	916,485,700
Almonds & Pistachios	912,075,400	893,975,400	878,684,300	851,894,400	831,926,800	820,121,700
Vegetables	784,114,800	776,109,200	772,530,100	767,693,200	765,404,400	763,036,400
Alfalfa & Pasture	547,079,900	511,764,500	499,047,600	478,787,100	448,984,800	412,026,600
Corn and All Silage	436,377,900	429,727,200	426,620,700	421,611,800	417,625,100	411,822,700
Processing Tomatoes	378,707,500	361,733,800	356,871,400	350,491,500	346,762,900	341,647,900
Wheat & Field Crops	197,730,000	194,567,100	192,738,100	189,629,700	188,037,600	184,549,000
Cotton	10,539,700	10,419,300	10,349,000	10,216,000	10,131,000	10,085,300
Total	9,313,167,000	9,144,800,400	9,061,740,700	8,876,031,800	8,672,316,000	8,398,863,000
Change from existing		-1.8%	-2.7%	-4.7%	-6.9%	-9.8%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under no replacement groundwater pumping conditions.

Table 8.4-7. Dry Year: Crop Revenue in the Sacramento/Delta, SWAP Model Analysis, Maximum Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	3,649,232,100	3,644,980,500	3,642,877,700	3,636,759,000	3,633,166,300	3,631,357,100
Rice	1,498,162,200	1,476,184,700	1,465,630,000	1,407,500,500	1,325,586,200	1,222,429,800
Vine	930,227,700	930,194,600	929,836,300	929,265,400	929,133,000	929,055,900
Almonds & Pistachios	932,547,900	927,929,500	919,843,800	903,167,800	896,178,000	891,899,400
Vegetables	785,822,800	782,803,800	781,011,000	777,048,900	773,873,000	772,684,000
Alfalfa & Pasture	569,657,300	566,234,500	563,558,300	550,640,100	541,435,700	536,954,800
Corn and All Silage	438,623,300	436,701,100	435,275,300	431,912,300	429,526,700	427,377,200
Processing Tomatoes	383,653,000	375,449,100	372,822,300	366,418,500	363,401,200	362,018,500
Wheat & Field Crops	194,888,500	194,778,800	193,960,300	192,951,800	190,570,800	190,378,800
Cotton	10,569,200	10,541,300	10,512,600	10,423,200	10,328,800	10,273,500
Total	9,393,384,100	9,345,797,900	9,315,327,500	9,206,087,400	9,093,199,600	8,974,429,100
Change from existing		-0.5%	-0.8%	-2.0%	-3.2%	-4.5%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under maximum replacement groundwater pumping conditions.

In response to reductions in Sacramento/Delta supply, individual water users may choose to increase groundwater pumping, where available and not locally restricted. Water users could also choose to plant lower-water-use crops, engage in deficit irrigation, or fallow land. Each of these actions can influence net crop revenues which are analogous to farm profits and are generally defined as gross crop revenues minus crop production costs. (For additional details, see Appendix A3, *Agricultural Economic Analysis Modeling Procedure*). As previously discussed, other water management actions could also be used to offset surface water supply reductions, such as water conservation, groundwater storage and recovery, water transfers, and use of recycled water. Where feasible, these other supply options could reduce the agricultural economic effects of changes in Sacramento/Delta water supplies.

The estimated economic effects are bounded on the low end by the maximum replacement groundwater pumping assumption in which reductions in Sacramento/Delta supply are offset by increased groundwater pumping. However, this analysis does not estimate the long-term effects of additional groundwater pumping on groundwater availability and pumping costs. As a result, additional costs that could be incurred related to deepening of groundwater wells, higher pumping, and other associated costs.

The groundwater analyses in Section 7.12.2, *Groundwater*, show that under the proposed Plan amendments, increased groundwater pumping and reductions in incidental groundwater recharge from applied irrigation could lower groundwater levels in some locations. Lower groundwater levels could lead to less flexibility for water management because of an inability to get groundwater supply when or where it is needed, leading to potential conversion of agricultural land to nonagricultural uses. While the model results provide conservative estimates under a no groundwater replacement scenario, it does not attempt to explicitly model agricultural conversion from groundwater-irrigated crops as this would be speculative. It is possible that some cropland fallowing could occur as a result of lower groundwater levels, with an accompanying effect on crop revenues.

There are portions of the Sacramento River watershed and Delta eastside tributaries regions (upper watersheds) that are not modeled in SWAP. As discussed in greater detail in Section 7.4, *Agriculture and Forest Resources*, most of the crops grown in the upper watersheds is pasture and alfalfa. On the west side in the Upper Cache Creek and Putah Creek basins, over 81 percent of irrigated land is grape vineyards or deciduous orchards. Groundwater use as a primary or supplemental source is common. Crop acreage in these upper watersheds comprise a small fraction of the total irrigated crop acreage in the Sacramento/Delta. However, it is possible that some additional changes in crop acreage and crop revenue could occur in the Sacramento/Delta watershed under the proposed Plan amendments beyond the results indicated by the SWAP model results.

8.4.2.2 San Joaquin Valley

The San Joaquin Valley produces a considerable diversity of crops. As noted in Section 7.4, *Agriculture and Forest Resources*, the largest agricultural production area is devoted to almonds, followed by alfalfa, silage,[4] and corn silage. Producing almond acreage has grown steadily from 2011 to 2016. Alfalfa was the highest acreage crop in 2010–2012, but a decline in 2015 puts it second to

[4] *Silage* includes that made from barley, oats, triticale, and wheat. Depending on the individual county reports, silage also may include sorghum or green chop, or those crops may be counted separately. However, silage made from corn typically is tallied separately from silage in the Agricultural Commissioners' reports.

almonds. Silage and corn silage have remained relatively constant over this timeframe, as have processing tomatoes. Pistachio orchard acreage has more than doubled from 2011 to 2016. Wine grapes have varied just slightly over the time period. (CDFA 2011–2016.)

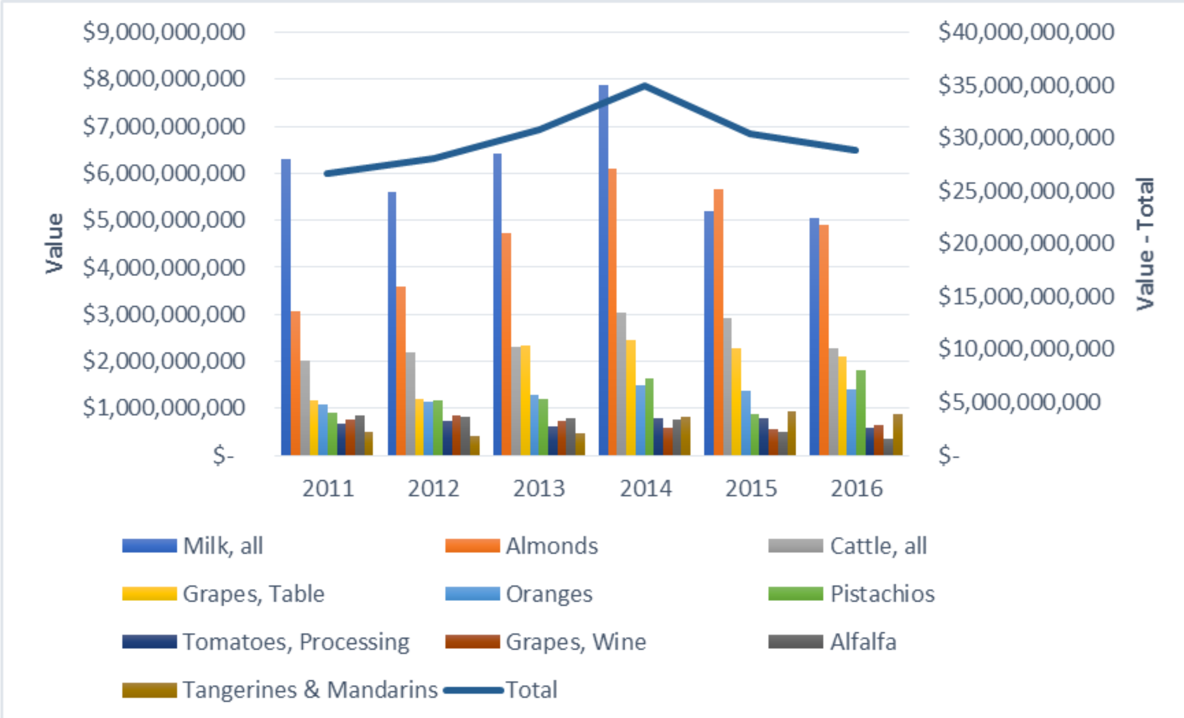
Table 8.4-8 shows average annual commodity revenue over the period of 2011–2016. Combined for all crops and agricultural products at the farm gate, the total average production was nearly $30.0 billion per year from 2011 to 2016.

Table 8.4-8. Top-Producing Commodities in the San Joaquin Valley by Production Revenue, 2011–2016 average

Crop	Revenue
Milk, all	$6,072,729,333
Almonds	$4,679,988,833
Cattle, all	$2,460,588,667
Grapes, Table	$1,917,171,500
Oranges	$1,291,728,500
Pistachios	$1,268,408,333
Tomatoes, Processing	$701,303,333
Grapes, Wine	$684,293,533
Alfalfa	$674,646,833
Tangerines & Mandarins	$669,733,167
Total—all commodities	$29,973,064,952

Sources: CDFA 2011–2016.

Figure 8.4-4 displays the production revenue during the 2011–2016 period for the top commodities and all commodities combined.



Sources: CDFA 2011–2016.

Figure 8.4-4. Top-Producing Commodities, and Total of All Commodities, by Revenue in San Joaquin Valley (2011–2016)

As demonstrated in Figure 8.4-4, revenues can vary considerably from year to year. Milk products were the top-producing commodity from 2011 to 2016 (second in 2015), but ranged from a high of $7.9 billion in 2014 to a low of $5.1 billion in 2016. Almond producers harvested $3.1 billion in crop revenue in 2011, and that increased to $6.1 billion in 2014. Cattle sales have resulted in revenues that have increased from $2.0 billion in 2011, to $3.0 billion in 2014, and declined to $2.3 billion in 2016.

Changes in Sacramento/Delta supply would affect agricultural crop revenues within the San Joaquin Valley. Table 8.4-9 presents the modeled total estimated agricultural crop revenues for the baseline and for each flow scenario for an average water year, with no replacement groundwater pumping. Figure 8.4-5 presents the corresponding change in revenue by crop category. Table 8.4-10 presents the modeled total estimated agricultural crop revenues for baseline and each flow scenario for an average water year, with maximum replacement groundwater pumping. The results indicate that crop revenues generally decrease with increasing flow scenarios. For the lower flow scenarios, revenue reductions occur to almonds and pistachios, alfalfa and pasture, corn, and other silage,[5] and wheat and field crops. At higher flow scenarios, additional revenue reductions occur to cotton, processing tomatoes, and vegetables.

As discussed above, it is uncertain how all water users may respond to reduced Sacramento/Delta supply regarding groundwater pumping. Modeling higher groundwater replacement pumping by

[5] Although the crop category of "Corn and Other Silage" shows a decrease in acreage and production value, the detailed SWAP model results indicate that most of the impact falls on grain corn, with lesser impact on other silage, and that corn silage acreage and value may decline by about 1 percent at the 55 scenario.

farmers and ranchers assumes more water is available for agriculture, which reduces effects on crop revenues. The model results presented in Table 8.4-10 for the flow scenarios with maximum replacement groundwater pumping show a smaller effect on crop production and revenue because some of the reduced surface water supply would be replaced by groundwater. The model results presented in Table 8.4-9 for the flow scenarios with no replacement groundwater pumping show a greater effect on crop production and revenue because availability of groundwater to replace reduced surface water supply would be limited.

A similar comparison can be made of estimated crop revenues from the baseline condition and flow scenarios for a dry water year. Table 8.4-11 presents the modeled total estimated agricultural crop revenues for baseline and each scenario for a dry water year, with no replacement groundwater pumping. Figure 8.4-6 presents the corresponding change in revenue by crop category. Table 8.4-12 presents the modeled total estimated agricultural crop revenues for baseline and each scenario for a dry water year, with maximum replacement groundwater pumping. These results show similar trends as observed for the average water year model results.

Tables 8.4-9 through 8.4-12 also display the percent reduction in overall crop revenue from the baseline for each flow scenario. Overall, the percent reduction in crop revenues are greater under the higher flow scenarios than the lower flow scenarios. The percent reduction in crop revenues are also higher with no replacement groundwater pumping than with maximum replacement groundwater pumping. The percent reduction in crop revenues are also generally similar to or slightly higher under the dry year model run than the average year model run.

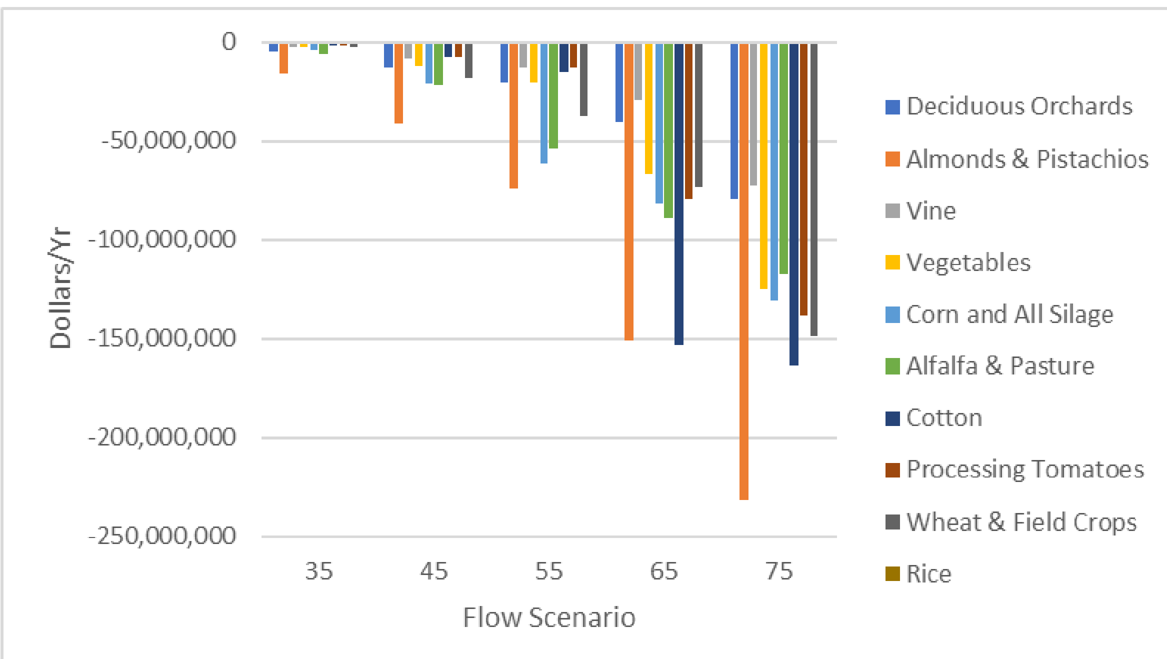


Figure 8.4-5. Changes in Crop Revenue, San Joaquin Valley, SWAP Model Analysis, Average Year, No Replacement Groundwater Pumping

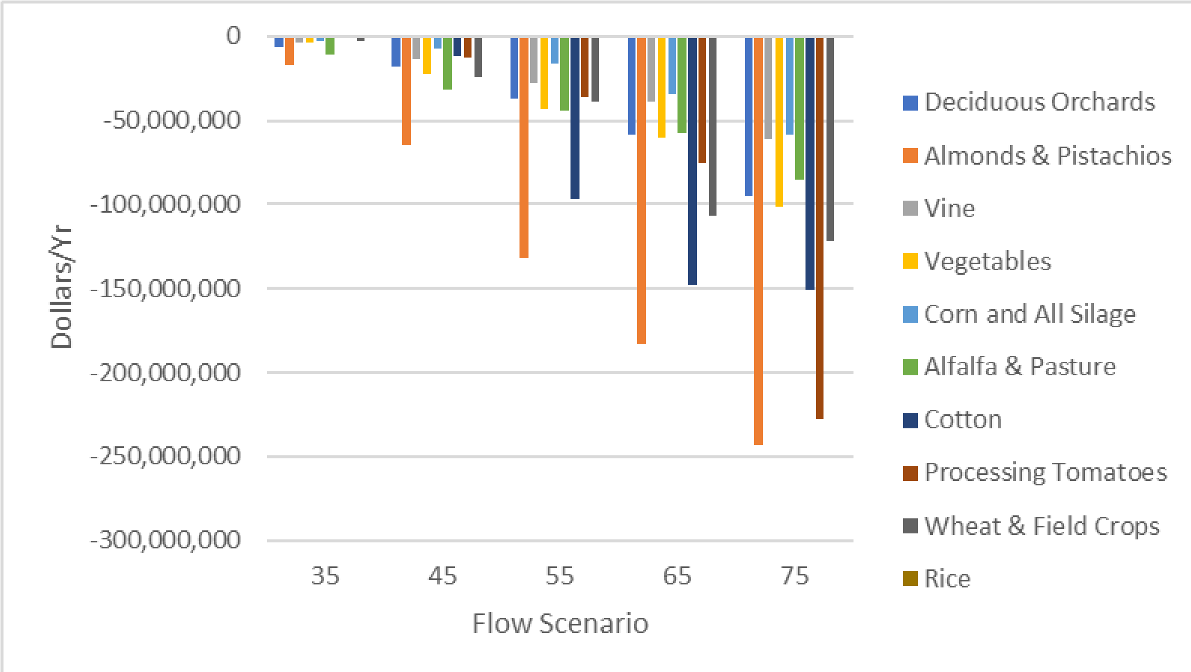


Figure 8.4-6. Changes in Crop Revenue, San Joaquin Valley, SWAP Model Analysis, Dry Year, No Replacement Groundwater Pumping

Table 8.4-9. Average Year: Crop Revenue in the San Joaquin Valley, SWAP Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	7,882,217,500	7,877,460,000	7,869,544,700	7,862,296,500	7,841,628,700	7,802,864,400
Almonds & Pistachios	6,006,154,900	5,990,527,200	5,964,966,300	5,931,839,600	5,855,463,500	5,774,566,400
Vine	3,425,590,400	3,423,223,600	3,417,685,000	3,412,827,700	3,396,387,100	3,353,054,900
Vegetables	2,509,455,000	2,506,929,900	2,497,817,100	2,488,905,400	2,443,231,600	2,384,637,500
Corn and All Silage	1,876,603,400	1,872,913,300	1,855,803,100	1,815,498,600	1,795,053,000	1,746,008,100
Alfalfa & Pasture	1,498,599,400	1,492,382,300	1,476,720,100	1,444,393,700	1,409,865,300	1,381,469,000
Cotton	908,441,600	906,553,700	900,970,800	893,257,400	754,932,900	744,895,600
Processing Tomatoes	831,512,300	830,238,300	824,130,200	818,723,700	752,344,800	693,504,000
Wheat & Field Crops	440,146,600	437,674,500	422,351,000	402,661,300	366,715,200	291,750,100
Rice	25,842,900	25,746,300	25,631,300	25,549,500	25,420,100	25,604,600
Total	25,404,564,000	25,363,649,300	25,255,619,500	25,095,953,400	24,641,042,100	24,198,354,600
Change from existing		-0.2%	-0.6%	-1.2%	-3.0%	-4.7%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under no replacement groundwater pumping conditions.

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Table 8.4-10. Average Year: Crop Revenue in the San Joaquin Valley, SWAP Model Analysis, Maximum Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	7,882,217,500	7,882,217,900	7,882,217,900	7,882,217,900	7,882,217,900	7,879,258,500
Almonds & Pistachios	6,006,154,900	6,006,156,100	6,006,156,100	6,006,156,100	6,006,156,100	5,986,063,800
Vine	3,425,590,400	3,425,590,500	3,425,590,500	3,425,590,500	3,425,590,500	3,424,777,000
Vegetables	2,509,455,000	2,509,455,300	2,509,455,300	2,509,455,300	2,509,455,300	2,507,423,000
Corn and All Silage	1,876,603,400	1,876,604,000	1,876,604,000	1,876,604,000	1,876,604,000	1,875,836,400
Alfalfa & Pasture	1,498,599,400	1,498,600,600	1,498,600,600	1,498,600,600	1,498,600,600	1,496,978,900
Cotton	908,441,600	908,441,900	908,441,900	908,441,900	908,441,900	907,746,400
Processing Tomatoes	831,512,300	831,512,700	831,512,700	831,512,700	831,512,700	831,371,400
Wheat & Field Crops	440,146,600	440,146,800	440,146,800	440,146,800	440,146,800	432,353,400
Rice	25,842,900	25,843,000	25,843,000	25,843,000	25,843,000	25,843,000
Total	25,404,564,000	25,404,568,800	25,404,568,800	25,404,568,800	25,404,568,800	25,367,651,800
Change from existing		0.0%	0.0%	0.0%	0.0%	-0.1%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under maximum groundwater pumping conditions.

Table 8.4-11. Dry Year: Crop Revenue in the San Joaquin Valley, SWAP Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	7,825,279,700	7,819,232,900	7,807,361,600	7,788,267,100	7,766,777,700	7,730,516,400
Almonds & Pistachios	5,895,958,500	5,878,785,100	5,831,227,300	5,763,839,400	5,713,300,100	5,653,191,700
Vine	3,384,027,400	3,380,151,500	3,370,944,000	3,356,558,800	3,345,481,200	3,322,963,700
Vegetables	2,463,182,200	2,459,833,000	2,440,442,300	2,420,287,700	2,402,978,700	2,362,056,000
Corn and All Silage	1,810,834,400	1,808,351,700	1,803,550,000	1,794,423,000	1,776,411,500	1,752,703,800
Alfalfa & Pasture	1,430,348,700	1,419,190,600	1,398,879,900	1,386,174,300	1,372,864,000	1,345,379,900
Cotton	901,674,600	900,482,900	890,372,000	804,742,700	753,348,500	750,605,700
Processing Tomatoes	796,829,500	795,977,200	784,022,200	760,616,300	721,545,800	568,779,400
Wheat & Field Crops	409,494,300	406,488,900	385,537,600	371,262,100	302,670,100	287,651,600
Rice	25,579,800	25,579,400	25,577,000	25,570,700	25,545,800	25,490,200
Total	24,943,209,200	24,894,073,300	24,737,913,800	24,471,741,900	24,180,923,400	23,799,338,300
Change from existing		-0.2%	-0.8%	-1.9%	-3.1%	-4.6%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under no replacement groundwater pumping conditions.

Table 8.4-12. Dry Year: Crop Revenue in the San Joaquin Valley, SWAP Model Analysis, Maximum Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Deciduous Orchards	7,874,932,900	7,874,934,400	7,873,919,900	7,872,340,700	7,870,993,000	7,869,443,200
Almonds & Pistachios	5,993,326,900	5,993,329,800	5,986,154,000	5,974,729,200	5,964,712,600	5,952,855,300
Vine	3,419,485,200	3,419,486,100	3,419,248,900	3,418,872,400	3,418,543,900	3,418,156,800
Vegetables	2,507,349,000	2,507,349,500	2,506,784,800	2,505,885,500	2,505,156,400	2,504,563,400
Corn and All Silage	1,875,107,000	1,875,108,700	1,874,967,700	1,874,332,000	1,874,332,000	1,874,332,000
Alfalfa & Pasture	1,479,946,200	1,479,949,400	1,479,807,400	1,479,531,700	1,479,283,900	1,478,368,200
Cotton	911,487,500	911,487,700	911,405,000	911,256,000	911,102,900	910,883,500
Processing Tomatoes	830,169,000	830,169,600	830,136,000	830,082,100	830,037,600	830,005,600
Wheat & Field Crops	437,202,200	437,202,700	436,231,100	435,053,300	434,361,200	433,072,500
Rice	25,871,100	25,871,100	25,871,100	25,871,100	25,871,100	25,871,100
Total	25,354,877,100	25,354,889,100	25,344,525,900	25,327,954,000	25,314,394,600	25,297,551,600
Change from existing		0.0%	0.0%	-0.1%	-0.2%	-0.2%

SWAP model crop revenue estimates for an average year by crop group for baseline and each flow scenario under maximum groundwater pumping conditions.

In response to reductions in Sacramento/Delta supply, individual water users may choose to increase groundwater pumping, where available and not locally restricted. Water users could also choose to plant lower-water-use crops, engage in deficit irrigation, or fallow land. Each of these actions can influence net crop revenues which are analogous to farm profits and are generally defined as gross crop revenues minus crop production costs. For additional details, see Appendix A3, *Agricultural Economic Analysis: SWAP Methodology and Modeling Results*.

The analysis includes the agricultural economic effects of a potential reallocation of surface supplies from the CVP Friant Division to the San Joaquin River exchange contractors to satisfy the San Joaquin River exchange contractors' water demands. In most years, the Exchange Contractors receive supplies exported from the Delta in exchange for use of water from the San Joaquin River under the exchange contractors' underlying rights as part of exchange contracts related to the development of the Friant Project by Reclamation. This "call" on Friant Division water comes at the expense of the lower-priority water right holders in the Friant Division services area who would otherwise receive their allotment from water stored behind Friant Dam. In this circumstance, supplies to Friant Division contractors in the south side of the San Joaquin Valley would be reduced. In the SWAP analysis, when there is a shortage to the Exchange Contractors, water is reallocated from the Friant Division to make up for the shortage from the Delta. However, since both the Friant Division and the Exchange Contractors are both within the San Joaquin Valley Region, the economic effects of the reallocation of Friant supplies is minimal at this scale. More detailed discussion of the agricultural effects of calls on Friant can be found in Section 7.4, *Agriculture and Forest Resources*.

As previously discussed, other water management actions could also be used to offset surface water supply reductions including water conservation, groundwater storage and recovery, water transfers, and use of recycled water. These actions could affect the changes in crop acreage and crop revenue estimated by the SWAP model.

The estimated economic effects are bounded on the low end by the maximum replacement groundwater pumping assumption in which reductions in Sacramento/Delta surface water supplies are offset by increased groundwater pumping. However, this analysis does not estimate the long-term effects of additional groundwater pumping on groundwater availability and pumping costs. As a result, additional costs that could be incurred related to deepening of groundwater wells, higher pumping, and other associated costs.

The groundwater analyses in Section 7.12.2, *Groundwater*, show that under the proposed Plan amendments, increased groundwater pumping and reductions in incidental groundwater recharge from applied irrigation could lower groundwater levels. Lower groundwater levels could lead to less flexibility for water management because of an inability to get groundwater supply when or where it is needed, leading to potential conversion of agricultural land to nonagricultural uses. Farmers could choose to convert groundwater-irrigated land to nonagricultural use. While the model results provide conservative estimates under a no groundwater replacement scenario, it does not attempt to explicitly model agricultural conversion from groundwater-irrigated crops as this would be speculative. It is possible that some cropland fallowing could occur as a result of lower groundwater levels, with an accompanying effect on crop revenues.

8.4.2.3 San Francisco Bay Area, Central Coast, and Southern California

In the San Francisco Bay Area, Central Coast and Southern California regions, agricultural water supply portfolios vary widely. Some suppliers would be little affected by Sacramento/Delta reductions because such water is a small part of their overall supply or they have alternative supplies that would experience little or no effect from the proposed Plan amendments, such as groundwater. In these regions, the CASRAA (California Sub-Regional Agricultural Analysis) analytical model is used to estimate the effects on agricultural production that could result from reductions in Sacramento/Delta supply. As discussed above in Section 8.4.1, *Approach to Analysis*, this model is a spreadsheet tool that uses an analytical approach similar to that used by the SWAP model to determine cropping patterns and water use.

Section 7.4, *Agriculture and Forest Resources,* presents the change in acreage for the flow scenarios. The sections below summarize the CASRAA results for changes in crop revenue in the San Francisco Bay Area, Central Coast, and Southern California regions.

San Francisco Bay Area

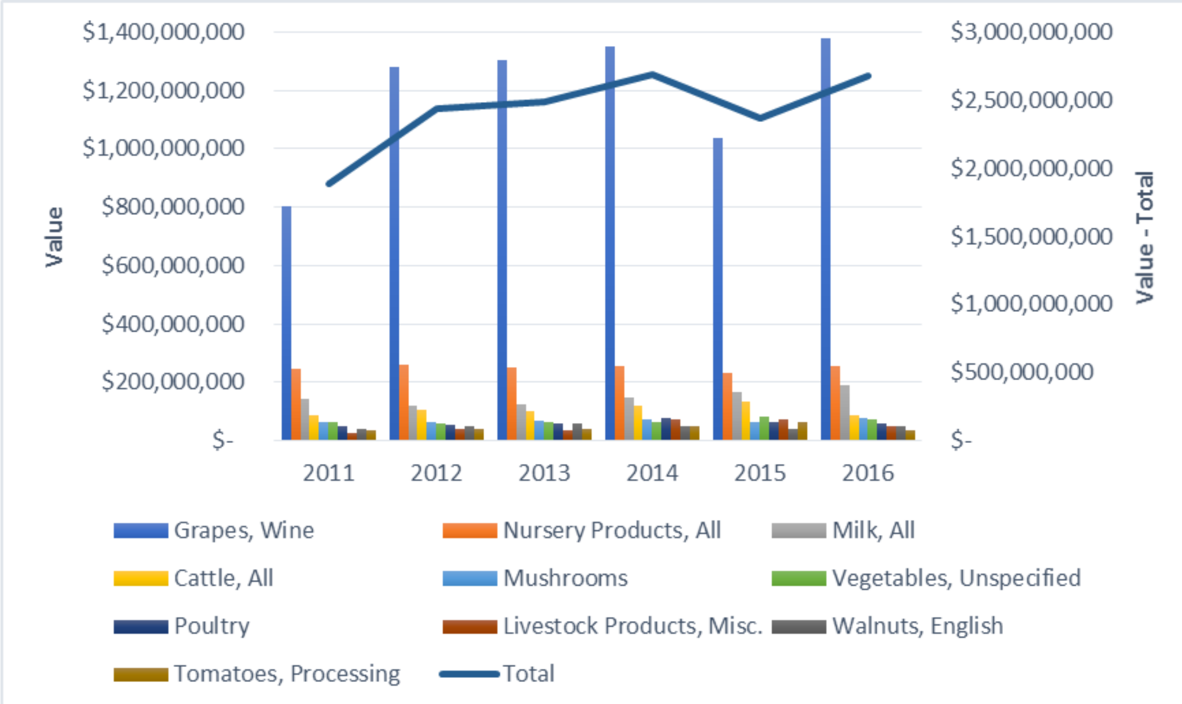
Table 8.4-13 shows the average annual commodity value of crops in the Bay Area region over the period of 2011–2016, with about half its value attributable to wine grapes.

Table 8.4-13. Top-Producing Commodities in the San Francisco Bay Area, by Production Revenue, 2011–2016 average

Commodity	Revenue
Grapes, Wine	$1,192,368,833
Nursery Products, All	$249,763,167
Milk, All	$147,952,833
Cattle, All	$105,567,500
Mushrooms	$68,223,667
Vegetables, Unspecified	$66,395,833
Poultry	$60,655,667
Livestock Products, Misc.	$48,970,667
Walnuts, English	$47,521,333
Tomatoes, Processing	$44,127,500
Total—all commodities	$2,425,253,983

Sources: CDFA 2011–2016.

All commodities combined produced an average of over $2.4 billion per year in revenue over the period. However, as shown by the solid blue line in Figure 8.4-7, crop revenue increased each year from 2011–2016. Aside from a slight decline in 2015, this increase occurred despite the 2011–2016 drought, as demand remained strong throughout the period. Individual commodities such as nursery products and milk have mirrored the increase in revenue, as did several others with minor exceptions.



Sources: CDFA 2011–2016.

Figure 8.4-7. Top-Producing Commodities, and Total of All Commodities, by Revenue in the San Francisco Bay Area (2011–2016)

As discussed in Section 2.8, *Existing Water Supply*, the San Francisco Bay Area uses water supply from several sources, including local surface water and groundwater as well as multiple sources of imported water supplies. Water from the Sacramento/Delta is supplied to the San Francisco Bay Area arrive in several different ways. SWP contract water is carried via the North Bay Aqueduct (Solano County Water Agency [SoCWA] and Napa County Flood Control and Water Conservation District [FC&WCD]) and South Bay Aqueduct (Alameda County Water District, Zone 7 Water Agency [Zone 7], and Santa Clara Valley Water District [Valley Water]). CVP water for municipal use arrives via the Pacheco Conduit and the Contra Costa Canal. Putah South Canal provides stored Reclamation water from Lake Berryessa. Additional diversions from the western Delta serve East Bay Municipal Utility District (EBMUD) and Antioch.

The Solano Irrigation District (SID) uses some Sacramento/Delta water supply from the Putah South Canal for use on lands located in the vicinity of Fairfield (discussed further in Section 7.4, *Agriculture and Forest Resources*).

Valley Water serves water to all of Santa Clara County, including agricultural lands (SCVWD 2015, p. 3-1). However, most agricultural users in the county rely on groundwater.

Zone 7 receives Sacramento/Delta water supplies through the South Bay Aqueduct. The majority of the water used by Zone 7 is for municipal use. However, Zone 7 also provides Sacramento/Delta water supplies to approximately 3,500 acres of agricultural lands, including crops such as vineyards and olives. The water demand for these irrigated land is currently about 5,600 AF, and the agricultural water demand is projected to increase to 7,800 AF by 2030 (Zone 7 2016, p. 4-3).

The CASRAA analysis was applied to the SID deliveries and to Zone 7 agricultural recipients of Sac/Delta water supplies based on SacWAM output for the flow scenarios. The CASRAA analysis estimates that in the SID service area, alfalfa and pasture lands are the most likely affected crops. The CASRAA analysis estimates that in Zone 7, the affected crops would include wine grapes and deciduous orchards.[6]

Table 8.4-14 presents the modeled total estimated agricultural crop revenues for baseline and each flow scenario for an average water year, with no replacement groundwater pumping. Figure 8.4-8 presents the corresponding change in revenue by crop category. Table 8.4-15 presents the modeled total estimated agricultural crop revenues for the baseline and each flow scenario for a dry water year, with no replacement groundwater pumping. Figure 8.4-9 presents the corresponding change in revenue by crop category. These results indicate that crop revenue would generally decrease with increasing flow scenarios. For both the average and dry water year model results, the CASRAA analysis estimates that wine grapes and alfalfa and pasture crop categories would experience the largest reduction in crop revenue. Under the 55 scenario, the overall crop revenue in the region could be reduced by approximately 1.3 percent and 1.5 percent under the average year and dry year model runs, respectively, with no replacement groundwater pumping.

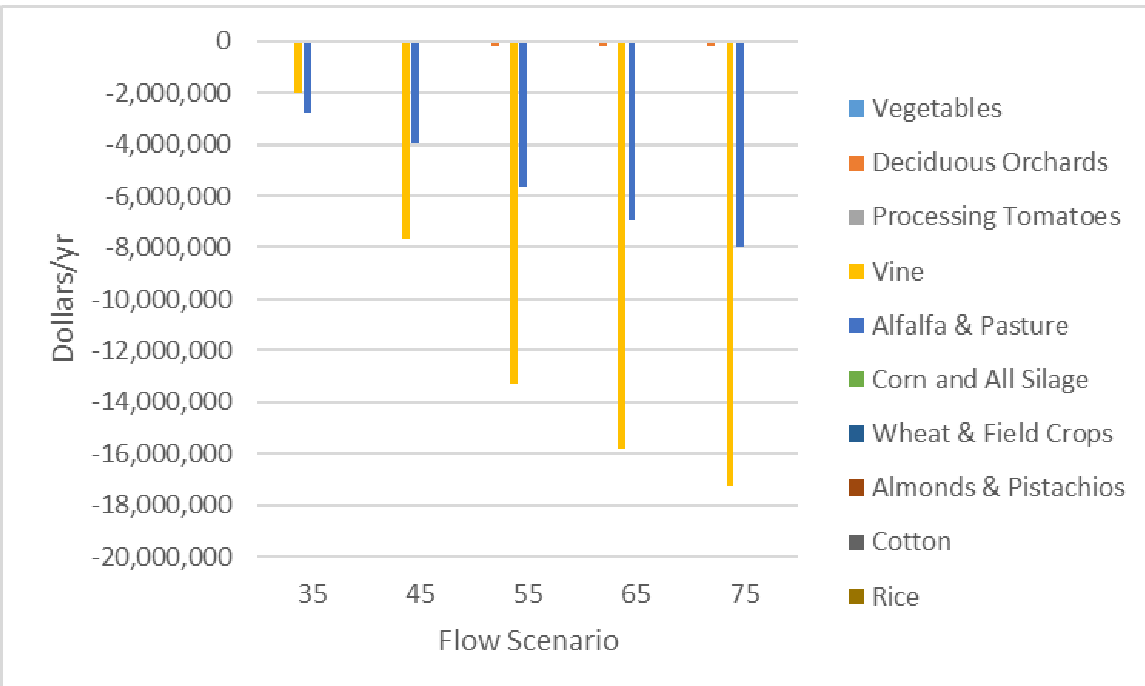


Figure 8.4-8. Changes in Crop Revenue, San Francisco Bay Area, CASRAA Model Analysis, Average Year, No Replacement Groundwater Pumping

[6] Pistachios are included in the Deciduous Orchards crop category in Tables 8.4-14 and 8.4-15 for purposes of presentation.

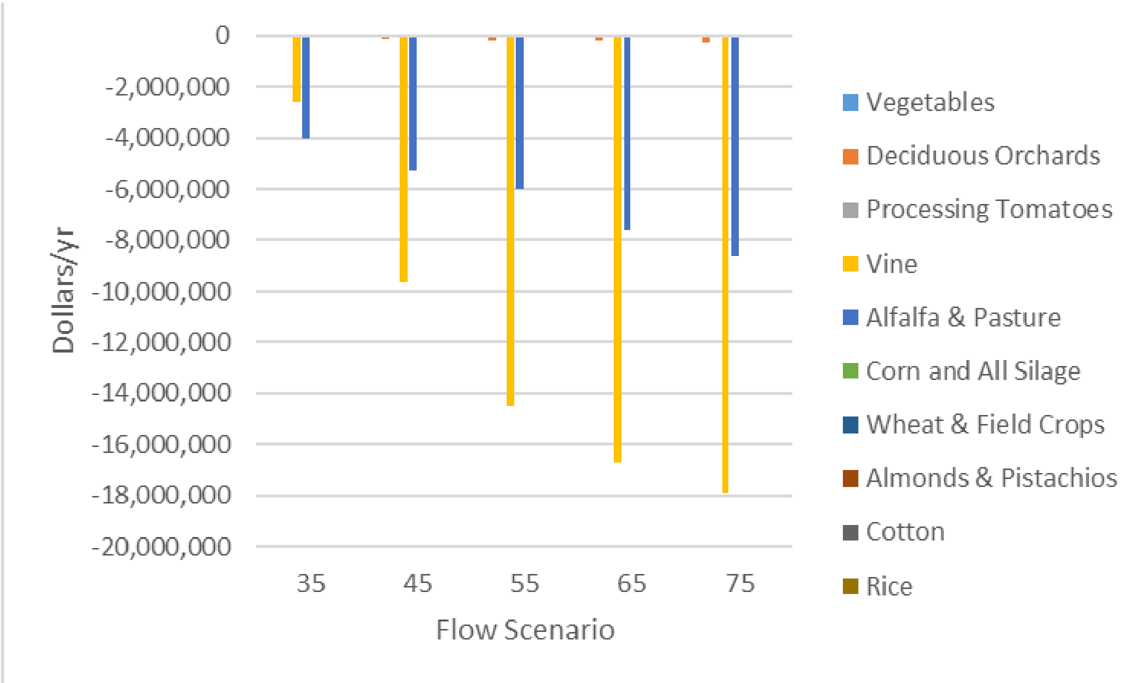


Figure 8.4-9. Changes in Crop Revenue, San Francisco Bay Area, CASRAA Model Analysis, Dry Year, No Replacement Groundwater Pumping

Table 8.4-14. Average Year: Crop Revenue in the San Francisco Bay Area, CASRAA Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Vegetables	66,395,800	66,395,800	66,395,800	66,395,800	66,395,800	66,395,800
Deciduous Orchards	47,521,300	47,495,300	47,420,000	47,346,600	47,313,400	47,294,200
Processing Tomatoes	44,127,500	44,127,500	44,127,500	44,127,500	44,127,500	44,127,500
Vine	1,192,368,800	1,190,392,500	1,184,680,900	1,179,107,700	1,176,584,600	1,175,132,300
Alfalfa & Pasture	34,336,900	31,582,900	30,374,200	28,678,900	27,403,700	26,380,300
Corn and All Silage	22,796,200	22,796,200	22,796,200	22,796,200	22,796,200	22,796,200
Wheat & Field Crops	10,038,100	10,038,100	10,038,100	10,038,100	10,038,100	10,038,100
Almonds & Pistachios	0	0	0	0	0	0
Cotton	0	0	0	0	0	0
Rice	0	0	0	0	0	0
Total	1,417,584,600	1,412,828,300	1,405,832,700	1,398,490,800	1,394,659,300	1,392,164,400
Change from existing		-0.3%	-0.8%	-1.3%	-1.6%	-1.8%

CASRAA model crop revenue estimates for an average year by crop group for existing and each flow scenario under no replacement groundwater pumping conditions.

Table 8.4-15. Dry Year: Crop Revenue in the San Francisco Bay Area, CASRAA Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Vegetables	66,395,800	66,395,800	66,395,800	66,395,800	66,395,800	66,395,800
Deciduous Orchards	47,521,300	47,486,900	47,394,600	47,330,300	47,301,200	47,285,400
Processing Tomatoes	44,127,500	44,127,500	44,127,500	44,127,500	44,127,500	44,127,500
Vine	1,192,368,800	1,189,754,700	1,182,750,200	1,177,866,900	1,175,659,600	1,174,459,600
Alfalfa & Pasture	34,336,900	30,337,900	29,027,100	28,326,700	26,698,900	25,691,300
Corn and All Silage	22,796,200	22,796,200	22,796,200	22,796,200	22,796,200	22,796,200
Wheat & Field Crops	10,038,100	10,038,100	10,038,100	10,038,100	10,038,100	10,038,100
Almonds & Pistachios	0	0	0	0	0	0
Cotton	0	0	0	0	0	0
Rice	0	0	0	0	0	0
Total	1,417,584,600	1,410,937,100	1,402,529,500	1,396,881,500	1,393,017,300	1,390,793,900
Change from existing		-0.5%	-1.1%	-1.5%	-1.7%	-1.9%

CASRAA model crop revenue estimates for a dry year by crop group for existing and each flow scenario under no replacement groundwater pumping conditions.

Central Coast

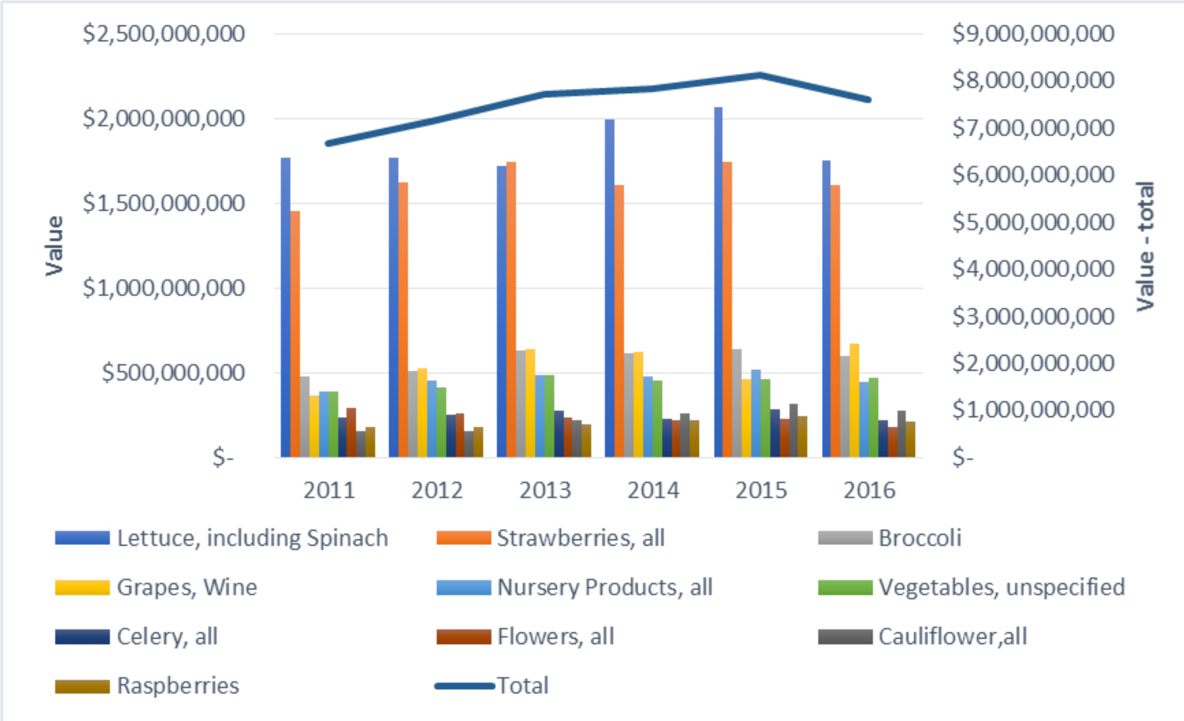
Table 8.4-16 shows average annual commodity revenue in the Central Coast from 2011 to 2016.

Table 8.4-16. Top-Producing Commodities in the Central Coast, by Production Revenue, 2011–2016 average

Commodity	Revenue
Lettuce, including Spinach	$1,845,167,500
Strawberries, all	$1,630,858,167
Broccoli	$577,813,500
Nursery Products, all	$547,245,500
Vegetables, unspecified	$463,032,500
Grapes, Wine	$445,079,667
Celery, all	$249,138,000
Flowers, all	$234,532,867
Cauliflower, all	$231,744,833
Raspberries	$206,270,667
Total—all commodities	**$7,514,763,795**

Sources: CDFA 2011–2016.

All commodities combined produced an average of more than $7.5 billion per year in revenue over the period. Figure 8.4-10 shows commodity revenue can vary considerably from year to year. Lettuce ranged from $1.7 billion to $2.1 billion. Wine grapes revenues ranged from $363 million in 2011 to $669 million in 2016.



Sources: CDFA 2011–2016.

Figure 8.4-10. Top-Producing Commodities, and Total of All Commodities, by Value in Central Coast (2011–2016)

Irrigated agriculture is found in every county of the Central Coast region but is concentrated in the north (Santa Clara and San Benito Counties), the Salinas Valley, portions of San Luis Obispo County, and in the Santa Maria and lower Santa Ynez Valleys in the south part of the region. As discussed in Section 2.8, the Central Coast is heavily reliant on groundwater for its water supply, including for agricultural water use. The SWP provides Sacramento/Delta water supply to San Luis Obispo and Santa Barbara Counties via the Coastal Branch Aqueduct, which diverges from the California Aqueduct. SWP contractors in the Central Coast Region include San Luis Obispo County FC&WCD and Santa Barbara County FC&WCD. According to SacWAM, SWP deliveries to the Central Coast are primarily for municipal purposes. However, the comingling of SWP and local surface water serve five small irrigation districts in Santa Barbara County. CVP's San Felipe Division also provides imported water to the Central Coast from San Luis Reservoir. Most of the CVP San Felipe Division water is used for municipal purposes; however, a portion of the Sacramento/Delta water supplied through the CVP San Felipe Division is used in the Central Coast for agricultural irrigation.

The CASRAA analysis was applied to the San Felipe Division agricultural deliveries and to Santa Barbara County FC&WCD agricultural recipients of Sacramento/Delta supply, based on SacWAM output for the flow scenarios.

Table 8.4-17 presents the modeled total estimated agricultural crop revenues for baseline and each flow scenario for an average water year, with no replacement groundwater pumping. Figure 8.4-11 presents the corresponding change in revenue by crop category. Table 8.4-18 presents the modeled total estimated agricultural crop revenues for baseline and each flow scenario for a dry water year, with no replacement groundwater pumping. Figure 8.4-12 presents the corresponding change in revenue by crop category. These results indicate that crop revenues would generally decrease with increasing flow scenarios. In the San Felipe Division, a mix of vegetables, processing tomatoes, and wine grapes could be affected, and the San Felipe Division also accounts for most of the agricultural economic effects in the Central Coast region. In Santa Barbara County, potentially affected crops include wine grapes, and deciduous orchards (avocados), and vegetables.[7]

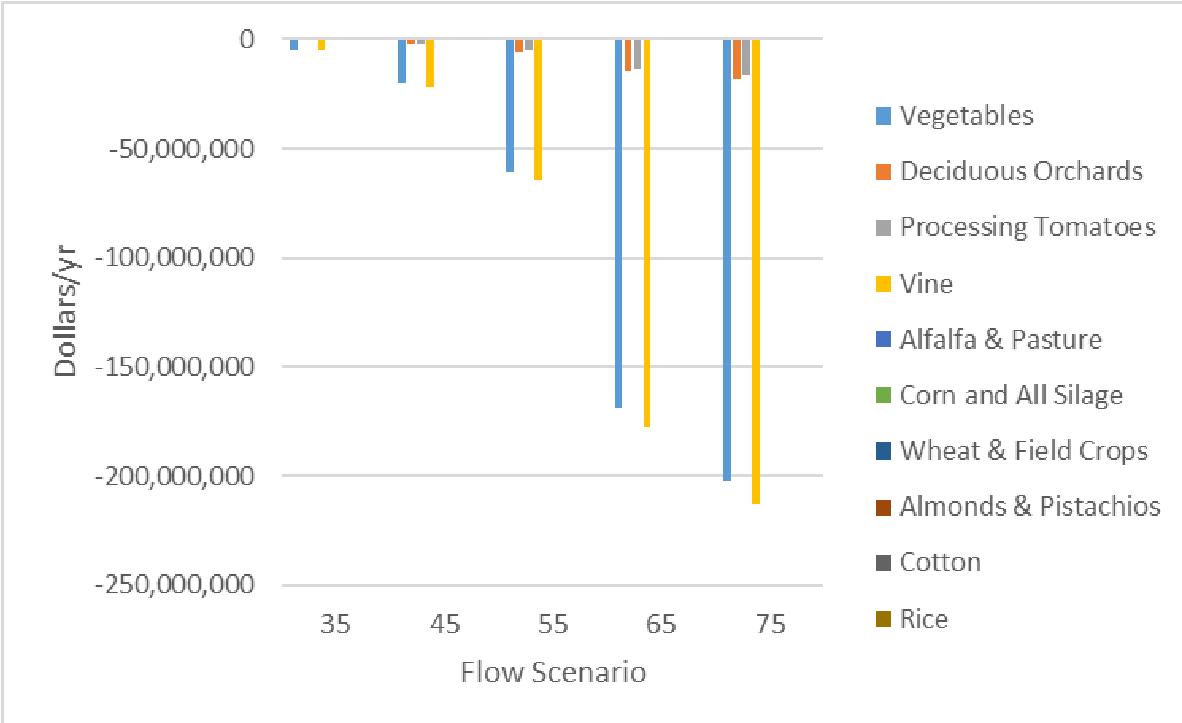


Figure 8.4-11. Changes in Crop Revenue, Central Coast, CASRAA Model Analysis, Average Year, No Replacement Groundwater Pumping

[7] Strawberries are included in the "Vegetables" crop category in Tables 8.4-22 and 8.4-23 for purposes of presentation.

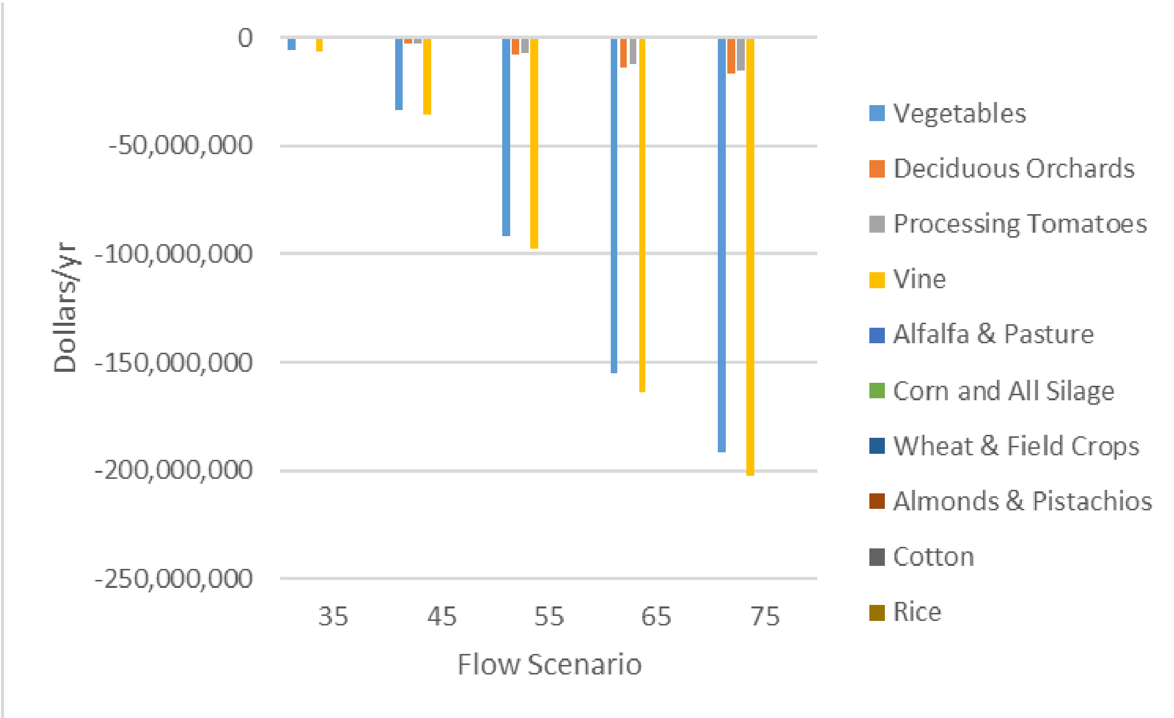


Figure 8.4-12. Changes in Crop Revenue, Central Coast, CASRAA Model Analysis, Dry Year, No Replacement Groundwater Pumping

Table 8.4-17. Average Year: Crop Revenue in the Central Coast, CASRAA Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Vegetables	5,204,025,200	5,199,250,100	5,183,653,900	5,143,434,800	5,035,587,700	5,001,730,100
Deciduous Orchards	521,852,500	521,427,200	520,052,600	516,541,300	507,177,400	504,213,200
Processing Tomatoes	19,572,500	19,199,700	17,958,200	14,700,700	5,880,000	3,151,500
Vine	445,079,700	439,904,200	423,222,500	380,722,000	267,549,000	231,643,300
Alfalfa & Pasture	54,631,000	54,631,000	54,631,000	54,631,000	54,631,000	54,631,000
Corn and All Silage	0	0	0	0	0	0
Wheat & Field Crops	32,223,600	32,223,600	32,223,600	32,223,600	32,223,600	32,223,600
Almonds & Pistachios	0	0	0	0	0	0
Cotton	0	0	0	0	0	0
Rice	0	0	0	0	0	0
Total	6,277,384,500	6,266,635,800	6,231,741,800	6,142,253,400	5,903,048,700	5,827,592,700
Change from existing		-0.2%	-0.7%	-2.2%	-6.0%	-7.2%

CASRAA model crop revenue estimates for an average year by crop group for existing and each flow scenario under no replacement groundwater pumping conditions.

Table 8.4-18. Dry Year: Crop Revenue in the Central Coast, CASRAA Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Vegetables	5,204,025,200	5,198,226,800	5,170,876,000	5,112,025,100	5,048,871,700	5,012,278,200
Deciduous Orchards	521,852,500	521,331,700	518,934,600	513,814,500	508,329,300	505,141,700
Processing Tomatoes	19,572,500	19,127,100	16,927,300	12,131,200	6,968,900	3,993,200
Vine	445,079,700	438,727,900	409,682,600	347,766,600	281,466,700	242,907,100
Alfalfa & Pasture	54,631,000	54,631,000	54,631,000	54,631,000	54,631,000	54,631,000
Corn and All Silage	0	0	0	0	0	0
Wheat & Field Crops	32,223,600	32,223,600	32,223,600	32,223,600	32,223,600	32,223,600
Almonds & Pistachios	0	0	0	0	0	0
Cotton	0	0	0	0	0	0
Rice	0	0	0	0	0	0
Total	6,277,384,500	6,264,268,100	6,203,275,100	6,072,592,000	5,932,491,200	5,851,174,800
Change from existing		-0.2%	-1.2%	-3.3%	-5.5%	-6.8%

CASRAA model crop revenue estimates for an average year by crop group for existing and each flow scenario under no replacement groundwater pumping conditions.

Southern California

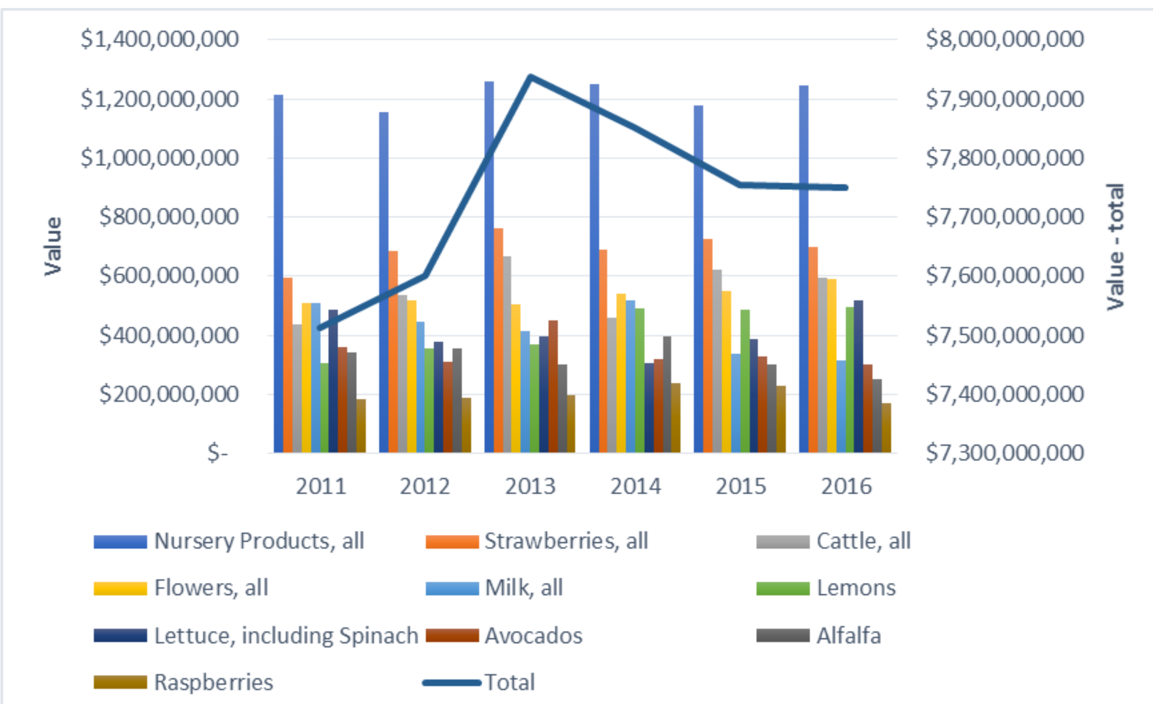
Table 8.4-19 shows the top-producing commodities in Southern California.

Table 8.4-19. Top-Producing Commodities in Southern California, by Production Revenue, 2011–2016 average

Commodity	Revenue
Nursery Products, all	$1,216,964,833
Strawberries, all	$692,925,283
Cattle, all	$552,374,500
Flowers, all	$535,359,600
Milk, all	$422,256,500
Lemons	$418,063,667
Lettuce, including Spinach	$412,224,083
Avocados	$344,963,500
Alfalfa	$325,071,333
Raspberries	$201,514,833
Total—all commodities	**$7,735,063,588**

Sources: CDFA 2011–2016.

Figure 8.4-13 shows commodity revenue can vary considerably from year to year.



Sources: CDFA 2011–2016.

Figure 8.4-13. Top-Producing Commodities, and Total of All Commodities, by Revenue in Southern California (2011–2016)

As discussed in Section 2.8, Southern California water sources include imported supplies from several sources, local surface water supplies and groundwater, as well as some recycled and desalinated water supplies. There are several sources of imported water supplies to Southern California, including SWP Sacramento/Delta water supplies. Sacramento/Delta water supply is conveyed to Southern California SWP contractors through the California Aqueduct. The California Aqueduct splits into two branches after crossing the Tehachapi Mountains: the West Branch and the East Branch. The West Branch delivers water to Lake Castaic and provides water to western Los Angeles County and vicinity. The East Branch delivers water to the Antelope Valley, San Bernardino/Riverside areas, and eventually to Lake Perris near Hemet. The East Branch and West Branch Aqueducts supply 13 SWP contractors, including the Metropolitan Water District of Southern California (MWD), a regional wholesaler that provides water to 19 million southern California residents. MWD has 26 member agencies, and water supplied to MWD is used within each member agency's service area. While most of the MWD's water supplies are ultimately used for municipal uses, MWD also provides a small portion of this water for agricultural water use.

Among MWD's 26 member agencies, four report providing water for agricultural use in their urban water management plans (Calleguas 2016, EMWD 2016, SDCWA 2016, WMWD 2016). These agencies include Calleguas Municipal Water District, Eastern Municipal Water District, San Diego County Water Authority (SDCWA), and Western Municipal Water District. The estimated total agricultural water demand in 2030 for these member agencies is provided in Table 8.4-20.

Table 8.4-20. Estimated Total Agricultural Water Demand, MWD Member Agencies

Metropolitan Water District of Southern California Member Agency	Estimated 2030 Average Annual Agricultural Water Demand (acre-feet)
Calleguas Municipal Water District	4,848
Eastern Municipal Water District	2,900
San Diego County Water Authority	49,897
Western Municipal Water District	11,358

Sources: Calleguas 2016; EMWD 2016; SDCWA 2016; WMWD 2016.

The CASRAA analysis was applied to the MWD and its member districts that provide Sacramento/Delta water supplies to agricultural irrigation customers. The analysis assumes that the reduced Sacramento/Delta water supply would not be replaced by other sources, and would lead to fallowing of crop land. For this reason, the impact analysis represents a conservative outcome for the purposes of estimating potential impacts on agricultural lands and may overestimate the economic effects. Changes in water supply are based on SacWAM output for the flow scenarios.

Table 8.4-21 presents the modeled total estimated agricultural crop revenues for baseline and each flow scenario for an average water year, with no replacement groundwater pumping. Figure 8.4-14 presents the corresponding change in revenue by crop category. Table 8.4-22 presents the modeled total estimated agricultural crop revenues for the baseline and each flow scenario for a dry water year, with no replacement groundwater pumping. Figure 8.4-15 presents the corresponding change in revenue by crop category. The results indicate that crop revenues would generally decrease with increasing flow scenarios. Commodities such as avocados and citrus are anticipated to be the most likely affected crops.

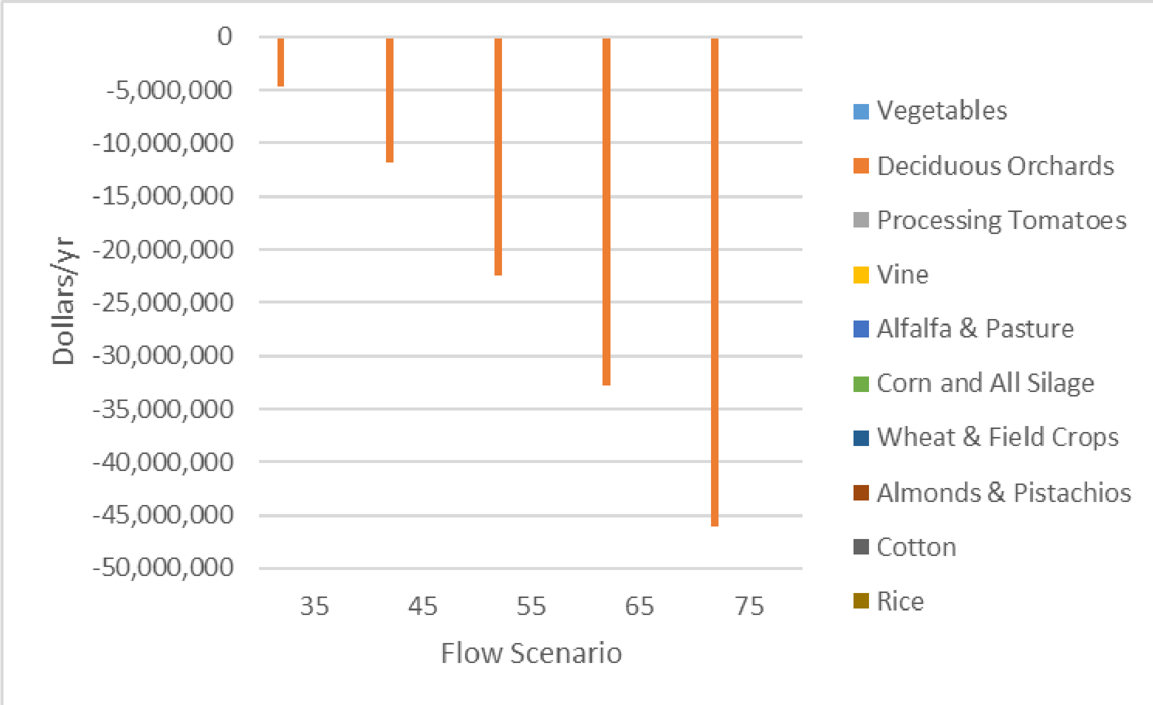


Figure 8.4-14. Changes in Crop Revenue, Southern California, CASRAA Model Analysis, Average Year, No Replacement Groundwater Pumping

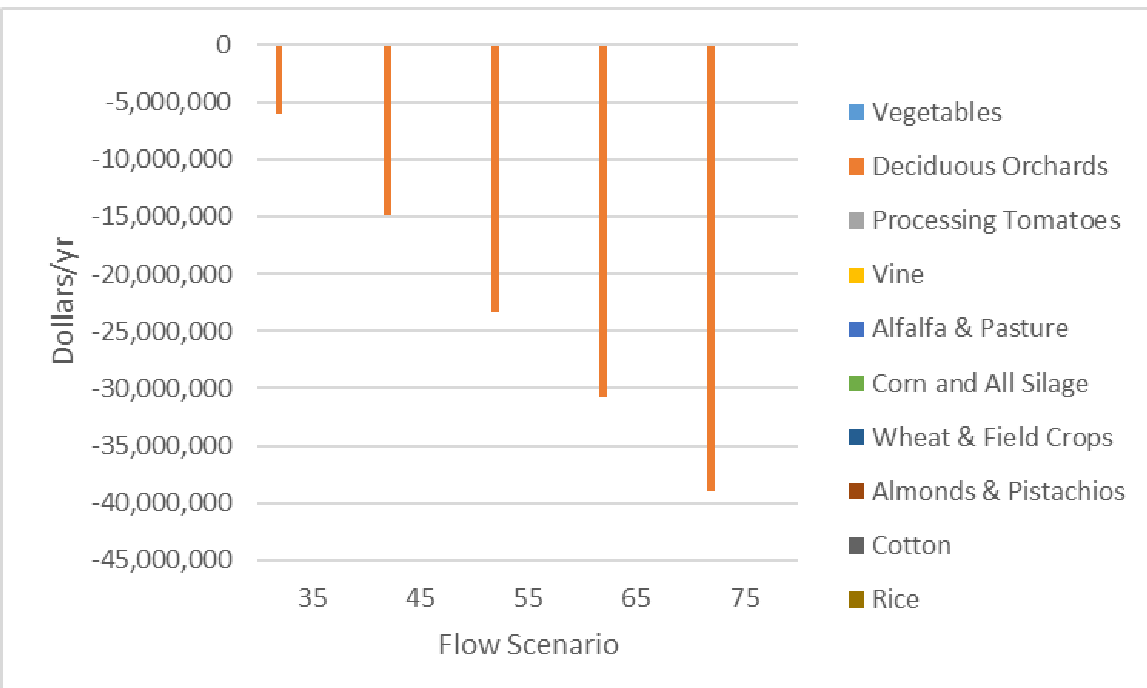


Figure 8.4-15. Changes in Crop Revenue, Southern California, CASRAA Model Analysis, Dry Year, No Replacement Groundwater Pumping

Table 8.4-21. Average Year: Crop Revenue in Southern California, CASRAA Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Vegetables	1,306,664,200	1,306,664,200	1,306,664,200	1,306,664,200	1,306,664,200	1,306,664,200
Deciduous Orchards	763,027,200	758,381,400	751,160,200	740,584,200	730,157,000	716,890,200
Processing Tomatoes	0	0	0	0	0	0
Vine	80,076,600	80,076,600	80,076,600	80,076,600	80,076,600	80,076,600
Alfalfa & Pasture	631,434,900	631,434,900	631,434,900	631,434,900	631,434,900	631,434,900
Corn and All Silage	7,926,000	7,926,000	7,926,000	7,926,000	7,926,000	7,926,000
Wheat & Field Crops	186,518,700	186,518,700	186,518,700	186,518,700	186,518,700	186,518,700
Almonds & Pistachios	0	0	0	0	0	0
Cotton	45,220,200	45,220,200	45,220,200	45,220,200	45,220,200	45,220,200
Rice	0	0	0	0	0	0
Total	3,020,867,800	3,016,222,000	3,009,000,800	2,998,424,800	2,987,997,600	2,974,730,800
Change from existing		-0.2%	-0.4%	-0.7%	-1.1%	-1.5%

CASRAA model crop revenue estimates for an average year by crop group for existing and each flow scenario under no replacement groundwater pumping conditions.

Table 8.4-22. Dry Year: Crop Revenue in Southern California, CASRAA Model Analysis, No Replacement Groundwater Pumping ($)

Crop Group	Existing	35	45	55	65	75
Vegetables	1,306,664,200	1,306,664,200	1,306,664,200	1,306,664,200	1,306,664,200	1,306,664,200
Deciduous Orchards	763,027,200	757,009,000	748,140,000	739,632,600	732,296,800	724,017,600
Processing Tomatoes	0	0	0	0	0	0
Vine	80,076,600	80,076,600	80,076,600	80,076,600	80,076,600	80,076,600
Alfalfa & Pasture	631,434,900	631,434,900	631,434,900	631,434,900	631,434,900	631,434,900
Corn and All Silage	7,926,000	7,926,000	7,926,000	7,926,000	7,926,000	7,926,000
Wheat & Field Crops	186,518,700	186,518,700	186,518,700	186,518,700	186,518,700	186,518,700
Almonds & Pistachios	0	0	0	0	0	0
Cotton	45,220,200	45,220,200	45,220,200	45,220,200	45,220,200	45,220,200
Rice	0	0	0	0	0	0
Total	3,020,867,800	3,014,849,600	3,005,980,600	2,997,473,200	2,990,137,400	2,981,858,200
Change from existing		-0.2%	-0.5%	-0.8%	-1.0%	-1.3%

CASRAA model crop revenue estimates for an average year by crop group for existing and each flow scenario under no replacement groundwater pumping conditions.

As discussed in Section 7.12.2, *Groundwater*, when faced with reduced surface water supplies, growers may replace some of that reduction with groundwater and/or local surface water supplies; however, there is often uncertainty about how much groundwater is available. Growers will also weigh the generally higher cost of groundwater against other cropping alternatives that require less water. In cases with little or no available groundwater, or profitable crop alternatives, growers may instead choose to fallow lands that had been farmed under baseline. However, it is not possible to precisely anticipate the magnitude of these effects. While the CASRAA model results may provide for conservative estimates of changes in crop acreage and corresponding changes in revenue because the model results assume that growers would not replace reduced surface water supplies with groundwater, the results do not attempt to model permanent agricultural land conversion to nonagricultural use as this would be speculative.

8.4.2.4 Effects on Farming-Dependent Industries

Providers of agricultural services, food processors, and other farming product–dependent industries such as dairies and livestock could be affected by changes in crop production in both the Sacramento/Delta and San Joaquin Valley. This section qualitatively assesses anticipated economic effects on these farming-dependent industries under the proposed Plan amendments, based on the outcomes of the SWAP analysis. The analysis considers reductions in service opportunities and related employment and, in the case of processors, dairies, and livestock, alternative sources of raw products or inputs.

Based on the CASRAA results, other geographic regions of the study area (including the San Francisco Bay Area, Central Coast, and Southern California) would experience a smaller change in agricultural production compared to the Sacramento/Delta watershed and San Joaquin Valley, and associated change in crop revenue would also be smaller under the proposed Plan amendments. For this reason, it is assumed that economic effects farming-dependent industries in the San Francisco Bay Area, Central Coast, and Southern California would be negligible.

Section 7.4, *Agriculture and Forest Resources*, discusses the crop types that would experience the largest change in acreage under the proposed Plan amendments based on SWAP model results. In the Sacramento/Delta watershed, under the 55 scenario and during an average year, if groundwater is not used to offset Sacramento/Delta surface water supply reductions, the crop acres primarily in decline include alfalfa and pasture, and rice. In the San Joaquin Valley, under the 55 scenario and during an average year, if groundwater is not used to offset surface water supply reductions, the model results indicate the largest reductions in terms of percentage would be wheat and field crops, alfalfa and pasture, and corn and other silage. Under the 55 percent unimpaired flow scenario and during a dry year, if groundwater is not used to offset surface water supply reductions, the model results indicate the largest reductions in crop acreage are in cotton, and wheat and field crop acres. Other categories with reductions in crop acreage include alfalfa and pasture and processing tomatoes.

Agricultural Services

Agricultural service companies provide support activities for farms that produce crops. As the SWAP model results for the Sacramento/Delta watershed indicate, under the proposed Plan amendments, reductions in Sacramento/Delta surface water supply would primarily affect production of rice, and alfalfa and pasture, although some other crop categories such as corn could also be affected. Suppliers for these farm types would be most affected by the proposed Plan amendments. In the San

Joaquin Valley, under the proposed Plan amendments (55 flow scenario), reductions in Sacramento/Delta surface water supply would primarily affect production of wheat and field crops, alfalfa and pasture, and corn and other silage. During a dry year, the model results indicate the largest reductions in crop acreage are in cotton, and wheat and field crops. Other categories with lesser reductions in crop acreage include alfalfa and pasture and processing tomatoes. The suppliers for these industries would be most affected.

Food Processing

For many food processors, there is a direct relationship between farm production levels and output (sales) and employment in value-added processing. Reductions in crop acreage and associated production could therefore adversely affect processing businesses. Processing facilities rely upon product flow from farms and size their processing plant according to expected quantities. If farm production of crops that are typically processed is estimated to decline substantially, food processing could eventually become unprofitable, and some food processing plants could choose to close. Farmers producing those crops could then lose their buyers.

The SWAP model results indicate that several types of crops could experience a change in crop acreage due to reduced Sacramento/Delta surface water supplies under the proposed Plan amendments that could affect associated food processing businesses. A summary is provided below. Detailed SWAP model results are available in Appendix A3, *Agricultural Economic Effects: SWAP Methodology and Modeling Results*.

As discussed above, the SWAP model results indicate that the proposed Plan amendments would result in a decrease in rice acreage in the Sacramento/Delta watershed, and there could be an accompanying effect on rice millers in the Sacramento/Delta. Under the highest flow scenarios, it is possible that some rice milling facilities could cease operations.

The SWAP model results indicate that the proposed Plan amendments would result in a decrease in acreage of processing tomatoes, which are produced in the southern portion of the Sacramento/Delta watershed and in the northern San Joaquin Valley. The SWAP model results indicate that the change in acreage of processing tomatoes in the Sacramento/Delta watershed would be relatively small (limited to approximately 1,000 to 4,000 acres under the 45 to 65 percent unimpaired flow scenarios), which would be expected to have a negligible effect on tomato processing plants. The change in acreage of processing tomatoes in the San Joaquin Valley region would be larger (approximately 1,500 to 19,000 acres under the 45 to 65 percent unimpaired flow scenarios) and could have a moderate effect on tomato processing plants in the San Joaquin Valley, particularly under the 65 percent unimpaired flow scenario.

The SWAP model results indicate that the proposed Plan amendments could affect the acreage of wheat and field crops in the Sacramento/Delta and San Joaquin Valley, which could affect grain mills. In the Sacramento/Delta, the SWAP model results indicate that wheat and field crops acreage could increase above the baseline under the proposed Plan amendments. This result reflects an economic assumption that some growers could substitute alfalfa and pasture, rice, and other crop acreage to wheat and field crops acreage that have lower applied water requirements. Accordingly, grain mills in the Sacramento/Delta watershed would not likely experience adverse effects. However, in the San Joaquin Valley, the SWAP model results indicate that wheat and field crops could decrease under the proposed Plan amendments. Some effect on grain mills in the San Joaquin Valley could occur under the proposed Plan amendments, particularly under the higher flow scenarios. However, these negative effects could be partially offset by increased production of wheat and field crops in the Sacramento/Delta watershed.

The SWAP model results indicate that almond and pistachio production could decrease in both the Sacramento/Delta watershed and San Joaquin Valley regions under the proposed Plan amendments. These decreases could similarly affect nut processors, although the effects would be felt gradually over time as producers would likely remove the least productive or older trees first. This could allow processors some time to adjust to the decline in supply, but nut processors would be expected to experience a negative economic effect.

The SWAP model results indicate that corn and silage production would be reduced in the Sacramento/Delta watershed and the San Joaquin Valley regions under the proposed Plan amendments. Some grain corn millers could be affected, particularly under the higher flow scenarios.

The SWAP model results indicate that cotton production would be reduced under the proposed Plan amendments. Cotton production takes place largely in the San Joaquin Valley, and changes in cotton production volume compared to baseline would be much greater under the 65 scenario compared to the 45 to 55 scenarios. Ginning mills could be negatively affected by a reduction in cotton production.

Several other crop types experience smaller changes in crop acreage under the proposed Plan amendments, and effects on associated processors (e.g., fruit processors, walnut processors) would likely be small or negligible, although some effects are possible.

Livestock

Dairy farms, dairy-based processed foods, and beef cattle are among the industries reliant on irrigated crops in both the Sacramento/Delta and San Joaquin Valley regions. Several crop types that are utilized by livestock would be affected by reductions in crop acreage under the proposed Plan amendments, such as alfalfa and pasture, corn silage, and other field crops that produce forage for livestock. Detailed information regarding changes in crop acreage is presented in Appendix A3, *Agricultural Economic Analysis: SWAP Methodology and Modeling Results*. Potential effects on these industries are discussed in this section.

Dairy Farms

As discussed in Section 8.2.6, *Farming Dependent Services*, the majority of the state’s dairy cows are located in the San Joaquin Valley. The majority of California’s dairy farms are also located in the San Joaquin Valley. There are also dairy cows and farms in the Sacramento/Delta watershed. Dairy farms in both regions rely on locally grown corn silage and other field crops, alfalfa hay, feed grains, and other locally available byproducts, such as almond hulls and cottonseed meal. Silage and field crops are grown in proximity to dairies because of the high transport cost. Alfalfa is also grown in the Sacramento/Delta and San Joaquin Valley for dairies, but the areas are net importers of alfalfa that use alfalfa grown in other areas.

As discussed above, the SWAP model results indicate that the proposed Plan amendments would result in a decrease in alfalfa and pasture production. In the Sacramento/Delta, a decrease in alfalfa production could result in increased imports of alfalfa to supply the needs of livestock, a trend that is already taking place under existing conditions. The SWAP model results indicate that the decrease in acreage of alfalfa production would be greater during dry years, so these associated effects would also be expected to be greater during dry years. In addition, in the SWAP model results indicate that there could also be a decrease in silage and field crop production, but the change in crop acreage would be relatively small, and dairies could respond to this change by revising their feed rations if necessary to substitute in other, more abundant byproducts. Adjustments to feed rations could result in higher costs to dairy operators during some years, either from the need to acquire alternative feed at a higher unit cost, or from transporting feed from more distant sources. For example, obtaining replacement alfalfa from other states could add 0.08 to 0.25 percent to the total cost of production for dairies.[8]

The SWAP model results indicate that similar effects could occur in the San Joaquin Valley under the proposed Plan amendments. The SWAP model results indicate that there could be a decrease in crop acreage of corn and silage, alfalfa and pasture, and wheat and field crops in the San Joaquin Valley. The decrease in the acreage of these crops has the potential to negatively affect dairy farms. Farmers could respond by revising feed rations to acquire more readily available byproducts. As discussed above, the San Joaquin Valley region is also a net importer of feedstock and relies on alfalfa from other regions in California and nearby states under existing conditions. A reduction in alfalfa acreage in the San Joaquin Valley could affect alfalfa feed costs if the proportion of alfalfa imported to the region increases. Additional imports of alfalfa could result in higher feed cost that reflect higher transportation costs. For example, by assuming a higher replacement silage or a wet roughage substitute cost, combined with an increased cost for alfalfa hay imported from other states, the cost of production to dairies would increase by about 0.4 percent under the 75 scenario; this effect would be less under the other flow scenarios.[9]

Overall, although the change in acreage of crops used as livestock feed could result in additional costs for dairies, the overall effect on milk production would be expected to be limited. In the San Joaquin Valley, wet and dry roughage feed combined accounts for only about a third of milk production costs. Even so, somewhat higher costs for more imported hay will generally have only a limited effect on overall milk production costs, and less influence on producer decisions than milk prices.

Beef Cattle

As discussed above, the proposed Plan amendments could result in a reduction in crop acreage of several types of crops that are used as livestock feed. Cattle production in the Sacramento/Delta watershed and San Joaquin valley could be affected to the extent that cattle production relies on hay, feed grain, and irrigated pasture. Cattle operations vary in terms of reliance on irrigated pasture compared to non-irrigated rangeland, and cattle operations that are reliant on non-irrigated rangeland would not be expected to experience effects related to additional feed costs. However, cattle operations in these regions that rely on irrigated pasture for feed could experience economic effects as a result of a reduction in acreage of irrigated pasture. Some cattle operations may substitute irrigated pasture feed with other feedstock, which would be expected to incur a higher cost than pasture. In addition, the reduction in alfalfa hay and irrigated pasture production within

[8] The cost to transport hay from Imperial Valley to Tulare dairies was assumed to be $45 to $50 per ton. By assuming an additional cost of $100 per ton for alfalfa for hay from Nevada or Arizona, the weighted average cost for all purchased alfalfa increases by 1 to 2 percent. Hay is approximately 11 percent of total production cost for dairies (derived from CDFA 2015, p. 9), resulting in an increase of 0.08 to 0.25 percent of total production cost.

[9] A cost of $100 per ton for a silage replacement, or the added cost of transporting silage from more distant locations, was assumed for this analysis. Furthermore, an additional transport cost of $100 per ton was assumed for alfalfa obtained from nearby states.

these regions could result in additional imports of feedstock from other states, or larger carryover stockpiles of hay grown in wetter years. Some substitution among feedstocks, involving almond hulls or cottonseed meal, could offset the cost of feed, but the net effect would likely be higher cost of production. Overall, these changes would be expected to increase the production cost of raising beef cattle.

8.4.3 Regional Economic Effects

8.4.3.1 Regional Economic Effects Analysis Approach

Changes in agricultural production could result in additional economic effects that affect total industry output (sales), income, and employment. These effects are discussed and evaluated in this section, for the Sacramento/Delta watershed and for the State of California.

A regional economic analysis was conducted to estimate how changes in water supply and resulting changes at the local agricultural economy would affect regional economic activity in the Sacramento/Delta watershed and the state as a whole. The regional economic analysis estimates how changes in agricultural production could cause additional effects that affect total industry output (sales), income, and employment. The regional economic analysis relies on the IMPLAN Input-Output modeling system. IMPLAN is a widely-used, proprietary data and modeling software system. SWAP model results for crop revenues and expenditures under the flow scenarios were the primary inputs to the regional economic modeling.

The analyses presented in this section do not incorporate the results of the CASRAA analysis. Additional localized effects are possible as a result of changes in water supply and crop acreage in the San Francisco Bay Area, Central Coast, and Southern California. However, because the changes in crop acreage in these regions is smaller than the changes that would occur in the Sacramento/Delta watershed and San Joaquin Valley, these additional changes would be expected to be negligible on a statewide level.

Appendix A4, *Regional Economic Analysis Modeling Procedure*, provides more information regarding IMPLAN and the approach and procedure used to evaluate regional economic effects as well as detailed results based on model output.

Two regional models were constructed to analyze regional economic effects in the following two areas.

- **Plan Area (Sacramento/Delta) Regional Model**—The model consists of 22 contiguous counties encompassing the geographic scope of the Sacramento River watershed, Delta eastside tributaries, and Delta regions; it includes the location of source waters directly affected by the proposed Plan amendments.
- **State of California Model**—The model includes all 58 counties in the state of California.

The purpose for having two models is to capture how the proposed Plan amendments would affect the regional economy in the respective areas. The Plan Area (Sacramento/Delta) regional model estimates regional economic effects in the areas where Sacramento/Delta supplies originate in or are diverted from. It provides useful information on the economic effects within the Sacramento/Delta watershed. However, there could be additional effects in the other geographic regions of the study area. The State of California model therefore allows for the capture of the extent of the ripple effects through all sectors of the economy throughout the state.

8.4.3.2 Sacramento/Delta Watershed Regional Analysis

The Sacramento/Delta regional analysis relies upon SWAP model results for agricultural sectors' revenues and expenditures under the various flow scenarios for the Sacramento/Delta. The Sacramento/Delta regional analysis provides the direct economic effects of changes relative to baseline conditions in purchases of agricultural inputs, and payments to labor and net income, plus indirect and induced effects on 536 IMPLAN industry sectors, 9 household income categories, and state and local governments in the Sacramento/Delta watershed. For ease of presentation, the detailed IMPLAN model results are aggregated to 19 higher-level industry categories, which are presented in Appendix A4, *Regional Economic Analysis Modeling Procedure*. A summary of the Sacramento/Delta regional analysis results for the flow scenarios is presented in Table 8.4-23.

Table 8.4-23. Summary of IMPLAN-Estimated Regional Economic Effects in the Sacramento/Delta from SWAP-Modeled Changes in Agricultural Production by Flow Scenario

	Change in:		
Flow Scenario	Output ($ millions)	Income ($ millions)	Number of Jobs
35	-131	-72	-1,324
45	-217	-121	-2,214
55	-416	-234	-4,283
65	-793	-445	-8,149
75	-1,392	-779	-14,280

As shown in Table 8.4-23, results from the Sacramento/Delta regional analysis show that regional output (sales), income and employment would be affected by changes in Sacramento/Delta supply. Overall, the results show that there would be effects on regional output (sales), income, and employment under all the flow scenarios. The effects would be largest under the 75 scenario, and smallest under the 35 scenario.

Detailed results for all 19 higher-level industry categories for all flow scenarios are provided in Appendix A4, *Regional Economic Analysis Modeling Procedure*. Table 8.4-24 shows results for the 55 scenario, showing the direct, indirect, and induced effects.

Table 8.4-24. IMPLAN-Estimated Economic Effects on the Sacramento/Delta Regional Economy Due to SWAP-Modeled Changes in Agricultural Production under the 55 Scenario

Industry/Sector	Change in Output ($ millions)	Change in Income ($ millions)	Change in Number of Jobs
55 Scenario			
Agriculture	-130	-127	-2,240
Other Natural Resources & Mining	-30	-18	-423
Utilities	-4	-1	-24
Construction	-13	-2	-15
Food Processing	-1	-0	-2
Other Non-Durables Manufacturing	-21	-1	-12
Durables Manufacturing	-1	-0	-4
Transportation & Warehousing	-14	-4	-60
Wholesale Trade	-7	-2	-46
Retail Trade	-25	-11	-269
Information & Communications Services	-8	-1	-16
Finance, Insurance, & Real Estate Services	-37	-8	-175
Legal, Rental, Professional, Scientific, Mgt & Tech Services	-30	-13	-216
Employment, Administrative, & Waste Services	-6	-3	-89
Education, Health & Social Services	-22	-13	-228
Arts, Entertainment & Recreation Services	-2	-1	-34
Accommodation & Food Service	-9	-3	-135
Other Services	-13	-6	-133
Government & Miscellaneous	-44	-17	-163
Totals	-416	-234	-4,283
Total FTE jobs (total income/average earnings per job)	-	-	*-4,099*

Source: Appendix A4, *Regional Economic Analysis Modeling Procedure,* IMPLAN results for the Sacramento/Delta Regional Model. Combined direct, indirect, and induced effects on business, household, and government sectors in the Sacramento/Delta regional economy attributable to backward linkage effects of modeled agricultural production activities, expressed as change relative to estimated effects of baseline (existing) condition agricultural activity.
FTE = full time equivalent.

The results in the Table 8.4-24 indicate that, under the 55 scenario, most of the effects are concentrated in agriculture and related sectors, but some effects are distributed throughout the other sectors in the regional economy as well. Results shown in Appendix A4, *Regional Economic Analysis Modeling Procedure*, for the other flow scenarios are similar to those shown above, but the effects are less under the 35 and 45 scenarios and greater under the 65 and 75 scenarios.

8.4.3.3 State of California Analysis

The State of California analysis relies upon SWAP model results for agricultural sectors' revenues and expenditures under the various flow scenarios for the Sacramento/Delta watershed and the San Joaquin Valley. These results are shown below in Table 8.4-25; the table summarizes the direct economic effects of changes in revenues and expenditures by the affected agricultural sectors plus indirect and induced effects on the 536 IMPLAN industry sectors relative to baseline in the 58-county IMPLAN California state model. This analysis captures the broader level recirculation of expenditures, including additional economic effects the extend beyond the Sacramento/Delta regional analysis. For ease of presentation, the detailed IMPLAN model results are aggregated to 19 higher-level industry categories, which are presented in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

Table 8.4-25. IMPLAN-Estimated Economic Effects on the California Economy from SWAP-Modeled Changes in Agricultural Production by Flow Scenario

	Change in:		
Flow Scenario	Output $ millions)	Income ($ millions)	Number of Jobs
35	-209	-112	-1,790
45	-497	-266	-4,216
55	-996	-535	-8,490
65	-2,220	-1,202	-19,012
75	-3,650	-1,975	-31,322

As shown in Table 8.4-25, results from the State of California analysis show that output (sales), income, and employment would be affected by changes in Sacramento/Delta supply. Overall, there would be effects on output (sales) income, and employment under all flow scenarios. The effects would be largest under the 75 scenario, and would be smallest under the 35 scenario. The modeled statewide effects are also larger than the modeled effects for the Sacramento/Delta watershed.

Detailed results for all 19 higher-level industry categories for all flow scenarios are provided in Appendix A4, *Regional Economic Analysis Modeling Procedure*. Table 8.4-26 provides results for the 55 scenario, showing the direct, indirect, and induced effects.

Table 8.4-26. IMPLAN-Estimated Economic Effects on California Statewide Economy Due to SWAP-Modeled Changes in Agricultural Production under the 55 Scenario

Industry/Sector	Change in Output ($ millions)	Change in Income ($ millions)	Change in Number of Jobs
55 Scenario			
Agriculture	-282	-276	-4,161
Other Natural Resources & Mining	-63	-37	-900
Utilities	-9	-3	-50
Construction	-49	-10	-56
Food Processing	-9	-1	-18
Other Non-Durables Manufacturing	-64	-5	-47
Durables Manufacturing	-9	-2	-27
Transportation & Warehousing	-36	-12	-135
Wholesale Trade	-21	-7	-115
Retail Trade	-55	-25	-566
Information & Communications Services	-27	-7	-43
Finance, Insurance, & Real Estate Services	-86	-23	-344
Legal, Rental, Professional, Scientific, Mgt & Tech Services	-85	-42	-496
Employment, Administrative, & Waste Services	-14	-7	-190
Education, Health & Social Services	-49	-30	-501
Arts, Entertainment & Recreation Services	-7	-3	-75
Accommodation & Food Service	-20	-8	-294
Other Services	-30	-14	-291
Government & Miscellaneous	-79	-22	-182
Totals	-996	-535	-8,490
Total FTE jobs (total income/average earnings per job)	-	-	*-8,059*

Source: Appendix A4, *Regional Economic Analysis Modeling Procedure,* IMPLAN results for the State of California Model. Combined direct, indirect, and induced effects on business, household, and government sectors in the California statewide economy attributable to backward linkage effects of modeled agricultural production activities, expressed as change relative to estimated effects of baseline (existing) condition agricultural activity.
FTE = full time equivalent

8.4.4 Agricultural Economic Effects on Economically Disadvantaged Communities

In California, DACs (also sometimes referred to as *environmental justice communities* or *vulnerable communities*) are formally defined by a variety of factors, including pollutant burdens and population characteristics. Chapter 10, *Economically Disadvantaged Communities,* provides an overview of DACs and their water supplies; the chapter incorporates information from several other sections and chapters to summarize possible effects of the Sacramento/Delta update to the Bay-Delta Plan on DACs under current regulatory conditions. The State Water Board is at the forefront of assisting DACs with obtaining clean, safe, and reliable water supplies, and Chapter 10 also discusses relevant State Water Board financial and technical assistance programs.

This section discusses potential agricultural economic effects of the flow scenarios on DACs. In particular, the assessment considers the extent to which reduced Sacramento/Delta surface water supply and changes in crop acreage could affect agriculture-related employment in and associated with DACs.

Figure 8.4-16[10] displays the median household income (MHI) level for census block groups within the study area; the figure shows that DACs and severely disadvantaged communities (SDACs) occur in each of the geographic regions of the study area. Also displayed on the map is the exterior boundary extent of the SWAP agricultural model.

IMPLAN model results from the California Statewide Economy analysis are presented below and provide employment information relevant to agricultural economic effects on DACs. The SWAP agricultural model results are used as input to IMPLAN. Results for changes in number of agriculture related jobs are presented below. Detailed model results are provided in Appendix A4, *Regional Economic Analysis Modeling Procedure*. As discussed previously, the IMPLAN model results for the California Statewide Economy analysis assume that groundwater would not be used as a replacement for reduced Sacramento/Delta surface water supplies. In reality, some individual water users could choose to increase groundwater pumping as a substitute supply, where available and not locally restricted. If individual water users choose to increase groundwater pumping as a substitute supply, the reductions in crop acreage and associated agricultural economic effects could be less than indicated by the IMPLAN modeling results.

Table 8.4-27. Estimated Change in Agriculture Output, Income, and Jobs for Each Flow Scenario

	Change in:		
Scenario	Output ($ millions)	Income ($ millions)	Number of Jobs
35 scenario	-58	-57	-861
45 scenario	-139	-136	-2,046
55 scenario	-282	-276	-4,161
65 scenario	-644	-630	-9,504
75 scenario	-1,055	-1,030	-15,554

The results presented in Table 8.4-27 show change in agriculture output, income, and jobs under the flow scenarios compared to baseline. Information on changes in crop revenues presented in prior sections show that economic effects would occur primarily in the Sacramento/Delta watershed and San Joaquin Valley regions, and the change in agriculture employment would also be expected to occur primarily in these regions. However, some localized effects are also possible in the San Francisco Bay Area, Central Coast, and Southern California regions. Many of the agriculture jobs indicated above may correspond to agricultural laborers who may reside in DACs. Farm laborers and communities associated with farm types that would experience changes in crop acreage could be affected.

The IMPLAN results also identify changes in employment for other categories, including some additional agricultural support jobs (in the category of "Other Natural Resources and Mining") and food processing jobs (in the category of "Food Processing") that could also decrease. These results are presented below, and in Appendix A4, *Regional Economic Analysis Modeling Procedure*. These

[10] Figure 8.4-16 is related to Figure 10-1 from Chapter 10, *Economically Disadvantaged Communities*.

changes could have some additional employment-related effects relevant to DACs, although some of these employment types may not directly relate to DACs.

Table 8.4-28. Estimated Change in Other Natural Resources and Mining Output, Income, and Jobs for Each Flow Scenario

	Change in:		
Scenario	Output ($ millions)	Income ($ millions)	Number of Jobs
35 scenario	-15	-9	-220
45 scenario	-32	-19	-459
55 scenario	-63	-37	-900
65 scenario	-129	-76	-1,836
75 scenario	-220	-129	-3,121

Table 8.4-29. Estimated Change in Food Processing Output, Income, and Jobs for Each Flow Scenario

	Change in:		
Scenario	Output ($ millions)	Income ($ millions)	Number of Jobs
35 scenario	-2	0	-4
45 scenario	-4	-1	-9
55 scenario	-9	-1	-18
65 scenario	-20	-2	-41
75 scenario	-33	-4	-67

The IMPLAN results presented above show that changes in employment for the other natural resources and mining and food processing categories would be smaller compared to the changes in employment for the agriculture category. However, it is possible that some additional jobs located in and near DACs could be affected. For example, some decline in employment is possible among rice milling and almond and walnut processing jobs. In addition, some employment related to transportation of certain crops (e.g., hay products) could be affected.

8.4.5 Financial Assistance for Agricultural Water Conservation

Numerous current and past financial assistance programs have been used to support agricultural water conservation efforts, including federal and state funded assistance programs. This section discusses and provides examples of financial assistance programs that support agricultural water conservation related efforts. Current and past financial assistance programs related to agricultural water conservation efforts have provided funding for research, planning, and implementation of measures to conserve water and use water more efficiently for agricultural purposes. Examples of public financing include grant funds; single-purpose appropriations from federal, state, and/or local legislative bodies; and bond indebtedness and loans from government institutions.

For most of these programs, the explicit goal includes water conservation, but unless the saved water is explicitly designated for other purposes (such as groundwater recharge or instream flow enhancement), many water conservation projects may not necessarily result in a reduction in surface water diversions and increased instream flows; water may be retained by the water users for supply enhancement or use on existing farmland (e.g., increasing crop acreage).

8.4.5.1 Recent Funding for Agricultural Water Conservation

Examples of agricultural water conservation projects funded by recent federal and state funding programs are described in the following subsections.

Bay-Delta Initiative

The Bay-Delta Initiative (BDI) Program was a U.S. Department of Agriculture (USDA) effort. The BDI program provided financial assistance for multiple projects. In 2011, the State of California used Bay Delta Initiative (BDI) funds to partner on a joint pilot project with Reclamation to improve irrigation infrastructure as well as improve on-farm irrigation efficiencies. The project included five water storage and irrigation districts in the Central Valley and resulted in irrigation system improvements. (USDA NRCS 2011).

In 2013, $500,000 was provided to agricultural water users in the South San Joaquin Irrigation District, Division Nine Irrigation Enhancement Area. The funding was used to install new pipelines, micro-irrigation sprinklers, and other equipment for on-farm water conservation.

From fiscal year (FY) 2014 through FY 2016, the BDI Program received almost $40 million in funding (USDA NRCS n.d.(a)).

Agricultural Water Enhancement Program

USDA's Agricultural Water Enhancement Program (AWEP), was part of the Environmental Quality Incentives Program (EQIP). The program was targeted at promoting groundwater and surface water conservation and water quality improvements on agricultural lands. Between FY 2009 and FY 2016, over $350 million of AWEP funds were provided for various projects. Of these total funds, 28 percent were allocated to California projects (USDA NRCS n.d.(b)).

The Anderson Cottonwood Irrigation District (ACID) Water Efficiency Improvement Project was funded by AWEP. A $2.8 million grant from AWEP, along with funds from participating ACID customers, enabled ACID to replace lateral ditches with underground pipelines to reduce water losses, add water control structures, and plant selected areas for erosion control purposes. Between 2010 and 2013, 54 landowners in the irrigation district participated in this project. Efficiency improvements enabled the water district to deliver water needed by customers despite mandatory water cutbacks during the drought in 2014 and 2015 (USDA NRCS 2011, 2015).

Agricultural Drainage Management Loan Program

The state-funded Agricultural Drainage Management Loan Program (ADMLP) provided loan and grant funding for land and facilities for the treatment, storage, conveyance, reduction, or disposal of agricultural drainage water that, if discharged untreated, would pollute or threaten to pollute the waters of the state. This program was available to any city, county, district, joint power authority, or other political subdivision of the state involved with water management.

One project that was funded through the ADMLP was the Panoche Drainage District Irrigation System Improvement Project. This project replaced less efficient irrigation systems (e.g., head-ditch/furrow and siphon tube irrigation) with more efficient irrigation systems (e.g., tailwater recirculation system, gated-pipe/furrow, drip, or micro sprinkler systems with water recycling systems). These improvements resulted in reduced irrigation tailwater and contaminants (including selenium, boron, salt, and oxygen-consuming nutrients) discharged to the San Joaquin River and the Delta. In addition to the water quality benefits, the irrigation improvements provide direct water conservation benefits as water supply enhancements to the district.

Prior to this project, the Panoche Drainage District had received $1.8 million in ADMLP funding for implementation of similar projects. Under the most recent loan, the Panoche Drainage District had $4.0 million in ADMLP financing assistance to fund these projects (SWRCB n.d.).

8.4.5.2 Available Funding Programs

This section provides an overview of several federal and state funding programs currently available for agricultural water conservation and water efficiency projects.

Environmental Quality Incentives Program

EQIP is a federal program managed by USDA. EQIP provides financial and technical assistance to agricultural producers for conservation practices that improve water resources as well as soil, plant, animal, air, and other related natural resources. (U.S.C., tit. 16, part IV, § 3839aa).

EQIP conservation practices include a wide range of activities on agricultural lands as well as non-industrial forest lands. For irrigated agriculture, the primary EQIP-funded conservation practices include structures for water control, irrigation water management, irrigation pipelines, and sprinklers. Based on an analysis of EQIP contract data, microsprinklers and drip irrigation are the most common technologies receiving funding from EQIP in the Mountain West, including California, as well as technical assistance through adoption of improved water management practices such as better irrigation scheduling (Wallander 2017, p. 4).

California growers have been beneficiaries of EQIP funding. From FY 2014 through FY 2016, California farm producers received over $347 million in EQIP total obligations, more than any other state. In that 3-year period, 2.3 million acres in California were under contract for EQIP projects (USDA NRCS n.d.(a)).

Conservation Innovation Grants

The Conservation Innovation Grants (CIG) Program uses EQIP funds to award competitive grants. The purpose of the CIG Program is to help stimulate development and adoption of conservation approaches and technologies, while leveraging the federal investment in environmental enhancement and protection in conjunction with agricultural production (USDA NRCS n.d.(c)). Eligible CIG grants address a broad range of conservation issues including soil health, plant quality, oak woodland health, water conservation, water quality, air quality, energy conservation, waste recycling, and wildlife.

In 2017, two grants were awarded to support California growers. One grant funded an integrative planning, tracking, adaptive management tool for producers in Solano County for managing surface water and groundwater use (The Freshwater Trust 2017). A second grant explores the use of advanced metering infrastructure to facilitate water quantity trades to help meet new groundwater regulations in the Central Valley and western Ventura County.

Regional Conservation Partnership Program

The Regional Conservation Partnership Program (RCPP) is a USDA program through which state agencies and non-governmental organizations cooperate to provide financial and technical assistance to farmers to install water conservation measures and other activities (NSAC 2018).

The San Diego County Partners Agricultural Sustainability Project is an example RCPP project. The Mission Resource Conservation District and 15 local partners will improve irrigation system efficiency on 120 agricultural properties in San Diego County through the San Diego County Partners Agricultural Sustainability Project. Partners will encourage property owners to implement irrigation systems and conservation practices through enrollment in EQIP. Irrigation system evaluations and conservation plans will be utilized to ascertain the baseline conditions of each participating property and to determine the conservation practices needed to ensure sustainability.

Conservation Stewardship Program

The Conservation Stewardship Program (CSP) helps agricultural producers maintain and improve existing conservation programs and adopt additional conservation practices. CSP contracts are for 5 years with a renewal option if the initial contract is fulfilled and the producer wants to add other conservation measures. CSP provides two kinds of payments in these 5-year contracts: (1) annual payments for installing new conservation activities and maintaining existing practices; and (2) supplemental payments for adoption of resource-conserving crop rotation. Eligible lands include private and Tribal agricultural lands, cropland, grassland, pastureland, rangeland, and non-industrial private forest land. CSP does not place any restriction on the size of the operation or the type of crops produced (USDA NRCS n.d.(d)). From FY 2009 through FY 2016, CSP provided $55 million to California producers, which was about 1 percent of the national CSP expenditures in that 8-year period (USDA NRCS n.d.(e)).

State Water Efficiency and Enhancement Program

The State Water Efficiency and Enhancement Program (SWEEP) provides financial assistance in the form of grants to implement irrigation systems that reduce greenhouse gases and save water on California agricultural operations. Eligible system components include (among others) soil moisture monitoring, drip systems, switching to low pressure irrigation systems, pump retrofits, variable frequency drives and installation of renewable energy to reduce on-farm water use and energy.

SWEEP provides incentives to agricultural operations through a competitive grant program administered by the California Department of Food and Agriculture in coordination with the State Water Board and DWR. The funding comes from the Greenhouse Gas Reduction Fund (GGRF) (California Climate & Agriculture Network 2016). SWEEP projects are required to reduce both water usage and greenhouse gas emissions, which often means incorporating several different projects to achieve both goals.

Agricultural Water Conservation and Efficiency Program

The Agricultural Water Conservation and Efficiency (AWCE) Program started in 2011 and is a joint program between Reclamation and the USDA. The goal of the program is to promote district-level water conservation improvements that facilitate on-farm water use efficiency and conservation. Grants from this program allow applicants to leverage resources by cost sharing with Reclamation.

Water that is conserved is used for supply enhancement for irrigators. Some recent projects demonstrate the scope of its funding.

North Kern Water Storage District, $1 million. The funding will line 2,631 linear feet of Calloway Canal with concrete to eliminate canal seepage losses into a contaminated groundwater area from a former oil refinery. By eliminating leakages the project would also improve water supply reliability. It will also implement metering, water level and quality sensors and modernize methods to determine the water requirement of crops for irrigation scheduling. This project is expected to save 1,346 AF of water annually over the 50-year life of the project, to be used by the district (Reclamation 2017a).

Rancho California Water District, $1 million. The project converted high-water-use agricultural crops to lower-water-use crops on 154 acres, including avocado and citrus for conversion to lower-water-use crops such as grapes. The water allocations for the converted areas will be reduced by 396 AF annually over the 10-year life of the project for use elsewhere in the water district (Rancho California Water District 2016).

Agricultural Water Use Efficiency Grant Program

The Agricultural Water Use Efficiency Grant Program, funded by Proposition 1, is one of several programs under DWR's Water Use Efficiency Financial Assistance Program. The overall assistance program is instrumental in helping urban and agricultural communities cope with water shortages and drought conditions through the implementation of water use efficiency projects that would achieve water savings, and provide improved operational efficiencies, water quality improvements, energy savings, and environmental benefits. Almost $30 million was awarded to agricultural water conservation projects (DWR 2016).

8.5 Municipal Water Supply Economic Effects

Implementation of the proposed Plan amendments could result in surface water and groundwater supply reductions to municipal water users. Section 7.20, *Utilities and Service Systems,* provides information on existing municipal use, and potential impacts on municipal supply that could result from the proposed Plan amendments. The analysis in Section 7.20 also considers whether and how communities that rely in whole or in part on Sacramento/Delta supply would be able to meet municipal demand using other water management actions in response to changes in supply. Some communities may already be vulnerable, particularly in dry years, if their water supply is not enough to meet demand. This is true for municipal use that relies primarily on Sacramento/Delta supply, without access or funding to develop or utilize other supplies. It is possible that lower groundwater levels could also reduce the availability and quality of groundwater on which municipal providers and private users rely, including DACs.

This analysis estimates the potential costs to affected municipal service providers of securing reliable water supplies, with the focus on (1) increased cost of meeting the same demand through development of other water supplies; (2) the opportunity cost of lost supply if no other supply sources are available; or (3) costs of meeting the same demand using other water supplies already being used by municipalities within existing water portfolios.

8.5.1 Approach to Analysis

The relative economic costs of obtaining other water supplies is dependent on the amount of reduced Sacramento/Delta supply, the availability of other water supplies, the amount of water municipalities have in reserve, and the general costs for installing or implementing the other water supplies that are available. This analysis examines the marginal cost associated with shifting water sources within existing water portfolios or obtaining water from other sources.

The amount of reduced Sacramento/Delta supply was obtained from SacWAM results for the modeled flow scenarios. As a whole, Sacramento/Delta water supply to municipal uses decreases with increasing flow requirements and varies by water year type and by region (Tables 7.20-5 and 7.20-6). This analysis examines results for the average reduction by flow scenario and by region. In many cases Sacramento/Delta supply represents only a portion (or none) of providers' supply, so the effects on the providers and the municipalities they serve can range from large to small, or to none at all, based upon the respective balance between supplies and demand. The response by individual municipalities to reduced Sacramento/Delta supply is expected to vary depending on the extent of reliance on those supplies, the balance between supplies and existing demand, the variety of water sources in their existing water portfolio, ability for water transfers or exchanges, and the extent of availability and access to groundwater. Municipal water conservation and efficiency measures are among management actions all service providers could implement to meet current and future water needs.

The types of measures to augment water supplies vary by region. Municipal water sources of supply and demand were gathered for a sample of moderate-sized and larger municipalities in the study area. This information includes cities and urban water providers in the Sacramento River watershed, Delta eastside tributaries, and Delta, as well as water wholesalers and water providers in other regions that receive exported Sacramento/Delta supply. Urban water management plan (UWMP) documents, DWR's aggregated 2020 UWMP database, and other local planning documents, such as Integrated Regional Water Management Plans and water district planning documents were reviewed to determine the types and availability of other water supplies that municipalities would be likely to implement. More details on this approach are provided in Appendix D, *Supplemental Municipal Supply Analysis Information*. Forecasted future water supplies up to the year 2030 were used to represent potential availability of additional other water supplies; however, predicting the precise combination of strategies that various agencies will use is beyond the scope of this analysis. In general, the assumptions reflect what the providers indicate as their most likely options for other water supplies, and the analysis may not reflect the totality of opportunities available. The options were also evaluated as an un-prioritized list, meaning that each other water supply is equally likely to be selected to replace reduced deliveries. This has the effect of possibly overestimating the cost of water replacement, because providers facing a reduction in one source of supply may prioritize replacement based on least cost first.

The general costs for installing or implementing additional groundwater pumping, groundwater recovery and storage, recycled water, water transfers, and desalination are described in Section 8.3, *Costs Associated with Other Water Management Actions*. This analysis assumes that some water users could choose to increase groundwater pumping to offset reduced Sacramento/Delta supplies; however, the analysis does not consider that groundwater may be unavailable or locally restricted in some locations (see Section 8.8.3, *Groundwater Wells and Groundwater Storage and Recovery*, for cost information on groundwater wells). Some water providers have reserve supplies, or supplies that exceed demand, that may be accessed during dry years and other times of shortage. This may include water supplies that could be provided under exchange agreements, storage in reservoirs, groundwater storage and recovery facilities, or groundwater banking. There would be a lower monetary cost for these municipalities to use their reserve supplies first, without replenishing any reserves used. For some municipalities, there could be no additional monetary costs from switching to an alternative water source because the municipality has enough water in reserve to replace reduced Sacramento/Delta supply. Other municipalities might not have enough reserve supplies, or do not have any reserve supplies at all. The analysis uses the assumed costs of other water supplies, and the other water supplies that are likely to be used, to estimate the monetary costs for these municipalities to replace reduced Sacramento/Delta supply. A summary of the analysis details is provided in Appendix D, *Supplemental Municipal Supply Analysis Information.*

The costs are estimated as a range representing the extent to which municipal providers may rely on demand management measures and use reserve supplies, if available, versus the cost of acquiring additional water supplies to fully replace the reduction in the Sacramento/Delta water supply. A water provider's actual cost most likely would fall between the lower and upper bound.

- Lower Bound—The lower bound represents the minimum annual cost to municipalities to replace the service of reduced Sacramento/Delta supply. Urban water conservation measures are evaluated in the lower bound analysis for all regions as these measures were explicitly identified as future water portfolio strategies in various urban water management plans. Generally, a reduction in municipal supply of up to 10 percent often would be managed through more intensive use of demand management measures (DWR 2021). The analysis assumes that urban water conservation measures represent the first source of replacement water and also assumes no economic cost to the municipal provider.

  Any remaining water needed would then be met by other water supplies. For example, municipalities could choose to tap into their unused reserves (at no added cost) before acquiring additional water. Under existing conditions, wholesalers or municipalities may have sufficient reserve supply. With reduced Sacramento/Delta supply, municipalities may choose to use any or all reserve supply to replace the reduced supply, followed by acquisition of additional supply. Under this assumption, if a municipality has sufficient water supply reserves to replace reduction in Sacramento/Delta supply, additional water supplies would not be required. If reserves are large enough, effects on the water supply portfolio could result in an internal cost that would be absorbed by the provider or its customers. These internal costs are not reflected in the estimated costs shown.

- Upper Bound—The upper bound represents the maximum annual estimated cost for using reserve supplies to replace reduced Sacramento/Delta supply and the estimated cost for purchasing additional water supplies to completely replenish any reserves used to replace the reduced Sacramento/Delta supply, with no action to manage demand through demand management measures. The estimated costs account for new acquisitions of other supplies that would leave the water provider with the same reserve supply. Under this assumption, all reduction in surface water supply would be replaced on an equal basis, regardless of the municipality's reserve status, and the cost of obtaining new supplies would be counted. This represents a conservative estimate because the analysis assumes that demand management measures (e.g., water conservation) would not be implemented to maximize the use of existing water supplies.

Municipal water providers will factor into their rates the additional costs associated with providing delivered water. In order to provide some context to the magnitude of the estimated additional costs, the results are presented as a range of annual costs and as "cost as a share of economic output." This is estimated by dividing the lower and upper bound costs, as described above, by the total economic output (sales of all goods and services) generated in the respective region. The value of economic output for each region is discussed in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

Table 8.5-1 includes a summary of estimated costs for municipalities to replace supply due to reduced Sacramento/Delta supply under the 55 percent unimpaired flow scenario (55 scenario). Appendix D, *Supplemental Municipal Supply Analysis Information*, contains comparable information regarding partial replacement and full replacement volumes for the 35, 45, 65, and 75 scenarios, and the subsections below contain corresponding cost estimates. Regions that receive relatively small volumes of Sacramento/Delta supply for municipal use, such as the Delta eastside tributaries, Delta, Central Coast, and San Joaquin Valley regions show the smallest volume reductions. Estimated costs to replace reduced delivery varies based on the portfolio of options for additional supply. More detail for each region is provided in the following sections.

Table 8.5-1. Lower Bound and Upper Bound Annual Average Supply Needs to Replace Reduction in Sacramento/Delta Supplies for Municipal Use (TAF/yr), and Range of Estimated Costs for Municipalities to Replace Reduced Supply by Region for the 55 Flow Scenario

Region	Lower Bound (Partial Replacement) (TAF/yr) [a]	Upper Bound (Full Replacement) (TAF/yr) [b]	Cost ($) [c]
Sacramento River watershed	3	52	$213,000 to $4,499,000
Delta eastside tributaries	8	15	$408,000 to $2,544,000
Delta	0	1	$0 to $423,000
San Francisco Bay Area	41	166	$32,206,000 to $154,764,000
Central Coast	8	12	$9,152,000 to $14,475,000
San Joaquin Valley	0	22	$0 to $10,296,000
Southern California	22	446	$20,837,000 to $529,798,000

[a] Source: Appendix D, Supplemental Municipal Supply Analysis Information.
[b] Source: Table 7.20-6, Section 7.20, *Utilities and Service Systems*.
[c] Sources: Appendix D, Supplemental Municipal Supply Analysis Information, and Section 8.5, Economic Analysis and Other Considerations.
TAF/yr = thousand acre-feet per year

Projecting the specific ways that all municipal users may respond to reduced surface supply would require undue speculation. Therefore, this analysis is general in nature and evaluates how reductions in Sacramento/Delta supply could affect municipal water supplies and associated costs.

This analysis does not evaluate additional costs that could be incurred to deepen groundwater wells as a response to possible groundwater level declines. As discussed in Section 7.12.2, *Groundwater*, increased groundwater pumping in response to reduced Sacramento/Delta supplies could lower groundwater levels in some locations. Water user response to the proposed Plan amendments could exacerbate groundwater overdraft in some locations. Communities that rely on groundwater for drinking water supplies in the San Joaquin Valley have been facing challenges from declining groundwater levels under baseline conditions, with critical shortages or dry wells occurring in some areas during prolonged drought periods. The frequency and severity of these challenges likely would increase as a result of the proposed Plan amendments, even with no replacement groundwater pumping. Section 8.8.3, *Groundwater Wells and Groundwater Storage and Recovery*, provides additional information about the costs to deepen existing groundwater wells.

8.5.2 Sacramento River Watershed

Table 8.5-2 provides a summary of the range of potential economic costs for municipalities to respond to reduced Sacramento/Delta supply in the Sacramento River watershed, along with the share of economic output (expressed as a percentage) that the cost represents. Several other metropolitan area purveyors in this region receive CVP water originating in the American River watershed. Apart from the Sacramento metropolitan area, numerous municipalities in the region are highly dependent on groundwater to meet municipal water demand.

The costs shown in Table 8.5-2 reflect the assumption that, in general, municipalities in the Sacramento River watershed may increase groundwater pumping as a substitute supply; these costs are reflected in the lower bound estimates below where demand management measures would not be sufficient. As discussed above, this analysis assumes that increased groundwater pumping could be used to offset reduced Sacramento/Delta supplies; however, the analysis does not consider that groundwater may be unavailable or locally restricted in some locations. In addition, review of 2020 UWMPs and other planning documents (see Appendix D, *Supplemental Municipal Supply Analysis Information*) indicates potential additional supply sources in 2030, including reliance on water purchases, surface water, and other water supplies and recycled water use, in addition to the existing supplies. The range of costs for municipal suppliers in Sacramento River watershed could be greater than the lower bound estimate if these or other water supply sources are used to replace Sacramento/Delta water supplies. The upper bound estimate is conservative because, even in cases where excess supply is available, the analysis assumes replacement of the full amount of reduced surface water supply from the Sacramento/Delta, without any demand management measures.

Table 8.5-2. Range of Estimated Costs for Municipalities in Sacramento River Watershed to Respond to Reduced Sacramento/Delta Supply and Costs as a Share of Economic Output

Flow Scenario	Cost ($)			Share of Economic Output (%)		
35	$0	to	$1,342,000	0.00000	to	0.00061
45	$30,000	to	$2,603,000	0.00001	to	0.00119
55	$213,000	to	$4,499,000	0.00010	to	0.00206
65	$710,000	to	$7,489,000	0.00033	to	0.00343
75	$1,206,000	to	$9,376,000	0.00055	to	0.00429

Source: Appendix D, Supplemental Municipal Supply Analysis Information.
Cost as a share of economic output is calculated as estimated cost (lower bound and upper bound) divided by the total value of the region's economic output, as estimated in Appendix A4, *Regional Economic Analysis Modeling Procedure*. Economic output for the Sacramento River watershed is estimated as the population-weighted portion of the total output for the Sacramento/Delta.

8.5.3 Delta Eastside Tributaries

Table 8.5-3 provides a summary of the range of potential economic costs for municipalities to respond to reduced Sacramento/Delta supply in the Delta eastside tributaries region.

For this analysis, local groundwater pumping, recycled water, and transfers were assumed for estimating replacement costs. Review of 2020 UWMPs and other planning documents (see

Appendix D, *Supplemental Municipal Supply Analysis Information*) indicates potentially different additional supply sources in 2030, including reliance on water purchases, and surface water, in addition to the existing supplies. On one hand, the costs to municipal suppliers in Delta eastside tributaries region could be greater if costlier water sources are used. However, the assumption that the full amount of reduced surface water supply from the Sacramento/Delta would be replaced, even in cases where excess supply is available, is conservative because it is likely that municipal water suppliers could maximize the use of existing supplies through demand management strategies (e.g., water conservation). The costs include amounts that might be incurred by communities that receive portions of their water supplies from the Lower San Joaquin River tributaries.

Table 8.5-3. Range of Estimated Costs for Municipalities in Delta Eastside Tributaries to Respond to Reduced Sacramento/Delta Supply and Costs as a Share of Economic Output

Flow Scenario	Cost ($)			Share of Economic Output (%)		
35	$59,000	to	$1,726,000	0.00017	to	0.00509
45	$215,000	to	$2,093,000	0.00063	to	0.00617
55	$408,000	to	$2,544,000	0.00120	to	0.00750
65	$553,000	to	$3,991,000	0.00163	to	0.01177
75	$704,000	to	$5,137,000	0.00208	to	0.01515

Source: Appendix D, Supplemental Municipal Supply Analysis Information.
Cost as a share of economic output is calculated as estimated cost (lower bound and upper bound) divided by the total value of the region's economic output, as estimated in Appendix A4, *Regional Economic Analysis Modeling Procedure*. Economic output for the Delta eastside tributaries is estimated as the population-weighted portion of the total output for the Sacramento/Delta.

8.5.4 Delta

Table 8.5-4 provides a summary of the range of potential economic costs for municipalities to respond to reduced Sacramento/Delta supply in the Delta.

The costs shown in Table 8.5-4 represent potential utilization of groundwater storage and recovery projects and water transfers, based on review of UWMPs and other planning documents (see Appendix D, *Supplemental Municipal Supply Analysis Information*). The costs include amounts that might be incurred by communities that receive portions of their water supplies from the Lower San Joaquin River tributaries.

Table 8.5-4. Range of Estimated Costs for Municipalities in the Delta to Respond to Reduced Sacramento/Delta Supply and Costs as a Share of Economic Output

Flow Scenario	Cost ($)			Share of Economic Output (%)		
35	$0	to	$0	0.00000	to	0.00000
45	$0	to	$88,000	0.00000	to	0.00015
55	$0	to	$423,000	0.00000	to	0.00073
65	$0	to	$1,623,000	0.00000	to	0.00279
75	$0	to	$3,071,000	0.00000	to	0.00529

Source: Appendix D, Supplemental Municipal Supply Analysis Information.
Cost as a share of economic output is calculated as estimated cost (lower bound and upper bound) divided by the total value of the region's economic output, as estimated in Appendix A4, *Regional Economic Analysis Modeling Procedure*. Economic output for the Delta is estimated as the population-weighted portion of the total output for the Sacramento/Delta.

8.5.5 San Francisco Bay Area

Table 8.5-5 summarizes the range of potential economic costs for municipalities to respond to reduced Sacramento/Delta supply within the San Francisco Bay Area.

The costs shown in Table 8.5-5 reflect groundwater pumping, surface storage, water transfers (including in-basin transfers and transfers from other regions), recycled water, and desalination based on review of UWMPs and other planning documents (see Appendix D, *Supplemental Municipal Supply Analysis Information*.

Table 8.5-5. Range of Estimated Costs for Municipalities in the San Francisco Bay Area to Respond to Reduced Sacramento/Delta Supply and Costs as a Share of Economic Output

Flow Scenario	Cost ($)			Share of Economic Output (%)		
35	$71,000	to	$48,984,000	0.00001	to	0.00414
45	$7,029,000	to	$93,400,000	0.00059	to	0.00789
55	$32,206,000	to	$154,764,000	0.00272	to	0.01307
65	$60,098,000	to	$240,953,000	0.00508	to	0.02035
75	$83,116,000	to	$303,603,000	0.00702	to	0.02565

Source: Appendix D, Supplemental Municipal Supply Analysis Information.
Cost as a share of economic output is calculated as estimated cost (lower bound and upper bound) divided by the total value of the region's economic output, as estimated in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

8.5.6 San Joaquin Valley

Table 8.5-6 summarizes the range of potential economic costs for municipalities to respond to reduced Sacramento/Delta supply within the San Joaquin Valley.

Most of the costs shown in Table 8.5-6 are associated with in-basin water transfers, and groundwater storage and recovery (based on review of UWMPs and other planning documents (see Appendix D, *Supplemental Municipal Supply Analysis Information*. The costs include amounts that might be incurred by communities that receive portions of their water supplies from the Lower San Joaquin River tributaries. The upper bound costs may be overestimated because the analysis assumes reliance on the more expensive sources, such as transfers, as large sources for additional water supply, without considering any demand management measures (e.g., water conservation).

Table 8.5-6. Range of Estimated Costs for Municipalities in the San Joaquin Valley to Respond to Reduced Sacramento/Delta Supply and Costs as a Share of Economic Output

Flow Scenario	Cost ($)			Share of Economic Output (%)		
35	$0	to	$1,677,000	0.00000	to	0.00067
45	$0	to	$5,148,000	0.00000	to	0.00204
55	$0	to	$10,296,000	0.00000	to	0.00408
65	$1,368,000	to	$15,956,000	0.00054	to	0.00633
75	$2,391,000	to	$22,735,000	0.00095	to	0.00902

Source: Appendix D, Supplemental Municipal Supply Analysis Information.
Cost as a share of economic output is calculated as estimated cost (lower bound and upper bound) divided by the total value of the region's economic output, as estimated in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

8.5.7 Central Coast

Table 8.5-7 summarizes the range of potential economic costs for municipalities to respond to reduced Sacramento/Delta supply within the Central Coast.

Most of the costs shown in Table 8.5-7 are associated with water transfers, recycled water use, desalination, and increased use of local groundwater supply, based on review of UWMPs and other planning documents (see Appendix D, *Supplemental Municipal Supply Analysis Information*). The estimated costs may be overestimated because the analysis assumes reliance on the more expensive sources, such as transfers, recycled and desalination as sources for additional supply.

Table 8.5-7. Range of Estimated Costs for Municipalities in the Central Coast to Respond to Reduced Sacramento/Delta Supply and Costs as a Share of Economic Output

Flow Scenario	Cost ($)			Share of Economic Output (%)		
35	$0	to	$2,614,000	0.00000	to	0.00212
45	$2,816,000	to	$8,007,000	0.00228	to	0.00648
55	$9,152,000	to	$14,475,000	0.00741	to	0.01172
65	$15,204,000	to	$20,570,000	0.01231	to	0.01666
75	$22,677,000	to	$28,043,000	0.01836	to	0.02271

Source: Appendix D, Supplemental Municipal Supply Analysis Information.
Cost as a share of economic output is calculated as estimated cost (lower bound and upper bound) divided by the total value of the region's economic output, as estimated in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

8.5.8 Southern California

Table 8.5-8 summarizes the range of potential economic effects from the flow scenarios in Southern California.

Most of the costs shown in Table 8.5-8 are associated with water portfolio adjustments that MWD and its wholesale customers may implement. MWD is the largest SWP contractor and a major wholesaler of water in Southern California. The lower bound estimate assumes that MWD's existing supply sources would be used to help offset reductions in Sacramento/Delta waters supplies, and assumes that MWD would not replace its reserves in response to changes in Sacramento/Delta supply in the lower flow scenarios. This reflects the variety of other water supplies already being planned and implemented by MWD, as well as options the agency has identified for future supplies in their integrated water resource management plan. The upper bound reflects the costs for MWD to replenish their reserves to existing levels after responding to reduced Sacramento/Delta supply. As such, the upper bound costs may be overestimated because the analysis assumes replacement of the full amount of reduced surface water supply from the Sacramento/Delta even in cases where excess supply is available, and without any efforts to manage demand.

Table 8.5-8. Range of Estimated Costs for Municipalities in Southern California to Respond to Reduced Sacramento/Delta Supply and Costs as a Share of Economic Output

Flow Scenario	Cost ($)			Share of Economic Output (%)		
35	$0	to	$109,071,000	0.00000	to	0.00498
45	$5,264,000	to	$281,851,000	0.00024	to	0.01287
55	$20,837,000	to	$529,798,000	0.00095	to	0.02419
65	$49,651,000	to	$773,901,000	0.00227	to	0.03534
75	$88,549,000	to	$1,083,629,000	0.00404	to	0.04948

Source: Appendix D, Supplemental Municipal Supply Analysis Information.
Cost as a share of economic output is calculated as estimated cost (lower bound and upper bound) divided by the total value of the region's economic output, as estimated in Appendix A4, *Regional Economic Analysis Modeling Procedure*.

8.5.9 Economically Disadvantaged Communities and Drinking Water

On February 16, 2016, the State Water Board adopted Resolution 2016-0010 identifying the human right to water as a top priority and core value of the State Water Board and Regional Water Quality Control Boards. The resolution directs the State and Regional Water Boards to work "to preserve, enhance, and restore the quality of California's water resources and drinking water for the protection of the environment, public health, and all beneficial uses, and to ensure proper water resource allocation and efficient use, for the benefit of present and future generations." The resolution cements the Water Boards' commitment to considering how its activities impact and advance the human right to safe, clean, affordable, and accessible water to support basic human needs. The human right to water will be considered in actions taken by the Water Boards that pertain to sources of drinking water. These actions may include revising or establishing water quality control plans, policies, and grant criteria; permitting; site remediation and monitoring; and water right administration.

As discussed in Chapter 10, *Economically Disadvantaged Communities*, DACs often are served by small public water systems and rely on groundwater either in whole or in part for their water supply. Their groundwater wells often are shallow and thus are more susceptible to water quality issues or the risk of going dry if the groundwater level is lowered. While the public water systems serving DACs still are required to maintain essential resources and meet public health requirements, these systems are less likely to have the resources (e.g., infrastructure and financing) of more affluent communities to respond adequately to water supply or water quality emergencies. Systems serving DACs may be unable to treat their water source, find alternative supplies for a contaminated drinking water source, deepen their wells, or build new wells. As a result, DACs may be more vulnerable than other municipalities and cities to impacts on surface water and groundwater supplies.

Many DACs also experience poor water quality, and may have challenges meeting current water quality standards. Although most of the state's residents receive drinking water that meets federal and state drinking water standards, many drinking water systems in the state consistently fail to provide safe drinking water to their customers. Lack of safe drinking water is a problem that disproportionately affects residents of California's DACs. Over 95 percent, of Californians are served by water systems that meet drinking water standards, but this leaves almost a million people being served by failing water systems and over a million more getting their drinking water from at-risk public water systems, or at-risk state small water systems or domestic wells.

The State Water Board's 2023 Drinking Water Needs Assessment report (SWRCB 2023b), required to be carried out by the Safe and Affordable Funding for Equity and Resilience (SAFER) program (discussed further in Chapter 10, *Economically Disadvantaged Communities*), provides foundational information regarding water systems in DACs, including SDACs. There are multiple failing, at-risk, and potentially at-risk public water systems in the Sacramento/Delta watershed and the other geographic regions in the study area. The analysis of the risk assessment results presented in the 2023 Drinking Water Needs Assessment indicates the majority (86 percent) of at-risk water systems are small water systems with 3,000 service connections or less.

Many communities in the study area rely on groundwater as their primary source of supply, either as municipal supply or supply from private domestic wells. Although the proposed Plan amendments would not directly affect these supplies, there could be indirect effects on groundwater supply and quality as discussed in Section 7.12.2, *Groundwater*, because groundwater levels may lower as a result of increased substitute groundwater pumping and reduced incidental and managed recharge of groundwater. These effects could result in higher exposure to groundwater contaminants.

Reductions in Sacramento/Delta surface water supplies and related potential changes to groundwater resources would vary by region. Although SGMA implementation could reduce or eliminate groundwater impacts, particularly in medium- and high-priority basins, the potential remains for the proposed Plan amendments to result in depletion in groundwater supplies at the local level. Communities that rely solely on groundwater could experience economic effects as they could need to obtain new municipal supply water entitlements or pay more for treating replacement supplies of lower quality.

Chapter 10, *Economically Disadvantaged Communities*, discusses various financial and technical assistance programs available to assist public water systems serving DACs. These programs are designed to ensure access to safe, clean, and affordable water supplies and maintain compliance with all applicable water laws and regulation. The State Water Board is at the forefront of assisting DACs with obtaining clean, safe, and reliable water supplies. In doing so, the State Water Board is making its commitment to the human right to water through financial assistance, technical assistance, consolidations, and other means.

In addition, the following section discusses potential sources of funding for municipal water conservation, which may be relevant to DACs in California.

8.5.10 Potential Sources of Funding for Municipal Water Conservation

A variety of programs are available to provide funding for water conservation efforts in California. Municipal water providers are often eligible to secure funding from public and private sources for water conservation initiatives and measures. These sources include grants; single purpose appropriations from federal, state, and/or local legislative bodies; municipal bond indebtedness; and low-interest loans from government institutions. Federal agencies with funding for various forms of water conservation include the United States Environmental Protection Agency, USDA's Rural Utilities Service, USDA's Rural Business-Cooperative Service, U.S. Economic Development Administration, U.S. Department of Housing and Urban Development Office of Community Planning and Development, and the U.S. Department of Health and Human Services.

There are also multiple state funding sources that could be used to support municipal water conservation efforts, such as Proposition 1 funding discussed further below. Chapter 10, *Economically Disadvantaged Communities*, also discusses relevant State Water Board financial and technical assistance programs.

Two examples are provided below.

Proposition 1 Funding

Proposition 1 authorized $7.545 billion in general obligation bonds for water projects including surface and groundwater storage, ecosystem and watershed protection and restoration, and drinking water protection (SWRCB 2019, p. 1). The State Water Board administers Proposition 1 funds for five programs: small community wastewater, water recycling, drinking water, stormwater, and groundwater (SWRCB 2019, p. 1). The projects funded through Proposition 1 primarily focus on technical assistance and infrastructure (e.g., feasibility studies or providing wellhead treatment on a groundwater well). As of 2019, approximately 53 percent of the dollars associated with these five programs had been disbursed for a total of $297,656,992 and approximately 350 projects covering the entire state (SWRCB 2019, p. 1).

DWR administers the Sustainable Groundwater Planning Grant Program, using funds authorized by Proposition 1, to encourage sustainable management of groundwater resources that support SGMA. A total of approximately $86.3 million has been made available, with at least $10 million made available to projects that serve SDACs and the remaining amount for planning, development, or preparation of groundwater sustainability plans (GSP). Eligible projects must address high- and medium-priority basins as identified in DWR Bulletin 118 or a non-adjudicated portion of one of these basins. Final grant awards were announced in April 2018. Eligible GSP project types include those activities associated with the planning, development, or preparation of GSPs that will comply with and meet the requirements of the GSP Regulations (DWR 2017). Examples of eligible projects include vulnerability assessments, feasibility studies for groundwater management projects, technical assistance for participating in groundwater sustainability planning activities, and retrofitting existing wells to have treatment capabilities.

Metering for New Connections and Retrofit of Existing Connections

The American Recovery and Reinvestment Act of 2009 appropriated $2 billion to the Drinking Water State Revolving Fund to help states finance infrastructure projects related safe drinking water. Installations of new water meters as well as upgrades of existing water meters are eligible for this funding. In California, the Drinking Water State Revolving Fund Program provides financing to publicly owned and privately owned community water systems as well as non-profit or publicly owned non-community systems.

Another source of funding for metering is the WaterSMART (Sustain and Manage America's Resources for Tomorrow) Program, established in 2010. WaterSMART enables all bureaus within the U.S. Department of the Interior to work with states, tribes, local governments, water agencies and non-governmental organizations to provide a sustainable water supply. An example of a metering project partially funded by WaterSMART is a 2017 project in San Bernardino County to upgrade 105 domestic and commercial water meters in Oro Grande. About half the cost of the $150,000 project is funded by a WaterSMART grant (Reclamation 2017b).

8.6 Other Economic Effects

This section considers other economic effects that could occur as a result of the Sacramento/Delta update to the Bay-Delta Plan, including effects on commercial and recreational fisheries, recreation, ecosystem services, wildlife refuges, and energy (hydropower) production.

8.6.1 Recreational and Commercial Fisheries

As discussed in Chapter 4, *Other Aquatic Ecosystem Stressors*, the Delta and its tributaries currently support recreational and commercial fisheries. Recreational fisheries include a marine and freshwater fishery for striped bass, largemouth bass, black bass, white sturgeon, Chinook salmon, steelhead, catfish, and American shad. The only commercial fisheries in the Delta are for threadfin shad and crayfish, although the Delta and its tributaries also support a commercial ocean salmon fishery. As discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, there has been a substantial decline in population abundance of salmonids, sturgeon, splittail, starry flounder, and California bay shrimp over the past 50 years. A number of factors contribute to these declines, including but not limited to loss of flow and physical habitat, along with the effects of other stressors.

This section addresses potential economic effects concerning commercial and recreational sport fisheries, with an emphasis on Chinook salmon. As discussed in previous chapters, in response to declines of several native aquatic species since the Bay-Delta Plan was last comprehensively updated, the State Water Board is in the process of updating and implementing the Bay-Delta Plan to provide for the reasonable protection of native fish and wildlife. Accordingly, the Sacramento/Delta update to the Bay-Delta Plan would be expected to result in positive economic effects related to commercial and recreational sport fisheries as discussed further below.

The Pacific Fishery Management Council (PFMC) estimates that in the period 2018 through 2022, approximately $65.6 million in personal income annually and 1,283 jobs in California were associated with commercial salmon harvesting and processing and derived from recreational fisheries (PFMC 2023a).

Ocean commercial harvest levels for Chinook salmon in California have varied considerably over the last several decades, but (as mentioned above) there has been a substantial decline in population abundance of Chinook salmon and other species over the past 50 years. Chapter 3, *Scientific*

Knowledge to Inform Fish and Wildlife Flow Recommendations, provides a summary of the natural production of all four runs of Chinook salmon (including spring-run, fall-run, late fall-run, and winter-run Chinook salmon) in the Sacramento and San Joaquin River basins for the period of 1967–1991 and 1992–2015 that shows significant declines in the natural production of these populations. California commercial Chinook salmon catch numbers have also declined over time. Excluding the near full closure of the ocean salmon fishery from 2008 through 2009, California commercial Chinook salmon catch between 1976 and 2022 varied from approximately 14.4 million pounds (dressed weight) in 1988 to a low of 228 thousand pounds in 2010. Since 2010, average harvests from 2011 through 2022 were 1.8 million pounds, less than one quarter of the 1986–1990 average annual harvest, and less than half of the 1996–2005 average (PFMC 2023a). As a consequence of recent and projected low returns of Klamath River and Sacramento River Chinook salmon stocks, PFMC implemented a full closure of the ocean salmon fishery in 2023 (PFMC 2023b).

In addition, based on recent and projected low returns of Klamath River and Sacramento River Chinook salmon stocks, PFMC implemented a full closure of the ocean salmon fishery in 2023 in response to near-historically low stock abundance forecasts for the fall run Chinook salmon runs originating from the Sacramento and Klamath rivers (PFMC 2023b). This closure is anticipated to take a toll on California's salmon fishing industry that will result in loss of 100 percent of the 5-year average annual ex-vessel value of $15,033,200 (Office of the Governor 2023). A loss of over $45 million is projected from the 2023 closure of the Sacramento River fall-run Chinook salmon and Klamath River fall-run Chinook salmon runs (Office of the Governor 2023).

Overall, the Sacramento/Delta update to the Bay-Delta Plan is expected to provide for reasonable protection of fish and wildlife beneficial uses and would be expected to contribute to the recovery of Chinook salmon and other native fish species, which would have positive economic effects on California's commercial and recreational fishing industries. Healthier populations and more viable fisheries would have economic benefits for California residents and businesses, as well as for out-of-state visitors or those who reside out of the state but place value on maintaining and improving salmon stocks. The near full closure of the ocean salmon fishery in 2008 through 2009 and the full closure of the ocean salmon fishery in 2023 resulted in detrimental economic effects on California's commercial fishing industries, and the recovery of Chinook salmon and other native fish species would help to avoid future fishery closures.

8.6.2 Recreation

The proposed Plan amendments could provide for economic benefits related to recreational opportunities that are supported by healthy rivers and a functioning watershed. Outdoor recreation generates economic benefits in terms of the value (net benefit) to those participating in the activities, as indicated by their willingness to pay (WTP) over and above trip expenditures (e.g., transportation, entrance fee costs) for these recreational opportunities. This measure of value depends, to a large extent, on the quality of the recreation environment. For example, wildlife watching may be more rewarding when there is more viewable wildlife, creating greater value in that environment. Improving the quality of the environment can augment recreational benefits, which is typically measured by the increase in WTP for recreational activities.

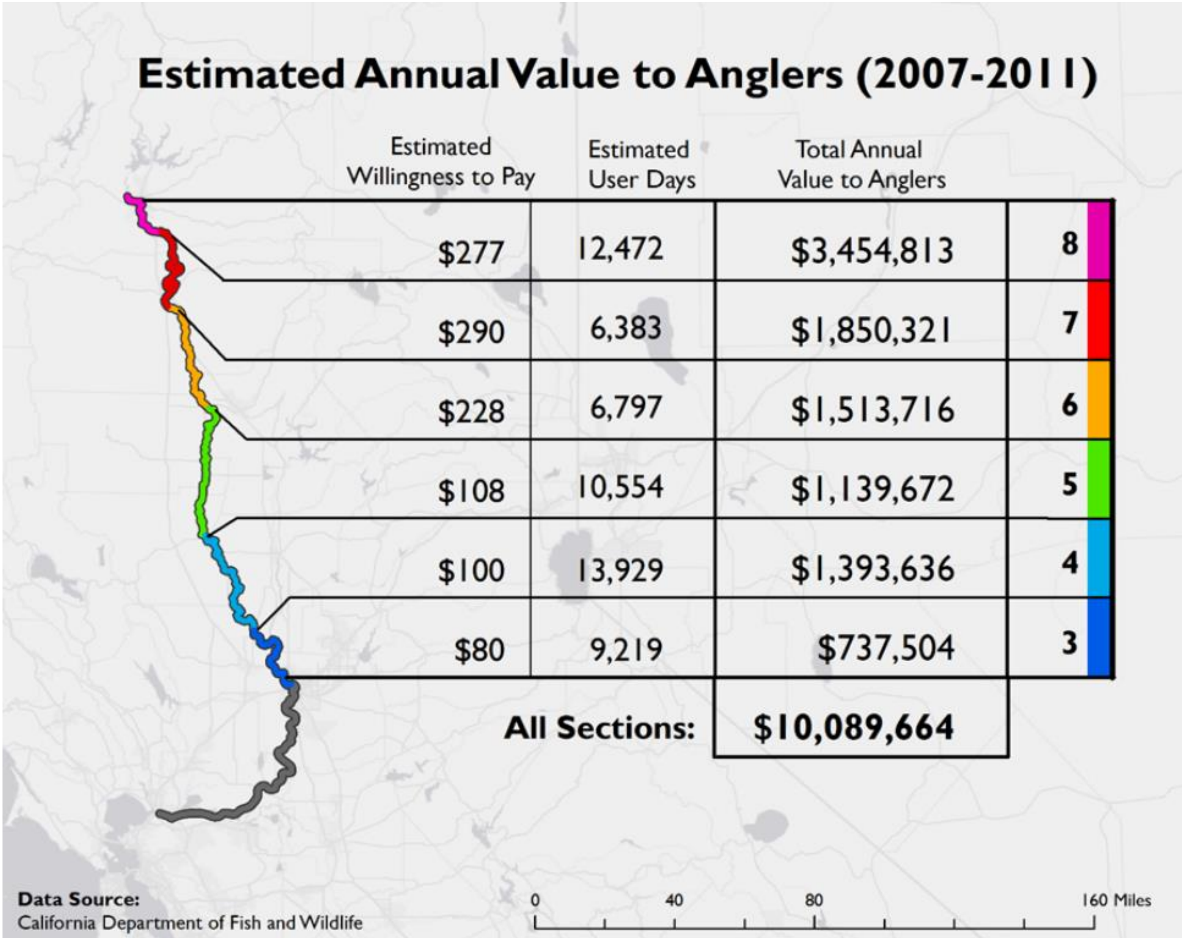
The following discussion focuses on waterbody types affected by the proposed Plan amendments, general information on recreational activity in the study area, and its relationship to river flows and reservoir levels.

8.6.2.1 Rivers

Rivers and streams throughout the Sacramento River and Delta eastside tributaries offer water-based recreational opportunities, such as swimming, boating, rafting, kayaking, and sportfishing as well as land-based recreational opportunities, such as hiking and biking along the banks. Rivers also support on-bank recreational areas, such as beaches, campgrounds, picnic areas, and fishing piers. Several tributary streams in these regions are state- or federally designated as Wildlife and Scenic Rivers. Additional discussion is provided in Section 7.18, *Recreation*.

Although formal estimates of recreation visitation in the Sacramento River watershed are limited or focused on specific sites, a recent study estimated annual consumptive use visitors (e.g., hunters, anglers) at 77,638 on the Sacramento River between the confluence with the Feather River and the foot of Keswick Dam, and 61,879 non-consumptive use visitors (e.g., walking, picnicking, wildlife viewing,), or a total of 139,417 (Tsournos et al. 2016b, p. 19). Approximating recreation activity is useful for evaluating the relative economic importance of these recreational areas within the surrounding region. These visitation estimates reasonably characterize existing levels of recreational activity in the watershed.

The benefits that visitors receive from recreational activity comprise primarily non-market components, and the "value" placed by visitors is not readily observable from published data. As such, various methods exist to elicit value, and complex studies can derive very different results that are highly dependent upon assumptions. A recent study estimated that anglers on the Sacramento River received estimated WTP benefits of $80 to $290 per day (in 2007 dollars) depending upon river section (see Figure 8.6-1) (Tsournos et al. 2016a, p. 24). A separate study estimates WTP benefits of $86.70 per day for non-consumptive users of a shorter stretch of the Sacramento River (Tsournos et al. 2016b, p. 11).



Source: Tsournos et al. 2016a, p. 24.

Figure 8.6-1. Estimates of Willingness to Pay Value to Recreational Anglers Visiting the Sacramento River (in 2007 Dollars)

As discussed in Section 7.18, *Recreation*, higher flows in Sacramento/Delta tributaries could increase the number of popular locations for whitewater rafting and kayaking and could expand the length of the season for those activities (i.e., increase the number of boatable days) compared with baseline conditions, including on recreational Wild and Scenic Rivers. These changes in hydrology would provide a benefit to these recreational activities. Some tributaries could have lower flows during summer months, which could increase or decrease the boating difficulty of rapids for rafting and kayaking; however, opportunities would still be available in existing locations, such as the American River and other locations in the Sacramento River watershed and Delta eastside tributaries regions. Overall, the proposed Plan amendments could provide economic benefits related to rafting and kayaking in some locations. A study from Colorado found that whitewater river kayakers and river rafters had WTP values of $55 to $97 per day (2013 dollars), with the highest values associated with higher flow volumes (Loomis and McTernin 2014).

The proposed Plan amendments would have little effect on swimming and wading opportunities. It is possible that swimming, wading, and other recreational opportunities associated with healthy rivers could increase in some locations. Higher visitation for recreation purposes could have an additional economic benefit to some communities that are located proximate to or nearby recreation sites. Along with visitation is local spending for supplies, fuel, and in some cases lodging or guide services. Any increased local spending will have a ripple (multiplier) effect on other sectors of the region's economy.

8.6.2.2 Reservoirs

Reservoirs in the Sacramento River watershed and Delta eastside tributaries regions offer several water-based recreational opportunities, such as swimming, windsurfing, boating, and sportfishing, as well as land-based recreational opportunities such as hiking and biking along the shore. Beaches, boat ramps, trails, access roads, and picnic areas add to the recreation experience at reservoirs. These types of recreational facilities are prevalent around the shorelines of reservoirs. Sportfishing is a popular activity at reservoirs (e.g., Shasta, Oroville), involving cold water species such as salmon and trout (e.g., Chinook salmon, rainbow trout) and warm water species such as bass, crappie, and sunfish. Boating is one of the most prominent forms of recreation on reservoirs, including motor boating for tubing, water-skiing, house-boating, and jet-skiing.

Under the proposed Plan amendments, changes in reservoir water elevations could affect access to the water from established recreational facilities or affect the reservoir surface area, potentially affecting recreational opportunities. During the recreation season (May through September), the water elevation could be lower in some reservoirs, which could affect recreational opportunities in some locations. However, in many locations, boat ramps and other water access points would still be accessible.

Overall, while water levels in some reservoirs could change under the proposed Plan amendments and could affect certain recreational opportunities in some locations, the overall economic effects on recreational opportunities at many reservoirs would likely be small. Benefits to local residents and effects on visitor spending associated with reservoir recreation activity would be relatively small or unchanged in many locations. Some reservoirs could experience periods of lower water elevation that, when compared to baseline conditions, would result in associated boat ramps or docks becoming inaccessible. These locations may require construction or expansion of recreational facilities, which would result in an additional cost to maintain existing recreational opportunities.

8.6.3 Ecosystem Services

Ecosystem services are defined as the benefits that humans receive from the natural processes and functioning of ecosystems. Humans use ecosystems, and thus receive value from ecosystem services, in diverse ways. Some values generated by ecosystem services are directly tied to market activity, such as use by humans of timber, raw materials, food, and fuel. Other values generated by ecosystem services may be indirectly tied to market activity, or may not have ties to market activity. Values of goods and services that fall outside of market activity are called non-market values by economists. The non-market values of ecosystem services can be difficult to quantify and monetize.

Economists that seek to quantify and monetize the value of ecosystem services have developed a classification scheme for the values that these services provide. Generally, the values attributed to ecosystem services can be described as use or non-use values. Within the set of use values, ecosystem services provide economic value direct use of these services by humans. Some direct uses of ecosystem services involve human consumption, such as harvesting timber and other forest products, food, and fuel. Other direct uses, such as viewing wildlife, hiking, and enjoying scenic vistas, do not involve any actual consumption (and are thus called *non-consumptive* by economists).

Humans also can use ecosystem services indirectly, which occurs when an ecosystem service is an input to something that is directly used by people. One example of indirect use is ecosystem provision of habitat for plants and animal species that are then used by people, either consumptively or non-consumptively. Other examples of indirect use of ecosystem services include the ecosystem's ability to regulate air quality, waste assimilation, and climate regulation (i.e., carbon storage, sequestration).

In addition to current use of ecosystem services, people can benefit from (and therefore place a value on) the knowledge that they can use a good or service in the future. One example is the value an individual might place on a wilderness area they hope to visit in the future, or the value they place on a species of bird they hope to someday view.

Another way in which ecosystem services generate societal value is through non-use values, which do not involve any actual direct or indirect use. Similarly, to the value individuals might place on knowing that a good or service would be available for use by future generations, distinct from their own personal use.

Although the concept of ecosystem services is decades old, a coordinated effort in 2001 by the United Nations launched the Millennium Ecosystem Assessment (MA), which focuses on the benefits people obtain from natural systems. The MA describes the linkages between ecosystem services and how these affect human livelihoods and how humans affect the amount of ecosystem services available by our socioeconomic choices (TEEB 2010). The MA has been adopted internationally and by several federal resource agencies in the United States (MA 2005). The MA identified four main categories of ecosystem services.

1. *Provisioning services* provide material or energy outputs from ecosystems that are used directly by people. Examples include food, fuel, fiber, genetic resources, biochemical resources, ornamental resources, and fresh water.
2. *Supporting services* are processes that maintain the provision and regulatory services. Examples include habitat for species and maintenance of genetic diversity. This can include biodiversity, soil formation, primary production, nutrient cycling, water cycling, and photosynthesis.
3. *Regulating services* are aspects of the functioning ecosystem that directly benefit people, such as regulation of air, soil, and water quality, as well as water flow and flood and disease control.
4. *Cultural services* are the non-material benefits of ecosystems. Examples include education, cultural heritage, recreation and tourism, aesthetic value, and spiritual enrichment.

The proposed Plan amendments are intended to provide for the reasonable protection of fish and wildlife beneficial uses in the Sacramento/Delta watershed, which would complement ecosystem services. As described in detail in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, since the time the Bay-Delta Plan was last updated and implemented, populations of native aquatic species in the Bay-Delta watershed have shown significant signs of decline due to a combination of factors, including hydrologic modifications, non-flow physical habitat degradation, water quality impairments, and climate change. Scientific information indicates that restoration of natural flow functions is needed to address these declines in an integrated fashion with physical habitat improvements. Changes to the Sacramento/Delta provisions in the Bay-Delta Plan could help to address these issues.

8.6.4 Wildlife Refuges

As discussed in Section 7.18, *Recreation*, wildlife refuges are set aside to protect wildlife habitat and, in some instances, to create a space for public use such as recreational opportunities for hiking, hunting, photography, bird watching, and sportfishing. Wildlife refuges may have federal, state, or local levels of protection. In the study area, the Sacramento River watershed and San Joaquin Valley are the only geographic regions with wildlife refuges that receive Sacramento/Delta water supplies. Wildlife refuges have importance to migrating birds of the Pacific Flyway and other wetland-dependent wildlife (USFWS 2017a, 2017b). Overall, wildlife refuges provide economic benefits related to ecosystem services and recreation.

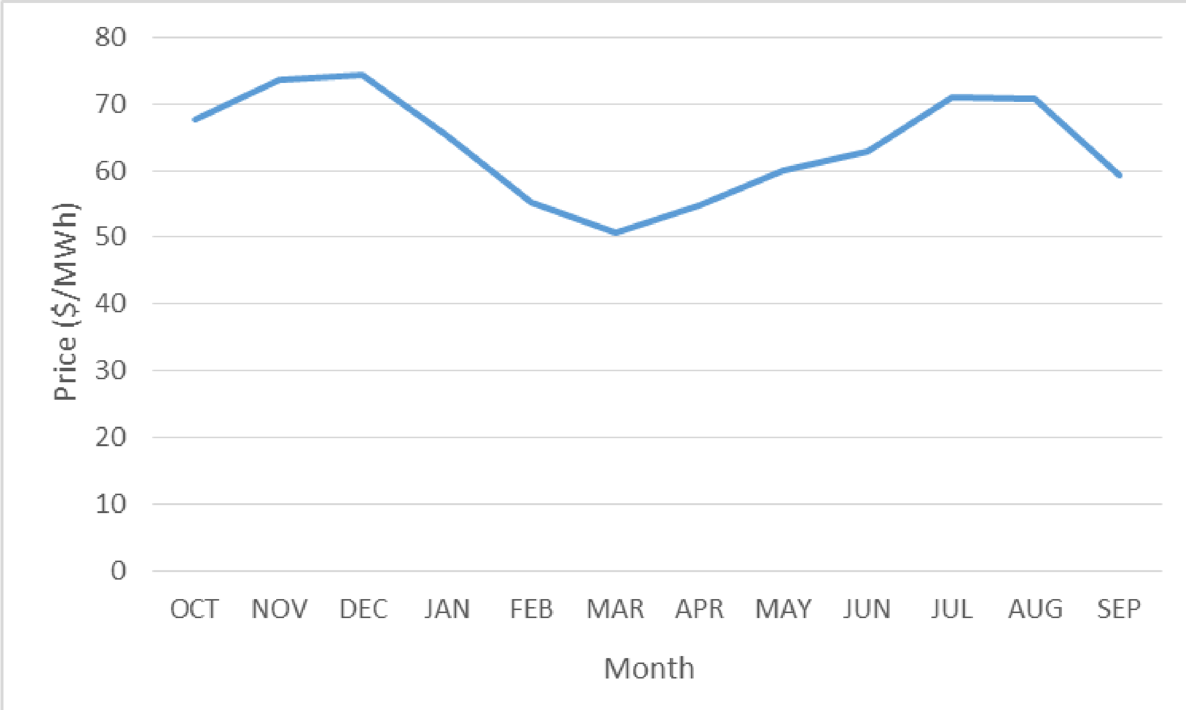
The Sacramento River watershed includes the Sacramento National Wildlife Refuge (NWR), Delevan NWR, Colusa NWR, and Sutter NWR. This region also includes the Gray Lodge State Wildlife Area (WA). The San Joaquin Valley includes the San Luis NWR Complex, Kesterson NWR, and Merced NWR and the Los Banos State WA, Volta WA, Mendota WA, and North Grasslands WA. These parks and wildlife refuges support land-based recreational activities such as hiking and bird watching. Chapter 2, *Hydrology and Water Supply*, and Section 7.6.1, *Terrestrial Biological Resources*, discuss these areas further.

As discussed in Chapter 6, *Changes in Hydrology and Water Supply*, and Section 7.6.1, *Terrestrial Biological Resources*, the proposed Plan amendments would result in reductions in surface water deliveries to wildlife refuges in the Sacramento River watershed and San Joaquin Valley. Reduced Sacramento/Delta water supplies to wildlife refuges could result in reduction in habitat for waterfowl and shorebirds and other species. Since the economic value placed on wildlife refuges is closely associated with their interaction with wildlife, these changes could also result in negative economic effects. However, the proposed Plan amendments include provisions that prioritize water supplies to refuges that could reduce these economic effects.

8.6.5 Energy

Numerous hydropower generation facilities are located within the Sacramento/Delta watershed. As discussed in Section 7.8, *Energy*, the proposed Plan amendments could result in changes in hydropower generation. Changes in hydrology would result in an increase in hydropower generation in the spring and a decrease in summer. Annually, hydropower effects would be relatively small because the total annual flow would not change, and reservoir storage would not be expected to be greatly reduced. Additional discussion of the estimated effects on hydropower generation is provided in Section 7.8.

Changes in the timing of hydropower generation, including an increase of hydropower generation in the spring and a decrease in summer, could affect hydropower generation revenues. California Independent System Operators (CAISO) data indicate that the price for generated power is typically higher during the summer months compared to the spring months (CAISO unpublished data), as shown in Figure 8.6-2. Accordingly, although hydropower effects would be relatively small on an annual basis, the proposed Plan amendments could result in a decrease in annual hydropower generation revenues.



Source: Derived from California Independent System Operators unpublished data.

Figure 8.6-2. Average Price (in dollars per megawatt hours) for Generated Power, by Month of Calendar Year

To the extent that hydropower generation changes in both overall quantity and timing, there may be an associated change in the use of other energy generators, particularly natural gas-powered facilities to either increase or decrease in operation during the year to balance supply with demand needs for energy. This could result in some additional economic effects associated with energy production costs.

8.7 Costs Associated with Habitat Restoration and Other Ecosystem Projects

The proposed Plan amendments provide a framework that would allow stakeholders to implement complementary ecosystem projects in addition to flow requirements, and actions that other entities could take that would contribute toward achieving the overall goal of improving conditions for fish and wildlife in the Sacramento/Delta watershed. These actions include physical habitat restoration projects as well as predation and invasive species control measures. In addition, the narrative cold water habitat objective would address tributary-specific temperature needs by requiring that cold water flows from reservoirs be maintained and timed to provide for downstream temperatures to protect salmon at critical times of year, or that alternate protective measures are implemented to protect native fish. The cold water habitat objective habitat objective could be implemented in part through certain construction projects such as reservoir temperature management facilities or fish passage facilities. These types of habitat restoration and other ecosystem projects are described in detail and analyzed in Section 7.21, *Habitat Restoration and Other Ecosystem Projects*.

This section provides information on relative costs associated with implementing habitat restoration and other ecosystems projects. The actual cost for specific actions can vary widely depending upon local needs, scale of facilities, and type of activity performed. The costs associated with ecosystem projects include outlays of funds for materials and devices, equipment, construction services, transportation, labor, and professional services needed to plan, place, construct, and implement the project. Once in place, the ecosystem projects may require ongoing operation and periodic maintenance, with associated material costs over time. Ecosystem projects may also include monitoring and adaptive management components that may result in additional costs. However, habitat restoration and other ecosystem projects may also result in beneficial economic effects, such as from visitors to these sites. Ecosystem projects have both implementation and ongoing costs that must be acknowledged, in consideration with the biological benefits such ecosystem projects would provide.

8.7.1 Physical Habitat Restoration

Habitat restoration includes the physical restoration of tidal, floodplain, and riparian habitats to increase hydrologic connectivity and habitat complexity. Tidal habitat restoration projects in the Sacramento/Delta watershed are typically focused on San Pablo and San Francisco Bays, Suisun Marsh, and the Delta. Floodplain and riparian habitat restoration projects are typically focused on the lowland mainstem and tributary reaches of Sacramento/Delta rivers.

As discussed in Section 7.21, *Habitat Restoration and Other Ecosystem Projects*, physical habitat restoration projects can vary widely in size. Riparian restoration projects may focus on areas of less than 1 acre for bank protection and plantings or may undertake channel rehabilitation along 1 or more miles of river; floodplain restoration projects may reconnect a few acres or hundreds of acres to the river and flooding; and tidal restoration projects may restore narrow tidal areas or entire estuaries. Some larger or multipurpose habitat restoration projects may include hardscape elements or additional or modified water infrastructure and interpretive facilities (e.g., signage, public viewing platforms) or other features in addition to the habitat modifications. Accordingly, physical habitat restoration project costs can vary substantially based on the goals, scope, and complexity of the project.

Some restoration projects may be completed as one component or phase of a larger restoration program or plan. For example, multiple restoration projects in California have received funding through the Anadromous Fish Restoration Program of the U.S. Fish and Wildlife Service. The fiscal year 2015, fiscal year 2016, and fiscal year 2017 annual budgets for the Anadromous Fish Restoration Program were $11 million, $6.1 million, and $9.9 million, respectively (Reclamation and USFWS 2014, 2015, 2016).

Example floodplain and riparian habitat restoration projects include the following.

- The Yolo Bypass Wildlife Area Drainage Improvement Project will create 220 acres of new wetlands and improve water management on 1,250 acres of existing wetlands and 540 acres of agricultural land. The Delta Conservancy funds most of the project (Delta Conservancy 2016). The Delta Conservancy funded $2 million of the project funds (Kulakow 2016).
- The Southport Setback Levee Project, located along the Sacramento River in West Sacramento, will provide multiple benefits of flood control and ecosystem enhancement by creating 152 acres of mixed floodplain and riparian habitat (Delta Plan Interagency Implementation

Committee 2017). Funding for the levee setback project and the restoration project is $130 million and $5 million, respectively (California EcoRestore n.d.(a)).

- The Sherman Island Setback Levee and Habitat Enhancement Project increased the levee stability and provided habitat restoration along Mayberry Slough on Sherman Island (California EcoRestore n.d.(b)). The project was completed in 2009 for $5.8 million and was funded by Proposition 84 and 1E and General Fund. (California EcoRestore n.d.(b)).

Enhancement of in-channel complexity is a subset of habitat restoration that focuses on the placement of large wood or boulder structures and gravel augmentation to assist in the restoration of degraded river ecosystems. Enhancement of in-channel complexity projects are often done in conjunction with gravel augmentation. Gravel augmentation is the artificial addition of spawning-sized gravel to streams to increase the quantity and quality of spawning and incubation habitat where the natural processes of gravel recruitment have been disrupted by dams, regulated flows, gravel mining, and other instream activities (e.g., bank stabilization).

Two spawning and rearing habitat restoration projects in the Sacramento River watershed provide insight into gravel augmentation applications and costs.

- Gravel has been placed recurrently on two sites in the Upper Sacramento River near Keswick Dam, funded by the Reclamation Restoration Fund (Hannon et al. 2013). In 2018, $1.8 million was funded by the Reclamation Restoration Fund (Reclamation and USFWS 2018).
- Gravel has been placed at sites in the American River in 1999 and 2008–2012—three locations at Sailor Bar, two locations at upper Sunrise, downstream of Lower Sunrise Bridge, and at Sacramento Bar (Hannon et al. 2013). In 2018, $1 million was funded by the Reclamation Restoration Fund (Reclamation and USFWS 2018).

8.7.2 Fish Passage Improvements

Fish passage improvement projects include fish screens and fishways, temperature control devices, and dam removal to facilitate fish passage at dams and other potential passage impediments and improve the survival rate of migrating adult and juvenile Chinook salmon and steelhead as they return to and from their natal spawning ground. The construction and maintenance costs associated with fish passage improvement projects can vary substantially.

Fish screens may include screening unscreened diversions or upgrading existing fish screens as necessary to meet fishery agency criteria. Fish screen costs vary widely depending upon the size of the existing diversion intake. Agricultural fish diversion screens in the western United States range from $5,000 to $80,000 for the initial capital investment, and the average producer spends between $5,000 and $9,500 per cubic foot per second (cfs) in operations and maintenance costs (FCA 2018). The Ecosystem Restoration Program has helped fund several large fish screen projects in California, including the American Basin Fish Screen and Habitat Improvement Project (CDFW n.d.).

Fishways (ladders and nature-like) naturally attract returning adult salmonids to swim up the inflow at the base of the ladder to either a holding pond at a fish hatchery or to upstream habitat. As discussed in Section 7.21, the design of a fishway depends on the degree to which the structure can hydraulically self-regulate, the species and the number of fishes that should be accommodated, and the structure's efficiency over a range of different flows. The cost of installing a fishway is highly dependent on the fishway design. Two examples are provided below.

- **Mirabel Fish Ladder:** The $12 million concrete structure on the Russian River, which includes a video monitoring system for counting fish, a publicly accessible viewing gallery, and seismic upgrades, was completed in August 2016. Project costs were funded by a surcharge on Sonoma County Water Agency customer water bills ($10.5 million) and a state grant ($1.5 million). The fish ladder and fish screen allow outmigrating juvenile coho salmon and steelhead trout to safely swim past the Sonoma County Water Agency's Inflatable Dam. (Kovner 2016; SCWA n.d.).
- **Alameda Creek Fish Ladders:** The $10 million project, led by the Alameda County Water District, is grant-funded by several California agencies and voter-approved Proposition 1 (Geha 2018). The Alameda County FC&WCD, in collaboration with the Alameda Creek Fisheries Restoration Workgroup, has been leading efforts to restore the federally-listed, threatened steelhead trout to Alameda Creek (Alameda County FC&WCD 2017). Construction of the first of two fish ladders in Alameda Creek began in April 2018. The second fish ladder, in partnership with the Alameda County FC&WCD, will start construction in 2019 (Trout Unlimited 2018). Both fish ladders are planned to be completed by late 2021(Geha 2018). Once both fish ladders are completed, steelhead trout will have a direct route, past two rubber dams and a large flood control structure, to its native habitat in Alameda Creek (Trout Unlimited 2018).

Installation or modification of temperature control devices can be used to manage water temperatures below reservoirs with outlet shutters and thermal curtains. Outlet shutters allow a reservoir operator to pull water from different levels depending on desired outflow temperature, which can improve a reservoir's ability to provide downstream cool water temperatures. Thermal curtains are used to create a barrier that draws cooler water from deeper in the reservoir into the intake by blocking warmer water near the surface, allowing only the desired colder water to flow downstream to anadromous salmonid spawning and rearing habitat. Curtains can be constructed out of synthetic rubber fabric and are suspended from floating tanks on a reservoir surface and hang vertically. A curtain may be tethered to the reservoir bottom with long cables to leave space for water to pass underneath. An example project is the Whiskeytown Reservoir Temperature Control Project, where replacement curtains lowered the temperature by 2 to 3 degrees Celsius. The replacement curtain project was completed in 2011 for a cost of $3 million (Gee et al. 2012).

Dam removal projects include the removal of small structures (e.g., diversion dams) and potentially the removal of larger structures (e.g., reservoirs) as appropriate. Small dams include permanent, flashboard, debris basin, earthen, and seasonal dams that have a relatively small volume of sediment available for release (relevant to the size of the stream channel). For large dam and reservoir removal, the approach and removal methods used are dependent on location and type of dam and the amount and type of sediment stored in the reservoir. A review of project costs from over 600 dams removed in the United States between 1965 and 2020 found that per-dam removal costs ranged from $1,000 to $268.8 million, when adjusted for inflation into 2020 (Duda et al. 2023). Dam removal costs were found to be largest for dams greater than 10 meters in height.

8.7.3 Predatory Fish Control

Strategies for predatory fish control include direct removal methods and modifications of physical barriers such as bridges and weirs that can provide conditions conducive to some nonnative predators. Direct removal methods include electrofishing, hook-and-line fishing, passive trapping (e.g., fyke nets, hoop nets, gillnets) and active capture methods (e.g., trawls, beach seines). Structural modifications that may reduce local aggregations of predators or their feeding efficiency include the removal or modification of abandoned structures (e.g., dams, bridge piers, docks), water diversion facilities (e.g., water intakes, forebays), and scour holes. Direct removal methods are generally less costly than modifications of physical barriers.

The costs of modification of physical barrier projects, designed to reduce predator habitat in the Delta and upstream tributaries, have been estimated as part of several recovery programs, such as: the Golden Gate Salmon Association Salmon Rebuilding Plan, the National Marine Fisheries Service (NMFS) Final Recovery Plan[11] (NMFS 2014), the Habitat Restoration Plan for the Lower Tuolumne River Corridor (USFWS 2000), and the San Francisco Estuary Project 2007 Comprehensive Conservation and Management Plan (SFEP 2007). The project costs are dependent on the extent of the modifications needed but generally vary in cost from $100,000–$300,000 per site for reducing predator habitat at large screen structures, to over $4.6 million for filling a gravel pit to reduce/eliminate habitat favored by predatory bass species, and replacing with high-quality Chinook salmon habitat (McBain and Trush 2000; SFEP 2007; GGSA 2013; NMFS 2014). On a broader scale, the NMFS Recovery Plan estimated implementing projects to minimize predation at weirs, diversions, and related structures in the Delta at $50 million over a period of 50 years (NMFS 2014).

8.7.4 Invasive Aquatic Vegetation Control

Invasive aquatic vegetation control can prevent the introduction and control the spread of invasive aquatic species. Chemical control (herbicide applications) is considered a feasible and effective control method because herbicides can be used to rapidly control invasive aquatic plants over large areas (hundreds or thousands of acres). Physical control, which can be successful at relatively small scales, involves the removal of invasive aquatic vegetation by hand or machine and disposal on land. Machine removal requires a mechanical harvester that cuts and collects aquatic plants. Cut plants are removed from the water by a conveyor belt system and stored on the harvester until ready for disposal. From 2013 to 2016, the California Department of Boating and Waterways along with Reclamation, Port of Stockton, Contra Costa and San Joaquin County Weed Control Districts, and more than 88 active marinas, spent over $46.8 million on invasive weed control (Jetter and Nes 2018).

8.8 Costs Associated with New or Modified Facilities

Implementation of the proposed Plan amendments would reduce Sacramento/Delta water supplies at certain times and locations. In response, water users could increase efforts to prioritize limited available water supplies and/or develop other water supply sources. Section 7.22, *New or Modified Facilities,* addresses actions that entities may take that would involve construction to modify or build new facilities and infrastructure to supplement or conserve surface water supplies and other construction projects that may result from implementation of the proposed Plan amendments. Projects include new or modified dams/reservoirs and points of diversion; groundwater wells and groundwater storage and recovery projects; and new or modified drinking water treatment plants,

[11] The NMFS Final Recovery Plan targets the evolutionarily significant units of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and the distinct population segment of California Central Valley steelhead. This action originated from the Bay Delta Conservation Plan Administrative Draft, available: http://baydeltaconservationplan.com/Library/DocumentsLandingPage/BDCPDocuments.

including desalination plants and wastewater treatment plants (WWTPs). This section provides information regarding the costs to modify or build these types of facilities.

8.8.1 New or Modified Existing Reservoirs and Points of Diversion

Although uncommon in California, new reservoirs may be proposed to improve water supply reliability. New water supply projects could enhance California's water resiliency if designed and operated in a manner that does not exacerbate existing pressures on the Delta ecosystem. A few locations have been identified where new, large-scale reservoirs may be developed, including the proposed Sites Reservoir in the Sacramento Valley and Temperance Flat Reservoir on the upper San Joaquin River. Water diverters on the smaller unregulated tributaries subject to flow requirements may choose to construct surface water storage facilities as well. Reservoirs vary in size from a small pond to a large lake. Reservoirs can be located on-stream, where water is impounded in place, or off-stream, where the reservoir is located away from the streambed and supplied by a pipeline or aqueduct. Reservoirs inundate land, modify and diminish natural flows, and can impede fish migration if located on a stream. Constructing a dam involves diverting the river, preparing the foundation and building the dam (concrete or embankment), filling the reservoir, testing the valves and floodgates, and monitoring. New reservoirs would likely include the construction of associated facilities, including canals, pipelines, electrical substations, administrative and maintenance buildings, and bridges across reservoirs or access roads.

Modification and expansion of existing reservoirs can increase storage capacity by increasing dam height, which would involve increasing the capacity or footprint of an existing reservoir and would likely involve construction and modification of the reservoir's existing system facilities.

Costs to construct or modify on-stream and off-stream reservoirs can vary based on project-specific characteristics, such as the size and location of the reservoir. A recent infrastructure study contained a meta-review of the cost of developing surface water storage in California; it found that the average cost to construct storage ranged from $580 to $2,200 per AF, with an overall average of $1,224 per AF (Dayton et al. 2016, p. 24).

Points of diversion are locations where water is being drawn from a surface water source such as a river or reservoir. A new point of diversion associated with a new reservoir could be located at or near the reservoir or downstream of where water is released. New or changed points of diversion may also be proposed independent of a reservoir to make water delivery more accessible and efficient. New points of diversion would likely include the construction of associated facilities, including pumping plants, water conveyance pipelines and canals, and sediment settling and drying basins.

The costs to construct or modify points of diversion can vary based on project size, location, and other characteristics. Two example projects related to new points of diversion in rivers in Oregon are provided below.

- **Yamhill Regional Water Authority.** The water authority commissioned an independent cost estimate for a water intake on the Willamette River to be shared by three communities (McMinnville, Lafayette, and Carlton). The capacity was assumed to be 30 to 40 cfs. Total cost for all construction including pump station, intake screens and cleaning station, supply pipe; nonconstruction costs (e.g., permits, engineering design, and rights-of-way), and contingency was estimated to be $11,271,000 (Carollo Engineers 2016).

- **City of Lake Oswego.** The city constructed a new river intake pump station on the Clackamas River in 2015. The new facility has a capacity to pump up to 38 million gallons per day (or 58.8 cfs). Total cost of the project was $11,400,000 (Lake Oswego-Tigard Water Partnership 2015).

8.8.2 Water Treatment Facilities

In response to reduced Sacramento/Delta water supplies, drinking water providers may need to rely on other sources of water that are lower in quality and require additional treatment. A new or expanded drinking water treatment plant may need to be constructed. In addition, changes in hydrology and water supply may require or result in construction of new water treatment facilities or expansion of existing facilities as analyzed in Impact UT-b under *Changes in Hydrology and Water Supply* (refer to Section 7.20, *Utilities and Service Systems*). Municipalities and wastewater treatment service providers may construct new WWTPs or modify existing WWTPs to support the development of recycled water sources to augment water supply at facilities that are large enough to have existing WWTP infrastructure (e.g., Sacramento, Los Angeles, San Diego). Information on water recycling is in Chapter 6, *Changes in Hydrology and Water Supply* (see subsection 6.6.1.3, *Recycled Water*), and in Chapter 7, *Environmental Analysis (*see subsection 7.1.4.4, *Reasonably Foreseeable Methods of Compliance and Response Actions – Changes in Water Supply – Other Water Management Actions – Water Recycling*).

This section discusses potential costs related to new or modified drinking water treatment plants and wastewater treatment plants.

8.8.2.1 New or Modified Drinking Water Treatment Plants

Drinking water plants range from simple structures, such as a single well in a small enclosure or building, to much larger facilities, such as a city drinking water plant.

Water systems that serve drinking water are required to meet all drinking water standards, and suppliers must conduct routine sampling and analysis of their drinking water supplies to certify compliance. Drinking water standards are set at levels necessary to protect the public from acute and chronic health risks associated with consuming contaminants in drinking water supplies. To meet drinking water standards, water may be treated differently in different communities depending on the quality of the water that enters the treatment plant. Typically, surface water requires more treatment and filtration than groundwater because lakes, rivers, and streams contain more sediment and pollutants and are more likely to be contaminated than groundwater. Treatment for drinking water production involves removal of contaminants from raw water to produce water that meets drinking water standards. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, nitrate, arsenic, and minerals such as iron and manganese. The processes involved in removing the contaminants include physical processes such as settling and filtration, chemical processes such as disinfection and coagulation, and biological processes such as slow sand filtration.

Two recent projects provide example costs of a new water treatment plant.

- **Davis-Woodland Water Supply Project.** The Davis-Woodland Water Supply Project will construct a surface water intake, water treatment plant, pump stations, storage tanks, and associated transmission lines to develop 45,000 AF/yr of new, high-quality water from the Sacramento River. Estimated cost is $337.0 million, including $236.9 million for a water treatment plant.
- **City of Stockton Delta Water Supply Project (DWSP**). The DWSP will develop 33,600 AF/yr of new water resources in the Delta. The DWSP has completed construction of a new surface water intake, water treatment plant, pump stations, and pipelines. The estimated project costs are $234.7 million, including $176.6 million for a water treatment plant.

Desalination facilities of both ocean and brackish water provide a specialized drinking water treatment and represent an alternative source of water for areas with limited groundwater supplies and reduced surface water availability, including both coastal and inland areas. Throughout northern and southern California, water agencies for inland and coastal areas utilize desalination technology to expand water supply.

A typical desalination water project would consist of the following: an intake system (such as a seawater or groundwater pipeline), pretreatment facilities, a desalination facility using pretreatment and reverse osmosis technology, post-treatment facilities, product water storage, on- and off-site landscaping, chemical storage facilities, on- and off-site booster pump stations, and product water transmission pipelines connecting to the existing water conveyance network. Additional design features could include stormwater drainage, noise mitigation, seawater turbidity and quality monitoring, and greenhouse gas reduction plans. In addition to producing treated water, desalination would generate a brine stream requiring storage and treatment or disposal.

Construction costs to build desalination plants can vary. In addition, ongoing costs are incurred at desalination plants to produce freshwater supplies. As discussed in Section 8.3.5, *Desalination*, seawater desalination has a median cost of $2,100 per AF for large projects and $2,800 per AF for smaller projects; desalination and is currently among the most expensive water supply options. Brackish water desalination is much less expensive, at median prices of $1,100 to $1,600 per AF, due to lower energy and treatment costs (Cooley and Phurisamban 2016, p. 14).

8.8.2.2 New or Modified Wastewater Treatment Plants and Recycled Water

Municipal wastewater contains sewage, gray water (i.e., water from sinks and showers), and sometimes industrial wastewater. A WWTP is a facility where pollutants are removed through various treatment processes (e.g., physical, chemical, biological) prior to discharge to surface water, ocean, or land. Regulation of waste discharges is discussed in more detail in subsection 7.12.1.2, *Environmental Setting*, of Section 7.12.1, *Surface Water*; and subsection 7.12.2.2, *Environmental Setting*, of Section 7.12.2, *Groundwater*. Wastewater treatment methods, including primary, secondary, and tertiary treatment, are described in detail in Section 7.20, *Utilities and Service Systems.*

Recycled water is wastewater treated by various processes until it reaches an acceptable water quality standard at a WWTP and then is distributed for use. Recycled water can be used to offset potable water used for landscape irrigation; agricultural irrigation; process water for commercial, institutional, and/or industrial uses; and for direct potable use. Water treatment varies according to end use. Direct potable use of recycled water would require that water be treated to drinking water standards.

Water recycling techniques vary based on their intended end use. As discussed in Section 7.22, *New or Modified Facilities*, these techniques include advanced treatments that may include a combination of biological treatment, membrane filtration, and membrane desalination such as reverse osmosis, ozone, and advanced oxidation.

Water may be recycled for potable or non-potable uses. Non-potable recycling includes any application not involving drinking water for human consumption, such as landscape or agricultural irrigation; commercial applications, such as car washes or dual-plumbed office buildings; or industrial process, such as oil refineries or cooling towers. Potable water is drinking water. Direct potable reuse is treated water conveyed directly from the wastewater treatment plant to a raw or treated drinking water supply lines. Indirect potable reuse is treated water from the wastewater treatment plant discharged into recharge basins to infiltrate into groundwater aquifers or into surface water reservoirs used for drinking water supply.

Construction costs to build and modify WWTPs and water recycling facilities can vary and are dependent on multiple factors. In addition, As discussed in Section 8.3.4, *Water Recycling*, non-potable recycling ranges in cost from $1,500 to $2,100 per AF, according to a recent study (Cooley and Phurisamban 2016, p. 12). A large scale indirect potable reuse project (more than 10,000 AF/yr) is similar in cost at $1,600 to $2,000 per AF, and a smaller scale project can average about $2,300 per AF (Cooley and Phurisamban 2016, p. 12). Although the treatment cost is higher for an indirect potable facility, the distribution pipeline cost is much less since a separate conveyance system is not required.

8.8.3 Groundwater Wells and Groundwater Storage and Recovery

As discussed in Section 7.22, *New and Modified Facilities*, in response to reduced Sacramento/Delta water supplies, agricultural and municipal water diverters and providers may develop new wells to supplement their supplies with groundwater. In addition, groundwater storage and recovery projects may be constructed to facilitate conjunctive use, which is the coordinated management of surface water and groundwater to improve the sustainability of the resource. Conjunctive use can be an effective approach in long-term water supply planning, so long as it does not impair the quality and sustainability of either water source.

The cost of a new groundwater well can vary considerably depending upon site characteristics, location, well depth, casing diameter, size of pump system required, and conveyance system to connect to an existing municipal system. One recent California study reported costs of $1.0 to $1.2 million for completion of a municipal well (Jasechko and Perrone, 2020, p. 10). A recent review of agricultural irrigation well completion costs found a range of $260,000 to $750,000, with a median cost of $363,000 (Jasechko and Perrone, 2020, p. 10). A review of 26 domestic wells in California constructed between 2009 and 2019 found a cost range of $3,250 to $87,000, with a median cost of $20,000 (Jasechko and Perrone, 2020, p. 10).

Water users may also choose to deepen existing wells. The cost to deepen a well is similar to the cost of drilling a well on a per-foot basis; one analysis cited by the Central Valley Flood Protection Board suggests a cost range of $35 to $84 per foot (CVFPB 2020, EIS Attachment, p. 9). The overall cost may be less than drilling a new well if existing equipment (e.g., well pump, pipes, electrical) is reusable. A deeper well will also involve higher operating costs for a municipality due to greater electricity (or diesel) requirements to pump from lower depths (Moran et al. 2014).

Groundwater storage and recovery involves storage of water for later recovery by intentionally recharging groundwater basins when excess surface water or other water sources are available. Surface water can be stored actively using injection wells. Water can come from streams during high runoff but can also utilize treated wastewater, stormwater, and agricultural runoff. Groundwater storage and recovery projects include land and appurtenant facilities, including extraction and injection wells, recharge ponds and spreading grounds, treatment and conveyance systems, and monitoring devices. Typical storage components are gravity recharge basins or injection wells that move water under pressure from the surface to an aquifer. Injection wells may be newly installed or may be retrofitted extraction wells already in place. Typical water extraction components are wells that pump groundwater from the aquifer and send the water to an existing treatment facility or directly into a distribution system for beneficial use.

Factors affecting the cost of groundwater storage and recovery projects include site characteristics; water recharge supply; conveyance infrastructure; and the ability to integrate the management of surface, groundwater, and conveyance facilities (Dayton et al. 2016, p. 24). A recent study found the average cost ranged from $305 to $887 per AF, and an average across all studies of $576 per AF (Dayton et al. 2016, p. 24). A separate study found that the median cost of over 100 projects was $410 per AFY, including capital and operation and maintenance; median cost was $320 per AFY when managed aquifer recharge was the primary goal of the project, and $830 per AFY when managed aquifer recharge was an ancillary goal of the project (Perrone and Rhode 2016, p. 7).

8.9 References

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