REGIONAL ECONOMIC IMPACT CAUSED BY A REDUCTION IN IRRIGATION WATER SUPPLIED TO TURLOCK IRRIGATION DISTRICT AND MODESTO IRRIGATION DISTRICT: METHODOLOGY TECHNICAL MEMORANDUM

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Modesto Irrigation District

Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

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List of Acronyms and Abbreviations

CPI	consumer price index
DPPMP	Don Pedro PMP Model
DPP	Districts' Preferred Plan
ET	evapotranspiration
FERC	Federal Energy Regulatory Commission
I-O	input-output
MID	Modesto Irrigation District
PMP	Positive Mathematical Programming
Project	Don Pedro Project
RDI	regulated deficit irrigation
SED40	SED 40% Unimpaired Flow Alternative
SED40_WSF	SED 40% Unimpaired Flow with Districts' operating rules for water supply allocation (Water Supply Factor)
SED60_WSF	SED 60% Unimpaired Flow with Districts' operating rules for water supply allocation (Water Supply Factor)
SGMA	Sustainable Groundwater Management Act
SJI	San Joaquin Index
SWB	State Water Board
TAF	Thousand Acre Feet
TID	Turlock Irrigation District
W&AR-15	Water & Aquatic Resources-15 Socioeconomics Study
WY	Water Year

1.0 INTRODUCTION

1.1 Purpose

This document presents estimates of potential effects to agricultural production and related sectors of the Merced, Stanislaus and Tuolumne counties' economy from potential changes in allowable surface water diversions from the Don Pedro Project (Project) (Figure 1.1-1). The document is a companion piece to work previously completed for the Federal Energy Regulatory Commission (FERC) relicensing of the Don Pedro Hydroelectric Project. Specifically, the document extends work presented in the Amendment of Application, Attachment C Final Study Reports: Water & Aquatic Resources-15 Socioeconomics Study (TID/MID 2014).

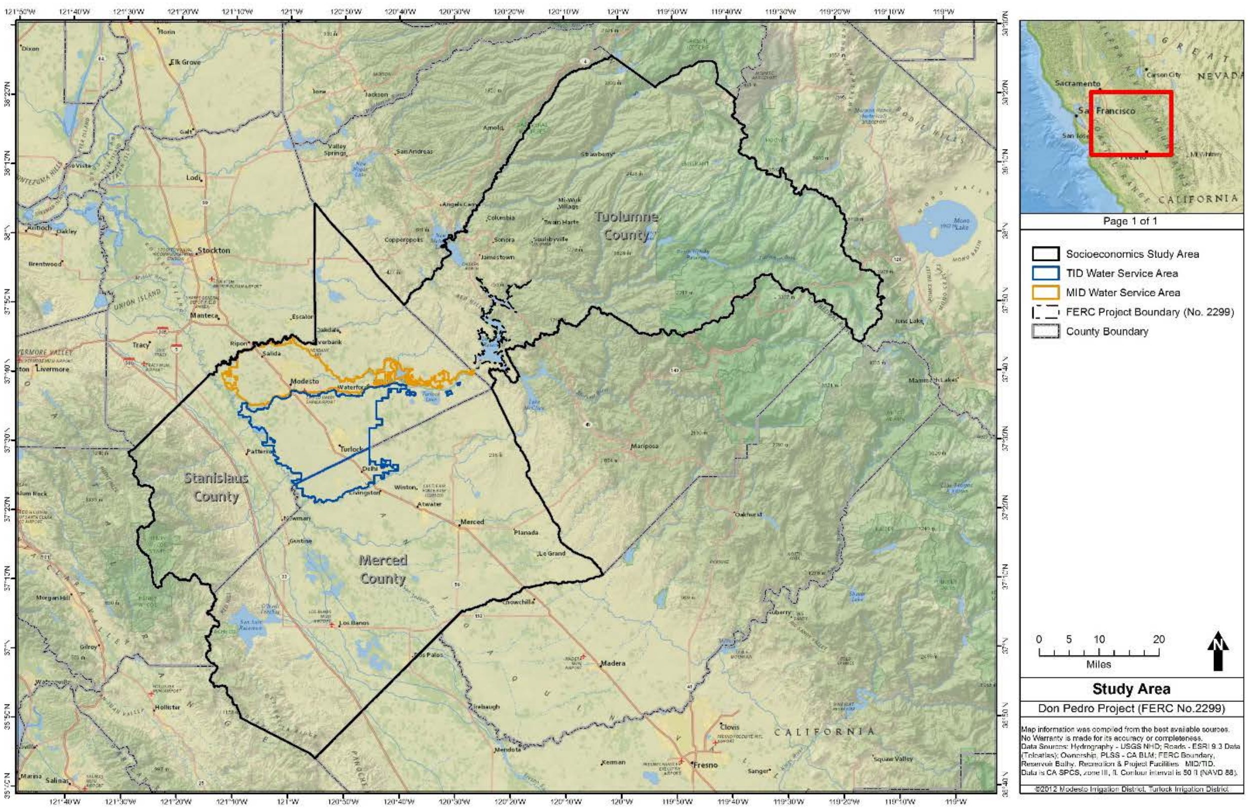

Figure 1.1-1. Study area (Source: TID/MID 2014).

1.2 Overview

Assumptions and data used to estimate the effects to agricultural production and related sectors of the potential reduction in allowable surface water diversions to the Project are described below.

1.2.1 Project Life

The number of years analyzed corresponds to the 42 years (1971-2012) included in the hydrologic model of the Project (Table 1.2-1).

1.2.2 Data Sources

1.2.2.1 Water Supply

The hydrologic operations model (TID/MID 2017) provides estimates of the annual allowable canal water deliveries for a 42-year period for each of the five alternatives. The five alternatives differ in the assumptions used for operational rules and flow regimes. The alternatives are listed below and described in detail in the Appendix E-1, Attachment G and Attachment H.

- Base Case
- Districts' preferred plan of future project operations (Preferred Plan) (DPP)
- State Water Board (SWB) Substitute Environmental Document 40 Percent Unimpaired Flow Alternative using the Districts' operating rules for water supply allocation (Water Supply Factor) (SED40_WSF)
- Substitute Environmental Document 40 Percent Unimpaired Flow Alternative (SED40) and using SWB's reservoir operating constraints and restrictions
- Substitute Environmental Document 60 Percent Unimpaired Flow Alternative using the Districts' operating rules for water supply allocation (SED60_WSF)

Table 1.2-1 shows the estimated annual canal water deliveries by water year (WY) under each of the alternatives and for full demand. Full demand, as the name implies, is the estimated canal deliveries required to meet estimated historical agricultural demand. Under full demand, the estimated annual average canal deliveries are 862 thousand acre feet (TAF), with deliveries ranging between a high of 965 TAF (in 1972, a dry water-year type) and a low of 753 TAF (in 1983, a wet water-year type).

Under the Base Case the long-term average annual canal water deliveries decline from full demand by 20 TAF to 842 TAF or 97 percent of full demand. However, considering water supply impacts by comparing *"average"* annual water supply effects over the long-term has little meaning or value if reliable water supplies are not available during drought years or sequential drought years. A single extended drought can have catastrophic and irreversible effects on local and regional economies and on affected populations, communities, and businesses. Planning for drought conditions is at the core of water supply system design and water supply impact analysis. Properly designed water supply projects have to be able to deliver reasonably reliable water supplies during drought and extended drought conditions. The nut and fruit orchards, the dairy farm operations, and the food processing industries that dominate the agricultural economy of the Districts' service areas are long-term investments which require reliable and sufficient water supplies year after year in normal and drought conditions. Therefore, only considering the reduction in average annual canal deliveries misrepresents the real magnitude of the impact of a change in canal deliveries. Under all the alternatives, the impact of a change in canal deliveries on the agricultural economy is a consequence of both: 1) **consecutive years** of water shortages and 2) **the frequency** of water shortages and 3) **magnitude** of those shortages.[1]

Consecutive years of water shortages reduce the ability of the industry to withstand financial hardships that come with water shortages and threaten the long-term economic viability of the agricultural economy. Growers are frequently prepared to manage through a year or two of financial challenges, however under all the alternatives consecutive-year water shortages last between three and ten years (Figure 1.2-1). And the types of crops grown in the region, primarily trees and vines or animal feed, reduces the feasibility of sustaining operations during periods of prolonged water restrictions. For example, crop fallowing is not a viable option for perennial crops and animal operations dependent on animal-feed crops.

For example, during the 1987 to 1992 drought period under all of the SEDxx alternatives (e.g., SED40_WSF, SED40 and SED60_WSF) the Districts would be facing a 30-percent to 40-percent water shortage six years in a row. With significant shortages both preceding and following the 1987 to 1992 drought, effectively stretching to 10 years the period of shortages.

Consecutive years of significant shortages like these reduce the water supply reliability of the Project. Water supply reliability is what encouraged growers to investment in high-valued permanent crops and animal operations. A reduction in water supply reliability would put their investments at risk. And likely change the structure of the entire agricultural industry. For example, growers may reduce their acres of perennial crops (e.g., high-value almonds, peaches, and grapes). Ranchers may consolidate or reduce herd size, reducing the demand for feed crops. Processors may close plants, downsize facilities or close, reducing demand for some crops.

Regional economic impacts that result from a reduction in water supply reliability and subsequently a structural change in the agricultural sector were not estimated in this analysis due to the considerable number of assumptions that would be required for such an analysis. Rather, the economic model, described in detail below, estimates annual changes in cropping patterns based on an estimated annual change in irrigation water supplies. As such, the estimated regional economic impacts described below are likely minimum impacts because they do not account for lag effects of water shortages and long-term shifts in cropping patterns.

Although the number of consecutive years of shortages is a significant driver of impacts the **magnitude and frequency** of water shortages also contributes to the threatening the long-term viability of the agricultural economy. Figure 1.2-2 summarizes the estimated annual percent reduction in canal water deliveries by water-year type compared to Full Demand. Wet water-year types occur 36 percent of the time over the course of the 42-year modeling term. In wet water-year types estimated water deliveries under all but the SED40 alternative are nearly equal to the deliveries under Full Demand. However, even in wet water-year types under the SED40 alternative there is an estimated average reduction in water deliveries of 12 percent relative to Full Demand.

[1] In the 46-year period from 1971 to 2016 period, there have been four droughts of note: (1) '76-'77, (2) '87-'92, (3) '01 – '04, and (4) '12-'15. For water supply planning purposes, the '87 through '92 drought is used. There are worse drought periods over the last 120 years, notably 1924-1934, inclusive. Depending on demands for water which further reduce amounts available for consumptive uses (e.g. flows for fish), a two year drought can end up posing three or more years of adverse economic impact. Financial impacts linger longer than the hydrologic period which causes them.

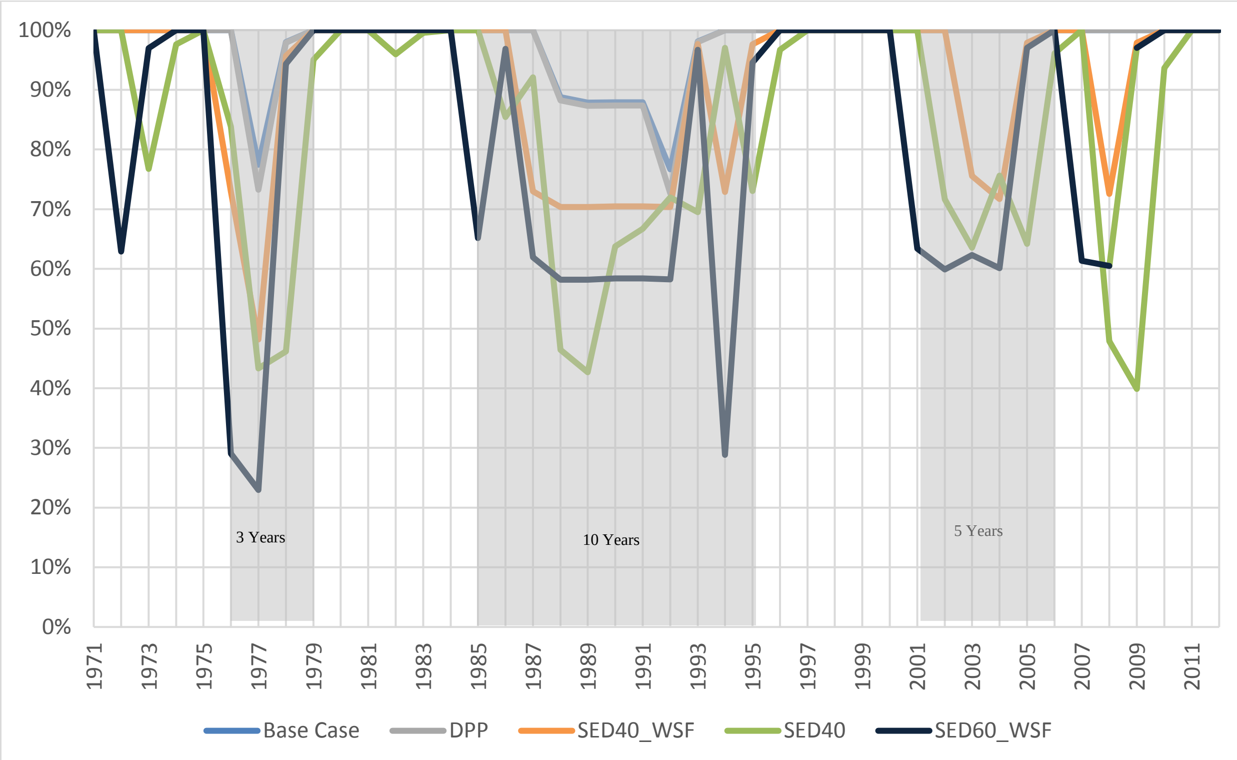

Figure 1.2-1. Annual canal water deliveries by year as a percent of full demand.

Above normal water-year types occur 14 percent of the time. Again, except for the SED40 alternative, average above-normal year-type water deliveries are estimated to be nearly the same as under Full Demand. Estimated average annual above-normal year-type water deliveries under the SED40 alternative are approximately 6 percent less than those under Full Demand.

Collectively below normal, dry and critical water-year types occur in half of the years modeled, 7 percent, 17 percent, and 26 percent, respectively. In below normal and dry water-year types there is no reduction in average water deliveries under the Base Case or the DPP alternative, however there are significant reductions in water deliveries under all other alternatives. Under the SED40 alternative in below normal years there is a 32 percent reduction in water deliveries, in dry years there is an 8 percent reduction in water deliveries, and in critical years there is a 31 percent reduction in water deliveries.[2] Under the SED40_WSF alternative a below normal year experiences a 9 percent reduction in water deliveries, in dry years a 4 percent reduction in water deliveries and in critical years a 28 percent reduction water deliveries. Under the SED60_WSF alternative there is an average 14 percent reduction in water deliveries in below normal water-year types and an average 27 percent reduction in dry water year types and an average 49 percent reduction in critical water-year types. Under the Base Case and DPP

[2] Reductions in water supply occur when the simulated reservoir level is too low and/or inflows are too low to meet demand. Impacts in below normal water-year types are estimated to be more severe than reductions in water deliveries in dry water-year types because there are only three below normal water-year types and two of those years begin with low reservoir levels. There are seven dry water-year types and only two of those years have low antecedent reservoir levels.

alternative, the in reduction average water deliveries in critical water-year types are estimated to be 8 percent and 9 percent, respectively.

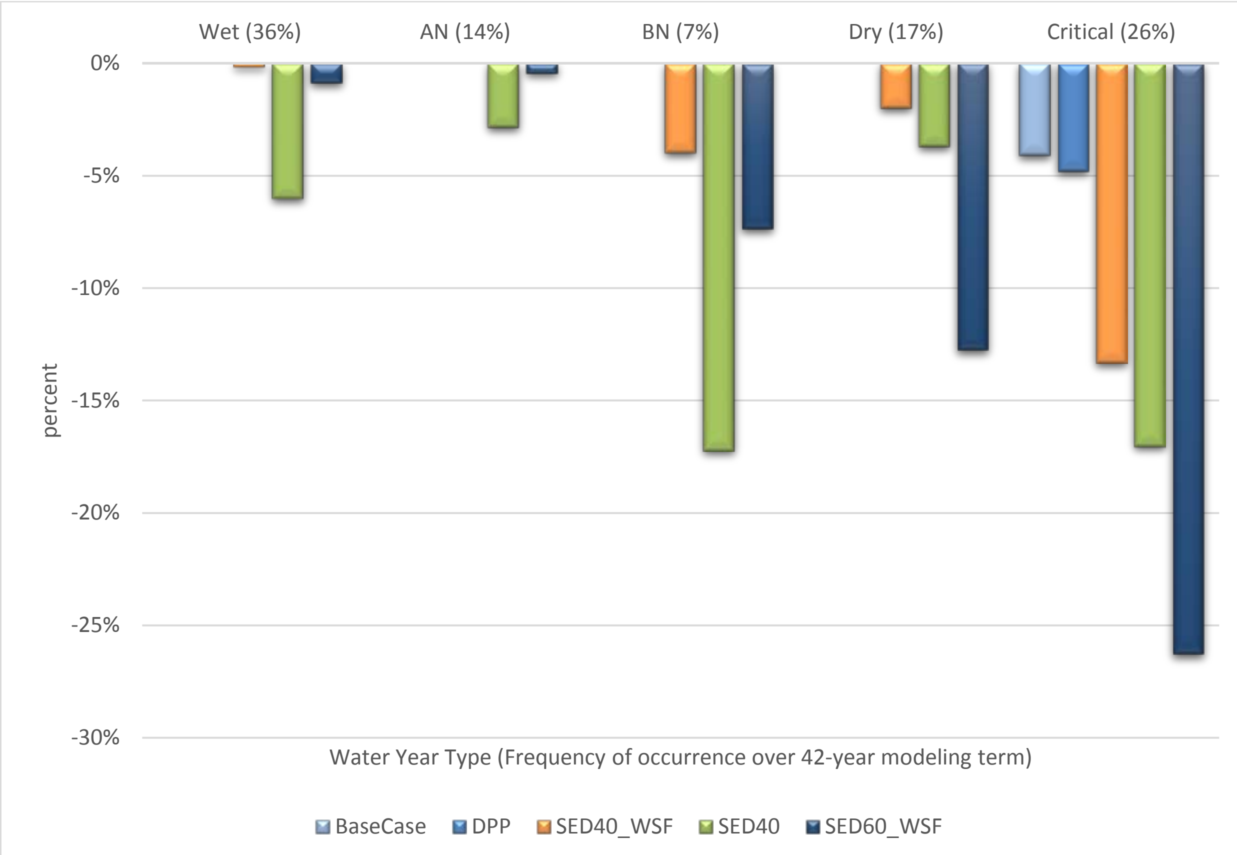

Figure 1.2-2. Average water-year type reductions in canal water deliveries as a percentage of full demand.

In summary, in critical years, which occur in one out of every four years there are shortages in annual water deliveries under all alternatives. Under the three SED alternatives (SED40_WSF, SED40, and SED60_WSF) significant water shortages occur in one out of every two years (in below normal, dry and critical water-year types). The magnitude of these shortages ranges from an average of 4 percent (SED40_WSF in a dry water-year type) to an average of 49 percent (SED60_WSF in a critical water-year type). Despite the fact that the estimated overall annual average reduction in water deliveries under SED40 (17 percent) and SED60_WSF (20 percent) are nearly the same size, the two alternatives differ in frequency and magnitude of estimated reductions across water-year types. Under **SED40 reductions occur, on average, in every water-year type**, ranging between 6 percent (above normal water-year type) and 32 percent (below normal water-year type).[3] Under **SED60_WSF reductions in water deliveries occur half of the time**, in below normal, dry and critical water year-types ranging between 14 percent and 49 percent. The difference between these two alternatives exemplifies the problem of

[3] Note that under SED40, 16 out of the 42 years in the model are estimated to have full water deliveries (e.g. 100 percent of Full Demand (see Table 1)). However in the analysis that average water deliveries by water-year type there is an average shortage in each of the water-year types.

focusing in annual averages instead of magnitude and frequency of water reductions when comparing alternatives.

In this analysis, groundwater was assumed to be available up to historical pumping volumes. Annual average volumes were estimated to meet approximately 15 percent of total annual demand for irrigation supplies. This assumption is consistent with the current effort to implement the Sustainable Groundwater Management Act (SGMA). Use of groundwater for irrigation outside the Districts' service territory, but within the Districts' underlying groundwater basin has dramatically increased since 1990. The impact of SGMA regulations over the term of a new FERC license is unknown, but is more likely to cause reductions in historical use than allow for increased use.[4]

1.2.2.2 Economic Data

For a full description of all the data used in the economic model including, crop acreage, crop enterprise budgets, crop prices, crop yields, water rates, etc. see Section 5.1.3 and Section 6 in TID/MID (2014).

[4] For further discussion of groundwater availability and SGMA regulations, see Exhibit B of the Amendment of Application

Table 1.2-1. Hydrologic operations model output, Full Demand, Base Case, DPP, SED40_WSF, SED 40 and SED60_WSF.

Water Year	Water Year Type	Full Demand	Base Case		DPP-1		SED40_WSF		SED 40		SED60_WSF	
	(SJI)	(TAF)	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*
1971	BN	874	874	*100%*	874	*100%*	874	*100%*	874	*100%*	874	*100%*
1972	D	965	965	*100%*	965	*100%*	965	*100%*	965	*100%*	607	*63%*
1973	AN	865	865	*100%*	865	*100%*	865	*100%*	664	*77%*	839	*97%*
1974	W	825	825	*100%*	825	*100%*	825	*100%*	805	*98%*	825	*100%*
1975	W	873	873	*100%*	873	*100%*	873	*100%*	873	*100%*	873	*100%*
1976	C	915	915	*100%*	915	*100%*	668	*73%*	768	*84%*	266	*29%*
1977	C	921	713	*77%*	675	*73%*	444	*48%*	399	*43%*	211	*23%*
1978	W	767	752	*98%*	751	*98%*	734	*96%*	354	*46%*	724	*94%*
1979	AN	878	878	*100%*	878	*100%*	878	*100%*	834	*95%*	878	*100%*
1980	W	852	852	*100%*	852	*100%*	852	*100%*	852	*100%*	852	*100%*
1981	D	916	916	*100%*	916	*100%*	916	*100%*	916	*100%*	916	*100%*
1982	W	770	770	*100%*	770	*100%*	770	*100%*	739	*96%*	770	*100%*
1983	W	753	753	*100%*	753	*100%*	753	*100%*	749	*100%*	753	*100%*
1984	AN	912	912	*100%*	912	*100%*	912	*100%*	912	*100%*	912	*100%*
1985	D	896	896	*100%*	896	*100%*	896	*100%*	896	*100%*	584	*65%*
1986	W	839	839	*100%*	839	*100%*	839	*100%*	717	*85%*	813	*97%*
1987	C	895	895	*100%*	895	*100%*	654	*73%*	824	*92%*	555	*62%*
1988	C	855	759	*89%*	755	*88%*	602	*70%*	397	*46%*	498	*58%*
1989	C	846	744	*88%*	739	*87%*	596	*70%*	361	*43%*	493	*58%*
1990	C	876	771	*88%*	766	*87%*	618	*70%*	559	*64%*	512	*58%*
1991	C	881	774	*88%*	770	*87%*	621	*70%*	588	*67%*	514	*58%*
1992	C	844	647	*77%*	613	*73%*	594	*70%*	607	*72%*	491	*58%*
1993	W	823	807	*98%*	806	*98%*	803	*98%*	572	*70%*	796	*97%*
1994	C	835	835	*100%*	835	*100%*	609	*73%*	811	*97%*	241	*29%*
1995	W	774	774	*100%*	774	*100%*	756	*98%*	566	*73%*	732	*95%*
1996	W	841	841	*100%*	841	*100%*	841	*100%*	813	*97%*	841	*100%*
1997	W	918	918	*100%*	918	*100%*	918	*100%*	918	*100%*	918	*100%*
1998	W	757	757	*100%*	757	*100%*	757	*100%*	757	*100%*	757	*100%*
1999	AN	890	890	*100%*	890	*100%*	890	*100%*	890	*100%*	890	*100%*
2000	AN	798	798	*100%*	798	*100%*	798	*100%*	798	*100%*	798	*100%*
2001	D	865	865	*100%*	865	*100%*	865	*100%*	865	*100%*	548	*63%*

Water Year	Water Year Type	Full Demand	Base Case		DPP-1		SED40_WSF		SED 40		SED60_WSF	
	(SJI)	(TAF)	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*	(TAF)	*(% of Full)*
2002	D	898	898	*100%*	898	*100%*	898	*100%*	644	*72%*	538	*60%*
2003	BN	885	885	*100%*	885	*100%*	668	*76%*	562	*64%*	551	*62%*
2004	D	940	940	*100%*	940	*100%*	674	*72%*	711	*76%*	565	*60%*
2005	W	874	874	*100%*	874	*100%*	856	*98%*	561	*64%*	848	*97%*
2006	W	830	830	*100%*	830	*100%*	830	*100%*	798	*96%*	830	*100%*
2007	C	920	920	*100%*	920	*100%*	920	*100%*	920	*100%*	564	*61%*
2008	C	882	882	*100%*	882	*100%*	640	*73%*	422	*48%*	534	*61%*
2009	BN	903	903	*100%*	903	*100%*	884	*98%*	360	*40%*	876	*97%*
2010	AN	826	826	*100%*	826	*100%*	826	*100%*	773	*94%*	826	*100%*
2011	W	823	823	*100%*	823	*100%*	823	*100%*	823	*100%*	823	*100%*
2012	D	890	890	*100%*	890	*100%*	890	*100%*	890	*100%*	890	*100%*

Source: E-mail communication from Rob Sherrick, HDR to Susan Burke, Cardno dated 8/25/2017.

2.0 METHODOLGY

2.1 Background

The Districts provide irrigation supplies to over 230,000 acres, contributing an estimated annual average of $4.1 billion to the local economy through agricultural production and processing (TID/MID 2014). This contribution can be understood by considering three components of the agricultural economy (Figure 2.1-1).

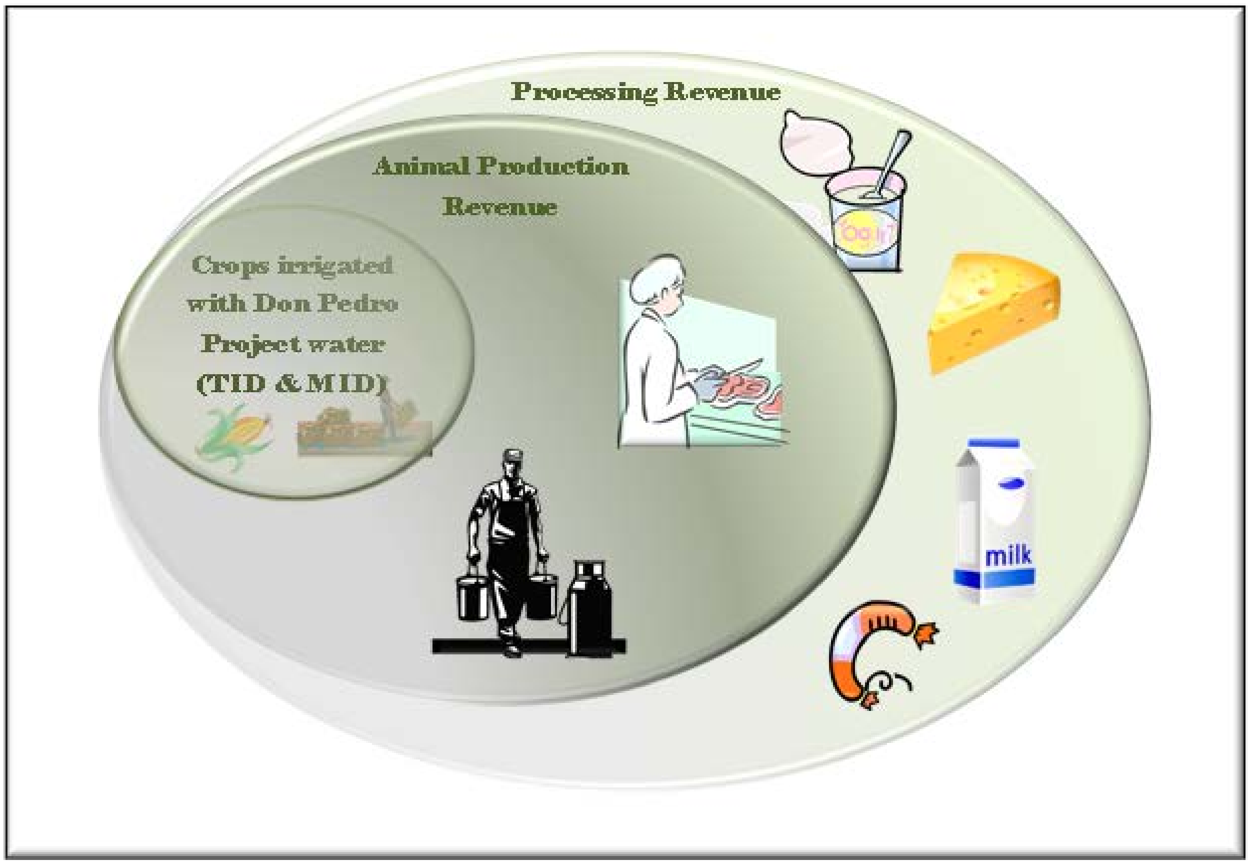

Figure 2.1-1. Components of the agricultural economy.

The first component of the agricultural economy is value generated by the crop commodities grown on the approximately 230,000 acres that are irrigated with Project water. This is the smallest component represented in Figure 2.1-1 (entitled *Crops irrigated with Don Pedro Project Water (TID and MID)*, nested within the other two components; Animal Production Revenue and Processing Revenue.

These irrigated crops demonstrate growers' investment in high value permanent crops, such as trees and vines and animal feed crops that support diaries and cattle and calf operations (Figure 2.1-2). Of the 230,000 acres approximately 23,000 acres, or 10 percent is planted in annual crops not devoted to animal feed (vegetables and field crops). Feed crops comprise more than half the irrigated acres, with fruit and nut crops comprising approximately 38 percent of irrigated acres.

The estimated economic impacts presented in this memo include the value of all the inputs to crop production, referred to as "backward linkages". These include seed and fertilizer costs as well as labor for planting, harvesting, pruning, etc. and costs such as pollination services. Backward linkages are also referred to as indirect and induced effects.

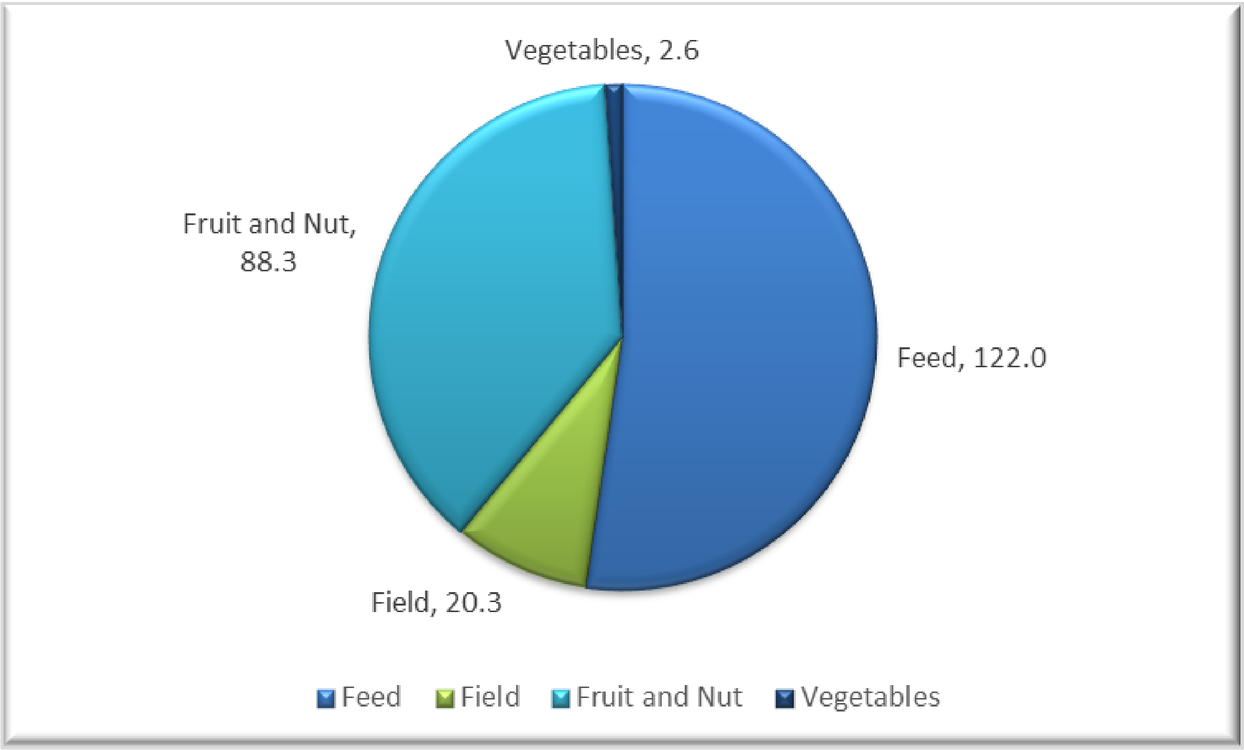

Figure 2.1-2. Average annual acres irrigated with Project water by crop type (MID/TID, 2007 – 2011). Source: TID/MID (2014).

The second component of the agricultural economy is the value of animal commodities. The feed crops grown are used to produce milk and beef. Milk comprises the largest percent of total commodity value, estimated to be $537 million (annual average from 2007-2011). Cattle and Calves produce another $128 million. Combined animal production makes up 55 percent ($128 million of cattle and calves, and $537 million in milk) of the commodity value supported by crops grown with water delivered by the Project (Figure 2.1-3). The estimates shown in Figure 2.1-3 are only the "direct" economic contribution to the local economy, measured as the production value of animal production and do not include the production value of the "backward linkages", or the "indirect" and "induced" economic contribution, which increase the total value of animal production.

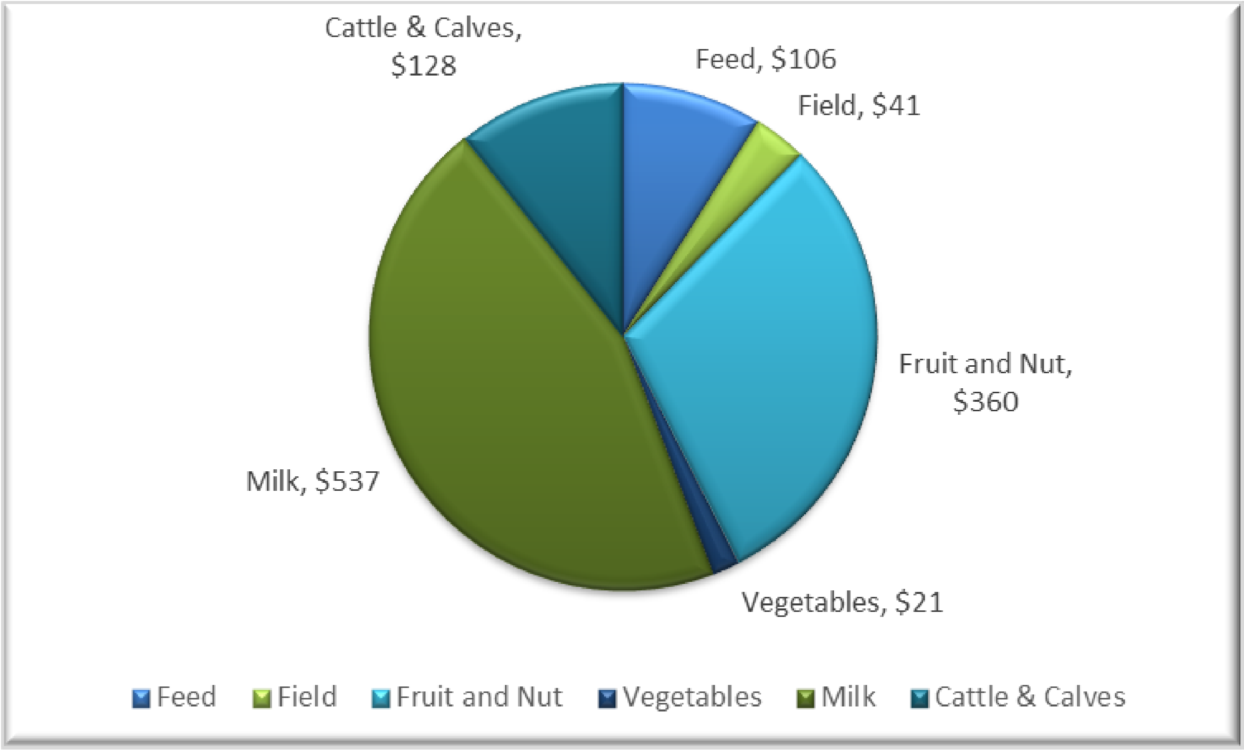

Figure 2.1-3. Average annual direct production value of commodity, 2007–2011, (2012$s in thousands). Source: Cardno estimate.

The third and final component of the agricultural industry is the processing sector. The magnitude of agricultural production output in the region has given rise to a large agricultural processing sector in the region. See TID/MID (2014) for the list of agricultural processing employers operating in Merced and Stanislaus counties. Conservative estimates place the number of jobs created by the agricultural processing sector alone at 6,540 (TID/MID 2014). Combined with all the crop and animal production jobs, including backward linkages the number of jobs in the region supported by crops irrigated with Project water is approximately 18,900.

The above summary of the value of the crop and animal production and the processing industry is used as the baseline against which impacts of a reduction in allowable surface water diversion are estimated. This analysis uses the following models to estimate potential impacts for each component of the agricultural economy: (1) modeled on-farm irrigated crops revenue using a Positive Mathematical Programming (PMP) model and named Don Pedro PMP (DPPMP)[5]; (2) dairy and livestock production using spreadsheet model; and (3) three-county processing using IMPLAN. All backward linkages of on-farm irrigated crops were estimated using IMPLAN. See TID/MID (2014) for a detailed description of these models.

The impact assessment models were run sixteen times, each time reducing the percent of surface water available, compared to Full Demand, in 5 percent steps. This produced incremental estimates of impacts that are used in combination with the hydrologic operational model output

[5] The PMP method of modeling impacts to agricultural output is described in detail in W&AR-15.

to estimate the impact of a reduction in surface irrigation supplies for various alternatives over the 42-year project life. Results of the three models are displayed below. Following the representation of the three individual models' results is a summary that combines the individual model results with the hydrologic operations model output for each of the five alternatives to estimate the impact of each alternative.

2.2 On-Farm Irrigated Crops – Don Pedro PMP

See TID/MID (2014) for a description of the DPPMP model as well as the reasoning for using this model.

2.2.1 Perennial crops

The estimated yield response of perennial crops to a reduction in irrigation water is based on a literature review of studies that test the yield response of trees and vines to stress irrigation. This literature is described below.

2.2.1.1 Almonds

Although almond trees are considered drought tolerant (Fereres and Goldhamer 1990; Hutmacher et al. 1994; Torrecillas et al. 1996), there is no doubt that irrigation is critical in producing high yields of top quality nuts (Castel and Fereres 1982; Prichard et al. 1993; Nanos et al. 2002). Water stress can negatively affect both the primary yield components in almond, kernel size (Girona et al. 1993) and fruit load (Goldhamer and Smith 1995; Goldhamer and Viveros 2000; Esparza et al. 2001). Figure 2.2-1 shows the results of a field trial that tested yield (measured as kernel yield) over a range of reductions in evapotranspiration (ET), as well as a range of delivery patterns (Goldhamer 2006). The yield ranges between a 4.0 percent reduction when ET is 85.0 percent (under a uniform stress delivery pattern) of full ET up to a 29.0 percent reduction when ET is 55.0 percent of full ET (under a post-harvest delivery pattern). The average of the yield response curves presented in Figure 2.2-1 was used to estimate impacts of a reduction in allowable surface water diversions in this study. Where the hydrologic model results estimated reduction in allowable water diversions greater than 55 percent, the average curve was extrapolated.

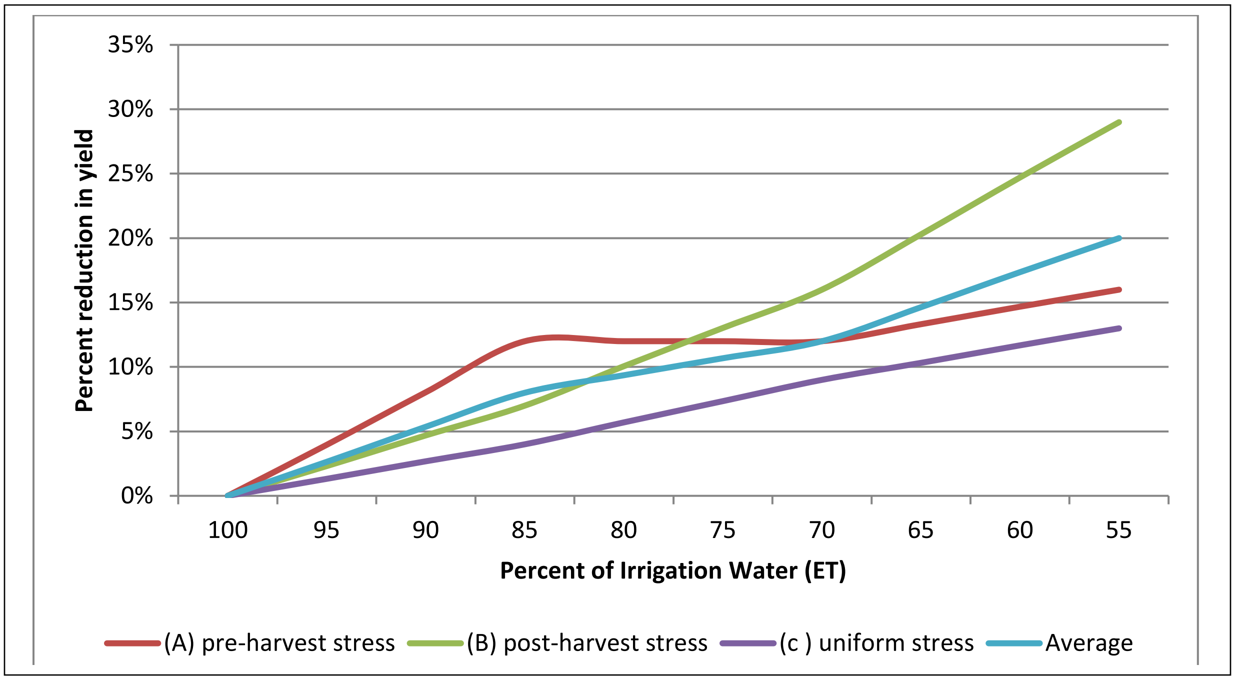

Figure 2.2-1. Percent change in almond yield for variations in applied water. Source: Goldhamer, D.A. 2006. NOTE: the Goldhamer study estimated the yield response to an 85.0 percent, 70.0 percent and 55.0 percent change in crop ET. For exposition purposes the data presented in the graph includes a liner extrapolation for the points in between the data available in Goldhamer.

2.2.1.2 Peaches

In a deep soil under flood irrigation, peach trees have been shown to survive and remain productive for four consecutive years with no irrigation between June and October (Larson et al. 1988; Johnson et.al. 1992). However, 'Water stress in late summer also interferes with flower bud development and can cause fruit defects the following year. Fruit doubles (Figure 2.2-2), deep sutures (Figure 2.2-2), split pits, and smaller fruit size can all result from water stress (Handley and Johnson 2000; Johnson and Phene 2008).

Without information on which to base an annual yield response of peaches to stress irrigation the assumption was made to use a linear yield response curve, e.g. a 10 percent reduction in irrigation water would induce a 10 percent reduction in peach yield.

Source: University of California Fruit Report., http://ucanr.edu/sites/fruitreport/Irrigation/Deficit_Irrigation_Strategies/

Deep suture in nectarine cause by water stress.

Source: University of California Fruit Report., http://ucanr.edu/sites/fruitreport/Irrigation/Deficit_Irrigation_Strategies/

Water stress late in the previous summer

Figure 2.2-2. Examples of deep suture and fruit doubles that can be the result of water stress.

2.2.1.3 Grapes

In the late 1990s growers began adopting a practice called regulated deficit irrigation (RDI) on wine grapes. RDI means applying less than the full potential water requirement on vines with a drip irrigation system to achieve properly timed mild water stress. The results are improved wine quality and conservation of water and energy. For the purposes of the DPPMP model we assume that grapes grown in TID and MID are already being given the desired volume of water under the RDI practice and reductions in irrigation supplies that could result from the relicensing go beyond the desired RDI levels.

The DPPMP model estimates a range of yield reductions between 2 percent for a 90 percent irrigation water supply, up to a 13.0 percent reduction in yield, for a 60 percent irrigation water supply.

2.2.2 DPPMP Results

The DPPMP model was run multiple times, each time reducing surface water irrigation in 5-percent steps relative to Full Demand irrigation supplies. As a consequence of constraining water transfers the modeled response of the crops to a reduction in irrigation supplies is linear, except for nut crops, where the yield curves were modified as described above (Figure 2.2-3).

When surface water irrigation supplies are 100 percent of Full Demand, the value of crop production is estimated to be greater than $500 million. As the percent of surface water irrigation supplies declines relative to Full Demand the crop values also decline.

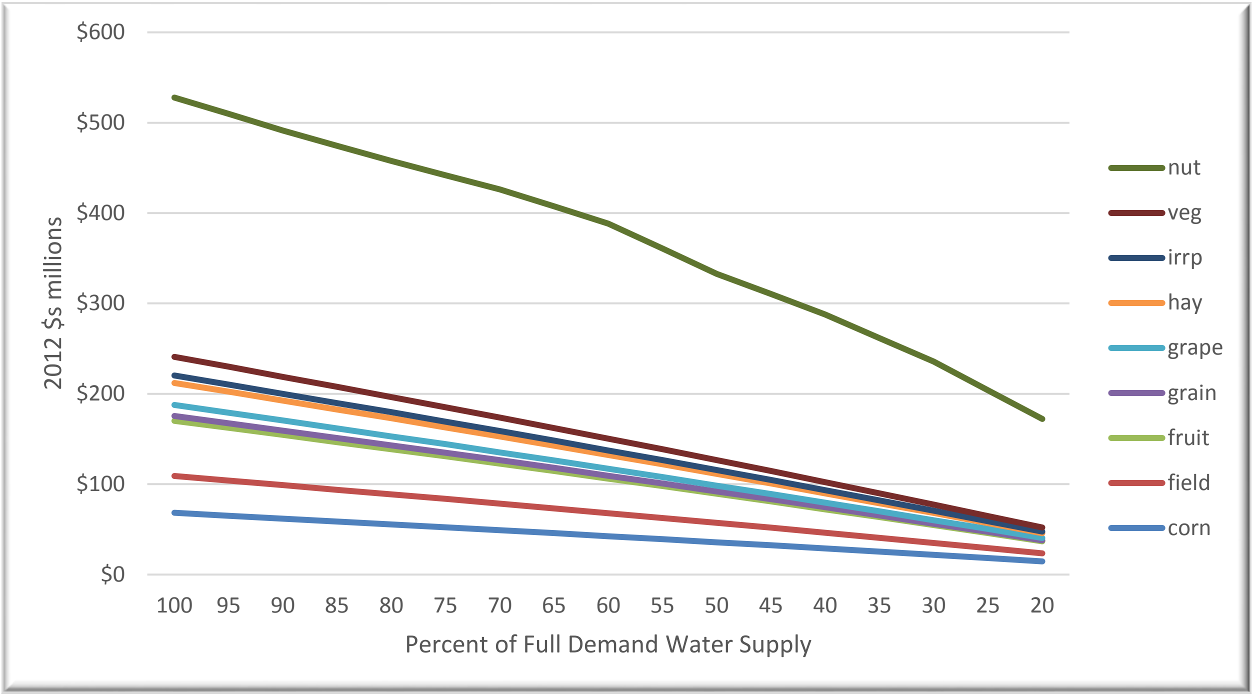

Figure 2.2-3. Estimate of crop production value for declining surface irrigation supplies (direct only). Source: Cardno.

2.2.3 DPPMP Model limitations and shortcomings

DPPMP is a short-term model, estimating one-year changes to cropping patterns resulting from a change in surface water irrigation supplies. The model does not account for carry-over impacts from one year to the next. The implications of that on the estimated economic impacts of a change in surface water is described below.

- Stress irrigation impacts tree yield in both the year in which the stress occurs and in the subsequent year; however, DPPMP does not account for this lag effect from stress irrigation.
- If changes in surface water availability occur with significant frequency over the 42-year study period it could be assumed that a structural change would occur in the agricultural sector. For example, under the SED40 alternative the hydrologic operations model estimates that water deliveries are only 100 percent of Full Demand in 16 of the 42-year modeling term, or 38 percent of the years modeled. The reduction in water deliveries ranges to a low of 60 percent of Full Demand (see Table 1, 2009). A reduction of water supply reliability of this magnitude could change the structure of the agricultural industry. The number of cattle than can be supported with feed crops may decline, or current operations may consolidate. Processing plants could relocate, reduce shifts (e.g. run at less than full capacity) or close as a consequence of increasing uncertainty in the availability of raw inputs. This could cause a change in the cropping patterns that is not currently accounted for in the annual DPPMP model.

- The relatively high percentage of both perennial crops (trees and vines) and crops that support animal operations reduces the number of short-term (annual) grower responses that the model can represent.

2.3 Dairy and Livestock Production

Estimating the response of livestock (dairy and cattle/calf) operations to a change in irrigation supplies, and consequently a reduction in the supply of animal feed crops, is made difficult because of the diversity of responses available to operators. The economic model assumes, as rational economic agents, with the objective of maximizing profit, dairy farmers and ranchers respond to a change in locally grown feed supplies with the least cost (i.e., reduction in profit) solution. Solutions may increase cost, reduce revenue, or both. An operation's ability to respond can depend on several individual characteristics of the operation including the degree to which land and other capital is leveraged, reliance on purchased feed, current scale relative to the minimum efficient scale, and marketing and contractual commitments.

The model assumes that groundwater is not available above historical pumping volumes and, as such, livestock operations may have limited ability to find alternative sources of feed supply, particularly roughage. Roughage, in the form of corn silage and alfalfa hay, accounts for approximately 40 percent of feed costs in the diet of dairy cows. Irrigated pasture accounts for the majority of roughage feed to beef cattle. All of these crops are grown with irrigation water supplied by the Project. See TID/MID 2014 for a full description of animal feeding requirements.

The estimated reduction in animal production (e.g., milk and beef) caused by a reduction in feed crops grown with Project water was modeled two ways, representing the ends of a continuum of likely outcomes, e.g. a minimum impact and a maximum impact. The maximum impact was modeled assuming a linear relationship between the number of acres of feed crops and the volume of animal production. Tying the change in the value of animal production to a change in the availability of feed assumes that it is not economical to transport feed crops to replace the crops that could not be grown locally due to lack of irrigation water. This is a reasonable assumption given that corn silage, one of the main components of roughage, is heavy and therefore expensive to transport, and irrigated pasture is also not 'transportable'. However it is likely that some portion of the animal feed crops no longer grown locally could be imported. The estimated minimum impact assumes that all of the roughage can be imported and or the animal diet can be modified to replace roughage which cannot be imported.

The maximum impact assumes that a reduction in animal production could be the result of either reducing herd size or switching feeds, or a combination of both. Reducing herd size is an expensive option for animal operations as profits are sensitive to the scale of production. However, in cases of extreme drought this has happened; in Texas, for example, herd size fell 12 percent from 2011 to 2012 (Strom 2013). Operations could also be moved out of state. Several states have been enticing California dairies to move to their states (Daniels 2015).

Finding substitute rations for cows when high-quality roughage is not available can also be expensive. This minimum impact is assumed to maintain the production volume of milk. The impact is reflected in an estimate of declining profit for animal operations and is discussed in more detail in the regional economic section 2.4 because the impact is measured in terms of declining labor income for operators versus a reduction in the value of animal commodity production.

Figure 2.3-1 shows the estimated value of animal production under the maximum impact assumptions, the minimum impact assumptions, and the average of the two. Under the maximum impact, the value of animal production declines from approximately $660 million per year to a low of $234 million when available water supplies decline to 20 percent of Full Demand. Under the minimum impact, there is no change in the production value regardless of the percent of available water supplies.

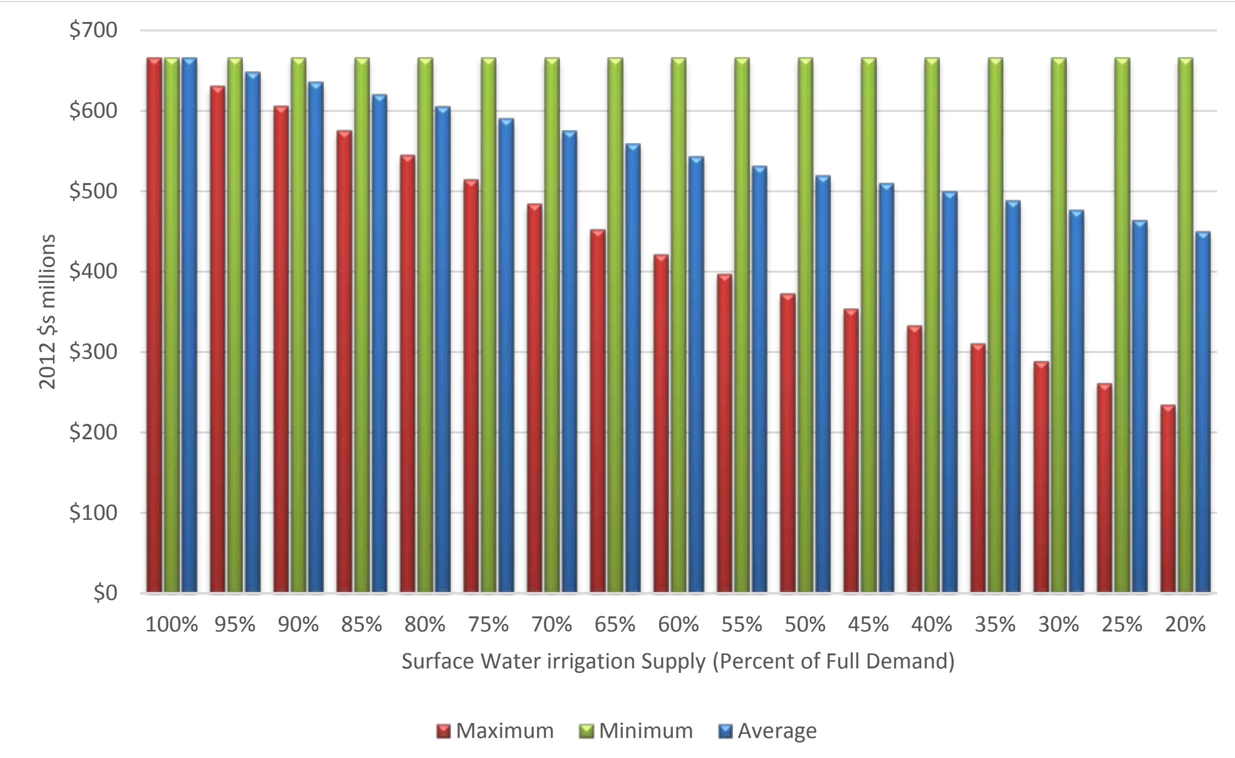

Figure 2.3-1. Estimate minimum, maximum and average reduction in animal production measured in value of production (direct only).

Figure 2.3-2 shows the same information that was presented in Figure 2.3-1, except the values are expressed as a percent of the Full Demand value of production. As before, under the minimum impact assumptions the value of animal production is 100 percent of Full Demand regardless of the percent of available surface water supply. Under the maximum impact assumptions, the value of animal production falls to approximately 34 percent of Full Demand when available water supply is 20 percent of Full Demand, reflecting some flexibility in the operators' ability to manage for a shortage in roughage.

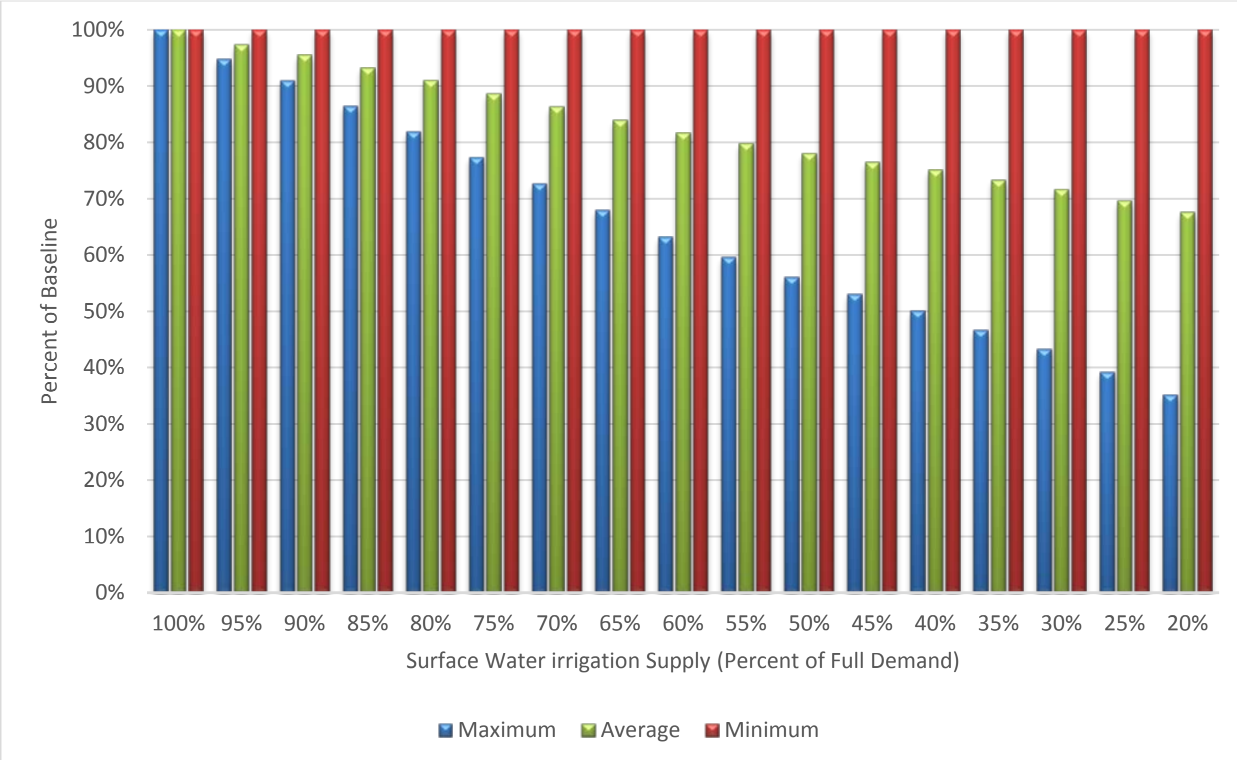

Figure 2.3-2. Estimate minimum, maximum and average reduction in animal production, measured as a percent of full demand (direct only).

2.4 Regional Economics

This section presents estimates of how changes in crop production and animal production, presented above, translate into economic impacts (jobs, income, and output) in all sectors throughout the regional economy. The IMPLAN model was used to estimate economic impacts. This is the same model that was used to estimate the Full Demand economic benefits presented in TID/MID (2014).

Economic impacts are estimated and presented in terms of total output, employment, and income supported by irrigation water deliveries from the Districts. As described in detail above, total economic impacts include not just the direct benefits of crop production in the agricultural sector, but also indirect benefits to other sectors that are closely tied to agriculture, such as agricultural suppliers and food processors. A reduction in allowable surface water supplies that affects the level of crop production (such as wine grapes), reduces the amount of farm labor, chemicals, trucking, warehousing, packing, and other inputs purchased by farms – sometimes referred to as backward linkages.

Additionally, as fewer crops are produced, there is less availability of crops as inputs to canneries, wineries, and frozen food facilities to process into higher valued products, potentially resulting in less processing - sometimes called forward linkages. Consequently, reduced agricultural production in the Districts' service area may affect the level of economic activity and associated jobs and income in economic sectors throughout the study area.

Another impact included in the analysis is a measure of the effects that reductions in household income may have to restaurants and shops in the study area if farm workers, farmers and manufacturing processor employees have less disposal income to spend. These impacts are referred to as induced impacts. Total impacts refer to the sum of direct, indirect, and induced impacts.

The magnitude of total economic impacts depends not only on the magnitude of the initial water supply and subsequent crop production changes, but also on several other variables. For example, a ten percent reduction in crop production does not necessarily mean a ten percent reduction in crop processing. Processing sectors may be able to adjust to obtain required crop inputs, or if some portion of crop production is currently exported outside the three-county study area, then changes in production may affect exports only and not local processing plants. Likewise, effects may not be linear. For example, a twenty percent reduction in crop production may cause an impact on processing that is more than double the impact of a ten percent reduction in crop output. Processors may be able to make adjustments to small changes in crop production, but may reach a point where adjustments are no longer feasible and may be required to reduce output. In the extreme case, processing plants could close if reliable local crop supplies are not available. Recognizing that effects on processors may not be proportionately the same as impacts on irrigated agricultural production, a range of potential impacts is estimated for forward-linked industries such as food processing and animal production.

Findings indicate that reducing irrigation water supply to the Districts' service area will impact output, employment, and income, with the largest expected impact on local area income.[6] Estimated adverse annual employment impacts vary from a reduction of 460 to 1,420 jobs in a 90 percent water year to a reduction of 4,110 to 10,960 jobs in a 25 percent water year.[7] Estimated adverse annual income impacts vary from a reduction of $38.0 million to $72.2 million in a 90 percent water year to a reduction of $351.6 million to $595.7 million in a 25 percent water supply year. The decline in employment in the 25 percent water supply year equates to a 22 to 58 percent decrease from employment supported by the Districts' under baseline water supply conditions, while the reduction in labor income equates to a 48 to 81 percent decrease in income supported by the Districts' under Full Demand water supply conditions.

The following sections provide detail on the approach and results.

2.4.1 Approach to Impact Estimation

This section describes the approach to impact estimation, including general steps and methods for backward and forward linkages, and limitations and assumptions.

[6] Income impacts are higher than employment impacts, particularly in the lowest water supply years, due to our assumption that any change in permanent crop revenue (i.e., a yield reduction) directly translates, dollar for dollar, into an income reduction.[6] As the same acres are in cultivation, we conservatively assume no direct reduction in farm employment on permanent crop acreage

[7] Throughout the document expressions such as: "… in a 90 percent water year.." is synonymous with "…a year in which canal deliveries are 90 percent of Full Demand".

2.4.1.1 Backward Linkages: Crop Production

For backward linked industries providing inputs to District agricultural operation, and in accordance with IMPLAN and general input-output (I-O) methods, we assume linearly proportionate impacts. However, our approach differs for annual versus permanent crops.

For annual crops, the reduction in output is expected to be largely due to a change in harvested acreage, with a consequent reduction in all variable input costs. The change in estimated annual crop production value is the direct output change to be modeled in IMPLAN, e.g. for every one percent change in irrigated annual crop production value, there is a one-percent drop in the direct and total employment, output, and income supported by agriculture in the Districts' service area. Employment reported in this analysis represents both full and part-time jobs. Note, employment in particular may be impacted differently, as employers may reduce hours or wages in response to reduced agricultural production, but not total number of jobs.

For permanent crops, fallowing for a single year at a time is not an option. The assumption used in the model is that growers can deficit irrigate, but do not reduce acres of vines or trees. Reduction in crop production are caused by reduced yields, not reduced acreage. Reduced yields in permanent crops reduce revenue, but will have no effect on fixed costs (which are high for permanent crops), and little effect on non-labor variable costs. In other words, reduced water supplies and associated reduced yields would be expected to lower such variable costs as irrigation labor costs and harvest labor costs, but are expected to have relatively little effect on other, non-labor input costs. As such, the permanent crop reduction in revenue translates nearly dollar for dollar into an income change, either to farm laborers or farm proprietors (rather than an output effect)[8], with no effect on direct farm employment and no effect on demand for indirect inputs. As such, all multiplier effects associated with reduced water supply and deficit irrigation on permanent crops are induced effects related to reduced income to, and associated reduced spending by, farming households.

2.4.1.2 Forward Linkages: Crop and Animal Product Processing

In terms of forward linkages, there is significant uncertainty regarding the level of dependence of local processors on local crop production although close geographic proximity is important. In particular, for fruit and vegetable manufacturing facilities, geographic proximity is important because: 1) less transportation time means fruits and vegetables can fully ripen before harvest to minimize spoilage and maximize flavor, and 2) smaller distances mean transportation costs are lower. For the dairy processing sector, close proximity is also very important as fluid milk is heavy and costly to transport.

The question is: if local crop production declines, will local processors continue to obtain sufficient raw crop inputs, or will processing also decline? If so, to what extent will it decline? Ideally, an analysis of impacts on local animal producers and processors would draw from extensive local data on these relationships, including interviews with local processors and industry experts. However, due to confidentiality concerns of local processors to reveal the

[8] We enter the change in crop production revenue as a direct 'income effect' in IMPLAN.

source of production inputs, that data is not available. Several types of published data sources, largely based on inter-industry industry data in IMPLAN, were used to understand potential forward linkages effects of reduced water supplies.

The drawback to using IMPLAN inter-industry relationship data as the main source of information on the processing sector dependence on local crop and animal production is that IMPLAN crop categories are aggregated such that all vegetables are grouped together, and all fruits (including grapes) are grouped together. This aggregation can obscure an understanding of the dependence of processors on specific crops.

Furthermore, IMPLAN data, as well as anecdotal evidence, indicate that there is significant 'cross-hauling' in the Central Valley within each crop category, with similar crops shipped back and forth across county lines. This is due not only to the aggregation of crops into crop categories, but also due to contractual arrangements and specific demand requirements within each crop type. For most crop production sectors, IMPLAN data simultaneously indicate substantial importing and exporting of each crop type, which limits our understanding of how changes in production would influence processing sectors.

Aside from IMPLAN data, impacts of reduced crop production on processing sectors will be greater if sourcing of crops from other areas is not attractive due to such factors as cost, reliability, and quality. Neighboring counties to the study area include San Joaquin, Madera, and Fresno Counties, all of which are significant agricultural production counties which produce many of the same crops at similar quality to those in the study area. However, despite the abundant nearby agricultural production, for several reasons it is not clear to what extent local processors would be able to obtain crops from neighboring counties (or from other agricultural areas within the study area) to offset reductions in crop production in the Districts' water service area. First, growers and processors have established relationships and contracts, and it may be very difficult for processors to obtain sufficient supplies on a short-term basis to offset production reductions that would occur in just the low water years. Second, water scarcity is affecting agricultural areas throughout California. It is likely that low water supply years in the Districts' service area will also be low water supply years for many other agricultural areas in California, thereby reducing agricultural output throughout the State and severely limiting the availability of alternative crop sources for study area processors.

Due to this significant uncertainty regarding the effect on local processors, two scenarios of possible 'direct' crop and animal product processing sector impacts are developed:

- High Impact Estimate: The high impact estimate assumes that output from animal producers and crop processors is impacted immediately and proportionately with a change in crop production. This scenario assumes that the market for feed and food crops, particularly in low water years, is highly competitive and that alternative sources of crops are not economically feasible for animal producers and food processors to purchase (due either to high cost or lack of crop availability due to pre-existing contracts or other supply chain factors). Consequently, in the high impact estimate, if Districts' feed crop production declines by 10 percent, animal production supported by the Districts declines 10 percent. Similarly, if fruit production in the Districts declines by 10 percent, then local processing of fruit supported by the Districts declines 10 percent. These impacts are all estimated as direct output impacts, both in the animal production sectors and the crop processing sectors.

- Low Impact Estimate. The low impact estimate assumes that animal producers and crop processors can find alternative crop sources to offset 100 percent of the reduction in Districts' crop production in reduced water years. We assume no impact on crop processors as IMPLAN data indicates that, even in 25 percent water years, there may be sufficient local supply to meet local processor demand (i.e., local production still exceeds local demand within aggregated crop categories). Consequently, in the low impact estimate, crop processing in all water years is the same as in Full Demand water supply years. Furthermore, we assume no increased crop transportation cost as there may be available crop supplies locally that could be obtained by local processors.

  Forward linkage impacts in the low impact scenario are limited to income effects to dairies and cattle ranchers of increased feed hauling costs. We assume that dairies and cattle ranchers are able to maintain herd size and production levels despite decreased local feed crop production. We assume that there is availability and feasibility of importing adequate silage and hay crops from other areas to offset decreased local production. The increased cost of transporting feed crops from outside the study area is analyzed as an income effect in IMPLAN to determine the total induced impacts in the local economy, based on the assumption that cattle and dairy farmers reduce their spending as their disposable income declines. Thus, for animal production in the low estimate, there are direct income effects (and induced employment, income, and output effects), but no direct employment or output effects. As there are assumed to be no changes in animal production, there are no impacts on processing in the low estimate.

2.4.1.3 Limitations and Assumptions

Key assumptions and limitations include:

- Short-Term vs. Long-Term Impacts. As estimated, adverse impacts include all effects on businesses that are reliant on current levels of crop production, either through supplying inputs such as machinery and seed to agriculture (backward linkages) or using crop outputs for animal production or food processing (forward linkages). As is typical professional practice, this analysis does not consider the extent to which, in the long-term, individuals and businesses could identify alternative economic activities that could offset declines in the agricultural economy and absorb labor and other resources (thereby diminishing long-term adverse effects).
- No Carry-Over of Annual Impacts. This analysis estimates each water supply year as a one-year event, and does not consider the potential consequences of low water year effects on subsequent production years. This likely results in an underestimate of impacts, for several reasons. First, deficit irrigation of permanent crops, particularly in very low water years, can affect quality and quantity of yields in subsequent years. Second, lack of reliability in acreage and yields in all crops may affect supplier relationships. Third, multiple low water years in a row, in which producers and processors may experience higher than normal transportation and other costs, may result in closure of some firms. Finally, in low water

years with low feed crop production, animal producers may reduce herd size, which would likely impact output in subsequent years.

- Linearity. As discussed in TID/MID (2014), standard economic impact analysis assumes a linear level of impact – for every $1 of output in a given crop sector, there is the same level of impact in other economic sectors, both for industries supplying agriculture (back-linked) and for industries processing crop and animal products (forward-linked). In other words, IMPLAN uses fixed, proportional relationships, with the result that it predicts the same incremental income and employment impact for every $1 change in industry output. In reality, impacts may be larger or smaller than estimated by the model, depending on the size of the change and the response by businesses. For example, IMPLAN estimates may overstate job impacts if employers reduce employee hours but not jobs, or if people who lose a job in agriculture are able to easily transition and start a new position. IMPLAN estimates may understate job and income impacts if output changes are large and result in business closures and/or relocations.
- Potential Magnification of Modeling Limitations. Inputs to the regional economic impact analysis are results from the modeling of agricultural crop production and animal production, as described in previous sections. Any modeling limitations or estimation discrepancies from previous steps become magnified in the economic impact analysis.

2.4.1.4 Regional Economic Impacts: Crop Production

Table 2.4-1 presents the total regional economic impacts associated with crop production supported by the Project at different water supply levels. (Total effects account for changes across all industries with economic linkages to agricultural production, including direct, indirect, and induced impacts). Overall, the total annual direct value of crops grown in the Districts' service area under Full Demand water supplies is $527.9 million. Adding to this, the regional economic impacts of the indirect and induced effects brings the contribution of crops produced with irrigation water supplied from the two Districts to a total of $860.2 million. This total output value of agricultural production declines linearly to $365.9 million in the lowest water supply modeled, 25 percent of Full Demand water supply. Correspondingly, labor income and jobs declines also; $281.3 million in labor income, and 7,340 jobs (full and part-time) in the Full Demand water supply year down to $365.9 in output, *negative* $20.7 million in income (due to substantial income losses by permanent crop farmers as costs remain high and revenues drop), and 3,560 jobs (full and part-time).

Table 2.4-1. Annual regional economic impacts by water year type – crop production (direct, indirect and induced effects).[1,2]

Economic Metric	Water Supply (Percentage of Full Demand Supply)								
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**25%**
Total Output ($millions)									
Impact Value	$860.2	$804.5	$752.5	$704.3	$646.2	$562.0	$493.0	$413.9	$365.9
Decline from Baseline		*-$55.8*	*-$107.7*	*-$155.9*	*-$214.0*	*-$298.2*	*-$367.2*	*-$446.3*	*-$494.3*
% Change from Baseline		*-6%*	*-6%*	*-6%*	*-8%*	*-13%*	*-12%*	*-16%*	*-12%*
Total Labor Income ($millions)									
Impact Value	$281.3	$249.7	$222.3	$198.9	$166.5	$108.2	$65.7	$13.6	-$20.7
Decline from Baseline		*-$31.6*	*-$59.0*	*-$82.3*	*-$114.7*	*-$173.1*	*-$215.6*	*-$267.6*	*-$302.0*
% Change from Baseline		*-11%*	*-11%*	*-10%*	*-16%*	*-35%*	*-39%*	*-79%*	*-252%*
Total Employment (full and part-time jobs)									
Impact Value	7,340	6,920	6,490	6,110	5,670	5,040	4,510	3,920	3,560
Decline from Baseline		-420	-850	-1,230	-1,670	-2,300	-2,830	-3,420	-3,780
% Change from Baseline		*-6%*	*-6%*	*-6%*	*-7%*	*-11%*	*-11%*	*-13%*	*-9%*

Source: Highland Economics (based on IMPLAN modeling).
[1] Monetary values reported in constant 2012 dollars adjusted using the California consumer price index (CPI).
[2] Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

2.4.1.5 Agriculture-Dependent Industries (Forward Linkages)

As described above and in detail in TID/MID (2014), three industries particularly dependent on local agricultural production are dairy, beef cattle ranching, and food and beverage processing. The forward linkage analysis for each of these three industries is presented below.

2.4.1.6 Dairy and Beef Cattle Ranching

The results of the forward-linkage impact analysis by water supply year for the dairy industry are presented in Tables 2.4-2 (high estimate) and Table 2.4-3 (low estimate). The high impact estimate for dairy milk production assumes that milk production declines at the same rate as the decline in District feed crop production. The low impact estimate for milk production assumes no drop in dairy milk production, but a decline in dairy milk producers' income equal to the increased cost to transport feed from other areas. As modeled in the low impact scenario for milk production, there is no direct output and employment effect, but there is a direct income effect and induced effects on output, employment, and income. Total benefits to the regional economy are expected to vary from 3,630 full and part-time jobs and $75.3 million in labor income in Full Demand water years, to 1,090 to 3,390 full and part-time jobs and $22.7 million to $38.8 million in 25 percent water supply years.

Table 2.4-2. High estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – dairy milk production (direct, indirect and induced effects).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**25%**
Total Output ($millions)									
Total Impact Value	$816.7	$731.5	$645.3	$557.6	$468.1	$401.2	$346.6	$284.1	$245.9
Decline from Baseline		*-$85.2*	*-$171.4*	*-$259.1*	*-$348.6*	*-$415.5*	-$470.1	-$532.7	-$570.8
% Change from Baseline		*-10%*	*-21%*	*-32%*	*-43%*	*-51%*	-58%	-65%	-70%
Total Labor Income ($millions)									
Impact Value	$75.3	$67.4	$59.5	$51.4	$43.1	$37.0	$31.9	$26.2	$22.7
Decline from Baseline		*-$7.9*	*-$15.8*	*-$23.9*	*-$32.1*	*-$38.3*	-$43.3	-$49.1	-$52.6
% Change from Baseline		*-10%*	*-21%*	*-32%*	*-43%*	*-51%*	-58%	-65%	-70%
Total Employment (full and part-time jobs)									
Impact Value	3,630	3,250	2,870	2,480	2,080	1,780	1,540	1,260	1,090
Decline from Baseline		*-380*	*-760*	*-1,150*	*-1,550*	*-1,850*	-2,090	-2,370	-2,540
% Change from Baseline		*-10%*	*-21%*	*-32%*	*-43%*	*-51%*	-58%	-65%	-70%

Source: Highland Economics (based on IMPLAN modeling).
[1] Monetary values reported in constant 2012 dollars adjusted using the California CPI.
[2] Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

Table 2.4-3. Low estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – dairy milk production (direct, indirect and induced effects).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**25%**
Total Output ($millions)									
Total Impact Value	$816.7	$812.0	$807.3	$802.2	$797.2	$792.4	$787.7	$783.0	$780.6
Decline from Baseline		*-$4.7*	*-$9.5*	*-$14.5*	*-$19.6*	*-$24.3*	*-$29.0*	*-$33.8*	*-$36.2*
% Change from Baseline		*-1%*	*-1%*	*-2%*	*-2%*	*-3%*	*-4%*	*-4%*	*-4%*
Total Labor Income ($millions)									
Impact Value	$75.3	$70.5	$65.7	$60.6	$55.5	$50.7	$45.9	$41.2	$38.8
Decline from Baseline		*-$4.8*	*-$9.6*	*-$14.7*	*-$19.8*	*-$24.5*	*-$29.3*	*-$34.1*	*-$36.5*
% Change from Baseline		*-6%*	*-13%*	*-19%*	*-26%*	*-33%*	*-39%*	*-45%*	*-49%*
Total Employment (full and part-time jobs)									
Impact Value	3,630	3,600	3,570	3,530	3,500	3,470	3,430	3,400	3,390
Decline from Baseline		*-30*	*-60*	*-100*	*-130*	*-160*	*-200*	*-230*	*-240*
% Change from Baseline		*-1%*	*-2%*	*-3%*	*-4%*	*-4%*	*-6%*	*-6%*	*-7%*

Source: Highland Economics (based on IMPLAN modeling).
[1] Monetary values reported in constant 2012 dollars adjusted using the California CPI.
[2] Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

The results of the forward-linkage analysis for the cattle ranching industry are presented in Table 2.4-4 (high estimate) and Table 2.4-5 (low estimate). Cattle ranching production supported by District water is estimated to directly and indirectly support total economic benefits varying from approximately 1,200 full and part-time jobs and $22.7 million labor income in Full Demand water years, down to 940 to 1,130 full and part-time jobs and $9.7 to $17.6 million in labor income in 25 percent water years. As described for milk production, high estimates of the impact of reduced water supplies on cattle production assume that reductions in feed crop availability result in a proportionate change in cattle production. The low estimates assume that cattle ranchers maintain herd size (and total animal production value) by purchasing feed from outside the region, incurring increased transportation costs that reduce their profit. This decreased local area income then results in reduced household spending, with subsequent adverse effects on study area total output, income, and employment.

Table 2.4-4. High estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – cattle ranching production supported by crops from Districts' water service area (direct, indirect and induced effects).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**25%**
Total Output ($millions)									
Total Impact Value	$233.0	$226.2	$219.3	$212.2	$205.1	$198.0	$190.9	$183.8	$180.3
Decline from Baseline		*-$6.8*	*-$13.7*	*-$20.8*	*-$27.9*	*-$35.0*	*-$42.1*	*-$49.2*	*-$52.7*
% Change from Baseline		*-3%*	*-6%*	*-9%*	*-12%*	*-15%*	*-18%*	*-21%*	*-23%*
Total Labor Income ($millions)									
Impact Value	$22.7	$22.1	$21.4	$20.7	$20.0	$19.3	$18.6	$17.9	$17.6
Decline from Baseline		*-$0.7*	*-$1.3*	*-$2.0*	*-$2.7*	*-$3.4*	*-$4.1*	*-$4.8*	*-$5.1*
% Change from Baseline		*-3%*	*-6%*	*-9%*	*-12%*	*-15%*	*-18%*	*-21%*	*-23%*
Total Employment (full and part-time jobs)									
Impact Value	1,220	1,190	1,150	1,110	1,070	1,040	1,000	960	940
Decline from Baseline		*-30*	*-70*	*-110*	*-150*	*-180*	*-220*	*-260*	*-280*
% Change from Baseline		*-2%*	*-6%*	*-9%*	*-12%*	*-15%*	*-18%*	*-21%*	*-23%*

Source: Highland Economics (based on IMPLAN modeling).
1 Monetary values reported in constant 2012 dollars adjusted using the California CPI.
2 Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

Table 2.4-5. Low estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – cattle ranching production supported by crops from Districts' water service area (direct, indirect and induced effects).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	90%	80%	70%	60%	50%	40%	30%	25%
Total Output ($millions)									
Total Impact Value	$233.0	$231.3	$229.7	$227.9	$226.2	$224.4	$222.7	$220.9	$220.1
Decline from Baseline		*-$1.7*	*-$3.3*	*-$5.1*	*-$6.8*	*-$8.6*	*-$10.3*	*-$12.1*	*-$12.9*
% Change from Baseline		*-1%*	*-1%*	*-2%*	*-3%*	*-4%*	*-4%*	*-5%*	*-6%*
Total Labor Income ($millions)									
Impact Value	$22.7	$21.0	$19.3	$17.6	$15.8	$14.0	$12.3	$10.5	$9.7
Decline from Baseline		*-$1.7*	*-$3.4*	*-$5.1*	*-$6.9*	*-$8.7*	*-$10.4*	*-$12.2*	*-$13.1*
% Change from Baseline		*-7%*	*-15%*	*-22%*	*-30%*	*-38%*	*-46%*	*-54%*	*-57%*
Total Employment (full and part-time jobs)									
Impact Value	1,220	1,210	1,200	1,190	1,170	1,160	1,150	1,140	1,130
Decline from Baseline		*-10*	*-20*	*-30*	*-50*	*-60*	*-70*	*-80*	*-90*
% Change from Baseline		*-1%*	*-2%*	*-2%*	*-4%*	*-5%*	*-6%*	*-7%*	*-7%*

Source: Highland Economics (based on IMPLAN modeling).
1 Monetary values reported in constant 2012 dollars adjusted using the California CPI.
2 Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

As discussed in detail TID/MID (2014), different sectors of the food and beverage processing industry are dependent on food crop production, dairy production, and cattle ranching. Separate forward linkage results of these three types of processing sub-sectors are presented in Tables 2.4-6 through 2.4-11, with a separate table for high and low impact estimates within each subsector.

At Full Demand water supply, the direct value of processing output supported by the Districts' food crop production is estimated at $569.1 million annually (see Table 6.3-5 in TID/MID [2014]) adding to this the indirect and induced impacts brings total contribution from Districts' water supply up to $854.9 million (Table 2.4-6). This includes output in the following processing sectors: winery; other animal food manufacturing; frozen food manufacturing; fruit and vegetable canning, pickling and drying; and "snack food" manufacturing. The associated total annual economic benefits of this processing activity are estimated at nearly 2,860 full and part-time jobs and $165.8 million in labor income. The effect on these economic benefits of a change in water supplies depends on the availability of alternative crop inputs. On the low end, it is feasible that there could be no impacts on processors, as available data indicates that there may be sufficient alternative local sources to meet processor demand without impacting output (Table 2.4-7).

On the other hand, due to pre-existing contractual arrangements and possible water shortages in other agricultural producing areas within California, low water years in the Districts' service area could proportionately impact food processors. We thus estimate that, at the high end, the level of output, employment, and income associated with crop processing that is supported by District crop production may closely mirror the water supply level. In this case, for every 10 percent reduction in water supply to the Districts' service area, the level of income, employment, and output would fall by nearly 10 percent as well, until at the 25 percent water year supply level, regional economic benefits may fall by up to 73 percent compared to Full Demand supply water years. This would equate to a fall from nearly 2,900 full and part-time jobs and $165.8 million in labor income to 770 full and part-time jobs and $44.6 million in income (Table 2.4-6).

Table 2.4-6. High estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – food and beverage processing dependent on crop production in the Districts' water service area (direct, indirect and induced effects).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**25%**
Total Output ($millions)									
Total Impact Value	$854.9	$777.0	$696.8	$616.3	$535.2	$449.1	$363.1	$275.2	$229.9
Decline from Baseline		*-$77.9*	*-$158.1*	*-$238.6*	*-$319.8*	*-$405.9*	*-$491.8*	*-$579.8*	*-$625.1*
% Change from Baseline		*-9%*	*-18%*	*-28%*	*-37%*	*-47%*	*-58%*	*-68%*	*-73%*
Total Labor Income ($millions)									
Impact Value	$165.8	$150.7	$135.1	$119.5	$103.8	$87.1	$70.4	$53.4	$44.6
Decline from Baseline		*-$15.1*	*-$30.7*	*-$46.3*	*-$62.0*	*-$78.7*	*-$95.4*	*-$112.4*	*-$121.2*
% Change from Baseline		*-9%*	*-18%*	*-28%*	*-37%*	*-47%*	*-58%*	*-68%*	*-73%*
Total Employment (full and part-time jobs)									
Impact Value	2,860	2,600	2,340	2,070	1,790	1,510	1,220	920	770
Decline from Baseline		*-260*	*-520*	*-790*	*-1,070*	*-1,350*	*-1,640*	*-1,940*	*-2,090*
% Change from Baseline		*-9%*	*-18%*	*-28%*	*-37%*	*-47%*	*-57%*	*-68%*	*-73%*

Source: Highland Economics (based on IMPLAN modeling).
[1] Monetary values reported in constant 2012 dollars adjusted using the California CPI.
[2] Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

Table 2.4-7. Low estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – food and beverage processing dependent on crop production in the Districts' water service area (direct, indirect and induced effects).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**25%**
Total Output ($millions)									
Total Impact Value	$854.9	$854.9	$854.9	$854.9	$854.9	$854.9	**$854.9**	**$854.9**	**$854.9**
Decline from Baseline		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Total Labor Income ($millions)									
Impact Value	$165.8	$165.8	$165.8	$165.8	$165.8	$165.8	**$165.8**	**$165.8**	**$165.8**
Decline from Baseline		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Total Employment (full and part-time jobs)									
Impact Value	2,860	2,860	2,860	2,860	2,860	2,860	**2,860**	**2,860**	**2,860**
Decline from Baseline		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*

Source: Highland Economics (based on IMPLAN modeling).
[1] Monetary values reported in constant 2012 dollars adjusted using the California CPI.
[2] Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

The effect on these economic benefits of a change in water supplies depends on the impact on local dairy production of a change in feed crop availability, and also the availability and economic feasibility of purchasing alternative milk supplies. On the low end, it is feasible that there could be no impacts on processors, if milk producers are able to obtain alternative feed and maintain herd size and milk output.

On the other hand, due to pre-existing contractual arrangements and possible water shortages in other agricultural producing areas within California, milk producers may be unable to obtain alternative feed supplies in low water years in the Districts' service area, resulting in a decline in milk production proportionate to the change in feed crop production. Due to the high transport cost of milk, and potential lack of availability of supplies from elsewhere, in this high impact scenario, decline in milk production may then proportionately impact dairy processors. We thus estimate that, at the high end, the level of output, employment, and income associated with dairy processing that is supported by District crop production may closely mirror the water supply level. In this case, for every 10 percent reduction in water supply to the Districts' service area, the level of income, employment, and output would fall by nearly 10 percent as well, until at the 25 percent water year supply level, regional economic benefits from dairy processing (that is supported indirectly by the District feed crops) may fall by up to 70 percent compared to Full Demand supply water years. This would equate to a fall from over 3,000 full and part-time jobs and $156.3 million in labor income to 910 full and part-time jobs and $47.1 million in income.

Table 2.4-8. High estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – food and beverage processing dependent on milk production supported by crops grown in the Districts' water service area (direct, indirect and induced).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	90%	80%	70%	60%	50%	40%	30%	25%
Total Output ($millions)									
Total Impact Value	$1,143.1	$1,023.7	$903.1	$780.4	$655.1	$561.5	$485.1	$397.6	$344.2
Decline from Baseline		*-$119.3*	*-$239.9*	*-$362.6*	*-$487.9*	*-$581.6*	-$658.0	-$745.5	-$798.9
% Change from Baseline		*-10%*	*-21%*	*-32%*	*-43%*	*-51%*	-58%	-65%	-70%
Total Labor Income ($millions)									
Impact Value	$156.3	$140.0	$123.5	$106.7	$89.6	$76.8	$66.3	$54.4	$47.1
Decline from Baseline		*-$16.3*	*-$32.8*	*-$49.6*	*-$66.7*	*-$79.5*	-$90.0	-$101.9	-$109.2
% Change from Baseline		*-10%*	*-21%*	*-32%*	*-43%*	*-51%*	-58%	-65%	-70%
Total Employment (full and part-time jobs)									
Impact Value	3,030	2,720	2,400	2,070	1,740	1,490	1,290	1,060	910
Decline from Baseline		*-310*	*-630*	*-960*	*-1,290*	*-1,540*	-1,740	-1,970	-2,120
% Change from Baseline		*-10%*	*-21%*	*-32%*	*-43%*	*-51%*	-57%	-65%	-70%

Source: Highland Economics (based on IMPLAN modeling).
1 Monetary values reported in constant 2012 dollars adjusted using the California CPI.
2 Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

Table 2.4-9. Low Estimate: Annual regional economic impacts by percent of Full Demand canal water deliveries – food and beverage processing dependent on milk production supported by crops grown in the Districts' water service area (direct, indirect and induced).[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	90%	80%	70%	60%	50%	40%	30%	25%
Total Output ($millions)									
Total Impact Value	$1141.3	$1141.3	$1141.3	$1141.3	$1141.3	$1141.3	$1141.3	$1141.3	$1141.3
Decline from Baseline		*$0*	*$0*	*$0*	*$0*	*$0*	$0	$0	$0
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	0%	0%	0%
Total Labor Income ($millions)									
Impact Value	$156.3	$156.3	$156.3	$156.3	$156.3	$156.3	$156.3	$156.3	$156.3
Decline from Baseline		*$0*	*$0*	*$0*	*$0*	*$0*	$0	$0	$0
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	0%	0%	0%
Total Employment (full and part-time jobs)									
Impact Value	3,030	3,030	3,030	3,030	3,030	3,030	3,030	3,030	3,030
Decline from Baseline		*0*	*0*	*0*	*0*	*0*	0	0	0
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	0%	0%	0%

Source: Highland Economics (based on IMPLAN modeling).
1 Monetary values reported in constant 2012 dollars adjusted using the California CPI.
2 Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

Finally, cattle ranching supported by crops irrigated by the Districts' water is, in turn, estimated to support approximately $119.8 million of animal processing output. In total, animal processing associated with the Don Pedro Full Demand water supply supports an estimated $24.2 million in labor income, and over 600 full and part-time jobs (in addition to the effects in the dairy production sector, and in the cattle ranching and feed crop production sectors estimated above). The effect on these economic benefits of a change in water supplies depends on the impact on local cattle production of a change in feed crop availability, and also the availability and economic feasibility to animal processors of purchasing alternative animal products. On the low end, it is feasible that there could be no impacts on processors, if animal producers are able to obtain alternative feed and maintain herd size and cattle production.

On the other hand, due to pre-existing contractual arrangements and possible water shortages in other agricultural producing areas within California, if cattle producers are unable to obtain alternative feed supplies in low water years in the Districts' service area, the result could be a decline in beef cattle production, and a reduction in beef cattle availability to cattle processors. Based on the estimated relationships between local feed crop production, local cattle production, and local cattle processing, we estimate how changing water supplies would impact cattle processing in Table 2.4-10. Impacts on cattle processing are commensurate with estimated impacts on cattle production: approximately a three percent reduction in the total output, employment, and income supported by crops in the Districts' service area for every 10 percent decline in water supply. Thus, at the maximum impact, regional economic benefits would fall from over 600 full and part-time jobs and $24.2 million in labor income (Full Demand water supply year) to 480 full and part-time jobs and $18.7 million in income in a 25 percent of Full Demand supply water year (Table 2.4-10).

Table 2.4-10. High estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – regional food processing dependent on cattle supported by crops grown in the Districts' water service area.[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	90%	80%	70%	60%	50%	40%	30%	25%
Total Output ($millions)									
Total Impact Value	$166.0	$161.2	$156.3	$151.2	$146.2	$141.1	$136.1	$131.0	$128.5
Decline from Baseline		*-$4.8*	*-$9.8*	*-$14.8*	*-$19.9*	*-$24.9*	-$30.0	-$35.0	-$37.6
% Change from Baseline		*-3%*	*-6%*	*-9%*	*-12%*	*-15%*	-18%	-21%	-23%
Total Labor Income ($millions)									
Impact Value	$24.2	$23.5	$22.7	$22.0	$21.3	$20.5	$19.8	$19.1	$18.7
Decline from Baseline		*-$0.7*	*-$1.4*	*-$2.2*	*-$2.9*	*-$3.6*	-$4.4	-$5.1	-$5.5
% Change from Baseline		*-3%*	*-6%*	*-9%*	*-12%*	*-15%*	-18%	-21%	-23%
Total Employment (full and part-time jobs)									
Impact Value	630	610	590	570	550	530	510	490	480
Decline from Baseline		*-20*	*-40*	*-60*	*-80*	*-100*	-120	-140	-150
% Change from Baseline		*-3%*	*-6%*	*-10%*	*-13%*	*-16%*	-19%	-22%	-24%

Source: Highland Economics (based on IMPLAN modeling).
1 Monetary values reported in constant 2012 dollars adjusted using the California CPI.
2 Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

Table 2.4-11. Low estimate: annual regional economic impacts by percent of Full Demand canal water deliveries – food and beverage processing dependent on milk production supported by crops grown in the Districts' water service area.[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	90%	80%	70%	60%	50%	40%	30%	25%
Total Output ($millions)									
Total Impact Value	$166.0	$166.0	$166.0	$166.0	$166.0	$166.0	$166.0	$166.0	$166.0
Decline from Baseline		*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	$0.0	$0.0	$0.0
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	0%	0%	0%
Total Labor Income ($millions)									
Impact Value	$24.2	$24.2	$24.2	$24.2	$24.2	$24.2	$24.2	$24.2	$24.2
Decline from Baseline		*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	$0.0	$0.0	$0.0
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	0%	0%	0%
Total Employment (full and part-time jobs)									
Impact Value	630	630	630	630	630	630	630	630	630
Decline from Baseline		*0*	*0*	*0*	*0*	*0*	0	0	0
% Change from Baseline		*0%*	*0%*	*0%*	*0%*	*0%*	0%	0%	0%

Source: Highland Economics (based on IMPLAN modeling).
1 Monetary values reported in constant 2012 dollars adjusted using the California CPI.
2 Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

2.4.2 Summary of Regional Economic Effects

Under the Full Demand water supply assumption, accounting for all directly-supported activities and forward-linked sectors, and including hydropower and recreation benefits, the Project is estimated to support approximately 18,900 total jobs and $737.9 million in total labor income annually. Figures 2.4-1 and 2.4-2 and Tables 2.4-12 and 2.4-13 summarize how this total income and employment benefit decline in lower water supply years.

Estimated adverse annual employment impacts vary from a reduction of 460 to 1,420 jobs in a 90 percent water year to a reduction of 4,110 to 10,960 jobs in a 25 percent water year. Estimated adverse annual income impacts vary from a reduction of $38.0 million to $72.2 million in a 90 percent water year to a reduction of $351.6 million to $595.7 million in a 25 percent water supply year. The decline in employment in the 25 percent water supply year equates to a 22 to 58 percent decrease from employment supported by the Districts' service area in a Full Demand water year, while the reduction in labor income equates to a 48 to 81 percent decrease in income supported by the Districts' service area in a Full Demand water year.

Income impacts are higher than employment impacts, particularly in the lowest water supply years primarily due to our assumption that any change in permanent crop revenue (i.e., a yield reduction) directly translates into reduced income, dollar for dollar, into an income reduction.[9]

9 As discussed above, all effects on permanent crops are reduced yields, not reduced acreage. We expect that reduced yields in permanent crops will reduce revenue, but will have no effect on fixed costs, and little effect on non-labor variable costs. In other words, water supplies and associated reduced yields would be expected to reduce such labor variable costs as irrigation labor costs and harvest labor costs, but are expected to have relatively little effect on other input costs. We conservatively model this as a proprietor income effect, with no effect on direct farm employment.

As the same acres are in cultivation, we conservatively assume no direct reduction in farm employment on permanent crop acreage.

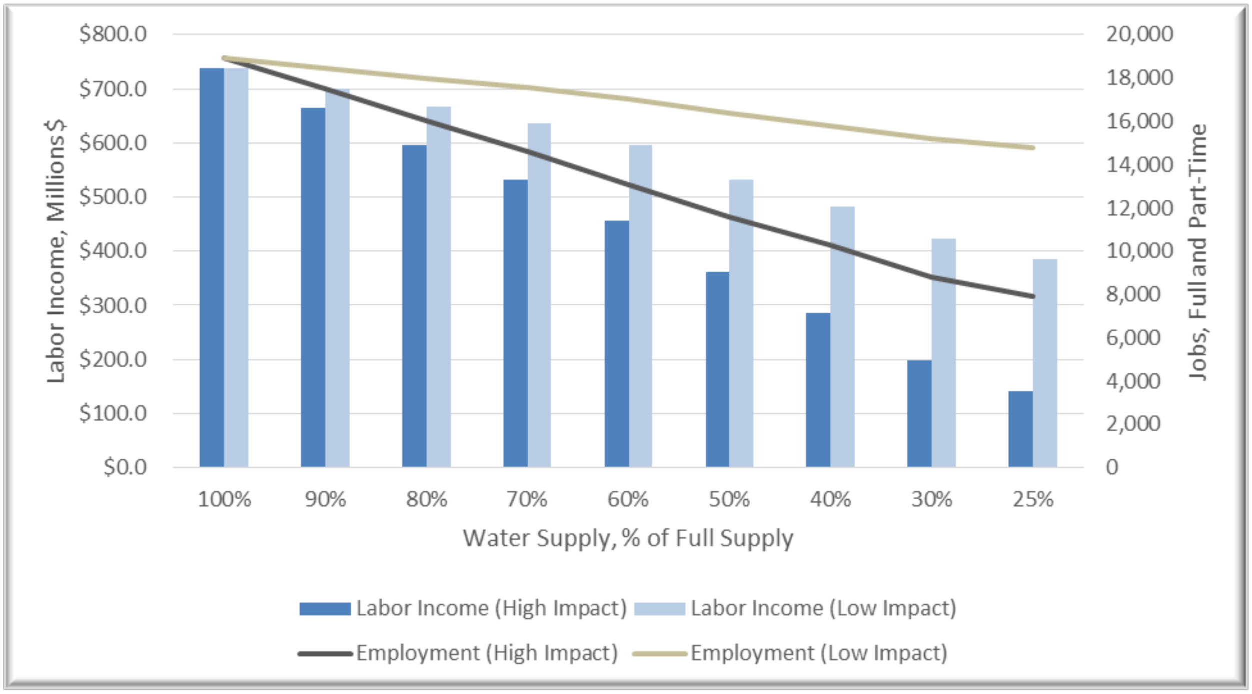

Figure 2.4-1. Summary of jobs and labor income impacts by percent of full demand canal water deliveries.[1, 2]

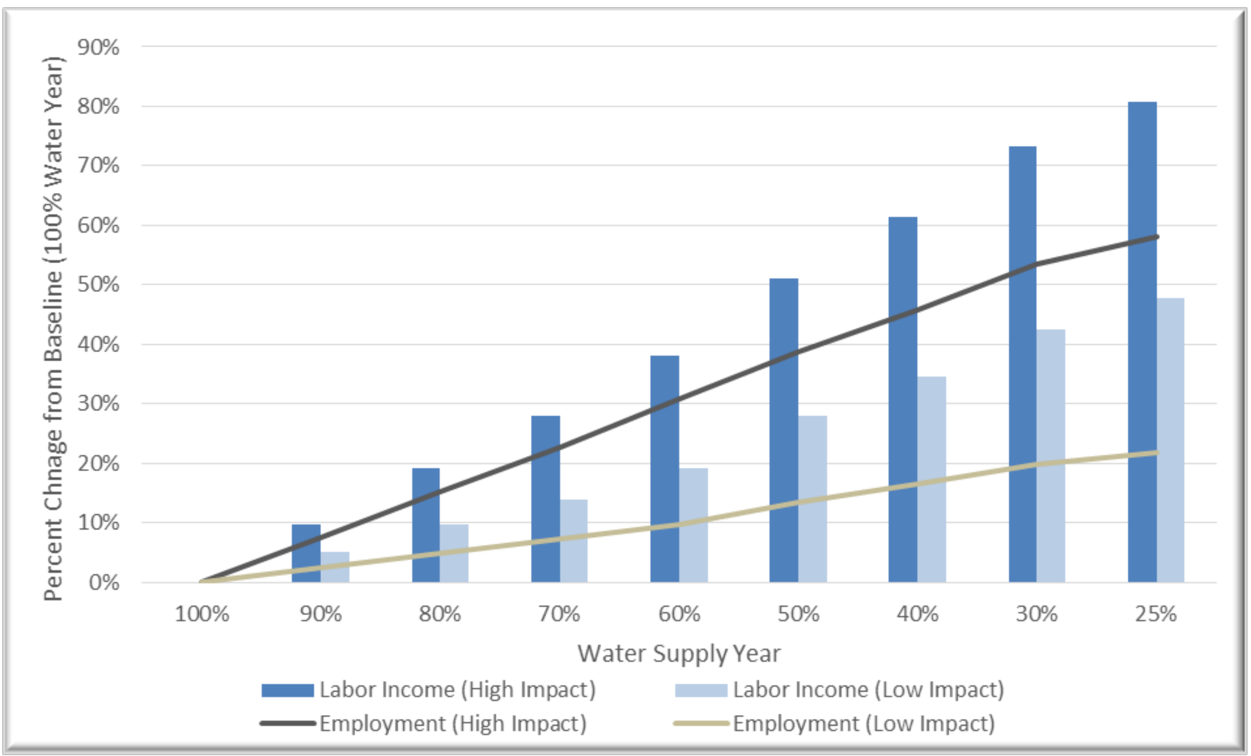

Figure 2.4-2. Percent reduction (from baseline water year) in jobs and labor income by percent of full demand canal water deliveries.[1,2]

Table 2.4-12. High estimate: changes in annual regional economic impacts by percent of Full Demand canal water deliveries – summary of impacts to crop production, animal production, and processing dependent on water supply from Districts.[1,2,3]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**25%**
Total Output ($millions)									
Total Impact Value	$4,073.9	$3,765.0	$3,414.3	$3,063.0	$2,696.8	$2,353.8	**$2,055.7**	**$1,726.5**	**$1,494.6**
Decline from Baseline		-349.8	-700.6	-1,051.9	-1,418.1	-1,761.1	**-2,059.2**	**-2,388.4**	**-2,579.4**
% Change from Baseline		*-9%*	*-17%*	*-26%*	*-34%*	*-43%*	**-50%**	**-58%**	**-63%**
Total Labor Income ($millions)									
Impact Value	$737.9	$665.7	$596.9	$531.7	$456.8	$361.3	**$285.2**	**$197.0**	**$142.2**
Decline from Baseline		-$72.2	-$141.0	-$206.3	-$281.2	-$376.7	**-$452.7**	**-$541.0**	**-$595.7**
% Change from Baseline		*-10%*	*-19%*	*-28%*	*-38%*	*-51%*	**-61%**	**-73%**	**-81%**
Total Employment (full and part-time jobs)									
Impact Value	18,900	17,480	16,030	14,600	13,090	11,580	**10,260**	**8,800**	**7,940**
Decline from Baseline		-1,420	-2,870	-4,300	-5,810	-7,320	**-8,640**	**-10,100**	**-10,960**
% Change from Baseline		*-8%*	*-15%*	*-23%*	*-31%*	*-39%*	**-46%**	**-53%**	**-58%**

Source: Highland Economics (based on IMPLAN modeling).
[1] Monetary values reported in constant 2012 dollars adjusted using the California CPI.
[2] Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).
[3] Results do not include economic benefits from hydropower and recreation that are not expected to change by water year type.

Table 2.4-13. Low estimate: changes in annual regional economic impacts by percent of Full Demand canal water deliveries – summary of impacts to crop production, animal production, and processing dependent on water supply from Districts.[1,2]

Economic Metric	Water Supply (Percentage of Baseline Supply)								
	100%	90%	80%	70%	60%	50%	40%	30%	25%
Total Output ($millions)									
Total Impact Value	$4,073.9	$4,052.7	$3,994.4	$3,939.4	$3,874.5	$3,783.8	**$3,708.3**	**$3,622.7**	**$3,571.5**
Decline from Baseline		-62.2	-120.5	-175.5	-240.4	-331.1	**-406.6**	**-492.2**	**-543.4**
% Change from Baseline		*-2%*	*-3%*	*-4%*	*-6%*	*-8%*	**-10%**	**-12%**	**-13%**
Total Labor Income ($millions)									
Impact Value	$737.9	$699.9	$666.0	$635.8	$596.6	$531.6	**$482.6**	**$424.0**	**$386.3**
Decline from Baseline		-$38.0	-$72.0	-$102.1	-$141.4	-$206.3	**-$255.4**	**-$313.9**	**-$351.6**
% Change from Baseline		*-5%*	*-10%*	*-14%*	*-19%*	*-28%*	**-35%**	**-43%**	**-48%**
Total Employment (full and part-time jobs)									
Impact Value	18,900	18,440	17,970	17,540	17,050	16,380	**15,800**	**15,170**	**14,790**
Decline from Baseline		-460	-930	-1,360	-1,850	-2,520	**-3,100**	**-3,730**	**-4,110**
% Change from Baseline		*-2%*	*-5%*	*-7%*	*-10%*	*-13%*	**-16%**	**-20%**	**-22%**

Source: Highland Economics (based on IMPLAN modeling).
[1] Monetary values reported in constant 2012 dollars adjusted using the California CPI.
[2] Results represent regional effects in three-county study area (Stanislaus, Merced, and Tuolumne counties).

2.4.2.1 Results in Study Area Context

This section puts the economic impact results in the context of the total study area economy. Table 2.4-14 focuses on the role of the Districts' agricultural production in supporting study area employment. Of the 18,900 jobs supported in a Full Demand water year by the Project, 18,710 are supported directly and indirectly by agriculture (the other 190 are supported by recreation and hydropower generation). This represents six percent of the total three-county study area employment. The Districts' service area produces approximately 22 percent of the agricultural value produced in Stanislaus and Merced counties. If we extrapolate employment supported by agricultural lands in the Districts' water service area to all county agricultural lands, then agriculture in Stanislaus and Merced counties supports approximately 25 percent of total study area employment (Table 2.4-14).

Table 2.4-15 shows how this employment base would be eroded under different water supply levels. The reductions in employment at the 90 percent water year would result in a reduction of study area employment of approximately 0.1 percent to 0.4 percent, increasing to a reduction in study area employment of approximately 1.2 percent to 3.3 percent in the lowest modeled water year of 25 percent of Full Demand water supply. This could equate to an equivalent rise in the unemployment rate during these reduced water years.

Table 2.4-16 provides corresponding data on how total study area income would change under different water supply levels. Under the Full Demand water supply assumption agricultural production in the Districts' service area directly and indirectly supports $725.5 million in labor income. This represents approximately 4 percent of the study area's total earnings of $16,248.4 million (see Table 4.4-3 of TID/MID 2014). The reductions in income at the 90 percent water year would result in a reduction of study area income of approximately 0.2 percent to 0.4 percent, increasing to a reduction in study area employment of approximately 2.2 percent to 3.7 percent in the lowest modeled water year of 25 percent of Full Demand water supply.

Table 2.4-14. District and all county agricultural lands support of study area employment.

Employment Data	Total 3-County Employment Supported
	100%
Geographic Area	
District Agricultural Acreage *(Estimated in Study)*	18,710[1]
3-County Area All Employment *(BEA data, see Table 4.4-1 in TID/MID 2014)*	332,083
Proportion 3-County Baseline Employment Supported	
District Agriculture	5.6%
Extrapolated All Agriculture in 3-County Area[2]	25.2%

[1] Total District supported employment is 18,900, of which 190 jobs is generated through recreation and hydropower. As this table is focused on agriculture-supported jobs, we use a District-supported employment base of 18,710 to exclude the hydropower and recreation-related jobs.

[2] Agricultural acreage in Districts' water service produces an estimated $526.5 million in output. Agricultural output in Stanislaus and Merced counties totals approximately $2,352.8 million (see Section 4.5.2.2 of TID/MID 2014), or approximately 450% of the value in the Districts. Assuming District and non-District agricultural lands contribute equally, on a production value basis, to total employment base in the study area, then all farmland in the county supports approximately 25 percent of all employment in the 3-County area (5.6% multiplied by 4.5).

Table 2.4-15. District agricultural lands' support of regional employment.

Impact Metric	Water Supply (% of Full Demand Water Year)			
	100%	**90%**	**60%**	**25%**
Employment Supported by District Agriculture	18,710	17,290 to 18,250	12,900 to 16,860	7,750 to 14,600
Regional Employment Base	332,083	N/A	N/A	N/A
Percent Reduction in 3-County Employment Base		0.1%-0.4%	0.6% to 1.7%	1.2% to 3.3%

Table 2.4-16. District agricultural lands' support of regional labor income (millions $).

Impact Metric	Water Supply (% of Full Demand Water Year)			
	100%	**90%**	**60%**	**25%**
Income Supported by District Agriculture	$725.5	$653.3 to $687.5	$444.4 to $584.2	$129.8 to $373.9
Regional Income Base	$16,248.4			
Percent Reduction in 3-County Earnings Base		0.2% to 0.4%	0.9% to 1.7%	2.2% to 3.7%

3.0 RESULTS

3.1 Estimating Impacts of Alternatives

Estimating the impact of any hydrologic scenario (e.g., a 40-percent unimpaired flow) is accomplished in two-steps:

(1) Estimate the change in output, labor income and employment, as described in section 2.0, for each 5 percent reduction in canal water deliveries irrigation compared to Full Demand.

(2) Correspond the estimated annual economic impacts associated with the various percent of estimated annual water delivery with the appropriate level of estimated annual water deliveries for each year in each alternative.

Each of these two steps is described below.

3.1.1 Estimated Change in Output, Labor Income and Employment

The maximum and minimum estimated impact to total output, total labor income and total employment expressed as a percent of Full Demand **assuming no intra- or inter-district trading** (the NT modeling scenario) are summarized in Figures 3.1-1 through 3.1-3. As expected, estimated output declines as the supply of surface water irrigation declines from 100 percent of Full Demand to 20 percent of Full Demand. However under both the maximum and the minimum impact estimates, the percent decline in output is not as rapid as the percent decline in surface water supply.

For example, when water supply is 65 percent of Full Demand, output is estimated to be between 95 percent (minimum impact) to 70 percent (maximum impact) of Full Demand levels. The estimated minimum impact is bolstered by the assumptions discussed above, namely: 1) animal feed crops are imported from outside the region maintaining animal product yield (e.g. hundred weight [cwt] of milk) and 2) raw inputs of crops and animal products are imported from outside the region to keep processing plants running at Full Demand capacity. The average of the minimum and maximum impacts estimates is 82 percent of Full Demand output.

The estimated maximum percent decline in output more closely approximates the percent decline in surface water supplies. In the example cited above, when surface water irrigation supply is 65 percent of Full Demand estimated output is 70 percent of Full Demand. Recall the assumption for the maximum scenario is that animal production and processing output fall in proportion to the reduction in crops. The only reason the percent reduction in output is not the same as the percent reduction in surface irrigation water is because, as discussed above, the literature describing the results of stress irrigation field trials suggest the yield of almond trees does not decline in proportion to the decline of evapotranspiration.

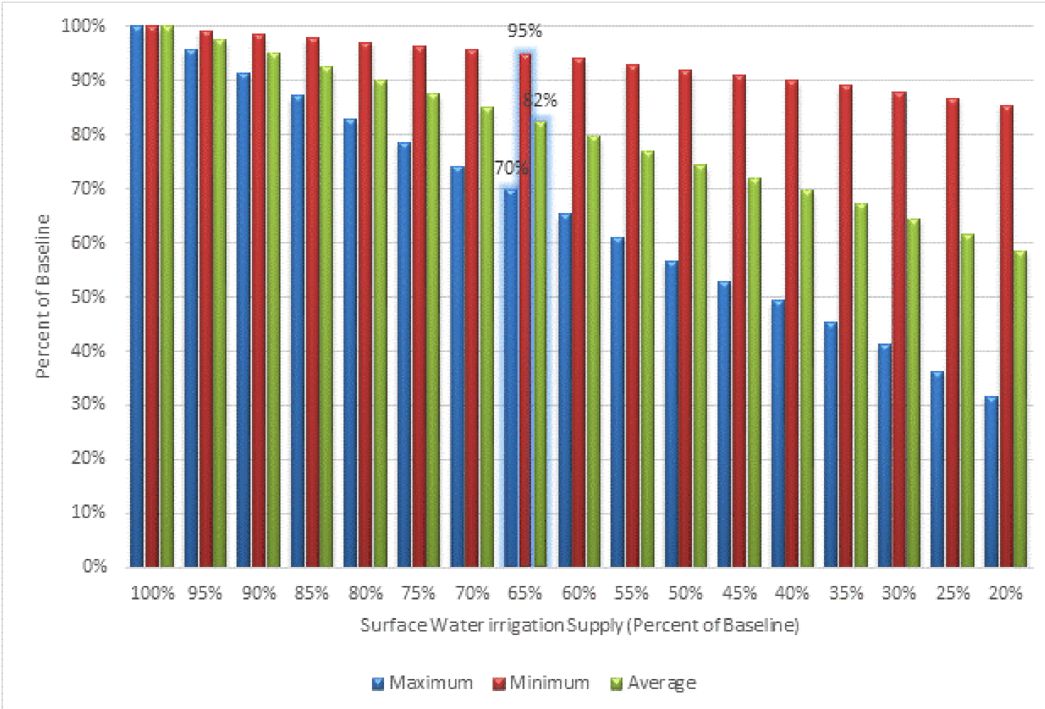

Figure 3.1-1. Estimated maximum and minimum percent change in total output caused by a reduction in surface water irrigation supply.

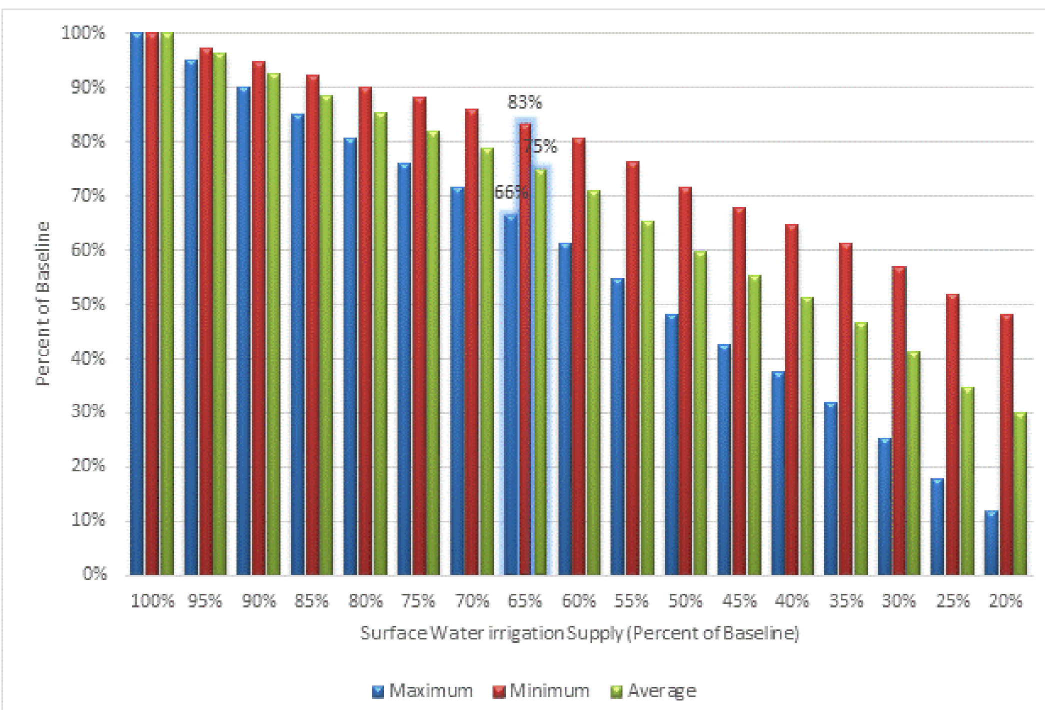

Figure 3.1-2. Estimated maximum and minimum percent change in total labor income caused by a reduction in surface water irrigation supply.

The disparity between estimated maximum and minimum impacts of a reduction in surface water irrigation on total labor income is not as great as the estimated impacts on output. When surface irrigation water supply is 65 percent of Full Demand the estimated minimum and maximum impact on labor income is 83 percent of Full Demand and 66 percent of Full Demand, respectively. Recall that the assumptions for the minimum impact on labor income includes the reduction in dairy ranch owners' income as a consequence of increases in feed price due to limited supply. The average impact is estimated to by 75 percent of Full Demand.

The estimated percent change in total employment from reduced surface water irrigation supply is relatively close to the estimated percent change in total output. When surface water irrigation supply is 65 percent of Full Demand the estimated percent change in total employment is 73 percent of Full Demand and 92 percent of Full Demand for the maximum and minimum scenarios, respectively. The average impact is estimated to be 82 percent of Full Demand.

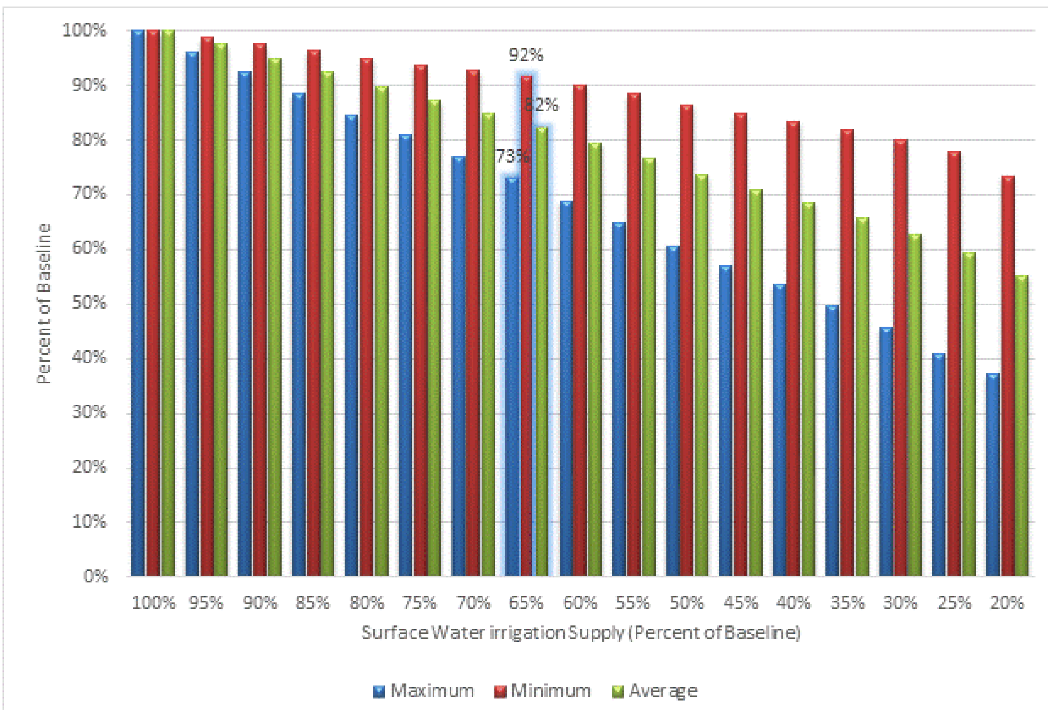

Figure 3.1-3. Estimated maximum and minimum percent change in total on-farm, animal production and processing, employment caused by a reduction in surface water irrigation supply.

3.1.2 Combining Economic Model Results with Hydrology

Combining the annual output from the hydrologic operations model with the annual output from the economic model produces an estimate of the total economic impact for each alternative, Base Case and Full Demand over the 42-year modeling term. The models' annual data is combined by corresponding the annual estimated annual percent of Full Demand water deliveries. The correspondence is achieved by first rounding the estimated percent water deliveries from the operations model to the nearest 5 percent. For example, the operations model estimated that canal deliveries in water year 1976 under SED40 would have been 83.9 percent of Full Demand (see Table 1.2-1). Rounding 83.9 percent to the nearest 5 percent results in 85 percent. Then the output from the economic model for an 85 percent water-delivery year is used in the estimate of output, labor income and employment for 1976 for the SED40 alternative.

The figures that follow present the estimated maximum regional economic impact assuming no intra- or inter-district transfers of water. Figure 3.1-4 shows that the estimated annual regional agricultural output of the Project under Full Demand is just over $4.0 billion. Reductions in output follow the pattern of reductions in water deliveries as presented in Figure 1.2-1. Reductions in output occur in consecutive years, ranging in duration from 3 years to 10 years. For example estimates of output under the SED60_WSF alternative in the ten-year period between 1985 and 1995 decline to between $3.9 billion (in 1986) down to a low of $1.7 billion (in 1994). Or conversely in those ten years there is between a 5 percent and approximately 60 percent reduction in agricultural output.

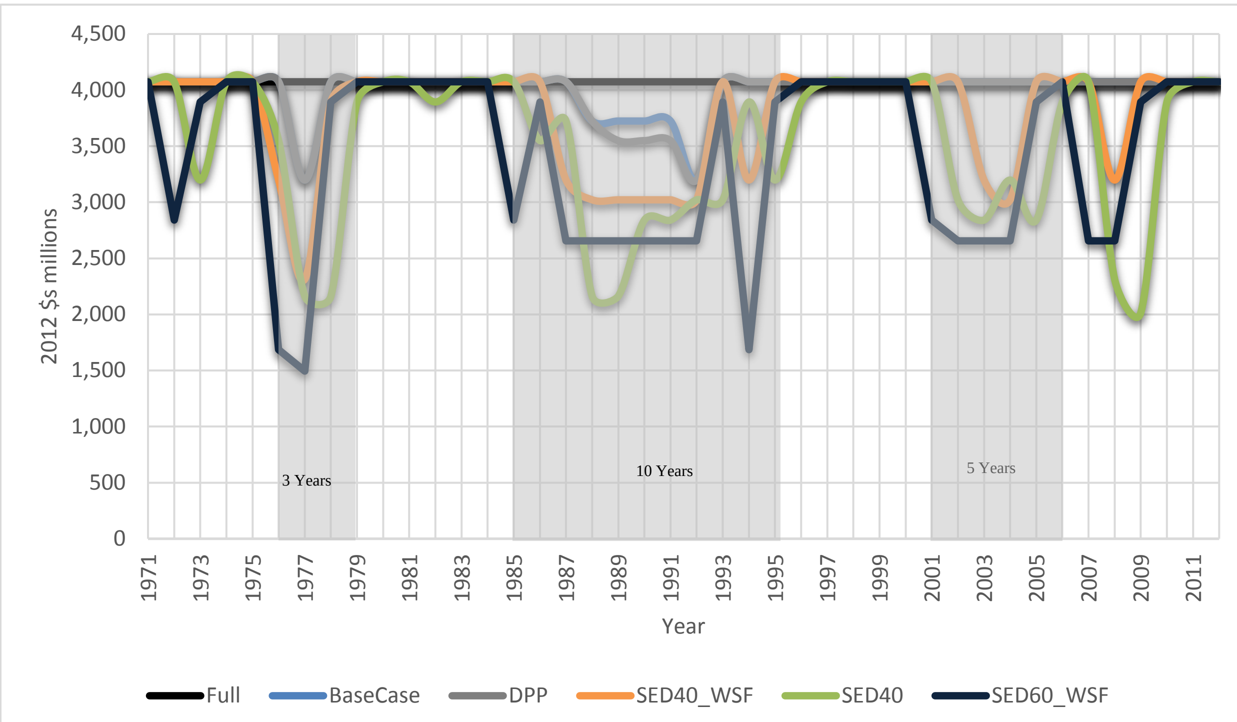

Figure 3.1-4. Estimated maximum annual regional economic output by year, all alternatives.

Figure 3.1-5 summarizes the estimated average annual economic output by water-year types and shows the results as an economic loss calculated by subtracting the estimated economic output under Full Demand from the estimated output for each alternative. Under the DPP estimated output only declines in critical water-year types (by $285 million).

Under the SED40_WSF alternative average output losses occur in below normal, dry and critical water-year types, or 50 percent of the time. Average losses range between $150 million in dry water-year types (4 percent of Full Demand output) to $957 million (23 percent of Full Demand output) in critical water-year types. And since critical water-year types occur in 1 out of 4 years SED40_WSF would see a 23 percent average reduction in output 26 percent of the time.

Under the SED40 alternative average annual losses occur in every water-year type ranging between $200 million (5 percent of Full Demand output) in above normal water-year types to $1.1 billion (27 percent of Full Demand output) in critical water-year types. One in four years (critical water-year types) would see an average 27 percent reduction in output.

Under the SED60_WSF alternative average annual losses occur in every water-year type ranging between $30 million (1 percent of Full Demand output) in above normal water-year types to $1.7 billion (41 percent of Full Demand output) in critical water-year types. One in four years (critical water-year types) would see an average 41 percent reduction in output.

The estimated economic impact to labor income from a reduction in available water supply is greater than the estimated impact to output. Recall that for the minimum economic impact the production value of animal commodities did not decline, rather the shortage in feed crops was assumed to be replaced with imported supply. However, the cost of this imported feed supply is greater than the cost of local grown supply. So the economic impact of increased costs is reflected in the results as a reduction in the profits of animal operations, which results in a reduction in operator's labor income.

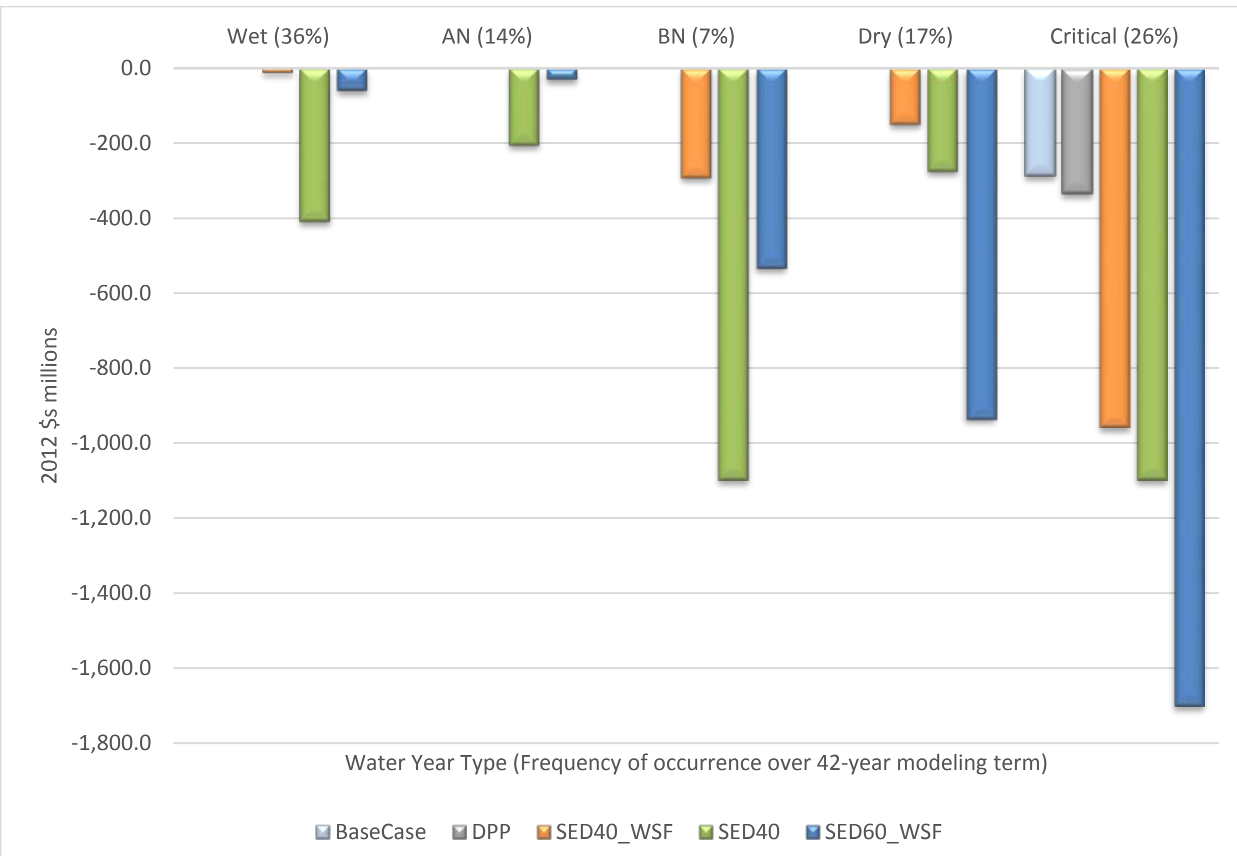

Figure 3.1-5. **Estimated water-year type-average annual maximum regional economic output loss, all alternatives.**

Annual regional agricultural employment, measured as full or part-time jobs, supported with water deliveries from the Project is estimated to be just under 19,000 (Figure 3.1-6). Under all the SED alternatives, the number of jobs lost in water short years estimated to be roughly between 5,000 and 11,000. And, as with output, the employment losses are estimated to occur in 3-year to 10-year consecutive years.

In below normal, dry and critical water year types, under all the SED alternatives, the average annual loss in employment ranges between 50 full and part-time jobs to 7,000 full and part-time jobs (Figure 3.1-7). In critical water-year types, or 25 percent of the time, the number of lost jobs ranges between 4,000 and 7,000 for all the SED alternatives.

The estimated annual labor income for each alternative is presented in Figure 3.1-8 and the estimated loss in average annual labor income by water-year type is shown in Figure 3.1-9

The estimated annual farm-gate revenue for each alternative is presented in Figure 3.1-10 and the estimated loss in average annual farm-gate revenue by water-year type is shown in Figure 3.1-11

The information shown in Figure 3.1-4 through Figure 3.1-11 is the estimated **maximum** regional economic impact of a reduction in water deliveries under the assumption that there are no intra- or inter-district transfers of water. Figure 3.1-12 through Figure 3.1-17 present the same information for the estimated minimum economic impact of a reduction in water deliveries.

There is only one estimate of farm-gate revenues. All of the assumptions about maximum and minimum impacts relate to animal production and agricultural processing, not to on-farm crop production.

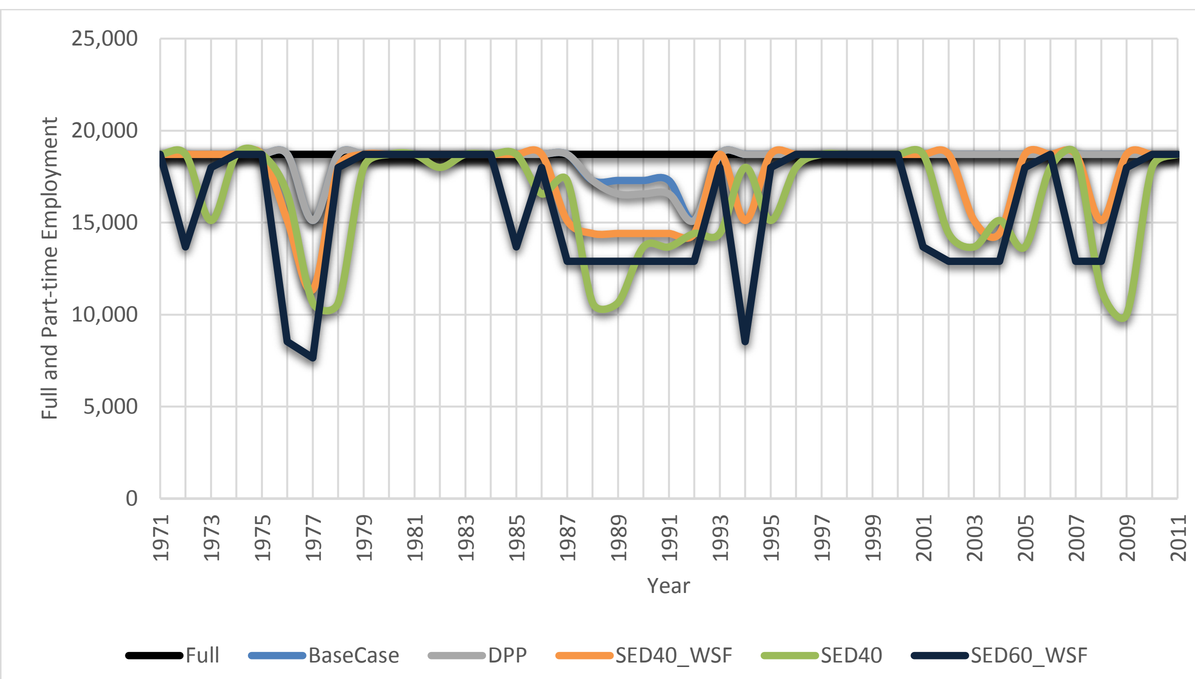

Figure 3.1-6. Estimated average maximum annual regional economic employment by year, all alternatives.

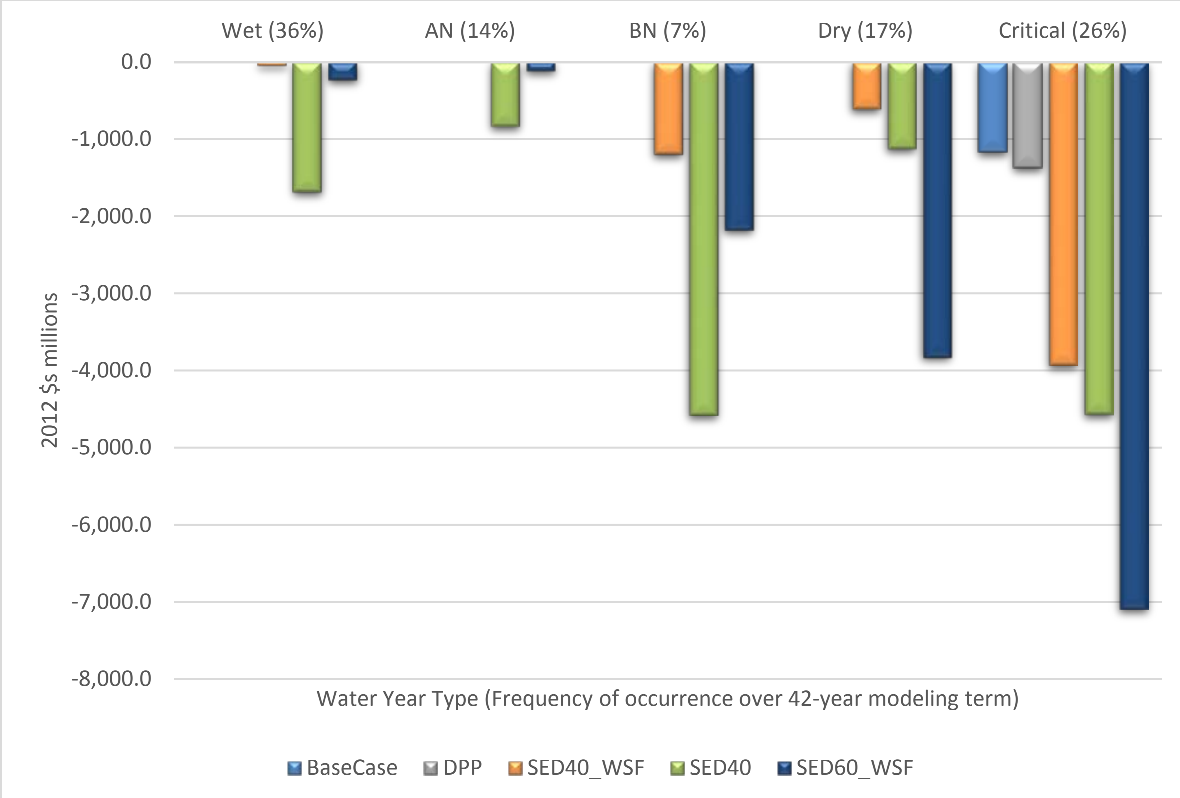

Figure 3.1-7. Estimated water-year type maximum annual regional economic employment loss, all alternatives.

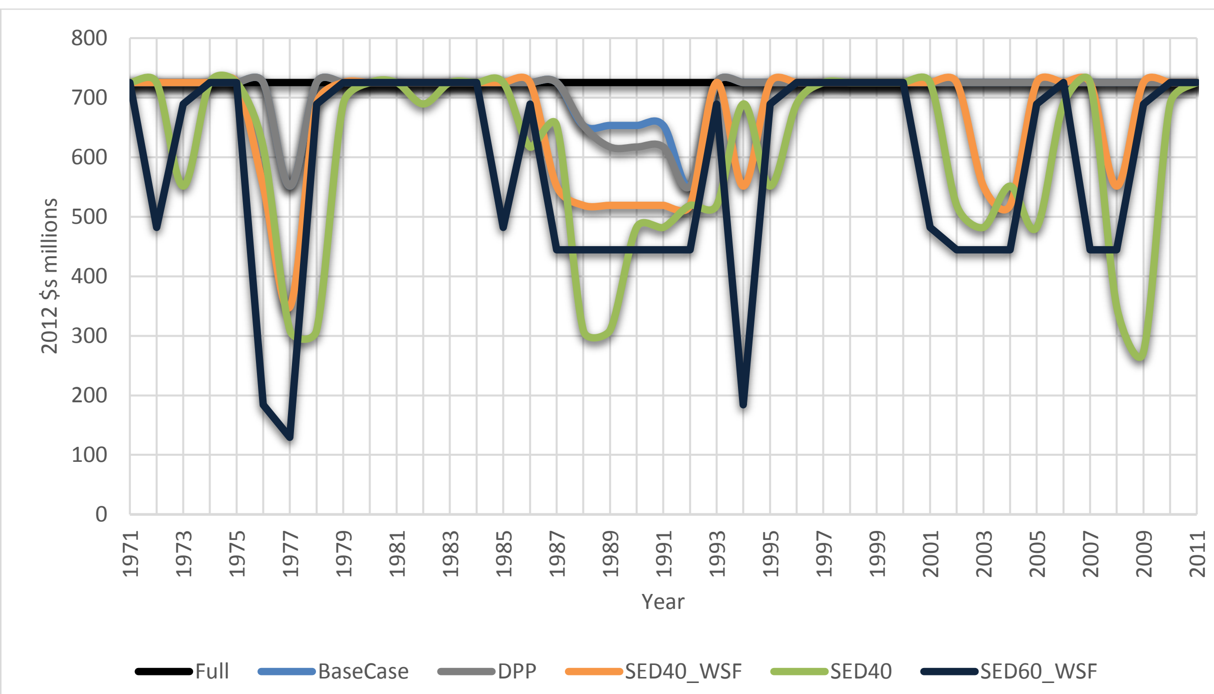

Figure 3.1-8. Estimated average maximum annual regional economic labor income by year, all alternatives.

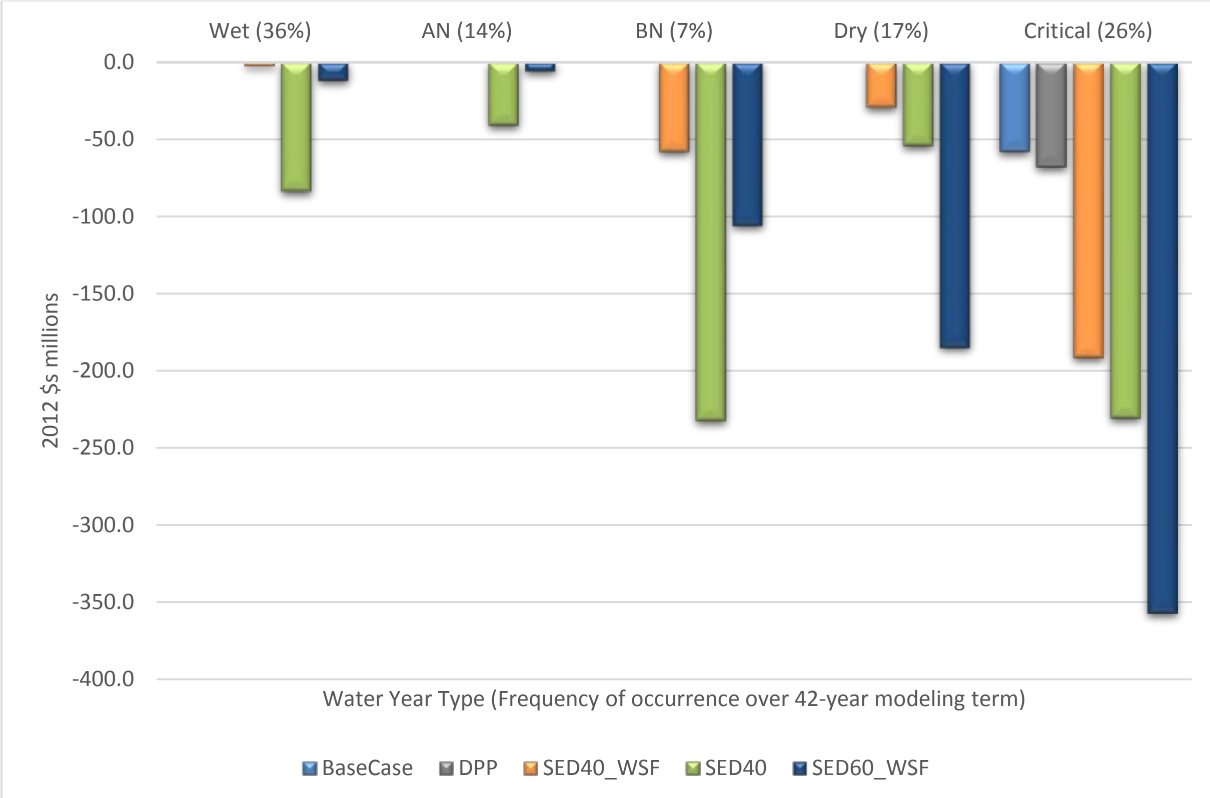

Figure 3.1-9. Estimated average maximum annual regional economic labor income loss by water-year type, all alternatives.

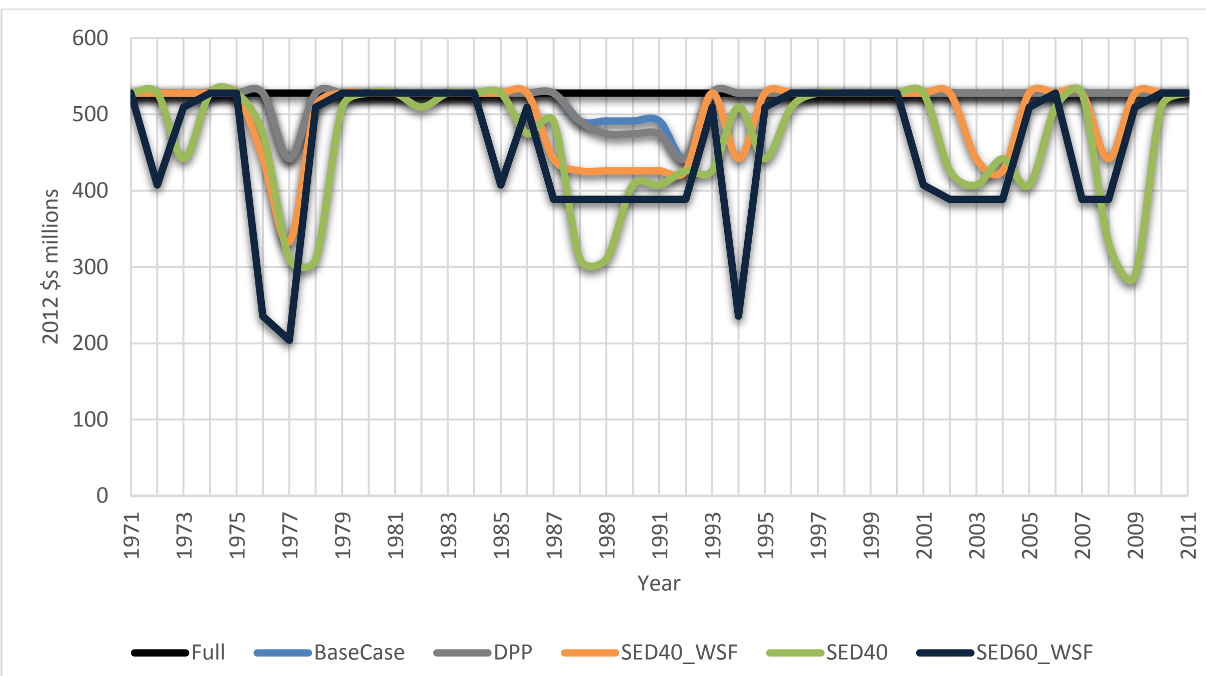

Figure 3.1-10. Estimated average maximum annual farm-gate revenue by year, all alternatives.

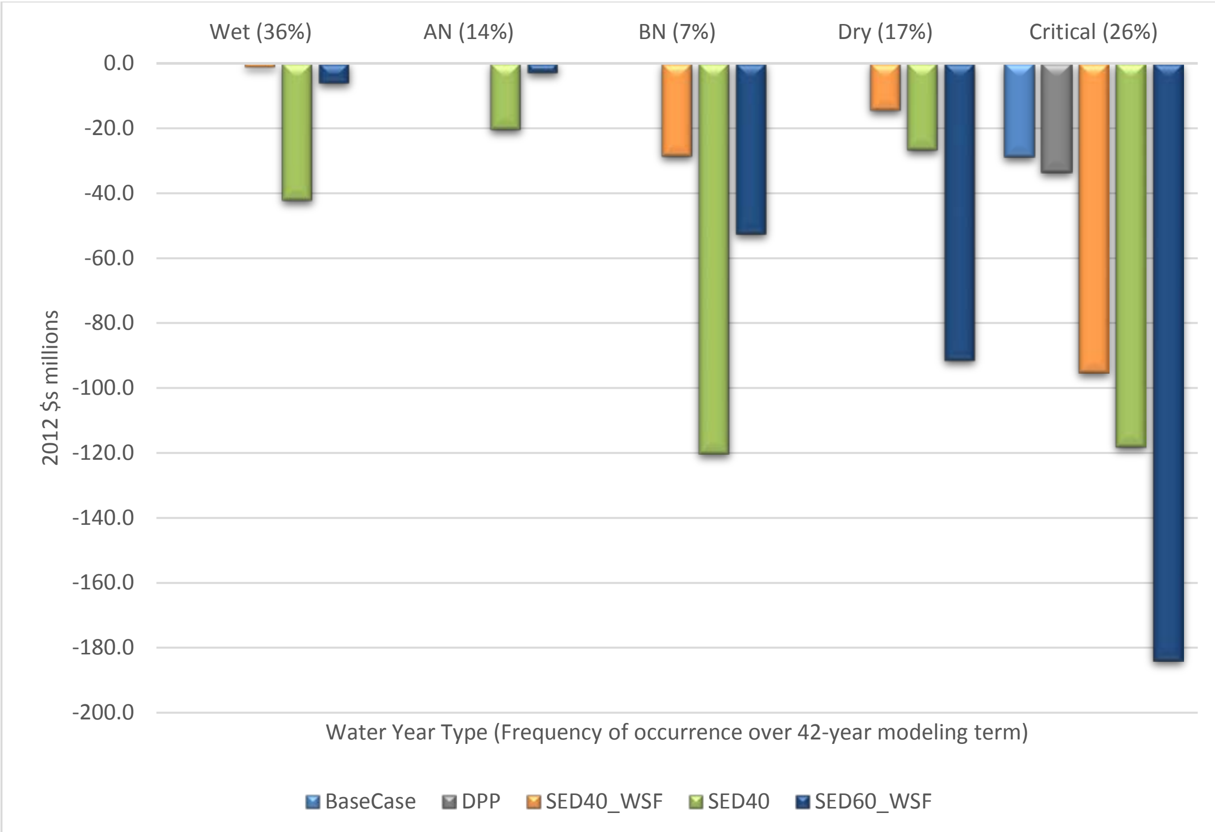

Figure 3.1-11. Estimated average maximum annual farm-gate revenue loss by water-year type, all alternatives.

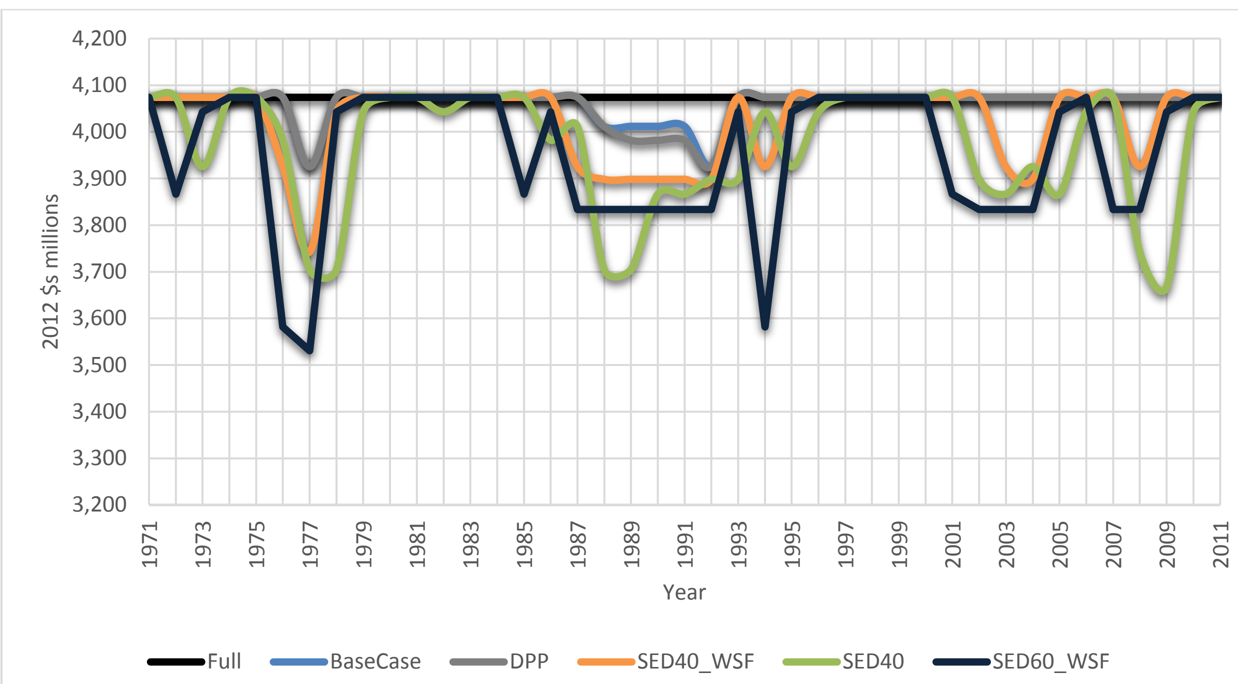

Figure 3.1-12. Estimated minimum annual regional economic output by year, all alternatives.

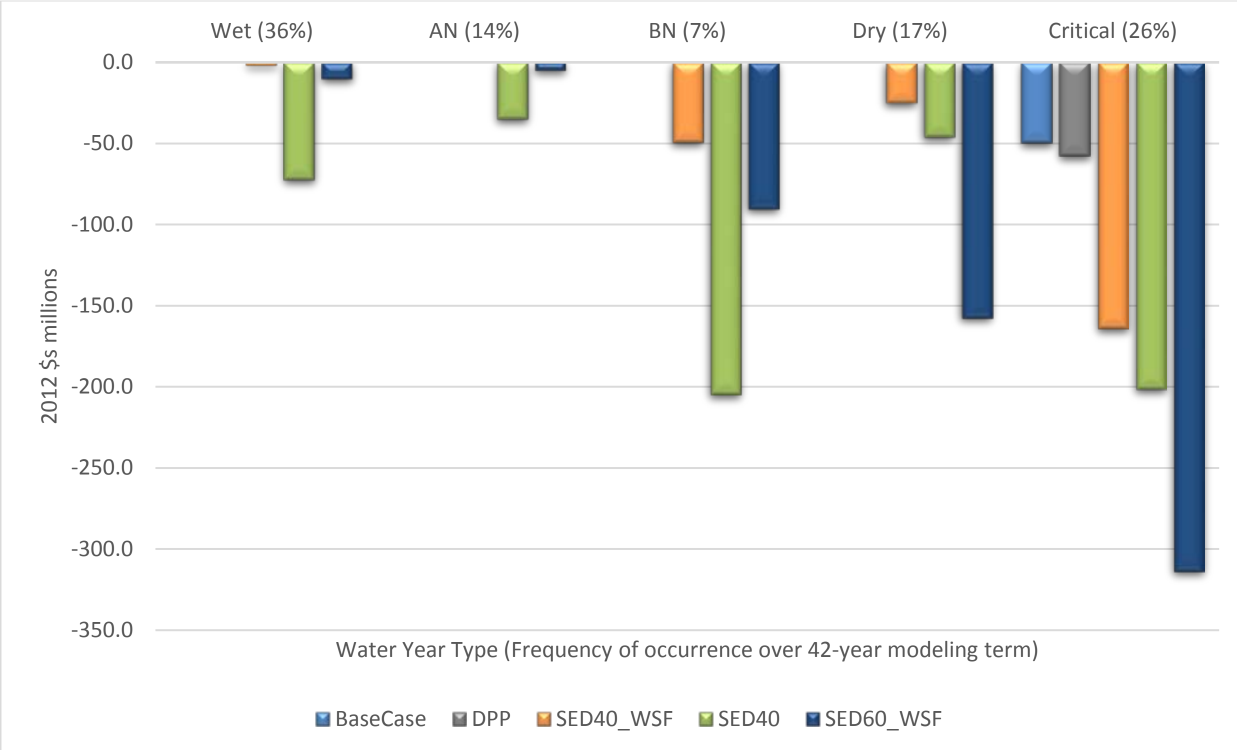

Figure 3.1-13. Estimated average annual minimum regional economic output loss by water-year type, all alternatives.

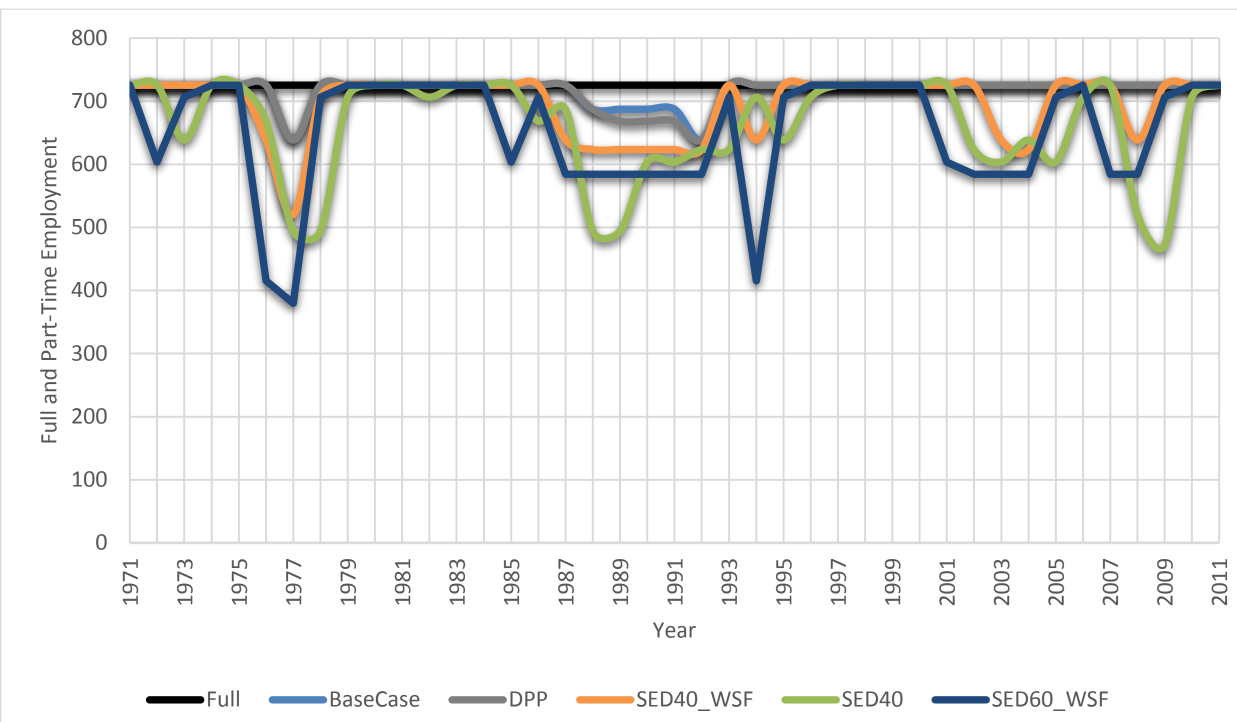

Figure 3.1-14. Estimated average minimum annual regional economic employment by year, all alternatives.

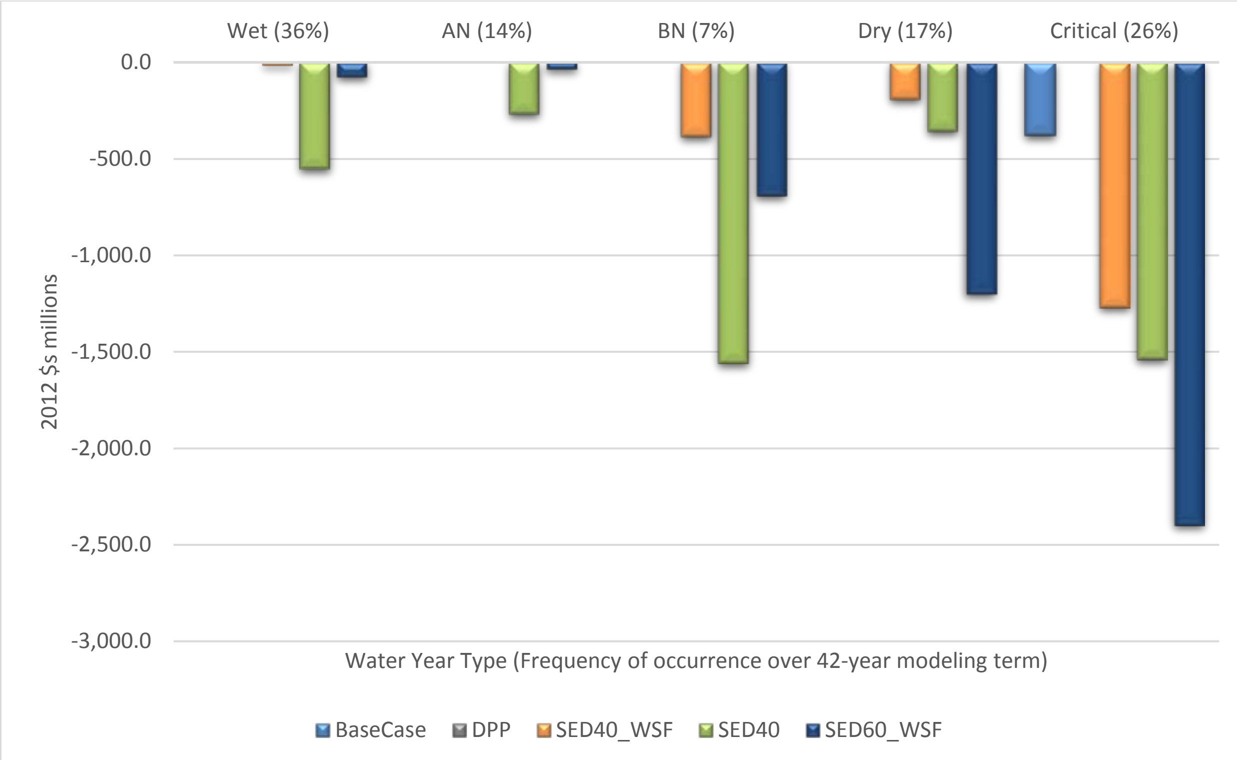

Figure 3.1-15. **Estimated average minimum annual regional economic employment loss by water-year type, all alternatives.**

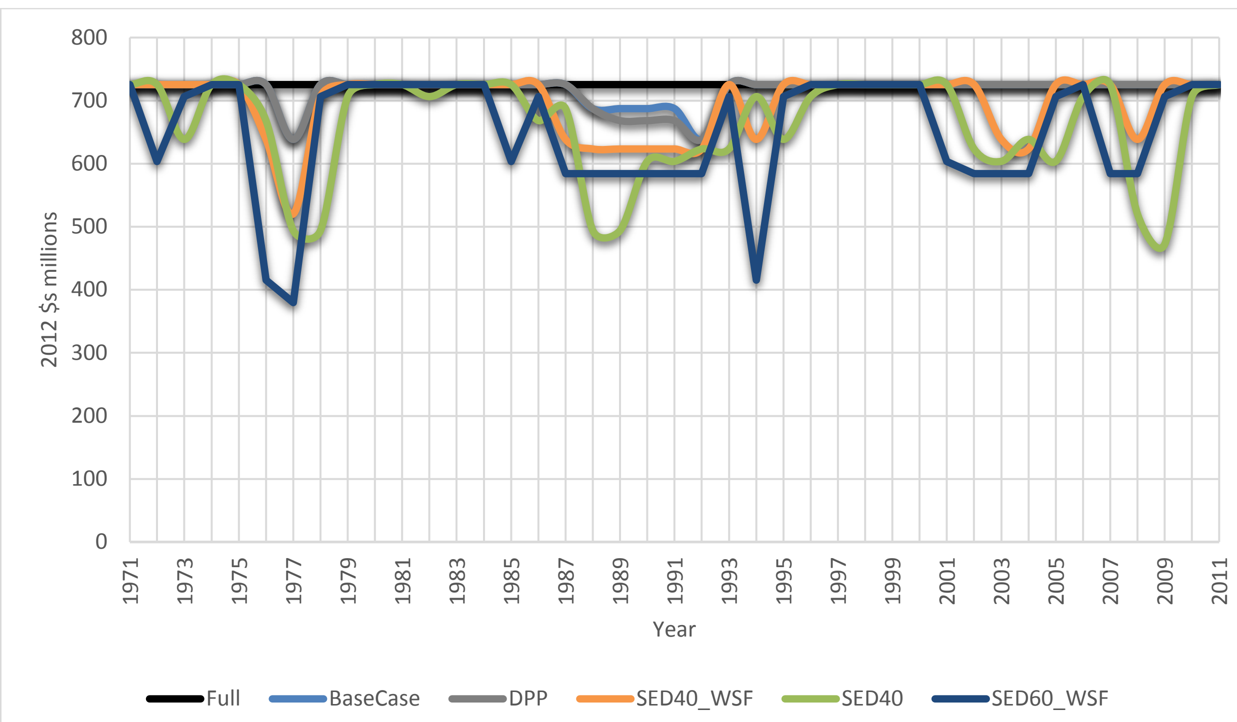

Figure 3.1-16. **Estimated average minimum annual regional economic labor income by year, all alternatives.**

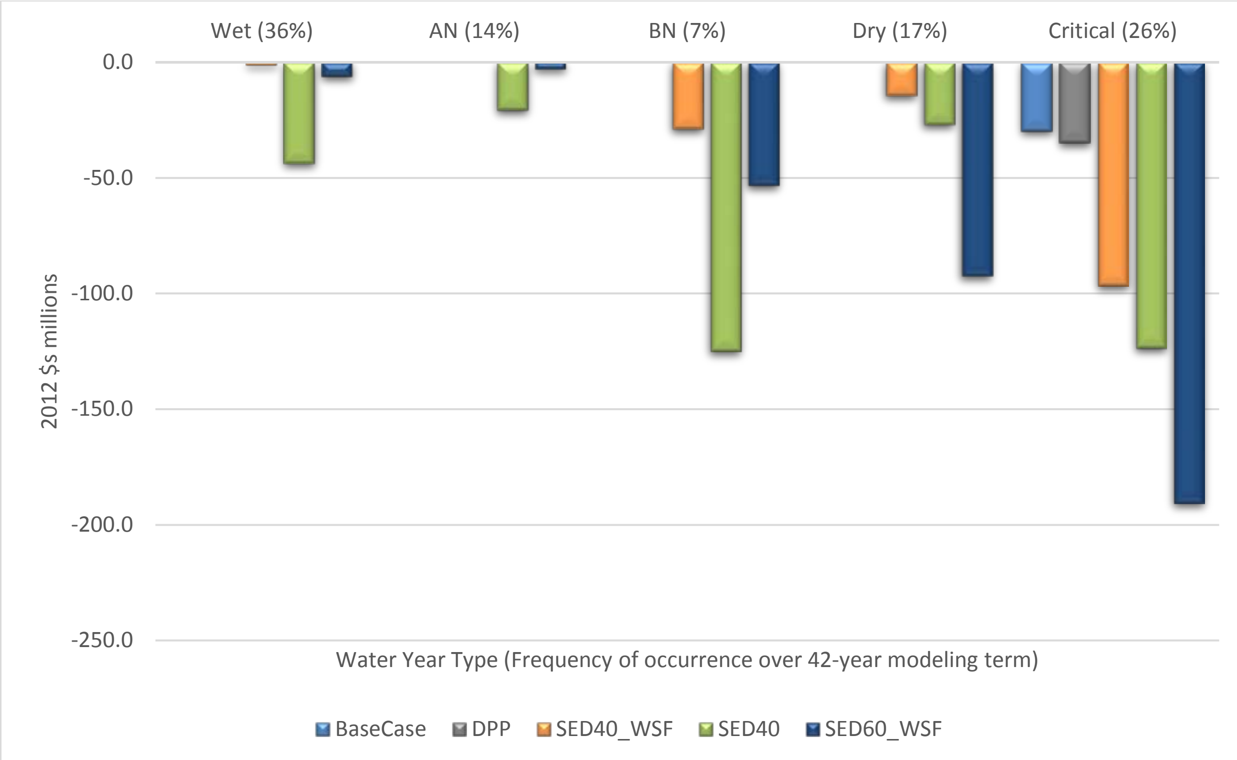

Figure 3.1-17. Estimated average minimum annual regional economic labor income loss by water-year type, all alternatives.

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