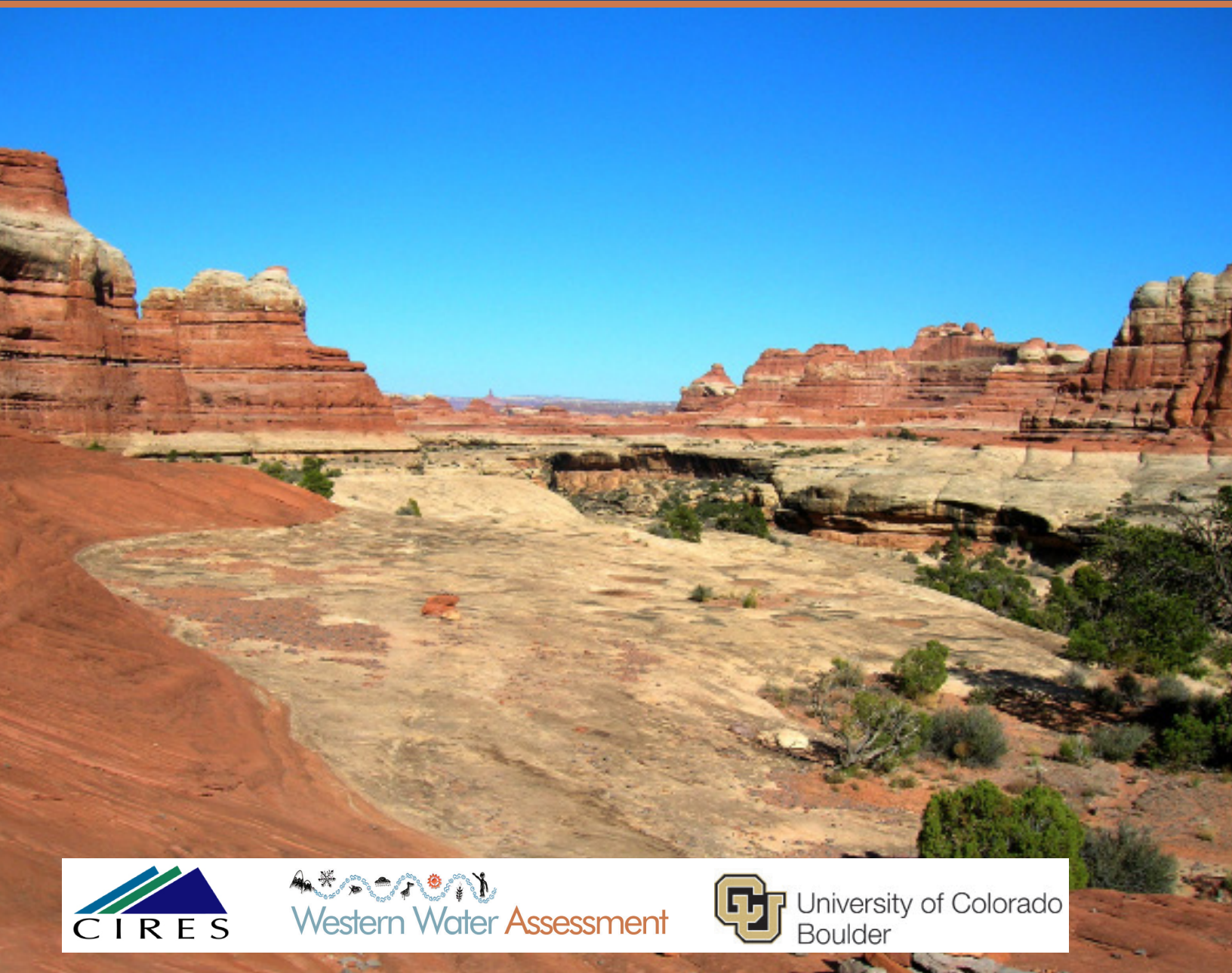
Western Water Assessment's
THE UTAH MODEL REPORT

February 2014
Western Water Assessment
Cooperative Institute for Research in Environmental Sciences

Edited by Elizabeth C. McNie, PhD



CIRES

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University of Colorado Boulder

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Dead Horse Lake, High Uinta Wilderness. Photo: Tim Bardsley

I. BACKGROUND

The NOAA Climate Program Office-sponsored RISA (Regional Integrated Sciences and Assessments) programs have historically been located or co-located in university settings. The original thinking behind this strategy was to place the RISA programs in the heart of robust research environments given that one of RISA's primary goals is to explore, discover and implement novel ways of linking climate science with policy for improved decision support. During the past two decades the RISA program has evolved and grown with demonstrable success, indicating that the university-based context of the programs has salient benefits. These include access to physical, social and natural-science researchers with PhDs from a wide variety of disciplines; administrative, infrastructure, and computational support; and the social capital and legitimacy that comes from being associated with universities thus supporting the RISA's efforts to appear as 'honest brokers' of information.

The Western Water Assessment (WWA) is one RISA program and has been based at the University of Colorado at Boulder and the Cooperative Institute for Research in Environmental Sciences (CIRES) for over a decade. In its last 5-year re-bid, WWA proposed to expand its operations into Wyoming and Utah by hiring WWA 'affiliates' to conduct research and provide more context-sensitive decision support to policy-makers in both states. The original goal was to follow the well-established RISA model and hire affiliates based at a university.

Despite many efforts, and for a variety of reasons, WWA was unable to identify and co-locate researchers at any university in Utah or Wyoming. Despite setbacks, WWA did eventually hire a 'liaison' in Utah, however this employee is directly employed by WWA and not by a university in Utah.

This case study examines what WWA calls the 'Utah Model' and how this alternative approach to the traditional university-based research expanded WWA's network and provided climate-related decision-support activities in novel ways. As with many RISA activities, the Utah Model is a work in progress, so findings are rather limited at this time. Furthermore, our sample size of stakeholders is very small so this case study should be viewed as the starting point for discussions about the role of RISAs within a broader decision-support community, and not be construed as conclusive. This paper will highlight the successes achieved thus far, discuss opportunities for improvement, and identify ongoing and desired future research trajectories.

2. CHALLENGES TO PROGRAM EXPANSION

During the early years, most RISA programs were based at a single university, for example, the Climate Impacts Group was based at the University of Washington, The Climate Assessment of the Southwest was based at the University of Arizona, and the WWA was based at the University of Colorado. Subsequent decisions by the Climate Program Office have supported the expansion of RISA programs to multiple universities, particularly with the newer RISA programs, for example, the Great Lakes RISA is co-located at two universities. This new approach embraces the notion that broadening knowledge networks and leveraging the human and social capital through such expansion would result in the development of more relevant decision-support information. Current research in social network analysis supports these views. WWA's desire to expand into Utah and Wyoming-based universities was informed by such research and was supported and encouraged by the Climate Program Office.

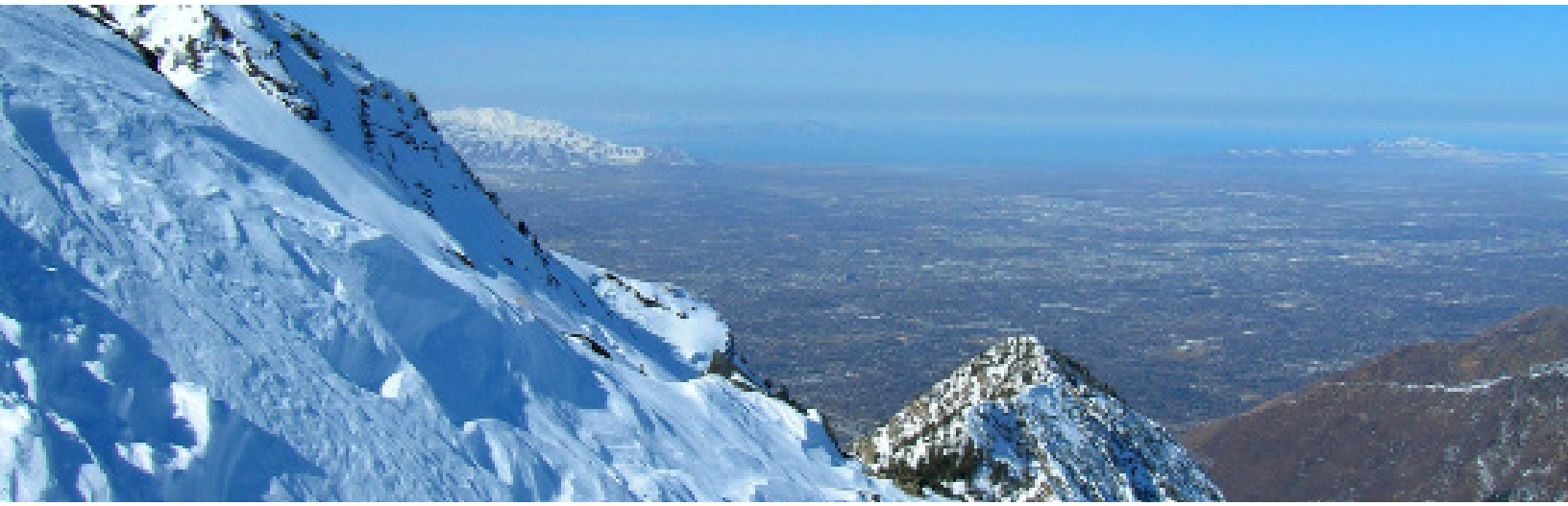
Early efforts to expand into Utah and Wyoming-based universities, however, proved to be very difficult. In both states, the logical choices for partner institutions were the land-grant universities (Utah State University and University of Wyoming) that had a history of research and extension, particularly in climate and water-related endeavors. Another strategy was to develop partnerships with the state climatologist in each state, a strategy that has worked quite well for WWA in Colorado. Several challenges emerged in building university-based relationships in both states.

First, Wyoming lost its state climatologist (he moved to another state) and the state elected not to have the position any longer, leaving the position unfilled to this day. Developing other research relationships at the University of Wyoming was problematic given that there were only a limited number of potential research partners conducting water-related research. Many of these individuals already had full research portfolios and were not motivated to pursue new research agendas in collaboration with WWA.

Second, WWA faced a problem largely driven by hydrogeography. Most of WWA's research efforts focused on the Upper Colorado River Basin, the Platte River Basin, the Arkansas River Basin and to lesser extents the Rio Grande and Lower Colorado River Basins. All of these river basins share similar headwaters in the Intermountain West, physical characteristics that are consistent with WWA's overall mission. Yet a large portion of northeast Colorado, and most of Wyoming sit in the Missouri River Basin, one that has not, previously, been a significant focus of WWA's work. WWA's knowledge networks, social capital and expertise were largely absent in the Missouri basin at that time, making it more difficult to forge new relationships with researchers in Wyoming.

Third, one of the factors that enabled the development of effective working relationships in the Intermountain west is WWA's social capital, its perception as an honest broker of information, and its affiliation with the University of Colorado, factors that have worked in WWA's favor with Colorado and other Upper Colorado-River Basin stakeholders. WWA's ability to enter the water research and policy world in Wyoming, however, was difficult. Many stakeholders confused the 'WWA' acronym with another more activist non-governmental organization that was already operating in Wyoming. Further, WWA's close affiliation with existing Colorado institutions created some distrust and wariness about collaborating with WWA, particularly among local and state agencies in Wyoming. Decision makers in Wyoming were also more spatially distributed, which made building relationships more difficult due to travel constraints.

Fourth, perhaps one of the biggest challenges WWA faced in building new research collaborations in Wyoming was related to the 'climate problem' itself. For a variety of reasons, public skepticism related to the problem of climate change and global warming was, and remains high. Part of this stems from the fact that the state is politically conservative, and research has shown that political orientation can be correlated to doubt about the reality of climate change. Another reason concerned the dominant role that oil and natural gas extraction play in Wyoming's economy and the notion that promotion of that industry and concern about climate change are mutually exclusive conditions. Finally, from a cultural



The Salt Lake Valley, and Great Salt Lake from Stairs Gulch Big Cottonwood Canyon. Photo: Tim Bardsley.

perspective, Wyoming has a strong libertarian tradition and the solutions often discussed to address the problem of climate change are seen as another potential avenue for increased interference by the national government in issues of state sovereignty.

Fifth, another challenge, albeit smaller in scope, was that Wyoming has fewer resources to deploy at state and local levels to address issues related to water and climate change. Many of the smaller water districts were already operating at or close to financial capacity and did not have economic capital to allocate to new projects.

Building relationships in Utah posed some similar challenges in terms of the state's overall belief in climate change, aversion to national interference in state sovereignty issues, lack of economic capital to undertake new projects, spatially distributed decision makers and the difficulty traveling to such locations, and some issues of mistrust with a Colorado-based institution such as WWA. On the other hand, a large portion of Utah sits in the Upper Colorado River Watershed and WWA already had working relationships with many stakeholders in the region. WWA also had a relationship with the state climatologist who was located at Utah State University. Despite these relative advantages, however, several challenges still remained for Utah.

First, concerns grew that locating the new researcher at Utah State University would place them too far away from Salt Lake City where most of the policy-makers and climate-related decisions are made. Second, issues of accounting and grant management became an obstacle. Due to the way that WWA was funded, and co-located at both NOAA and the University of Colorado, efforts to co-locate someone at Utah State University would create double overhead costs. This posed a major challenge given the fact that WWA was committed to expanding its program into both Utah and Wyoming yet received no extra funds to do so. Third, and most importantly, some disagreement arose over questions of human resources, specifically, over whether the Utah state climatologist would hire and supervise the new researcher, or whether WWA would hire and supervise the new employee. Ultimately the Climate Program Office weighed in on the issue, requiring that WWA hire and manage the new researcher directly, ruling out the option of housing the liaison at the state climatologist's office. For these reasons, WWA decided against collaborating directly with Utah State University and the state climatologist.

3. CREATING THE LIAISON ROLE

In response to these challenges, WWA undertook a search for a state 'liaison' based on the notion that hiring a local expert, who had already developed social capital, would mitigate some of the remaining challenges related to expanding to other states. WWA also thought that by working off of existing

social capital, it would be better positioned to work with stakeholders who already had an interest in working with them rather than attempting to build brand new relationships from scratch, something that the liaison could do at a later time should opportunities arise. As explained in the 2009 rebid, WWA proposed the following goals for the Utah and Wyoming liaison:

> *(1) Identify the major providers and generators of climate information in the state, (2) build on the existing stakeholder networks of the state climatologist and NOAA personnel, (3) connect stakeholders and science providers when appropriate, and (4) populate and expand the Regional Databases…The WWA liaison will operate in the model of an intergovernmental extension agent to connect with a broad and diverse user base of agencies and non-governmental partners. The ultimate goal is to expand the WWA network by engaging state and local entities in order to better integrate users with the science intended to inform vulnerability assessment and adaptation planning. The database information will also help inform our long-term strategies in the state.*

Specific skills sought in the liaison were:

- Master's or PhD in climatology, hydrology, natural resource management, environmental studies, or other related field
- Understanding of policy issues in Utah
- Strong understanding of climate science
- Excellent communication skills
    - Demonstrated ability to speak to general audiences about complex science issues
    - Strong writing skills
    - Facilitation and organizational skills necessary to pull together interdisciplinary and applied research projects and prototypes
- Organizational skills
- Ability to travel throughout Utah and make infrequent trips to Colorado
- Self-motivated and able to work independently

In hiring its liaison, WWA had to weigh the relative advantages of hiring someone with extensive research experience, someone with a PhD, someone with existing relationships in the water community, and someone who possessed good 'soft-system skills' e.g. effective communication and relationship building skills. Rarely does one find all of these attributes in a single person. WWA opted for hiring someone who was already connected to the Utah water community, someone with related – yet not extensive – research experience, and someone with excellent soft-systems skills. WWA believed that any shortcomings in the liaison's ability to conduct specific climate research, or research conducted at a level of an experienced PhD, could be mitigated by the liaison's ability to collaborate with and network with existing climate and water researchers in the area. These assumptions have largely panned out with positive results.

The Utah liaison began work in December 2010 and was based at the NOAA Colorado Basin River Forecast Center (CBRFC) offering several advantages in that the new liaison would be able to leverage the CBRFC's existing social capital, collaborate directly with climate-related work it was doing, and not have to pay for the space that WWA was using at the center. The liaison's role was designed to be similar in scope to efforts already used by existing WWA personnel, but were also intended to be fluid so the new liaison could adapt and modify the duties to respond to specific policy, cultural and climatological conditions in the state. Initial job duties were:

Limber pine (Pinus flexilis), along ridgeline between Big and Little Cottonwood Canyons. Photo: Tim Bardsley.

- Understand the WWA model in Colorado and apply/mold it to Utah.
- Identify critical climate-related issues in resource management across Utah.
- Coordinate with core WWA office in Boulder, Colorado, including participating in monthly WWA team meetings.
- Populate and update WWA stakeholder and science databases.
- Collaborate with local expertise in Utah including, but not limited to, NOAA personnel, Utah Climate Center, researchers at Utah Universities, and experts within state agencies.
- Organize collaborative projects involving WWA and other expertise to facilitate applied research and prototyping to critical climate-related issues in Utah.

4. EVALUATION OF WWA'S EFFORTS IN UTAH

In the fall of 2013, WWA conducted an evaluation of its efforts in Utah with the aim of understanding the strengths and weaknesses of its Utah model, the efficacy of its outreach and programmatic activities in the state, processes that supported successful engagement and outcomes, and future information and service needs of its stakeholders in the state. WWA's evaluation coordinator conducted 16 semi-structured interviews (questions are listed in Appendix A) using a purposive sampling technique aimed primarily at its 'major' stakeholders. Interviews averaged 50 minutes in length and were conducted over the phone. Interviews were then coded and analyzed, the findings from which are reported here. Stakeholders (considered 'minor') in Wyoming were not interviewed. This section begins with a reporting of the specific tasks identified for the liaison's work in Utah and a status update of such tasks, and follows with data gleaned from the semi-structured interviews. All findings are listed and thus may not reflect any hierarchy of frequency of responses nor level of importance among the stakeholder community.

A. Tasks and Status of Completion

After the liaison was hired, specific tasks were identified for completion during the first two years. Each of the tasks is listed below followed by a short assessment about the state of completion and other relevant information.

1. Learn as much as possible about WWA, the RISA program, and the evolution of climate service-type

work provided by NOAA and other entities.

a. Task completed and ongoing.

b. The exact process for undertaking this task was purposefully vague. The liaison learned much about WWA and the RISA program by conducting many informal interviews, and having more casual interactions, with stakeholders. Completion of this this task complimented many of the other tasks.

2. Prepare a version of the "What is WWA?" presentation for use at conferences and events such as the UT Water Users' Conference.

a. Task completed and ongoing.

b. The 'What is WWA?' presentation is still used today, albeit with modifications to the original version to reflect the evolving work of WWA.

3. Assist Kevin Werner (at the CBRFC) and Kristen Averyt (Director of WWA) in the preparation of their short course at American Meteorological Society (AMS) in 2011.

a. Task completed.

b. Course called "Hydrologic Prediction and Verification Techniques with a Focus on Water Supply" delivered at AMS meeting.

4. Organize and assist with a short streamflow-forecast workshop with the CBRFC for the Utah Water Users Meeting St. George, Utah March 15th.

a. Task completed.

b. The content focused on the development of decision-support tools and introduction for decision makers on how to use them.

5. Organize a Salt Lake City workshop on decision-support tools offered by Colorado Basin River Forecast Center (CBRFC). This workshop will build on a previous one held in Grand Junction and organized by WWA and CLIMAS (Climate Assessment of the Southwest) in conjunction with the CBRFC. The purpose of the workshop is to provide CBRFC with feedback on the utility of specific web-based tools while providing the RISAs with information on how to design and evaluate effective climate tools.

a. Task completed.

b. The workshop had two scenario exercises focused on forecast use, one focused on messaging and the other on flood management. An additional exercise focused on the access, education, and evaluation of web-based tools available on the CBRFC, and now suspended, NWS Water Resources Outlook pages. These tools allow access and analysis of a variety of streamflow forecast products as well as forecast verification products.

6. Work with Salt Lake City Public Utilities to facilitate and assist with their climate adaptation plan.

a. Task ongoing.

b. The Salt Lake City Public Utilities climate-adaptation plan continues to be a work in progress. WWA still has active role in its development in the issues of water supply and management.

7. Develop list of climate-sensitive stakeholders in Utah for WWA, to be shared with NOAA Regional Climate Services Directors and National Climate Assessment personnel as needed. The primary purpose of such an effort will inform the National Climate Assessment. It will also provide a valuable

Stairs Gulch penstock intake, Big Cottonwood Canyon. Photo: Tim Bardsley.

list for future efforts undertaken by WWA or other entities with similar missions.

a. Task ongoing.

b. Identifying and developing a complete list is difficult given the ambiguity about how 'stakeholder' is defined, for example, at what scale the stakeholder operates, what entity they represent, and other variables. Identifying 'major' stakeholders has resulted in list of approximately 30 people and organizations, but as the list expands it becomes more difficult to define what constitutes a stakeholder and thus whom should be included on this list.

8. Develop a list of scientists at universities and other institutions across Utah who can provide relevant research to meet stakeholder needs. Similar to the efforts described in #7, this effort will entail meeting with researchers working on a variety of climate-related issues, compiling a list of their contact information and expertise, and connecting researchers with stakeholders where appropriate.

   a. Task ongoing.

   b. New research-oriented relationships have been developed and research is underway on a variety of topics with these researchers.

   c. New relationships between researchers and other stakeholders have also been developed and realized.

   d. Completing this task is difficult given that drawing a boundary around what constitutes 'relevant' science is a moving target.

9. Develop a list of under-utilized water and climate tools for introduction to stakeholders.

   a. Task ongoing.

   b. Relevant water and climate tools for Utah decision makers are already available and being used. Additional tools that have been developed for other regions have potential to be relevant for Utah decision makers but would need to be modified and updated for these decision makers. Other tools would also require significant investment or training to utilize.

10. Conduct informal, semi-structured interviews with stakeholders. Utilize State Extension Service when possible. Once a comprehensive list is developed, the liaison should request informal meetings with stakeholder representatives to make a face-to-face introduction and better assess stakeholder

needs. This will allow WWA to 1) understand the suite of climate-related stakeholder needs in Utah and 2) identify the most logical specific contacts at given organizations.

a. Task ongoing.

b. Other WWA researchers had already begun the process of assessing stakeholders' information needs through survey instruments, so liaison used some of these outputs to help complete this task.

c. Work with the Wasatch Area Dendroclimatology Research group (WADR), a collaborative effort between Utah State University, Brigham Young University, and the US Forest Service, also aided in the identification and clarification of stakeholders' information needs.

d. Liaison also conducted selective informal interviews with major stakeholders.

e. State extensions specialists were not used in this outreach process.

11. Create a science-stakeholder database for the state of Utah. The information above should be compiled into a database accessible to WWA staff and researchers and directly useful to the National Climate Assessment. Work with WWA staff to create and populate a web-based database.

a. Task not completed.

b. Most data exists in the form of an Excel spreadsheet with contact information of stakeholders but has not been incorporated into any database.

c. Most of the information collected was done ad-hoc and not consistent with a process necessary for a robust database.

d. Development of a dynamic and searchable database would require more detailed and skilled work by someone who has database development experience.

B. From what sources do stakeholders get their information?

Stakeholders obviously get information from WWA but also from a variety of sources, albeit mostly federal in origin. Mechanisms for accessing information include the use of static websites, webinars, data portals, white papers and reports, direct communication with researchers, list-serves, and websites that are updated frequently with the most recent information. These sources include:

- Bureau of Reclamation (e.g. Colorado River Basin Study)
- National Oceanic and Atmospheric Administration
- Climate Prediction Center
- Intermountain West Climate Dashboard
- National Weather Service
- National Resource Conservation Service
- NOAA
- PRISM (from the Oregon State University)
- National Weather Service Colorado Basin River Forecast Center

Canyons of the Escalante. Photo: Tim Bardsley.

- US Drought Monitor
- USGS
- Utah State Division of Water Rights
- WWA

C. What kind of climate information do Utah stakeholders use?

Stakeholders use the following data and models to help inform their ongoing learning, planning and development of decisions:

- Precipitation
- Temperature
- Stream flow
- Dendrochronology
- Palmer Drought Severity Index
- SNOTEL
- CMIP3 and CMIP5 model outputs
- Recent climate data (from 1980 on)
- Downscaled models
- Evapotranspiration
- Short and longer-term forecasts

D. How do stakeholders use climate and water data and information?

Stakeholders use the climate data for a variety of purposes. One of the most frequently stated purposes is simply to educate themselves and their staff about the current and projected weather (e.g. stream

flow) and climate conditions. Few stakeholders have begun to incorporate climate data into their own organizations' models or decision tools. Many are just now beginning to understand if and how climate data can be used to help inform planning and decision making, or beginning to understand issues of skill and uncertainty in the use of climate data. Nevertheless, stakeholders are still using climate information in a variety of ways, or planning to in the near future. Stakeholders use information to:

- Integrate paleo-climate data and future projections into 'what if' planning scenarios given different extreme precipitation, temperature and seasonal variability conditions. Utilize paleo-climate information to inform the range of possible variations and vulnerabilities related to longer-term water planning. Utilize paleo-climate information to help identify and describe future 'worst case scenarios'.

- Develop long-term weather forecasts (seven to ten days) and short-term climate forecasts (monthly and seasonal) to predict stream flow and its impact on water management for hydropower production, ecosystem management and recreation uses.

- Improve understanding of the various climatic drivers that effect changes in temperature and precipitation.

- Inform short-term climate forecasts (six months to two+ years) and long-range climate projections (50-150 years) to improve understanding of climate change and its impacts on organizational operations and planning. Develop long-range climate projections to inform large-scale infrastructure development and construction projects to improve supply of water.

- Develop short and long-term climate projections to inform qualitative comparisons to historical records (e.g. future possible changes are < or > than historical records).

- Provide more detailed historical climate reconstructions (e.g. dendrochronology) to improve understanding of climate change broadly construed and to understand the scope and duration of past climate fluctuations.

- Characterize and understand how climate variability and change effects the health of, and changes in, forests and ecosystems.

- Reduce 'cone' of uncertainty with future climate, precipitation, temperature and stream-flow projections.

- Integrate climate-change trend analysis in the development of new models and decision tools. Incorporate climate-change information into various planning models, reservoir models, evapotranspiration models, etc.

- Translate climate information into products that are aimed at improving the public's, and elected/appointed officials, understanding of climate change and possible future impacts.

E. What are the reasons why stakeholders do not use climate information?

Despite the availability of numerous climate data, many stakeholders are not yet using the information for planning or decision purposes, thereby limiting the utility of the information. Some of the reasons why stakeholders are not yet using the data include:

- Not enough skill in short-term forecasting or lack of understanding of what skill means and how it applies to decision making.

- Current hydrological forecast systems are insufficient to incorporate or benefit from climate information, and new hydrological forecast systems that can better incorporate information are still under development. New models and tools are still in beta testing, so they aren't yet usable

Stansbury Mountains. Photo: Tim Bardsley.

for planning or decision purposes. It is still unclear to stakeholders how to incorporate climate information writ large into existing knowledge systems including model runs and planning tools.

- Despite growing use of paleo-climate information in models, stakeholders are still wary of (risk averse) using climate projections in models.
- Many stakeholders are still grounded in planning and operational conditions that are consistent with a paradigm of 'stationarity', one that views future climate conditions as analogous with past climate conditions.
- While some stakeholders are ready to begin to incorporate climate information, their bosses or organizations are not ready to do so.
- Significant resistance still exists in among elected officials and other appointees to accept the reality of climate change, and more importantly, to consider the use of climate and water-related information in planning and operations.

F. In what ways have stakeholders worked/collaborated/engaged with WWA and its Utah liaison?

Stakeholders have worked with WWA in a variety of ways. In some cases stakeholders sought out WWA to provide specific climate data that could help improve stakeholders' understanding of past climate and possible future projections. Stakeholders also sought out WWA input and information to help educate and improve understanding of climate-related issues among stakeholders' organizations, advisory boards, or the general public whom they serve. In other cases WWA was sought out, or WWA sought out, collaborative partnerships with stakeholders. Stakeholders have engaged with WWA – either as collaborators or as recipients of WWA outputs – for the following reasons:

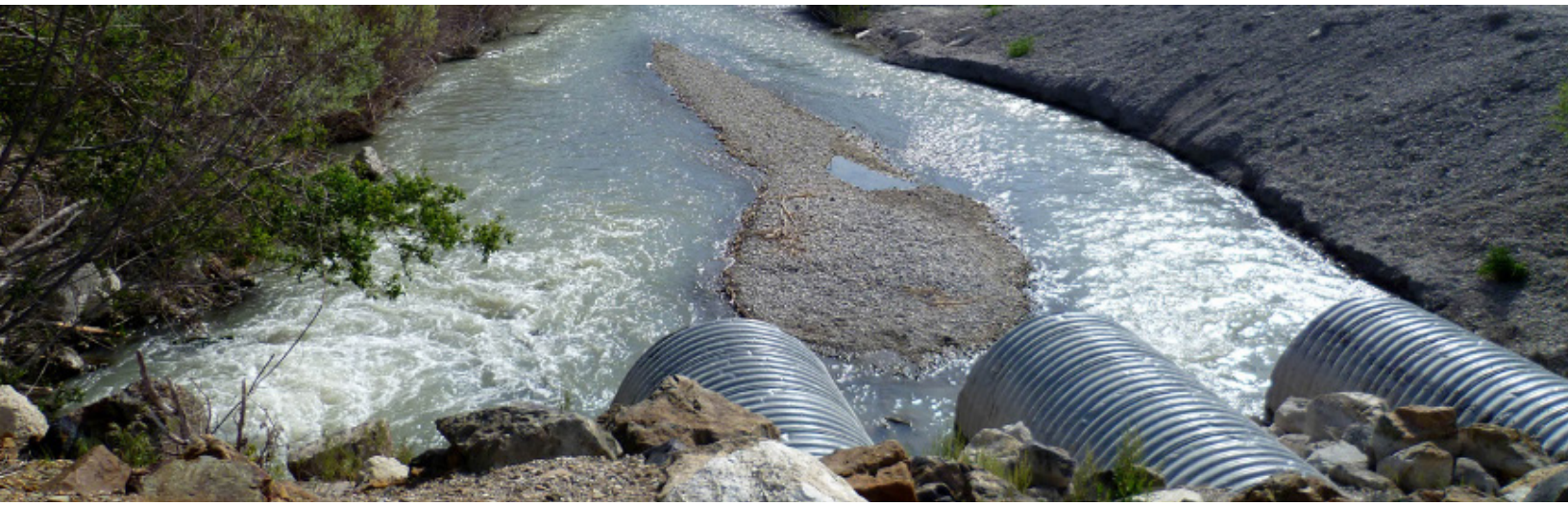
- Gathering and co-developing climate-trend data in a specific region and watershed in order to help improve understanding of climate conditions with the assumption that such information would eventually be incorporated into operational models and decision tools.
- Developing a range of climate-change scenarios that can be integrated into models projecting out 100 years for long-range planning efforts. For example, mid and end-of century climate scenarios were developed and run through the CBRFC hydro model along with temperature and precipitation sensitivities.
- Continuing the development of more robust and detailed dendrochronology information to clarify past climatic conditions.

- Responding to stakeholders' requests (both in person and for informational material) to improve their understanding of the effects that persistent drought has on beetle kill and dust on snow, and their combined impact on stream flow and water supply. The bark-beetle workshop in 2011 is one example or response.
- Quantifying and characterizing changes to water supply and stream flow forecasts.
- Developing and implementing a reservoir planning exercise for water planners and managers.
- Developing and deploying a large survey instrument to assess climate-information needs, and uses of climate information, among water managers in Utah and the region, and analyze findings.
- Increasing and enhancing extent and capacity of WWA network and of network between and among its stakeholders.
- Providing computational support for model runs of WWA research.
- Improving skill of seasonal predictions.
- Developing stronger understanding of localized impacts of climate change.
- Developing and delivering climate presentations to educate public and public utilities advisory board.
- Developing and conducting various workshops with stakeholders.
- Developing emergency water-supply plan for the state.
- Advising on the development of other planning tools.
- Identifying and characterizing the qualitative differences between various modeling tools and outputs (e.g. CMIP3 vs. CMIP5).

G. How have stakeholders benefited from their work/collaboration/engagement with WWA?

Stakeholders identified several ways in which their engagement with WWA has lead to positive outcomes. Stakeholders report improved understanding of climate-change science, paleo-climate, likely climate impacts and the range of climate-change projections. They also report benefits in the enhancement of their knowledge networks and their ability to educate their own stakeholders:

- Expanded stakeholders' understanding of the non-WWA information, opportunities and products that are available to satisfy stakeholders' needs.
- Enhanced quality and size of stakeholders' network of research collaborators and decision makers.
- Supported efforts of stakeholders to conduct outreach and educate their own stakeholders and advisory boards.
- Clarified what different sources of information meant and how stakeholders could use the information in their own planning and decision-making processes.
- Provided expertise in climate-change information where stakeholder knowledge was lacking.
- Leveraged WWA social capital to enhance knowledge networks.
- Improved stakeholder use and understanding of SNOTEL data and other NRCS data.
- Responded to specific questions stakeholders had about climate and water.



Jordan River at North Jordan Canal Diversion. Photo: Tim Bardsley.

H. In what ways have the stakeholders' engagement with WWA or the Utah liaison fell short?

Stakeholders report that the snow-modeling project aimed at quantifying forecast errors from dust on snow and beetle kill that began two to three years ago has been frustrating. The project appears to have taken 'twists and turns' and stakeholders are unclear about what they will get out of the project and doubt that any useful quantitative information will result. Stakeholders were hoping for more robust ways to communicate impacts from beetle kill to their own stakeholders but don't believe that will be a realistic outcome of the research. Stakeholders also report that there have been long intervals between updates on this project but also acknowledge that lack of communication has also been a result of inaction on their part. They also note some frustration with how the research trajectory has changed in ways that don't necessarily reflect the original intention of the research project.

Public understanding of climate change is still very low, many don't believe that human activity has influenced climate change, and many believe that any climate-related problems can be resolved through technological advances. Although WWA is currently involved in translational activities, it could spend more time and effort in translating climate science (in general) and more localized climate issues (specifically) 'down to the lay persons' level of understanding. Stakeholders believe that spending more time on public education is essential to moving public and elected-officials' sentiment from passive observation to more interested and active participants in climate change adaptation activities.

I. What can WWA and its Utah liaison do to further support stakeholders' needs and interests in the future?

Not surprisingly, the list describing what WWA can do to assist stakeholders is long, much longer and detailed than what WWA and the Utah liaison can possibly accomplish with the limited funds available. Many of the requests relate to the need for WWA to continue its current efforts, expand its efforts to assist the state of Utah in developing additional water-related reports, and in improving skill and downscaling in forecasts. Requests include:

- Improve skill of climate forecasting (short-term and long-term). Continue to improve upon climate forecasts and reducing the 'cone of uncertainty' with forecasts.
- Continue to provide assistance in developing and clarifying climate-change projections and possible future impacts in Utah.
- Improve use of climate and water-related information in models. Continue to assist with incorporating climate projections into existing models and decision tools. Continue to develop and complete 'first

generation' integration of climate information into models and then begin to expand and enhance integration of climate-change information in more sophisticated ways into existing and new models. Continue to help translate what different climate models mean and what they can and cannot do for informing decision making. Assist in the continued development of climate scenarios (e.g. from the Basin Study) and aid in the integration of such scenarios into existing models. Help to incorporate latest projections from IPCC ensemble modeling into existing models and data runs with the aim of understanding how model outcomes change. Support the development of iterative modeling for improved incorporation of IPCC information.

- Understand how precipitation extremes and associated impact on run-off and stream flow effects water rights, flooding rights, and other institutional arrangements.
- Continue to develop and demonstrate the success of Weber River models in order to spread the use of climate change projections into other basins in the state.
- Assist with developing the Department of Water Resources State Water Plan, especially with the climate change chapter. Contribute to improved understanding of water supply, demand, quality and uses of water in the eleven river basins in the state, and then contribute such findings to the State Water Plan.
- Assist in reviewing and revamping the Department of Water Resources public outreach program to improve public understanding of climate change and impacts to state resources.
- Continue to respond to stakeholders' climate and water-related information needs.
- Research the efficacy of integrating seasonal forecasts into societal decision making. 'We assume that if more people use such forecasts, they will make better decisions. But we lack research to substantiate these claims'.
- Develop case studies about how climate information is used by decision makers in actual mitigation and adaptation strategies that are specific to the state of Utah.
- More work can be done to improve the integration of CBRFC data and information into decision making. Many long-range and broad-scale policies and decision making are being made using existing models and internally-generated forecasts 'that often lack meteorological or hydrological information produced by experts in these fields'.
- Continue to educate public officials and other decision makers about the differences between deterministic and probabilistic forecasting and about inherent uncertainty in forecasting. Continue to educate stakeholders about the limitations of 'stationarity' in planning.
- Over the next five years, help improve the use and integration of climate and hydrological science and forecasting into the Inter-Operating Guidelines for the Colorado River Basin.
- Continue to support a multi-pronged approach to providing relevant and timely outreach and public education. For example, press releases, coupled with information from climate.gov and journal articles. The three-pronged approach related to water stress is a good example of this.
- Continue to support Utah-based efforts to collaborate and research climate-change topics and continue to expand the WWA knowledge network.
- Assist in translating and correlating tree-ring information so that it can be integrated into operational models.
- Continue to explore ways to improve downscaling of information.

Turner Dam, Jordan River (diverts water to the Utah and Salt Lake Canal on the west side, and the East Jordan Canal on the east side.) Photo: Tim Bardsley.

- Identify opportunities to improve engagement with the USFS and develop better baseline related to forest health conditions.
- Conduct research and improve understanding of how changes in T and P effect run-off and water supply and their impacts on water rights.
- Assist in improving research on the behavioral dimensions related to water demand and use in order to inform management and planning.
- Improve use of climate and water-related information into ecosystem planning and management. Improve research exploring climate-change impacts and issues of adaptation such as water quality issues, algae blooms, increased carbon loading in reservoirs from forest fires, endangered species moving up watersheds to higher elevations, increased water temperatures in streams and lakes and impact to fisheries health, and the emerging conflicts between the Clean Water Act and the Endangered Species Act.
- Continue to produce the Climate Dashboard but enhance information that is relevant to Utah.

5. OVERARCHING OUTCOMES

WWA's work in Utah has resulted in the development of many outputs and products, and overall has achieved three broad outcomes. Consistent with the definitions used in the policy sciences, outcomes are defined as the attainment of specific value preferences such as knowledge, well-being, wealth, relationships, etc. Some outcomes are necessary to achieve in order to achieve other outcomes.

A. Building a knowledge network:

First, working in Utah enabled WWA to identify key stakeholders, decision makers, and researchers engaged in climate and water-related problems. This network has a core membership of about ten organizations, 30 people and secondary stakeholders numbering over one hundred. One of the most important relationships WWA developed was with the Salt Lake City Department of Public Utilities (SLCDPU). This stakeholder was not only interested in climate-related issues, but also had the resources to pursue climate-related questions and research. Moreover, the SLCDPU is the largest utility in the state, and given its size and political relevance, building a relationship with them enabled WWA to leverage its social capital, gaining entry into other relationships in the state. Building a network is an ongoing process and was an important first step that supported the development and achievement of other outcomes.

B. Identifying stakeholders' needs and shaping research agendas:

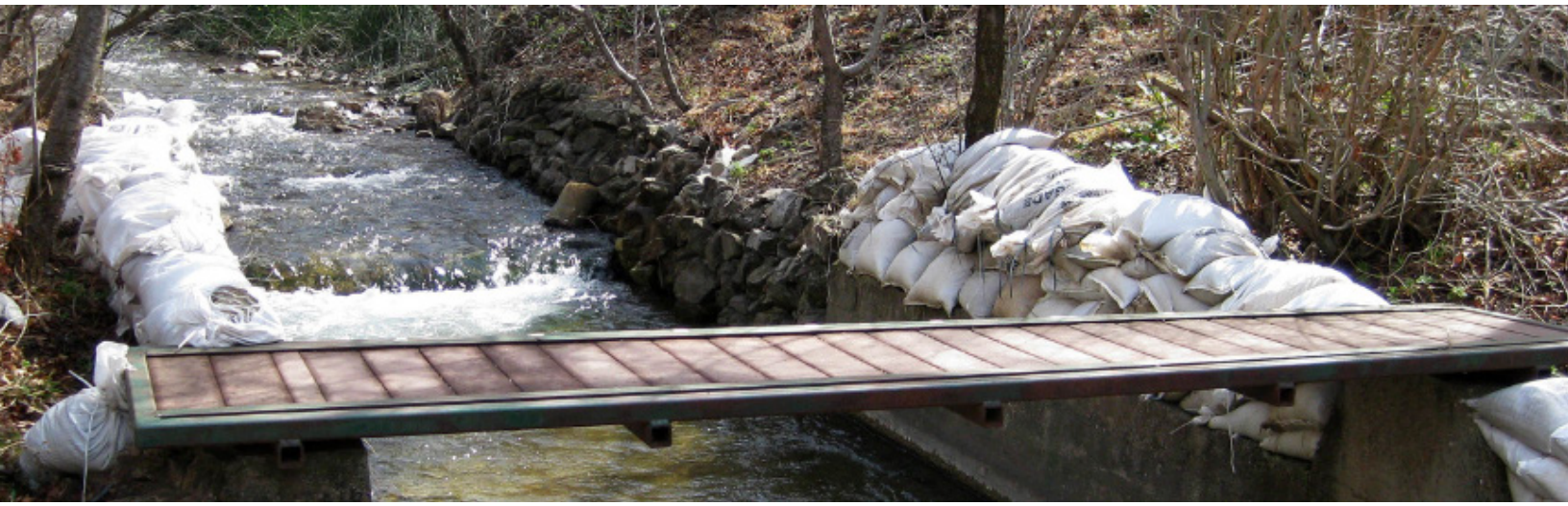
Second, WWA identified its stakeholders' information needs and concerns both from formal surveys, but more importantly, from informal interviews and engagement. Part of understanding stakeholders' needs required clarifying specific climate and water-related scientific questions. Another, and equally important dimension, required the identification and clarification of the social and political contexts in which stakeholders operated in Utah. Such information complimented the knowledge gained about stakeholders' needs. Working to identify these constraints was particularly important given WWA's lack of familiarity with Utah politics. Understanding stakeholders' informational needs and concerns resulted in the shaping of research agendas to address key questions, both among WWA personnel but also with its research affiliates. For example, WWA has responded to the information needs of the SLCDPU by developing systems-planning models that now incorporate scenario testing and planning. Other stakeholders expressed the need for evaluation of spatial variability of runoff sensitivities to better inform scenario planning which WWA was able to provide as a result of re-orienting their research priorities.

C**. Producing relevant outputs:**

As a result of the first two outcomes, WWA produced a variety of products that satisfied stakeholders' needs, but that also educated stakeholders and the public more broadly, e.g. workshops, informational material, presentations, models, decision tools, answers to discrete questions. WWA expanded its climate literacy activities, conducted policy-relevant research and outreach in areas such as vulnerability assessments, paleo-climate and forecasts, and conducted research that sought to answer more fundamental climate-related questions. Selected outputs include: climate-change sensitivity assessment for Salt Lake City Public Utilities; participation in various community groups focused on climate-change issues; research collaborations with researchers from the CBRFC, University of Utah, Utah State University, Brigham Young University, Salt Lake City Public Utilities and other entities; development of improved water forecast and sensitivity analyses; attendance at dozens of meetings and workshops. These outputs contributed to the development and enhancement of stakeholders' understanding of climate and water-related issues, and improved their understanding of how such information could be used in decision-making and thus achieve additional outcomes.

6. REMAINING CHALLENGES

One of the biggest limitations to achieving success in Utah concerns the lack of money and other resources to support new research and outreach activities in the state. Opportunities arise to develop new relationships or to produce policy-relevant information, but due to the lack of resources, WWA has to be conservative in selecting which activities to undertake. The question of resources has also effected the liaison's willingness to build new relationships for fear that doing so would create expectations on the part of the stakeholders for products or information that WWA is unable to deliver. This fundamental tension between balancing opportunities and being able to follow through on deliverables, a tension common among most publically-funded programs and RISA in particular, remains a problem in Utah given that WWA has a single liaison located in that state. Financial constraints also raise questions about the feasibility of renewing efforts to expand programmatically into Wyoming. In a strategic decision, the liaison has opted to enhance existing relationships, ones in which resources are available but also where stakeholders understand who WWA is, its mission, and its operational constraints. While WWA cannot do every worthy project, working with stakeholders with whom it already has an authentic relationship avoids unnecessary failures.



Mill Creek Canyon Creek, near stream gage. Photo: Tim Bardsley.

7. REFLECTIONS ON THE UTAH MODEL

Understandably, our sample size is very small, and research bias conditioned by a post-hoc evaluation limits our ability to compare WWA's efforts with other potential outcomes. Interviewing major stakeholders, ones with whom WWA has an established and mostly productive relationship, obviously skews the results in favor of positive reporting. Shortcomings in evaluation techniques and lack of metrics continue to be problematic in understanding the efficacy of RISA programs, of WWA, and of the liaison's role in particular. Nevertheless, lessons learned from the development and application of the liaison role for Utah, aka the 'Utah model', has yielded many observations and include:

- Co-locating the liaison outside of a university setting did not lead to any observable shortcomings in either research or computational capabilities, nor development and application of social capital.
- Co-locating the liaison in a federal agency dedicated to water-resource research and application helped to reduce overhead costs, improve collaboration with related researchers, and led to the access of a pre-existing stakeholder network.
- Hiring a liaison who did not have a PhD has not adversely effected WWA's ability to extend its research and application activities into Utah, although it is difficult to say whether a liaison with a PhD could have led to other research-related benefits.
- In addition to research skills, the liaison possessed other skills that were valuable in conducting public outreach and education, and building collaborations with other researchers, skills not often found in one person.
- Despite limited resources, WWA was able to leverage the resources of other Utah agencies to help support its research efforts.
- Lack of financial resources constrains WWA from expanding its knowledge network to more decision makers in the state, and perpetuates work with existing stakeholders, leading to missed opportunities for having a greater impact in the state.

APPENDIX A: SEMI-STRUCTURED INTERVIEW QUESTIONS

1. Tell me about the work you do.
2. What kind of climate information do you use in your job?
3. In what ways have you collaborated/worked/engaged with WWA and/or the WWA Utah liaison?
4. Was this collaboration/work/engagement beneficial to you or your organization?
5. If yes, in what ways?
6. If not, why not?
7. How can WWA support you or organization's effort in the future?

Western Water Assessment

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