

**Direct Economic Impact Analysis of the Cuyama Groundwater  
Basin Groundwater Sustainability Plan Demand Management  
Program**

**Prepared for**

Cuyama Basin Groundwater Sustainability Agency

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**Prepared by**

ERA Economics LLC

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## **1. Executive Summary**

The Cuyama Basin Groundwater Sustainability Agency (CBGSA) has developed a Groundwater Sustainability Plan (GSP) designed to achieve groundwater sustainability in the Cuyama Basin by 2040. The GSP considers several elements of groundwater sustainability including groundwater overdraft. To address groundwater overdraft, the plan proposes a series of supply enhancement projects and demand management actions. Implementation of projects and demand management imposes direct costs on water users in the basin. This analysis establishes the direct economic impact of the demand management actions specified in the GSP. Water supply projects specified in the GSP are described, but the additional water supply and project costs are not included in this economic impact assessment.

Farming in the Cuyama Basin is characterized by high-value, organic specialty crops produced for a wide range of domestic and export markets. The basin includes vertically integrated carrot farming operations, organic specialty apple farms, new vineyards, and a mix of other row crops, grains, and hays. Agricultural value has been increasing in the basin over the last several decades in response to strong market conditions for the crops produced in the basin. This economic activity supports the local economy, providing jobs, income, and tax revenue to the greater four-county region (Kern, Santa Barbara, San Luis Obispo, and Ventura) overlying portions of the basin.

Direct economic impacts of the GSP are quantified using an economic model of the Cuyama Basin representing crops, water use, and market conditions in the area. The economic model is developed using information gathered for the GSP, interviews with local producers, UC Cooperative Extension studies, and various production and price datasets compiled by CDFA and USDA. The economic model is calibrated to the markets, conditions, and water supply availability in the Cuyama Basin. To analyze the effects of demand management, a simulation of Cuyama Basin agriculture between 2020 -2040 is developed in which water availability is restricted, and water supply costs change, according to the demand management actions outlined in the GSP. The differences between the results of the simulation and current conditions represent the impacts associated with demand management implementation.

Current agricultural groundwater pumping in the basin is approximately 60,000 AF per year. The demand management program specified in the GSP includes a phased implementation period to achieve a total reduction in agricultural groundwater pumping of 40,000 AF per year by 2040 (average annual pumping of 20,000 AF). The program applies to regions of the Cuyama Basin where overdraft is deemed to be critical, which is primarily in the Central threshold region. The program is designed to make tiered reductions over a sixteen-year period, beginning with a 5% (2,000 AF) reduction of total overdraft in each of the first two years, followed by a 6.5% reduction of total overdraft annually over the remaining fourteen years.

As a result of the demand management program the size of the agricultural industry in the basin contracts by approximately two-thirds. The demand management results in average annual gross revenue losses of \$30 million. The present, discounted value of this stream of forgone revenue

during the GSP implementation period equals \$261 million in current dollars. When the demand management program is fully implemented in 2040, irrigated acres will have fallen 62%, annual gross revenue will have fallen 63%, and annual water use will have fallen 67%. Land idling as a result of the demand management program (not including any rotational fallowing) equals approximately 12,300 acres per year by 2040. Table ES-1 summarizes the economic impact results in terms of irrigated acreage (land idling), gross revenue, net revenue, and applied water (groundwater pumping).

**Table ES-1. Cuyama Basin Demand Management Program Direct Economic Impact Summary**

<b>Impact Measure</b>	<b>Current</b>	<b>2020 - 2040 Average</b>	<b>Full Implementation (2040)</b>
Irrigated Acres	18,300	12,800	7,000
Gross Revenue (millions)	\$121	\$91	\$45
Net Revenue (millions)	\$31	\$23	\$12
Applied Water (AF)	60,000	40,000	20,000

In addition to a reduction in the quantity of groundwater that can be pumped, the GSP imposes additional administrative costs that increase water costs in the basin. Reduced water availability and higher costs reduce net revenue and affect the relative shares of crops grown in the basin. Typically, lower value crops, including grains and hays in the basin, are significantly impacted because these crops have limited ability and willingness to pay for water. Higher-value vegetables and perennial crops are able to absorb small changes in water cost. However, the magnitude of the demand management program in the basin (reducing pumping by 67%) results in significant losses in these crops as well. As a result, net revenues per acre fall as water costs increase and the basin crop mix shifts towards crops that generate greater returns to water.

The Cuyama Basin economy is heavily dependent on farming and related activities. This (direct) impact analysis only considered the impact of the demand management program on primary farming activities. The average annual losses of \$30 million estimated in this analysis would have significant secondary (also called “multiplier” or “indirect and induced”) effects in the local economy. This includes retailers who sell inputs to producers and processors who handle the raw agricultural products produced in the basin. Local businesses will also see an impact as the individuals who work for farms and ancillary industries are forced to find work elsewhere. Exact quantification of these impacts to regional jobs, labor income (wages), and local tax revenues that support other public services in the area is a natural extension of this direct impact analysis.

Potential options for reducing economic costs are identified in the analysis. Examples include delayed pumping reduction schedules, inter-region water trading, flexibility in pumping reduction schedules, and value-based groundwater allocations. For example, delaying the pumping reduction schedule may allow producers to recover capital investments, avoid rapid changes in the agricultural footprint, and provide jobs, income, and tax revenue for the local economy. Detailed analysis of these options is a second natural extension of this study.

## 2. Introduction

The Cuyama Basin Groundwater Sustainability Agency (CBGSA) has prepared a draft Groundwater Sustainability Plan (GSP). The GSP provides a list of projects and management actions that may be implemented to ensure the basin achieves groundwater sustainability by 2040. Initial estimates indicate that groundwater pumping reductions on the order of 50 to 67 percent may be required to achieve sustainability in parts of the basin. This magnitude of reduction will undoubtedly change the economic conditions within the basin. In order to understand what future conditions in the basin will look like, assess the magnitude of potential economic impacts, and identify ways to minimize adjustment costs, the CBGSA commissioned this economic analysis of the effects the proposed GSP on the basin.

The goal of the CBGSA GSP is to provide a framework for achieving groundwater sustainability while minimizing the economic and social consequences of any necessary reductions in agricultural production. Implementation of the GSP will include possible projects and demand management actions that over time will balance the water budget within the basin. Projects are implemented to increase water supply in the basin. Demand management actions are programs designed to reduce pumping that, together with basin projects, ensure that basin groundwater pumping is sustainable. This report focuses on the impacts of the demand management program; however, preliminary analysis of proposed projects showed relatively small changes in the outcomes presented in this report resulting from project implementation.

This analysis concludes that GSP implementation will have substantial direct impacts on the economic footprint of agriculture in the basin. Results are presented in terms of five key measures of direct impact that are either directly relevant for current policy/planning purposes (e.g. rate studies, feasibility studies, grant applications) or feed naturally into additional analysis of secondary impacts in the basin and local economy:

- Land idling as a result of the demand management program over the 2020 – 2040 implementation period
- Change in crop mix in response to changes in water supply availability and cost, and the resulting effect of the shift in crop mix on basin agricultural value
- The total cost of water and any changes in regional applied water demands; changes in water cost include GSP administration costs, demand management administration cost, and the effect of changes in pumping lift on irrigation variable costs
- Change in gross agricultural returns as a result of land idling, market conditions, and shifts in the crop mix
- Change in net agricultural returns as a result of land idling, water costs, other administrative costs, market conditions, and shifts in the crop mix

The report is structured as follows. The following section describes the current economic footprint of agriculture in the basin and the drivers behind its value. This is followed by an

overview of management actions outlined in the GSP. The next sections present the methods and results of the economic impact analysis of the GSP. A concluding section summarizes limitations and extensions of this initial work. Additional details on the technical approach to the analysis are included in a technical appendix.

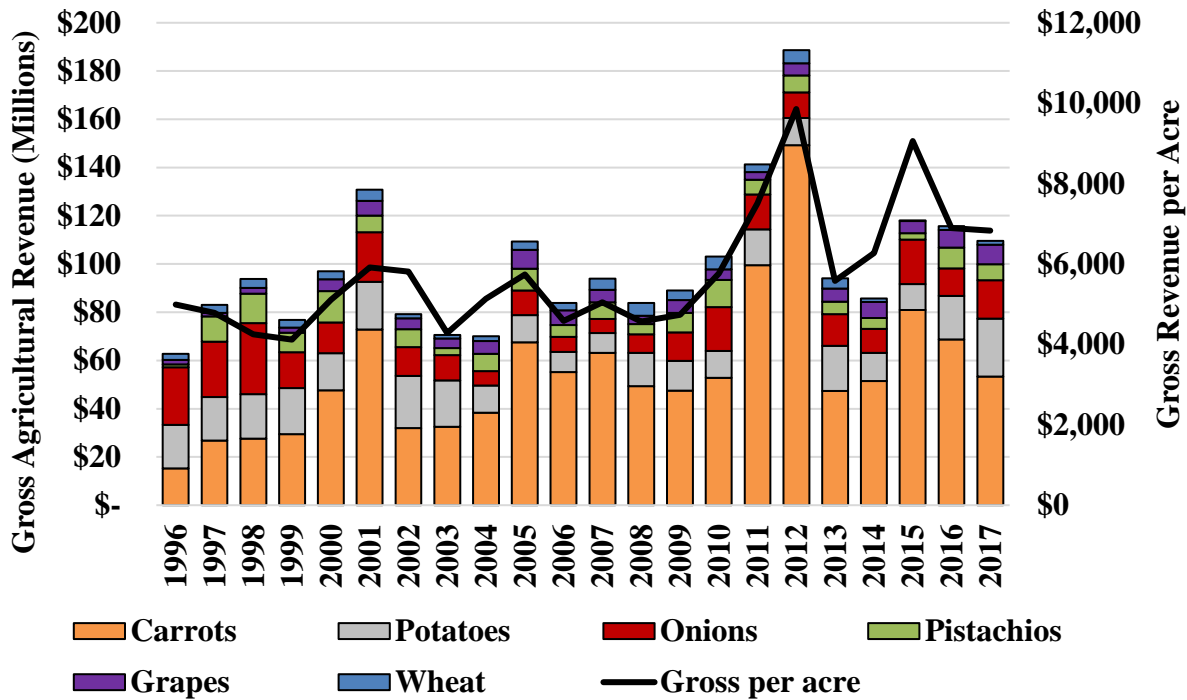
### **3. Economic Contribution of Agriculture**

Agriculture is the most important industry in the Cuyama Basin. Historically the basin has benefited from a large oil and gas field; however, since 2008 few wells have remained in production, making agriculture the dominant industry in the region. Three unincorporated communities in the basin are recognized by the state as Economically Disadvantaged Communities (DACs).

In 2016 the Cuyama Basin had a total of 32,294 acres of irrigable land. Of this total, only 50% (16,045 acres) was actively being used for crop production. High value vegetable crops account for roughly three quarters of the basin's acreage. Carrots, which the basin is known for, are commonly rotated with onions and potatoes. Other crops like wine grapes, pistachios, apples, and wheat make up the remaining agriculture in the region. Apples historically held a larger share of acreage in the basin, but changes in market conditions have caused production to shift to the Pacific Northwest. Other perennial crops such as pistachios and olives have increased in recent years. Wine grape acreage has also increased significantly in recent years, including the establishment of an 800-acre vineyard in 2018.

The gross value (gross farm revenue) of crops produced in the Cuyama Basin was estimated at approximately \$110 million in 2017. Between 1996 and 2017 value increased 75%, from \$63 million to \$110 million. Figure 1 illustrates trends in the gross value of agriculture in the basin between 1996 and 2017, grouped into six crop categories. Carrots make up the bulk of the revenue in the region. In 2017, carrots made up 49% of production value, potatoes made 22% of production value, and onions made up 14% of production value. The remainder of agricultural value came from three smaller crop groups: wine grapes (7%), pistachios and other orchards (6%), and wheat (2%). Figure 1 also illustrates a modest increase in production value per acre, consistent with trends across the state. Production value per acre is similar to nearby production regions in the Central Valley such as Kern County and is well above the statewide average of \$4,000 per acre in 2017 (NASS).

**Figure 1. Production Value and Value per Acre, 1996-2017 (in millions of 2018\$)**



Source: Calculations using USDA National Agricultural Statistics Service and GSP Acreage Data

Positive trends in markets and price, increased yields, and widespread changes in production practices have also benefitted the basin. Carrot yields were 50% higher in 2017 than they were in 1996 with prices being only 10% lower. At the same time, producers have shifted a large share of acreage to organic production. Apple growers raise special fresh market varieties branded with the name of the basin. Grape production has expanded, with over 15 varieties of wine grapes produced for regional wine markets. These investments have created a reputation for Cuyama as a region with high quality agricultural products.

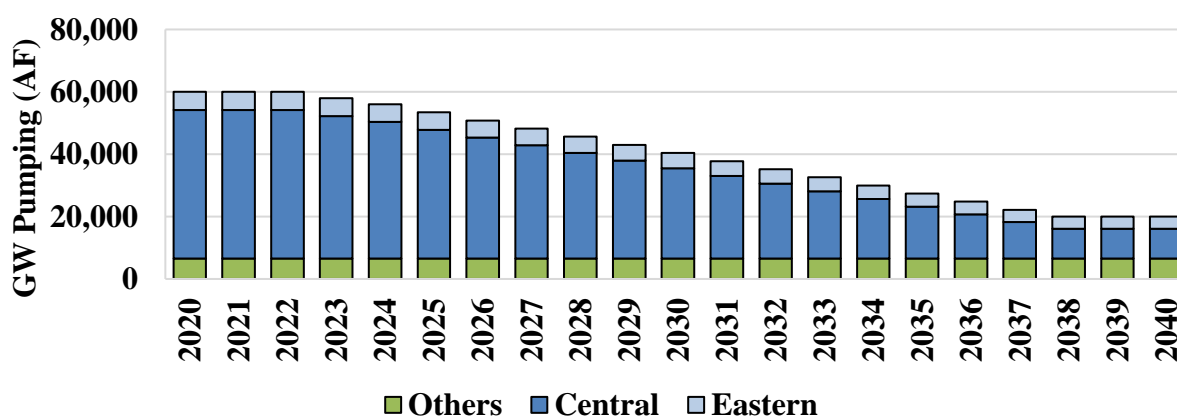
In addition to direct contribution from agricultural revenue, agriculture also provides secondary contributions to the basin local economy and surrounding areas. These indirect and induced benefits include the other income and jobs created by farm spending, additional income and jobs supported by the employed individuals, and the tax revenue created by all of this economic activity. Using default, uncalibrated economic data suggests that basin farming supports more than 1,150 full time equivalent jobs (2,300 – 3,500 seasonal jobs). A detailed assessment of the contribution of basin farming to regional jobs is beyond the scope of this direct impact analysis. A more detailed assessment of the secondary effects of basin agriculture, contribution to the regional economy, and evaluation of secondary impacts is recommended under subsequent analysis (see Section 7).

#### 4. Cuyama Basin GSP Overview

The Sustainable Groundwater Management Act (SGMA) requires that sustainable management of groundwater be achieved by 2040, which is defined as avoiding six impacts of groundwater overdraft. The GSP identifies five sustainability indicators, most of which are expressed in terms of changes in groundwater levels or storage. The basin is divided into six threshold regions<sup>1</sup> for the purposes of identifying and quantifying sustainability criteria. In order to achieve and maintain sustainability, the GSP includes a mix of demand management (pumping restrictions) and supply enhancement projects to bring pumping in balance with the sustainable yield. The sustainable yield is the estimated annual groundwater pumping the basin can sustain without causing one or more of the six impacts. The GSP estimates sustainable yield in the basin to be 20,000 AF per year. Currently, agricultural users in the basin pump 60,000 AF per year creating an overdraft of 40,000 AF<sup>2</sup> per year.

The CBGSA plans to reduce groundwater pumping by 40,000 AF per year by implementing a demand management program. This program will only be implemented in the Central and Eastern regions of the basin, because these are the only regions with projected overdraft. The program is implemented over a sixteen-year period, beginning with a 5% (2,000 AF) reduction of total overdraft in each of the first two years, followed by a 6.5% reduction of total overdraft annually over the remaining fourteen years. Reductions in the Central region will account for 95% (38,000 AF) of overdraft and reductions may be enforced in the Eastern region to make up the other 5% (2,000 AF). This equates to annual reductions in the Central region of 1,900 AF in each of the first two years and 2,470 AF in each of the following fourteen. In the Eastern region, annual reductions of 100 AF are required in each of the first two years and 130 AF in each of the following fourteen. A regional visualization of these reductions is shown in Figure 2 below.

**Figure 2. Proposed Groundwater Pumping Reductions**



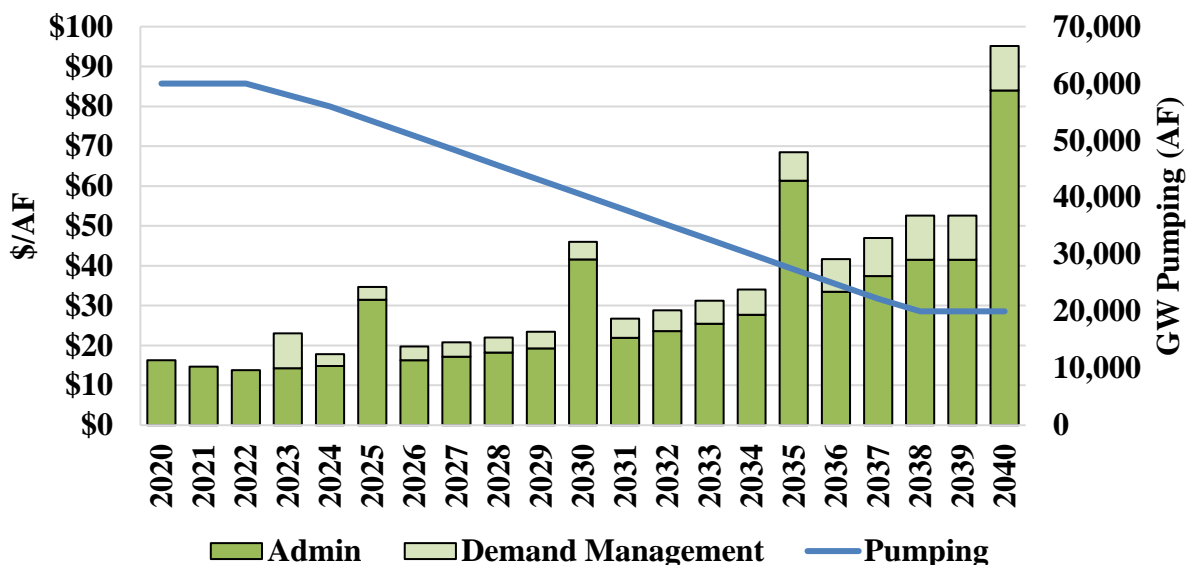
<sup>1</sup> Regions are defined in Section 5.2.1 of the GSP and include the Central, Eastern, Northwestern, Western, Southeastern, and Badlands threshold regions. Most irrigated agriculture is in the Central region. The Badlands regions includes no irrigated agriculture and is excluded from the analysis.

<sup>2</sup> All water quantities shown in this analysis are gross applied water values.



Demand management and GSP administration will impose direct costs on water users in the basin. These costs are calculated over the GSP implementation timeline (2020-2040) and broken down by individual activity. Administrative costs for the GSP plus any demand management program administration costs are approximately \$1 million annually, to be raised by an assessment on each acre foot of groundwater that agricultural users withdraw. These costs include the administration<sup>3</sup> of the GSP and the demand management program, and do not include any additional fees or direct costs associated with the demand management program (e.g. cost of land idling). GSP administration costs are the same for all groundwater pumpers in the basin. Demand management program administration costs would be covered by the Central and Eastern regions. Figure 3 illustrates the timeline of administration costs over the GSP implementation period. Administrative costs range from \$16 to \$90 per AF pumped<sup>4</sup>. This increase is driven by the decrease in total AF pumped in the basin. However, the GSP has not specified a final schedule of fees needed to cover these costs.

**Figure 3. GSP Implementation Costs per Acre Foot Pumped (2018\$)**



### 5. GSP Direct Economic Impact Analysis Methodology

The direct economic impacts of changes in water use and costs caused by the GSP demand management program are estimated using an economic model of basin agriculture and water use. This section provides a brief overview of the economic model and Appendix A provides additional technical details. The economic model calibrates to current market conditions and water use in the basin. It is used to simulate the response of the agricultural sector to changes in groundwater availability and cost imposed by the GSP. The basic assumptions of the model

<sup>3</sup> GSP administration includes annual and 5-year updates, and all required technical analysis, to the GSP to comply with the GSP regulations.

<sup>4</sup> These values do not reflect the total cost to producers to pump groundwater, which also includes the cost of extraction (well capital, operating, and maintenance costs for pumping).

follow standard economic practice. Producers maximize profit by producing the crops that provide the greatest return subject to costs, resources, and other technical constraints. Producers sell to a competitive market and are therefore unable to have much or any effect on the price of the product.

The diverse mix of crops grown in the basin were grouped into six crop categories (groups) for the purposes of the direct impact analysis. Costs and returns for each crop group were defined by the characteristics of a proxy crop chosen to represent all production in the crop group. Proxy crops identified for the analysis include carrots, onions, potatoes, wheat (grains and other misc. hays), pistachios, and grapes. The six crops chosen as proxy crops represent 80% of basin acreage and 84% of basin value. Table 1A in Appendix A summarizes each crop group and proxy crop.

Irrigated acreage in the basin varies from year-to-year due to market conditions, rotations, and variability in weather. The economic model was calibrated to average annual cropping patterns using the period 2010 – 2018. Trends in permanent crop plantings since 1994 were reviewed to assess establishment patterns, and capital outlays for establishment costs. Perennial crops, including pistachios, apples, and olives, have long productive economic life cycles, roughly 40 years, and establishment costs are spread across this life cycle. For a crop like pistachios, recouping establishment costs can be more than 10% of annual production costs. Following an orchard early creates a significant loss in investment, therefore this acreage is less responsive to changes in the cost of water.

Land use and production information was also used to infer (calculate) other technical characteristics of crop production in the basin that are not easily represented in observed farming costs and revenues. For example, factors such as risk aversion, unique soil or microclimate, labor availability, and producer skill/preferences affect regional farming, profitability, and response to changes in water availability and cost. Appendix A provides an overview of how these factors are represented in an economic model, as well as the data used to characterize market supply and demand in the basin.

## **6. Cuyama Basin GSP Direct Economic Impacts**

The economic model is used to estimate the direct effect of the GSP demand management program on agriculture in the subbasin. Direct impacts are a result of reduced water availability (under the demand management program) and higher water costs (as a result of GSP and demand management program administrative fees). As water scarcity increases, the mix of crops grown in the basin adjusts, land idling increases, and farm gross and net revenues fall. All dollar impacts are expressed in constant 2018 dollars, indexed using the GDP Implicit Price Deflator. Economic impacts are expressed in the following terms and summarized in Table 1:

- Gross crop revenue
- Net crop revenue

- Irrigated acreage and changes in the crop mix
- Land idling
- Groundwater pumping costs and the opportunity cost of land idling

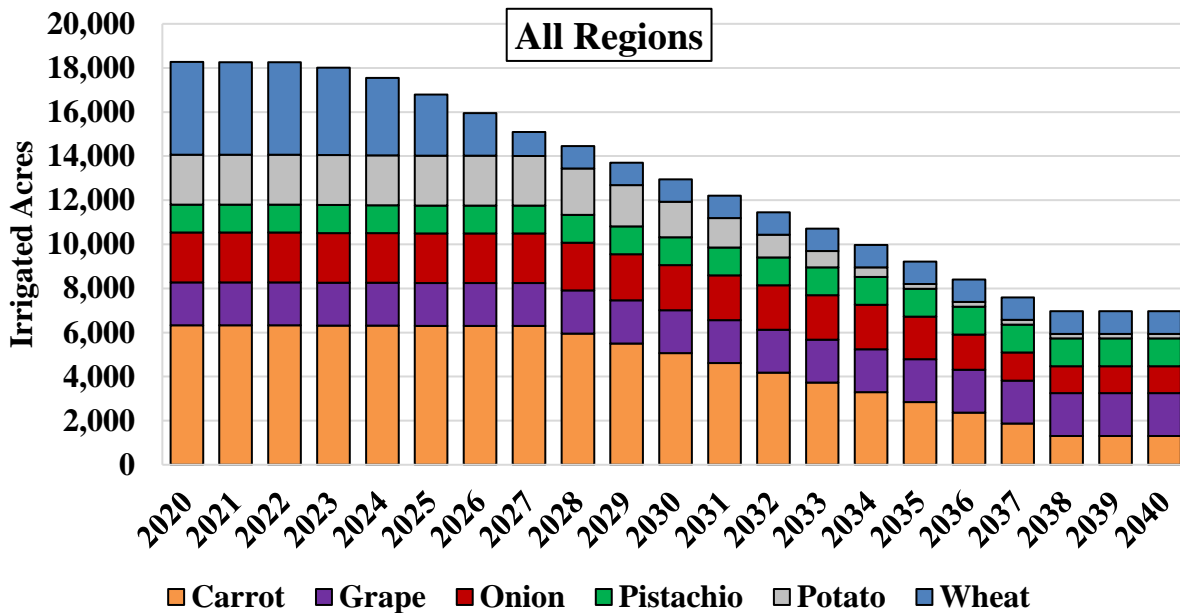
**Table 1. Cuyama Basin Economic Impact Summary**

<b>Impact Measure</b>	<b>Units</b>	<b>Current</b>	<b>2020 - 2040 Average</b>	<b>Full Implementation (2040)</b>	<b>Percent Change (2040)</b>
Gross Revenue	\$M	\$121	\$91	\$45	<b>(63%)</b>
Net Revenue	\$M	\$31	\$23	\$12	<b>(63%)</b>
Irrigated Acres	Acres	18,300	12,800	7,000	<b>(62%)</b>
Land Idling	Acres	0	5,500	11,300	
Applied Water	AF	60,000	40,000	20,000	<b>(66%)</b>
Pumping Cost	\$/AF	\$98	\$110	\$137	<b>40%</b>
Land Idling Cost	\$/AF	\$0	\$263	\$484	<b>-</b>

The costs of the demand management program to the basin are estimated to average \$30 million per year, increase nonlinearly over time, and will reach \$76 million per year in 2040 at full implementation. This is a 63% decrease in farm revenue over current conditions. These changes are non-linear, reflecting the phase-in period of the demand management program with small annual changes at the beginning of implementation and large annual value differences near the end of implementation. The present, discounted value of this stream of forgone gross revenue during the implementation period equals \$261 million in current dollars. This revenue loss is a result of the land idling that occurs as groundwater pumping is gradually reduced.

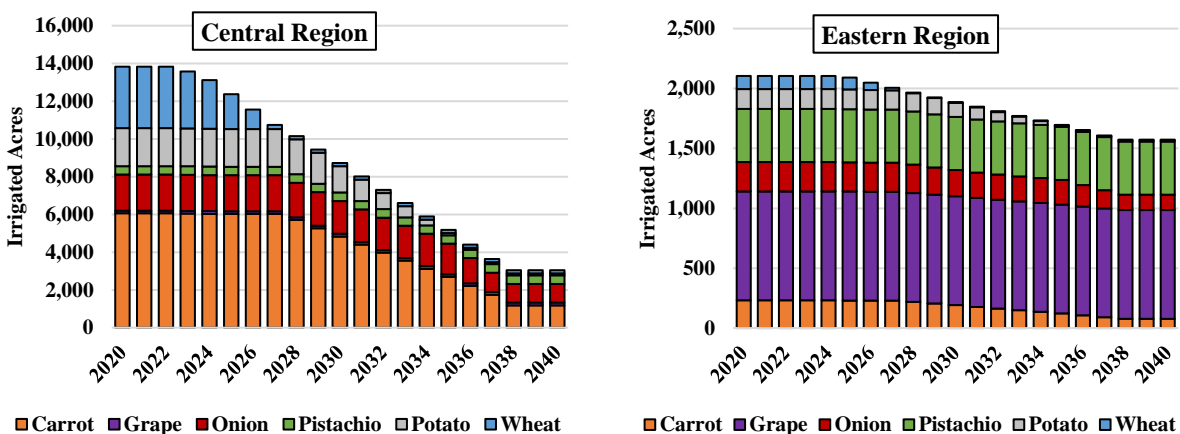
Total irrigated acreage in the basin declines from 18,264 acres to 6,960 acres, with significant changes occurring in the Central and Eastern regions. Under the demand management program specified in the GSP, by 2040 the Central region is only expected to have 3,048 acres in production, 22% of its current acreage. In the Eastern region, where demand management is more modest, there is an estimated 1,572 irrigated acres by 2040, or about 75% of its current acreage. Changes in permanent crops are more modest due to the significant capital investment in these lands. Most of the acreage decline comes from the carrots, other vegetables, rotational crops, and wheat/hay crop groups. Figure 4 illustrates changes in acreage by year for the entire basin. Wheat acreage is most affected early, followed by carrots and potatoes which begin to decline in about 2028.

**Figure 4. Estimated Acreage by Crop Group, 2020-2040**



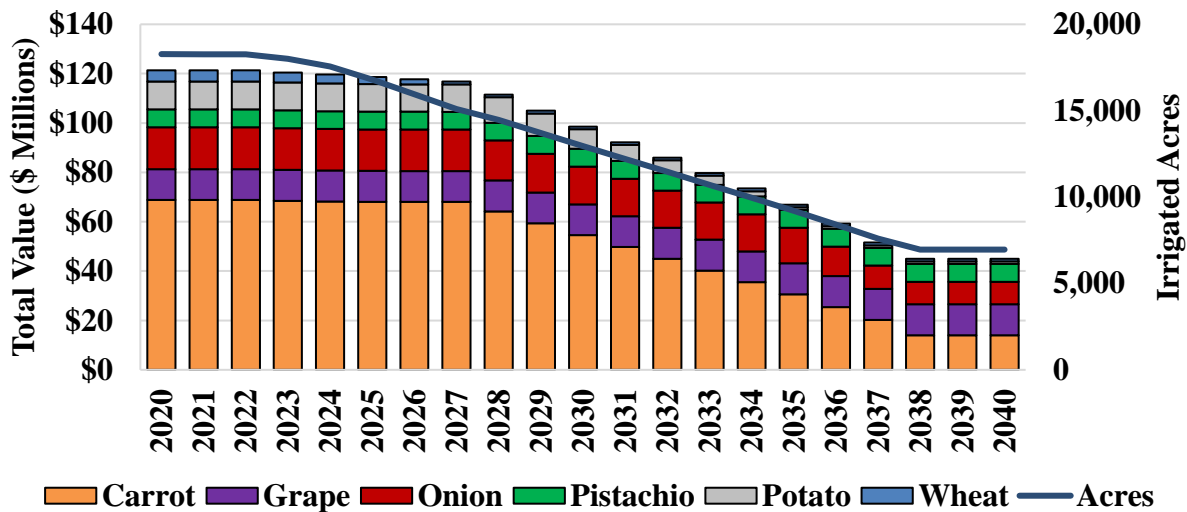
All basin crops are affected as water use is reduced, but the impact is not distributed evenly across crops, or across threshold regions in the basin. Carrots decline the most by 2040, dropping from 35% of basin acreage today to less than 18% by 2040. This is because carrots (and other rotational crops) account for a significant share of current groundwater pumping in the Central region. The reduction in grain/hay (wheat crop group) acreage is more modest, falling by around 33%, because much of its irrigated area is not in the Central and Eastern regions subject to the demand management program. Wheat acreage within the Central region falls by 95%. The share of permanent crop acreage in the basin increases from 18% to 46% by 2040, not because more acreage is planted, but rather because acreage remains more stable as other crop acreage declines. Figure 5 illustrates the change in crop mix in the Central and Eastern regions.

**Figure 5. Estimated Acreage by Region and Crop Group, 2020-2040**



While annual declines in acreage remain somewhat constant during the GSP implementation period, the decline in value of production is modest in early years but becomes more significant later. In response to higher water costs and increasing scarcity, lower return (low value per unit water) crops are typically idled first. Figure 5 illustrates the decline in value (gross revenue), which is initially small, but increases rapidly as progressively more valuable crops must be taken out of production. By 2040, carrots are still the highest-value crop in the region, however the share of total value is spread much more evenly across crop groups. A reduction of this magnitude in irrigated acreage in the basin would have additional impacts on farming operations. In particular, the ability to maintain a minimum viable industry scale is not guaranteed. Vertically integrated farming operations may consider moving production to other regions in the state, and this would have additional impacts in addition to the direct impacts shown in Figure 6. These secondary impacts can be evaluated under subsequent analyses.

**Figure 6. Estimated Value by Crop Group, 2020-2040 (in millions of 2018\$)**



Net farm revenues in the basin are also affected as a result of reduced acreage, changes in water costs, yields, and cultural practices. For example, pumping limits could cause some growers to invest in technology to optimize water<sup>5</sup> and other input use efficiency. Table 2 below summarizes changes in average net revenue per acre by crop group under current conditions (2020) and at full implementation of the demand management program (2040). Net revenues are based on basin average returns and correspond to the return over operating costs (not including any amortized capital costs). On a percentage basis, the decline in net revenue per acre is largest for wheat, grapes, and potatoes. In contrast, carrots, onions, and pistachios decline by less than 2 percent. Total net revenue declines by 63 percent from \$31 million to \$12 million.

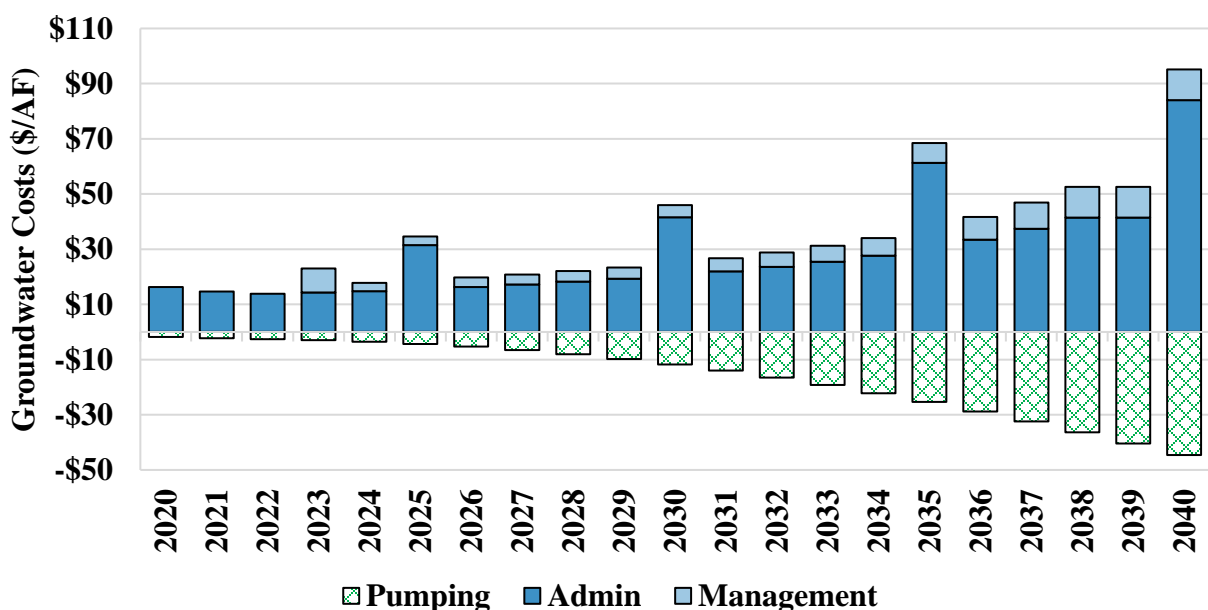
<sup>5</sup> Pumping reductions specified in the demand management program are expressed in terms of applied water, and therefore account for any return flows. An improvement in water use efficiency only adds groundwater to the basin if it reduces crop consumptive water use.

**Table 2. Change in Net Revenue by Crop Group, 2020-2040 (2018\$)**

	Carrot	Grape	Onion	Pistachio	Potato	Wheat
<b>Per Acre Change</b>						
2020	\$2,680	\$755	\$2,455	\$2,615	\$1,260	\$375
2040	\$2,635	\$720	\$2,410	\$2,570	\$1,210	\$355
<b>Change</b>	<b>(1.6%)</b>	<b>(5.1%)</b>	<b>(1.9%)</b>	<b>(1.7%)</b>	<b>(3.7%)</b>	<b>(5.4%)</b>
<b>Total Change (millions)</b>						
2020	\$16.8	\$1.5	\$5.5	\$3.3	\$2.8	\$1.5
2040	\$3.3	\$1.4	\$2.9	\$3.2	\$0.3	\$0.4
<b>Change</b>	<b>(80.4%)</b>	<b>(6.7%)</b>	<b>(47.3%)</b>	<b>(3.0%)</b>	<b>(89.3%)</b>	<b>(73.3%)</b>

As the GSP demand management program is implemented, the cost of water per AF changes for two reasons. First, the cost of GSP implementation (administration for the GSP and the demand management program) is spread over smaller volumes of pumped water, so the cost per AF rises. Second, reduced pumping improves groundwater storage and reduces depth to water. Changes in pumping depths are estimated using the relationship between historical overdraft and depth to groundwater as reported in the GSP. These two effects somewhat offset and are presented for the Central region in Figure 7 below. The GSP administration (admin) and demand management program administrative (management) costs are shown as positive values, and the cross-hatched areas represent the reduced pumping lift and cost (shown as a negative cost savings). The net effect of the GSP demand management program is an increase in the cost of groundwater to irrigators in the basin.

**Figure 7. Estimated Groundwater Pumping Costs, Central Region**



In addition to the changes in water costs, groundwater pumpers in the basin also incur a cost per acre foot of forgone net revenue, otherwise known as the opportunity cost. This opportunity cost is equal to the loss in net revenue as a result of land idling and changes in crop mix divided by the quantity of groundwater pumped. Therefore, this cost increases over the implementation period for two reasons. First, the quantity of water pumped is reduced as the demand management program is implemented. Second, the cost of land idling increases with the magnitude of the demand reduction as increasingly more valuable land/crops are removed from production (see Figures 4 and 6, above). The net effect of the demand management program is an increase in land idling, which is reflected in increasing groundwater cost (see Figure 7).

**Figure 8. Estimated Opportunity Cost of Implementation, Central Region**

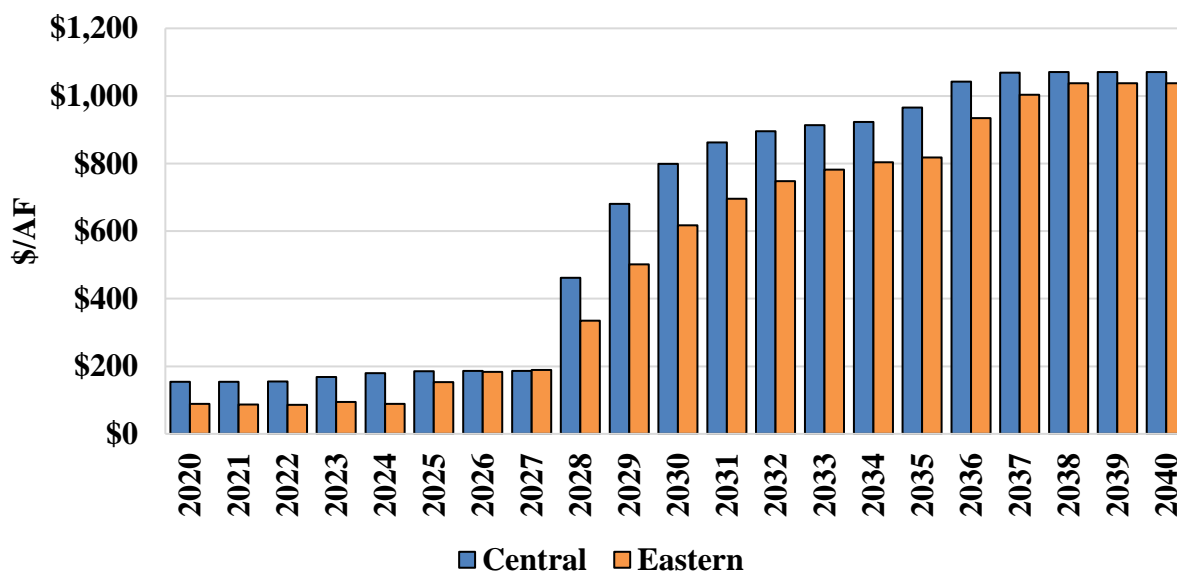


The value of water in different regions of the basin increases significantly as the demand management program is implemented (scarcity increases). The increasing value of water is important for broader planning purposes, in particular comparing the benefit of avoiding additional demand management against the cost of implementing capital water supply projects in the basin. The incremental value of water is the value in production of one additional AF of water. The value of an additional AF is not to be confused with the price or cost of water, rather it is the incremental benefit that the basin would receive if another unit of water was available. This value can also be thought of as the amount a producer would be willing to pay for one additional unit of water.

The incremental value of water is calculated using the economic model over the implementation period. The value varies by region in responses to difference in the economic return to water across the basin and is greatest in the Central and Eastern regions. Figure 9 illustrates values in these regions over the implementation period. A notable change in water value occurs between 2027 and 2028. This is the point during the GSP implementation period when the required

groundwater pumping reduction starts to affect higher-valued annual crops (e.g. carrots, other vegetable crops). That is, many of the crops/land that generates lower return to water has already been idled. By 2040 the incremental value of water exceeds \$1,000 per AF in both the Central and Eastern regions. This value likely exceeds the current average return to water for many crops and growers – instead it represents the most valuable use of new water after the cuts imposed by full implementation of GSP demand management. The incremental value of water is below \$200 per AF in the other regions that are not affected by the demand management program. These values are generally comparable, slightly above, values observed in other agricultural areas in the state.

**Figure 9. Incremental Value of Additional Water, Central and Eastern Regions (2018\$)**



The net effect of the GSP demand management program and associated GSP administrative costs is a reduction in the economic footprint of basin agriculture by more than two-thirds. This would have profound effects on the basin local economy, and the broader regional economy. Impacts increase non-linearly over the implementation period, equaling \$73 million per year by 2040, or over \$261 million in present value over the implementation period. The incremental value of water under the demand management program exceeds \$1,000 per AF at full implementation, suggesting that some water supply projects may be an economically feasible way to reduce overall implementation costs. Additional suggestions for reducing demand management program implementation costs are summarized under Section 7, below.

## 7. Other Considerations, Limitations, and Extensions

Quantification of direct impacts supports GSP implementation planning, however consideration of elements outside of the scope of this analysis may be equally important in protecting broader welfare considerations for basin growers, workers, and disadvantaged communities. This section provides a brief discussion of other considerations that were raised by stakeholders during



interviews and meetings. These include limitations and scalability of the economic model, multiplier effects (the indirect and induced impacts resulting from the direct impacts), and resource and environmental externalities (third-party costs) created or mitigated by agriculture in the basin.

The economic model used here is based on and calibrated to recent information on agricultural production in the basin. To the extent that projected conditions fall far outside what has been recently observed, the model may not capture all the impacts. A reduction in gross economic value as great as the one projected in this analysis may cause changes that the model is not able to forecast. For example, viable farming operations require a minimum scale to continue operating, which may be approached or exceeded under the demand management program. Additionally, acreage is concentrated among a few producers in a relatively small area in the basin. As a result, this may cause sudden changes rather than the gradual shifts projected in the model.

The economic analysis used estimates of projected pumping reductions described in the GSP that are based on the best available data and information as of June 2018. As noted in the GSP, it is expected that the groundwater model will be refined in the future as improved and updated monitoring information becomes in the Basin. These refinements may result in changes in the sustainable yield estimates included in the GSP and consequently would affect the results of this economic impact analysis.

A natural extension to the analysis provided here would be a multiplier analysis of indirect and induced (secondary) economic impacts. However, off-the-shelf impact multiplier models often prove to be inadequate for estimating indirect and induced impacts in small regions undergoing large changes. They do not incorporate site-specific information on labor and production practices or on relationships among sectors. In addition, such models assume proportionality between direct and indirect impacts and cannot assess the effect of major structural economic changes. A careful and policy-relevant analysis of the total impact this type of shift would require more detailed information on the labor practices within the basin, dependence of forward-linked industries (e.g., processors) on products from the basin, and the dependence of related industries on economic activity generated by agriculture in the basin. The CBGSA is currently evaluating options to commission this additional analysis.

Finally, this analysis does not assess changes to environmental, natural, and cultural resources within and outside the basin. These changes create both economic and non-economic costs and benefits. Changes include but are not limited to improved water quality, preservation or loss of open space, and cultural and social changes that could result from population leaving the basin. These externalities associated with groundwater pumping in the basin are an additional consideration in overall basin sustainability.

The current demand management program is a conservative approach to achieving sustainability in the basin. Future analysis could explore policy alternatives to the demand management program that reduce the direct economic impact of implementation in the basin. Examples of possible value enhancing policies identified through this analysis include the following:

1. Cuyama Basin sustainability is specified in the GSP terms of physical objectives – avoiding six undesirable results of groundwater overdraft. Meeting these objectives is only possible if pumping is reduced, resulting in economic impacts for the basin. A seventh sustainability indicator, economic viability of the basin, could be considered. Delaying the pumping reduction schedule may allow producers to recover capital investments, avoid rapid changes in the agricultural footprint, and provide jobs, income, and tax revenue for the local economy. This would come at the cost of additional depletion of groundwater storage, but the benefits may outweigh any costs.
2. The economic analysis shows that there is intra- and inter-regional variability in the value of water. This suggests there are potential gains from trading (allowing water to move to its highest and best use). An inter-region water trading program that allows groundwater to be transferred between regions would allow for water to move from lower to higher value uses, providing benefits to both buyers and sellers.
3. The pumping reduction specified in the demand management program is linear. That is, the same percentage reduction is applied every year regardless of conditions in the basin. A dynamic pumping reduction schedule that allows producers to react to market and weather trends could be considered to lower costs. For example, allowing flexibility for growers to increase pumping above the sustainable yield in years with high prices or decreased rainfall, so long as it is replenished in future years, could mitigate some of the losses associated with demand management.
4. The concept of groundwater allocations is implicit to this analysis. That is, the demand management program requires a pumping quota which would include assignment of allocations (how much individuals can pump). How allocations are developed and assigned affects the distribution of costs between groundwater pumpers as well as the overall implementation costs to the local economy. A careful economic analysis of alternative allocation approaches using the framework applied in this analysis could identify ways to reduce GSP implementation costs.

Analysis of value enhancing policies could benefit from further analysis of indirect and induced effects of demand management implementation. Growers purchase inputs from regional suppliers, employ workers, and rely on local trucking, storage, processing, and related businesses for post-harvest activities. Transportation, storage, processing, and other businesses purchase trucks, warehouses, machines, and hire workers required for their operations. The economic cluster of agriculture-dependent industries generates jobs in farming and other industries, and employees in all these related industries purchase housing, consumer items, and other goods and services in the basin and regional economy. Quantifying these relationships would provide data

and information to mitigate losses associated with GSP implementation and ensure that GSP implementation is not only efficient, but also equitable.

## **8. Appendix A: Economic Model Technical Overview**

This appendix summarizes the agricultural economic model of the Cuyama Basin that was applied to analyze the direct agricultural impacts of reducing groundwater pumping and, or, other supply augmentation projects, as discussed in the Cuyama Basin Groundwater Sustainability Plan (GSP). The following sections summarize model calibration and application to this analysis.

### **8.1 Cuyama Basin Economic Model Overview**

The Cuyama Basin model is a regional agricultural production and economic optimization model that simulates the markets for Cuyama Basin crops. It applies the same calibration methodology and economic approach as the Statewide Agricultural Production model (SWAP), which has been subject to peer review and applied to a range of water and agricultural impact analyses in California over the last several decades (Howitt et al. 2012).

The fundamental economic logic underlying the Cuyama Basin model is as follows. Crops are produced in competitive input and output markets. That is, no individual grower/operation can affect or control the price of any commodity. The model simulates inputs, costs, returns, water supplies, and other farm inputs, subject to water availability (e.g. the demand management program) and water costs (e.g. GSP administrative costs).

Agricultural production in the Cuyama Basin is solely dependent on groundwater. As conditions change within a Cuyama Basin region (e.g., a reduction in the amount of groundwater that can be pumped), the model optimizes production by adjusting the crop mix, water quantities used, and other inputs. It also fallsow land when that appears to be the most cost-effective response to resource conditions. The model can be extended to compare the long-run response of agriculture to other conditions affecting surface or groundwater conditions, markets, or other economic values or restrictions in the Cuyama Basin.

### **8.2 Model Calibration**

The model calibrates using a procedure based on Positive Mathematical Programming (PMP) (Howitt 1995) and the assumption that crops are produced in competitive markets. This allows incorporating information on the local market conditions (factors that affect supply and demand), allowing the model to exactly replicate a base year of observed input use and output. Conditions include a mix of management skill, inter-temporal effects of crop rotation, proximity to processing facilities, management skills, farm-level effects such as risk and input smoothing, and differences in soil and other physical capital/inputs. Model calibration translates these factors, in addition to observed average conditions, into an economic representation of production (supply) and market demand conditions (Howitt et al. 2012).

On the crop demand side, the model is specified with downward-sloping California statewide demand functions. That is, the model is specific to the Cuyama Basin but recognizes that Cuyama Basin farmers compete in the statewide (and global export) market for crops. The

demand curve is estimated from historical data on crop prices and quantities that reflects the consumer's willingness-to-pay for a given level of crop production.

### 8.2.1 Cuyama Regions and Crop Definitions

The Cuyama Basin model is modeled with five of the six regions defined in the GSP: Central, Eastern, Northwest, Southeast, and Western. Of the five regions modeled, the Central region accounts for nearly 80% of all agricultural acreage and is the only region subject to major changes in the GSP (e.g. the demand management program).

The economic model calibrates to average land use between 2010 and 2018. Crops are aggregated into 6 crop groups. Each crop group may represent several individual crops, but many are dominated by a single crop. Irrigated acres represent acreage of all crops within the group, production costs and returns are represented by a single proxy crop for each group. The current 6 crop groups were defined using the information provided Attachment C-1 of the Cuyama Basin GSP, which reports land use and consumptive water use in the Basin and information taken from interviews of local growers. Crop group and the corresponding proxy crop are shown in Table 1A.

**Table 1A. Cuyama Basin Model Crop Groups**

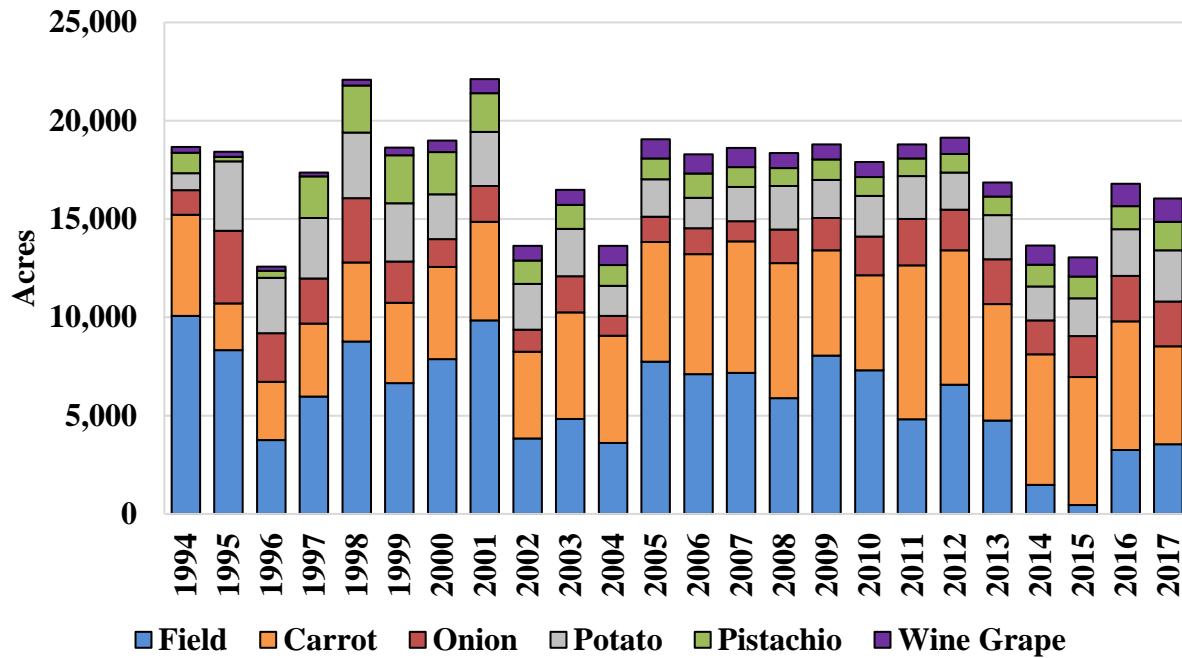
Crop Group	Proxy Crop	Other Crops
Carrots	Carrots	N/A
Potatoes	Potatoes	N/A
Grapes	Wine Grapes	N/A
Onions	Onions	Bush berries, Cole crops, Lettuce/leafy greens, Melons, Squash, Cucumbers
Pistachios	Pistachios	Apples, Citrus, Miscellaneous Deciduous, Miscellaneous Subtropical Fruit, Olives, Peaches/nectarines
Field	Wheat	Alfalfa & Alfalfa Mixtures, Beans (dry), Corn, Sorghum & Sudan, Miscellaneous Field Crops, Miscellaneous Grain and Hay, Miscellaneous Grasses, Mixed Pasture

### 8.2.2 Crop Acres

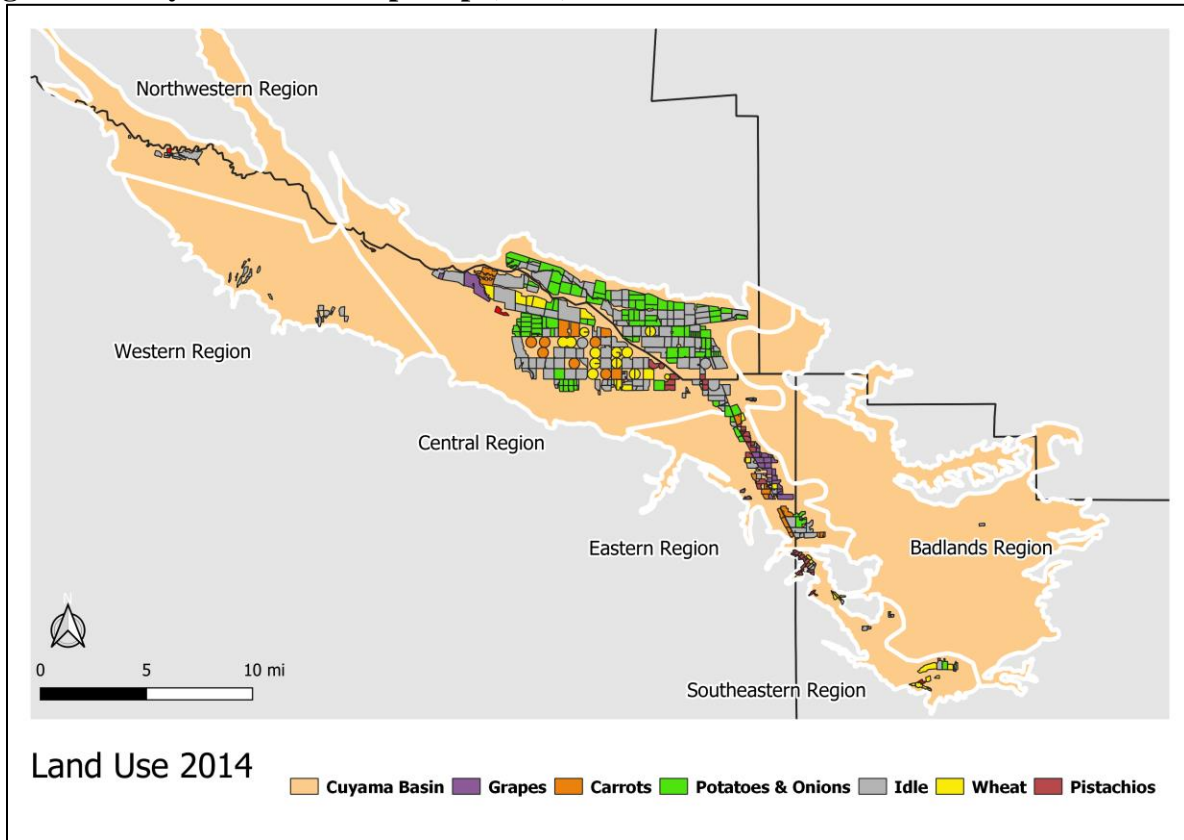
Most crop acreage in the basin has historically been divided between four of the six major crop groups: wheat, carrots, onions, and potatoes. In 2016, carrots accounted for 40% of non-idle cropland, however in 2017 carrots only accounted for 31% of non-idle cropland. This is not a result of sudden market changes, but rather a reflection of typical crop rotations in the area. Therefore, the model calibrates to 2010-2018 data to capture the most recent data while maintaining the effects of rotation.

While carrots may form the backbone of high-value agricultural production in the basin, other crop groups such as wine grapes are increasing. Wine grapes have steadily increased their share of acreage from 1% in 1996 to 7% of non-idle crop acreage in 2017. In addition, the planting of an 850-acre vineyard in 2018 increases this share closer to 13% of non-idle crop acreage. Figure 1A illustrates annual acreage distributions of non-idle cropland and Figure A2 illustrates the distribution of crop land use in the basin in 2014.

**Figure A1. Annual Changes in Non-Idle Crop Acreage**



**Figure A2. Cuyama Basin Crop Map (2014)**



### 8.2.3 Crop Returns

The economic model is designed to calibrate to the current conditions (market, prices, etc.). The model uses crop price data from a combination of county reports from Santa Barbara, San Luis Obispo, Kern, and Ventura counties, statewide and national price data, local UC estimates, and feedback from individuals familiar with farming in the basin.

Crop yields for each crop group in the model correspond to the proxy crops listed in Table A1 and are based on county averages, refined based on industry feedback. The corresponding costs of production, discussed in a subsequent section, are based on cost studies that reflect best management practices. Thus, crop yields in the economic model may be slightly higher than those estimated by calculating county averages but are more consistent with the production costs. An average of yields in the surrounding counties or statewide values are used when UCCE budget yields are not representative of production in the Cuyama Basin.

### 8.2.4 Crop Cost of Production Budgets

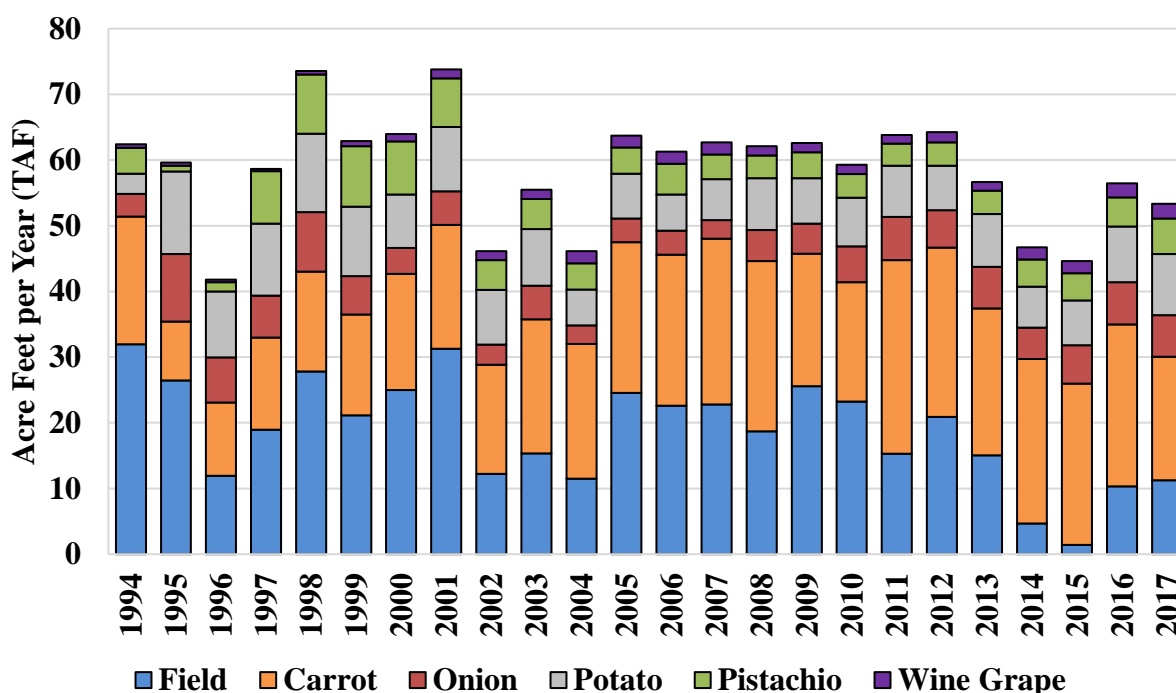
Land, labor, and other supply costs of production are estimated using internal data, UC budgets, and expert feedback to adjust for local conditions. All capital recovery and interest rates are adjusted for consistency to current conditions. Land costs are derived from county data and include land-related cash overhead plus rent and land capital recovery costs. Where appropriate,

interest rates are adjusted as described above. Other operating costs are developed based on UC budgets and interviews with experts in the region.

### 8.2.5 Water Supplies

Agricultural production in the Cuyama Basin is solely dependent on groundwater. Groundwater pumping capacity estimates are derived from the Cuyama Basin GSP. The GSP’s water budget (Table 2-5 GSP) estimates that agriculture pumps approximately 60,000 acre-feet per year (AFY). The GSP defines the “sustainable yield” for the GSA as the maximum average that the region can pump in a year given the aquifer characteristics and existing well capacities. Sustainable yield in the region is estimated at 20,000 acre-feet. Figure A3 illustrates annual groundwater pumping to meet crop demand between 1994 and 2017.

**Figure A3. Cuyama Basin Groundwater Applied Water Demand by Crop and Year**



Groundwater pumping costs are broken out into fixed, energy, and operations and maintenance (O&M) components in the economic model. Energy and O&M components are variable. Energy costs depend on the price of electricity. Base electricity costs are derived local data. Overall well efficiency is assumed to be 70 percent. As groundwater elevations change within the basin, variable pumping costs adjust accordingly.

### 8.2.1 Crop Water Requirements

Applied water is the amount of water applied by the irrigation system to an acre of a given crop for production in a typical year. Variation in rainfall and other climate effects will alter this requirement. Additionally, farmers may deficit irrigate crops or substitute other inputs in order to reduce applied water. Applied water per acre (base) requirements for crops in the model are



derived from Davids Engineering estimates of Evapotranspiration Applied Water presented in Attachment C-4 of the Cuyama GSP Appendix, land use estimates presented in Attachment C-1 of the Cuyama GSP Appendix, and total water use estimates presented in Table 2-5 of the Cuyama GSP. Applied water (AW) values and evapotranspiration applied water (ETAW) are presented in Table A2.

**Table A2. Applied Water (AW) and Evapotranspiration Applied Water (ETAW) by Crop**

<b>Crop Group</b>	<b>Proxy Crop</b>	<b>AW</b>	<b>ETAW</b>
		<i>acre-feet</i>	
Carrots	Carrots	3.77	3.17
Grapes	Wine Grapes	1.88	1.58
Onions	Onions	2.78	2.33
Pistachios	Pistachios	3.77	3.17
Potatoes	Potatoes	3.57	2.67
Field	Wheat	3.17	2.67

### 8.2.2 Other Economic Data

The Cuyama Basin model requires a number of economic response parameters, called elasticities, to estimate rates of change in variables. An elasticity is the percent change in a variable, per unit of percent change in another variable or parameter. For example, acreage response elasticity is one component of supply response. It is the percentage change in acreage of a crop from a one percent change in that crop's price. The model contains both long run and short run estimates. Long run acreage response elasticities are used for this analysis. Other elasticities including income, demand price, and population (among others) are representative of statewide market conditions in California, or in the export market as appropriate.

### 8.3 References

- Agricultural Commissioner of Kern County, Ventura County, Santa Barbara County, and San Luis Obispo. Various years. Agricultural Crop Report. County Department of Agriculture and Measurement Standards.
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