# Appendix D

Statewide Agricultural Production Model Documentation

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# Appendix D
# Statewide Agricultural Production Model Documentation

## D.1 Introduction

This technical appendix describes the agricultural economic model used in the analysis of Central Valley Project (CVP) Municipal and Industrial Water Shortage Policy (M&I WSP) alternatives. The scenarios evaluated for the Environmental Impact Statement (EIS) include Existing Conditions, the No Action Alternative, and action alternatives provided from CalSim II model output that were designed to cover the range of potential CVP allocation procedures. The Statewide Agricultural Production (SWAP) model was used to evaluate the effects on agricultural production for each alternative. The SWAP model results for each alternative were compared to the results of the No Action Alternative to quantify changes in agricultural production, irrigated acreage, and gross farm revenues.

## D.2 SWAP Model Overview

The SWAP model is a regional agricultural production and economic optimization model that simulates the decisions of farmers across 93 percent of agricultural land in California. It is the most current in a series of California agricultural production models, originally developed by researchers at the University of California at Davis in collaboration with the California Department of Water Resources (DWR) with additional funding provided by the Bureau of Reclamation (Reclamation).

The SWAP model has been subject to peer-review (Howitt et al. 2012). The SWAP model, and its predecessor the Central Valley Production Model (CVPM), have been used for numerous policy analyses and impact studies over the past 15 years, including the impacts of the Central Valley Project Improvement Act (Reclamation and United State Fish and Wildlife Service [USFWS] 1999), Upper San Joaquin Basin Storage Investigation (Reclamation 2008), the State Water Project (SWP) drought impact analysis (Howitt et al. 2009a), and the economic implications of Sacramento-San Joaquin River Delta (Delta) conveyance options (Lund et al. 2007).

### D.2.1 SWAP Model Mechanics

The SWAP model data coverage is most detailed in the Central Valley, but it also includes production regions in the Central Coast, South Coast, and desert areas.

The model assumes that farmers maximize profit subject to resource, technical, and market constraints. Farmers sell and buy in competitive markets, and no one farmer can affect or control the price of any commodity. The model selects those crops, water supplies, and other inputs that maximize profit subject to constraints on water and land, and subject to economic conditions regarding prices, yields, and costs. The competitive market is simulated by maximizing the sum of consumer and producer surplus subject to the following characteristics of production, market conditions, and available resources:

- Constant Elasticity of Substitution (CES) production functions for every crop in every region. CES has four inputs: land, labor, water, and other supplies. CES production functions allow for limited substitution between inputs which allows the model to estimate both total input use and input use intensity. Parameters are calculated using a combination of prior information and the method of Positive Mathematical Programming (PMP) (Howitt 1995).

- Groundwater pumping cost including depth to groundwater.

- California statewide commodity demand functions.

- Resource constraints on land, labor, water, and other input availability by region.

The SWAP model incorporates project water supplies (SWP and CVP), other local water supplies, and groundwater. As conditions change within a SWAP region (e.g., the quantity of available project water supply increases or the cost of groundwater pumping increases), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. It also fallows land when that appears to be the most cost-effective response to resource conditions.

The SWAP model is used to compare the long-run response of agriculture to potential changes in SWP and CVP irrigation water delivery, other surface or groundwater conditions, or other economic values or restrictions.

Results from Reclamation's and DWR's operations planning model CalSim II model are used as inputs into SWAP through a standardized data linkage tool. CalSim II output for the four alternative scenarios and Existing Conditions were used as inputs into the SWAP model. The CalSim II data file for each scenario includes nine water year types of which five were included in the SWAP model inputs. The water year types included: wet, above normal, below normal, dry, and critical conditions. For each scenario and water year type, the CalSim II model provides the SWAP model with CVP and SWP deliveries for each SWAP model region. For more information on the CalSim II model, please see Appendix B, Water Operations Model Documentation.

Alternative 4, Updated M&I WSP, was not explicitly modeled in SWAP as the CVP deliveries as simulated in the CalSim II model were the same as the No Action Alternative. See Appendix B for more information.

### D.2.2 SWAP Model Theory

The SWAP model self-calibrates using a three-step procedure based on PMP (Howitt 1995) and the assumption that farmers behave as profit-maximizing agents. In a traditional optimization model, profit-maximizing farmers would simply allocate all land, up until resource constraints become binding, to the most valuable crop(s). In other words, a traditional model would have a tendency for overspecialization in production activities relative to what is observed empirically. The method of PMP incorporates information on the marginal production conditions that farmers face, allowing the model to exactly replicate a base year of observed input use and output. Marginal conditions may include inter-temporal effects of crop rotation, proximity to processing facilities, management skills, farm-level effects such as risk and input smoothing, and heterogeneity in soil and other physical capital. In the SWAP model, PMP is used to translate these unobservable marginal conditions, in addition to observed average conditions, into a cost function.

Unobserved marginal production conditions are incorporated into the SWAP model through increasing land costs. Additional land brought into production is of lower quality and, as such, requires higher production costs, captured with an exponential "PMP" cost function. The PMP cost function is both region and crop specific, reflecting differences in production across crops and heterogeneity across regions. Functions are calibrated using information from acreage response elasticities and shadow values of calibration and resource constraints. The information is incorporated in such a way that the average cost data reflected in standard crop budgets (known data) are unaffected.

PMP is fundamentally a three-step procedure for model calibration that assumes farmers optimize input use for maximization of profits. In the first step a linear profit-maximization program is solved. In addition to basic resource availability and non-negativity constraints, a set of calibration constraints is added to restrict land use to observed values. In the second step, the dual (shadow) values from the calibration and resource constraints are used to derive the parameters for the exponential PMP cost function and CES production function. In the third step, the calibrated CES and PMP cost function are combined into a full profit maximization program. The exponential PMP cost function captures the marginal decisions of farmers through the increasing cost of bringing additional land into production (e.g., through decreasing quality). Other input costs, (supplies, land, and labor) enter linearly into the objective function in both the first and third step.

The SWAP model, and calibration by PMP, is a complicated process thus sequential testing is very useful for model validation, diagnosing problems, and debugging the model. At each stage in the SWAP model there is a corresponding model check. In other words, the calibration procedure has particular emphasis

on the sequential calibration process and a parallel set of diagnostic tests to check model performance. Diagnostic tests are discussed in Howitt et al. (2012).

### D.2.3 Constant Elasticity of Substitution Production Function

Crop production in the SWAP model is represented by a CES production function for each region and crop. In general, a production function is a mathematical specification used to capture the relationship between inputs and output. For example, land, labor, water, and other inputs are combined to produce output of any crop. CES production functions in the SWAP model are specific to each region, thus regional input use is combined to determine regional production for each crop. The calibration routine in SWAP guarantees that both input use and output exactly match a base year of observed data.

The generalized CES production function allows for limited substitution among inputs (Beattie and Taylor 1985). This is consistent with observed farmer production practices (farmers are able to substitute among inputs in order to achieve the same level of production). For example, farmers may substitute labor for chemicals by reducing herbicide application and increasing manual weed control. Or, farmers can substitute labor for water by managing an existing irrigation system more intensively in order to increase efficiency. The CES function used in version 6 of the SWAP model is non-nested, thus the elasticity of substitution is the same between all inputs.

### D.2.4 Crop Demand Functions

The SWAP model is specified with downward-sloping California statewide demand functions. The demand curve represents willingness-to-pay for a given level of crop production. All else constant, as production of a crop increases the price of that crop is expected to fall. The extent of the price decrease depends on the elasticity of demand or, equivalently, the price flexibility. The latter refers to the percentage change in crop price due to a percent change in production. The SWAP model is specified with linear demand functions.

#### *D.2.4.1 Demand Shifts*

The nature of the demand function for specific commodities can change over time due to tastes and preferences, population growth, changes in income, and other factors. The SWAP model incorporates linear shifts in the demand functions over time due to growth in population and changes in real income per capita. Changes in consumer tastes and preferences are difficult to predict and will have an indeterminate effect on demand and are consequently not considered in the model.

## D.3 SWAP Model Data

The SWAP model requires a wide range of data to simulate the supply and demand for statewide agricultural production. The necessary data are not available from a single source and are instead compiled from various publically available sources, including state and federal agencies, academic publications, and

water district reports. The last SWAP model data update was completed between 2009 and 2011 under contract with Reclamation, and the model data and code is currently being updated under contract with the California Department of Food and Agriculture. The model update completed in 2011 is known as SWAP version 6 and this version was used for analysis of the M&I WSP alternatives. The update in progress will be known as SWAP version 7, and is not expected to be complete until early 2015.

### D.3.1 SWAP Regions and Crop Definitions

The SWAP model has 27 base regions in the Central Valley. The current SWAP model covers agriculture in the original 21 CVPM regions, the Central Coast, the Colorado River region that includes Coachella, Palo Verde and the Imperial Valley and San Diego, Santa Ana and Ventura and the South Coast. Only the 27 regions in the Central Valley are included in the analysis of M&I WSP alternatives.

The SWAP model regions with CVP agricultural water service contractors were included in the summary of the M&I WSP alternatives. CVP agricultural water service contractor regions include regions 2, 3a, 3b, 4, 5, 6, 9, 10, 13, 14a, 15a, 17, 18, and 20. These 14 regions were further aggregated into the Sacramento Valley (2, 3a, 3b, 4, 5, 6), San Joaquin River (9, 10, 13), and Tulare Lake (14a, 15a, 17, 18, 20) regions. Table D-1 summarizes some of the major water users in each of the regions.

**Table D-1. SWAP Model Region Summary**

| Region | Major Surface Water Users |
|---|---|
| 1 | CVP Users: Anderson Cottonwood Irrigation District (ID), Clear Creek Community Services District (CSD), Bella Vista Water District (WD), and miscellaneous Sacramento River water users. |
| 2 | CVP Users: Corning Canal, Kirkwood WD, Tehama, and miscellaneous Sacramento River water users. |
| 3a | CVP Users: Glenn Colusa ID, Provident ID, Princeton-Codora ID, Maxwell ID, and Colusa Basin Drain Mutual Water Company (MWC) |
| 3b | Tehama Colusa Canal Service Area. CVP Users: Orland-Artois WD and Westside WD. |
| 4 | CVP Users: Princeton-Codora-Glenn ID, Colusa Irrigation Co., and miscellaneous Sacramento River water users. |
| 5 | Most Feather River Region riparian and appropriative users. |
| 6 | Yolo and Solano Counties. CVP Users: Conaway Ranch and miscellaneous Sacramento River water users. |
| 7 | Sacramento County north of American River. CVP Users: Natomas Central MWC., miscellaneous Sacramento River water users, Pleasant Grove-Verona WMC., and Placer County Water Agency. |
| 8 | Sacramento County south of American River and northern San Joaquin County. |
| 9 | Direct diverters within the Delta region. CVP Users: Banta Carbona ID, West Side WD, and Plainview. |
| 10 | Delta Mendota service area. CVP Users: Panoche WD, Pacheco WD, Del Puerto WD, Hospital WD, Sunflower WD, San Joaquin River Exchange Contractors. |
| 11 | Stanislaus River water rights: Modesto ID, Oakdale ID, and South San Joaquin ID. |

| Region | Major Surface Water Users |
|---|---|
| 12 | Turlock ID. |
| 13 | Merced ID. CVP Users: Madera ID, Chowchilla WD, and Gravely Ford. |
| 14a | CVP Users: Westlands WD. |
| 14b | Southwest corner of Kings County |
| 15a | Tulare Lake Bed. CVP Users: Fresno Slough WD, James ID, Tranquility ID, Traction Ranch, Laguna WD, and Reclamation District 1606. |
| 15b | Dudley Ridge WD and Devils Den (Castaic Lake) |
| 16 | Eastern Fresno County. CVP Users: Friant-Kern Canal, Fresno ID, Garfield WD, and International WD. |
| 17 | CVP Users: Friant-Kern Canal, Hills Valley ID, Tri-Valley WD, and Orange Cove. |
| 18 | CVP Users: Friant-Kern Canal, County of Fresno, Lower Tule River ID, Pixley ID, and Tulare ID. |
| 19a | SWP Service Area, including Belridge Water Storage District (WSD), Berrenda Mesa WD. |
| 19b | SWP Service Area, including Semitropic WSD |
| 20 | CVP Users: Friant-Kern Canal. Shafter-Wasco, and South San Joaquin ID. |
| 21a | CVP Users: Cross Valley Canal and Friant-Kern Canal |
| 21b | Arvin Edison WD. |
| 21c | SWP service area: Wheeler Ridge-Maricopa WSD. |
| 23-30 | Central Coast, Desert, and Southern California |

Note: the list above does not include all water users. It is intended only to indicate the major users or categories of users. All regions in the Central Valley also include private groundwater pumpers.

Crops are aggregated into 20 crop groups which are the same across all regions. Each crop group represents a number of individual crops, but many are dominated by a single crop. Irrigated acres represent acreage of all crops within the group, production costs and returns are represented by a single proxy crop for each group. The current 20 crop groups were defined in collaboration with DWR and were last updated in March 2011. Crop group definitions and the corresponding proxy crop are shown in Table D-2.

**Table D-2. SWAP Model Crop Groups**

| SWAP Definition | Proxy Crop | Other Crops |
|---|---|---|
| Almonds and Pistachios | Almonds | Pistachios |
| Alfalfa | Alfalfa Hay | |
| Corn | Grain Corn | Corn Silage |
| Cotton | Pima Cotton | Upland Cotton |
| Cucurbits | Summer Squash | Melons, Cucumbers, Pumpkins |
| Dry Beans | Dry Beans | Lima Beans |
| Fresh Tomatoes | Fresh Tomatoes | |
| Grain | Wheat | Oats, Sorghum, Barley |
| Onions and Garlic | Dry Onions | Fresh Onions, Garlic |
| Other Deciduous | Walnuts | Peaches, Plums, Apples |
| Other Field | Sudan Grass Hay | Other Silage |
| Other Truck | Broccoli | Carrots, Peppers, Lettuce, Other Vegetables |
| Pasture | Irrigated Pasture | |

| SWAP Definition | Proxy Crop | Other Crops |
|---|---|---|
| Potatoes | White Potatoes | |
| Processing Tomatoes | Processing Tomatoes | |
| Rice | Rice | |
| Safflower | Safflower | |
| Sugar Beet | Sugar Beets | |
| Subtropical | Oranges | Lemons, Miscellaneous Citrus, Olives |
| Vine | Wine Grapes | Table Grapes, Raisins |

### D.3.2 Crop Prices and Yields

The SWAP model is designed to calibrate to the actual conditions growers faced in 2005. Growers make current planting decisions based on expectations of prices. The SWAP model does not attempt to model how growers form their price expectations; as an approximation, SWAP uses a three-year simple average of county-level crop prices. Three year 2005 to 2007 averages of crop prices are calculated using the counties in the Central Valley regions within SWAP. Crop prices for each of the SWAP regions within the Central Valley correspond to one of these three areas. Data for county-level crop prices are obtained from the respective County Agricultural Commissioners' annual crop reports.

### D.3.3 Crop Yields

Crop yields for each crop group in the SWAP model correspond to the proxy crops listed in Table D-2 and are based on best management practices. The corresponding costs of production, discussed in a subsequent section, are based on cost studies that also reflect best management practices. Thus, crop yields in SWAP are slightly higher than those estimated by calculating county averages, but are more consistent with the production costs. Crop yield data are compiled from the University of California Cooperative Extension (UCCE) production cost budgets prepared by University of California at Davis and UCCE researchers. Yields for each region are based on the most recent proxy crop cost study available in the closest region. For example, if a cost study is not available for a particular crop in the Sacramento Valley, the North San Joaquin Valley study may be used.

### D.3.4 Crop Cost of Production Budgets

Land, labor, and other supply costs of production are obtained from the same UCCE crop budgets used to estimate crop yields. Each UCCE budget uses interest rates for capital recovery and interest on operating capital specific to the year of the study. These range from four percent to over eight percent and, as such, require adjustment to a common base year interest rate. Since the SWAP model is designed to replicate base 2005 conditions, interest rates are adjusted to reflect conditions in 2005.

Land costs are derived from the respective UCCE crop budget and include land-related cash overhead plus rent and land capital recovery costs. Where appropriate, interest rates are adjusted as described above.

The labor cost category in the SWAP model includes both machine and non-machine labor. Labor wages per hour differ for machine and non-machine labor and, as such, are reported separately in the UCCE budgets. Both machine and non-machine labor costs include overhead to the farmer of federal and state payroll taxes, workers' compensation, and a small percentage for other benefits which varies by budget. Additionally, a percentage premium (typically around 20 percent) is added to machine labor costs to account for equipment set-up, moving, maintenance, breaks, and field repair. The sum of these components, reported on a per acre basis, is used as input data into the SWAP model.

The supply cost category in the SWAP model includes all inputs not explicitly included in the other three input categories (land, labor, and water), including fertilizers, herbicides, insecticide, fungicide, rodenticide, seed, fuel, and custom costs. Additionally, machinery, establishment costs, buildings, and irrigation system capital recovery costs are included. Each sub-category of supply costs is broken down in detail in the respective crop budget. For example, safflower in the Sacramento Valley requires pre-plant Nitrogen as aqua ammonia at 100 lb per acre in fertilizer costs. Application of Roundup in February and Treflan in March account for herbicide costs. The sum of these individual components, on a per acre basis, is used as base supply input cost data in the SWAP model.

### D.3.5 Surface and Groundwater

The SWAP model includes five types of surface water: SWP delivery; three categories of CVP delivery; and local surface water delivery or direct diversion (LOC). The three categories of CVP deliveries are: water service contract, including Friant Class 1 (CVP1); Friant Class 2 (CL2); and water rights settlement and exchange delivery (CVPS)[1]. The SWAP model calibrates to a base year 2005 of land and water use. Water supply data in the base year of 2005 is derived from various sources, described below. CVP and SWP deliveries for the M&I WSP alternatives are from the CalSim II model, described in Appendix D.2.1.

The volume of deliveries for each water source in the base year of 2005 is estimated using data from DWR, Reclamation, and water district reports. CVP water deliveries were derived from Reclamation operations data. Contract deliveries were obtained from Reclamation, the difference between total and contract deliveries indicates deliveries for water rights settlements. SWP water deliveries are obtained from DWR Bulletin 132 (DWR 2008). Kern County Water Agency provides additional details on SWP deliveries to member agencies by region. Local surface water deliveries were obtained from individual district records and reports, DWR water balance estimates prepared for the California

[1] CVP Settlement water is delivered to districts and individuals in the Sacramento Valley based on their pre-CVP water rights on the Sacramento River, and San Joaquin River Exchange water is pumped from the Delta and delivered to four districts in the San Joaquin Valley in exchange for water rights diversion eliminated when Friant Dam was constructed. These two delivery categories are geographically distinct but for convenience are combined into one water supply category in SWAP.

Water Plan Update (DWR 2009), and where needed, data from the CVPM model. CVPM data were, in turn, provided by the Central Valley Ground-Surface Water Model.

A key source of irrigation water, and often the most costly, is groundwater pumping. Groundwater pumping capacity estimates are from a 2009 analysis by DWR in consultation with individual districts. Groundwater pumping capacity is intended to represent the maximum that a region can pump in a year given the aquifer characteristics and existing well capacities.

Groundwater pumping costs are broken out into fixed, energy, and operations and maintenance (O&M) components in the SWAP model. Energy and O&M components are variable. Energy costs depend on the price of electricity. The SWAP model version 6 uses the same unit cost of electricity per kilowatt-hour across all regions. Base electricity costs are derived from PG&E rate books and consultation with power officials at the Fresno, California office. Energy cost in 2005 dollars is 18.9 cents per kilowatt-hour, which is an average of PG&E's AG-1B and AG-4B rates (PG&E various years). Overall well efficiency is assumed to be 70 percent.

### D.3.6 Crop Water Requirements

Applied water is the amount of water applied by the irrigation system to an acre of a given crop for production in a typical year. Variation in rainfall and other climate effects will alter this requirement. Additionally, farmers may stress irrigate crops or substitute other inputs in order to reduce applied water. The latter effect is handled endogenously by the SWAP model through the respective CES production functions. Applied water per acre (base) requirements for crops in the SWAP model are derived from DWR estimates. DWR estimates are based on Detailed Analysis Units (DAU). An average of DAUs within a SWAP region is used to generate a SWAP region specific estimate of applied water per acre for SWAP crops.

### D.3.7 Elasticities

SWAP uses a number of economic response parameters, called elasticities, to estimate rates of change in variables. An elasticity is the percent change in a variable, per unit of percent change in another variable or parameter. Acreage response elasticity is one component of supply response. It is the percentage change in acreage of a crop from a one percent change in that crop's price. The SWAP model contains both long run and short run estimates, and the analyst decides which of the elasticities to use. Long run acreage response elasticities are used for this analysis.

### D.3.8 SWAP Model Data Sources

The SWAP model uses a base year of 2005. DWR is now developing more detailed annual time series data on agricultural land use, but the current version of the SWAP model calibrates to 2005 as a relatively normal base year. 2005 was neither abnormally dry nor wet, and crop markets had been relatively stable.

Since 2005, California has experienced drought and unusually high commodity prices, thus more recent base years are not used. All prices and costs in the SWAP model are in constant 2005 dollars for consistency with the land use data. Table D-3 summarizes input data and sources used in the SWAP model.

**Table D-3. SWAP Model Input Data Summary**

| Input | Source | Notes |
|---|---|---|
| Land Use | DWR | Base year 2005 |
| Crop Prices | County Agricultural Commissioners' | By proxy crop using 2005—2007 average prices |
| Crop Yields | UCCE Crop Budgets | By proxy crop for various years (most recent available) |
| Interest Rates | UCCE Crop Budgets | All interest rates normalized to year 2005 (6.35%) |
| Land Costs | UCCE Crop Budgets | By proxy crop for various years (most recent available) |
| Other Supply Costs | UCCE Crop Budgets | By proxy crop for various years (most recent available) |
| Labor Costs | UCCE Crop Budgets | By proxy crop for various years (most recent available) |
| Surface Water Costs | Reclamation, DWR, Individual Districts | By SWAP model region |
| Groundwater Costs | PG&E, Individual Districts | Total cost per acre-foot includes fixed, O&M, and energy cost |
| Irrigation Water | DWR | Average crop irrigation water requirements in acre-feet per acre |
| Available Water | CVPM, DWR, Reclamation, Individual Districts | By SWAP model region and water supply source |
| Elasticities | Green et al. 2006 | California estimates |

### D.3.9 Linkage to Other Models

The SWAP model has important interactions with other models. In particular, CalSim II, Reclamation's and DWR's project operations model for the CVP and the SWP, is used to estimate SWP and CVP supplies which are inputs into SWAP. An existing linkage tool has been developed to translate CalSim II delivery output to a corresponding SWAP input (on-farm applied water) file. Changes in depth to groundwater affect pumping costs and agricultural revenues. Changes in groundwater depth, and resulting changes in groundwater pumping costs can be included from other model, such as CVHM or C2VSim, output, if those models are run concurrently for the project.

## D.4 Implementing the SWAP Model for the M&I WSP Alternatives

Scenario analysis using the SWAP model can focus on a single point in time or on several future points. With reasonable interpolation, this approach will create a true time sequence to calculate net present value of a stream of costs or benefits.

The alternatives for the M&I WSP were evaluated at a single point in time, also called the level of development.

SWAP is used to compare the long-run agricultural economic responses to changes in CVP irrigation water delivery under the M&I WSP alternatives. Results from the CalSim II model are used as inputs into SWAP through a standardized data linkage tool. As described previously, CalSim II output for the four alternative scenarios and Existing Conditions were used as inputs into the SWAP model. The CalSim II data file for each scenario included nine water year types, of which five were included in the SWAP model inputs. The water year types included: wet, above normal, below normal, dry, and critical conditions. For each scenario and water year type, the CalSim II model provides the SWAP model with CVP and SWP on-farm water deliveries for each SWAP model region.

Additional adjustments relevant to the level of development in the M&I WSP alternatives are described below.

## D.4.1 Level of Development and Water Year Type

The No Action Alternative and action alternatives correspond to a 2030 level of development. The Existing Conditions scenario corresponds to the current 2014 level of development.

Each alternative and level of development was evaluated for five water year types, including: wet, above normal, below normal, dry, and critical.

### *D.4.1.1 Crop Demand Shifts*

Crop demands are expected to shift in the future due to increased population, higher real incomes, changes in tastes and preferences, and related factors. The key changes that are included in the analysis of M&I WSP alternatives are population and real income. An increase in real income is expected to increase demand for agricultural products. Similarly, population increase is expected to increase crop demand. Changes in consumer tastes and preferences will have an indeterminate effect on demand and are not included in this analysis.

Increases in demand for crops produced in California may be partially offset by other production regions depending on changing export market conditions. For example, today California is the dominant producer of almonds but this may change if other regions in the U.S. or the world increase production. Thus an increase in almond demand could be partially met by other regions. However, additional demand growth from markets like China may offset this effect. The net effect is indeterminate. In the absence of data or studies demonstrating which effect would dominate, California export share is assumed to remain constant for all crops in the future. This is a key assumption which is consistent with peer-reviewed publications for the California Energy Commission and the academic journal *Climatic Change* in addition to the 2009 DWR Water Plan (Howitt et al. 2009a, Howitt et al. 2009b).

Crop demands are linear in the SWAP model and population and real income changes induce a parallel shift in demand. Demand shifts are included for all of the alternative scenarios evaluated for the M&I WSP, including the No Action Alternative. The exception is the Existing Conditions alternative which includes no shift in demand. Consequently, comparison of the No Action Alternative to each action alternative compares identical future market conditions.

For purposes of the demand shift analysis, a distinction is made between two types of crops grown in California: California specific crops and global commodities. Global commodity crops include grain rice, and corn[2]; all other crop groups are classified as California crops. Global commodity crops are those for which there is no separate demand for California's production. For these crops, California faces a perfectly elastic demand, and is thus a price taker. For California specific crops, California faces a downward sloping demand for a market that is driven by conditions in the United States and international export markets. A routine in the SWAP model calculates the demand shift for the 2030 level of development for the M&I WSP alternatives.

#### *D.4.1.2 Electricity Costs*

Groundwater pumping is typically the most expensive water supply. Real power costs are expected to increase in the future, and groundwater pumping relies heavily on the cost of electricity. Energy pumping costs are escalated according to future marginal power cost estimates for the year 2030.

A marginal power cost escalator is determined for the year 2030 and applied to the energy cost component of groundwater costs. The cost escalator is the ratio of the expected future power cost in 2030 to the base power cost in 2005, in 2005 $/MWh. Expected future power costs are calculated using the DWR Forward Price Projections (DWR 2011) analysis using wholesale power costs. This calculates an average power cost for each month as the average of the peak (upper bound) and off-peak (lower bound) rates. An average of the monthly costs generates an average yearly cost. This cost is used to generate the power cost escalator by taking the ratio of the future year average to the current year average. The power cost escalator for 2030 is 1.54.

#### *D.4.1.3 Groundwater Depth*

The SWAP model can be linked to a groundwater model to estimate change in depth to groundwater, both static and dynamic, to estimate the additional lift, and therefore energy cost, for water year types. Dry years can result in groundwater levels dropping by several feet in some regions of the Central Valley, depending on local aquifer conditions. The CVHM or C2VSim models were not run for the M&I WSP alternatives. A review of existing studies using the SWAP model linked to CVHM determined that no basis was available to adjust depth to groundwater under the alternative water year types. As such, depth to

[2] Rice demand is very elastic but not perfectly elastic. For purposes of the demand shifting analysis, it is assumed to be perfectly elastic.

groundwater is held constant at the baseline levels under all water year types and alternatives.

#### *D.4.1.4 Other Factors*

The SWAP model includes a number of sub-routines that are included in studies on a case-by-case basis, but rarely included in evaluation of EIS alternatives. All of these other factors are held constant in the M&I WSP alternatives.
Climate change effects are held constant in the analysis of M&I WSP alternatives. The SWAP model has been linked to crop models, such as LAWS, to estimate the change in crop yield and crop evapotranspiration (ET) and therefore applied water requirements. Climate change effects on crop growth remain highly uncertain and are consequently held constant in the analysis.

Crop yields have been increasing for most crops due to technological innovations. Innovations like hybrid seeds, better chemicals and fertilizer, improved pest management, and irrigation and mechanical harvesting advances are some examples. The expected future rate of growth in crop yields remains a contentious topic among researchers. Consequently, yield changes due to technological innovations are held constant in the analysis of M&I WSP alternatives. It is important to note that the SWAP model does allow for some minor yield response to changing market conditions. This effect is referred to as endogenous yield changes. The SWAP model includes full CES production functions for each crop and region which allow for some endogenous yield change in response to changing market conditions, but there is no exogenous technological change included in the analysis.

## D.5 Summary of SWAP Results

This section describes the SWAP model results for Existing Conditions and the M&I WSP alternatives. Changes in economic conditions in the Central Valley are summarized in terms of irrigated acreage, gross farm revenues, groundwater use, and groundwater cost. As described previously, agricultural water service contractors in three regions, Sacramento Valley, San Joaquin River, and Tulare Lake, are included in the summary of economic changes. Water year types summarized in this section include wet, below normal, and critical conditions.

### D.5.1 Existing Conditions

The Existing Conditions scenario is defined as the baseline conditions for agricultural production in the Central Valley in the current (2014) period. All production conditions including land use, production costs, crop prices, crop yields, and market conditions are representative of the current period. Table D-4 shows the total irrigated acreage and gross farm revenues under Existing Conditions, and the change from the No Action Alternative, which is described in the following section. Table D-5 shows the total groundwater use and groundwater cost under Existing Conditions, and the change from the No Action Alternative.

Many of the differences between Existing Conditions and the policy alternatives are a result of changes that are not related to the M&I WSP. These factors were described in the previous sections and include population growth (crop demand shifts) and real electricity costs.

All of the alternatives are evaluated at a 2030 level of development. Demand for California agriculture is expected to increase between current conditions and 2030 due to population and real income growth. Increasing demand for California crops will increase the real price that growers receive for crop production, all else constant. The Existing Conditions scenario corresponds to the current level of development and consequently does not include the future changes in crop demand. As such, the difference between Existing Conditions and the No Action Alternative shows the effect of the change in real crop prices, which is not attributed to the M&I WSP.

The real cost of electricity is expected to increase between current conditions and the year 2030. The cost of electricity is the largest component of the variable cost of pumping groundwater to irrigate crops. As the cost of electricity increases growers will substitute away from groundwater to minimize the effect of these higher costs. Growers will substitute surface water for groundwater in districts where there is excess capacity to do so and, in areas where there is no available surface water growers will slightly reduce water application and shift the crop mix towards crops that use less water per acre. The difference between Existing Conditions and the No Action Alternative shows the effect of higher groundwater pumping costs, which is not attributable to the M&I WSP.

**Table D-4. Existing Conditions Acreage and Value Results**

| Analysis Metric | Existing Conditions | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,385.6 | -2.7 |
| San Joaquin River | 1,401.9 | -3.3 |
| Tulare Lake | 2,307.7 | -7.6 |
| **Total Value of Production (million $)** | | 0.0 |
| Sacramento Valley | 3,236.0 | -967.0 |
| San Joaquin River | 3,188.1 | -951.8 |
| Tulare Lake | 6,571.3 | -1,424.6 |
| | **Below Normal Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,382.7 | -1.8 |
| San Joaquin River | 1,401.4 | -2.7 |
| Tulare Lake | 2,288.2 | -20.3 |

| Analysis Metric | Existing Conditions | Change from the No Action Alternative |
|---|---|---|
| **Total Value of Production (million $)** | | 0.0 |
| Sacramento Valley | 3,234.8 | -963.5 |
| San Joaquin River | 3,192.2 | -949.1 |
| Tulare Lake | 6,541.9 | -1,455.1 |
| | **Critical Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,347.9 | 12.8 |
| San Joaquin River | 1,400.1 | -4.2 |
| Tulare Lake | 2,162.1 | -0.6 |
| **Total Value of Production (million $)** | 0.0 | 0.0 |
| Sacramento Valley | 3,192.7 | -899.0 |
| San Joaquin River | 3,206.5 | -956.5 |
| Tulare Lake | 6,379.0 | -1,464.3 |

## Table D-5. Existing Conditions Groundwater Use and Cost Results

| Analysis Metric | Existing Conditions | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Annual Groundwater Pumped (thousand acre-feet [TAF])** | | |
| Sacramento Valley | 1,316.3 | 67.8 |
| San Joaquin River | 1,044.7 | 48.5 |
| Tulare Lake | 2,453.9 | 21.5 |
| **Annual Cost of Pumping (million $)** | | 0.0 |
| Sacramento Valley | 51.2 | -9.4 |
| San Joaquin River | 54.8 | -10.3 |
| Tulare Lake | 199.4 | -54.4 |
| | **Below Normal Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,335.2 | 69.4 |
| San Joaquin River | 1,254.8 | 46.2 |
| Tulare Lake | 2,879.3 | -21.5 |
| **Annual Cost of Pumping (million $)** | | 0.0 |
| Sacramento Valley | 53.3 | -10.5 |
| San Joaquin River | 66.3 | -13.3 |
| Tulare Lake | 251.5 | -80.9 |
| | **Critical Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,367.2 | 50.1 |
| San Joaquin River | 1,576.4 | 6.4 |
| Tulare Lake | 3,274.3 | -10.5 |

| Analysis Metric | Existing Conditions | Change from the No Action Alternative |
|---|---|---|
| **Annual Cost of Pumping (million $)** | 0.0 | 0.0 |
| Sacramento Valley | 55.3 | -11.4 |
| San Joaquin River | 83.8 | -20.4 |
| Tulare Lake | 282.2 | -89.7 |

## D.5.2 Alternative 1, No Action Alternative

Alternative 1, the No Action Alternative, represents future (2030) market and production conditions for Central Valley agriculture where an action alternative is not implemented. The No Action Alternative is used to compare the M&I WSP Alternatives 2, 3, and 5. Table D-6 shows the total irrigated acreage and gross value of agricultural production under the No Action Alternative. Table D-7 shows the total groundwater pumping and cost under the No Action Alternative.

On average, in the Central Valley regions with agricultural water service contractors under the No Action Alternative nearly $16 billion in gross value of production would be generated on about 5.2 million irrigated acres. The wet water year conditions lead to the highest value and largest irrigated footprint. The total irrigated area and gross value decreases in below normal and critical conditions as growers shift the crop mix to lower water use crops and fallow land in response to constrained surface water supplies. For example, the Tulare Lake region irrigates 2.31 million acres in wet years and 2.16 million acres in critically dry years and the corresponding gross value of production decreases from $7.99 million to $7.83 million. Growers are able to partially offset reduced surface water supplies by increasing the amount of groundwater pumped. In the Tulare Lake region, groundwater pumping increases from 2.42 million acre-feet (AF) to 3.24 million AF between wet and critically dry years.

**Table D-6. No Action Alternative Acreage and Value Results**

| Analysis Metric | No Action Alternative |
|---|---|
| | **Wet Condition** |
| **Total Irrigated Acreage (thousand acres)** | |
| Sacramento Valley | 1,388.4 |
| San Joaquin River | 1,405.2 |
| Tulare Lake | 2,315.2 |
| **Total Value of Production (million $)** | |
| Sacramento Valley | 4,203.1 |
| San Joaquin River | 4,140.0 |
| Tulare Lake | 7,995.9 |
| | **Below Normal Condition** |
| **Total Irrigated Acreage (thousand acres)** | |
| Sacramento Valley | 1,384.5 |
| San Joaquin River | 1,404.1 |
| Tulare Lake | 2,308.5 |
| **Total Value of Production (million $)** | |

| Analysis Metric | No Action Alternative |
|---|---|
| Sacramento Valley | 4,198.3 |
| San Joaquin River | 4,141.3 |
| Tulare Lake | 7,996.9 |
| | **Critical Condition** |
| **Total Irrigated Acreage (thousand acres)** | |
| Sacramento Valley | 1,335.0 |
| San Joaquin River | 1,404.2 |
| Tulare Lake | 2,162.7 |
| **Total Value of Production (million $)** | |
| Sacramento Valley | 4,091.7 |
| San Joaquin River | 4,163.1 |
| Tulare Lake | 7,843.2 |

## Table D-7. No Action Alternative Groundwater Use and Cost Results

| Analysis Metric | No Action Alternative |
|---|---|
| | **Wet Condition** |
| **Annual Groundwater Pumped (TAF)** | |
| Sacramento Valley | 1,248.5 |
| San Joaquin River | 996.2 |
| Tulare Lake | 2,432.4 |
| **Annual Cost of Pumping (million $)** | |
| Sacramento Valley | 60.6 |
| San Joaquin River | 65.1 |
| Tulare Lake | 253.8 |
| | **Below Normal Condition** |
| **Annual Groundwater Pumped (TAF)** | |
| Sacramento Valley | 1,265.8 |
| San Joaquin River | 1,208.7 |
| Tulare Lake | 2,900.7 |
| **Annual Cost of Pumping (million $)** | |
| Sacramento Valley | 63.9 |
| San Joaquin River | 79.6 |
| Tulare Lake | 332.4 |
| | **Critical Condition** |
| **Annual Groundwater Pumped (TAF)** | |
| Sacramento Valley | 1,317.1 |
| San Joaquin River | 1,570.0 |
| Tulare Lake | 3,284.8 |
| **Annual Cost of Pumping (million $)** | |
| Sacramento Valley | 66.8 |
| San Joaquin River | 104.3 |
| Tulare Lake | 371.9 |

### D.5.3 Alternative 2, Equal Agricultural and M&I Allocation

Under Alternative 2, Equal Agricultural and M&I Allocation, agricultural and municipal and industrial (M&I) water service contractors are given equal allocations based on percentage of contract total. Alternative 2 is described in Chapter 2.

Table D-8 shows the total irrigated acreage and gross farm revenues under Alternative 2, and the change from the No Action Alternative. Table D-9 shows the total groundwater use and groundwater cost under Alternative 2, and the change from the No Action Alternative.

Agricultural deliveries are given equal allocation to M&I deliveries, consequently Alternative 2 shows a small increase in irrigated acreage and reduction in groundwater pumping relative to the No Action Alternative. In wet years Alternative 2 has a negligible effect on total irrigated acreage and value. In critically dry years the total value of irrigated crop production would increase by a total of $74 million on an additional 44 thousand irrigated acres per year. Total groundwater pumping decreases by 51 TAF at a cost savings of $4 million per year.

The effects of Alternative 2 are not constant across agricultural water service contractor regions in the Central Valley. In all water year conditions, the San Joaquin River region value of production decreases under Alternative 2. This is in contrast to the Sacramento Valley and Tulare Lake regions where the value of production increases. The reason for this difference is that deliveries to the San Joaquin River Exchange Contractors are unchanged under Alternative 2. Sacramento Valley and Tulare Lake regions increase production in response to additional surface water supplies, and this additional production slightly decreases the statewide price for crops (all else constant). Therefore, the San Joaquin River region then receives a lower price for the crops produced and suffers small economic losses under Alternative 2. The losses in the San Joaquin River region increases with drier water year conditions, with a maximum loss of crop value equal to $4.8 million per year in critically dry years.

**Table D-8. Alternative 2 Acreage and Value Results**

| Analysis Metric | Alternative 2 | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,388.4 | 0.0 |
| San Joaquin River | 1,405.2 | 0.1 |
| Tulare Lake | 2,315.2 | 0.0 |
| **Total Value of Production (million $)** | | 0.0 |
| Sacramento Valley | 4,203.1 | 0.0 |
| San Joaquin River | 4,140.0 | 0.0 |
| Tulare Lake | 7,995.9 | 0.0 |

| Analysis Metric | Alternative 2 | Change from the No Action Alternative |
|---|---|---|
| | **Below Normal Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,387.6 | 3.1 |
| San Joaquin River | 1,404.1 | 0.0 |
| Tulare Lake | 2,315.3 | 6.8 |
| **Total Value of Production (million $)** | | 0.0 |
| Sacramento Valley | 4,202.0 | 3.7 |
| San Joaquin River | 4,140.7 | -0.7 |
| Tulare Lake | 7,997.4 | 0.5 |
| | **Critical Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,344.7 | 9.6 |
| San Joaquin River | 1,404.2 | 0.0 |
| Tulare Lake | 2,196.9 | 34.2 |
| **Total Value of Production (million $)** | | |
| Sacramento Valley | 4,127.4 | 35.7 |
| San Joaquin River | 4,158.2 | -4.8 |
| Tulare Lake | 7,886.5 | 43.2 |

**Table D-9. Alternative 2 Groundwater Use and Cost Results**

| Analysis Metric | Alternative 2 | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,245.5 | -3.0 |
| San Joaquin River | 986.7 | -9.5 |
| Tulare Lake | 2,407.3 | -25.1 |
| **Annual Cost of Pumping (million $)** | | |
| Sacramento Valley | 60.3 | -0.3 |
| San Joaquin River | 64.4 | -0.7 |
| Tulare Lake | 248.9 | -4.9 |
| | **Below Normal Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,264.5 | -1.3 |
| San Joaquin River | 1,191.3 | -17.4 |
| Tulare Lake | 2,875.1 | -25.7 |
| **Annual Cost of Pumping (million $)** | | |
| Sacramento Valley | 63.8 | -0.1 |
| San Joaquin River | 78.5 | -1.2 |
| Tulare Lake | 327.6 | -4.8 |

| Analysis Metric | Alternative 2 | Change from the No Action Alternative |
|---|---|---|
| | **Critical Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,314.0 | -3.1 |
| San Joaquin River | 1,535.2 | -34.8 |
| Tulare Lake | 3,271.3 | -13.5 |
| **Annual Cost of Pumping (million $)** | | |
| Sacramento Valley | 66.6 | -0.2 |
| San Joaquin River | 101.9 | -2.4 |
| Tulare Lake | 370.4 | -1.5 |

### D.5.4 Alternative 3, Full M&I Allocation Preference

Under Alternative 3, Full M&I Allocation Preference, M&I water service contractors are given priority over agricultural water service contractors. Alternative 3 is described in detail in Chapter 2.

Table D-10 shows the total irrigated acreage and gross farm revenues under Alternative 3, and the change from the No Action Alternative. Table D-11 shows the total groundwater use and groundwater cost under Alternative 3, and the change from the No Action Alternative.

In Alternative 3, M&I water service contractors are given priority, consequently Alternative 3 shows a small decrease in irrigated acreage and increase in groundwater pumping relative to the No Action Alternative. In wet years Alternative 3 has a negligible effect on acreage and value. In critically dry years the total value of irrigated crop production would decrease by $57 million on 27 thousand fewer irrigated acres per year. Total groundwater pumping increases to offset the decreased surface water, by 27 TAF at an additional cost of $2.2 million per year.

The effects of Alternative 3 are not constant across agricultural water service contractor regions in the Central Valley. In all water year conditions, the San Joaquin River region value of production increases under Alternative 3. This is in contrast to the Sacramento Valley and Tulare Lake regions where the value of production decreases. The reason for this difference is surface water deliveries to the San Joaquin River Exchange Contractors are unchanged under Alternative 3. Sacramento Valley and Tulare Lake regions decrease production in response to additional surface water supplies, and this drop in production slightly increases the statewide price for crops (all else constant). Therefore, the San Joaquin River region has access to adequate water supplies and receives a higher price for the crops produced. The increase in value in the San Joaquin River region increases with drier water year conditions, with a maximum increase of crop value equal to $5.2 million per year in critically dry years.

**Table D-10. Alternative 3 Acreage and Value Results**

| Analysis Metric | Alternative 3 | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,388.4 | 0.0 |
| San Joaquin River | 1,405.1 | 0.0 |
| Tulare Lake | 2,315.2 | 0.0 |
| **Total Value of Production (million $)** | | 0.0 |
| Sacramento Valley | 4,203.1 | 0.0 |
| San Joaquin River | 4,140.0 | 0.0 |
| Tulare Lake | 7,995.9 | 0.0 |
| | **Below Normal Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,383.1 | -1.4 |
| San Joaquin River | 1,404.1 | 0.0 |
| Tulare Lake | 2,301.8 | -6.7 |
| **Total Value of Production (million $)** | | 0.0 |
| Sacramento Valley | 4,195.3 | -3.0 |
| San Joaquin River | 4,141.8 | 0.4 |
| Tulare Lake | 7,996.1 | -0.8 |
| | **Critical Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,330.8 | -4.2 |
| San Joaquin River | 1,404.2 | 0.0 |
| Tulare Lake | 2,139.8 | -22.9 |
| **Total Value of Production (million $)** | 0.0 | 0.0 |
| Sacramento Valley | 4,075.6 | -16.1 |
| San Joaquin River | 4,168.2 | 5.2 |
| Tulare Lake | 7,797.3 | -45.9 |

**Table D-11. Alternative 3 Groundwater Use and Cost Results**

| Analysis Metric | Alternative 3 | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,249.0 | 0.4 |
| San Joaquin River | 999.6 | 3.4 |
| Tulare Lake | 2,443.4 | 11.0 |
| **Annual Cost of Pumping (million $)** | | 0.0 |
| Sacramento Valley | 60.6 | 0.0 |
| San Joaquin River | 65.3 | 0.2 |
| Tulare Lake | 256.0 | 2.2 |

| Analysis Metric | Alternative 3 | Change from the No Action Alternative |
|---|---|---|
| | **Below Normal Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,266.4 | 0.6 |
| San Joaquin River | 1,218.6 | 9.9 |
| Tulare Lake | 2,903.9 | 3.1 |
| **Annual Cost of Pumping (million $)** | | 0.0 |
| Sacramento Valley | 63.9 | 0.0 |
| San Joaquin River | 80.3 | 0.7 |
| Tulare Lake | 332.7 | 0.3 |
| | **Critical Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,318.3 | 1.2 |
| San Joaquin River | 1,588.8 | 18.7 |
| Tulare Lake | 3,291.9 | 7.0 |
| **Annual Cost of Pumping (million $)** | 0.0 | 0.0 |
| Sacramento Valley | 66.8 | 0.1 |
| San Joaquin River | 105.6 | 1.3 |
| Tulare Lake | 372.6 | 0.8 |

### D.5.5 Alternative 5, M&I Contractor Suggested WSP

Under Alternative 5, M&I Contractor Suggested WSP, there are negligible differences in SWAP results compared to the No Action Alternative. Alternative 5 is described in detail in Chapter 2.

Table D-12 shows the total irrigated acreage and gross farm revenues under Alternative 5, and the change from the No Action Alternative. Table D-13 shows the total groundwater use and groundwater cost under Alternative 5, and the change from the No Action Alternative.

Alternative 5 has a negligible effect on irrigated acreage, gross value, and groundwater under all water year conditions. The Tulare Lake region in critically dry conditions shows a small decrease in gross value due to a shift in the crop mix and increase in groundwater pumping to offset reduced surface water supplies.

**Table D-12. Alternative 5 Acreage and Value Results**

| Analysis Metric | Alternative 5 | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,388.4 | 0.0 |
| San Joaquin River | 1,405.2 | 0.0 |
| Tulare Lake | 2,315.2 | 0.0 |

| Analysis Metric | Alternative 5 | Change from the No Action Alternative |
|---|---|---|
| **Total Value of Production (million $)** | | |
| Sacramento Valley | 4,203.1 | 0.0 |
| San Joaquin River | 4,140.0 | 0.0 |
| Tulare Lake | 7,995.9 | 0.0 |
| | **Below Normal Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,384.5 | 0.0 |
| San Joaquin River | 1,404.1 | 0.0 |
| Tulare Lake | 2,308.5 | 0.0 |
| **Total Value of Production (million $)** | | |
| Sacramento Valley | 4,198.3 | 0.0 |
| San Joaquin River | 4,141.3 | 0.0 |
| Tulare Lake | 7,996.9 | 0.0 |
| | **Critical Condition** | |
| **Total Irrigated Acreage (thousand acres)** | | |
| Sacramento Valley | 1,335.0 | 0.0 |
| San Joaquin River | 1,404.2 | 0.0 |
| Tulare Lake | 2,162.7 | 0.0 |
| **Total Value of Production (million $)** | | |
| Sacramento Valley | 4,091.7 | 0.0 |
| San Joaquin River | 4,163.1 | 0.0 |
| Tulare Lake | 7,843.2 | -0.1 |

## Table D-13. Alternative 5 Groundwater Use and Cost Results

| Analysis Metric | Alternative 5 | Change from the No Action Alternative |
|---|---|---|
| | **Wet Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,248.5 | 0.0 |
| San Joaquin River | 996.3 | 0.0 |
| Tulare Lake | 2,432.6 | 0.2 |
| **Annual Cost of Pumping (million $)** | | |
| Sacramento Valley | 60.6 | 0.0 |
| San Joaquin River | 65.1 | 0.0 |
| Tulare Lake | 253.8 | 0.0 |
| | **Below Normal Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,265.8 | 0.0 |
| San Joaquin River | 1,208.7 | 0.0 |
| Tulare Lake | 2,900.8 | 0.1 |

| Analysis Metric | Alternative 5 | Change from the No Action Alternative |
|---|---|---|
| **Annual Cost of Pumping (million $)** | | |
| Sacramento Valley | 63.9 | 0.0 |
| San Joaquin River | 79.6 | 0.0 |
| Tulare Lake | 332.4 | 0.0 |
| | **Critical Condition** | |
| **Annual Groundwater Pumped (TAF)** | | |
| Sacramento Valley | 1,317.1 | 0.0 |
| San Joaquin River | 1,570.1 | 0.1 |
| Tulare Lake | 3,284.9 | 0.0 |
| **Annual Cost of Pumping (million $)** | | |
| Sacramento Valley | 66.8 | 0.0 |
| San Joaquin River | 104.3 | 0.0 |
| Tulare Lake | 371.9 | 0.0 |

## D.6 SWAP Model Limitations

The SWAP model is an optimization model that makes the best (most profitable) adjustments to water supply and other changes. Constraints can be imposed to simulate restrictions on how much adjustment is possible or how fast the adjustment can realistically occur. Nevertheless, an optimization model can tend to over-adjust and minimize costs associated with detrimental changes or, similarly, maximize benefits associated with positive changes.

SWAP does not explicitly account for the dynamic nature of agricultural production; it provides a point-in-time comparison between two conditions. This is consistent with the way most economic and environmental impact analysis is conducted, but it can obscure sometimes important adjustment costs.

SWAP also does not explicitly incorporate risk or risk preferences (e.g., risk aversion) into its objective function. Risk and variability are handled in two ways. First, the calibration procedure for SWAP is designed to reproduce observed crop mix, so to the extent that crop mix incorporates risk spreading and risk aversion, the starting, calibrated SWAP base condition will also. 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 types.

Groundwater is an alternative source to augment SWP and CVP delivery in many subregions. The cost and availability of groundwater therefore has an important effect on how SWAP responds to changes in delivery. However, SWAP is not a groundwater model and does not include any direct way to adjust pumping lifts and unit pumping cost in response to long-run changes in pumping quantities.

Similar to other DWR water models including Least Cost Planning Simulation Model, SWAP currently does not differentiate between water delivered under the Table A, Article 21, or Article 56 provisions of the SWP water contracts, treating the supplies as equally valuable for crop production.

## D.7 References

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# Appendix E
Air Quality Emission Calculations

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**General Conformity Applicability Evaluation for Sacramento Valley Air Basin**

**Table 1. Groundwater Pumping Emissions in Sacramento Metro 8-Hour Ozone Nonattainment Area**

| Year Type | Groundwater Pumping by SWAP Model Region (TAF/year) | | | | | | | Annual Emissions (tons per year) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V03B | V04 | V05 | V06 | V09 | Total | Change | VOC | NOx | CO | SOx | PM10 | PM2.5 |
| **Alternative 1 (No Action)/Alternative 4** | | | | | | | | | | | | | |
| Wet | 8.1 | 18.5 | 290.0 | 478.9 | 100.0 | 895.4 | n/a | | | | | | |
| Above Normal | 13.6 | 11.9 | 290.0 | 477.9 | 100.0 | 893.3 | n/a | | | | | | |
| Below Normal | 74.7 | 0.0 | 290.0 | 473.7 | 101.0 | 939.5 | n/a | | | | | | |
| Dry | 74.7 | 0.0 | 290.0 | 474.5 | 102.9 | 942.1 | n/a | | | | | | |
| Critical | 74.7 | 2.0 | 290.0 | 473.8 | 107.5 | 948.0 | n/a | | | | | | |
| **Alternative 2** | | | | | | | | | | | | | |
| Wet | 5.4 | 18.5 | 290.0 | 478.9 | 100.0 | 892.7 | (2.7) | (0.2) | (3.0) | (3.9) | (1.0) | (0.2) | (0.2) |
| Above Normal | 9.5 | 11.9 | 290.0 | 477.9 | 100.0 | 889.2 | (4.1) | (0.2) | (4.5) | (5.9) | (1.5) | (0.4) | (0.4) |
| Below Normal | 74.7 | 0.0 | 290.0 | 473.6 | 100.3 | 938.6 | (0.9) | (0.0) | (0.9) | (1.2) | (0.3) | (0.1) | (0.1) |
| Dry | 74.7 | 0.0 | 290.0 | 474.5 | 101.6 | 940.8 | (1.3) | (0.1) | (1.4) | (1.9) | (0.5) | (0.1) | (0.1) |
| Critical | 74.7 | 1.9 | 290.0 | 473.7 | 105.8 | 946.3 | (1.7) | (0.1) | (1.9) | (2.4) | (0.6) | (0.1) | (0.1) |
| **Alternative 3** | | | | | | | | | | | | | |
| Wet | 8.5 | 18.5 | 290.0 | 478.9 | 100.0 | 895.8 | 0.4 | 0.0 | 0.4 | 0.6 | 0.1 | 0.0 | 0.0 |
| Above Normal | 15.3 | 11.9 | 290.0 | 477.9 | 100.0 | 895.1 | 1.8 | 0.1 | 1.9 | 2.5 | 0.6 | 0.2 | 0.1 |
| Below Normal | 74.7 | 0.0 | 290.0 | 473.8 | 101.4 | 940.0 | 0.5 | 0.0 | 0.6 | 0.8 | 0.2 | 0.0 | 0.0 |
| Dry | 74.7 | 0.0 | 290.0 | 474.5 | 103.8 | 943.1 | 0.9 | 0.1 | 1.0 | 1.3 | 0.3 | 0.1 | 0.1 |
| Critical | 74.7 | 2.0 | 290.0 | 473.8 | 108.3 | 948.9 | 0.9 | 0.1 | 1.0 | 1.3 | 0.3 | 0.1 | 0.1 |
| **Alternative 5** | | | | | | | | | | | | | |
| Wet | 8.1 | 18.5 | 290.0 | 478.9 | 100.0 | 895.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 13.6 | 11.9 | 290.0 | 477.9 | 100.0 | 893.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 74.7 | 0.0 | 290.0 | 473.7 | 101.0 | 939.5 | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) |
| Dry | 74.7 | 0.0 | 290.0 | 474.5 | 102.9 | 942.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical | 74.7 | 2.0 | 290.0 | 473.8 | 107.5 | 948.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Note:

Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)

Although the PM2.5 nonattainment region is different than the 8-hour O3 nonattainment region, the affected SWAP regions are the same.

Key:

CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
SWAP = Statewide Agricultural Production
TAF = thousand acre-feet
VOC = volatile organic compounds

**Table 2. Groundwater Pumping Emissions in Sacramento PM10 Maintenance Area**

| Year Type | SWAP Model Region (TAF/year) | | Annual Emissions (tons per year) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | V09 | Change | VOC | NOx | CO | SOx | PM10 | PM2.5 |
| **Alternative 1 (No Action)/Alternative 4** | | | | | | | | |
| Wet | 100.0 | n/a | | | | | | |
| Above Normal | 100.0 | n/a | | | | | | |
| Below Normal | 101.0 | n/a | | | | | | |
| Dry | 102.9 | n/a | | | | | | |
| Critical | 107.5 | n/a | | | | | | |
| **Alternative 2** | | | | | | | | |
| Wet | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 100.3 | (0.7) | (0.0) | (0.8) | (1.0) | (0.3) | (0.1) | (0.1) |
| Dry | 101.6 | (1.3) | (0.1) | (1.4) | (1.9) | (0.5) | (0.1) | (0.1) |
| Critical | 105.8 | (1.7) | (0.1) | (1.8) | (2.4) | (0.6) | (0.1) | (0.1) |
| **Alternative 3** | | | | | | | | |
| Wet | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 101.4 | 0.4 | 0.0 | 0.5 | 0.6 | 0.1 | 0.0 | 0.0 |
| Dry | 103.8 | 0.9 | 0.1 | 1.0 | 1.3 | 0.3 | 0.1 | 0.1 |
| Critical | 108.3 | 0.9 | 0.0 | 0.9 | 1.2 | 0.3 | 0.1 | 0.1 |
| **Alternative 5** | | | | | | | | |
| Wet | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 101.0 | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) |
| Dry | 102.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical | 107.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Note:
Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)
PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.
Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
SWAP = Statewide Agricultural Production
TAF = thousand acre-feet
VOC = volatile organic compounds

**Table 3. Fugitive Dust Emissions in Sacramento PM10 Maintenance Area**

| Year Type | SWAP Model Region (TAF/year) | | Annual PM10 Emissions (tpy) | | | |
|---|---|---|---|---|---|---|
| | V09 | Change | Land Prep | Harvesting | Windblown Dust | Total |
| **Alternative 1 (No Action)/Alternative 4** | | | | | | |
| Wet | 406.0 | n/a | | | | |
| Above Normal | 405.3 | n/a | | | | |
| Below Normal | 404.9 | n/a | | | | |
| Dry | 404.9 | n/a | | | | |
| Critical | 404.9 | n/a | | | | |
| **Alternative 2** | | | | | | |
| Wet | 406.1 | 0.1 | 7.97E-04 | 6.70E-05 | -5.26E-05 | 8.12E-04 |
| Above Normal | 405.4 | 0.1 | 9.64E-04 | 8.10E-05 | -6.36E-05 | 9.82E-04 |
| Below Normal | 404.9 | 0.0 | 1.39E-04 | 1.16E-05 | -9.14E-06 | 1.41E-04 |
| Dry | 404.8 | (0.0) | -4.16E-05 | -3.49E-06 | 2.74E-06 | -4.23E-05 |
| Critical | 404.9 | 0.0 | 2.09E-05 | 1.75E-06 | -1.38E-06 | 2.13E-05 |
| **Alternative 3** | | | | | | |
| Wet | 406.0 | (0.0) | -2.87E-04 | -2.41E-05 | 1.90E-05 | -2.93E-04 |
| Above Normal | 405.2 | (0.0) | -3.39E-04 | -2.85E-05 | 2.24E-05 | -3.45E-04 |
| Below Normal | 404.8 | (0.0) | -9.03E-05 | -7.59E-06 | 5.96E-06 | -9.19E-05 |
| Dry | 404.9 | 0.0 | 2.30E-08 | 1.93E-09 | -1.52E-09 | 2.34E-08 |
| Critical | 404.9 | (0.0) | -1.50E-06 | -1.26E-07 | 9.88E-08 | -1.52E-06 |
| **Alternative 5** | | | | | | |
| Wet | 406.0 | (0.0) | -3.10E-06 | -2.60E-07 | 2.04E-07 | -3.15E-06 |
| Above Normal | 405.3 | (0.0) | -6.67E-06 | -5.60E-07 | 4.40E-07 | -6.79E-06 |
| Below Normal | 404.9 | (0.0) | -8.85E-08 | -7.43E-09 | 5.84E-09 | -9.01E-08 |
| Dry | 404.9 | (0.0) | -4.84E-08 | -4.06E-09 | 3.19E-09 | -4.92E-08 |
| Critical | 404.9 | (0.0) | -1.52E-08 | -1.27E-09 | 1.00E-09 | -1.54E-08 |

Note:
Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)
PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.
Key:
PM10 = inhalable particulate matter
SWAP = Statewide Agricultural Production
TAF = thousand acre-feet
tpy = tons per year

**Table 4. Fugitive Dust Emissions in Sacramento PM2.5 Nonattainment Area**

| Year Type | Total Irrigated Acreage by SWAP Model Region (thousand acres) | | | | | | | Annual PM2.5 Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | V03B | V04 | V05 | V06 | V09 | Total | Delta | Land Prep | Harvesting | Windblown Dust | Total |
| **Alternative 1 (No Action)/Alternative 4** | | | | | | | | | | | |
| Wet | 91.0 | 259.4 | 363.5 | 238.5 | 406.0 | 1,358.4 | n/a | | | | |
| Above Normal | 91.0 | 259.4 | 363.5 | 238.5 | 405.3 | 1,357.6 | n/a | | | | |
| Below Normal | 84.4 | 262.1 | 363.5 | 238.5 | 404.9 | 1,353.3 | n/a | | | | |
| Dry | 67.0 | 262.8 | 363.5 | 238.5 | 404.9 | 1,336.7 | n/a | | | | |
| Critical | 37.4 | 259.3 | 363.5 | 238.6 | 404.9 | 1,303.7 | n/a | | | | |
| **Alternative 2** | | | | | | | | | | | |
| Wet | 91.0 | 259.4 | 363.5 | 238.5 | 406.1 | 1,358.5 | 0.1 | 1.21E-04 | 1.01E-05 | -1.06E-05 | 1.20E-04 |
| Above Normal | 91.0 | 259.4 | 363.5 | 238.5 | 405.4 | 1,357.7 | 0.1 | 1.46E-04 | 1.22E-05 | -1.28E-05 | 1.45E-04 |
| Below Normal | 87.5 | 262.1 | 363.5 | 238.5 | 404.9 | 1,356.5 | 3.2 | 4.73E-03 | 3.97E-04 | -4.16E-04 | 4.71E-03 |
| Dry | 72.3 | 262.8 | 363.5 | 238.5 | 404.8 | 1,342.0 | 5.3 | 7.98E-03 | 6.70E-04 | -7.02E-04 | 7.95E-03 |
| Critical | 47.1 | 259.3 | 363.5 | 238.6 | 404.9 | 1,313.3 | 9.6 | 1.45E-02 | 1.21E-03 | -1.27E-03 | 1.44E-02 |
| **Alternative 3** | | | | | | | | | | | |
| Wet | 91.0 | 259.4 | 363.5 | 238.5 | 406.0 | 1,358.4 | (0.0) | -4.35E-05 | -3.65E-06 | 3.83E-06 | -4.33E-05 |
| Above Normal | 91.0 | 259.4 | 363.5 | 238.5 | 405.2 | 1,357.6 | (0.0) | -5.17E-05 | -4.34E-06 | 4.55E-06 | -5.15E-05 |
| Below Normal | 82.9 | 262.1 | 363.5 | 238.5 | 404.8 | 1,351.9 | (1.5) | -2.20E-03 | -1.85E-04 | 1.94E-04 | -2.19E-03 |
| Dry | 63.9 | 262.8 | 363.5 | 238.5 | 404.9 | 1,333.6 | (3.1) | -4.63E-03 | -3.89E-04 | 4.08E-04 | -4.61E-03 |
| Critical | 33.3 | 259.3 | 363.5 | 238.6 | 404.9 | 1,299.5 | (4.2) | -6.32E-03 | -5.31E-04 | 5.57E-04 | -6.30E-03 |
| **Alternative 5** | | | | | | | | | | | |
| Wet | 91.0 | 259.4 | 363.5 | 238.5 | 406.0 | 1,358.4 | (0.0) | -4.68E-07 | -3.94E-08 | 4.12E-08 | -4.67E-07 |
| Above Normal | 91.0 | 259.4 | 363.5 | 238.5 | 405.3 | 1,357.6 | (0.0) | -1.01E-06 | -8.46E-08 | 8.87E-08 | -1.00E-06 |
| Below Normal | 84.4 | 262.1 | 363.5 | 238.5 | 404.9 | 1,353.3 | 0.0 | 1.75E-06 | 1.47E-07 | -1.54E-07 | 1.74E-06 |
| Dry | 67.0 | 262.8 | 363.5 | 238.5 | 404.9 | 1,336.7 | (0.0) | -1.97E-05 | -1.65E-06 | 1.73E-06 | -1.96E-05 |
| Critical | 37.4 | 259.3 | 363.5 | 238.6 | 404.9 | 1,303.7 | (0.0) | -7.23E-06 | -6.07E-07 | 6.37E-07 | -7.20E-06 |

Note:
Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)
PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.
Although the PM2.5 nonattainment region is different than the 8-hour O3 nonattainment region, the affected SWAP regions are the same.
Key:
PM2.5 = fine particulate matter
tpy = tons per year
SWAP = Statewide Agricultural Production

**Table 5. Total PM Emissions in Sacramento Region**

| Year Type | Annual PM10 Emissions (tpy) | | | Annual PM2.5 Emissions (tpy) | | |
|---|---|---|---|---|---|---|
| | Exhaust | Dust | Total | Exhaust | Dust | Total |
| **Alternative 2** | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | (0.2) | 0.0 | (0.2) |
| Above Normal | 0.0 | 0.0 | 0.0 | (0.4) | 0.0 | (0.4) |
| Below Normal | (0.1) | 0.0 | (0.1) | (0.1) | 0.0 | (0.1) |
| Dry | (0.1) | (0.0) | (0.1) | (0.1) | 0.0 | (0.1) |
| Critical | (0.1) | 0.0 | (0.1) | (0.1) | 0.0 | (0.1) |
| **Alternative 3** | | | | | | |
| Wet | 0.0 | (0.0) | (0.0) | 0.0 | (0.0) | 0.0 |
| Above Normal | 0.0 | (0.0) | (0.0) | 0.1 | (0.0) | 0.1 |
| Below Normal | 0.0 | (0.0) | 0.0 | 0.0 | (0.0) | 0.0 |
| Dry | 0.1 | 0.0 | 0.1 | 0.1 | (0.0) | 0.1 |
| Critical | 0.1 | (0.0) | 0.1 | 0.1 | (0.0) | 0.1 |
| **Alternative 5** | | | | | | |
| Wet | 0.0 | (0.0) | (0.0) | 0.0 | (0.0) | 0.0 |
| Above Normal | 0.0 | (0.0) | (0.0) | 0.0 | (0.0) | 0.0 |
| Below Normal | (0.0) | (0.0) | (0.0) | (0.0) | 0.0 | (0.0) |
| Dry | 0.0 | (0.0) | 0.0 | 0.0 | (0.0) | 0.0 |
| Critical | 0.0 | (0.0) | 0.0 | 0.0 | (0.0) | 0.0 |

Note:
Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)
PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.
Although the PM2.5 nonattainment region is different than the 8-hour ozone nonattainment region, the affected SWAP regions are the same.
Key:
PM = particulate matter
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
tpy = tons per y ear

Average Pump Rate: 2,500 gallons per minute
*(estimated from Long-Term Water Transfers data)*

Average Engine Rating: 160 horsepower
*(estimated from Long-Term Water Transfers data)*

Conversions

| | | |
|---|---|---|
| 1 TAF = | 1,000 | acre feet |
| 1 acre-foot = | 325,851 | gallons |
| | http://www.water.ca.gov/pubs/dwrnews/california_water_facts_card/waterfactscard.pdf | |
| 1 hour = | 60 | minutes |
| 1 pound = | 453.6 | grams |
| 1 ton = | 2,000 | pounds |

Size Fractions

| Description | PM10 | PM2.5 | Ratio |
|---|---|---|---|
| PM Profile ID No. 411, Windblown Dust - Agricultural | 0.5 | 0.1 | 0.2 |
| PM Profile ID No. 417, Agricultural Tilling Dust | 0.4543 | 0.0681 | 0.1499 |

Note:
Fraction of PM10 (FRPM10) from wind erosion: 0.50
(PM10 Emissions = PM x FRPM10)

**Summary of Results by Watershed**

**Table 6. Alternative 1: Change in Emissions from Existing Conditions (tons per year)**

| | | | | | PM10 | | | PM2.5 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year Type | VOC | NOx | CO | SOx | Exhaust | Fugitive | Total | Exhaust | Fugitive | Total |
| Sacramento River | | | | | | | | | | |
| Wet | -3.9 | -73.7 | -96.9 | -24.2 | -5.8 | 226.7 | 220.9 | -5.8 | 33.9 | 28.1 |
| Above Normal | -4.0 | -76.6 | -100.7 | -25.1 | -6.0 | 221.3 | 215.3 | -6.0 | 33.1 | 27.1 |
| Below Normal | -4.0 | -75.4 | -99.2 | -24.7 | -6.0 | 232.7 | 226.7 | -5.9 | 34.8 | 28.9 |
| Dry | -3.5 | -67.4 | -88.7 | -22.1 | -5.3 | 195.2 | 189.9 | -5.3 | 29.3 | 24.0 |
| Critical | -2.9 | -54.5 | -71.7 | -17.9 | -4.3 | 163.5 | 159.2 | -4.3 | 24.9 | 20.7 |
| San Joaquin River | | | | | | | | | | |
| Wet | -2.8 | -52.7 | -69.4 | -17.3 | -4.2 | 40.1 | 35.9 | -4.1 | 5.2 | 1.1 |
| Above Normal | -2.9 | -54.2 | -71.3 | -17.8 | -4.3 | 41.1 | 36.8 | -4.2 | 5.4 | 1.2 |
| Below Normal | -2.6 | -50.2 | -66.0 | -16.4 | -4.0 | 41.4 | 37.4 | -3.9 | 5.5 | 1.6 |
| Dry | -1.9 | -35.9 | -47.2 | -11.8 | -2.8 | 42.4 | 39.5 | -2.8 | 5.8 | 3.0 |
| Critical | -0.4 | -6.9 | -9.1 | -2.3 | -0.5 | 38.6 | 38.1 | -0.5 | 4.8 | 4.2 |
| Tulare Lake | | | | | | | | | | |
| Wet | -1.2 | -23.3 | -30.7 | -7.7 | -1.8 | -6.8 | -8.6 | -1.8 | -3.0 | -4.9 |
| Above Normal | -1.7 | -32.7 | -43.0 | -10.7 | -2.6 | -7.0 | -9.6 | -2.6 | -3.1 | -5.6 |
| Below Normal | 1.2 | 23.3 | 30.7 | 7.7 | 1.8 | -15.8 | -14.0 | 1.8 | -7.8 | -6.0 |
| Dry | -0.2 | -4.1 | -5.4 | -1.3 | -0.3 | -15.5 | -15.9 | -0.3 | -5.3 | -5.6 |
| Critical | 0.6 | 11.4 | 15.1 | 3.8 | 0.9 | -6.4 | -5.5 | 0.9 | -1.1 | -0.2 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
VOC = volatile organic compounds

**Table 7. Alternative 2: Change in Emissions from Alternative 1 (tons per year)**

| | | | | | PM10 | | | PM2.5 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year Type | VOC | NOx | CO | SOx | Exhaust | Fugitive | Total | Exhaust | Fugitive | Total |
| Sacramento River | | | | | | | | | | |
| Wet | -0.2 | -3.3 | -4.3 | -1.1 | -0.3 | 0.0 | -0.3 | -0.3 | 0.0 | -0.3 |
| Above Normal | -0.3 | -5.0 | -6.5 | -1.6 | -0.4 | 0.0 | -0.4 | -0.4 | 0.0 | -0.4 |
| Below Normal | -0.1 | -1.4 | -1.8 | -0.5 | -0.1 | 4.9 | 4.8 | -0.1 | 0.6 | 0.5 |
| Dry | -0.1 | -1.5 | -1.9 | -0.5 | -0.1 | 40.7 | 40.6 | -0.1 | 5.9 | 5.8 |
| Critical | -0.2 | -3.4 | -4.5 | -1.1 | -0.3 | 27.4 | 27.2 | -0.3 | 3.8 | 3.5 |
| San Joaquin River | | | | | | | | | | |
| Wet | -0.5 | -10.3 | -13.6 | -3.4 | -0.8 | -0.2 | -1.0 | -0.8 | 0.0 | -0.9 |
| Above Normal | -0.7 | -13.0 | -17.1 | -4.3 | -1.0 | -0.2 | -1.3 | -1.0 | -0.1 | -1.1 |
| Below Normal | -1.0 | -18.9 | -24.9 | -6.2 | -1.5 | 0.3 | -1.2 | -1.5 | 0.0 | -1.4 |
| Dry | -1.7 | -32.8 | -43.2 | -10.8 | -2.6 | 0.0 | -2.6 | -2.6 | 0.0 | -2.6 |
| Critical | -2.0 | -37.8 | -49.7 | -12.4 | -3.0 | 0.1 | -2.9 | -3.0 | 0.0 | -2.9 |
| Tulare Lake | | | | | | | | | | |
| Wet | -1.4 | -27.2 | -35.8 | -8.9 | -2.1 | 0.0 | -2.1 | -2.1 | 0.0 | -2.1 |
| Above Normal | -2.2 | -41.3 | -54.3 | -13.5 | -3.3 | 0.0 | -3.2 | -3.2 | 0.0 | -3.2 |
| Below Normal | -1.5 | -27.9 | -36.7 | -9.2 | -2.2 | -16.5 | -18.7 | -2.2 | -4.3 | -6.5 |
| Dry | -0.7 | -13.0 | -17.1 | -4.3 | -1.0 | -30.6 | -31.7 | -1.0 | -12.2 | -13.3 |
| Critical | -0.8 | -14.7 | -19.4 | -4.8 | -1.2 | -36.1 | -37.3 | -1.2 | -14.6 | -15.7 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
VOC = volatile organic compounds

**Table 8. Alternative 3: Change in Emissions from Alternative 1 (tons per year)**

| Year Type | VOC | NOx | CO | SOx | PM10 | | | PM2.5 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Exhaust | Fugitive | Total | Exhaust | Fugitive | Total |
| Sacramento River | | | | | | | | | | |
| Wet | 0.0 | 0.5 | 0.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.1 | 2.1 | 2.8 | 0.7 | 0.2 | 0.0 | 0.2 | 0.2 | 0.0 | 0.2 |
| Below Normal | 0.0 | 0.7 | 0.9 | 0.2 | 0.1 | -6.3 | -6.3 | 0.1 | -0.9 | -0.8 |
| Dry | 0.0 | -0.4 | -0.5 | -0.1 | 0.0 | -25.9 | -26.0 | 0.0 | -3.8 | -3.8 |
| Critical | 0.1 | 1.3 | 1.7 | 0.4 | 0.1 | -4.5 | -4.4 | 0.1 | -0.5 | -0.4 |
| San Joaquin River | | | | | | | | | | |
| Wet | 0.2 | 3.7 | 4.9 | 1.2 | 0.3 | 0.1 | 0.4 | 0.3 | 0.0 | 0.3 |
| Above Normal | 0.2 | 4.7 | 6.1 | 1.5 | 0.4 | 0.1 | 0.5 | 0.4 | 0.0 | 0.4 |
| Below Normal | 0.6 | 10.7 | 14.1 | 3.5 | 0.8 | -0.2 | 0.6 | 0.8 | 0.0 | 0.8 |
| Dry | 1.2 | 22.4 | 29.5 | 7.4 | 1.8 | 0.0 | 1.8 | 1.8 | 0.0 | 1.8 |
| Critical | 1.1 | 20.4 | 26.8 | 6.7 | 1.6 | -0.1 | 1.5 | 1.6 | 0.0 | 1.6 |
| Tulare Lake | | | | | | | | | | |
| Wet | 0.6 | 11.9 | 15.7 | 3.9 | 0.9 | 0.0 | 0.9 | 0.9 | 0.0 | 0.9 |
| Above Normal | 0.8 | 15.8 | 20.8 | 5.2 | 1.2 | 0.0 | 1.2 | 1.2 | 0.0 | 1.2 |
| Below Normal | 0.2 | 3.4 | 4.4 | 1.1 | 0.3 | 17.5 | 17.8 | 0.3 | 4.4 | 4.7 |
| Dry | 0.5 | 9.2 | 12.1 | 3.0 | 0.7 | 19.2 | 19.9 | 0.7 | 7.7 | 8.4 |
| Critical | 0.4 | 7.6 | 10.0 | 2.5 | 0.6 | 26.1 | 26.7 | 0.6 | 10.0 | 10.6 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
VOC = volatile organic compounds

**Table 9. Alternative 5: Change in Emissions from Alternative 1 (tons per year)**

| Year Type | VOC | NOx | CO | SOx | PM10 | | | PM2.5 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Exhaust | Fugitive | Total | Exhaust | Fugitive | Total |
| Sacramento River | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 |
| Critical | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| San Joaquin River | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tulare Lake | | | | | | | | | | |
| Wet | 0.0 | 0.2 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.6 | 0.8 | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 |
| Below Normal | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Critical | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
VOC = volatile organic compounds

**Groundwater Pumping Emissions**

**Table 10. Alternative 1: Diesel Exhaust Emissions**

| SWAP Region | Change from Existing Conditions (TAF) | Annual Emissions (tons per year) VOC | NOx | CO | SOx | PM10 | PM2.5 |
|---|---|---|---|---|---|---|---|
| **Wet Condition** | | | | | | | |
| Sacramento River | -67.8 | -3.88 | -73.67 | -96.93 | -24.16 | -5.82 | -5.76 |
| San Joaquin River | -48.5 | -2.77 | -52.72 | -69.37 | -17.29 | -4.16 | -4.12 |
| Tulare Lake | -21.5 | -1.23 | -23.35 | -30.72 | -7.66 | -1.84 | -1.83 |
| **Above Normal Condition** | | | | | | | |
| Sacramento River | -70.5 | -4.03 | -76.56 | -100.74 | -25.11 | -6.04 | -5.99 |
| San Joaquin River | -49.9 | -2.85 | -54.17 | -71.28 | -17.76 | -4.28 | -4.24 |
| Tulare Lake | -30.1 | -1.72 | -32.67 | -42.98 | -10.71 | -2.58 | -2.56 |
| **Below Normal Condition** | | | | | | | |
| Sacramento River | -69.4 | -3.97 | -75.38 | -99.18 | -24.72 | -5.95 | -5.90 |
| San Joaquin River | -46.2 | -2.64 | -50.16 | -66.00 | -16.45 | -3.96 | -3.92 |
| Tulare Lake | 21.5 | 1.23 | 23.34 | 30.71 | 7.65 | 1.84 | 1.83 |
| **Dry Condition** | | | | | | | |
| Sacramento River | -62.1 | -3.55 | -67.43 | -88.72 | -22.11 | -5.32 | -5.27 |
| San Joaquin River | -33.0 | -1.89 | -35.87 | -47.20 | -11.76 | -2.83 | -2.81 |
| Tulare Lake | -3.7 | -0.21 | -4.07 | -5.35 | -1.33 | -0.32 | -0.32 |
| **Critical Condition** | | | | | | | |
| Sacramento River | -50.1 | -2.87 | -54.48 | -71.68 | -17.86 | -4.30 | -4.26 |
| San Joaquin River | -6.4 | -0.36 | -6.93 | -9.12 | -2.27 | -0.55 | -0.54 |
| Tulare Lake | 10.5 | 0.60 | 11.44 | 15.06 | 3.75 | 0.90 | 0.90 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
SWAP = Statewide Agricultural Production
TAF = thousand acre-feet
VOC = volatile organic compounds

**Table 11. Alternative 2: Diesel Exhaust Emissions**

| SWAP Region | Change from Alternative 1 (TAF) | Annual Emissions (tons per year) VOC | NOx | CO | SOx | PM10 | PM2.5 |
|---|---|---|---|---|---|---|---|
| **Wet Condition** | | | | | | | |
| Sacramento River | -3.0 | -0.17 | -3.27 | -4.30 | -1.07 | -0.26 | -0.26 |
| San Joaquin River | -9.5 | -0.54 | -10.34 | -13.60 | -3.39 | -0.82 | -0.81 |
| Tulare Lake | -25.1 | -1.43 | -27.22 | -35.81 | -8.92 | -2.15 | -2.13 |
| **Above Normal Condition** | | | | | | | |
| Sacramento River | -4.6 | -0.26 | -4.98 | -6.55 | -1.63 | -0.39 | -0.39 |
| San Joaquin River | -11.9 | -0.68 | -12.97 | -17.07 | -4.25 | -1.02 | -1.01 |
| Tulare Lake | -38.0 | -2.17 | -41.30 | -54.35 | -13.54 | -3.26 | -3.23 |
| **Below Normal Condition** | | | | | | | |
| Sacramento River | -1.3 | -0.07 | -1.39 | -1.83 | -0.46 | -0.11 | -0.11 |
| San Joaquin River | -17.4 | -1.00 | -18.93 | -24.91 | -6.21 | -1.49 | -1.48 |
| Tulare Lake | -25.7 | -1.47 | -27.91 | -36.73 | -9.15 | -2.20 | -2.18 |
| **Dry Condition** | | | | | | | |
| Sacramento River | -1.4 | -0.08 | -1.47 | -1.94 | -0.48 | -0.12 | -0.12 |
| San Joaquin River | -30.2 | -1.73 | -32.81 | -43.17 | -10.76 | -2.59 | -2.57 |
| Tulare Lake | -12.0 | -0.68 | -13.00 | -17.11 | -4.26 | -1.03 | -1.02 |
| **Critical Condition** | | | | | | | |
| Sacramento River | -3.1 | -0.18 | -3.40 | -4.47 | -1.11 | -0.27 | -0.27 |
| San Joaquin River | -34.8 | -1.99 | -37.79 | -49.72 | -12.39 | -2.98 | -2.96 |
| Tulare Lake | -13.5 | -0.77 | -14.72 | -19.36 | -4.83 | -1.16 | -1.15 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
SWAP = Statewide Agricultural Production
TAF = thousand acre-feet
VOC = volatile organic compounds

**Table 12. Alternative 3: Diesel Exhaust Emissions**

| SWAP Region | Change from Alternative 1 (TAF) | Annual Emissions (tons per year) VOC | NOx | CO | SOx | PM10 | PM2.5 |
|---|---|---|---|---|---|---|---|
| **Wet Condition** | | | | | | | |
| Sacramento River | 0.4 | 0.02 | 0.46 | 0.61 | 0.15 | 0.04 | 0.04 |
| San Joaquin River | 3.4 | 0.19 | 3.70 | 4.87 | 1.21 | 0.29 | 0.29 |
| Tulare Lake | 11.0 | 0.63 | 11.93 | 15.70 | 3.91 | 0.94 | 0.93 |
| **Above Normal Condition** | | | | | | | |
| Sacramento River | 2.0 | 0.11 | 2.14 | 2.81 | 0.70 | 0.17 | 0.17 |
| San Joaquin River | 4.3 | 0.25 | 4.66 | 6.13 | 1.53 | 0.37 | 0.36 |
| Tulare Lake | 14.5 | 0.83 | 15.77 | 20.75 | 5.17 | 1.25 | 1.23 |
| **Below Normal Condition** | | | | | | | |
| Sacramento River | 0.6 | 0.03 | 0.65 | 0.86 | 0.21 | 0.05 | 0.05 |
| San Joaquin River | 9.9 | 0.57 | 10.74 | 14.13 | 3.52 | 0.85 | 0.84 |
| Tulare Lake | 3.1 | 0.18 | 3.37 | 4.44 | 1.11 | 0.27 | 0.26 |
| **Dry Condition** | | | | | | | |
| Sacramento River | -0.3 | -0.02 | -0.35 | -0.47 | -0.12 | -0.03 | -0.03 |
| San Joaquin River | 20.6 | 1.18 | 22.42 | 29.50 | 7.35 | 1.77 | 1.75 |
| Tulare Lake | 8.5 | 0.49 | 9.22 | 12.13 | 3.02 | 0.73 | 0.72 |
| **Critical Condition** | | | | | | | |
| Sacramento River | 1.2 | 0.07 | 1.31 | 1.73 | 0.43 | 0.10 | 0.10 |
| San Joaquin River | 18.7 | 1.07 | 20.36 | 26.79 | 6.68 | 1.61 | 1.59 |
| Tulare Lake | 7.0 | 0.40 | 7.61 | 10.02 | 2.50 | 0.60 | 0.60 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
SWAP = Statewide Agricultural Production
TAF = thousand acre-feet
VOC = volatile organic compounds

**Table 13. Alternative 5: Diesel Exhaust Emissions**

| SWAP Region | Change from Alternative 1 (TAF) | Annual Emissions (tons per year) VOC | NOx | CO | SOx | PM10 | PM2.5 |
|---|---|---|---|---|---|---|---|
| **Wet Condition** | | | | | | | |
| Sacramento River | -0.002 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| San Joaquin River | 0.03 | 0.00 | 0.04 | 0.05 | 0.01 | 0.00 | 0.00 |
| Tulare Lake | 0.2 | 0.01 | 0.19 | 0.25 | 0.06 | 0.02 | 0.02 |
| **Above Normal Condition** | | | | | | | |
| Sacramento River | 0.02 | 0.00 | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 |
| San Joaquin River | 0.07 | 0.00 | 0.08 | 0.10 | 0.02 | 0.01 | 0.01 |
| Tulare Lake | 0.6 | 0.03 | 0.64 | 0.85 | 0.21 | 0.05 | 0.05 |
| **Below Normal Condition** | | | | | | | |
| Sacramento River | -0.002 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| San Joaquin River | -0.007 | 0.00 | -0.01 | -0.01 | 0.00 | 0.00 | 0.00 |
| Tulare Lake | 0.08 | 0.00 | 0.09 | 0.12 | 0.03 | 0.01 | 0.01 |
| **Dry Condition** | | | | | | | |
| Sacramento River | 0.1 | 0.01 | 0.12 | 0.15 | 0.04 | 0.01 | 0.01 |
| San Joaquin River | 0.08 | 0.00 | 0.09 | 0.12 | 0.03 | 0.01 | 0.01 |
| Tulare Lake | 0.03 | 0.00 | 0.03 | 0.04 | 0.01 | 0.00 | 0.00 |
| **Critical Condition** | | | | | | | |
| Sacramento River | 0.006 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| San Joaquin River | 0.06 | 0.00 | 0.06 | 0.08 | 0.02 | 0.00 | 0.00 |
| Tulare Lake | 0.01 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SOx = sulfur oxides
SWAP = Statewide Agricultural Production
TAF = thousand acre-feet
VOC = volatile organic compounds

Average Pump Rate: 2,500 gallons per minute
*(estimated from Long-Term Water Transfers data)*

Average Engine Rating: 160 horsepower
*(estimated from Long-Term Water Transfers data)*

Conversions

| | | |
|---|---|---|
| 1 TAF = | 1,000 | acre feet |
| 1 acre-foot = | 325,851 | gallons |
| | http://www.water.ca.gov/pubs/dwrnews/california_water_facts_card/waterfactscard.pdf | |
| 1 hour = | 60 | minutes |
| 1 pound = | 453.6 | grams |
| 1 ton = | 2,000 | pounds |

**Fugitive Dust**

**Table 14. Alternative 1: Detailed Fugitive Dust Emission Calculations**

| SWAP Region | SWAP Crop Type | Representative Crop | Irrigated Acreage (Change from Ex. Con.) (acres) | Emission Factor (lbs/acre/year) | | | Annual PM10 Emissions (tpy) | | | | Annual PM2.5 Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Land Prep | Harvesting | Windblown Dust | Land Prep | Harvesting | Windblown Dust | Total | Land Prep | Harvesting | Windblown Dust | Total |
| **Wet Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 25,089.4 | 20 | 1.68 | 1.32 | 2.51E+02 | 2.11E+01 | -1.66E+01 | 2.55E+02 | 3.76E+01 | 3.16E+00 | -3.31E+00 | 3.75E+01 |
| | Field | Corn | -10,577.7 | 6.9 | 1.68 | 1.32 | -3.65E+01 | -8.89E+00 | 6.98E+00 | -3.84E+01 | -5.47E+00 | -1.33E+00 | 1.40E+00 | -5.41E+00 |
| | Forage | Alfalfa | -24,305.3 | 4 | 0 | 1.32 | -4.86E+01 | 0.00E+00 | 1.60E+01 | -3.26E+01 | -7.29E+00 | 0.00E+00 | 3.21E+00 | -4.08E+00 |
| | Vegetable/Truck Crops | Vegetables | 11,151.0 | 8.5 | 0.17 | 1.32 | 4.74E+01 | 9.48E-01 | -7.36E+00 | 4.10E+01 | 7.10E+00 | 1.42E-01 | -1.47E+00 | 5.77E+00 |
| | Orchards and Vineyards | Almonds | 1,380.4 | 3.13 | 0.08 | 1.32 | 2.16E+00 | 5.52E-02 | -9.11E-01 | 1.30E+00 | 3.24E-01 | 8.28E-03 | -1.82E-01 | 1.50E-01 |
| | Sacramento River Subtotal | | 2,737.8 | n/a | n/a | n/a | 2.15E+02 | 1.32E+01 | -1.81E+00 | 2.27E+02 | 3.23E+01 | 1.98E+00 | -3.61E-01 | 3.39E+01 |
| San Joaquin River | Grain | Wheat | 2,162.7 | 3.7 | 5.8 | 9.75 | 4.00E+00 | 6.27E+00 | -1.05E+01 | -2.67E-01 | 6.00E-01 | 9.40E-01 | -2.11E+00 | -5.68E-01 |
| | Field | Corn | -2,517.0 | 6.9 | 1.68 | 9.75 | -8.68E+00 | -2.11E+00 | 1.23E+01 | 1.47E+00 | -1.30E+00 | -3.17E-01 | 2.45E+00 | 8.35E-01 |
| | Forage | Alfalfa | -24,116.4 | 4 | 0 | 9.75 | -4.82E+01 | 0.00E+00 | 1.18E+02 | 6.93E+01 | -7.23E+00 | 0.00E+00 | 2.35E+01 | 1.63E+01 |
| | Vegetable/Truck Crops | Vegetables | 22,074.7 | 8.5 | 0.17 | 9.75 | 9.38E+01 | 1.88E+00 | -1.08E+02 | -1.19E+01 | 1.41E+01 | 2.81E-01 | -2.15E+01 | -7.17E+00 |
| | Orchards and Vineyards | Almonds | 5,676.4 | 3.13 | 0.08 | 9.75 | 8.88E+00 | 2.27E-01 | -2.77E+01 | -1.86E+01 | 1.33E+00 | 3.40E-02 | -5.53E+00 | -4.17E+00 |
| | San Joaquin River Subtotal | | 3,280.4 | n/a | n/a | n/a | 4.98E+01 | 6.26E+00 | -1.60E+01 | 4.01E+01 | 7.46E+00 | 9.39E-01 | -3.20E+00 | 5.20E+00 |
| Tulare Lake | Grain | Wheat | 2,855.7 | 3.7 | 5.8 | 10.70 | 5.28E+00 | 8.28E+00 | -1.53E+01 | -1.71E+00 | 7.92E-01 | 1.24E+00 | -3.06E+00 | -1.02E+00 |
| | Field | Corn | -19,151.0 | 6.9 | 1.68 | 10.70 | -6.61E+01 | -1.61E+01 | 1.02E+02 | 2.03E+01 | -9.90E+00 | -2.41E+00 | 2.05E+01 | 8.18E+00 |
| | Forage | Alfalfa | -14,422.1 | 4 | 0 | 10.70 | -2.88E+01 | 0.00E+00 | 7.72E+01 | 4.83E+01 | -4.32E+00 | 0.00E+00 | 1.54E+01 | 1.11E+01 |
| | Vegetable/Truck Crops | Vegetables | 25,522.0 | 8.5 | 0.17 | 10.70 | 1.08E+02 | 2.17E+00 | -1.37E+02 | -2.59E+01 | 1.63E+01 | 3.25E-01 | -2.73E+01 | -1.07E+01 |
| | Orchards and Vineyards | Almonds | 12,761.4 | 3.13 | 0.08 | 10.70 | 2.00E+01 | 5.10E-01 | -6.83E+01 | -4.78E+01 | 2.99E+00 | 7.65E-02 | -1.37E+01 | -1.06E+01 |
| | Tulare Lake Subtotal | | 7,566.1 | n/a | n/a | n/a | 3.88E+01 | -5.13E+00 | -4.05E+01 | -6.80E+00 | 5.82E+00 | -7.68E-01 | -8.10E+00 | -3.05E+00 |
| **Above Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 24,649.3 | 20 | 1.68 | 1.32 | 2.46E+02 | 2.07E+01 | -1.63E+01 | 2.51E+02 | 3.69E+01 | 3.10E+00 | -3.25E+00 | 3.68E+01 |
| | Field | Corn | -10,714.3 | 6.9 | 1.68 | 1.32 | -3.70E+01 | -9.00E+00 | 7.07E+00 | -3.89E+01 | -5.54E+00 | -1.35E+00 | 1.41E+00 | -5.48E+00 |
| | Forage | Alfalfa | -24,359.3 | 4 | 0 | 1.32 | -4.87E+01 | 0.00E+00 | 1.61E+01 | -3.26E+01 | -7.30E+00 | 0.00E+00 | 3.21E+00 | -4.09E+00 |
| | Vegetable/Truck Crops | Vegetables | 11,072.0 | 8.5 | 0.17 | 1.32 | 4.71E+01 | 9.41E-01 | -7.31E+00 | 4.07E+01 | 7.05E+00 | 1.41E-01 | -1.46E+00 | 5.73E+00 |
| | Orchards and Vineyards | Almonds | 1,326.3 | 3.13 | 0.08 | 1.32 | 2.08E+00 | 5.31E-02 | -8.75E-01 | 1.25E+00 | 3.11E-01 | 7.95E-03 | -1.75E-01 | 1.44E-01 |
| | Sacramento River Subtotal | | 1,974.0 | n/a | n/a | n/a | 2.10E+02 | 1.27E+01 | -1.30E+00 | 2.21E+02 | 3.15E+01 | 1.90E+00 | -2.60E-01 | 3.31E+01 |
| San Joaquin River | Grain | Wheat | 2,171.4 | 3.7 | 5.8 | 9.75 | 4.02E+00 | 6.30E+00 | -1.06E+01 | -2.68E-01 | 6.02E-01 | 9.44E-01 | -2.12E+00 | -5.70E-01 |
| | Field | Corn | -2,508.2 | 6.9 | 1.68 | 9.75 | -8.65E+00 | -2.11E+00 | 1.22E+01 | 1.46E+00 | -1.30E+00 | -3.16E-01 | 2.44E+00 | 8.32E-01 |
| | Forage | Alfalfa | -24,456.9 | 4 | 0 | 9.75 | -4.89E+01 | 0.00E+00 | 1.19E+02 | 7.03E+01 | -7.33E+00 | 0.00E+00 | 2.38E+01 | 1.65E+01 |
| | Vegetable/Truck Crops | Vegetables | 22,094.5 | 8.5 | 0.17 | 9.75 | 9.39E+01 | 1.88E+00 | -1.08E+02 | -1.19E+01 | 1.41E+01 | 2.82E-01 | -2.15E+01 | -7.18E+00 |
| | Orchards and Vineyards | Almonds | 5,648.5 | 3.13 | 0.08 | 9.75 | 8.84E+00 | 2.26E-01 | -2.75E+01 | -1.85E+01 | 1.33E+00 | 3.39E-02 | -5.51E+00 | -4.15E+00 |
| | San Joaquin River Subtotal | | 2,949.3 | n/a | n/a | n/a | 4.92E+01 | 6.29E+00 | -1.44E+01 | 4.11E+01 | 7.37E+00 | 9.44E-01 | -2.87E+00 | 5.44E+00 |
| Tulare Lake | Grain | Wheat | 2,855.9 | 3.7 | 5.8 | 10.70 | 5.28E+00 | 8.28E+00 | -1.53E+01 | -1.71E+00 | 7.92E-01 | 1.24E+00 | -3.06E+00 | -1.02E+00 |
| | Field | Corn | -19,169.0 | 6.9 | 1.68 | 10.70 | -6.61E+01 | -1.61E+01 | 1.03E+02 | 2.03E+01 | -9.91E+00 | -2.41E+00 | 2.05E+01 | 8.18E+00 |
| | Forage | Alfalfa | -14,275.4 | 4 | 0 | 10.70 | -2.86E+01 | 0.00E+00 | 7.64E+01 | 4.78E+01 | -4.28E+00 | 0.00E+00 | 1.53E+01 | 1.10E+01 |
| | Vegetable/Truck Crops | Vegetables | 25,497.1 | 8.5 | 0.17 | 10.70 | 1.08E+02 | 2.17E+00 | -1.36E+02 | -2.59E+01 | 1.62E+01 | 3.25E-01 | -2.73E+01 | -1.07E+01 |
| | Orchards and Vineyards | Almonds | 12,691.2 | 3.13 | 0.08 | 10.70 | 1.99E+01 | 5.08E-01 | -6.79E+01 | -4.75E+01 | 2.98E+00 | 7.61E-02 | -1.36E+01 | -1.05E+01 |
| | Tulare Lake Subtotal | | 7,599.7 | n/a | n/a | n/a | 3.88E+01 | -5.14E+00 | -4.07E+01 | -6.98E+00 | 5.82E+00 | -7.71E-01 | -8.13E+00 | -3.08E+00 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Below Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 25,588.6 | 20 | 1.68 | 1.32 | 2.56E+02 | 2.15E+01 | -1.69E+01 | 2.60E+02 | 3.84E+01 | 3.22E+00 | -3.38E+00 | 3.82E+01 |
| | Field | Corn | -9,424.6 | 6.9 | 1.68 | 1.32 | -3.25E+01 | -7.92E+00 | 6.22E+00 | -3.42E+01 | -4.87E+00 | -1.19E+00 | 1.24E+00 | -4.82E+00 |
| | Forage | Alfalfa | -26,840.2 | 4 | 0 | 1.32 | -5.37E+01 | 0.00E+00 | 1.77E+01 | -3.60E+01 | -8.05E+00 | 0.00E+00 | 3.54E+00 | -4.50E+00 |
| | Vegetable/Truck Crops | Vegetables | 11,194.3 | 8.5 | 0.17 | 1.32 | 4.76E+01 | 9.52E-01 | -7.39E+00 | 4.11E+01 | 7.13E+00 | 1.43E-01 | -1.48E+00 | 5.80E+00 |
| | Orchards and Vineyards | Almonds | 1,301.9 | 3.13 | 0.08 | 1.32 | 2.04E+00 | 5.21E-02 | -8.59E-01 | 1.23E+00 | 3.05E-01 | 7.81E-03 | -1.72E-01 | 1.41E-01 |
| | Sacramento River Subtotal | | 1,820.1 | n/a | n/a | n/a | 2.19E+02 | 1.46E+01 | -1.20E+00 | 2.33E+02 | 3.29E+01 | 2.19E+00 | -2.40E-01 | 3.48E+01 |
| San Joaquin River | Grain | Wheat | 2,175.5 | 3.7 | 5.8 | 9.75 | 4.02E+00 | 6.31E+00 | -1.06E+01 | -2.69E-01 | 6.03E-01 | 9.46E-01 | -2.12E+00 | -5.71E-01 |
| | Field | Corn | -2,605.1 | 6.9 | 1.68 | 9.75 | -8.99E+00 | -2.19E+00 | 1.27E+01 | 1.52E+00 | -1.35E+00 | -3.28E-01 | 2.54E+00 | 8.64E-01 |
| | Forage | Alfalfa | -24,510.5 | 4 | 0 | 9.75 | -4.90E+01 | 0.00E+00 | 1.19E+02 | 7.04E+01 | -7.35E+00 | 0.00E+00 | 2.39E+01 | 1.65E+01 |
| | Vegetable/Truck Crops | Vegetables | 22,022.9 | 8.5 | 0.17 | 9.75 | 9.36E+01 | 1.87E+00 | -1.07E+02 | -1.19E+01 | 1.40E+01 | 2.81E-01 | -2.15E+01 | -7.15E+00 |
| | Orchards and Vineyards | Almonds | 5,635.1 | 3.13 | 0.08 | 9.75 | 8.82E+00 | 2.25E-01 | -2.75E+01 | -1.84E+01 | 1.32E+00 | 3.38E-02 | -5.49E+00 | -4.14E+00 |
| | San Joaquin River Subtotal | | 2,717.8 | n/a | n/a | n/a | 4.84E+01 | 6.22E+00 | -1.32E+01 | 4.14E+01 | 7.26E+00 | 9.32E-01 | -2.65E+00 | 5.54E+00 |
| Tulare Lake | Grain | Wheat | 4,171.3 | 3.7 | 5.8 | 10.70 | 7.72E+00 | 1.21E+01 | -2.23E+01 | -2.50E+00 | 1.16E+00 | 1.81E+00 | -4.46E+00 | -1.49E+00 |
| | Field | Corn | -9,159.0 | 6.9 | 1.68 | 10.70 | -3.16E+01 | -7.69E+00 | 4.90E+01 | 9.71E+00 | -4.74E+00 | -1.15E+00 | 9.80E+00 | 3.91E+00 |
| | Forage | Alfalfa | -16,359.5 | 4 | 0 | 10.70 | -3.27E+01 | 0.00E+00 | 8.75E+01 | 5.48E+01 | -4.90E+00 | 0.00E+00 | 1.75E+01 | 1.26E+01 |
| | Vegetable/Truck Crops | Vegetables | 28,555.9 | 8.5 | 0.17 | 10.70 | 1.21E+02 | 2.43E+00 | -1.53E+02 | -2.90E+01 | 1.82E+01 | 3.64E-01 | -3.06E+01 | -1.20E+01 |
| | Orchards and Vineyards | Almonds | 13,047.9 | 3.13 | 0.08 | 10.70 | 2.04E+01 | 5.22E-01 | -6.98E+01 | -4.89E+01 | 3.06E+00 | 7.82E-02 | -1.40E+01 | -1.08E+01 |
| | Tulare Lake Subtotal | | 20,256.6 | n/a | n/a | n/a | 8.52E+01 | 7.35E+00 | -1.08E+02 | -1.58E+01 | 1.28E+01 | 1.10E+00 | -2.17E+01 | -7.80E+00 |
| **Dry Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 22,555.8 | 20 | 1.68 | 1.32 | 2.26E+02 | 1.89E+01 | -1.49E+01 | 2.30E+02 | 3.38E+01 | 2.84E+00 | -2.98E+00 | 3.37E+01 |
| | Field | Corn | -12,367.8 | 6.9 | 1.68 | 1.32 | -4.27E+01 | -1.04E+01 | 8.16E+00 | -4.49E+01 | -6.40E+00 | -1.56E+00 | 1.63E+00 | -6.32E+00 |
| | Forage | Alfalfa | -21,846.4 | 4 | 0 | 1.32 | -4.37E+01 | 0.00E+00 | 1.44E+01 | -2.93E+01 | -6.55E+00 | 0.00E+00 | 2.88E+00 | -3.67E+00 |
| | Vegetable/Truck Crops | Vegetables | 10,689.6 | 8.5 | 0.17 | 1.32 | 4.54E+01 | 9.09E-01 | -7.05E+00 | 3.93E+01 | 6.81E+00 | 1.36E-01 | -1.41E+00 | 5.54E+00 |
| | Orchards and Vineyards | Almonds | 494.1 | 3.13 | 0.08 | 1.32 | 7.73E-01 | 1.98E-02 | -3.26E-01 | 4.67E-01 | 1.16E-01 | 2.96E-03 | -6.52E-02 | 5.37E-02 |
| | Sacramento River Subtotal | | -474.8 | n/a | n/a | n/a | 1.85E+02 | 9.49E+00 | 3.13E-01 | 1.95E+02 | 2.78E+01 | 1.42E+00 | 6.27E-02 | 2.93E+01 |
| San Joaquin River | Grain | Wheat | 2,171.9 | 3.7 | 5.8 | 9.75 | 4.02E+00 | 6.30E+00 | -1.06E+01 | -2.68E-01 | 6.02E-01 | 9.44E-01 | -2.12E+00 | -5.70E-01 |
| | Field | Corn | -2,521.8 | 6.9 | 1.68 | 9.75 | -8.70E+00 | -2.12E+00 | 1.23E+01 | 1.47E+00 | -1.30E+00 | -3.18E-01 | 2.46E+00 | 8.36E-01 |
| | Forage | Alfalfa | -24,849.5 | 4 | 0 | 9.75 | -4.97E+01 | 0.00E+00 | 1.21E+02 | 7.14E+01 | -7.45E+00 | 0.00E+00 | 2.42E+01 | 1.68E+01 |
| | Vegetable/Truck Crops | Vegetables | 21,855.5 | 8.5 | 0.17 | 9.75 | 9.29E+01 | 1.86E+00 | -1.07E+02 | -1.18E+01 | 1.39E+01 | 2.78E-01 | -2.13E+01 | -7.10E+00 |
| | Orchards and Vineyards | Almonds | 5,651.0 | 3.13 | 0.08 | 9.75 | 8.84E+00 | 2.26E-01 | -2.75E+01 | -1.85E+01 | 1.33E+00 | 3.39E-02 | -5.51E+00 | -4.15E+00 |
| | San Joaquin River Subtotal | | 2,307.2 | n/a | n/a | n/a | 4.73E+01 | 6.26E+00 | -1.12E+01 | 4.24E+01 | 7.10E+00 | 9.39E-01 | -2.25E+00 | 5.79E+00 |
| Tulare Lake | Grain | Wheat | 6,362.2 | 3.7 | 5.8 | 10.70 | 1.18E+01 | 1.85E+01 | -3.40E+01 | -3.82E+00 | 1.76E+00 | 2.77E+00 | -6.81E+00 | -2.28E+00 |
| | Field | Corn | -28,576.7 | 6.9 | 1.68 | 10.70 | -9.86E+01 | -2.40E+01 | 1.53E+02 | 3.03E+01 | -1.48E+01 | -3.60E+00 | 3.06E+01 | 1.22E+01 |
| | Forage | Alfalfa | -12,046.3 | 4 | 0 | 10.70 | -2.41E+01 | 0.00E+00 | 6.45E+01 | 4.04E+01 | -3.61E+00 | 0.00E+00 | 1.29E+01 | 9.28E+00 |
| | Vegetable/Truck Crops | Vegetables | 32,100.4 | 8.5 | 0.17 | 10.70 | 1.36E+02 | 2.73E+00 | -1.72E+02 | -3.26E+01 | 2.05E+01 | 4.09E-01 | -3.43E+01 | -1.35E+01 |
| | Orchards and Vineyards | Almonds | 13,294.7 | 3.13 | 0.08 | 10.70 | 2.08E+01 | 5.32E-01 | -7.11E+01 | -4.98E+01 | 3.12E+00 | 7.97E-02 | -1.42E+01 | -1.10E+01 |
| | Tulare Lake Subtotal | | 11,134.3 | n/a | n/a | n/a | 4.63E+01 | -2.29E+00 | -5.96E+01 | -1.55E+01 | 6.94E+00 | -3.44E-01 | -1.19E+01 | -5.31E+00 |
| **Critical Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 20,304.5 | 20 | 1.68 | 1.32 | 2.03E+02 | 1.71E+01 | -1.34E+01 | 2.07E+02 | 3.04E+01 | 2.56E+00 | -2.68E+00 | 3.03E+01 |
| | Field | Corn | -11,377.3 | 6.9 | 1.68 | 1.32 | -3.93E+01 | -9.56E+00 | 7.51E+00 | -4.13E+01 | -5.88E+00 | -1.43E+00 | 1.50E+00 | -5.82E+00 |
| | Forage | Alfalfa | -22,543.4 | 4 | 0 | 1.32 | -4.51E+01 | 0.00E+00 | 1.49E+01 | -3.02E+01 | -6.76E+00 | 0.00E+00 | 2.97E+00 | -3.78E+00 |
| | Vegetable/Truck Crops | Vegetables | 10,110.3 | 8.5 | 0.17 | 1.32 | 4.30E+01 | 8.59E-01 | -6.67E+00 | 3.72E+01 | 6.44E+00 | 1.29E-01 | -1.33E+00 | 5.24E+00 |
| | Orchards and Vineyards | Almonds | -9,338.6 | 3.13 | 0.08 | 1.32 | -1.46E+01 | -3.74E-01 | 6.16E+00 | -8.83E+00 | -2.19E+00 | -5.60E-02 | 1.23E+00 | -1.01E+00 |
| | Sacramento River Subtotal | | -12,844.5 | n/a | n/a | n/a | 1.47E+02 | 7.98E+00 | 8.48E+00 | 1.64E+02 | 2.20E+01 | 1.20E+00 | 1.70E+00 | 2.49E+01 |
| San Joaquin River | Grain | Wheat | 2,336.9 | 3.7 | 5.8 | 9.75 | 4.32E+00 | 6.78E+00 | -1.14E+01 | -2.89E-01 | 6.48E-01 | 1.02E+00 | -2.28E+00 | -6.14E-01 |
| | Field | Corn | -1,764.1 | 6.9 | 1.68 | 9.75 | -6.09E+00 | -1.48E+00 | 8.60E+00 | 1.03E+00 | -9.12E-01 | -2.22E-01 | 1.72E+00 | 5.85E-01 |
| | Forage | Alfalfa | -24,270.7 | 4 | 0 | 9.75 | -4.85E+01 | 0.00E+00 | 1.18E+02 | 6.97E+01 | -7.28E+00 | 0.00E+00 | 2.37E+01 | 1.64E+01 |
| | Vegetable/Truck Crops | Vegetables | 21,682.8 | 8.5 | 0.17 | 9.75 | 9.22E+01 | 1.84E+00 | -1.06E+02 | -1.17E+01 | 1.38E+01 | 2.76E-01 | -2.11E+01 | -7.04E+00 |
| | Orchards and Vineyards | Almonds | 6,178.5 | 3.13 | 0.08 | 9.75 | 9.67E+00 | 2.47E-01 | -3.01E+01 | -2.02E+01 | 1.45E+00 | 3.70E-02 | -6.02E+00 | -4.54E+00 |
| | San Joaquin River Subtotal | | 4,163.5 | n/a | n/a | n/a | 5.15E+01 | 7.39E+00 | -2.03E+01 | 3.86E+01 | 7.72E+00 | 1.11E+00 | -4.06E+00 | 4.77E+00 |
| Tulare Lake | Grain | Wheat | 8,148.6 | 3.7 | 5.8 | 10.70 | 1.51E+01 | 2.36E+01 | -4.36E+01 | -4.89E+00 | 2.26E+00 | 3.54E+00 | -8.72E+00 | -2.92E+00 |
| | Field | Corn | -44,256.3 | 6.9 | 1.68 | 10.70 | -1.53E+02 | -3.72E+01 | 2.37E+02 | 4.69E+01 | -2.29E+01 | -5.57E+00 | 4.74E+01 | 1.89E+01 |
| | Forage | Alfalfa | -11,842.1 | 4 | 0 | 10.70 | -2.37E+01 | 0.00E+00 | 6.34E+01 | 3.97E+01 | -3.55E+00 | 0.00E+00 | 1.27E+01 | 9.12E+00 |
| | Vegetable/Truck Crops | Vegetables | 34,379.4 | 8.5 | 0.17 | 10.70 | 1.46E+02 | 2.92E+00 | -1.84E+02 | -3.49E+01 | 2.19E+01 | 4.38E-01 | -3.68E+01 | -1.44E+01 |
| | Orchards and Vineyards | Almonds | 14,198.0 | 3.13 | 0.08 | 10.70 | 2.22E+01 | 5.68E-01 | -7.60E+01 | -5.32E+01 | 3.33E+00 | 8.51E-02 | -1.52E+01 | -1.18E+01 |
| | Tulare Lake Subtotal | | 627.7 | n/a | n/a | n/a | 7.04E+00 | -1.01E+01 | -3.36E+00 | -6.37E+00 | 1.06E+00 | -1.51E+00 | -6.72E-01 | -1.12E+00 |

Key:
SWAP = Statewide Agricultural Production lbs/acre/year = pounds per acre per year PM10 = inhalable particulate matter PM2.5 = fine particulate matter tpy = tons per year

**Table 15. Alternative 2: Detailed Fugitive Dust Emission Calculations**

| SWAP Region | SWAP Crop Type | Representative Crop | Irrigated Acreage (Change from Alt 1) (acres) | Emission Factor (lbs/acre/year) | | | Annual PM10 Emissions (tpy) | | | | Annual PM2.5 Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Land Prep | Harvesting | Windblown Dust | Land Prep | Harvesting | Windblown Dust | Total | Land Prep | Harvesting | Windblown Dust | Total |
| **Wet Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 0.4 | 20 | 1.68 | 1.32 | 3.52E-03 | 2.96E-04 | -2.33E-04 | 3.59E-03 | 5.28E-04 | 4.44E-05 | -4.65E-05 | 5.26E-04 |
| | Field | Corn | 1.5 | 6.9 | 1.68 | 1.32 | 5.25E-03 | 1.28E-03 | -1.00E-03 | 5.52E-03 | 7.86E-04 | 1.91E-04 | -2.01E-04 | 7.77E-04 |
| | Forage | Alfalfa | -1.4 | 4 | 0 | 1.32 | -2.90E-03 | 0.00E+00 | 9.56E-04 | -1.94E-03 | -4.34E-04 | 0.00E+00 | 1.91E-04 | -2.43E-04 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 1.32 | 3.38E-05 | 6.76E-07 | -5.25E-06 | 2.92E-05 | 5.07E-06 | 1.01E-07 | -1.05E-06 | 4.12E-06 |
| | Orchards and Vineyards | Almonds | 0.1 | 3.13 | 0.08 | 1.32 | 1.63E-04 | 4.17E-06 | -6.88E-05 | 9.86E-05 | 2.45E-05 | 6.25E-07 | -1.38E-05 | 1.13E-05 |
| | Sacramento River Subtotal | | 0.5 | n/a | n/a | n/a | 6.07E-03 | 1.58E-03 | -3.54E-04 | 7.29E-03 | 9.10E-04 | 2.37E-04 | -7.08E-05 | 1.08E-03 |
| San Joaquin River | Grain | Wheat | -2.3 | 3.7 | 5.8 | 9.75 | -4.24E-03 | -6.64E-03 | 1.12E-02 | 2.83E-04 | -6.35E-04 | -9.96E-04 | 2.23E-03 | 6.02E-04 |
| | Field | Corn | 10.2 | 6.9 | 1.68 | 9.75 | 3.53E-02 | 8.59E-03 | -4.98E-02 | -5.97E-03 | 5.29E-03 | 1.29E-03 | -9.97E-03 | -3.39E-03 |
| | Forage | Alfalfa | 66.7 | 4 | 0 | 9.75 | 1.33E-01 | 0.00E+00 | -3.25E-01 | -1.92E-01 | 2.00E-02 | 0.00E+00 | -6.50E-02 | -4.50E-02 |
| | Vegetable/Truck Crops | Vegetables | 2.8 | 8.5 | 0.17 | 9.75 | 1.19E-02 | 2.39E-04 | -1.37E-02 | -1.51E-03 | 1.79E-03 | 3.58E-05 | -2.74E-03 | -9.12E-04 |
| | Orchards and Vineyards | Almonds | 0.7 | 3.13 | 0.08 | 9.75 | 1.06E-03 | 2.72E-05 | -3.31E-03 | -2.22E-03 | 1.60E-04 | 4.08E-06 | -6.63E-04 | -4.99E-04 |
| | San Joaquin River Subtotal | | 78.1 | n/a | n/a | n/a | 1.77E-01 | 2.21E-03 | -3.81E-01 | -2.01E-01 | 2.66E-02 | 3.32E-04 | -7.61E-02 | -4.92E-02 |
| Tulare Lake | Grain | Wheat | 0.1 | 3.7 | 5.8 | 10.70 | 2.69E-04 | 4.22E-04 | -7.78E-04 | -8.73E-05 | 4.03E-05 | 6.32E-05 | -1.56E-04 | -5.20E-05 |
| | Field | Corn | 2.1 | 6.9 | 1.68 | 10.70 | 7.08E-03 | 1.72E-03 | -1.10E-02 | -2.18E-03 | 1.06E-03 | 2.58E-04 | -2.20E-03 | -8.76E-04 |
| | Forage | Alfalfa | -3.5 | 4 | 0 | 10.70 | -6.95E-03 | 0.00E+00 | 1.86E-02 | 1.17E-02 | -1.04E-03 | 0.00E+00 | 3.72E-03 | 2.68E-03 |
| | Vegetable/Truck Crops | Vegetables | 0.1 | 8.5 | 0.17 | 10.70 | 2.89E-04 | 5.77E-06 | -3.63E-04 | -6.90E-05 | 4.33E-05 | 8.65E-07 | -7.27E-05 | -2.85E-05 |
| | Orchards and Vineyards | Almonds | 0.2 | 3.13 | 0.08 | 10.70 | 3.57E-04 | 9.12E-06 | -1.22E-03 | -8.54E-04 | 5.35E-05 | 1.37E-06 | -2.44E-04 | -1.89E-04 |
| | Tulare Lake Subtotal | | -1.0 | n/a | n/a | n/a | 1.04E-03 | 2.16E-03 | 5.27E-03 | 8.47E-03 | 1.56E-04 | 3.24E-04 | 1.05E-03 | 1.53E-03 |
| **Above Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 0.6 | 20 | 1.68 | 1.32 | 6.25E-03 | 5.25E-04 | -4.13E-04 | 6.37E-03 | 9.37E-04 | 7.87E-05 | -8.25E-05 | 9.34E-04 |
| | Field | Corn | 2.1 | 6.9 | 1.68 | 1.32 | 7.21E-03 | 1.76E-03 | -1.38E-03 | 7.59E-03 | 1.08E-03 | 2.63E-04 | -2.76E-04 | 1.07E-03 |
| | Forage | Alfalfa | -2.6 | 4 | 0 | 1.32 | -5.13E-03 | 0.00E+00 | 1.69E-03 | -3.44E-03 | -7.69E-04 | 0.00E+00 | 3.38E-04 | -4.31E-04 |
| | Vegetable/Truck Crops | Vegetables | 0.1 | 8.5 | 0.17 | 1.32 | 2.36E-04 | 4.72E-06 | -3.66E-05 | 2.04E-04 | 3.54E-05 | 7.07E-07 | -7.32E-06 | 2.87E-05 |
| | Orchards and Vineyards | Almonds | 0.2 | 3.13 | 0.08 | 1.32 | 2.45E-04 | 6.25E-06 | -1.03E-04 | 1.48E-04 | 3.67E-05 | 9.37E-07 | -2.06E-05 | 1.70E-05 |
| | Sacramento River Subtotal | | 0.4 | n/a | n/a | n/a | 8.82E-03 | 2.29E-03 | -2.40E-04 | 1.09E-02 | 1.32E-03 | 3.44E-04 | -4.79E-05 | 1.62E-03 |
| San Joaquin River | Grain | Wheat | -2.9 | 3.7 | 5.8 | 9.75 | -5.30E-03 | -8.30E-03 | 1.40E-02 | 3.54E-04 | -7.94E-04 | -1.24E-03 | 2.79E-03 | 7.52E-04 |
| | Field | Corn | 11.2 | 6.9 | 1.68 | 9.75 | 3.86E-02 | 9.40E-03 | -5.45E-02 | -6.53E-03 | 5.79E-03 | 1.41E-03 | -1.09E-02 | -3.71E-03 |
| | Forage | Alfalfa | 81.9 | 4 | 0 | 9.75 | 1.64E-01 | 0.00E+00 | -3.99E-01 | -2.35E-01 | 2.46E-02 | 0.00E+00 | -7.98E-02 | -5.53E-02 |
| | Vegetable/Truck Crops | Vegetables | 3.1 | 8.5 | 0.17 | 9.75 | 1.33E-02 | 2.67E-04 | -1.53E-02 | -1.69E-03 | 2.00E-03 | 4.00E-05 | -3.06E-03 | -1.02E-03 |
| | Orchards and Vineyards | Almonds | 0.8 | 3.13 | 0.08 | 9.75 | 1.22E-03 | 3.13E-05 | -3.81E-03 | -2.56E-03 | 1.83E-04 | 4.69E-06 | -7.62E-04 | -5.74E-04 |
| | San Joaquin River Subtotal | | 94.2 | n/a | n/a | n/a | 2.12E-01 | 1.40E-03 | -4.59E-01 | -2.46E-01 | 3.17E-02 | 2.09E-04 | -9.18E-02 | -5.98E-02 |
| Tulare Lake | Grain | Wheat | 0.4 | 3.7 | 5.8 | 10.70 | 7.56E-04 | 1.19E-03 | -2.19E-03 | -2.45E-04 | 1.13E-04 | 1.78E-04 | -4.37E-04 | -1.46E-04 |
| | Field | Corn | 4.6 | 6.9 | 1.68 | 10.70 | 1.58E-02 | 3.84E-03 | -2.44E-02 | -4.84E-03 | 2.36E-03 | 5.75E-04 | -4.89E-03 | -1.95E-03 |
| | Forage | Alfalfa | -9.4 | 4 | 0 | 10.70 | -1.87E-02 | 0.00E+00 | 5.01E-02 | 3.14E-02 | -2.81E-03 | 0.00E+00 | 1.00E-02 | 7.21E-03 |
| | Vegetable/Truck Crops | Vegetables | 0.2 | 8.5 | 0.17 | 10.70 | 7.97E-04 | 1.59E-05 | -1.00E-03 | -1.90E-04 | 1.19E-04 | 2.39E-06 | -2.01E-04 | -7.88E-05 |
| | Orchards and Vineyards | Almonds | 0.5 | 3.13 | 0.08 | 10.70 | 7.53E-04 | 1.93E-05 | -2.58E-03 | -1.80E-03 | 1.13E-04 | 2.89E-06 | -5.15E-04 | -3.99E-04 |
| | Tulare Lake Subtotal | | -3.7 | n/a | n/a | n/a | -6.62E-04 | 5.06E-03 | 1.99E-02 | 2.43E-02 | -9.92E-05 | 7.58E-04 | 3.98E-03 | 4.64E-03 |
| **Below Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 52.4 | 20 | 1.68 | 1.32 | 5.24E-01 | 4.40E-02 | -3.46E-02 | 5.34E-01 | 7.86E-02 | 6.60E-03 | -6.92E-03 | 7.83E-02 |
| | Field | Corn | 80.6 | 6.9 | 1.68 | 1.32 | 2.78E-01 | 6.77E-02 | -5.32E-02 | 2.93E-01 | 4.17E-02 | 1.02E-02 | -1.06E-02 | 4.12E-02 |
| | Forage | Alfalfa | 2,931.5 | 4 | 0 | 1.32 | 5.86E+00 | 0.00E+00 | -1.93E+00 | 3.93E+00 | 8.79E-01 | 0.00E+00 | -3.87E-01 | 4.92E-01 |
| | Vegetable/Truck Crops | Vegetables | 30.2 | 8.5 | 0.17 | 1.32 | 1.28E-01 | 2.57E-03 | -1.99E-02 | 1.11E-01 | 1.92E-02 | 3.85E-04 | -3.98E-03 | 1.56E-02 |
| | Orchards and Vineyards | Almonds | 27.1 | 3.13 | 0.08 | 1.32 | 4.24E-02 | 1.08E-03 | -1.79E-02 | 2.56E-02 | 6.36E-03 | 1.63E-04 | -3.58E-03 | 2.95E-03 |
| | Sacramento River Subtotal | | 3,121.8 | n/a | n/a | n/a | 6.84E+00 | 1.15E-01 | -2.06E+00 | 4.89E+00 | 1.02E+00 | 1.73E-02 | -4.12E-01 | 6.30E-01 |
| San Joaquin River | Grain | Wheat | 10.1 | 3.7 | 5.8 | 9.75 | 1.86E-02 | 2.92E-02 | -4.91E-02 | -1.24E-03 | 2.79E-03 | 4.38E-03 | -9.82E-03 | -2.65E-03 |
| | Field | Corn | 58.6 | 6.9 | 1.68 | 9.75 | 2.02E-01 | 4.92E-02 | -2.85E-01 | -3.42E-02 | 3.03E-02 | 7.38E-03 | -5.71E-02 | -1.94E-02 |
| | Forage | Alfalfa | -125.8 | 4 | 0 | 9.75 | -2.52E-01 | 0.00E+00 | 6.13E-01 | 3.61E-01 | -3.77E-02 | 0.00E+00 | 1.23E-01 | 8.49E-02 |
| | Vegetable/Truck Crops | Vegetables | 26.5 | 8.5 | 0.17 | 9.75 | 1.13E-01 | 2.25E-03 | -1.29E-01 | -1.43E-02 | 1.69E-02 | 3.38E-04 | -2.58E-02 | -8.61E-03 |
| | Orchards and Vineyards | Almonds | 5.9 | 3.13 | 0.08 | 9.75 | 9.18E-03 | 2.35E-04 | -2.86E-02 | -1.92E-02 | 1.38E-03 | 3.52E-05 | -5.72E-03 | -4.30E-03 |
| | San Joaquin River Subtotal | | -24.8 | n/a | n/a | n/a | 9.09E-02 | 8.09E-02 | 1.21E-01 | 2.93E-01 | 1.36E-02 | 1.21E-02 | 2.42E-02 | 4.99E-02 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tulare Lake | Grain | Wheat | -280.4 | 3.7 | 5.8 | 10.70 | -5.19E-01 | -8.13E-01 | 1.50E+00 | 1.68E-01 | -7.78E-02 | -1.22E-01 | 3.00E-01 | 1.00E-01 |
| | Field | Corn | 3,168.5 | 6.9 | 1.68 | 10.70 | 1.09E+01 | 2.66E+00 | -1.70E+01 | -3.36E+00 | 1.64E+00 | 3.99E-01 | -3.39E+00 | -1.35E+00 |
| | Forage | Alfalfa | 3,903.1 | 4 | 0 | 10.70 | 7.81E+00 | 0.00E+00 | -2.09E+01 | -1.31E+01 | 1.17E+00 | 0.00E+00 | -4.18E+00 | -3.01E+00 |
| | Vegetable/Truck Crops | Vegetables | -126.7 | 8.5 | 0.17 | 10.70 | -5.38E-01 | -1.08E-02 | 6.78E-01 | 1.29E-01 | -8.07E-02 | -1.61E-03 | 1.36E-01 | 5.32E-02 |
| | Orchards and Vineyards | Almonds | 97.4 | 3.13 | 0.08 | 10.70 | 1.52E-01 | 3.90E-03 | -5.21E-01 | -3.65E-01 | 2.29E-02 | 5.84E-04 | -1.04E-01 | -8.08E-02 |
| | Tulare Lake Subtotal | | 6,762.0 | n/a | n/a | n/a | 1.78E+01 | 1.84E+00 | -3.62E+01 | -1.65E+01 | 2.67E+00 | 2.76E-01 | -7.24E+00 | -4.29E+00 |
| **Dry Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 3,351.1 | 20 | 1.68 | 1.32 | 3.35E+01 | 2.81E+00 | -2.21E+00 | 3.41E+01 | 5.02E+00 | 4.22E-01 | -4.42E-01 | 5.00E+00 |
| | Field | Corn | 1,556.8 | 6.9 | 1.68 | 1.32 | 5.37E+00 | 1.31E+00 | -1.03E+00 | 5.65E+00 | 8.05E-01 | 1.96E-01 | -2.05E-01 | 7.96E-01 |
| | Forage | Alfalfa | 24.4 | 4 | 0 | 1.32 | 4.88E-02 | 0.00E+00 | -1.61E-02 | 3.27E-02 | 7.31E-03 | 0.00E+00 | -3.22E-03 | 4.09E-03 |
| | Vegetable/Truck Crops | Vegetables | 209.8 | 8.5 | 0.17 | 1.32 | 8.92E-01 | 1.78E-02 | -1.38E-01 | 7.71E-01 | 1.34E-01 | 2.67E-03 | -2.77E-02 | 1.09E-01 |
| | Orchards and Vineyards | Almonds | 168.6 | 3.13 | 0.08 | 1.32 | 2.64E-01 | 6.74E-03 | -1.11E-01 | 1.59E-01 | 3.96E-02 | 1.01E-03 | -2.22E-02 | 1.83E-02 |
| | Sacramento River Subtotal | | 5,310.7 | n/a | n/a | n/a | 4.01E+01 | 4.15E+00 | -3.50E+00 | 4.07E+01 | 6.01E+00 | 6.22E-01 | -7.01E-01 | 5.93E+00 |
| San Joaquin River | Grain | Wheat | 6.5 | 3.7 | 5.8 | 9.75 | 1.20E-02 | 1.88E-02 | -3.16E-02 | -8.00E-04 | 1.80E-03 | 2.81E-03 | -6.31E-03 | -1.70E-03 |
| | Field | Corn | -80.5 | 6.9 | 1.68 | 9.75 | -2.78E-01 | -6.76E-02 | 3.92E-01 | 4.70E-02 | -4.16E-02 | -1.01E-02 | 7.84E-02 | 2.67E-02 |
| | Forage | Alfalfa | 28.2 | 4 | 0 | 9.75 | 5.64E-02 | 0.00E+00 | -1.38E-01 | -8.11E-02 | 8.46E-03 | 0.00E+00 | -2.75E-02 | -1.90E-02 |
| | Vegetable/Truck Crops | Vegetables | 4.6 | 8.5 | 0.17 | 9.75 | 1.97E-02 | 3.94E-04 | -2.26E-02 | -2.50E-03 | 2.96E-03 | 5.91E-05 | -4.52E-03 | -1.51E-03 |
| | Orchards and Vineyards | Almonds | -6.6 | 3.13 | 0.08 | 9.75 | -1.04E-02 | -2.66E-04 | 3.24E-02 | 2.17E-02 | -1.56E-03 | -3.99E-05 | 6.48E-03 | 4.88E-03 |
| | San Joaquin River Subtotal | | -47.8 | n/a | n/a | n/a | -2.00E-01 | -4.87E-02 | 2.33E-01 | -1.57E-02 | -3.00E-02 | -7.30E-03 | 4.66E-02 | 9.31E-03 |
| Tulare Lake | Grain | Wheat | 118.6 | 3.7 | 5.8 | 10.70 | 2.19E-01 | 3.44E-01 | -6.34E-01 | -7.12E-02 | 3.29E-02 | 5.15E-02 | -1.27E-01 | -4.25E-02 |
| | Field | Corn | 27,966.8 | 6.9 | 1.68 | 10.70 | 9.65E+01 | 2.35E+01 | -1.50E+02 | -2.97E+01 | 1.45E+01 | 3.52E+00 | -2.99E+01 | -1.19E+01 |
| | Forage | Alfalfa | 92.1 | 4 | 0 | 10.70 | 1.84E-01 | 0.00E+00 | -4.93E-01 | -3.09E-01 | 2.76E-02 | 0.00E+00 | -9.85E-02 | -7.09E-02 |
| | Vegetable/Truck Crops | Vegetables | 275.0 | 8.5 | 0.17 | 10.70 | 1.17E+00 | 2.34E-02 | -1.47E+00 | -2.79E-01 | 1.75E-01 | 3.50E-03 | -2.94E-01 | -1.16E-01 |
| | Orchards and Vineyards | Almonds | 86.2 | 3.13 | 0.08 | 10.70 | 1.35E-01 | 3.45E-03 | -4.61E-01 | -3.23E-01 | 2.02E-02 | 5.17E-04 | -9.22E-02 | -7.15E-02 |
| | Tulare Lake Subtotal | | 28,538.7 | n/a | n/a | n/a | 9.82E+01 | 2.39E+01 | -1.53E+02 | -3.06E+01 | 1.47E+01 | 3.58E+00 | -3.05E+01 | -1.22E+01 |
| **Critical Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 1,959.3 | 20 | 1.68 | 1.32 | 1.96E+01 | 1.65E+00 | -1.29E+00 | 1.99E+01 | 2.94E+00 | 2.47E-01 | -2.59E-01 | 2.93E+00 |
| | Field | Corn | 20.1 | 6.9 | 1.68 | 1.32 | 6.93E-02 | 1.69E-02 | -1.33E-02 | 7.30E-02 | 1.04E-02 | 2.53E-03 | -2.65E-03 | 1.03E-02 |
| | Forage | Alfalfa | 49.7 | 4 | 0 | 1.32 | 9.95E-02 | 0.00E+00 | -3.28E-02 | 6.67E-02 | 1.49E-02 | 0.00E+00 | -6.56E-03 | 8.35E-03 |
| | Vegetable/Truck Crops | Vegetables | 56.9 | 8.5 | 0.17 | 1.32 | 2.42E-01 | 4.83E-03 | -3.75E-02 | 2.09E-01 | 3.62E-02 | 7.25E-04 | -7.50E-03 | 2.94E-02 |
| | Orchards and Vineyards | Almonds | 7,541.6 | 3.13 | 0.08 | 1.32 | 1.18E+01 | 3.02E-01 | -4.98E+00 | 7.13E+00 | 1.77E+00 | 4.52E-02 | -9.95E-01 | 8.19E-01 |
| | Sacramento River Subtotal | | 9,627.6 | n/a | n/a | n/a | 3.18E+01 | 1.97E+00 | -6.35E+00 | 2.74E+01 | 4.77E+00 | 2.95E-01 | -1.27E+00 | 3.79E+00 |
| San Joaquin River | Grain | Wheat | 11.5 | 3.7 | 5.8 | 9.75 | 2.13E-02 | 3.34E-02 | -5.62E-02 | -1.42E-03 | 3.20E-03 | 5.01E-03 | -1.12E-02 | -3.03E-03 |
| | Field | Corn | 6.3 | 6.9 | 1.68 | 9.75 | 2.16E-02 | 5.25E-03 | -3.05E-02 | -3.65E-03 | 3.23E-03 | 7.87E-04 | -6.09E-03 | -2.07E-03 |
| | Forage | Alfalfa | 107.5 | 4 | 0 | 9.75 | 2.15E-01 | 0.00E+00 | -5.24E-01 | -3.09E-01 | 3.22E-02 | 0.00E+00 | -1.05E-01 | -7.26E-02 |
| | Vegetable/Truck Crops | Vegetables | 9.8 | 8.5 | 0.17 | 9.75 | 4.17E-02 | 8.34E-04 | -4.78E-02 | -5.28E-03 | 6.25E-03 | 1.25E-04 | -9.56E-03 | -3.19E-03 |
| | Orchards and Vineyards | Almonds | -138.0 | 3.13 | 0.08 | 9.75 | -2.16E-01 | -5.52E-03 | 6.73E-01 | 4.51E-01 | -3.24E-02 | -8.28E-04 | 1.35E-01 | 1.01E-01 |
| | San Joaquin River Subtotal | | -2.9 | n/a | n/a | n/a | 8.36E-02 | 3.40E-02 | 1.44E-02 | 1.32E-01 | 1.25E-02 | 5.10E-03 | 2.87E-03 | 2.05E-02 |
| Tulare Lake | Grain | Wheat | 39.7 | 3.7 | 5.8 | 10.70 | 7.35E-02 | 1.15E-01 | -2.13E-01 | -2.39E-02 | 1.10E-02 | 1.73E-02 | -4.25E-02 | -1.42E-02 |
| | Field | Corn | 34,116.9 | 6.9 | 1.68 | 10.70 | 1.18E+02 | 2.87E+01 | -1.83E+02 | -3.62E+01 | 1.76E+01 | 4.30E+00 | -3.65E+01 | -1.46E+01 |
| | Forage | Alfalfa | 113.9 | 4 | 0 | 10.70 | 2.28E-01 | 0.00E+00 | -6.09E-01 | -3.82E-01 | 3.41E-02 | 0.00E+00 | -1.22E-01 | -8.77E-02 |
| | Vegetable/Truck Crops | Vegetables | 38.9 | 8.5 | 0.17 | 10.70 | 1.65E-01 | 3.31E-03 | -2.08E-01 | -3.95E-02 | 2.48E-02 | 4.96E-04 | -4.16E-02 | -1.64E-02 |
| | Orchards and Vineyards | Almonds | -138.6 | 3.13 | 0.08 | 10.70 | -2.17E-01 | -5.54E-03 | 7.42E-01 | 5.19E-01 | -3.25E-02 | -8.31E-04 | 1.48E-01 | 1.15E-01 |
| | Tulare Lake Subtotal | | 34,170.9 | n/a | n/a | n/a | 1.18E+02 | 2.88E+01 | -1.83E+02 | -3.61E+01 | 1.77E+01 | 4.31E+00 | -3.66E+01 | -1.46E+01 |

Key:
SWAP = Statewide Agricultural Production lbs/acre/year = pounds per acre per year PM10 = inhalable particulate matter PM2.5 = fine particulate matter tpy = tons per year

**Table 16. Alternative 3: Detailed Fugitive Dust Emission Calculations**

| SWAP Region | SWAP Crop Type | Representative Crop | Irrigated Acreage (Change from Alt 1) (acres) | Emission Factor (lbs/acre/year) | | | Annual PM10 Emissions (tpy) | | | | Annual PM10 Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Land Prep | Harvesting | Windblown Dust | Land Prep | Harvesting | Windblown Dust | Total | Land Prep | Harvesting | Windblown Dust | Total |
| **Wet Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | -0.1 | 20 | 1.68 | 1.32 | -1.28E-03 | -1.07E-04 | 8.42E-05 | -1.30E-03 | -1.91E-04 | -1.61E-05 | 1.68E-05 | -1.90E-04 |
| | Field | Corn | -0.5 | 6.9 | 1.68 | 1.32 | -1.90E-03 | -4.62E-04 | 3.63E-04 | -2.00E-03 | -2.84E-04 | -6.92E-05 | 7.25E-05 | -2.81E-04 |
| | Forage | Alfalfa | 0.5 | 4 | 0 | 1.32 | 1.05E-03 | 0.00E+00 | -3.46E-04 | 7.02E-04 | 1.57E-04 | 0.00E+00 | -6.91E-05 | 8.79E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 1.32 | -1.24E-05 | -2.48E-07 | 1.92E-06 | -1.07E-05 | -1.86E-06 | -3.72E-08 | 3.85E-07 | -1.51E-06 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 1.32 | -5.91E-05 | -1.51E-06 | 2.49E-05 | -3.57E-05 | -8.86E-06 | -2.27E-07 | 4.99E-06 | -4.10E-06 |
| | Sacramento River Subtotal | | -0.2 | n/a | n/a | n/a | -2.20E-03 | -5.71E-04 | 1.28E-04 | -2.64E-03 | -3.29E-04 | -8.55E-05 | 2.56E-05 | -3.89E-04 |
| San Joaquin River | Grain | Wheat | 0.8 | 3.7 | 5.8 | 9.75 | 1.53E-03 | 2.41E-03 | -4.04E-03 | -1.02E-04 | 2.30E-04 | 3.61E-04 | -8.08E-04 | -2.18E-04 |
| | Field | Corn | -3.7 | 6.9 | 1.68 | 9.75 | -1.26E-02 | -3.07E-03 | 1.78E-02 | 2.13E-03 | -1.89E-03 | -4.60E-04 | 3.56E-03 | 1.21E-03 |
| | Forage | Alfalfa | -24.1 | 4 | 0 | 9.75 | -4.82E-02 | 0.00E+00 | 1.17E-01 | 6.92E-02 | -7.22E-03 | 0.00E+00 | 2.35E-02 | 1.63E-02 |
| | Vegetable/Truck Crops | Vegetables | -1.0 | 8.5 | 0.17 | 9.75 | -4.27E-03 | -8.54E-05 | 4.90E-03 | 5.41E-04 | -6.40E-04 | -1.28E-05 | 9.80E-04 | 3.27E-04 |
| | Orchards and Vineyards | Almonds | -0.2 | 3.13 | 0.08 | 9.75 | -3.81E-04 | -9.74E-06 | 1.19E-03 | 7.96E-04 | -5.71E-05 | -1.46E-06 | 2.37E-04 | 1.79E-04 |
| | San Joaquin River Subtotal | | -28.2 | n/a | n/a | n/a | -6.39E-02 | -7.58E-04 | 1.37E-01 | 7.26E-02 | -9.58E-03 | -1.14E-04 | 2.74E-02 | 1.78E-02 |
| Tulare Lake | Grain | Wheat | -0.1 | 3.7 | 5.8 | 10.70 | -9.70E-05 | -1.52E-04 | 2.81E-04 | 3.15E-05 | -1.45E-05 | -2.28E-05 | 5.61E-05 | 1.88E-05 |
| | Field | Corn | -0.7 | 6.9 | 1.68 | 10.70 | -2.56E-03 | -6.23E-04 | 3.97E-03 | 7.86E-04 | -3.83E-04 | -9.34E-05 | 7.93E-04 | 3.17E-04 |
| | Forage | Alfalfa | 1.3 | 4 | 0 | 10.70 | 2.51E-03 | 0.00E+00 | -6.72E-03 | -4.21E-03 | 3.77E-04 | 0.00E+00 | -1.34E-03 | -9.68E-04 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 10.70 | -1.05E-04 | -2.09E-06 | 1.32E-04 | 2.50E-05 | -1.57E-05 | -3.13E-07 | 2.63E-05 | 1.03E-05 |
| | Orchards and Vineyards | Almonds | -0.1 | 3.13 | 0.08 | 10.70 | -1.29E-04 | -3.29E-06 | 4.41E-04 | 3.08E-04 | -1.93E-05 | -4.94E-07 | 8.81E-05 | 6.83E-05 |
| | Tulare Lake Subtotal | | 0.4 | n/a | n/a | n/a | -3.75E-04 | -7.80E-04 | -1.90E-03 | -3.06E-03 | -5.63E-05 | -1.17E-04 | -3.81E-04 | -5.54E-04 |
| **Above Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 0.1 | 20 | 1.68 | 1.32 | 1.16E-03 | 9.73E-05 | -7.64E-05 | 1.18E-03 | 1.74E-04 | 1.46E-05 | -1.53E-05 | 1.73E-04 |
| | Field | Corn | -0.4 | 6.9 | 1.68 | 1.32 | -1.44E-03 | -3.50E-04 | 2.75E-04 | -1.51E-03 | -2.16E-04 | -5.25E-05 | 5.50E-05 | -2.13E-04 |
| | Forage | Alfalfa | -0.4 | 4 | 0 | 1.32 | -8.83E-04 | 0.00E+00 | 2.91E-04 | -5.92E-04 | -1.32E-04 | 0.00E+00 | 5.83E-05 | -7.41E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.1 | 8.5 | 0.17 | 1.32 | 2.40E-04 | 4.80E-06 | -3.73E-05 | 2.08E-04 | 3.60E-05 | 7.20E-07 | -7.45E-06 | 2.93E-05 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 1.32 | -1.47E-05 | -3.76E-07 | 6.19E-06 | -8.87E-06 | -2.20E-06 | -5.63E-08 | 1.24E-06 | -1.02E-06 |
| | Sacramento River Subtotal | | -0.7 | n/a | n/a | n/a | -9.39E-04 | -2.49E-04 | 4.59E-04 | -7.28E-04 | -1.41E-04 | -3.73E-05 | 9.18E-05 | -8.62E-05 |
| San Joaquin River | Grain | Wheat | 1.2 | 3.7 | 5.8 | 9.75 | 2.14E-03 | 3.36E-03 | -5.64E-03 | -1.43E-04 | 3.21E-04 | 5.03E-04 | -1.13E-03 | -3.04E-04 |
| | Field | Corn | -3.0 | 6.9 | 1.68 | 9.75 | -1.04E-02 | -2.54E-03 | 1.48E-02 | 1.77E-03 | -1.57E-03 | -3.81E-04 | 2.95E-03 | 1.00E-03 |
| | Forage | Alfalfa | -30.5 | 4 | 0 | 9.75 | -6.11E-02 | 0.00E+00 | 1.49E-01 | 8.77E-02 | -9.15E-03 | 0.00E+00 | 2.98E-02 | 2.06E-02 |
| | Vegetable/Truck Crops | Vegetables | -0.9 | 8.5 | 0.17 | 9.75 | -3.98E-03 | -7.96E-05 | 4.56E-03 | 5.04E-04 | -5.97E-04 | -1.19E-05 | 9.13E-04 | 3.04E-04 |
| | Orchards and Vineyards | Almonds | -0.2 | 3.13 | 0.08 | 9.75 | -3.02E-04 | -7.71E-06 | 9.40E-04 | 6.30E-04 | -4.52E-05 | -1.16E-06 | 1.88E-04 | 1.42E-04 |
| | San Joaquin River Subtotal | | -33.5 | n/a | n/a | n/a | -7.37E-02 | 7.27E-04 | 1.63E-01 | 9.05E-02 | -1.10E-02 | 1.09E-04 | 3.27E-02 | 2.18E-02 |
| Tulare Lake | Grain | Wheat | 0.2 | 3.7 | 5.8 | 10.70 | 4.11E-04 | 6.44E-04 | -1.19E-03 | -1.33E-04 | 6.15E-05 | 9.65E-05 | -2.37E-04 | -7.95E-05 |
| | Field | Corn | 1.9 | 6.9 | 1.68 | 10.70 | 6.63E-03 | 1.61E-03 | -1.03E-02 | -2.04E-03 | 9.94E-04 | 2.42E-04 | -2.06E-03 | -8.21E-04 |
| | Forage | Alfalfa | -1.5 | 4 | 0 | 10.70 | -3.06E-03 | 0.00E+00 | 8.18E-03 | 5.12E-03 | -4.58E-04 | 0.00E+00 | 1.64E-03 | 1.18E-03 |
| | Vegetable/Truck Crops | Vegetables | 0.1 | 8.5 | 0.17 | 10.70 | 4.38E-04 | 8.75E-06 | -5.51E-04 | -1.05E-04 | 6.56E-05 | 1.31E-06 | -1.10E-04 | -4.33E-05 |
| | Orchards and Vineyards | Almonds | 0.2 | 3.13 | 0.08 | 10.70 | 2.86E-04 | 7.30E-06 | -9.77E-04 | -6.84E-04 | 4.28E-05 | 1.09E-06 | -1.95E-04 | -1.51E-04 |
| | Tulare Lake Subtotal | | 0.9 | n/a | n/a | n/a | 4.71E-03 | 2.27E-03 | -4.82E-03 | 2.16E-03 | 7.06E-04 | 3.41E-04 | -9.64E-04 | 8.27E-05 |
| **Below Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | -262.9 | 20 | 1.68 | 1.32 | -2.63E+00 | -2.21E-01 | 1.73E-01 | -2.68E+00 | -3.94E-01 | -3.31E-02 | 3.47E-02 | -3.92E-01 |
| | Field | Corn | -788.5 | 6.9 | 1.68 | 1.32 | -2.72E+00 | -6.62E-01 | 5.20E-01 | -2.86E+00 | -4.08E-01 | -9.93E-02 | 1.04E-01 | -4.03E-01 |
| | Forage | Alfalfa | -49.6 | 4 | 0 | 1.32 | -9.92E-02 | 0.00E+00 | 3.27E-02 | -6.64E-02 | -1.49E-02 | 0.00E+00 | 6.54E-03 | -8.32E-03 |
| | Vegetable/Truck Crops | Vegetables | -137.3 | 8.5 | 0.17 | 1.32 | -5.83E-01 | -1.17E-02 | 9.06E-02 | -5.04E-01 | -8.74E-02 | -1.75E-03 | 1.81E-02 | -7.11E-02 |
| | Orchards and Vineyards | Almonds | -204.6 | 3.13 | 0.08 | 1.32 | -3.20E-01 | -8.18E-03 | 1.35E-01 | -1.93E-01 | -4.80E-02 | -1.23E-03 | 2.70E-02 | -2.22E-02 |
| | Sacramento River Subtotal | | -1,442.8 | n/a | n/a | n/a | -6.35E+00 | -9.03E-01 | 9.52E-01 | -6.30E+00 | -9.52E-01 | -1.35E-01 | 1.90E-01 | -8.97E-01 |
| San Joaquin River | Grain | Wheat | -7.1 | 3.7 | 5.8 | 9.75 | -1.31E-02 | -2.05E-02 | 3.45E-02 | 8.74E-04 | -1.96E-03 | -3.08E-03 | 6.90E-03 | 1.86E-03 |
| | Field | Corn | -31.8 | 6.9 | 1.68 | 9.75 | -1.10E-01 | -2.67E-02 | 1.55E-01 | 1.86E-02 | -1.65E-02 | -4.01E-03 | 3.10E-02 | 1.05E-02 |
| | Forage | Alfalfa | 81.4 | 4 | 0 | 9.75 | 1.63E-01 | 0.00E+00 | -3.97E-01 | -2.34E-01 | 2.44E-02 | 0.00E+00 | -7.94E-02 | -5.50E-02 |
| | Vegetable/Truck Crops | Vegetables | -22.3 | 8.5 | 0.17 | 9.75 | -9.49E-02 | -1.90E-03 | 1.09E-01 | 1.20E-02 | -1.42E-02 | -2.84E-04 | 2.18E-02 | 7.25E-03 |
| | Orchards and Vineyards | Almonds | -1.0 | 3.13 | 0.08 | 9.75 | -1.58E-03 | -4.05E-05 | 4.93E-03 | 3.31E-03 | -2.38E-04 | -6.07E-06 | 9.87E-04 | 7.43E-04 |
| | San Joaquin River Subtotal | | 19.2 | n/a | n/a | n/a | -5.64E-02 | -4.92E-02 | -9.37E-02 | -1.99E-01 | -8.45E-03 | -7.37E-03 | -1.87E-02 | -3.46E-02 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tulare Lake | Grain | Wheat | 300.4 | 3.7 | 5.8 | 10.70 | 5.56E-01 | 8.71E-01 | -1.61E+00 | -1.80E-01 | 8.33E-02 | 1.31E-01 | -3.21E-01 | -1.08E-01 |
| | Field | Corn | -2,661.5 | 6.9 | 1.68 | 10.70 | -9.18E+00 | -2.24E+00 | 1.42E+01 | 2.82E+00 | -1.38E+00 | -3.35E-01 | 2.85E+00 | 1.14E+00 |
| | Forage | Alfalfa | -4,407.8 | 4 | 0 | 10.70 | -8.82E+00 | 0.00E+00 | 2.36E+01 | 1.48E+01 | -1.32E+00 | 0.00E+00 | 4.72E+00 | 3.40E+00 |
| | Vegetable/Truck Crops | Vegetables | 171.3 | 8.5 | 0.17 | 10.70 | 7.28E-01 | 1.46E-02 | -9.17E-01 | -1.74E-01 | 1.09E-01 | 2.18E-03 | -1.83E-01 | -7.20E-02 |
| | Orchards and Vineyards | Almonds | -71.8 | 3.13 | 0.08 | 10.70 | -1.12E-01 | -2.87E-03 | 3.84E-01 | 2.69E-01 | -1.68E-02 | -4.30E-04 | 7.68E-02 | 5.95E-02 |
| | Tulare Lake Subtotal | | -6,669.3 | n/a | n/a | n/a | -1.68E+01 | -1.35E+00 | 3.57E+01 | 1.75E+01 | -2.52E+00 | -2.03E-01 | 7.14E+00 | 4.41E+00 |
| **Dry Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | -2,255.0 | 20 | 1.68 | 1.32 | -2.25E+01 | -1.89E+00 | 1.49E+00 | -2.30E+01 | -3.38E+00 | -2.84E-01 | 2.98E-01 | -3.37E+00 |
| | Field | Corn | -806.4 | 6.9 | 1.68 | 1.32 | -2.78E+00 | -6.77E-01 | 5.32E-01 | -2.93E+00 | -4.17E-01 | -1.02E-01 | 1.06E-01 | -4.12E-01 |
| | Forage | Alfalfa | -4.6 | 4 | 0 | 1.32 | -9.29E-03 | 0.00E+00 | 3.07E-03 | -6.23E-03 | -1.39E-03 | 0.00E+00 | 6.13E-04 | -7.80E-04 |
| | Vegetable/Truck Crops | Vegetables | -12.6 | 8.5 | 0.17 | 1.32 | -5.37E-02 | -1.07E-03 | 8.33E-03 | -4.64E-02 | -8.04E-03 | -1.61E-04 | 1.67E-03 | -6.54E-03 |
| | Orchards and Vineyards | Almonds | -6.6 | 3.13 | 0.08 | 1.32 | -1.03E-02 | -2.64E-04 | 4.36E-03 | -6.25E-03 | -1.55E-03 | -3.96E-05 | 8.72E-04 | -7.18E-04 |
| | Sacramento River Subtotal | | -3,085.2 | n/a | n/a | n/a | -2.54E+01 | -2.57E+00 | 2.04E+00 | -2.59E+01 | -3.81E+00 | -3.86E-01 | 4.07E-01 | -3.79E+00 |
| San Joaquin River | Grain | Wheat | -1.8 | 3.7 | 5.8 | 9.75 | -3.42E-03 | -5.36E-03 | 9.00E-03 | 2.28E-04 | -5.12E-04 | -8.03E-04 | 1.80E-03 | 4.85E-04 |
| | Field | Corn | 26.6 | 6.9 | 1.68 | 9.75 | 9.19E-02 | 2.24E-02 | -1.30E-01 | -1.55E-02 | 1.38E-02 | 3.36E-03 | -2.60E-02 | -8.84E-03 |
| | Forage | Alfalfa | -10.0 | 4 | 0 | 9.75 | -1.99E-02 | 0.00E+00 | 4.86E-02 | 2.86E-02 | -2.99E-03 | 0.00E+00 | 9.72E-03 | 6.73E-03 |
| | Vegetable/Truck Crops | Vegetables | -1.8 | 8.5 | 0.17 | 9.75 | -7.69E-03 | -1.54E-04 | 8.81E-03 | 9.74E-04 | -1.15E-03 | -2.30E-05 | 1.76E-03 | 5.87E-04 |
| | Orchards and Vineyards | Almonds | 1.1 | 3.13 | 0.08 | 9.75 | 1.73E-03 | 4.42E-05 | -5.38E-03 | -3.61E-03 | 2.59E-04 | 6.62E-06 | -1.08E-03 | -8.10E-04 |
| | San Joaquin River Subtotal | | 14.1 | n/a | n/a | n/a | 6.26E-02 | 1.69E-02 | -6.88E-02 | 1.07E-02 | 9.39E-03 | 2.54E-03 | -1.38E-02 | -1.85E-03 |
| Tulare Lake | Grain | Wheat | -43.4 | 3.7 | 5.8 | 10.70 | -8.03E-02 | -1.26E-01 | 2.32E-01 | 2.61E-02 | -1.20E-02 | -1.89E-02 | 4.65E-02 | 1.55E-02 |
| | Field | Corn | -17,820.4 | 6.9 | 1.68 | 10.70 | -6.15E+01 | -1.50E+01 | 9.53E+01 | 1.89E+01 | -9.22E+00 | -2.24E+00 | 1.91E+01 | 7.61E+00 |
| | Forage | Alfalfa | -44.8 | 4 | 0 | 10.70 | -8.96E-02 | 0.00E+00 | 2.40E-01 | 1.50E-01 | -1.34E-02 | 0.00E+00 | 4.79E-02 | 3.45E-02 |
| | Vegetable/Truck Crops | Vegetables | -73.8 | 8.5 | 0.17 | 10.70 | -3.14E-01 | -6.27E-03 | 3.95E-01 | 7.49E-02 | -4.70E-02 | -9.40E-04 | 7.90E-02 | 3.10E-02 |
| | Orchards and Vineyards | Almonds | -15.2 | 3.13 | 0.08 | 10.70 | -2.38E-02 | -6.09E-04 | 8.14E-02 | 5.70E-02 | -3.57E-03 | -9.13E-05 | 1.63E-02 | 1.26E-02 |
| | Tulare Lake Subtotal | | -17,997.7 | n/a | n/a | n/a | -6.20E+01 | -1.51E+01 | 9.63E+01 | 1.92E+01 | -9.29E+00 | -2.26E+00 | 1.93E+01 | 7.70E+00 |
| **Critical Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | -47.7 | 20 | 1.68 | 1.32 | -4.77E-01 | -4.01E-02 | 3.15E-02 | -4.86E-01 | -7.15E-02 | -6.01E-03 | 6.30E-03 | -7.12E-02 |
| | Field | Corn | -83.0 | 6.9 | 1.68 | 1.32 | -2.86E-01 | -6.97E-02 | 5.48E-02 | -3.01E-01 | -4.29E-02 | -1.04E-02 | 1.10E-02 | -4.24E-02 |
| | Forage | Alfalfa | -58.0 | 4 | 0 | 1.32 | -1.16E-01 | 0.00E+00 | 3.83E-02 | -7.77E-02 | -1.74E-02 | 0.00E+00 | 7.65E-03 | -9.74E-03 |
| | Vegetable/Truck Crops | Vegetables | 48.2 | 8.5 | 0.17 | 1.32 | 2.05E-01 | 4.10E-03 | -3.18E-02 | 1.77E-01 | 3.07E-02 | 6.14E-04 | -6.36E-03 | 2.50E-02 |
| | Orchards and Vineyards | Almonds | -4,066.7 | 3.13 | 0.08 | 1.32 | -6.36E+00 | -1.63E-01 | 2.68E+00 | -3.84E+00 | -9.54E-01 | -2.44E-02 | 5.37E-01 | -4.42E-01 |
| | Sacramento River Subtotal | | -4,207.2 | n/a | n/a | n/a | -7.04E+00 | -2.68E-01 | 2.78E+00 | -4.53E+00 | -1.06E+00 | -4.02E-02 | 5.55E-01 | -5.40E-01 |
| San Joaquin River | Grain | Wheat | -14.5 | 3.7 | 5.8 | 9.75 | -2.69E-02 | -4.22E-02 | 7.09E-02 | 1.80E-03 | -4.03E-03 | -6.32E-03 | 1.42E-02 | 3.82E-03 |
| | Field | Corn | -96.4 | 6.9 | 1.68 | 9.75 | -3.33E-01 | -8.10E-02 | 4.70E-01 | 5.62E-02 | -4.99E-02 | -1.21E-02 | 9.40E-02 | 3.20E-02 |
| | Forage | Alfalfa | -99.9 | 4 | 0 | 9.75 | -2.00E-01 | 0.00E+00 | 4.87E-01 | 2.87E-01 | -2.99E-02 | 0.00E+00 | 9.73E-02 | 6.74E-02 |
| | Vegetable/Truck Crops | Vegetables | 82.1 | 8.5 | 0.17 | 9.75 | 3.49E-01 | 6.98E-03 | -4.00E-01 | -4.42E-02 | 5.23E-02 | 1.05E-03 | -8.00E-02 | -2.67E-02 |
| | Orchards and Vineyards | Almonds | 113.9 | 3.13 | 0.08 | 9.75 | 1.78E-01 | 4.56E-03 | -5.55E-01 | -3.72E-01 | 2.67E-02 | 6.83E-04 | -1.11E-01 | -8.36E-02 |
| | San Joaquin River Subtotal | | -14.8 | n/a | n/a | n/a | -3.21E-02 | -1.12E-01 | 7.22E-02 | -7.15E-02 | -4.82E-03 | -1.67E-02 | 1.44E-02 | -7.10E-03 |
| Tulare Lake | Grain | Wheat | -5,465.4 | 3.7 | 5.8 | 10.70 | -1.01E+01 | -1.58E+01 | 2.92E+01 | 3.28E+00 | -1.52E+00 | -2.38E+00 | 5.85E+00 | 1.96E+00 |
| | Field | Corn | -9,336.6 | 6.9 | 1.68 | 10.70 | -3.22E+01 | -7.84E+00 | 5.00E+01 | 9.90E+00 | -4.83E+00 | -1.18E+00 | 9.99E+00 | 3.99E+00 |
| | Forage | Alfalfa | -61.3 | 4 | 0 | 10.70 | -1.23E-01 | 0.00E+00 | 3.28E-01 | 2.06E-01 | -1.84E-02 | 0.00E+00 | 6.56E-02 | 4.72E-02 |
| | Vegetable/Truck Crops | Vegetables | -6,331.1 | 8.5 | 0.17 | 10.70 | -2.69E+01 | -5.38E-01 | 3.39E+01 | 6.43E+00 | -4.03E+00 | -8.07E-02 | 6.77E+00 | 2.66E+00 |
| | Orchards and Vineyards | Almonds | -1,675.0 | 3.13 | 0.08 | 10.70 | -2.62E+00 | -6.70E-02 | 8.96E+00 | 6.27E+00 | -3.93E-01 | -1.00E-02 | 1.79E+00 | 1.39E+00 |
| | Tulare Lake Subtotal | | -22,869.5 | n/a | n/a | n/a | -7.20E+01 | -2.43E+01 | 1.22E+02 | 2.61E+01 | -1.08E+01 | -3.64E+00 | 2.45E+01 | 1.00E+01 |

Key:
SWAP = Statewide Agricultural Production lbs/acre/year = pounds per acre per year PM10 = inhalable particulate matter PM2.5 = fine particulate matter tpy = tons per year

**Table 17. Alternative 5: Detailed Fugitive Dust Emission Calculations**

| SWAP Region | SWAP Crop Type | Representative Crop | Irrigated Acreage (Change from Alt 1) (acres) | Emission Factor (lbs/acre/year) | | | Annual PM10 Emissions (tpy) | | | | Annual PM10 Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Land Prep | Harvesting | Windblown Dust | Land Prep | Harvesting | Windblown Dust | Total | Land Prep | Harvesting | Windblown Dust | Total |
| **Wet Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 0.0 | 20 | 1.68 | 1.32 | -1.37E-05 | -1.15E-06 | 9.06E-07 | -1.40E-05 | -2.06E-06 | -1.73E-07 | 1.81E-07 | -2.05E-06 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 1.32 | -2.04E-05 | -4.97E-06 | 3.90E-06 | -2.15E-05 | -3.06E-06 | -7.45E-07 | 7.81E-07 | -3.02E-06 |
| | Forage | Alfalfa | 0.0 | 4 | 0 | 1.32 | 1.13E-05 | 0.00E+00 | -3.72E-06 | 7.56E-06 | 1.69E-06 | 0.00E+00 | -7.44E-07 | 9.46E-07 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 1.32 | -1.33E-07 | -2.66E-09 | 2.06E-08 | -1.15E-07 | -1.99E-08 | -3.99E-10 | 4.13E-09 | -1.62E-08 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 1.32 | -6.36E-07 | -1.63E-08 | 2.68E-07 | -3.84E-07 | -9.54E-08 | -2.44E-09 | 5.36E-08 | -4.42E-08 |
| | Sacramento River Subtotal | | 0.0 | n/a | n/a | n/a | -2.36E-05 | -6.14E-06 | 1.38E-06 | -2.84E-05 | -3.54E-06 | -9.21E-07 | 2.75E-07 | -4.19E-06 |
| San Joaquin River | Grain | Wheat | 0.0 | 3.7 | 5.8 | 9.75 | 1.65E-05 | 2.59E-05 | -4.35E-05 | -1.10E-06 | 2.47E-06 | 3.88E-06 | -8.70E-06 | -2.34E-06 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 9.75 | -1.36E-04 | -3.31E-05 | 1.92E-04 | 2.30E-05 | -2.04E-05 | -4.97E-06 | 3.84E-05 | 1.31E-05 |
| | Forage | Alfalfa | -0.3 | 4 | 0 | 9.75 | -5.19E-04 | 0.00E+00 | 1.26E-03 | 7.45E-04 | -7.77E-05 | 0.00E+00 | 2.53E-04 | 1.75E-04 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 9.75 | -4.61E-05 | -9.22E-07 | 5.29E-05 | 5.84E-06 | -6.91E-06 | -1.38E-07 | 1.06E-05 | 3.52E-06 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 9.75 | -4.11E-06 | -1.05E-07 | 1.28E-05 | 8.59E-06 | -6.16E-07 | -1.58E-08 | 2.56E-06 | 1.93E-06 |
| | San Joaquin River Subtotal | | -0.3 | n/a | n/a | n/a | -6.88E-04 | -8.28E-06 | 1.48E-03 | 7.81E-04 | -1.03E-04 | -1.24E-06 | 2.96E-04 | 1.91E-04 |
| Tulare Lake | Grain | Wheat | 0.0 | 3.7 | 5.8 | 10.70 | -1.04E-06 | -1.64E-06 | 3.02E-06 | 3.39E-07 | -1.57E-07 | -2.45E-07 | 6.04E-07 | 2.02E-07 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 10.70 | -2.75E-05 | -6.70E-06 | 4.27E-05 | 8.46E-06 | -4.13E-06 | -1.01E-06 | 8.54E-06 | 3.41E-06 |
| | Forage | Alfalfa | 0.0 | 4 | 0 | 10.70 | 2.71E-05 | 0.00E+00 | -7.24E-05 | -4.53E-05 | 4.06E-06 | 0.00E+00 | -1.45E-05 | -1.04E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 10.70 | -1.12E-06 | -2.25E-08 | 1.42E-06 | 2.69E-07 | -1.69E-07 | -3.37E-09 | 2.83E-07 | 1.11E-07 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 10.70 | -1.39E-06 | -3.55E-08 | 4.74E-06 | 3.32E-06 | -2.08E-07 | -5.32E-09 | 9.49E-07 | 7.35E-07 |
| | Tulare Lake Subtotal | | 0.0 | n/a | n/a | n/a | -4.04E-06 | -8.40E-06 | -2.05E-05 | -3.29E-05 | -6.05E-07 | -1.26E-06 | -4.10E-06 | -5.96E-06 |
| **Above Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 0.0 | 20 | 1.68 | 1.32 | -5.02E-05 | -4.22E-06 | 3.31E-06 | -5.11E-05 | -7.53E-06 | -6.32E-07 | 6.63E-07 | -7.50E-06 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 1.32 | -5.23E-05 | -1.27E-05 | 1.00E-05 | -5.50E-05 | -7.84E-06 | -1.91E-06 | 2.00E-06 | -7.75E-06 |
| | Forage | Alfalfa | 0.0 | 4 | 0 | 1.32 | 4.11E-05 | 0.00E+00 | -1.35E-05 | 2.75E-05 | 6.15E-06 | 0.00E+00 | -2.71E-06 | 3.45E-06 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 1.32 | -2.30E-06 | -4.59E-08 | 3.56E-07 | -1.98E-06 | -3.44E-07 | -6.88E-09 | 7.13E-08 | -2.80E-07 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 1.32 | -1.85E-06 | -4.72E-08 | 7.78E-07 | -1.11E-06 | -2.77E-07 | -7.07E-09 | 1.56E-07 | -1.28E-07 |
| | Sacramento River Subtotal | | 0.0 | n/a | n/a | n/a | -6.56E-05 | -1.70E-05 | 9.03E-07 | -8.17E-05 | -9.83E-06 | -2.55E-06 | 1.81E-07 | -1.22E-05 |
| San Joaquin River | Grain | Wheat | 0.0 | 3.7 | 5.8 | 9.75 | 3.62E-05 | 5.68E-05 | -9.55E-05 | -2.42E-06 | 5.43E-06 | 8.52E-06 | -1.91E-05 | -5.15E-06 |
| | Field | Corn | -0.1 | 6.9 | 1.68 | 9.75 | -2.71E-04 | -6.59E-05 | 3.82E-04 | 4.58E-05 | -4.06E-05 | -9.88E-06 | 7.65E-05 | 2.60E-05 |
| | Forage | Alfalfa | -0.6 | 4 | 0 | 9.75 | -1.13E-03 | 0.00E+00 | 2.75E-03 | 1.62E-03 | -1.69E-04 | 0.00E+00 | 5.50E-04 | 3.81E-04 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 9.75 | -9.30E-05 | -1.86E-06 | 1.07E-04 | 1.18E-05 | -1.39E-05 | -2.79E-07 | 2.13E-05 | 7.11E-06 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 9.75 | -8.67E-06 | -2.22E-07 | 2.70E-05 | 1.81E-05 | -1.30E-06 | -3.32E-08 | 5.40E-06 | 4.07E-06 |
| | San Joaquin River Subtotal | | -0.7 | n/a | n/a | n/a | -1.46E-03 | -1.12E-05 | 3.17E-03 | 1.69E-03 | -2.20E-04 | -1.68E-06 | 6.34E-04 | 4.13E-04 |
| Tulare Lake | Grain | Wheat | 0.0 | 3.7 | 5.8 | 10.70 | -6.61E-06 | -1.04E-05 | 1.91E-05 | 2.15E-06 | -9.91E-07 | -1.55E-06 | 3.82E-06 | 1.28E-06 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 10.70 | -1.34E-04 | -3.26E-05 | 2.08E-04 | 4.12E-05 | -2.01E-05 | -4.89E-06 | 4.15E-05 | 1.66E-05 |
| | Forage | Alfalfa | 0.1 | 4 | 0 | 10.70 | 1.49E-04 | 0.00E+00 | -4.00E-04 | -2.50E-04 | 2.24E-05 | 0.00E+00 | -8.00E-05 | -5.76E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 10.70 | -6.99E-06 | -1.40E-07 | 8.80E-06 | 1.67E-06 | -1.05E-06 | -2.09E-08 | 1.76E-06 | 6.91E-07 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 10.70 | -6.34E-06 | -1.62E-07 | 2.17E-05 | 1.52E-05 | -9.51E-07 | -2.43E-08 | 4.34E-06 | 3.36E-06 |
| | Tulare Lake Subtotal | | 0.0 | n/a | n/a | n/a | -4.42E-06 | -4.33E-05 | -1.43E-04 | -1.90E-04 | -6.63E-07 | -6.49E-06 | -2.85E-05 | -3.57E-05 |
| **Below Normal Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 0.0 | 20 | 1.68 | 1.32 | -2.36E-04 | -1.98E-05 | 1.56E-05 | -2.40E-04 | -3.53E-05 | -2.97E-06 | 3.11E-06 | -3.52E-05 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 1.32 | -7.16E-05 | -1.74E-05 | 1.37E-05 | -7.54E-05 | -1.07E-05 | -2.61E-06 | 2.74E-06 | -1.06E-05 |
| | Forage | Alfalfa | 1.2 | 4 | 0 | 1.32 | 2.50E-03 | 0.00E+00 | -8.24E-04 | 1.67E-03 | 3.74E-04 | 0.00E+00 | -1.65E-04 | 2.10E-04 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 1.32 | -5.59E-05 | -1.12E-06 | 8.68E-06 | -4.83E-05 | -8.38E-06 | -1.68E-07 | 1.74E-06 | -6.81E-06 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 1.32 | 1.12E-06 | 2.86E-08 | -4.72E-07 | 6.75E-07 | 1.68E-07 | 4.29E-09 | -9.43E-08 | 7.76E-08 |
| | Sacramento River Subtotal | | 1.2 | n/a | n/a | n/a | 2.13E-03 | -3.83E-05 | -7.86E-04 | 1.31E-03 | 3.20E-04 | -5.74E-06 | -1.57E-04 | 1.57E-04 |
| San Joaquin River | Grain | Wheat | 0.0 | 3.7 | 5.8 | 9.75 | -1.45E-05 | -2.27E-05 | 3.82E-05 | 9.68E-07 | -2.17E-06 | -3.41E-06 | 7.64E-06 | 2.06E-06 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 9.75 | -6.22E-05 | -1.52E-05 | 8.79E-05 | 1.05E-05 | -9.33E-06 | -2.27E-06 | 1.76E-05 | 5.98E-06 |
| | Forage | Alfalfa | 0.1 | 4 | 0 | 9.75 | 1.40E-04 | 0.00E+00 | -3.42E-04 | -2.02E-04 | 2.11E-05 | 0.00E+00 | -6.85E-05 | -4.74E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 9.75 | -8.61E-05 | -1.72E-06 | 9.87E-05 | 1.09E-05 | -1.29E-05 | -2.58E-07 | 1.97E-05 | 6.58E-06 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 9.75 | 2.36E-06 | 6.04E-08 | -7.35E-06 | -4.93E-06 | 3.54E-07 | 9.05E-09 | -1.47E-06 | -1.11E-06 |
| | San Joaquin River Subtotal | | 0.0 | n/a | n/a | n/a | -2.00E-05 | -3.96E-05 | -1.25E-04 | -1.84E-04 | -2.99E-06 | -5.93E-06 | -2.50E-05 | -3.39E-05 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tulare Lake | Grain | Wheat | 0.1 | 3.7 | 5.8 | 10.70 | 2.76E-04 | 4.32E-04 | -7.97E-04 | -8.94E-05 | 4.13E-05 | 6.48E-05 | -1.59E-04 | -5.33E-05 |
| | Field | Corn | 0.2 | 6.9 | 1.68 | 10.70 | 5.79E-04 | 1.41E-04 | -8.97E-04 | -1.78E-04 | 8.67E-05 | 2.11E-05 | -1.79E-04 | -7.16E-05 |
| | Forage | Alfalfa | -3.3 | 4 | 0 | 10.70 | -6.62E-03 | 0.00E+00 | 1.77E-02 | 1.11E-02 | -9.92E-04 | 0.00E+00 | 3.54E-03 | 2.55E-03 |
| | Vegetable/Truck Crops | Vegetables | 0.1 | 8.5 | 0.17 | 10.70 | 4.92E-04 | 9.84E-06 | -6.19E-04 | -1.18E-04 | 7.38E-05 | 1.48E-06 | -1.24E-04 | -4.87E-05 |
| | Orchards and Vineyards | Almonds | 0.0 | 3.13 | 0.08 | 10.70 | -3.04E-05 | -7.78E-07 | 1.04E-04 | 7.28E-05 | -4.56E-06 | -1.17E-07 | 2.08E-05 | 1.61E-05 |
| | Tulare Lake Subtotal | | -2.9 | n/a | n/a | n/a | -5.30E-03 | 5.82E-04 | 1.55E-02 | 1.08E-02 | -7.95E-04 | 8.72E-05 | 3.10E-03 | 2.39E-03 |
| **Dry Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | -9.1 | 20 | 1.68 | 1.32 | -9.12E-02 | -7.66E-03 | 6.02E-03 | -9.28E-02 | -1.37E-02 | -1.15E-03 | 1.20E-03 | -1.36E-02 |
| | Field | Corn | -3.9 | 6.9 | 1.68 | 1.32 | -1.35E-02 | -3.29E-03 | 2.58E-03 | -1.42E-02 | -2.02E-03 | -4.92E-04 | 5.16E-04 | -2.00E-03 |
| | Forage | Alfalfa | 0.0 | 4 | 0 | 1.32 | -7.98E-05 | 0.00E+00 | 2.63E-05 | -5.35E-05 | -1.20E-05 | 0.00E+00 | 5.27E-06 | -6.70E-06 |
| | Vegetable/Truck Crops | Vegetables | -0.1 | 8.5 | 0.17 | 1.32 | -4.76E-04 | -9.52E-06 | 7.39E-05 | -4.12E-04 | -7.14E-05 | -1.43E-06 | 1.48E-05 | -5.80E-05 |
| | Orchards and Vineyards | Almonds | 0.1 | 3.13 | 0.08 | 1.32 | 1.75E-04 | 4.47E-06 | -7.38E-05 | 1.06E-04 | 2.62E-05 | 6.71E-07 | -1.48E-05 | 1.22E-05 |
| | Sacramento River Subtotal | | -13.1 | n/a | n/a | n/a | -1.05E-01 | -1.09E-02 | 8.62E-03 | -1.07E-01 | -1.57E-02 | -1.64E-03 | 1.72E-03 | -1.57E-02 |
| San Joaquin River | Grain | Wheat | 0.0 | 3.7 | 5.8 | 9.75 | -4.18E-05 | -6.55E-05 | 1.10E-04 | 2.79E-06 | -6.26E-06 | -9.81E-06 | 2.20E-05 | 5.93E-06 |
| | Field | Corn | 0.1 | 6.9 | 1.68 | 9.75 | 2.64E-04 | 6.43E-05 | -3.73E-04 | -4.46E-05 | 3.96E-05 | 9.63E-06 | -7.46E-05 | -2.54E-05 |
| | Forage | Alfalfa | -0.1 | 4 | 0 | 9.75 | -1.36E-04 | 0.00E+00 | 3.30E-04 | 1.95E-04 | -2.03E-05 | 0.00E+00 | 6.61E-05 | 4.57E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 9.75 | -6.11E-05 | -1.22E-06 | 7.01E-05 | 7.75E-06 | -9.17E-06 | -1.83E-07 | 1.40E-05 | 4.67E-06 |
| | Orchards and Vineyards | Almonds | 0.1 | 3.13 | 0.08 | 9.75 | 1.88E-04 | 4.82E-06 | -5.87E-04 | -3.94E-04 | 2.82E-05 | 7.22E-07 | -1.17E-04 | -8.84E-05 |
| | San Joaquin River Subtotal | | 0.1 | n/a | n/a | n/a | 2.14E-04 | 2.40E-06 | -4.49E-04 | -2.33E-04 | 3.21E-05 | 3.59E-07 | -8.98E-05 | -5.74E-05 |
| Tulare Lake | Grain | Wheat | -0.4 | 3.7 | 5.8 | 10.70 | -7.33E-04 | -1.15E-03 | 2.12E-03 | 2.38E-04 | -1.10E-04 | -1.72E-04 | 4.24E-04 | 1.42E-04 |
| | Field | Corn | -99.9 | 6.9 | 1.68 | 10.70 | -3.45E-01 | -8.39E-02 | 5.35E-01 | 1.06E-01 | -5.17E-02 | -1.26E-02 | 1.07E-01 | 4.27E-02 |
| | Forage | Alfalfa | -0.5 | 4 | 0 | 10.70 | -9.88E-04 | 0.00E+00 | 2.64E-03 | 1.66E-03 | -1.48E-04 | 0.00E+00 | 5.29E-04 | 3.81E-04 |
| | Vegetable/Truck Crops | Vegetables | -0.6 | 8.5 | 0.17 | 10.70 | -2.71E-03 | -5.42E-05 | 3.41E-03 | 6.47E-04 | -4.06E-04 | -8.12E-06 | 6.82E-04 | 2.68E-04 |
| | Orchards and Vineyards | Almonds | 0.4 | 3.13 | 0.08 | 10.70 | 5.94E-04 | 1.52E-05 | -2.03E-03 | -1.42E-03 | 8.90E-05 | 2.28E-06 | -4.06E-04 | -3.15E-04 |
| | Tulare Lake Subtotal | | -101.1 | n/a | n/a | n/a | -3.49E-01 | -8.51E-02 | 5.41E-01 | 1.07E-01 | -5.22E-02 | -1.28E-02 | 1.08E-01 | 4.31E-02 |
| **Critical Condition** | | | | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 0.0 | 20 | 1.68 | 1.32 | -4.35E-04 | -3.65E-05 | 2.87E-05 | -4.43E-04 | -6.52E-05 | -5.48E-06 | 5.74E-06 | -6.50E-05 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 1.32 | -8.29E-05 | -2.02E-05 | 1.59E-05 | -8.73E-05 | -1.24E-05 | -3.03E-06 | 3.17E-06 | -1.23E-05 |
| | Forage | Alfalfa | -0.1 | 4 | 0 | 1.32 | -1.27E-04 | 0.00E+00 | 4.18E-05 | -8.49E-05 | -1.90E-05 | 0.00E+00 | 8.36E-06 | -1.06E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 1.32 | -1.23E-04 | -2.46E-06 | 1.91E-05 | -1.06E-04 | -1.84E-05 | -3.68E-07 | 3.81E-06 | -1.50E-05 |
| | Orchards and Vineyards | Almonds | -4.6 | 3.13 | 0.08 | 1.32 | -7.27E-03 | -1.86E-04 | 3.06E-03 | -4.39E-03 | -1.09E-03 | -2.78E-05 | 6.13E-04 | -5.04E-04 |
| | Sacramento River Subtotal | | -4.8 | n/a | n/a | n/a | -8.03E-03 | -2.45E-04 | 3.17E-03 | -5.11E-03 | -1.20E-03 | -3.67E-05 | 6.34E-04 | -6.07E-04 |
| San Joaquin River | Grain | Wheat | 0.0 | 3.7 | 5.8 | 9.75 | -3.15E-05 | -4.93E-05 | 8.29E-05 | 2.10E-06 | -4.71E-06 | -7.39E-06 | 1.66E-05 | 4.47E-06 |
| | Field | Corn | 0.0 | 6.9 | 1.68 | 9.75 | -2.87E-05 | -6.98E-06 | 4.05E-05 | 4.85E-06 | -4.30E-06 | -1.05E-06 | 8.10E-06 | 2.76E-06 |
| | Forage | Alfalfa | -0.1 | 4 | 0 | 9.75 | -2.89E-04 | 0.00E+00 | 7.05E-04 | 4.16E-04 | -4.34E-05 | 0.00E+00 | 1.41E-04 | 9.77E-05 |
| | Vegetable/Truck Crops | Vegetables | 0.0 | 8.5 | 0.17 | 9.75 | -5.51E-05 | -1.10E-06 | 6.32E-05 | 6.98E-06 | -8.26E-06 | -1.65E-07 | 1.26E-05 | 4.21E-06 |
| | Orchards and Vineyards | Almonds | 0.2 | 3.13 | 0.08 | 9.75 | 2.98E-04 | 7.61E-06 | -9.28E-04 | -6.22E-04 | 4.46E-05 | 1.14E-06 | -1.86E-04 | -1.40E-04 |
| | San Joaquin River Subtotal | | 0.0 | n/a | n/a | n/a | -1.07E-04 | -4.98E-05 | -3.56E-05 | -1.92E-04 | -1.60E-05 | -7.46E-06 | -7.12E-06 | -3.06E-05 |
| Tulare Lake | Grain | Wheat | -0.1 | 3.7 | 5.8 | 10.70 | -1.09E-04 | -1.70E-04 | 3.14E-04 | 3.53E-05 | -1.63E-05 | -2.55E-05 | 6.29E-05 | 2.10E-05 |
| | Field | Corn | -46.8 | 6.9 | 1.68 | 10.70 | -1.61E-01 | -3.93E-02 | 2.50E-01 | 4.96E-02 | -2.42E-02 | -5.89E-03 | 5.01E-02 | 2.00E-02 |
| | Forage | Alfalfa | -0.2 | 4 | 0 | 10.70 | -3.59E-04 | 0.00E+00 | 9.60E-04 | 6.01E-04 | -5.38E-05 | 0.00E+00 | 1.92E-04 | 1.38E-04 |
| | Vegetable/Truck Crops | Vegetables | -0.1 | 8.5 | 0.17 | 10.70 | -2.31E-04 | -4.62E-06 | 2.91E-04 | 5.52E-05 | -3.47E-05 | -6.93E-07 | 5.82E-05 | 2.29E-05 |
| | Orchards and Vineyards | Almonds | 0.2 | 3.13 | 0.08 | 10.70 | 3.39E-04 | 8.66E-06 | -1.16E-03 | -8.11E-04 | 5.08E-05 | 1.30E-06 | -2.32E-04 | -1.80E-04 |
| | Tulare Lake Subtotal | | -46.9 | n/a | n/a | n/a | -1.62E-01 | -3.95E-02 | 2.51E-01 | 4.95E-02 | -2.43E-02 | -5.92E-03 | 5.01E-02 | 2.00E-02 |

Key:
SWAP = Statewide Agricultural Production  lbs/acre/year = pounds per acre per year  PM10 = inhalable particulate matter  PM2.5 = fine particulate matter  tpy = tons per year

Size Fractions

| **Description** | **PM10** | **PM2.5** | **Ratio** |
|---|---|---|---|
| PM Profile ID No. 411, Windblown Dust - Agricultural | 0.5 | 0.1 | 0.2 |
| PM Profile ID No. 417, Agricultural Tilling Dust | 0.4543 | 0.0681 | 0.1499 |

Note:
Fraction of PM10 (FRPM10) from wind erosion: 0.50
(PM10 Emissions = PM x FRPM10)

**Table 18. SWAP Output - Annual Groundwater Pumped**

| | | | | | | *Alternative 2 - Alt 1* | *Alternative 3 - Alt 1* | *Alternative 5 - Alt 1* | *Alt 1 - Existing* |
|---|---|---|---|---|---|---|---|---|---|
| | **Annual Groundwater Pumped (TAF)** | | | | | **Change from Alt 1 (TAF)** | | | |
| **SWAP Region** | **Alternative 1** | **Alternative 2** | **Alternative 3** | **Alternative 5** | **Existing Conditions** | **Alternative 2** | **Alternative 3** | **Alternative 5** | **Existing Conditions** |
| **Wet Condition** | | | | | | | | | |
| Sacramento River | 1,248.5 | 1,245.5 | 1,249.0 | 1,248.5 | 1,316.3 | -3.0 | 0.4 | -0.002 | -67.8 |
| San Joaquin River | 996.2 | 986.7 | 999.6 | 996.3 | 1,044.7 | -9.5 | 3.4 | 0.03 | -48.5 |
| Tulare Lake | 2,432.4 | 2,407.3 | 2,443.4 | 2,432.6 | 2,453.9 | -25.1 | 11.0 | 0.2 | -21.5 |
| **Above Normal Conditions** | | | | | | | | | |
| Sacramento River | 1,240.5 | 1,235.9 | 1,242.4 | 1,240.5 | 1,310.9 | -4.6 | 2.0 | 0.02 | -70.5 |
| San Joaquin River | 1,122.3 | 1,110.3 | 1,126.6 | 1,122.4 | 1,172.1 | -11.9 | 4.3 | 0.1 | -49.9 |
| Tulare Lake | 2,771.5 | 2,733.4 | 2,786.0 | 2,772.0 | 2,801.5 | -38.0 | 14.5 | 0.6 | -30.1 |
| **Below Normal Conditions** | | | | | | | | | |
| Sacramento River | 1,265.8 | 1,264.5 | 1,266.4 | 1,265.8 | 1,335.2 | -1.3 | 0.6 | -0.002 | -69.4 |
| San Joaquin River | 1,208.7 | 1,191.3 | 1,218.6 | 1,208.7 | 1,254.8 | -17.4 | 9.9 | -0.01 | -46.2 |
| Tulare Lake | 2,900.7 | 2,875.1 | 2,903.9 | 2,900.8 | 2,879.3 | -25.7 | 3.1 | 0.1 | 21.5 |
| **Dry Condition** | | | | | | | | | |
| Sacramento River | 1,271.6 | 1,270.2 | 1,271.3 | 1,271.7 | 1,333.6 | -1.4 | -0.3 | 0.1 | -62.1 |
| San Joaquin River | 1,315.5 | 1,285.3 | 1,336.1 | 1,315.6 | 1,348.5 | -30.2 | 20.6 | 0.1 | -33.0 |
| Tulare Lake | 3,047.0 | 3,035.1 | 3,055.5 | 3,047.1 | 3,050.8 | -12.0 | 8.5 | 0.03 | -3.7 |
| **Critical Condition** | | | | | | | | | |
| Sacramento River | 1,317.1 | 1,314.0 | 1,318.3 | 1,317.1 | 1,367.2 | -3.1 | 1.2 | 0.01 | -50.1 |
| San Joaquin River | 1,570.0 | 1,535.2 | 1,588.8 | 1,570.1 | 1,576.4 | -34.8 | 18.7 | 0.1 | -6.4 |
| Tulare Lake | 3,284.8 | 3,271.3 | 3,291.9 | 3,284.9 | 3,274.3 | -13.5 | 7.0 | 0.01 | 10.5 |

Key:
SWAP = Statewide Agricultural Production TAF = thousand acre-feet

**Table 19. SWAP Output - Irrigated Acreage**

| | | | | | | | | *Alternative 2 - Alt 1* | *Alternative 3 - Alt 1* | *Alternative 5 - Alt 1* | *Alt 1 - Existing* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Representative | Total Irrigated Acreage (thousand acres) | | | | | Change from Alternative 1 (acres) | | | |
| SWAP Region | SWAP Crop Type | Crop | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 5 | Existing Conditions | Alternative 2 | Alternative 3 | Alternative 5 | Existing Conditions |
| **Wet Condition** | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 616 | 616 | 616 | 616 | 591 | 0.35 | -0.13 | -0.00 | 25,089.44 |
| | Field | Corn | 116 | 116 | 116 | 116 | 127 | 1.52 | -0.55 | -0.01 | -10,577.72 |
| | Forage | Alfalfa | 126 | 126 | 126 | 126 | 150 | -1.45 | 0.52 | 0.01 | -24,305.28 |
| | Vegetable/Truck Crops | Vegetables | 129 | 129 | 129 | 129 | 118 | 0.01 | -0.00 | -0.00 | 11,150.97 |
| | Orchards and Vineyards | Almonds | 401 | 401 | 401 | 401 | 400 | 0.10 | -0.04 | -0.00 | 1,380.37 |
| | Sacramento River Subtotal | | 1,388 | 1,388 | 1,388 | 1,388 | 1,386 | 0.54 | -0.19 | -0.00 | 2,737.77 |
| San Joaquin River | Grain | Wheat | 77 | 77 | 77 | 77 | 75 | -2.29 | 0.83 | 0.01 | 2,162.72 |
| | Field | Corn | 466 | 466 | 466 | 466 | 469 | 10.23 | -3.65 | -0.04 | -2,517.01 |
| | Forage | Alfalfa | 275 | 275 | 275 | 275 | 299 | 66.69 | -24.09 | -0.26 | -24,116.37 |
| | Vegetable/Truck Crops | Vegetables | 224 | 224 | 224 | 224 | 202 | 2.81 | -1.01 | -0.01 | 22,074.66 |
| | Orchards and Vineyards | Almonds | 363 | 363 | 363 | 363 | 357 | 0.68 | -0.24 | -0.00 | 5,676.38 |
| | San Joaquin River Subtotal | | 1,405 | 1,405 | 1,405 | 1,405 | 1,402 | 78.12 | -28.16 | -0.30 | 3,280.39 |
| Tulare Lake | Grain | Wheat | 116 | 116 | 116 | 116 | 113 | 0.15 | -0.05 | -0.00 | 2,855.73 |
| | Field | Corn | 897 | 897 | 897 | 897 | 916 | 2.05 | -0.74 | -0.01 | -19,150.98 |
| | Forage | Alfalfa | 217 | 217 | 217 | 217 | 232 | -3.48 | 1.26 | 0.01 | -14,422.07 |
| | Vegetable/Truck Crops | Vegetables | 271 | 271 | 271 | 271 | 245 | 0.07 | -0.02 | -0.00 | 25,522.04 |
| | Orchards and Vineyards | Almonds | 815 | 815 | 815 | 815 | 802 | 0.23 | -0.08 | -0.00 | 12,761.36 |
| | Tulare Lake Subtotal | | 2,315 | 2,315 | 2,315 | 2,315 | 2,308 | -0.98 | 0.36 | 0.00 | 7,566.08 |
| **Above Normal Condition** | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 616 | 616 | 616 | 616 | 591 | 0.63 | 0.12 | -0.01 | 24,649.29 |
| | Field | Corn | 116 | 116 | 116 | 116 | 127 | 2.09 | -0.42 | -0.02 | -10,714.32 |
| | Forage | Alfalfa | 126 | 126 | 126 | 126 | 150 | -2.57 | -0.44 | 0.02 | -24,359.26 |
| | Vegetable/Truck Crops | Vegetables | 129 | 129 | 129 | 129 | 118 | 0.06 | 0.06 | -0.00 | 11,071.98 |
| | Orchards and Vineyards | Almonds | 401 | 401 | 401 | 401 | 400 | 0.16 | -0.01 | -0.00 | 1,326.31 |
| | Sacramento River Subtotal | | 1,388 | 1,388 | 1,388 | 1,388 | 1,386 | 0.36 | -0.70 | -0.00 | 1,974.01 |
| San Joaquin River | Grain | Wheat | 77 | 77 | 77 | 77 | 75 | -2.86 | 1.16 | 0.02 | 2,171.42 |
| | Field | Corn | 466 | 466 | 466 | 466 | 469 | 11.19 | -3.03 | -0.08 | -2,508.19 |
| | Forage | Alfalfa | 274 | 274 | 274 | 274 | 299 | 81.91 | -30.53 | -0.56 | -24,456.87 |
| | Vegetable/Truck Crops | Vegetables | 224 | 224 | 224 | 224 | 202 | 3.14 | -0.94 | -0.02 | 22,094.48 |
| | Orchards and Vineyards | Almonds | 363 | 363 | 363 | 363 | 357 | 0.78 | -0.19 | -0.01 | 5,648.50 |
| | San Joaquin River Subtotal | | 1,404 | 1,405 | 1,404 | 1,404 | 1,401 | 94.16 | -33.53 | -0.65 | 2,949.34 |
| Tulare Lake | Grain | Wheat | 116 | 116 | 116 | 116 | 113 | 0.41 | 0.22 | -0.00 | 2,855.90 |
| | Field | Corn | 897 | 897 | 897 | 897 | 916 | 4.57 | 1.92 | -0.04 | -19,169.03 |
| | Forage | Alfalfa | 217 | 217 | 217 | 217 | 232 | -9.36 | -1.53 | 0.07 | -14,275.45 |
| | Vegetable/Truck Crops | Vegetables | 271 | 271 | 271 | 271 | 245 | 0.19 | 0.10 | -0.00 | 25,497.14 |
| | Orchards and Vineyards | Almonds | 815 | 815 | 815 | 815 | 802 | 0.48 | 0.18 | -0.00 | 12,691.17 |
| | Tulare Lake Subtotal | | 2,315 | 2,315 | 2,315 | 2,315 | 2,308 | -3.72 | 0.90 | 0.03 | 7,599.72 |
| **Below Normal Condition** | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 616 | 616 | 616 | 616 | 591 | 52.43 | -262.90 | -0.02 | 25,588.62 |
| | Field | Corn | 117 | 117 | 116 | 117 | 126 | 80.63 | -788.47 | -0.02 | -9,424.63 |
| | Forage | Alfalfa | 121 | 124 | 121 | 121 | 148 | 2,931.46 | -49.58 | 1.25 | -26,840.16 |
| | Vegetable/Truck Crops | Vegetables | 129 | 129 | 129 | 129 | 118 | 30.19 | -137.25 | -0.01 | 11,194.29 |
| | Orchards and Vineyards | Almonds | 401 | 401 | 401 | 401 | 399 | 27.11 | -204.62 | 0.00 | 1,301.94 |
| | Sacramento River Subtotal | | 1,385 | 1,388 | 1,383 | 1,385 | 1,383 | 3,121.82 | -1,442.82 | 1.19 | 1,820.05 |
| San Joaquin River | Grain | Wheat | 77 | 77 | 77 | 77 | 75 | 10.07 | -7.07 | -0.01 | 2,175.47 |
| | Field | Corn | 466 | 466 | 466 | 466 | 469 | 58.58 | -31.81 | -0.02 | -2,605.08 |
| | Forage | Alfalfa | 274 | 274 | 274 | 274 | 298 | -125.80 | 81.44 | 0.07 | -24,510.51 |
| | Vegetable/Truck Crops | Vegetables | 224 | 224 | 224 | 224 | 202 | 26.50 | -22.32 | -0.02 | 22,022.87 |
| | Orchards and Vineyards | Almonds | 363 | 363 | 363 | 363 | 357 | 5.86 | -1.01 | 0.00 | 5,635.08 |
| | San Joaquin River Subtotal | | 1,404 | 1,404 | 1,404 | 1,404 | 1,401 | -24.79 | 19.22 | 0.03 | 2,717.82 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tulare Lake | Grain | Wheat | 116 | 116 | 116 | 116 | 112 | -280.45 | 300.41 | 0.15 | 4,171.33 |
| | Field | Corn | 893 | 896 | 891 | 893 | 902 | 3,168.52 | -2,661.48 | 0.17 | -9,159.04 |
| | Forage | Alfalfa | 214 | 218 | 209 | 214 | 230 | 3,903.14 | -4,407.80 | -3.31 | -16,359.50 |
| | Vegetable/Truck Crops | Vegetables | 271 | 271 | 271 | 271 | 242 | -126.65 | 171.30 | 0.12 | 28,555.87 |
| | Orchards and Vineyards | Almonds | 815 | 815 | 815 | 815 | 802 | 97.42 | -71.76 | -0.02 | 13,047.92 |
| | Tulare Lake Subtotal | | 2,308 | 2,315 | 2,302 | 2,308 | 2,288 | 6,761.99 | -6,669.33 | -2.90 | 20,256.58 |
| **Dry Condition** | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 610 | 614 | 608 | 610 | 588 | 3,351.13 | -2,254.97 | -9.12 | 22,555.75 |
| | Field | Corn | 109 | 110 | 108 | 109 | 121 | 1,556.79 | -806.39 | -3.91 | -12,367.82 |
| | Forage | Alfalfa | 121 | 122 | 121 | 121 | 143 | 24.40 | -4.65 | -0.04 | -21,846.41 |
| | Vegetable/Truck Crops | Vegetables | 128 | 128 | 128 | 128 | 117 | 209.79 | -12.63 | -0.11 | 10,689.59 |
| | Orchards and Vineyards | Almonds | 399 | 400 | 399 | 399 | 399 | 168.60 | -6.61 | 0.11 | 494.10 |
| | Sacramento River Subtotal | | 1,368 | 1,373 | 1,365 | 1,368 | 1,368 | 5,310.71 | -3,085.24 | -13.07 | -474.79 |
| San Joaquin River | Grain | Wheat | 77 | 77 | 77 | 77 | 75 | 6.48 | -1.85 | -0.02 | 2,171.92 |
| | Field | Corn | 466 | 466 | 466 | 466 | 469 | -80.47 | 26.64 | 0.08 | -2,521.81 |
| | Forage | Alfalfa | 274 | 274 | 274 | 274 | 299 | 28.22 | -9.97 | -0.07 | -24,849.49 |
| | Vegetable/Truck Crops | Vegetables | 224 | 224 | 224 | 224 | 202 | 4.64 | -1.81 | -0.01 | 21,855.49 |
| | Orchards and Vineyards | Almonds | 363 | 363 | 363 | 363 | 357 | -6.65 | 1.10 | 0.12 | 5,651.04 |
| | San Joaquin River Subtotal | | 1,404 | 1,404 | 1,404 | 1,404 | 1,402 | -47.78 | 14.12 | 0.09 | 2,307.16 |
| Tulare Lake | Grain | Wheat | 117 | 117 | 117 | 117 | 110 | 118.58 | -43.43 | -0.40 | 6,362.20 |
| | Field | Corn | 851 | 879 | 833 | 851 | 879 | 27,966.79 | -17,820.44 | -99.91 | -28,576.67 |
| | Forage | Alfalfa | 209 | 209 | 209 | 209 | 221 | 92.09 | -44.81 | -0.49 | -12,046.34 |
| | Vegetable/Truck Crops | Vegetables | 271 | 271 | 271 | 271 | 239 | 275.05 | -73.80 | -0.64 | 32,100.40 |
| | Orchards and Vineyards | Almonds | 815 | 815 | 815 | 815 | 801 | 86.15 | -15.22 | 0.38 | 13,294.68 |
| | Tulare Lake Subtotal | | 2,262 | 2,291 | 2,244 | 2,262 | 2,251 | 28,538.67 | -17,997.70 | -101.06 | 11,134.26 |
| **Critical Condition** | | | | | | | | | | | |
| Sacramento River | Grain | Rice | 601 | 603 | 601 | 601 | 581 | 1,959.30 | -47.71 | -0.04 | 20,304.46 |
| | Field | Corn | 105 | 105 | 104 | 105 | 116 | 20.10 | -82.99 | -0.02 | -11,377.28 |
| | Forage | Alfalfa | 121 | 121 | 121 | 121 | 143 | 49.74 | -58.00 | -0.06 | -22,543.39 |
| | Vegetable/Truck Crops | Vegetables | 120 | 120 | 120 | 120 | 110 | 56.86 | 48.20 | -0.03 | 10,110.30 |
| | Orchards and Vineyards | Almonds | 389 | 397 | 385 | 389 | 398 | 7,541.63 | -4,066.72 | -4.64 | -9,338.59 |
| | Sacramento River Subtotal | | 1,335 | 1,345 | 1,331 | 1,335 | 1,348 | 9,627.64 | -4,207.22 | -4.80 | -12,844.50 |
| San Joaquin River | Grain | Wheat | 77 | 77 | 77 | 77 | 75 | 11.53 | -14.54 | -0.02 | 2,336.94 |
| | Field | Corn | 466 | 466 | 466 | 466 | 468 | 6.25 | -96.40 | -0.01 | -1,764.09 |
| | Forage | Alfalfa | 274 | 274 | 274 | 274 | 298 | 107.50 | -99.87 | -0.14 | -24,270.75 |
| | Vegetable/Truck Crops | Vegetables | 224 | 224 | 224 | 224 | 202 | 9.81 | 82.07 | -0.01 | 21,682.81 |
| | Orchards and Vineyards | Almonds | 363 | 363 | 363 | 363 | 357 | -138.05 | 113.92 | 0.19 | 6,178.53 |
| | San Joaquin River Subtotal | | 1,404 | 1,404 | 1,404 | 1,404 | 1,400 | -2.95 | -14.82 | 0.01 | 4,163.45 |
| Tulare Lake | Grain | Wheat | 117 | 117 | 111 | 117 | 108 | 39.75 | -5,465.42 | -0.06 | 8,148.60 |
| | Field | Corn | 751 | 785 | 742 | 751 | 795 | 34,116.95 | -9,336.57 | -46.79 | -44,256.28 |
| | Forage | Alfalfa | 209 | 209 | 209 | 209 | 221 | 113.88 | -61.34 | -0.18 | -11,842.06 |
| | Vegetable/Truck Crops | Vegetables | 271 | 271 | 264 | 271 | 236 | 38.91 | -6,331.11 | -0.05 | 34,379.44 |
| | Orchards and Vineyards | Almonds | 815 | 815 | 814 | 815 | 801 | -138.61 | -1,675.01 | 0.22 | 14,197.97 |
| | Tulare Lake Subtotal | | 2,163 | 2,197 | 2,140 | 2,163 | 2,162 | 34,170.88 | -22,869.45 | -46.86 | 627.68 |

Key:
SWAP = Statewide Agricultural Production

Note:
Change from Alt 1 for Action Alternatives = Action Alternative minus Alternative 1 (No Action)
Change from Alt 1 for Existing Conditions = Alternative 1 (No Action) minus Existing Conditions

If acreage is not irrigated, then fields would be left barren and subject to windblown dust.
Less irrigated acreage (as compared to Alt 1) would equal a decrease in harvest/land preparation emissions.

**Table 20. Annual Groundwater Pumped (TAF) by SWAP Region**

| SWAP Region | | Wet Years | | | | | Above Normal | | | | | Below Normal | | | | | Dry | | | | | Critical | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 3 | Alt 3 | Alt 5 |
| Sacramento River | V01 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V02 | 380.0 | 318.7 | 318.4 | 318.7 | 318.7 | 380.0 | 318.6 | 318.2 | 318.9 | 318.7 | 380.0 | 324.7 | 323.4 | 325.2 | 324.7 | 380.0 | 331.0 | 329.0 | 332.3 | 331.0 | 380.0 | 348.2 | 346.4 | 349.0 | 348.2 |
| | V03A | 151.7 | 134.4 | 134.4 | 134.4 | 134.4 | 143.9 | 128.5 | 128.4 | 128.5 | 128.5 | 120.5 | 102.7 | 102.8 | 102.7 | 102.7 | 118.1 | 101.4 | 102.0 | 99.8 | 101.5 | 134.5 | 128.4 | 127.2 | 128.8 | 128.4 |
| | V03B | 19.5 | 8.1 | 5.4 | 8.5 | 8.1 | 22.8 | 13.6 | 9.5 | 15.3 | 13.6 | 74.7 | 74.7 | 74.7 | 74.7 | 74.7 | 74.7 | 74.7 | 74.7 | 74.7 | 74.7 | 93.4 | 74.7 | 74.7 | 74.7 | 74.7 |
| | V04 | 0.0 | 18.5 | 18.5 | 18.5 | 18.5 | 0.0 | 11.9 | 11.9 | 11.9 | 11.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 1.9 | 2.0 | 2.0 |
| | V05 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 | 290.0 |
| | V06 | 475.1 | 478.9 | 478.9 | 478.9 | 478.9 | 474.2 | 477.9 | 477.9 | 477.9 | 477.9 | 470.0 | 473.7 | 473.6 | 473.8 | 473.7 | 470.8 | 474.5 | 474.5 | 474.5 | 474.5 | 469.3 | 473.8 | 473.7 | 473.8 | 473.8 |
| | V07 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| San Joaquin River | V08 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V09 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.9 | 101.0 | 100.3 | 101.4 | 101.0 | 102.2 | 102.9 | 101.6 | 103.8 | 102.9 | 106.4 | 107.5 | 105.8 | 108.3 | 107.5 |
| | V10 | 170.1 | 125.6 | 116.1 | 129.0 | 125.6 | 260.9 | 211.8 | 199.9 | 216.1 | 211.9 | 312.9 | 269.6 | 253.0 | 279.0 | 269.6 | 352.6 | 322.5 | 293.6 | 342.2 | 322.6 | 532.9 | 529.6 | 496.2 | 547.6 | 529.6 |
| | V11 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V12 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V13 | 774.6 | 770.6 | 770.6 | 770.6 | 770.6 | 811.3 | 810.5 | 810.5 | 810.5 | 810.5 | 841.0 | 838.0 | 838.0 | 838.1 | 838.0 | 893.7 | 890.0 | 890.1 | 890.0 | 890.0 | 937.0 | 933.0 | 933.2 | 932.8 | 933.0 |
| Tulare Lake | V14A | 222.1 | 182.3 | 160.5 | 192.5 | 182.4 | 428.1 | 384.6 | 350.4 | 397.5 | 385.2 | 480.0 | 480.0 | 459.6 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 | 480.0 |
| | V14B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V15A | 907.2 | 913.9 | 911.7 | 914.2 | 913.9 | 938.0 | 938.2 | 936.4 | 938.7 | 938.2 | 940.7 | 944.9 | 942.1 | 947.2 | 944.9 | 957.8 | 960.5 | 957.1 | 962.7 | 960.5 | 990.1 | 990.8 | 986.6 | 992.8 | 990.8 |
| | V15B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V16 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V17 | 115.0 | 115.0 | 115.0 | 115.0 | 115.0 | 115.0 | 115.3 | 115.2 | 115.3 | 115.3 | 115.0 | 115.4 | 115.4 | 115.4 | 115.4 | 117.9 | 118.6 | 118.3 | 118.8 | 118.6 | 127.8 | 126.4 | 126.4 | 126.3 | 126.4 |
| | V18 | 870.2 | 895.4 | 894.9 | 895.6 | 895.4 | 960.1 | 987.1 | 986.0 | 987.7 | 987.1 | 986.8 | 1013.5 | 1012.5 | 1013.7 | 1013.5 | 1110.9 | 1121.9 | 1117.4 | 1125.2 | 1121.9 | 1238.5 | 1259.0 | 1253.8 | 1261.8 | 1259.0 |
| | V19A | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V19B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V20 | 339.5 | 325.8 | 325.3 | 326.0 | 325.8 | 360.4 | 346.3 | 345.4 | 346.8 | 346.3 | 356.8 | 347.0 | 345.5 | 347.6 | 347.0 | 384.2 | 366.0 | 362.3 | 368.8 | 366.0 | 438.0 | 428.7 | 424.5 | 430.9 | 428.7 |
| | V21A | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V21B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V21C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Key:
Alt = Alternative NA = No Action TAF = thousand acre-feet

**Table 21. Total Irrigated Acreage (thousand Acres) by SWAP Region**

| SWAP Region | | Wet Years | | | | | Above Normal | | | | | Below Normal | | | | | Dry | | | | | Critical | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 2 | Alt 3 | Alt 5 | Existing (2010) | Alt 1/ NA | Alt 3 | Alt 3 | Alt 5 |
| Sacramento River | V01 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V02 | 159.1 | 160.9 | 160.9 | 160.9 | 160.9 | 159.1 | 160.9 | 160.9 | 160.9 | 160.9 | 159.1 | 160.9 | 160.9 | 160.9 | 160.9 | 159.2 | 160.9 | 160.9 | 160.9 | 160.9 | 159.2 | 160.9 | 160.9 | 160.9 | 160.9 |
| | V03A | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.2 | 275.3 | 275.2 | 275.2 | 275.3 | 275.2 |
| | V03B | 90.9 | 91.0 | 91.0 | 91.0 | 91.0 | 90.9 | 91.0 | 91.0 | 91.0 | 91.0 | 87.1 | 84.4 | 87.5 | 82.9 | 84.4 | 72.6 | 67.0 | 72.3 | 63.9 | 67.0 | 51.8 | 37.4 | 47.1 | 33.3 | 37.4 |
| | V04 | 259.8 | 259.4 | 259.4 | 259.4 | 259.4 | 260.5 | 259.4 | 259.4 | 259.4 | 259.4 | 260.5 | 262.1 | 262.1 | 262.1 | 262.1 | 260.5 | 262.8 | 262.8 | 262.8 | 262.8 | 260.6 | 259.3 | 259.3 | 259.3 | 259.3 |
| | V05 | 365.3 | 363.5 | 363.5 | 363.5 | 363.5 | 365.3 | 363.5 | 363.5 | 363.5 | 363.5 | 365.3 | 363.5 | 363.5 | 363.5 | 363.5 | 365.3 | 363.5 | 363.5 | 363.5 | 363.5 | 365.4 | 363.5 | 363.5 | 363.5 | 363.5 |
| | V06 | 235.5 | 238.5 | 238.5 | 238.5 | 238.5 | 235.5 | 238.5 | 238.5 | 238.5 | 238.5 | 235.5 | 238.5 | 238.5 | 238.5 | 238.5 | 235.6 | 238.5 | 238.5 | 238.5 | 238.5 | 235.7 | 238.6 | 238.6 | 238.6 | 238.6 |
| | V07 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| San Joaquin River | V08 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V09 | 401.1 | 406.0 | 406.1 | 406.0 | 406.0 | 400.5 | 405.3 | 405.4 | 405.2 | 405.3 | 400.1 | 404.9 | 404.9 | 404.8 | 404.9 | 400.1 | 404.9 | 404.8 | 404.9 | 404.9 | 400.1 | 404.9 | 404.9 | 404.9 | 404.9 |
| | V10 | 431.5 | 426.0 | 426.0 | 426.0 | 426.0 | 431.6 | 426.0 | 426.0 | 426.0 | 426.0 | 431.7 | 426.1 | 426.0 | 426.1 | 426.1 | 432.1 | 426.2 | 426.1 | 426.2 | 426.2 | 430.1 | 426.3 | 426.2 | 426.3 | 426.3 |
| | V11 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V12 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V13 | 569.3 | 573.1 | 573.1 | 573.1 | 573.1 | 569.4 | 573.1 | 573.1 | 573.1 | 573.1 | 569.5 | 573.2 | 573.1 | 573.2 | 573.2 | 569.7 | 573.2 | 573.2 | 573.2 | 573.2 | 569.9 | 573.1 | 573.1 | 573.1 | 573.1 |
| Tulare Lake | V14A | 485.7 | 479.5 | 479.5 | 479.5 | 479.5 | 485.7 | 479.6 | 479.6 | 479.6 | 479.6 | 466.3 | 473.0 | 479.6 | 466.4 | 473.0 | 428.9 | 426.4 | 455.0 | 408.4 | 426.3 | 339.9 | 326.7 | 360.9 | 303.9 | 326.6 |
| | V14B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V15A | 629.8 | 634.3 | 634.3 | 634.3 | 634.3 | 629.8 | 634.3 | 634.3 | 634.3 | 634.3 | 629.8 | 634.3 | 634.3 | 634.3 | 634.3 | 629.8 | 634.3 | 634.3 | 634.3 | 634.3 | 629.8 | 634.4 | 634.4 | 634.4 | 634.4 |
| | V15B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V16 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V17 | 263.1 | 264.3 | 264.3 | 264.3 | 264.3 | 263.1 | 264.3 | 264.3 | 264.3 | 264.3 | 263.2 | 264.3 | 264.3 | 264.3 | 264.3 | 263.2 | 264.3 | 264.3 | 264.3 | 264.3 | 263.3 | 264.7 | 264.7 | 264.7 | 264.7 |
| | V18 | 720.2 | 726.0 | 726.0 | 726.0 | 726.0 | 720.2 | 726.0 | 726.0 | 726.0 | 726.0 | 720.1 | 725.8 | 726.0 | 725.8 | 725.8 | 720.1 | 725.8 | 725.8 | 725.8 | 725.8 | 720.1 | 725.8 | 725.8 | 725.8 | 725.8 |
| | V19A | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V19B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V20 | 208.9 | 211.0 | 211.0 | 211.0 | 211.0 | 208.9 | 211.1 | 211.1 | 211.1 | 211.1 | 208.9 | 211.1 | 211.1 | 211.1 | 211.1 | 208.9 | 211.1 | 211.1 | 211.1 | 211.1 | 208.9 | 211.0 | 211.1 | 211.0 | 211.0 |
| | V21A | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V21B | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | V21C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Key:
Alt = Alternative NA = No Action

### Diesel Exhaust Emission Factors

**Table 22. Emission Factors for Uncontrolled Diesel Industrial Engines**

| Pollutant | Emission Factor (lb/hp-hr) (power output) | Emission Factor (lb/MMBtu) (fuel input) |
|---|---|---|
| NOx | 0.031 | 4.41 |
| CO | 6.68E-03 | 0.95 |
| SOx | 2.05E-03 | 0.29 |
| PM10 | 2.20E-03 | 0.31 |
| CO2 | 1.15 | 164 |
| Aldehydes | 4.63E-04 | 0.07 |
| TOC | | |
| Exhaust | 2.47E-03 | 0.35 |
| Evaporative | 0.00 | 0.00 |
| Crankcase | 4.41E-05 | 0.01 |
| Refueling | 0.00 | 0.00 |

*Source: EPA. 1996. Compilation of Air Pollutant Emission Factors (AP-42), Fifth Edition, Volume I, Section 3.3: Gasoline and Diesel Industrial Engines, Table 3.3-1. October. Available online at: http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s03.pdf [Accessed on November 2, 2014].*

*Key:*

CO = carbon monoxide
CO2 = carbon dioxide
lb/hp-hr = pounds per horsepower-hour
lb/MMBtu = pounds per million British Thermal Units
NOx = nitrogen oxides
SOx = sulfur oxides
TOC = total organic compounds

**Table 23. Emission Standards Noncertified Greater than 50 BHP In-Use Stationary Diesel-Fueled Engines Used in Agricultural Operations**

| Horsepower Range | Application | Compliance On or After December 31 | Diesel PM Not to Exceed (g/bp-hr) | HC, NOx, NMHC+NOx, and CO Not to Exceed (g/bhp-hr) |
|---|---|---|---|---|
| Greater Than 50 But Less Than 75 | Generator Sets | 2015 | 0.02 | Off-Road CI Engine Certification Standards for an off-road engine of the model year and maximum rated power of the engine installed to meet the applicable PM standard.[1] |
| | All Other Applications | 2011 | 0.30 | |
| Greater Than or Equal to 75 But Less Than 100 | Generator Sets | 2015 | 0.01 | |
| | All Other Applications | 2011 | 0.30 | |
| Greater Than or Equal to 100 But Less Than 175 | Generator Sets | 2015 | 0.01 | |
| | All Other Applications | 2010 | 0.22 | |
| Greater Than or Equal to 175 But Less Than or Equal to 750 | All Applications | 2010 | 0.15 | |
| Greater Than 750 | All Applications | 2014 | 0.075 | |

Note:
[1]If no limits have been established for an off-road engine of the same model year and maximum rated power, then the in-use stationary diesel-fueled engine used in an agricultural operation shall not exceed Tier 1 standards in title 13, California Code of Regulations, section 2423 for an off-road engine of the same maximum rated power irrespective of model year.

Key:

BHP = brake-horsepower
CI = compression ignition
CO = carbon monoxide
g/bhp-hr = grams per brake-horsepower hour
HC = hydrocarbons
NOx = nitrogen oxides
PM = particulate matter

**Table 24. Tier 1, Tier 2, and Tier 3 Exhaust Emission Standards**

| Maximum Rated Power | Tier | Model Year | (g/kW-hr) NOx | HC | NMHC+NOx | CO | PM | (g/hp-hr) NOx | HC | NMHC+NOx | CO | PM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kW<8 | T1 | 2000-2004 | - | - | 10.5 | 8.0 | 1 | - | - | 7.8 | 6.0 | 0.75 |
| *hp <11* | T2 | 2005 -2007 | - | - | 7.5 | 8.0 | 0.8 | - | - | 5.6 | 6.0 | 0.60 |
| 8≤kW<19 | T1 | 2000-2004 | - | - | 9.5 | 6.6 | 0.8 | - | - | 7.1 | 4.9 | 0.60 |
| *11<=hp<25* | T2 | 2005 -2007 | - | - | 7.5 | 6.6 | 0.8 | - | - | 5.6 | 4.9 | 0.60 |
| 19≤kW<37 | T1 | 2000-2003 | - | - | 9.5 | 5.5 | 0.8 | - | - | 7.1 | 4.1 | 0.60 |
| *25<=hp<50* | T2 | 2004 -2007 | - | - | 7.5 | 5.5 | 0.6 | - | - | 5.6 | 4.1 | 0.45 |
| 37≤kW<56 | T1 | 2000-2003 | 9.2 | - | - | - | - | 6.9 | - | - | - | - |
| *50<=hp<75* | T2 | 2004-2007 | - | - | 7.5 | 5.0 | 0.4 | - | - | 5.6 | 3.7 | 0.30 |
| | T3 | 2008 -2011 | - | - | 4.7 | 5.0 | 0.4 | - | - | 3.5 | 3.7 | 0.30 |
| 56≤kW<75 | T1 | 2000-2003 | 9.2 | - | - | - | - | 6.9 | - | - | - | - |
| *75<=hp<100* | T2 | 2004-2007 | - | - | 7.5 | 5.0 | 0.4 | - | - | 5.6 | 3.7 | 0.30 |
| | T3 | 2008-2011 | - | - | 4.7 | 5.0 | 0.4 | - | - | 3.5 | 3.7 | 0.30 |
| 75≤kW<130 | T1 | 2000-2002 | 9.2 | - | - | - | - | 6.9 | - | - | - | - |
| *100<=hp<175* | T2 | 2003-2006 | - | - | 6.6 | 5.0 | 0.3 | - | - | 4.9 | 3.7 | 0.22 |
| | T3 | 2007 -2011 | - | - | 4.0 | 5.0 | 0.3 | - | - | 3.0 | 3.7 | 0.22 |
| 130≤kW<225 | T1 | 1996-2002 | 9.2 | 1.3 | - | 11.4 | 0.54 | 6.9 | 1.0 | - | 8.5 | 0.40 |
| *175<=hp<300* | T2 | 2003-2005 | - | - | 6.6 | 3.5 | 0.2 | - | - | 4.9 | 2.6 | 0.15 |
| | T3 | 2006 -2010 | - | - | 4.0 | 3.5 | 0.2 | - | - | 3.0 | 2.6 | 0.15 |
| 225≤kW<450 | T1 | 1996-2000 | 9.2 | 1.3 | - | 11.4 | 0.54 | 6.9 | 1.0 | - | 8.5 | 0.40 |
| *300<=hp<600* | T2 | 2001-2005 | - | - | 6.4 | 3.5 | 0.2 | - | - | 4.8 | 2.6 | 0.15 |
| | T3 | 2006 -2010 | - | - | 4.0 | 3.5 | 0.2 | - | - | 3.0 | 2.6 | 0.15 |
| 450≤kW≤560 | T1 | 1996-2001 | 9.2 | 1.3 | - | 11.4 | 0.54 | 6.9 | 1.0 | - | 8.5 | 0.40 |
| *600<=hp<750* | T2 | 2002-2005 | - | - | 6.4 | 3.5 | 0.2 | - | - | 4.8 | 2.6 | 0.15 |
| | T3 | 2006 -2010 | - | - | 4.0 | 3.5 | 0.2 | - | - | 3.0 | 2.6 | 0.15 |
| kW>560 | T1 | 2000-2005 | 9.2 | 1.3 | - | 11.4 | 0.54 | 6.9 | 1.0 | - | 8.5 | 0.40 |
| *hp>750* | T2 | 2006 -2010 | - | - | 6.4 | 3.5 | 0.2 | - | - | 4.8 | 2.6 | 0.15 |

*Source: Title 13, California Code of Regulations, Division 3, Chapter 9, Article 4, Section 2423, "Off-Road Compression-Ignition Engines and Equipment."*

*Key:*

CO = carbon monoxide
g/hp-hr = grams per horsepower-hour
g/kW-hr = grams per kilowatt-hour
HC = hydrocarbons
hp = horsepower
kW = kilowatts
NOx = nitrogen oxides
PM = particulate matter
T1 = Tier 1
T2 = Tier 2
T3 = Tier 3

Nitrogen oxides (NOx) and Non-Methane hydrocarbon (NMHC) fraction - Table B-26

| | |
|---|---|
| NOx | 95% |
| NMHC | 5% |

http://www.arb.ca.gov/msprog/moyer/guidelines/cmp_guidelines_part4.pdf

PM Size Fractions

| | |
|---|---|
| PM10 | 0.976 |
| PM2.5 | 0.967 |
| Ratio | 0.99 |

CARB PMSIZE Profile No. 114 (STAT. I.C. ENGINE-DIST/DIESEL)

Conversion

| | | |
|---|---|---|
| 1 kilowatt = | 1.34 | horsepower |

**Agricultural Land Preparation**

**Table 25. Summary of Crop Profile, Acre-Pass, and Emission Factor**

| Crop profile | Land Preparation Operations | Category | Acre-Pass | Emission Factor | |
|---|---|---|---|---|---|
| | | | | Operation (lbs PM10/Acre-pass) | Crop (lbs PM10/Acre/year) |
| Alfalfa | Unspecified | Discing | 1.25 | 1.2 | 4 |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| Almonds | Float | Land Planing | 0.25 | 12.5 | 3.13 |
| Citrus | Unspecified | Discing | 0.06 | 1.2 | 0.07 |
| Corn | List & Fertilize | Weeding | 1 | 0.8 | 6.9 |
| | Mulch Beds | Discing | 1 | 1.2 | |
| | Finish Disc | Discing | 1 | 1.2 | |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| | Stubble Disc | Discing | 1 | 1.2 | |
| Cotton | Land Preparation | Discing | 4 | 1.2 | 8.9 |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| | Seed Bed Preparation | Weeding | 2 | 0.8 | |
| DryBeans | Land Maintenance | Land Planing | 0.2 | 12.5 | 7.7 |
| | Chisel | Discing | 1 | 1.2 | |
| | Shaping | Weeding | 1 | 0.8 | |
| | Disc | Discing | 2 | 1.2 | |
| | Listing | Weeding | 1 | 0.8 | |
| Garbanzo | Chisel | Discing | 1 | 1.2 | 7.7 |
| | Listing | Weeding | 1 | 0.8 | |
| | Shaping | Weeding | 1 | 0.8 | |
| | Disc | Discing | 2 | 1.2 | |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| Garlic | Land Maintenance | Land Planing | 0.2 | 12.5 | 6.5 |
| | Disc & Roll | Discing | 1 | 1.2 | |
| | Chisel | Discing | 1 | 1.2 | |
| | List | Weeding | 1 | 0.8 | |
| | Shape Beds | Weeding | 1 | 0.8 | |
| Grapes-Raisin | Terrace | Weeding | 1 | 0.8 | 2.6 |
| | Spring Tooth | Weeding | 0.2 | 0.8 | |
| | Subsoil | Ripping | 0.05 | 4.6 | |
| | Disc & Furrow-out | Discing | 1 | 1.2 | |
| | Level (new vineyard) | Land Planing | 0.02 | 12.5 | |
| Grapes-Table | Subsoil | Ripping | 0.05 | 4.6 | 0.83 |
| | Disc & Furrow-out | Discing | 0.5 | 1.2 | |
| Grapes-Wine | Level (new vineyard) | Land Planing | 0.02 | 12.5 | 1.5 |
| | Spring Tooth | Weeding | 0.2 | 0.8 | |
| | Subsoil | Ripping | 0.05 | 4.6 | |
| | Disc & Furrow-out | Discing | 0.75 | 1.2 | |

| Crop profile | Land Preparation Operations | Category | Acre-Pass | Emission Factor | |
|---|---|---|---|---|---|
| | | | | Operation (lbs PM10/Acre-pass) | Crop (lbs PM10/Acre/year) |
| Lettuce* | Land Maintenance | Land Planing | 0.2 | 12.5 | 12.75 |
| | Disc & Roll | Discing | 2/2 | 1.2 | |
| | Chisel | Discing | 2/2 | 1.2 | |
| | List | Weeding | 2/2 | 0.8 | |
| | Plane | Land Planing | ½ | 12.5 | |
| | Shape Beds & Roll | Weeding | 2/2 | 0.8 | |
| Melon | Plow | Discing | 1 | 1.2 | 5.7 |
| | Shape Beds | Weeding | 1 | 0.8 | |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| | Disc | Discing | 1 | 1.2 | |
| No Land Prep. | Unspecified | Discing | 0 | 1.2 | 0 |
| Onions | List | Weeding | 1 | 0.8 | 6.5 |
| | Shape Beds | Weeding | 1 | 0.8 | |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| | Chisel | Discing | 1 | 1.2 | |
| | Disc & Roll | Discing | 1 | 1.2 | |
| Rice | Chisel | Discing | 1 | 1.2 | 20 |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| | Post Burn/Harvest Disc | Discing | 0.5 | 1.2 | |
| | Roll | Weeding | 1 | 0.8 | |
| | 3 Wheel Plane | Land Planing | 1 | 12.5 | |
| | Harrow Disc | Discing | 1 | 1.2 | |
| | Stubble Disc | Discing | 1 | 1.2 | |
| Safflower | List | Weeding | 1 | 0.8 | 4.5 |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| | Stubble Disc | Discing | 1 | 1.2 | |
| Sugar Beets | Disc | Discing | 1 | 1.2 | 22.8 |
| | Land Plane | Land Planing | 1 | 12.5 | |
| | Subsoil-deep chisel | Ripping | 1 | 4.6 | |
| | Stubble Disc | Discing | 1 | 1.2 | |
| | List | Weeding | 1 | 0.8 | |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| Tomatoes | Bed Preparation | Weeding | 2 | 0.8 | 10.1 |
| | Land Preparation | Discing | 5 | 1.2 | |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |
| Vegetables | Land Maintenance | Land Planing | 0.2 | 12.5 | 8.5 |
| | Unspecified | Discing | 5 | 1.2 | |
| Wheat | Stubble Disc | Discing | 1 | 1.2 | 3.7 |
| | Land Maintenance | Land Planing | 0.2 | 12.5 | |

*Source:*

*CARB. 2003. Emission Inventory Documentation, Section 7.4: Agricultural Land Preparation. January. Accessed on: May 5, 2012. Available at: http://www.arb.ca.gov/ei/areasrc/arbmiscprocresfarmop.htm*

Key:

lbs = pounds PM10 = inhalable particulate matter

**Agricultural Harvest Operations**

**Table 26. Summary of Crop Emission Factor Assumptions**

| CDFA Crop Code | CDFA Crop Description | Crop Profile | Assumption | Emission Factor (lbs PM10/acre/yr) |
|---|---|---|---|---|
| 101999 | WHEAT ALL | Wheat | Wheat/1 | 5.8 |
| 104999 | RYE FOR GRAIN | Wheat | Wheat/1 | 5.8 |
| 106199 | RICE, FOR MILLING | Rice | Cotton/2 | 1.68 |
| 106269 | FIELD CROP BY PRODUCTS | Cotton | Cotton/20 | 0.17 |
| 108999 | FOOD GRAINS, MISC | Corn | Cotton/2 | 1.68 |
| 111559 | CORN, WHITE | Corn | Cotton/40 | 0.08 |
| 111991 | CORN FOR GRAIN | Corn | Cotton/2 | 1.68 |
| 111992 | CORN FOR SILAGE | Corn | Cotton/20 | 0.17 |
| 112999 | OATS FOR GRAIN | Wheat | Wheat/1 | 5.8 |
| 113994 | BARLEY, MALTING | Wheat | Wheat/1 | 5.8 |
| 113995 | BARLEY, FEED | Wheat | Wheat/1 | 5.8 |
| 113999 | BARLEY, UNSPECIFIED | Wheat | Wheat/1 | 5.8 |
| 114991 | SORGHUM, GRAIN | Wheat | Wheat/1 | 5.8 |
| 121219 | COTTON LINT, UPLAND | Cotton | Cotton/1 | 3.37 |
| 121229 | COTTON LINT, PIMA | Cotton | Cotton/1 | 3.37 |
| 121299 | COTTON LINT, UNSPEC | Cotton | Cotton/1 | 3.37 |
| 132999 | SUGAR BEETS | Sugar Beets | Cotton/2 | 1.68 |
| 151999 | COTTONSEED | Cotton | Cotton/1 | 3.37 |
| 153999 | PEANUTS, ALL | Safflower | Cotton/2 | 1.68 |
| 158269 | SAFFLOWER | Safflower | Wheat/1 | 5.8 |
| 158316 | SUNFLOWER SEED, PLANTING | Corn | Wheat/1 | 5.8 |
| 158319 | SUNFLOWER SEED | Corn | Wheat/1 | 5.8 |
| 158499 | JOJOBA | Melon | Cotton/40 | 0.08 |
| 161131 | BEANS, LIMAS, LG. DRY | Dry Beans | Cotton/2 | 1.68 |
| 161132 | BEANS, LIMAS, BABY DRY | Dry Beans | Cotton/2 | 1.68 |
| 161199 | LIMA BEANS, UNSPECIFIED | Dry Beans | Cotton/2 | 1.68 |
| 161717 | BEANS, RED KIDNEY | Dry Beans | Cotton/2 | 1.68 |
| 161721 | BEANS, PINK | Dry Beans | Cotton/2 | 1.68 |
| 161741 | BEANS, BLACKEYE (PEAS) | Dry Beans | Cotton/2 | 1.68 |
| 161742 | BEANS, GARBANZO | Garbanzo | Cotton/2 | 1.68 |
| 162399 | BEANS, FAVA | Dry Beans | Cotton/2 | 1.68 |
| 163999 | PEAS, DRY EDIBLE | Dry Beans | Cotton/20 | 0.17 |
| 169999 | BEANS, UNSPEC. DRY EDIBLE | Dry Beans | Cotton/2 | 1.68 |
| 171019 | SEED WHEAT | Wheat | Wheat/1 | 5.8 |
| 171049 | SEED RYE | Wheat | Wheat/1 | 5.8 |
| 171069 | SEED RICE | Rice | Cotton/2 | 1.68 |
| 171129 | SEED OATS | Wheat | Wheat/1 | 5.8 |
| 171139 | SEED BARLEY | Wheat | Wheat/1 | 5.8 |
| 171519 | SEED, COTTON FOR PLANTING | Cotton | Cotton/1 | 3.37 |
| 171582 | SEED, SAFFLOWER, PLANTING | Safflower | Wheat/1 | 5.8 |
| 171619 | SEED BEANS | Dry Beans | Cotton/2 | 1.68 |

| CDFA Crop Code | CDFA Crop Description | Crop Profile | Assumption | Emission Factor (lbs PM10/acre/yr) |
|---|---|---|---|---|
| 171639 | SEED PEAS | Dry Beans | Cotton/20 | 0.17 |
| 171949 | SEED, MISC FIELD CROP | Corn | Cotton/20 | 0.17 |
| 171959 | SEED, VEG & VINE CROP | Vegetables | Cotton/20 | 0.17 |
| 172119 | SEED, ALFALFA | Alfalfa | Zero/1 | 0 |
| 172289 | CLOVER, UNSPECIFIED SEED | Alfalfa | Zero/1 | 0 |
| 173079 | SEED, BERMUDA GRASS | Alfalfa | Zero/1 | 0 |
| 173669 | SEED, SUDAN GRASS | Alfalfa | Zero/1 | 0 |
| 173999 | SEED, GRASS, UNSPECIFIED | Alfalfa | Zero/1 | 0 |
| 178999 | SEED, OTHER (NO FLOWERS) | Alfalfa | Cotton/20 | 0.17 |
| 181999 | HAY, ALFALFA | Alfalfa | Zero/1 | 0 |
| 188499 | HAY, GRAIN | Alfalfa | Cotton/2 | 1.68 |
| 188799 | HAY, WILD | Alfalfa | Cotton/2 | 1.68 |
| 188899 | HAY, SUDAN | Alfalfa | Zero/1 | 0 |
| 188999 | HAY, OTHER UNSPECIFIED | Alfalfa | Cotton/2 | 1.68 |
| 194599 | PASTURE, IRRIGATED | No Land | Zero/1 | 0 |
| 194699 | PASTURE, RANGE | No Land | Zero/1 | 0 |
| 194799 | PASTURE, MISC. FORAGE | No Land | Zero/1 | 0 |
| 195199 | SILAGE | Wheat | Cotton/20 | 0.17 |
| 195299 | HAY, GREEN CHOP | Alfalfa | Zero/1 | 0 |
| 195399 | STRAW | Alfalfa | Wheat/1 | 5.8 |
| 198199 | RICE, WILD | Rice | Cotton/2 | 1.68 |
| 198999 | FIELD CROPS, UNSPEC. | Corn | Cotton/20 | 0.17 |
| 201119 | ORANGES, NAVEL | Citrus | Cotton/40 | 0.08 |
| 201519 | ORANGES, VALENCIAS | Citrus | Cotton/40 | 0.08 |
| 201999 | ORANGES, UNSPECIFIED | Citrus | Cotton/40 | 0.08 |
| 202999 | GRAPEFRUIT, ALL | Citrus | Cotton/40 | 0.08 |
| 203999 | TANGERINES & MANDARINS | Citrus | Cotton/40 | 0.08 |
| 204999 | LEMONS, ALL | Citrus | Cotton/40 | 0.08 |
| 205999 | LIMES, ALL | Citrus | Cotton/40 | 0.08 |
| 206999 | TANGELOS | Citrus | Cotton/40 | 0.08 |
| 207999 | KUMQUATS | Citrus | Cotton/40 | 0.08 |
| 208059 | CITRUS, MISC BY-PROD | Citrus | Cotton/40 | 0.08 |
| 209999 | CITRUS, UNSPECIFIED | Citrus | Cotton/40 | 0.08 |
| 211999 | APPLES, ALL | Citrus | Cotton/40 | 0.08 |
| 212199 | PEACHES, FREESTONE | Citrus | Cotton/40 | 0.08 |
| 212399 | PEACHES, CLINGSTONE | Citrus | Cotton/40 | 0.08 |
| 212999 | PEACHES, UNSPECIFIED | Citrus | Cotton/40 | 0.08 |
| 213199 | CHERRIES, SWEET | Citrus | Cotton/40 | 0.08 |
| 214199 | PEARS, BARLETT | Citrus | Cotton/40 | 0.08 |
| 214899 | PEARS, ASIAN | Citrus | Cotton/40 | 0.08 |
| 214999 | PEARS, UNSPECIFIED | Citrus | Cotton/40 | 0.08 |
| 215199 | PLUMS | Citrus | Cotton/40 | 0.08 |
| 215399 | PLUMCOTS | Citrus | Cotton/40 | 0.08 |
| 215999 | PRUNES, DRIED | Citrus | Cotton/40 | 0.08 |

| CDFA Crop Code | CDFA Crop Description | Crop Profile | Assumption | Emission Factor (lbs PM10/acre/yr) |
|---|---|---|---|---|
| 216199 | GRAPES, TABLE | Grapes-Table | Cotton/20 | 0.17 |
| 216299 | GRAPES, WINE | Grapes-Wine | Cotton/20 | 0.17 |
| 216399 | GRAPES, RAISIN | Grapes-Raisin | Cotton/20 | 0.17 |
| 216999 | GRAPES, UNSPECIFIED | Grapes-Wine | Cotton/20 | 0.17 |
| 217999 | APRICOTS, ALL | Citrus | Cotton/40 | 0.08 |
| 218199 | NECTARINES | Citrus | Cotton/40 | 0.08 |
| 218299 | PERSIMMONS | Citrus | Cotton/40 | 0.08 |
| 218399 | POMEGRANATES | Citrus | Cotton/40 | 0.08 |
| 218499 | QUINCE | Citrus | Cotton/40 | 0.08 |
| 218839 | CHERIMOYAS | Citrus | Cotton/40 | 0.08 |
| 218889 | ORCHARD BIOMASS | Almonds | Cotton/40 | 0.08 |
| 218899 | FRUITS & NUTS, UNSPEC. | Citrus | Cotton/40 | 0.08 |
| 221999 | AVOCADOS, ALL | Citrus | Cotton/40 | 0.08 |
| 224999 | DATES | Citrus | Almonds/20 | 2.04 |
| 225999 | FIGS, DRIED | Citrus | Almonds/20 | 2.04 |
| 226999 | OLIVES | Citrus | Cotton/40 | 0.08 |
| 228019 | GUAVAS | Citrus | Cotton/40 | 0.08 |
| 229999 | KIWIFRUIT | Citrus | Cotton/40 | 0.08 |
| 230639 | BERRIES, BLACKBERRIES | Grapes-Table | Cotton/40 | 0.08 |
| 230869 | BERRIES, BOYSENBERRIES | Grapes-Table | Cotton/40 | 0.08 |
| 234799 | BERRIES, LOGANBERRIES | Grapes-Table | Cotton/40 | 0.08 |
| 236199 | BERRIES, RASPBERRIES | Grapes-Table | Cotton/40 | 0.08 |
| 237199 | STRAWBERRIES, FRESH MKT | Melon | Cotton/40 | 0.08 |
| 237299 | STRAWBERRIES, PROC | Melon | Cotton/40 | 0.08 |
| 237999 | STRAWBERRIES, UNSPECIFIED | Melon | Cotton/40 | 0.08 |
| 239999 | BERRIES, BUSH, UNSPECIFIED | Grapes-Table | Cotton/40 | 0.08 |
| 261999 | ALMONDS, ALL | Almonds | Almonds/1 | 40.77 |
| 263999 | WALNUTS, ENGLISH | Almonds | Almonds/1 | 40.77 |
| 264999 | PECANS | Almonds | Almonds/10 | 4.08 |
| 265999 | WALNUTS, BLACK | Almonds | Almonds/1 | 40.77 |
| 266999 | CHESTNUTS | Almonds | Almonds/10 | 4.08 |
| 267999 | MACADAMIA NUT | Almonds | Almonds/10 | 4.08 |
| 268079 | PISTACHIOS | Almonds | Almonds/10 | 4.08 |
| 268099 | ALMOND HULLS | Almonds | Almonds/1 | 40.77 |
| 301999 | ARTICHOKES | Melon | Cotton/40 | 0.08 |
| 302199 | ASPARAGUS, FRESH MKT | Melon | Cotton/2 | 1.68 |
| 302299 | ASPARAGUS, PROC | Melon | Cotton/2 | 1.68 |
| 302999 | ASPARAGUS, UNSPECIFIED | Melon | Cotton/2 | 1.68 |
| 303999 | BEANS, GREEN LIMAS | Dry Beans | Cotton/2 | 1.68 |
| 304199 | BEANS, SNAP FR MKT | Dry Beans | Cotton/20 | 0.17 |
| 304299 | BEANS, SNAP PROC | Dry Beans | Cotton/20 | 0.17 |
| 304399 | BEANS FRESH UNSPECIFIED | Dry Beans | Cotton/20 | 0.17 |
| 304999 | BEANS, UNSPECIFIED SNAP | Dry Beans | Cotton/20 | 0.17 |
| 305999 | BEETS, GARDEN | Sugar Beets | Cotton/2 | 1.68 |

| CDFA Crop Code | CDFA Crop Description | Crop Profile | Assumption | Emission Factor (lbs PM10/acre/yr) |
|---|---|---|---|---|
| 306999 | RAPINI | Sugar Beets | Cotton/40 | 0.08 |
| 307189 | BROCCOLI, FOOD SERV | Vegetables | Cotton/40 | 0.08 |
| 307199 | BROCCOLI, FR MKT | Vegetables | Cotton/40 | 0.08 |
| 307299 | BROCCOLI, PROC | Vegetables | Cotton/40 | 0.08 |
| 307919 | BROCCOLI, UNSPECIFIED | Vegetables | Cotton/40 | 0.08 |
| 308999 | BRUSSELS SPROUTS | Melon | Cotton/40 | 0.08 |
| 309999 | CABBAGE, CH. & SPECIALTY | Lettuce | Cotton/40 | 0.08 |
| 310999 | CABBAGE, HEAD | Lettuce | Cotton/40 | 0.08 |
| 313189 | CARROTS, FOOD SERV | Sugar Beets | Cotton/20 | 0.17 |
| 313199 | CARROTS, FR MKT | Sugar Beets | Cotton/20 | 0.17 |
| 313299 | CARROTS, PROC | Sugar Beets | Cotton/20 | 0.17 |
| 313999 | CARROTS, UNSPECIFIED | Sugar Beets | Cotton/20 | 0.17 |
| 314189 | CAULIFLOWER, FOOD SERV | Vegetables | Cotton/40 | 0.08 |
| 314199 | CAULIFLOWER, FR MKT | Vegetables | Cotton/40 | 0.08 |
| 314299 | CAULIFLOWER, PROC | Vegetables | Cotton/40 | 0.08 |
| 314999 | CAULIFLOWER, UNSPECIFIED | Vegetables | Cotton/40 | 0.08 |
| 316189 | CELERY, FOOD SERV | Lettuce | Cotton/40 | 0.08 |
| 316199 | CELERY, FR MKT | Lettuce | Cotton/40 | 0.08 |
| 316299 | CELERY, PROC | Lettuce | Cotton/40 | 0.08 |
| 316999 | CELERY, UNSPECIFIED | Lettuce | Cotton/40 | 0.08 |
| 318999 | RADICCHIO | Lettuce | Cotton/40 | 0.08 |
| 320999 | CHIVES | Lettuce | Cotton/40 | 0.08 |
| 322999 | COLLARD GREENS | Lettuce | Cotton/40 | 0.08 |
| 323999 | CORN, SWEET ALL | Corn | Cotton/40 | 0.08 |
| 325999 | CUCUMBERS | Vegetables | Cotton/40 | 0.08 |
| 330999 | EGGPLANT, ALL | Vegetables | Cotton/40 | 0.08 |
| 331999 | ENDIVE, ALL | Lettuce | Cotton/40 | 0.08 |
| 332999 | ESCAROLE, ALL | Lettuce | Cotton/40 | 0.08 |
| 333999 | ANISE (FENNEL) | Lettuce | Cotton/2 | 1.68 |
| 335999 | GARLIC, ALL | Garlic | Cotton/2 | 1.68 |
| 337999 | KALE | Lettuce | Cotton/40 | 0.08 |
| 338999 | KOHLRABI | Lettuce | Cotton/40 | 0.08 |
| 339196 | LETTUCE, BULK SALAD PRODS. | Lettuce | Cotton/40 | 0.08 |
| 339999 | LETTUCE, UNSPECIFIED | Lettuce | Cotton/40 | 0.08 |
| 340999 | LETTUCE, HEAD | Lettuce | Cotton/40 | 0.08 |
| 341999 | LETTUCE, ROMAINE | Lettuce | Cotton/40 | 0.08 |
| 342999 | LETTUCE, LEAF | Lettuce | Cotton/40 | 0.08 |
| 343999 | MELON, CANTALOUPE | Melon | Cotton/40 | 0.08 |
| 348999 | MELON, HONEYDEW | Melon | Cotton/40 | 0.08 |
| 354299 | MELON, UNSPECIFIED | Melon | Cotton/40 | 0.08 |
| 354999 | MELON, WATER MELONS | Melon | Cotton/40 | 0.08 |
| 355999 | MUSHROOMS | No Land Prep. | Zero/1 | 0 |
| 356999 | MUSTARD | Lettuce | Cotton/40 | 0.08 |
| 357999 | OKRA | Lettuce | Cotton/40 | 0.08 |

| CDFA Crop Code | CDFA Crop Description | Crop Profile | Assumption | Emission Factor (lbs PM10/acre/yr) |
|---|---|---|---|---|
| 358999 | ONIONS | Onions | Cotton/2 | 1.68 |
| 359999 | PARSLEY | Lettuce | Cotton/40 | 0.08 |
| 361299 | PEAS, GREEN, PROCESSING | Dry Beans | Cotton/20 | 0.17 |
| 361999 | PEAS, GREEN, UNSPECIFIED | Dry Beans | Cotton/20 | 0.17 |
| 363999 | PEPPERS, BELL | Tomatoes | Cotton/40 | 0.08 |
| 364999 | PEPPERS, CHILI, HOT | Tomatoes | Cotton/40 | 0.08 |
| 366999 | PUMPKINS | Melon | Cotton/20 | 0.17 |
| 367999 | RADISHES | Sugar Beets | Cotton/40 | 0.08 |
| 368999 | RHUBARB | Lettuce | Cotton/40 | 0.08 |
| 370999 | RUTABAGAS | Sugar Beets | Cotton/2 | 1.68 |
| 372999 | ONIONS, GREEN & SHALLOTS | Onions | Cotton/40 | 0.08 |
| 374189 | SPINACH, FOOD SERV | Lettuce | Cotton/40 | 0.08 |
| 374199 | SPINACH, FR MKT | Lettuce | Cotton/40 | 0.08 |
| 374299 | SPINACH, PROC | Lettuce | Cotton/40 | 0.08 |
| 374999 | SPINACH UNSPECIFIED | Lettuce | Cotton/40 | 0.08 |
| 375999 | SQUASH | Melon | Cotton/20 | 0.17 |
| 376999 | SWISS CHARD | Lettuce | Cotton/40 | 0.08 |
| 378199 | TOMATOES, FRESH MARKET | Tomatoes | Cotton/40 | 0.08 |
| 378299 | TOMATOES, PROCESSING | Tomatoes | Cotton/20 | 0.17 |
| 378999 | TOMATOES, UNSPECIFIED | Tomatoes | Cotton/20 | 0.17 |
| 380999 | TURNIPS, ALL | Sugar Beets | Cotton/2 | 1.68 |
| 381999 | GREENS, TURNIP & MUSTARD | Lettuce | Cotton/40 | 0.08 |
| 387999 | LEEKS | Onions | Cotton/40 | 0.08 |
| 391999 | POTATOES, IRISH ALL | Sugar Beets | Cotton/2 | 1.68 |
| 392999 | SWEET POTATOES | Sugar Beets | Cotton/2 | 1.68 |
| 393999 | HORSERADISH | Onions | Cotton/40 | 0.08 |
| 394199 | SALAD GREENS NEC | Lettuce | Cotton/40 | 0.08 |
| 394999 | PEAS, EDIBLE POD (SNOW) | Dry Beans | Cotton/20 | 0.17 |
| 395999 | VEGETABLES, ORIENTAL, ALL | Vegetables | Cotton/40 | 0.08 |
| 396999 | SPROUTS, ALFALFA & BEAN | Lettuce | Cotton/40 | 0.08 |
| 398199 | CUCUMBERS, GREENHOUSE | No Land Prep. | Zero/1 | 0 |
| 398299 | TOMATOES, GREENHOUSE | No Land Prep. | Zero/1 | 0 |
| 398399 | TOMATOES, CHERRY | Tomatoes | Cotton/40 | 0.08 |
| 398499 | TOMATILLO | Tomatoes | Cotton/40 | 0.08 |
| 398559 | CILANTRO | Lettuce | Cotton/40 | 0.08 |
| 398599 | SPICES AND HERBS | Lettuce | Cotton/40 | 0.08 |
| 398899 | VEGETABLES, BABY | Vegetables | Cotton/40 | 0.08 |
| 398999 | VEGETABLES, UNSPECIFIED | Vegetables | Cotton/20 | 0.17 |
| 832919 | POTATOES SEED | Sugar Beets | Cotton/2 | 1.68 |
| 892999 | NURSERY TURF | No Land Prep. | Zero 1 | 0 |

*Source:*
*CARB. 2003. Emission Inventory Documentation, Section 7.5: Agricultural Harvest Operations. January.*
*Accessed on: May 5, 2012. Available at: http://www.arb.ca.gov/ei/areasrc/arbmiscprocresfarmop.htm.*
Key:
CDFA = California Department of Food and Agriculture
lbs = pounds
PM10 = inhalable particulate matter

**Table 27. Estimated Regional Emission Factors for Windblown Dust**

| Region | Counties | Emission Factor (tons/acre/year) | Process Rate (acres) | Weighted Average Emission Factor (tons/acre/year) |
|---|---|---|---|---|
| Sacramento River | Tehama | 0.00035146 | 955,350 | 0.001320 |
| | Glenn | 0.004957 | 186,067 | |
| | Butte | 0.001154 | 116,869 | |
| | Colusa | 0.004702 | 229,747 | |
| | Sutter | 0.00037084 | 71,500 | |
| | Yolo | 0.00061919 | 136,870 | |
| | Solano | 0.00039453 | 131,360 | |
| | Yuba | 0.00023892 | 207,600 | |
| San Joaquin River | Solano | 0.00039453 | 131,360 | 0.009747 |
| | Sacramento | 0.002479 | 117,770 | |
| | Contra Costa | n/a | n/a | |
| | San Joaquin | 0.003527 | 387,278 | |
| | Alameda | n/a | n/a | |
| | Stanislaus | 0.009052 | 229,805 | |
| | Merced | 0.013659 | 364,804 | |
| | Fresno | 0.013761 | 864,164 | |
| | Madera | 0.008032 | 141,617 | |
| Tulare Lake | Fresno | 0.013761 | 864,164 | 0.010701 |
| | Kings | 0.012856 | 473,817 | |
| | Tulare | 0.004693 | 471,664 | |
| | Kern | 0.008662 | 408,313 | |

Note:
Emission factor for pasture lands used if emission factor for agricultural lands is not available.

**Table 28. Windblown Dust - Agricultural Lands**

| Air Basin Code | County Name | Emission Factor (tons/acre/year) | Process Rate (acres) | Particulate Matter Emissions (tons/year) |
|---|---|---|---|---|
| NCC | Monterey | 0.020478 | 279,178 | 5,717.07 |
| | San Benito | 0.015936 | 50,009 | 796.96 |
| | Santa Cruz | 0.002485 | 14,873 | 36.97 |
| SCC | San Luis Obispo | 0.006876 | 109,694 | 754.2 |
| | Santa Barbara | 0.00319 | 80,732 | 257.56 |
| | Ventura | 0.018418 | 54,568 | 1,005.02 |
| SED | Imperial | 0.141666 | 490,409 | 69,474.43 |
| SJV | Fresno | 0.013761 | 864,164 | 11,891.35 |
| | Kern | 0.008662 | 408,313 | 3,536.73 |
| | Kings | 0.012856 | 473,817 | 6,091.62 |
| | Madera | 0.008032 | 141,617 | 1,137.47 |
| | Merced | 0.013659 | 364,804 | 4,982.86 |
| | San Joaquin | 0.003527 | 387,278 | 1,365.96 |
| | Stanislaus | 0.009052 | 229,805 | 2,080.26 |
| | Tulare | 0.004693 | 471,664 | 2,213.29 |
| SV | Butte | 0.001154 | 116,869 | 134.87 |
| | Colusa | 0.004702 | 229,747 | 1,080.31 |
| | Glenn | 0.004957 | 186,067 | 922.39 |
| | Placer | 0.002172 | 6,963 | 15.12 |
| | Sacramento | 0.002479 | 117,770 | 291.92 |

Note:
Fraction of PM10 (FRPM10): 0.50
(PM10 Emissions = PM x FRPM10)
Key:
NCC = North Central Coast
SCC = South Central Coast
SED = Salton Sea
SJV = San Joaquin Valley
SV = Sacramento Valley

**Table 29. Windblown Dust - Pasture Lands**

| Air Basin Code | County Name | Emission Factor (tons/acre/year) | Process Rate (acres) | Particulate Matter Emissions (tons/year) |
|---|---|---|---|---|
| NCC | Monterey | 0.00110562 | 1,108,000 | 1,225.03 |
| | San Benito | 0.00109336 | 512,000 | 559.8 |
| | Santa Cruz | 0.0001605 | 8,000 | 1.28 |
| SCC | Santa Barbara | 0.00021801 | 602,913 | 131.44 |
| | San Luis Obispo | 0.00046964 | 1,102,500 | 517.78 |
| | Ventura | 0.00050356 | 210,918 | 106.21 |
| SED | Imperial | 0.00867346 | 158,449 | 1,374.30 |
| SJV | Fresno | 0.00149089 | 907,300 | 1,352.69 |
| | Kern | 0.00082834 | 1,527,603 | 1,265.37 |
| | Kings | 0.00146875 | 142,777 | 209.7 |
| | Madera | 0.00116178 | 421,000 | 489.11 |
| | Merced | 0.00155578 | 642,700 | 999.9 |
| | San Joaquin | 0.0005228 | 167,700 | 87.67 |
| | Stanislaus | 0.00107875 | 434,300 | 468.5 |
| | Tulare | 0.00063424 | 713,400 | 452.47 |
| SV | Butte | 0.00014292 | 288,500 | 41.23 |
| | Colusa | 0.00046444 | 181,900 | 84.48 |
| | Glenn | 0.00048846 | 256,575 | 125.33 |
| | Placer | 0.00026499 | 65,656 | 17.4 |
| | Sacramento | 0.00019538 | 118,000 | 23.05 |
| | Shasta | 0.00034146 | 459,000 | 156.73 |
| | Solano | 0.00039453 | 131,360 | 51.83 |
| | Sutter | 0.00037084 | 71,500 | 26.51 |
| | Tehama | 0.00035146 | 955,350 | 335.76 |
| | Yolo | 0.00061919 | 136,870 | 84.75 |
| | Yuba | 0.00023892 | 207,600 | 49.6 |

Note:
Fraction of PM10 (FRPM10): 0.50
(PM10 Emissions = PM x FRPM10)
Key:
NCC = North Central Coast
SCC = South Central Coast
SED = Salton Sea
SJV = San Joaquin Valley
SV = Sacramento Valley

*Source:*
*CARB. 1997. Emission Inventory Documentation, Section 7.12: Windblown Dust - Agricultural Lands. July. Accessed on: May 5, 2012. Available at: http://www.arb.ca.gov/ei/areasrc/arbmiscprocfugwbdst.htm.*

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# Appendix F

Climate Change Analysis Emissions Calculations

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## Groundwater Pumping Emissions

**Table 1. Alternative 1: Diesel Exhaust Emissions**

| Location | Change from Ex. Cond. (TAF) | Operation (hr/yr) | Fuel Consumption (gallons/year) | GHG Emissions (metric tons/year) | | | GHG Emissions (metric tons CO2e per year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CO2 | CH4 | N2O | CO2 | CH4 | N2O | Total |
| **Wet Condition** | | | | | | | | | | |
| Sacramento River | -67.8 | -147,293 | -1,322,128 | -13,499 | -0.55 | -0.11 | -13,499 | -14 | -33 | -13,545 |
| San Joaquin River | -48.5 | -105,413 | -946,206 | -9,661 | -0.39 | -0.08 | -9,661 | -10 | -23 | -9,694 |
| Tulare Lake | -21.5 | -46,685 | -419,051 | -4,279 | -0.17 | -0.03 | -4,279 | -4 | -10 | -4,293 |
| **Wet Condition Total** | | | | -27,438 | -1.11 | -0.22 | -27,438 | -28 | -66 | -27,532 |
| **Above Normal Condition** | | | | | | | | | | |
| Sacramento River | -70.5 | -153,080 | -1,374,066 | -14,029 | -0.57 | -0.11 | -14,029 | -14 | -34 | -14,077 |
| San Joaquin River | -49.9 | -108,309 | -972,195 | -9,926 | -0.40 | -0.08 | -9,926 | -10 | -24 | -9,960 |
| Tulare Lake | -30.1 | -65,311 | -586,245 | -5,986 | -0.24 | -0.05 | -5,986 | -6 | -14 | -6,006 |
| **Above Normal Condition Total** | | | | -29,941 | -1.21 | -0.24 | -29,941 | -30 | -72 | -30,044 |
| **Below Normal Condition** | | | | | | | | | | |
| Sacramento River | -69.4 | -150,712 | -1,352,812 | -13,812 | -0.56 | -0.11 | -13,812 | -14 | -33 | -13,860 |
| San Joaquin River | -46.2 | -100,291 | -900,224 | -9,191 | -0.37 | -0.07 | -9,191 | -9 | -22 | -9,223 |
| Tulare Lake | 21.5 | 46,666 | 418,883 | 4,277 | 0.17 | 0.03 | 4,277 | 4 | 10 | 4,291 |
| **Below Normal Condition Total** | | | | -18,727 | -0.76 | -0.15 | -18,727 | -19 | -45 | -18,791 |
| **Dry Condition** | | | | | | | | | | |
| Sacramento River | -62.1 | -134,817 | -1,210,141 | -12,356 | -0.50 | -0.10 | -12,356 | -13 | -30 | -12,398 |
| San Joaquin River | -33.0 | -71,729 | -643,851 | -6,574 | -0.27 | -0.05 | -6,574 | -7 | -16 | -6,596 |
| Tulare Lake | -3.7 | -8,136 | -73,026 | -746 | -0.03 | -0.01 | -746 | -1 | -2 | -748 |
| **Dry Condition Total** | | | | -19,675 | -0.80 | -0.16 | -19,675 | -20 | -48 | -19,742 |
| **Critical Condition** | | | | | | | | | | |
| Sacramento River | -50.1 | -108,919 | -977,676 | -9,982 | -0.40 | -0.08 | -9,982 | -10 | -24 | -10,016 |
| San Joaquin River | -6.4 | -13,865 | -124,457 | -1,271 | -0.05 | -0.01 | -1,271 | -1 | -3 | -1,275 |
| Tulare Lake | 10.5 | 22,883 | 205,399 | 2,097 | 0.09 | 0.02 | 2,097 | 2 | 5 | 2,104 |
| **Critical Condition Total** | | | | -9,156 | -0.37 | -0.07 | -9,156 | -9 | -22 | -9,187 |

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
GHG = greenhouse gas
hr/yr = hours per year
N2O = nitrous oxide
TAF = thousand acre-feet

**Table 2. Alternative 2: Diesel Exhaust Emissions**

| Location | Change from Alt 1 (TAF) | Operation (hr/yr) | Fuel Consumption (gallons/year) | GHG Emissions (metric tons/year) CO2 | CH4 | N2O | (metric tons CO2e per year) CO2 | CH4 | N2O | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **Wet Condition** | | | | | | | | | | |
| Sacramento River | -3.0 | -6,530 | -58,612 | -598 | -0.02 | 0.00 | -598 | -1 | -1 | -600 |
| San Joaquin River | -9.5 | -20,670 | -185,539 | -1,894 | -0.08 | -0.02 | -1,894 | -2 | -5 | -1,901 |
| Tulare Lake | -25.1 | -54,420 | -488,485 | -4,987 | -0.20 | -0.04 | -4,987 | -5 | -12 | -5,005 |
| **Wet Condition Total** | | | | -7,480 | -0.30 | -0.06 | -7,480 | -8 | -18 | -7,506 |
| **Above Normal Condition** | | | | | | | | | | |
| Sacramento River | -4.6 | -9,950 | -89,310 | -912 | -0.04 | -0.01 | -912 | -1 | -2 | -915 |
| San Joaquin River | -11.9 | -25,933 | -232,777 | -2,377 | -0.10 | -0.02 | -2,377 | -2 | -6 | -2,385 |
| Tulare Lake | -38.0 | -82,586 | -741,301 | -7,569 | -0.31 | -0.06 | -7,569 | -8 | -18 | -7,595 |
| **Above Normal Condition Total** | | | | -10,857 | -0.44 | -0.09 | -10,857 | -11 | -26 | -10,894 |
| **Below Normal Condition** | | | | | | | | | | |
| Sacramento River | -1.3 | -2,780 | -24,956 | -255 | -0.01 | 0.00 | -255 | 0 | -1 | -256 |
| San Joaquin River | -17.4 | -37,849 | -339,735 | -3,469 | -0.14 | -0.03 | -3,469 | -4 | -8 | -3,481 |
| Tulare Lake | -25.7 | -55,809 | -500,954 | -5,115 | -0.21 | -0.04 | -5,115 | -5 | -12 | -5,132 |
| **Below Normal Condition Total** | | | | -8,838 | -0.36 | -0.07 | -8,838 | -9 | -21 | -8,869 |
| **Dry Condition** | | | | | | | | | | |
| Sacramento River | -1.4 | -2,946 | -26,445 | -270 | -0.01 | 0.00 | -270 | 0 | -1 | -271 |
| San Joaquin River | -30.2 | -65,601 | -588,841 | -6,012 | -0.24 | -0.05 | -6,012 | -6 | -15 | -6,033 |
| Tulare Lake | -12.0 | -25,996 | -233,340 | -2,382 | -0.10 | -0.02 | -2,382 | -2 | -6 | -2,391 |
| **Dry Condition Total** | | | | -8,664 | -0.35 | -0.07 | -8,664 | -9 | -21 | -8,694 |
| **Critical Condition** | | | | | | | | | | |
| Sacramento River | -3.1 | -6,791 | -60,961 | -622 | -0.03 | -0.01 | -622 | -1 | -2 | -625 |
| San Joaquin River | -34.8 | -75,554 | -678,187 | -6,924 | -0.28 | -0.06 | -6,924 | -7 | -17 | -6,948 |
| Tulare Lake | -13.5 | -29,426 | -264,132 | -2,697 | -0.11 | -0.02 | -2,697 | -3 | -7 | -2,706 |
| **Critical Condition Total** | | | | -10,243 | -0.42 | -0.08 | -10,243 | -10 | -25 | -10,279 |

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
GHG = greenhouse gas
hr/yr = hours per year
N2O = nitrous oxide
TAF = thousand acre-feet

**Table 3. Alternative 3: Diesel Exhaust Emissions**

| Location | Change from Alt 1 (TAF) | Operation (hr/yr) | Fuel Consumption (gallons/year) | GHG Emissions (metric tons/year) | | | GHG Emissions (metric tons CO2e per year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CO2 | CH4 | N2O | CO2 | CH4 | N2O | Total |
| **Wet Condition** | | | | | | | | | | |
| Sacramento River | 0.4 | 924 | 8,295 | 85 | 0.00 | 0.00 | 85 | 0 | 0 | 85 |
| San Joaquin River | 3.4 | 7,396 | 66,385 | 678 | 0.03 | 0.01 | 678 | 1 | 2 | 680 |
| Tulare Lake | 11.0 | 23,860 | 214,171 | 2,187 | 0.09 | 0.02 | 2,187 | 2 | 5 | 2,194 |
| **Wet Condition Total** | | | | 2,949 | 0.12 | 0.02 | 2,949 | 3 | 7 | 2,959 |
| **Above Normal Condition** | | | | | | | | | | |
| Sacramento River | 2.0 | 4,276 | 38,380 | 392 | 0.02 | 0.00 | 392 | 0 | 1 | 393 |
| San Joaquin River | 4.3 | 9,318 | 83,641 | 854 | 0.03 | 0.01 | 854 | 1 | 2 | 857 |
| Tulare Lake | 14.5 | 31,535 | 283,059 | 2,890 | 0.12 | 0.02 | 2,890 | 3 | 7 | 2,900 |
| **Above Normal Condition Total** | | | | 4,136 | 0.17 | 0.03 | 4,136 | 4 | 10 | 4,150 |
| **Below Normal Condition** | | | | | | | | | | |
| Sacramento River | 0.6 | 1,304 | 11,708 | 120 | 0.00 | 0.00 | 120 | 0 | 0 | 120 |
| San Joaquin River | 9.9 | 21,476 | 192,768 | 1,968 | 0.08 | 0.02 | 1,968 | 2 | 5 | 1,975 |
| Tulare Lake | 3.1 | 6,747 | 60,558 | 618 | 0.03 | 0.01 | 618 | 1 | 1 | 620 |
| **Below Normal Condition Total** | | | | 2,706 | 0.11 | 0.02 | 2,706 | 3 | 7 | 2,715 |
| **Dry Condition** | | | | | | | | | | |
| Sacramento River | -0.3 | -710 | -6,370 | -65 | 0.00 | 0.00 | -65 | 0 | 0 | -65 |
| San Joaquin River | 20.6 | 44,832 | 402,417 | 4,109 | 0.17 | 0.03 | 4,109 | 4 | 10 | 4,123 |
| Tulare Lake | 8.5 | 18,437 | 165,492 | 1,690 | 0.07 | 0.01 | 1,690 | 2 | 4 | 1,695 |
| **Dry Condition Total** | | | | 5,733 | 0.23 | 0.05 | 5,733 | 6 | 14 | 5,753 |
| **Critical Condition** | | | | | | | | | | |
| Sacramento River | 1.2 | 2,627 | 23,583 | 241 | 0.01 | 0.00 | 241 | 0 | 1 | 242 |
| San Joaquin River | 18.7 | 40,713 | 365,442 | 3,731 | 0.15 | 0.03 | 3,731 | 4 | 9 | 3,744 |
| Tulare Lake | 7.0 | 15,224 | 136,650 | 1,395 | 0.06 | 0.01 | 1,395 | 1 | 3 | 1,400 |
| **Critical Condition Total** | | | | 5,367 | 0.22 | 0.04 | 5,367 | 5 | 13 | 5,386 |

Key:

CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
GHG = greenhouse gas
hr/yr = hours per year
N2O = nitrous oxide
TAF = thousand acre-feet

**Table 4. Alternative 5: Diesel Exhaust Emissions**

| Location | Change from Alt 1 (TAF) | Operation (hr/yr) | Fuel Consumption (gallons/year) | GHG Emissions (metric tons/year) CO2 | CH4 | N2O | (metric tons CO2e per year) CO2 | CH4 | N2O | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **Wet Condition** | | | | | | | | | | |
| Sacramento River | -0.002 | -5 | -45 | 0 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| San Joaquin River | 0.034 | 74 | 662 | 7 | 0.00 | 0.00 | 7 | 0 | 0 | 7 |
| Tulare Lake | 0.177 | 385 | 3,453 | 35 | 0.00 | 0.00 | 35 | 0 | 0 | 35 |
| **Wet Condition Total** | | | | 42 | 0.00 | 0.00 | 42 | 0 | 0 | 42 |
| **Above Normal Condition** | | | | | | | | | | |
| Sacramento River | 0.02 | 38 | 343 | 4 | 0.00 | 0.00 | 4 | 0 | 0 | 4 |
| San Joaquin River | 0.07 | 151 | 1,355 | 14 | 0.00 | 0.00 | 14 | 0 | 0 | 14 |
| Tulare Lake | 0.59 | 1,287 | 11,551 | 118 | 0.00 | 0.00 | 118 | 0 | 0 | 118 |
| **Above Normal Condition Total** | | | | 135 | 0.01 | 0.00 | 135 | 0 | 0 | 136 |
| **Below Normal Condition** | | | | | | | | | | |
| Sacramento River | -0.002 | -3 | -30 | 0 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| San Joaquin River | -0.007 | -16 | -141 | -1 | 0.00 | 0.00 | -1 | 0 | 0 | -1 |
| Tulare Lake | 0.083 | 180 | 1,620 | 17 | 0.00 | 0.00 | 17 | 0 | 0 | 17 |
| **Below Normal Condition Total** | | | | 15 | 0.00 | 0.00 | 15 | 0 | 0 | 15 |
| **Dry Condition** | | | | | | | | | | |
| Sacramento River | 0.1 | 232 | 2,086 | 21 | 0.00 | 0.00 | 21 | 0 | 0 | 21 |
| San Joaquin River | 0.1 | 176 | 1,584 | 16 | 0.00 | 0.00 | 16 | 0 | 0 | 16 |
| Tulare Lake | 0.0 | 62 | 553 | 6 | 0.00 | 0.00 | 6 | 0 | 0 | 6 |
| **Dry Condition Total** | | | | 43 | 0.00 | 0.00 | 43 | 0 | 0 | 43 |
| **Critical Condition** | | | | | | | | | | |
| Sacramento River | 0.006 | 12 | 111 | 1 | 0.00 | 0.00 | 1 | 0 | 0 | 1 |
| San Joaquin River | 0.058 | 126 | 1,133 | 12 | 0.00 | 0.00 | 12 | 0 | 0 | 12 |
| Tulare Lake | 0.012 | 27 | 240 | 2 | 0.00 | 0.00 | 2 | 0 | 0 | 2 |
| **Critical Condition Total** | | | | 15 | 0.00 | 0.00 | 15 | 0 | 0 | 15 |

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
GHG = greenhouse gas
hr/yr = hours per year
N2O = nitrous oxide
TAF = thousand acre-feet

Average Pump Rate: 2,500 gallons per minute
*(estimated from Long-Term Water Transfers data)*

Average Engine Rating: 160 horsepower
*(estimated from Long-Term Water Transfers data)*

Conversions

| | | |
|---|---|---|
| 1 acre-foot = | 325,851 | gallons |
| 1 TAF = | 1,000 | acre-feet |
| 1 hour = | 60 | minutes |
| 1 metric ton = | 1,000 | kilograms |

http://www.water.ca.gov/pubs/dwrnews/california_water_facts_card/waterfactscard.pdf

Diesel Engine Fuel Consumption

| | | |
|---|---|---|
| 0.4 | pounds per horsepower-hour | *(Based on spec sheet for John Deere 6068H, 6.8L Engine, 173 HP)* |
| 0.855 | grams per milliliter | *(Based on Material Safety Data Sheet for Hess Diesel Fuel [All Types])* |
| 7.13 | pounds per gallon | |

Global Warming Potential

| | |
|---|---|
| CO2 | 1 |
| CH4 | 25 |
| N2O | 298 |

**Table 5. SWAP Output - Annual Groundwater Pumped**

| | | | | | | *Alternative 2 - Alt 1* | *Alternative 3 - Alt 1* | *Alternative 5 - Alt 1* | *Alt 1 - Existing* |
|---|---|---|---|---|---|---|---|---|---|
| | **Annual Groundwater Pumped (TAF)** | | | | | **Change from Alt 1 (TAF)** | | | |
| **SWAP Region** | **Alternative 1 (No Action Alternative)** | **Alternative 2** | **Alternative 3** | **Alternative 5** | **Existing Conditions** | **Alternative 2** | **Alternative 3** | **Alternative 5** | **Existing Conditions** |
| **Wet Condition** | | | | | | | | | |
| Sacramento River | 1,248.5 | 1,245.5 | 1,249.0 | 1,248.5 | 1,316.3 | -3.0 | 0.4 | -0.002 | -67.8 |
| San Joaquin River | 996.2 | 986.7 | 999.6 | 996.3 | 1,044.7 | -9.5 | 3.4 | 0.03 | -48.5 |
| Tulare Lake | 2,432.4 | 2,407.3 | 2,443.4 | 2,432.6 | 2,453.9 | -25.1 | 11.0 | 0.2 | -21.5 |
| **Above Normal Conditions** | | | | | | | | | |
| Sacramento River | 1,240.5 | 1,235.9 | 1,242.4 | 1,240.5 | 1,310.9 | -4.6 | 2.0 | 0.02 | -70.5 |
| San Joaquin River | 1,122.3 | 1,110.3 | 1,126.6 | 1,122.4 | 1,172.1 | -11.9 | 4.3 | 0.1 | -49.9 |
| Tulare Lake | 2,771.5 | 2,733.4 | 2,786.0 | 2,772.0 | 2,801.5 | -38.0 | 14.5 | 0.6 | -30.1 |
| **Below Normal Conditions** | | | | | | | | | |
| Sacramento River | 1,265.8 | 1,264.5 | 1,266.4 | 1,265.8 | 1,335.2 | -1.3 | 0.6 | -0.002 | -69.4 |
| San Joaquin River | 1,208.7 | 1,191.3 | 1,218.6 | 1,208.7 | 1,254.8 | -17.4 | 9.9 | -0.01 | -46.2 |
| Tulare Lake | 2,900.7 | 2,875.1 | 2,903.9 | 2,900.8 | 2,879.3 | -25.7 | 3.1 | 0.1 | 21.5 |
| **Dry Condition** | | | | | | | | | |
| Sacramento River | 1,271.6 | 1,270.2 | 1,271.3 | 1,271.7 | 1,333.6 | -1.4 | -0.3 | 0.1 | -62.1 |
| San Joaquin River | 1,315.5 | 1,285.3 | 1,336.1 | 1,315.6 | 1,348.5 | -30.2 | 20.6 | 0.1 | -33.0 |
| Tulare Lake | 3,047.0 | 3,035.1 | 3,055.5 | 3,047.1 | 3,050.8 | -12.0 | 8.5 | 0.03 | -3.7 |
| **Critical Condition** | | | | | | | | | |
| Sacramento River | 1,317.1 | 1,314.0 | 1,318.3 | 1,317.1 | 1,367.2 | -3.1 | 1.2 | 0.01 | -50.1 |
| San Joaquin River | 1,570.0 | 1,535.2 | 1,588.8 | 1,570.1 | 1,576.4 | -34.8 | 18.7 | 0.1 | -6.4 |
| Tulare Lake | 3,284.8 | 3,271.3 | 3,291.9 | 3,284.9 | 3,274.3 | -13.5 | 7.0 | 0.01 | 10.5 |

Note:
Change from No Action Alternative for Action Alternatives = Alternative minus Alternative 1 (No Action)
Change from No Action Alternative for Existing Conditions = Alternative 1 (No Action) minus Existing Conditions
Key:
SWAP = Statewide Agricultural Production TAF = thousand acre-feet

**Table 6. Diesel Emission Factors**

| Pollutant | Emission Factor | Unit | Emission Factor Description |
|---|---|---|---|
| CO2 | 10.21 | kg/gallon | Table 12.1, Distillate Fuel Oil No. 2 |
| CH4 | 0.003 | kg/MMBtu | Table 12.9, Petroleum Products, Industrial |
| N2O | 0.0006 | kg/MMBtu | Table 12.9, Petroleum Products, Industrial |
| Heat Content | 0.138 | MMBtu/gallon | Table 12.1, Distillate Fuel Oil No. 2 |

*Source: The Climate Registry. 2014. 2014 Climate Registry Default Emission Factors with U.S. EPA 11/29/2013 Update (Released: March 14, 2014). Accessed on: May 12, 2014. Available at: http://www.theclimateregistry.org/downloads/2014/03/2014-TCR-Default-EFs-with-EPA-11.29.2013-update.pdf*

Key:

CH4 = methane
CO2 = carbon dioxide
kg = kilograms
MMBtu = million British Thermal Units
N2O = nitrous oxide

# Appendix G

M&I Economic Model Documentation

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# Appendix G
# M&I Economic Model Documentation

This technical appendix documents two economic models used to develop economic impact estimates for water supply changes to Central Valley Project (CVP) municipal and industrial (M&I) water service contractors for the regional economic analysis of the M&I Water Shortage Policy (WSP) Environmental Impact Statement. This appendix provides results of the analyses and explains linkages to the regional impact analysis.

Both the Least Cost Planning Simulation Model (LCPSIM) and the Other Project Water Economic Model (OPWEM) accept an annual time series of CVP M&I water service contractor deliveries as input, and estimate amounts and costs of water supplies and shortage needed to balance demand and supply. In this analysis, LCPSIM includes all the San Francisco Bay Area CVP M&I water service contractors, and OPWEM includes all other CVP M&I water service contractors who might be affected by the M&I WSP. Cost and retail revenue changes are calculated by comparison to the No Action Alternative. Water supply cost changes are assumed to be passed onto regional water end-users who must change their discretionary spending by a similar amount. These changes in regional spending have "multiplier effects" in the regional economy which are estimated using the IMpact analysis for PLANning (IMPLAN) model. The IMPLAN analysis is presented in Chapter 13, Socioeconomics.

## G.1 LCPSIM

For this analysis, the Bay Area LCPSIM is used to estimate the economic benefits and costs of water supply for M&I purposes in the urban areas of Santa Clara Valley Water District, Contra Costa Water District, and East Bay Municipal Utility District (EBMUD).

LCPSIM uses CalSim II results for annual CVP deliveries to M&I water service contractors under the 2030 condition over the 1922 to 2003 hydrologic period as input (See Appendix B, Water Operations Model Documentation, for more detail on the CalSim II model, assumptions, and results). For each year of the hydrologic period, demand and supply quantities are compared. If supply is insufficient to meet demand, the costs of additional water supplies are calculated. Additional water supplies can be temporary, such as temporary water transfers, or long-term, such as permanent water use efficiency improvements or water reclamation facilities. LCPSIM is an annual time-step urban water system model that finds the mix of temporary and long-term options that minimizes the sum of the total annual cost of these options, including the total expected annual shortage

costs that remain after their adoption. To estimate costs of shortage, the model uses a shortage loss function derived from contingent valuation studies and water agency shortage allocation strategies.

Long-term measures available for the Bay Area LCPSIM are indoor conservation, outdoor conservation, and water recycling. The model accounts for the ability of shortage management (contingency) measures, including temporary water transfers, to reduce regional costs and losses associated with shortage events, and for the ability of long-term regional demand reduction and supply augmentation measures, in conjunction with regional carryover storage opportunities, to reduce the frequency, magnitude, and duration of shortage events.

The model requires data on water demands and supplies and the costs and amounts of water supply and conservation options as input. Some local supplies and supply options are modeled using conveyance and storage capacities, and the model conducts storage operations to utilize these options. Data for the model were generally obtained from California Department of Water Resources (DWR) planning documents and from local sources such as the Urban Water Management Plans (UWMPs). Most of these data were vetted as part of the CALFED common assumptions process in 2007 to 2008. The Bay Area version of the model was reviewed and updated in 2008 to 2009, and again, more recently, for the Bay Delta Conservation Plan.

The model outputs include annual shortage size, costs and losses due to shortage, quantities and costs of water transfers, surface and groundwater carryover storage operations, and overall system operations costs.

### G.1.1 LCPSIM Results

Table G-1 provides a summary of LCPSIM results for the five M&I WSP alternatives. Alternative 2, Equal Agricultural and M&I Allocation, would increase economic costs, including net operations costs, urban water supply and shortage costs in the Bay Area by an average of about $14.2 million annually, relative to the No Action Alternative (Alternative 1). Alternative 3, Full M&I Allocation Preference, would decrease these net costs by about $6.5 million annually, under 2030 conditions, relative to the No Action Alternative. For modeling purposes, there is no difference between the No Action Alternative and Alternative 4, Updated M&I WSP (see Appendix B); therefore, Alternative 4 has the same economic effects as the No Action Alternative. The effects of Alternative 5, M&I Contractor Suggested WSP, in the Bay Area are near zero relative to the No Action Alternative.

## Table G-1. Bay Area LCPSIM Model Results

| Model inputs and results | Alternative | | | | Change relative to the No Action Alternative | | |
|---|---|---|---|---|---|---|---|
| | Alternative 1 (No Action Alternative) & Alternative 4 | Alternative 2 | Alternative 3 | Alternative 5 | Alternative 2 | Alternative 3 | Alternative 5 |
| CVP M&I Contract Deliveries (thousand acre-feet [TAF])[1] | | | | | | | |
| Wet Year Average (26 years) | 267 | 248 | 275 | 267 | -19 | 8 | 0 |
| Above Normal Year Average (12 years) | 267 | 236 | 284 | 267 | -31 | 17 | 0 |
| Below Normal Year Average (14 years) | 228 | 154 | 269 | 228 | -74 | 41 | 0 |
| Dry Year Average (18 years) | 198 | 123 | 258 | 198 | -75 | 60 | 0 |
| Critical Year Average (12 years) | 166 | 57 | 211 | 166 | -109 | 45 | 0 |
| Annual Average | | | | | | | |
| CVP M&I Contract Deliveries (TAF) | 230 | 175 | 262 | 230 | -56 | 32 | 0 |
| Average Applied Demand Reduction (TAF) | 25 | 32 | 0 | 25 | 7 | -25 | 0 |
| Average Water Market Deliveries (TAF) | 5 | 25 | 4 | 5 | 20 | -1 | 0 |
| Annual Average Cost ($1,000) | | | | | | | |
| System Operations Cost | $188,074 | $186,961 | $194,138 | $188,074 | ($1,113) | $6,064 | ($0) |
| Shortage Loss/Cost | $12,926 | $21,531 | $8,349 | $12,927 | $8,605 | ($4,576) | $1 |
| Annualized Option Cost | $6,885 | $9,438 | ($777) | $6,885 | $2,553 | ($7,662) | $0 |
| Water Market Cost | $1,055 | $5,200 | $760 | $1,056 | $4,144 | ($296) | $0 |
| Total Loss/Cost | $208,940 | $223,129 | $202,471 | $208,942 | $14,189 | ($6,470) | $1 |
| Reduced Expenditure for Regional Models | | | | | $6,697 | ($7,958) | $0 |
| Marginal Option Cost ($/AF) | $354 | $381 | $330 | $354 | $27 | ($24) | $0 |

[1]Does not include EBMUD deliveries

### G.1.2 Bay Area Regional Economic Effects

LCPSIM was developed to calculate economic costs and benefits. Regional economic analysis focuses on different economic measures such as value of output, income and employment. The relationship between economic costs or benefits and regional economic effects is complicated.

The regional input-output analysis uses LCPSIM results that are not the same, but are related to, costs and benefits. In particular, LCPSIM calculates the change in water supply cost experienced by water suppliers. It is assumed that an increase in water costs must be recovered. For the regional analysis, this cost is passed onto end-users which reduces their discretionary spending by an equivalent amount. For Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by $6.697 million relative to the No Action Alternative, so by assumption, other expenditures by end-users would be reduced by $6.697 million. For Alternative 3, annual average water supply costs would be reduced by $7.958 million, and these savings would be passed onto end-users who would increase their spending by $7.958 million.

LCPSIM also calculates end-user shortage cost. This cost is the disutility or unhappiness of end-users who must reduce their water use even though they would prefer to buy the water at the existing price. LCPSIM shortage cost does not have a direct regional effect because most of this cost is not reflected in regional sales, income, or other economic activity. This unhappiness might affect the decisions of water end-users (primarily residents and businesses) about where to live and do business, and those decisions might have regional effects. These regional effects, if any, cannot be modeled with LCPSIM and IMPLAN.

### G.1.3 LCPSIM Limitations for Regional Effects Analysis

This section discusses modeling limitations in LCPSIM and suggests how associated regional effects might be affected.

LCPSIM models the entire region as one region. All demands and supplies are aggregated. This aggregation would not create inaccuracy if all water agencies within the region shared equally in water supplies and shortages. Bay Area water suppliers have infrastructure in place to share some water supplies, recognize that potential cost savings can be obtained by more sharing, and are actively engaged in projects that will allow for more sharing among them (Bay Area Water Supply and Conservation Agency [BAWSCA] 2014). There may be more sharing of water supplies by 2030, but even under anticipated conditions, the LCPSIM aggregation is not entirely appropriate.

In particular, some Bay Area CVP water service contractors are currently in a better position to cope with changes in CVP water allocations than others. Marginal and total costs in some sub-regions of the Bay Area are likely to be less than, and some more than, LCPSIM implies. Given increasing marginal costs, the

net effect is likely to be an understatement of total economic costs and impacts of CVP M&I supply reductions.

The LCPSIM aggregation assumption, combined with the different reliability of water supplies by sub-region, means that some sub-regions have relatively more costs and impacts than others. The relatively large additional shortages in some sub-regions could be a disincentive for people and industry to locate in these sub-regions. Similarly, the improvement in water supply conditions could provide incentive for people, businesses, and industry to operate in these sub-regions.

LCPSIM was designed to operate more or less within the range of historical experience. CVP M&I water delivery reductions in some years under Alternative 2 would be much larger than have historically occurred. To cope with such supply reductions, Bay Area providers might develop new supply alternatives that are included in LCPSIM. There is no information to judge whether these alternative might be more or less expensive than the costs implied by LCPSIM results.

LCPSIM alone does not include all potential economic effects of water shortage. LCPSIM estimates the economic costs of water shortage, but these costs might themselves have economic consequences that are not quantified. In particular, the end-user shortage cost, or reduced end-user shortage benefit, may affect the decisions of water users about where to live and do business, and these decisions might have regional effects. These regional effects cannot be directly modeled with LCPSIM or IMPLAN.

LCPSIM does not include an explicit production or cost function for commercial and industrial (C&I) water shortage. Water suppliers generally protect C&I users from water shortage, and this is reflected in LCPSIM logic. However, CVP water delivery reductions in some years under Alternative 2 would be very severe. CalSim II results show that, during critical years (12 out of 82 years), CVP supplies for the region would be reduced from 166,000 acre-feet (AF) to 57,000 AF on average. Parts of the Bay Area also receive State Water Project supplies that would be unreliable in dry years. Under the Alternative 2, the portfolio of supplies for the region becomes even less reliable in dry years. C&I users would incur unusual costs in some years to cope with water shortage, and without economical supply alternatives, decisions regarding production, employment, and siting of facilities might be affected.

## G.2 OPWEM

OPWEM has been developed to estimate representative economic benefits or costs of changes in CVP M&I supplies for all urban areas outside of the Bay Area that receive these supplies. The model is intended to be similar to LCPSIM in terms of the types of water management actions taken in response to changing CVP supplies, and in the calculation and costs of end-user shortage. Water

demands and non-CVP supplies for the 2030 condition are based on information provided by 2010 UWMPs, where available.

The model includes areas served by CVP water service contractors in the Sacramento Valley, American River basin, and San Joaquin Valley. Twenty-four providers who have CVP M&I water service contracts and 13 providers who have CVP agricultural water service contracts and provide some water for M&I purposes are included. Each provider is modeled separately. The model includes small amounts of agricultural use that could not be separated from urban use.

The model uses CalSim II results for annual CVP M&I water deliveries under the 2030 condition over the 1922 to 2003 hydrologic period as input. For each year of this hydrologic period, demand and supply quantities are compared. If supply is insufficient to meet demand, the costs of additional water supplies are calculated. These costs are the amount of supply times its unit cost. Each provider is associated with two different unit costs of water supplies: one for years that are wetter than dry years; and another for dry and critical years. The unit costs are based on data from individual providers, where available, but most costs are representative groundwater costs or water transfer costs developed from secondary information.

The model also includes potential water shortage costs in dry and critical years. Shortage costs are based on individual retail water prices and quantities, and a short-run demand elasticity of -0.1. That is, demand functions used to estimate shortage costs are fit using a price-quantity point and a slope (see Attachment A for more detail regarding OPWEM). Shortage costs developed in this manner are similar to the shortage costs in LCPSIM for a similar retail price.

The regional analysis assumes that the change in water supply costs must be passed onto end-users who then must reduce their other spending accordingly. Water costs are smaller (as absolute values) than the total cost because they do not include the end-user shortage costs.

### G.2.1 OPWEM Results

Table G-2 provides aggregated results of the OPWEM analysis. Alternative 3, Full M&I Allocation Preference, has the largest average amount of CVP M&I deliveries at 317,500 AF, and Alternative 2, Equal Agricultural and M&I Allocation, has the least at 210,200 AF.

**Table G-2. OPWEM Results by CVP Contractor Group and Alternative; Annual Average CVP Deliveries and Shortage Costs**

| Region | Alternatives | | | |
|---|---|---|---|---|
| | Alternative 1 & 4 | Alternative 2 | Alternative 3 | Alternative 5 |
| **Sacramento Valley Region** | | | | |
| Average Annual CVP Deliveries (TAF) | 49.2 | 39.3 | 56.1 | 49.2 |
| Costs, $1,000 Annual Average, Difference from No Action Alternative | | | | |
| Total Shortage Cost | | $3,589 | -$1,140 | NA |
| Water Supply Only | | $2,234 | -$1,140 | NA |
| Average $/AF Change from No Action Alternative | | $364 | $165 | NA |
| **American River Region** | | | | |
| Average Annual CVP Deliveries (TAF) | 154.6 | 120.3 | 173.9 | 154.6 |
| Costs, $1,000 Annual Average, Difference from No Action Alternative | | | | |
| Total Shortage Cost | | $21,735 | -$6,451 | NA |
| Water Supply Only | | $8,024 | -$4,606 | NA |
| Average $/AF Change from No Action Alternative | | $632 | $334 | NA |
| **San Joaquin Valley Region** | | | | |
| Average Annual CVP Deliveries (TAF) | 73.1 | 50.6 | 87.4 | 73.8 |
| Costs, $1,000 Annual Average, Difference from No Action Alternative | | | | |
| Total Shortage Cost | | $13,868 | -$5,047 | -$287 |
| Water Supply Only | | $6,998 | -$3,807 | -$254 |
| Average $/AF Change from No Action Alternative | | $619 | $352 | $371 |
| **All Regions** | | | | |
| Average Annual CVP Deliveries (TAF) | 276.9 | 210.2 | 317.5 | 277.6 |
| Average $/AF Change from No Action Alternative | | $413 | $381 | $349 |

In the Sacramento Valley region, Alternative 3 would increase average CVP M&I deliveries by 6,900 AF and reduce total costs by $1.14 million annually compared to the No Action Alternative. All of this cost savings consists of costs of supplies no longer needed to meet demands. The average value of an acre-foot of CVP M&I delivery above the No Action Alternative levels in terms of reduced costs is $165. In this region, Alternative 2 reduces CVP M&I average deliveries by 9,900 AF relative to the No Action Alternative. Total costs increase by $3.589 million, so the average additional total cost per acre-foot of delivery reduction from the No Action Alternative is $364. Most of this cost increase consists of water supply costs, but Alternative 2 also results in some end-user shortage costs.

For the regional analysis, for Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by $2,234 million, so other expenditures by end-users would be reduced by $2.234 million. For Alternative 3, annual average water supply costs would be reduced by $1.14 million, and these savings would be passed onto end-users who would increase their spending by $1.14 million.

In the American River Region, Alternative 3 would increase average CVP M&I deliveries by 19,300 AF and reduce total costs by $6.451 million annually compared to the No Action Alternative. Most of this cost savings consists of costs of avoided supplies, but the total includes $1.845 million of reduced end-user shortage costs. The average total reduced cost of an acre-foot of change in CVP delivery (compared to No Action Alternative levels) is $334. In this region, Alternative 2 reduces average CVP M&I deliveries by 34,300 AF relative to the No Action Alternative. Total costs increase by $21.735 million annually, so the average additional total cost per acre-foot change in deliveries is $632. Most of this cost increase consists of end-user shortage costs, but the total cost of Alternative 2 includes $8.024 million of water supply costs.

For the regional analysis, for Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by $8.024 million, so other expenditures by end-users would be reduced by $8.024 million. For Alternative 3, annual average water supply costs would be reduced by $6.451 million, and these savings would be passed onto end-users who would increase their spending by $6.451 million.

In the San Joaquin Valley region, Alternative 3 would increase average CVP M&I deliveries by 14,300 AF and reduce total costs by $5.047 million annually compared to the No Action Alternative. Most of this cost savings ($3.807 million) consists of costs of avoided supplies. The average value of an acre-foot of CVP M&I delivery above No Action levels in terms of reduced costs is $352. In this region, Alternative 2 reduces average CVP M&I deliveries by 22,500 AF relative to the No Action Alternative. Total costs increase by $13,868 million, so the average additional shortage cost per acre-foot of delivery reduction is $619. About half of this cost increase consists of water supply costs, and half is end-user shortage costs. San Joaquin Valley results for Alternative 5 are strongly affected by one individual contractor whose deliveries in some years are protected by public health and safety criteria.

For the regional analysis, for Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by $6.998 million, so other expenditures by end-users would be reduced by $6.998 million. For Alternative 3, annual average water supply costs would be reduced by $3.807 million, and these savings would be passed onto end-users who would increase their spending by $3.807 million.

Alternative 2, with reduced CVP delivery amounts, has higher marginal and average shortage costs than Alternative 3 because shortage becomes increasingly expensive as the amount of shortage increases. Alternative 3 has the smallest average shortage cost per acre-foot of CVP delivered above the No Action Alternative. The overall average cost per acre-foot delivered below the No Action Alternative for Alternative 2 is $588/AF. The overall average benefit per AF delivered above the No Action Alternative for Alternative 3 is $311/AF. This

pattern is expected as a given increment of water supply is more valuable as the total amount of water supply decreases.

### G.2.2 OPWEM Limitations for Regional Effects Analysis

OPWEM limitations are similar to those for LCPSIM except that OPWEM considers each CVP contract holder to be a separate entity so there is little potential error arising from aggregation.

For some M&I water service contractors in the OPWEM model, total water supply under Alternative 2 is very unreliable. CVP water delivery reductions in some years under Alternative 2 would be unprecedented. Some urban providers currently rely solely on CVP M&I supplies and have limited alternatives. New supply development might be required to maintain an attractive economic climate and public health and safety levels.

## G.3 References

Black and Veatch. 2006. *2006 California Water Rate Survey*. Los Angeles.

City of Coalinga. 2006. *2005 Urban Water Management Plan*. July 2006.

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# Attachment A
# Additional Information for OPWEM

## A.1 Detailed Description of OPWEM for M&I WSP

OPWEM is a spreadsheet model of water supplies and demands for CVP contractors not covered by LCPSIM. Each of the CVP service areas is independent of the others so their benefits are additive. All CVP service areas are analyzed in a similar way. Annual CVP M&I deliveries are input from CalSim II model results. The 2010 UWMPs were used, if available, to estimate 2030 water demand and non-CVP supplies for an average condition and a dry condition, and data on marginal water supplies and their costs were obtained.

A number of M&I water service contractors do not prepare UWMPs. For these, data from the Bureau of Reclamation were used to estimate demand[1]. The UWMP data were often inadequate for this analysis, especially for costs (which are not required in an UWMP), so other planning documents, typical groundwater pumping costs, and local transfer prices were often relied on.

For each year of the hydrologic period, demand and supply quantities are compared. If supply is insufficient to meet demand, the costs of additional water supplies are calculated. If the year type is below normal or wetter, the model calculates the cost of supply based on a unit value per AF for these year types.

If the year type is dry or critical, the model allows for shortfalls to be eliminated with dry/critical supply sources and with end-user shortage. The incremental amounts and costs of additional supplies and shortage needed to achieve water balance in the dry condition are estimated and a cost is assigned. In dry and critical years, the difference between with and without CVP deliveries is provided a value even if there is no shortage showing in these years. This is appropriate under the assumption that there are opportunity costs for CVP water in dry and critical years even if the local agency has no shortage. The provider could take the CVP supply and free up the same amount of some other supply which, because it is a dry year, can then be put to valuable use elsewhere.

If supplies are less than demand in the dry or critical year type, and the marginal water supply for the provider is a water transfer, then end-use shortages up to five percent must be applied first. This allocation logic is consistent with LCPSIM. Then, providers can acquire dry-year supplies to eliminate shortfalls up to 50 percent. These supplies have unit costs specific to the dry and critical condition. Thereafter it is assumed that end-users must take additional shortage.

[1] See Appendix A, M&I Contractor Data Summary.

If the marginal water supply for the provider is not a water transfer, then the five percent end-use shortage is not required first. The provider can eliminate a shortfall of up to 50 percent of demand using the dry/critical supply, but end-user shortage must be used to cope with any larger shortfalls.

The model calculates shortage costs based on recent retail water prices (Black and Veatch 2006), the level of demand, and a constant elasticity of demand (CED) loss function with a demand elasticity of -0.1. That is, the retail price and demand quantity are a point on the demand function, and the elasticity provides the slope. The marginal value of water from the CED function can be capped; the current cap is set at $7,000/AF more than the provider's retail water price.

Table 1 shows the CVP agencies included in OPWEM, their expected CVP contract amount, and a 2030 demand forecast. Other (non-CVP) supplies for an average and dry condition must be included. Table 2 provides these 2030 supply estimates for years that are wetter than dry years for each agency, and Table 3 provides dry and critical condition supplies.

The model includes about 318,000 AF of CVP M&I contract amounts, 11,000 AF of additional use of agricultural contracts for meeting 2030 M&I demand, and 750,000 AF of M&I demand in 2030. This demand includes small amounts of agricultural demand which is included because water supplies for urban and agricultural uses cannot be separated.

**Table 1. Agencies Included in OPWEM, Their Contracts, and 2030 Demand Forecast**

| CVP Contract Holder Agency | CVP contract (AF/year) | 2030 Normal Year Demand (AF/year) | Notes |
|---|---|---|---|
| City of Redding | 6,140 | 27,852 | City of Redding 2012 |
| Bella Vista Water District | 24,578 | 24,578 | See Appendix A |
| Clear Creek Community Services District (CSD) | 15,300 | 15,300 | See Appendix A |
| Shasta CSD, City of Shasta Lake, and United States Forest Service (USFS) | 5,410 | 5,410 | See Appendix A |
| Centerville CSD, Mountain Gate CSD, and Shasta County Water Agency | 5,272 | 5,272 | See Appendix A |
| City of Roseville | 32,000 | 49,334 | City of Roseville 2011: Table 3.11a |
| El Dorado Irrigation District | 7,550 | 57,039 | El Dorado Irrigation District 2011: Total Use Table 3-9 minus agriculture, Table 3-5. |
| Placer County Water Agency (PCWA) | 35,000 | 130,711 | PCWA 2011: Western Area, minus untreated sales to others |
| Sacramento County Water Agency (SCWA) | 52,000 | 114,898 | SCWA 2011: Table 4-15 |
| Sacramento Municipal Utility District (SMUD) | 30,000 | 30,000 | See Appendix A |
| San Juan Water District (SJWD) | 24,200 | 94,290 | SJWD 2011: No agricultural water included, sales to cities of Folsom and Roseville, page 18 |
| San Benito County Water District | 43,800 | 89,345 | Water Resources Association of San Benito County 2004: Includes about half agriculture, 3,000 losses |
| United States (U.S.) Department of Veterans Affairs, and State of California | 860 | 860 | See Appendix A |
| City of Tracy | 17,500 | 31,000 | City of Tracy 2011: Table 8 |
| City of Avenal | 3,500 | 3,500 | See Appendix A |
| City of Coalinga | 10,000 | 11,819 | City of Coalinga 2006 |
| City of Huron | 3,000 | 3,000 | See Appendix A |
| Cross Valley Canal | 1,704 | 1,704 | See Appendix A |
| Agricultural contractors with small M&I delivery, Sacramento River Division | 508 | 508 | See Appendix A |
| Agricultural contractors with small M&I delivery, Delta Division | 1,150 | 1,150 | See Appendix A |
| Agricultural contractors with small M&I delivery, Export | 7,904 | 7,904 | See Appendix A |
| TOTAL | 328,716 | 704,852 | |

**Table 2. 2030 Non-CVP Supplies (AF), Years Wetter than Dry Years**

| CVP Contract Holder | Surface Water | Natural Groundwater | Other Groundwater | Recycled Water | Transfers | Other, or Multiple Sources |
|---|---|---|---|---|---|---|
| City of Redding | 21,000 | 13,405 | | | | |
| Bella Vista Water District | | | | | | |
| Clear Creek CSD | | 30 | | | | |
| Shasta CSD, City of Shasta Lake, and USFS | | 2,000 | | | | |
| Centerville CSD, Mountain Gate CSD, and SCWA | | 900 | | | | |
| City of Roseville | 34,000 | | | 1,709 | 4,000 | |
| El Dorado Irrigation District | 0 | 23,000 | 15,080 | 7,730 | 21,560 | 7,500 |
| PCWA | 100,400 | 0 | | 6,987 | 3,400 | 36,000 |
| SCWA | 27,000 | 25,000 | 7,500 | 4,400 | 14,498 | 7,540 |
| SMUD | 0 | | | | | 18,024 |
| SJWD | 33,000 | | | | | 25,000 |
| San Benito County Water District | | 49,925 | | | | |
| U.S. Department of Veterans Affairs, and State of California | | | | | | |
| City of Tracy | | | | | | 18,500 |
| City of Avenal | | | | | | |
| City of Coalinga | | | 1,500 | 500 | | |
| City of Huron | | | | | | |
| Cross Valley Canal | | | | | | |
| Agricultural contractors with small M&I delivery, Sacramento River Division | | | | | | |
| Agricultural contractors with small M&I delivery, Delta Division | | | | | | |
| Agricultural contractors with small M&I delivery, Export | | | | | | |

Note: supplies amounts are not always unambiguously associated with the type of supply indicated. Some supplies from diverse sources are disaggregated into these columns rather than show them all as “Other.” The totals are unaffected by the categorization.

**Table 3. 2030 Non-CVP Supplies (AF), Dry and Critical Years**

| CVP Contract Holder Agency | Surface Water | Natural Groundwater | Other Groundwater | Recycled Water | Transfers | Banking | Storage Depletion | Other |
|---|---|---|---|---|---|---|---|---|
| City of Redding | 16,600 | 13,405 | | | | | | |
| Bella Vista Water District | | | | | | | | |
| Clear Creek CSD | | | | | | | | |
| Shasta CSD, City of Shasta Lake, and USFS | | 2,000 | | | | | | |
| Centerville CSD, Mountain Gate CSD, and SCWA | | 930 | | | | | | |
| City of Roseville | 24,000 | | | 3,397 | | | | |
| El Dorado Irrigation District | 0 | 23,000 | 15,080 | 7,730 | 17,000 | 7,500 | 4,560 | |
| PCWA | 100,400 | 0 | | 6,987 | 1,700 | | | 28,800 |
| SCWA | 63,000 | 37,200 | 7,500 | 4,400 | 9,300 | 6,000 | | 5,198 |
| SMUD | | | | | | | | 18,024 |
| SJWD | 33,000 | | | | 20,000 | | | |
| San Benito County Water District | | 49,925 | | | | | | |
| U.S. Department of Veterans Affairs, and State of California | | | | | | | | |
| City of Tracy | | | | | | | | 25,000 |
| City of Avenal | | | | | | | | |
| City of Coalinga | | | | | | | | |
| City of Huron | | | | | | | | |
| Cross Valley Canal | | | | | | | | |
| Agricultural contractors with small M&I delivery, Sacramento River Division | | | | | | | | |
| Agricultural contractors with small M&I delivery, Delta Division | | | | | | | | |
| Agricultural contractors with small M&I delivery, Export | | | | | | | | |

Note: supplies are not always unambiguously associated with the type of supply indicated

# A.2. OPWEM M&I Water Service Contractor Assumptions

Other than the San Francisco Bay Area (which is covered in LCPSIM), the primary areas that obtain urban water from the CVP are the Shasta and Trinity River Divisions, the American River Division, and the City of Tracy and San Benito County Water District south of the Sacramento-San Joaquin River Delta (Delta).

## A.2.1 Shasta and Trinity River Divisions

In the Shasta and Trinity River Divisions, 56,700 AF of CVP M&I contract is available to serve over 78,000 AF of urban demand in 2030. Most urban users have limited supplies to augment their CVP contracts, except that the City of Redding also has surface water rights and groundwater. Relatively small amounts of groundwater are also available to the City of Shasta Lake (2,000 AF) and Centerville CSD (900 AF). For this region, the alternative supply available in case of shortage is generally groundwater ($145 per AF) or water transfers ($246 or $307 in below normal/above normal/wet or dry/critical years, respectively). For Clear Creek CSD, a recent claim of $200 per AF for M&I use is used.

## A.2.2 American River Division

Most water demand and supply estimates in the American River Division are based on 2010 UWMPs. The American River basin includes about 476,000 AF of 2030 urban demands and 445,000 AF of non-CVP supplies in normal years. There are a number of permanent transfers among agencies within this region and overlying service areas that complicate the counting of demands and supplies. PCWA has over 250,000 AF of contract and water right supply. About 120,000 AF of PCWA's total supplies are provided by the Middle Fork Project, and most of the remainder, over 100,000 AF, is provided by agreements with Pacific Gas & Electric Company.

A large share of PCWA's supply is wholesaled to other agencies. PCWA expects to provide about 20,400 AF to SJWD in 2030, of which 4,000 AF will be provided to the City of Roseville. PCWA also wholesales 29,000 AF to Sacramento Suburban Water District in wetter years, but no delivery is expected for dry years. The City of Roseville obtains another 30,000 AF from PCWA in normal years (PCWA 2011). SJWD has its own pre-1914 water right for 33,000 AF, and SJWD expects to wholesale 1,540 AF to the City of Folsom by 2030 (SJWD 2011). Water provided to the City of Lincoln is included with PCWA. A summary of water rights and contract entitlements is provided in the 2006 American River Basin Integrated Regional Water Management Plan (Regional Water Authority 2006).

El Dorado Irrigation District has a variety of non-CVP supplies including, in normal years, water from Jenkinson Lake (23,000 AF), and a variety of other surface water sources (El Dorado Irrigation District 2011). El Dorado Irrigation District 2030 demands and supplies are reduced for 12,581 AF of agricultural demands (El Dorado Irrigation District 2011).

SMUD is expected to have a 2030 demand of 30,000 AF, the same amount as its CVP M&I contract, and 18,024 AF of other supplies are available to meet demand (see Appendix A).

SCWA wholesales some of its supplies; City of Folsom obtains 7,000 AF of 101-514 "Fazio water" when available from SCWA, and SCWA obtains wholesale water through agreements with the City of Sacramento. Regional demands and supplies include the City of Folsom, included with SCWA, which has 22,000 AF of its own pre-1914 water rights, and City of Folsom receives 5,000 AF from Golden State Water Company.

### A.2.3 South of the Delta

In San Benito County, it is assumed that the CVP M&I water service contract will be entirely converted to M&I use by 2030. San Benito County Water District has groundwater supplies to augment its CVP contract. In the San Joaquin Valley, the City of Tracy is the largest single user of CVP M&I contract water. Tracy has a variety of other water supplies.

### A.2.4 Agricultural Water Service Contractors

Relatively small amounts of contract and demand are included for Sacramento Valley agricultural water service contractors, the San Joaquin Valley cities of Avenal, Coalinga, and Huron, and San Joaquin Valley agricultural water service contractors with relatively small M&I use projected for 2030. UWMPs were generally not available for these smaller water users. Appendix A contains assumptions about supplies and 2030 demand levels are generally assumed equal to the contract amounts.

Table 4 provides unit costs used for alternative water supplies in years that are classified as below normal or wetter, and in dry and critical years. Cost data were generally based on a provider's most likely alternative supply source. Groundwater costs are intended to be based on full costs including capital, energy, and external costs. External costs are generally effects on groundwater tables and expected value for that water for future use. Groundwater costs are intended to reflect the groundwater tables used for urban supply which are often much deeper than water used for agricultural supplies. Conjunctive use costs are assumed for providers having access to established projects. Groundwater and conjunctive use costs estimates were updated to 2030 levels using forecast increases in real energy prices amounting to 2.3 percent annually. A large share of groundwater and conjunctive use costs are energy.

Water transfer costs are based on an evaluation of opportunity costs of agricultural water use conducted in the mid-2000s using the Central Valley Production Model, water transfer price data, and information on land rents and prices. Central Valley transfer costs are assumed to increase at a real rate of 1.5 percent per year. This rate of increase is consistent with observed rates of increase from the mid-2000s water transfer studies (Mann and Hatchett 2006).

**Table 4. Unit Costs of Additional Water Supplies in OPWEM ($/AF, 2030 Condition)**

| Contractors | Wetter than Dry condition | Dry or Critical condition |
|---|---|---|
| City of Redding | $145 | $217 |
| Bella Vista Water District | $145 | $217 |
| Agricultural contractors with small M&I delivery, Sacramento River Division | $145 | $217 |
| Clear Creek CSD | $254 | $254 |
| Shasta CSD, City of Shasta Lake, and USFS | $216 | $269 |
| Centerville CSD, Mountain Gate CSD, and SCWA | $145 | $217 |
| All American River Contractors | $236 | $331 |
| San Benito County Water District | $336 | $336 |
| U.S. Department of Veterans Affairs, and State of California | $297 | $345 |
| Cities of Tracy, Avenal, Coalinga, Huron | $297 | $345 |
| Cross Valley Canal | $297 | $345 |
| Agricultural contractors with small M&I delivery, Delta Division | $297 | $345 |
| Agricultural contractors with small M&I delivery, Export | $297 | $345 |

Note: In wetter than dry condition, unit costs can be zero when there is excess supply.

## A.3 References

Black and Veatch. 2006. 2006 California Water Rate Survey. Los Angeles.

City of Coalinga. 2006. 2005 Urban Water Management Plan. July 2006.

City of Redding. 2012. 2010 Urban Water Management Plan. July 17, 2012.

City of Roseville. 2011. 2010 Urban Water Management Plan. August 2011.

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