Title:
WaterSMART: A platform toward an early warning system for shortages in Colorado River water supply

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Table of Contents

Technical Proposal and Evaluation Criteria 3

Executive Summary 3

Technical Project Description and Milestones 4

Category B applicant 4

Problem Statement 4

Objective 5

Scientific Background 6

Planned Work 8

Planned Schedule 9

Project Location 10

Data Management Practices 10

Evaluation Criteria: 11

Criteria A – Benefits to Water Supply Reliability 11

Criteria B – Need for Project and Applicability of Project Results 12

Criteria C – Project Implementation 14

Criteria D – Dissemination of Results 16

Criteria E – Department of the Interior Priorities 17

References 17

Project Budget 19

Funding Plan and Letters of Funding Commitment 19

Budget Proposal 23

Budget Narrative 25

Environmental and Cultural Resources Compliance 27

Required Permits or Approvals 28

Letter of Participation 28

Official Resolution 32

Technical Proposal and Evaluation Criteria

Executive Summary

Applicant:
October 30, 2019
PI: Yoshimitsu Chikamoto, Utah State University, Logan, Cache Valley, UT
co-I: Simon Wang, Utah State University, Logan, Cache Valley, UT

Project summary:
Skillful drought forecasts on longer timescales have vast potential to mitigate damages from water resource shortages. In the Colorado River basin, water use has increased every year for the past 60 years, and demands are projected to continue in the future. By contrast to higher water demand, there was a multi-year drought event during 2000-2015 causing severe water scarcity not only in the Colorado River basin but also across many states in the Intermountain West. For proactive planning purposes against the next water crisis, reliable forecasts for when a long-lasting drought will start or end is desired for decision-makers and water resource managers. Using a state-of-the-art decadal climate prediction system, the PI has demonstrated that the Colorado River water supply is predictable for several years in advance by utilizing multi-year ocean memories and natural filtering effects in the land processes. Whereas an outcome of this research is translatable into an early warning system for the shortage of the Colorado River water supply, there is still a gap between our scientific outcome and an operational management tool. To fill this gap, this project aims to build a new platform for monitoring and forecasting the Colorado River water supply by partnering with various regional water and agriculture agencies in Utah.

Project length and completion date:
Two years from October 1, 2020 to September 30, 2022.

Federal facility:
The proposed project is not located on a Federal facility.

Technical Project Description and Milestones

Category B applicant

This project team is categorized as the Category B applicant (*universities*) partnering with the state agencies in Utah (Category A). The partner agencies include the Utah Division of Water Resources, the Salt Lake City Department of Public Utilities, and the Utah Farm Bureau. Those agencies show their keen interests in our multi-year drought forecasting product because water supply is a fundamental source for their activities. Moreover, members in this project have collaborated with them in other projects previously. These partner agencies committed in-kind contributions corresponding to $10,000 from each agency (see the letters of participation). Those partner agencies will contribute to this project by providing their information and knowledge in order to translate scientific outcomes into a user-friendly interface and format. Because of the broad applications in our project outcomes, potential partners in this project will include a wide range of agencies in the Intermountain West, such as water and natural resources, hydropower, agriculture, and the economy.

Problem Statement

Reliable forecasts for severe water scarcity are among the greatest challenges facing science and society. Well-known high-impact examples include recent multi-year drought events in the Colorado River basin during 2000-2016, which severely stressed regional water supply and reservoirs as well as other resources, such as hydropower, recreation, and ecologic services (Bureau of Reclamation 2012). Consistent with this prolonged drought event, the elevation of Great Salt Lake has dropped 10 feet from 2000 to 2016 (Wang et al. 2012). These multi-year drought events affected a wide range of sectors in agriculture, energy, food security, forestry, drinking water, and tourism (Grigg 2014; Littell et al. 2016). From the perspective of proactive management, skillful forecasts of climate conditions and hydrological risk for the upcoming several years are desired for water resource managers, farmers, ranchers, and the public.

Despite such enormous demands, current operational drought forecasts in the U.S. mainly focus on day-to-month outlooks of drought severity, such as the short-term drought indicator and the monthly drought outlook from the National Drought Mitigation Center. These forecasts rely on precipitation predictability that is limited to a few weeks in advanced due to relatively short-term weather phenomena (Goddard et al. 2001). Beyond this weather timescale, however, large-scale atmospheric variability is modulated by interannual-to-decadal climate variability associated with multi-year ocean memory (Chikamoto et al. 2017). In addition to this ocean memory, the land systems (e.g., soils, groundwater, streamflow, vegetation, and perennial snowpack) can effectively filter out the high-frequency precipitation component and thereby exhibit a longer persistence of the variability through the natural integration of the atmospheric signals over time (Chikamoto et al. 2015; Wang et al. 2016). By utilizing these long-term ocean memories and natural filtering effects, the PI developed a state-of-the-art decadal climate prediction system that demonstrated a high fidelity to predict multi-year drought conditions in the Southwestern U.S. (Chikamoto et al. 2017, 2019). This dynamical prediction system has also demonstrated a high fidelity to predict the annual Colorado River water supply for several years in advance (see Scientific background).

Whereas an outcome of this research is translatable into an early warning system for the shortage of the Colorado River water supply up to several years ahead, few platforms provide an operational management tool for water resource managers and stakeholders to monitor and obtain outlooks of water scarcity for the upcoming year. Since the dynamical climate prediction system consists of massive datasets including global atmosphere-ocean conditions as well as hydrological states simulated for more than 60 years with 10 ensemble members (corresponding to more than 100TB data storage), a study is required to convert from these "big data" into an accessible format for water resource managers and stakeholders. In our previous project (BoR WaterSMART grant, *Synthesizing drought characteristics prediction to inform drought resiliency decisions from days to years*, R18AC00018), we have built a webpage to disseminate the future prospect of Utah water storage from 2016 to 2025 through the Utah Climate Center (UCC), which is based on our state-of-the-art climate prediction system. The UCC also provides the Great Salt Lake Annual Level Prediction (Fig. 1). These formats and webtools significantly contribute to filling a gap between scientific outcomes and the needs of water resource managers; however, an early warning system of multi-year drought potential in the Colorado River basin is unavailable for the public.

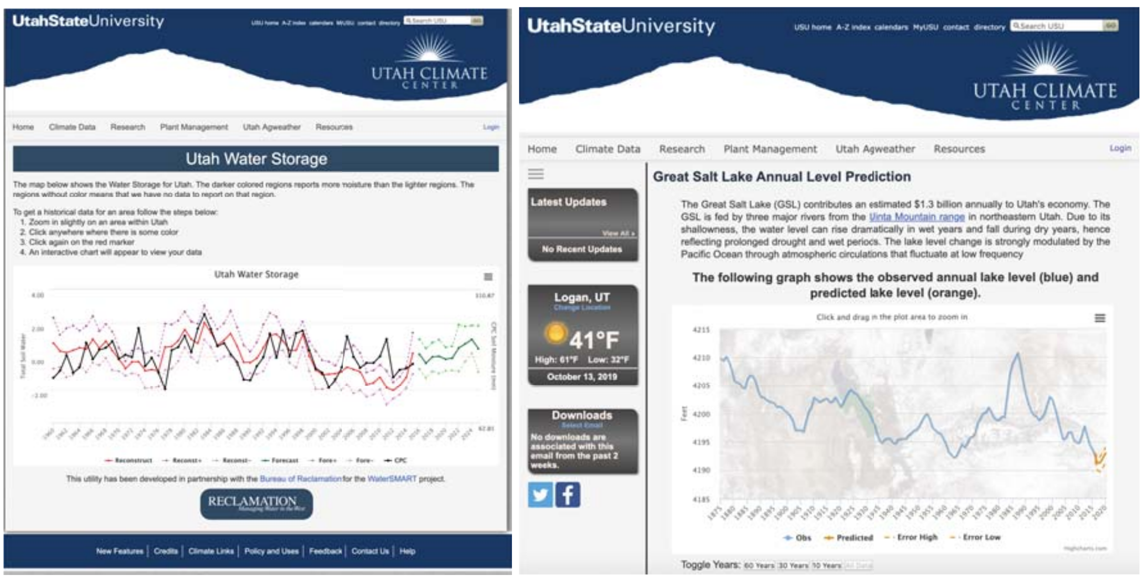


Figure 1: **An example of webpage-based platform**. A Utah Climate Center webpage for the dynamical forecast of Utah water storage (left: beta version) and statistical forecasts of the Great Salk Lake annual level prediction (right: open on public).

Objective

This project aims to build a platform to connect water resource managers and stakeholders with scientific outcomes in forecasting a prolonged shortage of the Colorado River water supply for upcoming years. Previous studies demonstrated that multi-year drought events in the Colorado River basin originate from a specific ocean temperature pattern in the tropical Pacific and Atlantic (see Scientific background). Based on that knowledge, we propose three main tasks:

- Task 1: constructing an ocean precursor index that affects the shortage of the Colorado River water supply,
- Task 2: developing a data-based monitoring system for such a precursor index,
- Task 3: building a platform at UCC to disseminate the early warning for a serious shortage of the Colorado River water supply.

Scientific Background

Reconstruction of the annual water supply in the Colorado River:

The BoR provides a historical record of year-to-year Colorado River water supply up to 2012, which shows wet periods around the years of 1984 and 1997 as well as dry periods around the years of 1990, 2002, and 2012 (blue line in Fig 3a). Whereas this water supply variability correlates with annual mean precipitation around the Colorado River basin, more significant correlations are found with soil water observations (Fig. 2), such as that provided by NOAA Climate Prediction Center (van den Dool et al. 2003). In other words, a shortage of the Colorado River water supply accompanies dry soil conditions in the Intermountain West across the states of Utah, Colorado, Nevada, Arizona, and California. As a result, the annual Colorado River water supply can be reconstructed by the area average of soil water observations in the Intermountain West (black box in Fig 2b and black dashed line in Fig 3a). Consistent with this significant correlation between the water supply and the soil water, the Colorado River water supply also highly correlates with the elevation variability of the Great Salt Lake (Wang et al. 2018). Because of the natural filtering effect in the land system, soil water contains lower frequency variability compared to precipitation variability, which provides theoretically longer forecast skills beyond weather timescales (Chikamoto et al. 2015; Wang et al. 2016).

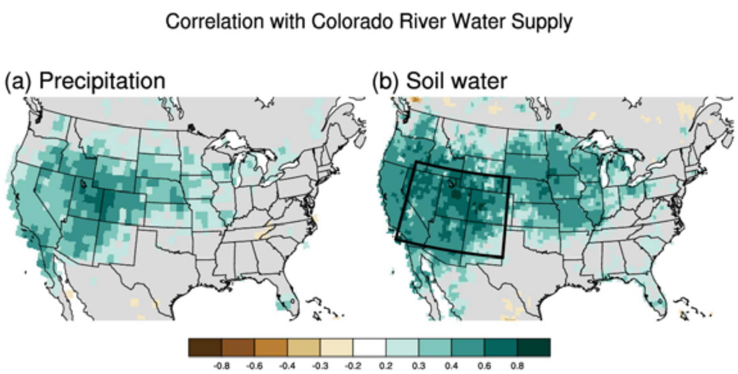


Figure 2: Precipitation and soil water patterns linked with the Colorado River water supply. Correlation maps of observed annual mean anomalies in (a) precipitation and (b) soil water associated with the Colorado River water supply. The black box denotes the area-averaged region for reconstruction of the Colorado River water supply based on the observed soil water anomalies.

The state-of-the-art climate prediction system:

To predict the Colorado River water supply, the PI developed the decadal climate prediction system using the state-of-the-art Community Earth System Model (CESM) combining with an ocean data assimilation method (Chikamoto et al. 2019). The CESM consists of a global climate model coupled with atmosphere, ocean, land, and sea-ice components, which includes the hydrological process of a full water budget for both surface and subsurface dynamics. In our prediction system, the observed ocean information is assimilated into the ocean component of CESM with prescribing natural and anthropogenic radiative forcings. We refer to this model experiment as the ocean assimilation run. Therefore, the ocean assimilation run provides the estimate of soil water variability originating from ocean variability. The solid black line in Fig. 3a provides a reconstruction of the Colorado River water supply estimated by the ocean assimilation run. This model simulation captures local peaks of minimum and maximum water supply, such as wet years in 1984 and 1997 and dry years in 1990, 2002, and 2012. The model simulated water supply shows more smoothed temporal variations compared to observations, indicating the fact that multi-year drought events in the Intermountain West rely mainly on long-term ocean memory.

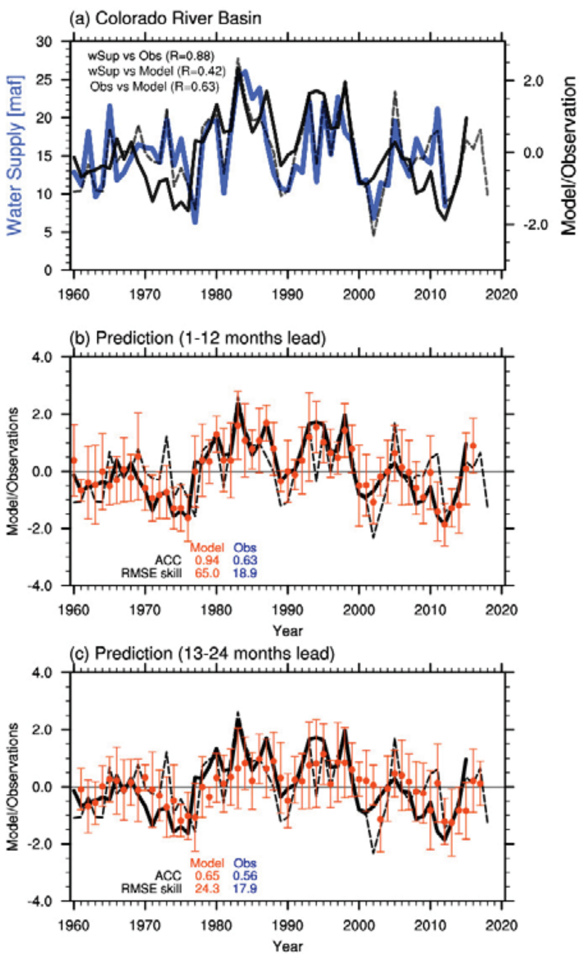


Figure 3: Reconstructions and predictions of the Colorado River water supply. (a) Time series of the Colorado River water supply (blue) and its reconstruction by soil water anomalies in observation (black dashed) and model simulation (black solid). Predictability of reconstructed Colorado River water supply for (b) 1-12 and (c) 13-24 months lead time. Red circles and bars denote ensemble mean and spread of 10-member hindcast runs initialized on January 1st, every year, based on our state-of-the-art dynamical climate prediction system.

To evaluate the predictive skills of the Colorado River water supply, we conducted the hindcast experiment, in which initial conditions at January 1st every year are obtained from the ocean assimilation run and then, from those initial conditions, the model free runs are conducted without any constraint of observational information (a similar way with weather forecasts; Fig. 3b and 3c). These hindcast experiments provide reliability of our forecasting skills for the Colorado River water supply for 1-12 and 13-24 months lead time, and our results demonstrate high fidelity to predict the Colorado River water supply even through two years ahead. Since the Colorado River water supply highly links with soil water content in the Intermountain West (Fig. 2), our successful predictions of water supply can translate into an early warning system of water scarcity for upcoming years, not only in the Colorado River basin but also surrounding states, such as Utah, Colorado, Nevada, California, Oregon, Idaho, and Wyoming. Nevertheless, the dynamical climate prediction system is still computationally expensive, and many resources are required for providing an operational forecast of the Colorado River water supply. Instead of the operational dynamical forecast, a more efficient approach would be to utilize ocean precursors for forecasting the prolonged shortage of the Colorado River water supply.

Ocean precursor:

Our dynamical prediction system allows us to trace ocean sources of long-term predictability for the Colorado River water supply. Figure 4 shows precursor patterns of sea surface temperature for the shortage of the Colorado River water supply at 2 and 1 years ahead. As pointed out by previous studies (Chikamoto et al. 2017; Wang et al. 2014; Switanek and Troch 2011), we can find a specific pattern, such as ocean temperature cooling in the tropical Pacific, its surrounding warming, and tropical Atlantic warming, particularly in 1 year prior to the shortage of the Colorado River water supply (Fig. 4b). In other words, such an ocean temperature pattern is recognized as the precursor for a severe drought event in the upcoming year. By monitoring the ocean precursor operationally, we can assess the risk of a water supply shortage in the Colorado River and multi-year drought events in the Intermountain West.

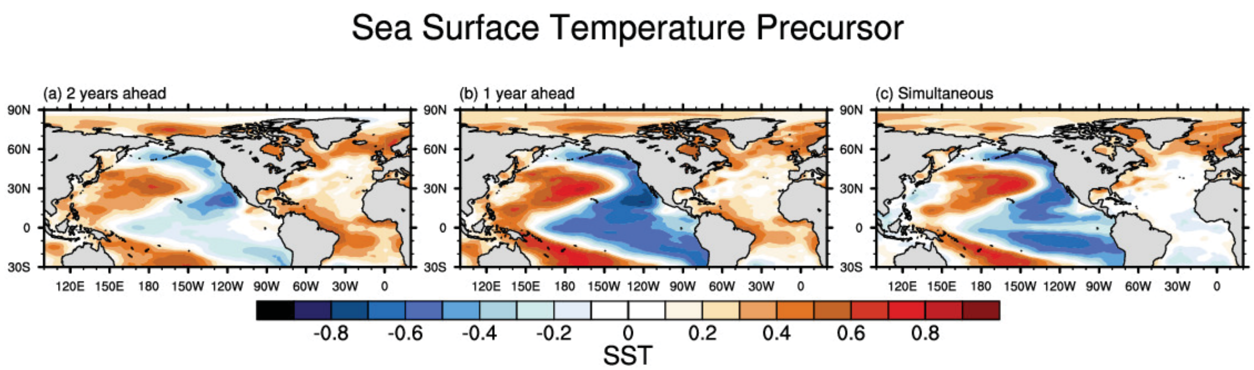


Figure 4: Ocean Precursors. Sea surface temperature precursors at (a) 2 years ahead, (b) 1 year ahead and (c) simultaneous conditions against the severe shortage of the Colorado River water supply.

Planned Work

Based on the scientific background described above, the Colorado River water supply and annual mean soil water in the Intermountain West are closely linked with the ocean precursor 1 year ahead. Using this relationship, this project will build an early warning system of water supply shortage in the Colorado River in order to provide a forecasting tool for water resource managers and stakeholders. To achieve this goal, this project plans three main tasks, as described below.

Task 1: Ocean precursor index

By communicating with water resource managers and stakeholders, this project will find an optimized choice between the ocean precursor index and the Colorado River water supply. In this task, this project will develop an ocean precursor index that connects with the shortage of the Colorado River water supply. Whereas the scientific background provides a clear sea surface temperature pattern as the precursor, more analysis is required to optimize the relationship between an ocean precursor index and the Colorado River water supply. Generally, subsurface ocean temperature has longer memory compared to the sea surface temperature, which may provide a longer lead time compared to the current 1 year lead time. In addition to ocean variables, this project needs to evaluate the availability of ocean data for operational purposes because the updating frequency of most recent ocean data differs from each forecast center. Another concern is the definition of a year. The Colorado River water supply provided by BoR is based on the calendar year (from January to December), whereas some water resource managers may prefer the water year (from the previous October to September). Our reconstruction based on the soil water observation allows us more flexible choices for these definitions. The scientific result in this task will be summarized and published in a scientific journal and presented in a conference, such as the American Meteorological Society meeting, the American Geophysical Union meeting, or the Utah Water Users Workshop.

Task 2: Monitoring system for the ocean precursor index

Using the result in Task 1, this project will build a data-based monitoring system for the ocean precursor index of the Colorado River water supply, for operational use. Ocean observations will be obtained from the NOAA Climate Prediction Center as well as other international centers, such as the European Centre for Medium-Range Weather Forecasts and the Japan Meteorological Agency. The PI and co-I have already built many collaborations with members in those centers and have full access to available datasets for operational purposes. The NOAA Climate Prediction Center is providing soil water reanalysis on a monthly basis, which applies to the reconstruction of the Colorado River water supply. By correcting data from several sources, this project will manage unexpected pitfalls for our monitoring system. The final goal of this task is building a beta-version webpage at the Utah Climate Center to share the monitoring system with water resource managers and stakeholders.

Task 3: Building a platform for an early warning system

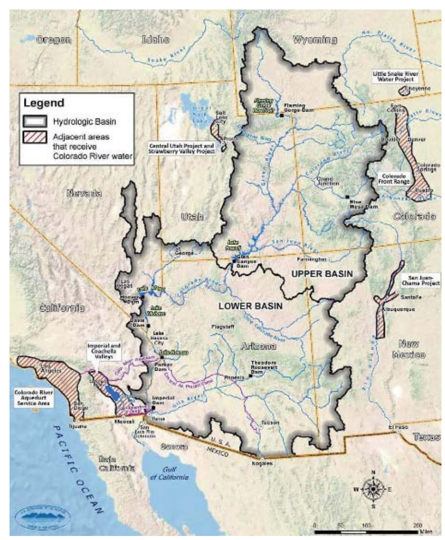
Based on the monitoring system developed by Task 2, this task involves building a website-based platform of an early warning system for the shortage of the Colorado River water supply. This platform consists of user-friendly interface and information, such as high, medium, or low chances in water shortage, as well as educational contents and professional use to provide a detail perspective of multi-year drought potential upon request. By communicating with water resource managers and stakeholders, this platform will be modified and updated based on their needs and feedback. The final product will be provided for water resource managers, stakeholders, and the public through the Utah Climate Center.

Planned Schedule

This project plans to conduct three major tasks for two years (see the table). During the first 5 quarters, this project will conduct the Task 1 objective that consists of three works: i) analyzing observational data and model experiments to identify ocean precursor patterns, ii) making an optimized ocean precursor index for the shortage of the Colorado River water supply, and iii) writing a manuscript draft to summarize the scientific result in this project. Since Task 2 relies heavily on the ocean precursor index developed by Task 1, this project will start to conduct the Task 2 objective from the fourth quarter. In Task 2, this project plans to i) determine ocean data sources for the precursor index for operational purposes, ii) develop a beta-webpage for a data-based monitoring system of the ocean precursor index and a forecasting system for the shortage of the Colorado River water supply, and iii) communicating with partnering agencies to provide useful information for them. The beta-webpage in Task 2 significantly contributes to the Task 3 objective: “establishing a platform of early warning for the upcoming shortage of the Colorado River water supply.” To have a smooth transition from Task 2 to Task 3, this project plans to start the Task 3 objective from the fifth quarter by overlapping with Task 2. When this project establishes the first version of the platform, the project team will communicate with partner agencies to improve the platform for a user-friendly interface during the seventh quarter. The final version of webpage-based platform is planned to release and disseminate through the Utah Climate Center at the end of this project (the eighth quarter).

	2020-2021				2021-2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1	Analyzing data and model experiments							
			Making an ocean precursor index					
				Writing a manuscript draft				
Task 2				Determining data sources				
				developing a beta-webpage for a minotring system of water scarcity				
					Communicating with agencies			
Task 3					Establishing a platfrom with user-friendly inferface			
							Communicating with agencies	
								Releasing & dissemination

Project Location



This project focuses on the Colorado River basin and the Intermountain West. The map of the Colorado River basin is obtained from the Colorado River Water Conservation District webpage (the figure on the right, https://www.coloradoriverdistrict.org/map-gallery/). The soil water contents in the Intermountain West is defined as the black box area in Fig. 2b.

Data Management Practices

The products in this project include the webpage-based platform (e.g., Fig. 1) and the ocean precursor index. Whereas the ocean precursor index would be provided in a user-friendly interface through a webpage, the data will be able to be downloaded in a CSV format (comma separated value). To create the ocean precursor index, this project requires observational datasets of soil water content, sea surface temperature, and ocean heat content. Those datasets are already available and accessible on webpages provided by the NOAA, Asia-Pacific Data-Research Center, National Center for Atmospheric Research, Met Office Hadley Centre, European Centre for Medium-Range Weather Forecasts, and the Japan Meteorological Agency.

Evaluation Criteria:

Criteria A – Benefits to Water Supply Reliability

A.1. Describe the water management issue(s) that your project will address. For example, will your project address water supply shortfalls or uncertainties, the need to meet competing demands for water, complications arising from drought, conflicts over water, or other water management issues? Describe the severity of the water management issues to be addressed through your project.

Water is an essential resource in the Intermountain West, and a multi-year drought event causes serious problems for farmers, ranchers, and the public through shortages of water supply. In Utah, for example, Governor Gary Herbert announced the 2018 executive order declaring a state of emergency due to drought that harmed the livelihood of many families and strained agricultural producers, industry, and even wildlife and recreation. Whereas this drought declaration has been rescinded on September 30, 2019, a question still remains when the next threat of a prolonged drought will occur across the state of Utah and the Intermountain West. In order to establish mitigation strategies and proactive management plans, water resource managers and stakeholders require reliable forecasts for the timing and duration of a prolonged drought event in upcoming years. However, there are few tools and platforms to satisfy such needs because of a lack of scientific and technical knowledge.

This project aims to support two types of water management objectives described in this funding opportunity: i) *to enhance modeling capabilities to improve water supply reliability and increase flexibility in water operations* and ii) *to improve or adapt forecasting tools and technologies to enhance management of water supplies and reservoir operations.* As described in the water management objectives, reliable forecasts are an important water management tool that can be used to optimize operations and improve water management, detect risks, and inform water allocation strategies, or even water marketing. This objective also connects with the model capability: modeling tools can improve water supply reliability and flexibility by providing an accurate representation of the physical system and more reliable information about water availability. Our project fits these objectives because a fundamental concept in our project arises from the modeling capability and reliability to predict multi-year variations of the Colorado River water supply.

A.2. Explain how your project will address the water management issues identified in your response to the preceding bullet. In your response, please explain how your project will contribute to one or more of the following water management objectives and provide support for your response.

This project plans to provide a platform toward an early warning system of water supply shortage for upcoming years based on ocean precursors. Our recent studies demonstrated that the severe water shortage in the Colorado River occurs 1 year after the unique ocean temperature pattern with the tropical Pacific cooling and the equatorial Atlantic warming. By monitoring such ocean precursors, this project aims to provide a platform to inform water managers and stakeholders about a risk of water shortage in the Colorado River for the upcoming year. Such information will contribute to decision making processes, including in the provided water manager objective list: *a) water supply reliability, b) management of water deliveries, d) drought management activities, and e) conjunctive use of ground and surface water.*

A.3. Describe to what extent your project will benefit one of the water management objectives listed in the preceding bullets. In other words, describe the significance or magnitude of the benefits of your project, either quantitatively or qualitatively, in meeting one or more of the listed objectives.

An outcome in this project includes an early warning system of water supply shortage in the Colorado River and prolonged drought potential in the Intermountain West at least 1 year ahead. This 1-year buffer time helps water managers and stakeholders to establish mitigation strategies and proactive management plans, such as deliveries, allocations, conservations, and efficient usages of operational water supply on an annual basis. This outcome will be beneficial to the provided objective list: *a) water supply reliability, b) management of water deliveries, d) drought management activities, and e) conjunctive use of ground and surface water.*

A.4. Explain how your project complements other similar applicable to the area where the project is located. Will your project complement or add value to other, similar efforts in the area, rather than duplicate or complicate those efforts? Applicant should make a reasonable effort to explore and briefly describe related ongoing projects.

Whereas this project focuses mainly on multi-year forecasts of the Colorado River water supply, the water supply variability highly links to soil water contents in the Intermountain West, such as the states of Utah, Colorado, Arizona, Nevada, California, Oregon, Idaho, and Wyoming. As a result, our project outcomes are immediately applicable to assess the upcoming hydrological drought risks in those states and creating the path forward for Utah leading water resource management in the Intermountain West.

Criteria B – Need for Project and Applicability of Project Results

B.1. Does your project meet an existing need identified by a water resource manager(s) within the 17 Western States?

Yes. Our project provides a reliable forecast tool regarding the annual shortage of the Colorado River water supply to water resource managers and stakeholders.

> *B.1.a Explain who has expressed the need and describe how and where the need for the project was identified (even if the applicant is the primary beneficiary of the project). For example, was the need identified as part of a prior water resources planning effort, through the course of normal operations, or raised by stakeholders? Provide support for your response (e.g., identify the entities that have expressed a need or cite planning or other documents expressing a need for the project).*
>
> As described in this funding opportunity announcement, reliable forecasts of water supply are an essential water management tool that can be used to optimize operations and improve water management, manage risks, and inform water allocation strategies, or even water marketing (see the next answer as well).
>
> *B.1.b Provide letters of support from any resource managers, stakeholders or partners that have stated that they will benefit from the project, or, for Category B applicants, letters of participation from partners who have committed to participate in the proposed project. Identify any contribution (e.g., cost share, staff time, or other resources) by partners other than the applicant to the non-Federal cost share requirement for the project.*

This project is the first attempt to provide an early warning system of upcoming water scarcity. To communicate with water resource managers and stakeholders closely, this project collaborates with three local organizations, as described below.

State of Utah, Department of Natural Resources, Division of Water Resources is one of the seven divisions housed within the Department of Natural Resources. Their tasks include planning, conserving, developing and protecting Utah's water resources. They have a mission to find sustainable solutions to meet the future water needs through a combination of multi-faceted solutions that include conservation, efficiency, optimization, agriculture conversion and water development. They recognized that our project outcomes are beneficial to plan and mitigate multi-year drought threats. They will participate in this project by providing their input and feedback in terms of the needs of water resource managers, and explain how they plan and make operational decisions on demand and water supply. They committed to participating in this project with the amount of $10,000 towards in-kind contribution.

Salt Lake City Department of Public Utilities is the water provider and actively protects the water sources in the Wasatch canyons watershed and promote conservation through efficient water use. Their important activity includes developing and maintaining a resilient and sustainable water supply. They are interested in our proposed project and can use our project outcomes to improve operational decisions on water supply demands. As described in the letter of support, they committed to participating in this project with the amount of $10,000 towards in-kind contribution.

The Utah Farm Bureau Federation is the state's largest voluntary organization of farmers and ranchers, which consists of more than 34,000 member families committed to protecting Utah's farms and ranches, and ensuring a safe, fresh and locally grown food supply. The farmers and ranchers are strongly impacted by multi-year droughts. In 2018, the state of Utah experienced a severe drought, which caused significant damages to agricultural producers. In Blanding, for example, irrigation water was completely depleted, which caused reductions in alfalfa, a lack of normal nutrition for livestock, and an economic downturn of agricultural productions. Reliable forecasts for a serious drought event with longer lead time helps farmers and ranchers make a mitigation plan for future drought risk. They found that our project outcomes would benefit farmers and ranchers, and they committed to participating in this project with the in-kind contribution of $10,000.

B.2. Will the project result in an applied science tool(s) or information that is readily applicable, and highly likely to be used by water resource managers in the West?

Yes. The project outcomes provide the information of upcoming multi-year drought risk by translating the scientific outcomes into user-friendly information. Water resource managers will use such information during their decision processes. The following is an answer for each subcategory question.

B.2.a How will the project results be used?

The outcome of this project will be used for monitoring and detecting the potential of water scarcity for the upcoming years. When the decision makers and resource managers make their plans and actions, our project outcomes will give them a perspective on how much drought risk they may have for the upcoming years.

B.2.b Will the results of this project inform water resource management actions and decisions immediately upon completion of the project, or will additional work be required?

Once the high risk of water scarcity for the upcoming years is detected from the monitoring and forecasting system in our project, water resource managers will require appropriate actions to make a proactive management plan. Otherwise, no additional work is needed.

B.2.c Will the results of this project be transferrable to other users and locations?
Yes. Whereas this project focuses mainly on the Colorado River water supply, the results of this project apply to hydrological drought detection for many states in the Intermountain West. The project outcomes are accessible to the public because they are based on the webpage-based interface.

B.2.d If the applicant is not the primary beneficiary of the project, describe how the project beneficiaries have been or will be involved in planning and implementing the project?
The final goal of this project is the webpage-based platform with user-friendly format based on scientific outcomes. To translate the scientific findings into the user-friendly information, comments and feedback from the primary beneficiaries of this project are fundamental. In particular, this project requires when and how often they need our multi-year drought forecasts for their operational use. This project also plans to conduct surveys to agencies, hold a workshop, and attend the meeting through the Utah Climate Center activities, which will give them an opportunity to reach out to this project.

Criteria C – Project Implementation

C.1. Describe the objectives of the project and the methodology and approach that will be undertaken. Provide support for your methodology and approach.
The goal of this project is to establish a platform to connect water resource managers and stakeholders with scientific outcomes of multi-year predictions of the Colorado River water supply. The dynamical climate prediction system and the approach to assess the regional water resource variability have been already published in scientific journals by PIs (see the Scientific background). To translate these scientific outcomes into the early warning system for the upcoming shortage of the Colorado River water supply, this project proposes three main tasks:

- Task 1: constructing an ocean precursor index that affects the shortage of the Colorado River water supply,
- Task 2: developing the monitoring system for such a precursor index,
- Task 3: building a platform at UCC to disseminate the early warning for a severe shortage of the Colorado River water supply.

C.2. Describe the work plan for the project. Include an estimated project schedule that shows the stages and duration of the proposed work, including major tasks, milestones, and dates.
The estimated project schedule is summarized in the table below. During Task 2, this project will organize one-day meetings and surveys with resource managers and stakeholders to gain feedback for the monitoring system. At the end of Task 3, the platform developed in this project will be released to the public through the UCC webpage. More detailed schedule of the proposed work is also described in the “planned schedule” above.

Activity (Tasks)	2020-2021				2021-2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Constructing an ocean precursor index	x	x	x	x	x			
2. Developing the monitoring system				x	x	x		
3. Building a platform at UCC					x	x	x	x

C.3. Describe the availability and quality of existing data and models applicable to the project.

The PI conducted all model simulations that are archived in a local server at USU. Observation-based datasets for soil water and ocean temperature are available to the public and updated operationally. These datasets are accessible through the webpages in the NOAA Climate Prediction Center, the Earth System Research Laboratory, the European Centre for Medium-Range Weather Forecasts, and the Japan Meteorological Agency.

C.4. Identify staff with appropriate credentials and experience and describe their qualifications. Describe the process and criteria that will be used to select appropriate staff members for any positions that have not yet been filled. Describe any plans to request additional technical assistance from Reclamation or via a contract.

The project team comprises well-qualified expertise on climate dynamics and hydrological application. Our team members and their specific roles are:

- Principal Investigator (PI): Dr. Yoshimitsu Chikamoto (assistant professor at Utah State University) has expertise on decadal climate prediction. He served as a contributing author for the Intergovernmental Panel on Climate Change, Fifth Assessment Report, Chapter 11 *Near-term Climate Change: Projections and Predictability* and has published several high-impact papers that demonstrate the capability of earth system modeling to predict prolonged droughts in the southwestern U.S. He will direct and coordinate the project to pursue the proposed tasks. He is involved in the 2018 BoR WaterSMART project "*Synthesizing drought characteristics prediction to inform drought resilience decisions from days to years"* as a co-I.
- Co-I: Dr. S.-Y. Simon Wang (professor at Utah State University) has demonstrated expertise and productivity in climate dynamics and prediction, with experience in dissemination of research results through the Utah Climate Center. He will assist with project tasks and work with collaborating with water agencies to disseminate project outcomes. He led two BoR projects in the past and one on-going project (see below).
- Other personnel: One graduate student to be named will pursue all tasks proposed by this project with supervision from the PI and co-I (Chikamoto and Wang).

C.4.a Have the project team members accomplished projects similar in scope to the proposed project in the past either as a lead or team member?

Members in this project team were involved in the previous and ongoing BoR WaterSMART projects that are similar in scope to the proposed project. Those projects are:

- the 2011 BoR WaterSMART "*Effective Assessments for Climate Uncertainties in Dynamical Downscaling over the Colorado Regions*" (Co-I: Wang).
- the 2013 BoR WaterSMART "*Building Decadal Prediction of Extreme Climate for Managing Water in the Intermountain West*", (PI: Wang).
- the 2018 BoR WaterSMART "*Synthesizing drought characteristics prediction to inform drought resilience decisions from days to years*", (PI: Wang, Co-I: Chikamoto).

C.4.b Is the project team capable of proceeding with tasks within the proposed project immediately upon entering into a financial assistance agreement?

Yes. Based on the expertise and experience, this project team is capable of proceeding with tasks within the proposed project immediately upon entering into a financial assistance agreement.

C.5. Provide a summary description of the products that are anticipated to result from the project. These may include data, metadata, digital or electronic products, reports and publications.

The products in this project include a scientific research article (Task 1), digital data (Task 2), and webpage-based information for risks of the Colorado River water supply shortage (Task 3). In Task 1, the analyses to connect between the ocean precursor index and the Colorado River water supply will be summarized as a scientific research article and contribute a portion of a thesis for the graduate student. Task 2 will produce digital data, such as the ocean precursor index, the reconstruction of the Colorado River water supply, and soil water contents in the Intermountain West. The webpage-based information in Task 3 will consist of the user-friendly interface of digital data produced in Task 2, a short description of a concept of our prediction system based on Task 1, and the water scarcity potential of the Colorado River for the upcoming year.

Criteria D – Dissemination of Results

D.1 Describe how the tools, frameworks, or analyses being developed will be disseminated, communicated, or made available to water resources managers who may be interested in the results.

D.1.a If the applicant is the primary beneficiary of the project, explain how the project results will be communicated internally, and to interested stakeholders and interested water resources managers in the area, if appropriate.

This does not apply to this project because the applicant is not the primary beneficiary. Please see the next answer.

D.1.b If the applicant is not the primary beneficiary of the project (e.g., universities or research institutes) describe how project results will be communicated to project partners and interested water resources managers in the area.

The project products will be disseminated, communicated, and made available to water resources managers through the project website on Utah Climate Center (UCC; https://climate.usu.edu) at Utah State University and in scheduled meetings and webinar workshops. The UCC routinely provides climate information through extension activities and through contacts with the media and will communicate the results of this project to water resources managers and stakeholders through its well-established service and outreach role. The UCC data server achieves over 11,000 hits per month, and most of those hits are for data download. There will be no restrictions in using/placing the data on the UCC webpage. The data on the webpage will be open and accessible to the public. As the UCC assistant director, co-I Wang will manage data archiving in this project. Through the UCC activities and past BoR projects, co-I Wang had hosted several meetings with the water agencies, first in 2011 and again in 2012, 2013, and 2016, to update them on the water-climate research progress. This project plans to have a similar meeting to communicate with the water agencies. In addition to working directly with water agencies, we will present project results at scientific conferences and regional water user meetings such as the annual Utah Water Users Workshop. Research results will also be published in peer-reviewed journals and a part of a thesis for the graduate student.

D.1.c Explain why the chosen approach is the most effective way to disseminate the information to end users in a usable manner.

The approach proposed in this project is the most effective way to disseminate the information to end users in a convenient manner because of availability, accessibility, and reliability. The platform produced in this project is the webpage-based information, which is always available and accessible as long as the UCC website is activated. These availability and accessibility allow end users to satisfy their emergency and immediate needs of information. The platform also provides contact information that helps end users to gain reliable information of forecasted products upon request.

Criteria E – Department of the Interior Priorities

Explain how your project supports Department of the Interior Priorities (or at least one priority).

Water is an essential resource in the Intermountain West. Prolonged droughts cause severe damages to the environment. Reliable forecasts of multi-year drought events at longer lead times are vital to manage land and water resources and adapt to the drought condition proactively. This project aims to provide an early warning for serious shortage in the Colorado River water supply by translating the scientific outcomes into a user-friendly information and format. This project direction perfectly fits with one of the Department of the Interior Priorities "*Creating a conservation stewardship legacy second only to Teddy Roosevelt,*" such as *utilizing science to identify best practices to manage land and water resources and adapt to changes in the environment.* The early warning system developed in our project will also give an opportunity for water resource managers to make proactive management and action plans against severe drought events. Therefore, our project outcomes significantly support another priority at the Department of the Interior: *Utilizing our natural resources,* particularly for utilizing the use of water resources more efficiently than before.

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Project Budget

Funding Plan and Letters of Funding Commitment

Table 1. Summary of non-Federal and Federal Funding Sources

Funding Sources	Funding Amount
Non-Federal Entities	
1. Utah State University*	$ 61,079.53
2. SLC Department of Public Utilities	$ 10,000.00
3. Utah Division of Water Resources	$ 10,000.00
4. Utah Farm Bureau	$ 10,000.00
Non-Federal Subtotal:	$ 91,079.53
Other Federal Entities	None
Requested Reclamation Funding:	$ 91,078.17
Total Project Funding:	$182,157.70

USU's contribution to the cost-share requirement will include waived indirect costs both on the federal request and on the contribution by USU. The USU's contribution also includes partial travel support for the project members and the assistantship and fringe benefits for the graduate student.

Funding partners and the types of contributions committed per the attached letters and Third Party Sharing Commitment Forms are:
• Salt Lake City Department of Public Utilities commits in-kind salary, benefits, and travel costs.
• Utah Division of Water Resources commits in-kind salary and fringe benefits as outlined in the letter of commitment.
• Utah Farm Bureau commits in-kind salary, fringe benefits, and travel costs as outlined in the letter of commitment.
.
In the following pages are included letters of funding commitment from the three collaborating agencies. If more detailed letters of commitment than the following are requested, they will be supplied within two weeks of notice of award.

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Sponsored Programs

THIRD PARTY COST SHARING COMMITMENT FORM

Project Title: WaterSMART: A platform toward an early warning system for shortages
Project Period: From October 1, 2020 to September 30, 2022
USU PI/PD: Yoshimitsu Chikamoto
Contributing Organization: Salt Lake City Department of Public Utilities

Proposed Cost Share

Personnel (salary, wages, & fringe benefits):	$ 8,000.00
Travel:	$ 2,000.00
Supplies:	
Capital Equipment (Over $5000):	
Other:	
Indirect Cost:	
Total Contribution:	$ 10,000.00

Description of "Other" budget items: ______

An auditable record of the above contribution to USU will be provided as required by the Prime Award and Uniform Guidance, Title 2, Subtitle A, Chapter II, Part 200, Subpart D, § 200.306 Cost sharing or matching, as applicable for the duration of the project.

USU and your organization, by virtue of your in-kind support, are subject to the Uniform Guidance Title 2, Subtitle A, Chapter II, Part 200, Subpart D, § 200.306 Cost sharing or matching: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=42ca0bc21c09b15826e1d166d3c9cc92&mc=true&n=sp2.1.200.d&r=SUBPART&ty=HTML#se2.1.200_1306. In reviewing this section, you will note that all contributions, including your portion, will be accepted as part of the cost sharing or matching when the contributions meet all of the following criteria:

1. Are verifiable from the non-Federal entity's records;
2. Are not included as contributions for any other Federal award;
3. Are necessary and reasonable for accomplishment of project or program objectives;
4. Are allowable under Subpart E—Cost Principles of this part;
5. Are not paid by the Federal Government under another Federal award, except where the Federal statute authorizing a program specifically provides that Federal funds made available for such program can be applied to matching or cost sharing requirements of other Federal programs;
6. Are provided for in the approved budget when required by the Federal awarding agency; and
7. Conform to other provisions of this part, as applicable.
8. Costs may only be incurred during the project period of performance.
9. The basis for determining the valuation of the personnel service, material, equipment, building and land must be documented.

Contributor: [signature] Date: 10/24/19

Typed Name & Title: Laura Briefer, Director

As USU PI/PD, I certify that the proposed cost share:

1. Is necessary and reasonable for the efficient accomplishment of the specified project; and
2. Is allowable under the applicable cost principles and other terms and conditions of the award or program.

USU PI: [signature] Date: 10/24/19

Revised: 03/31/2017
Second Revision: 08/2019

OFFICE OF RESEARCH
UtahStateUniversity.

Sponsored Programs

THIRD PARTY COST SHARING COMMITMENT FORM

Project Title: WaterSMART: A platform toward an early warning system for shortages
Project Period: From October 1, 2020 to September 30, 2022
USU PI/PD: Yoshimitsu Chikamoto
Contributing Organization: Utah Division of Water Resources

Proposed Cost Share

Personnel (salary, wages, & fringe benefits):	$ 10,000.00
Travel:	
Supplies:	
Capital Equipment (Over $5000):	
Other:	
Indirect Cost:	
Total Contribution:	$ 10,000.00

Description of "Other" budget items: ______

An auditable record of the above contribution to USU will be provided as required by the Prime Award and Uniform Guidance, Title 2, Subtitle A, Chapter II, Part 200, Subpart D, § 200.306 Cost sharing or matching, as applicable for the duration of the project.

USU and your organization, by virtue of your in-kind support, are subject to the Uniform Guidance Title 2, Subtitle A, Chapter II, Part 200, Subpart D, § 200.306 Cost sharing or matching: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=42ca0bc21c09b15826e1d166d3c9cc92&mc=true&n=sp2.1.200.d&r=SUBPART&ty=HTML#se2.1.200_1306. In reviewing this section, you will note that all contributions, including your portion, will be accepted as part of the cost sharing or matching when the contributions meet all of the following criteria:

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4. Are allowable under Subpart E—Cost Principles of this part;
5. Are not paid by the Federal Government under another Federal award, except where the Federal statute authorizing a program specifically provides that Federal funds made available for such program can be applied to matching or cost sharing requirements of other Federal programs;
6. Are provided for in the approved budget when required by the Federal awarding agency; and
7. Conform to other provisions of this part, as applicable.
8. Costs may only be incurred during the project period of performance.
9. The basis for determining the valuation of the personnel service, material, equipment, building and land must be documented.

Contributor: [signature] Date: 10/24/2019

Typed Name & Title: Eric Millis. Director

As USU PI/PD, I certify that the proposed cost share:

1. Is necessary and reasonable for the efficient accomplishment of the specified project; and
2. Is allowable under the applicable cost principles and other terms and conditions of the award or program.

USU PI: [signature] Date: 10/24/2019

Revised: 03/31/2017
Second Revision: 08/2019

OFFICE OF RESEARCH
UtahStateUniversity.

Sponsored Programs

THIRD PARTY COST SHARING COMMITMENT FORM

Project Title: WaterSMART: A platform toward an early warning system for shortages
Project Period: From October 1, 2020 to September 30, 2022
USU PI/PD: Yoshimitsu Chikamoto
Contributing Organization: Utah Farm Bureau

Proposed Cost Share

Personnel (salary, wages, & fringe benefits):	$ 8,000.00
Travel:	$ 2,000.00
Supplies:	
Capital Equipment (Over $5000):	
Other:	
Indirect Cost:	
Total Contribution:	$ 10,000.00

Description of "Other" budget items: ____________________

An auditable record of the above contribution to USU will be provided as required by the Prime Award and Uniform Guidance, Title 2, Subtitle A, Chapter II, Part 200, Subpart D, § 200.306 Cost sharing or matching, as applicable for the duration of the project.

USU and your organization, by virtue of your in-kind support, are subject to the Uniform Guidance Title 2, Subtitle A, Chapter II, Part 200, Subpart D, § 200.306 Cost sharing or matching: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=42ca0bc21c09b15826e1d166d3c9cc92&mc=true&n=sp2.1.200.d&r=SUBPART&ty=HTML#se2.1.200_1306. In reviewing this section, you will note that all contributions, including your portion, will be accepted as part of the cost sharing or matching when the contributions meet all of the following criteria:

1. Are verifiable from the non-Federal entity's records;
2. Are not included as contributions for any other Federal award;
3. Are necessary and reasonable for accomplishment of project or program objectives;
4. Are allowable under Subpart E—Cost Principles of this part;
5. Are not paid by the Federal Government under another Federal award, except where the Federal statute authorizing a program specifically provides that Federal funds made available for such program can be applied to matching or cost sharing requirements of other Federal programs;
6. Are provided for in the approved budget when required by the Federal awarding agency; and
7. Conform to other provisions of this part, as applicable.
8. Costs may only be incurred during the project period of performance.
9. The basis for determining the valuation of the personnel service, material, equipment, building and land must be documented.

Contributor: Brett Behling Date: 10/22/2019

Typed Name & Title: Brett Behling, Southern Regional Manager

As USU PI/PD, I certify that the proposed cost share:

1. Is necessary and reasonable for the efficient accomplishment of the specified project; and
2. Is allowable under the applicable cost principles and other terms and conditions of the award or program.

USU PI: [signature] Date: 10/22/2019

Revised: 03/31/2017
Second Revision: 08/2019

Budget Proposal

White, blue and green shades indicate federal, applicant, and third-party funding in the table below.

Table 2. Funding Sources

Funding Sources	**Percent of Total Project Cost**	**Total Cost by Source**
Reclamation Funding	50%	$ 91,078.17
Applicant Funding	34%	$ 61,079.53
Third Party Funding	16%	$ 30,000.00
Totals	100%	$182,157.70

Table 3. Budget Proposal

Budget Item Description	$/Unit	Quantity	Type	Total Cost
Key Personnel Salaries/Wages				**$ 34,887.37**
Yoshimitsu Chikamoto, Y1	$ 7,838.46	1	month	$ 7,838.46
Yoshimitsu Chikamoto, Y2	$ 8,073.61	1	month	$ 8,073.61
Simon Wang, Y1	$ 3,115.81	3	week	$ 9,347.44
Simon Wang, Y2	$ 3,209.29	3	week	$ 9,627.86
Other Personnel Salaries/Wages				**$ 40,754.51**
Graduate Student TBN Y1	$1,666.66	12	month	$ 20,000.00
Graduate Student TBN Y2	$1,729.54	12	month	$ 20,754.51
Fringe Benefits				**$ 21,294.46**
Yoshimitsu Chikamoto, Y1	$0.45627	7,838.46	Salary dollar	$ 3,576.51
Yoshimitsu Chikamoto, Y2	$0.46127	8,073.61	Salary dollar	$ 3,724.18
Simon Wang, Y1	$0.45627	9,347.44	Salary dollar	$ 4,265.03
Simon Wang, Y2	$0.46127	9,627.86	Salary dollar	$ 4,441.11
Graduate Student, Academic Y1	$0.008	15,000.00	Salary dollar	$ 120.00
Graduate Student, Summer Y1	$0.083	5,000.00	Salary dollar	$ 415.00
Graduate Student, Academic Y2	$0.008	15,565.88	Salary dollar	$ 124.53
Graduate Student, Summer Y2	$0.083	5,188.63	Salary dollar	$ 430.66
Graduate Student health insurance Y1	$2018.00	1	Annual Premium	$ 2,018.00
Graduate Student health insurance Y2	$2,179.44	1	Annual Premium	$ 2,179.44
Travel				**$ 5,000.00**
2019-2020 Professional Meetings	$2,500	1	Trip	$ 2,500.00
2020-2021 Professional Meetings	$2,370	1	Trip	$ 2,370.00
2020-2021 Professional Meetings	$ 130	1	Trip	$ 130.00
Equipment	-----------	------------	---------------	$ 0
Materials & Supplies				**$ 1,000.00**

Miscellaneous lab supplies & equipment maintenance, Y1	$ 500	1	Year	$ 500
Miscellaneous lab supplies & equipment maintenance, Y2	$ 500	1	Year	$ 500
Contractual	-----------	------------	---------------	$ 0
Third Party In-Kind Contributions				**$ 30,000.00**
SLC Department of Public Utilities				**$ 10,000.00**
Salary/benefits	$4,000	2	Year	$ 8,000.00
Travel	$1,000	2	Year	$ 2,000.00
Utah Division of Water Resources				**$ 10,000.00**
Salary/benefits	$5,000	2	Year	$ 10,000.00
Utah Farm Bureau				**$ 10,000.00**
Salary/benefits	$4,000	2	Year	$ 8,000.00
Travel	$1,000	2	Year	$ 2,000.00
Environmental Regulatory Compliance Costs	-------	-------	-------	**$ 0**
Other Expenses				**$ 2,000.00**
Publication Fee, Y2	$ 2,000.00	1	Year	$ 2,000.00
Reporting Costs	-------	--------	----------	$ 0
TOTAL DIRECT COST				**$ 134,936.34**
TDC Federal Funding				**$ 77,513.34**
TDC USU Cost Share				**$ 27,423.00**
TDC Third Party In-Kind				**$ 30,000.00**
INDIRECT COSTS	$ 0.45	104,936.34	MTDC Dollar	**$ 47,221.36**
IDC on Federal Funding @ CESU rate	$ 0.175	77,513.34	TDC dollar	$ 13,564.83
Waived IDC on Federal funding	$ 0.275	77,513.34	TDC dollar	$ 21,316.17
Waived IDC on USU Cost Share	$ 0.45	27,423.00	MTDC dollar	$ 12,340.36
IDC on Third Party In-Kind	$ 0			$ 0.00
Total Federal Funds Requested				**$ 91,078.17**
USU Cost Share Committed				**$ 61,079.53**
Third Party Cost Share Committed				**$ 30,000.00**
Total Estimated Project Costs				**$ 182,157.70**

Budget Narrative

1. **<u>Salaries and Wages: $75,641.88</u> ($55,641.88 Federal funding; $20,000 cost share)**

All labor rates proposed represent the actual labor rates of the identified personnel with anticipated 3% annual increase for faculty.

A. **<u>Key Personnel Salary: $34,887.37</u> ($34,887.37 Federal funding; $0 cost share)**
   - PI/Program Manager Chikamoto requests 1 month salary/year (8.33% effort/year) for a total of $15,912.07 requested funding. Dr. Chikamoto will direct the project and mentor a graduate student to pursue associated tasks as well as dissemination.
   - Co-Investigator Wang requests 3 week salary/year (5.77% effort/year) for a total of $18,9675.30 requested funding. Dr. Wang will work with collaborating water agencies and stakeholder to disseminate drought prediction results and provide interpretation as well as mentoring a graduate student with PI.

B. **<u>Other Personnel Salary: $40,754.51</u> ($20,754,51 Federal funding; $20,000 cost share)**
   - One graduate student to be named for 12 months of research assistantship per year at $1,666.66 per month for Y1 and $1,729.54 per month for Y2, with a total of $20,754.51 requested funding and $20,000 cost share. Graduate student will work with PI Chikamoto and co-I Wang to conduct project tasks and build a platform of early warning system.

2. **<u>Fringe Benefits: $21,294.46</u> ($18,741.46 Federal funding; $2,553.00 cost share)**
   - Fringe benefits are charged at 45.5% for FY2021 (46.0% for FY2022) for faculty, 8.3% for student summer months and 0.8% student academic year. These are USU's proposal preparation benefit rates and for faculty and staff they cover Social Security, retirement, insurance, unemployment, disability, and Worker's Compensation costs.
   - Mandatory graduate student health insurance is also requested as cost share at $2,018 in Y1 and Federal funding at $2,179.44 for Y2.

3. **<u>Travel Costs: $9,000</u> ($130 Federal funding; $8,870 cost share)**
   - Domestic travel costs are included for one trip per year for PI Chikamoto or other project members to present results at the American Geophysical Union Fall Meeting, the American Meteorological Society meeting, the American Geophysical Union meeting, or the Utah Water Users Workshop. Each 5-day trip is budgeted at $2,500 to cover conference registration ($500), abstract fees ($65), airfare and ground transportation ($750), hotel (4 nights at $250), and per diem (4 days at $46). Total cost per year is $2,500, and total cost of $5,000 is requested as cost share at $4,870 and Federal funding at $130 for Y2.
   - Travel costs of $4,000 are requested as in-kind contributions at $1,000/year x 2 years each for Utah Farm Bureau and Salt Lake City Public Utilities to hold discussions and collect information regarding the needs of farmers and ranchers.

4. **<u>Equipment: None</u>**

5. **<u>Materials, Supplies and Consumables: $1,000 Federal funding</u>**
    - Costs of printing materials, communication allowance, mailing, computer lab supplies and maintenance are estimated using current costs and budgeted to be $500 Federal funding each year. Total is $1,000.

6. **<u>Contractual: None</u>**

7. **<u>Collaborating Organizations: $30,000</u> ($0 Federal funding; $30,000 cost share)**
    A. *Salt Lake City Department of Public Utilities: $10,000.00 ($0 Federal Funds, $10,000 cost share)*
    - Water Resources Scientist, $8,000 ($100/hour, total 80 hours in Year 1 & Year 2)
    - Travel cost, $2,000 for 2 trips during Year 1 & Year 2.

    B. *Utah Division of Water Resources: $10,000.00 ($0 Federal Funds, $10,000 cost share)*
    - Assistant Director, $1,300 ($65/hour, total 20 hours in Year 1 & Year 2)
    - Manager, $3,600 ($60/hour, total 60 hours in Year 1 & Year 2)
    - Staff Engineers, $4,100 ($41/hour, total 100 hours in Year 1 & Year 2)

    C. *Utah Farm Bureau: $10,000.00 ($0 Federal Funds, $10,000.00 cost share)*
    - Brett Behling, Southern Regional Manager, $4,000,00 in Year 1 and Year 2 ($100/hour, 20 hours for each year). He will participate in the project-coordinated meeting and provide feedback to our webpage-based platform from the perspective of farmers and ranchers. He also supports to connect this project team with other regional managers.
    - Regional Manager, $4,000,00 in Year 1 and Year2 ($100/hour, 20 hours for each year), will participate in the coordinated meetings and surveys, as well as evaluating the project outcomes.
    - Travel cost of $2,000 is requested for 1 trip each in Year 1 & 2 to participate the coordinated meetings.

8. **<u>Environmental Regulatory Compliance Costs: None required</u>**

9. **<u>Other Expenses: $2,000.00 ($2000.00 Federal funding; $0 cost share)</u>**
    - A cost is requested to pay for one scientific journal publication in Y2 ($2,000/paper) based on the standard Open Access charge of the AGU journals. The total cost of $2,000 is requested as Federal funding.

10. **<u>Direct Costs: $134,936.34 ($77,513.34 Federal funds; $27,423.00 USU cost share, $30,000.00 Third Party In-kind Cost Share)</u>**

11. **<u>Indirect Costs: $47,221.36</u> ($13,564.83 Federal funds; $33,656.53 USU cost share)**
    Indirect Costs are calculated at USU's Federally-negotiated rate of 45.0% Modified Total Direct Costs ($104,936.34), but only 17.5% TDC are charged to the grant per CESU Agreement. The remaining unrecovered indirect costs are included as cost share.

12. **Federal Funding Requested: $91,078.17**

13. **Total Cost Share Committed: $91,079.53**

14. **Total Project Cost: $182,157.70**

Environmental and Cultural Resources Compliance

Basically, this is not applicable to our project because our project mainly focuses on providing information through the data analysis. The following is more detailed answers for each question.

- **Will the proposed project impact the surrounding environment?**
  No. This project has no direct impact on the surrounding environment because this project consists of analyzing data that is already available on the public.

- **Are you aware of any species listed or proposed to be listed as a Federal threatened or endangered species, or designated critical habitat in the project area?**
  This project has no direct impact on any species because main tasks in this project is data analysis. However, the upcoming drought information provided in this project may be helpful to protect species as a result of the proactive management by the state agencies.

- **Are there wetlands or other surface waters inside the project boundaries that potentially fall under CWA jurisdiction as "Waters of the United States?"**
  This is not applicable to our project because our project proposes no constructions and assessments relating to the clear water.

- **When was the water delivery system constructed?**
  This is not applicable to our project because we have no construction plan of water delivery system.

- **Will the proposed project result in any modification of or effects to, individual features of an irrigation system?**
  No. Our project has no irrigation system.

- **Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places?**
  This is not applicable to our project because our project has no buildings, structures, and features in the irrigation district.

- **Are there any known archeological sites in the proposed project area?**
  Although our project area covers the Colorado River basin and the Intermountain West, our project has no impact on archeological sites because our project uses the already available datasets.

- **Will the proposed project have a disproportionately high and adverse effect on low**

<u>income or minority populations?</u>

No. Our project has no impact on low income or minority populations.

- **<u>Will the proposed project limit access to and ceremonial use of Indian sacred sites or result in other impacts on tribal lands?</u>**

  No. Our project has no impact to Indian sacred sites and tribal lands.

- **<u>Will the proposed project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area?</u>**

  No. Our project has no contribution to the introduction, continued existence, spread of noxious weeds, and non-native invasive species.

Required Permits or Approvals

Not applicable.

Letter of Participation

This proposal includes three letters of participation as listed:

- Salt Lake City Department of Public Utilities
- Utah Division of Water Resources
- Utah Farm Bureau.

[redacted]