Roadmap for Considering Water for Arizona's Natural Areas

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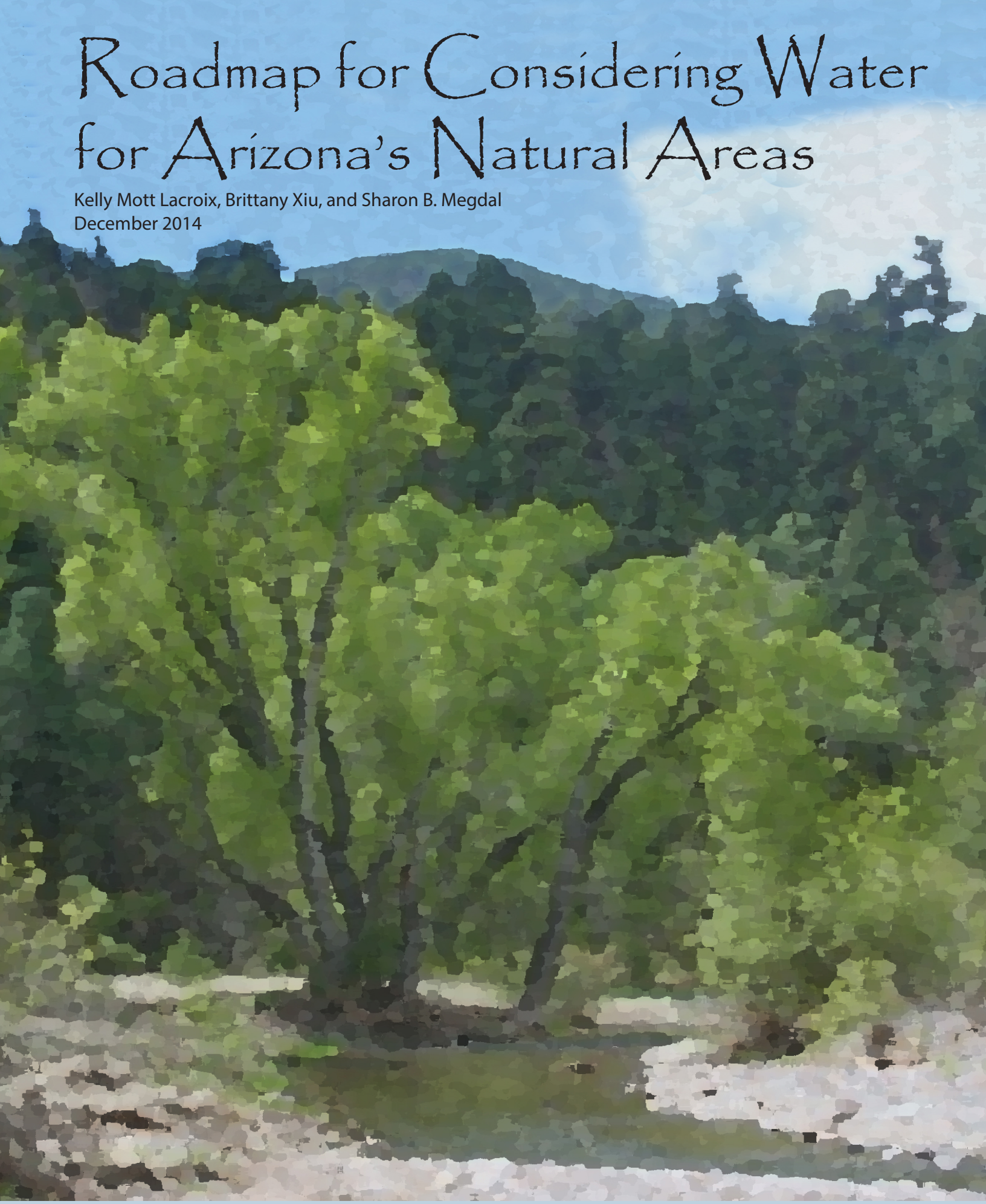

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Water RAPIDS
Water Research and Planning Innovations for Dryland Systems

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The University of Arizona Water Resources Research Center (WRRC) promotes understanding of critical state and regional water management and policy issues through research, community outreach, and public education. The Water Research and Planning Innovations for Dryland Systems (Water RAPIDS) program at the WRRC specializes in assisting Arizona communities with their water and natural resources planning needs. The goal of the Water RAPIDS program is to help communities balance securing future water supplies for residential, commercial, industrial, and agricultural demands with water needs of the natural environment. An electronic version of the *Roadmap for Considering Water for Arizona's Natural Areas* and information on other Water RAPIDS programs can be found at wrrc.arizona.edu/waterrapids

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Front Cover: Blue River, Arizona. Photo by Kelly Mott Lacroix.

Table of Contents

The Bird's Eye View – Executive Summary

In Arizona, as with many other arid regions, there is a dichotomy in the way residents think about natural resources. On one hand, Arizonans take great pride in the natural beauty of the state's landscapes, and on the other, communities rely on the use of those landscapes for economic prosperity. Nowhere is this dichotomy more pronounced than in the demands residents place on the ribbons of green that snake through arid landscapes. Arizona's water resources support crops, cities, and allow industries to tap into other natural resources, like copper. Yet, citizens also want that water to stay in the environment for outdoor activities in and around streams, and for the sake of the ecosystems that depend upon those streams.

The Roadmap for Considering Water for Arizona's Natural Areas contains information on the current scientific understanding of water for natural areas and existing legal considerations for providing water to natural areas, examples of where natural areas are already included in water management decisions, and an overview of available paths forward for including natural areas alongside human uses.

This Roadmap document is the culmination of a three-year project funded by the Nina Mason Pulliam Charitable Trust and convened by the Water Research and Planning Innovations for Dryland Systems (Water RAPIDS) program at the University of Arizona Water Resources Research Center (WRRC). The Roadmap is designed to examine possible routes, as well as roadblocks, to considering the water needs of riparian and aquatic ecosystems in Arizona water management and planning decisions. As there is little in Arizona's legal framework to compel the consideration of water for natural areas, the WRRC sought throughout the Roadmap project to foster dialogue among water users about voluntary, stakeholder-driven options for

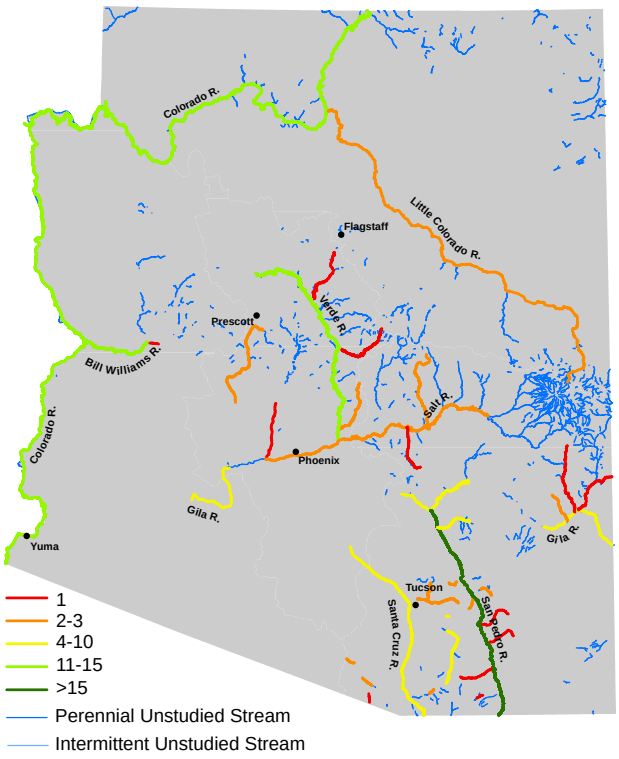
addressing natural areas. This was done within the context of limited water supplies and existing water rights and claims.

One of the most significant project challenges has been finding the right words to use when talking about water for animals and plants that live near and in rivers and streams. During the course of the project, the WRRC has used the terms environmental flow needs, water for water dependent natural resources, and environmental water demand. These terms were confusing to some and distasteful to others, so the WRRC developed new terms in response to stakeholder input. The resulting terminology, *water for natural area*s and *water needs of riparian and aquatic ecosystems*, is used throughout the Roadmap. Water for natural areas refers to water for animals and plants that live near and in rivers and streams; water needs of riparian and aquatic ecosystems refers to how much water is required to keep the animals and plants that live in and near streams healthy over time. Key to this Roadmap is the understanding that the 'water needs' and 'health' of an ecosystem are defined within the context of human priorities.

78% of perennial and intermittent river miles have not been studied for the water needs of riparian and aquatic species.

The project began with an analysis of 121 studies on the water needs of riparian (along the stream) and aquatic (within the stream) ecosystems conducted throughout Arizona over the past three decades. This investigation revealed that 78% of perennial (those that flow year-round) and intermittent (those that flow part of the year) river miles have *not* been studied for the water needs of riparian and aquatic species. Further exploration also found that there are very few analyses of the surface water and groundwater requirements for intermittent or ephemeral (those that flow only in response to a storm event) river systems. Even in the more specific context of aquatic species, there are only limited generalizable data. Similarly, few data are available on the flow requirements for vegetation, with the exception of a few species, such as Cottonwood (*Populous fremontii*) and Willow (*Salix gooddingii*). Statewide, the water needs of only 25% of species have been studied more than once. Gaps in data make it difficult to consider ecosystems in water management; however, a paucity of information on water needs is not the only barrier to considering water for natural areas in management. Perhaps even more challenging is understanding the perspectives of water users and managers toward the consideration of water for riparian and aquatic ecosystems.

Given the scarcity and sometimes competing uses of water, an open discussion about water for natural areas is complex. All water-using sectors, whether municipal,



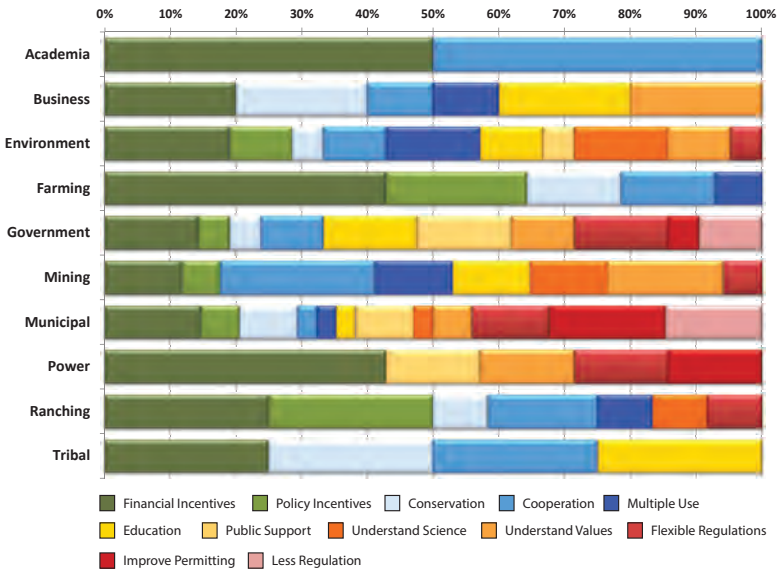
Streams with quantified or described water needs for riparian and aquatic species or ecosystems. Colors indicate the number of studies conducted for each stream.

industrial, or agricultural, have an interest in preserving existing water rights and uses for future growth, new applications, and continued supply reliability. Discussions are further complicated by the variance among and within water sectors on how to consider water for natural areas. In an effort to gather a broad sample of the many perspectives and ideas on considering water for natural areas, the WRRC engaged more than 1,000 stakeholders in project activities, including a survey, individual interviews, focus groups, workshops, and presentations. During this project, participants from academic, business, environmental, farming, government, mining, municipal, power, ranching, and tribal interests volunteered approximately 1,900 hours of their time, with many participating in multiple activities.

In response to questions about how water should be provided to natural areas, participants most frequently discussed the need for cooperation, financial incentives, priority setting, education, and ways to find multiple benefits for each water use.

At the beginning of this Roadmap-building process, a widely-circulated survey indicated that 67% of respondents believed that a lack of data was the driver most likely to discourage consideration of water for natural areas. Further, 83% of respondents indicated that an increased understanding of the connections between water in ecosystems and human well-being would encourage consideration of water for natural areas. More than 90% of survey respondents agreed that changes in climate, growing communities near riparian areas, and rapid expansion of agricultural or industrial water demand threatened water for natural areas.

Many of these concerns were echoed in subsequent Roadmap focus group discussions. For example, 58% of participants were concerned about water security and cited water quality, climate change, increasing human demand, neighboring populations, and cost as the primary reasons for their concern. In response to questions about how they think water should be provided to natural areas, participants most frequently discussed the need for cooperation, financial incentives, priority setting, education, and ways to find multiple benefits for each water use. During these focus group meetings, participants from all water-interest groups expressed frustration over laws that were meant to protect people and natural resources, but ended up pitting water users against one another or creating disincentives. Participants from environment, government, mining, municipal, power, and ranching interests indicated that a solution to providing water for natural areas was to create flexibility within, or reduce the amount of, regulation. Others from environment, government, municipal, power, academia, and tribal interests indicated the opposite, and thought additional regulation that requires water for ecosystems was the best way forward. Perhaps most significantly, no focus group participant said that Arizona should not allocate at least some water to natural areas; however, some participants from the business, farming, mining,



Themes from answers to the focus group question: What would make considering water for natural areas more attractive to you?

municipal, and ranching interests noted that it should not be done at the expense of human populations.

These highlights demonstrate the diversity of ideas presented on how to consider water for natural areas, which illustrates the need for multiple routes forward. Some of these routes will intertwine and overlap, some will run parallel, and others may require the construction of new avenues or the removal of roadblocks. Four principal routes forward, as identified through the Roadmap building process, are to: 1) improve education on the history and importance of water for riparian and aquatic ecosystems; 2) provide funding to maintain water in natural areas; 3) set priorities for water in natural areas through an assessment of how Arizonans value these ecosystems; and 4) manage water supplies for multiple benefits, including natural areas. These recommendations are summarized in Table 1 below.

Table 1: Recommended strategies and action items from the regional workshop series identified three or more times by workshop participants.

Recommendation	*Key Aspects*	*In the Next Year…*
Improve Education	• Across-the-board education about how all water-using sectors benefit natural areas and how they use and conserve water • Education about the history, heritage, and importance of Arizona's riparian and aquatic ecosystems	• Form a water education advisory committee to identify existing programs and resources appropriate for providing the public with foundational water knowledge • Pool resources to create an educational "toolbox" or online clearinghouse for materials • Identify, evaluate, and support an existing program, if a suitable program already exists
Provide Funding to Maintain Water in Natural Areas	• Connect water conservation to preservation of natural areas through allocating the water or financial savings to enhance or preserve natural areas • Offer financial compensation to encourage more efficient use and/or leave water flowing through natural areas	• Examine available options for funding water for natural areas including how a tax credit program for providing water to natural areas would work, the One for the Verde program, and the Conserve2Enhance program • Evaluate existing funding mechanisms to gauge how successful they could be as a large-scale funding source for natural areas, including an assessment of how well the mechanism currently works, what needs to change to adapt it to community/statewide goals, and what should be added so the program can meet those goals
Set Priorities and Assess Values	• Establish a localized process to promote cooperation and collaboration among regional stakeholders • Examine how other areas have established community/regional priorities • Establish a process for all sectors to voluntarily coordinate with one another	• Conduct a statewide survey to objectively assess and rank public values for water and natural areas • Establish regional working groups to: - Create a problem statement based on regional concerns with riparian and aquatic ecosystems - Establish clear goals and objectives to address the problem statement - Identify pilot projects based on the problem, goals, and objectives
Manage Water Supply for Multiple Benefits, Including Natural Areas	• Provide incentives for near-stream recharge and discharge of reclaimed water into natural areas • Ensure reclaimed water would be available long-term • Consider natural areas in stormwater management • Utilize land use planning that considers water resources	• Identify common interests and shared goals about the use of water resources for local ecosystems • Identify existing water use agreements and regulatory constraints that may hinder allocating water to natural areas • Identify a pilot project or area to explore impacts of modified stormwater management and rainwater harvesting on riparian and aquatic ecosystems

Roadmap Recommendations

1. Improving Education on Water Resources and Water for Natural Areas

Although the need for education was a common theme throughout the Roadmap building process, recommended strategies for how to go about education varied among regions and within discussion groups. There was, however, consensus that any educational program should make use of existing resources and involve simple, clear messaging. Two frequently discussed themes were education on: 1) how all water-using sectors benefit natural areas, as well as how they use and conserve water; and 2) the history, heritage, and importance of Arizona's riparian and aquatic ecosystems.

Education: Form a water education advisory committee to identify existing programs and resources appropriate for providing the general public with foundational water knowledge.

The primary recommendation that emerged during the Roadmap development process for improving education on water resources and water for natural areas is to bring people together to identify funding sources, set curriculum, and prioritize desired audiences for an educational campaign. Participants indicated that this should be done by forming a statewide water-education advisory committee, made up of educators, community members, and organizations that have experience communicating information about natural resources. This group could then be tasked with identifying existing programs and resources, such as Arizona Project WET (Water Education for Teachers), appropriate for providing the public with foundational water knowledge, as defined by the committee. These resources could then be pooled to create an educational "toolbox" or online clearinghouse of materials. Once this is complete, the water education advisory committee could assess how each of these existing resources can be used for each target audience and region to prepare for a formal education campaign. One option for such a campaign is to develop a Water 101 course for the public that has both online and in-person program options.

2. Providing Funding to Maintain Water in Natural Areas

Providing financial compensation as a means to encourage efficiency or leave water instream emerged during all phases of the Roadmap development process. For example, focus group participants cited a lack of funding for conserving water, maintaining watersheds, and planning for the future as obstacles to providing water to natural areas. Stakeholders throughout the Roadmap development process also agreed that a financial mechanism is needed to address the disincentives to conserving or discharging water to natural areas.

Not all Roadmap participants were optimistic about providing funding to natural areas. These concerns were based on Arizona's "first-in-time, first-in-right" system of water law, and the difficulty of identifying individuals or organizations with funding and/or water rights to contribute to a program. Additional concerns centered around the longevity of water allocations, incentive programs, and funding sources.

Roadmap Case Study: Las Cienegas National Conservation Area includes a large educational component that has contributed to the project's success. Photo: LCNCA landscape by Shela McFarlin.

To overcome these obstacles, participants cited a need for conversations among senior water rights holders and claimants (including municipalities, agriculture, and industry), natural resource managers, and community leaders. Other groups that were identified as necessary to these conversations were non-governmental organizations, existing conservation program managers, and water providers.

Funding: Evaluate existing funding mechanisms to gauge how successful they could be as a large-scale funding source for natural areas.

Recommended strategies for how funding could be used to provide water to natural areas centered around two approaches: 1) connecting water conservation to preservation of natural areas by allocating the conserved water, or financial savings, to enhance or preserve natural areas; and 2) offering financial compensation to encourage more efficient use and/or leave water flowing through natural areas. Near-term actions for these strategies include a focused conversation on sustainable funding mechanisms for water for natural areas and an evaluation of an existing mechanism, called Conserve2Enhance™, to gauge whether a program like this could be successful as a large-scale funding source for natural areas.

Roadmap Case Study: Conserve2Enhance™ provides an example of a mechanism to encourage voluntary water conservation and allocate saved dollars to natural areas. Photo: Before (black and white) and after (color) transformation of Tucson C2E Atturbury Wash enhancement site by WRRC.

Roadmap Case Study: Verde River Ditch Gates provides an example of how the value of natural areas to the local economy and financial incentives can be used to successfully increase efficiency. Photo: TNC and Diamond S Ditch representatives at new automated ditch gate. Photo by Darin Kopp.

3. Setting Priorities and Assessing Values

The need for establishing priority areas was clear in all aspects of Roadmap development. Though the vast majority of Roadmap participants agree that natural resources should be considered, determining what areas should receive priority, and how community values should be assessed, can be complex. For example, of those that discussed priority setting in focus groups, 70% voiced concerns about providing water to natural areas arbitrarily. These participants emphasized the importance of understanding how much water the flora and fauna need, and setting priorities accordingly. The lack of a central organization or formal process for assessing priorities and values, and a lack of funding to enable the establishment of either, were noted as weaknesses in Arizona's current ability to provide water for natural areas. Another challenge to creating a community organization for priority setting is the lack of a driving force to bring together diverse water interest groups. Many participants agreed that prioritizing water for natural areas should be tied to regional conditions and community values. Priorities could be set based on contribution to the local economy, cultural or historical importance, vulnerability of water for the ecosystem, valuation of the

Roadmap Case Study: Yuma East and West Wetlands Restoration is an example of how the local community used priority setting to benefit residents, as well as the region's aquatic and riparian ecosystems. Photo: Aerial photo of Yuma Wetlands by Fred Phillips.

ecosystem itself, or likelihood of conflict between human needs and the water natural areas need to survive.

Priority Setting: Conduct a statewide survey to objectively assess and rank public values for water and natural areas.

Recommended strategies for establishing priorities and assessing values include: 1) establishing a localized, voluntary process for all water-using sectors to promote cooperation and collaboration among regional stakeholders; 2) examining how other states have established community or regional priorities; and 3) conducting a stakeholder survey. To implement these strategies, a statewide survey could be conducted to assess public values for water and natural areas. Results from this survey could be used by communities to set regional action items in motion, including a more detailed exploration of regional priorities and valuation of water for natural areas. This effort should be led by voluntary partnerships, composed of diverse interests from the community, as well as professional advisors, in the form of regional working groups. Each of these groups should create a problem statement based on regional needs and set forth clear goals and objectives for addressing that problem statement. Finally, the regional working groups should facilitate an iterative dialogue to identify pilot projects based on the problems, goals, objectives, and plans for considering the regional water needs of natural areas.

4. Managing Water Supply for Multiple Benefits, Including Natural Areas

Managing water supplies for multiple benefits was a common theme in all stages of Roadmap development. In discussing how to achieve water management for multiple benefits, participants identified the need for cooperation and partnerships among water interest groups. In forming these partnerships, participants noted that it is particularly important to do so equitably. For example, at separate focus groups, participants from farming, mining, municipal, and ranching interests each stated that they felt as if they alone were asked to share their water with natural areas. Future partnerships should encourage shared responsibility in providing water to natural areas.

Recommended strategies to achieve water management for multiple benefits include: 1) increasing reclaimed water use and rainwater harvesting; 2) providing incentives for near-stream recharge; 3) discharging effluent into natural areas; 4) considering natural areas in stormwater management;

Roadmap Case Study: Bill Williams River Corridor Steering Committee provides an example of water management for multiple benefits where cooperation and partnerships were important for project success. Photo: Bill Williams River by The Nature Conservancy

Roadmap Case Study: Glen Canyon Adaptive Management provides an example of efforts to manage for multiple benefits where cooperation was an important to the project. Glen Canyon Dam viewed from downstream. Image from: http://www.gcdamp.gov

and 5) linking land use planning and water planning for multiple benefits. One near-term option for implementation of these strategies is bringing local stakeholders together to identify opportunities for allocating water to natural areas through changes in water management practices. Another proposed action is conducting case studies on existing partnerships that provide water, especially reclaimed water, to natural areas.

Multiple Benefits: bring local stakeholders together to identify opportunities for allocating water to natural areas through changes in water management practices

The voluntary participation of over 1,000 stakeholders, 400 of whom directly helped to build the recommendations in this Roadmap, demonstrates that there is significant interest in providing water to natural areas in Arizona. While opinions on how to provide water to riparian and aquatic ecosystems vary, there is general agreement that any approach should involve cooperation across different water-using groups and should focus on local priorities and solutions. Although our understanding of how much water riparian and aquatic ecosystems need remains incomplete, there are opportunities to take available information and use it to explore how to manage water resources with natural areas in mind. While this Roadmap is the culmination of three years of stakeholder engagement and learning, the WRRC hopes that the Roadmap for Considering Water for Arizona's Natural Areas marks only the beginning of a journey toward understanding and inclusion of water for natural areas in Arizona's water management and planning decisions.

1. Roadmap Legend – Overview and Project Purpose

In Arizona, as with many other arid regions, there is a dichotomy in the way residents think about natural resources. On one hand, Arizonans take great pride in the natural beauty of the state's landscapes, and on the other, communities rely on the use of those landscapes for economic prosperity. Nowhere is this dichotomy more pronounced than in the demands residents place on the ribbons of green that snake through arid landscapes. Arizona's water resources support crops, cities, and allow industries to tap into other natural resources, like copper. Yet, citizens also want that water to stay in the environment for outdoor activities in and around streams, and for the sake of the ecosystems that depend upon those streams.

This Roadmap document is the culmination of a three-year project funded by the Nina Mason Pulliam Charitable Trust and convened by the Water Research and Planning Innovations for Dryland Systems (Water RAPIDS) program at the University of Arizona Water Resources Research Center (WRRC). The Roadmap is designed to examine possible routes, as well as roadblocks, to considering the water needs of riparian and aquatic ecosystems in Arizona water management and planning decisions. As there is little in Arizona's legal framework to compel the consideration of water for natural areas, the WRRC sought throughout the Roadmap project to foster dialogue among water users about voluntary, stakeholder-driven options for addressing natural areas. This was done within the context of limited water supplies and existing water rights and claims.

Despite past challenges and limited legal mechanisms, water managers and those concerned about water management from a variety of backgrounds are increasingly interested in understanding what it would mean to recognize ecosystems as a "water sector". These efforts include the 2011 Arizona Water Resources Development Commission (WRDC) and the resulting WRDC Environmental Workgroup Report, the 2012 *Colorado River Basin Water Supply and Demand Study*, and the January 2014 release of the Arizona Department of Water Resources (ADWR) planning report *Arizona's Next Century: A Strategic Vision of Water Supply Sustainability*. In each of these undertakings, water managers are beginning to examine the sustainability of our water resources, not just from the standpoint of human uses, but also how these uses are related to water for natural areas. This shift in the way we think about and manage our water resources comes with many challenges. Chief among these are two complex problems: understanding how much water ecosystems and species

A Note about the Words Used in the Roadmap

One of the most significant project challenges has been finding the right words to use when talking about water for animals and plants that live near and in rivers and streams. During the course of the project, the WRRC has used the terms environmental flow needs, water for water dependent natural resources, and environmental water demand. These terms were confusing to some and distasteful to others, so the WRRC developed new terms in response to stakeholder input. The resulting terminology, ***water for natural areas*** and ***water needs of riparian and aquatic ecosystems***, will be used throughout this Roadmap to refer to water for animals and plants that live near and in rivers and streams and how much water is required to keep the animals and plants that live in and near streams healthy over time. It should be understood that the 'water needs' and 'health' of an ecosystem are defined within the context of human priorities.

need and identifying how Arizonans think natural areas should be considered in water management.

Understanding how much water aquatic and riparian ecosystems need to survive and thrive has been the focus of study for many years. With the development of the "natural flow regime" concept, an international consensus has emerged regarding the methodologies that best quantify the water needs of these ecosystems. Less well understood is how to identify and implement effective policies that include water for natural areas. When water is scarce, establishing baseline water needs for an ecosystem, and incorporating those identified needs into water management and planning, is problematic because existing use often already exceeds sustainable supply. Considering the water needs of natural areas is further complicated by a paucity of data. Research conducted by the WRRC for this project found that only 22% of perennial (those that flow year-round) and intermittent (those that flow part of the year) river miles in Arizona have been studied and, although the flow needs and responses for a wide array of species have been investigated in Arizona, few species are studied more than once. To make informed management decisions, it is critical not only to understand the water needs of natural areas, but also how those needs align with the perspectives of various regional water interest groups.

The purpose of this project is to examine how, if, and where water for natural areas should be considered in statewide water management and planning decisions.

Surveys such as those conducted by Public Opinion Strategies (2013) and The Arizona We Want campaign (2009) show a growing public concern about and value for rivers and Arizona's natural environment. However, a water management strategy that accounts for the needs of natural areas requires an understanding that goes beyond public opinion. In order to identify innovative solutions that maintain water in natural areas, it is important to consult with diverse water interests. Given the scarcity and sometimes competing uses of water, an open discussion about water for natural areas is complex. All water-using sectors, whether municipal, industrial, or agricultural, have an interest in preserving existing water rights and uses for future growth, new applications, and continued supply reliability. Discussions are further complicated by the variance among and within water sectors on how to consider water for natural areas.

This Roadmap marks the culmination of the EnWaP project and includes: 1) methods to create the Roadmap; 2) an overview of what is known about water for natural areas in Arizona and existing legal considerations for providing water to natural areas; 3) concerns and ideas from a diverse array of Arizonans on water for natural resources; and 4) recommendations and tools for how Arizonans might consider water for natural areas in management and planning, based on stakeholder ideas and case studies of previous efforts.

In an effort to more deeply understand the relationship between existing water management and Arizona's riparian and aquatic ecosystems, the WRRC developed the Connecting the Environment to Arizona Water Planning (EnWaP) project with funding from the Nina Mason Pulliam Charitable Trust. EnWaP began in August 2011 and over the course of three years became an iterative stakeholder engagement process to examine how, if, and where water for natural areas should be considering in statewide water management and planning decisions. As there is little in Arizona's legal framework to compel the consideration of water for natural areas, the WRRC sought throughout the project to foster dialogue among water users about voluntary, stakeholder-driven options for addressing the environment within the context of limited water supplies and existing water rights and claims.

The EnWaP project engaged more than 1,000 stakeholders in a survey, focus groups, workshops, and presentations. In all, participants volunteered approximately 1,900 hours of their time, with many participating in multiple activities. The perspectives gathered during these EnWaP project activities were used to create this final Roadmap document. EnWaP participants were not offered any incentive other than being a part of the dialogue. Throughout this process, the WRRC was able to engage with academic, business, environmental, farming, government, mining, municipal, power, ranching, and tribal interests. Representatives from most of these water interest groups actively participated on the Roadmap Steering Committee and were present for each project activity.

The EnWaP project engaged more than 1,000 stakeholders in a survey, focus groups, workshops, and presentations. In all, participants volunteered approximately 1,900 hours of their time, with many participating in multiple activities.

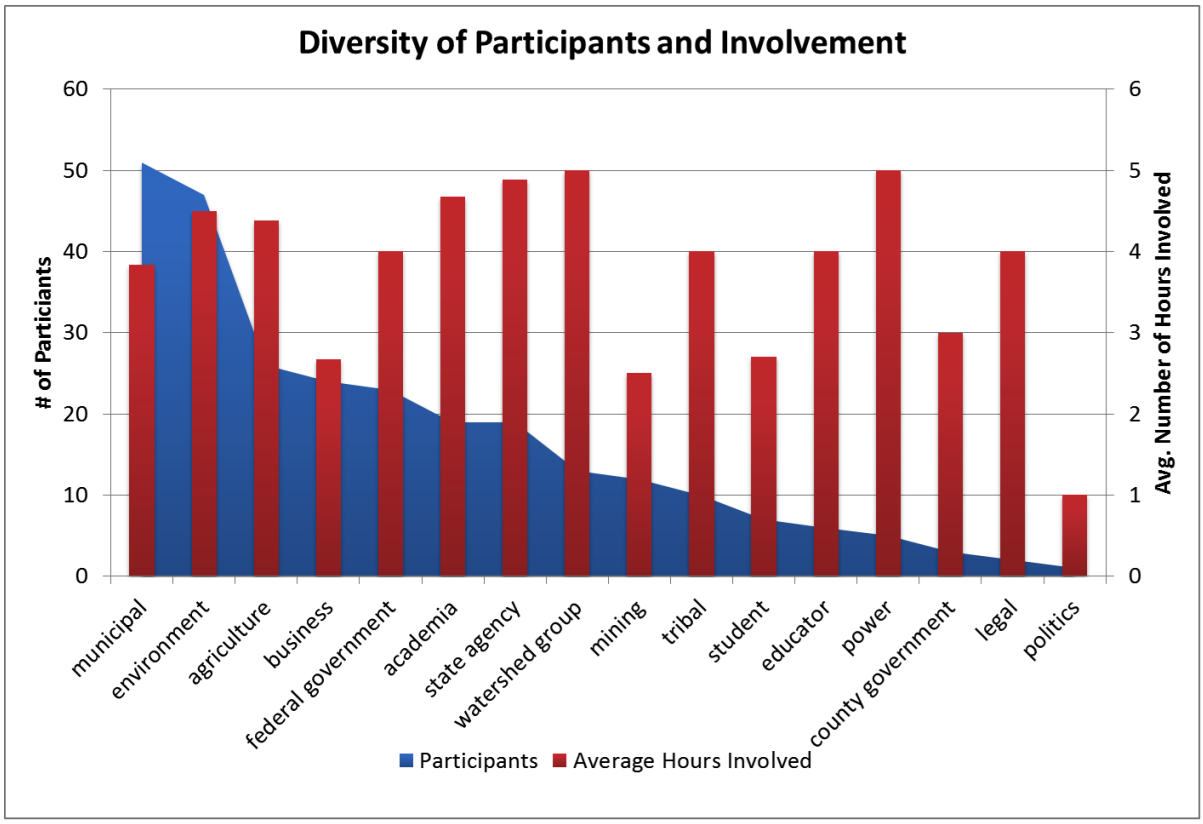
Though roadblocks emerged throughout the development of this Roadmap, so did pathways forward for incorporating natural areas into the state's water planning. While the stakeholders who participated in this project may not have always agreed about how to go about it, there was consensus that water for natural areas *should* be considered in water management and planning decisions. In all aspects of the Roadmap process, the WRRC was impressed by the quality of the dialogue among participants. Discussions about water resources in Arizona can be tense, but those who attended Roadmap activities were eager to talk with one another and consistently came to the table willing to listen, even when others had differing opinions. Not only were participants willing to engage in discussions about how to consider natural areas in water management and planning, they were also interested in identifying routes for cooperation among the diverse water interest groups. When the words used by participants were analyzed, similarities could be found between the water interest groups. For example, there were statistically significant correlations between environment and government; power and mining; as well as farming and ranching. This commonality among diverse participants demonstrates an overwhelming agreement for the need to establish community-identified priorities for how water resources are used. Despite different opinions about the importance of natural areas, or how they should be considered in planning, participants agreed that sound water management is vital.

While stakeholders may not have agreed about how, there was consensus that water for natural areas should be considered in water management and planning decisions.

Though the WRRC was not able to actively engage all water interest groups in all aspects of the EnWaP project, the WRRC and Roadmap Steering Committee are confident that the perspectives presented in this Roadmap document provide an appropriate foundation for moving the discussion on water for natural areas forward. Since the WRRC was only able to reach those who voluntarily came to the table, there was variability in the number and diversity of participants engaged in the Roadmap development process. To account for this, the WRRC tracked participant engagement to assess both the participant type and level of involvement in project activities. The number of people from a given interest group and the average number of hours they contributed are shown in Figure 1; this figure also provides a corresponding overview of the average hours of involvement per participant by each interest group throughout the Roadmap development process.

This final Roadmap document reflects the numerous conversations between the WRRC, project participants, and the Roadmap Steering Committee. Those involved

Figure 1: Diversity of participation and average hours of involvement by each participant in Roadmap project activities, arranged by water interest group.



identified a clear need for an overview of the current scientific understanding of water for natural areas and existing legal considerations for providing water to natural areas, examples of where natural areas are already included in water management decisions, and an overview of available paths forward for including natural areas alongside human uses. To address these needs, this Roadmap includes the following sections: 1) methods used to create the Roadmap; 2) an overview of human water use, what we know about water for ecosystems in Arizona, and existing legal considerations for providing water to natural areas; 3) concerns and ideas from a diverse array of Arizonans on water for natural areas; and 4) recommendations and tools for how Arizonans might consider water for natural areas in their water management and planning activities, based on stakeholder ideas and experiences from similar efforts.

2. Under Construction – Methods Used to Create the Roadmap

The EnWaP project began in August 2011 and included two phases. Phase I educated Arizonans about the water needs of riparian and aquatic ecosystems through presentations, publications, and the development of the Environmental Water Demands Database (EWDD). The EWDD is a spatial/tabular database that catalogs the known flow needs and responses of over 130 riparian and aquatic species. Phase I laid the groundwork for Phase II, which began in late 2012. Phase II focused on exploring voluntary, stakeholder-driven options for considering the water demands of natural areas, within the context of limited water supplies and existing water rights and claims. Perspectives gathered during this phase of the project informed the development of two White Papers (*Calculating and Considering Environmental Water Demand for Arizona* and *Perspectives on Water for Natural Resources in Water Management and Planning in Arizona*) that served as the foundation for this final "Roadmap" document.

The EnWaP project was completed in two phases: Phase I educated Arizonans about the water needs of riparian and aquatic ecosystems through presentations, publications, and the development of the Environmental Water Demands Database; Phase II focused on exploring voluntary, stakeholder-driven options for considering the water demands of natural areas, within the context of limited water supplies and existing water rights and claims.

The WRRC has a history of, and commitment to, involving stakeholders in its projects. From the beginning, the goal of this project was to facilitate interactive and iterative engagement to inform and understand both the water needs of riparian and aquatic ecosystems as well as how water users in Arizona think we should be addressing those needs in statewide water management and planning decisions. All participation in this project, either through outreach in Phase I or active engagement in Phase II, was voluntary. An overview of the steps in developing the Roadmap is provided in Table 1 and Figure 2. Although the steps in developing the Roadmap often built upon each other (e.g., themes identified through the focus groups informed the workshops) similar questions were asked throughout the process. It is the combined knowledge from all of these points of engagement that informed this final Roadmap document. The project kick-off meeting and presentations were focused on providing information to attendees; the remaining activities were focused on listening to and learning from participants.

The remainder of this methods section provides a brief overview of the steps used to create the Roadmap. It is important to note that the path to this Roadmap document was not predetermined. In fact, time was spent initially determining what a "Roadmap" should contain and the contents of what has become the final Roadmap have changed over time.

During the course of this Roadmap building process, the WRRC benefited tremendously from periodic advice from a professional facilitator, Tahnee Robertson of Southwest Decision Resources. Ms. Robertson advised the WRRC on aspects such as the formation of the Steering Committee as well as format and facilitation techniques for our meetings and workshops.

Figure 2: Timeline for Building the Roadmap

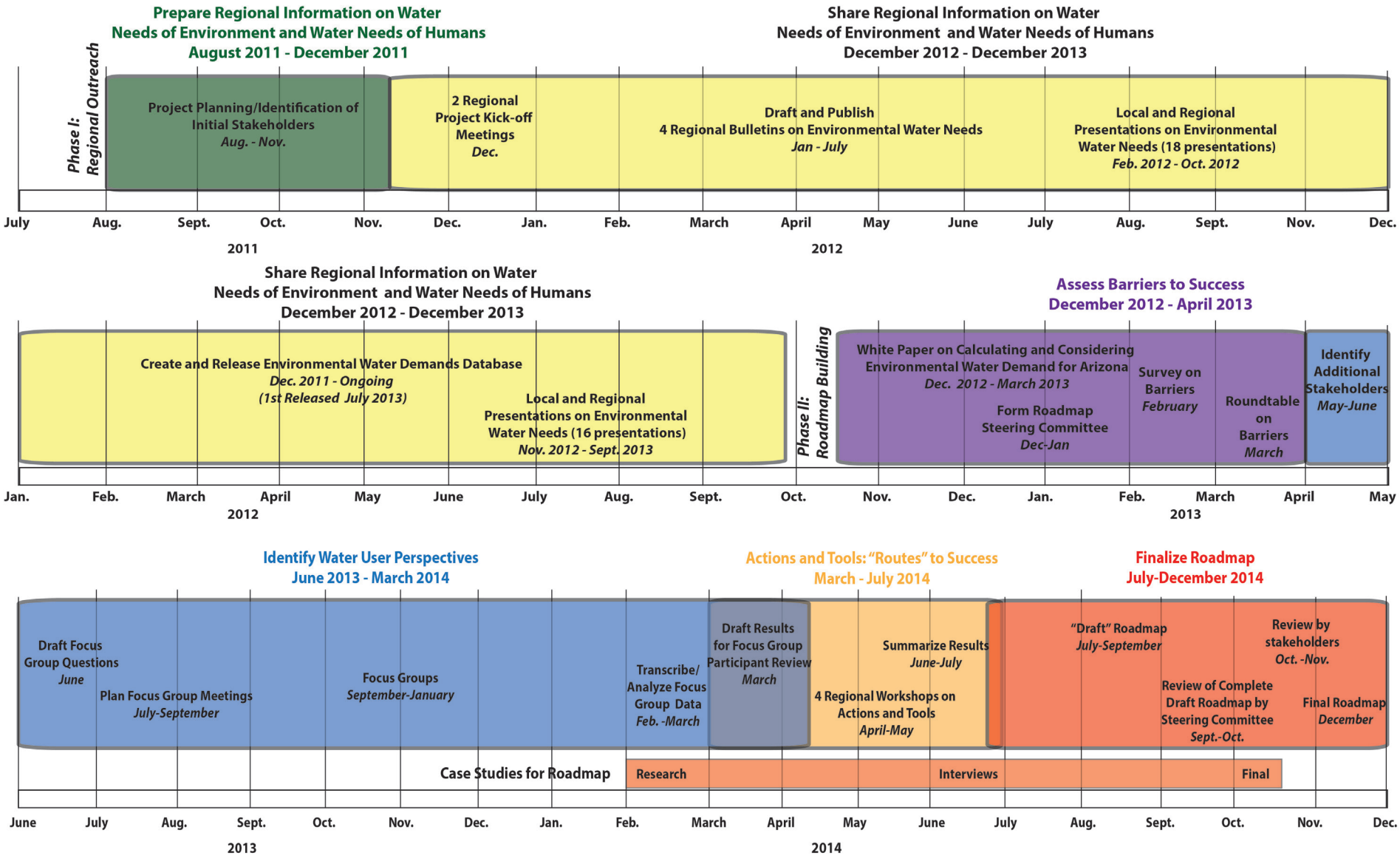


Table 1: Roadmap Project Activities (December 2012-August 2014)

Activity	Date *(Location)*	Number of Participants	Key Issues Addressed
Project Kick-off Meeting	Dec. 2011 *(Tucson and Phoenix)*	52	What is the goal of this project? What do we hope to accomplish?
Presentations on Water for Natural Areas	Dec. 2011 – Oct. 2013 *(32 presentations, 11 Arizona Counties)*	800+	What do we know about water for natural areas? What are the data gaps? How can the WRRC database on water needs of riparian and aquatic ecosystems be used for management and planning?
Survey	Jan. 2013 – Feb. 2013 *(Online)*	171	What makes a community decide to consider water for natural areas? *and* What makes water for natural areas vulnerable?
Roundtable	March 4, 2013 *(Tucson)*	50	What are the benefits, challenges, and reasons for including natural areas in water management and planning?
Focus Groups	Sep. 2013 – Mar. 2014 *(47 focus groups, 10 counties)*	226	How should we consider water for natural areas in water management and planning and what would make it more attractive to do so?
Regional Workshops	April 2014 – May 2014 *(Tucson, Phoenix, Flagstaff and Yuma)*	124	What strategies and actions should be taken to improve education, facilitate collaboration, set priorities, create incentives, and encourage water conservation to include natural areas in water management and planning?
Case Studies	June 2014 – Aug. 2014 (varies)	14	What are the lessons learned in considering water for the environment in your water management and planning?

Survey

As the WRRC began the Roadmap development process, the first questions asked were: 1) why would a community decide to provide water to natural areas (drivers)?; and 2) what do people think makes water in natural areas vulnerable (vulnerabilities)? To get a first impression of what people thought are drivers for and vulnerabilities to providing water to riparian and aquatic ecosystems, the WRRC created a 28-question survey. This survey was sent to over 700 people on the WRRC's Water RAPIDS electronic mailing list, many of whom were added as a result of their participation during the first 18 months of the Roadmap building process. Responses were anonymous, with the only identifying information being the reason for the participant's interest(s) in water and the county or counties the participant worked or had an interest in. It should be noted that the interest categories used for the survey are not identical to those used in later Roadmap activities. The survey was reviewed and approved by the University of Arizona's Human Subjects Institutional Review Board and administered online through SurveyMonkey.com. More information on the survey and complete survey results are included in Appendix B.

Steering Committee

In December 2012, the WRRC sent out an initial set of invitations for the Roadmap Steering Committee. Many initial invitees to the Steering Committee were selected from participants in the Environmental Working Group of the Water Resources Development Commission (WRDC), a commission created by the Arizona state legislature in 2010. These invitees were chosen because of their demonstrated interest in, and knowledge of, the challenges and opportunities for considering water for riparian and aquatic ecosystems. In order to round out the Steering Committee and achieve the WRRC's goal of having at least one representative from each major water-using sector in the state, two additional members were added from agriculture and mining in January 2013. After completing focus group interviews, two additional individuals asked to participate on the Steering Committee and were subsequently added to the roster. Table 2 contains the final list of Roadmap Steering Committee members and their respective affiliations.

Roundtable on Barriers to Considering Natural Areas

To discuss and build upon the survey on drivers and vulnerabilities, the WRRC hosted a half-day roundtable on March 4, 2013 to begin discussions about if and when to consider the water demands of natural areas in Arizona water planning and management. Participation was open to all with targeted invitations sent to the WRRC Water RAPIDS e-mail list. At the roundtable, participants discussed the benefits, challenges, and reasons to consider the environment, what role the environment should have in water planning, and what tools are needed to include the environment in statewide water planning. The roundtable began with brief presentations to introduce participants to the project, the survey results, and the work previously completed by the WRDC Environmental Working Group. Participants were then broken out into four smaller groups, each led by a Roadmap Steering Committee member, for a discussion of: benefits, challenges, and reasons to consider the environment; what role the

Table 2: Roadmap Steering Committee Members

Name	Affiliation
Karletta Chief	University of Arizona Soil Water & Environmental Science Department, Watershed Hydrology Assistant Professor
Rebecca Davidson	Salt River Project
Chad Fretz	Freeport McMoRan
Leslie Meyers	U.S. Bureau of Reclamation
Wade Noble*	Yuma County Agriculture Water Coalition
Joe Sigg	Arizona Farm Bureau
Linda Stitzer	Western Resource Advocates
Robert Stone*	Gila River Indian Community, Council Member
Warren Tenney	Southern Arizona Water Users Association, Metro Water
Chris Udall	Agribusiness & Water Council of Arizona
Summer Waters**	University of Arizona Cooperative Extension
Dave Weedman	Arizona Game & Fish

*Mr. Noble and Mr. Stone joined the Steering Committee in January 2014.
**Ms. Waters participated on the Steering Committee until August 2014, when she left her position at University of Arizona Cooperative Extension.

environment ought to play; and what tools are needed to consider the environment in water management. Stakeholder responses and feedback from the roundtable were used to develop the questions for the focus group interviews.

Focus Groups

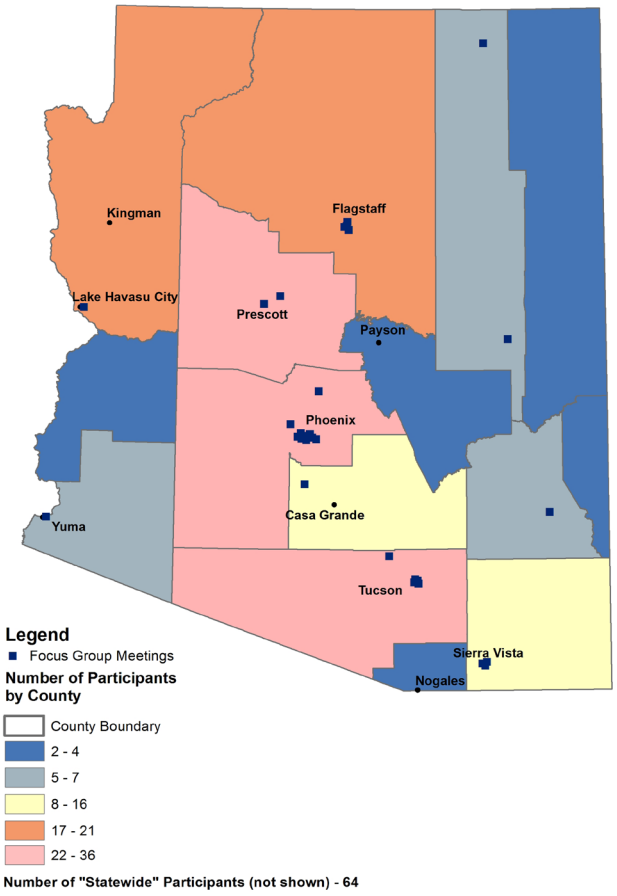
Roadmap Steering Committee meetings revealed concerns about communication around water for natural areas, and how to build trust and common ground on these issues in a state that has diverse perspectives. Initially, the WRRC tried to gain insight into these perspectives through the previously described online survey. The results, while interesting, were biased towards those who self-identified with an environmental interest. As a result, the WRRC decided to conduct a series of focus groups. Focus group participants were identified in consultation with Steering Committee members through a stakeholder mapping exercise. This exercise involved the Steering Committee identifying the key individuals and organizations in Arizona necessary to move forward the consideration of water for natural areas. This list was then reviewed by the Steering Committee to identify 'top priorities', or those who would offer key perspectives without which the Roadmap would be incomplete. During this process, 155 groups were identified and 47 of them were listed by at least one Steering Committee member as a 'top priority'. Steering Committee members then assisted the WRRC in contacting these 'top priority' groups to set up focus group meetings.

Themes and questions for the focus groups were based on the roundtable and subsequent discussion with the Steering Committee. The WRRC received approval for the process by the University of Arizona Institutional Review Board. All focus group participants were anonymous, with responses only categorized by the participant's self-identified water-related interest and the county or counties the participant works and/or lives in. The WRRC conducted 43 focus groups with a total of 226 participants between late August 2013 and early March 2014. Of the original list of 47 high priority groups, 41 were interviewed. Nineteen of the 21 groups identified as a 'top priority' by more than one Steering Committee member were interviewed. Participants spanned every county in Arizona (Figure 3), and were from many different water-interest groups. Transcribed data from the focus groups were analyzed using NVivo, a qualitative data analysis computer software package produced by QSR International.

Regional Workshops

In April and May 2014, four regional workshops were held to build on the concerns, ideas, and lessons learned from the survey, roundtable discussion, and/or focus group interviews. The primary workshop objective was to determine stakeholder

Figure 3: Location of focus group meetings and focus group participants, by county.



recommendations, tools, and action items for how Arizonans could consider water for natural areas in our water management and planning decisions. Workshops were held in Tucson, Phoenix, Flagstaff, and Yuma. Participation in the workshop series was open to all, with targeted email invitations sent to previous Roadmap participants. Attendance at each regional workshop varied considerably in number as well as the range of professional affiliations represented. Ninety-six individuals participated in the workshop series (Tucson: 36; Phoenix: 21; Flagstaff: 23; Yuma: 16).

Each workshop began with a one-hour 'brown bag' style presentation that outlined how participants in the Roadmap survey, roundtable, and focus groups thought water for natural areas should be considered in water management and planning decisions. During the workshop, participants were given the opportunity to select two thematic areas they were interested in discussing. Themes included: water use efficiency and conservation, incentives, education/communication, and priority setting/cooperation. These selections became the breakout groups participants rotated through during the workshop portion of the event. Participant discussions were guided by a facilitator using a series of questions crafted by the WRRC in consultation with the Roadmap Steering Committee for each thematic area. At the request of Steering Committee members, unlike the roundtable, facilitation for these workshops was provided by the WRRC so Steering Committee members could participate freely in the discussions. See Appendix C for a complete list of discussion questions for each thematic area.

After breakout group discussions were complete, participants voted on the recommended strategies from each thematic area. The recommended strategy with the highest percentage of votes for each thematic area was then used as the basis for a second round of breakout group discussions. The goal of the second round was to create realistic action items for the selected recommendation(s).

Review of Interim Documents

The Roadmap presented here is a combination of multiple interim documents. After each step in the Roadmap building process, the WRRC provided a copy of the results first the Steering Committee and then to the participants for review and comment. This process has resulted in two white papers, a roundtable summary, and a workshop summary. Comments from participants and the Steering Committee were addressed and incorporated into each document prior to its final release. All interim documents, as well as the Environmental Water Demands Database, can be found at: wrrc.arizona.edu/waterrapids.

Case Studies

The Roadmap includes detailed case studies on six existing efforts in Arizona to incorporate or increase water for natural areas through innovative management and planning. Roadmap participants, members of the Steering Committee, and WRRC staff proposed case studies for consideration. The WRRC selected the case studies for inclusion based on which best illustrate the most commonly discussed thematic areas identified throughout the Roadmap development process (cooperation, conservation and efficiency, education, financial incentives, flexible regulation, multiple uses of water, value of water, and priority setting) as well as which could contribute the most practical recommendations and action items to the Roadmap. For each case study, existing documents on the project were reviewed and interviews were conducted with project participants. The WRRC received approval for these interviews from the University of Arizona Institutional Review Board.

3. Roadmap Topography – Human Uses of Water and the Status of Water for Riparian and Aquatic Ecosystems in Science and Policy

To build a Roadmap for considering water for natural areas in Arizona, one must have a clear understanding of the lay of the land. Where does Arizona's water come from and how is it used? How much water would the state need to maintain its riparian ecosystems? While economic engines drive quantification and planning for the water futures of cities, farming, and the like, few have pursued the question of what would be needed to maintain the health of Arizona's riparian and aquatic ecosystems. The challenge is twofold: how to increase the understanding of how much water these ecosystems need, and how to determine how the people who interact with these ecosystems want to provide for those needs. This portion of the Roadmap provides basic background information about the interaction between policy, law, and human needs for water; how riparian and aquatic ecosystem water needs are determined in science and in policy; and what is known about the science and policy of water for natural areas in Arizona.

Human Aspects

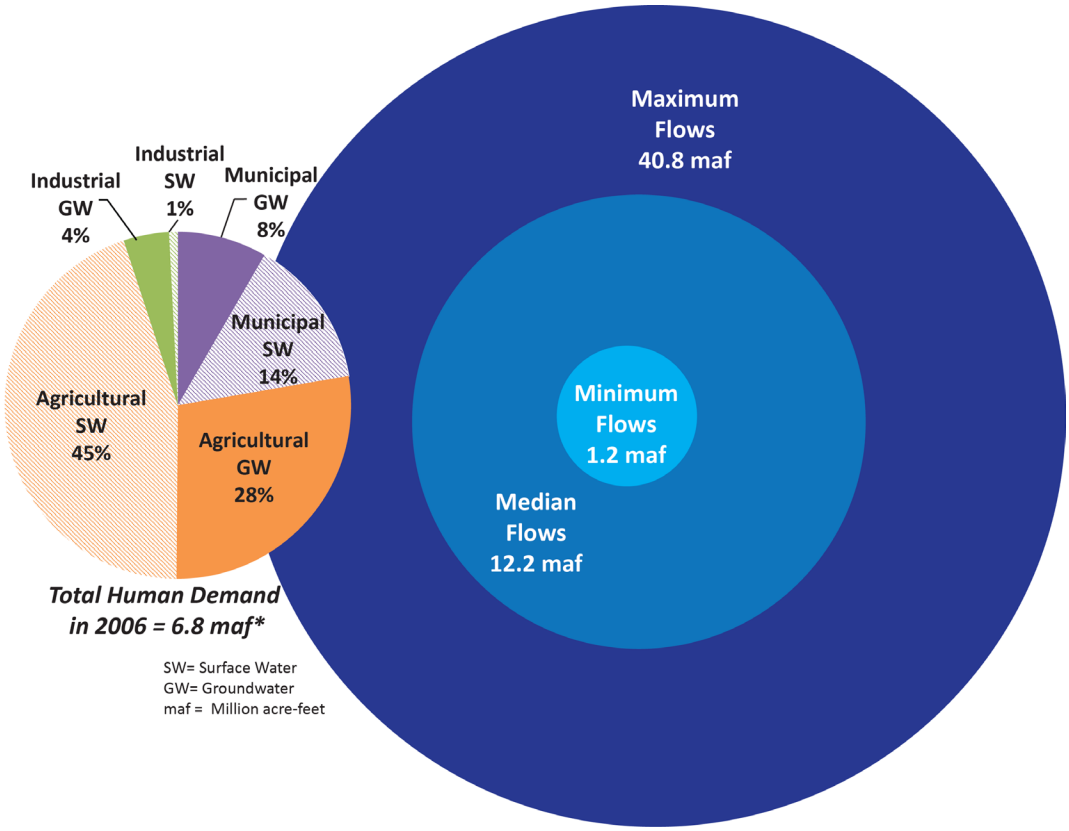
The legal landscape of water in Arizona is complex. Surface water and groundwater are treated differently under state law and are only legally "connected" to one another in limited situations. All surface water is subject to the doctrine of prior appropriation, whereby the first in time to put the water to a beneficial use holds the "senior right" or highest priority on their allocation. One "use" can be to keep water flowing in the channel through an instream flow permit. In Arizona, instream flow permits are only granted to protect existing flows and carry the priority date that the permit was issued. Because the first instream flow water right was recognized in 1983, these water right claims are junior to many others. This means that stream flows can be diverted off-stream for use by senior right holders. Additionally, legislation passed in 2012 increased the data requirements for determining the beneficial use of the flow quantity applied for, thereby increasing the difficulty of applying for a permit. Among the western states that follow the prior appropriation system (Arizona, Colorado, Idaho, Montana, Oregon, and Washington), Arizona has the least active instream flow program (Loehman, 2011). Considering water for natural areas is further complicated by the fact that surface water rights in Arizona are over-allocated, meaning that there are already more claims on state water resources than can be met by existing supply. This has resulted in ongoing adjudication proceedings to identify rightful users and a lack of clarity about who "owns" the water, even among human uses.

Surface water and groundwater are treated differently under Arizona state law, and are only legally "connected" to one another in limited situations.

In contrast with surface water, groundwater rights often correspond with land ownership rather than first use. Arizona's bifurcated approach to groundwater and surface water governance makes it difficult to prevent impacts on surface water resources caused by groundwater pumping. Monitoring groundwater withdrawals only occurs where the direct connection to surface water has been defined through a judicial proceeding, and for large wells in the state's five active management areas and, to some extent, in the three irrigation non-expansion areas. Small domestic wells in urban areas, and all groundwater pumping in rural areas, fall under less stringent oversight, despite the potential of this pumping to have a significant cumulative impact on surface flows.

Although significant amounts of water flow through and are used by riparian and aquatic ecosystems, this water is not generally represented as a piece of the total water

Figure 4: Annual human water demands and minimum, median, and maximum stream flows in Arizona (circle size indicates relative amount of water). Figure by WRRC, data source ADWR 2010 (stream gages) and WRDC 2011 (human demand).



demand "pie." Statewide water use is shown in Figure 4 comparing the relative scale of human surface and groundwater demands by sector to the minimum, median, and maximum flows available in Arizona's rivers and streams. The total size of the pie chart of human demands (far left) reflects the 6.8 million acre-feet annually withdrawn or diverted by all sectors (municipal, industrial, and agricultural). Median annual stream flows (right side of figure) are about double the amount used by all human demand sectors combined, while maximum flood flows are six times greater. Surface water imported from the Colorado River is included in human surface water demand, but not the streamflow quantities shown.

The Bureau of Reclamation's *Colorado River Basin Supply and Demand Study* concluded that as human uses of water grow, so will the gap between available water supplies and our ability to meet water demands. In focus groups for this Roadmap, participants were asked if their respective sectors anticipated an increase, maintenance, or decrease in their water use; participants representing academia and government were asked to make a general statement about anticipated water use rather than in the context of a specific sector. Though most participants were able to identify a single water-use future, some participants anticipated an array of possible water use futures and, as a result, were not comfortable selecting only one category; when this was the case, the WRRC noted their response as "All." Eight of the 10 interest groups and 52% of all respondents said they anticipate an increase in their future water use (Figure 5). Twenty-five percent of respondents anticipate maintenance in their water use, with only 14% anticipating a decrease. The only groups that did not anticipate an

increase in water use were ranching and tribal. Improved efficiency was cited by 37% of respondents, including participants from business, farming, mining, municipal, power, and ranching perspectives, as the driver behind an anticipated "decrease" or "maintenance" in water use. These participants noted that while their per-unit water use would decrease, they intend to use any savings to support increased population, acres farmed, or other outputs.

Water is a finite and shared resource and increased demand alongside uncertain supply threatens the security of the state's water future. All water-use sectors return some water to streams and aquifers after use, which means the same drop of water may be "used" multiple times. Similarly, many riparian and aquatic ecosystem flow "needs" are non-consumptive, i.e., the fish do not consume the water and the water they need can flow downstream to serve another use. Therefore, water traveling through a river to farming or domestic uses downstream can support aquatic and riparian (streamside) ecosystems along the way. These connections between riparian and aquatic ecosystem and human needs create opportunities for mutually beneficial water management, even in an uncertain future (Figure 6).

Although significant amounts of water flow through and are used by riparian and aquatic ecosystems, this water is not generally represented as a piece of the total water demand "pie."

With little direct legal protection or requirement to consider water for natural areas in Arizona law, and increasing concerns with

Figure 5: Focus group responses by primary water interest group to the question: How do you plan to use water in the future? Do you anticipate an increase, decrease, or maintenance in your water use? Responses are normalized by the number of respondents in each interest group who answered the question. Some participants anticipated an array of possible water use futures and, as a result, were not comfortable selecting only one category; when this was the case, the WRRC noted their response as "All".

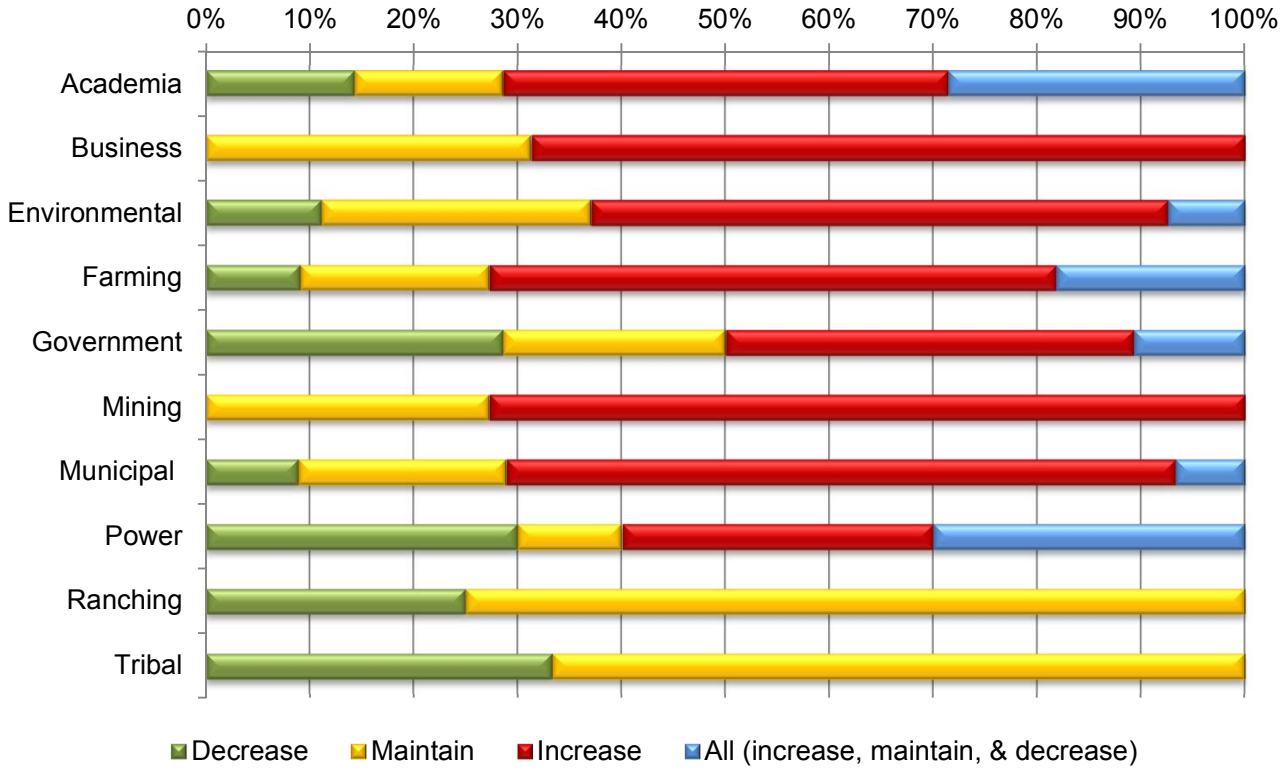
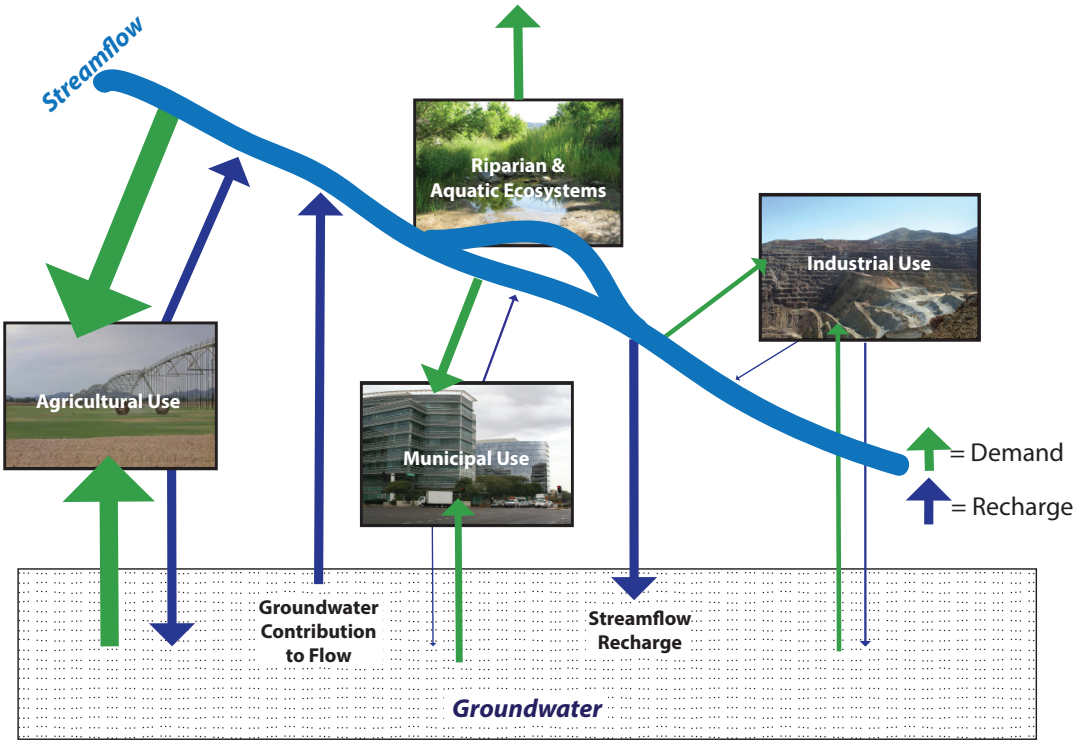


Figure 6: Relative amounts of water demanded (pumped from groundwater or diverted from streams) and returned in Arizona. Streamflow is represented as a single "stream." Outflows to human and ecosystem demands are marked by green arrows, while flows back into streams and aquifers are represented by blue arrows.



water security, water planning processes can offer opportunities to address the impacts of water management on riparian and aquatic ecosystems. Until recently, Arizona's state-level water planning efforts have not included natural areas or have had no major effect on natural areas. In 2010, the legislature created the Water Resources Development Commission (WRDC) to assess Arizona's demand for water and the supplies available to meet those demands for the next 25, 50, and 100 years. An Environment Working Group was formed as part of the WRDC.

Efforts of the WRDC Environment Working Group led to the creation of a comprehensive set of descriptive tables, narratives, and maps compiling available environmental information for the 51 Arizona groundwater basins. Limited information prevented an assessment of statewide water needs for riparian and aquatic ecosystems (with the exception of 12 groundwater basins where sufficient information was available). Instead, the Environment Working Group recommended that the ecological information it had assembled about current flows and water-dependent ecosystems be used in water planning and that additional studies be initiated to fill information gaps. While these recommendations were included in the WRDC's final report, natural areas were not treated in the same way as other sectors in terms of demand quantifications and projected future scenarios, mostly because the information required to do so does not exist. However, in the body

Water traveling through a river to farming or domestic uses downstream can support aquatic and riparian (streamside) ecosystems along the way. These connections between ecosystem and human needs create opportunities for mutually beneficial water management.

of the WRDC Water Supply and Demand Working Group's Report, an assessment of the technical and legal issues associated with developing additional supplies does include the identification of potential environmental issues and shows where the connections between groundwater and surface water physically exist for each of the 51 groundwater basins.

Despite past challenges and limited legal options, recognition of natural areas as a "water sector" in Arizona is increasing. This is evident by its inclusion in the WRDC report, state and federal partnerships for restoration projects, and efforts to assert instream flow rights for fish and wildlife. There have been a number of state initiatives and locally based efforts to restore or preserve important environmental resources. State agencies, such as the Arizona Department of Environmental Quality and Arizona Game and Fish Department, implement water quality and wildlife protection policies in part through support for watershed planning and local restoration projects. Local municipalities and counties also play a role by voluntarily contributing time and money to restoration and preservation projects. Ultimately, because of the variation around the state in both technical information about and interest in considering water for natural areas, state-level policies may be challenging to implement. As a result, local, voluntary efforts may be better positioned to address environmental needs under the prior appropriation system and ongoing adjudication process.

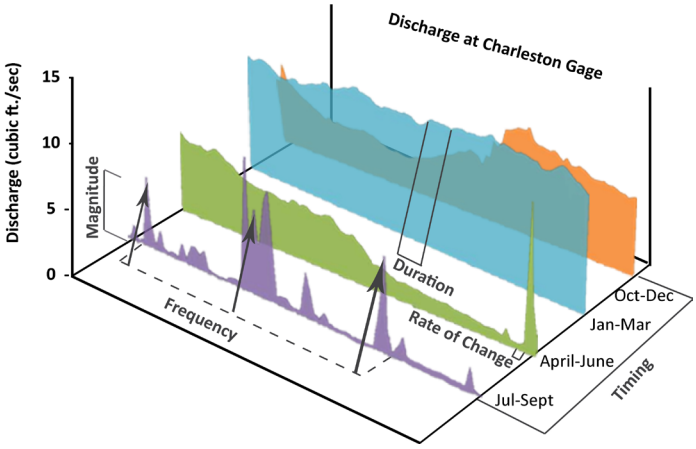
What is an Ecosystem or Species "Water Need"?

To consider natural areas alongside other water sectors, one must have an understanding of what the water needs of ecosystems are. Water in natural areas can be examined in numerous ways, but the simplest is through stream gauge data, which provides information on the amount of flow at a given point on the stream, as well as when different types of flow, e.g., low flow and floods, occur. This type of data does not, however, tell us how much water ecosystems or individual species use or need. Estimates of current flow that support natural areas (current quantified flow) use data on baseflow and groundwater underflow for the river together with evapotranspiration (water use, ET) by the vegetation and soils adjacent to the river. This estimate provides information on how much water an ecosystem is currently using (ET) and has (baseflow, not including floodflow), but still does not represent how much water that ecosystem might *need*.

Dynamic flows for species and ecosystems are commonly described according to the natural flow regime, which contains five elements of water flow: magnitude, duration, frequency, timing, and rate of change.

Defined at its simplest, the water needs of riparian and aquatic ecosystems are the amount of water necessary in a watercourse to sustain a healthy ecosystem. Behind this simple definition are two considerations: 1) riparian and aquatic ecosystems, including the species they contain, depend on dynamic flows, also known as the "natural flow regime,"; and 2) the definition of a "healthy" ecosystem is determined by the community allocating water to the natural area. Dynamic

Figure 7: The five elements of Environmental Demand, as shown through a series of seasonal hydrographs. Figure by WRRC, data from USGS gage at Charleston, Arizona.



Each of these five elements can be determined for the needs of an individual species or for the entire ecosystem. Also important to consider is that many areas throughout Arizona have lost surface flow and near-surface groundwater, and have therefore experienced complete riparian ecosystem collapse. This is an issue of shifting baselines: although these areas may not currently sustain a healthy ecosystem, they can be considered to have a water need for the rehabilitation of their lost ecosystems and ongoing support once restored. Determining how much water to provide to ecosystems goes beyond the ecology and hydrology of a system, because it also involves determining how much water is required to achieve a certain level of river health, as agreed upon by the water-using community. For example, a community could choose to prioritize the re-establishment of certain species, or the functioning of an ecosystem, in areas that have been impacted by surface and groundwater loss. In other words, defining water needs of natural areas is a "social process with a scientific eco-hydrological core" (International WaterCentre, 2010).

How Do We Determine Water Needs for Riparian and Aquatic Ecosystems?

Understanding how to determine environmental water demand has three components: 1) the *science* of identifying ecosystem flow needs and flow responses; 2) the *process* for prioritizing water for natural areas; and 3) policy and management *tools* for considering water for natural areas based on community priorities. Research about ecosystem flow needs and responses can be compiled in a number of ways and may not produce equivalent results. For example, methods that use both biological and hydrological data are not directly comparable to those that use only hydrological data as a proxy for biological needs. Furthermore, not all study methodologies will include quantitative analysis or examine the same hydrological components, thereby differentiating the type and variety of data generated. Sometimes researchers rely on historical flow patterns of a river to define its flow needs; other times present-day observations to identify relationships between ecological components and the flow regime are used. Some studies collect field data, perform sophisticated statistical analyses, and use spatial mapping to study flow/ecology relationships. Others rely on expert analysis of published literature and expert workshops to quantify flows that are then tested over time (Acreman et al., 2004). In all cases, it is important to understand the assumptions made in each study and how those assumptions can impact flow assessments (Jowett, 1997).

There is no tangible rule of thumb that can be used to determine the natural flow regime and ensure the health of a river system.

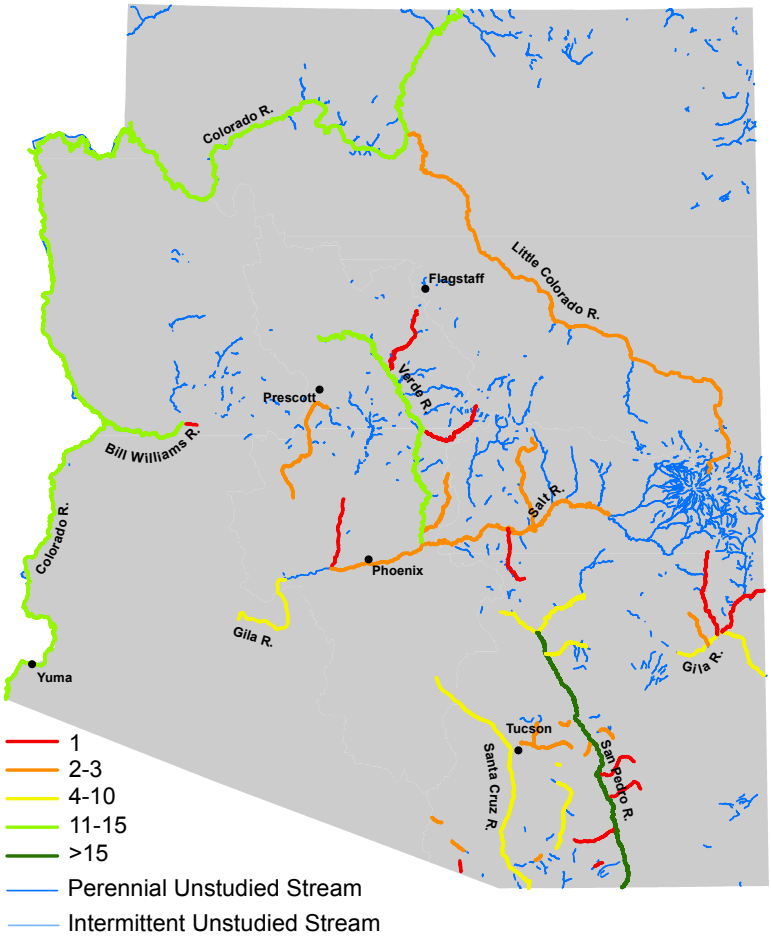
Until the mid-1990s, most determinations of ecological flow needs focused on average streamflow. Since then, management based on the natural flow regime has gradually become more widely understood and more frequently applied in river management. There is, however, still no tangible rule of thumb that can be used to determine the natural flow regime and ensure the health of a river system. Many attempts have been made to make universally applicable models. In fact, there are over 200 methods for determining in-stream flows for ecological benefits. Despite the acceptance of the natural flow regime paradigm, about 70% of these 200 models are based largely upon the minimum flow requirements for aquatic biota and do not consider either dynamic flows or the flow needs of the entire ecosystem (Merritt et al., 2010).

While the tools for management of river systems continue to evolve, the importance of adaptively managing these systems and the process for doing so is well established (Merritt et al., 2010; Richter et al., 2006; Arthington et al., 2010). Deciding which of the 200 plus methods to use when determining environmental demand for water management is complex, but

ultimately boils down to a few factors: time, money, available expertise and the priorities of the community determining the flow needs. The identification of the water needs of natural areas requires stakeholders to make decisions about the future character and health of these ecosystems. These decisions will guide the method selected to determine ecosystem demand and the tools used to connect environmental flow science to water policy. However, to make this connection, the community must first understand the water needs of the riparian and aquatic ecosystems.

In 2010, the WRRC completed the Arizona Environmental Water Needs Assessment (AzEWNA), which reviewed studies completed in Arizona over the past 20 years to determine the state of the knowledge for ecosystem flow needs and flow responses. Each study was reviewed to: 1) determine the species or ecosystem studied; 2) the methods used for the study; 3) biological element(s), e.g., abundance, age structure, or reproduction, studied; and 4) how the biological elements depended upon or were influenced by stream flow or groundwater. Since 2010, the AzEWNA has been transformed into a spatial and tabular database called the Environmental Water Demands Database (EWDD) that contains 121 studies and is current through June 2014. Of the 121 studies, 84 contain unique qualitative or quantitative data on flow needs or flow requirements for 135 different species, 13 functional groups (e.g., benthic macroinvertebrates, mesic annuals), and riparian and aquatic ecosystems as a whole. These 84 papers span 34 streams or rivers located

Figure 8: Streams with quantified or described water needs for riparian and aquatic species or ecosystems. Colors indicate the number of studies conducted for each stream.



throughout Arizona. Not surprisingly, some river systems were studied more than others, with the San Pedro River (32 studies), Colorado River (16 studies), Bill Williams River (15 studies), and Verde River (12 studies) being the most frequently studied (Figure 8). Although there are a few studies on smaller streams (e.g. Sycamore Creek in central Arizona, Santa Maria River in western Arizona), 84% of the papers that quantify or describe flow needs or flow responses are for the nine largest rivers in Arizona.

Although there are a few studies on smaller streams (e.g. Sycamore Creek in central Arizona, Santa Maria River in western Arizona), 84% of the papers that quantify or describe flow needs or flow responses are for the nine largest rivers in Arizona.

There are many perennial streams that have not been studied, especially in the central and eastern portion of Arizona. Statewide, approximately 22% of perennial or intermittent river miles have been studied, with 71% of those miles on perennial streams and 29% on intermittent streams. Four papers describe some aspect of riparian ecology along ephemeral streams, but no studies quantify surface water flow or groundwater level requirements or responses to alteration for ephemeral reaches.

Only five of the 34 Arizona rivers included in the EWDD have at least one reach where all elements of the natural flow regime are considered. Of the 84 studies that either quantify or describe flow or water level needs or responses, the most commonly studied element of the natural flow regime is magnitude (85%), followed by timing (43%). Least studied was frequency of flow (20%); however, this could also be an artifact of combining data on surface flows and groundwater flows into one dataset and the difficulty in translating the natural flow regime directly to groundwater level needs for vegetation.

Table 3: Frequently studied species or group. Vegetation is the most commonly studied taxa with 17 species or groups studied at least three times.

Study Subject	Number of Studies	Taxa
Freemont Cottonwood (Populus fremontii)	22	Veg.
Salt Cedar (Tamarix ramossisima)	14	
Gooding Willow (Salix gooddingii)	12	
Velvet Mesquite (Prosopis velutina)	12	
Cottonwood/Willow Forest	10	
Chinese Tamarisk (Tamarix chinensis)	5	
Seep Willow (Baccharis salicifolia)	5	
Speckled Dace (Rhinichthys osculus)	5	Fish
Roundtail Chub (Gila robusta)	5	
Big Sacaton (Sporobolus wrightii)	5	Veg
Cattail (Typha)	4	
Razorback Sucker (Xyrauchen texanus)	3	Fish
Longfin Dace (Agosia chrysogater)	3	
Humpback Chub (Gila cypha)	3	
Salt Bush (Atriplex)	3	
Beaver (Castor canadensis)	3	Mam.

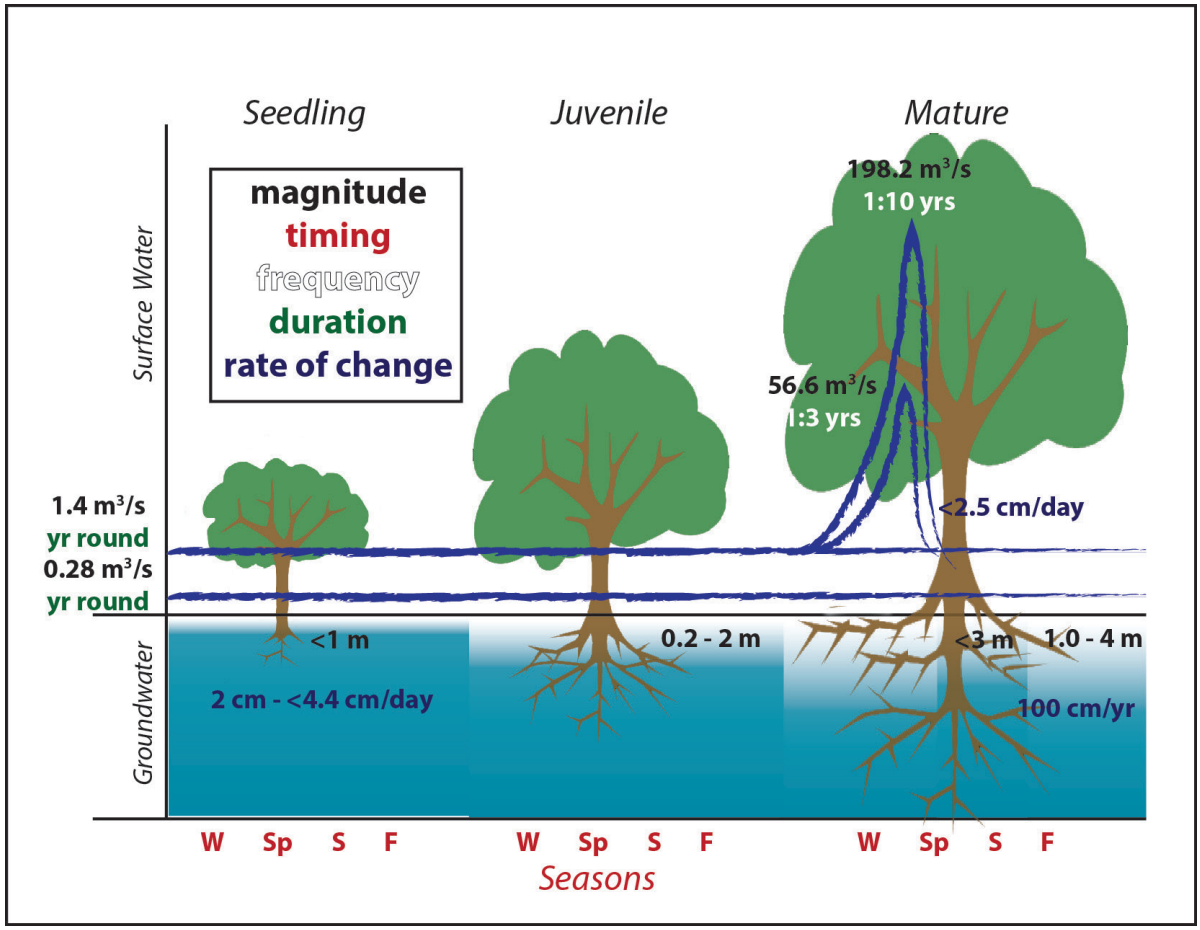
The majority of rivers in the EWDD have three or fewer taxa studied, and only three (Upper Colorado River, Upper Verde River, and Bill Williams River) have been examined for the flow needs or responses of the entire ecosystem within the context of a single

study. Despite the existing research on many individual taxa within a river system, such as the San Pedro, as of 2014, there is no single paper examining the flow needs or responses of an entire river ecosystem. Statewide, most studies examine the abundance or presence of species or functional groups relative to surface water or groundwater (75%). Survivorship (35%), health (32%), and reproduction (27%) were also frequently examined. All 84 papers link water availability with ecological health, with 55 of them demonstrating the importance of the groundwater and surface water connection.

Statewide, approximately 22% of perennial or intermittent river miles have been studied, with 71% of those miles on perennial streams and 29% on intermittent streams.

Although the flow needs and responses for a wide array of species have been investigated in Arizona, only 25% of species have been studied more than once and only 11% more than twice (Table 3). Researchers most frequently look at the water needs of Arizona's riparian plants, quantifying their water use, depth to water limits, and needed flood events. When multiple experiments have been conducted for a species or functional group, there is an increase in the certainty of flow need estimates. For example, flow needs or levels have been quantified for cottonwood/willow forests in 10 Arizona studies, allowing water managers to more confidently establish thresholds for water levels or prescribe volumetric flow needs. A graphical representation of information available on the water needs of cottonwoods is found in Figure 9.

Figure 9: Graphical representation of the available water needs data for seedling, juvenile, and mature cottonwoods in the WRRC Environmental Water Demands Database. Data is color-coded according to the five elements of the natural flow regime.



Although the flow needs and responses for 135 species have been investigated in Arizona, only 25% of species have been studied more than once and only 11% more than twice.

Information available about other species is not as robust, thereby limiting the ability of water managers to ensure flows will support the whole ecosystem. In cases where the manager is looking for guidance applicable across the whole state, s/he would find greater certainty where research has been completed in multiple locations with similar results. If local guidance is needed, having more information for the location(s) of interest would increase certainty.

As previously mentioned, although some Arizona streams have been studied for all five elements of flow, most do not address the flow demands and responses for the whole ecosystem. The spatial distribution of environmental flow needs and response studies in Arizona is in part driven by the legal, social, economic, and political landscape of the state, with some rivers being more studied than others because of community interest or laws that apply to the river. Statewide, ecosystem-level flow requirements remain poorly understood. Two areas of agreement have emerged from studies done across the state: 1) riparian areas need both access to sufficient groundwater and carefully-timed flood flows to maintain water levels for established plants and for new plant growth; and 2) change to any element of flow can impact Arizona's aquatic and riparian ecosystems if flows are altered beyond the range of tolerance of native species.

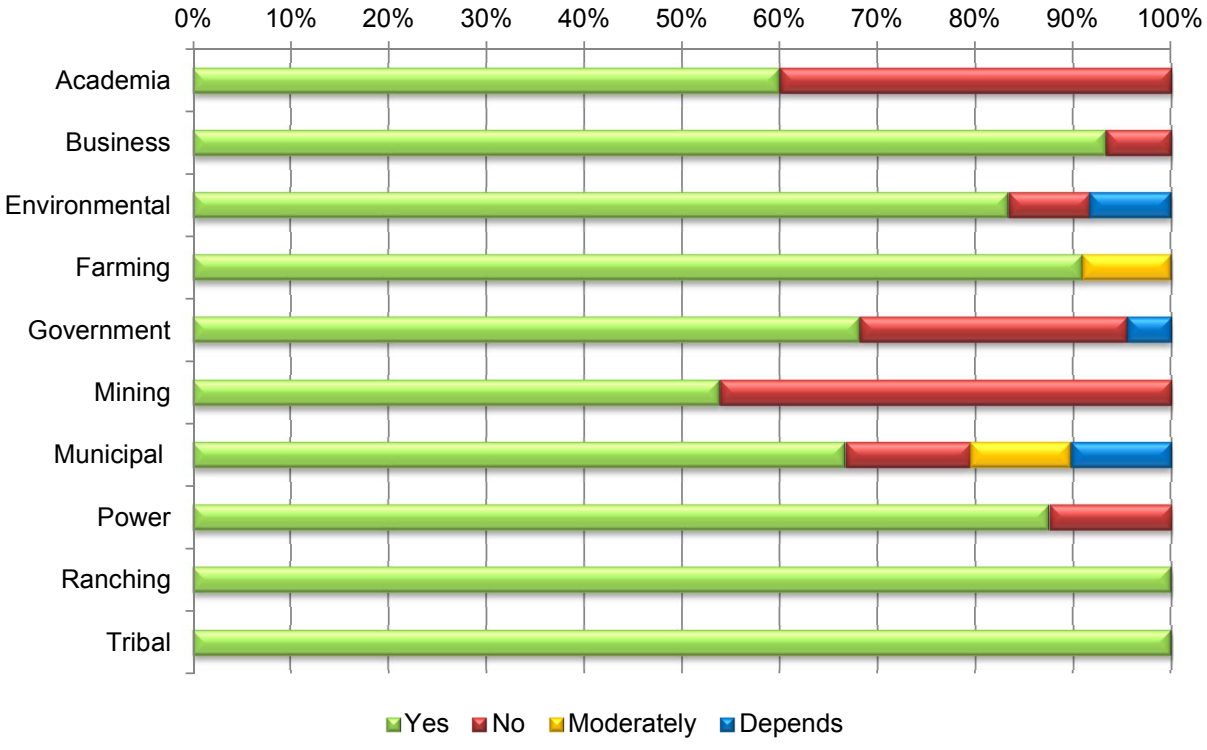
4. Choosing a Route and Avoiding Roadblocks – Perspectives on How to Provide Water to Natural Areas

The existing scientific information and policies regarding natural areas in Arizona define the topography for this Roadmap and influence the pathways that can be most easily constructed. However, the creation of routes toward considering water for Arizona's natural areas does not depend on available information alone. It is important to also grasp how the perspectives of different water-using groups vary regarding water for natural areas, and to recognize any cross-cutting values that could be used to design win-win policies or transactions. This section describes what the WRRC has learned about natural resource concerns; how those interviewed think water for natural areas should be considered; and some of the barriers to considering water for natural areas, as identified by roundtable, focus group, and case study participants.

Natural Resource Concerns

In focus group interviews, water was the chief natural resource concern identified by participants. This result is not surprising, given that the individuals interviewed were predominantly water professionals and individuals who depend upon a reliable supply of water for their livelihood. Of the focus group participants, 77% answered "yes" when asked if they are concerned about water security in their area of interest (Figure 10). Those concerned spanned all interest groups, with all participants representing tribal and ranching perspectives agreeing that it is a concern. Participants from the mining community expressed the least concern for water security, with 46% of mining respondents indicating that they are not concerned. Available water supply emerged as the main reason for water

Figure 10: Responses by primary sector to the question: Are you concerned about water security? Responses are normalized by the number of respondents in each sector who answered the question.



security concerns, with respondents most often citing water quality, climate change, increasing human demand, neighboring populations, and cost. To a lesser extent, acts of terrorism that impact available water supplies or water delivery mechanisms were also a water security concern.

The word cloud of responses to the question, "What natural resources are you most concerned about?" is shown in Figure 11. This figure displays the concerns indicated by three or more participants; larger text indicates words that were said more frequently. Frequent natural resource concerns included: forests, minerals, air, land, rivers, energy, groundwater, riparian areas, and coal. Aside from water, which was a concern cited by 95% of participants, only land was indicated as a concern for over 5% of the participants from all interest groups. Common concerns shared by 20% or greater of the group participants included minerals (mining and tribal), land (farming, power, and tribal), rivers (academia, environment, and farming), groundwater (environment and municipal), and coal (power and tribal).

Figure 11: Word cloud of responses to the question: What natural resources are you most concerned about? Word size and color correspond to the number of times a word was said. The word water was said 214 times.

Some interest groups had unique natural resource concerns. Business, mining, power, and ranching all had concerns that were not frequently mentioned by other interest groups. For example, ranching participants were most concerned about rural lands and forage, whereas power interests were most concerned with natural gas and land.

Considering Water for Natural Areas

The majority of time in each focus group was spent discussing how participants think Arizonans should be considering water for natural areas. All 10 interest groups identified water conservation and efficiency, cooperation, and financial incentives as ways that they are either considering water for the benefit of natural areas or ways that would make it more attractive (Table 4). Nine interest groups also responded that priority setting, understanding values, and multiple uses are favorable ways to consider water for natural areas, either currently or in the future. Fewer than three groups said that existing regulations are sufficient or that less regulation is needed; however, at least one participant from eight of the ten interest groups discussed the need for more flexibility within existing regulations. Conversely, participants from six interest groups suggested that more regulations would make providing water to natural areas more attractive. Participants from all interest groups agreed that considering water for the benefit of natural areas is important, but participants from the business, farming, mining, municipal, and ranching interests noted that it should not be done at the expense of human populations.

The diversity of themes, and the fact that no one theme was discussed by a majority of the participants, demonstrates a wide range of ideas on how water for natural areas should be considered, and a lack of consensus on the subject. While some of these themes will be discussed separately in the pages that follow, it is important to remember that many, if not most, themes are interrelated. For

example, conversations about using water for multiple uses were frequently followed by thoughts on conservation and cooperation; discussions about understanding the value of natural resources were often integral to a conversation on education, priority setting, and planning.

How Do You Currently Consider Water for Natural Areas?

Representatives from all interest groups stated that they already consider water for natural areas in some aspect of their management and planning decisions. The methods and extent of consideration for natural resources varied widely, both within and between interest groups. Municipal respondents, for example, discussed increased conservation, utility customer education, and aquifer recharge as ways they already consider water for natural areas. Government entities cited the legal protections given to select Arizona species with one agency explaining that "[considering] water for natural resources is at the source of what we do…without it, we don't have natural resources in the state of Arizona to manage." Farming participants highlighted their increased efficiency via technological improvements, such as lining canals and drip irrigation, and that the runoff and seepage from their fields aids riparian species. Similarly, ranching participants called attention to how their livestock ponds provide critical water resources and habitat to rangeland species.

How should we consider water for natural resources?

The most common themes that emerged from responses to the question, "How should we consider water for natural resources?" were cooperation, multiple use, conservation and efficiency, and priority setting. Figure 12 shows the top 10 themes associated with this question and the percent of respondents in each interest group that discussed the theme. Figure 13 offers selected partic-

Table 4: Themes identified in response to the questions: 1) if you were to consider water for the benefit of natural resources, how would you go about it?; and 2) what would make considering water for natural resources attractive to you? Themes are color coded based on the number of interest groups that discussed the theme.

Themes	% of Participants Who Discussed the Theme
Conservation and Efficiency	23%
Cooperation	16%
Education	15%
Financial Incentives	15%
Environment as a Water User	14%
Priority Setting	14%
Understanding Value of Water	13%
Multiple Uses for Water	13%
More Regulation/Laws Needed	10%
Water Resources Planning	10%
Flexible Regulation Needed	8%
Policy Incentives	8%
Restoration of Habitat	8%
Public Support	8%
Groundwater and Surface Water Connection	7%
Human Needs Come First	7%
Need to Improve Permitting	6%
Need to Understand Science	6%
Infrastructure	6%
Cost of Water	5%
Funding	5%
Forest Health	5%
Balanced Water Budget	5%
Trading Water	5%
Existing Regulation is Sufficient	4%
Need Less Regulation	4%
Voluntary	4%
Fairness	4%
Publicity	3%
Technology	3%
Local Solutions	3%
Green Infrastructure	3%
Involvement of Elected Officials	2%
Limit New Water Uses	2%
No Natural Resources to Manage	2%
Water-Energy Nexus	1%

Number of interest groups discussing the the

1-3
4-5
6-7
8-9
All Interest Groups

ipant responses on allocating water to natural areas. A closer look at what was said regarding the themes of cooperation (Figure 14); conservation and water-use efficiency (Figure 15); and priority setting (Figure 16) can be found in the pages that follow.

The most common themes that emerged from responses to the question, "How should we consider water for natural resources?" were cooperation and multiple use, conservation and efficiency, and priority setting.

Although not directly asked, 20% of participants talked about their perspectives on allocating water to natural areas in response to this question (Figure 13). Participants from environment, government, and tribal interests were more likely to discuss the intrinsic value of natural areas, whereas those from farming, mining, and ranching more frequently discussed meeting human needs first. Participants from municipal interests who discussed allocation of water to natural areas were equally divided as to whether humans or natural areas should receive preference. The fundamental difference between these viewpoints exemplifies the difficulty in moving forward conversations about water for natural areas.

Participants from eight of the 10 interest groups indicated that cooperation among water users was a preferred way to consider water for natural areas, and all but academia discussed cooperation and/or multiple uses, which are often intertwined. In discussions about cooperation, 47% of people discussed the importance of partnerships and 34% discussed equity (Figure 14). Interestingly, at separate focus groups, participants from farming, mining, municipal, and ranching interests conveyed that they felt that they alone were being targeted to give up their water for natural areas. This exemplifies the importance of fostering future partnerships designed to ensure that when water is provided to natural areas, it is done with appropriate consideration for all water users.

Conservation and water-use efficiency were mentioned by at least one participant from every interest group in response to the question "How should we consider water for natural areas?" Conversations about water-use efficiency demonstrated differences in the perception of "efficiency" between interest groups (see Figure 15). Participants in the farming, mining, power, and ranching interests emphasized that water is a key economic ingredient to their operations. These participants noted that the cost of water as an input in their business already motivates them to be quite efficient, because to do otherwise would harm their bottom-line. On the other hand, participants in the business, environment, government, and municipal community noted that agriculture in particular is inefficient, and should be required to use less water. While conservation and efficiency were common themes, less than 11% discussed ways to ensure that the water conserved is used to support natural areas. Of those individuals who did discuss this link, the most common suggestion was to do this through policy changes that require conserved water be dedicated to natural areas.

Participants from all interest groups agreed that considering water for the benefit of natural areas is important, but participants from the business, farming, mining, municipal, and ranching interests noted that it should not be done at the expense of human populations.

A number of participants highlighted the need to think critically about when and where Arizonans provide water for natural areas (Figure 15). Discussions of priority setting, and the related topic of planning, resulted in a key finding: no one interviewed said that Arizona should not allocate at least some water to natural areas. There

Figure 12: Themes by interest group in response to the question: If you were to consider water for the benefit of natural resources, how would you go about it? Responses are normalized by the number of respondents in each interest group who answered the question.

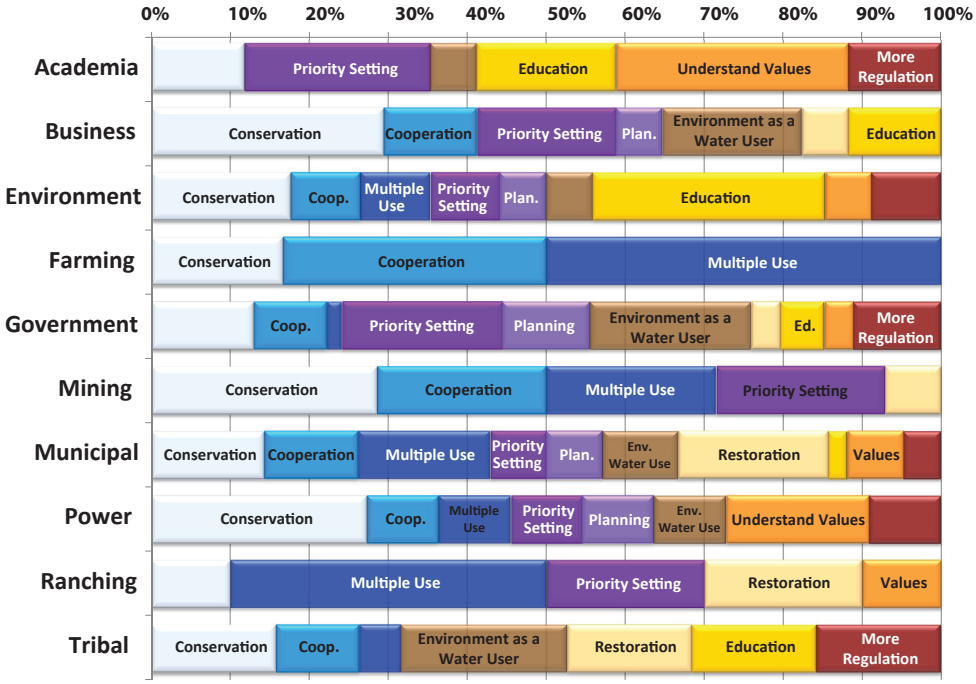


Figure 13: Selected participant perspectives on allocating water to natural areas.

Figure 14: Selected participant perspectives on the common theme of "Cooperation".

Figure 15: Selected participant perspectives on the common theme of "Water Conservation and Efficiency".

were, however, participants who were very concerned about *how* water is allocated to natural areas. Of those who discussed priority setting, 70% voiced concerns about providing water to natural areas arbitrarily, i.e., without priority setting and/or adequate understanding of how much water the flora and fauna need.

What would make consideration of water for natural areas more attractive to you?

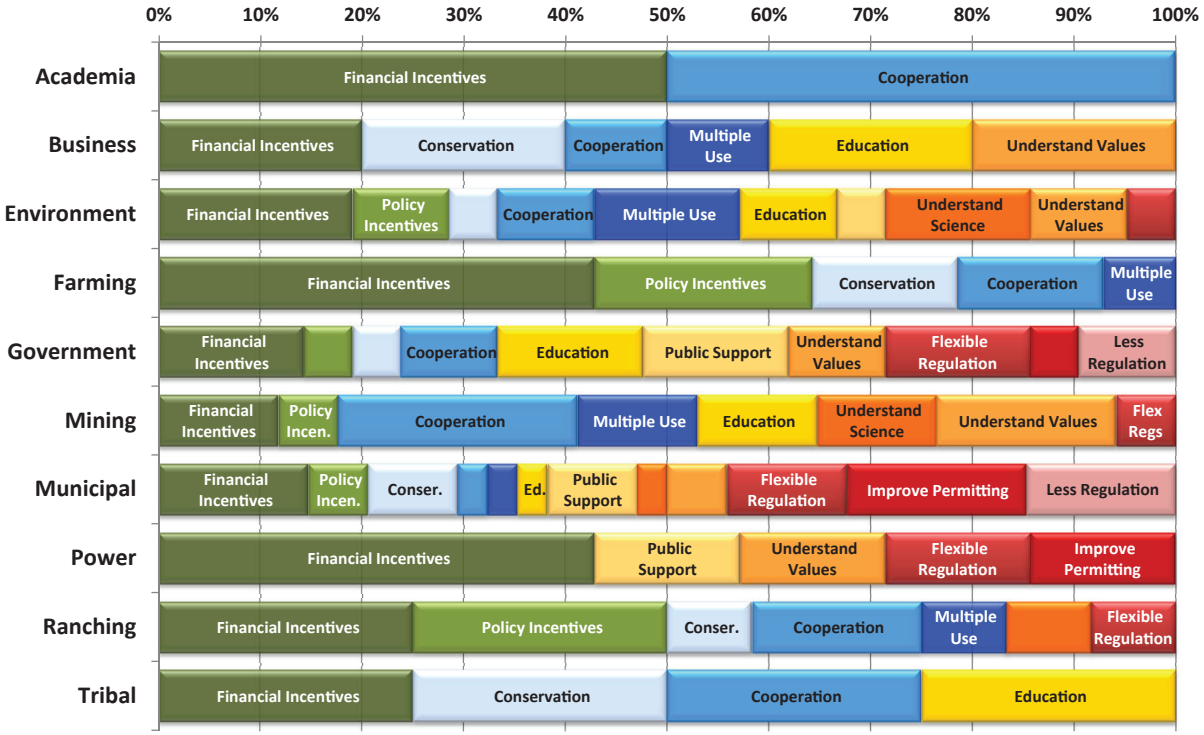
When asked, "what would make considering water for natural areas attractive?" conversations centered on incentives (financial and policy), cooperation, conservation, multiple use, education, public support, understanding (science and values), and regulations (flexible, improved permitting, or reduced) (Figure 17). All interest groups said that financial incentives, such as project subsidies or credits for improvements, would make considering water for natural resources attractive. Figure 19 offers select perspectives on the types of financial and policy incentives participants felt would make considering water for natural areas more attractive.

Of those who discussed priority setting, 70% voiced concerns about providing water to natural areas arbitrarily, i.e., without priority setting and/or adequate understanding of how much water the flora and fauna need.

The premise behind the Roadmap is that when progress is slowed due to legal challenges or a lack of statewide agreement or action, voluntary, community-driven initia-

Figure 16: Selected participant perspectives on the common theme of "Priority Setting".

Figure 17: Themes by interest group in response to the question: What would make considering water for natural resources attractive to you? Responses are normalized by the number of respondents in each interest group who answered the question.



tives can drive the consideration of water for the environment in planning and management decisions. Despite communicating this premise to Roadmap participants, six groups stated that regulatory measures are needed to make consideration of natural areas attractive. Municipal and government respondents were the primary parties interested in reducing current regulations and improving permitting. Establishing flexible regulations was of interest to environment, government, mining, municipal, power, and ranching participants. Proposed regulatory changes included revisions to the Endangered Species Act and Section 404 permitting of the Clean Water Act to allow more flexibility depending on circumstances; exemptions from long-term required maintenance of artificially created habitat; assistance with environmental compliance documents, such as permit applications; and credits for 'creating' a new water source, such as through conservation or other mechanisms to make additional water available for natural areas.

All interest groups said that financial incentives, such as project subsidies or credits for improvements, would make considering water for natural resources attractive.

In addition to incentives, participants from seven interest groups discussed the need for increased understanding, either in terms of the science used to describe the water needs of natural areas or the values humans place on natural areas, to create a level field to discuss water for natural areas. Similarly, seven groups brought up the need for education. Proposed education topics varied among the interest groups, and included: determining consistent definitions and language, such as what "water for natural areas" means; how information should

be disseminated, such as course curriculum or informational campaigns; and who should be the audience for an educational program. No consensus was reached, even among participants from the same interest group, regarding who should be the target audience for an educational campaign. Options considered included youth outreach, general public, water managers, and policy makers, with each category regarded as important for its unique ability to effect change.

Cross-cutting Themes

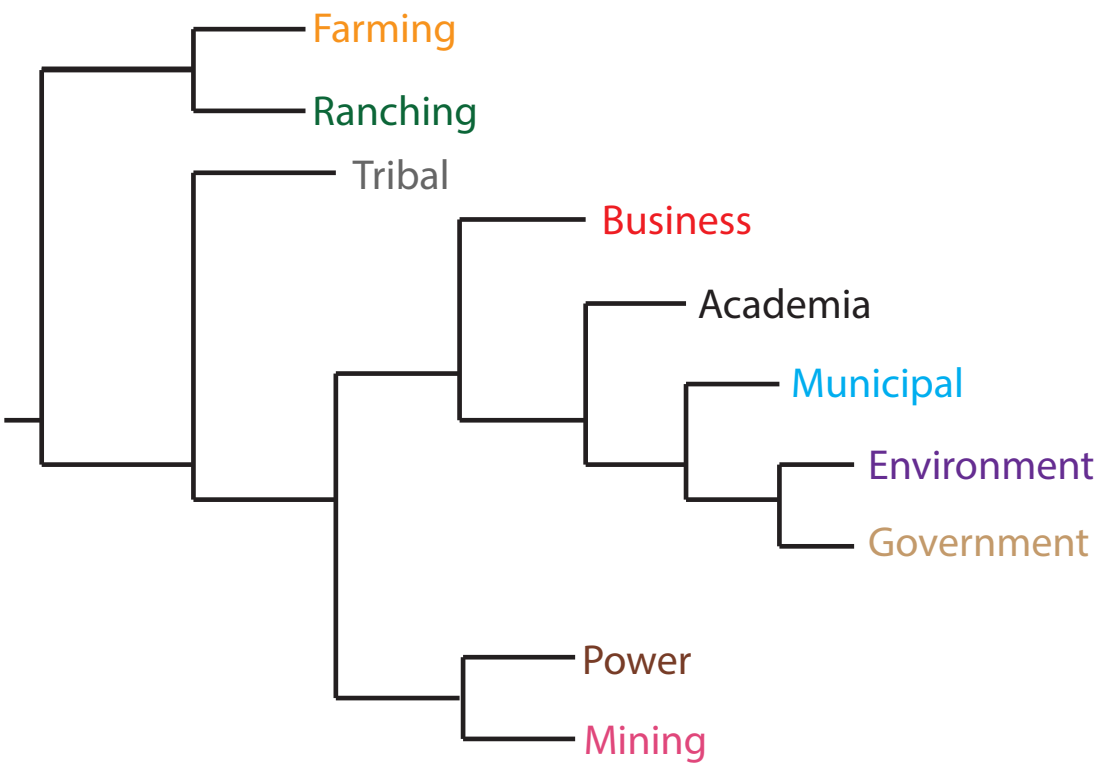
The challenge of this project is to determine where the perspectives from different water-using groups align and where they diverge. One way to look at similarities is to see how closely participant answers are to each other using a cluster analysis of the words used. In a cluster analysis, water-interest groups that have a higher degree of similarity based on the occurrence and frequency of their words are clustered together, and those that have a lower degree of similarity based on the occurrence and frequency of words are displayed further apart. One way to explore how responses from each sector relate to one another is through a dendrogram.

This form of cluster analysis is a branching diagram where similar items are clustered together on the same branch and different items are further apart. Dendrograms are particularly useful for comparing pairs of items. The dendogram in Figure 22 shows that conversations with mining and power were more similar to one another than conversations with academia, business, environment, government, or municipal sectors. Finally, it shows that conversations with farming, ranching, and tribal groups were generally dissimilar from discussions with the other seven water-using groups.

Figure 18: Selected participant perspectives on the common theme of "Incentives".

Figure 20: (a) Dendrogram showing similarity between water interest groups based on the words they used during focus group meetings, excluding the word "water"; (b) sample quotes from related sectors.

a)



b)

You have to find tradeoffs, everyone wants it all and you have to make it as easy as possible for those who don't want to give it up and have buy in from all sectors to ensure an equitable solution.

90% of time it comes down to money issues. You'll never get them to come around to what you think, because they aren't you. What they care about is that every cent is tied up into their farm, so we need to find out how to make it worth it to them.

The whole system of water management and allocation was set up in a backwards way, with the idea that water is being wasted if it's not being utilized for human needs... plants, animals, ultimately serve people so it's a huge question... There needs to be some solid policy changes, a shift in the way we think of water.

Invest time into managing the flow of water so the water hits the natural resource and doesn't get bypassed into diversions. The natural resources are being robbed of their water due to poor environmental planning.

Education and marketing in the short-term, long term advocacy of competent management with authority...education is necessary but not sufficient...need a regional water resource management authority.

There is interest in supporting more water for the support environmental resources ...this community wants to establish an instream riparian habitat but federal and local government are at odds.

I would like to see increased management for ecological supply, we are headed in the wrong direction.

The allotment of the water in an overall plan that includes natural resources, which have been left out in the past.

Anyway we can use resources more efficiently we do, for both our bottom line and natural resources. There is a cost to the water that we use, it is important to minimize those costs and operate more efficiently.

[We are] taking a stronger look at recycled water and improving our ability to recycle water

What Prevents Us from Considering Water for Natural Areas?

In order to determine how to consider water for natural areas, it is important to examine what the key obstacles might be. Of the many obstacles to providing water for natural areas participants raised throughout this process, the most frequently discussed were regulation, data, financial resources, and communication. These four obstacles are discussed in further detail below.

Regulation

A significant theme that emerged during focus group meetings and the roundtable was the issue of the unintended consequences of government regulation. Participants expressed frustration over laws that were meant to protect people and natural resources, but ended up pitting people against each other or creating disincentives. In a focus group meeting, one participant noted that "the Endangered Species Act falls short in protecting habitat versus species and it puts people in an adversarial role," and another said that there is a "disincentive to conserve or discharge water [because we are] penalized for doing that, and so there is an incentive in a water-short state to waste water and not release it to the environment." Mining, municipal, and ranching participants further expressed concerns that such a release may create habitat that they would then be legally responsible for maintaining.

Participants also expressed frustration over the inadequacy of existing laws, regulations, and policies in protecting natural areas. For example, in both the roundtable and the focus groups, participants discussed Arizona's bifurcated water law as a barrier. The disconnect between surface water and groundwater under Arizona law is problematic because riparian ecosystems are at the intersection of groundwater and surface water, and without legal recognition of this connection, it is challenging to preserve water for them. One focus group participant noted, "because our water management legal structure is so antiquated, we end up with hit-or-miss negotiations with landowners that would not require negotiation in the first place if it were clearer. We need a modernization of the regulations." In the survey, 48% of respondents indicated that formal recognition of the connection between surface water and groundwater decreases the vulnerability of water for natural areas. Throughout the focus group meetings, the lack of a secure water right for ecosystems was highlighted as a key barrier to the consideration of water for the environment. In the focus groups, 15% of participants discussed the need for a legal right to water for the environment. This response was most common with government and tribal participants, and not mentioned at all by participants from ranching, mining, or farming interests. In the survey, however, 63% of respondents across all water interest groups, including those from mining and agriculture, acknowledged that policies that protect environmental flows decrease the vulnerability of water for ecosystems.

Participants expressed frustration over laws that were meant to protect people and natural resources, but ended up pitting people against each other or creating disincentives.

Data

Even if regulations, laws, or policies were changed to remove barriers or provide incentives for the inclusion of water for ecosystems in management and planning, it remains crucial to understand how much water ecosystems "need," and what that water is worth. In the roundtable, participants indicated that there is a need for methods that quantify ecosystem water needs, as well as for information on the economic value of water if it is left in streams and aquifers. At the roundtable, opinions on how simple it would be to collect economic data ranged from "easy" to "difficult." Reasons given as to why it would be difficult to collect economic data included potential costs and a lack of criteria to guide the process.

The need for data on the "value" of instream water was also discussed by 13% of focus group participants, with a participant noting that we need to think about how we "maintain water supply from an economic perspective, and need to objectively be able to put a value on that natural resource to show the value of that resource to our community." Data gaps with reference to the water needed to maintain ecosystems was an issue less frequently discussed in the focus groups, but participants did note that "we need to set reasonable targets for natural resource use so our position is not 'I want everything you have,' but we first need science to get the target amount."

In the survey, a lack of data on the water needs of ecosystems was the driver most likely to discourage consideration of water for ecosystems, at 67%.

In the survey, a lack of data on the water needs of ecosystems was the driver most likely to discourage consideration of water for ecosystems, at 67%. Similarly, 55% of respondents indicated that understanding how much water ecosystems need decreases their vulnerability. These responses were consistent across interest groups with the exception of tribal (67%), educational (49%), and agricultural (48%) respondents, who did not think an understanding of water needs decreases or increases vulnerability of water for the environment (see Appendix B).

Financial Resources

In focus groups, a lack of funding for water conservation, maintaining watersheds, and planning for the future were all identified as obstacles to providing water to natural areas. Similarly, the lack of interest from decision makers in either providing funding or changing laws that would make considering water for natural areas easier was also discussed. In these conversations, participants noted that providing water to natural areas can be expensive, either in outright cost for the water, or in the revenue lost because the water is going somewhere else. Participants from the municipal and power interest groups in particular noted that they work on behalf of their customers, and until their customers ask them to take some of their money and put it toward water for the environment, it is not something a utility can consider.

Communication

Early in the Roadmap building process, the WRRC had multiple conversations with the Steering Committee regarding communication about water for natural areas. The key issue with communication is finding a way to talk about a sensitive and politically charged issue without immediately putting people on the defensive or offending them. This issue of communication and the language used also arose in the roundtable. During the roundtable, participants noted that it is critical to present the issue of water for ecosystems without bias because the dialogue on water for natural areas is so politically charged.

During the roundtable, participants noted that it is critical to present the issue of water for ecosystems without bias because the dialogue on water for natural areas is so politically charged.

To learn more about how to communicate across a broad swath of water interest groups, at the end of each focus group, participants were asked to give their initial reaction to five terms frequently used to talk about water for natural areas. Participants were not provided any context for the phrases or definitions. The phrases were chosen in consultation with the Steering Committee and included: "water dependent natural resources," "environmental water demand," "instream flow," "environmental flows and levels," and "ecological flow requirements." "Water dependent natural resources" is a phrase created by Arizona's recent

WRDC Environmental Working Group. "Environmental water demand" is a phrase the WRRC started using to describe water for natural areas in the same way human uses are described, e.g., municipal demand, industrial demand, agricultural demand. "Instream flow" was chosen because of the water rights structure in Arizona that provides for water to remain "in stream" for non-consumptive use. "Environmental flows and levels" is language used to describe the water needs of natural areas in flowing streams and in groundwater levels. Finally, "ecological flow requirements" is a term used in the South African national law, which discusses allocating water for basic human flow requirements and ecological flow requirements first, and then allows water to be used for other purposes.

Of the five terms discussed, no proposed terminology for describing the concept of providing water to natural areas was overwhelmingly accepted by focus group respondents (Figure 21). The most disliked phrase was "environmental water demand" with 57% of participant opinions being "negative," followed by "ecological flow requirements" at 41% "negative." 47% of respondents expressed that they had a negative reaction to these terms because saying that natural areas "demand" or "require" something implies a mandate, not a choice, and a perception that the level of demand cannot be changed depending on future circumstances. "Instream flow" may have been the most favored in terms of number of "positive" and "neutral" responses, but during discussion of the terms, those that had a "negative" reaction to "instream flow" had a very strong negative reaction. Even among those favoring "instream flow" to the other terms, including academic, environment, and tribal perspectives, it was noted that it is not descriptive enough because "instream flow" does not include groundwater. By interest group, the most "positive" responses to the five terms came from environment or tribal participants; farming or ranching participants had the most "negative" responses. Details about each interest group's response to each term are shown in Table 5.

Of the five terms discussed, no proposed terminology for describing the concept of providing water to natural areas was overwhelmingly accepted by focus group respondents.

Despite a lack of agreement on the five proposed phrases, respondents from environment, farming, municipal, ranching, tribal, and other interests agreed that when talking about providing water to natural areas one should just "say what you mean." In trying to appease multiple audiences, terminology is invented that is either too complicated or too watered-down to convey a concept. Many respondents agreed that

Figure 21: Responses to the question: What is your reaction to the following terms?

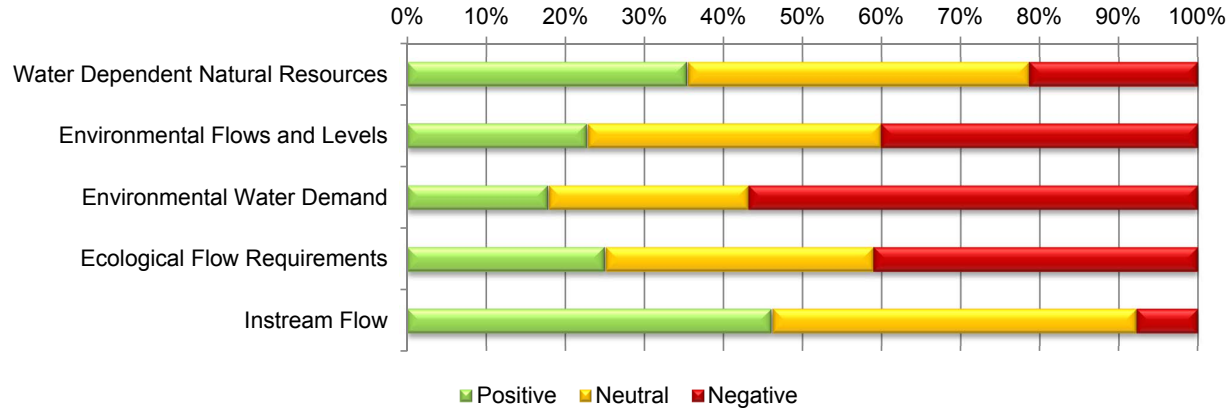


Table 5: Responses by sector to the question: What is your reaction to the following terms?

	Water Dependent Natural Resources			Environmental Flows and Levels		
	Positive	Negative	Neutral	Positive	Negative	Neutral
Academia	56%	11%	33%	11%	44%	44%
Business	20%	20%	60%	13%	53%	33%
Environmental	52%	18%	30%	50%	16%	34%
Farming	15%	38%	46%	0%	69%	31%
Government	21%	16%	63%	37%	32%	32%
Mining	56%	25%	19%	19%	75%	6%
Municipal	27%	22%	51%	11%	36%	52%
Power	13%	25%	63%	0%	25%	75%
Ranching	38%	25%	38%	22%	56%	22%
Tribal	58%	17%	25%	100%	0%	0%

	Environmental Water Demand			Ecological Flow Requirements			Instream Flow		
	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral
Academia	22%	67%	11%	22%	22%	56%	33%	0%	67%
Business	7%	73%	20%	13%	67%	20%	33%	7%	60%
Environmental	41%	44%	16%	53%	13%	34%	66%	9%	25%
Farming	0%	92%	8%	8%	69%	23%	38%	15%	46%
Government	22%	39%	39%	37%	21%	42%	63%	0%	37%
Mining	0%	50%	50%	6%	56%	38%	25%	0%	75%
Municipal	11%	67%	22%	18%	50%	32%	50%	5%	45%
Power	0%	38%	63%	0%	50%	50%	50%	0%	50%
Ranching	13%	63%	25%	11%	56%	33%	0%	56%	44%
Tribal	50%	30%	20%	100%	0%	0%	50%	0%	50%

this can lead to confusion or distrust and prevent progress. Another common theme across the responses was that participant interpretations of these terms and others will depend heavily on the context in which it is stated and who they are hearing the term from. This was illustrated in the conversations that followed focus group meetings, as once the origin of the terminology was described, participants tended to be more neutral or positive towards them. Multiple participants noted that if they heard one of these terms from a colleague or trusted contact they would be more likely to react positively or maintain an open mind versus if the term was presented to them by an organization that they viewed as opposing their interests.

5. The Path Forward – Recommendations and Actions for How to Consider or Incorporate Natural Areas in Water Management and Planning

Moving forward, the consideration of water for natural areas in Arizona should take multiple paths. Some of these routes will intertwine and overlap, some will run parallel, and some may require the construction of new avenues or the removal of roadblocks. The recommended strategies and actions presented here are based on the regional workshop series, follow-up conversations with Steering Committee members, and case studies of projects that are already increasing or including water for natural areas.

In the regional workshops, participants presented a diverse array of recommended strategies for how the water needs of natural areas could be considered in future water management and planning decisions. To identify the themes that emerged from the workshops, the WRRC reviewed facilitator notes and categorized like responses into subgroups, which resulted in a total of 10 thematic recommendation categories (Tables 6 and 7). Of these categories, the four most commonly discussed had three or more recommended strategies and actions associated with them. These four categories include: 1) improve education; 2) set priorities and assess values; 3) provide funding to maintain water in natural areas; and 4) manage water supplies for multiple benefits, including natural areas.

In the regional workshops, participants presented a diverse array of recommended strategies for how the water needs of natural areas could be considered in future water management and planning decisions.

It should be noted that although these recommendations and action items have been parsed into separate categories, no recommendation or action item can move forward without consideration of the other categories. For example, to provide funding to maintain water in natural areas a community would need to set priorities to determine the desired site, identify opportunities for multiple benefits considering an array of available water resources, and would likely want to implement an educational program for the community to explain what has been done and why.

The top four recommendation categories from the regional workshop discussions were also common themes from previous Roadmap conversations. For example, roundtable participants noted, “we need to educate the public, because they might know [water for the environment] is an issue, but it’s not something they’re willing to march on.” Similarly, discussions of the need to set priorities occurred throughout the project, beginning with the kickoff meetings where participants discussed setting priorities by comparing human demand to baseflows and identifying at-risk watersheds. A detailed discussion of each top category can be found in the pages that follow. For the remaining six recommended strategies, key aspects and ideas for immediate action items are listed in Table 7.

Although many voices were included in this process, the proposed recommendations and action items discussed in this Roadmap should not be considered a complete list of possibilities and may not accurately reflect all Arizonans’ interests and concerns about water for natural areas. This project focused on those who work in water management or who have a significant interest in water management. As a result, the general public was not actively recruited to participate in these discussions. However, the need to engage with the general public on water management issues and water for natural areas was expressed throughout the Roadmap development process.

Table 6: Recommended strategies and action items from the regional workshop series identified three or more times by workshop participants.

Recommendation	*Key Aspects*	*In the Next Year…*
Improve Education	• Across-the-board education about how all water-using sectors benefit natural areas and how they use and conserve water • Education about the history, heritage, and importance of Arizona's riparian and aquatic ecosystems	• Form a water education advisory committee to identify existing programs and resources appropriate for providing the public with foundational water knowledge • Pool resources to create an educational "toolbox" or online clearinghouse for materials • Identify, evaluate, and support an existing program, if a suitable program already exists
Provide Funding to Maintain Water in Natural Areas	• Connect water conservation to preservation of natural areas through allocating the water or financial savings to enhance or preserve natural areas • Offer financial compensation to encourage more efficient use and/or leave water flowing through natural areas	• Examine available options for funding water for natural areas including how a tax credit program for providing water to natural areas would work, the One for the Verde program, and the Conserve2Enhance program • Evaluate existing funding mechanisms to gauge how successful they could be as a large-scale funding source for natural areas, including an assessment of how well the mechanism currently works, what needs to change to adapt it to community/statewide goals, and what should be added so the program can meet those goals
Set Priorities and Assess Values	• Establish a localized process to promote cooperation and collaboration among regional stakeholders • Examine how other areas have established community/regional priorities • Establish a process for all sectors to voluntarily coordinate with one another	• Conduct a statewide survey to objectively assess and rank public values for water and natural areas • Establish regional working groups to: - Create a problem statement based on regional concerns with riparian and aquatic ecosystems - Establish clear goals and objectives to address the problem statement - Identify pilot projects based on the problem, goals, and objectives
Manage Water Supply for Multiple Benefits, Including Natural Areas	• Provide incentives for near-stream recharge and discharge of reclaimed water into natural areas • Ensure reclaimed water would be available long-term • Consider natural areas in stormwater management • Utilize water-dependent land use planning and widespread low-impact development, including rainwater harvesting	• Identify common interests and shared goals about the use of water resources for local ecosystems • Expand on the WRDC inventory of where and how effluent is currently being used to support riparian and aquatic ecosystems • Identify existing water use agreements and regulatory constraints that may hinder allocating water to natural areas • Identify a pilot project or area to explore impacts of modified stormwater management and rainwater harvesting on riparian and aquatic ecosystems

Table 7: Recommended strategies and action items from the regional workshop series identified less than three times by workshop participants.

Recommendation	*Key Aspects*	*In the Next Year…*
Address Data Gaps	• Address data gaps in current understanding of water needs of ecosystems • Determine where/how water is currently used for the benefit of riparian and aquatic ecosystems	• Inventory efforts to provide water for the benefit of riparian and aquatic ecosystems through an update to the WRRC's 2006 *Projects to Enhance Arizona's Environment* report and use of the Roadmap case studies (Appendix A) • Create a research agenda based on data gaps identified through the WRRC Environmental Water Demands Database
Establish Voluntary Partnerships	• Voluntary partnerships to facilitate efficiency, maximize impact, and identify available funding • Bring stakeholders together through: - Regional working groups to set priorities - Scenario planning exercises - Forum for discussing tribal water issues - Youth education partnerships	• See Set Priorities and Assess Values in Table 6
Develop Conservation Programs	• Implement a water conservation program that benefits natural areas with municipal, agricultural and industrial water users (e.g., Conserve2Enhance-like mechanisms) • Create utility-based conservation programs (e.g., expand utility checkbox program for conservation funds)	• Assess water-user interest in implementing conservation programs that benefit natural areas.
Improve Energy Efficiency (Water-Energy Nexus)	• Develop analogs from energy industry as models/incentives for water efficiency • Promote water-efficient renewable energy	• Evaluate existing energy industry efficiencies, models, and incentives for applicability to water resources management
Modify Permitting Process	• Modify water pricing, trading, or banking to encourage the provision of water to natural areas • Modify existing regulations to create flexibility (ex: Managed vs. Constructed recharge credits) and allow private utilities to recoup conservation costs • Simplify permitting process when there is a demonstrated benefit to natural areas	• See Set Priorities and Assess Values in Table 6 • Use regional forums to discuss interest, feasibility, and opportunities
Provide Legal Standing to Natural Areas	• Provide legal standing for natural areas • Reform instream flow certification process to give ecosystems a 'right'	• See Set Priorities and Assess Values in Table 6 • Use regional forums to discuss interest, feasibility, and opportunities

Improve Education on Water Resources and Water for Natural Areas

The need for education to advance the consideration of water for natural areas was discussed at each regional workshop and arose in all four workshop breakout groups (priority setting, water use efficiency and conservation, incentives, and education/communication). Recommended strategies varied between regions and within discussion groups. No consensus was reached, even among participants from the same water-interest group, regarding who should be the primary target of an educational campaign. The proposed topics for "education" also varied, as did ideas about how information should be disseminated, such as through course curriculum or informational campaigns.

Recommendations included across-the-board education about: 1) how all water-using sectors benefit natural areas as well as how they use and conserve water; and 2) the history, heritage, and importance of Arizona's riparian and aquatic ecosystems. Within each recommendation were variations in the desired target audience and educational approach. For example, Yuma participants were interested in educating the public about existing agricultural water conservation and the benefits this conservation provides to natural areas, Flagstaff participants suggested an outreach program designed for elected officials, while Phoenix and Tucson participants desired well-rounded informational campaigns for more general audiences. There was, however, consensus that any educational program should make use of existing resources and involve simple, clear messaging. Examples of how natural areas can benefit from educational programs can be found in each of the Roadmap case studies (Appendix A); in particular, the Las Cienegas case study includes a large educational component that has contributed to the project's success (Box 1).

Box 1. Las Cienegas National Conservation Area

The Las Cienegas National Conservation Area (LCNCA) and Sonoita Valley Acquisition Planning District (SVAPD) developed the Las Cienegas Resource Management Plan (RMP) in partnership with the Bureau of Land Management (BLM). The RMP includes clear, measurable management goals focused on maintaining and restoring the grassland watershed, riparian and aquatic areas, and native fish and wildlife. Diverse community partnerships are key to the success of the RMP; this list includes local municipalities, state and federal agencies, academia, and non-governmental organizations. Adaptive management promotes cooperative action based on relevant, powerful, and efficient data and monitoring programs, which facilitate stewardship of natural and cultural resources, while allowing human use. Importantly, flexibility in management allows the program to respond to community priorities and the ecological needs of the system without undergoing additional planning or reorganization efforts. To promote its mission, LNCA has organized educational programs for youth, decision makers, and members of the general public.

Major project theme: Cooperation & Communication

Key to project success: Cooperation & Communication

What would you change? Time to implement

Advice for others: Build a forum to act on good information that fosters communication

LCNCA landscape. Photo courtesy of Shela McFarlin.

Participants from all regional workshops, regardless of the thematic areas they chose to discuss, agreed upon the need for education and communication about providing water to natural areas. When asked "who needs education," the first response from all education discussion groups at all regional workshops was that "everyone" needs education. Education, on water resources and water for natural areas, was also a common theme in other stages of the Roadmap development process. Focus group participants from seven of the ten different water interest groups, and 15% of all focus group participants, identified education as an opportunity for considering water for natural areas. One focus group participant stated, "Education and understanding is important to how people view water, if you don't know where your water supply begins, how can you appreciate it?" Earlier in the project, roundtable participants spent time contemplating the possible options for how to educate and who should be educated. All roundtable groups agreed that there is a need for general outreach about environmental water demand to motivate citizens and decision makers to consider the environment and "spur better informed community choices."

Participants from all regional workshops, regardless of the thematic areas they chose to discuss, agreed upon the need for education and communication about providing water to natural areas.

During the Roadmap development process, participants also identified obstacles to an educational campaign. For example, education is hindered by a lack of public engagement and community buy-in: "we need people to realize that what they do to water affects other people, and that other people's actions affect you too." To address this concern over community support, many in the roundtable, focus groups, and workshops recommended adopting a simple messaging strategy citing that "a lot has to do with how the message is given." One roundtable participant explained how critical appropriate messaging can be by saying, "we're talking about how there are not environmental water rights, but we're sort-of saying we have a better use for your water than you do so give me your money and rights—we need to articulate the benefits to [other interest groups], not just tell them they're wrong." Similarly, there is a need for a consistent view on Arizona's future water supply outlook; one participant expressed that "what's hurting us the most right now [are organizations] telling everyone that Arizona is not in crisis and because of that, it's going to be hard to get people to move to action." Other concerns for an educational program were a "lack of financial support" and lack of organization among educators to share available materials. The desire for an informational repository, in particular, is not new. In 2010, a workshop on water resources and education was hosted at the WRRC Annual Conference where participants identified the need for an online clearinghouse of information and materials on water education and outreach. As of this publication, such a resource does not yet exist.

In order to overcome these obstacles and create a comprehensive educational program that encourages water for natural areas, participants determined the need for "more robust consideration and dialogue to uncover innovative solutions." They also determined that this dialogue should include not only educators from universities, K-12 schools, and existing natural resource related educational programs, but also government agencies, non-governmental organizations, tribal chapters, water providers, agricultural organizations, museums, multicultural organizations, and local watershed groups. Participants concluded that representatives from these organizations should form a statewide water education committee tasked with identifying

funding sources, setting curriculum, and prioritizing desired audiences. It would also be up to this committee to determine if they agreed with participants' perspectives on points such as, "while it's important to educate the general populace, it really boils down to the decision makers, and really the folks that influence the decision makers," or, "if we can show [the public] what the environment needs, they might be more inclined to do something." Participants were also interested in the collective power a unified committee could have by pooling resources, curriculum, and forging new partnerships. One workshop attendee said doing this would be an opportunity to "create stone soup—everyone can bring a little to the table and together we may have just what we need." Action items identified for moving an educational campaign forward included:

- Set a timeline and goals for the campaign
- Form a statewide water education committee
- Collect available materials into a central repository
- Develop a training module for educators
- Write a curriculum
- Research case studies for innovative ideas to motivate action
- Identify experiential learning opportunities.

In the next year: Stakeholders could come together to form a statewide water education advisory committee made up of educators, community members, and organizations that have experience communicating information about natural resources. This group should identify existing programs and resources, such as Arizona Project WET (Water Education for Teachers), appropriate for providing the public with foundational water knowledge, as defined by the committee. These resources should be pooled to create an educational "toolbox" or online clearinghouse of materials. Once this is complete, the water education advisory committee should assess how each of these existing resources can be used for each target audience and region to prepare for a formal education campaign. One option for such a campaign is to develop a Water 101 course for the public that has both online and in-person program options.

Provide Funding to Maintain Water in Natural Areas

The need for funding to maintain water in natural areas was discussed at all four regional workshops and was considered in the water use efficiency and conservation, education, and incentives discussion groups. Recommended strategies for how funding could be used to provide water to natural areas centered around two approaches: 1) connecting water conservation to preservation of natural areas by allocating the conserved water, or financial savings, to enhance or preserve natural areas; and 2) offering financial compensation to encourage more efficient use and/or leave water flowing through natural areas.

Providing financial compensation as a means to encourage efficiency or leave water instream emerged during all phases of the Roadmap development process.

Options discussed for implementing these strategies included adopting a Conserve2Enhance™ (C2E) type mechanism to encourage conservation and allocate saved dollars to natural areas (see Box 2 and the Conserve2Enhance case study in Appendix A), metering wells and providing conservation incentives for more efficient use, and creating a fund to pay water users to leave water in natural channels. In terms of connecting water conservation to preservation, roundtable, focus group, and workshop participants often discussed the use of a C2E-like program. One roundtable participant noted, "a process like C2E to get people to stop and think, since it's the best system we

have so far," could encourage conservation and provide funding to natural areas. Doing so could "create a fund for purchasing water for natural areas," which could be used long-term to encourage "non-development and keep water in streams."

Providing financial compensation as a means to encourage efficiency or leave water instream emerged during all phases of the Roadmap development process. For example, focus group participants cited a lack of funding for conserving water, maintaining watersheds, and planning for the future as obstacles to providing water to natural areas. Though some recommendations discussed modifications to the permitting process, the most common recommendations were for financial incentives; more than half of participant workshop recommendations included a monetary component in their proposed implementation.

Stakeholders throughout the Roadmap development process also agreed that a financial mechanism is needed to address the disincentives to conserving or discharging water to the environment. One focus group participant stated that we need to "incentivize some portion of everyone's portfolio being reuse" to make providing water to natural areas competitive and appealing. A challenge to this is that there can be "no [comprehensive] incentives unless economics are defined...how much money is [the environment] worth?" Answering this question will require communities to explore their water budgets and to weigh the benefits of natural areas against other uses for available water resources.

Conducting such an economic evaluation was brought up by participants, with one person citing the economic impact reports that have been prepared for the Arizona Game and Fish Department on the value of wildlife-related recreation as well as hunting and fishing. The Verde Ditch Gates case study (Box 3; Appendix A) provides an

Box 2. Conserve2Enhance™

The Water Resources Research Center's Conserve2Enhance (C2E) program provides a financial mechanism to support community-based environmental programs and water conservation. Participants implement conservation measures in their home or business, and keep track of their water use with the help of the C2E Water Use Dashboard (www.conserve2enhance.org). The C2E Dashboard associates a monetary value with the saved water, which serves as the basis for voluntary donations to a fund for environmental enhancement projects. C2E projects can include urban waterway improvements, purchasing instream flow rights, or other environmental needs identified by the community. By associating a monetary value with the conserved water, C2E links water savings directly to environmental projects of value to local communities or organizations. C2E has been helping connect water conservation with community action since 2010. Since this time, four C2E programs have been launched, more than 150 accounts have been created on the C2E Dashboard, and participants have conserved over five million gallons of water.

Major project theme: Conservation & Efficiency; Value of Water

Key to project success: Public Participation

What would you change? Secure long-term maintenance for programs; time to implement

Advice for others: Develop strong community partnerships and engage with participants

Before (black and white) and after (color) transformation of Tucson C2E Atturbury Wash enhancement site. Photo courtesy of WRRC.

example of how the value of natural areas to the local economy and financial incentives can be used to successfully increase efficiency.

Whether creating a C2E-type mechanism or providing direct financial compensation, a number of obstacles exist. Determining who will support funding options and how funds will be raised or allocated are just the first in a series of discussions that need to take place. Not all Roadmap participants were optimistic about providing funding to natural areas, with one saying that although "funding grants for water improvement systems is possible, that seems pretty far-fetched." And, even if funding is obtained, "the accounting systems that manage water make it nearly impossible, unless you are using it, to say 'it's still mine and I want to [allocate it elsewhere]'. That's water law. It's really hard to get around." Another obstacle is identifying individuals or organizations with water rights or natural areas interested in participating in a program, since "you have to change the perception of people with the money," not just the general public. Concern over longevity of water allocations, incentive programs, and funding sources also emerged in participant discussions.

In order to overcome these obstacles and provide funding for natural areas, participants determined the need for conversations between senior water rights holders and claimants (including municipalities, agriculture, and industry), natural resource managers, and community leaders. Other groups that were identified as necessary to these conversations were non-governmental organizations, existing conservation program managers, and water providers. One participant noted that no one "talks about environmental water use. You don't hear anything about this kind of thing. I hope that this kind of discussion will become a regular part of the dialogue...between different perspectives."

Box 3. Verde River Automated Ditch Operations

Irrigation is critical to sustaining the livelihood of multiple communities along the Verde River, but often competes with environmental flow demands. To balance environmental and agricultural water needs, The Nature Conservancy (TNC) and Diamond S Ditch Company worked in partnership to identify a "win-win" solution. The result was increasing system efficiencies via automated gates that make use of excess agricultural water to maintain consistent water levels instream. For the Diamond S, this project not only increased efficiency, but also decreased safety concerns and provided financial incentives for ditch maintenance. Some members of the Diamond S were initially reluctant to work with TNC, but by the end of the project they recognized that a strong Verde River is key to the valley's economic future, in terms of aesthetics, tourism, recreation opportunities, and ecological health, and that facilitating multiple uses of the river benefits all parties. This project now serves as a learning experience for agricultural and environmental interests as the two groups continue to work together.

Major project theme: Conservation & Efficiency; Financial Incentives

Key to project success: Cooperation & Communication; Financial incentives

What would you change? Time to implement

Advice for others: Build trust and develop community partnerships

TNC and Diamond S Ditch representatives at new automated ditch gate. Photo by Darin Kopp.

Among the tools and resources needed to establish a funding program for natural areas, monetary support, a water source, and identification of natural areas in need of supplemental water emerged as important considerations. Participants also expressed a need for information about future opportunities, such as scenario planning, as well as research on available technology, "social incentives" to encourage support, appropriate actions and sectors to incentivize, and what organization (existing or needing to be formed) is best suited to lead this effort. Action items identified for moving forward with creating a funding mechanism for providing water to natural areas included:

- Identify willing participants/partners
- Identify funding sources
- Develop a project list
- Implement pilot projects and a public education campaign to garner support
- Develop metrics for success, evaluate success of existing projects, and convey benefits of providing water to natural areas with the public and decision makers

In the next year: Stakeholders should come together to examine available options for funding water for natural areas. This could include an exploration of how a tax credit program for providing water to natural areas would work and if such a program is possible. One option for completing this would be to assemble a cohort of diverse water users who could either draft and implement surveys, or interview experts in a more targeted fashion. There could also be an evaluation of the C2E mechanism to gauge whether a program like this could be successful as a large-scale funding source for natural areas. This evaluation should include an assessment of how well the C2E mechanism currently works and identification of modifications necessary to adapt it to meet community and statewide goals.

Setting Priorities and Assessing Values

The importance of setting priorities for and assessing the value of water for natural areas was discussed at all four regional workshops in the water use efficiency and conservation discussion group as well as in the priority setting discussion group. Recommended strategies for establishing priorities and assessing values centered around: 1) establishing a localized, voluntary process for all sectors to promote cooperation and collaboration among regional stakeholders; 2) examining how other states have established community or regional priorities; and 3) conducting a stakeholder survey.

Roundtable participants called for the establishment of robust and collaborative water management solutions where information is openly shared and inclusive of stakeholder values.

The need for establishing priority areas was clear in all aspects of Roadmap development. Fourteen percent of focus group participants spanning eight of the ten water-using sectors talked about priority setting. No one interviewed in the focus groups said that Arizona should not allocate at least some water to natural areas. A few participants at the Yuma workshop, however, did indicate that they were not convinced that water should be provided to natural areas beyond current levels. Roundtable participants called for the establishment of robust and collaborative water management solutions where information is openly shared and inclusive of stakeholder values. Participants also noted that priority setting should be routine practice, with one participant stating that it "needs to be worked on where it works through a normal process, not keep waiting for [water supplies] to get to an emergency situation."

Though the vast majority of Roadmap participants agree that natural resources

should be considered, determining what areas should receive priority and how community values should be assessed can be quite complex. For example, of those that discussed priority setting in focus groups, seventy percent voiced concerns about providing water to natural areas arbitrarily, emphasizing the importance of establishing an adequate understanding of how much water the flora and fauna need, and setting priorities accordingly. One participant explained, "we need to develop a regional perspective and include all users--do we want to maintain current natural areas? Bring them back? You need to establish regional priorities before you can determine what the priorities are for the water." The lack of a central organization or formal process for assessing priorities and values, and a lack of funding to enable the establishment of either, were noted as weaknesses in Arizona's current ability to provide water for natural areas. Another challenge to creating a community organization for priority setting is the lack of a driving force to bring key actors together, which, according to one workshop participant, would require crisis on the scale of "Lake Mead drying up—most everything else would fall short."

Many participants agreed that prioritizing water for natural areas should be tied to regional conditions and community values. Every community in Arizona has natural areas of local importance—whether it be for recreational, spiritual, economic, or other reasons. In order to determine how much water to provide to riparian and aquatic ecosystems, the community must first define that need by setting priorities for water for natural areas. Priorities can be set based on contribution to the local economy, cultural or historical importance, vulnerability of water for the ecosystem, valuation of the ecosystem itself, or likelihood of conflict between human needs and the water natural areas need to survive. Rehabilitation of the Yuma Wetlands is an example of how the local community used priority setting to benefit residents as well as the region's

Box 4. Yuma East and West Wetlands Restoration

Prioritizing where we provide water to natural areas is a complex problem tied to local conditions and community values. In the case of the Yuma wetlands, mitigating the ongoing environmental and social damage in these areas had been a community priority for decades. Various ideas and plans were pitched over the years, but these early efforts were frustrated by patchwork land ownership, conflicting claims, community tensions, and distrust of government. Ultimately, disparate groups who had sometimes been in conflict with one another were able to come together, and through their creativity, expertise, and dedication, succeeded in the ambitious restoration of hundreds of acres of riparian and wetland habitat. Flexibility in regulation allows the City of Yuma to discharge spent filter backwash water from its Mail Street Water Treatment Plant to the Yuma East Wetlands, which is vital to the survival of the rehabilitated ecosystem. In order to do so, the City coordinated with the Arizona Department of Environmental Quality to establish a net ecological benefit that allowed modified, site-specific water quality standards for total selenium and total residual chlorine.

Major project theme: Flexible Regulation; Priority Setting

Key to project success: Cooperation & Communication; Making progress

What would you change? Technical details; Time to implement

Advice for others: Understand the importance of collaboration and remove personal agendas from the equation

Aerial photo of Yuma Wetlands. Photo courtesy of Fred Phillips.

Table 8: Criteria for setting priorities based on vulnerability of water for natural areas. Vulnerability criteria were evaluated by survey respondents for whether the criterion increases or decreases the vulnerability of water needed in the environment or is neutral and does not affect vulnerability. When more than 50% of respondents from a single interest group or region identified a criterion as "increases", that group or region is identified.

Vulnerability Criteria	Brief Summary of Vulnerability	Decreases	Increases	Neutral	> 50% Id'ed as Increasing Vulnerability	
					Interest Group	Regions
Evidence of climatic changes	Key for areas with intermittent streams or other environments that may be disproportionally affected by changes in climate.	2.22%	91.56%	6.22%	All	All
Growing communities near riparian areas	Impacts to quantity and quality of habitat as well as to quantity and quality of water. Identifying areas where regional resources are being demanded at higher levels than historically, and where those demands exceed a sustainable level as determined by the community, may be used as a criterion to prioritize flows for the environment. Depending on local priorities, may examine aquatic and riparian habitat and/or recreational opportunities that utilize natural resources.	2.67%	91.56%	5.78%	All	All
Rapid expansion of agricultural or industrial water demand		2.67%	92.89%	4.44%	All	All
Water Transfers (ag 2 muni)	Per acre, agricultural lands require more water than municipal development; however increased municipal demand does not automatically guarantee water savings and increased availability for environmental water demands because agricultural lands have significantly higher return flows to surface water and groundwater than the municipal sector. As a result, riparian areas that have come to depend on agricultural return flows may decline should land use change, thus providing a potential criterion for when to consider environmental water demands.	19.20%	37.50%	43.30%	Industrial, Other	Colorado River, Maricopa County
Policies that protect environmental flows	Presence of policies or regulations that protect environmental flows may make water for the environment less susceptible. On the other hand communities could look at such policies as a criterion if they decide to plan for future legal changes and prioritize alterations that comply with anticipated regulations. This may include increased water use efficiency or protecting natural resources to preserve a local landscape.	73.66%	13.84%	12.50%	None	None
Regional dependency on surface water	Depending on the water source(s), increased community reliance on surface water or groundwater may result in the increased vulnerability of the surrounding landscape. Identifying where these vulnerabilities occur and what level of impact is acceptable to the community may promote the protection of locally significant resources. It may also encourage the development of opportunities to expand the community's current water portfolio, through augmentation, exchanges, or other uses, to meet human needs that may, in turn, benefit the environment.	6.67%	69.33%	24.00%	All except for political	All except for Northeastern Arizona
Regional dependency on groundwater		5.78%	72.44%	21.78%	All except for political	All
Connection between groundwater and surface water understood	Information gaps in either water requirements for ecosystems or the connection between groundwater and surface water generate vulnerability from uncertainty. Determining what constitutes appropriate timing, quantity, or area of greatest need may help communities set priorities for if and when to consider environmental demands. Correspondingly, if an area understands the regional water demands and sees that all are met this may act as criteria for maintaining current actions or an opportunity to reallocate water resources for alternative uses.	48.20%	11.26%	40.54%	None	None
Water demands of riparian and aquatic ecosystems understood		55.56%	9.78%	34.67%	None	None
Regional water quality issues	Poor water quality may diminish the impact of adequate water quantities through the presence of contaminants, insufficient nutrient levels, or other undesirable attributes as determined by local flora and fauna. This makes using water quality criteria a practical aspect of assessing vulnerability and prioritizing when to consider environmental demands.	12.50%	35.71%	51.79%	Other	None

aquatic and riparian ecosystems (Box 4; Appendix A).

To help understand what criteria water managers and others concerned about water resources in Arizona think should be used to set priorities, the WRRC conducted a survey in which 14 criteria were proposed and respondents were asked to indicate if these elements increase, decrease, or are neutral to the vulnerability of water for natural areas. While this was not a comprehensive list, it provided a starting point for understanding the perceived influence of a criterion on water resource vulnerability or conflict, and which key regions and interest groups thought it was important. See Appendix B and Table 8 for more detailed results from this survey and how the vulnerabilities might be used to set priorities. Action items identified for setting priorities for and assessing values of water for natural areas included:

- Conduct a survey to understand how the general public values natural areas
- Research case studies on how to maintain equity among participants to ensure a constructive environment for discussion Explore successful (and unsuccessful) avenues for priority setting in other arid parts of the world, such as forging cooperative agreements or augmenting available water supplies, and determine the transferability of these initiatives to Arizona communities
- Create regional working groups to:
  - Establish metrics or criteria to determine priority areas
  - Continue dialogue on how, where, and why to provide water to natural areas
  - Increase understanding among diverse water interest groups

To comprehensively set regional priorities, workshop participants determined that there is a need to form multiple working groups throughout Arizona. Participants felt that each group should include representatives from state agencies, government, non-governmental organizations, academia, water providers (including utilities and irrigation districts), municipalities, businesses, tribes, water rights holders, environmental organizations, and community members. The need for a neutral convener to oversee these groups was discussed in all four workshops; participants felt that such a facilitator would be able to create the appropriate setting for divergent interests to come together.

In the next year: A statewide survey could be conducted to assess public values for water and natural areas. Results from this survey could be used by communities to set regional action items in motion, including a more detailed exploration of regional priorities and valuation of water for natural areas. This effort should be led by voluntary partnerships, composed of diverse interests from the communities and professional advisors, in the form of regional working groups. Each of these groups should create a problem statement based on regional needs and set forth clear goals and objectives for addressing that problem statement. Finally, the regional working groups should facilitate an iterative, dialogue to identify pilot projects based on the problems, goals, objectives, and plans for considering the water needs of natural areas in each region.

Manage Water Supply for Multiple Benefits, Including Natural Areas

The need to manage water supplies for multiple benefits, including natural areas, was discussed at the Flagstaff, Phoenix, and Tucson regional workshops in the water-use efficiency and conservation discussion group as well as in the incentives discussion group. Recommended strategies included: 1) increasing reclaimed water use and rainwater harvesting; 2) creating incentives for near-stream recharge; 3) discharging of effluent into natural areas; 4) considering natural areas in stormwater management; and 5) implementing water-dependent land use planning that encourages the

maintenance of water for the benefit natural areas.

Management for multiple benefits was a common theme in all stages of Roadmap development. Focus group participants from eight of the ten water-using sectors (13% of focus group participants) identified multiple use as an opportunity for providing water to natural areas. One focus group participant stated, "with science we are getting to the point where we can reuse more water, but everything is going to use more water so we need to do so more efficiently." Roundtable participants also shared in discussions about reusing our available water supplies to the benefit of natural areas, but much of this discussion centered on the challenges Arizona would face to do so. Two areas discussed that could be used as case study examples were the Rio de Flag near Flagstaff and Tres Rios in Phoenix.

One way to address the challenges associated with management for multiple benefits is through cooperation and partnerships. Cooperation was frequently discussed in conjunction with multiple use in the focus groups and at the workshops. The case studies on the Bill Williams River and of Glen Canyon Dam Adaptive Management Program provide examples of efforts to manage for multiple benefits where cooperation was important for project success (Boxes 5 and 6; Appendix A).

Participants proposed next steps for managing water supply for multiple benefits that included bringing local stakeholders together to identify where there might be water resources available for allocation to natural areas. Stakeholders to involve could include regional government, non-governmental organizations, agricultural perspectives, homebuilders, researchers, utilities, landowners, industry representatives, tribal partners, and voluntary community partnerships. This proposed stakeholder group should be responsible for researching case studies on

Box 5. Bill Williams River Corridor Steering Committee

The Bill Williams River Corridor Steering Committee (BWRCSC) was established to minimize conflict among agencies and stakeholders in the watershed. Interviewees felt that the BWRCSC's success is the direct result of inter-agency cooperation and the ability to establish a good rapport with all involved. There is an understanding among the member organizations that all goals and agendas cannot be met simultaneously, and that compromises are key to the functioning of the group. As a relatively new paradigm in dam operations, the Bill Williams River provides unique educational opportunities to learn about how adaptive management and flexible dam operations can be used to benefit the ecosystem --such as by coordinating water releases from the dam to more closely approximate natural flow regimes-- and to conduct scientific research. Flexibility in regulation has been key to overcoming obstacles; a case in point is the issuance of an incidental take permit to the USACE for four bald eagle eggs or fledglings every 10 years, or two southwestern willow flycatcher eggs or fledglings every 20 years.

Major project theme: Multiple Use; Flexible Regulation

Key to project success: Cooperation & Communication

What would you change? Funding mechanism

Advice for others: Create a productive atmosphere where participants can discuss and set common goals

Bill Williams River. Image provided by Dale Turner.

how entities have previously partnered to provide reclaimed water to natural areas, including prospective funding sources. The group would be tasked with the following:

- Identify appropriate locations for near-stream recharge
- Research where reclaimed water supplies are available
- Explore how reclaimed water is currently being used and how it is projected to be used
- Investigate what technology is available to improve existing reclaimed systems, and what rules and regulations will confine the desired goals
- Agree on locations or priority areas for allocating reclaimed water to natural areas and how much water would be needed over the long term
- Establish new (or support existing) demonstration projects that can be evaluated for similar efforts in the future
- Synthesize and disseminate research results for public review and comment

In the Next Year: Community and/or regional stakeholders could come together to identify common interests and shared goals about using water resources to benefit multiple uses, including their local ecosystems. Once goals are established, stakeholders could determine where and how water is currently being used to support riparian and aquatic ecosystems and explore the regional options for maintaining, expanding, or implementing new mechanisms to achieve their goals. As a part of this process, communities could identify existing water use agreements and regulatory constraints that may hinder allocating water to natural areas and, if they conflict with community goals, determine how to work within or around these constraints. Tres Rios is a successful existing model for stakeholder efforts to provide reclaimed water to natural areas and to create new habitat. The Blue Ribbon Panel Report, which identified many of the general obstacles to use of reclaimed water, is another excellent resource.

Box 6. Glen Canyon Dam Adaptive Management Program

The Adaptive Management Working Group (AMWG) was created in 1997, as a result of an Environmental Impact Statement for operations of Glen Canyon Dam. Members of the AMWG meet regularly and seek to directly incorporate public involvement into decisions regarding Glen Canyon Dam operation and downstream uses. Managing the dam optimally for multiple uses of the Colorado River is the overarching theme in this case study. In many ways the AMWG has taken on an impossible task, because the Colorado River's water is completely allocated and there is simply not enough water in the river to meet the needs of all competing interests. The Glen Canyon Dam Adaptive Management Program and the Grand Canyon Monitoring and Research Center are leading cutting-edge research about how and when to release water from the dam, and making recommendations for dam operations that are informed by scientific research. As such, they are better able to balance the needs of diverse users and protect natural and cultural resources as water moves through the system in a deliberate way.

Major project theme: Multiple Use; Flexible Regulation

Key to project success: Cooperation & Communication

What would you change? Simplify procedural requirements

Advice for others: Establish a formal understanding between partners and secure a reliable funding source

Glen Canyon Dam viewed from downstream. Image from: http://www.gcdamp.gov

6. In the Rearview Mirror – Conclusion

When the WRRC began this project in 2011, there were two principal goals: 1) further understand and communicate the water needs of riparian and aquatic ecosystems; and 2) involve individuals and organizations throughout Arizona in the development of options and strategies for incorporating the water needs of natural areas into water management and planning. While the goals were clear, the path to achieving them evolved along the way.

Perhaps the most important lesson learned in building this Roadmap is the importance of iteratively examining the problem, synthesizing an understanding of this problem, and then using this understanding to adjust the engagement process accordingly. Iterative examination of the issues allows time to include many different perspectives of stakeholders and approaches to engagement. This is important because effective water management requires a multifaceted approach that includes an understanding of legal, social, and scientific constraints that no one person could completely understand. This is especially true when management seeks to combine an understanding of the diversity of thoughts on how water should be used with how much water is needed by natural areas, which are complex in their own right. Through flexibility in the project approach, the WRRC has been able to take lessons learned along the way to improve the approach to examining how to consider water for natural areas in a number of ways and, most importantly, from a variety of perspectives.

Throughout the project, the WRRC found that while all water-interest groups were willing to participate, getting their input required significant planning and commitment to bringing as many voices as possible to the table.

The other critical lesson learned through this project is the amount of time necessary to bring people together. Throughout the project the WRRC found that while all water-interest groups were willing to participate, getting their input required significant planning and commitment to bringing as many voices as possible to the table. A key element of planning and bringing a diversity of ideas to the table was the dedication of the Roadmap Steering Committee, who spent many hours working with WRRC staff guiding the approach to the project, and suggesting whom to talk to, when, and how.

The voluntary participation of over 1,000 stakeholders, 400 of whom directly helped to build the recommendations in this Roadmap, demonstrates that there is significant interest in providing water to natural areas in Arizona.

The voluntary participation of over 1,000 stakeholders, 400 of whom directly helped to build the recommendations in this Roadmap, demonstrates that there is significant interest in providing water to natural areas in Arizona. While opinions on how to provide water to riparian and aquatic ecosystems vary, there is general agreement that any approach should involve cooperation across different water-using groups, and should focus on local priorities and solutions. Although our understanding of how much water riparian and aquatic ecosystems need remains incomplete, there are opportunities to take the information we do have and use it to explore how to manage water resources with natural areas in mind. While this Roadmap is the culmination of three years of stakeholder engagement and learning, the WRRC hopes that this document marks only the beginning of a journey toward understanding and including water for natural areas in Arizona's water management and planning decisions.

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Appendix A. Understanding the Decision to Incorporate Natural Areas into Water Management Plans – Case Studies

Case study interviews by Darin Kopp; summaries written by Emilie Brill Duisberg and Darin Kopp

To better understand how and why Arizona communities incorporate the water demands of natural areas into water management plans, the WRRC, in consultation with the Roadmap Steering Committee, selected six case studies from around the state (Figure A.1):

1. Bill Williams River Corridor Steering Committee
2. Conserve2Enhance™ (C2E)
3. Glen Canyon Dam Adaptive Management Program
4. Las Cienegas National Conservation Area
5. Verde River Automated Ditch Operations
6. Yuma East and West Wetlands Restoration

These case studies spotlight the eight most commonly discussed themes that emerged throughout the Roadmap development process, provide concrete examples of how these important elements coalesce in the planning and execution of successful, real-world projects, and contribute practical recommendations and action items to the Roadmap. The critical themes are as follows: the importance of communication and cooperation; conservation and efficiency; education, in terms of both scientific research and public outreach; financial incentives; flexible regulation; multiple uses of water; setting priorities and assessing values; and reliable data about the quantity and value of water involved. For each case study, existing documents and electronic resources were reviewed, and interviews were conducted with project participants either in person or over the phone using a common set of questions (see end of Appendix A); when possible, multiple interviews were conducted to increase the breadth of responses and develop a more comprehensive perspective on the case study. The WRRC received approval for these interviews from the University of Arizona Institutional Review Board.

Each project showcases multiple themes (Table A.1). To distinguish the role each thematic area played in a case study, the WRRC classified themes present as either ‘major’ or ‘minor’ (Table A.1). Major themes are those that were considered necessary for the project to exist, while minor themes are those that either support, or resulted from, project implementation. All six case studies incorporate aspects of cooperation. The prevalence of cooperation was most likely an artifact of case study selection: the WRRC intentionally selected collaborative projects. Meanwhile, the common thread of education, also present in all six projects, could indicate that project sites recognize the importance of outreach and regional learning to long-term success.

Project managers and participants themselves also identified cooperation as a major driver in five of the six projects, and cited the importance of collaboration or communication for future project success in all six projects. Four of the six projects said, if possible, they would have implemented the project faster. This may indicate that the benefits of completing these types of projects are disproportionately large relative to the costs, and that delaying implementation is not productive.

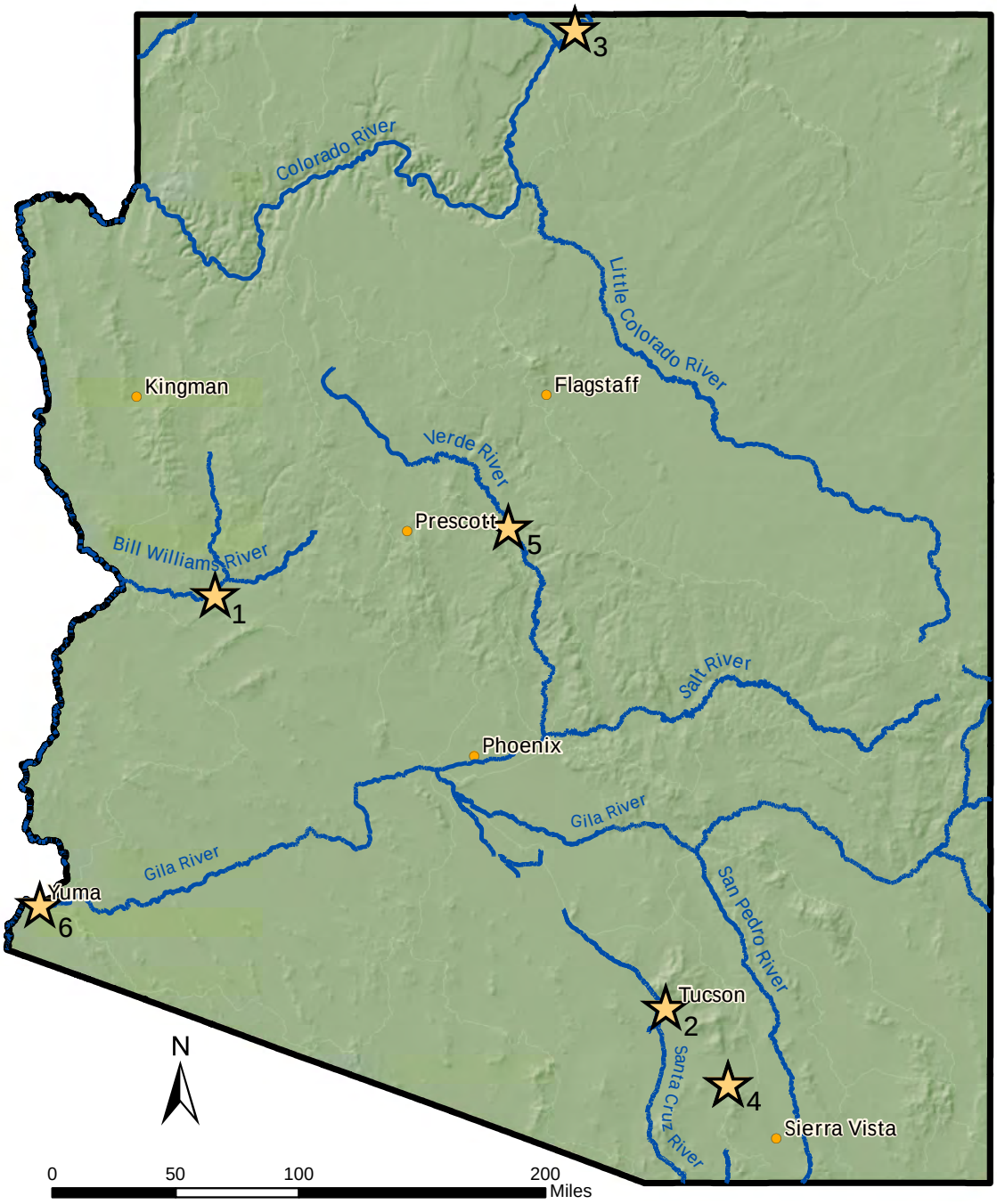


Figure A.1. Map of Roadmap case studies conducted throughout Arizona: 1) Bill Williams River Corridor Steering Committee; 2) Conserve2Enhance (C2E); 3) Glen Canyon Dam Adaptive Management Program; 4) Las Cienegas National Conservation Area; 5) Verde River Automated Ditch Operations; 6) Yuma East and West Wetlands Restoration

Table A.1: Themes identified in each case study. **"X",** indicates major themes and "x" indicates minor themes. Major themes are those that are closely related to the driving force behind water allocation decisions. Minor themes are defined as those that occurred as a response to, or in support of, the major diver.

Project Name	Cooperation & Communication	Conservation & Efficiency	Education	Financial Incentives	Flexible Regulation	Multiple Uses of Water	Value of Water	Priority Setting
Bill Williams River Corridor Steering Committee	x		x		**X**	**X**		
Conserve2Enhance (C2E)	x	**X**	x	x			**X**	x
Glen Canyon Dam Adaptive Management Program	x		x		**X**	**X**		
Las Cienegas National Conservation Area	**X**		x		x			x
Verde River Automated Ditch Operations	x	**X**	x	**X**		x	x	x
Yuma East and West Wetlands Restoration	x		x		**X**	x	x	**X**

Table A.2: Lessons learned from each project, as identified by the respective case study interview participant(s).

Project Name	Keys to Success	Things to change	Advice for others
Bill Williams River Corridor Steering Committee	Cooperation & Communication	Funding mechanism	Create a productive atmosphere where participants can discuss and set common goals
Conserve2Enhance (C2E)	Public Participation	Long-term maintenance for programs; time to implement	Develop strong community partnerships and engage with participants
Glen Canyon Dam Adaptive Management Program	Cooperation & Communication	Simplify procedural requirements	Establish a formal understanding between partners and secure a reliable funding source
Las Cienegas National Conservation Area	Cooperation & Communication	Time to implement	Build a forum to act on good information that fosters communication
Verde River Automated Ditch Operations	Cooperation & Communication; financial incentives	Time to implement	Build trust and develop community partnerships
Yuma East and West Wetlands Restoration	Cooperation & Communication; making progress	Technical details; time to implement	Understand the importance of collaboration and remove personal agendas from the equation

1. Bill Williams River Corridor Steering Committee

Key themes: multiple uses of water, flexible regulations, cooperation and communication, education

Bill Williams River. Image provided by Dale Turner

The Bill Williams River is a remote desert river that runs from east to west across Arizona and into the Colorado River, with one of the most variable historical flow records in the US. Between 1916 and 1939, peak flows in the neighborhood of 100,000 cfs occurred six times, while summer flows often fell to zero. In 1968, the Alamo Dam was constructed to provide flood control capacity, recreation, and water conservation. Thirty-nine miles of river extend below the dam to its confluence with the Colorado River. This corridor contains the last remaining native riparian habitat in the Lower Colorado River watershed, and serves as an oasis for migratory species in an otherwise inhospitable landscape that extends for many miles. The primary landowners and managers within this reach are: Arizona State Parks, Arizona Game & Fish Department (AZGFD), the Bureau of Land Management (BLM), Freeport-McMoRan, Inc. (Freeport), Arizona State Land Department, US Army Corps of Engineers (USACE), and US Fish & Wildlife Service (USFWS).

The Bill Williams River Corridor Steering Committee (BWRCSC) was established to minimize conflicts between the agencies and stakeholders in the watershed, while promoting conservation of its riparian ecosystems. This committee facilitates communication about each group's needs and desires among all interested parties. Interviewees felt that the BWRCSC's success is the direct result of inter-agency cooperation and the ability to establish a good rapport with all involved. There is an understanding among the member organizations that all goals and agendas cannot be met simultaneously and that compromises are key to the functioning of the group. There is also a strong degree of commitment and engagement, which supersedes and helps participants overcome their differences. Outside of the staff time invested in the project, member participation is voluntary. As one interviewee put it, "it's a labor of love."

In 1991, the BWRCSC appointed the Bill Williams River Technical Committee to complete a Proposed Water Management Plan for Alamo Lake and the Bill Williams River. This plan proposed an alternative to dam operations to better meet agency resource objectives and

Webpage header from: http://billwilliamsriver.org/Committee/

dam project purposes. In 2002, the Bill Williams was one of nine rivers enrolled in the Sustainable Rivers Project, a nationwide collaboration between the USACE and The Nature Conservancy (TNC) to improve the ecological effects of dam operations. The Ecologically Sustainable Water Management (ESWM) framework was incorporated to collaboratively define problems and solutions related to the adaptive management of flow releases in coordination with human and natural resource needs.

In 2005, a Memorandum of Understanding (MOU) between member agencies renewed the charter of the BWRCSC. MOU signatories included: AZGFD, Arizona State Parks, TNC, USACE, BLM, the Bureau of Reclamation (BOR), USFWS, and the Arizona Department of Water Resources. Delegates from the participatory agencies serve on the steering committee. BWRCSC meetings are conducted on a quarterly basis, and address the status of the lake and river and pertinent issues related to water management. Differing opinions arise periodically, and the meetings serve as a venue to address and resolve contention, and to provide input to the USACE regarding their dam operations. In this respect, the steering committee meetings serve as a vehicle for cooperation and collaboration between the diverse local, state, federal, and non-governmental entities involved in the project. All water releases from Alamo dam are coordinated between state and federal agencies that have interests in or concerns with the Bill Williams River or the lower Colorado River. Another example of this collaborative process was the Environmental Flows Workshop conducted in 2005 that consisted of over 50 scientists from 20 institutions working together to define the flow requirements needed to sustain the long-term health of the river.

The goal of the renewed BWRCSC charter is to “facilitate and implement an adaptive approach to water resource management and watershed health that aims to ensure the long-term ecological integrity, while meeting human needs, of the Bill Williams River Watershed.” The salient theme in this case study is the consideration of multiple uses of water, including environmental needs, in dam operations. For example, Alamo Lake above the dam is a popular sport fishery managed by the Arizona State Parks and AZGFD, while the 39-mile reach below the dam is considered a reference condition for historic riparian habitat within the Lower Colorado River Basin. The dam structure provides flood control, water conservation and supply, and, added in 2003 as an approved dam operation, fish and wildlife benefits. Collectively, the decision to incorporate environmental demands into the management of water has created a way for many water uses to be realized from the Bill Williams River and Alamo Lake conservation pool.

Bill Williams River. Image provided by Dale Turner

As a relatively new paradigm in dam operations, the Bill Williams River provides unique educational opportunities to learn about how adaptive management and flexible dam operations can be used to benefit the ecosystem --such as by coordinating water releases from the dam to more closely approximate natural flow regimes-- and to conduct scientific research. Data collection increased substantially following the Environmental Flows Workshop and large flood

events in 2005. As a result, the Bill Williams River is among the most investigated river systems in the Southwest and has been the subject of numerous publications. In addition, the public can view photo galleries or learn about its natural history and management through websites devoted to the BWRCSC and the Bill Williams National Wildlife Refuge.

Notwithstanding all its accolades, this riparian corridor faces a number of challenges and opportunities, including legal proceedings associated with the Endangered Species Act, issues around the water rights of Planet Ranch (owned by Freeport), and the development of flexible dam operations to enhance ecological health. Flexibility in regulation has been key to overcoming obstacles; a case in point is the issuance of an incidental take permit to the USACE for four bald eagle eggs or fledglings every 10 years, or two southwestern willow flycatcher eggs or fledglings every 20 years. Water rights litigation associated with Planet Ranch also demonstrates the importance of flexible regulation. Specifically, Freeport is interested in transferring some water rights certificates to existing holdings within the Bill Williams watershed and donating or leasing the remaining land and water rights to the Lower Colorado River Multi-Species Conservation Program and the AZGFD. Whether this plan is approved and irrigation is retired, or irrigation at Planet Ranch continues, will have implications for the Bill Williams River. Finally, allowing for flexible dam operations enables researchers to learn about the system and adjust management decisions to enhance ecosystem health, while complying with federal regulations. Monitoring, research, and adaptive management are the primary means for addressing the current uncertainties within the Bill Williams River.

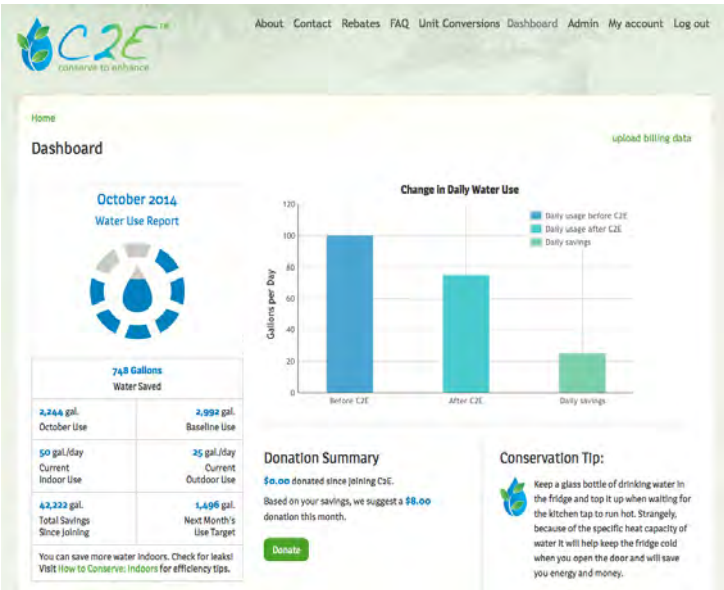
Interviewees indicated that if the project were to start over, the establishment of an annual funding mechanism would be beneficial, as current funding sources are often shared between membership agencies. Participants advise the architects of other projects to create a productive atmosphere where participants can discuss and set common goals, as doing so is a key to success. Participants also mentioned the use of the Ecologically Sustainable Water Management (ESWM) framework as key to reaching success and maintaining good scientific standards.

2. Conserve2Enhance™

Key themes: conservation and efficiency, value of water, cooperation, education, financial incentives, priority setting

Conserve2Enhance™ (C2E) connects conservation with community action. C2E is a voluntary water conservation program in which participants are encouraged to conserve water at their home or business, track their water savings using the online C2E Water Use Dashboard (www.conserve2enhance.org), and then donate some or all of the financial value of their water bill savings to support local environmental enhancement projects. The C2E program is housed within the University of Arizona Water Resources Research Center (WRRC); WRRC provides support for interested communities to develop their own C2E program at no cost. C2E programs are in place throughout the Southwest and growing in number. The success of C2E is contingent on efficiency retrofits and behavioral changes designed to increase water conservation. The environmental enhancement projects funded by the savings that result from these conservation efforts are themselves encouraged to use water management practices, such as rainwater harvesting, that promote sustainability, conservation, and efficiency.

The most robust C2E program to date is located in Tucson, Arizona. This program is led by a volunteer community Advisory Board, and aims to enhance urban waterways and wildlife habitat throughout Tucson. The launch of Tucson C2E was possible thanks to a partnership between the WRRC, the regional water utility, Tucson Water, and local non profits, Watershed Management Group (WMG) and Sonoran Institute. Bylaws and monthly meetings serve to guide and facilitate cooperation among the organizations involved in the program. The C2E board's recent switch to a volunteer structure, consisting of a steering committee, grants committee, board development committee, and outreach committee, poses new opportunities and challenges for cooperation and cross-pollination among member organizations. Cooperation is also important for groups seeking to fund environmental projects through C2E grants. For example, the Atturbury Wash Project, recipient of an $11,000 grant from Tucson C2E in 2012, involves cooperation between Arizona Parks and Recreation, neighborhood associations, and local high schools in the form of both informal and formal meetings and workshops.



Sample C2E Participant Dashboard from the C2E Water Use Dashboard (www.conserve2enhance.org). Image courtesy of WRRC.

Tucson C2E participates in several forms of community outreach, including presentations, workshops, printed articles, advertisements and multimedia postings, and has a program page on the WRRC's C2E Water

Use Dashboard (conserve2enhance.org/Tucson). The website provides a running tally of water savings and program donations, a description of Tucson C2E's environmental enhancement sites, as well as information about participating local businesses. Education is also incorporated into the environmental programs funded through the C2E program. The Atturbury Wash Project, for example, conducts regular birding tours to foster community engagement and also features interpretive signage explaining the work that has been done at the site.

Tucson C2E provided subsidies ($500-$1000) for pilot project participants to implement water harvesting infrastructure. The funds for this initiative were provided by an EPA grant to WMG and served to boost project participation and increase C2E brand recognition. Financial incentives in terms of staff time were also important in contributing to the success of the project: the Sonoran Institute, WRRC, and WMG contributed staff time for the pilot Tucson C2E program. After successful completion of the pilot, Tucson C2E is now a fully implemented program that has scaled up to include the entire Tucson Water service area. To date, Tucson C2E participants have conserved over five million gallons of water.

C2E project sites are determined by local priorities and the direction of the local C2E program oversight body. As a result, the project selection process can take many forms ranging from donations going to support a single pre-identified project to a formal request for proposals, which are then assessed by the local advisory committee. Key criteria for selecting any C2E enhancement site are the values and interests of the community, anticipated environmental benefits, and potential for community participation. One Tucson C2E grant recipient stated the choice for their project location was motivated by the presence of wildlife habitat, preexisting restoration efforts, and a motivated neighborhood association. A statewide C2E program is considering sites based on data-demonstrated critical habitat for species of interest and public familiarity.

Since C2E programs are intended to be self-financing through donations generated from water savings, the success of a C2E program is contingent on attracting and engaging with participants. The advisory board, grant programs, and staff time are also important factors that impact the success of a program. A challenge faced by the Tucson C2E program is that grant recipients are responsible for maintaining their enhancement sites beyond the initial C2E grant year. To address this, each member of the Tucson Advisory Board 'adopts' a project site and periodically checks in with site managers. Recommendations for other collaborative projects include the importance of organization, collaboration, and progress. It is difficult to create an organization from scratch, and identifying common goals and priorities is time-consuming, but important. Making measurable progress keeps members of the community engaged and highlights project successes.

Before (black and white) and after (color) transformation of Tucson C2E Atturbury Wash enhancement site. Photo courtesy of WRRC.

3. Glen Canyon Dam Adaptive Management Program

Key themes: multiple uses of water, flexible regulation, cooperation and communication, education

Glen Canyon Dam viewed from downstream. Image from: http://www.gcdamp.gov

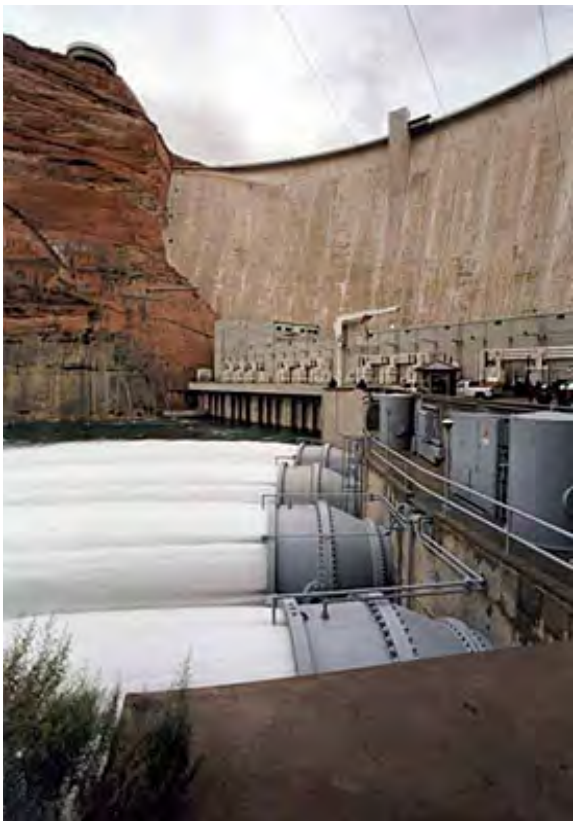
The construction of the Glen Canyon Dam on the Colorado River, completed in 1963, raised public alarm about the preservation of downstream cultural and natural resources. The Grand Canyon Protection Act, passed by Congress in 1992, directs the Department of the Interior to operate the dam in such a way as "to protect, mitigate adverse impacts to, and improve values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established," as well as to create a long-term monitoring and research program to inform dam management policies. In 1995, the Bureau of Reclamation produced a multi-agency Environmental Impact Statement (EIS) of existing and alternative dam operations from 1963-1990 to address concerns about the downstream impacts of the ongoing operation of the Glen Canyon Dam, including: water resources, sediment, riverine and riparian habitat and wildlife, endangered and special status species, cultural resources, air quality, recreation opportunities, hydropower, and non-use value.

The EIS proposed the implementation of adaptive management strategies, defined by the website of the Glen Canyon Dam Adaptive Management Program (GCDAMP) as "a dynamic process where people of many talents and disciplines come together to make the right decision in the best interests of the resources." Underscoring the important role of public policy, which 63% of Roadmap survey respondents noted has the potential to decrease the vulnerability of water for natural areas, the GCDAMP's stated purpose takes some of its language directly from the Grand Canyon Protection Act. It was created in partial fulfillment of the requirements of the Grand Canyon Protection Act and provides "an organization and process for cooperative integration of dam operations, downstream resource protection and management, and monitoring and research information, as well as to improve the values for which the Glen Canyon National Recreation Area and Grand Canyon National Park were established." The Grand Canyon Monitoring and Research Center (GCMRC), a part of the United States Geological Survey (USGS), conducts scientific research and monitoring for the GCDAMP in accordance with the law.

The fundamental units of the GCDAMP, funded by sales of hydropower from the dam, are several subcommittees, or working groups, that evaluate research and make

Webpage header from: http://www.gcdamp.gov

recommendations for dam operations and management. Adaptive management of the dam was first proposed in 1992, and the charter for the Adaptive Management Working Group (AMWG) was signed in 1997, with the EIS and Grand Canyon Protection Act of 1992 serving as guiding documents. The AMWG consists of representatives from federal agencies, Indian tribes, environmental groups, recreation interests, the seven Colorado River Basin states, federal power contractors, the Department of the Interior, and other stakeholders. It was designed to be as inclusive as possible of all interests on the River. Meetings are held twice a year. The Technical Working Group (TWG) is responsible for developing criteria and standards for monitoring, as well as the research questions to be addressed by the GCMRC, and meets more frequently (3-4 times per year). The management plan is structured to allow the GCMRC to generate research, the TWG to evaluate research, and the AMWG to make final recommendations. This process serves as an alternative to closed-door meetings and helps make issues public.



Glen Canyon Dam jet valves releasing water during November 2004 controlled flood. Image from: http://www.gcdamp.gov

Managing the dam optimally for multiple uses of the Colorado River is the overarching theme in this case study. This is a challenging task because the Colorado River's water is completely allocated and there is not enough water in the river to meet the needs of all competing interests. However, managers have been successful within the scope of their goals: that the GCDAMP and the GCMRC are leading cutting-edge research about how and when to release water from the dam, and to make recommendations for dam operations that are informed by scientific research. As such, they are better able to balance the needs of diverse users and protect natural and cultural resources as water moves through the system in a deliberate way.

To this end, flexible regulation in dam operations has been necessary for producing high flow experiments (HFE), which correspond to sediment inputs and mimic the pre-dam natural flood events. These experiments are intended to build habitat, create recreation opportunities, and protect archaeological sites downstream. Because the primary function of the dam is water delivery, management for multiple needs must take place within that framework. Flexibility in dam operations allows the timing, but not the total amount, of annual delivery from Lake Powell to Lake Mead to be changed, resulting in a loss of some hydropower but benefitting other uses of the river. Flexibility in regulation is another theme that Roadmap participants identified as important for the inclusion of natural areas in water management planning, as inflexible regulations may sometimes unintentionally pit people against each other or create disincentives.

When discussing the theme of communication in considering water for natural areas, Roadmap participants emphasized the critical need for trust, honesty, and unbiased dialogue in discussing what are frequently sensitive and politically charged issues. The interviewees in this case study echoed this sentiment multiple times, noting the importance of reaching out to “talk to others,” as “some offer great perspective,” as well as fostering engagement by “making people feel like they are a part” of the process, as “when they care, people can move mountains.” This cooperation, nurtured by functional and open communication, and in conjunction with consistent leadership, has been a crucial underpinning of the success of the GCDAMP.

Finally, public engagement, outreach, and education have been integral to this process. Public views about the impacts of the dam on downstream resources prompted the passage of the 1992 Grand Canyon Protection Act and served as the impetus for the creation of the GCDAMP. Its management plan is designed to promote transparency and public involvement. An informative website and a number of public outreach events engage the public, and an oral history project is currently in development. One interviewee stated that he is “a firm believer in adaptive management” and that the AMWG is in a “good place” and “looking toward the future.” If the project were to restart, he suggested that reducing the quantity of reporting commitments, while not reducing the insights they generate, could simplify some of the procedural requirements. With regard to recommendations for other water-based conservation efforts, good monitoring and collaboration, with a formal understanding among parties, as well as a reliable funding mechanism, are key features for success.

4. Las Cienegas National Conservation Area

Key themes: cooperation and communication, education, flexible regulations, priority setting

Las Cienegas National Conservation Area (LCNCA), consisting of 41,972 acres of public land, contains five of the rarest habitat types in the American Southwest: cottonwood-willow riparian forest, cienega marshland, sacaton floodplain, mesquite bosque, and semidesert grassland. It is home to six endangered species, and contains two eligible Wild and Scenic River segments. Seventy percent of Roadmap participants recognized the utility of priority setting to prevent the provision of water to natural areas arbitrarily; given its "exceptional biological, cultural, and scenic values" (Bodner and Simms, ii), the LCNCA is an undisputable priority for conservation. To that end, in 2000, the LCNCA and the Sonoita Valley Acquisition Planning District (SVAPD) were designated by Congress to "conserve, protect, and enhance the unique and nationally important aquatic, wildlife, vegetative, archaeological, paleontological, scientific, cave, cultural, historical, recreational, educational, scenic, rangeland and riparian resources and values of the public lands within the NCA, while allowing livestock grazing and recreation to continue in appropriate areas" (BLM 2003).

LCNCA landscape. Photo courtesy of Shela McFarlin.

LCNCA and the surrounding SVAPD are composed primarily of a mix of BLM, Arizona State Trust and private lands. In 1988, the land for the NCA was acquired through a Bureau of Land Management (BLM) land exchange and the BLM began actively seeking the involvement of local citizens in forming a partnership to develop a management plan for the area. One interviewee noted that this was not a court mandated effort or a paperwork exercise; the Bureau truly wanted to craft a partnership with local stakeholders to preserve this unique area of Southern Arizona. The interviewees stressed the importance of building interpersonal relationships and maintaining openness and trust throughout this process, particularly as local residents were not initially eagerly receptive to the idea of working with the BLM. However, many citizens realized their priority was on preserving this resource, and that common goal allowed people who might not normally choose to work together to do so.

The Sonoita Valley Planning Partnership (SVPP) was formed as a voluntary, ad hoc association, which serves to promote community-wide participation in public land management. Meetings began informally, and ultimately came to be held regularly in three subcommittees: Biological Planning, Technical Teams and Science on the Sonoita Plain. Informal discussions still take place and are considered important to the project. At its height, the SVPP had 35 to 40 actively working members and 200 to 300 people on its mailing list.

Through the Cienega Watershed Partnership, it maintains relationships with a diverse, extensive list of regional collaborators, including municipalities (Sonoita, Elgin, Patagonia, Huachuca City, Sierra Vista, Nogales, Tucson, Phoenix); federal agencies (U.S. Forest

Service (USFS), National Park Service (NPS), the BLM, the Natural Resources Conservation Service (NRCS), the U.S. Geological Survey's (USGS) Tucson Science Center, the U.S. Fish and Wildlife Service (USFWS)); state agencies (Arizona Game and Fish Department (AZGFD), AZ State Land Department); county governments (Pima Association of Governments, Pima County Parks and Recreation, Pima County Natural Resources, Pima County Flood Control District); academia (University of Arizona (UA) School of Natural Resources and the Environment, UA Climate Assessment for the Southwest (CLIMAS), UA Office of Arid Lands Studies, Arizona Nonpoint Education for Municipal Offices (NEMO), UA Institute of the Environment, Sustainability of Semi-arid Hydrology and Riparian Areas (SAHRA), UA Cooperative Extension 4H Youth Development); local schools (Empire High School, Cienega High School, Vail School District, Civano Middle School); and numerous non-governmental organizations and other private groups (The Nature Conservancy (TNC), Sky Island Alliance, Rincon Institute, Sonoran Institute, Arizona Land and Water Trust, Empire Ranch Foundation, Audubon Appleton-Whittell Research Ranch, Colossal Cave Mountain Park, Save the Scenic Santa Ritas, Sonoita Crossroads Community Forum, Rincon Valley Coalition, Ironwood Tree Experience, Southern Arizona Buffelgrass Coordination Center (SABCC), Pima Trails Association, Arizona Trail Association, Huachuca Hiking Club, Sonoran Desert Mountain Bicyclists, the Clyne Ranch, Caldwell Designs, High Haven Ranch, the Kelso Family, the Slattum Family, Ver Earl Ranch Inc, and Walker Ranch, Regional Partnership, Arizona Zoological Society of the Phoenix Zoo, Tucson Electric Power). This wide-ranging and varied approach to collaboration has been integral to successful management of LCNCA.

In 2003, the SVPP and the BLM collaboratively drafted the Las Cienegas Resource Management Plan (RMP), a science-based adaptive management plan intended to link land and resource management with continuous observations of ecological conditions in the area. The RMP includes clear, measurable management goals focused on maintaining and restoring the grassland watershed, riparian and aquatic areas, and native fish and wildlife. Adaptive management promotes cooperative action based on relevant and efficient data and monitoring programs, which facilitate stewardship of natural and cultural resources while allowing human use. Importantly, flexibility in management allows the program to respond to the ecological needs of the system without undergoing additional planning or reorganization efforts. Given that Roadmap participants noted that inflexible or inadequate regulation is often detrimental to efforts to provide water to natural areas, the latitude to make adaptive decisions based on monitoring data is a strength for LCNCA. For example, while adding

LCNCA community engagement events. Photos courtesy of Shela McFarlin.

certain disturbances, such as beaver or fire, “back into the system may succeed in turning the wooded swamp areas into herbaceous cienega with open, well-oxygenated pools… uncertainties highlight the need to use adaptive management in this situation, since either disturbance could have unintended consequences such as reducing densities of large cottonwoods or enhancing habitats for bullfrogs or other exotic species” (Bodner and Simms, iii). In 2004, TNC entered a cooperative agreement with the BLM to evaluate the existing monitoring plan against management objectives and ensure that it adequately measures progress toward RMP goals. This collaborative, adaptive approach is central to the success of LCNCA.

Participants in the Roadmap development process overwhelmingly agreed on the need for education initiatives about providing water to natural areas. In this regard, LCNCA can be a learning laboratory, with several ongoing educational programs. Current youth educational programs include River Pathways, Youth in Wilderness, Historic Preservation, Hands on the Land/Wild about the Grassland, Seeds of Stewardship, Youth Engaged Stewardship, Black-tailed Prairie Dog Reintroduction, and Pronghorn Habitat Improvement. Educational campaigns are also targeted towards individuals in decision-making roles to inform them of data collection and monitoring results. The heritage planning team associated with the Cienega Watershed Partnership supplies oral histories about the NCA through a website and the variety of natural resources and habitat support the interests of several scientific investigations.

Conservation efforts in LCNCA have been characterized by citizen involvement and the BLM’s ability to successfully incorporate public opinion into its management decisions, and the results of this approach speak for themselves. Since 1989, fencing Cienega Creek from livestock, closing wet road crossings, and removing dikes and canals has resulted in dramatic increases in the extent of riparian cottonwood-willow gallery forest, and in the number of creek miles in Proper Functioning Condition (up from 2% in 1993 to 61% in 2000). Interviewees stated that if they were to start over, they would implement the program more quickly, without cutting costs or participation. Their advice for other collaborative projects echoes the thoughts of Roadmap development participants, focusing on the importance of building a foundation to act upon good information, citizen involvement, sound decision-making, and hard work and dedication to communication.

5. Verde River Automated Ditch Operations

Key themes: conservation and efficiency, financial incentives, value of water, cooperation and communication, priority setting, education, multiple uses of water

The Verde River is a hotspot for biodiversity, and contains Arizona's only officially designated stretch of Wild and Scenic Rivers. Along its 192-mile run from the mountains north of Prescott to its confluence with the Salt River outside of Phoenix, it supports 92 species of mammals, including river otter, as well as native and endangered fish species and the highest densities of breeding birds ever recorded in North America. This area is threatened by reduced flows in the river. In 2008, a scientific assessment identified irrigation diversions, which are critical to sustaining the livelihood of multiple communities along the Verde River, as a major threat to the river's ecological health.

New automated ditch gate on the Vere River. Photo courtesy of Kim Schonek.

To address this, The Nature Conservancy (TNC) and the Diamond S Ditch Company, a five-mile long irrigation system that includes 80 users and irrigates 400 acres of land, worked in partnership to find a "win-win" solution to balance environmental and agricultural water needs. They accomplished this by modernizing the irrigation infrastructure, which has remained much the same as it was in the 1860s, consisting of earthen dams built in the river channel to divert flows for irrigation using only gravity. Historic flows in the Diamond S were 30 to 45 cubic feet per second (cfs), which was sometimes the entire flow of the Verde River. Unused water in the ditch returned to the river downstream, but this inefficiency left the intervening stretch of river depleted and sometimes completely dry. Modern, automated ditch gates now operate with a sensor powered by a solar panel and maintain consistent water levels, delivering a volume of water more closely matching irrigation needs. The excess water not needed for agriculture then stays in the river. By installing two automated ditch gates in the Diamond S system, this project has been able to increase flows in the Verde River during the dry summer months by 50%-100% in some areas, making it a resounding success.

The alignment of priorities and the inherent value—economic, aesthetic, and environmental—placed on leaving water in the river were crucial to the success of the project in this case study. Water is an irreplaceable resource in the conservation of riverine habitat, and also necessary to sustain the livelihoods of Diamond S Ditch users. Some members of the Diamond S were initially reluctant to work with TNC out of concern that their water rights could be at risk. However, members were not asked to reduce irrigated acreage or give up any water they needed; as long as members could get the full amount of water they needed, agricultural and environmental needs were not mutually exclusive and ditch users were happy to provide more water for instream flows. In fact, they recognized

that a strong Verde River is key to the valley's economic future, in terms of aesthetics, tourism, recreation opportunities, and ecological health, and that facilitating multiple uses of the river water through increased diversion efficiency is a boon to all parties. Furthermore, this project presented a solution to other concerns of the Diamond S, such as safety and convenience. The old system required manual adjustment by the ditch boss; the new automated headgates can be operated from home via his cell phone.

TNC and Diamond S Ditch representatives at new automated ditch gate. Photo by Darin Kopp.

Although Roadmap participants expressed concern that quantifying the value of water left instream could be "very difficult," this case study demonstrates that parties can agree on the value of water, and that leaving water instream has value and benefits for the whole community. In fact, the provision of compelling financial incentives is one of the key facets of the project that allowed it to be successful. As one member of the Diamond S explained, the financial incentives were critical to their willingness to collaborate with TNC, making the project "worth our time and effort." Each automated ditch gate costs approximately $10,000 and was paid for by the TNC, with funding from Coca-Cola and the Bonneville Environmental Foundation, contingent on the Diamond S users reducing their diversion volumes as specified in a diversion reduction agreement. In addition to covering the cost of the automated gates, TNC paid the Diamond S a supplemental sum for meeting a target of returning 5 cfs to Verde River flows, and will pay an even greater sum if the Company returns 10 cfs to the river in 2014. The company plans to use these funds to independently finance further infrastructural improvements that increase efficiency within its system. Throughout the Roadmap development process, participants cited lack of funding as a barrier to considering water for natural areas, and emphasized the powerful role financial incentives play in encouraging efficiency or leaving water instream. Indeed, without the financial support from TNC and its funding partners, this project would not have been possible.

The Nature Conservancy selected the Diamond S Ditch among the seven major ditch companies in the Verde Valley because it is located the farthest downstream and maintains a social environment conducive to collaboration. The ditch location meant that water saved as a part of the project would not be consumed by other users. The Diamond S is also just above the portion of the river designated a Wild and Scenic River, so flows returned to the river by the Diamond S directly and immediately benefit the flora and fauna of this ecological gem. TNC has set a minimum flow target, or a goal for the lowest the Verde River should ever get, of 30 cfs by 2020 throughout the Verde Valley. This figure represents 43% of the river's historic low flow, and TNC plans to meet this goal by gradually moving its way upriver, returning more and more water to the river by partnering with other ditch companies to improve efficiency.

Education and cooperation play pivotal roles in the ongoing success of this project. For example, TNC was able to teach the Diamond S about automated headgate technology by taking members on a field trip to the Phoenix area to see one in action. Other ditch

companies on the Verde can take inspiration from the success of the Diamond S and learn more about the process via the guided site tours the Company offers for researchers, reporters, and students, as well as through a website devoted entirely to the history and culture of the Company. The interviewees emphasized the importance of a foundation of mutual trust between the Ditch Company and TNC, and noted that the collaborative spirit and open communication cultivated at numerous informal meetings are essential to the successful management of a shared resource, such as water. TNC saw honesty and clarity, realistic expectations and strong interpersonal relationships as important factors driving success of the project, and summarized their advice for others simply: “be collaborative.” The Diamond S Ditch Company, for its part, viewed the elimination of safety concerns and the availability of financial resources as factors driving success, and stressed finding the right partner with whom to collaborate. The Diamond S indicated that in hindsight they would have implemented this project sooner, and if it were to start over, TNC would incorporate more capacity to provide assistance.

6. Yuma East and West Wetlands Restoration

Key themes: priority setting, flexible regulation, cooperation and communication, education, multiple uses of water, value of water

Yuma, a metropolitan area of around 200,000 people, sits on the Colorado River in the far southwestern corner of the state, near the borders of California, the Mexican states of Baja California and Sonora, and the Fort Yuma Indian Reservation of the Quechan Indian Tribe. For centuries, the Quechan have relied on the Colorado River for their livelihood, and valued it at the center of their existence. However, severe degradation of the Colorado's riverine and riparian ecosystems in the 20th century, as a result of decreased flows, invasion by exotic species, garbage dumping, salinization, and other challenges, severed the connections both of city residents and of the Quechan to the river. The riverbanks and historic channels became choked with impenetrable thickets of non-native salt cedar and giant reed, barring passage to the river. Yuma West Wetlands was used as the city landfill from 1910 until 1970, and Yuma East Wetlands was home to wildcat garbage dumping, noncommissioned housing, and other illegal activities.

As Roadmap participants noted, every community in Arizona has natural areas of local importance, spiritually, recreationally, economically, or otherwise. Prioritizing where we provide water to natural areas is a complex problem tied to local conditions and community values. In the case of the Yuma wetlands, mitigating the ongoing environmental and social damage in these areas had been a community priority for decades. Various ideas and plans were pitched over the years, but these early efforts were frustrated by patchwork land ownership, conflicting claims, community tensions, and distrust of government. Ultimately, disparate groups who had sometimes been in conflict with one another were able to come together in partnership based on shared values and priorities, and through their creativity, expertise, and dedication, succeeded in the ambitious restoration of hundreds of acres of riparian and wetland habitat. Priority setting, flexible regulation, and cooperation were key drivers in building this ground-breaking model for restoration projects along the Lower Colorado River, and revitalizing a desert community's connection to the river.

The Yuma Crossing, near the confluence of the Gila and Colorado Rivers, is marked by two massive granite outcroppings which narrow the Colorado River and form the only natural ford of the river in southern Arizona. As such, it has been a crossroads and transportation corridor for millennia, and the Ocean-to-Ocean Bridge was built over the Crossing in 1914, linking the East and West coasts of the United States in the only land route for 1,200 miles at the time. In 2000, Congress designated the Yuma Crossing National Heritage Area based on its historical and cultural significance, authorizing up to $10 million in federal matching funds through 2015. In 2002, a citizen task force, representing a diverse cross-section

Aerial photo of Yuma Wetlands. Photo courtesy of Fred Phillips.

of community, government, business, historical, and conservation interests, incorporated itself into the 501(c)(3) Yuma Crossing National Heritage Area Corporation to spearhead management and restoration of this newly-designated area. The City of Yuma committed long-term funding for staffing, allowing the Heritage Corporation to begin securing funding, developing a phased master plan for the area, and assembling an implementation team including a grant-writer, a planner, and a construction manager. Arizona's congressional delegation, particularly U.S. Congressman Ed Pastor, U.S. Congressman Raul Grijalva, and former U.S. Senator Jon Kyl, were instrumental in the designation of the Yuma Crossing National Heritage Area and in securing appropriations from the Bureau of Reclamation.

Yuma West Wetlands

The total cost of restoring the Yuma West Wetlands was approximately $10 million, much of the funding coming through Bureau of Reclamation appropriations, the City of Yuma, State of Arizona Heritage Funds, the Arizona Game and Fish Department, and members of the Yuma community themselves. The Environmental Protection Agency advised that six to eight feet of clean fill was the main requirement for mitigation to make the former landfill safe for public use. In December 2002, Phase One of the project opened after three years of work, encompassing about 33% of the entire 110 acre site and including the Millennium Tree Grove of 450 native trees, planted by 700 volunteers and now over 20 feet tall.

The "lower bench," of the West Wetlands, the area closest to the river, was overgrown with invasive plants and impassable. Given the land degradation and lack of water, some even questioned whether restoration would be possible. The 50 foot tall cottonwood and willow trees that line the river here today are a testament to the success of this pilot revegetation project, and "to the faith that the Lower Colorado River can, and is, being restored" (Vision, Conference 2008 issue, p. 2). The West Wetlands park also features a small lake opened in 2003; "Solar Garden," a solar demonstration area developed in 2005 in partnership with Arizona Public Service; and the Stewart Vincent Wolfe Creative Playground, completed in 2007 and "considered the most dynamic creative playground in the nation," built by thousands of community volunteers "in the style of an old-fashioned barn-raising" (Vision, Conference 2008 issue, p. 2-3). In the spirit of assessing values and setting priorities, the "playground has brought the entire community to the West Wetlands and has re-ignited a commitment to complete the park" (Vision, Conference 2008 issue, p. 3).

Yuma East Wetlands

The story of the Yuma East Wetlands is primarily the story of mending relationships and building partnerships among the Quechan, the City of Yuma, private landowners, federal agencies, and the Heritage Area. This story begins with the renovation and re-opening of the Ocean-to-Ocean Bridge, which was closed in 1988 due to structural problems. The Quechan Indian Tribe and the City of Yuma agreed to jointly fund the restoration of the bridge, which re-opened in 2002, both literally and figuratively linking the two sides of the river. The project strengthened the relationship between the two parties and nurtured a shared focus on the value of cleaning up the river, providing water for the benefit of natural areas, and creating an "ecological haven of wetlands, forests, and waterways" (Vision, Conference 2008 issue, p. 3).

The East Wetlands is a 1,418 acre site, two-thirds of which is owned by the Quechan Indian Tribe; the rest of the property ownership is a checkerboard of private agricultural holdings, City property, and other public and private agencies. Restoration efforts at the site have

required over $9 million in funding, from the Bureau of Reclamation, the Arizona Water Protection Fund, the City of Yuma, the North American Wetlands Conservation Act, the Arizona Game and Fish Department, the National Fish and Wildlife Foundation, the State of Arizona Heritage Fund, and others. A key component of the project has been the excavation and restoration of historic river channels, requiring the manual removal of invasive vegetation and over 220,000 cubic yards of fill. In all, some 500 acres have been restored, representing several miles of restored river channels, side channels, and backwater lakes. Community volunteers have planted over 6,000 trees.

Yuma Mayor Larry Nelson and Quechan President Mike Jackson Sr., present an appreciation plaque to Senator Jon Kyl in recognition of support for the Yuma East Wetlands. Photo courtesy of Fred Phillips.

Flexibility in regulation allows the City of Yuma to discharge spent filter backwash water from its Mail Street Water Treatment Plant to the Yuma East Wetlands, which is vital to the survival of the rehabilitated ecosystem. In order to do so, the City coordinated with the Arizona Department of Environmental Quality (ADEQ) to establish a net ecological benefit that allowed modified, site-specific water quality standards for total selenium and total residual chlorine. This had not been done before and required “out-of-the-box thinking,” with ADEQ concluding that the restored habitat, home to native and sensitive species, would be jeopardized without this discharge, and that “the environmental benefits associated with the discharge of filter backwash water to support the restoration of the Yuma East Wetlands outweigh the environmental costs associated with eliminating the discharge” (ADEQ Notice of Final Rulemaking Title 18 Chapter 11, p. 73). ADEQ further concluded that the cost of treatment to meet the standards would be prohibitive and that the site-specific standard would not contribute to water quality violations downstream. Additionally, the allocation of Lower Colorado River Multi-Species Conservation Program funds to support continued maintenance of the East Wetlands project also required flexibility in regulations because the site is actually maintained by the Yuma Crossing National Heritage Area. Lastly, the Lower Colorado River is prone to channel shifts throughout the floodplain, which causes problems for state boundaries. Here, these boundary problems were overlooked, and inter-jurisdictional cooperation is common in the Yuma East Wetlands.

Farmers in the area were initially reluctant to get involved with the Yuma Wetlands projects because of fears about losing their water rights. Eventually, however, they became important collaborative partners with immense expertise to share in the revegetation efforts: their knowledge of tilling, flood irrigation, and other farming techniques was invaluable in handling the enormous quantities of native plants and seed used in the project. One interviewee noted that this cooperation was made possible by communicating the details of the project and providing the farming community with a sense of ownership in the project.

Public outreach, education, and involvement have been irreplaceable in the Yuma East and West Wetlands from the outset. The Wetlands now comprise critical habitat for over 330 species of birds and other wildlife, and serve as an outdoor classroom to teach about the planning, implementation, and monitoring of a large-scale river restoration project. They feature other educational opportunities, such as the Solar Garden, and both are used for outdoor recreation and education, including activities such as canoeing, fishing, bird-watching, hiking, and nature walks. The recently restored quartermaster's house serves as a venue for learning, and the projects feature natural and cultural history interpretation centers. Since 2002, the annual Youth Cultural Festival has been held in the area, gathering students and adults from around the world to volunteer in the wetlands, share culture, art, and music, and learn about the importance of restoring the Colorado River. In addition, the projects have pioneered cutting-edge restoration techniques in areas some doubted would even be responsive to rehabilitation. They serve as a model throughout the region for riparian and wetland restoration under difficult conditions.

Interviewees noted that phased plans and the accomplishment of small projects along the way are critical for maintaining community interest and achieving success, as people are easily disheartened without demonstrated progress. Maintaining backwash water discharge into the wetlands will remain crucial to their viability, particularly during very low flows of the Colorado River. Interviewees indicated that if the project were to restart, some technical details would be changed (e.g. soil testing, irrigation practices) and the project would start sooner. Their advice for other projects included understanding the importance of collaboration and removing personal agendas from the equation.

Interview Participants

Gita Bodner, Ph.D. – The Nature Conservancy; Las Cienegas National Conservation Area
Emily Brott – Sonoran Institute; Conserve2Enhance (C2E)
Kevin Eatherly – City of Yuma; Yuma East and West Wetlands Restoration
Charles Flynn – City of Yuma; Yuma East and West Wetlands Restoration
Frank Geminden – Diamond S Ditch Company; Verde River Automated Ditch Operations
Steve Goetting – Diamond S Ditch Company; Verde River Automated Ditch Operations
Andrew Hautzinger – U.S. Fish and Wildlife Services, Division of Water Resources; Bill Williams River Corridor Steering Committee
John Jordan - Federation of Flyfishers; Glen Canyon Dam Adaptive Management Program
Kendall Kroesen – Tucson Audubon; Conserve2Enhance
Shela McFarlin – Cienega Watershed Partnership, Bureau of Land Management, Retired; Las Cienegas National Conservation Area
Fred Phillips - Fred Phillips Consulting; Yuma East and West Wetlands Restoration
Sarah Porter – Audubon Arizona; Audubon Arizona Conserve2Enhance
Candice Rupprecht – Tucson Water; Conserve2Enhance (C2E)
Kim Schonek – The Nature Conservancy; Verde River Automated Ditch Operations
Dale Turner – The Nature Conservancy; Bill Williams River Corridor Steering Committee
Ian Tomlinson – Vera Earl Ranch, Inc.; Las Cienegas National Conservation Area

Interview Questions

General Information

Name; Affiliation; Year(s) involved/role in the project

Project Purpose

1) What was the primary objective(s) of this project?

Priority Setting

2) Please describe the factors that influenced the selection of the site.

Cooperation

3) Who is directly involved in the project (the “core team,” e.g. community leaders, organizations, funders, etc.)?
4) How did you identify additional stakeholders?
    a. What did you do to get stakeholder input on the project?

Understanding the Value of Water

5) What are the primary source(s) of water?
    a. How are available water resources utilized in this project?

Conservation and Efficiency

6) Does this project incorporate strategies for water conservation or water use efficiency?

Multiple Uses of Water

7) How might this project facilitate/affect/support water uses other than those originally intended (does it increase/decrease…irrigation, recreation, habitat, storage)?

Financial Incentives

8) Why did you participate in this project (e.g. financial, required to, community values)?

Flexible Regulation/Legal Incentives

9) Was legal considerations part of the project (e.g., was there a mandate, water rights adjudication, ESA permit)?

Education

10) Did the project include education or outreach?

a. If so, what sort of education and outreach did you conduct (e.g. passive signage, active site tours)?

Lessons Learned

11) What is the current status of the project?
    a. Are there future management plans?
    b. Is there a long-term source of project funding?
12) What was the one thing that most impacted success?
13) What is one thing you would do differently if you were to start the project over again?
14) Do you have any advice of other collaborative projects?

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Glen Canyon Dam Adaptive Management Program

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Las Cienegas National Conservation Area

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The Nature Conservancy. Automation makes irrigation more efficient and leaves more water in the Verde River. Available online.

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Yuma Crossing National Heritage Area Corporation. (www.yumaheritage.com/)

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Fred Phillips Consulting. Yuma East Wetlands Progress Report. (2007). Available online as PDF, 29 pages.

Senate Report on Yuma Crossing National Heritage Area. (http://www.gpo.gov/fdsys/pkg/CRPT-109srpt242/html/CRPT-109srpt242.htm)

The Yuma Heritage Foundation. Yuma East and West Wetlands. (Conference 2008 Issue, October 2008). Vision: A Publication of the Arizona Chapter of the American Planning Association, p. 1-4.

Appendix B. Drivers for Including Water for the Environment and Vulnerabilities to Water for the Environment – Complete Survey Results

As the WRRC began the Roadmap development process, the first questions we asked were, 1) why a community would decide to provide water to natural areas (drivers)? and 2) what do people think makes water in natural areas vulnerable (vulnerabilities)? To get a first impression of what people thought are drivers for and vulnerabilities to providing water to riparian and aquatic ecosystems, the WRRC created a 28-question survey. This survey was sent to over 726 people on the WRRC's Water RAPIDS electronic mailing list, many of whom were added as a result of their participation in the first 18 months of the project. Responses were anonymous with the only identifying information being the reason for the participant's interest(s) in water and the county or counties the participant worked or had an interest in. It should be noted that the interest categories used for the survey are not identical to those used in later Roadmap activities. The survey was reviewed and approved by the University of Arizona's Human Subjects Institutional Review Board and administered online through SurveyMonkey.com.

Of the 726 people who were sent the survey we received 146 complete responses (160 partial) for a response rate of 20%. Over half of the respondents identified themselves as environmental stakeholders (51%). Other common interest groups were municipal (25%), educational (26%) and agricultural (13%).[1] Participants who identified themselves as being from Pima county or interested in issues statewide were two largest geographic areas, but there were at least 2 respondents from each Arizona county.

Highlights from the results include:

- Most agreement among survey respondents that legal mandates (80%), an increased awareness of environmental water needs (81%), and an increased understanding of the connections between human water use and environmental water use (83%) encourage consideration of water for natural areas.
- Most agreement among groups that economic instability (54%), negative experience with a restoration project (65%), and a lack of data (67%) discourage consideration of water for natural areas.
- Interestingly, 62% and 57% of all respondents thought that climate change and prolonged drought encouraged consideration of water for natural areas. However, respondents from a political and county perspective in particular disagreed with this perspective (61% and 75% for drought and 39% and 50% for climate).
- The most commonly indicated vulnerabilities to water in natural areas included changes in climate (92%), growing communities near riparian areas (92%), and rapid expansion of agricultural or industrial water demand (93%).

Figure B1 provides summary results for the question on drivers for consideration of water for the environment and Figure B2 provides summary results for the question on what makes water for the environment vulnerable. Tables B1a and b provide responses to the question on drivers by primary (first identified) water interest group and tables B2a and b provide responses for the question on vulnerabilities by primary interest group.

[1] Participation is equal to greater than 100% because participants were allowed to select more than one interest group.

Figure B.1
Responses to Survey Question: Do the following drivers discourage, neutral (neither encourage or discourage) or encourage consideration of water for the environment?

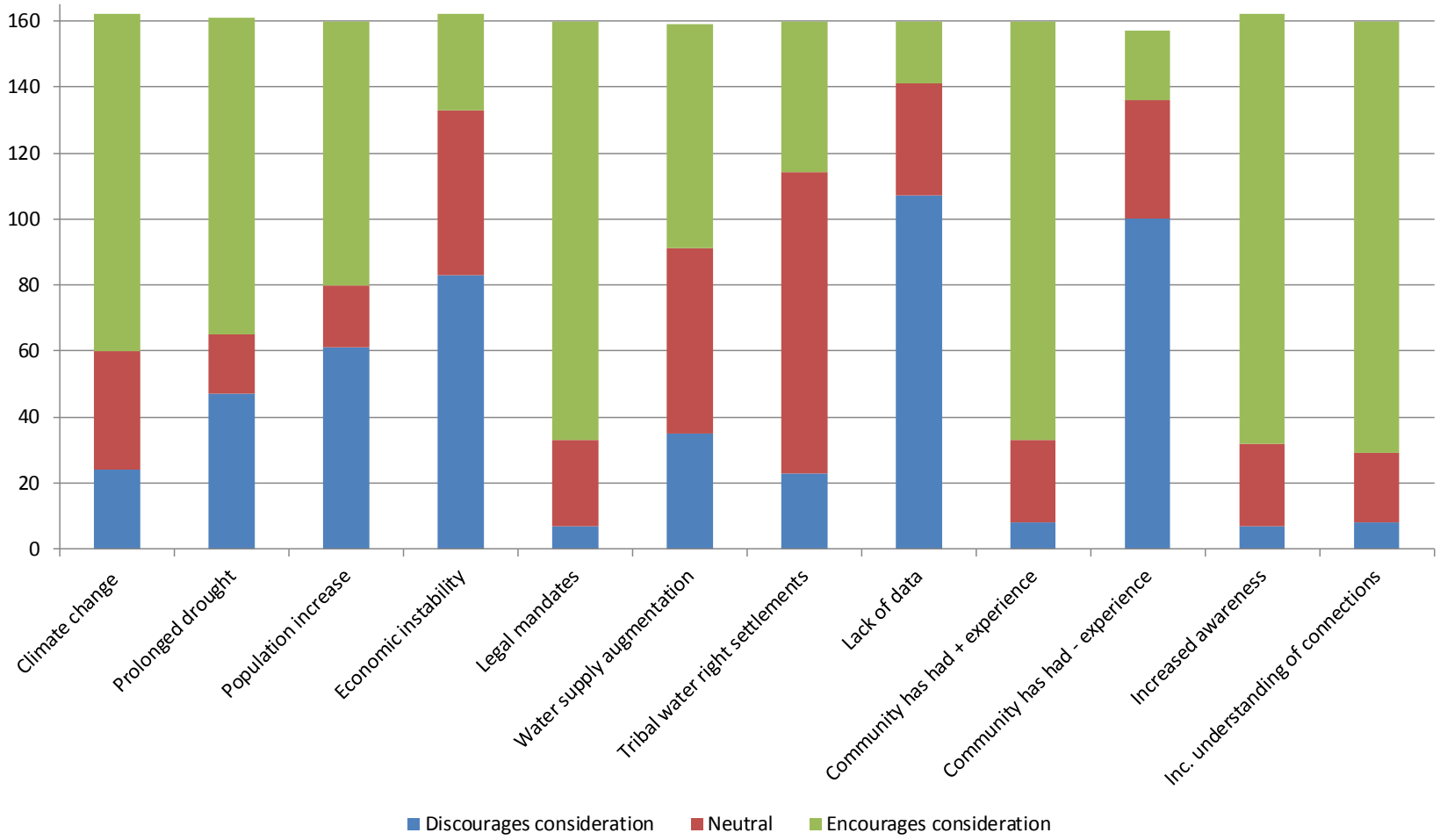

Figure B.2
Responses to the Survey Question: Do the following criteria increase, neutral (neither increase nor decrease), or decrease vulnerability of water needed in the environment?

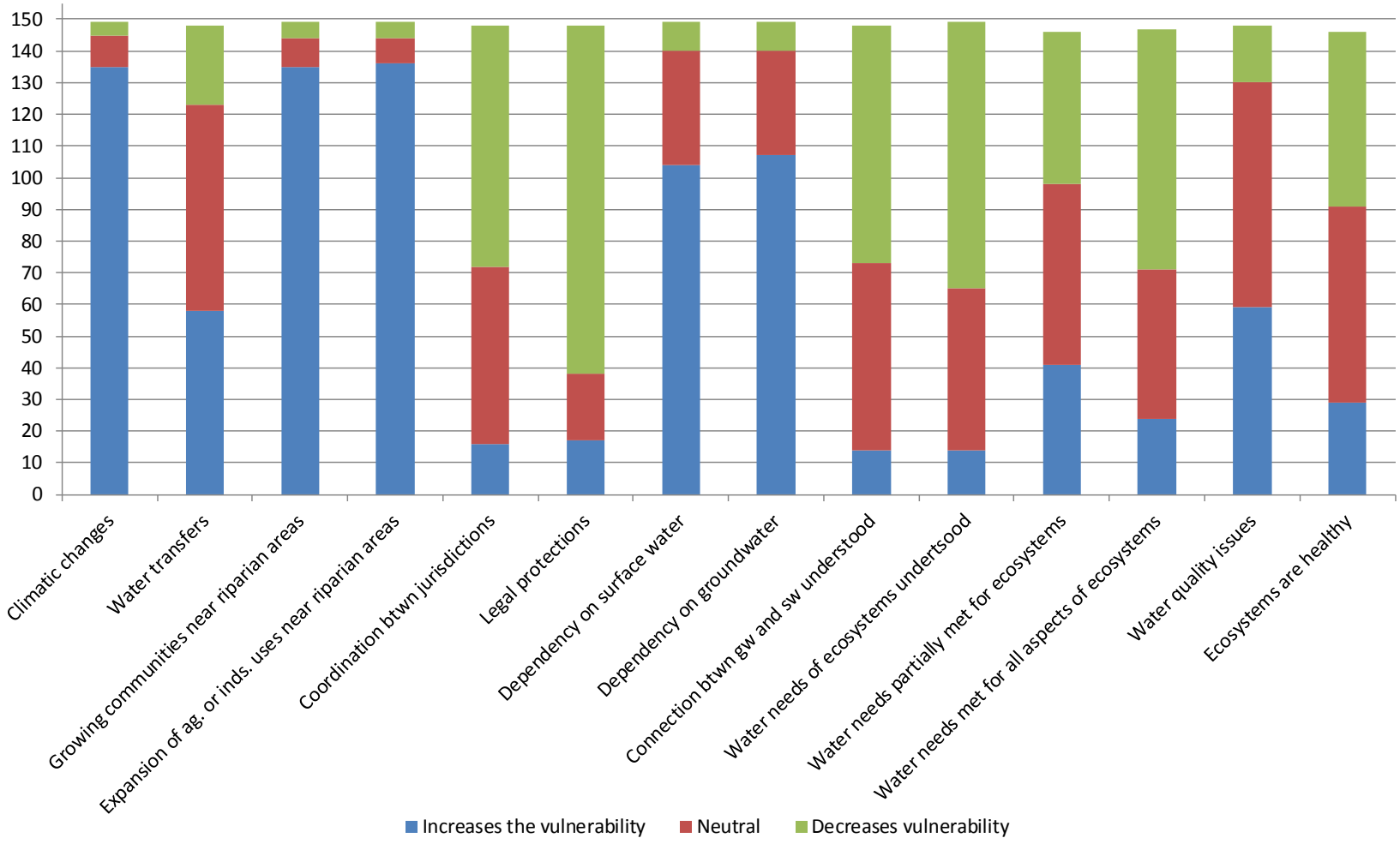

Table B.1a: Drivers for including water for the environment in water management and planning decisions.

	Climate change			*Prolonged drought*			*Population increase*		
Stakeholder	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**
Academia	0%	100%	0%	0%	0%	100%	0%	100%	0%
Agricultural	26%	57%	17%	43%	52%	4%	41%	45%	14%
Educational	14%	64%	22%	33%	58%	8%	41%	56%	3%
Energy	0%	0%	100%	0%	0%	100%	100%	0%	0%
Environmental	13%	68%	18%	29%	61%	10%	40%	53%	7%
Government	40%	40%	20%	40%	60%	0%	40%	20%	40%
Government-County	50%	25%	25%	75%	25%	0%	25%	50%	25%
Government-Federal	0%	75%	25%	0%	75%	25%	0%	100%	0%
Government-State	0%	0%	100%	0%	0%	100%	100%	0%	0%
Industrial	13%	38%	50%	25%	50%	25%	25%	50%	25%
Municipal	5%	70%	25%	31%	62%	8%	43%	43%	15%
Other	9%	73%	18%	9%	64%	27%	27%	45%	27%
Political	39%	33%	28%	61%	39%	0%	61%	22%	17%
Tribal	0%	100%	0%	0%	100%	0%	0%	75%	25%
Grand Total	15%	62%	23%	32%	57%	11%	40%	48%	12%

	Economic instability/reduced funding state agencies			*Legal mandates for environment*			*Water supply augmentation projects*		
Stakeholder	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**
Academia	100%	0%	0%	0%	100%	0%	0%	100%	0%
Agricultural	35%	26%	39%	4%	83%	13%	22%	65%	13%
Educational	58%	25%	17%	3%	86%	11%	19%	53%	28%
Energy	100%	0%	0%	0%	100%	0%	0%	0%	100%
Environmental	54%	20%	27%	1%	86%	13%	26%	37%	37%
Government	40%	0%	60%	0%	60%	40%	40%	60%	0%
Government-County	50%	0%	50%	0%	75%	25%	25%	25%	50%
Government-Federal	25%	50%	25%	0%	75%	25%	50%	50%	0%
Government-State	100%	0%	0%	0%	100%	0%	0%	100%	0%
Industrial	63%	0%	38%	13%	63%	25%	13%	75%	13%
Municipal	63%	5%	33%	3%	78%	20%	21%	31%	49%
Other	55%	18%	27%	18%	55%	27%	20%	40%	40%
Political	50%	17%	33%	6%	72%	22%	17%	28%	56%
Tribal	25%	25%	50%	0%	75%	25%	33%	67%	0%
Grand Total	54%	17%	29%	3%	80%	17%	23%	43%	34%

Table B.1b: Drivers for including water for the environment in water management and planning decisions (continued).

	Settlement of tribal water rights			*Lack of data*			*Community positive experience*		
Stakeholder	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**
Academia	0%	100%	0%	0%	100%	0%	100%	0%	0%
Agricultural	35%	26%	39%	52%	22%	26%	13%	65%	22%
Educational	14%	31%	54%	61%	19%	19%	8%	75%	17%
Energy	0%	0%	100%	100%	0%	0%	0%	100%	0%
Environmental	14%	25%	62%	73%	10%	17%	5%	88%	7%
Government	20%	20%	60%	80%	0%	20%	0%	60%	40%
Government-County	0%	33%	67%	75%	0%	25%	0%	33%	67%
Government-Federal	0%	25%	75%	50%	25%	25%	0%	50%	50%
Government-State	0%	100%	0%	100%	0%	0%	0%	100%	0%
Industrial	0%	25%	75%	75%	0%	25%	0%	75%	25%
Municipal	15%	18%	68%	75%	10%	15%	10%	80%	10%
Other	9%	36%	55%	60%	10%	30%	0%	73%	27%
Political	17%	22%	61%	61%	6%	33%	11%	61%	28%
Tribal	0%	75%	25%	50%	50%	0%	0%	100%	0%
Grand Total	15%	26%	59%	68%	13%	20%	7%	77%	16%

	Community has had a negative experience			*Increased awareness of env. water needs*			*Increased understanding of connections btwn env. water and human well being*		
Stakeholder	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**	**Discourages**	**Encourages**	**Neutral**
Academia	0%	0%	0%	0%	100%	0%	0%	100%	0%
Agricultural	61%	17%	22%	4%	70%	26%	9%	74%	17%
Educational	63%	14%	23%	11%	89%	0%	6%	91%	3%
Energy	100%	0%	0%	0%	50%	50%	0%	100%	0%
Environmental	70%	14%	16%	4%	85%	11%	5%	86%	9%
Government	60%	0%	40%	0%	100%	0%	0%	100%	0%
Government-County	0%	0%	100%	0%	100%	0%	0%	100%	0%
Government-Federal	75%	0%	25%	0%	75%	25%	0%	75%	25%
Government-State	100%	0%	0%	0%	100%	0%	0%	100%	0%
Industrial	88%	0%	13%	13%	50%	38%	13%	63%	25%
Municipal	70%	5%	25%	3%	80%	18%	5%	79%	15%
Other	50%	10%	40%	0%	73%	27%	0%	82%	18%
Political	50%	11%	39%	17%	67%	17%	11%	61%	28%
Tribal	25%	75%	0%	0%	100%	0%	0%	100%	0%
Grand Total	65%	12%	23%	5%	81%	14%	6%	83%	12%

Table B.2a: Vulnerabilities to providing water to riparian and aquatic ecosystems in water management and planning decisions.

	Evidence of climatic changes			*Growing communities near riparian areas*			*Rapid expansion of agricultural or industrial water demand*		
Stakeholder	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**
Agricultural	4.76%	85.71%	9.52%	9.52%	76.19%	14.29%	9.52%	80.95%	9.52%
Educational	2.70%	86.49%	10.81%	2.70%	91.89%	5.41%	0.00%	94.59%	5.41%
Environmental	3.95%	90.79%	5.26%	3.95%	90.79%	5.26%	3.95%	92.11%	3.95%
Government	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	92.31%	7.69%
Industrial	0.00%	100.00%	0.00%	0.00%	90.00%	10.00%	10.00%	90.00%	0.00%
Municipal	0.00%	95.00%	5.00%	0.00%	97.50%	2.50%	0.00%	97.50%	2.50%
Other	0.00%	100.00%	0.00%	0.00%	87.50%	12.50%	0.00%	100.00%	0.00%
Political	0.00%	94.12%	5.88%	0.00%	94.12%	5.88%	0.00%	94.12%	5.88%
Tribal	0.00%	66.67%	33.33%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%
Grand Total	2.22%	91.56%	6.22%	2.67%	91.56%	5.78%	2.67%	92.89%	4.44%

	Water Transfers (ag 2 muni)			*Coordination between jurisdictions*			*Policies that protect environmental flows*		
Stakeholder	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**
Agricultural	14.29%	47.62%	38.10%	28.57%	14.29%	57.14%	76.19%	9.52%	14.29%
Educational	18.92%	35.14%	45.95%	35.14%	13.51%	51.35%	67.57%	10.81%	21.62%
Environmental	14.67%	34.67%	50.67%	58.67%	12.00%	29.33%	73.33%	13.33%	13.33%
Government	46.15%	23.08%	30.77%	76.92%	7.69%	15.38%	92.31%	7.69%	0.00%
Industrial	0.00%	50.00%	50.00%	50.00%	10.00%	40.00%	80.00%	10.00%	10.00%
Municipal	22.50%	45.00%	32.50%	55.00%	15.00%	30.00%	82.50%	10.00%	7.50%
Other	12.50%	62.50%	25.00%	25.00%	25.00%	50.00%	75.00%	25.00%	0.00%
Political	35.29%	17.65%	47.06%	52.94%	17.65%	29.41%	58.82%	29.41%	11.76%
Tribal	0.00%	33.33%	66.67%	0.00%	33.33%	66.67%	0.00%	66.67%	33.33%
Grand Total	19.20%	37.50%	43.30%	49.55%	13.84%	36.61%	73.66%	13.84%	12.50%

	Regional dependency on surface water			*Regional dependency on groundwater*			*Connection btwn gw and sw understood*		
Stakeholder	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**
Agricultural	4.76%	66.67%	28.57%	9.52%	71.43%	19.05%	38.10%	9.52%	52.38%
Educational	2.70%	67.57%	29.73%	0.00%	70.27%	29.73%	50.00%	5.56%	44.44%
Environmental	5.26%	78.95%	15.79%	6.58%	80.26%	13.16%	53.33%	13.33%	33.33%
Government	0.00%	69.23%	30.77%	0.00%	61.54%	38.46%	38.46%	15.38%	46.15%
Industrial	0.00%	60.00%	40.00%	0.00%	50.00%	50.00%	60.00%	0.00%	40.00%
Municipal	2.50%	72.50%	25.00%	5.00%	82.50%	12.50%	38.46%	15.38%	46.15%
Other	12.50%	62.50%	25.00%	0.00%	75.00%	25.00%	62.50%	12.50%	25.00%
Political	41.18%	35.29%	23.53%	23.53%	47.06%	29.41%	52.94%	11.76%	35.29%
Tribal	0.00%	66.67%	33.33%	0.00%	33.33%	66.67%	33.33%	0.00%	66.67%
Grand Total	6.67%	69.33%	24.00%	5.78%	72.44%	21.78%	48.20%	11.26%	40.54%

Table B.2b: Vulnerabilities to providing water to riparian and aquatic ecosystems in water management and planning decisions (continued).

	Water demands of riparian and aquatic ecosystems understood			*Water demands currently being met for some aspects*			*Water demands currently being met for all aspects*		
Stakeholder	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**
Agricultural	42.86%	9.52%	47.62%	9.52%	61.90%	28.57%	23.81%	42.86%	33.33%
Educational	45.95%	5.41%	48.65%	24.32%	27.03%	48.65%	48.65%	18.92%	32.43%
Environmental	60.53%	13.16%	26.32%	40.00%	21.33%	38.67%	57.33%	13.33%	29.33%
Government	76.92%	0.00%	23.08%	38.46%	7.69%	53.85%	38.46%	7.69%	53.85%
Industrial	80.00%	0.00%	20.00%	40.00%	10.00%	50.00%	70.00%	20.00%	10.00%
Municipal	50.00%	10.00%	40.00%	20.51%	25.64%	53.85%	50.00%	20.00%	30.00%
Other	62.50%	25.00%	12.50%	37.50%	37.50%	25.00%	37.50%	37.50%	25.00%
Political	52.94%	11.76%	35.29%	18.75%	31.25%	50.00%	56.25%	12.50%	31.25%
Tribal	33.33%	0.00%	66.67%	33.33%	33.33%	33.33%	66.67%	0.00%	33.33%
Grand Total	55.56%	9.78%	34.67%	29.28%	27.03%	43.69%	50.22%	18.83%	30.94%

	Regional water quality issues			*Riparian and aquatic ecosystems are healthy*		
Stakeholder	**Decreases**	**Increases**	**Nuetral**	**Decreases**	**Increases**	**Nuetral**
Agricultural	14.29%	28.57%	57.14%	19.05%	38.10%	42.86%
Educational	5.41%	37.84%	56.76%	35.14%	18.92%	45.95%
Environmental	18.67%	40.00%	41.33%	37.84%	17.57%	44.59%
Government	0.00%	38.46%	61.54%	46.15%	30.77%	23.08%
Industrial	20.00%	20.00%	60.00%	40.00%	10.00%	50.00%
Municipal	7.50%	32.50%	60.00%	40.00%	27.50%	32.50%
Other	12.50%	50.00%	37.50%	0.00%	37.50%	62.50%
Political	11.76%	35.29%	52.94%	43.75%	18.75%	37.50%
Tribal	33.33%	0.00%	66.67%	33.33%	0.00%	66.67%
Grand Total	12.50%	35.71%	51.79%	35.59%	22.52%	41.89%

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Appendix C. Tables of Recommended Strategies and Action Items from Roadmap Workshops

Table C.1: Recommended strategies, by thematic area, for each regional workshop; strategies are ranked in descending order based on participants polling results.

	Tucson		Phoenix		Flagstaff		Yuma	
Water-use efficiency and conservation to benefit natural areas	**Effluent reuse to benefit wetlands, use for near-stream recharge**	26%	**Consider natural areas in stormwater management**	**28%**	**Modify water pricing/trading/banking to encourage providing water to natural areas**	**18%**	**Educate public about existing agricultural conservation and benefits to natural areas**	Results not available
	Voluntary partnerships to facilitate efficiency	24%	Create utility-based conservation programs	23%	Develop analogs from energy industry as models/incentives	16%	Have all regional environmental groups collectively define their priorities for the region	
	Utility-based conservation tools (expand checkbox program for conservation funds)	17%	Encourage place-based conservation	23%	Water-dependent land use planning	14%		
	Widespread low-impact development (LID), rainwater harvesting	15%	Long-term dedication of effluent to natural areas	16%	Land and water ethic	14%		
	Expand time-sensitive programs (ex: renewable water release agreements)	15%	Promote water-efficient renewable energy	9%	Legal standing for natural areas	14%		
	Urban and rural cooperation as well as efficiencies	4%			Increase agricultural water conservation	9%		
					Tourism and education on natural areas	9%		
					Implement a conservation program (WaterWise/Conserve2Enhance)	5%		
					Reclaimed water for offsets	2%		
Incentives for providing water to natural areas	**Collaboration between government and non-governmental organizations (NGOs)**	**41%**	**Connect conservation to preservation/allocate savings to natural areas**	**29%**	**Metering wells and providing conservation incentives for more efficient use**	**23%**	**Financial compensation, pay water users for the right to leave water in natural channels**	Results not available
	Ecotourism/economic development (provides local revenue source and increases awareness)	26%	Create a fund for providing water to natural areas, incentivize with tax credit	22%	Money for non-development agreements/Land trusts to buy land and keep water in streams	19%	Tourism: birding and sporting increase incentive to providing water and has economic benefits	
	Managed vs. Constructed recharge credits	15%	Incentivize recharge in natural areas to allow cost recuperation for treatment/discharge	20%	Incentives for agricultural irrigation efficiencies	16%		
	Simplify permitting process, provide payments for timely conservation	7%	Arizona Corporation Commission needs to establish more flexible regulations to allow private utilities to recoup conservation costs	20%	Social incentives, education to affect political will	14%		
	Direct payments or tax incentives for providing water to natural areas	7%	Reform process for instream flow certification--give environment a water right	10%	"Large user" rewards driven by consumers/labeling and marketing	9%		
	Complete the adjudication process	4%			Payments for ecosystem services	7%		
					Tiered water rates	7%		
					Statewide campaign for low-flow fixtures	5%		
					Fallowing payments	0%		
Education/ communication about water for natural areas	**Educate residents about history, heritage, importance, etc. of natural areas**	**25%**	**Use media/TV spots to educate public**	**32%**	**Outreach program for elected officials**	**35%**	*(Not discussed at Yuma workshop)*	
	Develop simple, consistent messaging	23%	Establish youth education partnerships	27%	Program for community engagement	33%		
	Capitalize on existing educational resources	19%	Develop a university-led "Water 101" course	23%	Develop youth education program	16%		
	Link interested groups together to maximize impact and available funding	15%	Provide curriculum for municipalities to educate residents about regional water supply and demand	18%	Educate about value of natural areas (economics, cultural significance, etc.)	12%		
	Use grassroots/state partnerships	13%			Establish an educational campaign for tourists	5%		
	Across the board education about how water using sectors are related	6%						
Priority setting process and avenues for cooperation on water for natural areas	**Bring stakeholders together**	**19%**	**Determine how the public "values" natural areas**	**30%**	**Look to how other areas have established community/regional priorities**	**24%**	**Regional (localized) priority setting and cooperation**	**44%**
	Economic development driver	15%	Use scenario planning as a way to bring people together	28%	Determine where/how water is currently used (address data gaps)	17%	Less of a priority on regulation	14%
	Address data gaps in current understanding of natural area water demands and historical management decisions	15%	Priority setting through watershed groups	26%	Have environmental groups set priorities first	15%	Increase understanding about agricultural water use efficiency	14%
	Cultural understanding framework, respect heritage	13%	Surveying to find convergence of interests	16%	Use adjudication process	15%	Find and build consensus	14%
	Education on why natural areas should be a priority	12%			Set a cap on water use and go from there	12%	Water use equal to financial representation	11%
	Advocating for legislation that brings people together	10%			Bring stakeholders together in a forum to talk about their priorities	12%		
	Voluntary process for all sectors	10%			Go to shareholders, not just employees	2%		
	Develop a forum for discussing tribal water issues	6%			Use Bureau of Reclamation process	2%		

Table C.2: Action items for the "education and communication about water for natural areas" theme, by regional workshop.

	Tucson	Phoenix	Flagstaff	Yuma
	Educate residents about history, heritage, importance, etc. of natural areas	**Use media/TV spots to educate public**	**Outreach program for elected officials**	*(Not discussed)*
Who needs to be part of this? Who are the likely allies and existing opportunities?	**INVOLVEMENT** Government and Non-Governmental Organizations Educators, existing water education programs, e.g. Project WET, museums, universities, K-12 schools Water providers Agricultural organizations Local watershed groups Managers of recharge facilities **OPPORTUNITIES** Collect oral histories from - community members, tribes (elders, council, community groups, youth), Groundwater code creators (1980 Groundwater Management Act) Use university institutes-> centralized hub (i.e. Climate Change, UA WRRC, ASU Decision Center for Desert Cities) Get corporate sponsors e.g., health food stores, days of service, sportsman stores, sports venues, associations	**INVOLVEMENT** Water and utility providers Agricultural organizations Local watershed groups, e.g. "Friends of..." groups NGOs State agencies, e.g. Arizona Department of Water Resources, Universities Federal agencies Students => drive, "be voice" Professional societies (wilderness, wildlife) **OPPORTUNITIES** Corporate sponsor/participant	**INVOLVEMENT** Private foundations Natural resource staff from state and federal agencies Tribal chapters Water and utility providers, e.g. Central Arizona Project, Salt River Project Large water right holders Agriculture Universities Prospective elected officials **OPPORTUNITIES** River Day- bring in different "non-scary" voices Water 101- fun, interactive, outdoor experience Assign roles/mock experiences Supporter and money for state	
What resources and tools do you need?	Money, lesson plans for K-12 and all audiences, media reach, cost sharing/in-kind partnerships, video production, GIS software, people power!, facilities Community meetings, equipment/materials- models, displays that can travel and engaging, etc., legislative expo, signage-all forms at locally significant sites- maps- watershed Social media platform (QR codes, YouTube channel) Mapping of community resources- stone soup, everyone can bring a little need to know what already exists/needs modification Multi-lingual (Spanish, sign language) Website/central repository- for education-e.g. Best Management Practices database with available resource Pool resources, map commonalities, success stories Identify representatives from all sectors to develop goals, simple message Tribal history, practices/seeds, living how to use	Money Leadership- champion Develop curriculum, technical experts => Modules, range of options A message-> preserve, conserve, restore, importance/value of natural areas Marketing Cooperative media outlet=> YouTube, TV, text/tweets, Facebook Established foundational information (history, water cycle/hydrologic cycle, distribution from source to sink) Established audience- tailor tools to different sectors Feedback- younger generation/parents	Allies, middle/impartial party and a safe forum Data, info on long term possibilities Talk about policies to ensure local control, e.g., Endangered Species Act, Arizona Game and Fish, heritage fund Proactive vs. reactive approach 1 page executive summary- focus on economy, legacy, alternatives: federal oversight Follow up/touch points Take them out- sponsor "an experience" to educate about opportunities Money- multi source, private foundations	
What are the steps that you would need to take? Near-term? Long-term?	Change in attitude of water for environment- motivate them to action Contact list, community relations list Script of what to say- scope of week, why we want money Grants Understand what is needed next/feedback Assessment of what is available Set goals for timeline, budget, facilitate where interest Econ data- ecotourism benefit, ecosystem services description Existing example of success Awareness survey Convene universities for existing resources- consolidate message and role of university Pilot program/monitoring- collaborative at all levels Launch showcase/rally point	Establish message through first developing Broad Stroke Messages Establish outreach plan with a K-6 Education component Social media-> need followers Established media campaign that informs about need for natural areas Connect with personal values Leaders, $, champions Start with basics then create excitement ("Kid Pressure") Incorporate with target audiences (fisherman, ranchers and generations)	Near- research market- what do you value? survey to gauge interest Mission, vision, values- What is the objective? Toolbox Gather steering committee- inclusive, collaborative, sector diversity Local needs to identify and support Identify experiential learning Incentivize attendance certification) Water Resource Development Commission Unify state universities Use resources/adventure to show example	

Table C.3: Action items for the "water-use efficiency and conservation to benefit natural areas" theme, by regional workshop.

	Tucson	Phoenix	Flagstaff	Yuma
	Effluent reuse to benefit wetlands, use for near-stream	**Consider natural areas in stormwater management**	**Modify water pricing/trading/banking to encourage**	*(Not discussed)*
Who needs to be part of this? Who are the likely allies and existing opportunities?	**INVOLVEMENT** Government and Non-Governmental Organizations Agriculture Home builders/contractors and plumbers Piping/infrastructure manufacturers Academic/university research (all state institutions) Utilities Landowners Voluntary Partners - e.g., Industry, Tribal partners, Universities, Trade Associations, Watershed groups **OPPORTUNITIES** More case studies (Tres Rios, Sweetwater) - Examine how entities have partnered, Share best practices Near stream recharge Place-based education Review Water Reuse Association reports from beyond Arizona or in Arizona Economic development opportunities	**INVOLVEMENT** Government Universities Environmental advocates Downstream water rights holders Affected landowners Mines and industry **OPPORTUNITIES** Take advantage of land use changes- such as old sand and gravel ops for recharge/wetlands, range land re-vegetation	**INVOLVEMENT** Stakeholders Developers- engaged in the process **OPPORTUNITIES** Revisit "safe yield" -> sustainable yield? Sever and transfer agreements	
What resources and tools do you need?	Effluent Supply, quality, current use, projected use, options, natural resources Messaging Extension publication, i.e., research to understand financial constraints and funding streams; infrastructure/district and treatment system Data collection/info gathering Examining existing reclaimed system Review of existing fed/state rule and regulations Voluntary partners Community feedback/buy-in/support Shareholder Identification and determination of offerings/interests Develop Plan/determine common interests and goals Begin a dialogue using a facilitator with trust (e.g., Arizona Department of Water Resources or Watershed groups) Pilot projects	Research - Inventory of existing areas of riparian and wetland ecosystems that could benefit from storm water Understanding local hydrologic cycle Change in dam flows management to facilitate water availability to natural areas Incentives, e.g., bonds/incentives during system improvements or Federal and state-level credits/incentives to municipalities for water permitting Public outreach/awareness of stormwater permitting and benefits to natural areas	Recognition of scarcity/finite measure of water Adjudication of surface and groundwater rights (e.g. Active Management Area areas, possible Gila adjudication) Legal authority and administrative procedures for trading Environmental Active Management Areas, maintenance of base flows in the state as a management goal Conjunctive management	
What are the steps that you would need to take? Near-term? Long-term?	Consider impacts from climate change/drought, population growth Quantify where it goes now Identify existing agreements, potential use sites and regulatory constraints Assess needs over long term Projections of effluent Incorporate effluent into state plans Identify Common/shared interests/incentives and goals Watershed level outreach through existing associations and watershed groups Link demo sites and case studies Engage policy makers Habitat/ecotourism/economic benefits/return on investment	Information gathering, e.g., inventory of potential areas, survey of public for social/environmental/economic values of target areas, survey of existing storm water quality (renew of MS-4) filings, hydrologic flood studies on development projections Public education to generate an understanding of the issues (near-term), e.g., forum with stakeholders facilitated by Arizona Department of Water Resources, Universities, or 4-H Bring together common interest groups (e.g. environmental groups) to review of success stories of macro rainwater/stormwater harvesting (e.g. Sierra Vista) Start small: pilot projects	Understand all stakeholder water rights Small scale? Short term How to set up existing infrastructure to meet needs? (carrying capacity) Reclaimed water and conservation for water credits Interstate mentoring process (e.g. Oregon)	

Table C.4: Action items for the "incentives for providing water to natural areas" theme, by regional workshop.

	Tucson	Phoenix	Flagstaff	Yuma
	Collaboration between government and non-governmental organizations (Non-Governmental Organizations)	**Connect conservation to preservation/allocate savings to natural areas**	**Metering wells and providing conservation incentives for more efficient use**	*(Not discussed)*
Who needs to be part of this? Who are the likely allies and existing opportunities?	**INVOLVEMENT** Government and Non-Governmental Organizations Tribes Resource managers and owners Active Management Areas Watershed groups- big ally, and/or Natural Resource Conservation Districts Decision makers, e.g. legislators Senior water right holders Private businesses Local conservation groups Water users (industry, agriculture, municipal) **OPPORTUNITIES** Ecotourism → tourism companies, collaboration with hotel industry and resource manager/agency Collaboration between Government and Non-Governmental Organizations SB 1322 - assured water supply implementation	**INVOLVEMENT** Water users - Residential, Agricultural, Industry, Commercial Agricultural Land Owners and Irrigation Districts Non-Profit environmental organizations, e.g., Audubon Existing mechanisms, e.g. Tucson C2E Municipalities Water providers/utility Neighborhood Associations (HOA)	Not discussed	
What resources and tools do you need?	Facilitator Staff and Materials Location- Neutral meeting place Common Goals and Standards Funding - numbers and money and cost/benefit analysis Information - historic context -> educate, repository for info & online forum site -> outreach programs Outreach/Educational Background/situational context of concerns Marketing Recognition of resources	Information - Options of outcomes, preserve, enhance, restore, database of water users and a list of quality projects to support Technology - water saving, monitoring (water meters), "Dashboard" website Partners Water source	Tiered water rates, large users give -> natural areas Social incentives-> moral, sense of well-being Ecosystem services/monetize resources, e.g. views, wildlife corridors Need social/political will Finding sources? What will be funded? Residential "Fallowing" of front yard? Payment needs to be more profitable Rain water harvesting incentive for landscape Conservation organizations to buy land and keep water in streams Incentive for agricultural efficiency Labeling and marketing	
What are the steps that you would need to take? Near-term? Long-term?	Invite everybody - engage stakeholders and conduct outreach Problem statement- clear/big picture Get all the issues out Establish goals and set priorities Identify beneficiaries/stakeholders What options are available? What's effective, what's not? Scheduled/regular meetings with core subgroups to accomplish tasks Timelines Regional approach- where are there opportunities? Where can multiple communities benefit? Control invasive plants Education/outreach for maintenance Conservation/efficiency benefits Permitting/user fees	Identify willing participants/partners Identify funding sources Develop Project List Implement Pilot Projects and public education campaign to garner support Develop metrics for success and evaluate success for projects Convey benefits and find conditional partners/support to expand	Education for lawmakers Create payment for ecosystem services through utility billing and surcharges Statewide campaign for more efficient fixtures	

Table C.5: Action items for the "priority setting process and avenues for cooperation on water for natural areas" theme, by regional workshop.

	Tucson	Phoenix	Flagstaff	Yuma
	Bring stakeholders together	**Determine how the public "values" natural areas**	**Look to how other areas have established community/regional priorities**	**Regional (localized) priority setting and cooperation**
Who needs to be part of this? Who are the likely allies and existing opportunities?	**INVOLVEMENT** Community groups, e.g., Hispanic groups, Tribes, HOAs, Economic development organizations Non-Governmental Organizations Government, e.g., Elected Officials, Federal agency/all levels (land managers, state), City/County Officials Academia, e.g., UA WRRC/Hydrology Department, Educators, Kitt Peak, Tech park, Biosphere2 Industry, e.g., Large corporations/mining Agriculture Youth Land owners by impact areas Lawyers Utilities Businesses, e.g., Outdoor recreation groups Foundations, e.g., Walton Family Foundation Local governments, e.g., Natural Resource Conservation Districts Media, social media, e.g., Arizona Star	**OPPORTUNITIES** Existing education programs, e.g. Project WET Look at licenses sold, park passes, e.g., boat registration, camping, pool permits, attendance at environmental festivals Mine data that is there on use and value Ask people what if there were water Collaborative efforts to develop survey Have polling conducted by unbiased entity	**INVOLVEMENT** Unbiased group, e.g., Arizona Department of Water Resources, local non-profits, US Geological Service or universities who participated in similar processes	**INVOLVEMENT** Government, e.g. Bureau of Reclamation Irrigation districts Businesses Municipalities Tribal Ag and other land holders Water right holders Environmental groups End users All water users—water is public resource in Arizona, but not everyone should have the same voice Convener of discussion - statewide organization, not local- such as irrigation district consortium
What resources and tools do you need?	Social media/traditional media Government, e.g. US Geological Service, Water Resource Development Commission Non-Governmental Organizations, e.g. Zoos, Audubon Money Academia: Extension, ASU or UA as convener/collaborator Initial stakeholder meeting at the regional level Visioning process to understand what's at stake Ecosystem services literature Attractions in rural Arizona	Determining how public values natural areas? Need to identify what values are, recreation Conduct polling then education Public=> Educate people about the watershed to build a case first because often there is a desire but a lack of knowledge	Continual dialogue Case studies on how maintain equity Understanding between users Settle differences Look at supply side and alternate water supplies Water use taxes to show true solutions and get money to do it Many different initiatives Funders, local NRCDs? Determine process for providing water to natural areas	Would need to quantify the conservation, if what you say is what you conserve Determine the need first, then determine if people want to pay for the need Security Incentive - driving force to cause us to have to come together, ex: Lake Mead driving up, most everything else would fall short Cooperation and collaborative ideas on a larger scale that can be used
What are the steps that you would need to take? Near-term? Long-term?	Establish community needs Education about how species can be a benefit	Need structure for polling and be geographically based Types of units and what resources Design process, create unique values and resources Key informants in regions? Steering committee- e.g. county planners, regional conservation groups, industry and large land owners and tribes, water rights holders, utilities Use polling Longer term- targeted education Why do this? No method currently to set priorities so need information that can be used to set priorities	Explore successful and unsuccessful case studies, look at Nevada and other Western states e.g. India Rainwater Harvesting, Middle East desalinization What about transferability? Look at whole system of governance Fostering environment where everyone is willing e.g. Oak Creek Watershed Council	Regional (localized) priority setting and cooperation

Appendix D. Glossary

Amphibians - A cold-blooded, smooth-skinned vertebrate of the class Amphibia, such as a frog or salamander that characteristically hatches as an aquatic larva with gills

Aquatic - Living or growing in, on, or near the water

Aquifer – A water-saturated zone underground where water is held in the pore spaces between permeable rock or unconsolidated materials (sand, silt, or clay).

Baseflow - The portion of stream flow entering the channel from a groundwater source

Biodiversity - The variability among living organisms from all sources

Biological - Of or relating to life or living things

Biomass - The amount (mass) of living biological organisms in a given area and time, this can be expressed as an average or total amount per unit area

Biota - The plant and animal life of a region

Case study – An exploratory analysis of an event, group, or program in order to identify causation or principles leading to success

Community - A group of interacting organisms that share a common environment

Discharge - Volume rate of water flow

Ecological flow requirements - A term used in the South African national law, which discusses allocating water for basic human flow requirements and ecological flow requirements first, and then allows water to be used for other purpose

Ecology - The science of observing relationships between organisms and their environment

Ecosystem - An interacting community of living organisms and nonliving physical components of an environment

Environmental flows - The amount of water needed in a watercourse to sustain a healthy ecosystem

Environmental flows and levels - Language used to describe the water needs of natural areas in flowing streams and in groundwater levels

Environmental water demand - A phrase created by the WRRC to describe water for natural areas in the same way human uses are described, e.g., municipal demand, industrial demand, agricultural demand

Evapotranspiration - The sum of evaporation and plant transpiration from the Earth's land surface to atmosphere

Facilitator – A person who unobtrusively aids a group in identifying commonalities and formulating a plan to achieve them

Fauna - All of the animal life of any particular region

Floodplain - Flat or nearly flat land adjacent to a waterway that has been built up by historical flood events through mud and rock deposits and is subject to flooding

Flow rate - The speed at which water in a river is traveling down the river (often reported in feet/second)

Flow regime - Encompasses the following characteristics of stream flow and their interactions: magnitude, timing, frequency, duration, and rate of change

Fluvial - Processes associated with rivers and streams and the deposits and landforms created by them

Focus group – An assembly of individuals representing the interests of their respective organizations in a form of qualitative research where participants are asked to share their options on a specific topic

Gauge - Records flow in a stream or river

Geographic - Of or relating to the science of studying the earth and its physical characteristics

Geomorphic - Relating to earth forms

Geomorphology - The study of present-day landforms and their relationships to underlying structures (this includes their classification, nature, origin, development, etc.)

Groundwater - Water beneath the earth's surface, often between saturated soil and rock, that supplies wells, springs, and some streams

Herbaceous - A plant that does not have a permanent woody stem (i.e. a flowering plant or an herb)

Hydraulic - Of or relating to the properties of water in motion, or flow

Hydrograph - Graph showing changes in the discharge of a river over a period of time

Hydrologic - The properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere

Instream flows - The water flowing in a stream

Irrigation - Supplying dry land with water by means of ditches and streams

Macroinvertebrate - An invertebrate that is large enough to be seen without the use of a microscope

Non-fluvial - Processes not associated with rivers and streams, such as landslides, debris flows, etc.

Phreatophyte - A deep-rooted plant that obtains a significant portion of the water that it needs from the phreatic zone (zone of saturation)

Population – A group of organisms that both belong to the same species and live in the same geographical area

Qualitative - A description or distinction based on a quality or characteristic rather than quantity or measured value

Quantitative - A description of distinction based on quantities or measured values rather than a characteristic

Remote sensing - The science of identifying, observing, and measuring an object without coming into direct contact with it; often using satellites

Reptiles - Animals characterized by breathing air, laying shelled eggs, and having skin covered in scales

Riffles - Fast-moving, higher-gradient, shallower water over coarse sand/gravel/cobble substrate

Riparian - Of or relating to or located on the banks of a river or stream

River reach - A river or stream segment of a specific length

River segment - A portion of a river that lies between two established points

Roundtable –A structured meeting where participants exchange ideas and discuss a proposed topic through facilitated discussions

Sedimentation - The tendency for solid particles in a liquid to settle out of the fluid and come to rest against a barrier

Spatial - Pertaining to space (i.e., global, state, regional, etc.)

Species - A group of organisms that share similar traits and are capable of interbreeding and producing fertile offspring; the basic category of biological classification

Stakeholder – A person, group, or organization with an interest in the direction or outcome of a project or proposed action

Stream flow - The volume of water moving down the river over a given time period (often reported in cubic feet/second)

Steering Committee – A group of individuals, typically high-level stakeholders, who advise the priorities and direction of an organization by providing professional expertise on proposed objectives and operations

Subwatershed or Subbasin - Extent of land where water from rain and melting snow or ice drains downhill into a body of water, such as a river or lake; smaller unit of a watershed

Surface water - Surface water is water collecting on the ground or in a stream, river, lake, wetland, or ocean

Survey – a series of questions posed to stakeholders to learn their opinion about a topic

Taxa - Plural form of taxon; a population or group of populations that are phylogenetically related and have common characteristics that differentiate them from other such groups (i.e. the kingdom, phylum, class, order, family, genus, or species)

Taxonomic group - A group of populations that are phylogenetically related and have common characteristics that differentiate them from other such groups (i.e. the kingdom, phylum, class, order, family, genus, or species)

Temporal – Pertaining to time

Terrestrial – Of or relating to the earth; inhabiting the land as opposed to the sea or air

Unregulated - An unregulated river flows according to gravity from its source to the mouth and is not interrupted by dams or hydroelectric power

Water dependent natural resources - A phrase created by Arizona's WRDC Environmental Working Group to describe water for natural areas

Water for natural areas - Water for animals and plants that live near and in rivers and streams

Water needs of riparian and aquatic ecosystems - How much water is required to keep the animals and plants that live in and near streams healthy over time.

Water table - The upper limit of the saturated zone within an aquifer

Watershed or River basin or Stream network - The area of land where all of the water that is under it or drains off of it goes into the same place

Workshop – Structured meetings where participants exchange ideas, provide feedback, and develop recommendations and/or action items on a proposed topic through facilitated discussions