

## PROJECT OVERVIEW

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Applegate Group and Colorado State University teamed together to study development of agriculturally related small hydro in existing irrigation infrastructure. The study intends to provide information on small hydro development, state-wide, to agricultural water users and policy makers, including guidance on site types, equipment and utility interconnection.

The study, “Exploring the Viability of Low Head Hydro in Colorado’s Existing Irrigation Infrastructure,” focuses on low head technologies which can be productively installed in existing constrained waterways that were originally intended for delivering irrigation water – a hydropower area that appears to be lacking in overall knowledge. A number of low cost, low head turbines have recently been introduced to the market, but are unknown to Colorado’s water users. There is limited knowledge of the viability of these low head turbines in typical irrigation structures, which are often both low-flow and low-head. There has also been no systematic identification of attractive sites within irrigation systems, and no developed process to easily classify and assess sites for development. The study also focuses on sites within existing infrastructure, due to the ease of permitting and developing projects within an existing canal or conduit. It is important to note that this study investigates only a portion of the hydropower potential in Colorado. Sources that do not meet the constraints of this study were not assessed, nor were efficiency enhancements at existing hydropower facilities – even low-head facilities.

The purpose of this study is to provide relevant information to agriculturally-related water users on the opportunities that may exist to implement low head hydropower on their systems. The study has three goals; 1) Research available low head technologies, 2) Match those technologies with typical irrigation structures by studying two project canals, 3) Estimate a state wide potential for low head hydropower. The results of this study will be conveyed through a final report submitted to the Colorado Department of Agriculture, and posted on a website dedicated to low head hydropower in Colorado. The project team has also held a number of workshops, and presentations and has written a number of conference papers and articles to disseminate this information. This effort is intended to provide a roadmap for agricultural water systems to develop their existing resources and with an end goal to provide a reliable secondary revenue stream to help support those systems.

## KEY FINDINGS AND RECOMMENDATIONS

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The intent of this study was to achieve three main goals; 1) Explore available technologies 2) Expose interconnection issues and 3) Investigate and quantify the statewide potential to produce low head hydropower. To accomplish these goals five tasks were outlined in the project proposal. These tasks are outlined and summarized below, and the results of the goals and tasks are detailed in the final report.

### TASK 1: RESEARCH LOW HEAD HYDROPOWER TECHNOLOGIES

Available low head hydropower technologies were researched. Over 20 turbines were found in varying stages of development and commercialization. These technologies are included in the appendix of the final report with a description of the technology, including flow rates and heads

necessary to economically produce power, and unique installation or operational requirements. Contact information for each manufacturer or distributor is also included.

## TASK 2: INVENTORY THE INFRASTRUCTURE AVAILABLE IN COLORADO FOR HYDROPOWER GENERATION

A two step approach was used to inventory the infrastructure in Colorado that has the potential of producing low head hydropower. First, agricultural ditches and canals across the state were identified using the Colorado Decision Support System (CDSS) and the collective knowledge of the Applegate staff. Paper surveys were sent to these organizations requesting information about low head drops on their systems. Second, two project canals were chosen to identify and investigate typical irrigation structures and the opportunity to add hydropower.

## TASK 3: INVESTIGATE INTERCONNECTION ISSUES

This analysis focused on the two “project locations” identified in Task 2. After structures were identified, CSU personnel made contact with the appropriate local utilities to estimate the costs of interconnection, value of a power purchase agreement, and equipment requirements. The results have been translated into set of decision guidelines that can be applied to locations statewide to estimate the best candidates’ development.

## TASK 4: COMPARE THE TECHNOLOGIES TO THE HYDRAULIC STRUCTURES

In order to determine the hydropower generation potential of the irrigation systems in Colorado, the technologies researched in Task 1 are compared to the physical characteristics of the structures identified in Task 2 to consider the technical feasibility of applying the researched technologies to the selected structures on the project canals.

## TASK 5: ESTIMATE A STATE WIDE POTENTIAL

The potential of low head power generation for all of the canals identified in Task 2 has been estimated. We hoped that these surveys would provide sufficient information to determine an overall potential of Colorado’s irrigation canals to produce low head hydropower. Unfortunately, the survey response was low, and to infer a statewide potential from this limited information would be very difficult. However, based on the information that we were able to collect, it is apparent that there is a significant amount of hydropower potential in Colorado and that it warrants evaluating approaches to develop it.

## DELIVERABLES

Three products have been completed as a result of this project; this final report, a website, along with presentations and public outreach. These products are intended to disseminate the findings of this study in three different forms in order to reach the target audience. The information contained in these products is meant to educate agricultural producers on the available technology and specific applications on their property.

## PROBLEMS ENCOUNTERED AND MITIGATING CIRCUMSTANCES

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Identification of the canals of interest was achievable, but obtaining information from all of the organizations involved proved challenging. There is an immense interest in hydropower in irrigation canals, but that interest did not translate into returned surveys. We made the surveys available in paper copies, electronically, and on a web based survey, hoping that the multi-media choices would promote completion and return. We also offered the incentive of being chosen as a project canal for this study which would include a no-cost hydropower analysis of the system, if the survey was returned. Even with those measures only 10% of the surveys were returned. Survey responses of the general public are between 1 and 20%, according to those statistics our return rate was average, all though much lower than we had hoped.

Irrigation companies and other districts are generally lightly staffed and rely heavily on volunteer participation. There are also a number of people involved in the organization, generally a board of appointed or elected members, and decisions are made collectively. These could be factors that contributed to the low return rate. We also learned that irrigation companies receive a number of surveys each year.

The team has learned that, to truly assess small hydropower potential state-wide, a researcher will need to travel the state and visit each canal that has promising overall characteristics such as flow rate and duration. This approach, or perhaps another approach of mid-level detail, should be explored further. Overall, the project has been a success in raising awareness and educating irrigation entities about the opportunities that exist in small hydro. This final report provides practical resources for those considering development. Estimating the overall state-wide potential has proven more difficult than expected, but the study indicates that potential does exist in a number of irrigation systems. These sites can be developed with minimal impact and the project will benefit a number of agricultural producers. Existing irrigation infrastructure deserves focused attention in the future development of low head hydropower in Colorado.

## NEXT STEPS TO BE TAKEN BASED ON FINDINGS AND RECOMMENDATIONS FROM COMPLETION OF THE PROJECT

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There has been a large amount of interest in this study from both the water and hydropower community nationally. Applegate and CSU will continue to disseminate the final report and the information contained within it. The Colorado FERC Streamlined permitting process is also of great interest nationally. Presenting information about the opportunities in Colorado on a national level will help other states that are considering increasing hydroelectric generation.

Attempting to inventory infrastructure throughout the state by survey proved to be challenging. It appears that the only way to obtain a realistic accounting of structures is to conduct an in person interview and site visit. We recommend using this method in the future if a quantification of potential is desired. A graduate student at CSU has been awarded with a Hydropower Research Fellowship to continue the work started in this project. He will be traveling the state and collecting data on specific sites. His research will be published in 2012, and will supplement this work.

The optimum choice of a power conversion and interconnect system for small hydropower is currently unclear. While directly coupled machines may benefit from simplicity and higher efficiency at rated load, power electronics solution may cost less to interconnect and produce higher efficiencies below rated loads. Ongoing work at CSU will study typical sites for potential system configurations and costs.

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## NOTABLE SUCCESSES AND ACCOMPLISHMENTS

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- A number of the sites identified in this study are being considered for development. This is seen as a direct success of this project. This research project has unveiled potential and educated agricultural producers about the opportunities to produce hydropower in their irrigation systems.
- This project resulted in over 10 public presentations, and 15 published articles. The interest in this project was immense both statewide and nationally.
- The research started in this project is continuing at Colorado State University through their graduate program.

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## ACCOUNTING OF PROJECT EXPENDITURES

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The following table summarizes the expenditures for this project.