Colorado River Conversations
Final Conference Report

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Conference organizers:

Kathy Jacobs, University of Arizona
Amy McCoy, Martin & McCoy
Season Martin, Martin & McCoy

Co-organizers:

Andrea Gerlak, University of Arizona
Amanda Leinberger, University of Arizona
Mariana Rivera-Torres, University of Arizona

Table of Contents

I: Executive Summary

The Colorado River Conversations Conference, held in Tucson on October 28-30, 2019, brought together 110 citizens of the Colorado River Basin. Participants included people from all seven basin states, Mexico, and six Tribal Nations. They were motivated by the upcoming re-negotiation of the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead which are set to expire December 31, 2025. The formal review process has been initiated and is scheduled to be complete by the end of 2020. Virtually all participants spoke about managing the river as a system and advocated for increased attention to social and physical sciences to design new management systems.

Over the course of three days, discussions covered a wide array of topics including: building on a solid foundation of past success; pathways for finding win-win solutions; addressing environmental flows and environmental restoration in more robust ways (even in the context of shrinking supplies); incorporating what we know of climate science and the potential for extreme events into the future management of the river; and exploring the degree to which current forms of governance are capable of withstanding various anticipated threats.

Many speakers highlighted how much has been accomplished through collaborative processes across the basin, in the context of leadership from Reclamation, the IBWC, Mexico, tribes, the states and NGOs, including:

- The enormous effort that went into the Drought Contingency Plans (DCPs) for the Upper and Lower Basins which were signed by President Trump in 2019.

- The completion of the Tribal Water Study and increasing engagement of tribes.

- The System Conservation Pilot Program that demonstrated the demand and utility of flexible mechanisms for voluntary, temporary reductions in consumptive use.

- The success of binational negotiations and adoption of Minute 319 and 323 including implementation of the Pulse Flow experiment which connected the river with its delta, at least momentarily. The experiment was a significant environmental achievement and a recognition of the connection people and communities have with the river and was a broadly experienced emotional moment in the river's recent history.

- Beneficial examples of incremental adaptive management actions that have respected the existing laws and framework as highlighted by the success of the Interim Guidelines in 2007 and the DCPs.

Even with broadly demonstrated accomplishments, the river basin faces unprecedented future pressures and many participants noted there is significant room for improvement. For example, historic negotiations have not meaningfully included the tribes and Mexico, who now more than ever are poised to be part of the solution. Key discussion topics included: possible options for starting the next negotiation process with a shared vision for the river's future; expanding substantial and impactful stakeholder and tribal involvement; meaningfully addressing shortages in river flows as a result of climate change and associated reductions in flows of the river.

There was wide recognition that the Colorado River is a watershed in transition in a plethora of ways, including changes in the U.S.-Mexico relationship, transitions in agricultural economies, changing priorities for environmental restoration, and the shift in focus from individual projects to systemic solutions. With transition comes opportunity to lean into new, innovative solutions. Participants emphasized that the next set of Guidelines could be as important as the original 1922 Compact and must be sufficiently flexible and responsive to drought, flood, and other unforeseen challenges. In particular, uncertainties presented by changing climate conditions (including increased temperatures, shifts in run-off, etc.) present a significant challenge.

Participants noted that the future management of the system must consider the river as a whole, not as two individual basins or as a series of separate segments between dams that are operated to optimize particular objectives. Considering the river as a whole requires accounting for groundwater, tributaries, sediment, temperature, salinity, the Salton Sea, and the Delta – not just the volumes of surface water that can be diverted from the mainstem under different flow regimes. It also means empowering the full array of stakeholders and affected parties to engage in discussions about the River's future.

As the Basin enters largely uncharted territory in river management, there will be significant, unanticipated, and extreme variations due to climate change and altered hydrology. These variations will arise from current conditions where ecosystems are strained and groundwater bills are coming due, which will require more discussion about groundwater and ecosystem dependence. Current models need substantial improvement, as the rates and scales of change are increasing. Maintaining essential and invaluable binational U.S.–Mexico relationships is a priority, as is broadening participation and bringing in new voices to address the future of the river. Despite many successes over the past couple of decades, we are not "there" yet. Governing institutions need to adapt to be more effective. Broadening participation is not just the right thing to do, but it helps to eliminate uncertainty and lawsuits that occur when parties are excluded.

Heading toward 2026, participants emphasized the need to expand the conversation beyond shortage guidelines and reservoir operations. If conversations are not expanded, an important window of opportunity may be missed to address a variety of important issues. For example, how can thresholds be defined in a system whose behavior we cannot predict? What actions can be taken now to preserve collaborative governance and cooperation? How can physical and agricultural infrastructure and landscapes be made more resilient?

We are grateful to all of those who participated in the Colorado River Conversations Conference and most especially to the Walton Family Foundation and the speakers, facilitators, and staff who made all of these conversations possible.

II. Background and Context

The reports from two previous Colorado River workshops at the University of Arizona can be accessed here.

A. Project Goals

The Colorado River Conversations Project is focused on developing an interdisciplinary science-based conversation to contribute ideas for future management of the river and to provide an informational foundation for the renegotiation of the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead. The overall objective is to bring systems-based science to bear to better understand the physical, social, and environmental conditions in the basin and contribute to setting the stage for more formal future conversations. The renegotiation of the Guidelines is slated to start in 2020 consistent with the requirement to have new Guidelines in place prior to the expiration of current Guidelines in 2026.

Many entities have been working to provide additional scientific inputs to the renegotiation process. They include an array of hydrology and climate science research, new modeling efforts, and work to clarify the objectives and potential roles of a range of water users in the basin. Because of the broad scope of this "Conversations" project and its framing as a "convener" of people, ideas, and processes, this conference aimed to create collaborative outcomes across these efforts.

Conference Goals

Convening conversations and providing a gathering ground for researchers, practitioners, and stakeholders who seek innovative ideas for managing the Colorado River's services by:

- Presenting the current state of hydrological, ecological, social, and climate science
- Sparking conversations about management objectives, operations of the Colorado River as a system, and preparing for extreme events
- Generating and discussing alternative approaches to river management for consideration
- Respecting cultural and spiritual values

B. Visions Of The River In The Future/Desired Outcomes

1: Reframing Solutions (Peter Culp, Culp & Kelly, LLP)

Culp pointed out there has been substantial progress in the Colorado Basin over last 20 years in terms of the conversation: relationships progressed from adversarial to collaborative, with states coming to the table to negotiate; issues of climate change and the challenges of drought are being addressed; more and diverse stakeholders are being part of the conversation; and there is substantial progress in the US-Mexico relationship.

Among the key challenges to be faced: We are entering largely uncharted territory and will see more variation due to climate change and altered hydrology. Ecosystems are strained and groundwater bills are coming due. Our models do not work very well and need substantial improvement. The rates and scales of change are increasing and will strain our collaborative adjustments. We must maintain the binational US-Mexico relationship that took so long to build and is threatened by multiple pressures. There is interest in broadening participation and bringing in new voices to address the future of the river.

Heading to 2026, the conversation needs to be about more than reservoir management guidelines. If not, it will be a huge missed opportunity. How do we define thresholds in a system whose behavior we can't predict? What actions can be taken now to preserve collaborative governance and cooperation? The physical and agricultural infrastructure and landscapes beneath them are facing challenges; we need to make them more resilient.

2: Redefining Stakeholder Engagement (Kathy Jacobs, Univ. Arizona)

We need to make the conversations more inclusive so that imagined futures are possible, but also be more respectful of the river and the people who are dependent on it. When you have 40 million people dependent on a river, they can't all have a voice, so how do you have a broader, inclusive process that's manageable? How can people truly engage in a meaningful way and still keep the process from becoming victim to incredible complexity? Many public engagement strategies end up missing important voices and perspectives.

What will be the next generation of communication and engagement strategies that can be harnessed to design the path forward? It is time to think about new ways to engage stakeholders in a meaningful way.

3: Institutional Resilience/Collaborative Governance (Mike Connor, WilmerHale)

Although there have been many successes over the past couple of decades, we are not "there" yet. Governing institutions matter and need to adapt to be more effective. Widening participation is not just the right thing to do, it helps to eliminate uncertainty and lawsuits that occur when parties are excluded.

Collaboration has been more meaningful, inclusive, and transparent in recent decades, leading to better outcomes, such as NEPA maturation. The intra-Arizona Drought Contingency Program (DCP) process was particularly good, transparent, and collaborative even though it teetered on the brink of failure. Other bright spots: operational certainty has improved; Minute 319 was implemented; and structural deficits have been addressed.

4: Tribal Insights (Daryl Vigil, Jicarilla Apache Nation)

The 29 unique and sovereign tribes within the Colorado Basin each have their own issues and are in different states of water development. The Ten Tribes Partnership grew out of Reclamation's 2012 Colorado River Basin Study; it is an ad hoc group of tribes on the main stem or tributaries of the river who cumulatively represent 20% of the river's flow or 3 million acre-feet of water rights in the Upper and Lower Basins. Prior to 2012 there was rarely any mention of tribes in discussions of the management and regulation of the Colorado; there was no tribal participation in the 2007 Guidelines or the 2009 Basin Study. Nevertheless, long before there was any notion or discussion of water rights, Native peoples believed that water was not something that could be owned, but something that was available to all living creatures and the land.

The signing of the Colorado River Compact in 1922 by the seven Basin states established a bureaucracy that precluded the involvement of tribes. However, at a Colorado River symposium in Santa Fe in September, almost all panels had tribal representation and a lot of conversation revolved around their inclusion. Although it has been overshadowed by the DCP process, the Ten Tribes Partnership has been well-utilized as a platform and is becoming a model for a Water and Tribes Initiative for the 29 tribes in the basin. Exclusion has encouraged the tribes to forge new partnerships among them.

5: Next Steps in Binational Collaboration (Jayne Harkins, IBWC Commissioner)

Water users on the Rio Grande want what the Colorado Basin has—more certainty in deliveries—but they have not devoted the necessary time for discussion. The Guidelines and DCP process are very advanced for the Colorado River in comparison and can serve as a model for the Rio Grande. Until recently, the relationship with Mexico regarding transboundary water was not good. Now there are conservation policies and projects and multiple Minutes to the 1944 Treaty. It is essential for US water users to continue collaborative efforts with Mexico. New models and scenarios should be developed collaboratively with Mexico. There is no reason to change governance over the Colorado River; it is working well for transboundary collaboration now, unlike in some other basins. Collaboration is much preferred over litigation.

6: Discussion Questions

The panelists seem to be unanimously suggesting there should be no change in governance, yet there is no formal governance structure. Compact commissioners soundly rejected the idea of a full-time commission and the Secretary of Interior consults with states only under very limited circumstances. Are you speaking of informal collaborative governance?

- Retain the current governance, it is flexible to change. We need to convene and facilitate in a way that's effective to build a durable solution and minimize unexpected or unsavory responses.
- The present structure might be working for some now, but it's not working for tribes. How do we institutionalize tribal participation? There is no formal process for us to participate in a broader, general way. We want a governance structure that's inclusive of tribes to begin with rather than to circle back and fit them in later.
- Rather than starting with the governance question, we should start with a vision of the River's future. Can we use the governmental structures we have today to prepare for

future challenges? Start with an ambitious vision of the river that we want to see. It's easy to get into reactionary posture with governance but we want to have a flexible, resilient and functional system.

- With Minute 318, the US knew what it wanted to accomplish. Mexico engaged in a completely new way, by talking directly with the Basin states. To get to that goal we had to have a different kind of discussion. This required a change in the way we had done business historically.

Previous big decisions have been stifled by definitions of scope, purpose, and need. How broad should we go for 2026?

- A lot of the positive change has been normative rather than legal/process oriented, which has been useful in driving adaptation. Our fallbacks are fairly rigid; we often go straight from collaborative dialogue to litigation on issues that are ill-defined. Where does the system break? What are predictable scenarios that are going to put us under the gun in terms of what the conversation is, and how the process will unfold? The Arizona DCP came dangerously close to breaking a few times. Why/how did it almost break and how could it have been changed? Can we use our time now to identify signals and plans for those breaking points? How do we deal with situations where there are flood risks or massive curtailments where we don't expect it?

- We need to start with broad thinking and expanded stakeholder/tribal involvement. Public involvement processes are important.

The informal governance structure has evolved slowly, but there are many smaller discussions in the Basin. Examples are the Arizona DCP process, and the IBWC work. We need to communicate across them. The fraught history of the All-American Canal may largely have been a result of differences in approach to governance, and this type of shakeup could occur again in 2026.

- We are trying to share as much as we can with Mexico and understand dynamics and integrate the basin as a whole. But there are local and state concerns and actions that are hard to keep track of.

- Transparency is important. Key to the adoption of Minutes 319 and 323 was that Mexico was convinced of the US intent to commit to water levels for shortages. But the Upper Basin may tire of its required releases. To the extent there's a shift in releases from Upper Basin, we need to communicate to Mexico how that will affect agreements in place.

- There are indigenous communities on either side of the border. The Cucup**á** view the river as a living entity, sovereign-to-sovereign conversations are essential. Include tribes in discussing what's going to happen to the water. The tribes look forward to building relationships and conversations with Mexico to further their inclusion in this process. An ad hoc collaborative structure can't be relied upon for the long-term.

What can we do in the next few years to improve lives of the Cucapá in Baja California and Sonora, Mexico, who have lost their river water? The people can no longer fish for their subsistence and the system doesn't allow for direct support of government. They need resources so they can connect with the river a few months a year again.

- This hits at heart of the issues that we overlook: environmental and social justice issues. Taking away the river from the Cucapá is akin to genocide. What can be done to bring the river to the Sea of Cortez? The pulse flow was inspirational. Tribes should not meekly ask "Can we do this with our water?" We want to make sure the water is living and sustainable. We need to really work on how to articulate tribal cultural/spiritual/traditional values with the tribes we're working with and create actionable items.
- It will be important to focus on how to bring tribal participation directly into binational process itself, and very soon. This effort may have to be led by NGOs on the American side, given the political situation.

A lot of conversation with this panel has been on the water supply side but there are problems with water demand. What in our governance structure addresses the demand side?

- The Upper Basin/Lower Basin agreement is driven by demand in the Lower Basin. Except for Arizona, states have not been very specific about managing demand. Agreement between basins will need to reduce demand across the basin. The Upper Basin can't bear the entire weight of climate change. Conversations on demand management will be key to addressing curtailments. How do we make room for additional necessary concerns such as environmental issues, tribal rights, and cultural interests? If not addressed, this fairly stable house of cards will get weaker and weaker.
- The DCP is about conservation and shortage sharing, but for tribes it is about developing their water rights.

9: Final thoughts by panelists:

- We're on the verge of a slightly different conversation, but we're not there yet. Over the past 100 years we've been playing a game where the objective is to divert and use the most water. Now how do we attract and drive investments that we need in tribal communities, rural agriculture, and landscapes that go beyond demand management and change objective of the game?
- Let's get back to basics and facilitate the collaboration and cooperation that has already occurred and is nonpartisan, bipartisan, and depoliticized. This basin has gone far by excluding politics.
- Tribes take responsibility for leading this discussion from a spiritual mandate for water to be protected and available for all living creatures. We have thousands of years of living sustainably in this area; how do we take that forward? The twenty-nine US tribes do not have the same answers. Don't think that everything can be resolved through the question "What's the tribal 'ask'?" This is an opportunity to check ourselves as human beings in how we interact with ourselves and our environment.
- Embrace being uncomfortable. Many of us live in our comfort zones.

C. Climate, Hydrology, and Social Science Updates

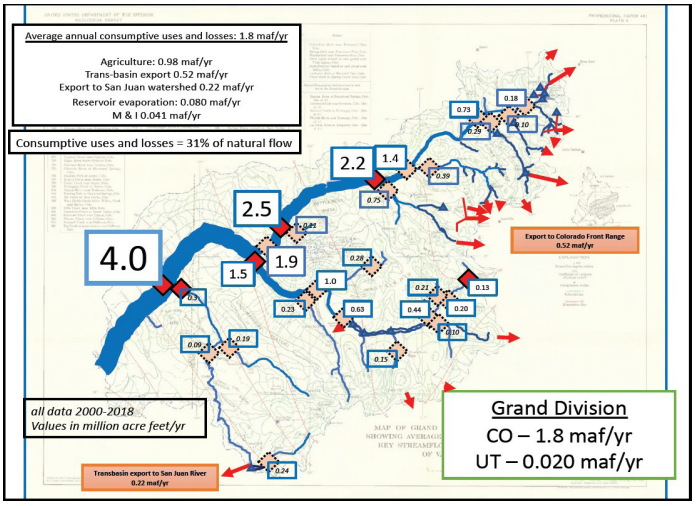
1: A Virtual Tour of the Colorado River (Jack Schmidt, Utah State)

To orient participants, Schmidt presented maps of the divisions of the Upper Colorado Basin, each showing the actual wet water in the river in millions of acre feet (maf)/year at USGS gauges from 2000- 2018. The maps also included transbasin diversions (see Figure 1).

0.22 maf/yr are exported to the San Juan River and 0.52 maf to the Colorado Front Range. Consumptive uses and losses amount to 31% of the natural flow. Lake Powell releases about 8.9 maf/yr. The two biggest junctions are the Grand and Green, with three key confluences upstream.

The current percentage of mean annual flow is much smaller than the previous mean annual flow in all the different divisions. Major decreases in streamflow are seen from the mid-20th century to early 21st century: flow at Cisco is 72% of the earlier period's wet water estimate. The Dolores is 34% of its previous mean annual flow, and tremendous decreases are seen in the Duchesne River as well.

Figure 1. Upper Basin Transbasin Diversions of Consuptive Uses



2: Research Efforts Led by the Basin States and Municipal Agencies (Seth Shanahan, Southern Nevada Water Authority)

To determine the state of current knowledge and knowledge gaps, a group of utilities hosted the 2017 Colorado River Hydrology Research Symposium. Symposium goals were: 1) synthesizing the science and technical practices; and 2) conveying gaps and uncertainties. The symposium initiated an ongoing dialog through the Colorado River Climate and Hydrology Work Group, which develops priorities for projects. The aim was to address unique user needs from the perspective of basin states and water utilities. Work Group participants expressed a desire for a synthesis report, thus the first of seven projects in progress is:

- State of the Science Report (Jeff Lukas, WWA; and Liz Payton, Univ. Colorado)

  The report is not yet finalized but is expected to be released in Winter 2019-2020. It builds on multiple existing resources:

  - *Reclamation's Interim Guidelines EIS Appendix U (Climate Technical Workgroup Report*)
  - Reports of the Colorado River Conservation Board
  - Reclamation's 2012 Basin Study
  - Ten Tribes Partnership study
  - The 2017 Colorado River Hydrology Research Symposium

  The report's objectives are to: synthesize science and technical practice; convey knowledge gaps; prompt research ideas and inform priorities. Other aspirational objectives are to inform the research community about Reclamation models; prompt research ideas and inform priorities; and provide the scientific and technical foundation for renegotiating the Interim Guidelines. The focus is on supply, not demand. The report does not address ecosystem management or water quality. It has a variety of sponsors, including Reclamation, NOAA, and WWA. The challenge will be to make accessible and comprehensive for managers, researchers, and policymakers.

3: Science Efforts Led by Reclamation (Jim Prairie and Rebecca Smith, Bureau of Reclamation)

Collaborative Upper and Lower Basin programs began in 2004. The first major products of the program were Appendix U (described above) and Appendix N of the 2007 Interim Guidelines EIS. In light of evidence of a changing climate, Appendix N analyzed system risks using paleodata as a step toward incorporating a broader range of conditions than those observed over the previous 100 years (this was Reclamation-wide, too confusing to fit into the CRB research summary). Political pushback regarding climate change was not present at the start of this work. The program was recently rebranded as CRB R2O (Colorado River Basin Research-to-Operations), with the aim of identifying research that will be used operationally to feed into current models that are being relied upon. Study areas include climate, hydrology, and decision science for multiple time horizons.

Short-term projects inform the 1- to 24-month time horizon. They're now working on climate-informed subseasonal-to-seasonal forecasts for streamflow and consumptive use modeling. Mid-term projects (in the 2 to 5-year horizon) include temperature-conditioned streamflow projections (how has temperature affected historical streamflow and can skillful temperature predictions improve midterm streamflow projections?) and a recently-completed Basin Streamflow Forecast Testbed to test future forecasts. In the long-term (5 to 50 years, using CRSS modeling*), Reclamation is comparing the skill of CMIP3 and CMIP5 projections in projecting climate, hydrology and system impacts, and two different GCM climate projection downscaling methods to see how they affect flows. They are also working on a new decision- making approach (Many Objective Robust Decision Making, MORDM) to address long-term planning in face of deep uncertainty. Reclamation is also conducting and supporting physical process research (e.g. reservoir evaporation studies.)

*** CRSS is a long-term planning model typically used to project river and reservoir conditions over a period of decades into the future.**

4: Other Research Updates

- *Impacts of Temperature on Colorado River Flows* (Brad Udall, Colorado State Univ., presenting work by Connie Woodhouse, Univ. Arizona)

  For forty years, climate scientists projected that temperature increase would decrease the flow of the Colorado. They looked at plausible drought scenarios using instrumental period droughts and warming and at paleo-precipitation and warming. Woodhouse's project focuses on plausible drought scenarios for the future, on runoff efficiency in the Upper and Lower Basins, and the ecological consequences of 20th -century-type droughts. It identified five research questions related to temperature, climate and runoff.

- *Evolving Approaches to US-Mexico Water Management* (Mariana Rivera-Torres, Univ. Arizona)

  The aim of this research was to shed light on recent binational collaboration trends for the Colorado River to understand the evolution of Mexico's role in river basin governance. Rivera-Torres developed a timeline of recent events of conflict and cooperation in the US-Mexico relationship. Before 2008, Mexico was not an active partner; now it is an engaged, proactive partner in governance of the river and in determining shared shortage/surplus guidelines. Now both countries seek to move away from a zero-sum game of water allocation and embraces transparency and information sharing, consistency, continuity, and patience. Challenges: how to get more diverse representation in the discussions; navigating the broader political context; and making processes nimble to change.

- *Dynamics and Predictability of Colorado River Streamflow* – (Balaji Rajagopalan, Univ. of Colorado)

  Rajagopalan looked at multidecadal variability of streamflow to improve long-term projections. Flows have 8 to 16-year cycles. You can compute a predictability index and use it to modify forecast skill. Over time, there are epochs where flow is highly predictable and others when it is not. During low predictability, be very conservative and place less trust in the forecast. Another aim is to understand the role of land surface and watershed processes in mediating predictability.

- *Institutional Perspectives and Stakeholder Perspectives on Hydropower* (Surabhi Karambelkar, Univ. Arizona)

  This study focused on governance challenges of operating Glen Canyon and Hoover Dams, and involved interviews of over three dozen stakeholders. As pointed out in *Cadillac Desert*, hydropower is a cash register for the Colorado Basin; hydropower revenue is directly correlated to dam operations and hydropower revenues are now being used for hydropower programs. Why do stakeholders think it is important to keep generating hydropower? The most popular response was for revenue, but it is also valued as a source of clean/renewable energy. The Upper Basin is at greater risk during a bad drought; it has unpaid debt to the US treasury of approximately $1 billion and many of its environmental programs depend on the Basin Fund. In the Lower Basin there is less unpaid debt and the multi-species program funding is assured until 2055. A 2018 OMB decision defunded Grand Canyon programs and threw jobs and research into turmoil, presaging what could happen in a future without hydro dollars. If Congressional approval is required, it's all at risk. Stakeholders are worried that survival of programs depends on hydropower revenue.

Audience Questions and Discussion (Kathy Jacobs, moderator)

Why isn't the demand side more a part of Reclamation's study? Why is the scope so limited?

- Current demand numbers as reported by states aren't examined for accuracy. Reclamation does need to address what climate change will do to demand. Reclamation's loss data report isn't necessarily backed up by states' data. Now they are reevaluating how they look at and estimate use. Reclamation has published numbers on consumptive uses and losses, but not for the Colorado River Basin.
- Reclamation used to issue estimates of tributary use and losses for the Lower Basin. In 2005, those reports were stopped so the basic numbers that are critically needed to renegotiate the Interim Guidelines are not available.

Groundwater depletion in the Colorado Basin is increasing; the water table is dropping. The more the river becomes disconnected from the aquifer, the more problems we will face in our efforts to put water in the river. How is that being translated to models for future flows?

In the Lower Basin main stem, there is a clear connection between ground and surface water between Hoover Dam and Yuma. Users in the Upper Basin don't distinguish whether water is pumped from the ground or taken from the river, both are diversions. Groundwater use is managed at the state level elsewhere, for example through AMAs in Arizona. Depending on where you are in the Basin, the importance of groundwater varies. A paper by Bridget Scanlon has shown that groundwater is vastly understudied in the Basin. Much of the runoff in the river is actually 1-year old groundwater.

A lot of recent science has come about in an age of multidecadal drought. Do you think annual variability will be as great in the future? Are we going to be surprised when we move into the next pluvial? Will it be really dramatic due to a warmer atmosphere?

Expect more variability/volatility on interdecadal time scales in the future. We've experienced this just in 2018 and 2019. There will be a new pluvial. We are less likely to be surprised by excessive precipitation but might be surprised by the sparsity of runoff. Can we expect a megapluvial? Maybe, but we know not nearly as much about drivers of long-term decadal variability. This year, a flash drought occurred in the Upper Basin despite all the earlier precipitation (110% of normal and with late runoff). Projections are that by 2100, the record-setting warm temperatures of 2018 will be too cool to occur.

We need to talk more about groundwater and ecosystem dependence. In the Lower Basin there are unique ecosystems that have great and vulnerable biodiversity but are dependent on springs. These ecosystems are left out of the discussion. In the Upper Basin, isotopic studies show half of the flow is from springs. Ecosystems are not always related to the river. Side canyon springs provide unique oases for endangered species. They don't have representation in River management discussions and are the most vulnerable ecosystems. Urge us to not always think in terms of mass water and groundwater production.

The federal process and scope of decisioins currently doesn't concern itself with ecosystem sustainability. What can we do to look at ecological vulnerability and instability in CRSS?

- Although the speakers here have focused on supply, there are federal science efforts looking into this topic, such as the USGS Grand Canyon Monitoring and Research Center (GCMRC) and the Upper Colorado River Endangered Fish Recovery Program. Some work is trying to fit in salinity and temperature. For ecosystem outcomes, streamflow is not the only driver. We need to look at alternative tools to CRSS that are easier to run. Unintended consequences can take us into deep uncertainty.

- The scope of the 2026 guidelines is determined by previous agreements that speak to water supply. How can we make sure we aren't limiting input to guidelines to just normative ways of looking at it? What new models do we need? Building a CRSS model that can do prediction on a daily basis is impossible.

- The Lower Santa Cruz River Basin study with Reclamation is looking at impacts of climate change on demand and supply for groundwater in the Tucson basin. Progress is being made using new sources of climate and modeling information.

My interests right now are not in decades into the future. What can you contribute now that will be useful in water supply analysis for 2020-2026 from the information already in hand?

- The normative discussion is not helpful. We need to raise the mitigation discussion. We know how to limit GHG emissions and need to move on this now.

- People are actually concerned with all the timescales, short- and long-term. Can we answer the near-term questions for 2026 while also considering the long-term?

- Private foundation support is helping fund an effort to use CRSS consistently to ask the more outrageous questions that could be helpful for getting us out of multidecadal drought in future, such as how to proceed if there is no Compact or if one reservoir is empty. We need to see whether there are tradeoffs for water supply safety and ecosystem issues; if there are plausible results we can move to the decision-making space. Academia is an appropriate place for this effort.

Based on your modeling studies, is there a possibility of increasing ecological flow releases out of dams on the mainstem or are we giving that up in favor of dealing with declining supply? Is hydropower management driving release regimes or is it subservient to water provision?

- On a practical level, Hoover Dam is managed for water releases but they do not conflict with hydropower. At Glen Canyon, you have annual and monthly delivery obligations, with caps for hydropower, which is a subservient use.

- There is a Glen Canyon Dam Adaptive Management Program that outlines several types of experiments, some of which have ecological benefits. The program is intended to gather what has been learned and identify how it has met or not met goals. Here is an opportunity to see how that might work.

- There is no denying that the Grand Canyon is the unique place where all the Colorado River water comes together; downstream it all disappears. Water supply is what is important, not hydropower. Once big agreements are set, you can finesse the hydropower. All of Hoover Dam's power production is affecting Lake Mojave right away. In Glen Canyon, impacts come much farther downstream. The price differential between peak and base power is really shrinking so the way we produce power in the future and hydropower's role will likely change dramatically.

How do we get the right people at the table for the 2026 negotiations, including NGOs, tribes, recreators, and those who have been previously excluded? How is it done on the Mexico side?

The US and Mexico have very different water policy mechanisms. In Mexico, water is owned by the federal government, which makes all its water decisions through CONAGUA. CONAGUA invites representative of NGOs, academia, water use groups, and states into small work groups. Some are included in the policy group that go into negotiations, but not all. There is a lot of progress to be made on including native peoples.

Rising temperatures will mean longer growing seasons, so consumptive use by agriculture is likely to go up. In response, farmers will operate differently. Is anybody thinking about this and extrapolating it into the future? What is the potential to exceed Compact obligations?

Some analysis at the state level has looked at the crop irrigation water requirement for the Western Slope. Assumptions are necessary to calculate this and we do not know how the crop mix will change. In some parts of Colorado, people are planting more heat and drought-tolerant varieties. You can't assume the same agricultural processes will be used in 60 years. For example, in 10 years, farmers may be able to plant a crop that couldn't be grown previously that has much higher water use requirements. The Colorado Basin Study looked at this issue a bit, however, and is not currently seeing an upward trend in consumptive use.

What riveting/relevant information do you want to highlight from the work presented in this session?

- A bottom-up approach to decision making could be transformative and has great potential.
- Recognize the importance of NGO work on communication in binational negotiations.
- Prepare better for contingencies. Issues may not be a problem now but will be. Anticipate funding needs, e.g. for infrastructure, in advance of emergencies.
- We live in a semi-arid and symbiotic region. Engineering is not the only place we should look for solutions; the system is constrained by nature, which laughs last.
- There are substantial opportunities for improvement in decision-making, data, and models. Incremental improvements in many different areas are possible.
- San Juan watershed runoff is radically different than it was before and differs from other basins. What is going on? Some areas of the watershed have been utterly transformed already by climate change. Do we try and change everything just a little bit or do we sacrifice certain rivers? What will be the model for the future?

D. OVERVIEW OF COORDINATED OPERATIONS OF LAKE MEAD & LAKE POWELL AND LESSONS LEARNED SINCE 2007 (Interim Guidelines)

1: Upper and Lower Basin Lessons/Perspectives (Don Ostler, Upper Colorado River Commission; Nicole Klobas, Arizona Dept. of Water Resources; Chuck Cullom, CAP)

- Ostler worked on the 2007 Interim Guidelines, which had two parts: 1) a set of operating requirements and policy, which required benefits to both the Upper and Lower Basins; and 2) other legal agreements to keep the Upper and Lower Basins from litigation. The Upper Basin is concerned about the amount of water it agreed to release. The Interim Guidelines provided a useful learning period so that we could reassess and move forward. The modeling used to draft the guidelines must be compared with what the river looks like now. If not for the guidelines, Lake Powell might be 20 or 25 feet higher now. It will be more difficult to show benefits to both basins under the Interim rules.

- Klobas started work in the Colorado Basin in the middle of interim guideline creation, when major negotiation had been done but much remained. Many interests in the Basin need to be represented in the 2026 Revision. The aim will be to avoid litigation and come up with more creative approaches; litigation doesn't necessarily lead to what's best for the Basin.

- Cullom has evaluated the models, work products, rules, and approaches from Reclamation/CWCD, particularly risk portfolios. How have different approaches affected the risk of delivery for water to municipal, tribal, and agricultural uses? The process of writing a binding agreement really defines issues much more than mere discussion. Often, you'll have a negotiation with a perceived common understanding, but when the discussants see the draft, they realize it doesn't match up. Implementation of the agreements is also an important process to build shared understanding, using annual and monthly timesteps. In the first years of implementing the ICS, colleagues had different understandings of the intention of the program.

Group Discussion (Vineetha Kartha, ADWR, moderator)

Should the Guidelines should be looked at from a more ambitious perspective, going beyond Lakes Mead and Powell?

- Klobas: What is already on the plate for negotiators is overwhelming and time-constrained. Additions to scope are best kept minimal, though negotiators should keep an open mind.

- Ostler: There is some need for expansion and the Upper Basin reservoirs should be added to the scope of work. They are part of the DCP process as a rescue mode for a Lake Powell crisis. This would, however, add significantly to complexity. Renegotiation, if it happens, must be bold and out-of-the-box to capture benefits for both basins. It will take significant time and effort.

- Cullom: Incremental adaptive management is best, respecting existing laws and framework, and acknowledging that IG 2007 and the DCPs are a very significant accomplishment, "a quiet revolution in the management of the CO River system." There are now new incentives to use less water, and benefits accruing through storage in Lake Mead, with opportunities for storage even in Lake Powell. It's a counter to the previous "use it or lose it" mentality that guided the Law of the River.

At what point is conservation no longer possible? What changes and transactions are needed in the next negotiations?

- Klobas: There is no universal answer. Each individual transaction can reach a point where something no longer works or is required. We need to look beyond conservation, e.g., to augmentation, which will require a lot of planning and forethought. But there will always be a place for conservation.
- Cullom: Conservation will always be a local solution. Local preferences will drive how conservation technologies are applied. In Arizona, for example, there is interest in developing local resources, increasing the reuse portfolio, using AMAs, and developing desalination technologies – these drive how much external conservation measures must be applied. Augmentation measures will be market-driven.
- Ostler: Conservation is clearly a large part of the existing Interim Guidelines program and will be in future. It is true that the market will have a big bearing, but there will be other factors. "Whenever you conserve, something dies." We can't put all our eggs in the conservation basket; the augmentation potential has to be explored.

What important concerns are there for the next round of Interim Guidelines development?

- Ostler: We need a process to increase efficiency in engaging with and hearing from stakeholders. The difficulty is figuring out how to do it. How do we want the system to perform and what functions do we want it to perform over the next 30 years? How does stakeholder input get to managers? Human nature is such that when deadlines loom, that's when decisions get made. While we are figuring this out, stakeholder work and technical and legal advising should proceed. Identify what data and modeling are needed and can be ready.
- Cullom: Find a shared vision for the river system for the new guideline period. How do we want "the system" to perform so as to provide clarity and avoid litigation? Acknowledge and respect the priorities and roles that have worked for 100 years. Avoid the missteps in the 2007 guidelines process, such as relationship missteps with Mexico and too much rigidity in operating rules. Because guidelines have rigidity, the uncertainty of hydrology and demand over the next period demand recognition. Think of guidelines as a framework for adaptive management; the US will use the NEPA process to guide it through work with stakeholders.
- Klobas: Respect that the conversations can be difficult and won't happen in a room of 100 or even 20 people. The most effective conversation can sometimes be a dialog of two people who respect the fact that there are others who will ultimately need to be consulted. Identify shared goals but also the more individualized goals and set them out for others to see and consider as a vision for the future. What are the boundaries you are not willing to cross? Put them out there. Also, you need a good suitcase!

Broader audience discussion:

Mexico is not represented on the panel here. Equitable conservation has not occurred. Under the treaty, Mexico gets 1.5 MAF. So, in a drier future, conservation must be a significant portion of the solution, correct? How do you see the current situation working with the next Minute in a climate of declining supply?

- Cullom: River water use is controlled by local choice and community values and regulations. In the Phoenix metro area, for instance, if you see a lot of grass, it may be served by the Salt River Project (SRP), not the Central Arizona Project (CAP). We do need to acknowledge that Mexico's interests and the process in both countries are independent and achieved via different processes. We have learned and improved greatly on the experience of 2007 and rebuilt injured relationships.
- Klobas: It's a completely different world than in 2007 in terms of binational cooperation, with shared benefits and shared risks. Mexico must be involved in the guideline development. How do you integrate those discussions? Find collaborative voluntary solutions, while respecting relationships. In 2007, US did treaty work on its own without state input. Reclamation and states were to work together on the US process. That didn't work well. Now there are binational work groups working on hydrology, binational projects, salinity, etc. There's a good foundation already in existence with experienced people who can be used again.
- Ostler: Mexico has been a great partner in the management of the Colorado River. Renegotiation will require an expanded role for Mexico. There are differences in water use in different areas of the basin; agree that conservation is a local decision. The idea of multiple tables, where many can add input to the negotiation process is appealing. Plans and mechanisms should be in place in case of crisis, such as severe drought.

What might the structural deficit look like after 2026?

- Cullom: Reliance on storage has to be complemented by benefits to the Upper Basin. The release of 9 MAF of river water from Powell plus conservation has temporarily stabilized Lake Mead and addressed the structural deficit so that Lake Mead has not fallen below the 1075' level. Favorable releases from Lake Powell to Lake Mead going forward can be discussed, but must provide benefits to the Upper Basin. Lower Basin demand management has been successful. How can we put more water in the system to achieve a shared, reliable supply?
- Klobas: Shared benefits are important, but there must also be shared risk and shared pain to achieve a collaborative solution. It is easy to say that Arizona accepted a junior priority to get CAP approved, but this mindset is not collaborative and not all parties are involved in the risk-taking.
- Ostler: It's an important topic that may become the elephant in the room in future. Since the Interim Guidelines came into existence, average releases from Lake Powell have been 8.8 maf /year. This is more than normal, yet we continue to see Lake Mead lose elevation. DCPs are a good first step, but don't allow Lake Mead to fully recover, only stabilize.

Tribes have borne the risks so far. Tribes have water they want to put to use and develop their rights. How do states conserve when tribes want to develop their water?

- Klobas: I'm not saying that Arizona won't bear risk. But tribes need to be included as many voices (not just one), as Arizona has learned especially through DCP. There are great partnership opportunities for water projects and water management. We can't just rely on Reclamation to use its formal channels with tribes; need to have conversations directly with tribes and their representatives early in the process.
- Cullom: In the 2016 DCP discussion, we learned there was a gap between nontribal conversations and what was being conveyed on the federal side. Direct participation through a steering committee really helped communication. We can't expect tribal water to continue to bail us out. The concept that we are somehow expecting tribal water to continue to be unused so that we can do things in central AZ is a fallacy. The CAP system considers development of tribal rights on the river as reducing water supply because of the nature of the CAP contract. Good communication will lead to new solutions.
- Ostler: Some tribal rights have still not been adjudicated; this is important to resolve so all tribes can be factored into management.

E. PLANNING SCENARIOS: CLIMATE VARIABILITY AND EXTREMES – PREPARING FOR FLOODS AND DROUGHTS, MANAGING ECOSYSTEMS (and many other factors)

1: Nightmares, Scenarios, and Next Steps – Walton Colorado River Conversations Project (Andrea Gerlak and Mariana Rivera-Torres (Univ. Arizona); and Amy McCoy and Season Martin (Martin & McCoy)

A companion process to this conference, a scenario planning effort, is investigating climate variability and extremes and low-probability, high-impact scenarios, such as megadroughts and megafloods. The idea is to explore uncertainty (extreme conditions) outside the normal parameters of planning (see Figure 2). An initial scenario planning workshop was held in June

Figure 2. Range of Planning Efforts.

2019 and examined scientifically supported "what-if" scenarios. The participants developed a list of over 70 nightmare drivers: economic, political, social, technological, physical, biological and infrastructure. One climate driver and two non-climate drivers were selected to build each of 8 storylines at the meeting in June. The components of the eight scenarios were researched over the summer; the scenarios are named "caught off guard," "water on the move," arid and unfair," "rural revival," "sad skiers," "disaster strikes," "dig it deeper, and "flood gates". These will be the focus of a second scenario planning workshop later this week.

Discussion:

"Black Swan" events (which are unpredictable, have extreme impacts, and inspire ex post facto explanations) lead to catastrophic outcomes. Taleb (2010) criticizes scenario planning and the probabilistic approach because they lack the epistemic possibilities that are the real drivers. Have you addressed this?

Our approach isn't probabilistic. We are exploring the potential impacts of the intersection of different kinds of extreme events in order to make it easier to talk about the potential for such things to happen even if we don't have a way to calculate likelihood/probability. Our approach is to talk about these kinds of events as possibilities, and then talk about the cascade of impacts that could occur. It's clear these things are hard to talk about in public forums but at least these discussions can explore where the linkages are. You won't be able to predict the full array of impacts. It's still valuable to develop consistent set of storylines and frameworks that states or municipalities might be able to use as an approach to managing risk.

How does the failure of the power grid affect these scenarios? Did you consider that?

It is not in one of the built-out nightmare drivers, but it was considered. It will be in the impacts list that cascade from multiple storylines.

F. ECOLOGICAL RESOURCES: SYSTEMS THINKING AND IMPLICATIONS FOR COLORADO RIVER MANAGEMENT

(Moderator, Charles Yackulic, USGS)

There is great uncertainty regarding the future of fish populations on the Colorado River. Ecosystems are modified at multiple trophic levels and a lot of species are missing now. Aquatic ecosystems through the Basin are altered to different extents, therefore what is "natural" is debatable. The relative importance of direct and indirect impacts of climate change varies spatially in a heterogenous landscape. For example, the direct impacts of climate on water temperature in the Upper Basin will be more important than indirect impacts of storage, however in the Lower Basin, changes in storage will have the greatest impact on water temperature and there is potential for rapid and nonlinear increases in water temperature that will radically modify aquatic ecosystems.

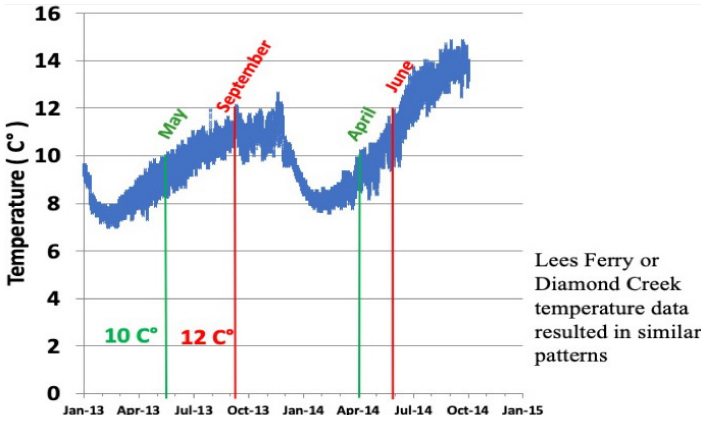
1. Native and Non-Native Species, Biodiversity Objectives (Tom Chart, US Fish and Wildlife Service; Scott VanderKooi, USGS)

Chart presented a timeline of fish recovery programs in the Upper Basin. There the focus is collaborative partnerships to implement the Endangered Species Act (ESA). The Upper Colorado River and San Juan River Recovery Program partnered with people working on the San Juan, state/tribal/federal representatives, tribes, and hydropower. The goal is to recover threatened and endangered fish through habitat development, screening irrigation canals, stocking endangered fish, education and communication, and flow management that mimics a natural hydrograph. There are flow recommendations for dry, average, and wet years. On the seasonal outlook, meeting the spring peaks in average years is challenging, as are baseflow targets in the drier hydrologies. Maintaining future flexibility at reservoirs like Flaming Gorge will play a key

role in our ability to achieve endangered species recovery. Climate change almost certainly will result in warming river temperatures, which will likely favor invasive species (smallmouth bass especially). The program stakeholders are keenly focused on describing and securing the post 2023 future, an important deadline for Upper Basin recovery programs.

VanderKooi: You need to take a 30,000-foot view of Lakes Mead and Powell to get the big picture of the Colorado River through Grand Canyon. How and when water moves matters, so needs to be thought about if there is interest in protecting the aquatic ecosystem in this reach of the Colorado River. The Grand Canyon has a novel aquatic ecosystem that is only about 55 years old (because artificially constructed by dams and diversions) and we keep changing its management. Unlike in the Upper Basin, the fish community in the Grand Canyon in the last 10 to 15 years has been dominated by native species. This is due to the happy circumstance of drought, which has lowered Lake Powell and resulted in warmer water releases, and the physical location of the canyon with respect to the reservoirs, rather than any specific management action or actions. Still, agencies look to manage this altered ecosystem to the benefit of native fishes as well as desirable non-native species such as rainbow trout. Downstream, low reservoir elevations also created a new rapid in western Grand Canyon that appears to be keeping non-native species from migrating upstream from Lake Mead.

Figure 3. Lake Powell's Influence on Lake Mead



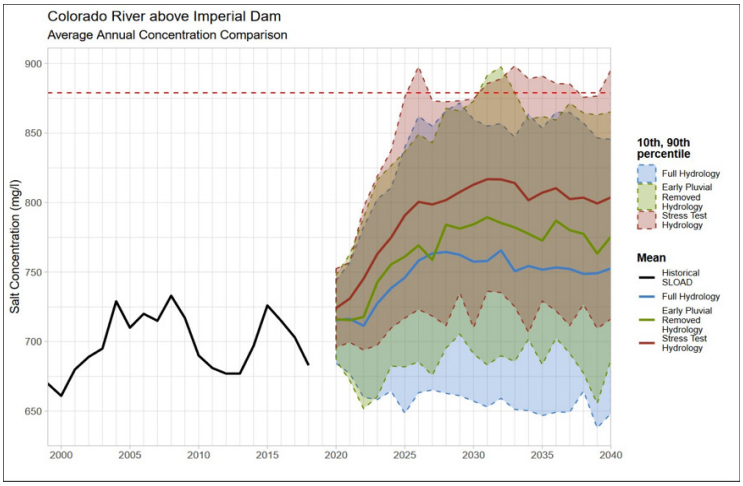
2. Implications of/for Temperatures, Salinity, and Sediments Managment (Todd Tietjen, Southern Nevada Water Authority; Don Barnett, Salinity Control Forum; and Jack Schmidt, Utah State Univ.)

Tietjen: Water quality work on Lake Mead showing the influence of Lake Powell releases in 2013 and 2014 examined an admittedly narrow time period, but is instructive in showing how releases from Lake Powell affect the water quality in Lake Mead. Warm temperatures early in 2013 made the water temperature in Lake Mead reach 10° C in May and 12° C by September. In 2014, water temperatures reached 12° C by April, and eventually reached 14° C (see Figure 3).

In June, anoxic conditions were starting to threaten. October 2014 had the largest hypoxic region ever seen in Lake Mead, which relies on cold water to keep the bottom of the lake oxygenated. Low-oxygen water gets carried further into the lake because of the density of water due to the temperature. Large, basin-wide changes need to be watched for. These temperatures don't impact water providers, but such large basin-wide changes must have impacts on species other than fish, such as microbes. This has not been studied.

Barnett: The forty-year-old Colorado River Basin Salinity Control Program has been extremely successful. Nine to ten million tons of salt come down the river each year. The Program has reduced the annual salt load by about 1.31 M tons and lowered the downstream concentration to 100 mg/L. "Conservation" means too many things to too many different people at present; he suggests using more specific terms such as consumptive use, water efficiency, return flows, and

Figure 4. Average Annual Salt Concentration Comparison



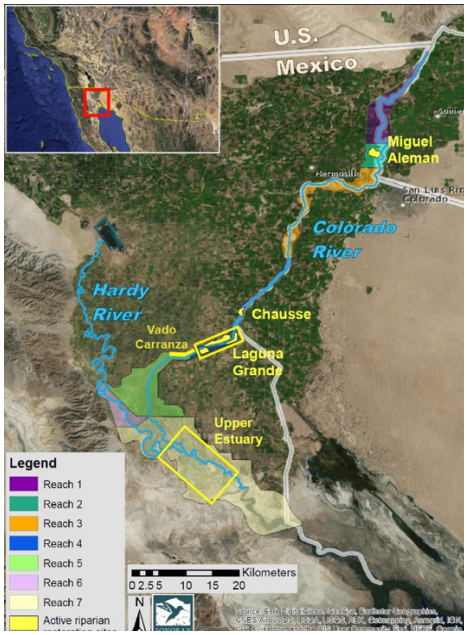
depletion. The Salinity Program focuses on water efficiency. The Upper Basin wants to keep the salt up north by solving leaky ditches and pipelines, lining them, and cutting off return flows to reduce salinity. The goal is to incentivize irrigators not to over-irrigate. Fifty percent of the water comes from the baseflow, but 80 to 90 percent of the salt comes through the flow path. Half a billion dollars in damages have occurred to downstream users due to salt; salinity is still a problem. CRSS modeling shows salinity levels will go up in a drier future but many effects are unknown (see Figure 4). Better modeling is needed. A new study shows the reduction in salinity levels ceased 15 years ago. Cleaner water means we can stretch the water further.

Schmidt: The size of the river channel is scaled to the magnitude of its common floods. Taking water out of the rivers will make the channels smaller; this is the most basic paradigm of geomorphology. Stop talking about restoration; keep noticing that we are changing the form of the river channels. Further depletions in any segment of the Colorado River will diminish channels. Large deliveries of water from the Upper to Lower Basins maintain a healthy habitat. Sediment is an important issue. Water supply decisions make a difference in the physical attributes of the river. The sand mass balance in the Grand Canyon will depend on release volumes from Lake Powell and monsoon season sand inputs. In a high snow-melt scenario, the sand bars will be obliterated. We need to develop new rules for releasing water from Powell to Mead that recognize the environmental objectives we are seeking in the Grand Canyon.

3: River Restoration for Habitat at the Watershed Scale (Gabriela Caloca Michel, Pronatura Noroeste; and Jennifer Pitt, Audubon)

Caloca: Restoration efforts in the Colorado Delta have been achieved through a binational partnership with a huge number of NGOs, governments, and academicians. Key strategies in Delta restoration include: research, planning, and monitoring; outreach and community involvement; binational negotiations and public policy; water for the environment; protection of key sites; and restoration.

Figure 5. Restoration Areas on the Colorado River Delta



Primary restoration sites have been Miguel Aleman (248 acres), Chausse (155 acres), and Laguna Grande (554 acres, of which 88 will be finished this year) (see Figure 5). Activities include clearing invasive vegetation, preparing land, doing plant production in nurseries of native plants, revegetating, planting native trees (cottonwood and mesquite), daily monitoring of water deliveries at restoration sites, and hosting volunteers. Restoration is a human process, with legal, economic, and political contexts. By finding common ground it is possible to create a social support system for restoration.

Pitt listed the top 10 lessons she has learned from working on Delta restoration:

1. The Minute 323 investment in science ($9 million in 9 years) has been essential and guides the optimization of scarce water and money.

2. Restoration is more than increasing habitat. The pulse flow demonstrated the social and cultural benefis of restoration.

3. Narrative matters and a good story is essential; the pulse flow brought priceless attention to the Delta.

4. Local communities are important. They must be engaged in the process and perceive the restoration as appropriate in context. NGOs must help them deal with changes of water deliveries, Minutes, and water conservation.

5. Restoration in the Delta (and anywhere) depends on ability to avoid water supply crises. The binational apparatus has been important in basin-scale negotiation.

6. We need a collaborative approach to managing Colorado River water supply and risk that includes Mexico and is sufficiently conservative to reduce the risk of unplanned shortages.

7. Groundwater at the border is critical; Colorado River shortages cannot be a precursor to increased reliance on groundwater. The cone of depression is getting larger and dropping the groundwater surface by 1 meter per year.

8. Restoration sites in the Delta are not self-sustaining and require stewardship. There is not sufficient water allocated to foster self-sustaining habitat.

9. We need sustainable funding commitments to keep the effort going long-term.

10. Donors don't want to invest without some assurance of permanence about what is being constructed.

4: Implications of Revised Guidelines for the Implementation of the LCR Multispecies Conservation Plan (Chris Harris, Colorado River Board of California)

For next set of guidelines, we need to continue to gain operational experience and use the lessons learned from previous Minutes, guidelines, and the DCP process and develop additional modeling tools and work on management assumptions to help us manage long-term. As we try to achieve a balance between water supply/demand, ecosystem development, and environmental restoration, we have learned the importance of a good working relationship with Mexico. Since Minute 306** (1999-2000), we have come far. The next set of guidelines will be as important as the 1922 Compact and must be sufficiently flexible and adaptive to drought, flood, and other challenges to allow an effective response. Uncertainties with climate change present a primary challenge. The Multispecies Conservation Program is currently working well; adaptive management is what makes the difference.

Audience Discussion (Charles Yackulic, USGS, moderator)

What are the primary factors influencing the resources about which you are an expert? (For example, influencing trans-basin diversions or large-scale depletions; storage and dam infrastructure; water year and the Law of the River water supply agreements; climate change).

What are the new frontiers and issues?

- **Binational desalination:** how will it impact Sea of Cortez and will it have benefits in the Delta? We don't know yet about desalination impacts. But Mexico requires a biosphere boundary on the coastline for any intakes. Arizona realizes that if ocean desalination is pursued, the relationship with Mexico is critical. A binational effort is required to examine desalination and the Sea of Cortez, to identify options. In the US, Arizona, California, and Nevada, parties have a shared burden for cost and investigation and recognize that a project in Mexico must benefit all and Mexico in an environmentally responsible way.
- **New dams and pumped storage are being proposed on Little Colorado:** The proposal is alarming to many people; there is information on impacts to fish that can help decision-makers.
- The Little Colorado River idea is an absurd nonstarter that is not worth our discussion; that river is a major sediment supplier and should not be dammed.
- Recent news on **macroinvertebrates:** Recent studies show that lowering flows on the weekends can be sufficient to allow macroinvertebrate species a place to lay their eggs.
- **Emerging contaminants** such as microplastics in water systems: The Southern Nevada

* Provided a conceptual framework for US and Mexico to conduct ecological studies of the limitrophe (borderlands) and Colorado Delta.

Water Authority (SNWA) has looked at endocrine disruptors in Lake Mead, motivated by an interest in the potential reuse of highly treated wastewater. Las Vegans are drinking their own wastewater in small amounts; there is about a 1% wastewater return to the intake. Results on endocrine disruptors are confusing. There are intersex issues with carp, but data on this are continuing to mature and not conclusive. The current drinking water processing seems to be sufficient to remove many larger microplastics in Las Vegas water treatment. Anyone who rafts and wears fleece on the Colorado River provides a big microplastic source. The risk of fluorinated compounds for SNWA water is low because they are mainly associated with manufacturing and Las Vegas doesn't have that industry. However, every washing of a nonstick pan contributes. Sucralose (a sugar substitute) is a tracer in wastewater; nothing destroys it and we don't really know the impacts.

- Tweaks to Law of the River pertaining to **delivery timing or volume**: Can sediment issues be addressed by shifting the timing of the movement through the system? What kind of tweaks could be imposed to shift the allowable timing of releases to maximize environmental benefit? Short-term, is it feasible to delay equalization flows by a year or two and wait for a good monsoon year? This might be a good step but could be politically difficult because Upper and Lower Basin interests will conflict. It seems that there may be some benefit in not releasing equalization flow in years that the Grand Canyon cannot deal with clear water. Sediment balance should be added into the management considerations. The fundamental dilemma for Grand Canyon is the stream water is out of balance with sediment supply. Can you pass the water around Lake Powell? Equalization flows wipe out sand bars. There are ecological consequences of moving that much water all at once.

- **What is a natural state?** Riverine segments of the Colorado River are novel ecosystems; there are almost no native ecosystems below the dams. Novel mixtures of native and non-native species are valued by society, so don't think in terms of just restoring to native status. Everybody wants something different.

- Do we abandon sand bars in the Grand Canyon? Or skew it for fish colonies? Drain Lake Powell and make it warmer? We need clear, articulate, coherent visions for each part of the river. The River won't return to 1920.

- To benefit aquatic ecosystems and endangered fish, summer is the key season in which we would like to manage water temperature and flows. There is no way to control temperature coming through Glen Canyon Dam through selective withdrawal with existing infrastructure and allowable operations. We don't know how much water needs to be moved until May/June and must move water by end of September, which is when you need the most flexibility in flows to achieve temperature goals. There is uncertainty associated with how to know how much water to move and what time to move it; a shift in the calendar year could have huge impacts on what decisions we make and could increase flexibility.

What is most uncertain about the future? Or what uncertainty is reducible?

- What is the **hydrology** going to be? How will we respond to what we learn? Tweaking or shifting water year definition might be something to consider. Operationally, adjustments can be made if we understand the future. How will the Basin respond to hydrologic variability? What are the stories we tell ourselves about what it means? Is it in crisis or is it something to thrive under? In a negative vision of future, the social will is likely to be lacking.

- Can we maintain the **binational partnership**? Can we find a way to make local sites as in the Delta more self-sustainable so the residents can enjoy restoration efforts and maintain them in the future?
- **Flow path** is a big concern in the Upper Basin in terms of salt concentration. How do hydrologic changes affect flow path?
- **Climate change and rates of change**. The rate of change has accelerated alarmingly and modeling is difficult. We need to quickly act when we gain information on changes, such as the non-native species changes mentioned above. We also need to understand what a recovered system would look like in terms of our commitment to managing it for the very long term.
- Improving understanding of **how to manage fish with flows.** We need to learn from different parts of the system and share knowledge, coordinating research on a basin scale.
- The future of the Upper Basin system down to Lake Mead looks hopeful because the substantial demands downstream guarantee that a lot of water be retained in the river upstream. In the Rio Grande, in comparison, most water is used in San Luis Valley and little reaches downstream. Managing sediment and habitat are essential, but sediment transport monitoring programs require additional research and funding. The future of the Lower Delta is much less secure.

What constraints do broad-scale decisions have on smaller scales? How do you make a few decisions at a broader scale that don't badly impact more local [segment-scale] issues?

- We all aspire to a more holistic management perspective but deal on a segment by segment basis, driven by our regulatory environment as well as protocols in place with Mexico, for example. Mexico has tried integrated conversations about ecosystems in the Basin. Ecological efforts by nature are segmented and this can be overcome by conversation, but we are not at that phase yet; context matters enormously.
- Regulatory frameworks set up an additional layer of constraints to restoration efforts. We have to pick and prioritize management options. In Mexico, the big issue is the river does not reach the ocean; there are no connected flows from the Delta to the Sea of Cortez. The issue is finding the water.

G. SALTON SEA ISSUES AND DELTA ISSUES AND SOLUTION

1: Salton Sea Issues (Tina Shields, Imperial Irrigation District)

Shields focused on the consequences of agriculture-to-urban water conservation transfers. The Salton Sea is one terminus of the Colorado River, the lowest point in the Imperial Valley, and the largest inland body of water in California (36 square miles and up to 52 feet deep). It currently holds 7.5 MAF of water, with annual inflows of up to 1.3 MAF (from Coachella and Imperial Irrigation District) and no outflow. It gets saltier every year; the challenge is the concentration of the salts. It is nearly 50% saltier than the ocean, yet it is heavily used by migratory waterfowl. The salts get leached off in farming and flow into the Sea. The salinity level has now reached an environmental tipping point where fish stop reproducing; tilapia is the only surviving species. Diminished flows mean that the Sea has a volume problem as well as salinity and is shrinking.

Sand and dust storms from the land that has been exposed pose a serious health program. The area has the highest childhood asthma rate in the nation. The Sea has become the poster child of something that dies where there is conservation.

The Quantification Settlement Agreement (QSA) was enacted by California in 2003 as a means to implement water transfers and supply programs to allow California to live within the state's 4.4-million- acre-foot basic annual apportionment of Colorado River water. Part of the QSA obligated California to undertake the restoration of the Salton Sea ecosystem, but it did not address mitigation. The state did not take action; a 2007 study identified a $8.9 billion preferred restoration alternative, but the study was shelved and became the impetus for the Imperial Irrigation District's current "smaller but sustainable" advocacy position. A task force in 2015 called for the immediate development and implementation of a Salton Sea management plan with specific habitat creation goals and accelerated implementation. The 15- year mitigation flow requirement authorized by the QSA was due to conclude, although no restoration projects for the Salton Sea had been initiated. In 2017 the state legislatively took responsibility and water agencies have put together a pot of money for habitat restoration for 30,000 acres. A draft 10-year Phase I Salton Sea Management Plan was approved. However, it has identified sources of funding only from 2018 to 2025 and has been missing its annual milestones.

Figure 6. IID's Salton Sea Air Quality Mitigation Program

With this funding, the Imperial Irrigation District and Imperial County initiated a Salton Sea Air Quality Mitigation Program to minimize and prevent dust emissions. 1,400 acres of pilot projects are active, with 650 more acres to be constructed this year (see Figure 6). The Program has added tillage; treated areas show visibly less silt and the exposed playa has diminished. Total exposed playa acreage even with the Plan, however, is projected to grow from 22,172 acres in 2018 to 66,948 acres in 2028.

2: Ideas for the Future of the Salton Sea (Chris Harris, Colorado River Board of California)

Harris is cautiously optimistic that California leaders understand the problem, see the importance of QSA transfers, and will find a sustainable future for the Salton Sea, including the possibility of a smaller area. The California governor has issued an executive order for a water resilience portfolio. Air quality and ecological threats are being recognized and the Phase I Plan is being implemented. The state is starting to roll out species conservation projects and habitat development and hopefully in 2020 will have a contract for the design build aspect.

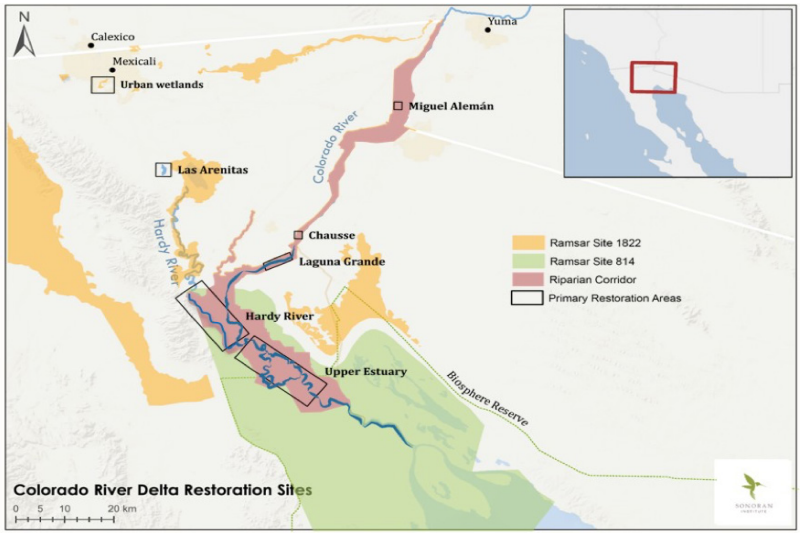
Permitting has been an issue but the state is working with the Army Corps of Engineers. Stakeholder outrage has been a critical aspect of process; citizens are very engaged. Outreach and public education are important. A species habitat conservation project covers 300 hectares near New River and the New River delta and dust abatement, and remediation projects are going on. A pilot project to test roughage/tillage remediation approaches may be ramped up.

3: Possible Delta Solutions (Francisco Zamora, Sonoran Institute; Karl Flessa, Univ. Arizona)

The biosphere reserve in the Colorado Delta has restoration sites along the Hardy River and Colorado River south of Laguna Grande (see Figure 7). The goal is to have water flowing along the mainstem, which gets to the upper estuary where it connects to the Sea of Cortez. "In Pursuit of Happiness" is the apt title of the Sonoran Institute's project. The Institute focuses on the welfare of both birds and people. The people component is not limited to recreation but also addresses livelihoods and traditions.

There are new sources of water: 50% of wastewater from Las Arenitas is being treated and dedicated to Hardy River. Also working with Pronatura Noroeste and TNC to promote more access to effluent associated with a growing population, doubling water availability in the next 10 years… for the river.

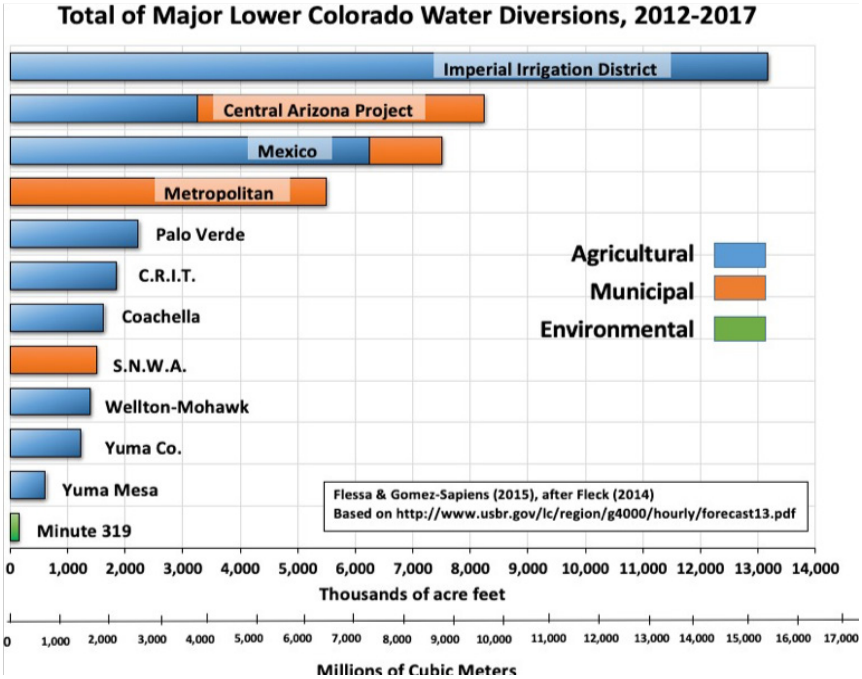
Figure 7. Map of Colorado River Delta Restoration



A small restoration project with the Cucapá Community (who are traditionally subsistence fishermen) is also in the planning phase. Treated effluent has lowered salinity, which may allow more propagation of cottonwood and mesquite trees. The upper estuary work has helped connect the river and the sea, with the involvement of residents. Connection has been reestablished along 13 miles and over 170 days per year.

Flessa is an active member of the Minute 323 monitoring and science team. Besides the Salton Sea and the Delta, the Colorado River actually ends in multiple other places, including San Diego, Tucson, Tijuana, etc.; therefore, you can't solve problems of the Delta in isolation. Major Lower Colorado water diversions from 2012-17, in order of their magnitude, are: the Imperial Irrigation District (IID), CAP, Mexico, Metropolitan Water, Palo Verde, the Colorado River Indian Tribes (CRIT), Coachella, SNWA, Wellton-Mohawk, Yuma County, Yuma Mesa, and Minute 319 (which represents only a very small fraction) (see Figure 8). The good news is that the little bit of

Figure 8. Major Lower Colorado Water Diversions, 2012-2017



water for Minute 319 has substantially restored habitat, although there is an enormous amount of habitat yet to be restored. In the Delta, water is being purchased by NGOs for restoration from willing buyers via the Delta Fund or leased for restoration. The Miguel Aleman restoration site makes particularly efficient use of water. You get more habitat per gallon of water at these restoration sites than anywhere else.

Discussion:

There's a proposal to link two ends of the river by pumping Gulf of California water over divide and down to Salton Sea, undermining the work just described. Is this a real risk?

There are about six desal proposals, but they are probably unrealistically expensive and unrealistic about minimum flows.

Is Salton Sea a problem for California to solve or do we need to think of it as a basin-wide problem?

It started local, then turned regional, now it's a Basin problem. The feds may be trying to avoid it, but they are the largest landowner of the Salton Sea and are going to have to deal with the bad air quality. But any successes can be translated to other areas.

The New River starts on the Mexico side, and goes north to the Salton Sea, making it a binational issue. Its main issue has been water quality, which has been improved by Mexico.

H. IDEAS FOR THE FUTURE, PART 1

1. Climate Risk on the Colorado (Season Martin, Martin & McCoy)

Climate uncertainty generates risks to the water supply. CRSS can be used to plan for it and is a widely trusted model. Will our models, including CRSS, adequately incorporate our data and knowledge to project the future in a way that will be useful? What are we planning for? Is it the median line or the variability we are likely to see in the future? Answers to those questions drive the type of solutions we put on the table. If we can deal with the worst conditions and extreme variability, we will have a more robust set of options for management.

2. Rethinking Governance (Andrea Gerlak, Univ. Arizona)

How do we govern water? Think of governance as sum of all the ways institutions and people manage their affairs; water governance incorporates political, economic, social, and administrative systems.

Governance does not equal only government; private sectors and NGOs matter. Colorado River water governance is:

a. decentralized, fragmented, and messy. Quantity issues and management are largely relegated to the states, and quality issues to the federal government. Although we are dependent on the federal government, there is a persistent fear and threat of perceived overreach. There are multiple scales of action and many different stakeholders.

b. increasingly collaborative. It also attracts international attention and interest because of its history and unique regulatory mechanisms.

c. evolving and dynamic. It's all about the process of addressing challenges at hand. The lack of adequate and appropriate governance can hinder achievement of multiple goals, including sustainability, equity, and conservation.

3. Power Markets and Changes in Portfolios (Steve Johnson, Western Area Power Administration)

Efficiency is the big issue for power generation because reservoir water levels are lowering. At 44 pounds per square inch for a 100-foot column of water, if the elevation lowers 100 feet, you lose significant power at the turbine. More water has to move through the system to generate the same amount of energy. There are also variability/reliability concerns. Especially in the smaller Upper Basin reservoirs, a string of a bad years could wipe out power generation.

4. Defining and Protecting Cultural and Existence Values of the River While Addressing Water/Energy Issues (Bidtah Becker, Navajo Tribal Utility Authority)

The Navajo Tribal Utility Authority (NTUA) was created 60 years ago to provide power to a hospital in Shiprock. It is now a billion-dollar company providing six utilities (photovoltaic, electric, water, wastewater, natural gas, telecommunications) in a service area the size of West Virginia. The Navajo Nation is at the heart of the river, spanning both the Upper and Lower basins. They are working on adjudicating water rights throughout the reservation. Macro issues for the tribe are the Navajo Generating Station – which is set to close next month – and the Four Corners Generating Station. The Nation does not use the power generated from these two

facilities, but both use a large amount of water. Most of the Nation's power comes from solar farms and Colorado River Storage Project Act hydropower; the development of solar farms is a recent shift. Power is needed to move water as well as to cool the power plants.

Discussion moderated by Amy McCoy:

What are the current challenges and how will they persist in future or be replaced by new ones?

- Martin: We have no reference point for the level of risk we will see in the future, due to climate change. The first step is to acknowledge that everything will be different. The second step is to create spaces for innovation.

- Johnson: From a grid operations standpoint, the changing energy mix is a big challenge. We are losing some sources of energy. Coal has competition from cheap natural gas, the renewable portfolio is increasing and making a glut of energy, plus nobody wants to take on long-term debt to start a new coal plant. We're losing traditional generation and the ancillaries that go with it. With wind and solar you'll have much larger frequency deviations and we're losing the capacity to recover from that. Energy prices are trending down. The Kw hour, which has been the operating standard, is becoming worth less and less. The capacity that is left is undervalued for what it does to keep the grid running. We need new tools. We have scheduled the grid on an hourly basis in the past. Now it needs to be done much more quickly than that, but renewable energies bring intermittency issues. Physics and the laws of thermodynamics constrain what we can do. With respect to the Colorado River, we have to figure how to build relationships to have critical conversations. There's no perfect solution, but there will be a best one. Consider the risks and benefits as a group.

- Becker: There are generational issues at Navajo: 20 to 40 percent of residents lack electricity or running water or telephone. The San Juan settlement is geared toward bringing clean water supplies to people. In addition, NTUA saw an opportunity to improve power supplies to the Nation through the water project authorized by the San Juan settlement. The Navajo Nation is in an interesting place in that it is taking more depletions rather than less; tribes have to be able to rise socioeconomically. The "Light up Navajo" project brings free labor to reservation to help with this. Tools are more of a concern than risks. It would be nice to have a holistic approach to solving Basin issues. Navajo Nation issues are an outgrowth of the big-growth focus following World War II: we want to be raised to the same standards as rest of the US.

- Gerlak: For governance, start from a place that is transparent, fair, equitable, and sustainable. Two main challenges: 1) How can we foster and maintain a more inclusive and participatory process? There are lots of good thinkers on this (e.g. John Berggren, David Getches) 2) How do we ensure fairness and equity in the process and outcomes? Provide adequate time for debate, recognize diverse values, etc.? Remember there will be unintended consequences and outcomes of decisions. We can be reactive and wait until people complain, or we can be proactive and intentional. Who is missing from the discussion and who needs to be involved? Who benefited last time? There is room for experimentation in engagement.

What proactive opportunity would you put forward for this conference?

- Martin: 1) Improve the quality of data and tools and create new tools. In the Colorado Basin, all models are wrong, but some are helpful. 2) Have conversations that look at full range of

possible futures and be willing to ask questions and learn from the answers, especially in a climate-risk sense. How does climate risk translate to water supply and how does it impact economics, equity, and turning investments back into the basin? Use systems thinking.

- Johnson: The kW hour downtrend will continue. Hydro capacity will be valued more highly. Another component is the social cost of carbon. What if it leads to a carbon tax? In hydropower, the kW hour could morph into something not yet known or some type of hybrid in electricity. Ramping quickly up (e.g., at sundown) is valuable to grid stability. Battery technologies are lagging and so is their scale. Be careful of lithium ion technology and its environmental impacts. Storage of large-scale solar also is an issue. Integrate tools to manage the risk in the market. We need to collaborate and have the hard conversations. We're at an interesting crossroads as an electrical industry; global energy demand is expected to double by 2035.

- Becker: What are the various tools, and how do we combine them? Outside-the-box thinking is needed. What haven't we considered yet? How do we bring the conversation about driving capital to this basin? How do we drive it to areas that need capital up and down the river?

- Gerlak: The opportunities are: 1) practical: Invest in, build, and experiment with new governance mechanisms that are more attuned to learning and more adaptive. They should be able to shape the current governance structure, build processes within them, and adjust as they go; and, 2) research: study how learning and adaptive learning happens in organizations. This can shed light on individual and group behavior. For example, how did the Arizona DCP process work and how can lessons learned there inform future collaboration? Social science is useful for looking at organizations describing how structures work, what to change, what works, and how certain groups are more vulnerable.

Discussion with Audience:

How will the future of hydropower translate into downstream flows?

Rate payers are what keeps us going; the customer base has to buy into any changes. One of the unique things about Reclamation dams and power plants is that they are fully self-funded. Any change in operations will have impacts. With higher penetration of wind and solar energies into the market, the ability to ramp up units quickly will be key.

Regarding the water and energy nexus: if the Navajo Generating Station is powering down, what is the future of the water that was used there?

Of the 50K af of water used, the Navajo Nation is using 20K; this includes groundwater that is not from Lake Powell. What's challenging to the Navajo Nation is the Upper Basin/Lower Basin distinction since the tribe straddles both basins. It can't just be exported out of the Upper Basin, even though communities just south of Lake Mead need the water. Capital is what drives the challenge; tens of millions of dollars would be needed to build a delivery structure to move water just one to two miles from Lake Powell.

There has been conversation about forming a market around water surges. Is there a need for more flexibility or would that minimize the need for flexibility in dam operations?

The closer we can track our customer base and demand, the better off we will be. If customers want different products or hours, we should listen. With massive solar and wind, the ability to flex fast-ramping units will be very important and increasingly valuable.

I. IDEAS FOR THE FUTURE, PART 2

1: The Gila River Indian Community Settlement (Gov. Stephen Roe Lewis, Gila River Indian Community)

The Gila River Indian Community Water Rights Settlement – the biggest Indian water rights settlement in US history – was approved and implemented by the Arizona Water Settlements Act of 2004. This has been a generational battle, and implementation (turning "paper" water into wet water) has been as difficult as the negotiations were. The agreement provided the Gila River Indian Community with a water budget of 653,500 acre-feet of water annually. The budget is composed of water from the Central Arizona Project, the Gila River, the Salt River, and groundwater. The agreement resolved water rights claims filed by the Gila River Indian Community (GRIC) and the United States to over 1 million AF of water. The federal government obligation is $200 million.

2: Managing the River for Multiple Uses (Ronda Newton, National Park Service)

The US National Park Service has to balance the management of natural and cultural resources with recreational opportunities, using the best available science. The NPS shares concerns about climate change and water availability, resources and recreation in Grand Canyon and Glen Canyon, and effects to recreation and regional economies around Lake Powell and Lake Mead; and if Flaming Gorge is re-operated, recreation and resources in Dinosaur NM and Canyonlands NP. The NPS is ready to work with partners to figure out where our shared concerns are and how they can be approached. At this point, we are not taking a position on specific flow regimes, but we are just pointing out effects that we are aware of and we want to listen how different flows affect others. We know the magnitude and frequency of the flows can greatly influence the resources and recreation in our parks. Our GRCA and GLCA world-class resources are important to those who may only get one chance a lifetime to experience the canyon. We know a lot more than we did in 2007 about how the magnitude and frequency of flows affect the resources in the canyons. Lake Mead and Powell affect the whole region economically with the tourism they bring to the areas and the annual volumes affect the lake levels that can influence that tourism. NPS wants to be very involved and wants to work collaboratively with others - we understand that ours are not the only concerns, but we can contribute much critical information to decision making. Although we have focused on our concerns, we recognize climate change, water availability, water quality, drought, water temperature, etc., are concerns we all share.

3: Municipal Solution Ideas (Colby Pellegrino, SNWA)

SNWA is responsible for a large portion of Nevada's entitlement to Colorado River water. It also oversees municipal conservation programs. Municipal conservation requires doing more with less, regardless of the sector or whether your demand is growing or shrinking. SNWA focuses on outdoor landscaping, which has been generally very effective in Las Vegas. However, there are limits. Cooling technology is an exciting area that has been so far unutilized as a program option in the US, although cooling is the second largest use of water in the West. When looking at ways to save water, people tend to look at what is the least water-intensive method based on the total water use. Instead, we need to look at consumptive use (regardless of total water use). As cooling demands are going to increase, we need to focus on conserving water for cooling in the future. We underestimate the "coalition of the willing" to get things done. Not everyone in entire basin has to agree to have a successful conservation program.

4: Incorporating Recreation Objectives in Adaptation Options (John Weisheit, Living Rivers)

Moab, Utah, is a poster child for the recreation industry. The recreation infrastructure there outweighs the residential infrastructure. The area has two national parks, three rivers, three BLM Resource Areas, a National Forest, and pristine wilderness. Recreation can have both positive and negative consequences on communities and the environment. Attitudes began to change in the late 19th century, when Americans found value in public lands and sought to defend and preserve them. Wallace Stegner referred to our public lands as the "Geography of Hope." John Muir maintained that outdoor recreation was a necessary element for human health, "…try the mountain passes. They will kill your cares, save you from deadly apathy, set you free, and call forth every faculty into vigorous and enthusiastic action." In Moab, recreation has stimulated an affordable housing crisis and traffic jams and caused water and air impacts, but the community is being proactive about addressing environmental challenges. For example, this community led a campaign to remove 16 million tons of uranium mill waste from the floodplain of the Colorado River. The needs of recreation are best satisfied by environmental laws such as the ESA, environmental flow regulations, salinity control, the Clean Air Act, and the Clean Water Act. If these public laws are functional and enforced, the recreation industry is healthy.

5: Agricultural Contributions to Water Sustainability (Tina Shields, Imperial Irrigation District)

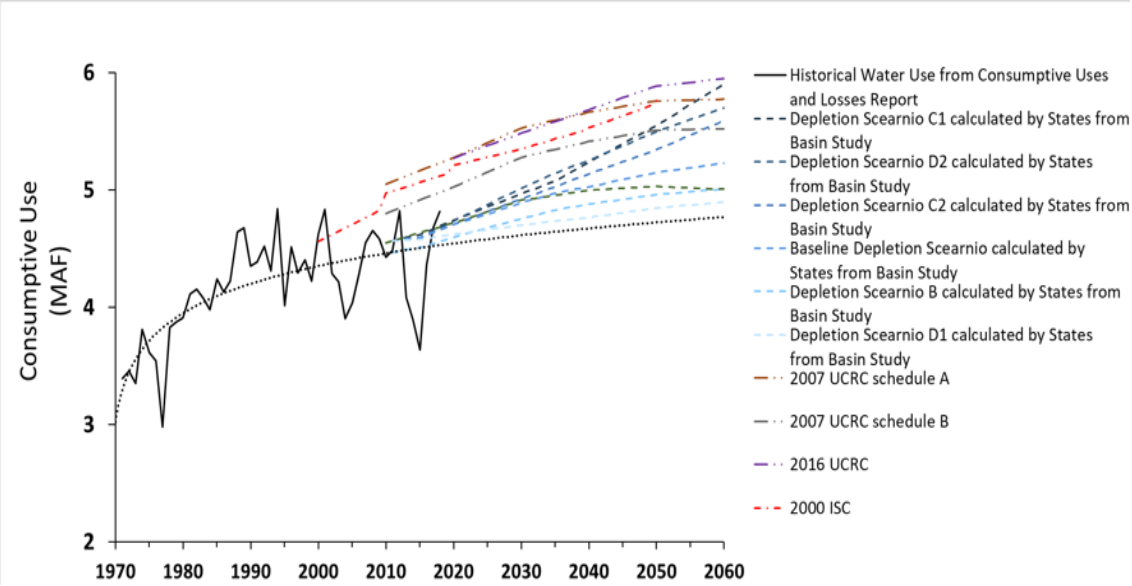
Agriculture is often seen as a reservoir for future urban water needs. IID faces many challenges because its senior water rights to the Colorado River make it a target. "Fallowing" and "forbearance" are the two "f-words" in the Valley: it is offensive to tell a farmer to "buy and dry," meaning to fallow their land.

Opportunities for partnerships exist between the IID and other Colorado River stakeholders. IID is shifting to less prescriptive programs that are continually updated. Farmers require certainty to have a viable business. If you want the support of agriculture in discussions on the future of the Colorado River, be there in both the good and bad times; farmers need the certainty of long-term relationships. Money raised through various fees and programs is used for community benefit. Many old irrigation systems haven't been updated, so IID and farms have begun to implement SCADA systems and other improvements. Overall, growers need to be brought into the conversation about the future of the river; allow them to be creative with how they can use less water.

6: Colorado Water Futures: Let's Talk Uncertainty (David Rosenberg, Utah State)

Water resources systems analysis allows researchers to see how components of rivers work together, synergistically or not. Rosenberg has been working on modeling the Colorado River's future system through the Colorado River Futures Project, with the goal of improving river systems and not harming the water supply. The approach embraces uncertainties so they can be discussed. Where there are many uncertainties, as in the Colorado River (e.g., in objectives, policies, ecosystem conditions, the reservoir/energy relationship), it is useful to further classify them to inform the scenario discussion (for example, as low-probability/high-consequence). There are many ways to model these concepts: statistical modeling can be used to model probabilities (see Figure 9) while robust decision-making can help to understand and weather potential futures.

Figure 9. Upper Basin Consumptive Use and Forecasts.



Discussion and Questions from Audience (Laurna Kaatz, Denver Water, moderator)

Some areas within IID have a bad economy and high unemployment. What will the changing nature of agriculture and the water picture mean in terms of exacerbating this situation?

The county is working to help develop agriculture-related facilities to support the economy. (Hemp is the new savior crop, tax revenues are enticing, and organics are effective.) Farm service providers are the most impacted. The area is trying to leverage water and water rights for the community benefit. El Centro is a challenging location for economic development, but it is a priority.

How do we better engage agricultural entities in a more productive and participatory conversation about reducing water use?

It can be hard to engage growers. Incremental programs tend to work well; huge programs are not necessary. Allow agricultural entities choices. Start at their level and don't be prescriptive. Bottom-up approaches are best.

What role did the Gila River Indian Community (GRIC) play in the development of Arizona's DCP?

It was very significant; tribes are the original innovators, tracing back to Hohokam canal constructors. State leadership was willing to work with GRIC. Tribes in fact never get their original water rights back. They have large in-lieu-of-water supply. So GRIC is now the largest recipient of river water through the CAP. Arizona's goal was protecting elevation levels in Lake Mead. GRIC proposed testing managed aquifer recharge (MAR) systems along the original Gila River, allowing Arizona to take less water and store it in Lake Mead. This is the future. It is our moral imperative to have water as a self-sustaining resource and not have it taken away because of poor planning or politics or bad policy that doesn't account for history or the future. We have to keep moving forward with new guidelines. Three Arizona tribes have more water guaranteed than the state of Nevada. Tribes have to be at the table, not an afterthought.

What is the next frontier of water efficiency and demand reduction for municipalities?

It's very community-specific and hard to generalize. Southern Nevada is dependent on its return flow ability. But overwhelmingly, the Southwest needs to stop acting like it's Kentucky. We don't need to grow Kentucky bluegrass everywhere. Tucson is proactive, but Nevada still has miles of grass medians. Transform our landscapes first, then figure out cooling. Cooling demands will go up and is already the second most demanding consumptive use.

Briefly, what are the ideas the conference participants should think about? What is your "provocative thought"? (Addressed to both panelists and audience.)

- Learn, adapt, innovate. The path forward is to identify our current constraints.
- Deal with difficult issues up front, such as the Salton Sea.
- Small actions can have surprising consequences both positive and negative. The introduction of exotic fish for sports fishing created the ESA from the Wilderness Act. NPS is now eradicating brown trout below Parker Dam – it was an incredibly bold move by NPS to make that decision. Cold water fisheries should not be located below dams; instead native fish.
- Solid and consistent funding is the big limitation to great successes.
- Generational change is happening in agencies; we need to cope with doing more with less.
- States and all stakeholders must view tribes as equal partners and involve them early on.

J. IDEAS FOR THE FUTURE, PART 3

Moderator questions (Steve Wolff, State of Wyoming, moderator)

- What is the current state of the river in your perspective?
- What is your vision of success in the next 20 years for the river?
- What are the biggest challenges to obtaining that success?

1: Integrating Mitigation Objectives (Taylor Hawes, The Nature Conservancy)

TNC goals are flexibility, resiliency, sustainability. Both temporary and permanent solutions are needed. The challenge is that we're reacting to climate change and we'll never catch up in efforts to adapt. Can we foster solutions that incorporate both mitigation and adaptation? TNC recently tried this by bringing together people from different sectors for small group discussions. They assumed that a more substantial outcome could result if they addressed underlying causes of climate and that broader partnerships and representation could benefit and educate all sectors. This could bring more political will and resources to the issue; there is substantial private interest in addressing climate issues (as well as water), especially by seeking more permanent fixes. Talking about climate change is complicated and fraught; the clear nexus of climate and water might make it easier to both focus discussions and produce clear outcomes.

Three ideas rose to the top of discussions: 1) regenerative agriculture (as described in Drawdown [Hawken, 2017], and which uses no tillage, diverse cover crops, in-farm fertility [no external

nutrients], no pesticides or synthetic fertilizers, and multiple crop rotations) – it's unclear if this can work in the West, but may work better for row crops; 2) more holistic forest management – especially in Upper Basin forests, this could increase water security, provide community benefits, and prevent catastrophic wildfires; 3) addressing coal plant closures in a new way – coal plants often have significant water rights, will likely be replaced with renewables, and communities will have to transition to new economies. Help them site and permit the renewable sources and acquire rights to make system more sustainable.

2: Collaborations with Mexico (Carlos de la Parra, El Colegio de la Frontera Norte)

Minute 323 extended Minute 319 for nine years and implemented a binational water scarcity agreement if the Lower Basin states were successful in achieving a DCP, but the reality is, it is all temporary. The Colorado River is a watershed in transition in terms of guidelines and management. Mexico is trying to shift from a reactive mode to dealing with the reality of climate change. The agricultural community is also in transition and Mexicali farmers are demographically different from those in Imperial Valley.

Environmental restoration is in flux and there is a need to think beyond individual projects and the successes of Minute 319. Ninety-seven percent of the Colorado Basin is in the US, but Colorado River issues in Mexico are not as simple as they appear and US issues may not be as complex as they seem. Bilingual and bicultural translation and dialog are needed.

We need to go beyond thinking in terms of "conservation" to think instead about a new regime. Consider something like a water intensity index, sort of a BMI for water. Demand management will be evolving; there are so many artificial systems in the Colorado River that we can tweak elements of the system to make it more of a river and less of a water management project.

In the future, need to consider Mexico right from the start when considering new guidelines. Mexico is struck by the similarities between its role and participation status and those of tribes. Mexico wants to participate in the post-2026 discussions and to be involved in the many planning teams. Participatory diplomacy worked in Minute 319. Salinity is still a big issue in Mexico and many have been involved and those participants and advocates can be a valuable resource. How do we reconcile that the 1.3 MAF of sewage that is dumped into the Pacific Ocean by California every year is almost equal to Mexico's share of Colorado River water? Mexico holds only three percent of the Colorado River Basin land, yet it is viewed by many in US as a source of water. Augmentation through desalination from Mexico is an idea that still needs to be tested and researched.

3: A California Municipal Perspective (Bill Hasencamp, MWDSC)

Status of the River: Metropolitan Water District (MWD) manages half of the water supply for the 19 million people in Southern California. Water demand in Southern California has dropped significantly in the past 17 years, from a regular 1.2 MAF diversion of Colorado River water annually to a variable diversion that in 2019 is approximately 0.5 MAF (the lowest since 1957). This year, 75% less water is coming from the Colorado compared to the past, despite increasing regulations, population increases, and wildfires. Demand for this source is expected to continue to go down. California is also planning the largest water recycling center in the nation. This is all good news.

Metropolitan Water partners with agriculture such as IID and the Coachella Valley Water District; they get the water they need and agriculture gets the financing they need. But there are clearly differences in perspective between agricultural and municipal entities. DCP was a great achievement for protecting Lake Mead and Lake Powell, but promoted more regionalism and factionalism at the expense of a unified vision of the Colorado River. There is still too much Upper Basin vs Lower Basin thinking and management, for example, and states figure out their cuts for themselves. IID and Metro were unable to come to agreement and there is litigation. If IID were part of the DCP, water levels would be higher. Whatever is done should benefit the whole and the benefit should be shared by all parts.

The System Conservation Agreement*** was a success; a pot of money was made available by the federal government for states to conserve water through voluntary participation. All states benefited from that pooling; all of us need to be better off and not left behind. How can we have a regional approach that doesn't leave people behind who could be part of the solution? Also, urban and agricultural entities have made good efforts to reduce water use but there is a new trend and threat from investors looking to capitalize on water rights by using more water to sell it at a greater profit in the future. Can we keep people from this investment strategy while solutions are being debated?

4: Navigating Water Markets and Water Transfers (Bonnie Colby, Univ. of Arizona)

What is water, money, and risk trading? It is paying for access to more water and/or more reliable water. This includes buying and leasing water rights (which are 95% of water transactions). Transactions also include paying for agricultural changes in water management and more contingent contracts, which are becoming more common.

Improved water trading will matter in era of uncertainty and extreme events. Trading will be an important part of future shortage sharing agreements, with more partnerships that not only include agriculture and urban users but also tribes and NGOs. Water markets were the rage in the 1980s, but "water markets" and "water trading" are becoming antiquated terms; now we see negotiated agreements for specialty needs. Pricing patterns are more rational and nuanced, reflecting wet/dry cycles and economic cycles that affect farm profitability. Environmental transactions have become more prominent, with states working on policies to reduce "buy and dry" transactions.

Sellers worry about selling water too low; buyers about paying too much. There is no transparency in prices. This anxiety can be reduced by indexing water payments to annual economic water supply/demand conditions in settlement provisions (when the economy changes, values and prices change). GRIC was the first entity to use this in water settlement provisions. Failure to provide a pricing adjustment formula destabilizes agreements. Next steps: water trading mechanisms to address groundwater decline work on neuroeconomics, use of innovative contingent transactions such as a small fee on transactions to fund social justice and environmental water programs in the basin.

*** A Pilot Program for Funding the Creation of Colorado River System Water through Voluntary Water Conservation and Reductions in Use, signed in 2014 by Reclamation, the Central Arizona Water Conservation District, Metropolitan Water, SNWA, and Denver Water. It marked the first time that water agencies from both the Upper and Lower basins and Reclamation agreed to jointly fund voluntary water conservation projects.

5: Managing the River as a System (Matt Rice, American Rivers)

Status of the River: He is hopeful about current state of river, as evidenced by the DCP approval in relatively short order; municipal conservation putting less demand on the river; and growing collaboration and trust among different stakeholders. American Rivers has made progress in this realm through storytelling, as NGOs have in the Delta. Stories such as how pulse flows reconnected people to the river can help engage more people in Colorado River decisions.

The health of rivers should be prioritized in management decisions that go beyond the operation of dams and reservoirs. How can we protect our last and best rivers? Think about this now as we plan for scarcity and about broadening participation in guideline development. In the future, funding should be reliable and sustainable for demand management and to address infrastructure needs. Without funding the stakeholders will be difficult to engage.

Discussion (Steve Wolff, State of Wyoming, moderator)

Regarding water transfers/markets: how can models and decision-makers take account of externalities on surrounding communities that are losing water?

- Metropolitan Water, SNWA, and Denver Water marked the first time that water agencies from both the Upper and Lower basins and Reclamation agreed to jointly fund voluntary water conservation projects.
- A Metro Water District partnership with Palo Verde Irrigation District provided financial compensation for communities that would be impacted by fallowing. A local board independent of the irrigation district was set up to deal and offset these impacts. The effort was funded with $6 million, half of which has been distributed in the form of loans. Another option is rotational fallowing, which allows farmers to stay in business and keep a percentage of their land active. Rural America needs a lot of investment.

Having journalists at conference like this could be helpful rather than excluding them for reasons of confidentiality. What do you all think?

American Rivers would like to see more journalistic coverage of the Colorado River. The Walton Family Foundation has helped to expand coverage and attention, but there are still trust issues. Young journalists should be mentored and cultivated by the conference participants. It is better to fund environmentalists to become journalists or use a seasoned communicator who is also an environmental advocate?

III. CLOSING REMARKS

(Moderated by Eric Kuhn)

The Colorado River, whose legal framework was based on an allocation of 17.5 MAF of water is now over-allocated and faces a future of great complexity. Negotiations for a post-2026 river will rival the importance of 1922. What are panelists' takeaways from this meeting?

Ted Kowalski (Walton Foundation)

We have come a long way in inclusion for stakeholders in Basin states. New approaches within states will be of mutual benefit for all Basin states. NGOs and tribes are important contributors to determining future of the basin. Litigation is not the way to go; we should be able to control our own destiny through collaboration. Philanthropy and funding support for tribes is essential to support their engagement in the conversations on their own terms. The Walton Family Foundation will be supporting some modeling with Utah State University, including looking at strengths and weaknesses of existing models, including CRSS. The Colorado River can be healthy, support environments, and flow to the sea. Walton is willing to help and support efforts such as this.

John Fleck (Univ. of New Mexico)

Narratives about what we do in the basin matter. We've gone beyond the conflict narrative, that "Water is for fighting over." It is encouraging and notable, as noted by Bill Hasencamp, that Southern California is taking less Colorado River water this year than they did in the 1950s. In many municipalities, water agencies are trying to ensure reliability by investing in portfolios that are larger than they need. This provides space for positive problem solving. Forget about the old narrative; we can use less water and reframe the conversation between rural and urban communities from a zero-sum game. There is also room to address environmental flows. Incorporate climate science in our thinking, decision-making, and governance. Explore the possibilities for better governance.

Carlos de la Parra (Colegio de la Frontera Norte)

"Water and borders do not mix" is an old axiom in environmental activism. Why might it be true? 1) With two different legal regimes you have different regulatory obligations, restrictions, regulations, and management. 2) Separate sets of data may present alternative facts. What are limitations to a truly sustainable river? Enough water for economy, people, and ecosystems. The border may actually have been a boon in saving the Delta; institutions have now broken the mold. Previous bilateral management has transitioned to a regional one. We've gotten past the unilateral decision-making in the All American Canal Lining Project and are looking forward to renegotiations.

Sharon Megdal (Univ. of Arizona)

The binational work on the Colorado River can be a model for other countries, as in Israel and Jordan. The focus on process, trust and respect is valuable.

Neha Gupta (Univ. of Arizona)

Gupta is a PhD student in Hydrology and is supporting the Lower Santa Cruz Basin Study, a

partnership with Reclamation, which is developing adaptation objectives and evaluation criteria for the watershed. Water for the environment has been given a strong voice in this process; she was surprised to find that this has not been a common practice. Restoration sites can do more with less, but it is important not to let existing valued riparian areas degrade. Spatial and temporal data about climate impacts in basins are important and useful, and new tools are available to produce them. Threshold behavior is important.

Environmental resilience can yield co-benefits in water and infrastructure. This translates to the need to develop a Colorado basin-wide River Network that provides concise information across the basin, especially when trade-offs are being considered.

Brad Udall (Colorado State Univ.)

We have focused almost exclusively on adapting to (and not on mitigating) climate change. We are acting as if we feel we have no agency. Emissions are the number one root cause of climate change. We need to deliver the idea to elected decision-makers that inaction on climate change is naïve, dangerous, and unacceptable. Commit to net zero emissions with the rest of the world. Act on this as one voice. The news is bleak (hundreds of millions of people forced from their homes; rising ocean levels; record heat years). The water community has gained respect and should leverage it in a nonpartisan way. As Lincoln said, "We are not enemies but friends. We must not be enemies. Though passion may have strained, it must not break our bonds of affection. The mystic chords of memory will swell again when touched, as surely they will be, by the better angels of our nature."

Laurna Kaatz (Denver Water)

The Colorado is an important basin with issues we cannot afford to wait to address. We need to embrace uncertainty; the future will be more chaotic. And recognize that climate change is here and now. It is not the next generations challenge. The question is how to plan and prepare accordingly while not adding to the problem. What objectives can we identify so that we can prepare for uncertainty? Scenario planning and understanding thresholds can be very useful for what we will be up against.

Beyond merely providing services and supporting users to deal with uncertainty, we must consider **What do we want the future river to look like? How will we get there?** These are the conversations that will resonate between renegotiation and long-term thinking. We have learned a lot in the past 100 years. It will be important to have frank and open conversations about topics such as the structural deficit in a safe environment.

Questions and comments from Audience:

Environmental justice: Environmental enforcement actions are down and communities of color and Native communities have an increased risk from exposure to contaminants, etc. What are your thoughts?

We can't wait for the federal government to be a leader in this. Solutions are coming from the local scale and those voices are needed in the conversation. You can consider multiple objectives. Environmental justice almost never comes up as a topic in federal decision-making. People do not know what it is. It needs to become part of the vocabulary.

The US federal budget deficit this year will surpass one trillion dollars (10% of the economy), with a total national debt at $22 trillion. This is clearly unsustainable. What solutions for the Basin do not include federal funding?

- In the state of Colorado there is a bill to legalize sports betting and put associated fees toward creating a water plan to support the environment. The Walton Family Foundation is also hosting conversations with the Gates Foundation and diverse utilities, environmental groups, and stakeholders, acknowledging that water needs sustainable funding. State funding may become more critical. There can be win-win solutions. Renewable energy and hydropower need to be injected into the funding conversation and not just be an afterthought. A lot of money went into the Arizona DCP from a non-federal funding scheme.
- Thinking big: Do we continue to approach the challenges that face us in the way the problem has been framed by the federal government? The only true expert is nature. The river is not just what is flowing now, it is also what it has been in the past and is in a continual state of flux. The river is telling us that it is changing, that the future is an immense crisis that will happen. That is the message and big idea. We shouldn't be thinking small. How can we get the attention of lawmakers and decisionmakers, to respond to the urgency that we all know it is there? Is there a process that we can do together to start doing exactly that?
- Start with having discussions with the seven Republican senators in the Basin. Speak to them respectfully and forcefully about the issue. Communication and open dialogue are critical.
- Basin states could try to agree on a policy related to climate change and its impact on the basin.
- It's very hard to get resolutions introduced. The Chairman of the Colorado River Water Users' Association (CRWUA) Resolutions Committee could help.
- There is very little agricultural representation in water discussions, but they are a politically powerful sector. They are not receptive to talking about climate change, thinking there will never be a solution to it.
- With the agricultural sector, the discussion needs to be tied to the bottom line… use the right (financial) language for the conversation, which can be relatively straight forward. Find ways to tie the implications of climate change to agriculture and other sectors.

How well did we do in addressing the goals of this conference?

Our goal was to convene conversations, provide a gathering ground for researchers, practitioners and stakeholders who seek innovative ideas for managing the Colorado River's services by:

- Presenting the current state of hydrological, ecological, social, and climate science
- Sparking conversations about management objectives, operations of the Colorado River as a system, and preparing for extreme events
- Generating and discussing alternative approaches to river management for consideration
- Respecting cultural and spiritual values

Participants agreed that the discussions did address all of these goals and thanked the organizers.

IV. REFERENCES

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V. ACKNOWLEDGEMENTS

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We appreciate the support of Mary Black, who produced this summary report from multiple sources of notes. She did an excellent job with a difficult assignment and we appreciate all of the work she put into this.

Amy McCoy and Season Martin of Martin & McCoy were instrumental in developing the entire event and for ensuring its success. They are amazing partners and demonstrated real-time adaptive qualities in leading the conference and scenario planning workshop to a successful conclusion.

Also, many thanks to our panel and breakout facilitators, who all stimulated excellent conversations:

- Andrea Gerlak
- Neha Gupta
- Laurna Kaatz
- Vineetha Kartha
- Eric Kuhn
- Season Martin
- Amy McCoy
- Matt McKinney
- Mariana Rivera-Torres
- Seth Shanahan
- Tim Thomure
- Steve Wolff
- Charles Yackulic

Thanks to our notetakers:

- Mary Black
- Chris Freimond
- Neha Gupta
- Maggie Heard
- Amanda Leinberger
- Adrianna Nicolay
- Garrett Rapp
- Mariana Rivera-Torres
- Sean Schrag-toso
- Mira Theilmann
- Madeleine Zaritsky

And a huge thanks to the Institute of the Environment (and its successor, the Arizona Institutes for Resilient Environment and Societies) and the entire Operations team, with particular note of the efforts of Liz Marsalla, Maggie Heard and Maya Patterson.

Finally, the success of this event was absolutely dependent on the efforts of Amanda Leinberger, the Adaptation Program Manager at the Center for Climate Adaptation Science and Solutions. Her attention to every detail of the logistics and the program management was amazing and we are all grateful.

October 28-30, 2019
ENR2 Building, 1064 E. Lowell St.
University of Arizona, Tucson, Arizona

Welcome to the Colorado River Conversations: Integrating Science and Identifying Solutions Conference!

Our goal is to convene conversations, provide a gathering ground for researchers, practitioners and stakeholders who seek innovative ideas for managing the Colorado River's services by:

I. **Presenting the current state of hydrological, ecological, social, and climate science**
II. **Sparking conversations about management objectives, operations of the Colorado River as a system, and preparing for extreme events**
III. **Generating and discussing alternative approaches to river management for consideration**
IV. **Respecting cultural and spiritual values**

APPENDIX A: AGENDA

Monday, October 28

11:00 – **12:00** *60 min*	Registration open	S107
12:00 – **1:00** *60 min*	Lunches available	S107
Welcome and Introductions		
1:00 – 1:50 *50 min*	**Welcome, Agenda and Purpose of Meeting** Kathy Jacobs, Center for Climate Adaptation Science and Solutions (CCASS), Univ. Arizona Amy McCoy, Martin & McCoy Season Martin, Martin & McCoy **Blessing** Austin Nunez, San Xavier District, Tohono O'odham Nation **Logistics** Amanda Leinberger, CCASS, Univ. Arizona **Self-Introductions** **River Introduction**	S107
Opening Panel: Visions of the River in the Future/Desired Outcomes		
1:50 – 3:00 *70 min*	**Reframing Solutions:** Peter Culp, Culp & Kelly, LLP **Redefining Stakeholder Engagement:** Kathy Jacobs, CCASS, Univ. Arizona **Institutional Resilience/Collaborative Governance:** Mike Connor, WilmerHale **Tribal Insights:** Daryl Vigil, Jicarilla Apache Nation **Next Steps in Binational Collaboration:** Jayne Harkins, IBWC Commissioner **Discussion** *Moderated by Tim Thomure, Tucson Water	S107

3:00 – 3:20 *20 min*	NETWORKING BREAK	S107
Panel II: Climate, Hydrology and Social Science Updates		
3:20 – 5:30 *130 min*	**A Virtual Tour of the Colorado River:** Jack Schmidt, Utah State **Efforts Led by the Basin States and Municipal Agencies:** Seth Shanahan, Southern Nevada Water Authority - **State of the Science Report:** Jeff Lukas, Western Water Assessment & Liz Payton, Univ. Colorado **Science Efforts Led by Reclamation:** Jim Prairie & Rebecca Smith, U.S. Bureau of Reclamation **Other Research Updates:** - **Impacts of Temperature on Colorado River Flows:** Brad Udall, Colorado State - **Evolving Approaches to US-Mexico Water Management:** Mariana Rivera-Torres, Univ. Arizona - **Dynamics and Predictability of Streamflow:** Balaji Rajagopalan, Univ. Colorado - **Institutional Perspectives and Stakeholder Perspectives on Hydropower:** Surabhi Karambelkar, Univ. Arizona **Discussion** *Moderated by Kathy Jacobs, CCASS, Univ. Arizona	S107
5:30	ADJOURN	S107
5:45	**Leave for dinner at Culinary Dropout** Bus leaves from pick-up area beneath 6th Street Parking Garage on the south side and will return to both the Marriott and the Parking Garage after the event	6th St. Parking Garage Bus Bay

Tuesday, October 29

8:00 – 9:00 *60 min*	Breakfast available	S107
9:00 – 9:05 *5 min*	**Welcome Back, Overview of the Day** Kathy Jacobs, CCASS, Univ. Arizona	S107
Overview of the Coordinated Operations of Lake Mead and Lake Powell and Lessons Learned Since 2007		
9:05 – 9:55 *50 min*	**Upper Basin Lessons/Perspectives:** Don Ostler, Upper Colorado River Commission, retired **Lower Basin Lessons/Perspectives:** Nicole Klobas, Arizona Department of Water Resources & Chuck Cullom, Central Arizona Project **Discussion** *Moderated by Vineetha Kartha, Arizona Department of Water Resources	S107
Planning Scenarios: Climate Variability and Extremes - Preparing for Floods and Droughts, Managing Ecosystems (and many other factors)		
9:55 – 10:10 *15 min*	**Nightmares, Scenarios and Next Steps – Walton Colorado River Conversations Project** Andrea Gerlak, Univ. Arizona; Mariana Rivera-Torres, Univ. Arizona; Amy McCoy, Martin & McCoy; & Season Martin, Martin & McCoy *Moderated by Kathy Jacobs, CCASS, Univ. Arizona	S107
10:10 – 10:40 *30 min*	NETWORKING BREAK	S107

Ecological Resources: Systems Thinking and Implications for Colorado River Management		
10:40 – 12:10 *90 min*	**Native and Non-Native Species, Biodiversity Objectives:** Tom Chart, USFWS & Scott VanderKooi, USGS **Implications of/for Temperature, Salinity and Sediment Management:** Todd Tietjen, Southern Nevada Water Authority; Don Barnett, Salinity Control Forum; & Jack Schmidt, Utah State **River Restoration for Habitat at the Watershed Scale:** Gabriela Caloca Michel, Pronatura Noroeste & Jennifer Pitt, Audubon **Implications of Revised Guidelines for the Implementation of the LCR Multispecies Conservation Plan:** Chris Harris, Colorado River Board of California **Discussion** *Moderated by Charles Yackulic, USGS	S107
12:10 – 1:00 *50 min*	LUNCH AND NETWORKING BREAK	S107
Salton Sea and Delta Issues and Solutions		
1:00 – 1:40 *40 min*	**Salton Sea Issues:** Thomas Gibson, California Natural Resources **Ideas for the Future of the Salton Sea:** Dan Denham, San Diego County Water Authority **Possible Delta Solutions:** Francisco Zamora, Sonoran Institute & Karl Flessa, Univ. Arizona **Discussion** *Moderated by Seth Shanahan, Southern Nevada Water Authority	S107
1:40 – 1:45 *5 min*	PANEL TRANSITION	S107
Ideas for the Future Part I		
1:45 – 2:40 *55 min*	**Rethinking Governance:** Andrea Gerlak, Univ. Arizona **Defining and Protecting Cultural and Existence Values of the River While Addressing Water/Energy Issues:** Bidtah Becker, Navajo Tribal Utility Authority **Climate Risk on the Colorado:** Season Martin, Martin & McCoy **Power Markets and Changes in Portfolios:** Steve Johnson, Western Area Power Administration **Discussion** *Moderated by Amy McCoy, Martin & McCoy	S107
2:40 – 2:45 *5 min*	PANEL TRANSITION	S107
Ideas for the Future Part II		
2:45 – 3:40 *55 min*	**Managing the River for Multiple Uses:** Ronda Newton, National Park Service **Municipal Solution Ideas:** Colby Pellegrino, Southern Nevada Water Authority **Agricultural Contributions to Water Sustainability:** Tina Shields, Imperial Irrigation District **Approaches to Modeling the Modern River:** David Rosenberg, Utah State **Incorporating Recreation Objectives in Adaptation Options:** John Weisheit, Living Rivers **Discussion** *Moderated by Laurna Kaatz, Denver Water	S107
3:40 – 4:00 *20 min*	NETWORKING BREAK	S107

Ideas for the Future Part III		
4:00 – 5:00 *60 min*	**Integrating Mitigation Objectives:** Taylor Hawes, The Nature Conservancy **Collaborations with Mexico:** Carlos de la Parra, El Colegio de la Frontera Norte **Navigating Water Markets and Water Transfers:** Bonnie Colby, Univ. Arizona **Managing the River as a System:** Matt Rice, American Rivers **A California Municipal Perspective:** Bill Hasencamp, Metropolitan Water District of Southern California **Discussion** *Moderated by Steve Wolff, State of Wyoming	S107
5:00 – 6:30	COURTYARD RECEPTION	1st Floor Courtyard
6:30	Dinner on your own	

Wednesday, October 30

8:00 *60 min*	Breakfast available	S107
9:00 – 9:05 *5 min*	**Welcome Back, Overview of the Day, Breakout Instructions** Kathy Jacobs, CCASS, Univ. Arizona	S107
World Café Breakout Sessions		
9:05 – 10:30 *85 min*	**New Concepts/Principles** (Topics will be selected during the conference; these are examples) - Managing for Extremes - Alternative Allocation/Institutional Approaches - Lessons from Coupled Human-Environmental Systems Approaches - Agricultural Contributions to Sustainability - System Reliability - Water Markets and Water Transfers - Building Inclusive Governance - Energy Issues: Changes in Supply, Demand and Regulation - Municipal Demand Issues and Opportunities *Facilitators: Kathy Jacobs, Amy McCoy, Season Martin, Andrea Gerlak, Mariana Rivera-Torres, Neha Gupta, Matt McKinney	S107 *See color on name tag for breakout group assignment*
10:30 – 10:50 *20 min*	NETWORKING BREAK	S107
Plenary Report-Out and Discussion of Outcomes and Next Steps		
10:50 – 11:20 *30 min*	*Moderated by Kathy Jacobs, CCASS, Univ. Arizona	S107
Closing Remarks Panel		
11:20 – 12:00 *40 min*	Brad Udall, Colorado State Ted Kowalski, Walton Foundation John Fleck, Univ. New Mexico Sharon Megdal, Univ. Arizona Neha Gupta, Univ. Arizona Laurna Kaatz, Denver Water **Discussion** *Moderated by Eric Kuhn, Colorado River Water Conservation District, retired	S107
12:00	ADJOURN Bagged lunches available	S107

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University of Arizona, Tucson, Arizona

Colorado River Conversations: Integrating Science and Identifying Solutions Conference

APPENDIX B: PARTICIPANT LIST

	First name	Last name	Affiliation	Position title	Email address
1	Vic	Baker	University of Arizona	Regents Professor of Hydrology and Atmospheric Sciences	baker@email.arizona.edu
2	Rajagopalan	Balaji	University of Colorado, Boulder, CO	Professor	balajir@colorado.edu
3	Don	Barnett	Colorado River Basin Salinity Control Forum	Executive Director	dbarnett@barnettwater.com
4	Joseph	Barsugli	University of Colorado Boulder and NOAA/ESRL/PSD	Research Scientist	joseph.barsugli@colorado.edu
5	Bidtah	Becker	Navajo Tribal Utility Authority	Associate Attorney	bidtahb@ntua.com
6	Mary	Black	University of Arizona (retired)	Editor/Writer	mblack@email.arizona.edu
7	Keely	Brooks	Southern Nevada Water Authority	Climate Change Policy Analyst	keely.brooks@snwa.com
8	Daniel	Bunk	Bureau of Reclamation	Deputy Chief, Boulder Canyon Operations Office (BCOO)	dbunk@usbr.gov
9	Alan	Butler	USBR	Hydrologic Engineer	rabutler@usbr.gov
10	Gabriela	Caloca Michel	Pronatura Noroeste	Coordinator of the Water and Wetland Conservation Program	gcaloca@pronatura-noroeste.org

	First name	Last name	Affiliation	Position title	Email address
11	Thomas E.	Chart	USFWS	UCREFRP, Program Director	tom_chart@fws.gov
12	Lorelei	Cloud	Southern Ute Tribe	Treasurer	locloud@southernute-nsn.gov
13	Bonnie	Colby	Univ Arizona	Professor	bcolby@email.arizona.edu
14	Mike	Connor	WilmerHale	Partner	Michael.Connor@wilmerhale.com
15	Charles	Cullom	Central Arizona Project	Manager, Colorado River Programs	ccullom@cap-az.com
16	Peter	Culp	Culp & Kelly, LLP	Partner	pculp@ckblueshift.com
17	Carlos	de la Parra	El Colegio de la Frontera Norte	Research Professor	cardelap@gmail.com
18	Jeff	Deems	U. of Colorado & Airborne Snow Observatory	Research Scientist	deems@nsidc.org
19	Dan	Denham	San Diego County Water Authority	Assistant GeneralManager	ddenham@sdcwa.org
20	Charles	DuMars	Imperial Irrigation District	Counsel	ctd@lrpa-usa.com
21	Charlie	Ester	Salt River Project	Manager, Surface Water Resources	Charlie.esteriii@srpnet.com
22	John	Fleck	University of New Mexico Water Resources Program	Director	fleckj@unm.edu
23	Karl	Flessa	University of Arizona	Professor	kflessa@email.arizona.edu
24	Chris	Freimund	University of Arizona	Graduate Student	cfreimund@email.arizona.edu
25	Michelle	Garrison	Colorado Water Conservation Board (Dept of Natural Resources)	Senior Water Resource Specialist, Colorado River Basin	michelle.garrison@state.co.us
26	Andrea	Gerlak	University of Arizona	Associate Professor	agerlak@email.arizona.edu
27	Tom	Gibson	California Natural Resources Agency	Deputy Secretary and Special Counsel for Water	Thomas.Gibson@resources.ca.gov
28	Jennifer	Gimbel	Colorado Water Center	Senior Water Policy Scholar	Jennifer.Gimbel@colostate.edu
29	Robert	Glennon	University of Arizona, College of Law	Regents Professor	glennon@law.arizona.edu
30	Gary	Gold	U.S. Senator Sinema	Policy Advisor	gary_gold@sinema.senate.gov
31	Neha	Gupta	University of Arizona	Graduate Research Assistant	nehagupta@email.arizona.edu

	First name	Last name	Affiliation	Position title	Email address
32	Nadia	Hardjadinata	Metropolitan Water District of Southern California	Resource Specialist	NHardjadinata@mwdh2o.com
33	Jayne	Harkins	International Boundary and Water Commission	Commissioner	jayne.harkins@ibwc.gov
34	Paul	Harms	New Mexico Interstate Stream Commission	Engineer	paul.harms@state.nm.us
35	Mark	Harris	Grand Valley Water Users Association	General Manager	mharris@gvwua.com
36	Christopher	Harris	Colorado River Board of California	Executive Director	csharris@crb.ca.gov
37	Bill	Hasencamp	Metropolitan Water District of Southern California	Manager, Colorado River Resources	whasencamp@mwdh2o.com
38	Lionel	Haskie	Navajo Nation NIIP - NAPI Enterprise	Operations & Maintenance Manager	lhaskie@navajopride.com
39	Taylor	Hawes	The Nature Conservancy	Director, Colorado River Program	thawes@tnc.org
40	Jim	Holway	Babbitt Center for Land and Water Policy	Director	jholway@lincolninst.edu
41	Kathy	Jacobs	Center for Climate Adaptation Science and Solutions, Univ of Arizona	Director	jacobsk@email.arizona.edu
42	Carly	Jerla	Bureau of Reclamation	Program Manager	cjerla@usbr.gov
43	Steve	Johnson	Western Area Power Administration	Senior Vice President and DSW Regional Manager	johnsons@wapa.gov
44	Laurna	Kaatz	Denver Water	Climate Program Director	Laurna.Kaatz@denverwater.org
45	Dave	Kanzer	Colorado River District	Deputy Chief Engineer	Dkanzer@crwcd.org
46	Surabhi	Karambelkar	University of Arizona	Ph.D. Candidate	surabhik@email.arizona.edu
47	Vineetha	Kartha	Arizona Department of Water Resources	Manager, Colorado River Section	vkartha@azwater.gov
48	Jamie	Kelley	Mohave County Water Authority	General Counsel	jamie@jkelleylaw.com
49	Eloise	Kendy	The Nature Conservancy	Senior Freshwater Scientist	ekendy@tnc.org
50	Nicole	Klobas	Arizona Department of Water Resources	Deputy Chief Counsel	ndklobas@azwater.gov

	First name	Last name	Affiliation	Position title	Email address
51	Ted	Kowalski	Walton Family Foundation	Senior Program Officer	tkowalski@wffmail.com
52	David	Kreamer	University of Nevada, Las Vegas	Professor	dave.kreamer@unlv.edu
53	Eric	Kuhn	Author	Former General Manager Colorado River District	glenwoodrek@gmail.com
54	Laura	Lamdin	Metropolitan Water District of Southern California	Associate Engineer	LLamdin@mwdh2o.com
55	Amanda	Leinberger	Center for Climate Adaptation Science and Solutions, Univ of Arizona	Adaptation Program Manager	aleinberger@email.arizona.edu
56	Jeff	Lukas	Western Water Assessment, CU-Boulder	Associate Scientist	lukas@colorado.edu
57	Mohammed	Mahmoud	Central Arizona Project	Senior Policy Analyst	mmahmoud@cap-az.com
58	Season	Martin	Martin & McCoy	Partner	season@martin-mccoy.com
59	John	McClow	Upper Gunnison River WCD; Upper Colorado River Commission	General Counsel; Alternate Commissioner for Colorado	jmcclow@ugrwcd.org
60	Daniel	McCool	University of Utah	Professor Emeritus	dan.mccool@poli-sci.utah.edu
61	Amy	McCoy	Martin & McCoy LLC	Partner	amy@martin-mccoy.com
62	Nora	McDowell	AhaMakav Cultural Society/Fort Mojave Indian Tribe	Project Manager	noramcdowell@fortmojave.com
63	Matthew	McKinney	Water & Tribes Initiative	Co-director	matthew.mckinney@umontana.edu
64	Sharon	Megdal	Water Resources Research Center, University of Arizona	Director	smegdal@email.arizona.edu
65	Paul	Miller	NOAA - Colorado Basin River Forecast Center	Service Coordination Hydrologist	paul.miller@noaa.gov
66	Rebecca	Mitchell	State of Colorado	Director Colorado Water Conservation Board	Rebecca.mitchell@state.co.us
67	Kim	Mitchell	Western Resource Advocates	Senior Water Policy Advisor	kim.mitchell@westernresources.org
68	Andy	Mueller	Colorado River District	General Manager	amueller@crwcd.org
69	Ronda	Newton	Grand Canyon National Park	Research Coordinator	ronda_newton@nps.gov
70	Adrianna	Nicolay	University of Arizona	Graduate Student	alnicolay@email.arizona.edu

	First name	Last name	Affiliation	Position title	Email address
71	Austin	Nunez	Tohono O'odham Nation, San Xavier District	Chairman	agn@waknet.org
72	Don	Ostler	Upper Colorado River Commission	Retired/Advisor	dostler@ucrcommission.com
73	Lane-Keifer	Pablo	Navajo Agricultural Products Industry (NAPI)	Engineer	lkpablo@navajopride.com
74	Liz	Payton	Western Water Assessment	Research Assistant	elizabeth.payton@colorado.edu
75	Colby	Pellegrino	SNWA	Director	colby.pellegrino@snwa.com
76	Bob	Peters	Denver Water	Water Resource Engineer	bob.peters@denverwater.org
77	David	Pettijohn	Los Angeles Department of Water and Power	Director of Water Resources	David.Pettijohn@LADWP.com
78	Jennifer	Pitt	Audubon	Director, Colorado River Program	jpitt@audubon.org
79	James	Prairie	Bureau of Reclamation	Hydrologic Engineer	jprairie@usbr.gov
80	Garrett	Rapp	University of Arizona	Graduate Student	grapp@email.arizona.edu
81	Matt	Rice	American Rivers	Director, Colorado River Basin Program	mrice@americanrivers.org
82	Mariana	Rivera-Torres	University of Arizona	Graduate Student	marianart@email.arizona.edu
83	David	Rosenberg	Utah State University	Associate professor	david.rosenberg@usu.edu
84	Jack	Schmidt	Utah State University	Professor	jack.schmidt@usu.edu
85	Rolf	Schmidt-Petersen	NM Interstate Stream Commission	Director	gloria.varela@state.nm.us
86	Sean	Schrag-toso	University of Arizona	Graduate Student	seanst@email.arizona.edu
87	Seth	Shanahan	SNWA	Colorado River Programs Manager	seth.shanahan@snwa.com
88	Tina	Shields	Imperial Irrigation District	Water Department Manager	tlshields@iid.com
89	Catlow	Shipek	Watershed Management Group	Policy and Technical Director	catlow@watershedmg.org
90	Rebecca	Smith	Reclamation, Lower Colorado Region	Civil Engineer	rebeccasmith@usbr.gov

	First name	Last name	Affiliation	Position title	Email address
91	John	Swett	Bureau of Reclamation	Program Manager LCRMSCP	jswett@usbr.gov
92	Mira	Theilmann	University of Arizona	Student	miratheilmann@email.arizona.edu
93	Tim	Thomure	Tucson Water	Director	timothy.thomure@tucsonaz.gov
94	Todd	Tietjen	Southern Nevada Water Authority	Regional Water Quality Manager	todd.tietjen@snwa.com
95	Tanya	Trujillo	Colorado River Sustainability Campaign	Lower Basin Project Director	tanya@rivercampaign.org
96	Crystal	Tulley-Cordova	Navajo Nation Dept of Water Resources - Water Management Branch	Principal Hydrologist	tulley-cordova@navajo-nsn.gov
97	Dale	Turner	The Nature Conservancy	Conservation Scientist	dturner@tnc.org
98	Brad	Udall	Colorado State University	Senior Scientist	bradley.udall@colostate.edu
99	Scott	VanderKooi	US Geological Survey, Grand Canyon Monitoring and Research Center	Chief	svanderkooi@usgs.gov
100	Julie	Vano	Aspen Global Change Institute	Research Director	jvano@agci.org
101	T. Daryl	Vigil	Jicarilla Apache Nation	Water Administrator	janwaterguy@gmail.com
102	Garrit	Voggesser	National Wildlife Federation	Tribal Partnerships Director	voggesser@nwf.org
103	Jay	Weiner	Quechan Indian Tribe	Water Counsel	jweiner@rosettelaw.com
104	John	Weisheit	Living Rivers & Colorado Riverkeeper	Conservation Director	john@livingrivers.org
105	Steve	Wolff	Wyoming State Engineer's Office	Interstate Streams Administrator	steve.wolff@wyo.gov
106	Charles	Yackulic	US Geological Survey	Research Statistician	cyackulic@usgs.gov
107	Francisco	Zamora	Sonoran Institute	Senior Director, Water and Ecosystem Restoration	Fzamora@sonoraninstitute.org
108	Madeleine	Zaritsky	BASIS Tucson North	Student Volunteer	madeleine.zaritsky@gmail.com