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Memorandum

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Subject	**2019 Research Plan for Agricultural Water Optimization in Utah**
Attention	Agricultural Water Optimization Task Force
From	Jeff DenBleyker
Date	February 22, 2019

House Bill 381 formed the Agricultural Water Optimization Task Force to identify and initiate research that identifies how the state could 1) optimize agricultural water supply and use and 2) improve quantification of agricultural water use on a basin level. House Bill 381 further directed that recommendations to accomplish these goals should "maintain or increase agricultural production while reducing the agriculture industry's water diversion and consumption." The Task Force summarized these duties in the form of one question encapsulating the primary objective and focus for research:

> ***What water and agricultural management practices can maintain or increase agricultural production while minimizing impacts upon water supply, water quality and the environment?***

The objective of this memorandum is to outline a research framework designed to answer this question at the both the basin and on-farm scale in Utah.

1. Research Needs

All eight task force members and nine people representing water users, industry, researchers and state agencies attended a workshop on January 18, 2019 with the goal of discussing and identifying research needs that would serve to answer the program objective. The task force heard presentations from the Division of Water resources, Division of Water Rights, Utah State University, Clearwater Supply (industry), and the Rural Water Technology Alliance (nongovernmental organization) regarding existing irrigation and water management practices, observed challenges and important research needs. The Task Force then summarized observed challenges and developed its own list of research needs. Meeting attendees then provided an initial prioritization of those needs. Table 1 provides a summary of the identified research needs and how they were prioritized by Task Force members and workshop attendees. Each attendee was able to independently vote a total of three times in this exercise. One Task Force member was excused and had to leave the workshop prior to the prioritization exercise.

2. Research Framework

The Task Force was charged with the responsibility to identify and oversee the studies required to address the question listed above. This question represents the overall program objective.

Table 1. Research Needs and Priorities

Priority (Task Force Members [7])	Priority (Attendees [8])	Priority (All [15])	Research Need
1 *(5 votes)*	3 *(6 votes)*	3 *(11 votes)*	**USU Depletion Studies.** Augment water depletion studies underway by Utah State University to define water consumption and economic benefits from alternative irrigation and agricultural management practices.
1 *(5 votes)*	2 *(7 votes)*	2 *(12 votes)*	**Water Measurement**. Identify challenges, benefits, gaps and opportunities in current water measurement practices at both the basin and farm level in Utah. Recommend new quantification methods and opportunities that optimize water use, improve decision making and provide added benefit at the basin and farm level. Add additional facilities to improve quantification of available water supply and demands.
3 *(4 votes)*	1 *(9 votes)*	1 *(13 votes)*	**Available Irrigation Technology & Implementation in Utah.** Review alternative irrigation technologies that are available for use and applicable in Utah and identify a short-list to be evaluated for implementation in Utah.
4 *(3 votes)*	4 *(1 vote)*	4 *(4 votes)*	**Socioeconomics of Agricultural Water Use**. Review the literature to better understand the history of agricultural water use in Utah and the socioeconomic drivers, barriers, and values that have incentivized current practices. Recommend new studies or investigations that can inform policy changes that provide maximum benefits and maximize likelihood of success.
5 *(1 vote)*	*(0 votes)*	6 *(1 vote)*	**Depletion-based water rights**. Develop a white paper exploring the benefits, consequences and hurdles of changing from a duty-based to depletion-based water rights system in Utah.
5 *(1 vote)*	4 *(1 vote)*	5 *(2 votes)*	**Environmental Benefits**. Review the literature to explore the benefits and consequences from various irrigation and agricultural management practices. Recommend new or changed practices, or further studies and investigations, that improve environmental benefits from optimized agricultural water use.
5 *(1 vote)*	4 *(1 vote)*	5 *(2 votes)*	**Crop Alternatives.** Summarize current and historical crop selection practices in Utah, identify economic benefits from various crops that have been used, and identify primary market factors that drive crop selection decisions. Review the literature to identify potential crop alternatives that maintain or increase agricultural production while minimizing impacts upon water supply, water quality and the environment. Begin field studies to prove feasibility in Utah.
5 (1 vote)	*(0 votes)*	*(0 votes)*	**Metrics**. Explore various metrics that are used to measure progress and enable optimization of water productivity, i.e., the beneficial output or agricultural yield per unit of water consumed.
(0 votes)	4 *(1 vote)*	6 *(1 vote)*	**Economics of Water.** Review the economic impact of agricultural water use in Utah including a discussion of the value of water, costs of water management and irrigation, and agricultural, community and environmental benefits. Recommend further studies or investigations to explore economic implications of improve water use and decision making.

Three questions were identified that follow from the program objective, i.e., these questions must be answered for the program objective to be achieved. The questions are as follows:

1. What irrigation and agricultural management practices can increase water productivity, i.e., increase the beneficial output or yield per volume of water consumed, in Utah?
2. How can quantification of available water supply and agricultural water use be improved to improve water management and increase water productivity?
3. How do the water quantification, irrigation and agricultural management practices affect the communities, water supply, water quality and the environment where they are implemented?

The two following key research areas were agreed upon to provide answers to these questions:

1. Advanced Irrigation Technology & Implementation in Utah
2. Quantification of Agricultural Water Supply and Demands

The third question will be addressed within each of these two research areas. Figure 1 illustrates how the various research projects fit into this structure, as well as accomplish the overall program objective. The objectives of each project are detailed in the following sections.

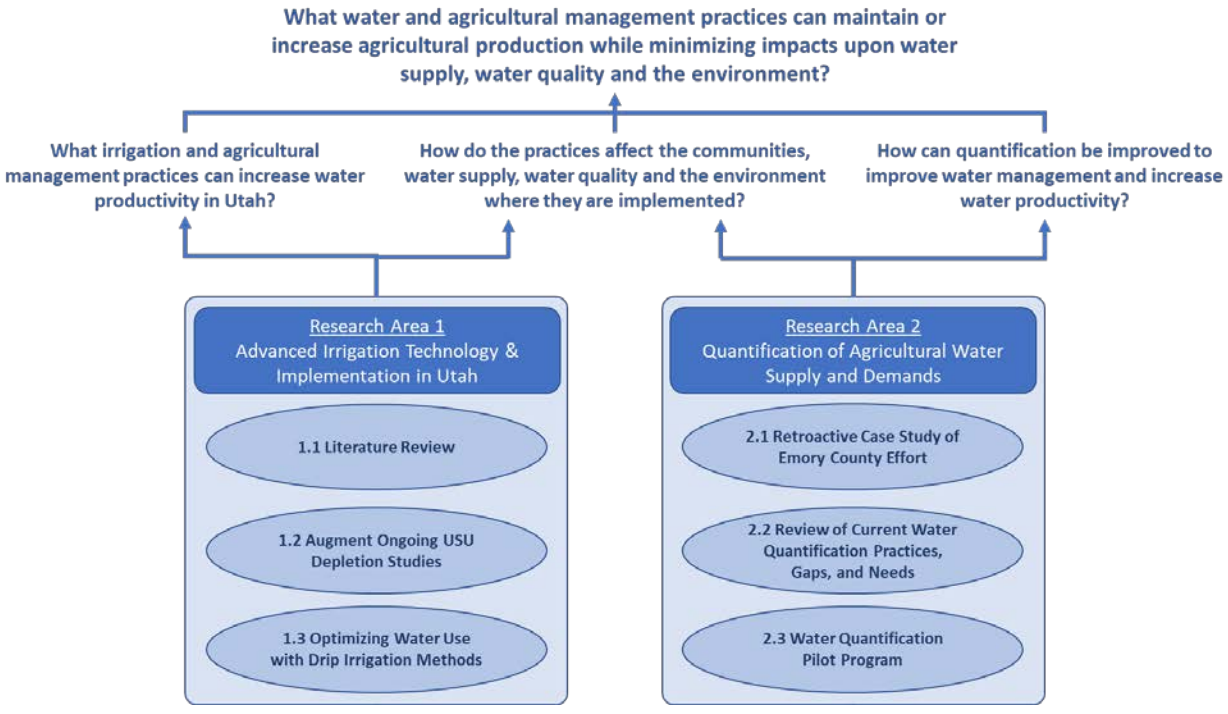

Figure 1. Overall structure of proposed research

2.1 Research Area 1: Advanced Irrigation Technology & Implementation in Utah.

Increasing competition in the market place and competing demands for water require an improved understanding of options to improve agricultural water productivity. Selection and implementation of the appropriate irrigation and agricultural management practices requires an in-depth understanding of available irrigation technologies, the complex interaction of cropping and application and management methods, related energy, water and nutrient use efficiencies, integrated crop/water economic models, and benefits to the community, water supply, water quality and the environment. More specifically, producers and water managers in Utah need to better understand which and how these technologies and management methods can be implemented successfully in Utah to meet the program objective.

This research area consolidates two of the top three research areas, the USU Depletion Study and Available Irrigation Technology & Implementation in Utah, into one research area (see Figure 2). The question this research area is focused upon answering is:

> ***What irrigation and agricultural management practices can increase water productivity, i.e., increase the beneficial output or yield per volume of water consumed, in Utah?***

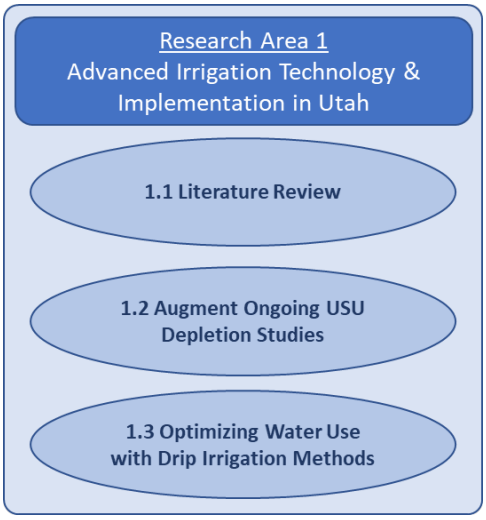

Figure 2. Proposed Projects in Research Area 1

Strategies include reviewing the state-of-the-art in irrigation technologies and investigating the influence of the following variables on water use, energy use and agricultural productivity:

- Different irrigation application systems operating at different irrigation rates (volume of water applied over time)
- Different cropping strategies (e.g., dominant [e.g., alfalfa], small grains, and alternative crops)
- Different means of conservation management (e.g., conventional vs. drought tolerant genetics and annual vs. no tillage)
- Different regions in Utah (Cache Valley, Cedar Valley, Vernal)

Expected short- and long-term outcomes and specific research projects within this focus area are described below.

Short-Term Outcomes

1. Improved understanding of various irrigation application methods that can inform the ongoing discussion about agricultural water optimization. Can improved irrigation practices increase agricultural productivity with the potential of consuming less water and minimizing impacts to water quality and the environment?
2. Comprehensive understanding of available irrigation solutions that address the program objective, influence and improve agricultural water use and production and minimize impacts to water quality and the environment.
3. Short list of irrigation application technologies and practices for further investigation and implementation in Utah. Action items for further investment.
4. Identification of high-potential alternatives for further investigation and implementation in Utah.

Long-Term Outcomes

1. Documented relationships between irrigation and agricultural management methods, water productivity and agricultural productivity that could serve to educate agricultural water users and improve current practices and profitability.
2. Improved methods for monitoring of crop quality and water use to enable better on-farm decision support and long-term profitability.
3. Improved methods and tools to select optimal combinations of crops and irrigation strategies.
4. Improved undersanding and better documentation of benefits to communities, water supply, water quality and the environment.
5. Potential to increase crop yields with limited water resources.
6. Reduction in agricultural management time and costs while maximizing water productivity.
7. Improved efficiency of water use and reduced consumption of water to stretch limited water supplies while protecting the environment.
8. Improved water conservation and environmental protection while maximizing agricultural productivity and crop quality and benefits to communities and the environment.

2.1.1 Project 1.1. Literature Review

Inputs/Resources

Principal Investigators:
Partners: Division of Water Resources, Division of Water Rights, Department of Agriculture and Food, Division of Water Quality

Objective

The objective of the literature review is to provide a systematic review of literature, including primary, secondary, and grey literature, describing prevalent and promising advanced irrigation application technologies and agricultural management practices that are applicable for use in Utah and that address the program objective.

The focus of this review is to address the following questions:

1. What irrigation (flood, sprinkler, drip, etc., and agricultural management, e.g., tillage, cropping, etc., practices have historically been implemented in Utah, why and to what degree?
2. What criteria has historically been used in selecting or changing irrigation practices at the farm level? What socioeconomic barriers or incentives have influenced their implementation?
3. How have historic irrigation practices performed in terms of irrigation efficiency, water consumption and agricultural productivity? How have they impacted communities and the environment? What performance measures or metrics are used or should be used?
4. What additional irrigation and agricultural management practices or technologies are being implemented globally that should be considered for evaluation and implementation in Utah? What are their potential benefits and impacts? How should they be evaluated for use in Utah?

5. How could new irrigation technologies and agricultural management practices improve water and energy use, water and nutrient use efficiencies, and agricultural productivity? How could they impact socioeconomics, water supply, water quality and the environment?
6. What methods and factors have been critical to successfully incentivizing water users to change their practices? What metrics have been most useful in tracking and measuring success?
7. What models or design aids are currently used to improve selection and design of alternative irrigation methods?

Activities

The literature review will be completed using rigorous and transparent methods of chain-of-citation and electronic database searches and through consultation with leading researchers. The Principal Investigator (PI) will use an electronic interface to collect, organize, cite, and share the identified literature. Annotations will be captured as notes to describe how each piece of literature addresses the questions above. Key findings will be summarized, and recommendations made identifying which irrigation application technologies and agricultural management practices show the most promise and should be investigated further.

Deliverables

- An electronic or hard copy of the original documents included in the literature review
- A draft and final technical memorandum summarizing methods, an annotated bibliography, key findings answering the identified questions, and key recommendations for further investigation and implementation in Utah.

Key Outcomes

- A thorough understanding of lessons learned in Utah and global state-of-the-art for irrigation technologies and agricultural management practices.
- Recommendations for further investigation and implementation in Utah.

2.1.2 Project 1.2. Augment Ongoing Utah State University Depletion Studies

Inputs/Resources

Principal Investigators: Matt Yost, Niel Allen and Earl Creech (Utah State University)
Current Project Title: Optimizing Water Use with Advanced Irrigation and Crop Management
Partners: Division of Water Resources, Division of Water Rights, Department of Agriculture and Food, Division of Water Quality

Objective

The objective of USU's project is to identify which combinations of pivot irrigation and crop management practices result in optimized use of limited water supplies, reduced consumptive use, and the best yield and profit outcomes for producers. The PIs have already obtained funding and approvals for an extensive experiment that will will be completed annually through 2021. The intent of the Task Force is to fund an additional effort to document the water supplied and used, the resulting costs and yield and profit outcomes for each treatment.

The Task Force's objective is to extend this work to evaluate how widespread implementation of these practices in Utah could maintain or increase agricultural production while minimizing impacts upon water supply, water quality and the environment.

Activities

Proposed treatments include three crops, four irrigation rates, four irrigation systems, four tiers of conservation management, and all in three different locations in Utah. This represents 64 combinations of irrigation/field management for each of three different crops; repeated in three different regions of Utah.

USU will measure precipitation, runoff and applied irrigation water volumes and monitor field soil water balance and evapotranspiration to develop a detailed water budget for each treatment. Local meteorological and groundwater conditions should be monitored. USU will quantify and document fertilizer application and quantity/quality of surface water runoff. USU will monitor plant health, yield, and quality and develop a water-yield relationship and an estimate of water and agricultural productivity for each treatment in various regions of Utah. USU will evaluate potential environmental impacts and benefits (e.g., water quality, energy use, etc.) from each of the different treatments.

USU will evaluate potential risks and factors critical toward full implementation of each of the treatments both at the farm and river basin level. What criteria should be used to evaluate the feasibility of implementation? What investment is required to implement each treatment? What is the estimated return on investment for implementation of each treatment? What risks or factors could influence successful implementation? What are the potential implications to socioeconomics, water supply, water quality and environment?

Deliverables

- A database of water use efficiencies, requirements and consumptive use for various crops and relationships between Kc, plant growth and reference evapotranspiration for various crops as influence by different irrigation practices.
- Recommendations for treatments that maintain or increas agricultural production while minimizing impacts upon water supply, water quality and the environment.
- Report summarizing the risks, costs and benefits of implementing alternative irrigation technologies in Utah. Provide recommendations to further evaluate the performance of and implementation of recommended technologies and practices.

Key Outcomes

- Improved understanding of the risks, costs and benefits of numerous irrigation technologies and agricultural management practices in Utah that will serve to educate and convince producers why they should change their current practices.
- Recommendations that accelerate the pace of research and implementation of the successful optimization of agricultural water use in Utah.

2.2 Project 1.3. Optimizing Water Use with Drip Irrigation Methods

Inputs/Resources

Principal Investigators: Rob Hougaard and Niel Allen????
Partners: Ron Gibson, Utah State University, Division of Water Resources, Division of Water Rights, Department of Agriculture and Food, Division of Water Quality

Objective

The objective of this project is to mirror the objectives, methods, and analyses completed as part of USU's ongoing "Optimizing Water Use with Advanced Irrigation and Crop Management" project but do so with the use of subsurface drip irrigation methods. Ron Gibson has indicated that he might be willing to participate using his existing onion operation with existing drip irrigation system as the experimental site. The Task Force would fund an additional effort to document the water supplied and used, the resulting costs and yield and profit outcomes for this treatment.

Activities

USU will coordinate with Utah Department of Agriculture and Food to l replicate methods used in Project 1.2 (above) to develop a detailed water budget for the drip irrigation system. USU will compare both drip irrigated onions and furrow-irrigated onions. Local meteorological and groundwater conditions should be monitored. USU will quantify and document fertilizer application and quantity/quality of surface water runoff. USU will monitor plant health, yield, and quality and develop a water-yield relationship and an estimate of water and agricultural productivity for the treatment. USU will evaluate potential environmental impacts and benefits (e.g., water quality, energy use, etc.) from each of the different treatments. USU will incorporate findings into the evaluation and deliverables completed in Project 1.2.

Key Outcomes

- The same as Project 1.2 with the addition of drip irrigated and furrow irrigated treatments for an onion crop.

2.3 Research Area 2: Quantification of Agricultural Water Supply and Demands

Accurate measurement and accounting of available water supplies and demands is critical to protecting and enhancing our agricultural economy particularly in light of increasing demands for limited water resources. Real-time monitoring and even forecasting of conditions provides farmers, ranchers and water managers with the knowledge required to make informed decisions that increase the effectiveness and productivity of our water supply and profitability of Utah's agricultural operations. Utah's producers and

water managers in Utah must have timely, accurate and thorough data quantifying water supply and agricultural water use. Informed decisions make for better decisions and results.

This research area addresses the remaining research area within the top three research needs identified by the Task Force. The question this research area is focused upon answering is:

> ***How can quantification of available water supply and agricultural use be improved to increase water productivity and improve water management?***

Strategies include learning from successful efforts in Utah to improve quantification of water supplies and agricultural use, reviewing current practices, identifying data gaps and needs, and designing and investing in a pilot program to improve quantification of water supplies and use in one sub-basin in Utah.

Figure 3. Proposed Projects in Research Area 2

Expected short- and long-term outcomes and specific research projects within this focus area are described below.

Short-Term Outcomes

1. Documentation of a current success story that can inform next steps and encourage further investigation and investment in this research area; proof of how what has been done can be repeated (and improved upon) successfully.
2. Improved understanding of socioeconomic risks and benefits from improved quantification of water resources.
3. Improved understanding of current water quantification practices, available data, gaps, risks and challenges that can inform the ongoing discussion about agricultural water optimization. Can improved water quantification increase agricultural productivity with the potential of consuming less water? Can it benefit the water supply, water quality and the environment?
4. Comprehensive understanding of available water quantification opportunities, strategies, and solutions that address the program objective and influence and improve agricultural water use and production.
5. Identification of high-potential alternatives for further investigation and implementation in Utah.

Long-Term Outcomes

1. Potential to increase crop yields with limited water resources.
2. Improved ability to identify and protect basins with limited water resources.
3. Improved confidence in water supply and use data.
4. Improved integration of water supply management with State water quality assessment and management.

5. Improved ability to forecast and evaluate various water and land development scenarios.
6. Improved methods for forecasting available water supply and demands and proactive identification of potential risks and challenges.
7. Documented relationships between water supply and use, water and agricultural productivity, and the environment.
8. Reduction in agricultural management time and costs while maximizing water productivity.
9. Improved efficiency of water use and reduced consumption of water to stretch limited water supplies.
10. Improved water conservation and environmental protection while maximizing agricultural productivity and crop quality.

2.3.1 Project 2.1. Retroactive Case Study of Emery County Water Quantification

Inputs/Resources

Principal Investigators:
Partners: Division of Water Rights, Division of Water Resources, Department of Agriculture and Food, Division of Water Quality

Objective

The objective of this project is to understand the risks and benefits from and evaluate how water users in Emery County successfully improved quantification of available water supply and use to improve water management and increase water productivity.

Activities

Identify and engage with water managers, producers and other stakeholders in Emery County to understand, document and evaluate the drivers, methods, costs, benefits and lessons learned from implementation of a network of flow measurement structures and transparent, real-time monitoring. The work should document 1) the challenges that created the need for a better solution to water management, 2) the process implemented to shape the solution, 3) a description of the practices, infrastructure and costs implemented, 4) costs and benefits as perceived by stakeholders and managers, 5) socioeconomic impacts and benefits, 6) impacts and benefits to water quality and the environment, 7) lessons learned and 8) recommendations that other basins should consider if they were to implement a similar solution.

Deliverables

Report summarizing methods, results and recommendations to the Task Force for future implementation of similar solutions.

Key Outcomes

Lessons learned from a Utah case study that can incentivize and guide future implementation in additional basins in Utah.

2.3.2 Project 2.2. Review of Current Water Quantification Practices, Data Gaps and Needs

Inputs/Resources

Principal Investigators:
Partners: Division of Water Resources, Division of Water Rights, Department of Agriculture and Food, Division of Water Quality

Objective

The objective of this project is to provide an overview of existing practices for quantifying water supply and agricultural use at a state, basin and water user level, develop recommendations for making improvements, and identify critical issues facing the state's long-term water supply.

Specific questions that should be answered include:

1. How are stream flows, lake and reservoir water levels, available storage, and groundwater levels and available groundwater supplies monitored and reported throughout the state? Where is this done? Who is responsible and is the funding source? What is the objective for this work, i.e., why? Where do we have gaps in our gauging network? What risks or challenges do we currently have? How might those gaps, risk and challenges be prioritized?
2. How is the available water supply and water balance determined, monitored, forecasted and reported? Who is responsible and is the funding source? Where do we have gaps in our gauging network? What risks or challenges do we currently have? How might those gaps, risk and challenges be prioritized?
3. How is agricultural water use measured, estimated, tracked and reported at a basin and state level? Where is this done? Who is responsible and is the funding source? Where do we have gaps in our gauging network? What risks or challenges do we currently have? How might those gaps, risk and challenges be prioritized?
4. What are current drivers to quantify water supply and agricultural use? How are these efforts integrated with required assessment of water quality?
5. How should gaps, risks and challenges in quantification of water supply and agricultural use be prioritized?
6. What opportunities exist to improve quantification of water supply and agricultural use to:
    a. facilitate transparent communication of water resources, sustainable management, and accurate forecasting and planning;
    b. improve water and agricultural productivity; and
    c. benefit Utah's communities and environment?

Activities

Develop a strategy to obtain an accurate assessment of statewide practices, gaps and needs. Identify and engage with pertinent managers and stakeholders to develop a comprehensive review of current practices and a plan for improving quantification of water supply and agricultural use in Utah. Work should identify critical issues facing the state's water supply and how improved quantification could be used to better manage limited water resources in the face of increasing demands. The work should

collaboratively develop strategies for improvement. The plan should provide actionable recommendations and estimates of required investment or changes to make such improvements.

Deliverables

Report summarizing methods, results and recommendations to the Task Force for future implementation.

Key Outcomes

- An understanding of how water resources are currently being quantified, why it is being completed, what is being done well, existing challenges that need to be overcome, and recommendations for improvement.
- An understanding of the agricultural, socioeconomic, water supply, water quality and environmental risks and benefits from current and recommended practices.
- Improved methods, confidence and ability to maintain or increase agricultural productivity and better forecast, evaluate, manage and protect Utah's water supply, water quality and environment.
- Improved accuracy, efficiency and confidence in making effective water resource management decisions at the farm, community, basin, and state level.

2.3.3 Project 2.3. Water Quantification Pilot Program

Inputs/Resources

Principal Investigators:
Partners: Division of Water Resources, Division of Water Rights, Department of Agriculture and Food, Division of Water Quality
Funding: Seek and incorporate matching funds

Objective

The objective of this project is to pilot recommendations from the "Retroactive Case Study of Emery County Water Quantification" and "Review of Current Water Quantification Practices, Data Gaps and Needs" projects.

Activities

Solicit interest from potential river sub-basins in Utah and select one sub-basin to participate in an evaluation of existing water quantification practices at the basin and farm level and development of a plan to improve integrated quantification of water supply, water quality and agricultural water use. Work will build upon lessons learned in the "Retroactive Case Study of Emery County Water Quantification" project to collaboratively identify current practices, concerns, gaps, needs, challenges and potential improvements. The PI shall work to collaboratively develop strategies and solutions with basin stakeholders to improve water quantification at the basin and farm level. The work shall identify opportunities for collaboration to improve upon remote sensing methods, document water diversions,

consumption and return flows, document changes in water and agricultural productivity, document changes in water quality and evaluate socioeconomic and environmental benefits.

Deliverables

Report summarizing methods, results and recommendations to the Task Force for future implementation.

Key Outcomes

- Implementation of recommended improvements at a small scale to inform future efforts.
- Opportunity to engage with stakeholders to further develop shared ownership in solutions.
- Opportunity for learning, adaptive management and improvement of methods and recommendations.
- Increased confidence in methods, benefits and results that propels further improvement.