WATER & POWER
Serving Central California since 1887
(209) 883.8300 • www.tid.com
333 East Canal Drive • P.O. Box 949 • Turlock, CA 95381-0949

March 16, 2017

via e-mail at commentletters@waterboards.ca.gov

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814-0100

Re: Comment to the Amendment to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary and Supporting Draft Revised Substitute Environmental Document (September 2016)

Dear State Water Resources Control Board:

Enclosed herewith are the comments of the Turlock Irrigation District (District) on the Amendment to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (WQCP) and Supporting Draft Revised Substitute Environmental Document (SED). The District also incorporates by reference all written and orally submitted comments of the San Joaquin Tributaries Authority (or its predecessor agency, the San Joaquin River Group Authority) to include the materials presented as Technical Comments to the Phase 1 SED (2012) and that these materials be included in the Administrative Record for this amendment to the WQCP and revised SED. Many of these materials are posted on the SWB's website with the 2012 SED, such materials to be found in the folder entitled "unsolicited comments." The District also incorporates by reference all written comments submitted on the amendment to the WQCP and the revised SED by the San Joaquin Tributaries Authority and the separate and joint comments submitted by its member agencies—the South San Joaquin Irrigation District, the Oakdale Irrigation District, the Modesto Irrigation District, the Turlock Irrigation District, and the City and County of San Francisco. Finally, the District also incorporates by reference comments submitted by the Merced Irrigation District.

These comments are grouped into five main areas: the effects of the SED on TID's water supply, the effects of the proposed LSJR Alternative 3 on groundwater resources, the economic impacts resulting from the loss in value in hydropower, comments on the economic analysis deficiencies, and the failure of the State Water Resources Control Board (SWB) to evaluate the proposed LSJR Alternative 3 in light of future climate change effects.

Water Supply Effects

The SED uses a Water Supply Effects (WSE) model developed by the SWB staff and others to simulate the operations of Don Pedro reservoir and reservoirs on the other tributaries. The model has a distinct advantage over real time operations in that it has perfect hindsight and foresight. This feature allowed the staff and consultants to "game" the model in a way to develop alternatives that attempted to maximize water for the February through June period apparently without causing what appeared to be significant effects on water supply and reservoir storage. Instead of actually modeling the proposed project of 40% of unimpaired flow on a running 7-day average from February through June, the SED moves water around. It proposes shifting water into other time periods that would significantly modifying water operations and severely limit the water supply reliability of the Don Pedro project. For example, the authors suggest flow shifting during certain years to move water into later periods of the season without any consideration of the flood control operations of the project. Don Pedro, like many other reservoirs in the Central Valley, is operated for flood control and operations from October through June can be constrained by the need to provide flood control. The SED does not even address this issue and instead puts thousands of acres and hundreds of thousands of people at risk.

Figure 1 is TID's estimate of water supply shortages as compared to the SED. TID's analysis indicates shortages in 83 of the 115 years while as opposed to shortages in only 15 years without the SED.

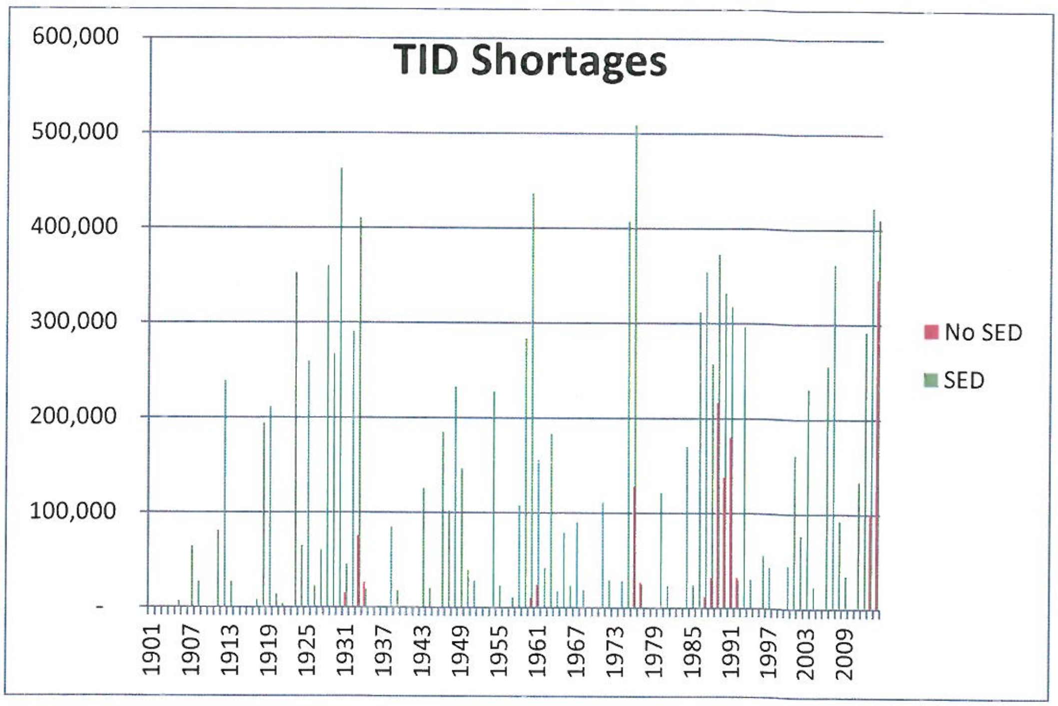


Figure 1 TID Water Supply Shortages

Groundwater

Appendix A enclosed with this letter is a review by Todd Groundwater of the SED's groundwater analysis and specific comments about the shortcomings of the analysis. Among the many concerns is that TID finds that the groundwater impact analysis in the SED fails to follow standard hydrogeologic practice and does not meet the standard of care for a CEQA impact analysis. Furthermore, the SED greatly underestimates the impact of reduced water deliveries to TID on groundwater levels. In addition to the comments in Appendix A, TID provides the following comments:

The geographic scale of the groundwater impact analysis is overly narrow

The geographic scale of the groundwater impact analysis is overly narrow, addressing only effects on pumping and recharge in the affected irrigation districts while ignoring the broader effects on groundwater subbasins. The result is an inadequate and misleading assessment of impacts to groundwater resources. As a result of these defects, the SED should be revised accordingly to present an honest assessment of groundwater impacts.

Leaving the areas outside of the districts out of the impact analysis ignores the broader challenges of groundwater management at the subbasin scale, especially considering the existing requirements of SGMA, which requires that local agencies within subbasins coordinate their efforts to manage groundwater sustainably. In fact, much of the water that would contribute to instream flow increases under the LSJR alternatives is water that has historically contributed to groundwater recharge or, in the future, could be used to increase recharge above historical levels. Thus, the SED alternatives would substantially foreclose on future opportunities to manage groundwater basins sustainably, while sustaining current levels of pumping and agricultural production. The implication, which is not addressed in the SED, is that future groundwater pumping would have to be reduced relative to existing conditions.

In direct conflict with this, the assumption is incorrectly made that not only will it be possible to continue existing levels of groundwater pumping, but that groundwater pumping could be increased to offset the loss of surface water dedicated to instream flows under the SED alternatives. There is simply not enough water to both increase instream flows per the LSJR alternatives and to manage groundwater basins sustainably at current levels of development. As a result of the flawed assumption regarding the future availability of groundwater, the impacts of the LSR alternatives are understated. Furthermore, less water available for recharge within the TID, for example, will impact water supplies and groundwater levels within TID's portion of the subbasin, and may impact the water available on the eastern side of the subbasin as well. This was not evaluated.

The groundwater impact analysis fails to account for the potential effects of increased groundwater pumping on existing groundwater wells

The groundwater impact analysis fails to account for the potential effects of increased groundwater pumping on existing groundwater wells, particularly domestic water supply wells. The assumption is incorrectly made that not only will it be possible to continue existing levels of groundwater pumping, but that groundwater pumping could be increased to offset the loss of surface water dedicated to instream flows under the SED alternatives. There is simply not enough water to both increase instream flows per the LSJR alternatives and to manage groundwater basins sustainably at current levels of development. As a result of the flawed assumption regarding the future availability of groundwater, the impacts of the LSJR alternatives are understated.

In Section 9.2, Environmental Setting, the various communities in each groundwater subbasin that rely partly or solely on groundwater as a supply source are briefly listed, but their groundwater supply infrastructure and operations are not described. Furthermore, the hundreds of domestic water supply wells in the region serving rural residences are not even mentioned. Although the volume of municipal and domestic well production is relatively small compared to agriculture, these users are in many cases solely dependent on groundwater, and their wells are typically not as deep as agricultural wells. These factors make the non-agricultural groundwater uses particularly vulnerable to changes in groundwater conditions, especially declining groundwater levels. Because the impact analysis does not address the effects of assumed large increases in groundwater pumping on groundwater levels, potential effects on existing wells, particularly shallow production wells, are ignored.

Because the impact analysis does not address the effects of assumed large increases in groundwater pumping on groundwater levels, the SED failed to evaluate the potential effects on existing wells, particularly shallow production wells.

The rationale and threshold for defining potentially significant groundwater impacts is arbitrary and misleading

The rationale and threshold for defining potentially significant groundwater impacts is arbitrary and misleading. The assumption that an average annual reduction in the groundwater balance for a subbasin (caused by increased groundwater pumping and reduced recharge from surface water) equivalent to 1 inch or more of water across the subbasin could be potentially significant is arbitrary and unsupported. Additionally, spreading the impact across the entire subbasin underestimates the impacts with the irrigation district. As stated above, the approach taken to the evaluation of ecosystem restoration or clear, thorough, understandable and tied to specific metrics and conclusions.

Not including the likely effects of Sustainable Groundwater Management Act (SGMA) in baseline conditions results in gross under-estimation of the water supply shortages

Not including the likely effects of Sustainable Groundwater Management Act (SGMA) in baseline conditions results in gross under-estimation of the water supply shortages that would result from the Lower San Joaquin River alternatives. Because SGMA will likely reduce the volumes of groundwater that can be extracted in the future, not increase them (as assumed for the SED impact analysis), the SWRCB has adopted an unrealistic, seriously flawed baseline condition, resulting in the water supply shortages caused by the proposed LSJR alternatives being grossly understated.

After acknowledging the likely effects of SGMA, the SED states: "*However, since the groundwater protections that will be afforded by SGMA cannot be determined at this time with precision, this chapter evaluates the potential impacts on groundwater levels from LSJR alternatives* ***without*** *including SGMA as an ameliorating factor, which means that estimates of impacts are likely more conservative (i.e., worse) than would occur in the groundwater basins over time (emphasis added).*" The fact that the SWRCB elected to leave SGMA out of the baseline is incredible on its own; however, the statement that doing so results in conservative (worse) estimates of impacts is contrary to the Board's own assessment.

It would appear from this statement that the SWRCB rationalizes that the "groundwater protections that will be afforded by SGMA", rather than limiting future groundwater extractions, will somehow enable the vast increases in pumping it assumes to be possible to offset the reductions in surface water supplies due to the LSJR alternatives. Because SGMA will likely reduce the volumes of groundwater that can be extracted in the future, not increase them, the SWRCB has adopted an unrealistic, seriously flawed baseline condition, resulting in the water supply shortages caused by the proposed LSJR alternatives being understated.

The SWRCB indicates that the subbasin could offset impacts caused by the SED by implementing SGMA and recharging the groundwater, however the SWRCB fails to provide any analysis as to where that water will come from. A draft report from DWR[1] evaluating water available for replenishment contradicts the SWRCB's assumption that there is water available for replenishment. The proposed SED will impact the subbasin by reducing the existing recharge, causing TID customers to rely more on the groundwater without a means of recharging it. This will compound the existing overdraft within the subbasin, making it even more difficult to comply with SGMA. The SED misses the mark with respect to evaluating the range of potential impacts, by assuming that additional recharge is available to offset some of the SED impacts. The SED should evaluate the potential range of impacts to groundwater, and the assumptions used seem to miss the worst case scenario. In order to truly bracket the possible range, the SED should also evaluate the impacts of reduced agricultural water supplies, without additional recharge, combined with increased pumping to offset the reduced surface water supplies.

The methods for estimating irrigation demands described in Chapter 11 and Appendix G do not follow generally accepted, peer-reviewed technical approaches

The methods for estimating irrigation demands described in Chapter 11 and Appendix G do not follow generally accepted, peer-reviewed technical approaches.

The generally accepted methodology for estimating irrigation demands involves the following steps in sequence for each crop in the cropping pattern: 1) estimating actual crop water use, 2) subtracting the portion of actual crop water use satisfied by precipitation to get the applied water requirement, 3) applying on-farm efficiency factor to account for on-farm losses and to estimate the farm water delivery requirement, and 4) applying a distribution system efficiency factor to account for system level losses and to estimate the diversion requirement. In contrast to this, the SED uses an unconventional methodology that is difficult to follow. The SED should rely on generally accepted practices and terminology, such as those described in the first edition and the recently released second edition of Manual 70 Evaporation, Evapotranspiration and Irrigation Water Requirements of the American Society of Civil Engineers (ASCE) series of Manuals and Reports on Engineering Practice (ASCE 2016) and peer reviewed literature on modeling of irrigation distribution and on-farm systems.

The agricultural economic impacts presented in Appendix G are under-stated

The agricultural economic impacts presented in Appendix G are under-stated for a number of reasons, summarized below. Some of the factors contributing to the under-statement of agricultural economic impacts are as follows:

---

[1] California Department of Water Resources, *Draft Water Available for Replenishment Report* (January 2017).

1) Because SGMA and its effects are not included in baseline conditions, the impact analysis allows unrealistic assumptions to be made regarding the volumes of groundwater that could be pumped in the future, resulting in under-stated estimates of agricultural water supply shortages.

2) Analysis of economic impacts is limited to the effects of increased water supply shortages on on-farm crop production only, to the neglect of impacts on related dairy and cattle production and food processing operations.

3) To the extent that intra-district markets do not actually exist, the assumed movement of water is not possible and therefore the economic impacts of water shortages are under-estimated.

4) The analysis apparently assumes that irrigated agricultural can expand and contract perfectly from year to year according to the available water supply, which is not realistic. Rather, farmers tend to scale their core operations, particularly capital investments in permanent crop production, based the amounts of water they expect to receive on a highly reliable basis.

5) The impact analysis assumes that future groundwater pumping lifts, and therefore costs, will be the same in the future as they have been recently, ignoring the higher cost of pumping as groundwater levels decline due to the assumed increases in pumping.

6) The economic analysis fails to account for the decrease in land values that will certainly result from the reduction in water supply reliability and increase in cost (fixed costs of irrigation district operations will be spread over fewer acre-feet of surface water, more relatively expensive groundwater will need to be pumped, and the cost of groundwater pumping will increase as groundwater levels decline). What happens to the growers who are capitalized based on existing levels of productivity and land values when land productivity suddenly declines, land values decrease, and they are no longer able to service their debts?

7) The perspective for assessing impacts to agricultural resources is overly narrow, focusing primarily on the potential for the LSJR alternatives to induce conversion of Prime Farmland, Unique Farmland and Farmland of Statewide significance to non-agricultural uses, neglecting the broader agricultural economy.

8) The analysis assumes that dry land farming is a feasible means of keeping agricultural lands in production during times when water supplies are short, but does not appear to take into account that rainfall alone is not adequate to sustain even low water use, winter crops in years of low rainfall.

The economic analysis methodology is confusing with regard to the use and limitations of models

The economic analysis methodology is confusing with regard to the use and limitations of models. On page 11-1, second paragraph, the SED states: "*...the management decisions of* *individual agricultural producers (farmers) are more sophisticated and driven by more variables than can be accounted for in modeling."* Then on page 11-2, it is explained that the Statewide Agricultural Production (SWAP) model is used to evaluate impacts. These statements are contradictory.

Hydropower

The 2016 SED fails to adequately capture the extent of the damages to the San Joaquin Valley, using biased and inconsistent assumptions that dramatically undervalue the effects of the unimpaired flow and increased carryover storage on hydroelectricity and agriculture.

As explained in Appendix B, the SED does not adequately account for the value lost from hydropower generation under LSJR Alternative 3, the 40% unimpaired flow alternative. Though the quantity of electricity lost under LSJR Alternative 3 is minimal, the value lost is quite significant. The value lost in electricity results from the LSJR Alternative 3's constraints on the flexibility of generation from the New Don Pedro Project (Don Pedro). The analysis reveals that the quantity of hydropower lost under the proposed alternative belies the true loss in value in hydropower. One of the most valuable assets of Don Pedro is its flexible capacity, or ability to generate power at any time with limited start-up and shut down costs. With the continual growth of intermittent renewables in California's energy market, flexible generation will continue to increase in value, as it can respond to the increasing volatility in generation resulting from intermittent renewable generation. The LSJR Alternative 3, however, would significantly restrict Don Pedro's flexibility, and in turn one of TID's chief sources of flexible generation. When considering the SED's impact on flexibility, and damages to Don Pedro's generation can be calculated to 4 components: (1) loss of value in energy, (2) loss of value in capacity, (3) loss of value ancillary services, (4) loss of consumer surplus. The total Net Present Value (NPV) damages from 2018-2040 are shown below.

Loss in Day-Ahead Sales	$19.0 M
Loss in Reservoir Capacity	$23.8 M
Replacement costs for loss in capacity	$256.1 M
Replacement costs for loss in ancillary services	$99.0 M
Loss in Consumer Surplus	$16.4 M
Total Damages (2018 USD)	**$414.3 M**

Economic Analysis Deficiencies

A review of the SED's Agricultural Economic Analysis by ERA Economics (attached as Appendix C) demonstrates that there are several potential deficiencies that warrant additional clarification. This review identified 10 key deficiencies, summarized below and in more detail in Appendix C. The deficiencies are such that the SWB economic analysis will require substantial revisions as recommended in Appendix C.

Point	Notes
1	The model applied for the SED is not the SWAP model
2	Model details, assumptions, and supporting data are not provided with public materials
3	The analysis shows implausible deficit irrigation of permanent crops
4	Fallowing costs are omitted from the SED analysis
5	The economic model calibration and supporting data is not described
6	The analysis does not distinguish between short-run and long-run economic impacts
7	The analysis does not consider the economic cost of an increase in water supply variability
8	The specification of the No Action (No Project) Alternative is not clear
9	The analysis does not consider the linkage from crop production to upstream high-value industries
10	Water supply costs and model calibration are not reported

Climate Change

Contrary to the SWB's own resolution adopting a Comprehensive Response to Climate Change, adopted on March 7, 2017, the SED relies exclusively on past hydrology for its assessment of water availability and water supply impacts. Instead of using tools that are readily available, the SWB chooses to ignore the reality that future runoff patterns, available precipitation, temperature changes, and other factors will significantly impact the assumptions it has made in the SED. Numerous climate change models indicate a progressively altered snow and runoff regime in the watershed. Snow accumulation is reduced and snow melts earlier in the spring. Fall and early winter runoff increases while late spring and summer runoff decreases. Total runoff is projected to decrease under the climate change scenarios evaluated, in some cases marginally and others significantly. The SED failed to evaluate any of these possible future scenarios.

Even if the SWB chooses to ignore the climate change models, a review of past Tuolumne River hydrology clearly shows that variability in the annual runoff is changing. Historical climate trends are more evident in graphs than in numerical tables. The historical streamflow record in the Tuolumne is 121 years, from 1897 to the present. Figure 2 shows the annual flow volume at La Grange with linear upper and lower bounds, one standard deviation above and below the mean.

Standard deviations are calculated over a 25-year period so the upper and lower bounds begin 25 years after the historical record begins. If annual streamflow is 'normally distributed', the annual streamflow in any year will have a 68 percent chance of falling within the upper and lower bounds.

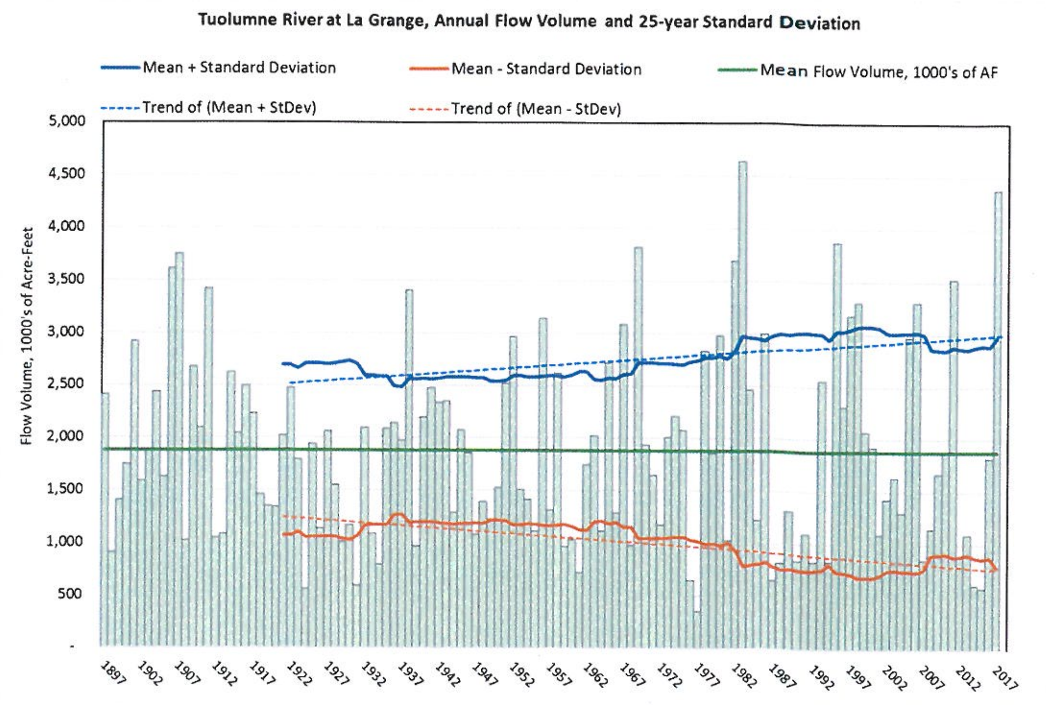


Figure 2 Annual Flow at La Grange, with Upper and Lower Bounds on Standard Deviation from the Mean

The statistical bounds in Figure 2 show what is evident visually; as time advances the annual flow range from high flows to low flows expands.

Figure 3 shows the same information with the Coefficient of Variation, which is the variability of annual flows relative to the mean.

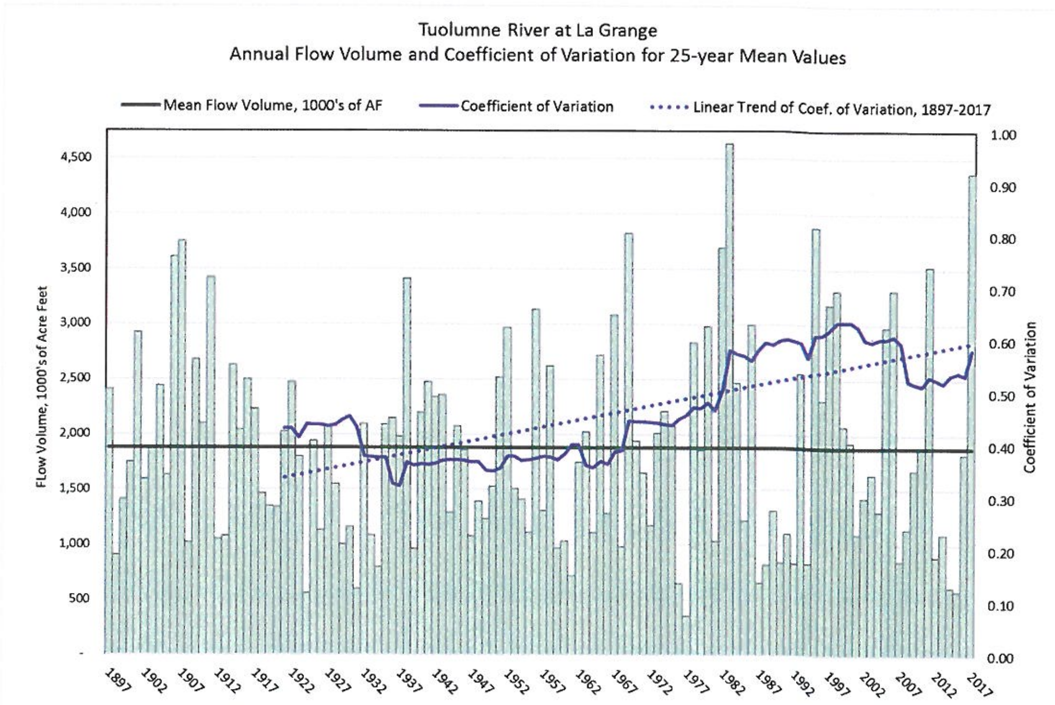


Figure 3 Annual Flow at La Grange, with the Coefficient of Variation

Figure 4 shows the historical Tuolumne River annual flow volume – the mean annual flow volume. The vertical line at 1965 is a marker – annual flows from 1897 to 1965 appear less variable than flows after 1965. In Figure 3, 1966 is the year where the Coefficient of Variation starts to increase.

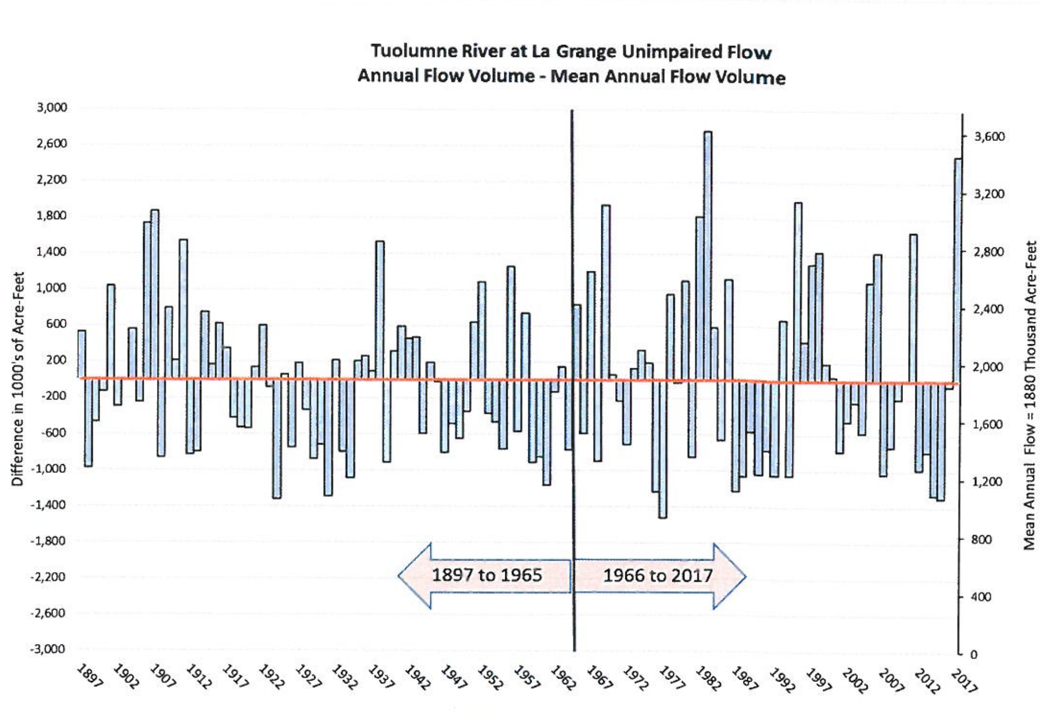


Figure 4 Annual flow volume at La Grange, less the mean annual flow volume

The failure of the SWB to recognize and acknowledge this variability is key to understanding the impacts to water supply, the loss of valuable hydropower resources, the inability to sustain and maintain natural production of viable native fish populations, the permanent damage to perennial crops and the associated economic losses. By not presenting information on the variability in runoff due to climate change, the SED significantly underestimates the extent of potential damages incurred by the LSJR Alternatives.

Conclusion

The State Water Board proposal and its singular focus on unimpaired flows is the wrong choice for the state's future. As you are aware, various parties including water districts, state agencies, and environmental organizations are engaged in voluntary settlement discussions. The discussions are complex. The resumption of a regulatory proceeding will polarize the parties, effectively negating the progress made to date, and jeopardizing any real opportunity to achieve a voluntary settlement. TID urges the State Water Board to set aside the unimpaired flows approach and recognize that the best outcome can be achieved through comprehensive, collaborative approaches that include "functional flows" as well as non-flow solutions that contribute real benefits.

Sincerely,

Casey J. Hashimoto
General Manager

Enclosures

1. Appendix A, Todd Groundwater Memorandum, San Joaquin River Flows and South Delta Water Quality Substitute Environmental Document—Comments on Groundwater Impact Analysis for the Turlock Subbasin, March 15, 2017.
2. Appendix B, Ascend Analytics, Economic Impact Analysis of Lower San Joaquin River Alternative 3, March 17, 2017
3. Appendix C, ERA Economics Technical Memorandum, Preliminary Review of the San Joaquin River SED Agricultural Economic Analysis, March 15, 2017

March 15, 2017

MEMORANDUM

To: Art Godwin, Turlock Irrigation District

From: Gus Yates, Senior Hydrologist

Re: San Joaquin River Flows and South Delta Water Quality Substitute Environmental Document—Comments on Groundwater Impact Analysis for the Turlock Subbasin

The Substitute Environmental Document (SED) for the Lower San Joaquin River (LSJR) flow program greatly underestimates the impact of reduced water deliveries to Turlock Irrigation District (TID) on groundwater levels. This was the result of inappropriate averaging of impacts over a large area and unrealistic assumptions regarding future increases in groundwater pumping in response to decreased surface water deliveries. In addition, the SED summarily dismisses concerns regarding the economic impacts of groundwater declines by asserting that issues related to groundwater imbalance will be solved at a future date by the Sustainable Groundwater Management Act (SGMA). However, even a cursory analysis of local water resources conditions indicates that SGMA would not be able to offset future increases in groundwater pumping with increased recharge because nearly all potential sources of water for replenishment are themselves tributary to the Tuolumne, Merced and San Joaquin Rivers. Those sources could not be developed for supplemental groundwater recharge without decreasing river flows and exacerbating the very problem the LSJR flow program is attempting to solve. The inevitable result of reduced water deliveries to TID at the magnitudes contemplated in the LSJR flow program is fallowing of substantial amounts of cropland with significant associated economic impacts.

These major comments are substantiated below, followed by a section containing additional comments on specific technical and interpretive deficiencies of the SED.

Comment 1: The SED underestimates groundwater impacts by averaging them over too large an area.

The SED incorrectly asserts that evaluation of impacts at a geographic scale smaller than whole subbasins is infeasible:

> "The impacts of the LSJR alternatives on groundwater elevations, aquifer storage, and risk of subsidence cannot be determined with certainty because groundwater conditions vary within each aquifer subbasin and water users would have varied responses to reduced surface water deliveries." (page 9-2)

It would have been a simple matter—using numbers already contained in the SED—to apply the change in surface-water deliveries to irrigation district service areas rather than entire subbasins. In the case of the Turlock Subbasin, the TID service area (151,000 irrigated acres; Table 9-5) covers only 43 percent of the Subbasin area (349,000 acres; Table 9-2) and is entirely within the western half of the subbasin. The SED should have applied the anticipated change in groundwater pumping and water levels to the service area, not the entire subbasin. This geographic factor increases the estimated impact by a factor of 2.3 (1/0.43 = 2.3).

Averaging groundwater impacts over an entire subbasin also overlooks existing acute groundwater problems in local areas. In the case of the Turlock Subbasin, there is a deep pumping trough in the eastern half of the Subbasin, which does not receive surface water for irrigation. The pumping trough has been clearly evident in water-level contour maps for years, such as the spring 2016 contours obtained from a California Department of Water Resources website and shown in **Figure 1**. Hydrographs of water levels in four wells near the pumping trough are shown in **Figure 2** and demonstrate the chronic overdraft in that area. Increased groundwater pumping in TID will exacerbate this overdraft.

To correct this geographic averaging error, TID simulated the localized effects of replacement groundwater pumping under LSJR Alternative 3 using a groundwater flow model of the Turlock Subbasin, as described in Comment 5.

Comment 2: A Long-Term Decline of 10 Inches per Year is Significant and Unsustainable

The SED used a significance threshold of 1 inch per year (in/yr) of deficit in the groundwater balance, equivalent to about 10 in/yr of water-level decline (page 9-46, last two paragraphs). This threshold is unreasonably large and inconsistent with SGMA. For example, average annual water-level declines in the four hydrographs from the overdrafted part of the Turlock Subbasin (**Figure 2**) are 10-22 in/yr. In other words, the SED asserts that increasing the existing amount of overdraft by 50-100 percent is less than significant. This is clearly absurd. A threshold of significance of 0 in/yr would almost achieve sustainability (the existing deficit at the Eastside pumping trough would remain) and thus more likely comply with SGMA. Although the SED concluded that impacts of LSJR Alternatives 3 and 4 on groundwater levels and storage would be significant and unavoidable, the use of an inappropriately high significance threshold deemphasizes the importance of those impacts.

Comment 3: Assuming that Groundwater Pumping Capacity in TID will Remain at the 2009 or 2014 Capacity is Unrealistic and Greatly Underestimates Future Replacement Pumping

The SED assumes that groundwater pumping in surface-water delivery areas would increase in response to reduced deliveries, but only up to the amount of pumping capacity that was available in 2009 (page 9-46, first paragraph). This is an unrealistic assumption. Faced with a foreseeable long-term decrease in surface-water deliveries, farmers will drill more wells until the pumping capacity provides the same reliability as the existing combination of surface deliveries and well capacities. The SED concedes this point by noting that well capacity increased from 2009 to 2014 in response to drought conditions (page 9-46, first paragraph). At the very least, the SED should have used 2014 well capacities as a base. If additional wells were installed due to drought, how can it be argued that additional wells would not be installed in response to permanent delivery curtailment under the SJR flow program? The realistic assumption is that over the long run farmers will install enough well capacity to fully replace the foregone surface deliveries. This is the amount that would keep all of their land in production.

The effect of the incorrect assumption regarding replacement pumping was to underestimate future increases in groundwater pumping, by a factor of 2.3 for the LSJR Alternative 3 for example. This is the ratio of the decrease in releases from Turlock Lake for surface-water deliveries to TID growers to the estimate of change in the subbasin groundwater balance under that alternative. LSJR Alternative 3—which requires 40 percent of baseline river flows—is referenced in this memorandum as "SED40". With full replacement, groundwater pumping would increase by an amount equal to the reduction in surface-water releases from Turlock Lake for irrigation. The decrease in TID releases from Turlock Lake under SED40 would average about 98,300 AFY after accounting for changes in releases from LaGrange Dam to the Tuolumne River and reduced deliveries from LaGrange Dam to Modesto Irrigation District (Monier, 2016).

In contrast, the SED (Table 9-12) estimates that under the SED40 alternative the groundwater budget of the Turlock Subbasin would become more negative by 43,600 AFY, which is equivalent to 1.5 in/yr over the 349,000-acre subbasin area. When return flows are accounted for, a decrease of 1 AFY in surface water delivery results in a negative shift of 1 AFY in the groundwater budget, assuming full replacement pumping. Thus, the SED's estimate of the increase in pumping is only 44 percent of the correct estimate (43,600 / 98,300 = 0.44).

To correct this error in the SED analysis, TID simulated the impacts of the correct estimate of replacement pumping using a groundwater flow model of the Turlock Subbasin, as described in Comment 5.

Comment 4: The SED Ignores the Effects of Replacement Pumping on River Flows, which Create a Positive Feedback Loop Requiring Even Greater Increases in Pumping

The SED assumes a constant rate of groundwater seepage into the lower ends of the Tuolumne and Merced rivers and into the San Joaquin River of 30,000 AFY (page 9-14, third paragraph). It further asserts that "groundwater-surface water interactions have a relatively small effect on river flow, generally changing flow by plus or minus 2 cubic feet per second (cfs) per mile (USGS 2015)." This dismissal of the importance of groundwater-surface water interaction is unsupportable and incorrect for several reasons:

- A small amount of surface flow is equivalent to a large amount of groundwater flow. A percolation rate of 2 cfs/mi along the 114 miles of river bounding the Turlock Subbasin equals 228 cfs of recharge, which is equivalent to 166,000 AFY. This is nearly four times the SED estimate of change in the subbasin groundwater budget (43,600 AFY per SED Table 9-12). Thus, the magnitude of groundwater-surface water interaction cited from the USGS study is significant in the context of the groundwater budget.
- The USGS estimates of river flow gains and losses were for existing (2009?) conditions. The USGS did not simulate the effect of increased pumping on those gains and losses, which is the relevant question for evaluating LSJR flow impacts.
- The USGS model was poorly calibrated to river flows. Thirty-two percent of simulated monthly river flows differed from measured flows by more than 500 cfs in the calibration simulation (USGS page 44). Therefore, the reliability of the USGS model for evaluating river flow gains and losses on the order of 2 cfs is questionable.
- In the long run, rivers, drains and storage are the only head-dependent boundaries that can respond to the GW budget deficit. When a groundwater flow system experiences a change in one budget item—in this case additional groundwater pumping—the system responds with compensating changes in head-dependent boundary flows. Although the groundwater system extends beyond the rivers to the north, west and south, it is reasonable to assume that water levels in those areas will decline in response to the LSJR flow program by amounts similar to the declines within the Turlock Subbasin. Therefore, the Turlock Subbasin cannot rely on increased inflow from adjacent subbasins to balance its own water budget. The TID groundwater modeling analysis showed the proportions of response among the head-dependent boundaries. Over the first 40 years of LSJR Alternative 3 implementation, nearly two-thirds of the water budget response was from rivers. Additional modeling details are provided in Comment 5.

Because replacement pumping would diminish river and drain flows, the assumed upstream reservoir releases would no longer be sufficient to meet the target flows at downstream compliance points. Consequently, additional water would need to be released from the reservoirs to the rivers. This sets up a positive feedback loop in which decreased surface water deliveries result in replacement pumping, which increases net depletion of river flows thereby requiring increased releases to the river and further decreases in surface water deliveries.

The SED ignored this feedback loop. Understanding the groundwater-surface water interaction is fundamental to evaluating the true impacts of the LSJR flow program. TID simulated the effect of replacement pumping on net river percolation using a groundwater flow model of the Turlock Subbasin, as described in Comment 5.

COMMENT 5: GROUNDWATER MODELING PROVIDES A MORE REALISTIC ESTIMATE OF THE LARGE IMPACT OF THE LSJR FLOW PROGRAM ON GROUNDWATER LEVELS AND DEPLETION OF RIVER FLOWS

TID used its existing groundwater flow model of the Turlock Subbasin to obtain more realistic estimates of the effects of the LSJR flow program on groundwater levels, groundwater budgets and river flows. A description of the model including data and assumptions important to simulating LSJR flow alternatives is presented in **Appendix A** of this memorandum. Groundwater flow during 2013-2052 was simulated under two scenarios: Base Case and LSJR Alternative 3 (SED40). Both simulations assumed constant land use corresponding to 2012 land use and 1973-2012 hydrology. Monthly surface water deliveries to TID and releases to the Tuolumne River from LaGrange Reservoir were developed by adding SED40 flow criteria to the existing operating rules for New Don Pedro Reservoir, LaGrange Dam and other Tuolumne River facilities (Monier, 2016). An additional set of operating rules and physical relationships was applied to translate the time series of releases from Turlock Lake into corresponding time series of canal deliveries, canal seepage, drainage well pumping, rented well pumping, and supplemental well pumping. Crop irrigation demand was estimated from crop area, rainfall, reference evapotranspiration, soil properties, root depth and irrigation efficiency. Groundwater pumping was assumed to supply any irrigation demand not met by surface water deliveries (that is, full replacement pumping).

Water-level hydrographs for the Base Case and SED40 simulations at five locations across the basin illustrate the impact of SED40 on groundwater levels. The hydrograph locations are shown in **Figure 3** and the hydrographs are shown in **Figure 4**. The first three locations are in the western half of the subbasin where the Corcoran Clay is present. Hydrographs are shown for shallow wells screened above the clay and for “intermediate zone” wells below the clay. Simulated water levels for the SED40 scenario steadily declined relative to Base Case water levels throughout the simulation period at all locations. Furthermore, the amount of divergence increased from west to east (from well pair S260/M054 to well pair S382/M114) because of greater distance from rivers. The rivers are head-dependent boundaries that compensate for increased pumping by an increase in percolation from the river and/or a decrease in groundwater seepage to the river. At the westernmost hydrograph location (wells S260/M054) SED40 water levels were 18-20 feet lower than Base Case water levels at the end of the simulation. Near the center of the subbasin near the eastern edge of TID (wells S382/M114), water levels were 30 feet lower than Base Case water levels in both the shallow and intermediate zones. The divergence at that location was still increasing at the end of the simulation, indicating that storage changes and induced river recharge had not fully equilibrated with the increase in pumping. The amount of water-level divergence between the two scenarios diminished farther to the east, outside the area that currently receives surface water deliveries. At well M212 the water-level difference at the end of the simulation was 28 feet, and at well M167 it was 8 feet. Even though the amount of groundwater pumping near these wells was the same in both scenarios, water levels were nevertheless impacted by increased pumping to the west in TID.

Hydrograph trends in the western half of the basin were more or less level in the Base Case simulation, but hydrographs in all parts of the subbasin were declining in the SED40 simulation. This confirms that the LSJR flow program with replacement groundwater pumping is not sustainable.

Contour maps of groundwater elevation and change in elevation show how differences between the two scenarios vary across the subbasin. The top map in **Figure 5a** shows simulated groundwater elevations in the shallow zone in July 2052 (the final year of the simulation) under the Base Case scenario. Note that the shallow zone is only present in the western half of the subbasin, corresponding to the areal extent of the Corcoran Clay. The middle map shows shallow-zone water levels under the SED40 scenario. In the Base Case scenario, the groundwater gradient was to the northwest, consistent with groundwater flow to the rivers. In contrast, a pumping trough had developed under the SED40 scenario. A pumping trough indicates a closed system and raises concerns about long-term salinity increases. The bottom map shows contours of the difference in shallow-zone water levels between the Base Case and SED40 simulations. The largest difference—about 30 feet—is near the eastern edge of TID in the central part of the basin. This area is farthest from the offsetting effects of induced river recharge.

Changes in water levels followed a similar pattern in the intermediate zone, as shown in **Figure 5b**. At its lowest point, the Eastside pumping trough was about 5 feet deeper under the SED40 scenario, demonstrating that the impacts of increased pumping in TID extend to the east. In the SED40 simulation (middle map), a second shallow pumping trough had developed in the western half of the subbasin. Again, this raises concerns regarding long-term accumulation of salinity in groundwater.

Simulated groundwater budgets also reveal how the system responds to the increase in pumping. **Figure 6** shows average annual magnitudes of eleven types of basin outflow (bars extending below the X axis) and nine components of inflow (bars extending above the axis). For each item, the Base Case value is paired with the SED40 scenario value. Pumping at TID drainage, rented and supplemental wells is greater under SED40 than under the Base Case reflecting the assumption of replacement pumping. Drainage and rented wells are operated by TID. Supplemental wells are private irrigation wells used by farmers to supplement deliveries from the TID canal system. Some of the increase in pumping was balanced by decreased groundwater outflow to drains and rivers, and some was balanced by increased percolation from rivers. Those responses occurred along gaining and losing river reaches, respectively. The decrease in irrigated lands recharge reflected an assumption that irrigation efficiency is higher (and hence return flow is lower) in fields irrigated with groundwater than in fields irrigated with surface water.

Table 1 summarizes how these components of the water budget responded to SED40 conditions. It shows that increased percolation from rivers and decreased groundwater outflow to rivers and drains together accounted for 62 percent of the response to the increase in pumping. Discharges from drains flow to the rivers and contribute to flow needed to meet compliance. This confirms that the change in groundwater-surface water interactions—which was ignored in the SED—is a major impact of the LSJR flow program.

This is extremely important because the effect directly undermines the objectives of the program by reducing river flows at downstream compliance points. Simply put, our modeling shows that for every acre-foot of water reallocated from TID to the Tuolumne River below LaGrange Dam, flows farther downstream along the Tuolumne, Merced and San Joaquin Rivers will be depleted by a combined total of 0.62 acre-foot due to the effects of increased groundwater pumping on net percolation from the rivers.

TID did not attempt to simulate an additional iteration of the feedback loop, but it would have shown even greater amounts of replacement pumping, lower groundwater levels and greater amounts of net percolation losses from the rivers.

The simulated impact of the SED40 scenario may be conservatively small because the model does not include boundary inflows that could also be impacted by the LSJR flow program. A separate groundwater flow model developed by Merced Irrigation District covers the Merced subbasin and also extends north about halfway across the Turlock subbasin (Amador, 2017). That model simulates the movement of groundwater between the subbasins. Simulations of future baseline and future LSJR flow program scenarios indicated that the Turlock Subbasin groundwater balance would become 13,100 AFY more negative under the SED40 scenario than the balance simulated by TID's model due to changes in Merced ID pumping within the Turlock Subbasin and changes in net flow between the subbasins, neither of which is included in TID's model.

Table 1. Response of Head-Dependent Fluxes to Changes in Specified Fluxes

Budget Item	Average Annual Flow 2013-2052 (AF)		Change in Flow (AF)	Percent of Change
	Base Case	SED40		
Specified Fluxes				
Turlock Lake releases - canal spills	420,716	332,133	-88,583	93%
Irrigated lands recharge	238,195	231,223	-6,971	7%
Net change in specified GW fluxes			-95,554	100%
Head-Dependent Fluxes				
Percolation from rivers	149,881	172,771	22,889	24%
Percolation from Turlock Lake	34,405	34,194	-211	0%
Groundwater outflow to rivers	40,280	17,879	-22,400	24%
Groundwater outflow to drains	25,220	12,523	-12,697	14%
Net annual storage change	-15,445	-51,018	-35,573	38%
Sum of absolute responses:			93,771	100%

AF = acre-feet Note: difference in totals reflects small change in canal seepage and evaporation.

The effect of groundwater pumping on simulated river flows is particularly noticeable under low-flow conditions. For example, **Figure 7** shows profiles of simulated flow along the Tuolumne, Merced and San Joaquin Rivers in October 2032 under Base Case and SED40 conditions. The biggest effect was a decrease in groundwater and drain inflows along the lower reaches of the Tuolumne and Merced Rivers and the entire length of the San Joaquin

River. At its confluence with the San Joaquin, Tuolumne River flow was 45 cfs (33 percent) lower under the SED40 scenario. In the Merced River, flow at the downstream end was 30 cfs (13 percent) lower and in the San Joaquin it was 60 cfs (20 percent) lower. Although these results are outside the February-June season targeted by the LSJR flow program, the depletion could have adverse biological effects not accounted for in the SED. Depletion of flow by groundwater pumping also occurred during February-June but was a smaller percentage of total flow.

Seasonal differences in river flows can be seen more easily in the hydrograph of simulated Tuolumne River flows at the San Joaquin River confluence shown in **Figure 8**. Under SED40, flow was higher in spring due to increased reservoir releases but lower in summer and fall due to depletion by groundwater pumping. To the extent that the summer/fall depletion adversely impacts fish, water quality or other users, the SED failed to address this impact.

Comment 6: SGMA Will Not be Able to Balance the Turlock Subbasin Groundwater Budget through Increased Recharge because All Sources of Water Available for Replenishment are Tributary to the Tuolumne, Merced and San Joaquin Rivers and Needed to Meet LSJR Flow Requirements

The SED inadequately addresses the combined effects of SGMA and the LSJR flow program. The SED evades the issue by stating that "groundwater protections that will be afforded by SGMA cannot be determined at this time with precision" (page 9-3). This is incorrect. SGMA is very explicit about the undesirable results that must be prevented to demonstrate groundwater sustainability. The LSJR flow program would exacerbate three of the six undesirable effects listed in SGMA and possibly initiate the fourth. These are:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon.
- Significant and unreasonable reduction of groundwater storage.
- Depletions of interconnected surface water that have significant and unreasonable impacts on beneficial uses of the surface water.
- Significant and unreasonable land subsidence that substantially interferes with surface land uses.

The water balance and groundwater modeling results presented in comments 1-5 demonstrate that the LSJR flow program will cause significant long-term lowering of groundwater levels, reduction in groundwater storage, and depletion of interconnected river flows. Because groundwater levels would eventually decline below historical minimums, subsidence could be initiated.

Maximum annual groundwater pumping would also increase under the LSJR flow program if the reduction in surface water deliveries is replaced by groundwater pumping. Maximum annual pumping can be estimated by the difference between the largest and smallest annual amounts of delivered surface water. For the Base Case scenario, this difference was

299,000 AFY and for the SED40 scenario it was 575,000 AFY. TID has already experienced impacts of high rates of pumping during previous droughts, when relatively shallow domestic wells began to go dry as water levels declined. Dry-year declines would be even larger under the SED40 scenario, leading to even greater impacts.

These undesirable results could theoretically be avoided by expanding groundwater recharge activities. However, for practical purposes, little or no water is available for replenishment because all potential local sources of stormwater, stream flow and wastewater discharge are already providing groundwater recharge or are tributary to the three rivers. In other words, those flows are already contributing to the LSJR flow requirements, and diverting them to water supply purposes would very likely end up requiring additional releases from the rim dams to continue meeting the requirements. There would be no net increase in water supply. To illustrate this point, municipal wastewater is already percolated at some treatment plants in the subbasin, and recycled water from others is already committed to irrigation and habitat enhancement projects, such as the North Valley Project. Rainfall runoff from lands overlying the subbasin only occurs under exceptionally wet conditions, when soils are already so saturated that additional infiltration is rejected. Growers in the eastern part of the subbasin are considering projects that would capture and infiltrate flows in small streams emanating from the eastern foothills, such as Sand, Mustang, MacDonald and Dry creeks. While that could benefit groundwater levels in the eastern part of the subbasin, it would divert water that currently contributes to flow in the Tuolumne, Merced and San Joaquin rivers. As a result, flows from these local streams are not likely to be available to compensate for the proposed reductions in irrigation supplies from the Tuolumne River.

A recent report on water available for replenishment (WAFR) prepared by DWR for the SGMA Program implementation suggests that about 10,000 AFY of additional water might be available for replenishment in the Turlock Subbasin (DWR, 2017). That estimate is too high because the WAFR analysis was based entirely on Delta outflow generically pro-rated to individual subbasins and did not consider constraints specific to the Turlock Subbasin. Specifically, the WAFR analysis was based entirely on Delta outflow simulated using DWR's CalSim II model. That model did not account for the SED proposed LSJR flow requirements. The majority of water purportedly available for replenishment is available during February-June, which is exactly the season during which the LSJR flow requirements render the water unavailable.

The WAFR report acknowledges that "more detailed analysis at a local level will need to be conducted by the GSAs as part of their groundwater sustainability plans (GSPs)." In addition, "these estimates of water available for replenishment need to be refined to provide ongoing support and technical assistance to GSAs". The SED needs to recognize the infeasibility of developing local water supplies to offset the decrease in existing surface-water deliveries under the LSJR flow program.

SGMA may not be used as a mitigation measure for the SED. SGMA will, instead, require the subbasin to achieve sustainability. If, as noted above, recharge is not available to offset reduced surface water supplies, SGMA will reduce the ability to make up for lost surface water supplies with groundwater pumping, as envisioned by the scenarios described above. Simply put, without a means to recharge, SGMA will require reduced pumping to avoid undesirable results.

Comment 7: About 16 Percent of TID Irrigated Area Would Have to Be Fallowed on Average Just to Balance the Subbasin Water Budget and Avoid Long-Term Water-Level Declines

The above comments demonstrate that due to multiple erroneous assumptions, the SED substantially underestimated the magnitude of impacts on groundwater budgets and agriculture in TID. The comments logically lead to a conclusion that the LSJR flow program in conjunction with SGMA will result in fallowing of cropland in TID. Using LSJR Alternative 3 (SED40) as an example:

1. Surface water deliveries to TID would be decreased by about 98,300 AFY on average.
2. TID growers cannot replace the surface water with groundwater because increased pumping would chronically deplete storage and river flows.
3. The amount of water-level decline and storage depletion is significant and would not meet SGMA criteria for sustainability. Simulated long-term water-level declines under SED40 are as much as 30 feet in 40 years and include an area east of TID where overdraft has already caused a deep, unsustainable pumping trough.
4. Depletion of river flows is not permissible because of LSJR in-stream flow requirements. Flow depletion could not simply be offset by additional reservoir releases because those would result in still more pumping and depletion.
5. Groundwater management efforts pursuant to SGMA will not be able to offset replacement pumping by increasing recharge. Nearly all local sources of water available for replenishment are tributary to the Tuolumne, Merced and San Joaquin Rivers. No regional water supply systems (e.g. SWP or CVP) serve the Turlock Subbasin.
6. Therefore, the only way to meet LSJR flow requirements and simultaneously prevent long-term water-level declines and storage depletion would be to maintain groundwater pumping at or below current amounts. Without replacement pumping, growers will be forced to fallow land.
7. The average amount of land fallowed annually would be proportional to the decrease in long-term average surface-water deliveries for irrigation. For the SED40 case, the 98,300 AFY reduction in surface water releases from Turlock Lake for irrigation purposes equals 16 percent of average TID irrigation water supplies (611,800 AFY during 1991-2014 [TID, 2015]). Therefore, if averaged over the long run, approximately 16 percent of TID cropland would have to be fallowed under LSJR Alternative 3.

COMMENT 8: VARIATIONS IN ANNUAL IRRIGATION PUMPING WOULD BECOME MUCH MORE EXTREME AND CAUSE UNACCEPTABLY SEVERE IMPACTS ON WELL OWNERS

In addition to the average annual impacts of the LSJR flow program described in Comment 7, there would be even more severe short-term impacts caused by large increases in groundwater pumping in individual years. **Figure 9** compares simulated annual agricultural groundwater pumping within TID under the Base Case and SED40 scenarios. The SED40 scenario assumed full replacement pumping, so the change in pumping from Base Case each year approximately equals the projected decrease in releases from Turlock Lake to the distribution canal system under the SED40 scenario. Under the Base Case scenario, agricultural pumping was exceptionally high (235,000 to 320,000 AFY) in 2017 and 2030-2032, which correspond to hydrologic years 1977 and 1990-1992. Historically during those periods, numerous well owners reported loss of well yield due to water-level declines. This especially impacted domestic wells, which are usually shallower than irrigation wells (Liebersbach, 2017). Regarding the impacts of the 1987-92 drought, in 1998 TID and Modesto Irrigation District submitted comments to the SWRCB on the 1995 Bay-Delta Water Quality Control Plan. Under the heading of groundwater impacts the comments indicated:

> The Turlock basin is not capable of sustaining increased groundwater withdrawals to meet new demands. In 1988, the TID rented pumps from individual farmers and increased groundwater pumping over previous levels to reduce the impact of surface water delivery curtailments resulting from the ongoing drought. The lowered groundwater table resulted in a lawsuit by domestic well owners against the district which was eventually dismissed. The TID paid claims totaling more than $200,000 to claimants allegedly impacted by the district's pumping operations.

This demonstrates that increased pumping during droughts can be problematic even under the Base Case scenario and would certainly be so with the much greater increases under the SED40 scenario.

Under LSJR Alternative 3 (SED40 scenario), agricultural groundwater pumping in TID would more than double in many dry years. In 14 years of the 40-year simulation, pumping would exceed the 200,000 AFY threshold historically associated with decreased well yields, particularly during droughts. For instance, surface water supplies would be extremely limited during a drought similar to 1976-1977. In simulation year 2016 (hydrologic year 1976) pumping was projected to be approximately 466,000 AF in the SED40 scenario. In simulation year 2017 (hydrologic year 1977), agricultural pumping reached 577,000 AF. Similarly, for simulation years 2027-2032 (corresponding to the hydrologic years 1987-1992) replacement pumping in the SED40 scenario ranged from 357,000 AF to 467,000 AF (with an average of 420,000 AFY over the 6 year period). A large, single-year increase in groundwater pumping of these magnitudes would be agriculturally and economically devastating, much less a longer dry cycle similar to the 1976-77 and 1987-1992 droughts:

- A significant percentage of crops grown in TID are tree and vine crops that cannot be fallowed for a year and resumed the following year. Water supply reliability is essential for those crops.
- Domestic wells are at high risk of going dry because they are typically relatively shallow. There are about 2,900 domestic wells in TID. While it may be desirable from a long-term water management standpoint not to limit operation of basin storage based on the shallowest well, it would be a huge financial burden on rural residents to expect most of them to deepen their wells. Furthermore, the need would likely come abruptly. In the time series of pumping (**Figure 9**) SED40 pumping was similar to Base Case pumping until the fourth year of the simulation, when SED40 pumping soared to 470,000 AFY. Water-level declines associated with that large an increase in total pumping would impact many wells at once. The water-well drilling industry is not large enough to deepen up to 2,900 wells in one year. Furthermore, interruption of water supply at rural residences could create a health and safety issue that could not reasonably be addressed by water delivery trucks or other make-shift remedies.
- Growers would be faced with the economic loss of losing their perennial crops or the very large expense of roughly doubling the number of irrigation wells. Again, when surface water deliveries abruptly drop it would not be feasible to drill enough additional wells to supply irrigation water before the permanent crops die.
- Pumping, and/or fallowing of this magnitude were not analyzed in the SED. As a result, the SED clearly underestimates the impacts associated with the proposed project.

COMMENT 9: THE SED FAILS TO CONSIDER THE CUMULATIVE IMPACT OF CLIMATE CHANGE ON WATER SUPPLY AND AGRICULTURAL IMPACTS

Watersheds draining the western slopes of the Sierra Nevada Mountains are shifting from snowmelt hydrologic regimes to rainfall hydrologic regimes. Locally, that will have a tremendous adverse impact on the water supply yields of New Don Pedro Reservoir and Lake McClure in addition to the impact of the LSJR flow program. When precipitation falls as snow, the water reaches the reservoirs as a relatively steady flow in the early part of the irrigation season. A relatively large percentage of the water can be productively used for irrigation. When it falls as rain, it reaches the reservoirs as storm-related flood events in winter and early spring. A smaller percentage of annual runoff can be stored for water supply purposes due to the increased frequency of reservoir spills and/or the need for larger flood pools in the reservoirs.

Climate change is not mentioned at all in the SED chapters on hydrology (Chapter 5) or groundwater (Chapter 9), nor was it accounted for in the Water Supply Effects model and other tools used for impact analysis (Appendix F). The loss of water supply due to climate change could easily be larger than the loss due to the LSJR flow program. Under Goal 6 of the LSJR flow program, the SWRCB must “take into consideration all of the demands” for water (page 3-2). In doing so, the impact of the LSJR flow program on water supplies must be considered on top of the impacts due to climate change.

SPECIFIC COMMENTS ON SED CHAPTER 9

1. Page 9-13. 3rd full paragraph. When describing the San Joaquin Valley Groundwater Basin, the SED mentions that "Groundwater levels have declined by as much as 100 ft in some areas, primarily in the southern and western-most portions of the basin outside of the plan area." This description doesn't recognize the cone of depression that has formed on the eastern side of the Turlock subbasin. Even though the Turlock subbasin was not identified as "critically overdrafted", Bulletin 118 recognizes the cone of depression and the localized overdraft. The SED misrepresents existing conditions by failing to disclose the current pumping trough and localized overdraft.

2. Page 9-14. 1st paragraph under "Interactions between Rivers and Groundwater". The estimate of 30,000 AFY of groundwater discharge to the Tuolumne, Merced and San Joaquin rivers developed by the Turlock Groundwater Basin Association (2008) referred to discharge from the Turlock subbasin only. Groundwater also discharges into the rivers from the opposite sides in amounts probably comparable to the accretion from the Turlock side. Consequently, the WSE model specifically and the SED in general underestimates the extent of groundwater-surface water interaction and the magnitude of river flow depletion that will result from future increases in groundwater pumping.

3. Page 9-15. 2nd paragraph under "Groundwater Balance and Elevations". The SED acknowledges that "if surface water applications are modified, then the subbasin's sustainable yield changes." A substantial amount of current groundwater yield derives from deep percolation of applied surface water. Furthermore, based on field evaluations within TID, growers tend to be more efficient in applying groundwater for irrigation than when applying surface water. Therefore, replacing surface water supplies with groundwater pumping will not only increase groundwater withdrawals but also decrease groundwater recharge.

4. Page 9-15, last line and Figure 9-4. By describing only water-level changes during 2005-2010 and characterizing them as "generally small", the SED implies that groundwater is plentiful. Surface water deliveries during that period were above average. The SED should also describe the water-level declines during 2010-2015, which occurred within TID in addition to the eastern half of the subbasin. This would present a more complete and realistic picture of groundwater levels and availability.

5. Page 9-17. Table 9-4. The table describes groundwater declines and overdraft conditions within the subbasins. The estimate for the Turlock subbasin is too low

because the referenced studies do not account for recent expansion of irrigated acreage in the eastern half of the subbasin. A study funded by DWR's Local Groundwater Assistance program documented an increase of 11,770 acres of irrigated cropland and 44,500 AFY of irrigation pumping from 2009 to 2014 (Todd Groundwater, 2016). Because that half of the basin is already in overdraft, the increase in pumping makes it even larger.

6. Page 9-18. Last paragraph before section 9.2.2. This section describes the subsidence that has occurred in the El Nido area. The last sentence in this paragraph states "Those areas that increased groundwater dependence while surface water was curtailed experienced subsidence during the drought periods, but very little subsidence between drought periods." Under the LSJR flow program, groundwater pumping in the western half of the Turlock subbasin would increase, especially during droughts. Because groundwater levels have historically been very stable, increased pumping combined with reduced recharge due to the SED would probably result in record low water levels during droughts and likely initiate subsidence.

7. Page 9-18. Bottom of the page. Stevinson Water District should be included in the list of agencies.

8. Table 9-5. Acreage estimates. Irrigated acreage has increased in recent years in the far eastern part of the Turlock subbasin (Todd Groundwater, 2016). The irrigated area for non-district areas within Turlock subbasin should be increased by 7,580 acres, to 126,000 acres.

9. Page 9-19. Last paragraph before "Groundwater quality". The SED states that "… the best indication of the potential for groundwater impacts that may occur if surface water diversions are reduced in drought years is the percentage of the irrigated area that falls within the irrigation district service areas and usually relies on surface water." This approach is reasonable because when surface water deliveries are replaced by groundwater pumping, there is a 1:1 impact on the groundwater balance. However, the impacts of lowered water levels within district service areas spread to adjacent non-district areas.

10. Page 9-20. First paragraph. The SED states, "The relatively low groundwater salinity on the eastern side can be attributed to the low salinity of Sierra Nevada runoff and application of surface water as a major irrigation source in the subbasins." While this may be true, there are saline soils on the western side of the Turlock Subbasin. Furthermore, the Turlock Subbasin has been identified in the CV-SALTS process as

having higher salinity/nutrient levels than the other eastern subbasins. Once again, this comment points to important local variability that the SED conceals by averaging data over entire subbasins.

11. Page 9-20. First paragraph. “In the Merced Groundwater basin, high TDS concentrations are principally the result of the migration of the deep saline water body which originates in regionally deposited marine sedimentary rocks that underlie the San Joaquin Valley.” The Turlock subbasin could similarly experience upwelling of deeper saline groundwater if pumping increases in response to decreased surface water deliveries. Furthermore, increased use of groundwater for irrigation combined with decreased net outflows to rivers will tend to increase the rate of salt accumulation in groundwater due to evaporative concentration of minerals in water applied for irrigation that are later leached from the soil to the water table.

12. Page 9-29. First and last paragraphs. These paragraphs describe the cone of depression centered east of TID near Eastside Water District and Ballico-Cortez Water District, both of which rely entirely on groundwater. This pumping trough has been present for many years and continues to deepen. The SED does not discuss additional overdraft that is occurring even farther to the east in the Turlock Subbasin. Water levels in the eastern non-district foothills area declined approximately 160 feet from 1970 to 2013. Irrigated acreage has also increased substantially in that area since 2009, which has exacerbated the overdraft (Todd Groundwater, 2016).

13. Page 9-29. Under “Turlock Irrigation District. The SED estimates that the minimum pumping within the district for drainage and irrigation purposes is 100 TAF/year, and the maximum is 275 TAF/year (referencing the 2008 GWMP). More recent Agricultural Water Management Plan reports show that pumping within TID during 2010-2015 ranged from 81 to 192 TAF/y (TID 2012, 2015). However, these values account for pumping during the irrigation season only and do not include drainage pumping and some crop watering during the non-irrigation season.

14. Page 9-29. Eastside Water District annexed additional land since the Turlock Basin Groundwater Management Plan was completed in 2008. Their area is now approximately 61,000 acres. Also, the acreage listed for Ballico-Cortez Water District appears to have an extra “0”. It should be more like 6,700 acres.

15. Page 9-37. Table 9-7 lists the Agricultural Water Management Plans referenced by the SED. For Turlock, the 2015 AWMP should have been used. It was readily available online (as required by the California Water Code).

16. Table 9-8. This table of water management strategies was purportedly developed from Agricultural Water Management Plans developed by water districts, including TID. It is unclear how the "All shortages managed with groundwater" column entry of "NA" (not applicable) for TID was determined. Within TID the only other water supply available to manage shortages is groundwater. It would be more accurate to put an "X" in that column for TID.

17. Page 9-41. Table 9-10. The table should include the East Stanislaus IRWMP.

18. Page 9-42. Table 9-11. The list of urban water management plans in the region is incomplete. For example, the cities of Turlock and Ceres prepare UWMPs. Also, the SED was completed after the release of the 2015 UWMPs, and those most recent editions should have been used for information in the SED.

19. Page 9-44. 2nd paragraph. "To the extent that water moves between subbasins, some of the groundwater impacts could have slight effects on adjoining subbasins, which would reduce the effects within the subbasins of concerns." This would not be true for the Turlock Subbasin, which is bounded by subbasins of concern. Groundwater modeling by Merced Irrigation District indicates that implementation of the LSJR flow program would decrease net groundwater flow from the Merced subbasin to the Turlock subbasin. For the SED40 scenario, their results suggest that impacts within the Turlock subbasin might be 13 percent larger than the impacts simulated using TID's groundwater model. Therefore, the SED's speculation about flows between subbasins is incorrect and results in an underestimation of the impacts to the Turlock Subbasin due to the LSJR flow program.

20. Page 9-44. 2nd paragraph. We acknowledge the difficulty of separating groundwater impacts by depth, but object to averaging impacts geographically over the entire subbasin area. Our major comment #1 elaborates on this issue. Among other things, estimating average water-level declines over the entire Turlock subbasin underestimates the potential for subsidence. Most of the water-level declines caused by replacement pumping would occur within TID in the western half of the subbasin. Over time, that area would experience record low water levels, and it is also the part of the subbasin where compressible clay layers are most likely to be present. Consequently, subsidence is a real risk that the SED fails to adequately characterize.

21. Page 9-46. 2nd paragraph under "Evaluation of Irrigation District Groundwater Balance and Impacts." Once again, the SED understates groundwater impacts by inappropriately averaging them over a large geographic area. The error is particularly blatant in this case because the SED calculated water balance impacts at the scale of water districts, then averaged the impacts over entire subbasins. The SED should have—and could have—calculated the water-level impacts at the scale of individual water districts where the water budget changes would occur.

22. Page 9-50. Figure 9-6. The period of record used for the analysis encompasses 1922-2002, which is the period simulated by regional planning models such as CVSIM II. Updating those models is a large effort that is understandably beyond the scope of the SED analysis. However, the 2013-2016 drought was exceptionally severe. The SED should at least describe that drought in terms of precipitation, water supply shortages and groundwater levels. Even if those are within the range of conditions simulated during 1922-2002, the occurrence of the recent severe drought increases the statistical probability of droughts in characterizing future impacts.

23. Page 9-50. Figure 9-6 partitioning of river base flow into end uses. This figure is for the Stanislaus River only. Similar figures for the Tuolumne and Merced rivers should be included.

24. Page 9-51. Figure 9-7b. Historically, TID has experienced much more groundwater pumping and much less unmet demand than shown in Figure 9-7b. As documented elsewhere in the SED, TID lands are planted in predominantly permanent crops. In past dry cycles, there has not been the significant fallowing of permanent crops that would have had to occur to result in the amount of unmet demand shown in the figure. In addition, the sum of "minimum" and "additional" groundwater pumping in Figure 9-7b is less than 140,000 AFY during droughts. Historically, irrigation pumping in TID alone exceeded 200,000 AFY for multiple years during the 1976-1977 and 1987-1992 droughts. This issue is discussed at greater length in our major comment #3.

    Furthermore, Figure 9-7b accounts only for irrigation pumping during the irrigation season. Additional pumping is required in the non-irrigation season for drainage, frost protection, unmet crop demand from rainfall, etc. The groundwater pumping identified in Table 3.5 in the AWMP only accounts for groundwater use during the irrigation season. The non-irrigation season pumping does not appear to be accounted for in the SED. As a result, the overall groundwater demand on the aquifer appears to be underestimated. Because of these errors, the SED analysis grossly underestimates the actual amount of pumping under historical conditions as well as the increase in pumping and the economic impacts of fallowing that would result from the LSJR flow program.

Furthermore, Figure 9-7b accounts only for irrigation pumping during the irrigation season. Additional pumping is required in the non-irrigation season for drainage, frost protection, unmet crop demand from rainfall, etc. The groundwater pumping identified in Table 3.5 in the AWMP only accounts for groundwater use during the irrigation season. The non-irrigation season pumping does not appear to be accounted for in the SED. As a result, the overall groundwater demand on the aquifer appears to be underestimated
Because of these errors, the SED analysis grossly underestimates the actual amount of pumping under historical conditions as well as the increase in pumping and the economic impacts of fallowing that would result from the LSJR flow program.

25. Page 9-56. Figure 9-12. Again, the volumes are based on the flawed assumption that pumping capacity will remain at 2009 or 2014 levels. As a result, it underestimates the likely impact of the SED alternatives on groundwater levels and budgets.

26. Page 9-59. 3rd full paragraph under "LSJR Alternative 2". "Under LSJR Alternative 2, the direction of groundwater flow would not change such that any existing localized groundwater contamination in the subbasins would be affected… Furthermore, LSJR Alternative 2 would not cause a significant amount of applied surface water, which is relatively low EC, to be replaced with applied groundwater, which has relatively high EC… Consequently, LSJR Alternative 2 would not cause an increase in salinity concentrations in the groundwater subbasins."

    This analysis understates salinity impacts in three respects. First, it underestimates the amount of groundwater that would be applied for irrigation (see previous comment). Second, it assumes that per-application irrigation efficiency is the same for surface water and groundwater. TID has found through empirical audits that irrigation efficiency is generally higher for groundwater users. This results in a higher degree of evaporative concentration of salts in the irrigation water. Third, TID's groundwater modeling shows that increased groundwater pumping to replace the lost surface water supplies in the western half of the Turlock subbasin would decrease the northwesterly groundwater gradients and even create a pumping trough. This decreases the amount of groundwater outflow, which is necessary to limit long-term salinity increases. Increased salinization of groundwater in the

Turlock subbasin is an expected result of the LSJR flow program and a definite concern for long-term agricultural sustainability.

27. Page 9-60. 1st full paragraph. TID agrees with the statement that "it is reasonable to assume that localized groundwater contamination that exists in the subbasins could move in undesirable directions (i.e. toward water supply wells) and reduction in deep percolation of the relatively low EC surface water could also affect groundwater quality by causing a gradual increase in salinity." Even without accounting for greater evaporative concentration of applied irrigation water and decreased groundwater outflow (see previous comment), the SED appropriately finds this impact to be significant.

28. Page 9-61. 1st full paragraph. It is the responsibility of a project applicant to fund mitigation measures identified as necessary in an environmental impact analysis. In this case, the SWRCB is the applicant and the lead agency for environmental review. The SED identifies "mitigation measures" but unreasonably assigns them to others to implement and fund.

    This section inappropriately uses SGMA as a mitigation measure. Although SGMA does require that agencies achieve sustainability, assigning SGMA implementation to local agencies as a means for "mitigating" for the SED impacts are inappropriate. SGMA was not designed to assign mitigation to local agencies for the SWRCB's actions. The additional impacts as a result of the SED will increase the costs associated with SGMA. It will make compliance with SGMA much more challenging as it reduces the surface water supplies available to achieve sustainability.

    Additionally, the SED ignores the fact that the SWRCB is the regulatory backstop to SGMA. As a result, if the local agencies are unable to achieve sustainability, made more difficult through the SED actions, the SWRCB would have to step in to achieve sustainability until such time as the local agencies can do so. SWRCB staff responsible for SGMA have been very clear that implementation of SGMA by the SWRCB would not involve anything to increase water supplies. It would simply involve reducing pumping until it falls within water supply constraints of the subbasin. However, the SED neglects to evaluate this possible future scenario, including the possible impacts to water supplies, agricultural crops, and the economy.

    Similarly, under the groundwater impacts section, the SED proposes as "mitigation" reductions in pumping to achieve sustainability. Reductions in pumping would reduce the amount of water available for irrigation supplies. That reduction in pumping was not evaluated and incorporated under the agricultural impacts section (where it was assumed that pumping would be able to be continued at existing levels). Therefore, the SED underestimates economic and other impacts of the LSJR flow program as a result of the proposed "mitigation" measure.

The proposed "conjunctive water management program that would divert surface water during non-irrigation months (e.g. October-April) during wet years into unlined canals and designated field to recharge the groundwater" is just an untested concept. There is no analysis of whether or not such actions are feasible or if they would achieve the desired results. They are simply provided as mitigation. Such a program would be challenging. As indicated in the SED, these water supplies would likely only be available in wet years when storms have likely left fields extremely wet already, and canals are being used to convey local stormwater flows. Also, these flows are at a time when additional flows are required for the rivers under the SED, so the only water that would be available for recharge would likely be during very high flow periods. They would be the flashiest flows that are most difficult to capture and utilize. Additionally, most of the canals are lined, precluding recharge in this manner. Removing the lining would impact water supplies in dry years, causing additional seepage losses when limited supplies must be conserved. A majority of land within the TID is also permanently cropped. It is currently unclear how almonds and other tree crops respond to the additional water being applied in these wet cycles. Lastly, these proposed wet weather flows would need to be conveyed through the canals in the non-irrigation season, which is the only time the District is able to remove canals from service for essential maintenance. All of these constraints and subsidiary impacts are foreseeable and should have been evaluated in the SED. The SED fails to demonstrate that the proposed "mitigation measures" would be feasible, sufficient and successful in mitigating the proposed impacts.

29. Pages 9-62 through 9-64. LSJR Alternative 3. All of our above comments regarding LSJR Alternative 2 (SED pages 9-59 through 9-63) also apply to LSJR Alternative 3.

30. Pages 9-65 through 9-66. All of our above comments regarding LSJR Alternative 2 (SED pages 9-59 through 9-63) also apply to LSJR Alternative 4.

31. Pages 9-67 through 9-70. Subsidence impacts. The SED inappropriately limits its discussion of subsidence to areas where it has historically been measured. Although subsidence has yet been detected in the Turlock subbasin, it will likely occur if groundwater pumping increases and water levels decline as a result of the LSJR flow program. Groundwater levels are most likely to decline in the western half of the

subbasin, which is where the Corcoran clay is present. The Corcoran Clay is known to have subsidence potential.

For all three LSJR alternatives, the SED states that, "Subsidence in the other subbasins is less likely to occur given that there is little evidence that the soils in these subbasins are subject to inelastic compaction." As a result they dismiss subsidence in basins other than the Extended Merced Subbasin. Studies done by the USGS have found significant potential for subsidence in the other subbasins within the project area. For example, one study measured little inelastic subsidence in the northern San Joaquin Valley during 2003-2010 but attributed that to the absence of drought and historical low groundwater levels during that period (Sneed and others, 2013). Another study simulated climate change through the remainder of the 21st century using a linked set of climate, hydrology, water operations and groundwater models (Hansen and others, 2012). In contrast to historical patterns, the models predicted greater subsidence on the eastern side of the San Joaquin Valley than on the western side because of a more drastic shift from surface water supplies to groundwater. Most of the Turlock Subbasin was in the two highest categories of projected subsidence ("great" and "extreme").

A compilation of clay compressibility data for the San Joaquin Valley derived from four different approaches found a fairly consistent average inelastic specific storage value of 3×10^{-4} ft^{-1} (Sneed, 2001). Studies referenced in that compilation found that about 60 percent of total alluvial thickness typically consisted of fine-grained materials. Thus, for a 600-foot-deep well there would typically be about 360 ft of fine-grained material with an overall inelastic storage coefficient of 0.11. This means that for 100 feet of water-level decline below the lowest historical water level, 11 feet of subsidence could be expected. Given simulated water-level declines of up to 30 feet in TID under SED40 (see major comment #5 above), this simple arithmetic suggests that 3 feet of subsidence might occur during that time frame. This is sufficient to collapse well casings and cause infrastructure concerns. The SED analysis of potential subsidence impacts in the Turlock subbasin is inadequate.

32. Pages 9-67 through 9-70. SGMA as mitigation. The SED proposes SGMA as mitigation for groundwater impacts but fails to describe the foreseeable impacts of SGMA implementation. Our major comments #1 through #7 lay out the logical steps that demonstrate that substantial land fallowing will be the inevitable result of implementing SGMA in conjunction with the LSJR flow program. The SED must acknowledge this reality.

    The SWRCB again proposes SGMA as a mitigation measure. However, doing so implies that groundwater pumping might need to be reduced in order to reduce the potential for subsidence. However, the economic impacts of fallowing caused by the overall reduction in irrigation supply resulting from the LSJR program and SGMA has not been evaluated.

33. Page 9-70. Chapter 9 offers no discussion of cumulative impacts and refers to Chapter 16, where only growth-inducing impacts and irreversible commitment of resources are discussed. A major weakness throughout the SED groundwater analysis is the failure to adequately and honestly account for the cumulative impacts of the LSJR flow program with SGMA and with climate change. Both of these current and foreseeable factors greatly amplify the impact of the LSJR flow program on local water supplies and consequently on agriculture and the economy.

34. Page 9-71. References cited. It is unclear why the SWRCB used current sources for some data but not others. Some references cited were from 2016. However, the SED did not use up-to-date groundwater level data (available online from DWR) or the current updates of Agricultural Water Management Plans (2015) and Urban Water Management Plans (June 2016).

References Cited

California Department of Water Resources (DWR). January 2017. Water Available for Replenishment. Draft Report. DWR Sustainable Groundwater Management Program, Sacramento, CA. Available at http://www.water.ca.gov/groundwater/sgm/wafr.cfm

Amador, Dominick. Woodard & Curran. February 2, 2017. Personal communication.

Durbin, T.J. December 2008. Turlock Irrigation District groundwater model documentation. Draft. Prepared for Turlock Irrigation District, Turlock, CA.

Durbin, T.J., and L.D. Bond. 1998. FEMFLOW3D: a finite-element program for the simulation of three-dimensional aquifers, Version 1.0. Open-File Report 97-810, U.S. Geological Survey, Sacramento, CA.

Hansen, R.T., L.E. Flint, A.L. Flint, M.D. Dettinger, C.C. Faunt, D. Cayan and W. Schmid. February, 2012. A method for physically based model analysis of conjunctive use in response to potential climate changes. Water Resources Research 48:

Liebersbach, Debbie. Water Planning Department Manager, Turlock Irrigation District. March 6, 2017. Personal communication.

Monier, Wes. Operations modeler, Turlock Irrigation District. December, 2016. Personal communication.

Sneed, M. 2001. Hydraulic and Mechanical Properties affecting Ground-Water Flow and Aquifer-System Compaction, San Joaquin Valley, California. Open-File Report 01-35. U.S. Geological Survey, Sacramento, CA.

Sneed, M., J. Brandt and M. Solt. 2013. Land subsidence along the Delta-Mendota Canal in the northern part of the San Joaquin Valley, California, 2003-10. Scientific Investigations Report 2013-5142. U.S. Geological Survey. Sacramento, CA.

Todd Groundwater. March 2016. Hydrogeologic characterization of the eastern Turlock Subbasin, Final Report. Alameda, CA. Prepared for City of Turlock CA.

Turlock Irrigation District. November 2015. 2015 Agricultural Water Management Plan. Turlock, CA.

Appendix A. TID Groundwater Model and Simulation of LSJR Alternative 3

Numerical Model Development and Calibration

For the past 15 years, TID has used a numerical groundwater model of the Turlock subbasin as an analysis tool to support water resources management. The model has been updated several times during that period to incorporate more recent input data, improve model calibration and add capabilities for simulating specific aspects of the groundwater flow and water management systems. The most recent complete documentation of the model was prepared in 2008 (Durbin, 2008). This appendix describes the main features of the model and documents data and assumptions used to simulate the future Base Case and SED40 scenarios.

The model is a finite-element model that uses the FEMFLOW3D modeling software developed by the U.S. Geological Survey (Durbin and Bond, 1998). A map of the model grid is shown in **Figure A-1**. The simulated flow domain is bounded on the north, west and south by the Tuolumne, San Joaquin and Merced rivers, respectively. The eastern edge is a no-flow boundary representing granitic bedrock of the Sierra Nevada foothills. The model contains layers corresponding to geologic formations. Basin thickness and the number of layers both increase from east to west, as shown in **Figure A-2**. At the eastern edge only the Ione Formation layer is present in the model. At the western edge, the layers from top to bottom correspond to the Modesto Formation, a shallow aquitard (within the Modesto Formation), the Riverbank Formation, the Corcoran Clay, the Turlock Lake Formation, Mehrten Formation, Valley Springs Formation and Ione Formation. The layers pinch out or bend up to intersect the land surface, and the eastern extent of each model layer is truncated accordingly.

The rivers are head-dependent boundaries in which seepage between the river and aquifer is a function of the water-level difference between the river surface and nearby water table and the wetted area and permeability of the riverbed. Where the river bottom is above the water table, river percolation is independent of water-table elevation and a function only of stage, width and bed permeability in the river. The river boundaries are in the top model layer. The edges of the deeper layers are no-flow boundaries.

The hydraulic conductivity and specific storage of the model elements were estimated by calibration, in which simulated water levels during 1991-2012 were compared with measured water levels. Calibration was achieved by a combination of manual adjustments and optimization methods (PEST).

The model incorporates spatial and temporal variations in land and water use in great detail. TID diverts surface water from the Tuolumne River and delivers it by a network of canals to agricultural lands throughout the western half of the subbasin. TID also pumps groundwater from a number of wells into the canal system to increase water availability in parts of the TID service area while decreasing shallow water table problems in other areas. Areas with shallow water table problems also have agricultural soil drainage systems. Those are included in the model as head-dependent drain boundaries.

Most growers in the TID service area also operate wells to make up any differences between surface water supplies and irrigation demand, especially during droughts. Because canal operation is not perfect, some water spills from the terminal segments of the canal system back into the rivers. Growers outside the surface water delivery areas rely exclusively on wells for irrigation. A number of cities and towns pump groundwater for municipal use, riparian landowners along the rivers divert surface water privately to irrigate their fields, and a small part of Merced Irrigation District is in the Turlock subbasin adjacent to the Merced River.

Irrigation demand, surface water deliveries, groundwater pumping, and recharge from canal leaks and irrigation return flow are all simulated using pre-processing programs that prepare the input files for FEMFLOW3D. For a specified time series of monthly surface water deliveries entering the canal system, these programs estimate drainage well and rented well pumping by TID, irrigation demand by crop and location (using monthly rainfall and reference evapotranspiration data), and supplemental pumping by growers. Municipal pumping data is obtained from the well operators. Canal leakage is estimated based on metered flow data from historical canal operations. Distributed recharge is estimated by means of a soil-moisture balance approach that incorporates root depth, available water capacity and assumed irrigation efficiency.

During 1991-2012, distributed recharge from rainfall and irrigation return flow accounted for about two-thirds of total recharge. Percolation from rivers and canals accounted for about 13 percent and 7 percent, respectively. The remainder is divided roughly equally between Turlock Lake leakage and percolation of irrigation water, pipe leaks and septic systems in developed areas.

Revisions to the model include improved estimates of irrigated area in the eastern part of the subbasin—where cropland has been expanding—and revised estimates of crop consumptive water use based on remote sensing data. **Figure A-3** shows hydrographs of simulated and measured water levels at 12 wells. This is a small subset of the 480 hydrographs evaluated during model calibration. Contours of simulated and measured water levels in April 2002 are shown in **Figure A-4** for intermediate-zone wells and in **Figure A-5** for shallow-zone wells. Although there are differences between simulated and measured water levels, the general patterns and trends match reasonably well. The magnitudes of the differences are comparable to previous calibrations of the model.

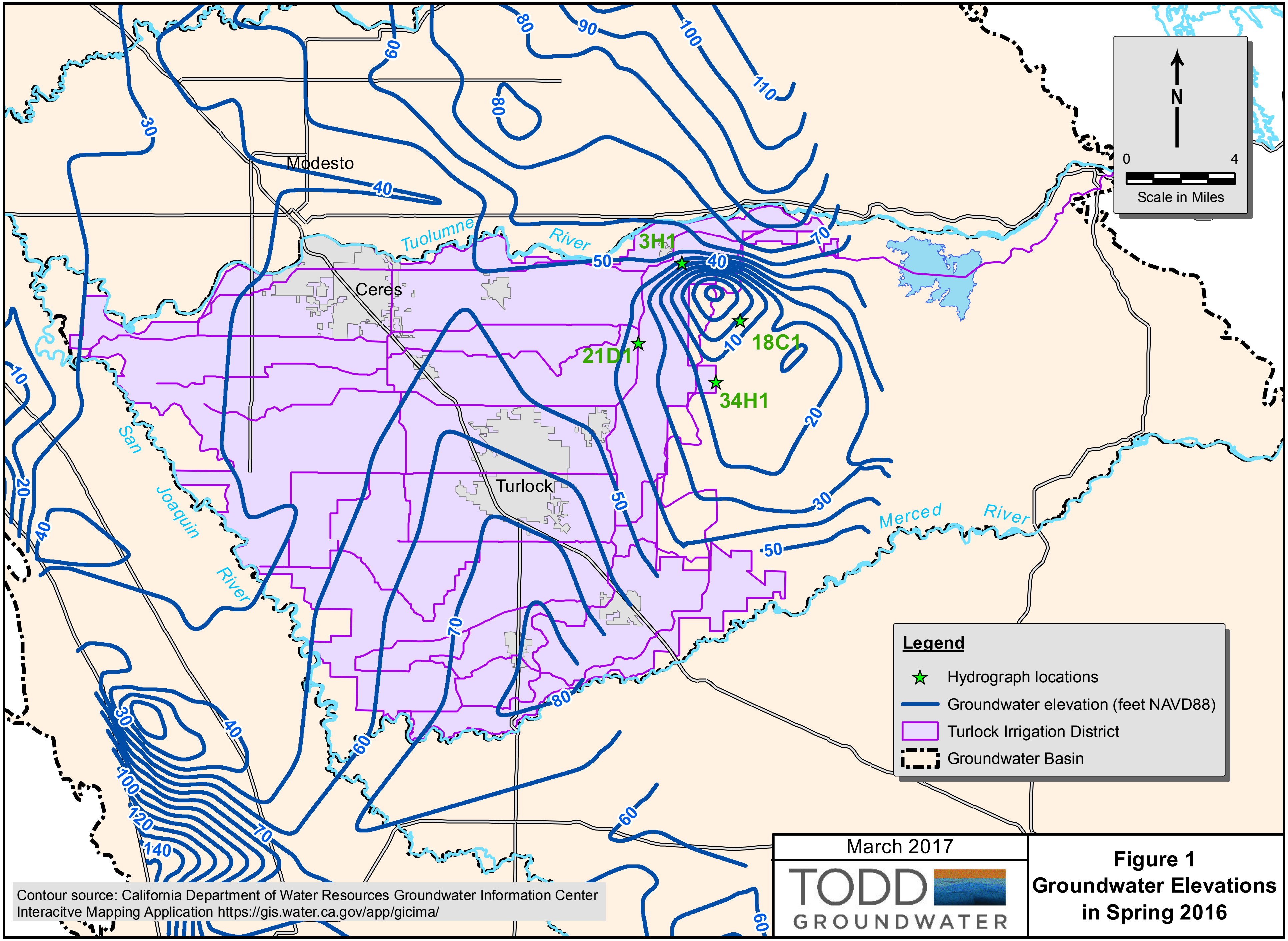
Simulated annual groundwater budgets for the 1991-2012 calibration simulation are shown in **Figure A-6**. Two-thirds to three-fourths of the recharge is from percolation of rain and irrigation water on irrigated lands, especially lands within TID. Net recharge from rivers is the next largest source of recharge, followed by smaller amounts of leakage from Turlock Lake and canals. The largest outflows in descending order are to Eastside Water District wells, non-district wells, wells within TID, outflow to rivers, phreatophyte evapotranspiration and municipal wells. Groundwater storage was relatively low at the start of the simulation due to several preceding drought years. Several wet years increased storage by about 500,000 AF by 2001. A preponderance of dry years decreased groundwater storage by about the same amount by 2012.

Data and Assumptions for Scenario Simulations

The calibrated model was used to simulate two scenarios representing possible future conditions: Base Case and LSJR Alternative 3. The model grid, aquifer characteristics and boundary conditions remained the same as in the calibration simulation and were the same for both scenarios. Variables that were changed to represent future conditions are described in **Table A-1**, along with relevant assumptions and data sources.

Table A-1. Modeling Data and Assumptions for Simulation of Future Scenarios

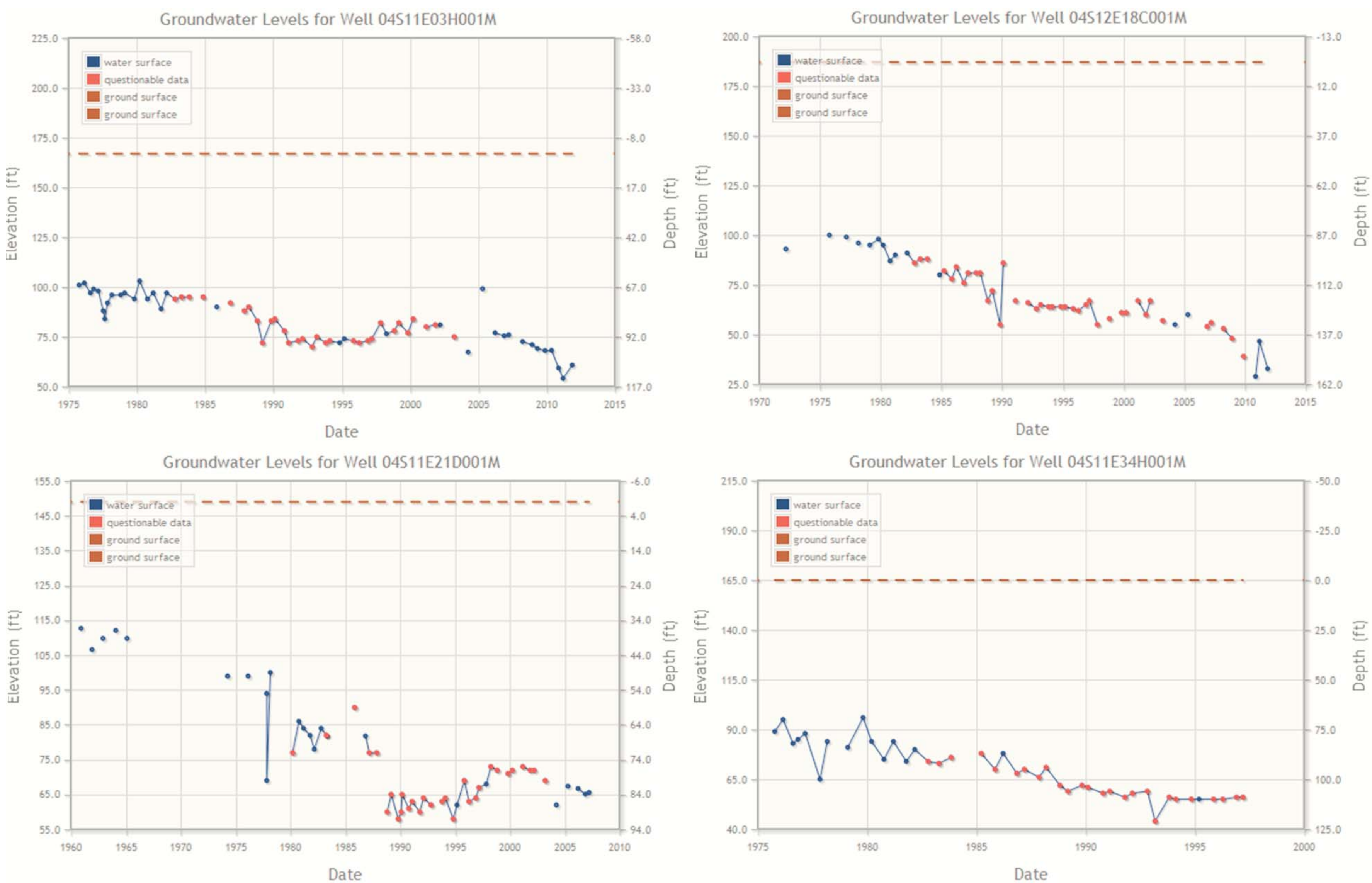
Model Input Variable	Data and Assumptions
Simulation period	Calendar years 2013-2052, using monthly time steps.
Hydrology	Historical rainfall and ET from 1973-2012, which includes two droughts and some very wet years.
Land use	Crop patterns in 2012 were assumed to remain constant throughout 2013-2052 for both scenarios.
Surface water deliveries to TID	Irrigation water diverted from the Tuolumne River at La Grange and delivered into the TID canal system via Turlock Lake was simulated under Base Case and LSJR Alternative 3 conditions using TID's Tuolumne River System (TRS) operations model. The model applied current operating rules and constraints for reservoirs in the watershed (including San Francisco's operation of the Hetch-Hetch system) to 1922-2003 unimpaired hydrology from the Calsim II model (the same hydrology used by the WSE model). The TRS model also applied the 40-percent-of-unimparied flow criterion for releases from La Grange Dam to the Tuolumne River to determine the amount of water available to TID each month.
Tuolumne River flows	TID's TRS model calculated monthly releases to the Tuolumne River using current operating rules for the Base Case scenario and the 40-percent-of-unimpaired-flow criterion for the LSJR Alternative 3 scenario.
Merced and San Joaquin river flows	Historical inflows and diversions during 1973-2012 were repeated for 2013-2052. The groundwater model dynamically calculates river flow gains and losses in each simulation based on river stage, area, bed permeability and nearby water table elevation.
TID pumping of drainage and rented wells	A second operations model simulated TID's canal and well system. Based on historical correlations with Turlock Lake releases, the model estimated pumping of drainage wells and rented wells into the canal system, canal spills, canal percolation losses, and deliveries to various irrigation customer categories.
Canal spills, losses and deliveries	Ditto.
Irrigation demand	Irrigation demand was calculated from crop area, crop coefficient, potential evapotranspiration and assumed irrigation efficiency using a soil-moisture-budget approach implemented in a groundwater model pre-processing program. Based on TID field studies, irrigation efficiency is higher when groundwater is the source of supply (90 percent) instead of surface water (75 percent).
Groundwater pumping for irrigation	In areas that receive TID canal water, supplemental groundwater pumping was assumed to make up the difference between irrigation demand and surface water delivery. For the LSJR Alternative 3 scenario this represents "full replacement" pumping. For areas supplied entirely by groundwater, pumping was the same for both scenarios.
Well depths and locations	The depths and locations of irrigation, municipal and rural domestic wells were the depths and locations of active wells in 2012. They remained unchanged in both scenarios. All that changed was the pumping rates for some well categories. This implies no restriction on pumping capacity for replacement pumping. If additional capacity is installed to offset chronic surface-water supply shortages, additional wells would be installed in the same general atreas and similar depths as existing irrigation wells, so this assumption is reasonable for basin-scale analysis.
Merced Irrigation District deliveries and pumping	Surface-water deliveries and groundwater pumping to the small part of Merced ID along the north side of the Merced River were assumed to equal historical deliveries and pumping during 1973-2012.
Municipal pumping	Municipal pumping in 2012 was repeated each year for 2013-2052 in both scenarios.
Turlock Lake percolation	Turlock Lake is simulated as a constant-head boundary in the groundwater model. Percolation is a function of lake area, bed permeability and elevation difference between the lake and adjacent water table.
Riparian phreatophyte ET	Evapotranspiration by phreatophytic riparian vegetation was assumed to equal the unrestricted plant ET demand (assumed equal to reference ET) minus current-month rainfall. The amount was assumed to be independent of water table elevation and was the same for both scenarios.



March 2017

TODD GROUNDWATER

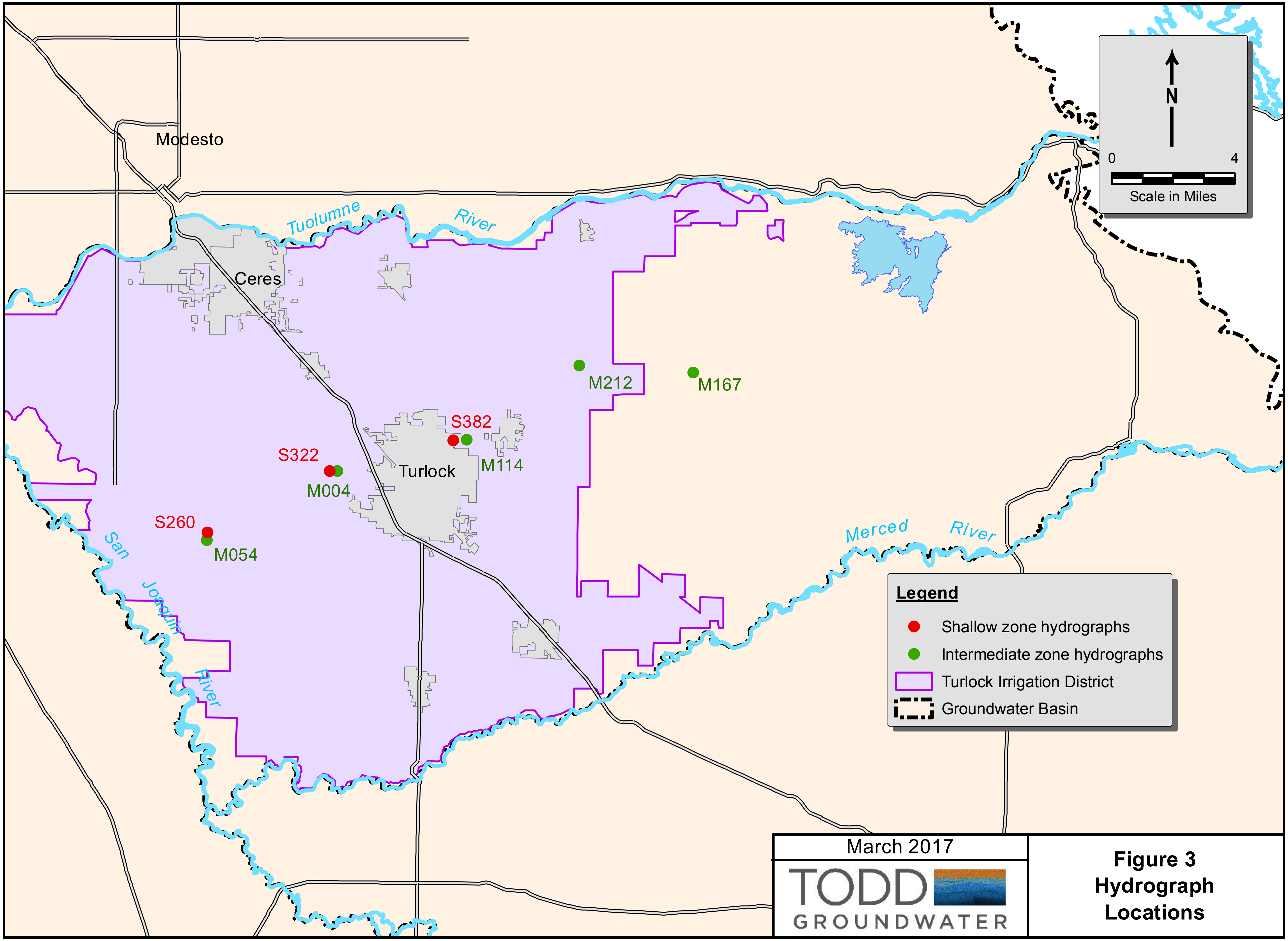
Figure 1
Groundwater Elevations in Spring 2016



March 2017

TODD GROUNDWATER

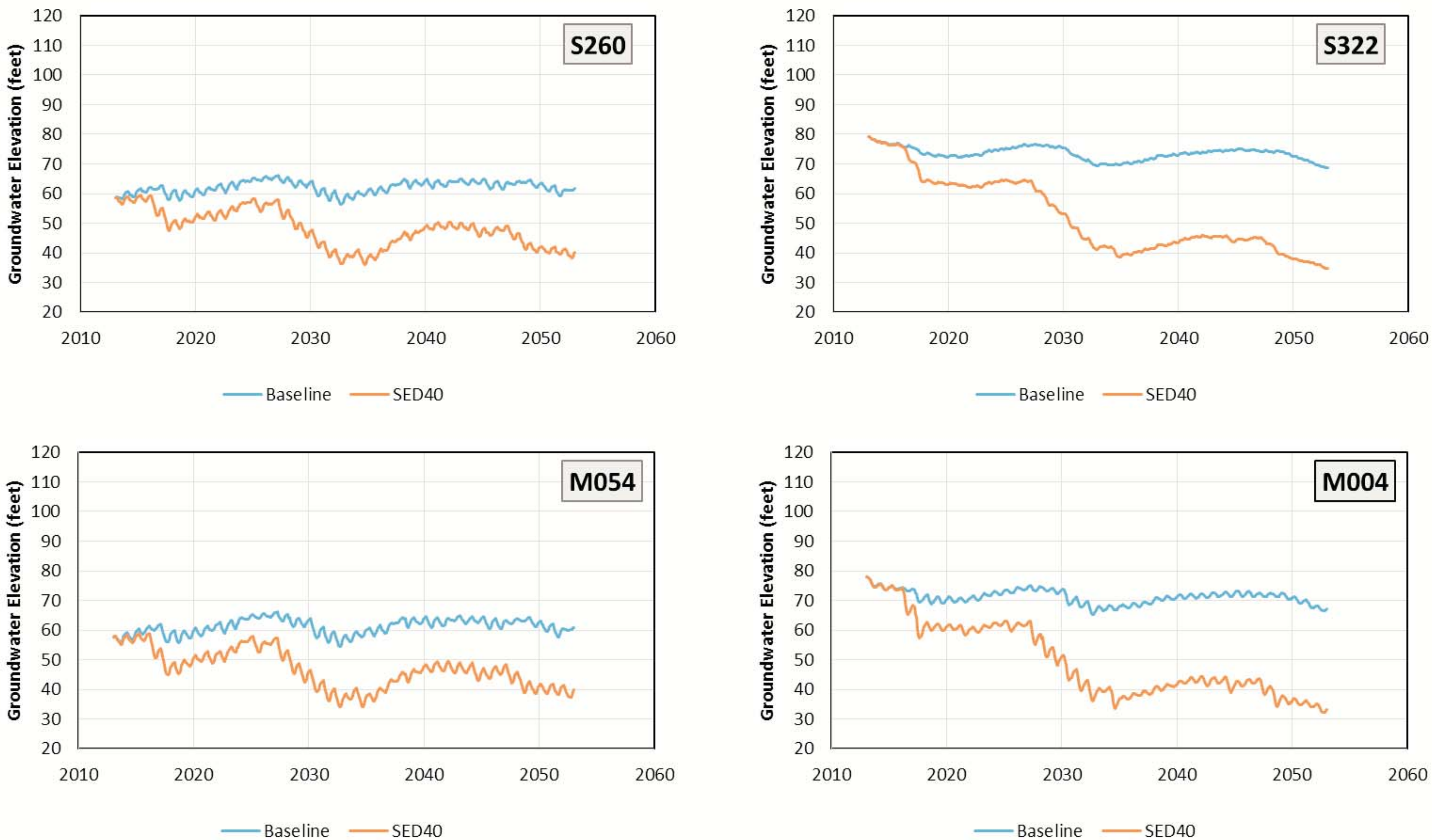
Figure 2
Groundwater Hydrographs near Eastside Pumping Trough



March 2017

TODD GROUNDWATER

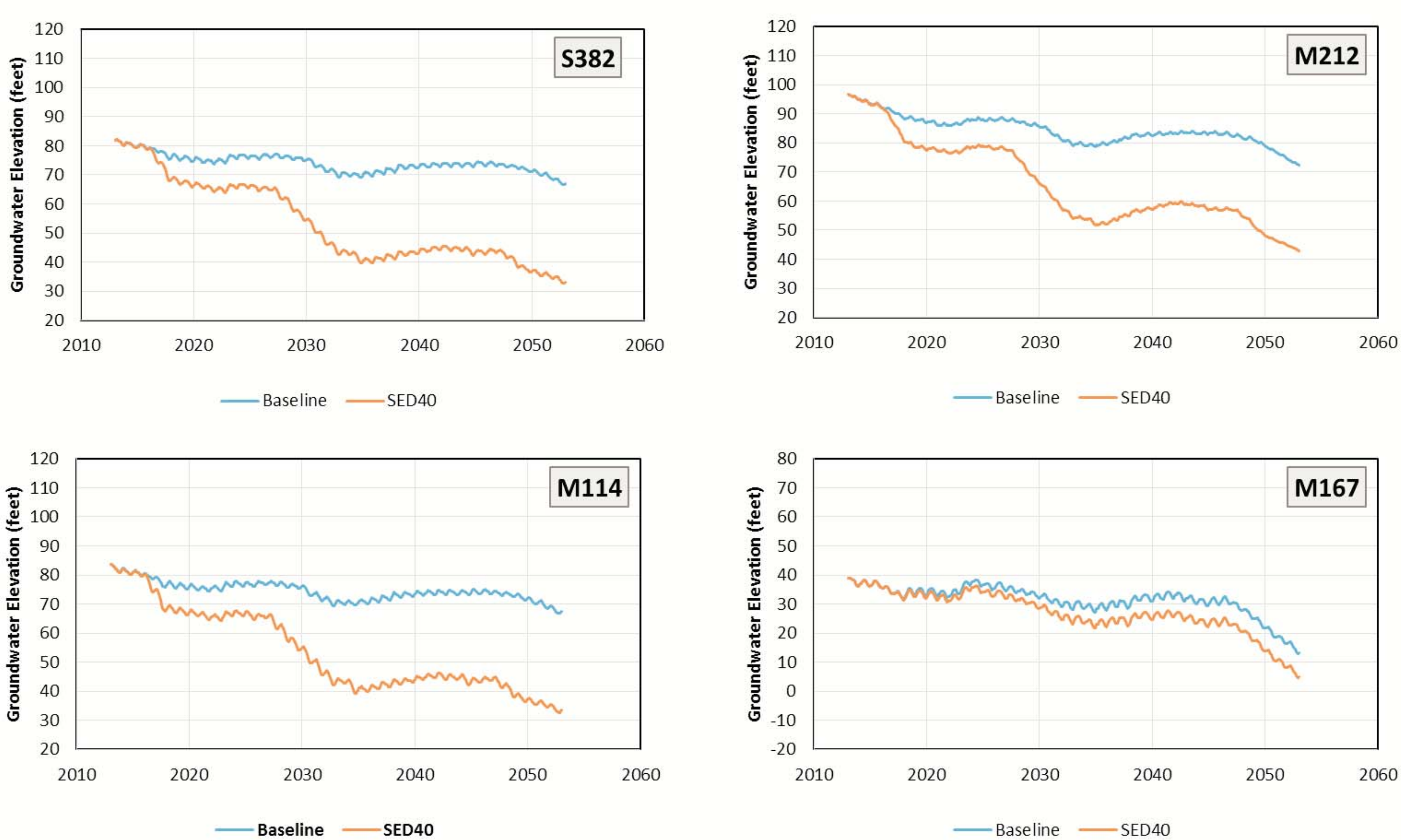
Figure 3
Hydrograph Locations



March 2017

TODD GROUNDWATER

Figure 4a
Hydrographs of Simulated Water Levels, Base Case, and SED40 Scenarios



March 2017

TODD GROUNDWATER

Figure 4b
Hydrographs of Simulated Water Levels, Base Case, and SED40 Scenarios

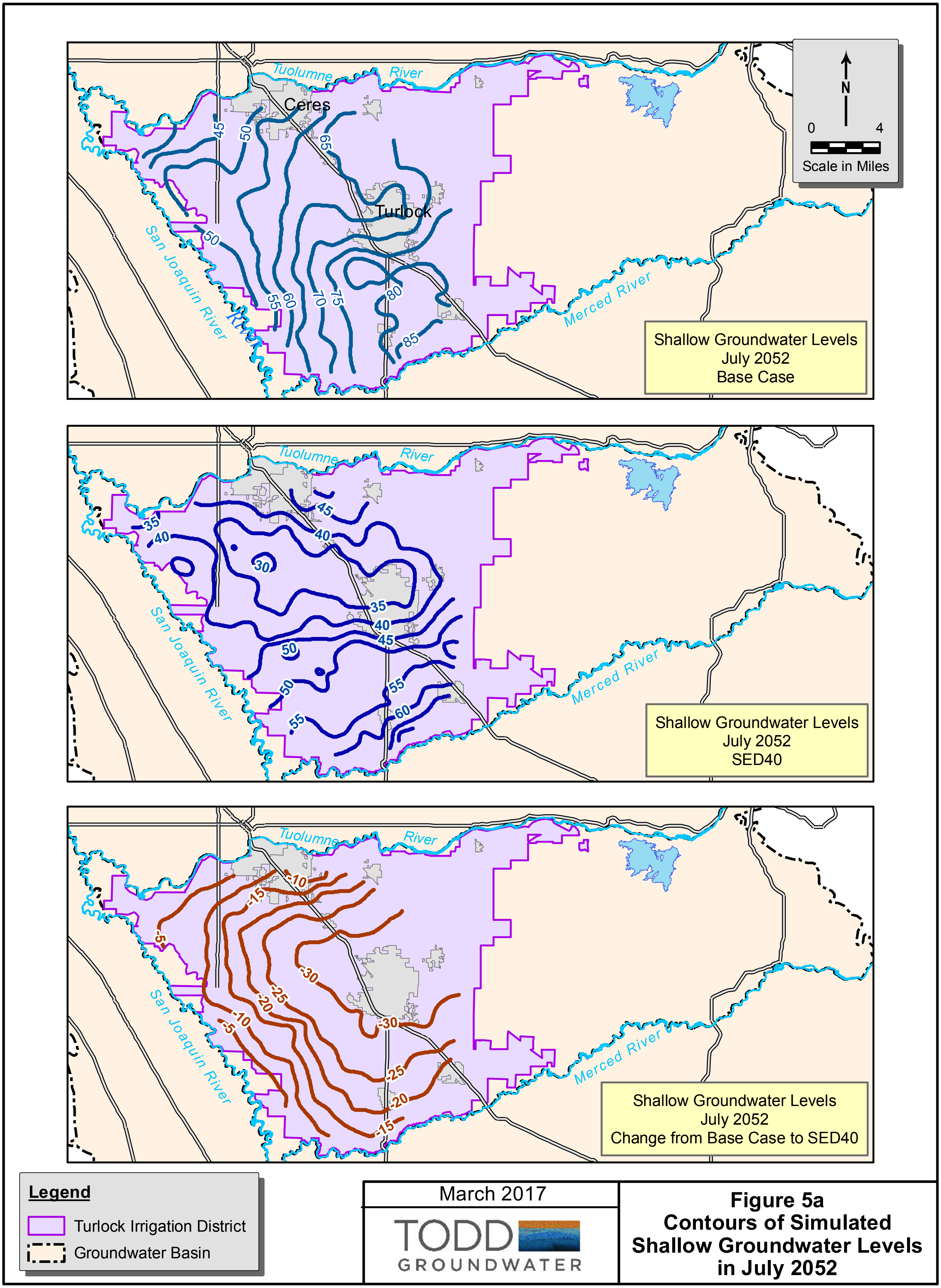
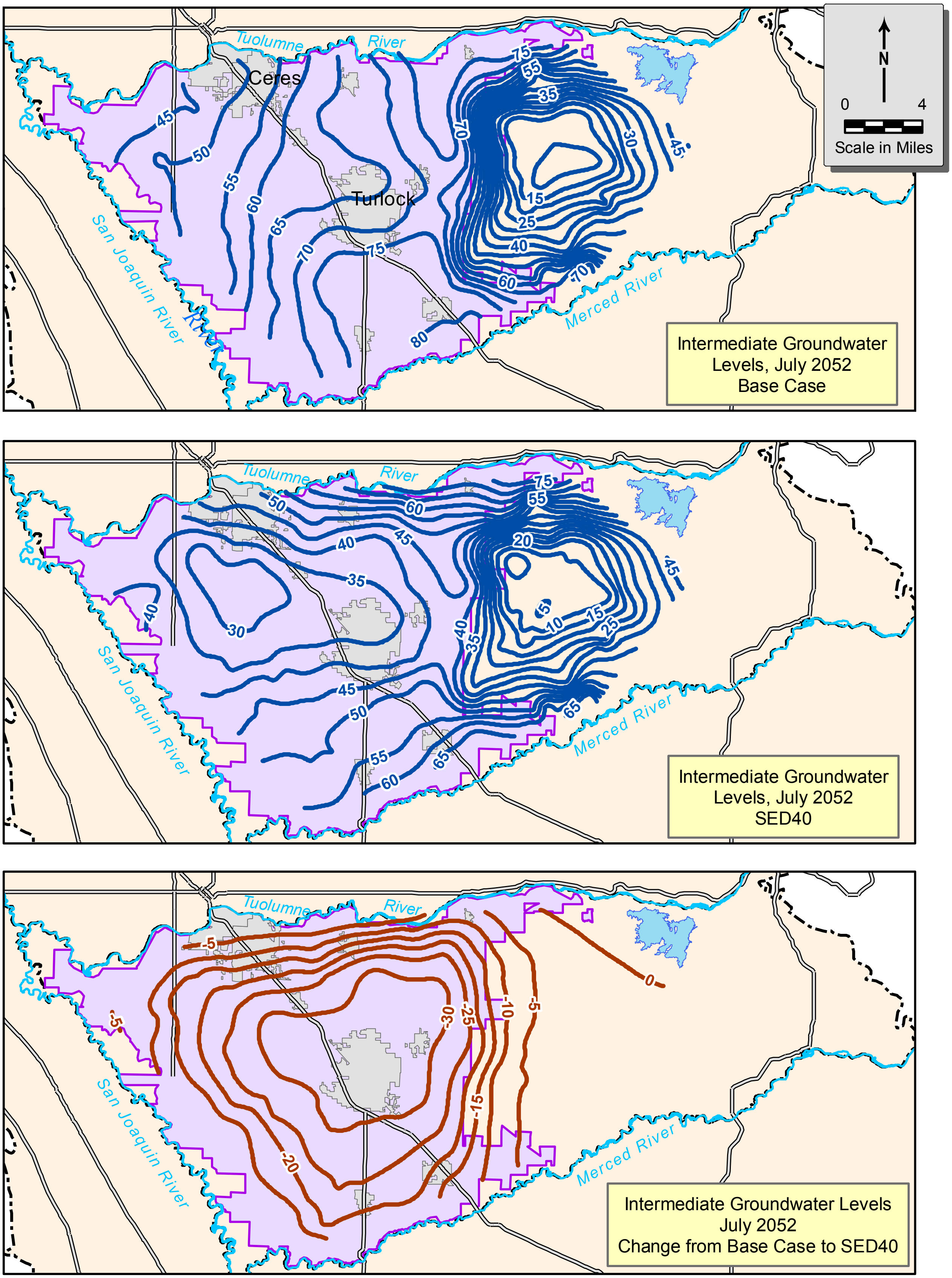


Figure 5a
Contours of Simulated Shallow Groundwater Levels in July 2052



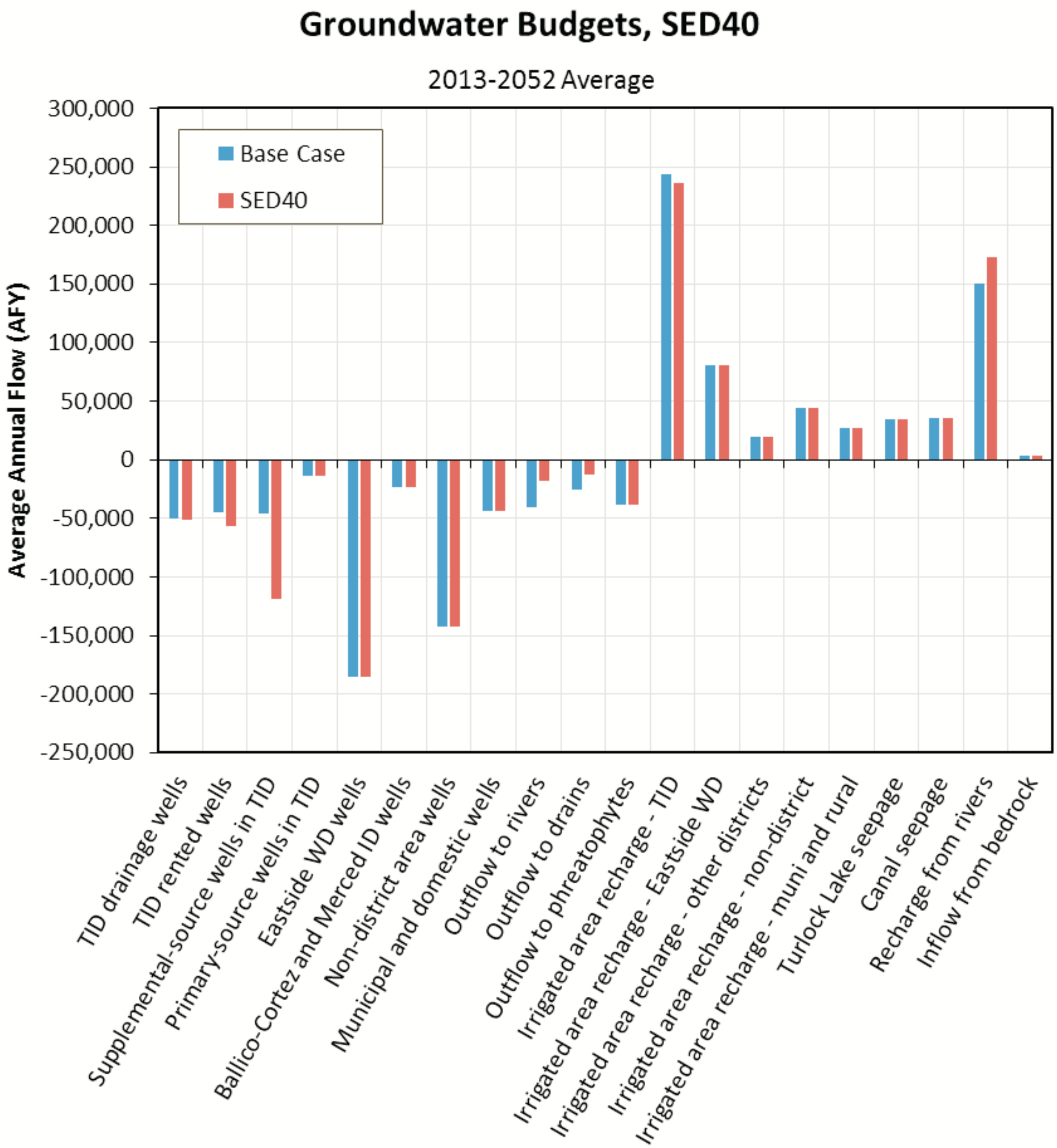
Legend

- Turlock Irrigation District
- Groundwater Basin

March 2017

TODD GROUNDWATER

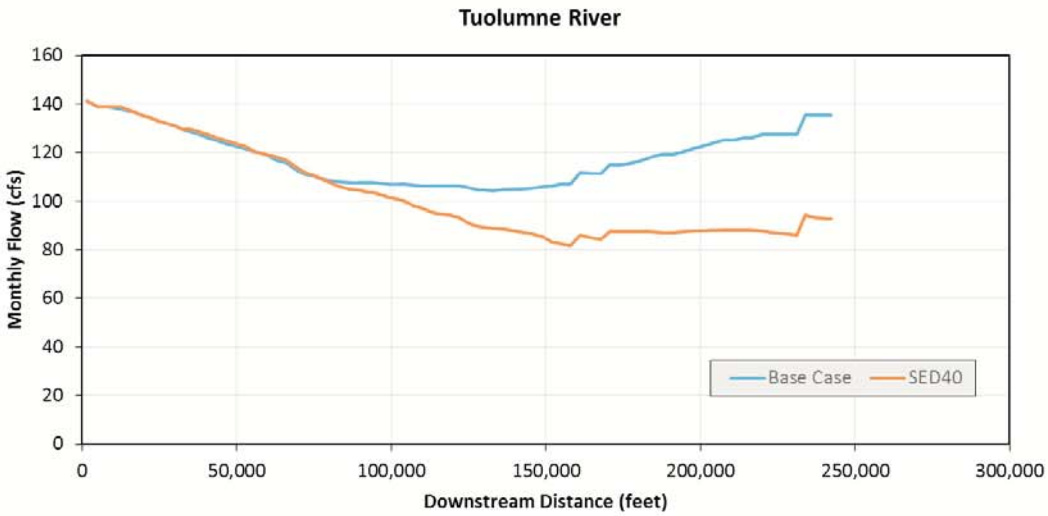
Figure 5b
Contours of Simulated Intermediate Groundwater Levels in July 2052

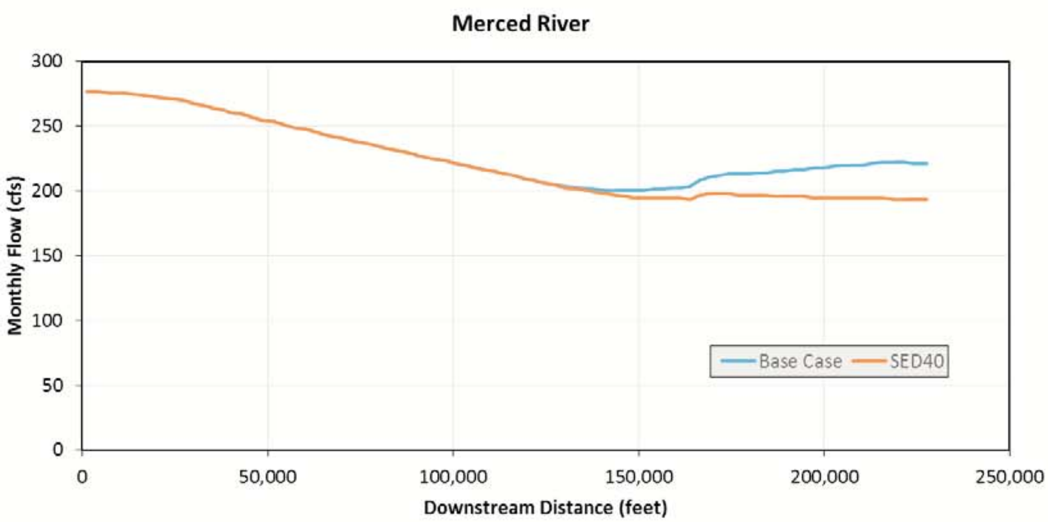


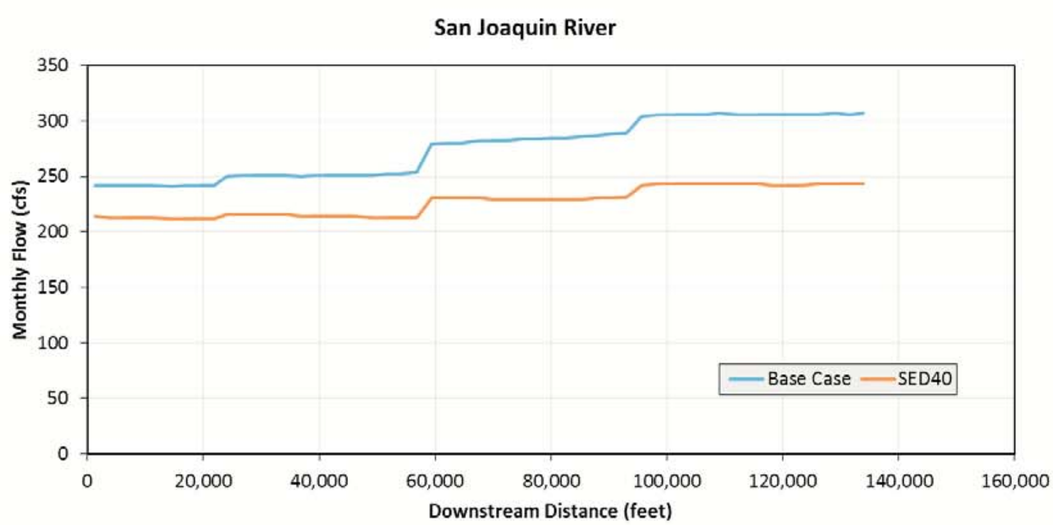
March 2017

TODD GROUNDWATER

Figure 6
Average Annual Water Budgets for Base Case and SED40 Simulations



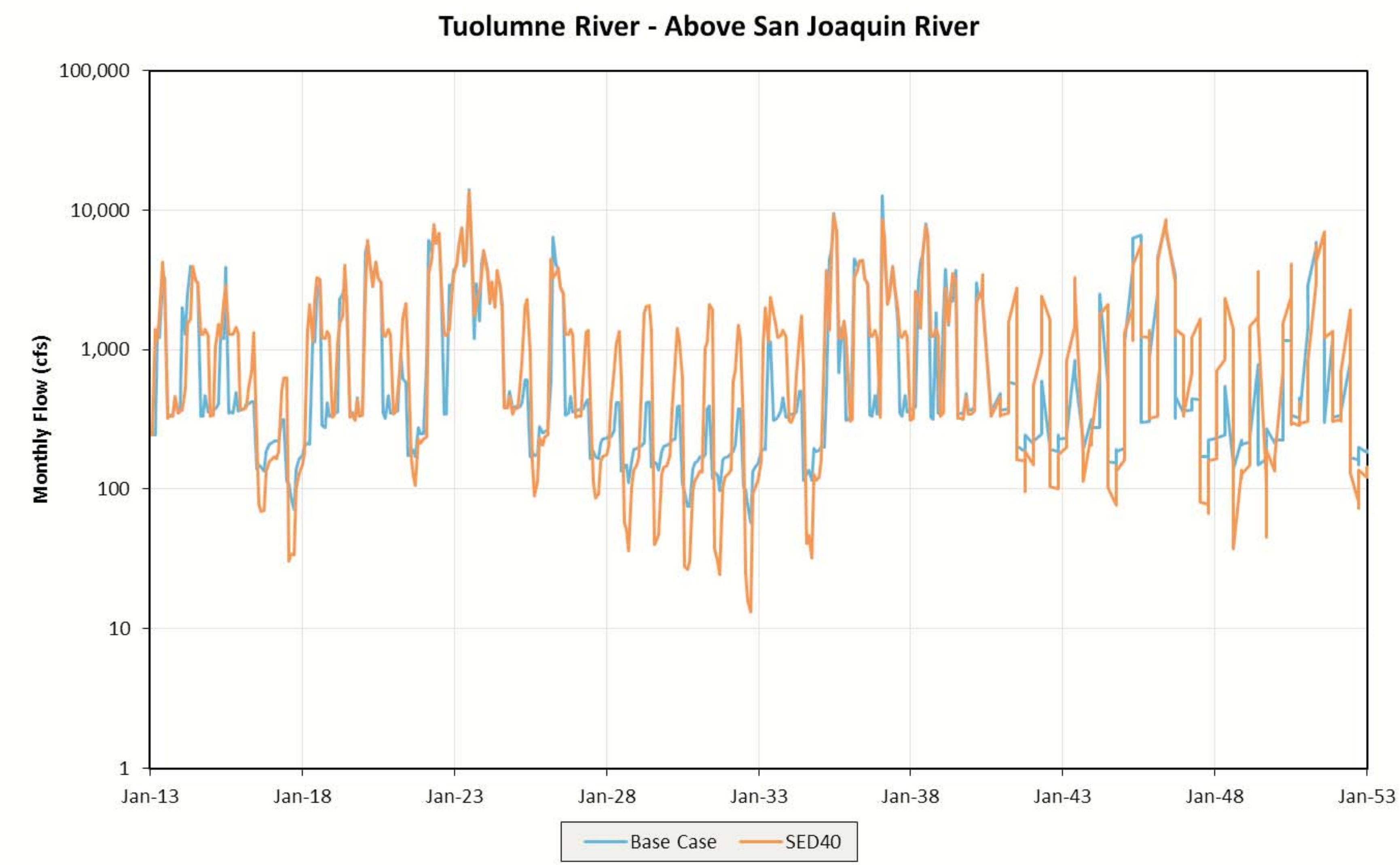




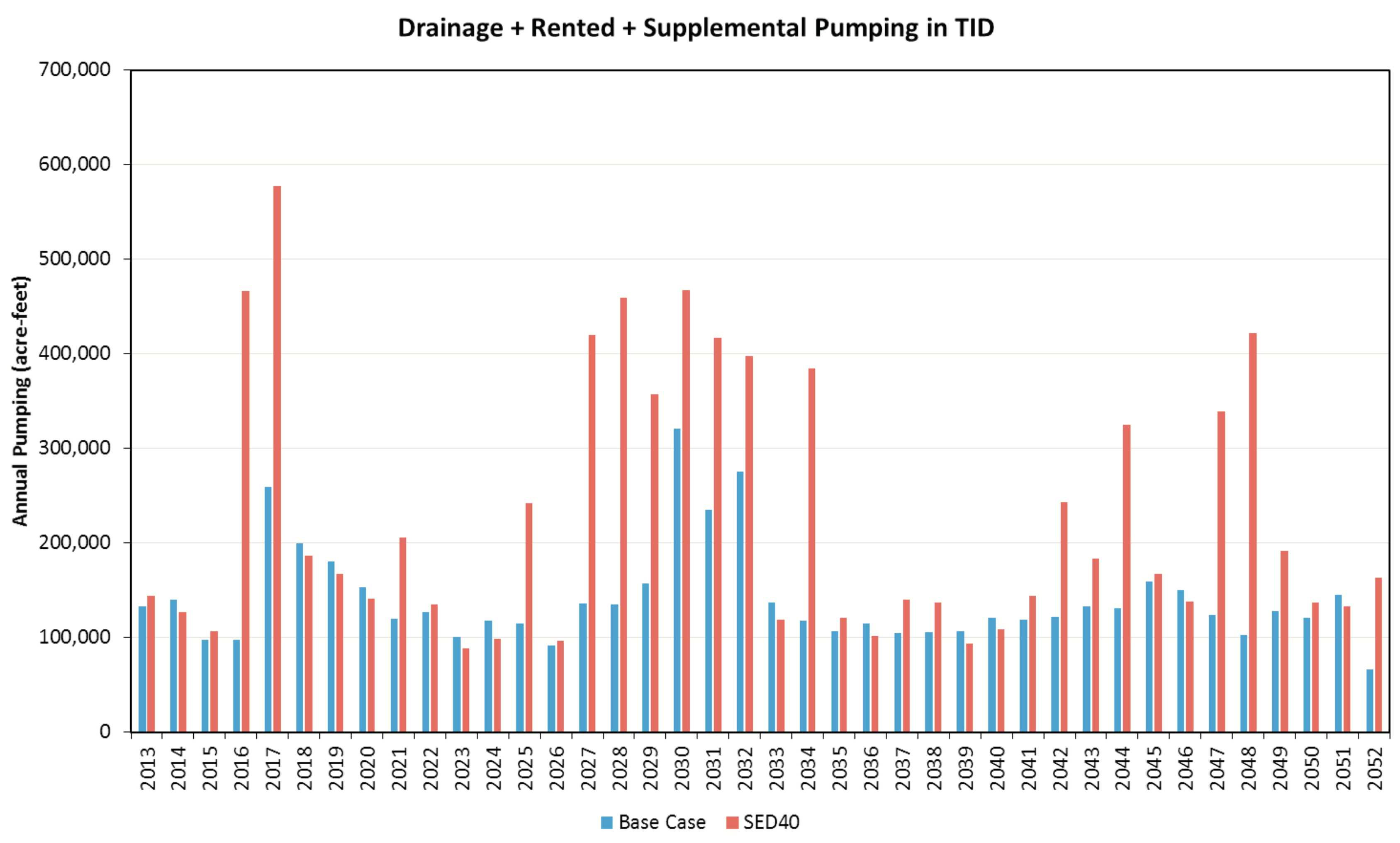
March 2017

TODD GROUNDWATER

Figure 7
Simulated River Flow Profiles in October 2032 (Dry Conditions)



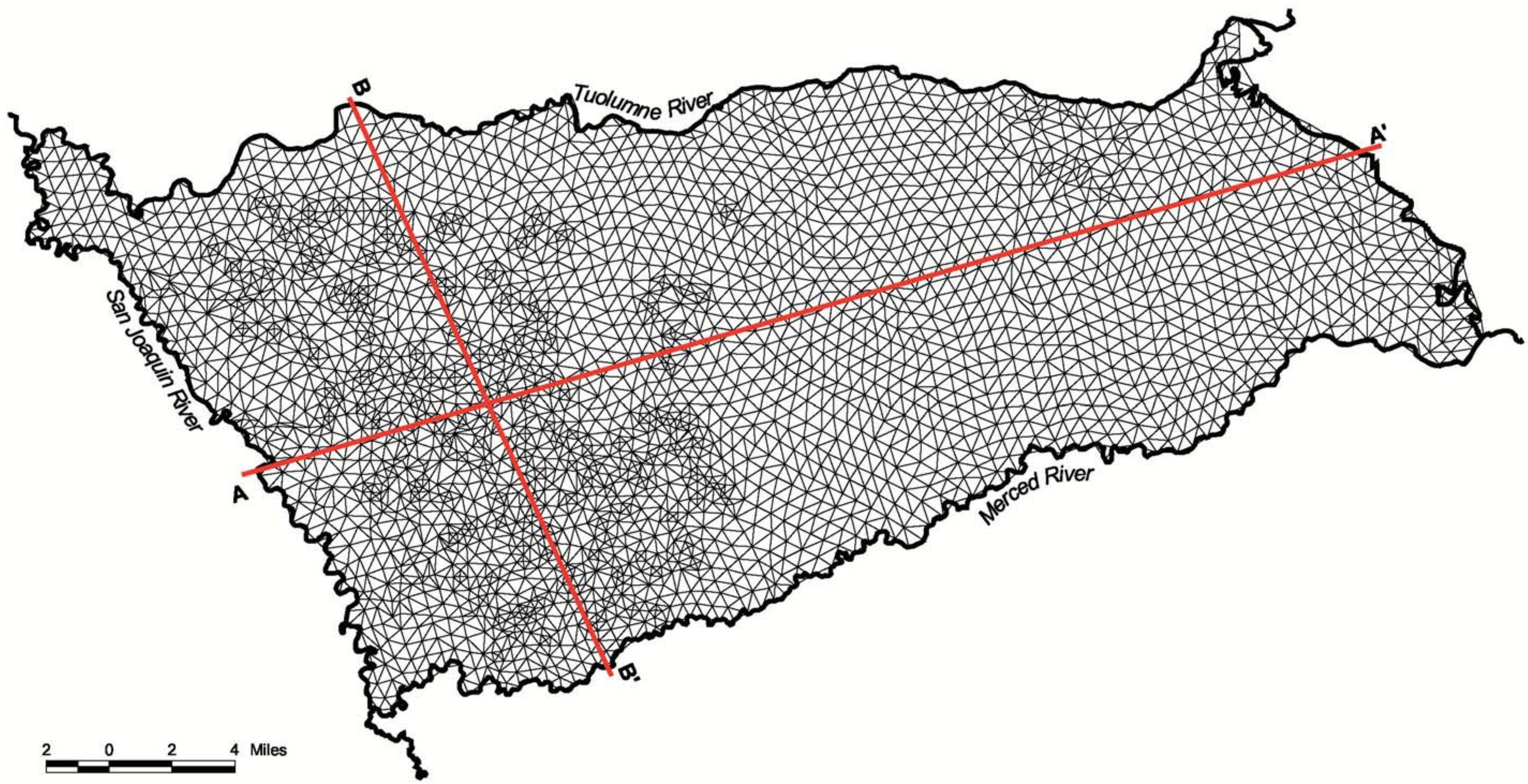
March 2017	**Figure 8**
TODD GROUNDWATER	**Hydrographs of Tuolumne River Flows under Base Case and SED40 Scenarios, 2013- 2052**



March 2017

TODD GROUNDWATER

Figure 9
Simulated Irrigation Pumping in TID, 2013 - 2052

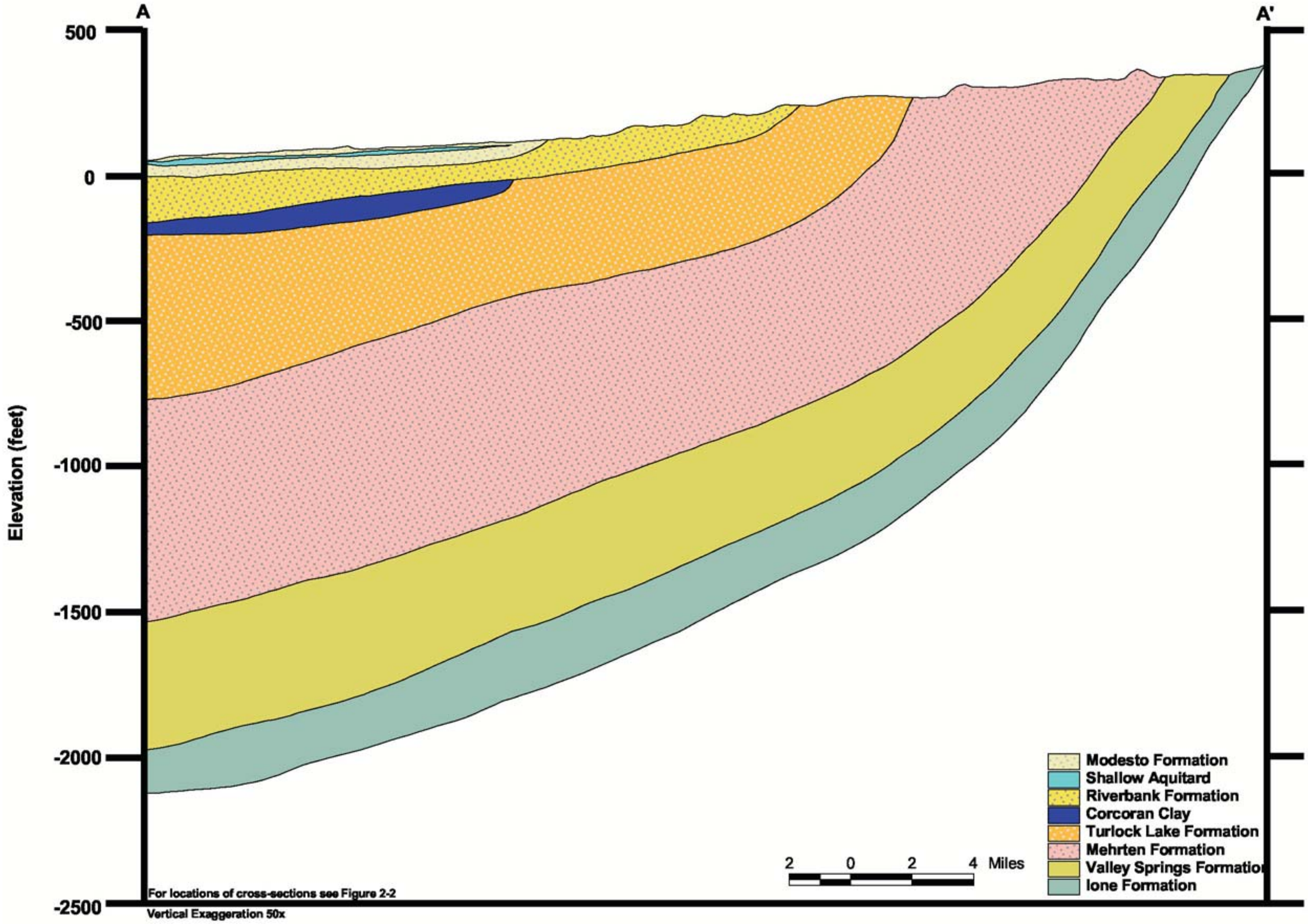


Source: Durbin (2008).

March 2017

TODD GROUNDWATER

Figure A-1
Finite-Element Mesh

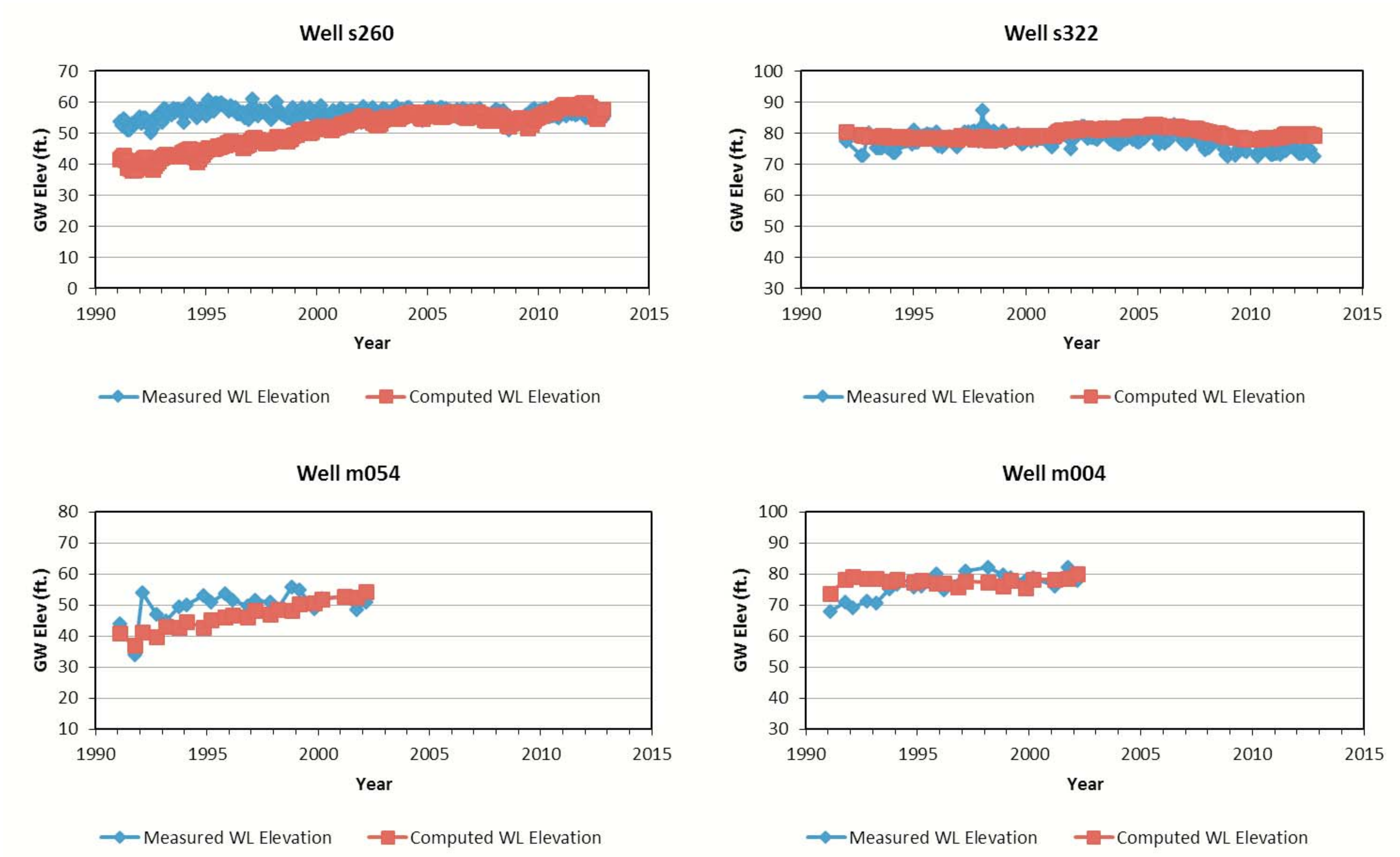


Source: Durbin (2008).

March 2017

TODD GROUNDWATER

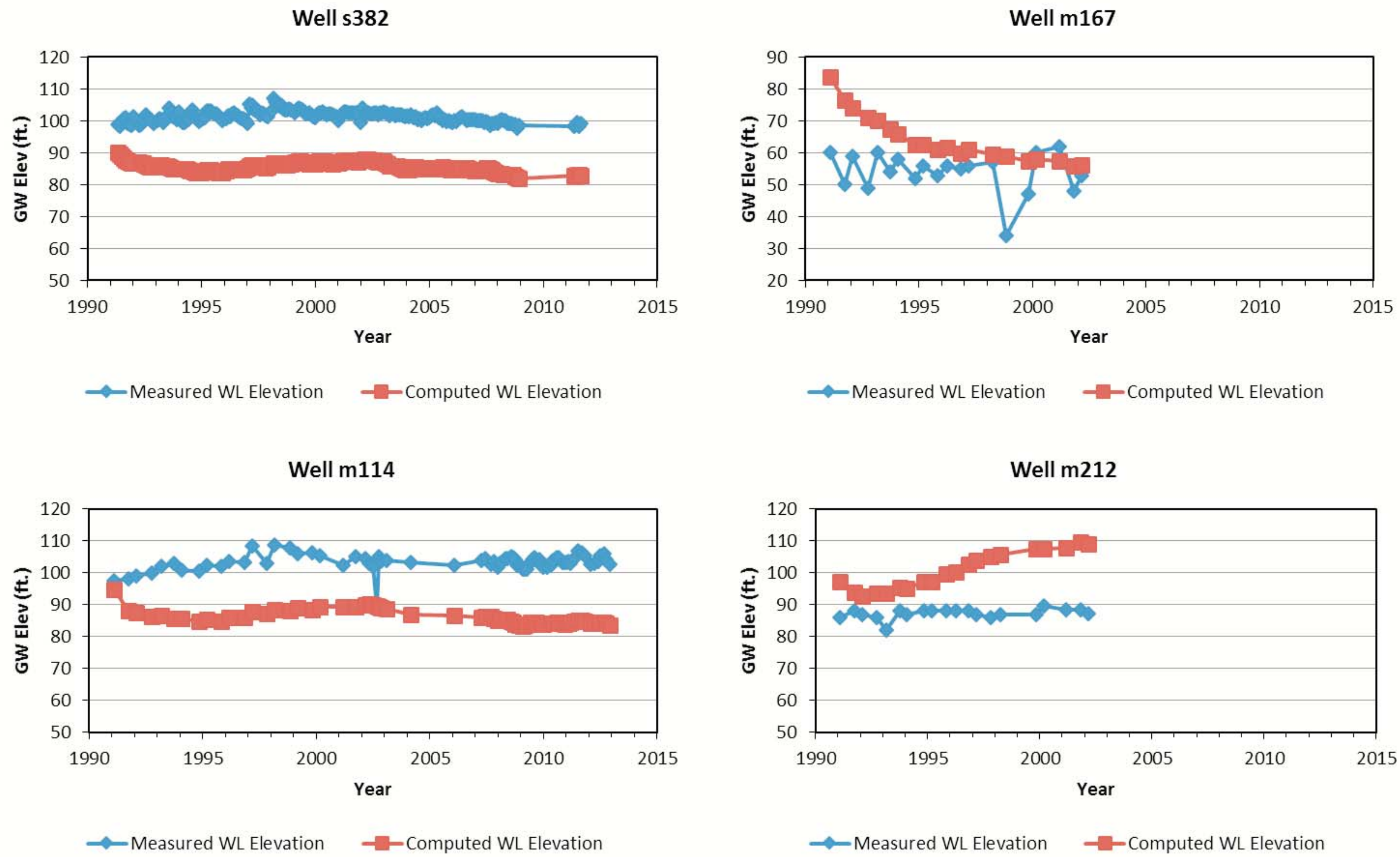
Figure A-2
East-West Cross Section Showing Hydrogeologic Units within the Groundwater Basin



March 2017

TODD GROUNDWATER

Figure A-3a
Hydrographs of Measured and Simulated Water Levels at Selected Calibration Wells, 1991 - 2012



March 2017

TODD GROUNDWATER

Figure A-3b
Hydrographs of Measured and Simulated Water Levels at Selected Calibration Wells, 1991 - 2012

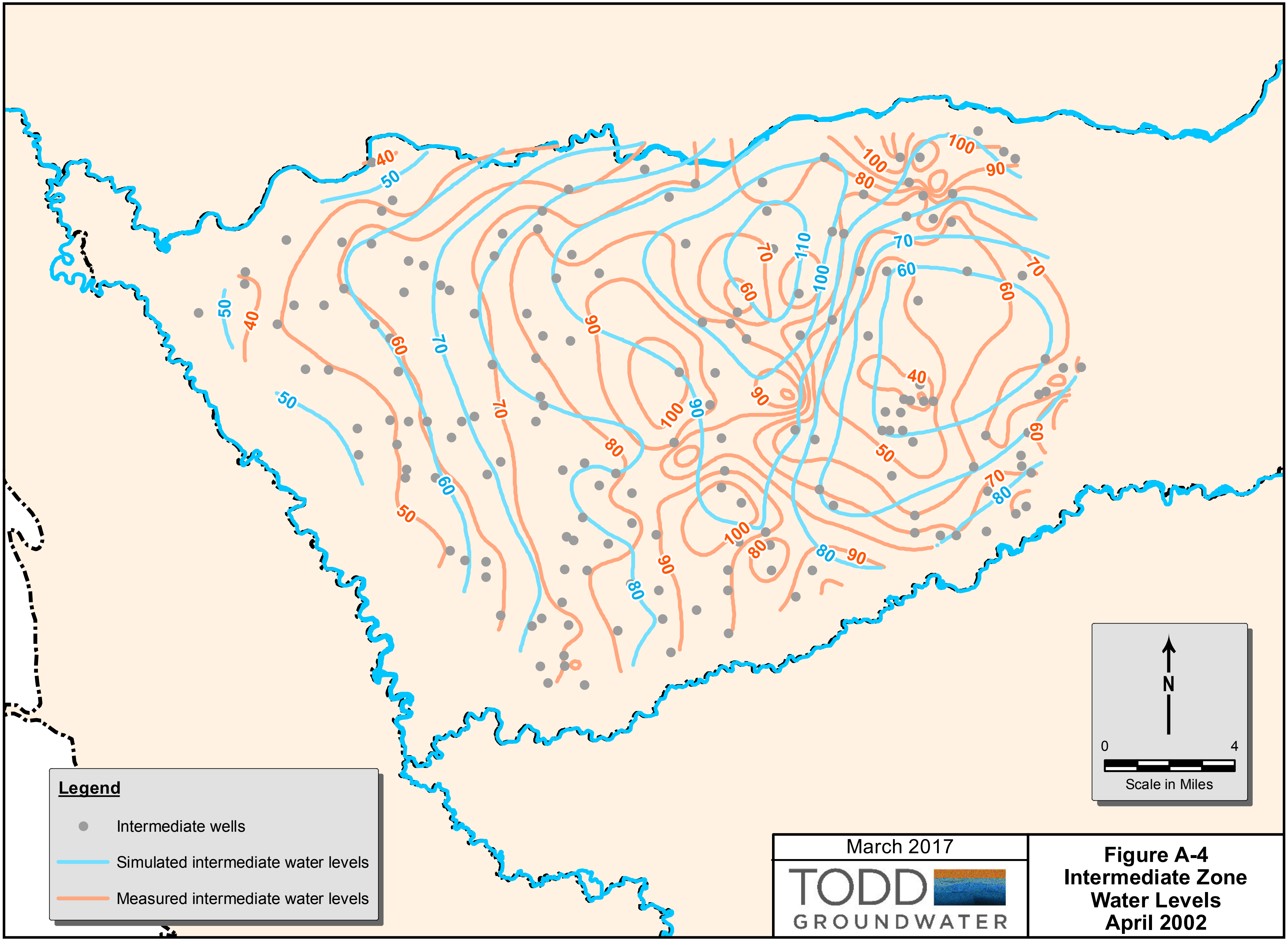
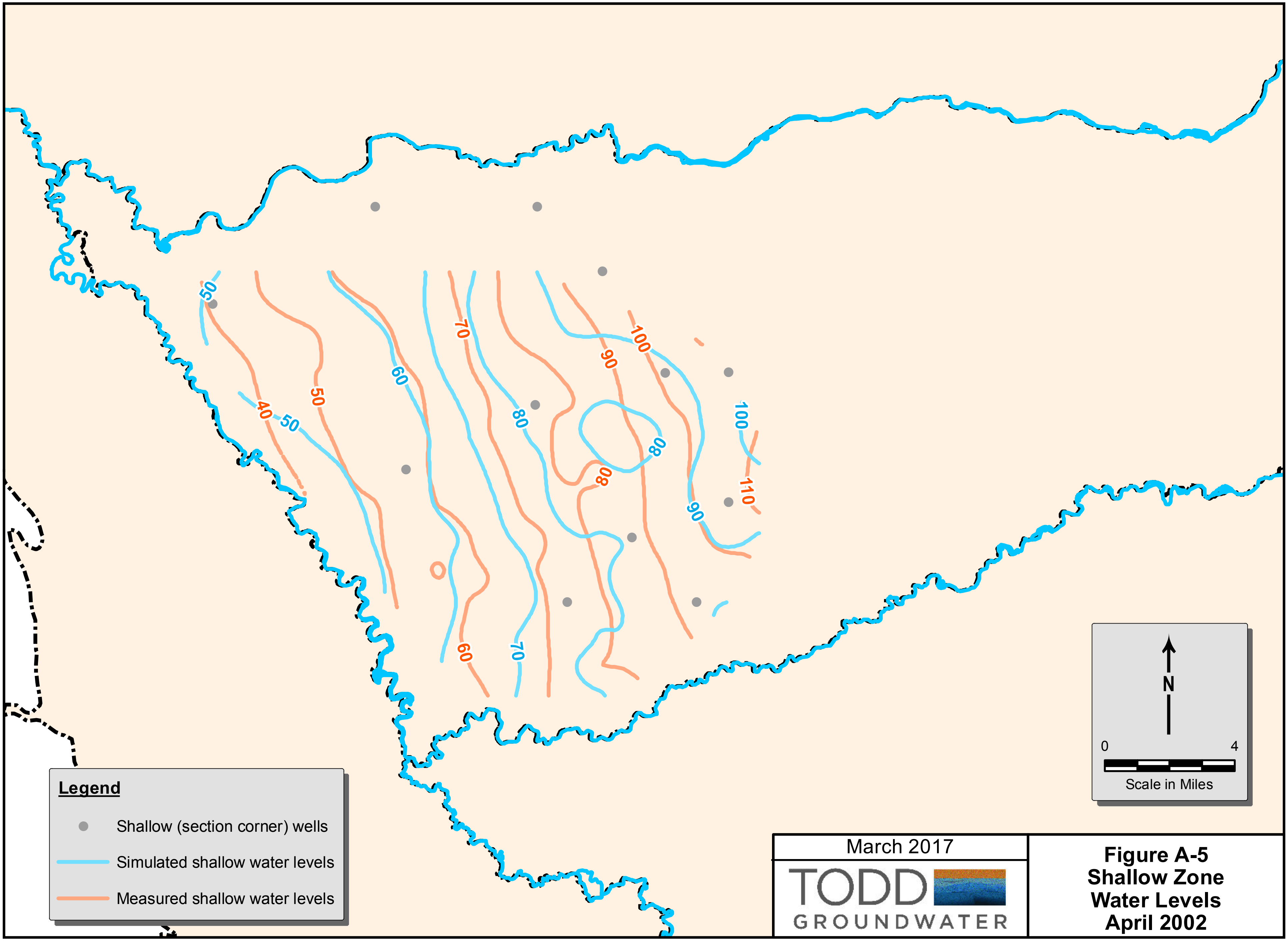


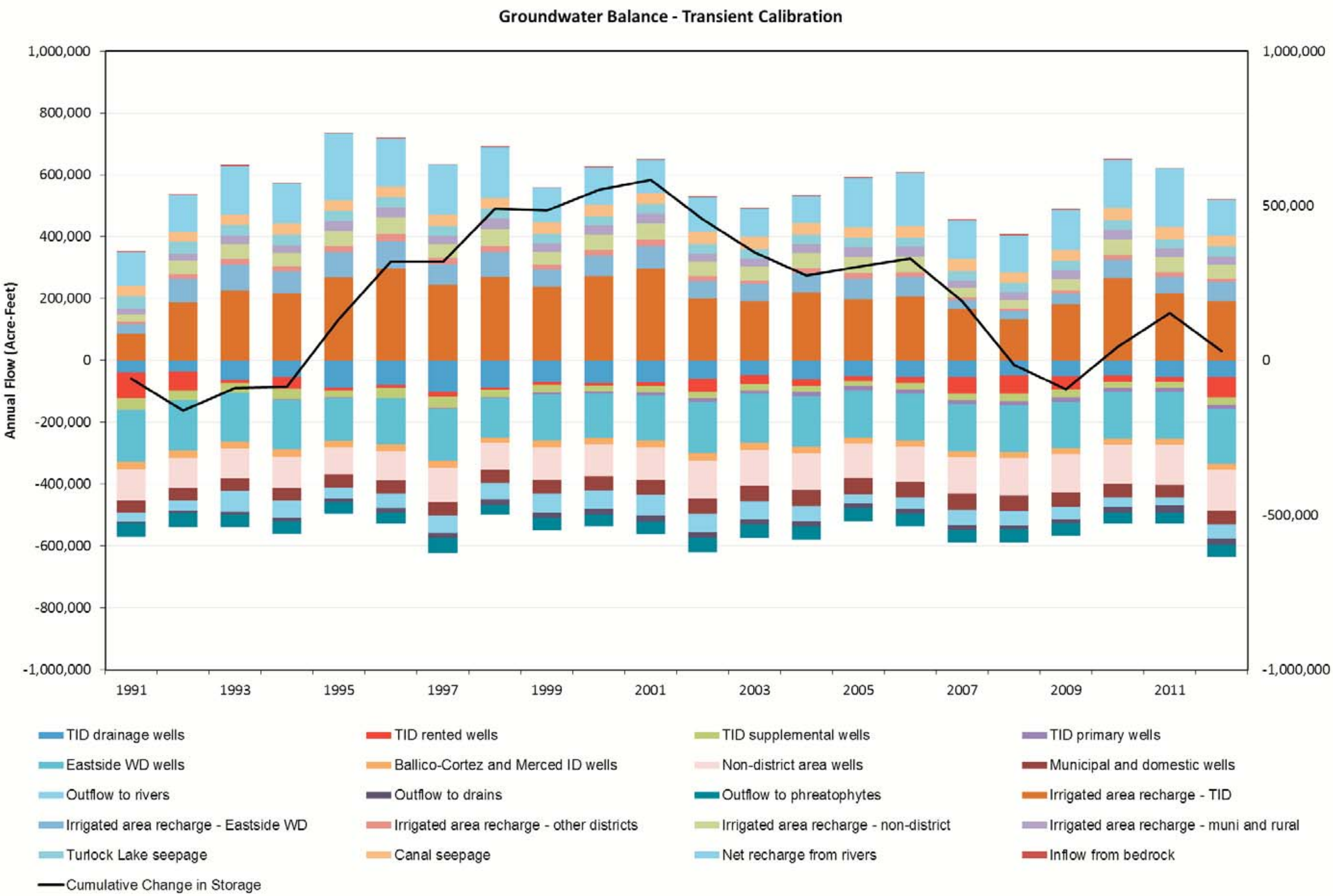
Figure A-4
Intermediate Zone
Water Levels
April 2002



March 2017

TODD GROUNDWATER

Figure A-5
Shallow Zone
Water Levels
April 2002



March 2017	**Figure A-6**
TODD GROUNDWATER	**Simulated Annual Groundwater Budgets, 1991 - 2012**

Analysis and Critical Commentary on California's 2016 SED

Prepared By:
Ascend Analytics
1877 Broadway
Suite 706
Boulder, CO 80302

March 17, 2017

Contents

List of Tables

List of Figures

1 Executive Summary

Under the Lower San Joaquin River Alternative 3 ('LSJR Alternative 3'), Turlock Irrigation District ('TID') and the larger San Joaquin Valley would face serious reductions in their water supply. The cutbacks in available water will cause irreparable harm to the region, threatening, particularly in the face of future drought, the economic and cultural livelihood of a vast section of California's agricultural heartland and one of the major centers of the world's almond industry.

The 2016 revised draft of the Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary ('SED') fails to adequately capture the extent of the damages to the San Joaquin Valley, using biased and inconsistent assumptions that dramatically undervalue the effects of the unimpaired flow and increased carryover storage requirements on hydroelectricity.

In this document, Ascend Analytics ('Ascend') puts forth its analysis of the economic impacts of LSJR Alternative 3 on hydropower generated from the New Don Pedro Dam ('Don Pedro'), as well as its comments on the SED. For its analysis on hydropower, Ascend evaluates and compares sales of energy under baseline conditions and conditions induced by LSJR Alternative 3 over a 23-year horizon. Ascend's analysis reveals that the quantity of hydropower lost under the proposed alternative belies the true loss in value of hydropower. One of the most valuable assets of Don Pedro is its flexible capacity, or ability to generate power at any time with limited start-up and shut down costs. With the continual growth of intermittent renewables in California's energy market, flexible generating units will continue to increase in value, as they can respond to the increasing volatility in generation resulting from intermittent renewable generation. LSJR Alternative 3, however, would significantly restrict Don Pedro's flexibility, and in turn one of TID's chief sources of flexible generation. Ascend's analysis takes LSJR Alternative 3's impact on flexibility into account, and calculates the damages to Don Pedro's generation under five components: (1) loss of value in energy, (2) loss of value of reservoir storage capacity, (3) loss of value in flexible capacity, (4) loss of value in ancillary services, (5) loss of consumer surplus. The total net present value (NPV) of damages from 2018-2040 is shown in

Damages	
Loss in Day-Ahead Sales	$19.0 M
Loss in Reservoir Capacity	$23.8 M
Replacement costs for loss in capacity	$256.1 M
Replacement costs for loss in ancillary services	$99.0 M
Loss in Consumer Surplus	$16.4 M
Total Damages (2018 USD)	**$414.3 M**

Table 1.

Damages	
Loss in Day-Ahead Sales	$19.0 M
Loss in Reservoir Capacity	$23.8 M
Replacement costs for loss in capacity	$256.1 M
Replacement costs for loss in ancillary services	$99.0 M
Loss in Consumer Surplus	$16.4 M
Total Damages (2018 USD)	**$414.3 M**

Table 1: Damages for hydroelectricity under LSJR Alternative 3

Second, Ascend expresses its concern over certain flawed assumptions operating in the SED. Ascend first cover issues related to SED's modeling assumptions. The issues include:

- Outdated prices of power.
- The growing portion of permanent crops in crop distributions, which the SED does not capture.
- The proposal for unsustainable levels of groundwater consumption.
- The geographically limited impact analysis.
- The biased presentation of economic impacts, which inadequately informs the SED's readership of the SED's economic impacts on the region during drought years.
- The failure to account for increasing variability in weather due to climate change.

Next, Ascend highlights the unrealistic assumptions within the SED on replacement water sources for the region. Though the SED mentions multiple alternatives for replacing the water lost under the LSJR Alternatives, giving the reader a sense that there are solutions to the incurred water losses, none of the alternatives, upon further investigation, prove to offer a sustainable and long-term path forward for comprehensively offsetting the water losses.

Lastly, Ascend comments on the distribution of benefits and costs of the LSJR Alternatives, and the social justice issue associated with it. The SED explains that the objective of the LSJR Alternatives is to improve environmental conditions for fish and wildlife. However, the SED fails to account for the extent and distribution of costs related to the new water restrictions, omitting that the costs incurred by LSJR Alternative 3 would be disproportionately placed on poorer areas of California.

2 Hydropower

LSJR Alternative 3 mandates 40% unimpaired flow requirements from February through June, as well as an increase in carryover storage from approximately 300 TAF to 800 TAF for the Don Pedro Reservoir. The SED states that these new requirements would have a minimal impact on Don Pedro's hydropower generation, reducing Don Pedro's revenues from hydropower by 1% (20-55). However, the SED's evaluation fails to adequately account for the actual value lost from hydropower generation under LSJR Alternative 3. Though the quantity of electricity lost under LSJR Alternative 3 is minimal, the value lost is quite significant. The value lost in electricity results largely from the constraints that LSJR Alternative 3 places on the flexibility of Don Pedro's hydropower generation.

This section will first outline the shifting regional dynamics in California, and the growing importance of flexible generation units such as Don Pedro. Then this section will provide an evaluation of the loss of long-term value incurred by LSJR Alternative 3 to Don Pedro's generation.

2.1 Shifting Regional Dynamics and the Importance of Flexibility

The energy market in California and the larger Western Electricity Coordinating Council (WECC) region is undergoing an unprecedented structural shift. The preeminent driver of the changing market dynamics is renewables, with renewables projected to be added to the WECC regional supply stack at 4 times the growth of base energy. Intermittent renewables such as wind and solar have negligible marginal costs, and bid at near-zero or negative prices, deriving their value mainly from renewable energy credits (RECs). As displayed in

Figure 1, the expected influx of cheap renewable generation shifts the supply stack to the right, effectively pricing the power plants with higher variable costs out of the market. The impact of this shift in supply fundamentals translates into broader changes in seasonal and hourly variability in power prices, discussed below, with direct carry-over to impinging on the value of Don Pedro.

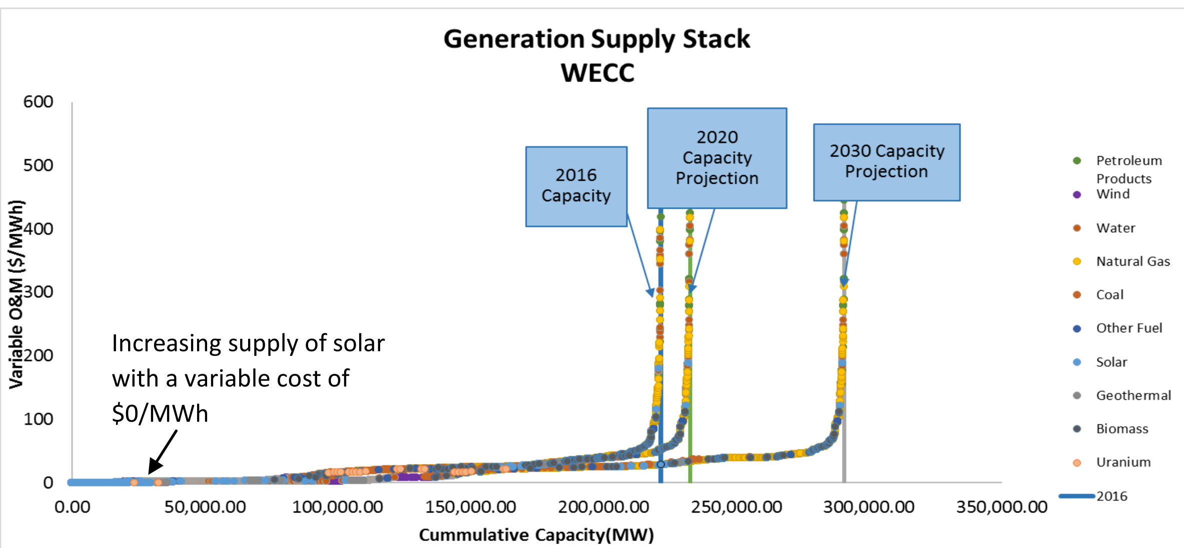


Figure 1: The changing supply stack of the WECC

Figure 2 below illustrates more directly the downward pressure exerted by renewables on energy prices in the North of Path 15 (NP-15) zone within California ISO (CAISO). With 0% renewable penetration, the day-ahead price along the trend line is upwards of $40/MWh, while at 10% renewable penetration the day-ahead price on the trend line is approximately $25/MWh.

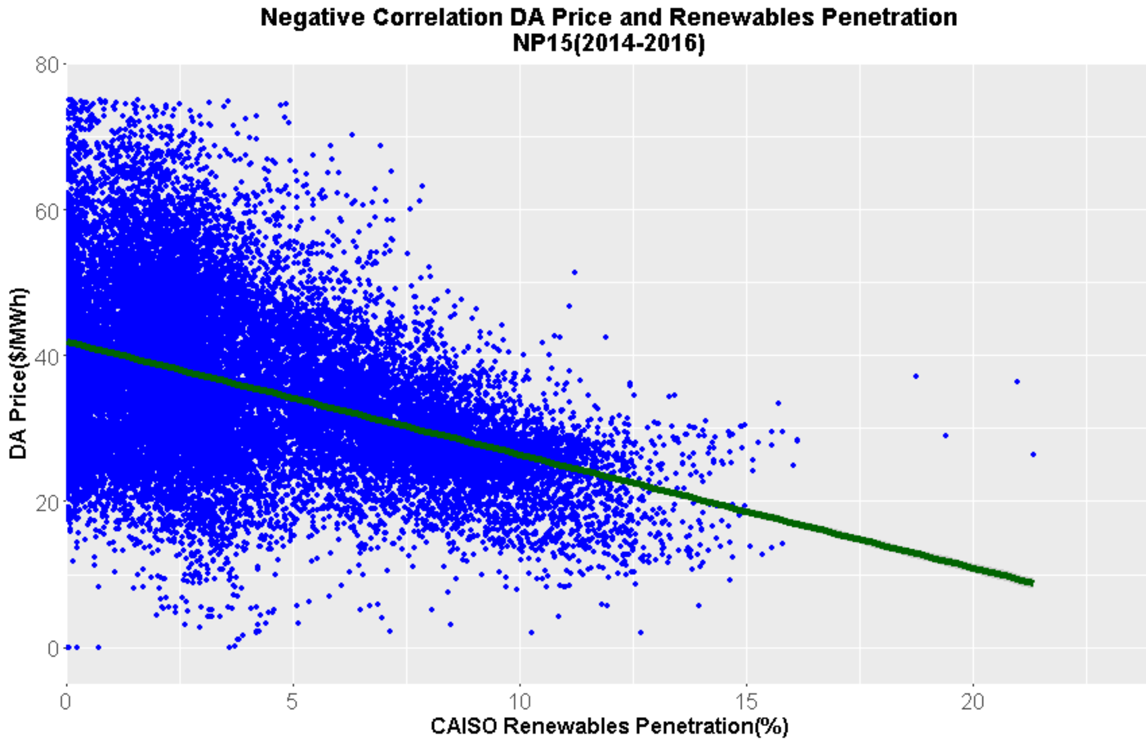


Figure 2: Relation between renewable penetration and DA market prices

Though increasing renewable penetration exerts downward pressure on power prices on average, it does not lower prices uniformly, and in fact causes prices to rise at certain points during the day. Solar generation in particular has a significant impact on the shape of hourly prices. As depicted in Figure 3, the preponderance of solar generation during daytime hours produces the ‘Duck Curve’ in load, causing net load to drop in the daytime, and large ramping events from thermal generation units to occur in the evening as solar generation tails off. Figure 4 below indicates that hourly prices mirror these generation behaviors. Figure 4 compares solar generation levels to the implied heat rate from 2014 to 2016. The implied heat rate, calculated by dividing the electricity price by the fuel price, gauges the maximum heat rate that would be profitable to operate given current electricity and fuel prices. The increasing solar generation over time has generally led to lower daytime implied heat rates. On the other hand, the evening implied heat rates have increased over time. The higher ramp rate requirements in the evenings induced by higher solar generation creates this increase in evening prices over time.

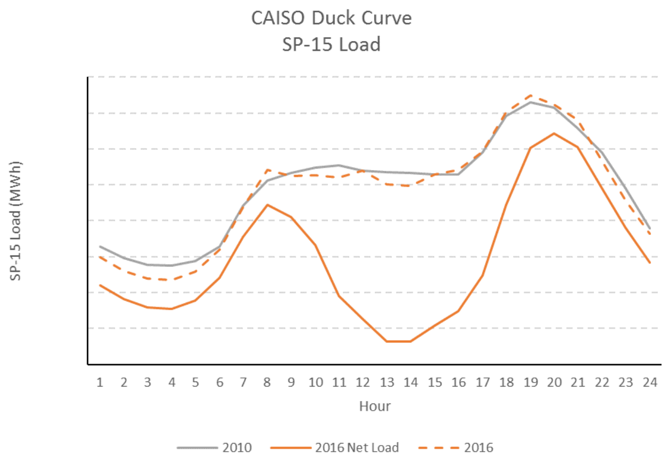


Figure 3: The Duck Curve - Solar generation's impact on load

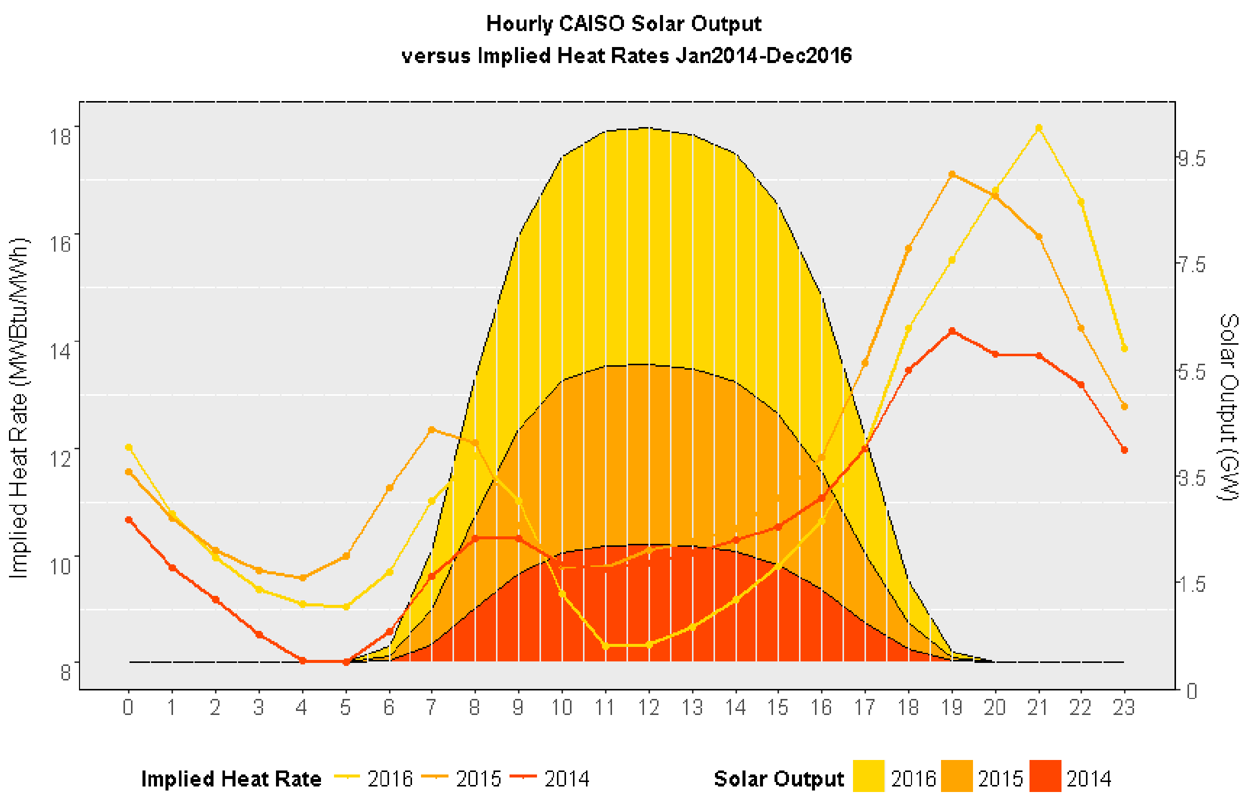


Figure 4: Solar generation's impact on prices

Under these market conditions, additional pressure is put on inflexible generation, such as steam generation, since, with their long start-up and shut-down times and the high costs associated with them, they are not able to efficiently complement the intermittency of renewables. Many times inflexible generators have to stay online when they are out of the money, in order to eventually be in a position where they can operate profitably. On the other hand, since Don Pedro has no start up and shut down costs and high maximum ramp rates, it is in an excellent position to capture the value of morning and evening prices under current and future market conditions. Under LSJR Alternative 3, however, there will be more instances from February through June when Don Pedro will be compelled to release unimpaired flows during the day, when lowered energy prices from solar is flooding the market. During August to January, in order to replenish the reservoir, system operators would have less discretionary water available, especially during dry periods, with which they could serve peak load.

Additionally, as intermittent renewable penetration increases, the volatility in power prices is expected to increase. Figure 5 to Figure 7 use CAISO market data over the last five years to illustrate the link between increased renewable generation and market price volatility. Figure 5 shows the increasing proportion of load served by renewable generation on a monthly basis. Correspondingly, renewable generation grows steadily over the last five years from about 10 percent to over 20 percent. With the doubling of renewable generation, Figure 6 shows a commensurate increase in the volatility of day-ahead prices. The day-ahead price volatility measures the percent variation in price (measured as the standard deviation in prices divided by the mean). The day-ahead price volatility calculations begin in 2014 at about 20% of price and doubles over 2.5 years to about 40% price. During this same 2.5 year period, renewable generation increased from 15% to 20%. However, the preponderance of price volatility effects derived from renewables resides in the real-time market. The real-time price volatility begins at about 50% in 2014 and increase to about 300% in 2016.

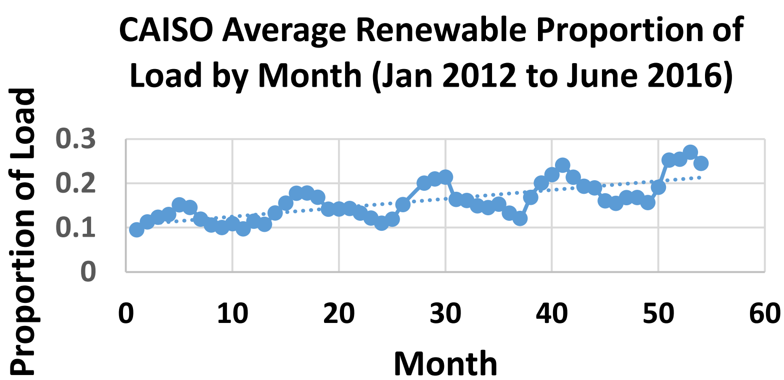


Figure 5: CAISO Average renewable proportion of load by month

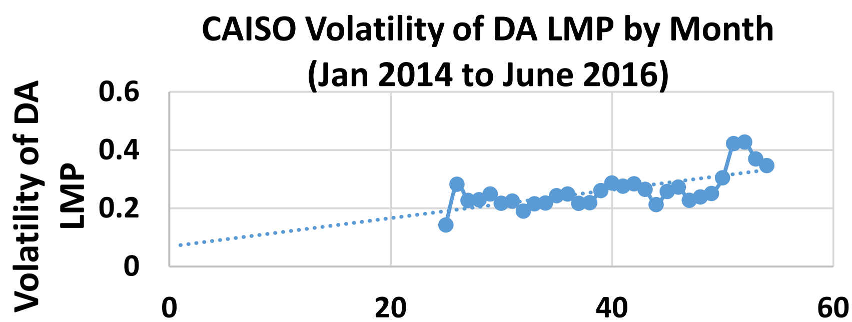


Figure 6: CAISO volatility of day-ahead locational market price

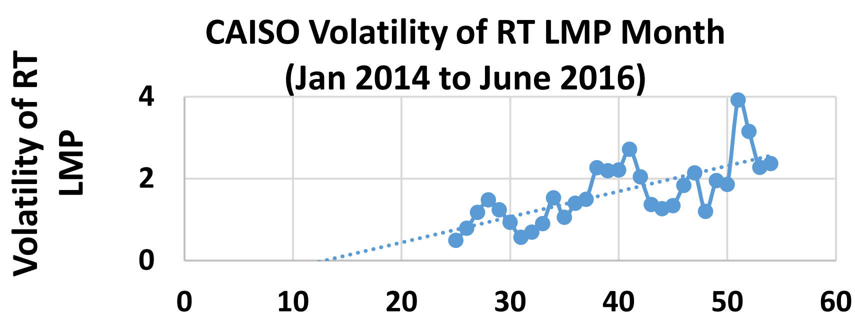


Figure 7: CAISO volatility of real-time locational market price

Figure 8 provides insight into the general volatility patterns in the NP-15 real-time market, depicting the frequency of price spikes by month and year. Price spikes are defined here as when the price of power reaches or exceed $100/MWh in the real-time market. Figure 8 indicates two noteworthy patterns. Firstly, from a monthly perspective, the frequency of price spikes reaches its highest when renewables serve a greater proportion of system load. Secondly, frequency of price spikes generally peaks around 5:00 pm to 6:00 pm. During this late-afternoon, early-evening period, (1) generation is transitioning from solar to thermal generation; (2) solar generation is diminishing and particularly variable; (3) thermal generation prices are high due to start up and ramping costs; (4) the energy system is experiencing peak load. All these factors contribute to the increased frequency in price spikes.

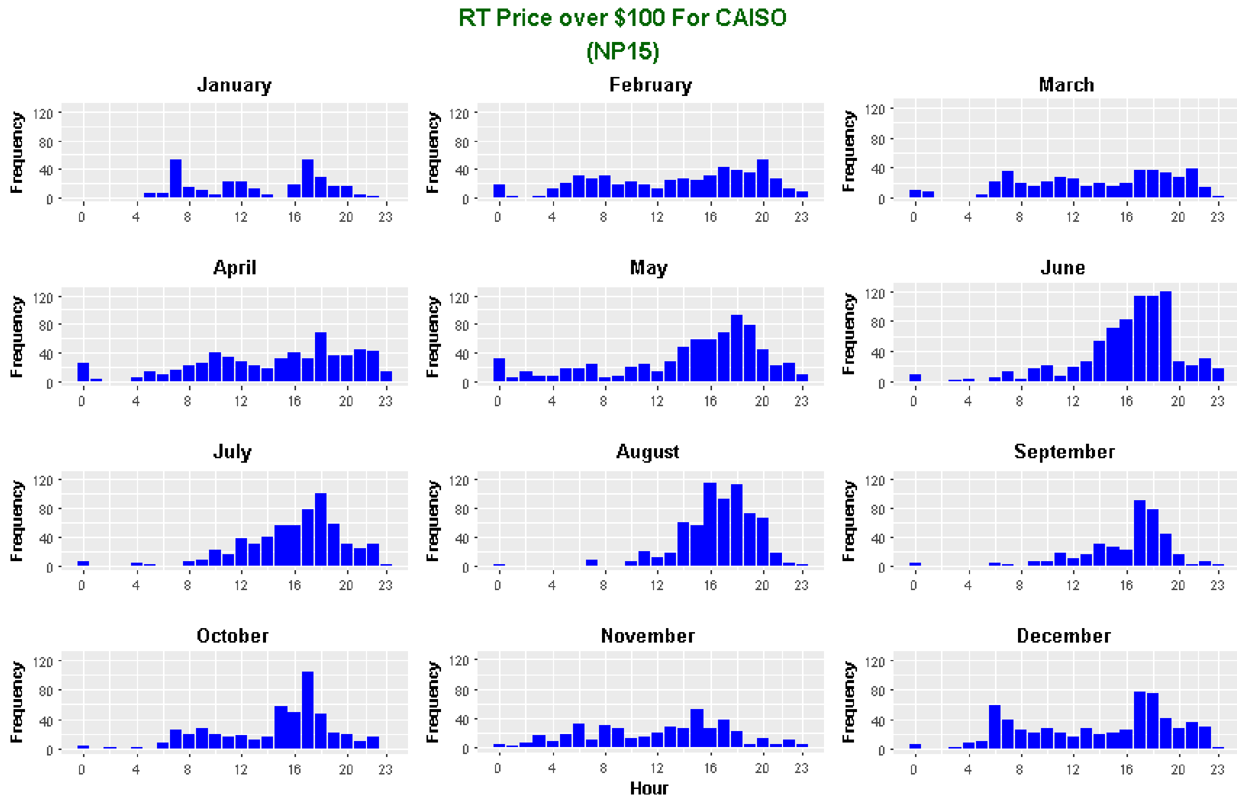


Figure 8: Price spikes in NP-15 over course of year

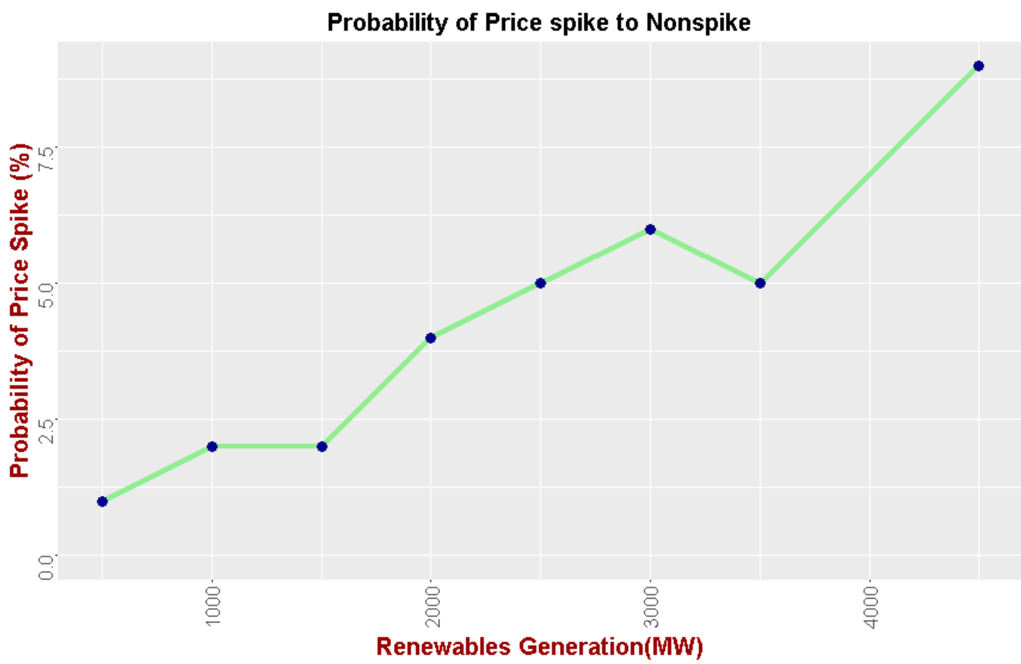


Figure 9: Relationship between the probability of Real-Time price spikes for CAISO and renewable generation

Figure 9 illustrates that there is a direct relationship between renewable generation and the probability of a price spike occurring. As the amount of renewable generation in CAISO doubles from 2000 MW to 4000 MW, the probability of prices spikes in the real-time market correspondingly more than doubles.

Don Pedro's flexible generation uniquely positions Don Pedro to act as a chief physical hedge in TID's supply mix against increasing market volatility. Yet the combination of the higher carryover storage requirement and increased flow requirements in LSJR Alternative 3 limits the capability of Don-Pedro to respond to these fluctuations.

LSJR Alternative 3 additionally puts deleterious restrictions on Don Pedro's flexibility on a monthly scale. As Figure 10 shows, the annual shape of the flows changes under LSJR Alternative 3. Higher levels of flow are expected from February to June due to the mandate for 40% unimpaired flows in this period, and, in order to both replenish the reservoir and maintain LJSR's higher carryover storage restrictions, less water will be released from August to January. Figure 10 presents the expected average monthly prices of energy in California from 2018-2040. From March to August the price of energy is expected to drop significantly, largely due to increased solar generation and demand. As Don Pedro generates coincident with flows, Don Pedro would be compelled under LSJR Alternative 3 to generate significantly more electricity during periods when the market price for power is rather low, and subsequently generate less in the later months of the year, when electricity prices rise.

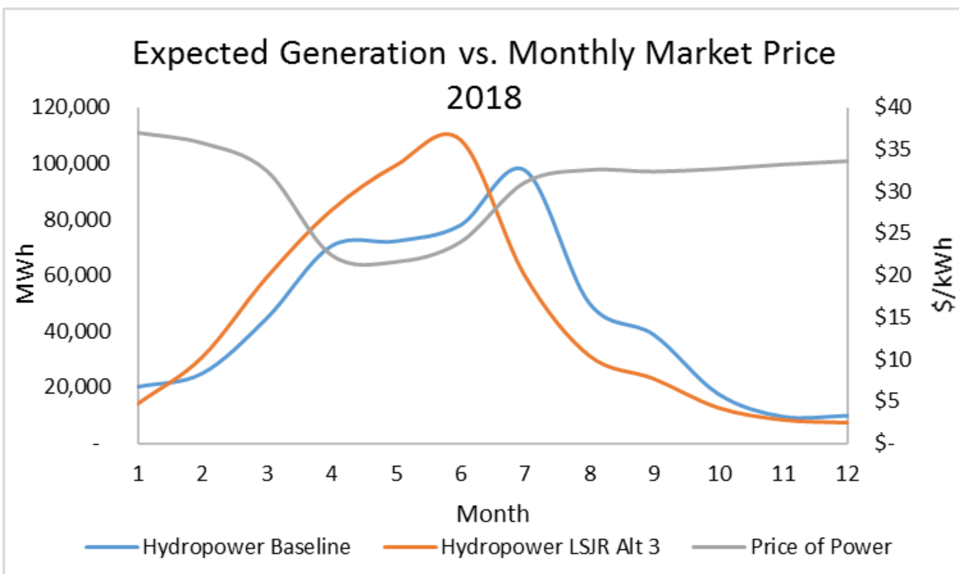


Figure 10: Comparison of monthly generation under baseline and LSJR Alternative 3 relative to the forecast of the monthly market price for power

Thus, with the diminished flexibility under LSJR Alternative 3, Don Pedro will not only be constrained in its ability to optimize dispatch on an hourly scale, but on a monthly scale as well. As market forces increasingly spur a growth in the value of flexible generation, the SED proposal would effectively revoke Turlock Irrigation District's most valuable and cleanest source of flexible generation capacity.

2.2 Quantification of Damages

In light of the importance of flexible generation, Ascend breaks up the loss of long-term value for the New Don Pedro Dam into five components:

- Energy
- Reservoir Storage Capacity
- Flexible Capacity
- Ancillary Services
- Consumer Surplus

2.2.1 Value of Energy

The first component of Ascend's determination of the loss in long-term value under the proposed flow requirements is the value of energy.

To model generation for the 2018-2040 study period, Ascend utilizes its PowerSimm software. PowerSimm optimizes hourly dispatch for Don Pedro to minimize costs with a mixed integer linear programming (MILP) problem. The impact on generation is quantified by running a base scenario and then a comparison run for generation under LSJR Alternative 3. Inputs for PowerSimm are TID's historical data on hydropower generation and existing flow regimes for Don Pedro from 1973 to 2015 under the baseline flow case and the LSJR Alternative 3 case, as evaluated by TID.

To determine monthly generation, Ascend simulated future weather scenarios through PowerSimm. The purpose of introducing variability in weather over time is to remain consistent with actual observed climatic conditions that become obscured through using average conditions. Moreover, one of the major shortcomings of the SED is its failure to analyze the economic impacts of the increased flow and carryover storage requirements on hydroelectricity under more extreme scenarios. The SED instead only provides average estimates of annual damages. With the volatility of weather patterns expecting to increase in California in the future, it is vital for the region to understand the effect of LSJR Alternative 3 under drought conditions. Thus, in its analysis Ascend incorporates a multiyear drought, similar in character to the 1987-1992 drought, from 2020 to 2025.

Don Pedro provides hydroelectricity for both TID and Modesto Irrigation District (MID). However, the historical data only provides information on generation for TID, which takes approximately two-thirds of Don Pedro's annual generation. Thus, once PowerSimm developed monthly generation patterns for the study period, Ascend scaled the generation results by 1.5, to account for MID's portion of hydropower.

Table 2 below shows the scaled results for monthly generation for the first 5 years of the study. As the results show, generation is comparatively greater from February to June for LSJR Alternative 3, while for the remaining months generation is greater for baseline.

Monthly Generation (MWh) for First 5 years of Study										
	2018		2019		2020		2021		2022	
	Base	LSJR Alt 3	Base	LSJR Alt 3	Base	LSJR Alt 3	Base	LSJR Alt 3	Base	LSJR Alt 3
Jan	20,076	14,041	17,997	13,413	8,704	5,585	8,986	4,519	18,215	11,033
Feb	24,886	30,732	22,309	29,359	10,789	12,225	11,139	9,891	22,579	24,150
Mar	44,635	59,263	40,013	56,615	19,351	23,574	19,979	19,074	40,498	46,569
Apr	70,514	83,194	63,213	79,477	30,571	33,093	31,563	26,776	63,979	65,375
May	72,289	99,267	64,803	94,832	31,340	39,487	32,357	31,950	65,589	78,005
Jun	77,974	108,546	69,900	103,695	33,805	43,178	34,902	34,936	70,747	85,296
Jul	97,789	59,970	87,663	57,290	42,395	23,855	43,771	19,302	88,726	47,125
Aug	50,142	31,270	44,950	29,873	21,739	12,439	22,444	10,064	45,495	24,572
Sept	38,760	23,023	34,746	21,994	16,804	9,158	17,349	7,410	35,167	18,092
Oct	17,554	12,643	15,736	12,078	7,610	5,029	7,857	4,069	15,927	9,935
Nov	9,410	8,298	8,436	7,927	4,080	3,301	4,212	2,671	8,538	6,521
Dec	16,227	7,257	14,547	6,933	7,035	2,887	7,263	2,336	14,723	5,703

Table 2: Comparison of monthly generation for Don Pedro under baseline and LSJR Alternative 3

The value of energy is a function of the quantity of energy generated multiplied by the market price of power over the 2018-2040 study period. The market price of power utilized in this analysis is derived from OTC Global Holdings' forward price of power for NP-15. The monthly prices of power for the first 5 years of the study are listed below in Table 3. Monthly prices are lowest from March to June. The annual average of monthly prices is expected to increase every year; yet prices in 2019 from January to June are expected to decrease significantly. In 2019, the June price drops the by greatest percentage relative to all months, decreasing by 14%.

Price of Power (2018 USD) for First 5 Years of Study					
	2018	2019	2020	2021	2022
January	37.03	34.65	35.37	37.19	38.70
February	35.81	34.32	35.02	37.05	38.64
March	32.51	32.82	33.50	35.33	35.69
April	22.51	21.32	24.97	26.68	26.15
May	21.68	20.83	24.35	26.13	25.60
June	24.02	20.64	24.40	25.97	25.46
July	31.12	33.23	33.95	35.88	35.17
August	32.61	35.10	36.02	37.94	37.18
September	32.41	35.39	36.33	38.32	39.48
October	32.74	34.44	35.84	37.80	39.52
November	33.26	34.81	36.33	38.27	39.96
December	33.66	35.42	37.00	38.91	40.81
Average	30.78	31.08	32.75	34.62	35.20

Table 3: Monthly price of power for first 5 years of study

Figure 11 presents PowerSimm's evaluation of the year-to-year reduction of day-ahead sales of electricity for LSJR Alternative 3. The results show that electricity sales vary greatly depending on weather conditions. From 2020 to 2025 there is a significant reduction in sales because of drought conditions. Particularly during multi-year droughts, TID would have significantly less discretionary water with which they could generate electricity in the months after June due to the higher storage requirements and higher amounts of water that they would be mandated to release from February to June. On the other hand, during a few wet years with particularly high river flows, the proportional increase of flows under the 40% unimpaired flow requirement causes sales under LSJR Alternative 3 to be slightly greater than under baseline.

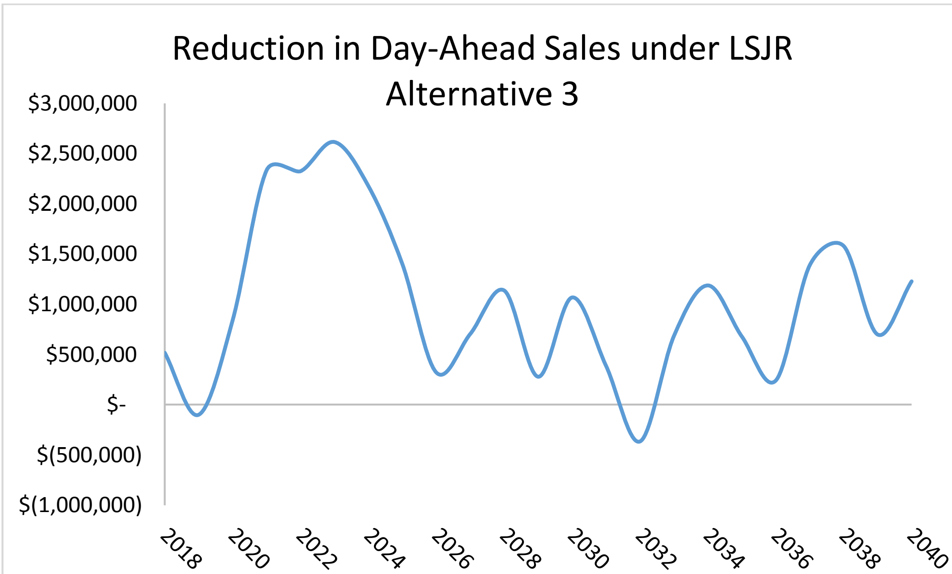


Figure 11: Year-by-year reduction in day-ahead sale of electricity under LSJR Alternative 3

The average annual reduction in electricity sales over the course of the study amounts to $810,709, which is over 2.5 times greater than the amount in reductions that the SED forecasts. Ascend's determination for the average reduction in sales under LSJR Alternative 3 corresponds to a 6% decrease relative to sales under baseline.

Average Annual Reductions in Day-Ahead Sales for Don Pedro under LSJR Alternative 3	
Ascend's Analysis	$1,007,848
SED's Analysis	$387,854

Table 4: Average annual reductions in day-ahead sales for Don Pedro under LSJR Alternative 3

Figure 12 below depicts the net present value (NPV) of day-ahead sales of electricity from 2018 to 2040 under current flow requirements (Baseline) and LSJR Alternative 3. The NPV is calculated with a 4% discount rate to account for future cash flows. Under LSJR Alternative 3, TID would lose approximately $19.0 M in sales of electricity.

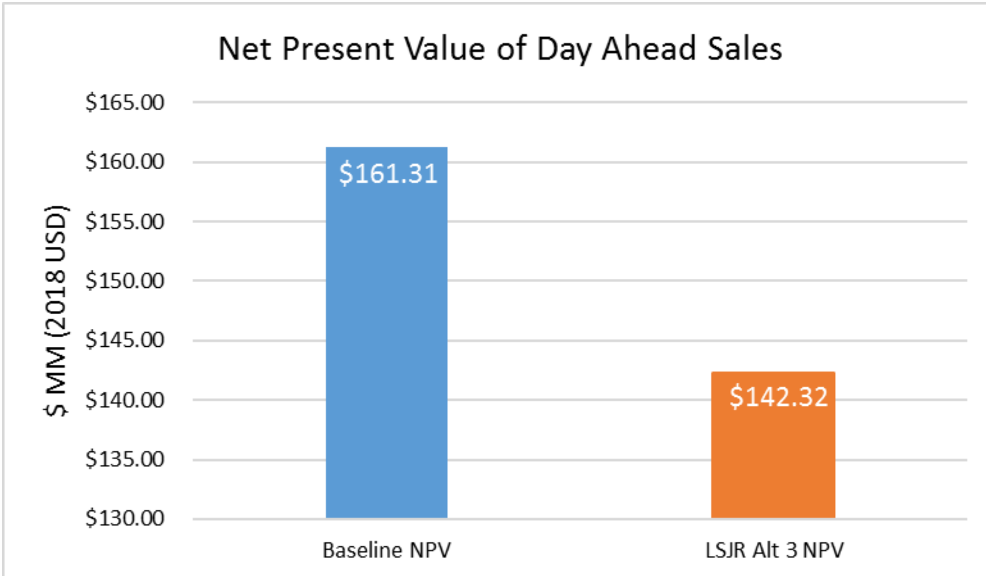


Figure 12: Comparison of day-ahead sales of power for Don Pedro under current conditions and LSJR Alternative 3.

2.2.2 Value of Reservoir Storage Capacity

The second component of the quantification of damages for Don Pedro is the value of lost water storage potential in the Don Pedro reservoir that results in loss of potential generation capacity. Prevailing water flow conditions allow Don Pedro to draw from its reservoir as a contingency measure in scenarios of insufficient surface water flows. LSJR Alternative 3 restricts Don Pedro reservoir to maintain at least 800,000 acre-feet of water storage. Don Pedro's dead storage capacity is 309,000 acre-feet, and its historically lowest carryover storage was 422,000 acre-feet in 2015. With the proposed increase in carryover storage requirements, Don Pedro will be constrained in its ability to draw extra power from the reservoir.

PowerSimm models future states of reservoir levels. With severe drought conditions being forecasted for future drought years, the reservoir levels are allowed to vary between 309,000 acre-feet and 1,900,000 acre-feet under baseline conditions and between 800,000 acre-feet and 1,900,000 acre-feet under LSJR Alternative 3. Stochastic simulations of future states allows capturing the variability in contingency requirements based on water flow availability to provide reliable power. Differences in modeled reservoir levels were translated into differences in potential power through dependence of power on acre-feet of water available. The conversion factor averages to 0.35 MWh/acre-feet. As Figure 13 below shows, the average loss in potential power available from the reservoir is 94 GWh while during the worst simulated year, the extra water drawn from the reservoir results in 158 GWh of lost energy potential. We discount power prices by 50% under this component, since the loss in reservoir storage is based on loss in potential energy sales. Assuming a discount rate of 4%, the NPV of the accumulated damages to lost energy potential are calculated to be $23.8 M over the study period.

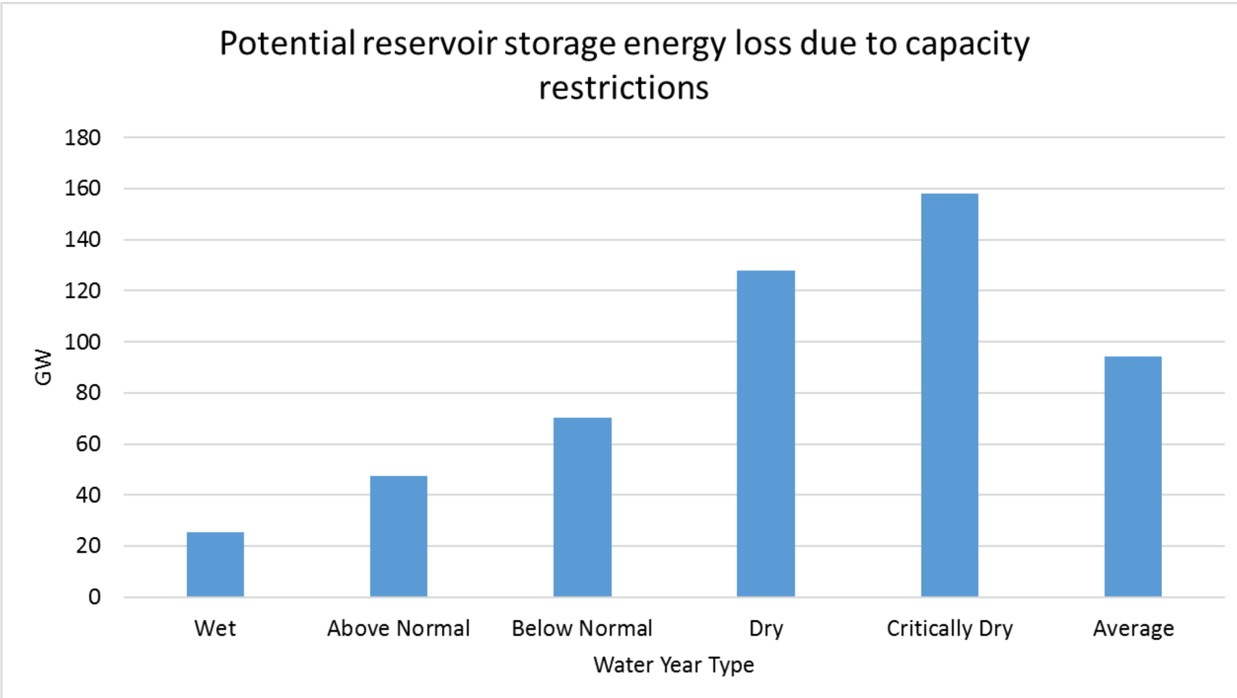


Figure 13: Modeled reservoir losses (GWh) by water year type

2.2.3 Value of Flexible Capacity: Replacing Loss in Capacity with Batteries

The third component of the quantification of damages for Don Pedro is the value of capacity. Due to the 40% unimpaired river flows and the additional carryover storage required under LSJR Alternative 3, Don Pedro's capacity, or capability to generate power when profitable, is severely curtailed. Particularly in dry years, TID would have significantly less discretionary water, severely stunting Don Pedro's effective capacity. Thus under LSJR Alternative 3, Don Pedro, one of TID's most important zero-emission sources of flexible and dependable capacity, becomes an intermittent resource.

To determine this loss of value, Ascend calculates replacement costs for the loss in zero-emission, flexible generation capacity. The most cost-effective, zero-emission replacement for hydropower capacity is load-shifting batteries. Ascend determines the replacement value by calculating the cost to supply 4 hours of sustained battery discharge at a level equal to the maximum hourly energy lost under LSJR Alternative 3 observed in the PowerSimm study. The maximum hourly energy lost under LSJR Alternative 3 relative to baseline is 128.5 MW, or 63% of Don Pedro's nameplate capacity.

The installation cost of 4-hour load-shifting batteries is approximately $350/kWh multiplied by the battery capacity. Additionally, Ascend assumed a 15-year lifetime for load-shifting batteries, at which point the battery can be refurbished at 50% of its initial installation cost. Assuming a 4% interest rate and that battery installation costs remain unchanged at 350/kWh, Ascend calculated the NPV of battery installation over the course of the study period to be $256.1 M.

2.2.4 Value of Ancillary Services: Replacing Loss in Ancillary Services with Batteries

The fourth component that Ascend takes under consideration in its calculations of the loss of long-term value for Don Pedro is the value of ancillary services. Ancillary services provide a fast and flexible generation response to keep the supply system in balance with electricity demand (load). There are two major components to ancillary services: 1) regulation reserves, and 2) contingent reserves. Regulation reserves are resources within the energy system that can respond rapidly to system-operator requests to balance out minute-to-minute fluctuations between supply and load, and keep the energy system operating at 60 Hz. Contingent reserves are resources that can be utilized in the event of unusual load requirements, particularly when a large generator trips offline. Table 5 elucidates the sub-components of regulation reserves and contingent reserves.

Service	**Service Description**		
	Response Speed	*Duration*	*Cycle Time*
Regulation Reserves			
Regulation-Up	Online resources with automatic generation control (AGC) that can respond rapidly to system-operator requests for up movements, i.e. additional generation.		
	~1 min	*Minutes*	*Minutes*
Regulation-Down	Online resources with automatic generation control (AGC) that can respond rapidly to system-operator requests for down movements, i.e. additional generation.		
	~1 min	*Minutes*	*Minutes*
Contingency Reserves			
Spinning Reserve	Online generation, synchronized to the grid that can increase output immediately in response to a major generator or transmission outage and can reach full output within 10 min to comply with NERC's Disturbance Control Standard (DCS). Used may be a couple times a year.		
	Seconds to <10 min	*10 to 60 min*	*Hours to Days*
Non-Spinning Reserve	Same as spinning reserve, but need not respond immediately; resources can be offline but still must be capable of reaching full output within the required 10 min.		
	<10 min	*10 to 60 min*	*Hours to Days*

Table 5: Definitions of key ancillary services

The intermittency of renewable generation largely determines the extent of regulation required, with solar in particular tending to have rapid fluctuations in generation that must be balanced out. As Figure 14 shows, the volatility in solar generation (yellow line) disrupts the quiescent behavior of net-load, or load minus renewable generation (blue line), and regulation reserves (black line) is tasked with smoothing out the imbalances that arise from these fluctuations.

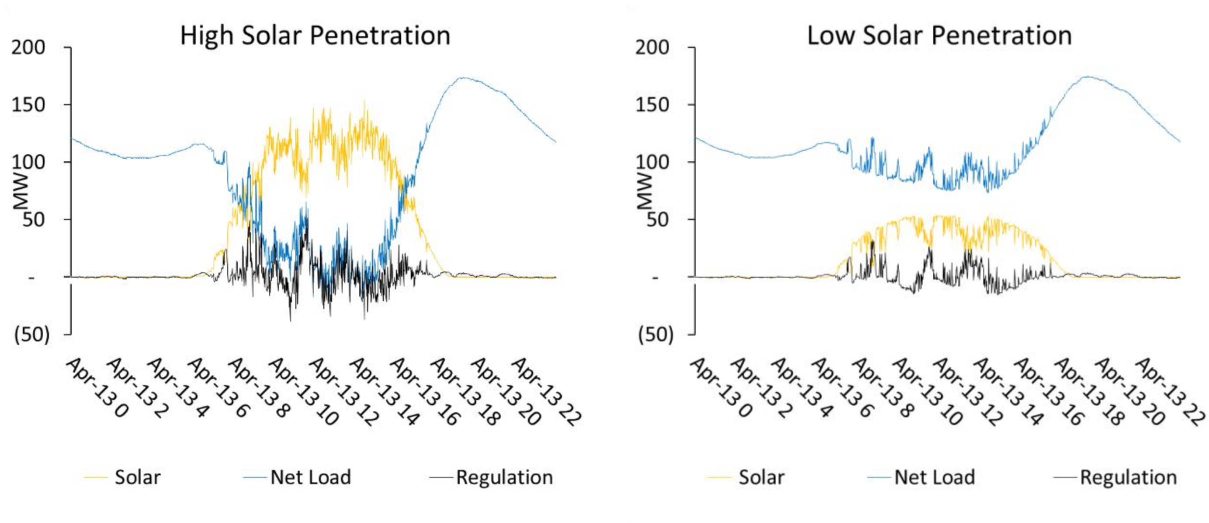


Figure 14: Comparison of regulation requirements for an energy system with higher and lower solar penetration.

TID is subject to rigorous ancillary service requirements, and Don Pedro services the chief portion of Turlock's ancillary service requirements. Table 6 shows that on average Don Pedro services 68% of TID's Regulation-Up requirements. Moreover, TID sells generation from Don Pedro on the Spin and Regulation-Up market. With forecasts of increasing renewable penetration, the prices in the Spin and Regulation-Up markets are expected to increase.

Average Percent of Ancillary Service Furnished by Don Pedro	
Regulation-Up	67.9%
Regulation-Down	30.4%
Spin	47%
Non-Spin	11.7%

Table 6: Average Percent of Ancillary Service Furnished by Don Pedro

LSJR Alternative 3's constraints placed on Don Pedro's flexibility takes away Don Pedro's capability to furnish ancillary service requirements. Particularly during a dry year, we forecast that Don Pedro would not be able to provide any ancillary service requirements. Thus, Ascend determines the costs to replace Don Pedro's capability to furnish ancillary services with regulation batteries. According to PowerSimm's results, the maximum regulation requirement for Don Pedro would be 72.4 MW. Ascend calculated the NPV of costs to install a regulation battery of this capacity, plus 14% further capacity for additional reserves. The installation costs for regulation batteries are higher than load shifting batteries, amounting to $613/kWh. Ascend has assumed that regulation batteries have an eleven-year lifetime due to their extremely frequent charging/discharging. Assuming an 4% interest rate and that battery installation costs remain unchanged at $613/kWh, Ascend calculated the NPV of battery installation over the course of the study period to be $99.0 M.

2.2.5 Loss in Consumer Surplus

Consumer surplus is the difference between how much consumers are willing and able to pay and how much they actually pay. In critically dry years, with greatly reduced power availability (i.e. reduced supply), the retail prices in the North San Joaquin Valley increases, reducing consumer surplus. Moreover, increased prices of basic commodities that result from substantially reduced agricultural output decreases consumers' willingness to pay for energy. Thus, the decrease in consumer surplus is a factor of increased retail price of electricity as well as a decreased willingness to pay. Ascend models the change in demand and supply of energy in the affected region through existing data on energy demand and historical power price dynamics. The potential change in the supply curves follows from the LSJR Alternative 3 flow requirements with demand response and loss in consumer surplus determined from the long-run elasticities of demand for electricity of -0.50. Ascend determines the loss in consumer surplus over the study period to be $16.4 M.

2.2.6 Overall Damages - Hydropower

The five components of Don-Pedro's loss in value under the proposed flow requirements amount to $388.7 M. The largest portion of the damages come from the replacement costs incurred by the loss in capacity (61.8%), and ancillary services (23.9%).

Damages	
Loss in Day-Ahead Sales	$19.0 M
Loss in Reservoir Capacity	$23.8 M
Replacement costs for loss in capacity	$256.1 M
Replacement costs for loss in ancillary services	$99.0 M
Loss in Consumer Surplus	$16.4 M
Total Damages (2018 USD)	**$414.3 M**

Table 7: Total damages for Don Pedro's generation under LSJR Alternative 3.

3 Concerns with SED report

In this section, Ascend outlines its concerns with certain flaws and limitations within the SED. The first subsection focuses on limitations in the SED's modeling assumptions related to hydropower generation and agriculture. The second subsection considers the SED's biased presentation of the replacement costs for lost water under the LSJR Alternatives. The last subsection considers the distribution of costs and benefits under the SED proposal, and the social justice issue produced by it.

3.1 Modeling Limitations

3.1.1 Outdated Prices of Power

In its evaluation of hydropower revenue, the SED uses prices of power from the 80th percentile of the 2006 prices of power, since these prices most closely matched the median price for power from 1998 to 2009 (20-51). The energy market 11 years ago, however, does not adequately capture current market conditions. As elucidated in section 2.1, the influx of intermittent renewables is causing the energy market to undergo a dramatic shift, which has radically altered the monthly prices of power.

The SED states, "Changes in summer hydropower generation will have a slightly greater effect on revenues because the price of energy is generally greater in summer than during the cooler months" (J-6). While historically this has been the case, the expected influx of solar generation has significantly modified the forecasts for the monthly price for power. Figure 15 illustrates the forecasted monthly prices for power from 2017 to 2019. Prices from April to June are forecasted to decline annually. The price of power in June decreases at an especially rapid rate, rendering June with the lowest monthly prices by 2019.

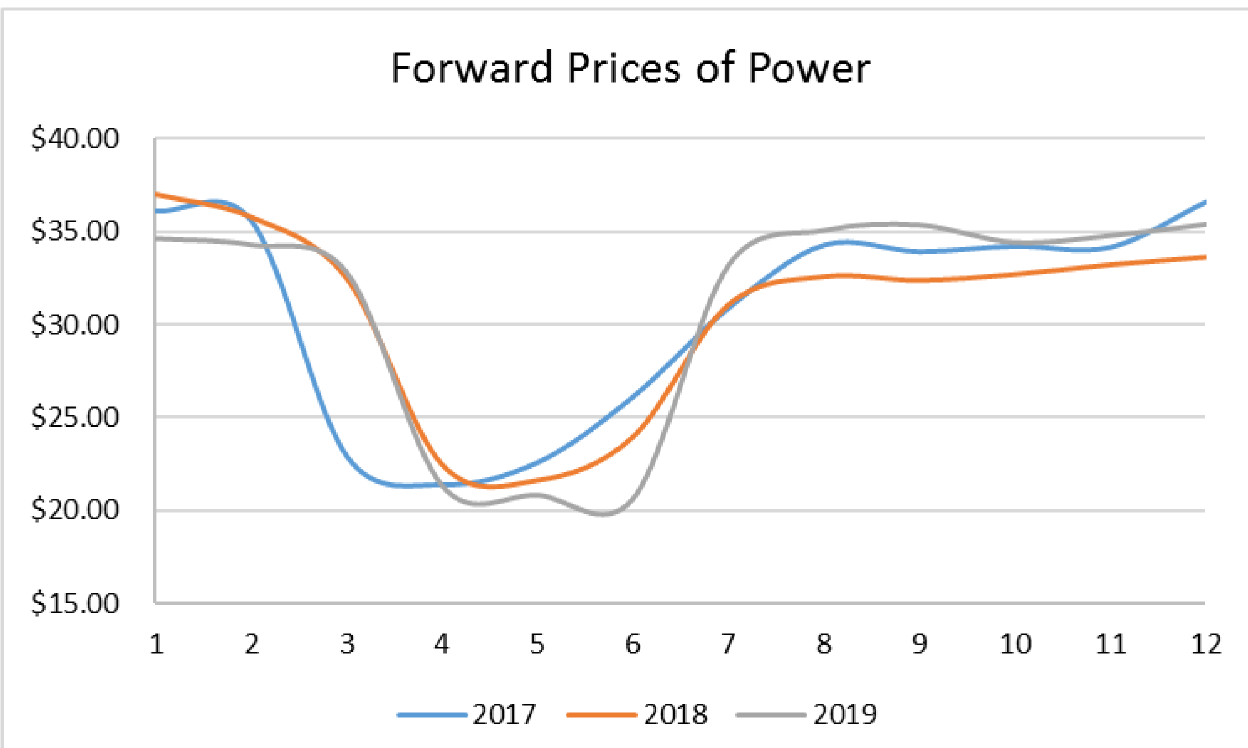


Figure 15: Forward Prices of Power 2017-2019

Moreover, the information provided in the SED on the average price of power in CAISO from 1998 to 2009 is implausible. The SED offers no verifiable source for their prices of power, stating only that "monthly values available from the California Independent System Operators (ISO) during the 2006 calendar year were used in the assessment" (20-51). There are unexplained gaps in their presented monthly prices of power, and the year-to-year volatility in prices is unlike anything ever seen by Ascend. All these factors lead to doubts on the trustworthiness of their analysis.

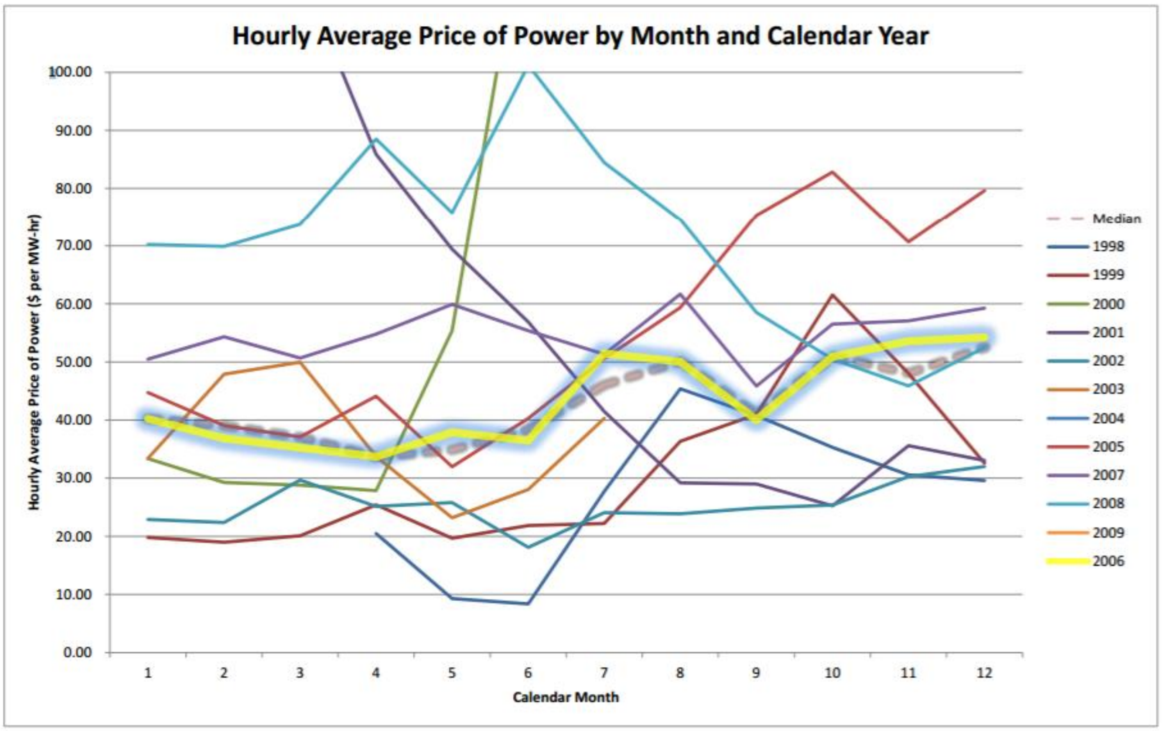


Figure 16: The SED's depiction of monthly prices for power from 1998-2008 (Figure 20.3.4-1 in SED)

3.1.2 Changing Crop Distributions

The SED does not capture current crop distributions in California. The SED derives crop distributions from 2010 data from the California Department of Water Resources (DWR). By 2015, however, crop distributions have undergone a significant shift, with permanent crops increasing statewide by 15%.[1] As Figure 17 shows, the acreage of nut trees has particularly increased, with a percent increase ranging from 21 to 29%.

[1] Daniel A. Sumner, "Appendix G: Acreage Data and California Drought," in *Economic Analysis of the 2016 California Drought on Agriculture*, preparers Josue Medellin-Azuara, Duncan MacEwan, Richard E. Howitt, Daniel A. Sumner and Jay R. Lund, (UC Davis, 2016), https://watershed.ucdavis.edu/files/Drought_Report_2016_Appendix_Set_20160811.pdf.

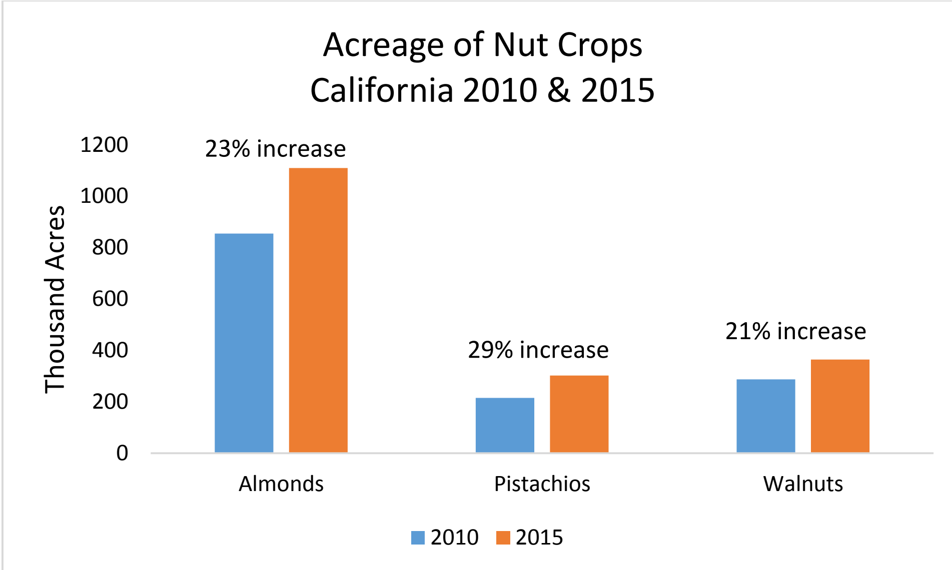


Figure 17: Acreage of Nut Crops California

Figure 18 confirms that the growth in acreage of permanent crops includes the San Joaquin Valley. From 2010 to 2015, the harvested acreages of almonds for Stanislaus County increased by 19% from 144,700 acres to 177,700 acres, while for San Joaquin County the harvested acreage of almonds and pistachios increased by 26% from 48,200 acres to 65,300 acres.

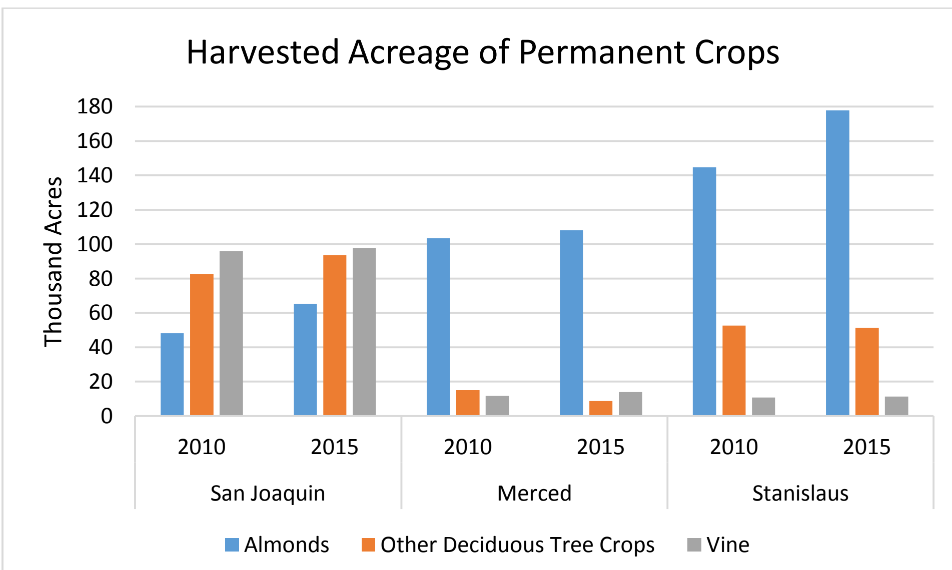


Figure 18: Harvested Acreage of Permanent Crops for the Three Counties Affected by SED[2]

Without taking these factors into consideration, the SED overestimates the acreage that is available to fallow, which leads to results for water demand that are artificially low relative to actual conditions.

[2] Information take from 2015 county crop reports for each county.

3.1.3 Intensification of Groundwater Pumping

The SED assumes increased groundwater pumping without adequately accounting for its negative effects. The SED proposes on average a 40% increase in groundwater pumping, from 260 TAF to 364 TAF (ES-4). Such a sustained intensification of groundwater pumping calls for the region to exceed sustainable levels of groundwater pumping at a time when local and state governments are pushing towards further regulations of groundwater. For more information on the deleterious effects of the overpumping of groundwater, see section 4.2.

3.1.4 Geographically Limited Impact Analysis

Figure 19 depicts the Detailed Analysis Units (DAUs) evaluated under the SED's economic impact analysis. The report, however, does not evaluate the economic impacts on the extended plan area (outlined in gray in Figure 20), rather circumscribing the analysis exclusively to the irrigation districts. Nevertheless, the SED states that the "reduction in availability of surface water could affect water users who obtain their water from diversions anywhere within the plan area and extended plan area—anywhere within the Stanislaus, Tuolumne, and Merced River Watershed" (ES-23). Thus, the agricultural and economic damages caused by the LSJR Alternatives would in reality extend further than the demarcated area in Figure 19.

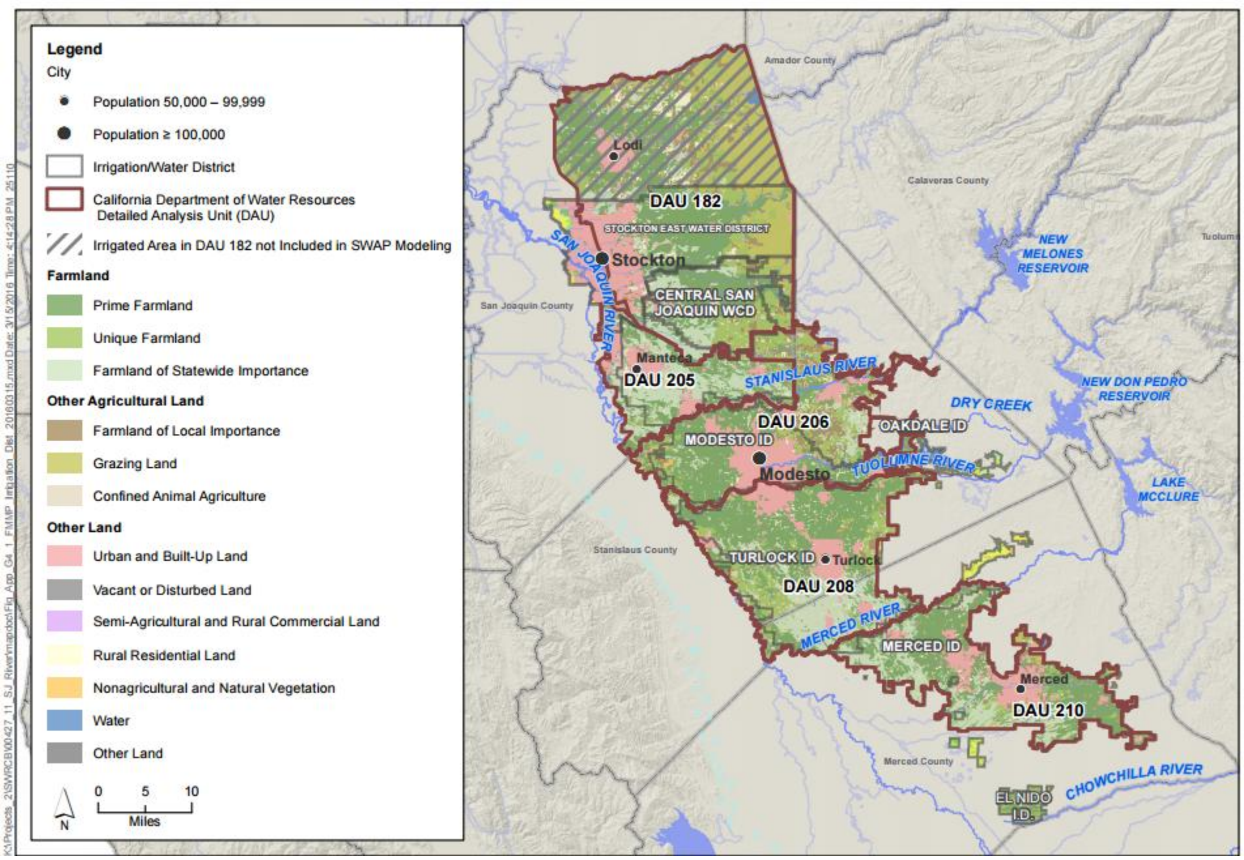


Figure 19: Area analyzed for economic impacts of the 2016 SED.

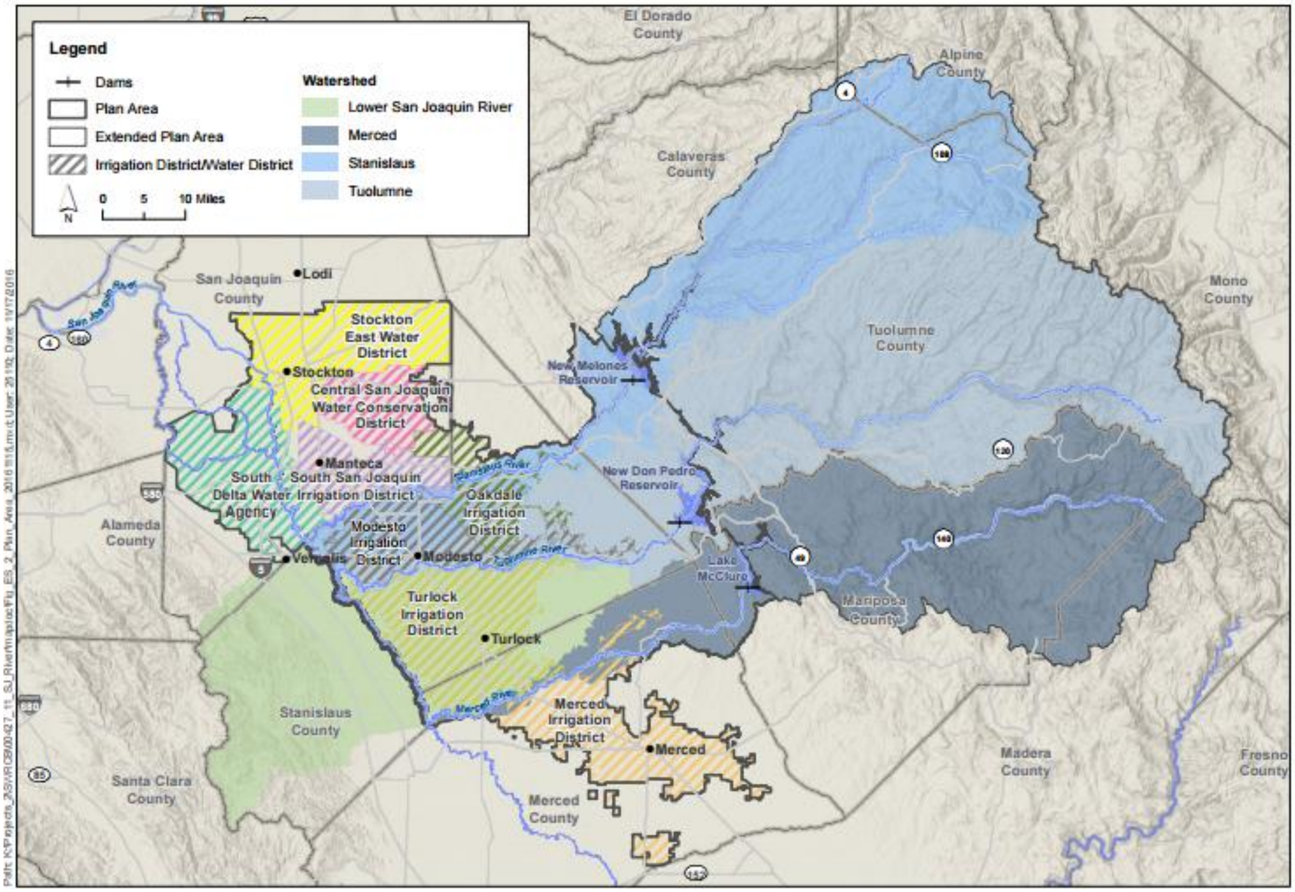


Figure 20: Plan area and extend plan area

3.1.5 Limitations in the presentation of results

The SED reports only the average annual reductions in agricultural revenues under the LSJR Alternatives. Given that the revenue losses are not normally distributed or symmetric, the average loss is not representative of the distribution of losses. Exclusively presenting the average economic impacts smooths out the volatility of the year-to-year water reductions and economic losses, and in turn does not inform the reader of the range of expected losses incurred by the LSJR Alternatives. For example, the WSE model determines that the reduction in water supply relative to baseline under LSJR Alternative 3 would on average be 38% in critically dry years (ES-23), and that there would concomitantly be a 23% increase in unmet water demand during critically dry years (ES-26). On the other hand, the average reduction in water supply is 14%, while the average unmet demand is 11%. By not clearly presenting information on the economic impacts during drier years, the SED inadequately represents the extent of potential damages incurred by the LSJR Alternatives.

3.1.6 Changing Climate Patterns

The SED model does not adequately capture the changing variability in weather caused by climate change. As the California Department of Water Resources states, "Climate change is also expected to result in more variable weather patterns throughout California. More variability can lead to longer and more severe droughts."[3] Relying on historical data ranging from 1922-2003, the SED does not factor into their model expectations for increased volatility in weather. An accurate representation of this volatility is key to understanding the risk of permanent damage to perennial crops and the associated economic losses. Increased likelihood of sequential dry years means more fruit and nut trees will die due to lack of water, and more acres of land will be converted to non-farming uses.

3.2 The Cost of Water and its Alternatives

In Chapter 16 of the SED, SWRCB provides multiple alternatives for offsetting the losses in surface water supply induced by LSJR Alternative 3. Though at first glance these alternatives may seem to provide the necessary and adequate responses to the water supply reductions, none of the alternatives offer sustainable long-term solutions to the shortages that TID and the whole San Joaquin Valley would be facing.

In this section, Ascend focuses on water replacement alternatives mainly in relation to TID, though many of the considerations are directly transferrable and relevant to the other affected irrigation districts.

3.2.1 Long-Term Water Transfers

The SED puts forth the option of affected parties engaging in long-term water transfers in the face of a water shortage. The State Water Board, citing a 2006 report of US Bureau of Reclamation, indicates a reasonable average price for long-term water purchases to be $310 per acre foot (2010 USD) (16-7). However, these prices do not take into account TID's geographic location and the lack of preexisting infrastructure for implementing water transfers. As Turlock is not connected to any aqueducts and its neighbors downstream will also be facing water shortages under the new flow requirements, the possibility of water transfers are extremely limited. Furthermore, Howitt et al. (2012) report that the only feasible inter-regional water transfers for TID or Modesto Irrigation District (MID) are with Merced Irrigation District.[4] The historical data confirm Howitt et al.'s evaluation on the dearth of water transfers within region. The only water transfers recorded in the Western Water Transfer Data Set involving TID are two short-term transfers to the Bureau of Reclamation in 1990 and 2001.[5]

Theoretically, TID could enter into water purchase agreement with the City and County of San Francisco, who owns and operates the Hetch Hetchy Reservoir, Cherry Lake and Lake Eleanor upstream. However, water transfers from urban to agricultural regions are extremely rare in California. Out of the 691 California water transfers recorded in Western Water Transfer Data Set, only 10 were urban to agriculture transfers. Moreover, San Francisco has not been looking to sell water to other irrigation districts, but buy water from them. Recently, SFPUC, attempting to secure backup water sources in response to the drought, was negotiating with Modesto Irrigation District (MID) for a long-term water transfer of 2,240 AF per year at a price of $700/AF.[6] (MID withdrew from negotiations due to local resistance against the transfer.) Additionally, SFPUC expects to experience exacerbated water shortages under SED's proposed flow requirements. Hetch Hetchy Regional Water System, suggest that the

[3] "Climate Change," California Department of Water Resources, http://www.water.ca.gov/climatechange/.
[4] Richard E. Howitt, Josue Medellin-Azuara, Duncan MacEwan, and Jay R. Lund, "Calibrating disaggregate economic models of production and water management," *Environmental Modelling & Software*, 38 (2012), 244-258.
[5] "California Water Transfer Records," Bren School of Environmental Science & Management, http://www.bren.ucsb.edu/news/water_transfers.htm.
[6] "MID Water Transfer FAQ," Modesto Irrigation District, http://www.mid.org/about/newsroom/projects/watertransfer/documents/MIDWaterTransferFAQ_5-17-12.pdf

implementation of the proposed flows could cause a shortage of 52% under drought conditions.[7] Assistant General Manager Steven Ritchie of the San Francisco Water Enterprise states that, with the new flow requirements, the number of dry year shortages for San Francisco would double or triple.[8] As the SED notes, the LSJR Alternatives have the potential to negatively affect the CCSF's water supply, especially during a drought. It should be noted that the SED accounts for this, mentioning the potential for SFPUC to buy water from other irrigation districts at $1000/AF. However, they do not account for other irrigation districts, which, threatened by shortage, would also be in want of additional sources of water at this time.

Moreover, growers in the region would have less flexibility than in the past because of the increase of permanent crop acreage within the region, which has hardened water demand. Sumner (2016) reports that permanent crops have increased statewide by 15% or 421,000 acres.[9] Figure 21 shows that the harvested acreage of almonds for Stanislaus County nearly doubles from 97,3000 acres in 2010 to 177,700 acres in 2015. Unlike with low value, annual crops, growers do not have incentive to fallow their permanent crops.

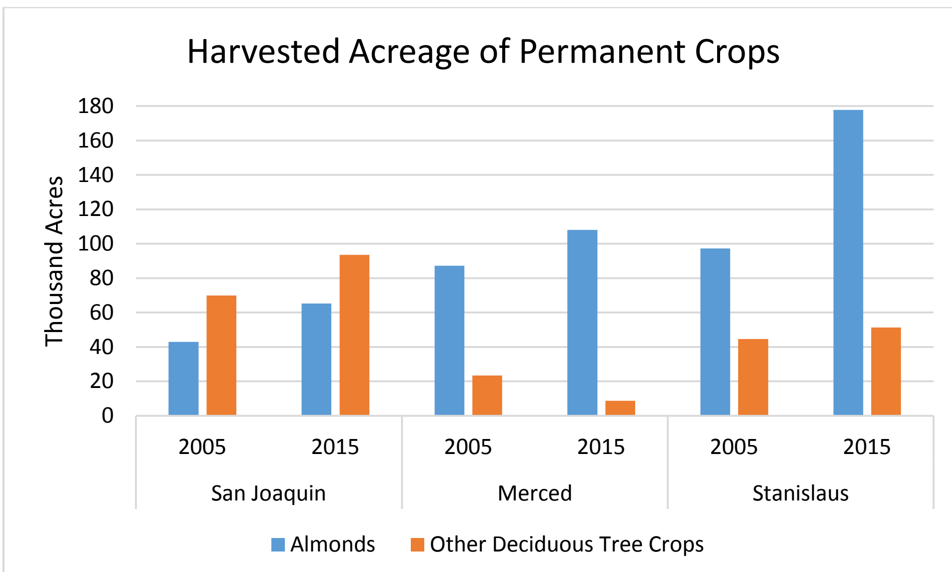


Figure 21: Harvested Acreage of permanent crops for three affected counties, 2010-2015

Drought conditions would only increase the price of potential water purchases. For example, "Average prices in the [Central Valley] spot market soared in 2014, rising from an average of $180/AF in 2013 to

---

[7] Ellen Levin, Donn Furman, Dan Steiner, David Sunding, "City and County of San Francisco Comments on the State Water Resources Control Board Substitute Environment Document," SFPUC, March 21,2013, http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/docs/dsedoc/sanfranciscocity.pdf

[8] San Francisco Public Utilities Commission, "Minutes," January 10, 2017, http://www.sfwater.org/Modules/ShowDocument.aspx?documentID=10281.

[9] Daniel A. Sumner, "Appendix G: Acreage Data and California Drought," in *Economic Analysis of the 2016 California Drought on Agriculture*, preparers Josue Medellin-Azuara, Duncan MacEwan, Richard E. Howitt, Daniel A. Sumner and Jay R. Lund, (UC Davis, 2016), https://watershed.ucdavis.edu/files/Drought_Report_2016_Appendix_Set_20160811.pdf.

$830/AF in 2014 as a result of the drought and record low water allocation."[10] Prices for water in the Central Valley for 2014 went as high as $1,350/AF[11].

The SED additionally provides prices on permanent water rights, indicating the average cost of permanent water rights to be $1,716/AF. However, their data is from 2002 to 2004, and the price of water is widely variable. Others sources provide the price for permanent water rights to be anywhere from $3,225/AF to $5,850/AF, increasing up to $8,663/AF when a reliability factor is incorporated.[12] [13] As explained above in regards to long-term water transfers, a purchase of permanent waters rights would be highly unlikely and prohibitively costly under the LSJR Alternatives, as other irrigation districts, utility companies and growers in the region will face water shortages and disincentives to permanently selling their water.

3.2.2 Groundwater

Groundwater seems to provide the simplest option for offsetting water losses associated with the implementation of LSJR Alternative 3. The SED presents typical groundwater costs for agriculture in the San Joaquin Valley in the range of $48-$64/AF for agriculture (16-18) and anywhere from $62-$1,937/AF for municipal groundwater production (16-19). Increased groundwater pumping, however, is an acceptable fallback option in periods of droughts, but not a long-term solution to meet the region's water needs under a structural water shortage.

Groundwater essentially functions as a contingency reserve during drought. LSJR Alternative 3 would, according to the SED, increase groundwater pumping within the plan area by 40% on average, and increase groundwater pumping by 73% for the three driest water year types (below normal, dry, and critically dry), which make up 51% of the historical years analyzed. To ask the plan area to increase their groundwater pumping by 73% for over half the time would deplete the groundwater reserves significantly, leaving the region with no safety net to fall back on in the event of future droughts.

---

[10] "WestWater Research Announces 2014 Water Rights Price Index Results," WestWater Research, 2015, http://www.waterexchange.com/wp-content/uploads/2015/09/15-0916-Q3-WWInsider-fnl-LO.pdf

[11] Lisa M. Krieger, "California Drought: High-bidding farmers battle in water auctions," *The Mercury News*, July 19, 2014, http://www.mercurynews.com/2014/07/19/california-drought-high-bidding-farmers-battle-in-water-auctions/.

[12] Indio Water Authority, "Supplemental Water Supply Program and Fee Study," http://www.indiowater.org/Modules/ShowDocument.aspx?documentid=2801

[13] Kavita Jain-Cocks, "California's Water Rights Controversy: Should farmers be Allowed to Transfer Water to Developers?", November 30, 2010, http://blogs.ei.columbia.edu/2010/11/30/california%E2%80%99s-water-rights-controversy-should-farmers-be-allowed-to-transfer-water-to-developers/.

Water Year Type	Average Annual Groundwater Use		
	Baseline	**LSJR Alternative 3**	**Projected Percent Increase under LSJR Alternative 3**
Wet	185	192	3%
Above Normal	203	235	16%
Below Normal	228	376	65%
Dry	221	524	137%
Critically Dry	485	614	27%
All Year Types	260	364	40%

Table 8: Projected percent increase of average annual groundwater use under LSJR Alternative 3

Groundwater overdraft is already a major concern in California. Since 1962, the Central Valley has depleted groundwater reserves by nearly 80 MAF. [14] In 2014, certain areas in the San Joaquin Valley registered groundwater levels at more than 100 feet below historic levels.[15] The Department of Water Resources states that the groundwater elevation in the Turlock-San Joaquin Valley has from 1971 to 2013 decreased by an average of 2.1 ft/yr.[16] As UC Davis Professor Richard Howitt remarks, the current situation of groundwater in California is "a slow-moving train wreck."[17]

[14] Bettina Boxall, "Overpumping of Central Valley groundwater creating a crisis, experts say," *Los Angeles Times,* March 18, 2015, http://www.latimes.com/local/california/la-me-groundwater-20150318-story.html.

[15] Janny Choy and Geoff McGhee, "Groundwater: Ignore It, and It Might Go Away," *Water in the West* (Stanford: 2014), http://waterinthewest.stanford.edu/groundwater/overview/index.html.

[16] Department of Water Resources, *Public Update for Drought Response: Groundwater Basins with Potential Water Shortages and Gaps in Groundwater Monitoring*, 2014, page 29, http://www.water.ca.gov/waterconditions/docs/Drought_Response-Groundwater_Basins_April30_Final_BC.pdf.

[17] Kat Kerlin, "Drought impact study: California agriculture faces greatest water loss even seen," UC Davis News, Jul 15, 2014, https://www.ucdavis.edu/news/drought-impact-study-california-agriculture-faces-greatest-water-loss-ever-seen.

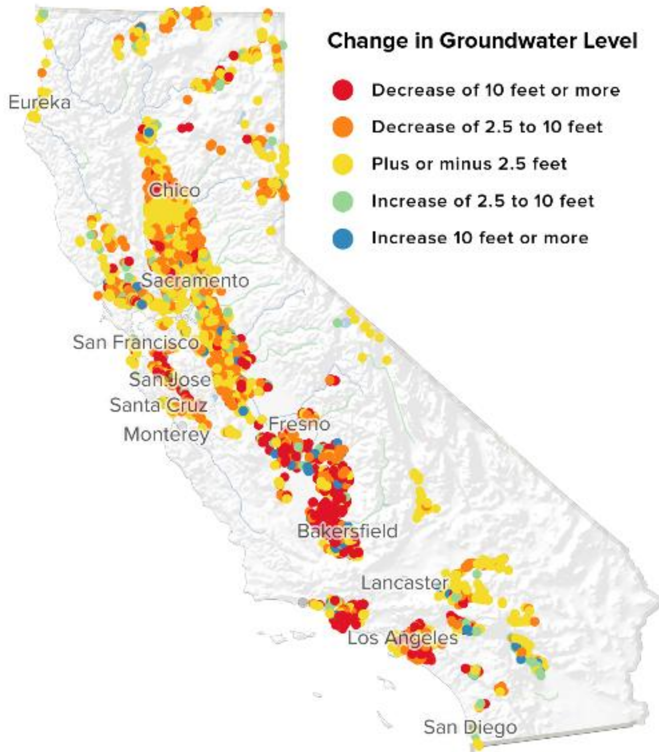


Figure 22: Change in Groundwater levels between 2013-2014 in California[18]

Unlike surface water in California, groundwater has largely been unregulated, and, until 2015, it was the only state that lacked a statewide framework for managing groundwater.[19] In response to systemic overdrafts of groundwater, the state of California has moved towards developing groundwater regulations with the Sustainable Groundwater Management Act (SGMA). As noted in the SED, SGMA is supposed to protect California's groundwater from "undesirable results" such as the unreasonable reductions and chronic lowering of groundwater levels (9-33). Thus, the SED proposal places the affected districts in an impossible position, encouraging them increase groundwater pumping and move contrary to the direction that California's policy is moving in.

Alongside depleting the region's drought reserve of water, there are multiple other deleterious effects associated with overpumping groundwater, none of which are rigorously evaluated in the SED. Ground water overdraft can lead to:

- **Diminished water quality and increased probabilities of water contamination.** As groundwater levels decline, natural and manmade pollutants can concentrate in the remaining groundwater, rendering the water unsafe for irrigation or potable use.

[18] Tara Moran, Janny Choy, and Carolina Sanchez, "The Hidden Costs of Groundwater Over Draft," *Water in the West* (Stanford: 2014), http://waterinthewest.stanford.edu/groundwater/overdraft/index.html.
[19] Kat Kerlin, "Drought impact study: California agriculture faces greatest water loss even seen," UC Davis News, Jul 15, 2014, https://www.ucdavis.edu/news/drought-impact-study-california-agriculture-faces-greatest-water-loss-ever-seen.

- The potential for contamination is particularly a problem for agricultural areas, which have higher concentrations of nitrates. The concentration of nitrates are growing in agricultural areas, and the costs of removing nitrates are prohibitively high.[20]
    - Professor Jay Lund of UC Davis state, "Most agricultural areas can expect nitrate contamination of drinking water supplies. Source control of nitrate discharge is only a partial long-term solution because of the large extent of contamination and its decades of travel in groundwater."[21]
    - Turlock had 4 groundwater wells closed due to contamination of nitrates. In Modesto, where there are 12 active groundwater wells, four have been offline due to water quality issues.[22]
- Additionally, salt accumulation can result from overpumping. The cost of desalinating brackish water can range from $950-$1,800/AF.[23]
    - A 2009 UC Davis study states that if salinity levels continue to increase in the Central Valley at current rates, there would be a $2.8 B to $5.3 B reduction in output in the Central Valley.[24]

- **Increasing energy usage and cost of pumping groundwater**, as aquifer levels decrease.
- **Land subsidence.**
    - In the San Joaquin Valley, subsidence necessitated by overdraft from 1955 to 1972 results in what would be $1.3 B in infrastructure repairs.
    - Subsidence in Santa Clara Valley is estimated to have resulted in more than $756 million in costs.[25]
- **Deterioration of groundwater-dependent ecosystems, and species**, some of which are endangered
    - Groundwater pumping also reduces water flow in many nearby rivers and wetlands. Scott River's average late-summer streamflow decreased by about 50% in the 1970's. The driving factor was farmers switching from surface water to groundwater to irrigate their fields.[26]

---

[20] Thomas Harter and Jay Lund, *Addressing Nitrates in California's Drinking Water,* (UC Davis, 2012), http://groundwaternitrate.ucdavis.edu/files/138956.pdf.

[21] Jay Lund and Thomas Harter,"California's groundwater problems and prospects," *California WaterBlog*, January 30,2013, https://californiawaterblog.com/2013/01/30/californias-groundwater-problems-and-prospects/.

[22] Turlock Irrigation District, *Groundwater Management Plan,* March, 2008, http://www.tid.org/sites/default/files/documents/tidweb_content/TID2015AWMP-Attachments_Public%20Review.pdf

[23] Heather Cooley and Rapichan Phurisamban, *The Cost of Alternative Water Supply and Efficiency Options in California,* (Pacific Institute, 2016), http://pacinst.org/app/uploads/2016/10/PI_TheCostofAlternativeWaterSupplyEfficiencyOptionsinCA.pdf.

[24]Richard Howitt, Jonathan Kaplan, Douglas Larson, Duncan MacEwan, Josue Medellin-Azuara, Gerald Horner and Nancy S. Lee, *The Economic Impacts of Central Valley Salinity,* (UC Davis, 2009), http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/library_reports_programs/econ_rpt_final.pdf.

[25] *Land Subsidence from Groundwater Us in California*," (Luhdorff & Scalmanini Consulting Engineers, 2014), ES-2, http://waterfoundation.net/wp-content/uploads/PDF/1397858208-SUBSIDENCEFULLREPORT_FINAL.pdf.

[26] Gus Tolley,"Scott Valley pioneers instream flow and groundwater management for reconciled water use," *California WaterBlog*, August 21, 2016, https://californiawaterblog.com/2016/08/21/scott-valley-pioneers-instream-flow-and-groundwater-management-for-reconciled-water-use/.

3.2.3 Recycled water

The SED presents the average price for recycled water to be $400-$2,100/AF (2011 USD) for irrigation, and $700-$1,200/AF for direct potable use. The Pacific Institute (2016) conducted a survey of 13 water recycling facilities in California and found the total costs to recycle water to range from $1,500/AF to $2,100/AF for non-potable reuse, and $1,600/AF to $2,700/AF for the cost of indirect potable reuse.[27] The California Public Utilities Company's 2016 survey of California water recycling projects shows higher costs, with the average cost of recycled water being $2,869/AF.[28] Such price levels are prohibitive for maintaining agricultural production in the area.

Moreover, the plan area's districts are unable to supply sufficient quantities of recycled water at reasonable costs. Recycled water projects are most effective in urban areas, where there is a significant amount of wastewater produced, and in turn is significantly limited in less densely populated agricultural regions.[29]

3.2.4 Aquifer Storage and Recovery

Aquifer storage recovery is an important way to mitigate some of the water loss, and many of the irrigation districts in San Joaquin Valley are developing and expanding conjunctive use of surface water and groundwater. However, aquifers storage is unable to absorb and discharge large volumes of water in a short period of time.[30] Additionally there can be significant concerns, around water contamination in these wells.[31] Thus aquifer storage and recovery, though beneficial, does not provide all the replacement water needed to meet the region's water needs.

Though the SED provides a 20-year amortized cost of $158-238/AF (2009 USD) (16-40), they also mention that cost can be highly variable depending on local conditions (22-23). Water in the West puts forth the cost of groundwater recharge projects at $90-$1,100/AF (2014 USD), with the median price being $390/AF, or approximately 79% greater the SED's mean price, when inflation is accounted for.

3.2.5 Desalination

Another option would be desalination. TID could theoretically enter into an agreement with SFPUC, wherein a desalination plant is built in San Francisco, and SFPUC transfers water from Lake Eleanor to TID at the cost of desalinating the same amount of water in San Francisco. The State Water Board provides average cost to desalinate water between $1,000/AF to $3,000/AF (16-72). The California

---

[27] Heather Cooley and Rapichan Phurisamban, *The Cost of Alternative Water Supply and Efficiency Options in California,* (Pacific Institute, 2016), http://pacinst.org/app/uploads/2016/10/PI_TheCostofAlternativeWaterSupplyEfficiencyOptionsinCA.pdf.

[28] California Public Utilities Commission, *What Will Be the Cost for Water?,* January 12, 2016, http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/PPD%20-%20Production%20costs%20for%20new%20water.pdf

[29] Jeremy Cusimano, Jean E. McLain, Susanna Eden, and Channah Rock, "Agricultural Use of Recycled Water for Crop Production in Arizona, (College of Agriculture & Life Sciences, 2015), page 1.

[30] "Chapter 2" in *Regional Issue in Aquifer Storage and Recovery for Everglades Restoration,* (Washington, D.C.: National Academies Press, 2002), https://www.nap.edu/read/10521/chapter/2.

[31] California State Water Board, *Staff Report: General Information Regarding Potential Water Quality Impacts of Aquifer Storage and Recovery Projects*, http://www.waterboards.ca.gov/rwqcb5/board_decisions/tentative_orders/0409/aquifer_storage/asr-issue-paper.pdf.

Public Utilities Commission (2016) presents the costs of water from three desalination plants to range from $2,367/AF to $5,100/AF,[32] while the Pacific Institute's survey of recently proposed desalination plants have costs ranging from $2,100/AF to $4,300/AF.[33] Such costs would be prohibitive to the agricultural region's future prospects. Moreover, TID expects their reductions of surface water diversions under LSJR Alternative 3 in the worst years to be above 100 TAF, which is more than any desalination plant could feasibly provide. The largest desalination plant in the US, the Carlsbad Desalination Plant, provides a maximum of 56 TAF per year.[34]

3.3 Broader Societal Ramifications: The Issue of Social Justice

The State Water Resources Control Board (SWRCB) explains that the objective of the SED proposal to increase flows upstream is to contribute to the improvement of the ecosystem along the San Francisco Bay/Sacramento-San Joaquin Estuary (Bay-Delta). The SED enumerates two central benefits of the LSJR Alternatives:

- Increased attainment of beneficial water temperatures for salmonids.
- Increased floodplain inundation for salmonids (ES-38).

Yet the benefits of the SED proposal pale in significance to their costs, in particular to their human costs. LSJR Alternative 3 threatens San Joaquin, Stanislaus and Merced Counties with grave long-term economic losses, and, in turn, the effective devastation of the counties' economic and cultural livelihood.

Moreover, when we start asking the question about distribution of these costs, it becomes clear that LSJR Alternative 3 creates a social justice issue. The SED does not emphasize that the burdens induced by the new requirements would be disproportionately placed on poorer regions of California. According to the Bureau of Economic Analysis, the 2011 income per capita of the San Joaquin, Stanislaus and Merced Counties ranges from $36,185 to $39,445. Income levels in the San Joaquin Valley are roughly 20% less than the average national income, and 29% less than California's average income.

---

[32] California Public Utilities Commission, *What Will Be the Cost for Water?,* January 12, 2016, http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/PPD%20-%20Production%20costs%20for%20new%20water.pdf

[33] Heather Cooley and Rapichan Phurisamban, *The Cost of Alternative Water Supply and Efficiency Options in California,* (Pacific Institute, 2016), http://pacinst.org/app/uploads/2016/10/PI_TheCostofAlternativeWaterSupplyEfficiencyOptionsinCA.pdf.

[34] "Nation's Largest Seawater Desalination Plant Marks One-Year Anniversary," Carlsbad Desalination Plant, 2016, http://carlsbaddesal.com/nations-largest-seawater-desalination-plant-marks-one-year-anniversary

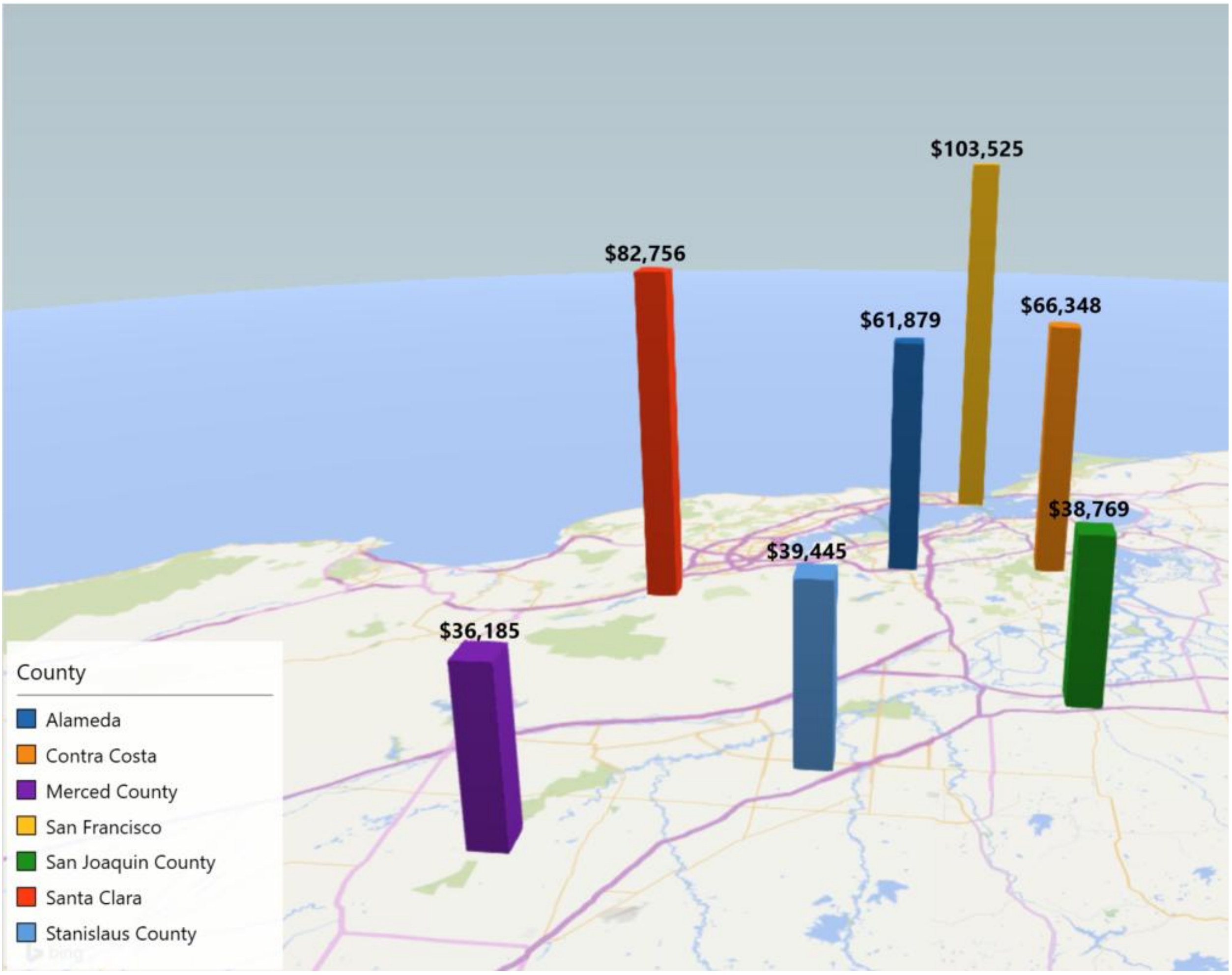


Figure 23: Per capita personal income (2011) of the affected counties in comparison to their neighbors due west

Not only are the affected counties in a less favorable economic position, but they are also beginning to regain their economic strength after the setbacks from the Great Recession and the droughts from 2007-2015. The three counties have just managed to creep past 2007 levels of income per capita in 2015. [35] The unemployment rate for the counties, which is still over 80% higher than the national unemployment rate, has managed to reach 2007 levels by last year. LSJR Alternative 3 has the potential to dramatically setback these counties, just as they are beginning to recover their economic footing.

One common complaint against the San Joaquin Valley is that the region consumes water at higher than average levels relative to the rest of the state. While the concern is understandable, it does not sufficiently take into consideration that the increased water consumption does not result from greediness or carelessness, but from the region's agricultural needs. As Zelezny et al. (2015) state, "It takes more water in the SJV to sustain the equivalent living conditions found in other parts of the state.

[35] *California County-Level Economic Forecast 2015-2040,* (The California Economic Forecast, 2015), http://www.dot.ca.gov/hq/tpp/offices/eab/docs/Full%20Report%202015.pdf

Decreased water availability in the SJV could cause collapse of both the economy and government, forcing the balance of the state to support the remaining population that cannot leave" (117).[36]

In terms of human benefits of the plan, the additional flows would provide recreationists a richer natural habitat to enjoy, as mentioned in SWRCB's Summary of the Proposed Updates.[37] However, SWRCB explains in its summary the environmental and human benefits of their proposal in relation to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, that is, in areas closer to or in wealthier pockets that would not be as damaged by the proposed flows. Thus, while the burden of the LSJR Alternatives is disproportionately placed on poorer regions, the human benefits of the SED proposal are not geared to the family growers, pickers and food processors of the San Joaquin Valley, but rather a select community of habitation restoration enthusiasts, who often will not have to suffer the costs of the proposal.

---

[36] Lynette Zelezny, *Impact of the Drought in the San Joaquin Valley of California*, (California State University, 2015), http://www.fresnostate.edu/academics/drought/documents/Fresno%20State_Drought%20Study%20Entire_FINAL.pdf.

[37] State Water Resources Control Board, "Summary of Proposed Updates to the bay-Delta Water Quality Control Plan, 2016, http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2016_sed/docs/prp_update_sum.pdf.

ERA Economics
Environment • Resources • Agriculture

ERA Economics LLC
1111 Kennedy Place, Suite #4
Davis, CA 95616

Technical Memorandum: Preliminary Review of the San Joaquin River SED Agricultural Economic Analysis

Prepared by: Duncan MacEwan, ERA Economics, LLC

Prepared for: Arthur Godwin, Mason, Robbins, Browning & Godwin, LLP

March 15, 2017

Purpose

This memo summarizes comments on the agricultural economic impact analysis prepared as part of the San Joaquin River flow Substitute Environmental Document (SED). This review is based on the data, summary information, and supporting documents available to the public as of March 9, 2017. In particular, Chapter 20 and Appendix G of the SED, and the "Agricultural Economic Analysis" Excel file.

As noted in the following, it is not possible to complete a detailed review of the data, methods, and results because the State Board has not provided all of the required economic model files and supporting information. The following comments have been prepared with this limitation in mind.

Comments fall into one or more of the following 4 categories:

1. **Clarification**. An issue with how results are presented or described.
2. **Analytic Error**. Potential economic modeling error.
3. **Data Error**. Potential data error.
4. **Omission**. Missing references, data, or other information.

Summary of Findings

This review identified 10 key points, summarized below and in more detail in the following subsections.

Point	Summary
1	The model applied for the SED is not the SWAP model
2	Model details, assumptions, and supporting data are not provided with public materials
3	The analysis shows implausible deficit irrigation of permanent crops
4	Fallowing costs are omitted from the SED analysis
5	The economic model calibration and supporting data is not described
6	The analysis does not distinguish between short-run and long-run economic impacts
7	The analysis does not consider the economic cost of an increase in water supply variability
8	The specification of the No Action (No Project) Alternative is not clear
9	The analysis does not consider the linkage from crop production to upstream high-value industries
10	Water supply costs and model calibration are not reported

Point 1 (Clarification; Omission)

The agricultural economic model applied for this study is not the well-known Statewide Agricultural Production Model (SWAP) that is commonly applied in agricultural economic impact analyses of changes in irrigation water supply. This review refers to it as the SED model. The SED model has different spatial scale, regions, assumptions, and underlying data which have not been described in the SED.

Explanation: The SWAP model has a well-established history of being used, reviewed, and vetted by public agencies in the public process of analyzing the economic impacts of water (and agricultural) policies. All of the underlying data and code have been published in various formats and subject to public and peer review. The SED model does not have this history and it is misleading to suggest that the SED model has been subject to the same vigorous vetting process as SWAP. The technical appendix and supporting data provided in the SED (Appendix G) do not adequately describe the SED model.

The SWAP model is developed specifically for statewide economic impact analyses of changes in water supply (and other factors) across distinct regions in California. As a statewide model, and not a detailed irrigation district-level model, studies that use SWAP will carefully interpret the results and note the limitations of this modeling approach. It is reasonable to apply the SWAP model methodology (i.e. calibrated optimization modeling) to more specific regions (e.g. the Study Area in the SED), but the model should be clearly defined and described.

The SED model is developed for a six irrigation districts in the Study Area, and as such, many of the generalizations that apply for the SWAP model do not apply to the Study Area. For example, the SWAP model explicitly assumes that irrigation water is perfectly substitutable within each model region. That is, the SWAP model is not able to differentiate between irrigation water supply (well, surface, etc), and cost, applied to different service areas within any single region. While this is a reasonable assumption at the aggregate level of the state, it may not be appropriate within individual irrigation districts. Access to district surface water, groundwater quality, and cost all vary within an irrigation district. In turn, cropping patterns typically vary between service areas, and the assumption of substitutable water supplies may not be appropriate.

Recommendation: The SED model is not the SWAP model so it must be carefully reviewed. As of March 9, 2017 the model code, data, and other underlying results are not available in the public SED documents.

Point 2 (Omission; Analytic Error)

It is not clear what assumptions (see below) have gone into developing the SED model because Appendix G is incomplete. Assumptions can have significant effects on the estimated economic impacts. If assumptions are incorrectly applied, the resulting economic impacts will be incorrect.

Explanation: The model description in Appendix G suggests that the SED model shares some similar code, data, and assumptions with the SWAP model. However, these assumptions and any supporting data have not been clearly described. Each modeling assumption needs to be considered carefully, clearly documented, and justified. Some examples from the SWAP model that could apply to the SED model and would affect the results of the SED agricultural economic analysis are presented below.

The SWAP model includes a routine to estimate real increases in energy costs based on California Energy Commission (CEC) projections. Typically, energy costs are forecast to increase in real terms over the foreseeable future. This means that the cost of groundwater pumping will increase and the additional groundwater pumping cost (a typically component of the economic impacts) will increase. In the SED analysis, Table 20.2-1 shows additional groundwater pumping cost equals $12.67 million/year under Alternative 4. It is not clear how this was modeled in the SED analysis, what future point in time (year) the economic analysis is developed for, and if there is any real increase in energy cost.

The SWAP model estimates the statewide market for crops, but it is not clear if the SED model does also. That is, the SWAP model estimates the market demand and supply for each of the crop categories using standard economic principles. This allows the analyst to consider two factors: (i) as the supply of a crop decreases, all else equal, the price for that crop will increase, and (ii) the demand for crops shifts over time. It is not clear what the SED analysis assumed about current and future market conditions for the crops produced in the Study Area.

It is not clear how the SED analysis calculates the gross and net return to farming for each crop included in the model. Typically, the SWAP model is based on aggregate crop categories and associated proxy crops as defined by DWR. However, these definitions are developed with the statewide market in mind. For example, the "other truck" category (miscellaneous vegetables) might have peppers or broccoli (fresh market) as the proxy crop. These crop budgets and corresponding proxy crops may not apply to the SED Study Area because they are not representative of agriculture in the region.

In short, technical appendix G is incomplete. There are no details about the SED model, the underlying data, or the modeling assumptions. There is no way for affected stakeholders and the general public to assess the validity of the assumptions, data, and resulting impacts. The SED does not indicate what model version of the SWAP model the SED model is based on (if any). Typical inputs and outputs from the SWAP model that are summarized in every technical appendix for EIR/S analyses in California include, but are not limited to, the following:

1. Summary tables of the model calibration ("base year") data including acreage, prices, costs, yields, and water use,
2. Crop group definitions, corresponding proxy crop, and supporting crop budget data,
3. Current and future market conditions and assumptions about how they evolve,
4. With-project conditions point in time (year or "level of development"),
5. Current and future production technology assumptions, and
6. Calibration assumptions such as short- or long-run analysis.

The references to the standard SWAP model are incorrect or incomplete. The SED cites various academic studies—where academic versions of the SWAP model have been applied—but offers no references where the SWAP model is applied for public policy/economic impact analyses, or how key data and assumptions are derived.

Recommendation: The SED must provide additional details about the SED model so that the reader can understand if appropriate assumptions have been applied.

Point 3 (Analytic Error)

The SED Appendix G provides a high-level overview of how the SWAP model allows for input substitution, but does not describe how these assumptions apply to (and are calibrated in) the SED model. The SED suggests that the ability to model input substitution is one reason why the SWAP model is superior to previous models of California agriculture and water, but the SED does not correctly describe how this economic substitution occurs and why it is important. The output results in the "Agricultural Economic Analysis" Excel Workbook indicate that there may be key errors in the SED model.

Explanation: The SWAP model is specified with a series of mathematical relationships called "production functions" that translate production inputs (e.g., chemicals, land, fertilizer, water, etc) into the amount of a crop produced (e.g., yield). The parameters that describe each of these relationships are calculated ("calibrated") using economic theory and observed (historical) land use decisions. This specification correctly allows for some limited substitution between inputs, and these responses are consistent with statewide data. The SED model is specified with a similar production functions. However, it is not possible to evaluate how well these functions are calibrated—meaning, how well they reproduce what actually happens—and the resulting estimated impacts.

There are errors in the SED model production function, calibration, or input substitutability. Without access to the SED model code it is not possible to say how important these errors are and the effect on the economic impact analysis. For example, the table below reproduces the estimated applied water to almonds, other deciduous, and subtropical permanent crops in each of the irrigation districts, using the "Agricultural Economic Analysis 09142016" Excel Workbook provided with the SED. The baseline column shows the initial applied water per acre. These are plausibly within the range of standard irrigation requirements in the region. The "60 Pct Flow (Alt 4)" column shows the applied water per acre estimated by the SED model under the 60 percent scenario (SED Alternative 4) and "2009 groundwater replacement" levels. The SED model is estimating an impossible response to water shortage—over 30 percent deficit irrigation in some regions—and crops are being deficit irrigated significantly.

For example, the SED model shows that under the 60 percent flow scenario almonds in Modesto ID are irrigated with 2.9 acre-feet per year, or nearly 19 percent below the average annual applied water. In other words, the SED model suggests that growers could apply 19 percent less water to almonds, relative to current use, and still produce a crop every year. Simply put, deficit irrigating crops at this rate is likely not feasible and it is not a reasonable long-run response to water shortage. Growers would instead fallow land or switch crops, resulting in lost revenues and economic activity in ancillary industries.

Table 1. Summary of crop irrigation water, baseline and 60 percent scenario with 2009 groundwater replacement assumption

District	Crop	Baseline	60 Pct Flow (Alt 4)	% Deficit Irrigation	Deficit Irrigation (ft)
SSJID	Almonds	3.452	3.090	-10.50%	0.36
	Other Deciduous	3.849	3.427	-10.96%	0.42
	Subtropical (Citrus)	3.384	2.483	-26.64%	0.90
OID	Almonds	3.651	3.295	-9.76%	0.36
	Other Deciduous	3.484	3.151	-9.54%	0.33
	Subtropical (Citrus)	3.115	2.717	-12.80%	0.40
SEWD + SCJWCD	Almonds	3.406	3.406	0.00%	0.00
	Other Deciduous	3.430	3.430	0.00%	0.00
	Subtropical (Citrus)	n/a	n/a	n/a	n/a
Modesto ID	Almonds	3.625	2.966	-18.19%	0.66
	Other Deciduous	3.458	2.875	-16.85%	0.58
	Subtropical (Citrus)	2.726	1.873	-31.26%	0.85
TID	Almonds	3.088	2.756	-10.75%	0.33
	Other Deciduous	3.449	3.076	-10.82%	0.37
	Subtropical (Citrus)	2.725	2.327	-14.59%	0.40
Merced ID	Almonds	3.276	3.193	-2.52%	0.08
	Other Deciduous	3.371	3.287	-2.49%	0.08
	Subtropical (Citrus)	n/a	n/a	n/a	n/a

Source: Reproduced from "Agricultural Economic Analysis 09142016.xlsx"

The same general trend holds for other crops and other SED Alternative scenarios, but the issue is most pronounced for the permanent crops highlighted in Table 1.

Recommendation: This is a shortcoming that warrants a significant revision of the analysis. The economic impact of water shortage is understated because the SED model allows implausible deficit irrigation.

Point 4 (Analytic Error)

The SED analysis assumes that fallowing a field is a costless activity. When a field is fallowed in response to water shortage in the short-run, the grower still must cover the costs to own and maintain the land. At minimum, there is a nominal charge to manage roads, dust, weeds, fences, and other structures. One cost estimate used by the U.S. Bureau of Reclamation for statewide planning studies is approximately $40 per acre in current dollars. This includes all short-run nominal maintenance costs for the fallow land. This would not include the full opportunity cost of the land if it must be permanently retired.

Explanation: Economic impacts are understated because they do not include fallow land costs. This cost must be included in the direct economic impact analysis, and analysis of indirect and induced effects.

There are over 70,000 acres estimated to be left fallow under the 60 percent flow scenario (Alternative 4). At $40 per acre nominal maintenance cost, this increases the direct economic cost of Alternative 4 by $2.8 million dollars annually. This cost would be borne by growers, resulting in a decrease in proprietor income in the regional economy. The cost of permanent land retirement is higher.

Recommendation: The SED analysis must account for full land fallowing cost.

Point 5 (Omission)

It is not clear what method is used to calibrate the parameters of the SED model. There have been significant methodological improvements in calibration approaches in the last several years that could be incorporated into the SED model. It is unclear whether the SED model has incorporated these advanced methods.

Explanation: Model calibration is the mathematical/statistical procedure used to calculate the parameters of an economic model. Calibration should ensure two things: (i) that the calibrated model reproduces observed conditions (e.g., cropping patterns, revenues, etc) in the Study Area, and (ii) that the calibrated model accurately reproduces response to changes in key parameters (e.g., prices, water supply, costs, etc) that are consistent with economic theory. Recent advances in calibration approaches that have been published in peer-reviewed economic journals allow for improved calibration of (ii), while still ensuring that condition (i) holds.

SED Appendix G provides insufficient information about the SED model calibration procedure. It is not possible to review the calibration approach, and in turn how well the model calibrates to criteria (i) and (ii). Errors in calibration could invalidate the resulting economic impacts.

Recommendation: The SED must provide additional technical details in Appendix G, and the associated SED model files so that the public can review the results of the analysis.

Point 6 (Data Error; Analytic Error)

The SED analysis does not distinguish between short run or long run impacts. The ability to deficit irrigate crops and adjust other input use on the farm is a short-run response to changes in water supply. The SED is concerned with permanent, long-run, changes in SJR flows which would permanently (depending on water conditions) reduce access to surface water.

Explanation: It is not a viable long-run strategy to deficit irrigate crops in response to water shortage, as indicated by the SED modeling. Growers' would fallow land or switch crops in the long run in response to water shortage, not irrigate a walnut orchard at 80 percent of full irrigation water requirements.

The SED does not indicate whether the SED model is calibrated for short or long run conditions. These are important parameters that determine the response to changes in water supply. In general, growers' ability to respond to changes in the long-run is more flexible (more "elastic") than it is in the short run. Intuitively, growers' can make long-run decisions to remove or not plant orchards, whereas in the short-run there is a fixed capital investment (e.g., establishment, irrigation system, other capital costs) that cannot be avoided, thus limiting options and increasing costs of water shortage.

Recommendation: The SED analysis must distinguish between short-run and long-run economic response and resulting economic impacts.

Point 7 (Data Error; Analytic Error)

The SED economic analysis does not consider variability in irrigation water supplies. SJR flow requirements under each with-project Alternative simultaneously reduce the average annual irrigation water supply and increase the variability of that supply. The SED analysis has estimated the cost of a decrease in average annual water supply, but has not considered the additional cost of increased water supply variability.

Explanation: The SED does not describe how changes in irrigation water supplies over time are modeled. Figures G.2-1A – G.2-1D of SED Appendix G clearly show that average annual surface water supply decreases (the yellow shaded area gets smaller) and average annual variability increases (the yellow shaded area increases and decreases more from year-to-year). Figure 1 reproduces the Merced River plot from Figure G.2-1A (the "baseline") and Figure G.2-1D (SJR flows Alternative 4) below. It is clear that average supply and variability increase.

Figure 1. Summary of Merced River Flows – Baseline and Alternative 4

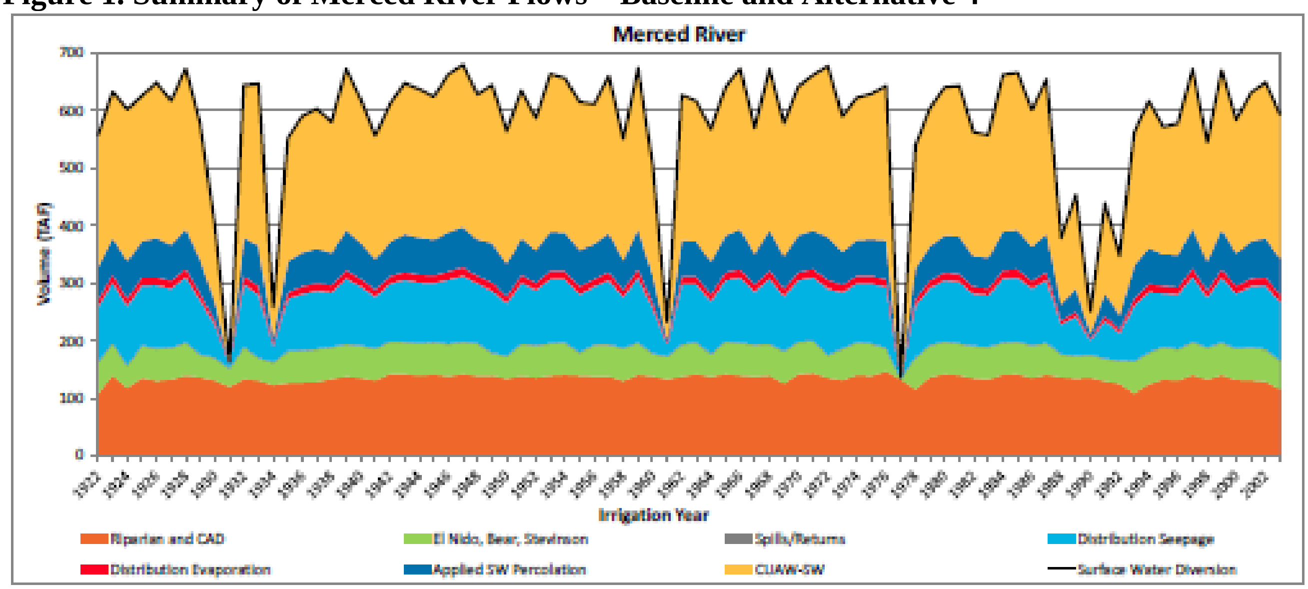


Figure G.2-1A. Partitioning of Baseline Diversions into End Uses

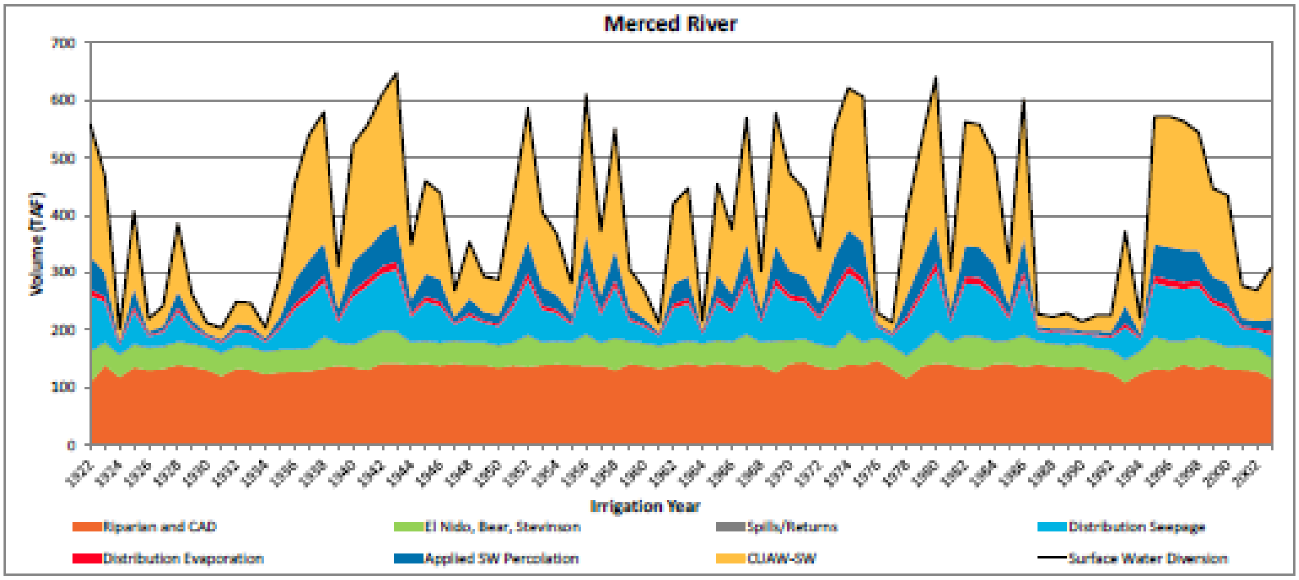


Figure G.2-1D. Partitioning of LSJR Alternative 4 Diversions into End Uses

Water supply variability is an important factor in planting decisions, and broader agricultural business decisions that is typically not included in a static SWAP-model-type analysis. In general, highly variability water supply discourages plantings perennial crops because it is less risky to plant annual crops that can be adjusted in response to changes in water supply (i.e., fallowed) much more easily. The SED model does not take these dynamic considerations into account. The model assumes that, even with highly variable surface supplies, irrigators are able to supply orchards with required demand (albeit, deficit irrigated).

The SED economic impact analysis must consider year-to-year variability in water supply in a dynamic economic analysis. The static analysis applied in the SED quantifies the cost of a decreased average surface water supply, but does not quantify the cost of increased variability in water supply.

Related to this point, the SED economic impacts should be summarized in terms of average annual economic impact (as they are currently) in addition to dry and wet year impacts. This allows the reader to understand the average annual cost of the SJR flow requirements in addition to the impact in dry and wet conditions, when the natural water supply is changed separate from the SJR flow requirements. For example, a sequence of dry years, such as 2013 – 2016, will lead to significantly greater economic impacts than average water supply conditions.

Recommendation: The static SED analysis should be revised to dynamically account for water supply variability. The current analysis understates economic impacts by omitting this factor.

Point 8 (Omission; Analytic Error)

It is not clear whether the SED agricultural economic analysis has correctly specified the "No Action Alternative." An economic impact analysis must compare the "with-project" to the "without-project" conditions. It would be incorrect to interpret the baseline (calibration data) as the without project conditions. Appendix G does not have sufficient information to determine whether this is the case.

Explanation: This is a critical requirement for an economic impact analysis. Incorrectly comparing future conditions under SJR flow restrictions (Alternatives) to the current (baseline) conditions in each of the districts would generate incorrect impacts. It is essential to establish a correct "future without project" condition so that the future opportunity cost of irrigation water is correctly quantified.

It is clear that the SED water supply modeling considers the no action and action alternatives, but it is not clear that these are carried this through the economic analysis. The no action alternative must specify all future (without project) economic conditions over the appropriate period of time. Then the incremental impact of the project is calculated as the difference between the no action and each with project alternative. The purpose of the No Action Alternative in an economic impact analysis is to establish this future value so that the reference point is correctly established.

Recommendation: If the No Action Alternative is not properly specified in the economic model, then the analysis must be revised. This should be considered jointly with Point 7, above.

Point 9 (Analytic Error)

The SED model does not include any forward-linkage to upstream industries that depend on the crops produced in the Study Area. For example, feed and fodder crops are inputs into the high-value dairy industry. As such, the marginal value of feed crops is understated in the SED model, and in turn the responsiveness of these crops to water shortage may be overstated.

Explanation: It is likely that the SED model assumes that the inputs to the dairy sector (namely, hay, silage, and cereal-based concentrates) from the crop sector can be accurately modeled by perfectly competitive market prices and supply responses. Hay and cereal-based concentrates can be accurately modeled as economic inputs that have known market prices and responses, but silage cannot because it is produced and consumed locally. The structure of the dairy and feed sector in the Study Area means that silage and milk production are essentially joint products. It follows that the economic impact of water reductions on the production of silage cannot be measured by changes in the opportunity cost of silage production alone, since much of the economic impact will derive from the ability of the dairy sector to respond to changes in the cost of feed inputs.

It is important to acknowledge that advances in economic calibration theory and methods over the last couple of years have made it theoretically possible to address upstream-linkages in a primary crop production model, such as the SED model. At a minimum, the SED analysis should be adjusted to account for these linkages and ensure that crop response, and resulting economic impacts, are correctly calculated.

Recommendation: The analysis should be updated to acknowledge upstream linkages to dairy and other high-value industries.

Point 10 (Omission; Analytic Error)

It is not clear how the SED model calibrates to the sources of water supply in the Study Area (and by service area within any given district). The correct cost of water should equal the rate charged to growers including all fixed and volumetric charges, and acknowledge any variation by service area.

Explanation: The value marginal product of water in part determines responsiveness to water shortage. Importantly, water must be specified in the SED model by source (and cost) within each district and service area. If the model does not calibrate (exactly) to water source and cost, then the response to changes in water supply will be incorrect. The SED materials available as of March 9, 2016, do not include any information about water supply costs and calibration to these supply sources.

Recommendation: The SED must describe the water calibration approach and supporting data (model code).