White Paper: Calculating and Considering Environmental Water Demand for Arizona

Kelly Mott Lacroix and Brittany Choate Xiu*
Water Resources Research Center
College of Agriculture and Life Sciences, University of Arizona

This paper is intended to provide a succinct background on how environmental demands are determined through science and policy in Arizona and beyond, as well as stimulate discussion on why a community might consider environmental demands in their water management and planning. It will eventually become part of the introduction to a roadmap, or toolbox, for considering the environment in Arizona water management and planning. The goals of the roadmap are to articulate common water management objectives, explore strategies to meet those objectives, and produce a document that describes "avenues" of opportunity for considering the environment in water decision making. Roadmap "avenues" will be designed in a way that allows communities to pursue and refine them at the local level to meet the needs and reflect the priorities of water users like you. We welcome your thoughts, concerns, questions and additions to this document and the larger roadmap building process.

In the southwestern United States, as with many other arid and semi-arid lands, there is a dichotomy in the way we think about natural resources. On one hand we take great pride in the natural beauty of our landscapes, and on the other we need to use those landscapes to continue our economic prosperity. Nowhere is this dichotomy more pronounced than in the demands we place on the ribbons of green that snake through our arid landscapes. Water from the environment supports our crops, powers our cities, quenches our thirst and allows us to tap other natural resources like copper. Yet increasingly we also want that water to stay in the environment for outdoor activities in and around streams and for the sake of the biota that depend upon those streams.

While economic engines drive quantification and planning for the water futures of cities, farming and the like, few have pursued the question of what it would take to maintain water in Arizona's environment. The challenge is twofold: how to increase our understanding of how much water the environment "needs" and how to determine how the people who interact with this environment want to provide for those needs. In order to inform discussion on water for the environment, this white paper provides basic background information on *what* are environmental demands, *how* are those demands determined in science and in policy, and *what* do we know about the science and policy for environmental water demand in Arizona. Based on this background, and in order to stimulate discussion on water for the environment, the second half of this white paper includes a discussion of *why* might a community consider environmental demands in their management and planning and *how* might a community prioritize environmental demands.

*Prepared with assistance from Joanna Nadeau

What is Environmental Water Demand?

Water in the environment can be examined in numerous ways. The simplest is through stream gage 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 the environment uses or needs. Estimates of current flow supporting the environment (current quantified flow) use data on baseflow and groundwater underflow for the river together with evapotranspiration (water use) by the vegetation and soils adjacent to the river. This estimate provides information on how much water the environment is currently using (ET) and has (baseflow) but still does not give us a sense for how much water the environment might *need*.

Defining Water in the Environment

Stream Flow
The amount of water in streams

Current Quantified Flow
Flow that currently supports the environment, including:

- Annual baseflow
- Groundwater underflow
- Riparian extent
- Average annual evapotranspiration

Environmental Demand
The amount of water needed in a watercourse to sustain a healthy ecosystem as defined by the water-using community and contains five elements of flow:

- Magnitude (how much
- Frequency (how often)
- Duration (how long)
- Timing (how predictable)
- Rate of Change (how variable)

Environmental water demand defined at its simplest is the amount of water needed in a watercourse to sustain a healthy ecosystem. Behind this simple definition are two considerations: 1) riparian and aquatic ecosystems 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 environment. Dynamic flows for the environment are commonly described according to the natural flow regime, which contains five elements of water flow: magnitude (how much), duration (how long), frequency (how often), timing (how predictable) and rate of change (how variable) (*see Figure 1*). Each of these five elements can be determined for individual species' needs as well as the entire ecosystems. Determining environmental demand, however, 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. In other words,

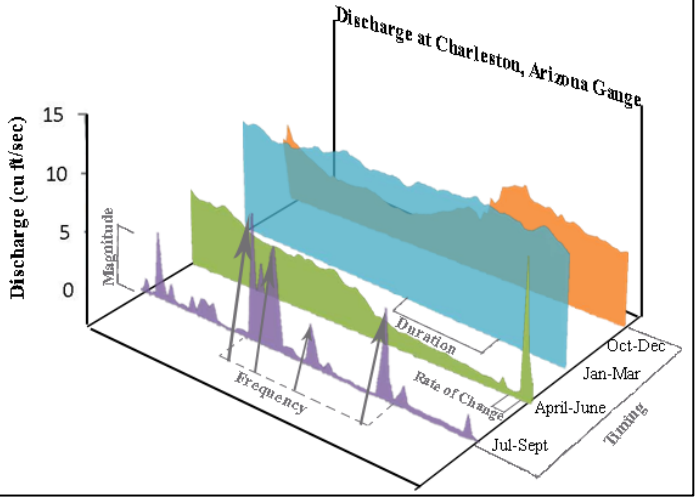


Figure 1: The five elements of Environmental Demand Occurring in Seasonal Hydrographs. *Source: WRRC 2011, data from USGS gage at Charleston, Arizona*.

defining environmental demand is a "social process with a scientific eco-hydrological core" (International WaterCentre, 2010).

How Do We Determine Environmental Water Demand?

Understanding how we determine environmental water demand takes three forms: 1) the science of identifying environmental flow needs and flow responses; 2) the process for prioritizing water for the environment; and 3) policy and management tools for considering environmental demand based on a community's priorities.

Research about environmental flow needs and responses can be done in different ways. Methods that use both biological and hydrological data can be distinguished from those that use only hydrological data as a substitute for data on biological needs. Methods can be distinguished according to the hydrological components they studied, as well as the method's ability to provide quantitative results. Sometimes researchers rely on historical flow patterns of a river to define its flow needs; other times they use present day observations to identify relationships between ecological components and aspects of the flow regime. 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 being made in each method and how they can affect flow assessments (Jowett, 1997).

What is it? Environmental Flow Need or Environmental Flow Response?

In understanding water for the environment a number of different terms are used, environmental flow need and environmental flow response are the most common. An environmental flow need is how much water is needed by biota and environmental flow response is how biota responds to changing flows. In general the term used throughout this paper, environmental demand, is synonymous with environmental flow need except that as we define it, environmental demand also takes into account the priorities of the water-using community, while environmental flow need may or may not include this consideration.

Until the mid-1990s most determination of environmental flow needs focused on average streamflow. Since this time, management based the natural flow regime (Poff et al., 1997) has gradually become both more widely understood and 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).

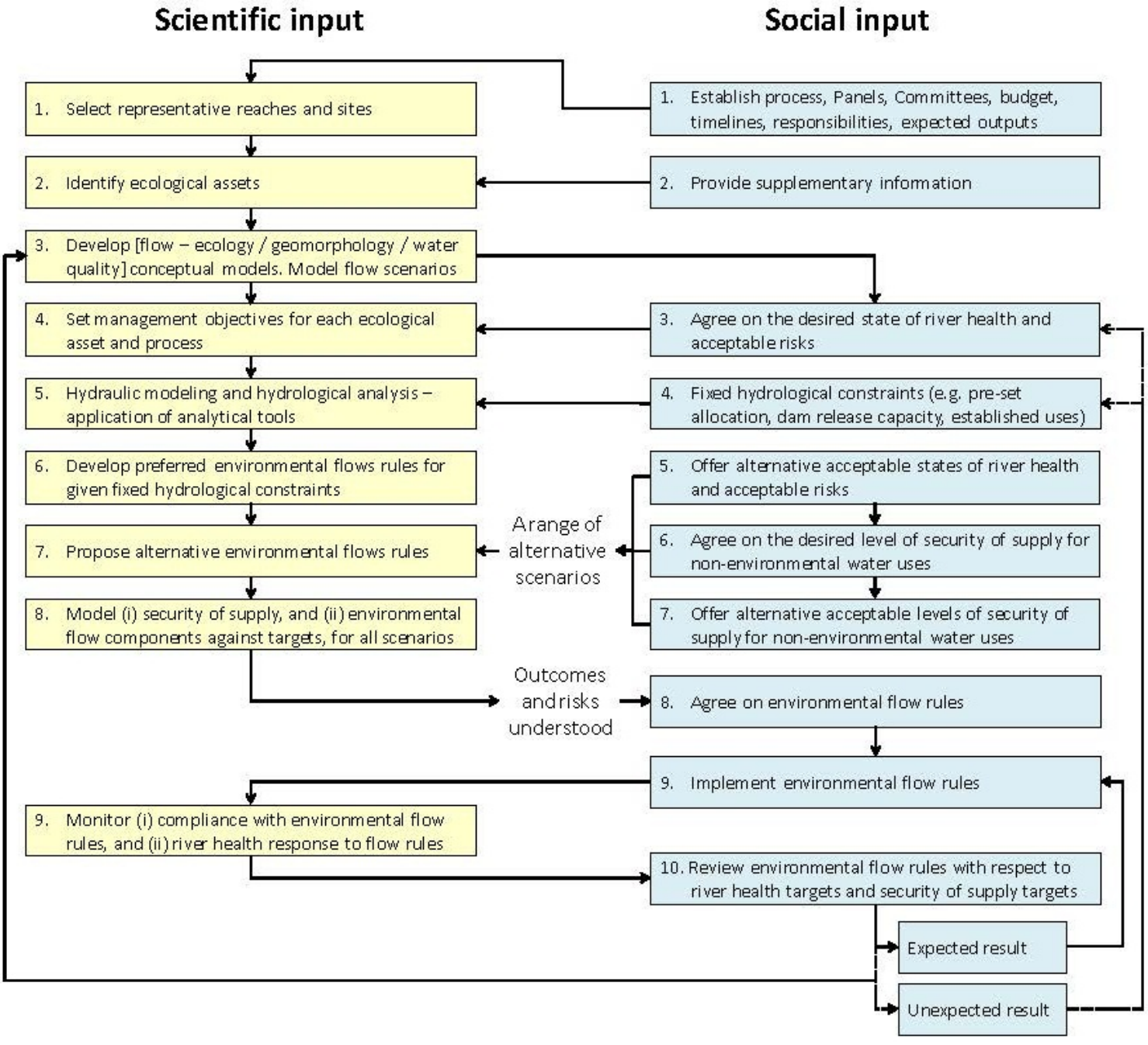
While the tools for management of river systems continue to evolve, the importance of adaptively managing these systems and the process for doing so is well established (Merritt et al., 2010; Richter et al., 2006; Arthington et al., 2010). Deciding which of the 200 some methods to use when determining environmental demand for water management is complex, but ultimately boils down to a few factors: time, money, available expertise and, perhaps most importantly, the priorities of the community trying to determine the flows. The identification of environmental demands requires stakeholders to make decisions about the future character and health of these ecosystems. Decisions about this will guide the choice of the method for determining the environmental demand and the tools used to connect environmental flow science to water policy. An example of a generic framework for determining both the physical flow requirements and the social priorities for flows is shown in Figure 2.

Although the mechanisms for incorporating environmental water demands into planning and management vary, there are other places where elements have contributed to advances in water management. These include education of the public and decision-makers on the value of environmental flows and increasing general awareness about river conditions (Dyson 2003, Katz 2006). Past experience suggests that the most successful attempts to incorporating water for the environment are those that begin simply and allow technical and managerial capacity to build with time (Lequesne, 2011). These efforts also follow an iterative and adaptive process. Similarly, any policy reform should not be thought of as a single event, but as a process with cycles of development, implementation, evaluation and review (MacKay and Roux, 2004; De Coning and Sherwell, 2004; De Coning, 2006). It is also critical to create sustainable financing mechanisms; in particular financial resources are necessary where re-allocation of water is required (Lequesne 2011). Financing is also important because it is critical for responding to increased scientific understanding and allowing for additional research and adaptive management (Arthington and Pusey 2003). Finally, successful efforts have ensured all relevant environmental, social and economic stakeholders are included in water allocation planning and decision-making on environmental water provisions (Arthington and Pusey, 2003).

Policy tools for incorporating environmental demands can be legal or statutory, voluntary or transaction based, part of planning processes or project planning and management. The most direct path toward considering water for the environment is to have recognition for the legitimacy of environmental flows in law. This can include legal recognition of beneficial use (Katz, 2006; Arthington and Pusey, 2003) and legislative provision of flows (Dyson and Scanlon, 2003). For example, Australian rivers and wetlands are now recognized as legitimate 'users' of water, and as a result, jurisdictions must provide water allocations to sustain and, where necessary, restore ecological processes and the biodiversity of water-dependent ecosystems (Arthington and Pusey, 2003). In the U.S., legal tools used to incorporate the environment into

water management and planning often only require new uses to consider the impact to water in the environment—as is the case with the instream flow legislation in both Michigan and Texas. The links between groundwater declines and ecosystem health mean that statutory restrictions on groundwater withdrawals can be an effective way of preserving instream flows; however, the majority of states with a groundwater law that could be used for this purpose find this is not the case (Annear, 2009).

Figure 2: Generic environmental flows assessment framework. Source: International WaterCentre, 2011.



Though legal and regulatory solutions have the potential to be very effective at incorporating the environment into water management, changes to existing laws can be difficult and may only occur when a crises arises. Voluntary approaches and market based mechanisms for increasing flows to the environment may provide an alternative. The success of these approaches, however, requires that priorities for environmental demands have been set, there is an understanding of and framework for navigating complex agency procedures and transfer rules, and willing sellers are engaged (Garrick et al., 2007). For example, some utility companies have made significant investments in improving river conditions. The Northwest Power Planning Council and Bonneville Power Administration have invested billions of dollars in habitat restoration and flow preservation on the Columbia River, and the Tennessee Valley Authority has spent more than $40 million modifying dams to increase flow and improve water quality (Poff 2003). In other parts of the country, groups have come up with strategic mechanisms to finance flows. Edwards Aquifer in Texas, for example, has developed a successful cap-and-trade program for water (Dyson and Scanlon, 2003).

What Do We Know About the Science and Policy for Environmental Water Demand in Arizona?

In 2010 the WRRC completed the Arizona Environmental Water Needs Assessment (AzEWNA). The AzEWNA reviewed over 90 studies completed in Arizona over the past 20 years to determine the state of the knowledge for environmental flow needs and flow responses. Each study was reviewed to 1) determine the species or ecosystem studied, 2) the environmental flow method used for the study, 3) biological element(s), e.g., abundance, age structure, or reproduction, studied, and 4) how the biologic elements depended

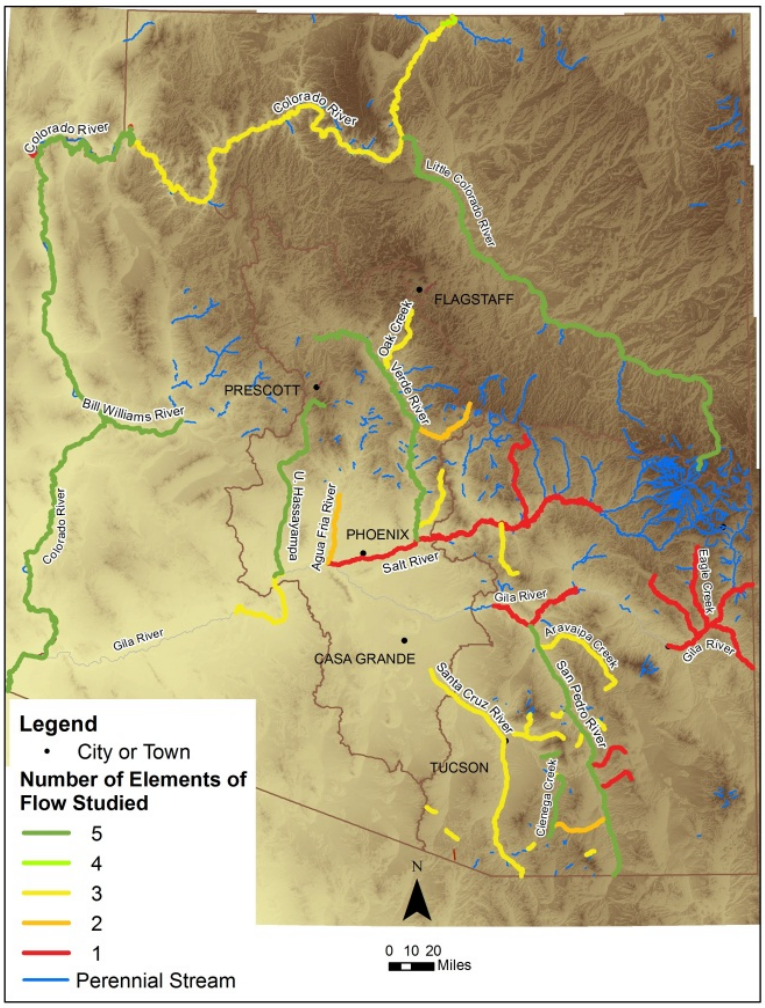
Table 1: Rivers Studied for Environmental Flow Needs and Flow Responses

River Name	Magnitude	Duration	Frequency	Timing of Flow	Rate of Change
	(% Studied)				
Agua Fria River	S *(22%)*	NS	NS	S *(22%)*	NS
Arivaca Creek	S	S	NS	NS	S
Aravaipa Creek	S	S	NS	NS	S
Babocomari River	S	NS	NS	S	NS
Bill Williams River	S	S	S	S	S
Bonita Creek	S	NS	NS	NS	NS
Cienega Creek	S	S (88%)	S	S (88%)	S (88%)
Cherry Creek	S	NS	NS	NS	NS
Colorado River	S	S	S (67%)	S	S
Eagle Creek	S	NS	NS	NS	NS
E. Verde River	S	NS	NS	S	NS
Gila River	S *(45%)*	NS	S *(10%)*	S *(23%)*	NS
Hassayampa River	S	S	S	S	S
Little Colorado River	S	S	S	S	S
Oak Creek	S	NS	S	S	NS
Pinto Creek	S	S	S	NS	NS
Rincon Creek	S	S (61%)	S	S (61%)	S
Sabino Creek	S	S	NS	NS	S
Salt River	S	NS	NS	NS	NS
San Francisco River	S	NS	NS	NS	NS
San Pedro River	S	S	S	S	S
Santa Cruz River	S	S	NS	NS	S
Sonoita Creek	S	NS	S	NS	S
Sycamore Creek	S	S	S	NS	NS
Tanque Verde Wash	S	NS	S	NS	S
Verde River	S	S	S	S	S

S = Reach (% of stream surveyed), S = Entire stream surveyed, NS = Not surveyed

= 5 elements studied (8 rivers)
= 4 elements studied (0 rivers)
= 3 elements studied (9 rivers)
= 2 elements studied (3 rivers)
= 1 element studied (6 rivers)

Figure 3: Location of Streams Studied for Environmental Flow Needs or Flow Responses



upon or were influenced by stream flow or groundwater. Of the studies reviewed, 27 provided information on quantified flow needs and 20 on quantified flow responses. An additional six studies quantified both flow needs and flow responses. Most looked at multiple species; studies on the flow needs and responses of riparian trees such as cottonwood, willow and tamarisk were most common. The remaining 39 studies reviewed provided either descriptions of flow needs and responses, e.g., increased flooding frequency caused greater abundance, or did not describe flow needs or responses at all, providing instead information on economic values or reports from monitoring efforts. The geography of where we know something about the science of environmental flow needs and responses in Arizona is in part driven by the legal, social, economic, and political landscape of the state, with some rivers receiving more studies then others because of available funding, community interest, or laws that apply to the river. Table 1 and Figure 3 provide a snapshot of the elements of flow that have been studied on Arizona streams and the location of these streams.

In addition to identifying areas with no data or with significant data gaps, the AzEWNA synthesis pointed to several implications for water management. Increasing depth to groundwater and diminished surface flows are major threats to freshwater ecosystems in Arizona. In particular, these threats have been shown repeatedly to influence species diversity, abundance, and reproductive success. Where studies have defined the flow needs of a stream, monitoring current flows can indicate whether prescribed needs are being met. For instance, when flows fall below prescribed limits managers have an indication that the system may be stressed. Only five studies in Arizona have defined flow volumes needed for a riparian (along the stream) or

aquatic (within the stream) ecosystem. Truly dynamic recommendations for minimum flows for each season, ranges of flow needs, frequency, rate of change, and size of flood flows are only available for one river in the state, the Bill Williams River. These recommendations were made by an expert panel and are designed to create the basis for adaptive management of the river; they reflect the "best guess" of the experts at the time, are intended to be dynamic, and may change over time as more is learned about ecosystem functionality.

The legal landscape of water in Arizona is complex. Surface water and groundwater are treated differently in the law and are only "connected" to one another in limited situations. As a western state, all surface waters are subject to the doctrine of prior appropriation whereby the first in time to put the water to a beneficial use holds the highest priority on their allocation. One "use" for water rights 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, that is, junior to all existing rights. This means that instream 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, making it more difficult to apply for permits. 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).

In contrast to surface water, groundwater rights 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 by groundwater pumping. Only groundwater withdrawals where the direct connection to surface water has been defined and large wells in the urban portions of the state are monitored. Small domestic wells in urban areas and all groundwater pumping in rural areas fall under weaker oversight, despite the potential of this pumping to have a significant cumulative impact.

With little direct legal protection or requirement of consideration for environmental water demands in Arizona law, water planning processes can offer opportunities to address the impacts of water management on the environment. Until recently, Arizona's state-level water planning efforts have not included the environment or, if they developed some environmental language, had no major effect. 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 this Group led to the creation of a comprehensive set of descriptive tables, narratives, and maps compiling available

environmental information for 51 of Arizona's groundwater basins. Limited available information prevented statewide environmental water demand quantification/estimates (with the exception of 12 groundwater basins), which left the WRDC unable to compare environmental demands with the forecasted demands of other water sectors. Instead, the Environment Working Group recommended that the ecological information they 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, the environment was not treated the same as other sectors in terms of demand quantifications and projected future scenarios, mostly because the information does not exist. However, in the body of the Water Supply and Demand Working Group's Report, an assessment of the Technical and Legal Issues associated with developing additional supplies includes the identification of potential environmental issues as well as showing where the connection between groundwater and surface water exist for each of the 51 groundwater basins. WRDC recommendations for considering the environment have not yet led to major reform, but information assembled by the Environment Working Group is being used in a handful of Arizona water management planning processes.

Despite past challenges and limited legal options, recognition of the environment 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 like 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 voluntarily contribute time and money to restoration and preservation projects. Ultimately, because of the variation around the state in both technical information, and varying interest for considering environmental flows, state-level policies may be challenging to implement. Thus local, voluntary efforts may have an advantage in addressing environmental needs under the prior appropriation system.

Why might a community consider environmental demands in their management and planning?

Embracing a voluntary program without the support of formal programs or strong legal backing is a challenge, but one that has already been met with varying degrees of success in some Arizona communities. Looking to these communities for why and when they decided to consider environmental water needs in their management

Drivers that Might Influence Consideration of the Environment in Water Management and Planning
• Climate variability • Prolonged drought • Protection for intermittent/ ephemeral streams • Population increase • Economic instability/reduced funding for state agencies • Legal mandates • Water supply augmentation

decisions could be instructive for communities just beginning to join the conversation of incorporating the environment into their water planning and management. Each Arizona community will have unique resources and regional characteristics that influence this process. Variations in the drivers and criteria leading up to the why and when, respectively, will vary, but exploring them may improve a region's understanding of when to enact new voluntary management strategies or how to apply changes that are inclusive of environmental demands. Explorations of proposed criteria and drivers are discussed in the following section. Determining what criteria and drivers exist in a region and where community priorities lay is central to engaging diverse stakeholders in productive discussions about considering environmental demands. Clearly defining these motivations can inform dialogue about voluntary options available to incorporate environmental demands within the context of limited water supplies and existing water rights.

Community decisions to consider the environment in planning efforts may be motivated by ongoing regional challenges, recent alterations to land use, or countless community-specific factors. The WRRC has identified potential drivers that may influence an Arizona community in their decision to consider the environment in regional water management. Rationales for why these potential drivers may lead a community to consider environmental water demands are outlined below. This list is not comprehensive, and additional drivers not identified by WRRC are probable and should be part of conversations about water for the environment. Furthermore, a driver that encourages one community to consider the environment may discourage another. Understanding that no single solution exists for incorporating environmental water demands into water management and planning is important for future discussions.

Climate variability—Climate variability (or climate change) can be defined as long term deviations from historically observed climate trends, e.g. fluctuations in temperature, precipitation or wind patterns (U.S. EPA, 2012). These atypical occurrences are influenced by human activity but largely remain out of human control. The breadth of challenges expected as a result of climate change will be felt by all Arizona residents including border communities, tribes, urban population centers and rural water users (Garfin et al., 2013). In the future, according to projections made by the Intergovernmental Panel on Climate Change (IPCC AR4), maximum and minimum temperatures will be higher in the Southwest, especially in the summer months (Dominguez et al., 2009). Precipitation is expected to be more intense and variable, however whether or not overall precipitation will decrease depends on the climate model used (Garfin et al., 2007). Although the likelihood of precipitation decreases, and when those decreases will occur varies depending on the climate model, the Southwest is one of the few places in the world where the models agree that streamflow will decrease (Milly et al.,

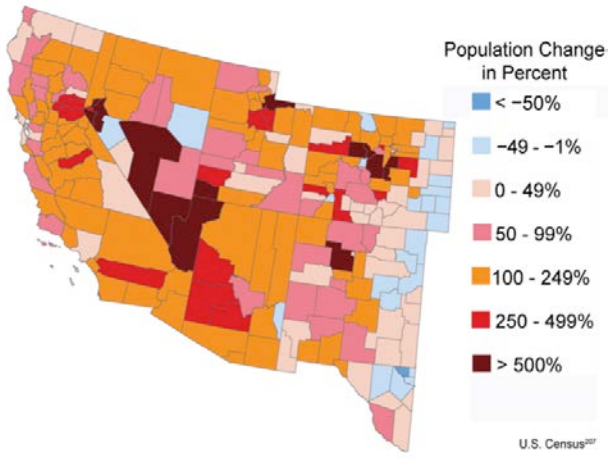
2008). These changes in flows could cause communities to consider alternative water management strategies that seek to include environmental demands in hopes of preserving local natural resources and their accompanying economic benefits in the face of an uncertain future.

Prolonged drought—Ninety-seven percent of Arizona is currently at a moderate or worse drought intensity (CLIMAS, 2013). Drought severity in the Southwest will likely increase in the future because of ongoing population growth and the persistence of global warming (U. S. Global Climate Change Program, 2009) This negatively impacts the state's already over-allocated water supplies and is expected to result in greater competition for available water supplies (Garfin et al., 2013). Such competition may cause communities to reconsider their current water management plans with the hope of identifying ways to balance the needs of regionally important resources. This may include provisions for the environment as many Arizona communities rely on natural resources such as rivers and lakes for recreation and tourism as well as to provide water for farming, ranching, or forestry.

Intermittent/ephemeral streams—Arizona has the highest percentage of intermittent or ephemeral waterways in the Southwest (94% of streams) (Levick et al., 2008). This leaves our non-perennial waterways responsible for the majority of Arizona's ecological diversity within riparian areas and human water withdrawals (Shaw, 2008). As a result, documented changes to intermittent and ephemeral waterways may inspire communities with available resources to adapt management strategies that preserve ecological integrity and the viability of regional water supplies.

Population increase—The Southwest is home to some of the fastest growing population centers in the country, exemplified by Arizona's population growth between 1970 and 2008 *(see Figure 4)*. Arizona's present population of more than 6.5 million is anticipated to exceed 10 million people by 2042 (U.S. Census Bureau, 2013; Arizona Dept. of Administration, 2012). This results "in a constant three-way tug-of-war" for resources between environment, human, and agricultural demands (Garfin et al., 2013). Balancing these demands may require communities to take a step back and reevaluate regional priorities—do they still represent past

Figure 4: Change in Population from 1970 to 2008 - Southwest. Source: U.S. Census Bureau, 2002



The map above of percentage changes in county population between 1970 and 2008 shows that the Southwest has experienced very rapid growth in recent decades (indicated in orange, red, and maroon).

concerns, are there new industries to consider, what changes need to be made to accommodate population growth? If any of these considerations involve the preservation of or continued use of local resources, a new or developed interest in addressing environmental demands may emerge.

Economic instability & reduced funding for state agencies—Economic instability or funding restrictions require communities to reevaluate available resources. This includes water management strategies and could provide an avenue for considering environmental water demands if doing so would benefit the region. For example, in areas where recreation or tourism is important, prioritizing water or the environment could help improve the local economy. The combination of slow economic recovery in many sectors and government funding on the decline (Governor's Office of Strategic Planning and Budgeting, 2012), with the increased use of state parks and local recreation (U.S. Fish and Wildlife Service, 2012), may lead communities to find that considering environmental water demands ensures a source of regional income in uncertain times.

Legal mandates that require consideration of water for the environment—At this time environmental demands are not considered as a part of Arizona's surface water law and groundwater law (Megdal et al., 2011). However, there are federal regulations such as the Endangered Species Act that can influence a community's decision to consider water for the environment in their water management and planning.

Water supply augmentation—Water supply augmentation may include importing supplies from other areas, new technology to stretch an existing water supply or additional supplies through agreements with other users, such as tribes. No matter the cause, increases or decreases to a region's water supply budget can spur changes to its water management. Deciding to prioritize environmental demands among new management practices such as desalinization, storm water catchment, or improved efficiency provides communities with an opportunity to explore ways to manage their water more effectively while planning to minimize harm to their natural resources.

How might a community prioritize environmental demands?

How a community defines priorities for providing water to the environment is tied to local conditions. Each community in Arizona has natural areas of local importance—be it for recreational, spiritual, economic, or some other reason. In order to determine environmental demand, the community must first define that demand through their priorities for water for the environment. One way to determine these priorities is though identifying where water for the environment is vulnerable, i.e., may decrease, or where there is a high likelihood of conflict

between human needs and environmental needs for water. Areas that are more vulnerable or have a higher potential for conflict could become a high priority for understanding and incorporating environmental water demands. The suggested list is not comprehensive, and additional criteria not identified by WRRC are probable and should be part of conversations about water for nature.

Potential Criteria for Determining Vulnerability of Water in the Environment
• Evidence of climatic changes • Growth near streams, springs and riparian areas • Transfer of water from agricultural to urban use • Policies/Regulations that Protect Environmental Flows • Extent of regional Dependency on Surface Water OR Groundwater • Understanding water demands of riparian and aquatic ecosystems • Regional water quality issues • Riparian and aquatic ecosystem health

Evidence of climatic changes—Changes in climate and the impact those changes will have on Arizona water supplies may be utilized as a criterion to prioritize water for the environment. This could be particularly true for areas with intermittent streams or other environments that may be disproportionally affected by changes in climate.

Growth near streams, springs, or riparian areas—Growth of municipal, industrial, or agricultural uses near riparian areas could potentially affect the quantity and quality of habitat as well as impact the 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, these resources may extend beyond water supplies to include preservation of aquatic and riparian habitat or recreational opportunities that utilize natural resources.

Transfers of water from agricultural to municipal use—Observing water demands shift from agricultural to municipal uses may lead a community to evaluate the need for including the environment in water management decisions. 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. This is because agricultural lands in Arizona 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.

Policies or regulations that protect environmental flows—In some cases the 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.

Extent of regional dependency on surface water or groundwater— 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.

Understanding water demands of riparian and aquatic ecosystems—Information gaps in our understanding of environmental water demands 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.

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.

Conclusion: What is the Next Step for Calculating and Considering Environmental Water Demand for Arizona?

Considering the environment in water planning and management in Arizona is not a new phenomenon—many communities have been thinking about these very issues for decades. What is new is perhaps a sense of urgency in examining when and how we incorporate environmental demand into water management. This stems from an increased knowledge of how much water the environment may need, and in many cases is not receiving, the benefit that a healthy environment provides us, and the growing certainty that there is a gap between water supplies and demands for existing uses. Creative solutions exist for these problems, but they are only discovered though open dialogue between the many users of water in Arizona. Through building a roadmap for consideration of environmental water demands in Arizona the WRRC hopes to work with water-users in Arizona to articulate common water management objectives, explore strategies to meet those objectives, and produce a document that describes

"avenues" of opportunity for considering the environment in water decision making. We welcome your thoughts, concerns, questions and additions to this document and the larger roadmap building process.

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