Master Response 2.3
Presentation of Data and Results in SED and Responses to Comments

Overview

Amendments to the 2006 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (Bay-Delta Plan) are an essential part of a comprehensive statewide effort to protect, restore, and enhance the aquatic ecosystem in the Bay-Delta and its surrounding watershed while continuing to provide a reliable water supply for communities and agriculture. The State Water Board released a recirculated substitute environmental document (SED) in support of changes to Bay-Delta plan amendments on September 15, 2016. A draft SED was previously circulated to the public in 2012. The SED contains information supporting the proposed plan amendments which include new and modified flow requirements for the Lower San Joaquin River (LSJR) and its major eastside tributaries, the Stanislaus, Tuolumne, and Merced Rivers (LSJR flow objectives), modifications to the southern Delta water quality (SDWQ) objectives for salinity, and programs of implementation for the objectives.

The presentation of data and results, particularly for a broad programmatic analysis like the SED, can be challenging. The SED environmental analysis for the plan amendments is, by its nature, complex. For example, a project-specific analysis, such as construction of a commercial building, knows exactly where the building will be located, its size, and the materials that will be used to construct it. The analysis can pinpoint the precise parcel(s) of land to be developed and their unique characteristics, such as if sensitive species inhabit the project site as well as which streets abut the parcel, their levels of service, the approximate number of trucks it will take to supply the construction site, and other site-specific and project-dependent factors such as who will neighbor the parcel and how sensitive those receptors may be to light and noise. In contrast, the SED evaluates the potential benefits and impacts of a proposed regulatory decision to increase required river flows to reasonably protect fish and wildlife, and to establish salinity levels that reasonably protect south Delta agriculture.

Unlike the fixed commercial building in the above example, water moves from place to place and the volume of water in a river changes depending on precipitation, demand, and other factors. In addition, the reaction of people to the proposed requirements could fall within a range of behaviors. For example, a grower's reaction to the LSJR flow objectives requiring more water instream (and thus less available surface water for diversion) might be to pump more groundwater, fallow land, or a combination of both. Because groundwater would be substitute water supply, then the more groundwater pumped equals the less land fallowed. This means that potential outcomes fall within ranges and also change based on environmental conditions (the more rain that falls, the less need to take either response). The State Water Board uses multiple tools to present data and results in the SED in order to communicate these ranges of outcomes to the public and decision makers in ways that are informative and meaningful.

Information is presented in the SED in various ways depending on what is being communicated and because people differ with respect to what forms of presentation they find to be most useful.

Although the SED utilizes widely-accepted analytical tools and common forms of presentation for data and results, some of these tools and methods of presentation are somewhat technical and can be challenging for non-technical readers to understand. The purpose of this master response is to help respond to commenters who stated that they did not understand some of the SED data summaries and data presentations that are used to describe changes and to evaluate impacts of the plan amendments, or were concerned that methods of data presentation in the SED masked or did not fully disclose the potential impacts of the plan amendments.

In addition to text, the SED uses tables, charts and graphs to fully describe the range of possible effects that could occur under the LSJR and SDWQ alternatives. Tables can be used to present concise information, such as how many acres of alfalfa are grown in an irrigation district. However, sometimes tables are not effective when long and wide columns of detailed numbers become burdensome and difficult for readers to interpret. Therefore, other types of presentations are used to summarize and visualize these results, such as line graphs, pie charts, bar charts, "cumulative distributions", and "exceedance plots." These can be less intuitive but help communicate important ideas, such as the probability that a certain outcome may happen as compared to other outcomes. Using the above example of the grower who might pump groundwater or fallow land depending on how hot and dry the weather has been illustrates the challenge because California's weather is highly variable. Thus, it becomes important to look at past precipitation records in order to evaluate weather patterns and then to communicate results in ways that reflect that variability. The SED did this using an 82-year period, from 1922 to 2003. Hydrologic data for this period is well-documented in a widely-used and accepted model that simulates California Hydrology called "CALSIM II." The State Water Board used CASIM II as the foundation and basis for the creation of the Water Supply Effects Model (WSE) used in the SED analysis. For more information regarding CALSIM II and WSE, please see Master Response 3.2, *Surface Water Analyses and Modeling*.

Data was also summarized using statistics, such as average, minimum, maximum, and median values. This allows the data to be presented as simplified results in order to easily convey summary information of potential effects to the reader. In addition, in many instances, the State Water Board presented the full set of data alongside the average conditions, in appendices, or through modeling files posted on the State Water Board's website for interested readers.

This master response includes for ease of reference a table of contents on the following page to help guide readers to specific subject areas. The table of contents is based on the recurring and common themes found in the comments that were received regarding data presentation in the SED. It is provided to help guide readers in finding where the topics of their concern are addressed. In general, this master response addresses the following topics regarding data presentation in the SED.

- Types of presentation methods.
- General summaries and statistics.
- Water year types and averages based on water year types.

These topics are also discussed to some extent in other master responses when related to specific topics covered in those master responses. In general, the SED uses many different methods to present data. The methods chosen are specific to each resource area being assessed and chosen in order to best disclose the potential effects and impacts.

Table of Contents

Types of Data

The term "data" as used in this master response, refers not only to collected or measured environmental information presented in the SED, but also to information resulting from modeling analyses. For example, flows can be measured at a California Data Exchange Center flow gage in a stream or a mathematical model can be used to simulate stream flows. The use of models is important because sometimes the condition being modeled is different from existing or past conditions. The challenge of performing an analysis on the Tuolumne River using only past hydrologic data provides a useful illustration. In 1923 the "Old" Don Pedro Dam was completed on the Tuolumne River and could impound about 290,400 acre-feet of water when full. In 1971, after four years of construction, the New Don Pedro Dam was completed. New Don Pedro inundated Old Don Pedro and created the sixth largest artificial lake in California, able to hold approximately 2,030,000 acre-feet of water. Because of these changes, any measurement of water on the Tuolumne between 1922 and 2003 could vary depending on whether it was below no Don Pedro, Old Don Pedro, or New Don Pedro. That means the only way to reconcile the existence of New Don Pedro with flows over the historic 1922-2003 period is through a model simulation.

Recorded or simulated information used to describe the environment can include, for example, rainfall data, flow data, temperature data, population data, etc. that can be summarized using various statistical approaches. For more information on the types of data presented in the SED, please see the various modeling appendices, such as Appendix F.1, *Hydrology and Water Quality Modeling,* Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, and Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results*.

Each potential environmental impact assessed in the SED uses an approach specific for each resource area to summarize the model results, compare the results against thresholds of significance, and make the impacts determinations. The environmental impact assessments are easily identifiable. Each chapter addressing a resource identifies potential impact categories with the word "Impact" and a letter and number code. The impact questions and evaluations are also summarized in a table in the Introduction section of the resource chapter. For example, "Impact GW-1," found in Chapter 9, *Groundwater Resources*, asks if implementation of the plan amendments could potentially "substantially deplete groundwater supplies or interfere substantially with groundwater recharge." As explained in the Overview to this section, that question is inherently about how people may respond to the potential for the implementation of the plan amendments to reduce surface water diversions. In other words, can they and will they pump groundwater? Or, for example, could someone who is using flood irrigation switch to a more efficient micro-sprinkler system and could that impact groundwater recharge? The resource areas evaluated in the SED differ widely and the description of impacts are specific to resources. For example, potential impacts to fish may be described by evaluating water temperature, whereas potential impacts to Important Farmland are described by evaluating changes in crop acreage. The SED uses multiple approaches to presenting data to communicate the range of potential effects and make impact determinations.

In addition to the resource chapters assessing whether there could be potentially significant adverse environmental impacts, the SED includes information and analyses on the environmental setting, potential benefits to fisheries, economics, and other areas that more fully inform and explain the potential consequences – both positive and negative – of approving the plan amendments. Examples include, but are not limited to, Chapter 2, *Water Resources*, Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30*, Chapter 20, *Economic Analyses*, Chapter 21, *Drought Evaluation,* and several appendices. Each of those chapters and appendices summarize data to explain and describe the different effects of the plan amendments. Methods of presenting data in these chapters and appendices are explained in this master response to clarify how data is presented throughout the SED and to respond to multiple comments related to this common theme.

Tables, Charts, and Graphs

As noted above, the SED used a wide variety of tables, charts and graphs in addition to text. That is because each has strengths and weaknesses for presenting information. A table is an arrangement of data in rows and columns. Tables are very useful for presenting raw information, but if the number of columns and rows becomes unwieldy, it can make comparisons difficult. A bar chart can provide a graphic comparison among discreet categories of information and a graph can show changes and patterns in changes. Tables are designated in the SED as "Table" followed by the chapter number or master response number and then numbered sequentially within that chapter or master response (e.g., Table 1-1, Table 1-2, etc.) Graphs, charts, exceedance plots, etc. are labeled "Figure" in the SED and follow the name numbering system of chapter or master response number, hyphen, and sequential number (i.e., Figure 1-1, Figure 1-2, etc.). A chapter or master response can have both tables and figures. To provide an example, crop acreages of four hypothetical irrigation districts (A, B, C, and D) are shown below in table (Table 2.3-1), chart (Figure 2.3-1), and graph (Figure 2.3-2) form.

Table 2.3-1. Crop Acreages of Irrigation Districts A–D

	Alfalfa	Nuts	Corn	Cotton
District A	4233	19673	8029	1845
District B	1620	13865	4209	1100
District C	6443	25789	12494	2409
District D	2783	15422	6822	1624

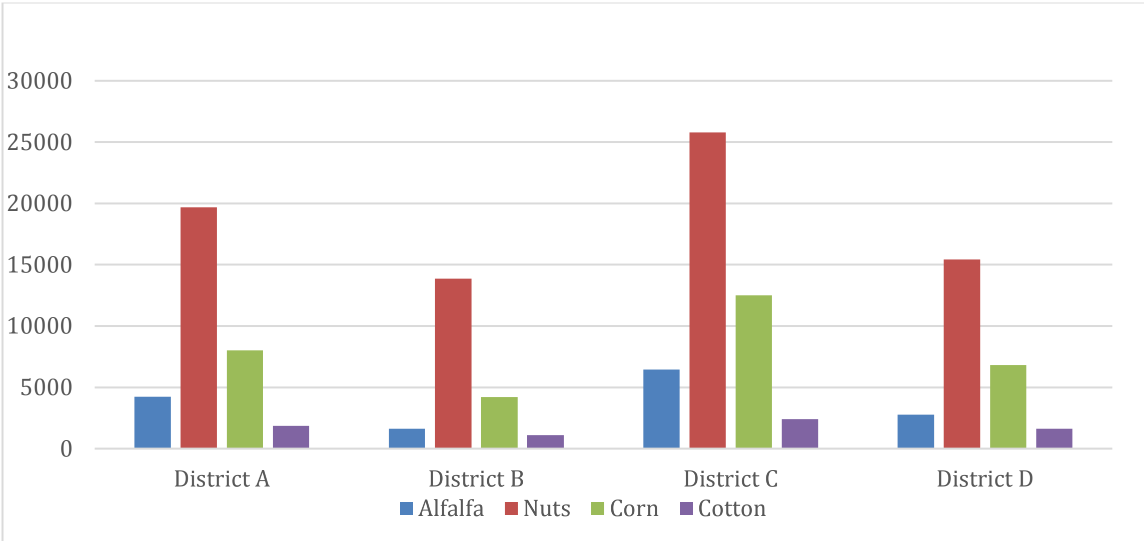

Figure 2.3-1. Crop Acreages of Irrigation Districts A–D

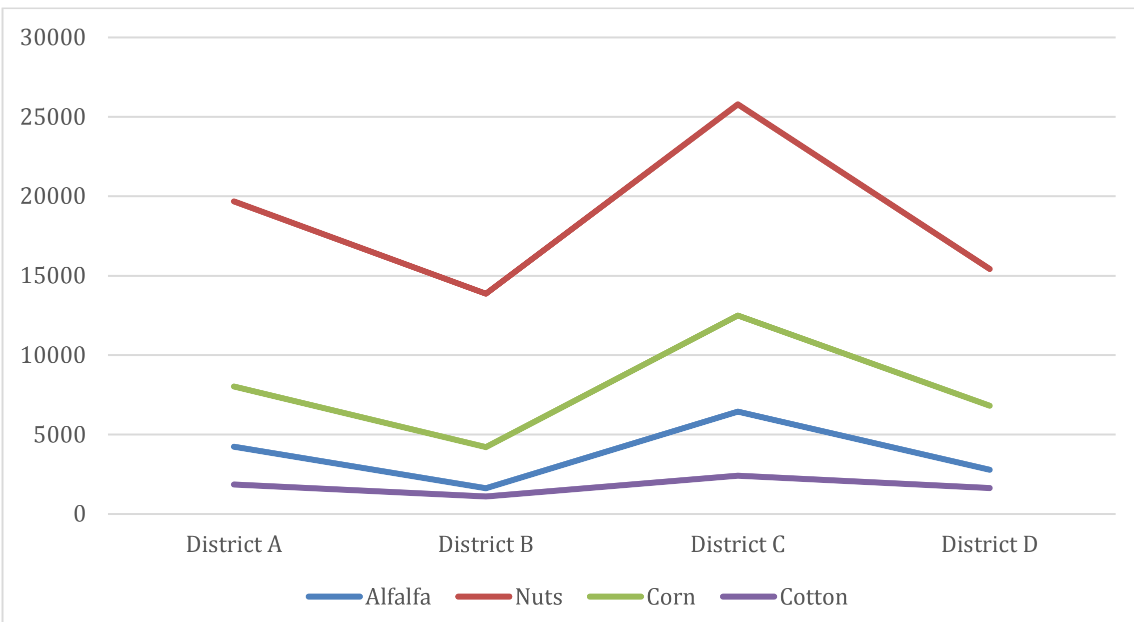

Figure 2.3-2. Crop Acreages of Irrigation Districts A–D

As demonstrated above, the use of various forms of data presentation can be helpful to visualize or emphasize different aspects of the same information, depending on the context.

General Summaries and Statistics

The State Water Board uses general summaries and basic statistics such as "average", "median", and "quartile" in the SED's summary sections, such as the environmental settings. Some impact determinations also use average values as the metric to determine whether a specific resource area will be impacted by the LSJR and SDWQ alternatives. The section below titled "Average (Mean)" describes how the SED uses average values to determine impacts of the alternatives. Other general summaries of data presentation are in the form of "time-series" and "frequency of occurrence."

These general summaries are valuable simplifications that allow many years of data to be more easily understood. Presenting the annual average deliveries, for example, allows a reader to quickly digest and understand how much water on average is available for diversion each year. Understanding that this is an average, each year could range up or down from this average value. Similarly, presenting the median annual delivery tells a reader that half of the time the annual delivery would be higher than this value, and half of the time the annual delivery would be lower.

When comparing two alternatives, the frequency of occurrence also becomes very useful. For example, if the baseline condition is already poor and the potential for a significant adverse impact increases under a given alternative relative to that baseline, the potential impact is likely significant. Thus, many of the impacts assessments are based on this type of data summary. The SED presents data using these general statistics and summaries in combination with other metrics, such as cumulative distributions, and percent of time equaled or exceeded, in order to portray the full range of potential impacts to readers. These kinds of general summaries and statistics are appropriate for determining environmental impacts in a programmatic level CEQA analysis. Averages, medians and quartiles, percentages, time-series, frequency of occurrence, cumulative distributions, and exceedance plots are all discussed in more detail below.

Averages

The average (or mean) is the sum of all data values divided by the number of data values. The average is a familiar summary statistic that describes a "typical" value in a dataset. This is useful when comparing regional impacts between a project alternative and baseline conditions. Continuing with the illustration using four hypothetical irrigation districts, the average number of acres for each category of crops would be derived by adding all of the acreage of a particular crop together for each of the four districts and then dividing by four, as follows in Table 2.3-2.

Table 2.3-2. Average Acres of Each Crop Type for Irrigation Districts A–D

	Alfalfa	Nuts	Corn	Cotton
District A	4233	19673	8029	1845
District B	1620	13865	4209	1100
District C	6443	25789	12494	2409
District D	2783	15422	6822	1624
Average	3770	18687	7889	1745

Medians and Quartiles

An average can be affected by high and low values in a dataset. The average can be higher than the middle value in the data set (i.e., the median) when large values are in the data set. Similarly, the average can be lower than the median when small values are in the data set. When the average is substantially higher or lower than the median, a few large or small values can be causing the average to differ from the median. Because it is less susceptible to effects from extremely high values and extremely low values (called "skew"), the median is often considered more representative of "typical" conditions. The median is the middle value in a data set between the highest and lowest values. Half of all data values are greater than the median, and half of all data values are less than the median. A quartile is similar to the median, but instead of being the midpoint, it is the one-quarter point. There are two quartiles, the upper quartile and the lower quartile. One quarter of the data values are above the upper quartile, one quarter are below the lower quartile, and half the data values are between the two quartiles. Using the above example of Irrigation Districts A-D and looking at Alfalfa, the average and the median are both displayed in Figure 2.3-3.

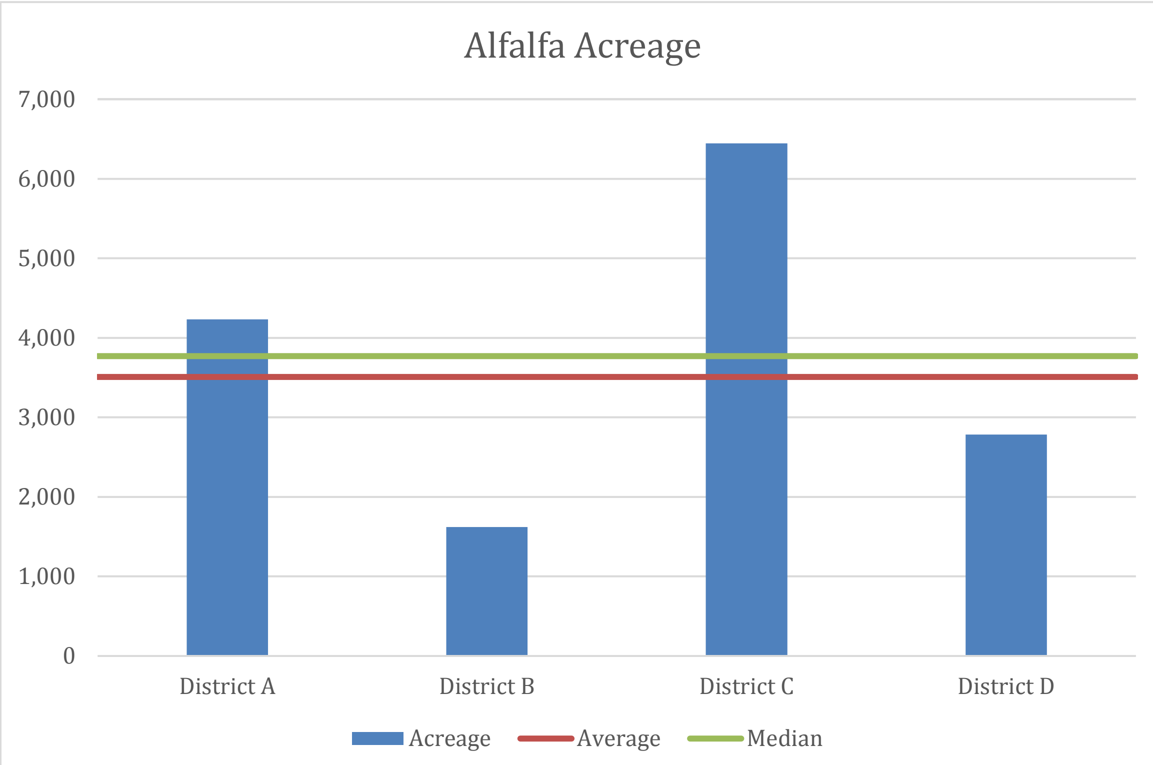

Figure 2.3-3. Average and Median Acreages of Alfalfa for Districts A–D

As mentioned in the Overview, the SED evaluated 82 years of unimpaired flow data (as monthly averages) for the LSJR, Stanislaus, Tuolumne, and Merced Rivers in recognition of the high variability in LSJR watershed precipitation (rain and snow) and surface hydrology. The unimpaired flow data are used to determine the frequency of occurrence of different types of water years from wet to critically dry. For example, out of the 82 years in the dataset, one year had an extremely high value (1983) and two years had very low values (1977 and 1931) of total unimpaired flow at Vernalis on the LSJR. These less frequent high flow years and low flow years result in the average value being greater than the median value; therefore, as noted above, the median is helpful to describe the typical conditions. The SED uses both the average and median to express relative changes in the percent of stream flow in order to evaluate how often different levels of flow are likely to occur and to explain and describe the potential effects of the LSJR plan amendments relative to the baseline.

Percentages

A percentage is a number or ratio that is expressed as a fraction of 100, often by the percent sign, "%." Percentages are used to express the proportionate part of a total. To find the percent, the numeric value is multiplied by 100. For example, if the only crops grown in Irrigation District A were alfalfa, nuts, corn, and cotton, as listed above, then alfalfa is approximately 8%. That is computed by dividing the alfalfa acreage by the total acreage, rounding to the nearest 100th and multiplying by 100 (i.e., $^{4233}/_{33,780}$ = .125; rounded up .13 x 100 = approximately 13%). Percentages are frequently represented by "pie charts" where the "pie" represents the whole and the proportional pieces the percentage. The crops for Irrigation District A are displayed as a pie chart in Figure 2.3-4.

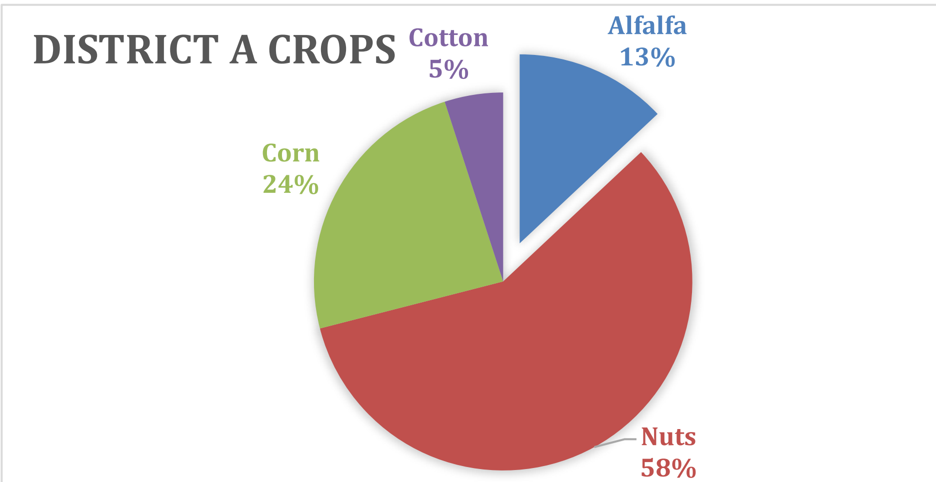

Figure 2.3-4. District A Crops by Percentage of Type

SED Use of Averages, Medians, and Percentages

The Executive Summary, section ES5.4, *Effects of the Flow Proposal*, provides an example of how the SED uses average values combined with percentages to generally describe water deliveries. The section states, "The long-term mean annual reduction in surface water supplies for the 40 percent of unimpaired flow proposal (LSJR Alternative 3) is 293 thousand acre-feet (TAF), which is a 14 percent reduction in surface water supply from the current condition in the plan area." The *Executive Summary* goes on to clarify that this is an average across all years and that effects are less in wet years and greater in dry and critically dry years using the following language, "Table ES-3 shows that the mean annual reduction in the plan area in dry and critically dry years is much higher—673 TAF (30 percent reduction) and 624 (38 percent reduction), respectively." Water year type classifications are described in more detail in the section below titled "Water Year Types." The *Executive Summary* is one example where general statistics describe effects over the long-term, other examples of summaries that use average, median, and quartiles to describe flows in some of the plan area rivers are found in Figures 2.6, 2.10, 2.11, and 2.12 of Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. Other chapters of the SED incorporate more detailed comparisons that are based on the entire distribution of data from the 82-year model simulation and present information as to specific water year types.

Multiple commenters stated that the use of an average to assess impacts either masks or does not provide full disclosure of the potential impact. However, not only does the SED often provide information in a variety of ways in addition to averages, such as detailed information in the technical appendices, on the State Water Board web site, or both, but the use of averages in the SED is appropriate. As discussed in Master Response 1.1, *General Comments*, the Board must comply with Section 21159 of CEQA, which states that "the agency may utilize numerical ranges or averages where specific data is not available; however, the agency shall not be required to engage in speculation or conjecture." (*Id*. at subd. (a) and (d).) (Pub. Resources Code, § 21159- Cal. Code Regs., tit. 23, § 3777, subd. (c).) Furthermore, as the Supreme Court noted in *Communities for a Better Environment*, "[e]nvironmental conditions may vary from year to year and in some cases it is necessary to consider conditions over a range of time periods." (*Communities for a Better Environment v. South Coast Air Quality Management District* (2010) 48 Cal.4th 310, 327-328, citing *Save Our Peninsula Committee v. Monterey County Bd. of Supervisors* (2001) 87 Cal.App.4th 99, 125.) This is particularly true for stream flow and hydrology in California which, as noted above, is highly variable.

For every impact assessment in the SED, best professional judgment was used to select the metrics best suited to present results and determine impacts. In many cases, using an average was determined to be appropriate for the assessment because the criteria for significance were generally driven by changes in long-term conditions, or an overall change from baseline conditions that, if significant, would change the long-term average for those conditions. The average, or mean, was determined to be a good impact metric in these cases and is easy for the reader to interpret. For example, SED Chapter 11, *Agricultural Resources* uses average acreage reduction to assess Impact AG-1. Average acreage reduction was used because it is representative of the changes in Important Farmland across all hydrologic conditions. Averages are also used to summarize general modeling and analysis results in various chapters such as the *Executive Summary*, Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30,* and Chapter 20, *Economic Analyses*. This is appropriate because it presents the data in a simple and easy to understand format. As noted above, many times these average summary values are accompanied by other, more detailed forms of data presentation (such as cumulative distributions and exceedance charts) to provide a more in-depth discussion of the impacts.

The SED uses average values in assessing significance determinations for the following impact categories.

- AQUA-2: Changes in availability of coldwater species reservoir habitat resulting from changes in reservoir storage (reduction in average end-of-September storage)
- AQUA-3: Changes in the quantity/quality of physical habitat for spawning and rearing resulting from changes in flow (reduction in average WUA of =>10 percent)
- AQUA-4: Changes in exposure of fish to suboptimal water temperatures resulting from changes in reservoir storage and releases (increase in monthly average 7DADM of 1^0F)
- GW-1 and GW-2: Substantially deplete groundwater supplies or interfere substantially with groundwater recharge and (GW-2) cause subsidence as a result of groundwater depletion (average annual net change in groundwater balance)
- AG-1: Potentially convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to nonagricultural use (average reduction in irrigated crop acreage)

The use of annual average to determine significance of AG-1 impacts is appropriate because the amount of irrigated acreage is relatively stable without substantial changes each year; the dataset does not have high variability (PPIC 2017, Figure 3). The use of annual average is also appropriate for the GW-1 impact category because changes in the annual average depth to groundwater indicate a long-term change relative to baseline. Groundwater levels are declining over time; however, the dataset is not characterized by high variability (PPIC 2015, Figure 3). Exceedance charts are provided to support GW-1 significance determinations by showing the full range of expected groundwater pumping rates in each groundwater subbasin for the baseline condition and LSJR Alternatives.

The use of averages is appropriate for AQUA-2, 3, and 4 significance determinations even though they are based on highly variable surface water hydrology. The AQUA-2, 3, and 4 impact analyses use seasonal averages (specific to life stage and habitat needs) and require a change of ten percent or more in the seasonal average to be considered significant. The complete range of changes to AQUA impact categories are provided in cumulative distribution tables that disclose the minimum, maximum, average, and the change at every tenth percentile of the data range.

The AQUA-2 impact category evaluates changes in availability of coldwater habitat in reservoirs that may occur due to the LSJR Alternatives. A reduction in average end -of-September storage was used to make CEQA impact determinations because it represents the month at the end of the summer irrigation season when reservoir storage and coldwater habitat availability are usually at their lowest levels. Chapter 7, *Aquatic Biological Resources*, states,

> the potential for significant impacts was assumed to exist if reservoir storage levels in September are reduced by 10 percent or more relative to baseline conditions. This is considered a reasonable criterion given the large seasonal and annual fluctuations in reservoir storage experienced by fish in reservoirs. A change in the average end-of-September greater than 10 percent indicates a persistent change of more or less coldwater reservoir habitat. Tables 7-9a, 7-9b, and 7-9c show the changes in end-of-September elevation for the three reservoirs compared to baseline.

Tables 7-9a, 7-9b, and 7-9c show the complete range of changes to average end-of-September storage including the minimum, maximum, average, and the change at every tenth percentile of the data range. Values in this table are the change from the average. Negative values show a reduction in average reservoir storage volume and positive values show an increase in average reservoir storage volume. The average is an appropriate impact metric for AQUA-2 because end-of-September storage volume represents the month with the lowest levels at which impacts are most likely to occur and an overall change from baseline conditions, if significant, would change the long-term reservoir coldwater habitat for reservoir fish species.

The AQUA-3 impact category evaluates changes in the quantity and quality of physical habitat for fall-run Chinook salmon and Central Valley steelhead spawning and rearing life stages due to river flow changes under the LSJR alternatives. Spawning and rearing habitat were evaluated by comparing the magnitude and frequency of average weighted usable area (WUA)[1] and floodplain inundation area under each of the LSJR alternatives to baseline conditions over the 82-year modeling period. For example, AQUA-3 impact determinations for fall-run Chinook salmon were made using average October – December WUA for spawning habitat with a significance threshold of a greater than 10 percent change. Rearing habitat impact determinations for fall-run Chinook salmon were based on a combination of average January – March WUA, average April – May WUA,

[1] WUA is a measure of the quantity and quality of habitat for a given species and life stage and is generally defined as the surface area of a stream having a certain combination of water depths. Please see Chapter 7 for more information.

and February – May frequency of floodplain inundation with a significance threshold of a greater than 10 percent change and best professional judgement. The use of averages is appropriate for AQUA-3 because the analysis uses seasonal averages specific to life stage and an overall change from average baseline conditions, if significant, would change the long-term quantity and quality of physical habitat for spawning and rearing. In addition, the complete range of changes to WUA and frequency of floodplain inundation including the minimum, maximum, average, and the change at every tenth percentile of the data range is provided in Chapter 7.

The AQUA-4 impact category evaluates changes in exposure of fish to suboptimal water temperatures resulting from changes in reservoir storage and releases. Significant impacts were identified using U.S. Environmental Protection Agency's (USEPA's) recommended temperature criteria for protection of salmonids (USEPA 2003). Chapter 7 states,

> Significant impacts were identified based on changes of 10 percent or more in the frequency of water temperatures exceeding the USEPA criteria, and/or changes in average 7DADM water temperature of 1°F or more. These thresholds in combination with consideration of the potential exposure of Chinook and steelhead populations to suboptimal water temperatures at key locations and months (Tables 7-18 and 7-19) were used to determine whether impacts are significant. Due to lack of quantitative relationships between a given change in environmental conditions and relevant population metrics (e.g., survival or abundance), 10 percent was selected because that value is assumed to be high enough to reveal significant change to a condition while a lessor amount of change could be due to error in the various analytical and modeling techniques.

The use of averages is appropriate for AQUA-4. The evaluation uses a monthly average of a 7-day average of the daily maximum (7DADM) temperature value. The 7DADM is used because it describes maximum temperatures in a stream but is not overly influenced by the maximum temperature of a single day. Thus, it reflects an average of maximum temperatures that fish are exposed to over weekly periods. The monthly average of 7DADM is appropriate for determination of significant effects a change of 10 percent or more in the monthly average indicates a long-term change in temperature conditions that could be significant for coldwater fish species. The complete range of changes to 7DADM water temperature relative to baseline are provided in Chapter 7 including the minimum, maximum, average, and the change at every tenth percentile of the data range. The reader is provided a full description of the potential temperature outcomes for each LSJR alternative relative to the baseline condition.

Please refer to Master Response 3.1, *Fish Protection*; Master Response 3.4, *Groundwater and the Sustainable Groundwater Management Act*; and Master Response 3.5 *Agricultural Resources* and Chapter 7, *Aquatic Biological Resources*; Chapter 9, G*roundwater Resources*; Chapter 11, *Agricultural Resources*; and Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30,* for additional information regarding significance determinations and disclosure of impacts to the impact categories discussed in this section and similar impact categories.

Time Series

Another approach used in the SED and response to comments is to present data in a table or chart containing a *time series* of monthly or annual model results, and in the case of the temperature model, daily results. For example, Figure 2.3-5 (which is a copy of Figure 5-9 from Chapter 5, *Surface Hydrology and Water Quality*) shows the time series of annual total diversion deliveries for the simulation period (1922 through 2003) for the baseline and LSJR alternatives. A time series allows a reader to quickly assess the magnitude and frequency of changes, for example in deliveries, and displays all data generated by the model so a reader can quickly pick out specific time periods they may be interested in. The SED uses monthly and annual time series in charts and tables throughout the document and appendices to present all relevant data needed to assess effects of the LSJR alternatives, especially to diversion deliveries, river flows and temperatures, and reservoir storage. These time series can be considered raw data.[2] Time-series are used frequently in the SED to present data on a monthly time step, and to show how the results of an alternative scenario change from the baseline scenario on a month to month basis. The time series, however, is not used alone to assess impacts because this does not allow an investigator to focus on a specific subset of the data. Time series are frequently used by investigators to visually compare datasets/results of multiple model runs, or to calibrate a model to the historic conditions.

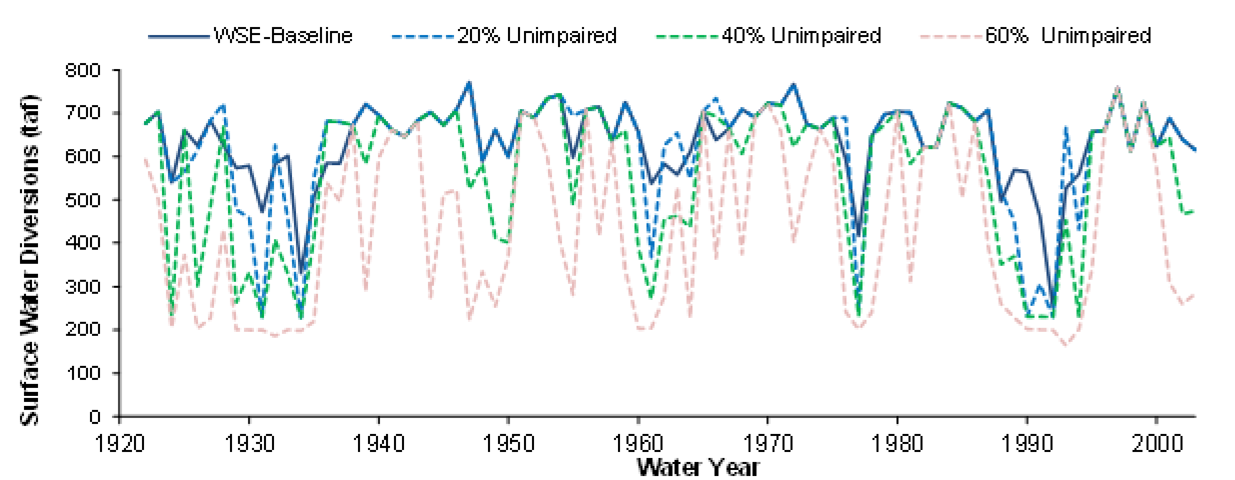

Figure 2.3-5. Comparison of WSE Model Results for Baseline and LSJR Alternatives: Stanislaus River Diversions for 1922–2003 (taf = thousand acre-feet) (Copy of Figure 5-9 of Chapter 5)

Frequency of Occurrence

The majority of impacts assessments in the SED use the *frequency of occurrence* of meeting a specific metric or significance threshold to compare baseline results to LJSR alternative results and make impact determinations. The frequency analysis uses the raw data to determine the frequency of occurrence of a specific condition. When comparing two alternatives, an impact can be easily determined if the frequency of an undesirable condition increases from baseline to an alternative. Thus, many of the impacts assessments are based on this type of data summary. Table 7-7A - *Summary of the Impact Thresholds, Variables, Criteria, and Data or Methods Used* in Chapter 7, *Aquatic Biological Resources*, states some of the types of data used to characterize and assess impacts related to aquatic biological resources.

Similarly, when comparing two alternatives, a benefit can be easily determined if the frequency of a desirable condition increases from baseline to an alternative. For example, an analysis in Chapter 19

[2] Raw data refers to directly measured or calculated values, for example measured flow rate or calculated flow from a simple equation or a complex model. Raw data have not been processed into summary statistics such as the average, median, mode, or standard deviation.

uses the frequency of attaining certain temperature thresholds in the project area rivers to compare alternative scenarios:

> The percentage of days during each month over the modeled 34-year period (1970-2003; n= number of days per specific month multiplied by 34 years) that USEPA criteria are expected to be met at each river location identified in Table 19-1 and Table 19-2 were used to quantify changes between baseline conditions and the conditions resulting from the modeled unimpaired flows. A 10% change in the amount of time that USEPA criteria is met, in combination with professional judgment, is used to determine a significant benefit or impact. Ten percent was selected because it accounts for a reasonable range of potential error associated with the assumptions used in the various analytical and modeling techniques.

The following impacts use the frequency of occurrence of a specific metric to make the impact determinations.

- FLO-1 and FLO-2: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river in a manner that would result in substantial erosion or siltation on- or off-site and (FLO-2) or substantially increase the rate or amount of surface runoff in manner that would result in flooding on- or off-site (increase in peak flow during wet years)
- AQUA-1: Changes in spawning success and habitat availability of warmwater species resulting from changes in reservoir water levels (frequency of month-to-month reservoir depth change greater than 15 feet [ft])
- AQUA-3: Changes in quantity/quality of physical habitat for spawning and rearing resulting from changes in flow (frequency of floodplain inundation at >= 50 acres)
- AQUA-4: Changes in exposure of fish to suboptimal water temperatures resulting from changes in reservoir storage and releases (frequency of water temp. over USEPA criteria)
- AQUA-6: Changes in exposure to suspended sediment and turbidity resulting from changes in flow (frequency of sediment-mobilizing flows)
- AQUA-7: Changes in redd dewatering resulting from flow fluctuations (frequency of month-to-month flow depth reduction greater than 1 ft)
- AQUA-8: Changes in spawning habitat quality resulting from changes in peak flows (frequency of gravel mobilizing flows)
- AQUA-9: Changes in food availability resulting from changes in flow and floodplain inundation (frequency of access to food sources by floodplain inundation)
- AQUA-10: Changes in predation risk resulting from changes in flow and water temperature (frequency of habitat availability and suboptimal temperatures)
- AQUA-11: Changes in disease risk resulting from changes in water temperature (frequency of temperature above 59^{0}F)
- REC-1 and REC-2: Substantially physically deteriorate existing recreation facilities on the rivers or at reservoirs and (REC-2) substantially degrade the existing visual character or quality of the reservoirs (frequency of specific ranges of flows and reservoir elevations appropriate for various recreational activities)

- BIO-1 Have a substantial adverse effect on any riparian habitat or other sensitive natural terrestrial communities identified in local or regional plans, policies, regulations or by CDFW and USFWS (frequency of Month-Month reservoir fluctuation of greater than 10 ft)
- WQ-1 Violate water quality standards by increasing the number of months with EC above the water quality objectives for salinity at Vernalis or southern Delta compliance stations (frequency monthly EC above objectives)

Frequency of occurrence is closely related to the cumulative distribution and percent of time equaled or exceeded, both of which are described in more detail in the following sections.

Cumulative Distributions

Multiple commenters stated that the SED failed to represent the full range of results of the alternatives. This section describes cumulative distributions and how the SED uses these summaries to present the full range of results in addition to the general summaries provided by averages and medians. The SED may evaluate effects using entire cumulative distributions, specific ranges within the cumulative distribution, or other specific values, such as frequency of occurrence, that can be investigated using a cumulative distribution. Cumulative distributions are a more complex concept but very helpful when looking at a condition like river flow, which varies according to that year's hydrology (rain and snowmelt).

Water is often measured in cubic feet per second (cfs), which is a rate of water passing a certain point, and acre-feet (AF), which is a volume of water. A cubic foot is about a basketball-sized amount. So, 1 cfs would only be enough flow in the stream to fill one basketball sized container every second and 500 cfs would be the rate of flow passing by a fixed point in a river powerful enough to fill 500 basketball sized containers every second. The other primary measurement of water, especially for irrigation, is an "acre-foot." An acre-foot is enough water to flood an acre one foot deep, or about a football field-sized area knee deep. There is a relationship between the two. A pipe discharging 1 cfs for 24 hours (i.e., pumping out about a basketball-sized amount of water every second) would discharge 2 acre-feet of water each day; enough to cover an acre in 2 feet of water. Both cfs and AF are used in the SED, including TAF thousand acre-feet) and MAF (million acre-feet).

For purposes of explaining cumulative distributions, Table 2.3-3 provides a simplified example using the annual volume of 11 fictional water years on "Unnamed River" measured in TAF. The rank indicates how large each flow value is relative to all other values in the set (1 is the smallest and 11 is the largest).

Table 2.3-3. Annual Volume of Water (thousand acre-feet) on Unnamed River for Years 1–11

Year	Flow volume	Rank
1	3,459	2
2	8,745	9
3	6,471	5
4	18,978	11
5	11,035	10
6	6,783	6
7	7,100	7
8	3,626	3
9	7,360	8
10	1,100	1
11	4,268	4

Figure 2.3-6 shows the variability, year to year on Unnamed River.

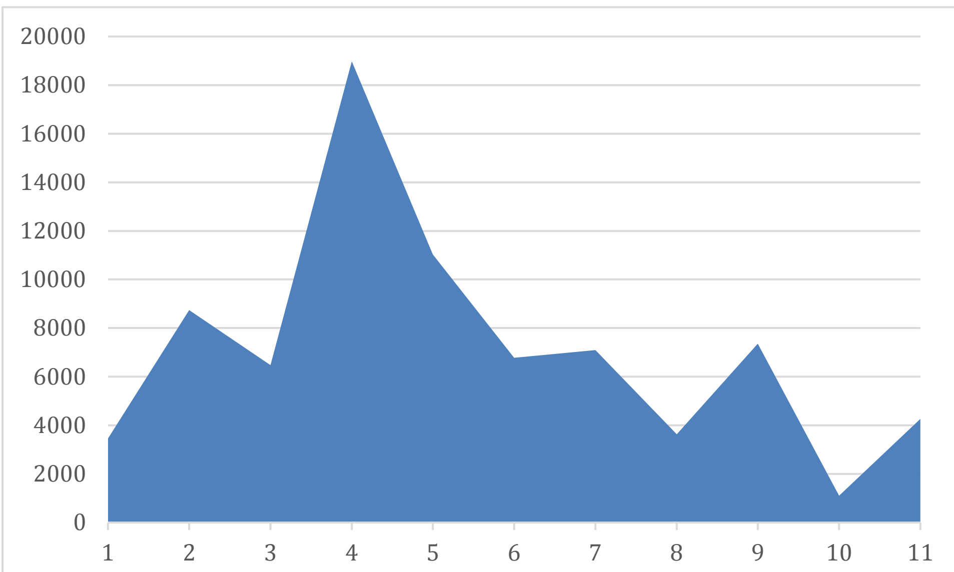

Figure 2.3-6. Unnamed River Annual Flow Volume (thousand acre-feet), Years 1–11

If all water years were arranged from driest to wettest with the driest year on the left and the wettest year on right, it would look like Figure 2.3-7.

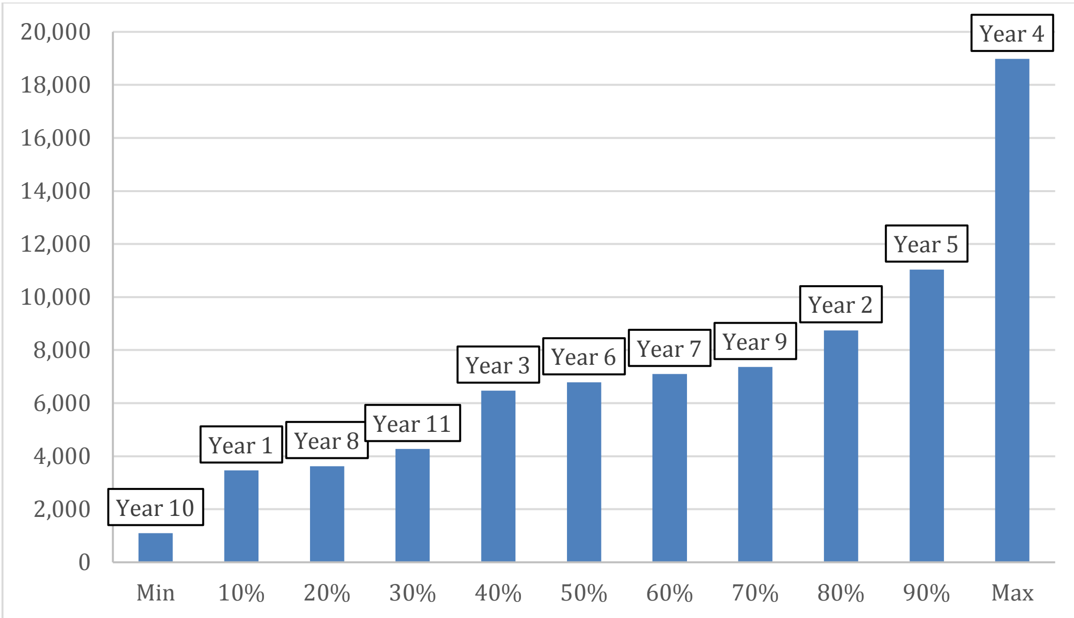

Figure 2.3-7. Unnamed River Annual Flow (thousand acre-feet), Years 1–11 in Order of Volume

There are 11 different water years represented in the above example of Unnamed River. "Year 10" represents the single driest year in Table 2.3-3, and is the minimum value in Figure 2.3-7 (left column of the figure) because there are 0 years in the range that are less than that year. In contrast, "Year 4" represents the single wettest year and is the maximum value in Figure 2.3-7 (right column of the figure) because 100% of the years (i.e. all of the years) are less than that year. Each of the other water years are between the minimum and maximum values and fall at every tenth percentile. A percentile is the value below which a given percentage of observations in the group falls. For example, the 20th percentile is the value (or score) below which 20 percent of the observations may be found. With regards to the data set on Unnamed River, the 80th percentile can be thought of as the dividing line where there is an 80% chance that this much flow *or less* will occur. Stated in the alternative, there is only a 20% chance, given the (limited) data set in the example, that this same level of flow is likely to be exceeded (i.e., that it will be wetter than this). Exceedance plots are discussed in more detail below but can represent the same information presented in an alternative way.

Water flow in a watershed is not random – it falls within a range -- but it is variable. Looking at cumulative distributions can be helpful for understanding the severity of impacts and the likelihood of impacts at that severity. For example, if a certain level of water supply can be used by irrigated agriculture in order to grow crops, it is important to know how often that level of demand is met in the baseline (i.e., without the effects of the project) and how it could be impacted by a project that reduces the water availability.

Table 2.3-4 is a copy of Table 5-20b from Chapter 5. (It is slightly reformatted to fit within the page width). It provides an example of how a cumulative distribution is used to present the potential effects of requiring more water to be left in the Stanislaus, Tuolumne, and Merced Rivers under the LSJR flow alternatives and how that impacts meeting water needs for irrigation demands. The irrigation water "demand" is based on how much of each type of crop is in the plan and the amount of water those crops need. The table includes enough information to determine the magnitude of effects as well as the frequency, or likelihood that effects will reach that magnitude. The percentile on the left corresponds to the 82-year hydrology, as explained in the example above, moving from the driest (minimum) to the wettest (maximum) in increments of 10%.

Table 2.3-4. Annual Cumulative Distributions of Percentage of Demand for Diversion Met for Baseline and LSJR Alternatives 2, 3, and 4 (20, 40, and 60 Percent Unimpaired Flow) for Irrigation Years 1922–2003 (Copy of Table 5-20b from Chapter 5)

	Stanislaus				Tuolumne				Merced			
Percentile	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4
Min	36	32	31	25	57	38	35	23	19	30	30	30
10	77	62	37	28	76	71	46	25	70	57	40	33
20	81	85	55	29	100	93	59	29	94	71	54	37
30	86	87	67	36	100	100	69	38	100	87	61	44
40	92	100	82	46	100	100	83	50	100	96	73	50
50	100	100	98	55	100	100	98	57	100	100	89	59
60	100	100	100	73	100	100	100	76	100	100	100	69
70	100	100	100	88	100	100	100	84	100	100	100	77
80	100	100	100	100	100	100	100	100	100	100	100	100
90	100	100	100	100	100	100	100	100	100	100	100	100
Max	100	100	100	100	100	100	100	100	100	100	100	100
Average	91	89	80	62	95	93	82	63	92	87	78	64

The above chart represents the hydrologic variability of the Stanislaus, Tuolumne, and Merced Rivers (based on the 82 years of data) and, in the context of that hydrologic pattern, the ability of the irrigation districts on each of the rivers to meet 100% of the irrigation demand. Note that even under the baseline conditions, the irrigation districts on the Stanislaus only expect to meet full demand (100%) in about half of the years (i.e., the 100 is at the 50th percentile mark in the baseline meaning half of the years have been drier than that and half of the years wetter). On the Tuolumne and Merced, full demand is more conservative. Irrigation Districts on the Tuolumne expect to be short of full demand in less than 20% of the years (i.e., the driest years). Irrigation Districts on the Merced expect to be short of full demand in less than 30% of the years. In other words, for the Merced the "100%" is still be being met at the 30th percentile. As a reader follows from the percentile in column 1 across the row to the right they are able to see, for each LSJR flow alternative, how implementation of that alternative could change the percent of demand that would be met as compared to the baseline. For example, for the Stanislaus, under LSRJ Alternative 3 (the 40% unimpaired flow alternative), demand decreases at the 50th percentile from 100% of demand being met in the baseline to 98% of the demand being met under Alternative 3; and, at the 40th percentile from 92% of demand being met under baseline to 82% of the demand being met under Alternative 3. However, the table does not reflect whether the potential impact could be mitigated. For example, if demand itself were reduced by more efficient methods of irrigation (e.g., micro-sprinklers for some crops as compared to flood irrigation) then even if there was less irrigation water available a higher percent of that (reduced) demand than is displayed in this table could be met.

Other chapters also use the cumulative distributions, for example, to assess effects to river flows and river temperatures, floodplain inundation, available diversions, and reservoir elevations. The data is presented as a cumulative distribution to display the full range of results under the 82-year hydrology and show how each variable is likely to change with the plan amendments. Aside from the direct effects to resources dependent on these variables, other chapters in the SED use cumulative distributions to describe and investigate potential effects regarding agricultural economics, fish benefits, and hydropower generation. Cumulative distribution tables, like the one above, are used throughout the SED to present results and compare alternatives. Below is a list of some of the chapters and impacts that use cumulative distributions to present data and effects of the alternatives.

The following impact analyses use the monthly cumulative distribution to make impact determinations.

- WQ-2 Substantially degrade water quality by increasing Vernalis or southern Delta salinity (EC) such that agricultural beneficial uses are impaired (distribution of average April – September EC)
- WQ-3 Substantially degrade water quality by increasing pollutant concentrations caused by reduced river flows (median and 10th percentile flow)
- REC-1 and REC-2 Substantially physically deteriorate existing recreation facilities on the rivers or at reservoirs (REC-2) Substantially degrade the existing visual character or quality of the reservoirs (frequency that modeled flow falls within optimal flow ranges for various recreational activities, frequency that modeled reservoir elevations fall within optimal ranges)

The following are some of the other chapters that also use a cumulative distribution to summarize data.

- Related to water resources (flows, diversions, reservoir storage), Chapter 5, Surface Hydrology and Water Quality; Appendix C, Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives; Appendix F.1, Hydrologic and Water Quality Modeling; and F.2, Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta.
- Related to agricultural resources, Chapter 11, Agricultural Resources, and Appendix G, Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results.
- Related to aquatic resources, Chapter 7, Aquatic Biological Resources, and Chapter 19, Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30.
- Related to economic effects, Chapter 20, *Economic Analyses*.
- Related to drought analysis, Chapter 21, *Drought Evaluation*.

Percent of Time Equaled or Exceeded (i.e., Exceedance Plots and Tables)

Several sections of the SED use "percent of time equaled or exceeded" or present this information in "exceedance charts" or exceedance distributions. For a given dataset, the exceedance distribution is related to the cumulative distribution in that all data values are presented in a ranked order. Cumulative distribution data values are ordered from smallest to largest while for an exceedance distribution data values are ordered from largest to smallest.

Figure 2.3-8 (which is a copy of Figure 11-9 from Chapter 11, *Agricultural Resources*) is an exceedance chart for South San Joaquin Irrigation District (SSJID) irrigated agriculture for baseline and the LSJR Alternatives.

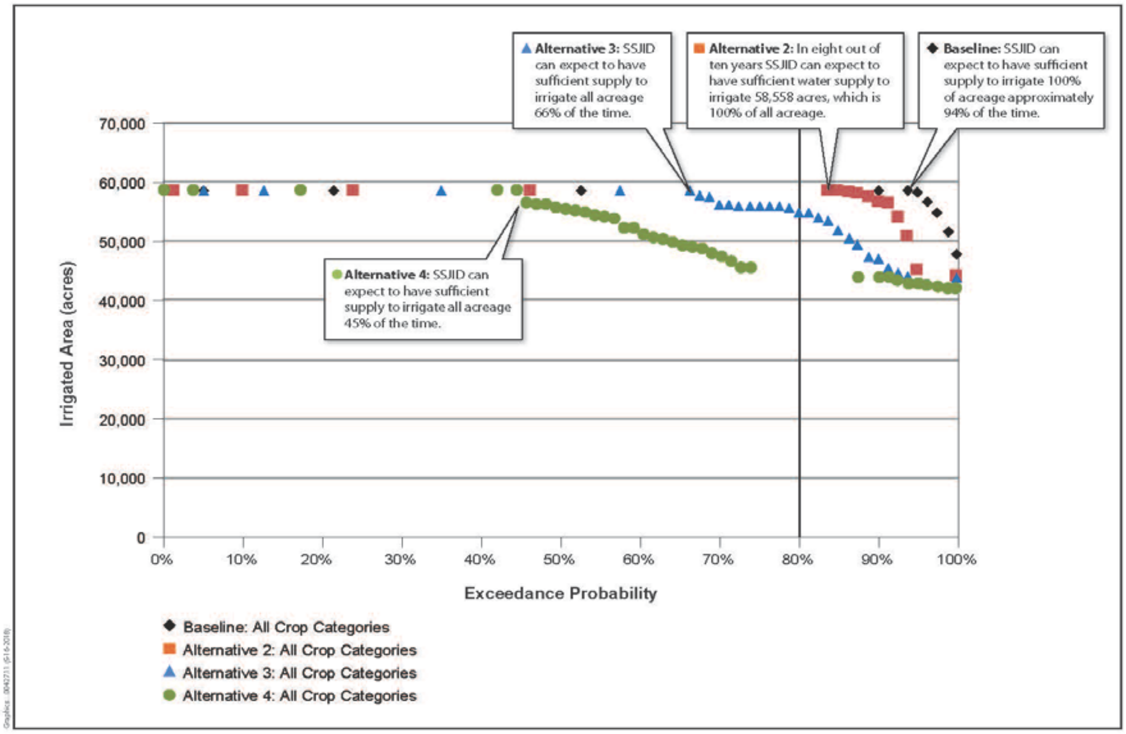

Figure 2.3-8. Irrigated Acreage in SSJID for All Crops, All LSJR Alternatives, and Baseline (Copy of Figure 11-9 of Chapter 11)

Note, the 80 percent exceedance probability line (marked on the chart for interpretation of effects of LSJR Alternative 2) is also considered the 20th percentile. That is because the 80% stands for the level that has an 80% likelihood of being exceeded. In other words, it is only in the 20% of driest years (20th percentile or worse) that this level is *not* exceeded. The black diamonds are baseline, with the orange squares, blue diamonds, and green circles representing how Alternatives 2, 3, and 4, respectively, would potentially change the level of surface water available for agricultural irrigation. The chart shows that in the current baseline, in the worst water years (driest), SSJID grows about 40,000 acres. So, in baseline, the level of irrigated agriculture in the district is always 40,000 acres or better (i.e. meets or exceeds 40,000 acres). The chart also shows that the maximum amount of irrigated agriculture is close to 60,000 acres. Under baseline, SSJID provides enough water to keep 60,000 acres in production 95% of the time. Since that is the maximum level of irrigated acreage, it does not increase even as you move to the left on the chart. In other words, at the 10% exceedance level (a level so wet that it is exceeded less than 10 percent of the time a.k.a. the 90th percentile in terms of the wettest years), the amount of irrigated agriculture is still roughly 60,000 acres.

Percent exceedance charts like this are used in various places throughout the SED, and extensively in Chapter 11 when summarizing the potential effects to irrigated acreage by crop type, within each irrigation district (Figure 11-3 through Figure 11-23). These charts are presented to disclose the full range of effects on irrigated agriculture, including how acreage will be affected over the entire range of hydrologic conditions (the effects for the driest years will correspond to the lowest acreage levels, and effects in the wettest years will correspond to the highest acreages). This presents much more information than an average or even averages based on water year type, as it contains each annual total similar to a time series graph, but ranked and plotted in ranked order (from largest to smallest). Users can inspect the graphs and determine the frequency at which to expect a certain delivery (for example in Figure F.1.3-3 of Appendix F.1, *Hydrologic and Water Quality Modeling*; and F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*) or the acreage that would be planted compared to baseline. Exceedance plots and cumulative distributions are industry standard for analyzing programmatic changes. For example, the Department of Water Resources (DWR) used exceedance plots to describe changes in SWP deliveries modeled with CALSIM II to develop Delivery Reliability Reports (DWR 2012, 2014).

Water Year Types

Multiple commenters were concerned that presenting results as annual averages for the agricultural and economic effects did not fully describe the impacts during critically dry years and many requested that the results be presented by year type. Water year types are a useful classification system to make general assumptions, and because many stakeholders are accustomed to understanding the system based on water year types, this is what they may feel comfortable with. To respond to comments and readers interested in seeing this type of summary, tables were created summarizing the agricultural and economic effects of the LSJR alternatives based on the 60-20-20 water year types in Master Response 3.5, *Agricultural Resources*, Master Response 8.1, *Local Agricultural Economic Effects and the SWAP Model*, and Master Response 8.2, *Regional Agricultural Economic Effects*.

Although water year types are useful in general assessments they may not be the best suited for assessing all types of impacts. An exceedance chart or cumulative distribution, as discussed above, presents the same data as a water year type summary and is sufficient to fully disclose the range of results. To provide full disclosure of the range of effects in all years, the SED included exceedance plots, cumulative distributions, and time series of results throughout the SED. As discussed previously, these exceedance plots and cumulative distributions reflect the historical frequency of different types of California water years. This allows readers to observe the estimated frequency and magnitude of, for example, irrigation reductions to various crop types or changes in flow as compared to the baseline. In other words, the exceedance plots and cumulative distributions go beyond simple averages and averages by water year types; they show varying degrees of impact and the relative likelihood that the degree of impact may occur along a continuum from minimum to maximum effects.

San Joaquin River 60-20-20 Index

The water year type classifications[3] used by in the State Water Board in development of Water Rights Decision 1641 (State Water Board 2000) were first developed for use in the 1978 Water Quality Control Plan (Basin Plan) for Sacramento River Outflow requirements (State Water Board 1978). The 1978 Basin Plan introduced five water year type classifications: Wet, Above Normal, Below Normal, Dry, and Critically Dry, each defined based on a range of runoff conditions. The 1991 Basin Plan updated the water year classification system for the Sacramento River and proposed a separate classification index for the San Joaquin River (SJR) in recognition of the distinct differences between the two watersheds (State Water Board 1991).

[3] A water year extends from October 1st of the preceding calendar year through September 30th of the current calendar year. For example, water year 2010 starts on October 1st 2009 and ends on September 30th 2010.

The 60-20-20 SJR Index was officially adopted in the 1995 Basin Plan to determine water year type for the San Joaquin Valley (State Water Board 1995). The 60-20-20 index is described in Figure 3, *San Joaquin River Valley Hydrologic Water Year Classification*, of Appendix K, *Revised Water Quality Control Plan*, and restated here as follows:

INDEX = 0.6 X + 0.2 Y + 0.2 Z

Where,
X is the current year's April through July forecasted San Joaquin Valley unimpaired flow,
Y is current year's October through March San Joaquin Valley unimpaired flow, and
Z is the previous year's index, capped at 4.5 million acre-feet (MAF).

The unimpaired flow estimates used to calculate X and Y above are the sum of Stanislaus River inflow to New Melones Lake, Tuolumne River inflow to New Don Pedro Reservoir, Merced River inflow to Lake McClure, and SJR inflow to Millerton Lake (all in MAF). The official water year type index is determined each year based on the May forecast of runoff and the classification is defined as follows:

If the index is greater than 3.8 MAF the year is **Wet**,
If the index is between than 3.1 and 3.8 MAF the year is **Above Normal**,
If the index is between than 2.5 and 3.1 MAF the year is **Below Normal**,
If the index is between than 2.1 and 2.5 MAF the year is **Dry**,
If the index is less than 2.1 MAF the year is **Critically Dry**.

However, in summarizing certain parameters, such as flow, caution should be used with this index because it was developed primarily to consider water availability, rather than to describe the actual hydrology or flow conditions. Figure 2.3-9 (which is based on Figure 2.5 of Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*) presents an exceedance chart of the total annual unimpaired flow at Vernalis from 1922 to 2003, with each annual unimpaired flow value color coded based on its respective 60-20-20 water year type classification. In addition, Table 2.3-5 shows the number of years from 1922 to 2003 that are classified as each water year type and the range of total annual unimpaired flow at Vernalis estimated for each water year type. Both the table and the figure indicate that there is some overlap between water year types using this classification system; in other words, the range of unimpaired flow estimates is not exclusive to a water year type, and two years that have the same unimpaired flow value may have different classifications. For example, if a year had an annual estimate for Vernalis unimpaired flow of 7.0 MAF it would fall within the range for both wet years and above normal years.

Another potential issue with using the 60-20-20 water year types is that each of the three eastside tributaries may experience slightly different precipitation and resulting flow. This could lead to one tributary experiencing a dry year, while the other experiences a critically dry year, for example. The 60-20-20 classification is made to classify conditions for the entire San Joaquin valley rather than the individual tributaries. Therefore, using the 60-20-20 classification to summarize data and results of the alternatives may misrepresent results at the more detailed scale of individual tributaries or irrigation districts.

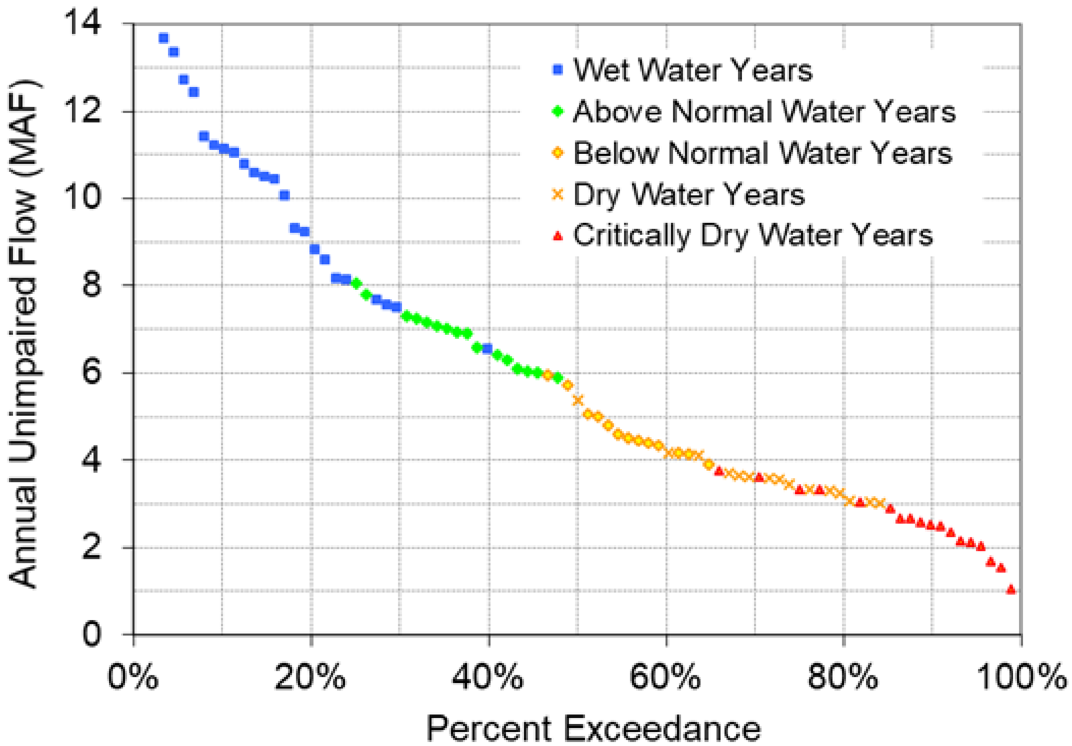

Figure 2.3-9. Exceedance Chart of Total Annual Unimpaired Flow at Vernalis, Color Coded by Water Year Type (MAF = million acre-feet) (Based on Figure 2.5 from Appendix C)

Table 2.3-5. Number and Percent of Years from 1922 to 2003 in each San Joaquin 60-20-20 Water Year Type Classification Category

Summary	Modeling period 1922-2003		Range of unimpaired flow[1]	
	#years	% of years	Lower (MAF)	Upper (MAF)
Full Period	82	100%	1	18.9
Wet	24	29%	6.5	18.9
Above Normal	16	20%	5.9	8.1
Below Normal	13	16%	3.9	6.0
Dry	13	16%	3	4.2
Critically Dry	16	20%	1	3.6

MAF = million acre feet

[1] Monthly Unimpaired flows reported by DWR in "California Central Valley Unimpaired Flow Data Draft, May 2007." Vernalis unimpaired flow taken as Page 45 (San Joaquin Valley Outflow) minus Page 42 (Minor West Side Streams UF 24).

Interpreting Water Year Type from a Cumulative Distribution or Exceedance Chart of Unimpaired Flow

Other investigators have created water year types on tributaries. For example, water year types developed for the *San Joaquin River Restoration Report Background Study* are based on the historic unimpaired flow, and do not include weighting or variables for storage and water availability like the SJR 60-20-20 or Sacramento 40-30-30 indices. The method uses the unimpaired flow ranked and assumes the five water year types are split at the 20, 40, 60 and 80 percentages. Additionally, as stated in Chapter 3, *Alternatives Description*, several entities, such as the Bay Institute, also provided flow recommendations using this similar type of categorization by percentile, with water year types based on the cumulative percent/percent rank of unimpaired flow.

Figure 2-5 of the *San Joaquin River Restoration Report Background Study*, shows how water year type based on percentiles correlates to the distribution of annual unimpaired flows (reprinted as Figure 2.3-10 herein) (McBain and Trush 2002). "The annual water yield volumes are plotted cumulatively from wettest to driest against exceedance probabilities, with water year classes divided symmetrically into five equally weighted classes separated by annual exceedance probabilities (p) of 0.20, 0.40, 0.60, and 0.80. Thus, the five classes can be named "Extremely Wet" (p = 0 to 0.20), "Wet" (p = 0.20 to 0.40), "Normal" (p = 0.40 to 0.60), "Dry" (p = 0.60 to 0.80), and "Critically Dry" (p = 0.80 to 1.00). The boundaries of the classes do not necessarily have to be in 0.20 increments; it is important that they are symmetrical around the median value (p=0.50) to ensure that wetter and drier years are weighted equally. This classification system helps depict the range of variability in the annual water yield and provides an equal probability for each class that a given water year will fall into that category (equally distributed around the mean), which in turn allows simpler interpretation of comparisons between water year types."

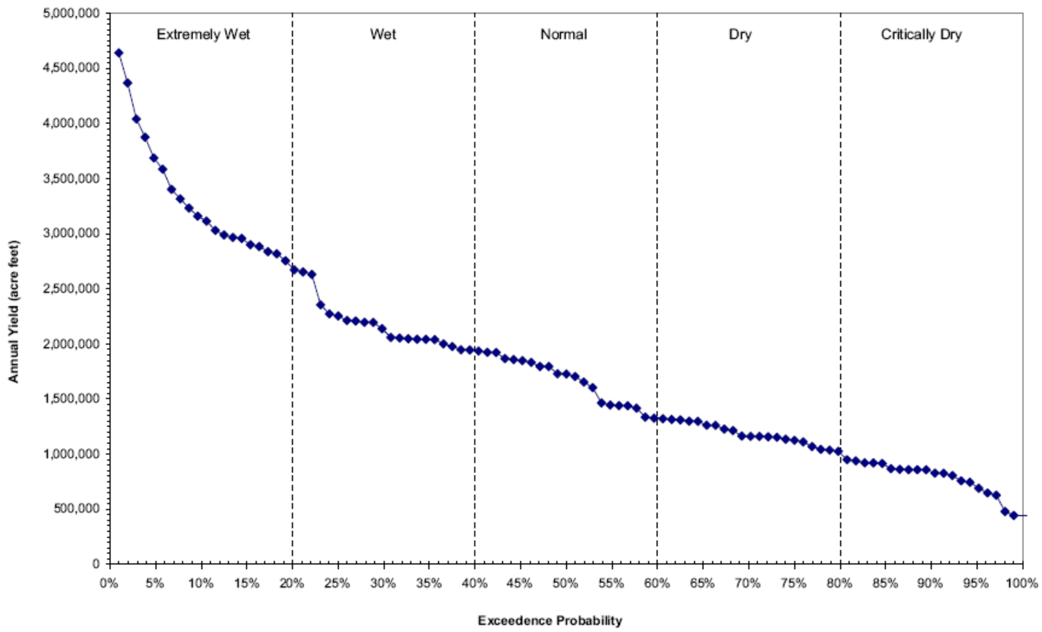

Figure 2-5. Water year classification at Friant Dam using computed unimpaired flow data from Madeheim (1999). This water year classification is used only for describing the hydrograph component analysis. ``

Figure 2.3-10. Example of Water Year Type Classification based on Percentiles of Unimpaired Flow

Use of Water Year Types in the SED

The 60-20-20 water year type classification was used to present results in some parts of the SED, primarily to give a general summary of more detailed results. For example, the Executive summary presents results for annual water supply, groundwater use, and February through June flow averaged by water year type. Furthermore, some of the modeling Appendices also summarize results by 60-20-20 water year types. Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results,* uses water year types to summarize both groundwater use and agricultural applied water demands and deliveries. Appendix F.1, *Hydrologic and Water Quality Modeling*, uses water year types to summarize water supply effects on each of the tributaries and for describing flow shifting (adaptive implementation method 3) in the WSE model. However, for the reasons described above, in order to provide full disclosure of the range of effects in all years, exceedance plots, cumulative distributions, and time series results are provided throughout the SED.

References Cited

California Department of Water Resources (DWR). 2007. *California Central Valley Unimpaired Flow Data*. Fourth edition. Draft. May. Available: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/sjrf_spprtinfo/dwr_2007a.pdf. Accessed: March 1, 2018.

———. 2012. *Technical Addendum to the State Water Project Delivery Reliability Report, 2011.* June. Available: http://baydeltaoffice.water.ca.gov/swpreliability/2011DRR_FINAL_TechAddendum_062112.pdf. Accessed: February 28, 2018.

———. 2014. *Technical Addendum to the State Water Project Delivery Reliability Report, 2013.* May. Available: https://msb.water.ca.gov/documents/86800/202762/DRR2013_TechnicalAddendum_Final_20140623.pdf?version=1.0. Accessed: February 28, 2018.

McBain and Trush. 2002. *San Joaquin River Restoration Study Background Report*. Prepared for Friant Water Users Authority. Lindsay, CA, and Natural Resources Defense Council, San Francisco CA. Arcata, California. December. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/sjrf_spprtinfo/mcbainandtrush_2002.pdf. Accessed: March 01, 2018.

Public Policy Institute of California (PPIC). 2015. *What If California's Drought Continues?* August. Available: http://www.ppic.org/publication/what-if-californias-drought-continues/. Accessed: June 27, 2018.

———. 2017. *Water Stress and a Changing San Joaquin Valley*. March. Available: http://www.ppic.org/publication/water-stress-and-a-changing-san-joaquin-valley/. Accessed: June 27, 2018.

State Water Resource Control Board (State Water Board). 1978. *Water Quality Control Plan, Sacramento–San Joaquin Delta and Suisun Marsh*. August. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/docs/1978wqcp.pdf. Accessed: June 22, 2018.

———. 1991. *Water Quality Control Plan for Salinity, San Francisco Bay/Sacramento–San Joaquin Delta Estuary*. May. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/docs/1991wqcp.pdf Accessed: June 22, 2018.

———. 1995. *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary*. May. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/1995wqcp/docs/1995wqcpb.pdf. Accessed: June 22, 2018.

———. 2000. *Water Right Decision 1641*. Revised March 15. Available: https://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1600_d1649/wrd1641_1999dec29.pdf. Accessed: February 14, 2018.

U.S. Environmental Protection Agency (USEPA). 2003. *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards*. April. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA. Available: https://nepis.epa.gov/Exe/ZyPDF.cgi/P1004IUI.PDF?Dockey=P1004IUI.PDF. Accessed: June 27, 2018.