WATER SAVINGS, COSTS, AND REGIONAL IMPACTS OF POTENTIAL ON-FARM WATER USE OPTIMIZATION AND CONSERVATION STRATEGIES IN UTAH'S UPPER COLORADO RIVER BASIN

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POLICY ANALYSIS FOR THE PUBLIC AND PRIVATE SECTORS

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Executive Summary

Purpose and Scope of the Study

Ensuring a sustainable water future for the Colorado River basin is essential for Utah's economic development and well-being. Given that agricultural producers are the primary water users in the state, their involvement is crucial in any strategy supporting a sustainable Colorado River system, an increase in water flows to Lake Powell, and mitigation against future drought scenarios. This study examines various strategies to optimize and conserve on-farm water use on lands in Utah's Colorado River Basins which drain to Lake Powell in terms of depletion savings potential, cost, and regional economic impact.

Methodological Framework

The study adopted a multifaceted approach, encompassing:

- **Quantification of Depletion Savings Potential:** The potential depletion savings for three on-farm conservation strategies—temporary acreage fallowing, crop substitution, and irrigation optimization—was assessed at three different operational scales – 25%, 50%, and 75% of the study region's current forage acreage.

- **Cost-Effectiveness Analysis:** A comparison of the farm-gate costs associated with these strategies, aiming to identify the most cost-effective water-saving options.[1]

- **Evaluation of Regional Economic Impacts:** A multi-region impact-output (MRIO) model is used to assess the broader economic effects of each strategy on the local economy, including an assessment of potential adverse impacts and mitigation strategies.

- **Review of Mitigation Strategies:** The study concludes with a review of commonly deployed approaches to mitigate negative economic and social costs resulting from public policies impacting particular regions or industries.

Key Findings

The key findings for the above areas of inquiry are as follows.

Depletion Savings and Costs

The study evaluated three strategies for on-farm water conservation in terms of potential depletion savings and associated costs:[2]

- **Temporary Land Fallowing:** This strategy emerged as the most cost-effective, with the potential to reduce depletion by up to 2.7 acre-feet per enrolled acre at an average cost of $240 per acre-foot. It could yield annual depletion savings on the order of four to five hundred thousand acre-

[1] The cost per acre-foot estimates presented hereafter reflect farm-gate pricing, analogous to Free on Board (FOB) terms. This signifies the cost of water savings at the farm delivery point, excluding any additional costs associated with setting up, administering, and monitoring the program.

[2] The depletion savings and cost estimates in this study assume a well-watered crop. Depletion savings will be lower and costs higher when irrigation supply is constrained due to drought or other factors.

feet at the highest program scale considered by the study.

- **Crop Substitution:** A forage-to-small-grain or forage-to-corn-grain crop substitution strategy could achieve a reduction in depletion of up to 0.8 acre-feet per enrolled acre, at an average cost of $363 per acre-foot for forage-to-grain and $530 per acre-foot for forage-to-corn. At the highest program scale considered, crop substitution could yield depletion savings on the order of 150,000 acre-feet annually.

- **Irrigation System Conversion:** Converting from flood and sprinkler irrigation to subsurface drip irrigation (SDI) could yield depletion savings of up to 0.8 acre-feet per enrolled acre, at an average cost of $270 per acre-foot for sprinkler-to-SDI conversions and $440 per acre-foot for flood-to-SDI conversions. Irrigation system conversion could yield annual depletion savings on the order of 130,000 acre-feet at the highest program scale considered.

Table ES-1 summarizes the depletion savings potential and cost per acre-foot of the conservation strategies evaluated.

Table ES-1. Summary of Potential Depletion Reduction and Cost of Alternative Conservation Strategies

				Potential Depletion Reduction (AF) by Acreage Enrollment %		
From	**To**	**Depletion Reduction**	**Cost per AF Saved**	**25%**	**50%**	**75%**
Forage	Fallow	100%	$240	155,578	311,155	466,733
Pivot	SDI	29%	$270	37,223	74,446	111,669
Forage	Grain	31%	$363	47,811	95,621	143,432
Flood	SDI	18%	$440	7,153	14,305	21,458
Forage	Corn	32%	$530	49,328	98,655	147,983

Notes: Program is assumed to target alfalfa and other hay acreage for conversions. Pivot depletion reduction and cost based on conversion of mid-elevation spray application (MESA) pivot systems. Cost and savings for irrigation system conversions are based on the acreages reported in Table 16 of the main report.

Regional Economic Impacts

A multi-regional Input-Output (MRIO) model of Utah's economy within the Upper Colorado River Basin was used to assess the potential impacts of the three conservation strategies on regional output, value added (analogous to gross domestic product), income, and employment. Key findings from the regional impact analysis include the following:

- **Potential for both positive and negative regional impacts**. While reduced farm output associated with fallowing-based conservation has the potential to decrease economic activity in the region, a strategy focused on upgrades to irrigation systems could offer a modest economic boost. Strategies based on crop substitution are not expected to result in significant impacts to the region due to the similar input requirements associated with the production of forage and grain crops.

- **Minimal overall regional impacts**. The analysis indicated minimal overall regional economic impacts from the conservation strategies, with the primary indicators for regional output, value added, income, and employment showing changes of less than 1% from baseline levels. This suggests that the broader economic structure of the region would likely remain stable under all of the conservation strategies considered by this study.

- **Geographic disparities in regional impacts**. However, specific counties within the study region, particularly Daggett, Duchesne, Emery, Uintah, and Wayne, might experience more pronounced impacts, highlighting geographic disparities in the effects of these conservation strategies. In these counties, impacts to output, value added, labor income, and employment may exceed 1% of their baseline values. While these counties are expected to be the most adversely impacted by fallowing-based conservation strategies, they also stand to gain the most from strategies focused on upgrades to irrigation systems. Below the county level, more significant localized impacts could be possible unless program enrollment is structured to prevent the clustering of fallowed acreage. Community-level impacts could not be directly assessed due to the resolution of the IMPLAN MRIO model.

- **Impacts cluster within a few key sectors**. The regional impact analysis also indicates that the conservation strategies are likely to affect a limited number of industries in the region, with just 3% of the sectors in the MRIO model accounting for 70 to 90 percent of the estimated impacts.[3] Retail and wholesale sectors stand to benefit the most from irrigation upgrades, while the agricultural support sector may face the greatest adverse impact from fallowing-based conservation strategies. However, the highly mechanized nature of agricultural production in the region as well as the reliance on proprietor and family labor is expected to limit the extent to which employment impacts would ripple through the broader regional economy.

Regional Impact Mitigation

Several strategies can help lessen the economic downsides of agricultural water conservation and land fallowing programs. These strategies fall into four main categories:

- **Direct Compensation:** Direct financial assistance to offset income losses incurred by program participants.

- **Job Retraining and Workforce Development:** Programs can be established to equip displaced agricultural workers with new skills, allowing them to transition to jobs in other sectors.

- **Economic Diversification and Community Development:** Initiatives promoting new industries and community development can lessen reliance on agriculture and create fresh job opportunities.

- **Rural Infrastructure Investment:** Upgrading infrastructure in rural areas, such as roads or broadband access, can improve the overall economic climate and attract new businesses.

This study has evaluated the potential economic impacts of various conservation strategies, along with mitigation strategies to lessen these effects. While job retraining, economic diversification, and rural infrastructure investment all have potential benefits, we conclude that direct compensation to program

[3] The MRIO model consists of 300 distinct economic sectors (also referred to as industries).

participants is the most efficient and effective approach for mitigating the majority of regional economic impacts associated with the conservation strategies considered here.

This conclusion rests on several key points:

- **Dominance of Small Farms:** The study region is characterized by a preponderance of small, family-operated farms. Compensation programs tailored to farm income loss can simultaneously induce participation and mitigate the majority of the regional impact caused by the program.

- **Limited Scale of Displacement:** The projected number of displaced workers, even under the largest program scale considered, is small, making targeted retraining programs less cost-effective due to insufficient scale.

- **Geographic Dispersion:** Job losses are expected to be geographically dispersed across the extensive study region, further diminishing the feasibility of targeted retraining efforts.

- **Mixed Effectiveness of Alternatives:** While economic diversification and infrastructure investments can offer long-term benefits, their success depends on various factors and can require a long time horizon to yield results. The track record of these types of programs in similar contexts is decidedly mixed.

In contrast, direct compensation provides a clear and immediate way to mitigate the economic impacts associated with program-induced changes to farm income. This approach aligns with a core assumption of our analysis – that farmers will be compensated for income loss due to program participation. Not only is this necessary to induce voluntary participation in these types of programs, but it will also greatly reduce the economic burden of these programs on rural communities in the study region.

1 Study Objectives

Ensuring a sustainable water future for the Colorado River basin is essential for Utah's economic development and overall well-being. Given that agricultural producers are the primary water users in the state, their involvement is crucial in any strategy supporting a sustainable Colorado River system, an increase in water flows to Lake Powell, and mitigation against future drought scenarios. This study examines various strategies to optimize and conserve on-farm water use in Utah's Upper Colorado River Basin.

Our investigation employs a comprehensive approach:

1. **Quantifying Depletion Savings Potential:** We assess the potential depletion savings of three alternative on-farm conservation strategies: temporary acreage fallowing, crop substitution, and irrigation optimization. This involved a thorough analysis of water use patterns for different crops and irrigation systems across the region.

2. **Cost-Effectiveness Comparison:** Recognizing that not all strategies are equally cost-effective, we provide a rigorous comparison of costs, expressed in dollars per acre-foot (AF) of conserved water. This analysis can help policymakers prioritize the most cost-effective options for achieving depletion savings.

3. **Understanding Regional Economic Impacts:** We examine how each strategy would impact agricultural production patterns in the region and translate these changes into broader economic impacts. Understanding these ripple effects on the local economy is crucial for informed decision-making and for providing accurate public information on potential program impacts, particularly to the general public in the communities in which the programs would operate.

4. **Assessing Mitigation Strategies:** Recognizing the importance of mitigating adverse impacts, we explore approaches to offsetting potential negative economic consequences associated with on-farm conservation. We provide examples of mitigation programs used to address similar impacts, and that were developed to facilitate cooperation and participation among farmers and surrounding communities.

In addressing these critical questions, our study aims to provide policymakers and stakeholders with valuable insights to effectively implement on-farm water conservation strategies for the benefit of Lake Powell and the broader community.

2 Study Approach and Models

The general approach is to estimate farm-level changes in production, costs, and returns, associated with participation in a conservation program and then to translate these impacts into changes in income and employment given the geographic distribution and scale assumed for the program.

Farm-level changes in production, costs, and returns for the major forage crops grown in the study region are estimated using crop-level production budgets prepared by state extension farm advisors. Utah State University Extension is the primary source for the alfalfa, grass hay, grain, and corn budgets that undergird this analysis.[4, 5] In some cases, these estimates were supplemented with data from crop cost studies prepared by University of California Extension.[6] Production costs, commodity prices, and average yields have been updated to current values using data compiled by the USDA National Agricultural Statistics Service (NASS).[7]

Farm-level costs and returns associated with specific irrigation technology conversions are primarily based on irrigation technology conversion cost-benefit studies completed by Utah State University Extension.[8] Costs for pivot irrigation technologies have been updated to current levels using information collected from local irrigation specialists.[9]

Estimates of changes in water depletion associated with fallowing irrigated land, switching to a different crop, or converting to a more efficient irrigation technology were prepared in conjunction with Jacobs Engineering and Utah State University Extension.[10] These estimates are used to calculate the cost per acre-foot (AF) of alternative conservation strategies aimed at reducing depletion in the study region.

Given the geographic distribution and scale assumed for a conservation program, regional changes in output, income and employment are estimated using an IMPLAN Multi-Regional Input-Output (MRIO) model of the study region.[11] An input-output (I-O) model is an economic model that represents the interdependencies between different sectors of an economy. It is a quantitative model that describes the flow of goods and services between different industries. I-O models are used to estimate the economic impacts of changes in economic activity, such as changes in government spending, changes in consumer demand, or changes in technology. An MRIO model differs from a Single-Region I-O (SRIO) model by considering not only the linkages between different sectors of the economy for a region of interest, but

[4] Sourced from https://extension.usu.edu/crops/research/crop-economics. It is important to recognize that crop production costs can vary significantly from farm-to-farm, region-to-region, and year-to-year, depending on a range of factors, including soil quality, availability and cost of irrigation water, weather and pest conditions, input prices, regulatory requirements, and other factors. The production costs utilized for this study have their foundation in cost and return studies prepared by USU Extension that were completed over the previous 13 years and have been brought to current dollars using NASS production cost indices. While it is believed these estimates are generally representative for the study region as a whole, it is fully anticipated that actual costs for different subregions and for individual operations could deviate from these estimates.

[5] Although owner/operator labor costs are included in the USU Extension cost and return studies, we remove them in this study when we determine the amount of compensation owner/operators would require to voluntarily remove crop acreage from production, where the break-even compensation amount is depends on the difference between crop revenue and out of pocket cash production costs. Alternatively, we could have retained owner/operator labor cost in the cost budget and then added this forgone labor income to the break-even amount to properly account for this component of owner/operator income. It amounts to the same thing, though we believe our approach is more intuitive in terms of how self-employed owner/operators actually calculate their income.

[6] https://coststudies.ucdavis.edu/en/

[7] https://www.nass.usda.gov/Statistics_by_State/Utah/index.php

[8] https://extension.usu.edu/crops/tools/irrigation-technology-cost-benefit-calculator

[9] Email communications, Nash McKee, Basin Irrigation, multiple dates.

[10] Jacobs Engineering (2023). Technical Memorandum dated May 9, 2023, to Central Utah Water Conservation District, entitled *Quantify the Possible*.

[11] IMPLAN is a software application that uses input-output economic modeling to estimate the economic impacts of economic events and policies. I-O modeling is a quantitative technique that traces the economic linkages between different sectors of the economy. It is commonly used in a variety of research, including by government agencies, economic development organizations, businesses, and academic researchers.

also the linkages between subregions that comprise the region of interest. This allows the MRIO model to estimate the impacts within each subregion as well as the spillover impacts on other subregions. For example, a decline in agricultural production in one subregion may have an impact on the input supply and transportation industries in adjacent subregions.

As described in the next section, the region of interest for this study is the combined area of three hydrologic basins that drain to Lake Powell (Utah's Upper Colorado River Basin) and the subregions used for the MRIO model are the 12 counties with significant levels of agricultural production overlaying these basins.

Prior to its use in this study, the MRIO model's crop production values for each county were calibrated to match crop production values derived from crop acreages, including irrigated pasture, reported in the 2022 Water Related Land Use Data.[12]

3 Study Region

The waters of the State of Utah drain to 12 hydrologic basins.[13] The study region is comprised of the three basins draining to Lake Powell:

- Uintah
- West Colorado River
- Southeast Colorado River

The study region is further delineated by the 12 counties with significant levels of agricultural production that overlay these hydrologic basins. These counties are:

Carbon	Duchesne	Garfield	San Juan	Summit	Wasatch
Daggett	Emery	Grand	Sevier	Uintah	Wayne

A map of the study region is provided in Figure 1.

3.1 Population and Demographics

Population and demographic statistics for the study region, as of 2021, are summarized in Table 1.[14] The study region's population of 220,320 represents about 7% of the state population. The gender distribution is nearly identical to the state as a whole, but the age distribution skews slightly older. The study region has a higher proportion of white/Caucasian and American Indian/Alaska Native residents than the state as a whole. Educational attainment and household income are somewhat lower in the study region than in the state overall. Unemployment rates for American Indian/Alaska Native and mixed race subpopulations in the study region are significantly higher than for the state as a whole.

[12] https://dwre-utahdnr.opendata.arcgis.com/pages/wrlu

[13] A map of the 12 basins can be found here.

[14] Study region demographics come from the IMPLAN Input-Output Model data files. The primary source of demographic data in these files is the Census American Community Survey. State demographics come from the 2021 Census American Community Survey 1-year estimates.

Figure 1. Study Region Hydrologic Basins and Counties

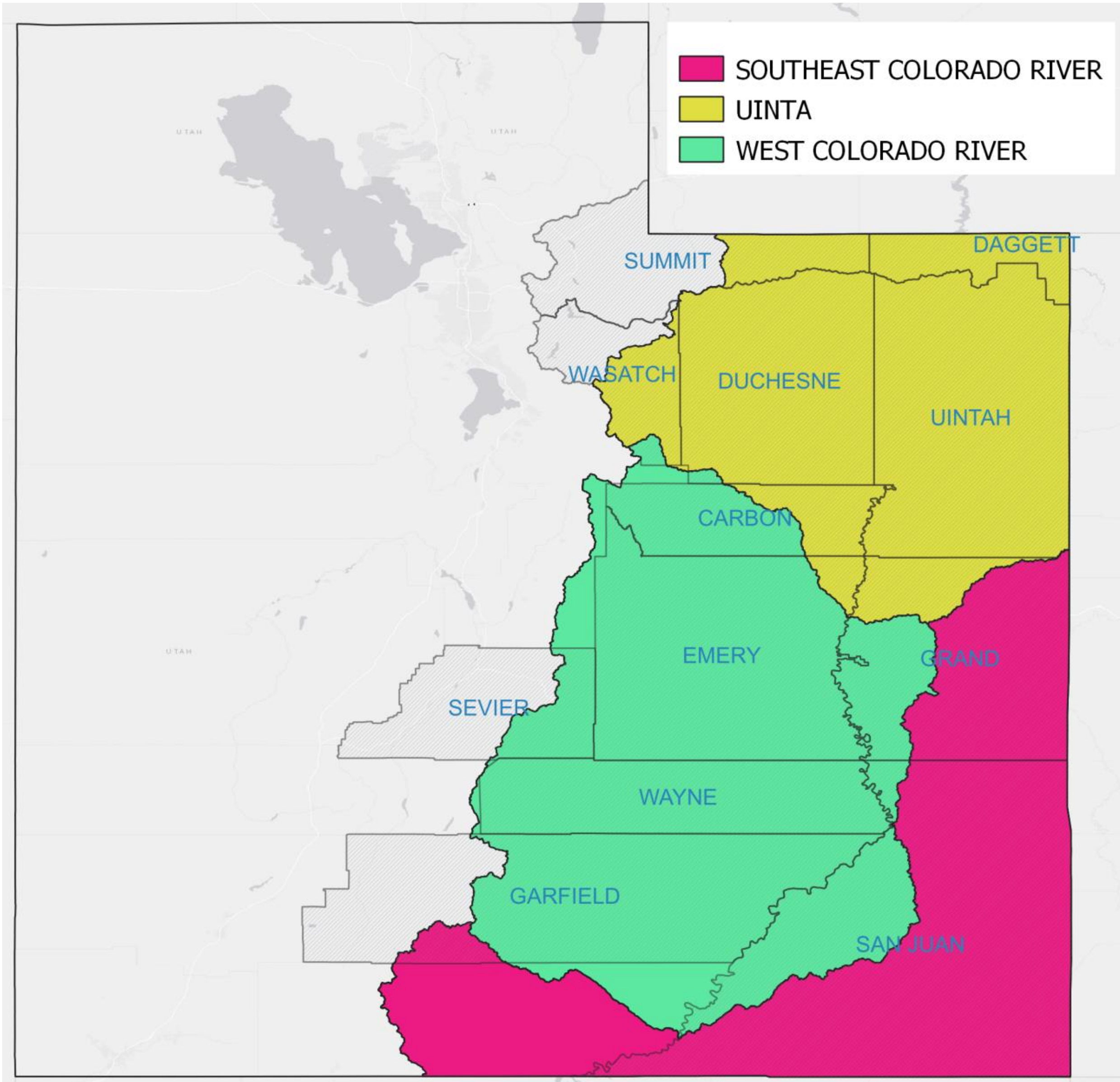

Table 1. Study Region Demographics as of 2021

	Study Region		Utah	
	Estimate	**Percent**	**Estimate**	**Percent**
Population	220,320		3,337,975	
Male	112,157	50.9%	1,694,770	50.8%
Female	108,163	49.1%	1,643,205	49.2%
Age Distribution				
Under 15	51,732	23.5%	776,419	23.2%
15-24	29,282	13.3%	550,829	16.5%
25-64	108,311	49.2%	1,622,607	48.7%
65 and older	30,995	14.1%	388,120	11.6%
Race & Ethnicity				
White	192,004	87.1%	2,647,741	79.3%
Black or African American	1,202	0.5%	35,982	1.1%
American Indian and Alaska native	11,315	5.1%	32,622	1.0%
Asian	2,106	1.0%	84,056	2.5%
Native Hawaiian and Other Pacific Islander	446	0.2%	28,855	0.9%
Some Other Race or Two or More Races	13,247	6.0%	508,719	15.2%
Hispanic Origin				
Non-Hispanic	198,751	90.2%	2,844,336	85.2%
Hispanic	21,569	9.8%	493,639	14.8%
Language Spoken at Home (ages 5+)				
English Only	179,521	87.5%	2,653,546	84.2%
English & Spanish	9,050	4.4%	332,752	10.6%
English & Other Languages	16,596	8.1%	166,038	5.2%
Educational Attainment (ages 25+)				
No High School Diploma	10,714	7.7%	142,635	7.0%
High School Graduate or Equivalency	38,025	27.3%	449,458	22.0%
Some College, No Degree	34,674	24.9%	472,228	23.1%
College Degree	55,893	40.1%	978,591	47.9%
Household Income				
Households LT50k	28,411	37.2%	317,232	28.8%
Households 50-100k	24,833	32.5%	362,393	32.9%
Households 100-200k	17,029	22.3%	313,927	28.5%
Households GT200k	6,081	8.0%	107,947	9.8%
Unemployment Rate (ages 16+)				
White		3.6%		3.1%
Black or African American		3.2%		6.9%
American Indian and Alaska native		15.7%		10.8%
Asian		0.0%		4.1%
Native Hawaiian and Other Pacific Islander		N		N
Some Other Race or Two or More Races		7.7%		4.5%

3.2 Regional Economy

Economic indicators for the study region in terms of industry output, value added, and employment are summarized in Table 2. Output represents the total dollar value of goods and services in the region. Value added constitutes the portion of this output going to regional factors of production – labor, capital, and land. It is synonymous with gross domestic product (GDP).[15] Total employment is the count of part- and full-time jobs and is divided into wage and salary employment and proprietor (or self) employment.

As of 2021, the study region accounted for about 6% of statewide output and value added, and about 7% of statewide employment.

The top 5 sectors in the study region in terms of output are:

1. Real Estate
2. Mining
3. Manufacturing
4. Construction
5. Finance and Insurance

In terms of regional value added, the top 5 sectors are:

1. Real Estate
2. Mining
3. Administrative Government
4. Construction
5. Accommodation and Food Services

In terms of regional wage and salary employment, the top 5 sectors are:

1. Administrative Government
2. Accommodation and Food Services
3. Retail Trade
4. Health Care
5. Construction

In terms of regional proprietor (self) employment, the top 5 sectors are:

1. Agriculture
2. Real Estate
3. Finance and Insurance
4. Professional Services
5. Other Services

Although agriculture is the predominant land use in the study region, its role in the regional economy is more mixed. It accounts for a significant share of proprietor employment (31.6%) and total employment (12.6%) but is not a major employer of wage and salary workers (2.4%). In terms of output and value

[15] Value Added is the sum of wage and salary income, proprietor income, other property income, and taxes on production and imports net of subsidies.

added, the agricultural sector ranks in the bottom quarter of the 21 sectors in Table 2, accounting for only 2.5% and 1.8% of the regional totals, respectively.

Table 2. Study Region Economic Indicators as of 2021

Sector	Output [Mil. $]	Rank	Val. Added [Mil. $]	Rank	Employ. [Total]	Rank	Employ. [Wage]	Rank	Employ. [Propr.]	Rank
Agriculture	620.3	16	243.8	17	19,327	1	2,377	14	16,949	1
Mining	3,120.3	2	1,867.3	2	5,177	12	4,363	8	814	15
Utilities	1,234.9	9	695.9	7	758	21	673	20	85	19
Construction	1,822.4	4	950.3	4	10,401	6	8,062	5	2,338	7
Manufacturing	1,953.0	3	505.4	12	4,302	15	3,444	10	858	14
Wholesale Trade	893.9	12	490.5	13	2,609	16	2,046	15	563	18
Retail Trade	1,395.1	7	745.2	6	13,281	4	10,945	3	2,336	8
Transportation	747.6	15	349.6	15	4,519	13	3,434	11	1,085	11
Information	757.1	14	303.3	16	1,557	19	963	19	594	17
Finance and Insurance	1,400.9	5	536.7	10	5,866	11	1,731	16	4,135	3
Real Estate	3,545.9	1	2,166.3	1	10,079	7	2,500	13	7,579	2
Professional Services	1,125.6	10	606.7	8	8,220	9	4,100	9	4,120	4
Management of Companies	221.5	20	60.1	20	1,669	17	341	21	1,328	10
Administrative and Support Services	454.7	18	196.0	18	4,475	14	2,727	12	1,748	9
Educational Services	77.5	21	45.2	21	1,586	18	980	18	606	16
Health Care	1,046.7	11	600.7	9	11,466	5	8,617	4	2,848	6
Entertainment and Recreation	593.9	17	396.1	14	5,887	10	4,984	7	902	13
Accommodation and Food Services	1,397.9	6	782.5	5	14,796	3	13,758	2	1,038	12
Other Services	816.2	13	507.6	11	9,152	8	5,510	6	3,642	5
Government Enterprises	360.2	19	171.9	19	1,439	20	1,439	17	0	20
Administrative Government	1,311.8	8	1,311.8	3	16,995	2	16,995	1	0	20
Region Total	24,897.5		13,532.9		153,560		99,991		53,569	
% of State	5.9%		5.9%		7.1%		5.9%		11.3%	

3.3 Agriculture Economic Contribution Analysis

To understand the impact of conservation programs that may lead to reductions in agricultural production on the study region's economy, it is useful to first examine the sector's overall economic contribution to the regional economy. This includes not only the direct output, income, and employment associated with agricultural production, but also the indirect economic activity it supports in other sectors. This provides an upper bound of the potential impact, as it shows the sector's total contribution of the regional economy, and thus what would be expected to occur if it were to exit the region.

We conducted an industry contribution analysis (ICA) for the agricultural sector using an IMPLAN I-O model of the study region. ICA estimates the economic contribution of an existing industry or group of industries in a region, at their current levels of production. ICA shifts the traditional I-O framework, which is focused on the impact of a discrete change in an industry's production level, to identify the industries and levels of production that are supported by current production in the industry (or industries) of interest. To avoid overstating an industry's contribution to the economy, ICA employs a constraint that removes feedback linkages or buybacks to the industry being analyzed.[16]

Table 3 summarizes the results of the ICA for the study region's agricultural sector. The first column shows the sector's share of the total for each economic indicator, recapitulating the information presented in Table 2. The second column shows the sector's overall contribution to the economy, accounting for the economic activity it supports in other sectors.

The results indicate that the agricultural sector makes a relatively small contribution to total regional output and value added, at about 4% and 3%, respectively. Its contribution to wage and salary employment is also modest, at just over 3%. However, it is a major contributor to proprietor (self) employment, accounting for about 33% of the regional total.

These results suggest three important points for assessing the potential regional economic impacts of conservation programs that lead to changes in agricultural production:

- The agricultural sector is not a major contributor to regional output and value added. Even large changes in agricultural production in the region would not be expected to have large impacts on the broader economy.
- The agricultural sector is not highly integrated with the rest of the regional economy, as evidenced by the relatively small differences between the sector's *share of* versus its *contribution to* overall regional economic activity. This suggests that there would not be significant spillover impacts from reductions in agricultural production, and that impacts would be largely contained within a relatively small set of businesses.[17]
- The group that would be most impacted by conservation programs that lead to changes in agricultural production would be farm proprietors. Under a voluntary program arrangement,

[16] In a traditional I-O framework buybacks are allowed because some of the industry's output may be used by the industry itself as an input to production. However, in an ICA, the industry of interest is removed from the economy entirely, so buybacks would not occur.
[17] This is not to suggest that these impacts would be inconsequential, particularly for the businesses being impacted.

these individuals would be expected to be directly compensated by the program in order to induce their participation in it.

Table 3. Agricultural Sector Contribution to Regional Economy as of 2021

Economic Indicator	Agricultural Sector Share of Regional Total	Agricultural Sector Contribution to Regional Total (from IMPLAN ICA)
Output	2.5%	3.7%
Value Added	1.8%	2.9%
Wage & Salary Income	1.6%	2.5%
Proprietor Income	15.3%	16.9%
Wage & Salary Employment	2.4%	3.3%
Proprietor Employment	31.6%	32.6%

3.4 Agricultural Acreage and Water Use

Agriculture dominates land use in the study region and is the largest water consumer.[18] Alfalfa and grass hay are the primary crops, grown either for local livestock or export. Table 4 details 2022 acreages of irrigated crops by irrigation method.

Irrigation is prevalent throughout the study region, with sprinkler irrigation being the most common method, followed by flood irrigation. Subsurface irrigation primarily benefits pastures, while drip irrigation remains extremely rare.[19]

Table 4. Study Region Irrigated Crop Acreage by Crop Type and Irrigation Method (Acres)

Crop	Subsurface Irrigation	Drip	Flood	Sprinkler	Total	% of Total
Alfalfa & Other Forage	189	0	63,896	163,265	227,351	65%
Field & Grain	0	0	2,821	12,024	14,845	4%
Fruit & Vegetable	0	32	218	318	567	0%
Pasture	35,895	0	49,256	21,105	106,257	30%
Total	36,085	32	116,192	196,712	349,020	100%
% of Total	10%	0%	33%	56%	100%	

Under ideal conditions, when water availability is not limited by hydrology or other factors, irrigated crops in the region deplete roughly 860,000 acre-feet (AF) of water annually when subsurface irrigation is included in the tally and approximately 790,0000 when it is excluded, as detailed in Table 5.[20] Depletion refers to the portion of irrigation water lost through evaporation, plant transpiration, or other

[18] All acreages in this section are from the 2022 Water Related Land Use Data (https://dwre-utahdnr.opendata.arcgis.com/pages/wrlu).

[19] It should be noted that subsurface irrigation applies to areas where crops benefit from a high water table; it is not an active irrigation practice.

[20] An acre-foot of water is the volume of water that will cover one acre to a depth of one foot. It is equal to 325,851 gallons. An acre-foot of water is typically sufficient to meet the annual demands of 2 to 4 single-family residences in a suburban setting.

means, making it unavailable for reuse. Utah State University Extension estimates that, on average, irrigation in Utah results in a 68% depletion rate.[21]

Table 5. Study Region Depletion by Crop Type and Irrigation Method (AF)

Crop	Subsurface Irrigation	Drip	Flood	Sprinkler	Crop Total	% of Total
Alfalfa & Other Forage	364	0	139,576	482,735	622,675	72%
Field & Grain	0	0	4,469	23,960	28,429	3%
Fruit & Vegetable	0	36	243	354	634	0%
Pasture	68,227	0	91,220	49,539	208,985	24%
Irr. Total	68,591	36	235,508	556,588	860,723	100%
% of Total	8%	0%	27%	65%	100%	

Table 6 details average depletion rates for different crop types and irrigation methods. The estimates are based on crop water requirements for the study region (Hill, 1994) and application and depletion rates associated with alternative irrigation methods compiled by USU Extension and Jacobs Engineering group. The depletion rates assume an unconstrained supply of irrigation water. Under such conditions, the average depletion rate across all crops and irrigation methods is 2.5 acre-feet per acre (AF/Ac).[22] Alfalfa and other forage crops exhibit the highest depletion rates, while fruit and vegetable crops have the lowest. Among irrigation methods, sprinkler irrigation has the highest depletion rates primarily due to wind-induced evaporative losses.

Table 6. Study Region Depletion Rates by Crop Type and Irrigation Method (AF/Ac)

Crop	Subsurface Irrigation	Drip	Flood	Sprinkler	Crop Avg.
Alfalfa & Other Forage	1.9		2.2	3.0	2.7
Field & Grain			1.6	2.0	1.9
Fruit & Vegetable		1.1	1.1	1.1	1.1
Pasture	1.9		1.9	2.3	2.0
Irr. Method Avg.	1.9	1.1	2.0	2.8	2.5

3.5 Crop Production Costs and Returns

Crop production costs and returns are important factors in this study for several reasons. Firstly, the profitability of growing a specific crop helps determine the compensation a farmer would require to voluntarily take it out of production. This information is essential for characterizing the participation costs of fallowing-based conservation strategies. Secondly, we consider the change in profitability that would result from switching to a different crop, such as growing winter or spring grain instead of alfalfa.

[21] Barker, Burdette, Matt Yost, and Cody Zesiger (2022). Agricultural Irrigated Land and Irrigation Water Use in Utah. Utah State University Extension.

[22] During periods of drought, average depletion rates may be 10-30% lower because irrigation demand cannot be fully met, and some acreage is deficit irrigated. Thus, total depletion during periods of drought may be on the order of 86,000 to 260,000 AF lower than shown in Table 5.

This helps estimate the payment needed to incentivize farmers to adopt crop substitution strategies. Similarly, the change in profitability associated with adopting a new irrigation technology, like switching from sprinkler to subsurface drip irrigation, informs the participation costs of irrigation-substitution strategies. Finally, estimated changes in on-farm investment and input purchases associated with each conservation strategy are fed into the IMPLAN MRIO model to assess the impact on the regional economy of the alternative conservation strategies at different program scales.

Crop production costs and returns were estimated for four key crops: alfalfa, other hay, winter/spring grain, and corn grain. Data sources for these crop budgets include Utah State University (USU) Extension publications from 2011 for Duchesne, Uintah, and other counties (where applicable). A more recent source (USU Extension Grain Corn Enterprise Budget, Utah North, 2019) was used for corn grain.

To ensure all costs reflect current (2023) economic conditions, we adjusted the original budgets using various production cost indices from the USDA National Agricultural Statistics Service (NASS). These indices cover expenses like pesticides, fertilizers, fuels, farm labor, agricultural services, and supplies and repairs.

Crop income per acre is calculated using a three-year average (2021-2023) of crop yields and farm-gate prices from Utah-specific NASS data.[23, 24] To account for variations in irrigation efficiency and crop water productivity, we adjust yields based on irrigation method. Compared to flood irrigation, sprinkler irrigation is expected to boost yields by an average of 10%, while subsurface drip irrigation is projected to increase yields by up to 25%. These adjustments are supported by a review of scientific literature on irrigation methods, crop production, and water use.[25]

Crop water use estimates, specifically the portion transpired by the plant, are also adjusted based on irrigation method. Flood and sprinkler irrigation exhibit a near one-to-one correlation between yield and crop water use. For example, a 10% increase in alfalfa yield typically translates to a 10% increase in crop water consumption.[26] Subsurface drip irrigation (SDI), however, appears to offer a significant advantage

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[23] We use wheat as the proxy crop for winter/spring grain. In the case of wheat, average yield is based on NASS yield reports for 2009, 2013, and 2018, the three most recent years for which wheat yield data for Utah are available.

[24] Commodity prices and crop yields fluctuate. While the prices and yields used in the analysis are reflective of market and growing conditions at the time this study was conducted, it is important to recognize that future prices and yields may diverge from these estimates. It will generally be necessary to recalibrate program compensation periodically to reflect prevailing conditions.

[25] Studies reviewed for this analysis include Daniel M. O'Brien, Freddie R. Lamm, Loyd R. Stone, and Danny H. Rogers, *The Economics of Converting from Surface to Sprinkler Irrigation for Various Pumping Capacity*, Kansas State University, November 2000; Hagemann, Robert W., Carl F. Ehlig. (1980) *Sprinkler Irrigation Raises Yields -- and Costs -- of Imperial Valley Alfalfa*. California Agriculture January 1980; Sanden, Blake L., Karen Klonsky, Daniel H. Putnam, Larry Schwankl and Khalid Bali. *Comparing Costs and Efficiencies of Different Alfalfa Irrigation Systems* (2011); Montazar, Aliasghar & Bali, Khaled & Zaccaria, Daniele & Putnam, Dan. (2018). *Viability of Subsurface Drip Irrigation for Alfalfa Production in the Low Desert of California*. 10.13031/aim.201800415; Hutmacher, R. B., Phene, C. J., Mead, R. M., Clark, D., Shouse, P., Vail, S. S., Swain, R., van Genuchten, M., Donovan, T., Jobes, J. (2001). *Subsurface drip and furrow irrigation comparison with alfalfa in the Imperial Valley*. In Proceedings, 31st California Alfalfa & Forage Symposium, December 11-13, Modesto, California.

[26] See, for example, Hill, Robert W. (1994). *Consumptive Use of Irrigated Crops in Utah*. Research Report 145, Utah Agricultural Experiment Station Projection No. 796, USU Control No. 90-391.

in water productivity compared to flood or sprinkler methods, as supported by recent research.[27] While SDI is expected to increase yields by up to 25% compared to flood irrigation, crop water use is estimated to increase by only about 3%.

Accounting for variations in yield, crop water use, and resulting depletion, we calculate crop returns, net income (revenue minus production costs), and average depletion for the four main crops analyzed in this study. Table 7 summarizes the estimated crop production costs and returns under flood and sprinkler irrigation, the two most prevalent irrigation methods in the region. Appendix A provides more detailed crop budgets that underpin the values in Table 7.

Table 7. Crop Net Cash Income for Flood and Sprinkler Irrigation

Crop	**Alfalfa**	**Other Hay**	**Grain**	**Corn**
Irrigation Method	Flood	Flood	Flood	Flood
Depletion (AF/Ac)	2.5	1.9	1.6	1.6
Yield	3.9 Ton/Ac	2.9 Ton/Ac	98.3 Bu/Ac [2/]	176.3 Bu/Ac
Price	$259.94	$208.11	$6.91	$6.23
Revenue	$1,023	$597	$679	$1,099
Cash Operating Cost	$410	$213	$430	$1,024
Net Cash Income	$613	$384	$250	$75
$/AF Depletion	$245	$206	$157	$48
Irrigation Method [1/]	Sprinkler	Sprinkler	Sprinkler	Sprinkler
Depletion (AF/Ac)	3.2	2.4	2.0	2.0
Yield	4.3 Ton/Ac	3.2 Ton/Ac	108.2 Bu/Ac [2/]	194.0 Bu/Ac
Price	$259.94	$208.11	$6.91	$6.23
Revenue	$1,125	$656	$747	$1,209
Cash Operating Cost	$419	$218	$440	$1,049
Net Cash Income	$705	$438	$307	$160
$/AF Depletion	$222	$186	$152	$80

1/ Based on center pivot mid-elevation spray application (MESA)
2/ Based on NASS wheat yield reports for 2009, 2013, and 2018, the three most recent years for which wheat yield data were reported.

4 Water Savings and Costs of Alternative Conservation Strategies

We consider three water conservation strategies with the potential to reduce depletion in the study region: land fallowing, crop substitution, and irrigation system conversion. We quantify the anticipated depletion savings achievable under each strategy and estimate the compensation likely required to incentivize farmer participation. While farmer compensation will be the primary cost driver for any program, additional costs for legal and administrative processes, monitoring activities, and reporting

[27] See, for example, Montazar, Ali. (2020). *A Viability Assessment of Subsurface Drip Irrigation in the Desert Southwest*. Presented at the 6th Decennial National Irrigation Symposium, San Antonio, Texas, November 30 – December 4, 2020.

requirements will also be incurred by the program administrator. The cost per AF estimates presented hereafter reflect farm-gate pricing, analogous to Free on Board (FOB) terms. This signifies the cost of water savings at the farm delivery point, excluding any additional costs associated with setting up, administering, and monitoring the program.

4.1 Land Fallowing

A land fallowing program would incentivize farmers to remove land from production through upfront and/or annual payments. Notably, large-scale land fallowing programs have successfully operated in California's Palos Verdes and Imperial Valleys for decades, contributing to the conservation and transfer of Colorado River water.

Land fallowing is most strategically targeted towards alfalfa and other hay production, the region's dominant crops with the highest depletion. We leverage data from Table 7, combining estimated depletion rates and crop acreage (by irrigation method) to calculate the average depletion rate and unit cost of water savings for the study region, which are presented in Table 8. These estimates assume the program would include a good-neighbor weed abatement requirement for enrolled acreage, which is estimated to cost participants $50 per acre, on average.[28] Under non-drought conditions with no water supply limitations, a fallowing program could reduce depletion by an average of 2.7 acre-feet per enrolled acre at an average cost of $240 per acre-foot. As noted above, under periods of drought average depletion rates may be 10-30% lower and cost per AF would likely be higher.[29]

Table 8. Average Fallowing Cost per AF of Depletion Saved

Study Area Acreage	**Alfalfa**	**Other Hay**	**Total**
Flood	32,244	31,653	63,896
Sprinkler	120,012	43,253	163,265
Total	152,256	74,905	227,161
Savings (AF/Ac)	**Alfalfa**	**Other Hay**	**Average**
Flood	2.5	1.9	2.2
Sprinkler	3.2	2.4	3.0
Average	3.0	2.1	2.7
Change in Income ($/Ac)	**Alfalfa**	**Other Hay**	**Average**
Flood	$663	$434	$549
Sprinkler	$755	$488	$685
Average	$736	$465	$647
Cost per AF	**Alfalfa**	**Other Hay**	**Average**
Flood	$265	$228	$250
Sprinkler	$236	$203	$228
Average	$245	$221	$240

[28] Another potential option would be to allow dry cropping on enrolled acreage.

[29] It is not automatic that compensation amounts during droughts would be higher than estimated here. Although reduced depletion rates would exert upward pressure on compensation per AF, the net effect also would depend on changes in crop yields, prices, input costs, and farmers' risk perceptions.

The costs per AF in Table 8 are the break-even amounts calculated to compensate farmers for forgone production income. A program participation risk premium may need to be added to induce participation, particularly at higher program scales which would need to draw in better quality land. Some farmers may be wary of participating in a fallowing program because of the impact this may have on future yields of multi-year forage crops.[30]

Table 9 shows the maximum potential water savings under three hypothetical fallowing enrollment levels. These estimates are predicated on the depletions rates in Table 8 and assume well-watered crops are taken out of production. During periods of drought, potential savings would likely be 10-30% lower for the reasons discussed above.

The hypothetical enrollment levels in Table 9 were chosen solely for the purpose of placing a bound on the potential regional economic impacts of crop fallowing which are discussed later in this report. It is important to emphasize that it is unlikely that these levels of participation could be achieved through a voluntary fallowing program. WestWater Research, for example, found that the System Conservation Pilot Program in the Upper Colorado River Basin achieved participation rates in Utah well under 10%.[31] It is expected that a fallowing-based strategy would primarily focus on the temporary fallowing of marginal, low productivity acreage.

Table 9. Land Fallowing Annual Water Savings at Three Levels of Acreage Enrollment

Enrollment %	Acreage	Maximum Savings (AF)
25%	56,790	155,578
50%	113,581	311,155
75%	170,371	466,733

4.2 Crop Substitution

A crop substitution program would incentivize farmers to switch to a crop that consumes less water than the crop or crops they have grown historically. While we are unaware of agricultural water conservation programs focused solely on crop substitution, it is potentially allowed under two USDA conservation programs:[32]

- **Conservation Reserve Program (CRP):** This program, run by the USDA Farm Service Agency, offers rental payments to farmers who voluntarily take marginal lands out of production and establish long-term conservation practices. While not explicitly focused on crop switching, some farmers may choose to plant less water-intensive cover crops on idled land enrolled in CRP.

[30] WestWater Research has estimated that grower compensation was, on average, 20% above the break-even payment rate across projects enrolled in the 2015-2018 System Conservation Pilot Program in the Upper Colorado River Basin. Memorandum from WestWater Research to Central Utah Water Conservancy District dated May 1, 2024.

[31] Ibid.

[32] Additionally, federal crop price support programs have a long history of influencing the mix of crops in different regions of the country and over different periods of time.

- **Environmental Quality Incentives Program (EQIP):** This USDA program provides financial and technical assistance to farmers for a variety of conservation practices, including irrigation system improvements and on-farm water management practices. While not all programs directly incentivize crop switching, some EQIP programs may offer funding for transitioning to less water-intensive crops as part of a comprehensive water conservation plan.

Similar to the land fallowing strategy, we consider a crop substitution program targeting alfalfa and other hay production, the region's dominant water users. Leveraging data from Table 7 once more, we can estimate the incentive payments required for farmer participation and the projected water savings. Table 10 summarizes these estimates for a program focused on substituting forage crops with winter/spring small grains.[33]

Assuming optimal irrigation conditions without water limitations, a forage-to-grain crop substitution program could achieve an average reduction in depletion of 0.8 acre-feet per enrolled acre, at an average cost of $363 per acre-foot saved. Table 11 explores potential water savings at varying hypothetical acreage enrollment levels. At the largest program scale considered, crop-substitution-based conservation could yield annual water savings on the order of 150,000 acre feet.

A forage to corn grain crop substitution program, as detailed in Tables 12 and 13, offers another potential water conservation strategy. Under ideal, non-limiting irrigation conditions, this program could achieve an average reduction in depletion of 0.9 acre-feet per enrolled acre. However, the estimated cost is significantly higher at $530 per acre-foot saved. The potential savings are similar in magnitude to a program focused on incentivizing conversion to grain production.

Beyond the financial considerations explored here, several additional factors will influence the success of a crop substitution program:

- **Soil and Climate Compatibility:** The chosen substitute crop must thrive in the existing soil and climate conditions on participating farms. Successful establishment, reduced risk of crop failure, and long-term productivity all hinge on this compatibility. Soil testing and consultations with agricultural experts can help identify suitable replacements. It should be noted that the high elevations that characterize much of the study area pose significant production risks for these crops.

- **Market Accessibility:** A crop substitution program's success also will hinge on adequate infrastructure for crop storage and transportation, along with access to established markets. Without these elements in place, conservation founded on crop substitution is unlikely to be successful. It should be noted that much of the necessary infrastructure to grow grain and corn crops as scale are not currently in place in the study area.

- **Farmer Risk Tolerance:** Farmers with substantial investments in knowledge and equipment tailored to their current crops, or that are vertically integrated with a livestock operation, may be hesitant to switch. As with temporary fallowing-based strategies, to mitigate transition risks and

[33] Estimates in this section are based on small grain and corn grain rather than grain and corn silage production.

incentivize participation, the program may need to offer a risk premium.[34] This suggests the cost estimates in Tables 10 and 12 might be on the lower end of what's necessary for successful implementation.

A crop substitution conservation strategy would need to overcome significant agronomic, infrastructure, and market barriers to be successful. In general, the study area does not have a comparative advantage over other regions in the production of these crops, does not have established markets for them, and its high elevations pose significant risks of crop failure.

Table 10. Average Forage to Small Grain Substitution Cost per AF of Depletion Saved

Study Area Acreage	**Alfalfa**	**Other Hay**	**Total**
Flood	32,244	31,653	63,896
Sprinkler	120,012	43,253	163,265
Total	152,256	74,905	227,161
Savings (AF/Ac)	**Alf --> Small Grain**	**Oth Hay --> Small Grain**	**Average**
Flood	0.9	0.3	0.6
Sprinkler	1.2	0.3	0.9
Average	1.1	0.3	0.8
Change in Income ($/Ac)	**Alf --> Small Grain**	**Oth Hay --> Small Grain**	**Average**
Flood	$363	$134	$250
Sprinkler	$398	$131	$327
Average	$391	$132	$305
Cost per AF	**Alf --> Small Grain**	**Oth Hay --> Small Grain**	**Average**
Flood	$398	$501	$421
Sprinkler	$344	$386	$348
Average	$354	$428	$363

Table 11. Forage to Small Grain Substitution Annual Water Savings at Three Levels of Acreage Enrollment

Enrollment %	Acreage	Savings (AF)
25%	56,790	47,811
50%	113,581	95,621
75%	170,371	143,432

[34] A crop substitution program also would need to stipulate restrictions on double cropping as well as putting rules in place to prevent enrollments which coincide with a normal cycle of rotation out of a multi-year forage crop and into an annual small grain or corn crop.

Table 12. Average Forage to Corn Grain Substitution Cost per AF of Depletion Saved

Study Area Acreage	**Alfalfa**	**Other Hay**	**Total**
Flood	32,244	31,653	63,896
Sprinkler	120,012	43,253	163,265
Total	152,256	74,905	227,161
Savings (AF/Ac)	**Alf --> Corn Grain**	**Oth Hay --> Corn Grain**	**Average**
Flood	0.9	0.3	0.6
Sprinkler	1.2	0.4	1.0
Average	1.1	0.3	0.9
Change in Income ($/Ac)	**Alf --> Corn Grain**	**Oth Hay --> Corn Grain**	**Average**
Flood	$538	$309	$425
Sprinkler	$545	$278	$475
Average	$544	$291	$460
Cost per AF	**Alf --> Corn Grain**	**Oth Hay --> Corn Grain**	**Average**
Flood	$576	$1,066	$690
Sprinkler	$460	$757	$490
Average	$481	$870	$530

Table 13. Forage to Corn Substitution Annual Water Savings at Three Levels of Acreage Enrollment

Enrollment %	**Acreage**	**Savings (AF)**
25%	56,790	49,328
50%	113,581	98,655
75%	170,371	147,983

4.3 Irrigation System Conversion

Depending on their design, irrigation system conversion programs can influence depletion in different ways in the study region. As previously discussed, sprinkler and drip irrigation can potentially increase yields, and consequently, crop water use, compared to flood irrigation. Converting from flood to pivot or subsurface drip irrigation (SDI) on an acre-for-acre basis would likely lead to higher water depletion in the region, as illustrated in Table 14.

To counteract this potential drawback, a program could implement one of two strategies:

- **Deficit Irrigation Requirement:** Participating farmers would be required to restrict water application below the crop's optimal water demand.
- **Acreage Fallowing Requirement:** A portion of the enrolled acreage would be removed from crop production altogether.

From an administrative perspective, an acreage fallowing requirement would likely be easier to monitor and enforce compared to a deficit irrigation strategy. The following analysis therefore focuses on this approach.

Table 14. Estimated Applied Water and Depletion per Acre of Alfalfa

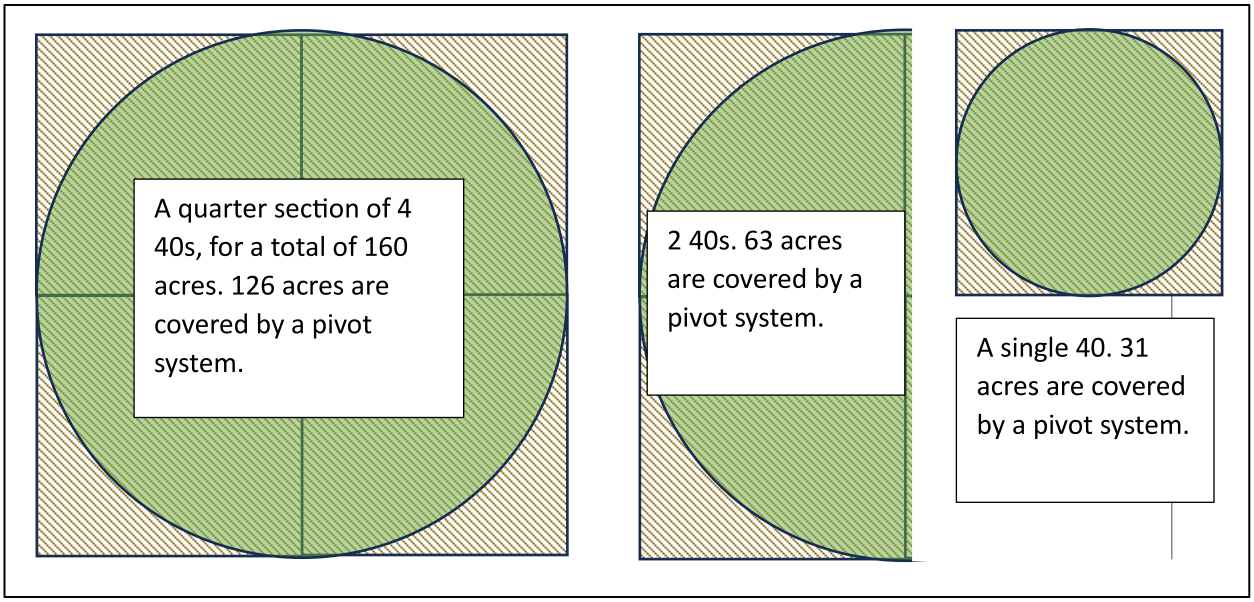
		Pivot			
Irrigation Water Use	**Flood**	**MESA**	**LEPA**	**LESA**	**SDI**
Yield (ton/ac)	3.93	4.33	4.33	4.33	4.92
Water Productivity (ton/in)	0.13	0.13	0.13	0.13	0.16
Crop Water Use (in)	30.0	33.0	33.0	33.0	30.8
Irrigation Efficiency (%)	79%	78%	86%	90%	98%
Losses (%)	21%	22%	14%	10%	2%
Applied Water (in)	38.0	42.3	38.4	36.7	31.5
Losses (in)	8.0	9.3	5.4	3.7	0.6
Loss Decomposition (%)					
Deep Percolation	95%	45%	14%	5%	100%
Wind Drift and Evap.	0%	55%	86%	95%	0%
Field Runoff	5%	0%	0%	0%	0%
Depletion (in)	30.04	38.08	37.60	36.48	30.83
Depletion (AF)	2.50	3.17	3.13	3.04	2.57

Notes: Irrigation efficiencies from USU Extension. Wind drift and evaporative losses for pivot irrigation capped at 12% of applied water, per Jacobs Engineering Group. Estimates assume the absence of administrative restrictions or controls on irrigation supplies.
MESA: Mid elevation spray application; LEPA: Low elevation precision application; LESA: Low elevation spray application.

For conversions from flood irrigation to pivot irrigation, a simple method leverages the geometry of pivot systems to implement acreage restrictions. Figure 2 illustrates typical pivot system configurations used on 40-acre quarter-quarter sections. If a program mandates that farmers take field corners out of production, the irrigated area would be reduced by 21.5%.[35] Consequently, water depletion per enrolled acre would decrease by 0.4 to 4.6 percent compared to flood irrigation, depending on the particular type of pivot system installed.

[35] Many farmers choose to irrigate field corners using flood irrigation or handset or wheel line sprinklers. The range of the pivot system can also be increased with the use of an end gun, which is a large sprinkler that attaches to the end of the pivot arm and can deliver water a hundred feet or more beyond the arm's radius.

Figure 2. Typical Pivot Irrigation System Configurations



Converting to Subsurface Drip Irrigation (SDI) will also necessitate some form of acreage restriction to achieve substantial water savings. For this analysis, we assume a program design that keeps production at current levels. Based on the yield estimates in Table 14, this translates to a 20% acreage retirement requirement when transitioning from flood to SDI and a 12% requirement when moving from sprinkler to SDI. As we demonstrate below, while acreage retirement significantly enhances water savings and lowers program costs for pivot-to-SDI conversions, it is not strictly required to achieve water savings altogether.

To determine the incentive payment needed for farmer participation, we estimate the net cost of transitioning to the new irrigation system. This cost has two components:

1. **System Acquisition and Installation:** The expense of purchasing and installing the new irrigation system.

2. **Production Cost and Income Changes:** This considers both potential yield improvements and any limitations on planted acreage due to the program design.

Importantly, we assume that any remaining undepreciated cost of the system being replaced will be offset by its salvage value. This is mostly relevant to the conversion of existing pivot systems, which entail a significant capital investment. [36]

System acquisition and installation costs are primarily based on irrigation system conversion costs compiled by USU Extension.[37] For conversion from flood to pivot irrigation, the USU Extension data is supplemented with pivot system cost data collected from Basin Irrigation, Inc., an irrigation system

[36] Although the analysis in this section uses pivot sprinkler conversion costs, both wheel-line and pivot systems would be candidates for conversion to SDI in an actual program. Both field geometry and conversion costs may favor wheel-line systems over pivot systems as conversion candidates.
[37] https://extension.usu.edu/crops/tools/irrigation-technology-cost-benefit-calculator.

provider operating in the study region. For financial analysis purposes, we employ the following common assumptions, drawn from USU Extension's irrigation technology cost-benefit calculator:[38]

- **Equipment Useful Life** is 20 years
- **Labor Rate** is $40.60/hr for management tasks and $17.40/hr for farm labor tasks
- **Loan Rate** is 8% for both operating and equipment loans
- **Inflation Rate** is 2.6%
- **Irrigation Season** is 20 weeks

For the sake of modeling, we assume that the program provides a 25% cost share towards the acquisition cost of the new system, coupled with 10 annual payments tailored to cover the remaining transition expenses on enrolled acreage.[39] The total cost of the program is determined by calculating the present value of both the cost share and annual payments. To ascertain the cost per acre-foot (AF), we annualize this present value cost over the useful life of the irrigation system and then divide it by the annual reduction in depletion. A breakdown of these calculations is provided in Appendix B for reference.

Table 15 presents a comprehensive overview of projected water savings and costs per acre-foot (AF) for each conversion scenario we have analyzed.

Table 15. Irrigation Conversion Savings and Cost Estimates

		Retire Acreage to Keep Production from Increasing					
		Yes			No		
FROM	TO	Depletion Reduction %	Acreage Retire %	Cost ($/AF)	Depletion Reduction %	Acreage Retire %	Cost ($/AF)
Flood	MESA	-0.4%	-21.5%	$15,340	*	*	*
Flood	LEPA	-1.7%	-21.5%	$4,078	*	*	*
Flood	LESA	-4.6%	-21.5%	$1,487	*	*	*
Flood	SDI	-17.9%	-20.0%	$440	*	*	*
MESA	SDI	-28.7%	-12.0%	$270	-19.0%	0.0%	$288
LEPA	SDI	-27.8%	-12.0%	$282	-18.0%	0.0%	$308
LESA	SDI	-25.6%	-12.0%	$316	-15.5%	0.0%	$369
* Conversion without land retirement requirement would increase depletion in the study region.							

Transitioning from flood to pivot irrigation necessitates retiring a portion of the land to achieve water savings. In our analysis, we assume the retirement of field corners, as depicted in Figure 2. However, these conversions yield minimal reductions in depletion and entail significant implementation costs. Consequently, flood to pivot conversions are not analyzed further in our study.

[38] Ibid.

[39] While our analysis adopts a different incentive structure (25% cost-sharing grant and 10 annual payments) than the Utah Department of Agriculture and Food's current Agricultural Water Optimization Program, this does not impact our core findings. This is because we assume the program will be financially balanced, meaning the present value of the compensation offered will be equivalent to the present value of the conversion costs for farmers.

In contrast, transitioning from flood to SDI holds promise, potentially reducing depletion by approximately 18% under a scenario where output (crop production) remains constant through land retirement. The data in the table indicate that achieving this reduction would necessitate retiring 20% of the enrolled acreage. Without mandating some level of land retirement, such conversions may lead to an increase in depletion within the study region (as reflected in Table 14).

Similarly, converting from pivot to SDI could yield a depletion reduction of approximately 28% if current output is maintained through land retirement. Without a requirement for land retirement, the reduction decreases to roughly 17%. Incorporating a retirement mandate into the program would unlock greater savings at a lower cost per enrolled acre.

Table 16 shows the potential depletion savings across various program scales, considering a land retirement provision is part of the program. These estimates specifically focus on conversions from flood to SDI and from MESA to SDI, as these are the predominant irrigation methods currently employed in the region for forage crops.

It is important to emphasize, however, that there is an inherent uncertainty in modeling the economics of irrigation system conversion to SDI because of the lack of large-scale implementation in the Upper Colorado River Basin. SDI research has mostly been based on its application in other parts of the western United States, primarily California. As noted by WestWater Research, large scale adoption of SDI in the study area is not considered feasible until multiple pilot or experiment sites are established local to Utah.[40]

Table 16. Irrigation Conversion Annual Water Savings at Three Levels of Forage Acreage Enrollment

Enrollment	Enrolled Forage Acreage			Depletion Savings (AF)		
%	Flood	Sprinkler	Total	Flood	Sprinkler	Total
25%	15,974	40,816	56,790	7,153	37,223	44,376
50%	31,948	81,632	113,581	14,305	74,446	88,751
75%	47,922	122,448	170,371	21,458	111,669	133,127

4.4 Summary of Potential Savings and Cost of Alternative Conservation Strategies

Table 17 offers an overview of potential savings and costs per AF saved for the alternative conservation strategies discussed above. According to our analysis, fallowing emerges as the option with the highest savings potential at the lowest cost per AF saved, albeit potentially posing the most significant disruption to the regional economy. Following fallowing, sprinkler to SDI conversion represents the next most economical option, succeeded by forage to winter/spring grain crop substitution.

In considering these estimates, it is important to keep in mind that the depletion reduction volumes shown in the table are predicated on a well-watered crop. When water supply is constrained because of

[40] Memorandum from WestWater Research to Central Utah Water Conservancy District dated May 1, 2024.

drought or other factors the potential depletion reduction would be lower and the cost per AF would likely increase.[41]

Table 17. Summary of Savings Potential and Cost-Effectiveness of Alternative Conservation Strategies

From	To	Depletion Reduction %	Cost per AF Saved	Potential Depletion Reduction (AF) by Acreage Enrollment % 25%	50%	75%
Forage	Fallow	100%	$240	155,578	311,155	466,733
Pivot	SDI	29%	$270	37,223	74,446	111,669
Forage	Grain	31%	$363	47,811	95,621	143,432
Flood	SDI	18%	$440	7,153	14,305	21,458
Forage	Corn	32%	$530	49,328	98,655	147,983

Notes: Program is assumed to target alfalfa and other hay acreage for conversions. Pivot depletion reduction and cost based on conversion of MESA pivot systems. Cost and savings for irrigation conversions assume acreage retirement as shown in Table 16.

5 Regional Economic Impacts of Alternative Conservation Strategies

After analyzing the potential water conservation savings and costs associated with various strategies in the preceding section, our focus now shifts to how these programs might affect the economy of the study region. As outlined in Section 2, we utilized an IMPLAN Multi-Regional Input-Output (MRIO) model covering the 12 counties intersecting the study area to estimate changes in regional output, value added, income, and employment.

Given our assumption that participating farmers will be compensated for income changes, this analysis centers on understanding how program-induced changes in on-farm investment and input purchases will impact the regional economy.

Among the conservation strategies considered, we anticipate significant regional impacts only from fallowing-based and irrigation-based approaches. Crop substitution is not expected to yield notable regional effects due to the similarity in input requirements for forage, grain, and corn production, both in terms of cost and quantity.[42]

Of the two strategies projected to have regional impacts, fallowing-based conservation is more straightforward to assess. With acreage removed from production, there will be a nearly proportional reduction in production input purchases.[43] We input expenditure data from the crop budgets provided in

[41] As noted above, the net effect of reduced supply on program participation cost would depend on multiple factors in addition to reduced depletion rates, including changes to crop yields, crop prices, production costs, and grower risk tolerances. This is a difficult general equilibrium question that goes beyond the scope of this study.

[42] Large scale operation of fallowing and crop substitution strategies could necessitate either increased importation of livestock feed into the region or reduction of livestock inventory. This potential impact has not been modeled as part of this study. At the margin of production, imported and locally produced feed costs would be similar under competitive market conditions.

[43] Experience with fallowing-based conservation programs in the Palos Verdes and Imperial Valleys in California indicate the relationship is not strictly one-to-one due to the offsetting effects of program payments to farmers which have been shown to spur additional on-farm investment and expenditure above what would be expected absent the programs. See, for example, M.Cubed (2002) and M.Cubed (2004).

Appendix A into the IMPLAN MRIO model to estimate the effects on businesses supplying farm inputs and services in the region.

For irrigation-based conservation, two regional effects are anticipated. Firstly, there will be an increase in on-farm investment for new irrigation equipment, temporarily benefiting the regional economy during the transition period. Secondly, the retirement of a portion of the enrolled acreage will lead to a near proportional reduction in production input purchases, albeit on a smaller scale compared to a program relying solely on fallowing to conserve water. The economic impact of this land retirement is modeled similarly to the fallowing-based program.

5.1 IMPLAN Economic Event Specification

IMPLAN is a powerful tool for analyzing how changes in a regional economy ripple through various sectors. By simulating different scenarios involving spending, investment, or production shifts within specific industries, we can estimate the resulting impacts on key economic indicators like employment, income, and value added.

This analysis relies on "commodity output events" within the IMPLAN model. A commodity output event specifies the total cost of a good or service, reflecting the price paid by the final purchaser (not just the producer's price). This approach provides a more complete picture of the economic activity generated by a particular commodity within the region. Using purchaser prices, IMPLAN distributes the economic impact across all relevant sectors involved in bringing the good or service to market, including producers, transportation, wholesalers, and retailers.

For commodities that go through wholesale or retail channels, IMPLAN incorporates margins to account for the additional costs associated with transportation, wholesaling, and retailing activities. This is particularly important in our study because most non-labor inputs going into the production of forage crops are produced outside of the region. The primary regional economic activity lies in transporting, warehousing, wholesaling, and retailing these inputs to farmers. Margins essentially allocate each dollar spent by the farmer to the sectors comprising the supply chain bringing the inputs to market.

A second IMPLAN model parameter, the Local Purchase Percentage (LPP), allows us to specify the portion of a commodity purchased locally. While some services used in the production of forage crops likely are sourced from outside the study region, this analysis employs IMPLAN's default settings, assuming 100% local purchase for non-marginable services and reflecting regional purchase coefficients (RPC) for marginable commodities. By assuming all service inputs are locally sourced, this conservative approach provides a larger, more cautious estimate of potential economic impacts.

5.1.1 Temporary Fallowing-Based Conservation Events

Table 18 details the "fallowing-based conservation events" used to simulate the regional decline in forage production input purchases due to temporary land fallowing. These events leverage the alfalfa and grass hay production budgets provided in Appendix A. The production costs are then assigned to the corresponding sectors within the IMPLAN model.

To estimate the regional economic impacts, we employ acreage-weighted averages of the alfalfa and other hay production costs as the basis for our economic event specifications. The program weed abatement cost at the end of Table 18 is shown as a negative value because it represents an offsetting program-induced increase in farm input purchases related to the assumed good-neighbor weed abatement requirement on fallowed acreage.

5.1.2 Irrigation-Based Conservation Events

As discussed earlier, the economic impact assessment considers two types of program-related events:

- **Irrigation Equipment Investment:** This event captures the economic activity associated with farmers purchasing and installing new irrigation systems. The specific costs for SDI systems, used in these simulations, were sourced from the USU Extension irrigation technology cost-benefit calculator.
- **Land Retirement:** This event reflects the economic consequences of removing a portion of enrolled land from production. The specifications for land retirement are the same as for the temporary fallowing-based program as shown in Table 18.

Table 18. IMPLAN Forage Crop Production Input Purchase Events ($/Acre)

Alfalfa Production Cost (67% of forage acreage)					
Event Title	**Event Type**	**IMPLAN Sector**	**Value**	**Margined**	**LPP**
Chemical Inputs	Commodity Output	3167 - Nitrogenous fertilizer	161.52	Yes	RPC
Fuel Inputs	Commodity Output	3154 - Refined petroleum products	43.47	Yes	RPC
Custom Service and Repair	Commodity Output	3019 - Support activities for agriculture	131.37	No	100%
Irrigation	Commodity Output	3049 - Water, sewage, and other systems	34.68	No	100%
Insurance	Commodity Output	3445 - Insurance agencies, brokerages, etc.	34.54	No	100%
Other Cash Overhead	Commodity Output	3456 - Accounting, tax preparation, etc.	31.55	No	100%
Total			437.13		

Other Hay Production Cost (33% of forage acreage)					
Event Title	**Event Type**	**IMPLAN Sector**	**Value**	**Margined**	**LPP**
Chemical Inputs	Commodity Output	3167 - Nitrogenous fertilizer	0.00	Yes	RPC
Fuel Inputs	Commodity Output	3154 - Refined petroleum products	16.52	Yes	RPC
Custom Service and Repair	Commodity Output	3019 - Support activities for agriculture	164.84	No	100%
Irrigation	Commodity Output	3049 - Water, sewage, and other systems	7.79	No	100%
Insurance	Commodity Output	3445 - Insurance agencies, brokerages, etc.	16.19	No	100%
Other Cash Overhead	Commodity Output	3456 - Accounting, tax preparation, etc.	7.46	No	100%
Total			212.81		

Acreage-Weighted Average Forage Production Cost					
Event Title	**Event Type**	**IMPLAN Sector**	**Value**	**Margined**	**LPP**
Chemical Inputs	Commodity Output	3167 - Nitrogenous fertilizer	107.68	Yes	RPC
Fuel Inputs	Commodity Output	3154 - Refined petroleum products	34.49	Yes	RPC
Custom Service and Repair	Commodity Output	3019 - Support activities for agriculture	142.52	No	100%
Irrigation	Commodity Output	3049 - Water, sewage, and other systems	25.71	No	100%
Insurance	Commodity Output	3445 - Insurance agencies, brokerages, etc.	28.42	No	100%
Other Cash Overhead	Commodity Output	3456 - Accounting, tax preparation, etc.	23.52	No	100%
Program Weed Abatement	Commodity Output	3019 - Support activities for agriculture	-50.00	No	100%
Total			312.35		

Table 19. IMPLAN SDI Installation Events ($/Acre)

Alfalfa Production Cost (67% of forage acreage)					
Event Title	**Event Type**	**IMPLAN Sector**	**Value**	**Margined**	**LPP**
SDI Equipment Purchase	Commodity Output	3245 - Hardware	3,000.00	Yes	RPC
SDI Installation Labor	Commodity Output	3019 - Support activities for agriculture	17.40	No	100%
Total			3,017.40		

5.2 Regional Impacts of Fallowing-Based Conservation Program

Table 20 summarizes the simulated economic impacts of fallowing-based conservation programs across three hypothetical program scales, at both the regional and county level. Impacts are expressed as a percentage change from the baseline scenario (no program) and are rounded to the nearest tenth of a percent.

The analysis reveals minimal regional economic effects for all program scales considered. Overall impacts on the study region remain below one percent of baseline levels, suggesting that temporary fallowing-based conservation would have a negligible influence on key economic indicators.

Table 20 also reveals a geographic disparity in program effects. While overall regional impacts are minimal, some counties experience a more pronounced impact than others. The five counties most affected, relative to their baseline levels, are Daggett, Duchesne, Emery, Uintah, and Wayne. In contrast, the remaining seven counties exhibit significantly lower impacts as a percentage of their baseline condition.

The geographic resolution of IMPLAN MRIO model does not give it the ability to determine impacts below the county level. More significant localized impacts could be possible in smaller communities where agriculture is the primary economic driver. One way to avoid this would be to place limits on the amount of acreage that could be enrolled in different areas in order to avoid clustering of impacts.

In addition to the geographic disparity in the level of impact, the simulation also indicates impacts will concentrate within a small group of industries. Table 21 identifies the 10 sectors out of the 300 included in the IMPLAN MRIO model most impacted by the program, revealing a concentration of these effects in a handful of key areas. However, it is important to remember that even within these sectors, the actual changes remain small compared to baseline levels.

5.3 Regional Impacts of Irrigation-Based Conservation Program

We summarize the impacts of irrigation-based conservation in accordance with the two event types previously described.

5.3.1 Impacts of Irrigation Equipment Investment

The regional impacts associated with irrigation equipment investment are summarized in Table 22, again at both the regional and county level. As before, impacts are expressed as a percentage change from the baseline scenario (no program) and are rounded to the nearest tenth of a percent.

The simulation indicates that on-farm investment in new irrigation equipment would provide a modest economic stimulus to the region's economy, positively boosting key economic indicators by more than one percent at the largest program scale we considered.

As with fallowing-based conservation, there is a geographic disparity in these effects, with the largest effects occurring in Daggett, Duchesne, Emery, Uintah, and Wayne counties. At the highest program scale considered, impacts in these counties are roughly 2 to 6 percent of the baseline level.

In terms of the sectoral distribution of regional impacts, Table 23 indicates that approximately three-quarters of the total impact would be concentrated in the retail and wholesale sectors. These sectors stand to gain from conservation strategies focused on irrigation system upgrades.[44]

While simulation results indicate that irrigation system upgrades can provide a temporary stimulus to the regional economy during the installation phase, this represents a short-term benefit of irrigation-based conservation strategies. It is also important to consider the potential long-term economic consequences associated with any land retirement requirements that might be attached to the program.

5.3.2 Impacts of Land Retirement Requirements

As discussed above (see Table 15), land retirement is a potential component of irrigation system upgrades. To model these impacts, we assumed a 20% retirement requirement for flood-to-SDI conversions and a 12% requirement for pivot-to-SDI conversions in order to hold crop production constant.

Table 24 summarizes the long-term economic impacts of the land retirement requirements. In most cases, the changes to regional economic indicators are negligible, amounting to less than one-tenth of a percent. Even at the county level, impacts are minimal, reaching two-tenths of a percent only in a few counties and at the highest program scale considered.

These minor economic effects are largely offset by the long-term benefits of improved water productivity achieved through increased irrigation efficiency.[45] As with fallowing-based conservation, impacts cluster in a relatively few sectors of the economy (refer to Table 21 for details).

5.4 Summary of Regional Impact Assessment

Temporary fallowing-based conservation programs are expected to result in minimal regional economic impacts, with decreases in the primary economic indicators considered amounting to less than 1% from baseline levels. However, there may be some geographic disparities observed across counties, with five counties in particular – Daggett, Duchesne, Emery, Uintah, and Wayne – experiencing the largest impacts. Additionally, more severe localized impacts could result unless the enrollment is structured to avoid clustering of program acreage.[46]

On the other hand, upgrades to irrigation systems could offer a modest short-term economic boost to the region, with increases in the primary economic indicators exceeding 1% from baseline levels.

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[44] These findings echo similar observations from past studies. In the 1990s and early 2000s, we conducted research on conservation programs in the Palos Verdes and Imperial Valleys in California. Interestingly, a follow-up interview with an agricultural equipment dealer in Palos Verdes revealed a surprising outcome. This dealership, initially a vocal opponent of the program due to concerns about decreased business, was in the process of expanding with a new showroom. The owner, a former critic, had become a strong advocate, highlighting a surge in business activity.

[45] Improved productivity means there is no decrease in farm output under this scenario and thus much of the potential impact is mitigated, being limited to relatively small reductions in farm input purchases.

[46] As discussed in the following section, locally controlled economic mitigation funds also can be used to offset adverse impacts. A notable example is the is the Palo Verde Valley Community Improvement Fund (PVVCIF), established by the Metropolitan Water District of Southern California as part of the Palo Verde Valley Fallowing and Forbearance Program. Managed by local citizens, this fund is dedicated to supporting various initiatives such as community improvement programs, small business development, and workforce training within the Palo Verde Valley.

Nonetheless, there might be minor long-term effects due to potential land retirement requirements attached to these programs, resulting in changes of less than 0.2% from baseline levels.

Importantly, both types of programs are likely to affect a limited number of industries in the region. Retail and wholesale sectors stand to benefit the most from irrigation upgrades, while the agricultural support sector may face the greatest adverse impact from temporary fallowing-based conservation strategies.

Table 20. Regional Economic Impacts of Temporary Fallowing-Based Conservation Program at Three Acreage Enrollment Levels

Output													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	-0.1%	0.0%	-0.4%	-0.3%	-0.2%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.5%
50%	-0.1%	-0.1%	-0.9%	-0.5%	-0.3%	-0.1%	-0.1%	0.0%	0.0%	0.0%	-0.3%	0.0%	-0.9%
75%	-0.2%	-0.1%	-1.3%	-0.8%	-0.5%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	-0.4%	0.0%	-1.4%
Value Added													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	-0.1%	0.0%	-0.3%	-0.3%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.3%
50%	-0.1%	0.0%	-0.6%	-0.5%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	-0.3%	0.0%	-0.5%
75%	-0.2%	-0.1%	-0.9%	-0.8%	-0.2%	-0.2%	-0.1%	0.0%	0.0%	0.0%	-0.4%	0.0%	-0.8%
Labor Income													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	-0.1%	0.0%	-0.3%	-0.4%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.2%	0.0%	-0.3%
50%	-0.1%	-0.1%	-0.6%	-0.7%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.0%	-0.3%	0.0%	-0.6%
75%	-0.2%	-0.1%	-0.9%	-1.1%	-0.3%	-0.2%	-0.1%	0.0%	0.0%	0.0%	-0.5%	0.0%	-0.9%
Employment													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	-0.1%	-0.1%	-0.3%	-0.4%	-0.3%	-0.1%	-0.1%	0.0%	0.0%	0.0%	-0.2%	0.0%	-0.3%
50%	-0.2%	-0.1%	-0.5%	-0.8%	-0.6%	-0.2%	-0.2%	-0.1%	0.0%	0.0%	-0.5%	0.0%	-0.7%
75%	-0.3%	-0.2%	-0.8%	-1.2%	-0.9%	-0.2%	-0.3%	-0.1%	0.0%	0.0%	-0.7%	0.0%	-1.0%

Table 21. Concentration of Regional Impacts of Land-Fallowing Conservation in Top 10 Affected Sectors

Value Added		
IMPLAN ID	Sector Name	% of Total Impact
19	Support activities for agriculture and forestry	15%
405	Retail - Building material and garden equipment and supplies stores	12%
445	Insurance agencies, brokerages, and related activities	9%
473	Business support services	8%
534	Other local government enterprises	6%
11	Beef cattle ranching and farming	5%
49	Water, sewage and other systems	5%
449	Owner-occupied dwellings	4%
399	Wholesale - Petroleum and petroleum products	3%
400	Wholesale - Other nondurable goods merchant wholesalers	3%
	Subtotal	71%
Labor Income		
IMPLAN ID	Sector Name	% of Total Impact
19	Support activities for agriculture and forestry	28%
473	Business support services	13%
405	Retail - Building material and garden equipment and supplies stores	10%
445	Insurance agencies, brokerages, and related activities	8%
11	Beef cattle ranching and farming	6%
534	Other local government enterprises	5%
14	Animal production, except cattle and poultry and eggs	2%
400	Wholesale - Other nondurable goods merchant wholesalers	2%
478	Other support services	2%
49	Water, sewage and other systems	2%
	Subtotal	78%
Employment		
IMPLAN ID	Sector Name	% of Total Impact
19	Support activities for agriculture and forestry	52%
473	Business support services	9%
405	Retail - Building material and garden equipment and supplies stores	7%
445	Insurance agencies, brokerages, and related activities	7%
11	Beef cattle ranching and farming	4%
447	Other real estate	1%
534	Other local government enterprises	1%
408	Retail - Gasoline stores	1%
478	Other support services	1%
49	Water, sewage and other systems	1%
	Subtotal	85%

Table 22. Regional Economic Impacts of Irrigation-Based Conservation Program at Three Acreage Enrollment Levels

Output													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.4%	0.2%	2.1%	1.7%	0.7%	0.3%	0.2%	0.1%	0.0%	0.0%	0.8%	0.0%	1.7%
50%	0.7%	0.3%	4.2%	3.4%	1.4%	0.6%	0.4%	0.1%	0.1%	0.0%	1.6%	0.0%	3.5%
75%	1.1%	0.5%	6.4%	5.0%	2.1%	0.9%	0.6%	0.2%	0.1%	0.0%	2.3%	0.0%	5.2%
Value Added													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.3%	0.2%	1.0%	1.8%	0.7%	0.3%	0.2%	0.0%	0.0%	0.0%	0.9%	0.0%	2.0%
50%	0.7%	0.3%	2.0%	3.6%	1.3%	0.6%	0.4%	0.1%	0.1%	0.0%	1.7%	0.0%	3.9%
75%	1.0%	0.5%	3.0%	5.4%	2.0%	0.9%	0.6%	0.1%	0.1%	0.0%	2.6%	0.0%	5.9%
Labor Income													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.4%	0.2%	0.7%	1.9%	0.9%	0.3%	0.2%	0.0%	0.0%	0.0%	0.8%	0.0%	1.6%
50%	0.7%	0.4%	1.4%	3.8%	1.8%	0.6%	0.4%	0.1%	0.1%	0.0%	1.7%	0.0%	3.3%
75%	1.1%	0.6%	2.1%	5.7%	2.7%	0.9%	0.5%	0.1%	0.1%	0.0%	2.5%	0.0%	4.9%
Employment													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.4%	0.3%	1.8%	1.7%	1.1%	0.4%	0.2%	0.1%	0.0%	0.0%	1.0%	0.0%	1.8%
50%	0.9%	0.6%	3.5%	3.5%	2.1%	0.7%	0.4%	0.1%	0.1%	0.0%	2.0%	0.0%	3.5%
75%	1.3%	0.8%	5.3%	5.2%	3.2%	1.1%	0.7%	0.2%	0.1%	0.0%	2.9%	0.0%	5.3%

Table 23. Concentration of Regional Impacts of Irrigation System Investment in Top 10 Affected Sectors

IMPLAN ID	Sector Name	% of Total Impact
Value Added		
405	Retail - Building material and garden equipment and supplies stores	64%
396	Wholesale - Other durable goods merchant wholesalers	11%
449	Owner-occupied dwellings	3%
417	Truck transportation	2%
447	Other real estate	2%
441	Monetary authorities and depository credit intermediation	1%
47	Electric power transmission and distribution	1%
422	Warehousing and storage	1%
512	Automotive repair and maintenance, except car washes	1%
534	Other local government enterprises	1%
	Subtotal	86%
Labor Income		
IMPLAN ID	Sector Name	% of Total Impact
405	Retail - Building material and garden equipment and supplies stores	64%
396	Wholesale - Other durable goods merchant wholesalers	10%
417	Truck transportation	3%
422	Warehousing and storage	2%
447	Other real estate	1%
526	Postal service	1%
512	Automotive repair and maintenance, except car washes	1%
47	Electric power transmission and distribution	1%
19	Support activities for agriculture and forestry	1%
420	Scenic and sightseeing transportation and support activities	1%
	Subtotal	85%
Employment		
IMPLAN ID	Sector Name	% of Total Impact
405	Retail - Building material and garden equipment and supplies stores	66%
396	Wholesale - Other durable goods merchant wholesalers	7%
447	Other real estate	4%
19	Support activities for agriculture and forestry	2%
417	Truck transportation	1%
422	Warehousing and storage	1%
510	Limited-service restaurants	1%
512	Automotive repair and maintenance, except car washes	1%
421	Couriers and messengers	1%
469	Management of companies and enterprises	1%
	Subtotal	85%

Table 24. Regional Economic Impacts of Irrigation-Based Land Retirement Requirement at Three Acreage Enrollment Levels

Output													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
50%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
75%	0.0%	0.0%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.2%
Value Added													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
75%	0.0%	0.0%	-0.2%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%
Labor Income													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
75%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
Employment													
Forage Acreage Enrolled	**Study Region**	**Carbon**	**Daggett**	**Duchesne**	**Emery**	**Garfield**	**Grand**	**San Juan**	**Sevier**	**Summit**	**Uintah**	**Wasatch**	**Wayne**
25%	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
50%	0.0%	0.0%	-0.1%	-0.2%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%
75%	-0.1%	0.0%	-0.1%	-0.2%	-0.2%	0.0%	-0.1%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.2%

6 Mitigating Economic Impacts of Conservation Programs

Several strategies can help lessen the economic downsides of agricultural water conservation and temporary land fallowing programs. These strategies fall into four main categories:

1. **Direct Mitigation Payments:** Direct payments to program participants can be used to offset program-induced income losses. For instance, the Palo Verde Valley Fallowing and Forbearance Program operating in the Palo Verde Valley of California provides landowners with both an initial enrollment payment and annual payments when land is rotated out of production.

2. **Job Retraining and Workforce Development:** Programs can be established to equip displaced agricultural workers with new skills, allowing them to transition to jobs in other sectors.

3. **Economic Diversification and Community Development:** Initiatives promoting new industries and community development can lessen reliance on agriculture and create fresh job opportunities.

4. **Rural Infrastructure Investment:** Upgrading infrastructure in rural areas, such as roads or broadband access, can improve the overall economic climate and attract new businesses.

6.1 The Importance of Participant Compensation

A core assumption in our analysis is that farmers will receive compensation for income lost due to program participation. These payments directly address the regional economic effects that would otherwise arise from reduced farm income.

Given the predominance of small, family-operated farms in the study region, compensation programs tailored to income loss are expected to mitigate most program impacts. As previously discussed, the third-party effects from changes in farm input purchases are relatively minor and unlikely to cause significant economic disruption. Therefore, we view direct compensation as the most efficient and effective strategy for mitigating the majority of regional economic impacts associated with the conservation strategies we have considered.

6.2 Job Retraining and Workforce Development

The effectiveness of job retraining and workforce development programs in mitigating job losses and improving employment outcomes is a topic of ongoing research with mixed findings. A brief summary of some of the pertinent literature follows:

- **Short-Term Wage Gains:** Heckman, J. J., Ichimura, H., & Todd, P. E. (2010) show that program participation can lead to short-term wage increases for participants compared to non-participants. However, the sustainability of these wage gains over time is not always clear.

- **Increased Employment Rates:** Some studies suggest that retraining programs can improve job placement rates for participants compared to a control group (Oreopoulos, P., & Pgattas, C. (2005)). However, the quality and intensity of the training program can significantly impact these outcomes.

- **Improved Skills and Knowledge:** Participation in retraining programs can equip workers with new skills and knowledge relevant to in-demand jobs, potentially increasing their employability, but the success of such programs can vary widely (Gutiérrez, M. P., & Saxon, M. L. (2006)).

There is a growing body of research, however, indicating these types of programs may have limited effectiveness, particularly over the long-term, for the following reasons:

- **Limited Long-Term Impact:** Some research suggests that the positive effects of retraining programs may fade over time, with wages returning to pre-training levels after a few years (Hotchkiss, C. (2015)).

- **Selection Bias:** Studies often struggle to account for selection bias, as individuals who self-select into retraining programs may already be more motivated or have better job prospects compared to the general population of displaced workers (Dehli, J., & Dustmann, C. (2005)).

- **Job Market Mismatch:** Additionally, retraining programs may not always be effective if they do not adequately address the specific needs of the local job market or emerging industries (National Academies of Sciences, Engineering, and Medicine. (2017)).

While job retraining and workforce development programs are often recommended to assist displaced workers, their effectiveness depends greatly on the scale of the program. The success of such initiatives relies on having a sufficient number of participants to justify the initial investment and ongoing operational costs. In the context of evaluating conservation strategies, the projected number of displaced workers is relatively small. Even with the largest program scale considered for a fallowing-based conservation program, the expected impact on wage and salary employment is only 331 jobs, accounting for approximately 0.3% of the total regional workforce. Additionally, these job losses are anticipated to be spread across the extensive study region. Given the limited number and widespread distribution of displaced workers, a targeted retraining program tailored specifically for this demographic may not be the most cost-effective solution.

6.3 Economic Diversification and Community Development

Economic diversification and community development programs aim to strengthen local economies by reducing dependence on a single industry and fostering new opportunities. As with job retraining and workforce development, research on their effectiveness presents a mixed picture, with some programs leading to positive outcomes and others showing limited impact. A brief summary of some of the pertinent literature follows:

- **Increased Job Growth:** Studies suggest that successful diversification programs can stimulate job creation in new sectors outside the dominant industry (Lowe, M., & Marques, R. (2018)). This is particularly important for rural communities heavily reliant on agriculture, which may be facing economic decline.

- **Improved Tax Revenue Base:** A diversified economy can broaden the tax base, leading to more stable and sustainable local government revenue streams (McCann, P., & Agyemen, B. W. (2016).

- **Enhanced Community Resilience:** Diversification efforts can make communities less vulnerable to economic shocks or downturns in a single industry (Henry, C., & Toft, H. (2004).

Other studies suggest caution regarding program effectiveness is warranted.

- **Planning and Implementation Challenges:** Developing and implementing successful diversification strategies can be complex, requiring careful planning, collaboration between stakeholders, and sustained funding (Halfacree, K. H. (2006)).

- **Limited Success in Some Regions:** Programs may not always be effective in all contexts, particularly in areas with limited resources or lacking access to key infrastructure (Vogel, S. K. (2016)).

- **Long Time Horizon:** It can take time for diversification efforts to show clear results, making it crucial to maintain long-term commitment and investment (Peters, M., Kniveton, D., Lundy, M., & Robson, P. (2010).

In the case of fallowing-based conservation, one notable example is the Palo Verde Valley Community Improvement Fund (PVVCIF), established by the Metropolitan Water District of Southern California as part of the Palo Verde Valley Fallowing and Forbearance Program. Managed by local citizens, this fund is dedicated to supporting various initiatives such as community improvement programs, small business development, and workforce training. The overarching goal of PVVCIF is to diversify the local economy and create new opportunities that are not solely reliant on agriculture. The funding level of the program was determined based in part on an analysis of the regional economic impacts associated with temporary agricultural land fallowing. However, the final funding amount was ultimately determined through collaboration and negotiation among the various stakeholders in the region.

6.4 Rural Infrastructure Investment

The effectiveness of investing in rural infrastructure to lessen economic displacement caused by other public policies, such as land retirement or environmental regulations, is another topic with ongoing research and mixed findings. A brief summary of some of the pertinent literature follows:

- **Improved Connectivity and Access:** Upgrading transportation infrastructure (roads, bridges) or broadband access in rural areas can enhance connectivity to markets, educational opportunities, and other resources. This can attract new businesses and investments, potentially creating new jobs for displaced workers (Ozgen, C., & Ulubasoglu, M. A. (2016)).

- **Increased Productivity and Efficiency:** Infrastructure investments in areas like irrigation systems or storage facilities for agricultural products can help improve the efficiency and productivity of existing businesses, potentially offsetting some job losses caused by other policies (World Bank. (2009)).

- **Enhanced Quality of Life:** Upgrading water and sanitation systems, healthcare facilities, or educational institutions in rural areas can improve the overall quality of life for residents, making these communities more attractive to businesses and workers seeking a better living environment (Lichter, D. T., & Knopf, G. (2000)).

However, other studies suggest more limited potential:

- **Limited Job Creation Potential:** Infrastructure investments may not always translate directly into job creation, particularly in areas with limited skilled workforce or lacking supportive policies (Vogel, S. K. (2016)).

- **High Initial Costs:** Building and maintaining rural infrastructure can be expensive, requiring careful cost-benefit analysis to ensure projects are financially viable (Carlino, G. A., & Kerr, S. P. (2013).

- **Long Time Horizon:** It can take time to see the full economic benefits of infrastructure investments, requiring long-term commitment and planning strategies (Aschauer, D. (1989)).

Overall, the effectiveness of infrastructure investments in mitigating economic displacement depends on several factors, including the specific infrastructure project, the needs of the local economy, and the availability of skilled labor. However, when strategically planned and executed in conjunction with other economic development initiatives, these investments can play an important role in promoting long-term economic growth and creating new opportunities in rural communities facing economic change.

6.5 Summary of Mitigation Strategies

This study has evaluated the potential economic impacts of various conservation strategies, along with mitigation strategies to lessen these effects. While job retraining, economic diversification, and rural infrastructure investment all have potential benefits, we conclude that direct compensation to program participants is the most efficient and effective approach for mitigating the majority of regional economic impacts associated with the conservation strategies considered here.

Our analysis rests on several key points:

- **Dominance of Small Farms:** The study region is characterized by a predominance of small, family-operated farms. Compensation programs tailored to income loss can simultaneously induce participation and mitigate the majority of the regional impact caused by the program.

- **Limited Scale of Displacement:** The projected number of displaced workers, even under the largest program scale considered, is relatively small, making targeted retraining programs less cost-effective.

- **Geographic Dispersion:** Job losses are expected to be geographically dispersed across the extensive study region, further diminishing the feasibility of targeted retraining efforts.

- **Mixed Effectiveness of Alternatives:** While economic diversification and infrastructure investments can offer long-term benefits, their success depends on various factors and can take time to yield results.

In contrast, direct compensation provides a clear and immediate way to mitigate the economic impacts associated with program-induced changes to farm income. This approach aligns with the core assumption of our analysis – that farmers will be compensated for income loss due to program participation. Not only is this necessary to induce voluntary participation in the program, but it will also greatly reduce the economic burden of these programs on rural communities in the study region.

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Appendix A – Crop Production Costs

This appendix contains the Utah State University Extension crop production cost estimates used in this study to calculate returns to production. The original budgets were updated to 2023 constant dollars using the NASS production cost indices shown in the following tables.

Alfalfa Hay Production Costs and Returns Per Acre

Duchesne County Alfalfa Production Costs and Returns, 2011
Wheel line irrigation

Source: https://extension.usu.edu/apec/files/uploads/Agribusiness-and-Food/Budgets/Crops/Duchesne/DuchesneCounty.pdf

Operating Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Insecticide	20.00	Insecticides	105.6	21.12
Herbicide	0.00	Herbicides	155.8	0.00
Fertilizer	120.00	Fertilizer Totals, incl Lime & Soil Conditioners	117	140.40
Custom Chem App	10.00	Ag Services	141.5	14.15
Custom Spread and Fert	5.00	Ag Services	141.5	7.08
Testing (soil & Forage)	1.00	Ag Services	141.5	1.42
Irrigation	25.00	Farm Sector	138.7	34.68
Hired Labor	20.00	Labor, Wage Rates	165.5	33.10
Fuel & Lube	47.25	Fuels	92	43.47
Maintenance	47.67	Supplies & Repairs	144.1	68.69
Miscellansous	5.00	Farm Sector	138.7	6.94
Total Operating Costs	300.92			371.03

Overhead Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Crop Insurance	17.50	Farm Sector	138.7	24.27
Accounting & Legal	6.50	Farm Sector	138.7	9.02
Office & Travel	16.25	Farm Sector	138.7	22.54
Other Taxes & Insurance	7.14	Taxes	143.8	10.27
Total Cash Overhead Costs	47.39			66.09
Total Cash Costs	**348.31**			**437.13**

Uintah County Alfalfa Production Costs and Returns, 2011
Wheel line irrigation

Source: https://extension.usu.edu/apec/files/uploads/Agribusiness-and-Food/Budgets/Crops/Uintah/UintahCounty2011Crops-DF7-17.pdf

Operating Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Insecticide	10.00	Insecticides	105.6	10.56
Herbicide	15.00	Herbicides	155.8	23.37
Fertilizer	120.00	Fertilizer Totals, incl Lime & Soil Conditioners	117	140.40
Custom Chem App	11.00	Ag Services	141.5	15.57
Custom Spread and Fert	0.00	Ag Services	141.5	0.00
Testing (soil & Forage)	1.00	Ag Services	141.5	1.42
Irrigation	26.88	Farm Sector	138.7	37.28
Hired Labor	57.00	Labor, Wage Rates	165.5	94.34
Fuel & Lube	32.52	Fuels	92	29.92
Maintenance	34.61	Supplies & Repairs	144.1	49.87
Miscellansous	5.00	Farm Sector	138.7	6.94
Total Operating Costs	313.01			409.65

Overhead Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Crop Insurance	13.44	Farm Sector	138.7	18.64
Accounting & Legal	8.96	Farm Sector	138.7	12.43
Office & Travel	17.92	Farm Sector	138.7	24.86
Other Taxes & Insurance	5.75	Taxes	143.8	8.27
Total Cash Overhead Costs	46.07			64.19
Total Cash Costs	**359.08**			**473.85**

Daggett County Alfalfa Production Costs and Returns, 2011
Wheel line irrigation

Source: https://extension.usu.edu/apec/files/uploads/Agribusiness-and-Food/Budgets/Crops/Daggett/DaggettCounty2011Crops-DF7-17.pdf

Operating Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Insecticide	0.00	Insecticides	105.6	0.00
Herbicide	0.00	Herbicides	155.8	0.00
Fertilizer	70.00	Fertilizer Totals, incl Lime & Soil Conditioners	117	81.90
Custom Chem App	0.00	Ag Services	141.5	0.00
Custom Spread and Fert	44.00	Ag Services	141.5	62.26
Testing (soil & Forage)	3.57	Ag Services	141.5	5.05
Irrigation	5.71	Farm Sector	138.7	7.92
Hired Labor	37.50	Labor, Wage Rates	165.5	62.06
Fuel & Lube	18.27	Fuels	92	16.81
Maintenance	25.54	Supplies & Repairs	144.1	36.80
Miscellansous	5.00	Farm Sector	138.7	6.94
Total Operating Costs	209.59			279.74

Overhead Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Crop Insurance	11.00	Farm Sector	138.7	15.26
Accounting & Legal	3.77	Farm Sector	138.7	5.23
Office & Travel	6.29	Farm Sector	138.7	8.72
Other Taxes & Insurance	5.31	Taxes	143.8	7.64
Total Cash Overhead Costs	26.37			36.85
Total Cash Costs	**235.96**			**316.59**

Grass Hay Production Costs and Returns Per Acre

Center pivot irrigation

Source: https://extension.usu.edu/apec/files/uploads/Agribusiness-and-Food/Budgets/Crops/Daggett/DaggettCounty2011Crops-DF7-17.pdf

Operating Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Insecticide	0.00	Insecticides	105.6	0.00
Herbicide	0.00	Herbicides	155.8	0.00
Fertilizer	0.00	Fertilizer Totals, incl Lime & Soil Conditioners	117	0.00
Custom Chem App	0.00	Ag Services	141.5	0.00
Custom Spread and Fert	44.00	Ag Services	141.5	62.26
Testing (soil & Forage)	0.00	Ag Services	141.5	0.00
Irrigation	5.62	Farm Sector	138.7	7.79
Hired Labor	37.50	Labor, Wage Rates	165.5	62.06
Fuel & Lube	17.96	Fuels	92	16.52
Maintenance	26.19	Supplies & Repairs	144.1	37.74
Miscellansous	2.00	Farm Sector	138.7	2.77
Total Operating Costs	133.27			189.15

Overhead Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Crop Insurance	5.88	Farm Sector	138.7	8.16
Accounting & Legal	2.02	Farm Sector	138.7	2.80
Office & Travel	3.36	Farm Sector	138.7	4.66
Other Taxes & Insurance	5.59	Taxes	143.8	8.04
Total Cash Overhead Costs	16.85			23.66
Total Cash Costs	**150.12**			**212.81**

Winter Wheat Production Costs and Returns Per Acre

Wheel line irrigation

Duchesne County Winter Wheat Production Costs and Returns, 2011

Source: https://extension.usu.edu/apec/files/uploads/Agribusiness-and-Food/Budgets/Crops/Duchesne/DuchesneCounty.pdf

Operating Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Insecticide	0.00	Insecticides	105.6	0.00
Herbicide	8.00	Herbicides	155.8	12.46
Fertilizer	50.00	Fertilizer Totals, incl Lime & Soil Conditioners	117	58.50
Custom Chem App	15.00	Ag Services	141.5	21.23
Custom Harvest	75.00	Ag Services	141.5	106.13
Testing (soil & Forage)	15.00	Ag Services	141.5	21.23
Irrigation	25.00	Farm Sector	138.7	34.68
Hired Labor	20.00	Labor, Wage Rates	165.5	33.10
Fuel & Lube	29.26	Fuels	92	26.92
Maintenance	31.21	Supplies & Repairs	144.1	44.97
Miscellansous	5.00	Farm Sector	138.7	6.94
Total Operating Costs	273.47			366.14

Overhead Costs	**Cost (2011 $)**	**NASS Cost Index (2011 = 100)**	**2023 Index**	**Cost (2023 $)**
Crop Insurance	17.50	Farm Sector	138.7	24.27
Accounting & Legal	6.50	Farm Sector	138.7	9.02
Office & Travel	16.24	Farm Sector	138.7	22.52
Other Taxes & Insurance	5.40	Taxes	143.8	7.77
Total Cash Overhead Costs	45.64			63.58
Total Cash Costs	**319.11**			**429.72**

Corn Grain Production Costs and Returns Per Acre

Northern Utah Production Costs and Returns, 2019

Source: https://extension.usu.edu/apec/files/Northern-Utah-Corn-Budget-2019.pdf

Operating Costs	Cost (2019 $)	NASS Cost Index (2011 = 100)	2019 Index	2023 Index	Cost (2023 $)
Land Preparation					
Plow	29.64	Ag Services	116.7	141.5	35.94
Disc	31.12	Ag Services	116.7	141.5	37.73
Land Plan	9.10	Ag Services	116.7	141.5	11.03
Harrow	14.46	Ag Services	116.7	141.5	17.53
Cultivation	28.82	Ag Services	116.7	141.5	34.94
Drill/Plant	16.75	Ag Services	116.7	141.5	20.31
Seed	118.80	Seeds & Plants Totals	112.9	131.7	138.58
Fertilizer	143.00	Fertilizer Totals, incl Lime & Soil Conditioners	71.8	117	233.02
Application	17.00	Ag Services	116.7	141.5	20.61
Herbicide	17.63	Herbicides	99.6	155.8	27.58
Application	8.50	Ag Services	116.7	141.5	10.31
Irrigation	20.00	Farm Sector	105.3	138.7	26.34
Labor	48.57	Labor, Wage Rates	133.2	165.5	60.35
Combine/Harvest	37.11	Ag Services	116.7	141.5	45.00
Trucking	78.75	Ag Services	116.7	141.5	95.49
Drying	67.50	Ag Services	116.7	141.5	81.84
Storage	45.00	Ag Services	116.7	141.5	54.56
Total Operating Costs	731.75				951.18

Overhead Costs	Cost (2019 $)	NASS Cost Index (2011 = 100)	2019 Index	2023 Index	Cost (2023 $)
Crop Insurance	30.00	Farm Sector	105.3	138.7	39.52
Interest	27.20	Interest	115.1	142.7	33.72
Total Cash Overhead Costs	57.20				73.24
Total Cash Costs	**788.95**				**1,024.41**

Appendix B – Irrigation System Conversion Costs

This appendix contains the irrigation system conversion cost estimates. The conversion cost and irrigation efficiency assumptions used in these calculations are based on estimates prepared by Utah State University Extension and Jacobs Engineering.

Convert Flood Irrigation to Subsurface Drip Irrigation (SDI)

Existing System: A surface irrigation method where water flows onto a strip of land that is confined by borders as it flows accross the field. Assumes 10% of losses go to runoff, the the rest to deep percolation. Assumes similar evaporation losses compared to other systems, thus none are included here.

New System: A subsurface drip system. No wind drift losses or runoff, and less than normal evaporative losses because the surface may not even wet (thus the higher efficiency). All losses to deep percolation are due to non-uniformity.

General Assumptions	**Value**
Hardware/Equipment Lifespan (years)	20.00
Management Cost Rate ($/hr)	$40.60
Labor Cost Rate ($/hr)	$17.40
Operating or Equip Loan Interest Rate (%)	8%
Inflation Rate (%)	2.6%
Irrigation Season Length (weeks)	20

Program Assumptions		
Enrolled Field Size (acres)	160	
Planted Field Size (acres)	128	Hold Output Constant
Irrigation System Cost	$384,000	Yes
Irrigation System Cost Share	25%	
Enrolled Acreage Annual Payment Term (yrs)	10	
Enrolled Acreage Break-Even Payment ($/Acre)	$234	

Depletion Reduction	**Pre**	**Post**
Crop water productivity (ton/in)	0.131	0.159
Crop Water Use (in/yr)	30.00	30.83
Overall Irrigation Efficiency (%)	79%	98%
Losses to Deep Perculation (%)	95%	100%
Losses to Wind Drift and Evaporation (%)	0%	0%
Losses to Field Runoff (%)	5%	0%
Applied Water (in/yr)	37.97	31.46
Crop Water Use (in/yr)	30.00	30.83
Total Losses (in/yr)	7.97	0.63
Losses to Deep Percolation (in/yr)	7.58	0.63
Losses to Wind Drift and Evaporation (in/yr)	0.00	0.00
Losses to Field Runoff (in/yr)	0.40	0.00
Depletion Calculation		
Crop Water Use (in/yr)	30.00	30.83
Wind Drift and Evaporation (in/yr)	0.00	0.00
Field Runoff (in/yr)	0.04	0.00
Total Depletion (in/yr)	30.04	30.83
Acres irrigated	160	128
Total Depletion (AF/yr)	400.5	328.9
Change in Depletion (AF/yr)		-71.6
Change in Depletion (%)		-17.9%

*Depletion estimates based on USU Irrigation Conversion Water Savings Destination Calculator

Program Cost per AF of Depletion Reduction			
		Total	**Per Enrolled Acre**
Upfront Program Cost Share		$96,000	$600
PV of Enrolled Acreage Annual Payments (10 Yrs)		$283,624	$1,773
Total Present Value Program Cost		$379,624	$2,373
Annualized Program Cost over Savings Lifecycle (20 yrs)		$31,504	$196.90
Program Reduction in Annual Depletion (AF/Yr)		71.64	0.45
Annualized Program Cost per AF of Depletion Reduction ($/AF)		**$440**	**$440**
Enrolled Acreage Break-Even Analysis			
Upfront, One-Time, Non-Recurring Costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Install Cost Paid by Farmer ($)	$288,000	$23,900.10	$149.38
Upfront Management Time Required (hours)	40.00	$134.77	$0.84
Upfront Unskilled Labor Required (hours)	128.00	$184.83	$1.16
Recurring Irrigation Season costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/week)	0.00	$0.00	$0.00
Labor Time Required (hrs/week)	26.67	$9,280.00	$58.00
Ongoing Expenses ($/week)	0.00	$0.00	$0.00
Recurring Annual Costs for Irrigation System	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/year)	0	$0.00	$0.00
Labor Time Required (hrs/year)	0.00	$0.00	$0.00
Ongoing Expenses ($/year)	$0.00	$0.00	$0.00
Change in Crop Revenue (Alfalfa Hay)	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Price ($/ton)	$259.94		
Pre-Conversion			
Yield (tons/acre)	3.93		
Acres	160		
Production (tons)	629.4		
Crop Revenue		$163,602.89	$1,022.52
Post-Conversion			
Yield Increase (%)	25%		
Yield (tons/acre)	4.92		
Acres	128		
Production (tons)	629.4		
Crop Revenue		($163,602.89)	($1,022.52)
Change in Cash Operating Cost	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Avoided Production Cost ($/acre)	409.65		
Acres removed from production	-32.00	($13,108.93)	($81.93)
Yield-related Increase in Harvest Cost ($/acre)	$24.58		
Acres with increased yield	128	$3,146.14	$19.66
		Annualized Cost	**Per Enrolled Acre**
Net Cost of Conversion (negative is benefit)		**$23,536.91**	**$147.11**
PV of 20 Year Lifecycle Cost to Grower		**$283,623.54**	**$1,772.65**
Break-Even Payments to Enrolled Acres over 10 years		**$37,447.43**	**$234.05**

Convert MESA Pivot Irrigation to Subsurface Drip Irrigation (SDI)

Existing System: A center pivot or linear move irrigation system with sprinklers mounted at a mid-elevation of 5-10 ft from the soil surface (mid elevation spray application). Assumes no runoff. Catch can efficiency tests average about 83%, primarily due to wind drift and evaporation losses.

New System: A subsurface drip system. No wind drift losses or runoff, and less than normal evaporative losses because the surface may not even wet (thus the higher efficiency). All losses to deep percolation are due to non-uniformity.

General Assumptions	**Value**
Hardware/Equipment Lifespan (years)	20.00
Management Cost Rate ($/hr)	$40.60
Labor Cost Rate ($/hr)	$17.40
Operating or Equip Loan Interest Rate (%)	8%
Inflation Rate (%)	2.6%
Irrigation Season Length (weeks)	20

Program Assumptions		
Enrolled Field Size (acres)	126	Hold Output Constant
Planted Field Size (acres)	111	Yes
Irrigation System Cost	$331,752	
Irrigation System Cost Share	25%	
Enrolled Acreage Annual Payment Term (yrs)	10	
Enrolled Acreage Break-Even Payment ($/Acre)	$305	

Depletion Reduction	**Pre**	**Post**
Crop water productivity (ton/in)	0.131	0.159
Crop Water Use (in/yr)	33.00	30.83
Overall Irrigation Efficiency (%)	78%	98%
Losses to Deep Percolation (%)	45%	100%
Losses to Wind Drift and Evaporation (%)	55%	0%
Losses to Field Runoff (%)	0%	0%
Applied Water (in/yr)	42.31	31.46
Crop Water Use (in/yr)	33.00	30.83
Total Losses (in/yr)	9.31	0.63
Losses to Deep Percolation (in/yr)	4.23	0.63
Losses to Wind Drift and Evaporation (in/yr)	5.08	0.00
Losses to Field Runoff (in/yr)	0.00	0.00
<u>Depletion Calculation</u>		
Crop Water Use (in/yr)	33.00	30.83
Wind Drift and Evaporation (in/yr)	5.08	0.00
Field Runoff (in/yr)	0.00	0.00
Total Depletion (in/yr)	38.08	30.83
Acres irrigated	126	111
Total Depletion (AF/yr)	398.7	284.1
Change in Depletion (AF/yr)		-114.6
Change in Depletion (%)		-28.7%

*Depletion estimates based on USU Irrigation Conversion Water Savings Destination Calculator

Program Cost per AF of Depletion Reduction				
			Total	**Per Enrolled Acre**
Upfront Program Cost Share			$82,938	$660
PV of Enrolled Acreage Annual Payments (10 Yrs)			$290,203	$2,309
Total Present Value Program Cost			$373,141	$2,969
Annualized Program Cost over Savings Lifecycle (20 yrs)			$30,966	$246.42
Program Reduction in Annual Depletion (AF/Yr)			114.60	0.91
Annualized Program Cost per AF of Depletion Reduction ($/AF)			**$270**	**$270**

Enrolled Acreage Break-Even Analysis			
Upfront, One-Time, Non-Recurring Costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Install Cost Paid by Farmer ($)	$248,814	$20,648.20	$164.31
Upfront Management Time Required (hours)	40.00	$134.77	$1.07
Upfront Unskilled Labor Required (hours)	110.58	$159.68	$1.27
Recurring Irrigation Season costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/week)	0.00	$0.00	$0.00
Labor Time Required (hrs/week)	20.94	$7,288.49	$58.00
Ongoing Expenses ($/week)	0.00	$0.00	$0.00
Recurring Annual Costs for Irrigation System	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/year)	0	$0.00	$0.00
Labor Time Required (hrs/year)	31.42	$546.64	$4.35
Ongoing Expenses ($/year)	$0.00	$0.00	$0.00
Change in Crop Revenue (Alfalfa Hay)	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Price ($/ton)	$259.94		
Pre-Conversion			
Yield (tons/acre)	4.33		
Acres	126		
Production (tons)	543.7		
Crop Revenue		$141,342.75	$1,124.77
Post-Conversion			
Yield Increase (%)	14%		
Yield (tons/acre)	4.92		
Acres	111		
Production (tons)	543.7		
Crop Revenue		($141,342.75)	($1,124.77)
Change in Cash Operating Cost	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Avoided Production Cost ($/acre)	409.65		
Acres removed from production	-15.08	($6,177.44)	($49.16)
Yield-related Increase in Harvest Cost ($/acre)	$13.41		
Acres with increased yield	111	$1,482.58	$11.80
		Annualized Cost	**Per Enrolled Acre**
Net Cost of Conversion (negative is benefit)		**$24,082.93**	**$191.65**
PV of 20 Year Lifecycle Cost to Grower		**$290,203.19**	**$2,309.36**
Break-Even Payments to Enrolled Acres over 10 years		**$38,316.15**	**$304.91**

Convert LEPA Pivot Irrigation to Subsurface Drip Irrigation (SDI)

Existing System: A center pivot or linear move irrigation system with emitters spaced closely together (2-5 ft usually) that dribble water directly onto the soil surface. (low energy precision application). Assumes no runoff. Catch can efficiency tests average about 96%, primarily due to wind drift and evaporation losses.

New System: A subsurface drip system. No wind drift losses or runoff, and less than normal evaporative losses because the surface may not even wet (thus the higher efficiency). All losses to deep percolation are due to non-uniformity.

General Assumptions	**Value**
Hardware/Equipment Lifespan (years)	20.00
Management Cost Rate ($/hr)	$40.60
Labor Cost Rate ($/hr)	$17.40
Operating or Equip Loan Interest Rate (%)	8%
Inflation Rate (%)	2.6%
Irrigation Season Length (weeks)	20

Program Assumptions		
Enrolled Field Size (acres)	126	
Planted Field Size (acres)	111	Hold Output Constant
Irrigation System Cost	$331,752	Yes
Irrigation System Cost Share	25%	
Enrolled Acreage Annual Payment Term (yrs)	10	
Enrolled Acreage Break-Even Payment ($/Acre)	$305	

Depletion Reduction	**Pre**		**Post**	
Crop water productivity (ton/in)	0.131		0.159	
Crop Water Use (in/yr)	33.00		30.83	
Overall Irrigation Efficiency (%)	86%		98%	
Losses to Deep Percolation (%)	14%		100%	
Losses to Wind Drift and Evaporation (%)	86%		0%	
Losses to Field Runoff (%)	0%		0%	
Applied Water (in/yr)	38.37	% of Applied	31.46	% of Applied
Crop Water Use (in/yr)	33.00	86%	30.83	98%
Total Losses (in/yr)	5.37	14%	0.63	2%
Losses to Deep Percolation (in/yr)	0.77	2%	0.63	2%
Losses to Wind Drift and Evaporation (in/yr)	4.60	12%	0.00	0%
Losses to Field Runoff (in/yr)	0.00	0%	0.00	0%
<u>Depletion Calculation</u>				
Crop Water Use (in/yr)	33.00		30.83	
Wind Drift and Evaporation (in/yr)	4.60		0.00	
Field Runoff (in/yr)	0.00		0.00	
Total Depletion (in/yr)	37.60		30.83	
Acres irrigated	126		111	
Total Depletion (AF/yr)	393.8		284.1	
Change in Depletion (AF/yr)			-109.7	
Change in Depletion (%)			-27.8%	

*Depletion estimates based on USU Irrigation Conversion Water Savings Destination Calculator

Program Cost per AF of Depletion Reduction			
		Total	**Per Enrolled Acre**
Upfront Program Cost Share		$82,938	$660
PV of Enrolled Acreage Annual Payments (10 Yrs)		$290,203	$2,309
Total Present Value Program Cost		$373,141	$2,969
Annualized Program Cost over Savings Lifecycle (20 yrs)		$30,966	$246.42
Program Reduction in Annual Depletion (AF/Yr)		109.66	0.87
Annualized Program Cost per AF of Depletion Reduction ($/AF)		**$282**	**$282**

Enrolled Acreage Break-Even Analysis			
Upfront, One-Time, Non-Recurring Costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Install Cost Paid by Farmer ($)	$248,814	$20,648.20	$164.31
Upfront Management Time Required (hours)	40.00	$134.77	$1.07
Upfront Unskilled Labor Required (hours)	110.58	$159.68	$1.27
Recurring Irrigation Season costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/week)	0.00	$0.00	$0.00
Labor Time Required (hrs/week)	20.94	$7,288.49	$58.00
Ongoing Expenses ($/week)	0.00	$0.00	$0.00
Recurring Annual Costs for Irrigation System	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/year)	0	$0.00	$0.00
Labor Time Required (hrs/year)	31.42	$546.64	$4.35
Ongoing Expenses ($/year)	$0.00	$0.00	$0.00
Change in Crop Revenue (Alfalfa Hay)	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Price ($/ton)	$259.94		
Pre-Conversion			
Yield (tons/acre)	4.33		
Acres	126		
Production (tons)	543.7		
Crop Revenue		$141,342.75	$1,124.77
Post-Conversion			
Yield Increase (%)	14%		
Yield (tons/acre)	4.92		
Acres	111		
Production (tons)	543.7		
Crop Revenue		($141,342.75)	($1,124.77)
Change in Cash Operating Cost	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Avoided Production Cost ($/acre)	409.65		
Acres removed from production	-15.08	($6,177.44)	($49.16)
Yield-related Increase in Harvest Cost ($/acre)	$13.41		
Acres with increased yield	111	$1,482.58	$11.80
		Annualized Cost	**Per Enrolled Acre**
Net Cost of Conversion (negative is benefit)		**$24,082.93**	**$191.65**
PV of 20 Year Lifecycle Cost to Grower		**$290,203.19**	**$2,309.36**
Break-Even Payments to Enrolled Acres over 10 years		**$38,316.15**	**$304.91**

Convert LESA Pivot Irrigation to Subsurface Drip Irrigation (SDI)

Existing System: A center pivot or linear move irrigation system with emitters spaced closely together (2-5 ft usually), and are mounted at a low elevation (1-3 ft usually) that have sprinklers on them (low elevation spray application). Assumes no runoff. Catch can efficiency tests average about 96%, primarily due to wind drift and evaporation losses.

New System: A subsurface drip system. No wind drift losses or runoff, and less than normal evaporative losses because the surface may not even wet (thus the higher efficiency). All losses to deep percolation are due to non-uniformity.

General Assumptions	**Value**
Hardware/Equipment Lifespan (years)	20.00
Management Cost Rate ($/hr)	$40.60
Labor Cost Rate ($/hr)	$17.40
Operating or Equip Loan Interest Rate (%)	8%
Inflation Rate (%)	2.6%
Irrigation Season Length (weeks)	20

Program Assumptions		
Enrolled Field Size (acres)	126	
Planted Field Size (acres)	111	Hold Output Constant
Irrigation System Cost	$331,752	Yes
Irrigation System Cost Share	25%	
Enrolled Acreage Annual Payment Term (yrs)	10	
Enrolled Acreage Break-Even Payment ($/Acre)	$305	

Depletion Reduction	**Pre**		**Post**	
Crop water productivity (ton/in)	0.131		0.159	
Crop Water Use (in/yr)	33.00		30.83	
Overall Irrigation Efficiency (%)	90%		98%	
Losses to Deep Percolation (%)	5%		100%	
Losses to Wind Drift and Evaporation (%)	95%		0%	
Losses to Field Runoff (%)	0%		0%	
Applied Water (in/yr)	36.67	% of Applied	31.46	% of Applied
Crop Water Use (in/yr)	33.00	90%	30.83	98%
Total Losses (in/yr)	3.67	10%	0.63	2%
Losses to Deep Percolation (in/yr)	0.18	1%	0.63	2%
Losses to Wind Drift and Evaporation (in/yr)	3.48	9%	0.00	0%
Losses to Field Runoff (in/yr)	0.00	0%	0.00	0%
<u>Depletion Calculation</u>				
Crop Water Use (in/yr)	33.00		30.83	
Wind Drift and Evaporation (in/yr)	3.48		0.00	
Field Runoff (in/yr)	0.00		0.00	
Total Depletion (in/yr)	36.48		30.83	
Acres irrigated	126		111	
Total Depletion (AF/yr)	382.1		284.1	
Change in Depletion (AF/yr)			-97.9	
Change in Depletion (%)			-25.6%	

*Depletion estimates based on USU Irrigation Conversion Water Savings Destination Calculator

Program Cost per AF of Depletion Reduction			
		Total	**Per Enrolled Acre**
Upfront Program Cost Share		$82,938	$660
PV of Enrolled Acreage Annual Payments (10 Yrs)		$290,203	$2,309
Total Present Value Program Cost		$373,141	$2,969
Annualized Program Cost over Savings Lifecycle (20 yrs)		$30,966	$246.42
Program Reduction in Annual Depletion (AF/Yr)		97.91	0.78
Annualized Program Cost per AF of Depletion Reduction ($/AF)		**$316**	**$316**

Enrolled Acreage Break-Even Analysis			
Upfront, One-Time, Non-Recurring Costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Install Cost Paid by Farmer ($)	$248,814	$20,648.20	$164.31
Upfront Management Time Required (hours)	40.00	$134.77	$1.07
Upfront Unskilled Labor Required (hours)	110.58	$159.68	$1.27
Recurring Irrigation Season costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/week)	0.00	$0.00	$0.00
Labor Time Required (hrs/week)	20.94	$7,288.49	$58.00
Ongoing Expenses ($/week)	0.00	$0.00	$0.00
Recurring Annual Costs for Irrigation System	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/year)	0	$0.00	$0.00
Labor Time Required (hrs/year)	31.42	$546.64	$4.35
Ongoing Expenses ($/year)	$0.00	$0.00	$0.00
Change in Crop Revenue (Alfalfa Hay)	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Price ($/ton)	$259.94		
Pre-Conversion			
Yield (tons/acre)	4.33		
Acres	126		
Production (tons)	543.7		
Crop Revenue		$141,342.75	$1,124.77
Post-Conversion			
Yield Increase (%)	14%		
Yield (tons/acre)	4.92		
Acres	111		
Production (tons)	543.7		
Crop Revenue		($141,342.75)	($1,124.77)
Change in Cash Operating Cost	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Avoided Production Cost ($/acre)	409.65		
Acres removed from production	-15.08	($6,177.44)	($49.16)
Yield-related Increase in Harvest Cost ($/acre)	$13.41		
Acres with increased yield	111	$1,482.58	$11.80
		Annualized Cost	**Per Enrolled Acre**
Net Cost of Conversion (negative is benefit)		**$24,082.93**	**$191.65**
PV of 20 Year Lifecycle Cost to Grower		**$290,203.19**	**$2,309.36**
Break-Even Payments to Enrolled Acres over 10 years		**$38,316.15**	**$304.91**

Convert Flood Irrigation to MESA Pivot

Existing System:	A surface irrigation method where water flows onto a strip of land that is confined by borders as it flows accross the field. Assumes 10% of losses go to runoff, the the rest to deep percolation. Assumes similar evaporation losses compared to other systems, thus none are included here.
New System:	A center pivot or linear move irrigation system with sprinklers mounted at a mid-elevation of 5-10 ft from the soil surface (mid elevation spray application). Assumes no runoff. Catch can efficiency tests average about 83%, primarily due to wind drift and evaporation losses.

General Assumptions	**Value**
Hardware/Equipment Lifespan (years)	20.00
Management Cost Rate ($/hr)	$40.60
Labor Cost Rate ($/hr)	$17.40
Operating or Equip Loan Interest Rate (%)	8%
Inflation Rate (%)	2.6%
Irrigation Season Length (weeks)	20

Program Assumptions	
Enrolled Field Size (acres)	160
Planted Field Size (acres)	126
Irrigation System Cost	$179,269
Irrigation System Cost Share	25%
Enrolled Acreage Annual Payment Term (yrs)	10
Enrolled Acreage Break-Even Payment ($/Acre)	$236

Depletion Reduction	**Pre**		**Post**	
Crop water productivity (ton/in)	0.131		0.131	
Crop Water Use (in/yr)	30.00		33.00	
Overall Irrigation Efficiency (%)	79%		78%	
Losses to Deep Perculation (%)	95%		45%	
Losses to Wind Drift and Evaporation (%)	0%		55%	
Losses to Field Runoff (%)	5%		0%	
Applied Water (in/yr)	37.97	% of Applied	42.31	% of Applied
Crop Water Use (in/yr)	30.00	79%	33.00	78%
Total Losses (in/yr)	7.97	21%	9.31	22%
Losses to Deep Percolation (in/yr)	7.58	20%	4.23	10%
Losses to Wind Drift and Evaporation (in/yr)	0.00	0%	5.08	12%
Losses to Field Runoff (in/yr)	0.40	1%	0.00	0%
<u>Depletion Calculation</u>				
Crop Water Use (in/yr)	30.00		33.00	
Wind Drift and Evaporation (in/yr)	0.00		5.08	
Field Runoff (in/yr)	0.04		0.00	
Total Depletion (in/yr)	30.04		38.08	
Acres irrigated	160		125.7	
Total Depletion (AF/yr)	400.5		398.7	
Change in Depletion (AF/yr)			-1.8	
Change in Depletion (%)			-0.4%	

*Depletion estimates based on USU Irrigation Conversion Water Savings Destination Calculator

Program Cost per AF of Depletion Reduction			
		Total	**Per Enrolled Acre**
Upfront Program Cost Share		$44,817	$280
PV of Enrolled Acreage Annual Payments (10 Yrs)		$286,250	$1,789
Total Present Value Program Cost		$331,067	$2,069
Annualized Program Cost over Savings Lifecycle (20 yrs)		$27,474	$171.71
Program Reduction in Annual Depletion (AF/Yr)		1.79	0.01
Annualized Program Cost per AF of Depletion Reduction ($/AF)		**$15,340**	**$15,340**
Enrolled Acreage Break-Even Analysis			
Upfront, One-Time, Non-Recurring Costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Install Cost Paid by Farmer ($)	$134,452	$11,157.70	$69.74
Upfront Management Time Required (hours)	40.00	$134.77	$0.84
Upfront Unskilled Labor Required (hours)	160.00	$231.03	$1.44
Recurring Irrigation Season costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/week)	0.00	$0.00	$0.00
Labor Time Required (hrs/week)	26.67	$9,280.00	$58.00
Ongoing Expenses ($/week)	0.00	$0.00	$0.00
Recurring Annual Costs for Irrigation System	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/year)	0	$0.00	$0.00
Labor Time Required (hrs/year)	-400.00	($6,960.00)	($43.50)
Ongoing Expenses ($/year)	481.71	$481.71	$3.01
Change in Crop Revenue (Alfalfa Hay)	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Price ($/ton)	$259.94		
Pre-Conversion			
Yield (tons/acre)	3.93		
Acres	160		
Production (tons)	629.4		
Crop Revenue		$163,602.89	$1,022.52
Post-Conversion			
Yield Increase (%)	10%		
Yield (tons/acre)	4.33		
Acres	125.7		
Production (tons)	543.7		
Crop Revenue		($141,342.75)	($883.39)
Change in Cash Operating Cost	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Avoided Production Cost ($/acre)	409.65		
Acres removed from production	-34.34	($14,066.00)	($87.91)
Yield-related Increase in Harvest Cost ($/acre)	$9.83		
Acres with increased yield	125.7	$1,235.49	$7.72
		Annualized Cost	**Per Enrolled Acre**
Net Cost of Conversion (negative is benefit)		**$23,754.84**	**$148.47**
PV of 20 Year Lifecycle Cost to Grower		**$286,249.70**	**$1,789.06**
Break-Even Payments to Enrolled Acres over 10 years		**$37,794.16**	**$236.21**

Convert Flood Irrigation to LEPA Pivot

Existing System:	A surface irrigation method where water flows onto a strip of land that is confined by borders as it flows accross the field. Assumes 10% of losses go to runoff, the the rest to deep percolation.
	Assumes similar evaporation losses compared to other systems, thus none area included here.
New System:	A center pivot or linear move irrigation system with emitters spaced closely together (2-5 ft usually) that dribble water directly onto the soil surface. (low energy precision application). Assumes no runoff. Catch can efficiency tests average about 96%, primarily due to wind drift and evaporation losses.

General Assumptions	**Value**
Hardware/Equipment Lifespan (years)	20.00
Management Cost Rate ($/hr)	$40.60
Labor Cost Rate ($/hr)	$17.40
Operating or Equip Loan Interest Rate (%)	8%
Inflation Rate (%)	2.6%
Irrigation Season Length (weeks)	20

Program Assumptions	
Enrolled Field Size (acres)	160
Planted Field Size (acres)	126
Irrigation System Cost	$179,269
Irrigation System Cost Share	25%
Enrolled Acreage Annual Payment Term (yrs)	10
Enrolled Acreage Break-Even Payment ($/Acre)	$236

Depletion Reduction	**Pre**		**Post**	
Crop water productivity (ton/in)	0.131		0.131	
Crop Water Use (in/yr)	30.00		33.00	
Overall Irrigation Efficiency (%)	79%		86%	
Losses to Deep Perculation (%)	95%		14%	
Losses to Wind Drift and Evaporation (%)	0%		86%	
Losses to Field Runoff (%)	5%		0%	
Applied Water (in/yr)	37.97	% of Applied	38.37	% of Applied
Crop Water Use (in/yr)	30.00	79%	33.00	86%
Total Losses (in/yr)	7.97	21%	5.37	14%
Losses to Deep Percolation (in/yr)	7.58	20%	0.77	2%
Losses to Wind Drift and Evaporation (in/yr)	0.00	0%	4.60	12%
Losses to Field Runoff (in/yr)	0.40	1%	0.00	0%
<u>Depletion Calculation</u>				
Crop Water Use (in/yr)	30.00		33.00	
Wind Drift and Evaporation (in/yr)	0.00		4.60	
Field Runoff (in/yr)	0.04		0.00	
Total Depletion (in/yr)	30.04		37.60	
Acres irrigated	160		125.7	
Total Depletion (AF/yr)	400.5		393.8	
Change in Depletion (AF/yr)			-6.7	
Change in Depletion (%)			-1.7%	

*Depletion estimates based on USU Irrigation Conversion Water Savings Destination Calculator

Program Cost per AF of Depletion Reduction		
	Total	**Per Enrolled Acre**
Upfront Program Cost Share	$44,817	$280
PV of Enrolled Acreage Annual Payments (10 Yrs)	$286,250	$1,789
Total Present Value Program Cost	$331,067	$2,069
Annualized Program Cost over Savings Lifecycle (20 yrs)	$27,474	$171.71
Program Reduction in Annual Depletion (AF/Yr)	6.74	0.04
Annualized Program Cost per AF of Depletion Reduction ($/AF)	**$4,078**	**$4,078**

Enrolled Acreage Break-Even Analysis			
Upfront, One-Time, Non-Recurring Costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Install Cost Paid by Farmer ($)	$134,452	$11,157.70	$69.74
Upfront Management Time Required (hours)	40.00	$134.77	$0.84
Upfront Unskilled Labor Required (hours)	160.00	$231.03	$1.44
Recurring Irrigation Season costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/week)	0.00	$0.00	$0.00
Labor Time Required (hrs/week)	26.67	$9,280.00	$58.00
Ongoing Expenses ($/week)	0.00	$0.00	$0.00
Recurring Annual Costs for Irrigation System	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/year)	0	$0.00	$0.00
Labor Time Required (hrs/year)	-400.00	($6,960.00)	($43.50)
Ongoing Expenses ($/year)	481.71	$481.71	$3.01
Change in Crop Revenue (Alfalfa Hay)	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Price ($/ton)	$259.94		
Pre-Conversion			
Yield (tons/acre)	3.93		
Acres	160		
Production (tons)	629.4		
Crop Revenue		$163,602.89	$1,022.52
Post-Conversion			
Yield Increase (%)	10%		
Yield (tons/acre)	4.33		
Acres	125.7		
Production (tons)	543.7		
Crop Revenue		($141,342.75)	($883.39)
Change in Cash Operating Cost	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Avoided Production Cost ($/acre)	409.65		
Acres removed from production	-34.34	($14,066.00)	($87.91)
Yield-related Increase in Harvest Cost ($/acre)	$9.83		
Acres with increased yield	125.7	$1,235.49	$7.72
		Annualized Cost	**Per Enrolled Acre**
Net Cost of Conversion (negative is benefit)		**$23,754.84**	**$148.47**
PV of 20 Year Lifecycle Cost to Grower		**$286,249.70**	**$1,789.06**
Break-Even Payments to Enrolled Acres over 10 years		**$37,794.16**	**$236.21**

Convert Flood Irrigation to LESA Pivot

Existing System: A surface irrigation method where water flows onto a strip of land that is confined by borders as it flows accross the field. Assumes 10% of losses go to runoff, the the rest to deep percolation. Assumes similar evaporation losses compared to other systems, thus none are included here.

New System: A center pivot or linear move irrigation system with emitters spaced closely together (2-5 ft usually), and are mounted at a low elevation (1-3 ft usually) that have sprinklers on them (low elevation spray application). Assumes no runoff. Catch can efficiency tests average about 96%, primarily due to wind drift and evaporation losses.

General Assumptions	**Value**
Hardware/Equipment Lifespan (years)	20.00
Management Cost Rate ($/hr)	$40.60
Labor Cost Rate ($/hr)	$17.40
Operating or Equip Loan Interest Rate (%)	8%
Inflation Rate (%)	2.6%
Irrigation Season Length (weeks)	20

Program Assumptions	
Enrolled Field Size (acres)	160
Planted Field Size (acres)	126
Irrigation System Cost	$179,269
Irrigation System Cost Share	25%
Enrolled Acreage Annual Payment Term (yrs)	10
Enrolled Acreage Break-Even Payment ($/Acre)	$236

Depletion Reduction	**Pre**		**Post**	
Crop water productivity (ton/in)	0.131		0.131	
Crop Water Use (in/yr)	30.00		33.00	
Overall Irrigation Efficiency (%)	79%		90%	
Losses to Deep Perculation (%)	95%		5%	
Losses to Wind Drift and Evaporation (%)	0%		95%	
Losses to Field Runoff (%)	5%		0%	
Applied Water (in/yr)	37.97	% of Applied	36.67	% of Applied
Crop Water Use (in/yr)	30.00	79%	33.00	90%
Total Losses (in/yr)	7.97	21%	3.67	10%
Losses to Deep Percolation (in/yr)	7.58	20%	0.18	1%
Losses to Wind Drift and Evaporation (in/yr)	0.00	0.0%	3.48	9.5%
Losses to Field Runoff (in/yr)	0.40	1%	0.00	0%
<u>Depletion Calculation</u>				
Crop Water Use (in/yr)	30.00		33.00	
Wind Drift and Evaporation (in/yr)	0.00		3.48	
Field Runoff (in/yr)	0.04		0.00	
Total Depletion (in/yr)	30.04		36.48	
Acres irrigated	160		125.7	
Total Depletion (AF/yr)	400.5		382.1	
Change in Depletion (AF/yr)			-18.5	
Change in Depletion (%)			-4.6%	

*Depletion estimates based on USU Irrigation Conversion Water Savings Destination Calculator

Program Cost per AF of Depletion Reduction			
		Total	**Per Enrolled Acre**
Upfront Program Cost Share		$44,817	$280
PV of Enrolled Acreage Annual Payments (10 Yrs)		$286,250	$1,789
Total Present Value Program Cost		$331,067	$2,069
Annualized Program Cost over Savings Lifecycle (20 yrs)		$27,474	$171.71
Program Reduction in Annual Depletion (AF/Yr)		18.48	0.12
Annualized Program Cost per AF of Depletion Reduction ($/AF)		**$1,487**	**$1,487**

Enrolled Acreage Break-Even Analysis			
Upfront, One-Time, Non-Recurring Costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Install Cost Paid by Farmer ($)	$134,452	$11,157.70	$69.74
Upfront Management Time Required (hours)	40.00	$134.77	$0.84
Upfront Unskilled Labor Required (hours)	160.00	$231.03	$1.44
Recurring Irrigation Season costs	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/week)	0.00	$0.00	$0.00
Labor Time Required (hrs/week)	26.67	$9,280.00	$58.00
Ongoing Expenses ($/week)	0.00	$0.00	$0.00
Recurring Annual Costs for Irrigation System	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Management Time Required (hrs/year)	0	$0.00	$0.00
Labor Time Required (hrs/year)	-400.00	($6,960.00)	($43.50)
Ongoing Expenses ($/year)	481.71	$481.71	$3.01
Change in Crop Revenue (Alfalfa Hay)	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Price ($/ton)	$259.94		
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Yield Increase (%)	10%		
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Change in Cash Operating Cost	**Value**	**Annualized Cost**	**Per Enrolled Acre**
Avoided Production Cost ($/acre)	409.65		
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Yield-related Increase in Harvest Cost ($/acre)	$9.83		
Acres with increased yield	125.7	$1,235.49	$7.72
		Annualized Cost	**Per Enrolled Acre**
Net Cost of Conversion (negative is benefit)		**$23,754.84**	**$148.47**
PV of 20 Year Lifecycle Cost to Grower		**$286,249.70**	**$1,789.06**
Break-Even Payments to Enrolled Acres over 10 years		**$37,794.16**	**$236.21**