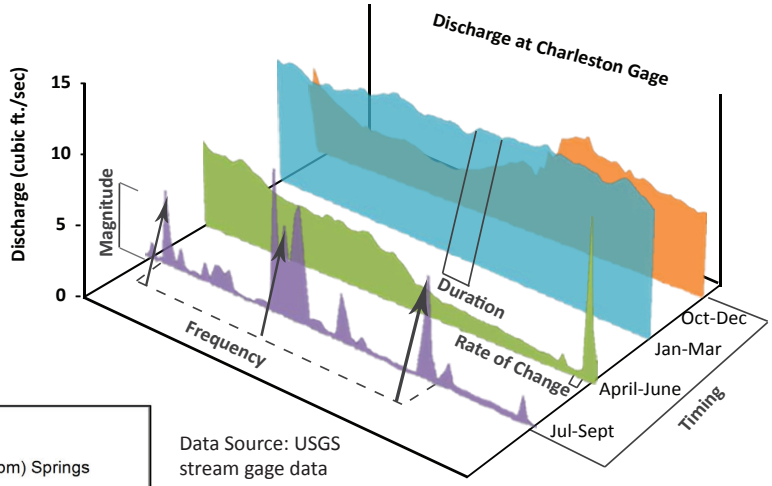
Water Resources Research Center
A University of Arizona Water Resources Research Center Project

Environmental Flows and Water Demands: Colorado River Region

Water is an increasingly scarce resource and is essential for Arizona's future. With Arizona's population growth and continued drought, citizens and water managers have been taking a closer look at water supplies in the state. Municipal, industrial, and agricultural water users are well-represented demand sectors, but water supplies and management to benefit the environment are not often considered. This bulletin explains the water demands of the environment in the Colorado River Region, an area including Big Sandy, Bill Williams, Gila Bend, Hualapai, Lake Havasu, Lake Mohave, Lower Gila, Parker, Sacramento and Yuma groundwater basins as well as nine other basins.

Figure 1. **Elements of Environmental Flow Occurring in a Seasonal Hydrograph**



Data Source: USGS stream gage data

This Colorado River Region bulletin also introduces information essential for considering environmental water demands in discussions about water management. Environmental water demands (or environmental flow) refers to how much water a freshwater ecosystem needs to sustain itself. Arizona's native animals and plants are dependent on dynamic flows, which are commonly described according to five elements: magnitude, duration, frequency, timing and rate of change. For example, seasonal flood events (e.g. timing) and constant flows (e.g. duration) cue important biological events, like reproduction. The five elements of environmental flows are displayed in Figure 1, a hydrograph of Southeastern Arizona's San Pedro River over the course of a year.

To consider the environment alongside other water sectors, we must first study the water demands of ecosystems. Figure 2 shows the streams where we have quantified the current amount of streamflow that supports the environment (white lines) and environmental water demands (black lines). This region contains streams that are perennial (those that flow year-round, dark blue lines) and intermittent (those that flow only part of the year, light blue lines) as well as riparian areas and many major springs.

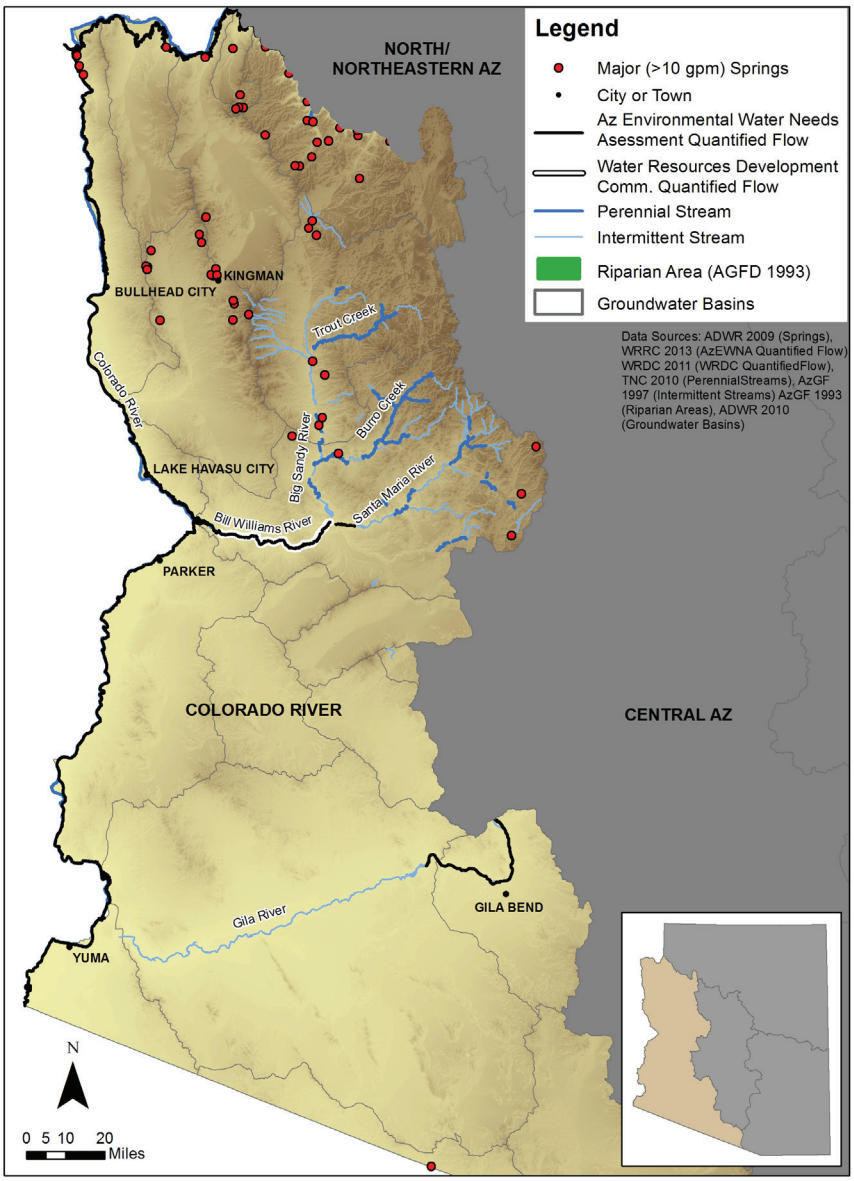


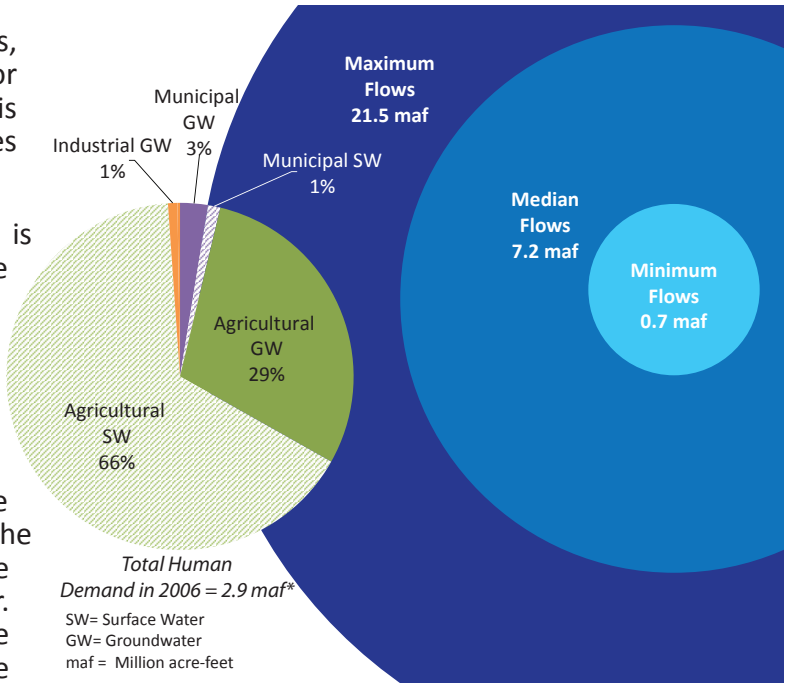
Figure 2. **Streams with Quantified Flows/Demands and Surface Water Resources in the Colorado River Region**

Updated July 2013

Humans have an interconnected and dependent relationship with the environment. Nature provides recreation opportunities, economic benefits, and water supplies to sustain our communities. For example, more than $1.7 billion in state revenue is generated from wildlife-based recreation activities (Southwick Associates Inc., 2003).

How water is used in the Colorado River Region is shown in Figure 3 by comparing the relative scale of human water demands by sector to existing minimum, median, and maximum flows available in the environment. The total size of the pie chart of human demands (at right) reflects the 2.9 million acre-feet annually withdrawn by all sectors (municipal, industrial, and agricultural) by source in the region. Median annual flows for the gaged rivers in the region are about 2.5 times of the amount used by all human demand sectors, while maximum flood flows are almost 7 times greater. Although human and environmental demands are not always mutually exclusive, some streams in the region no longer contain perennial flows because of water use by humans.

Figure 3: **Human Demand and Current Flow in the Colorado River Region**
(circle size indicates relative amount of water)

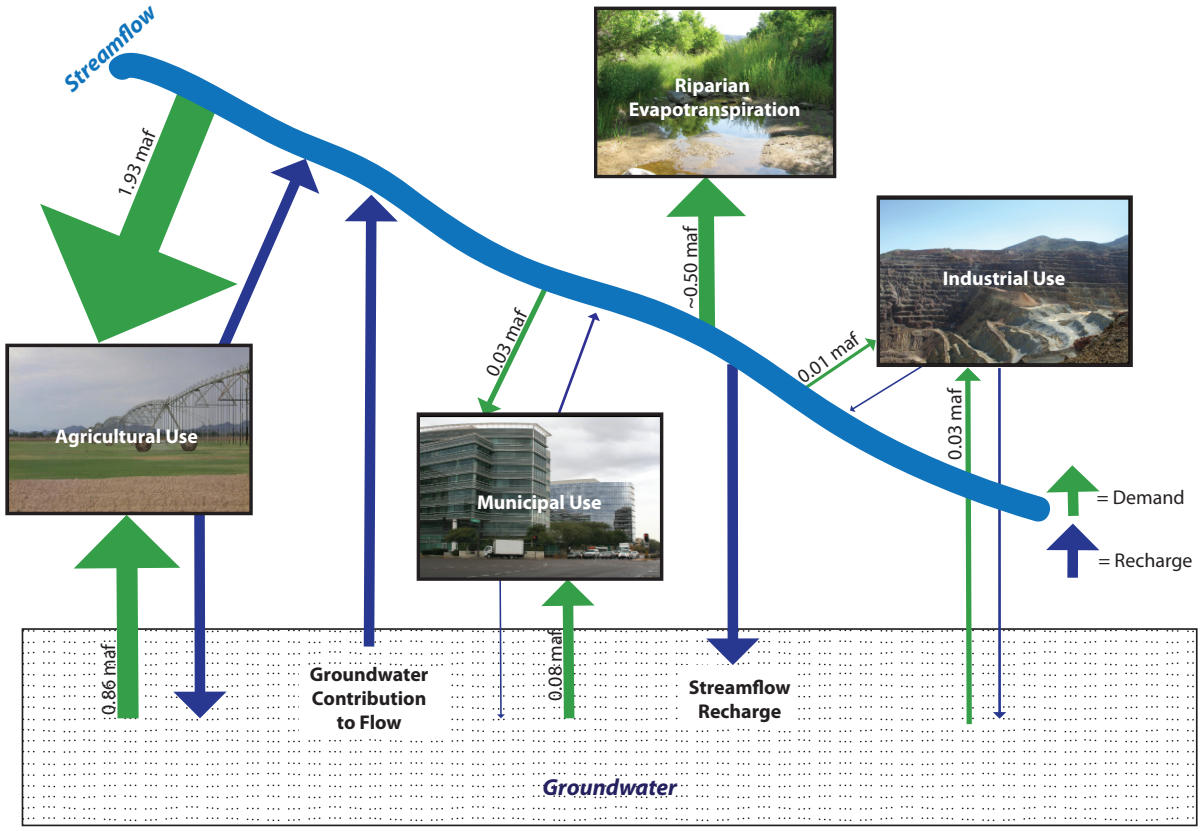


**In 2006 an additional 0.005 maf of effluent was also used to meet demand*

Data Sources: ADWR 2010 (streamflow as measured by stream flow gages), WRDC 2011 (human demand)

Figure 4 shows the Colorado River Region's median streamflow as a single "stream" and how it interacts with groundwater and human demands. Flows into the environment are represented by blue arrows, while outflows to human and environmental demands are marked by green arrows. Note that all human sectors return some water to the environment after use. Also, water traveling through a river to farming or domestic uses downstream can support aquatic and riparian (streamside) ecosystems along the way. These connections between environmental and human demands can create opportunities for water management that is mutually beneficial.

Figure 4: **Water Demand and Use in the Colorado River Region**
(arrows indicate relative size of demand and recharge)



Data Source: WRDC 2011

In the Colorado River Region slightly more stream reaches have intermittent flow (53%) than perennial flow (46%). However, only 6% of all intermittent stream reaches in this region have been studied, as compared with 69% of all perennial stream reaches (see Table 1a). As of July 2013, there are 24 known studies in this region that characterize some aspect of environmental water demands (17 quantitative and/or descriptive and seven containing other information). These studies provide information on the flow velocity, timing, and depth to groundwater needed to support native species. Eighteen of the 24 studies include the Bill Williams River. In this region there are 160 database entries that quantify flow needs or response to flow alteration for 17 species.

Table 1b categorizes available information for select streams in the region by the elements of flow that have been studied. Ten quantitative studies in this region examined multiple species' needs, six contained quantitative data on environmental flow demands and 10 provided information on ecological response to flow alteration. Most of the studies in the region focus on the demands of a few riparian species and do not address the flow demands and responses for the whole ecosystem. Two studies in this region, on the Bill Williams River, describe the flow volumes needed to maintain riparian ecosystem function (Hautzinger et al., 2006 and BWRC Technical Committee, 1994). Hautzinger et al. (2006) provides unified flow and baseflow prescriptions for the Bill Williams River, integrated from flow needs developed independently for aquatic, riparian bird and riparian non-bird species. As of 2013, this was the only known study in Arizona to provide flow prescriptions for a range of aquatic and riparian species in terms of all five components of flow: magnitude, duration, frequency, timing and rate of change.

Official designations by the state and/or federal government are made to protect stream reaches with high environmental values. These designations include Wild and Scenic Rivers, Instream Flow Permits and Applications, Arizona Department of Environmental Quality Unique Waters, Endangered Species Act Critical Habitat, and Federal Conservation Lands such as National Forest Wilderness or National Parks. A few stream reaches, such as on the Big Sandy River, have multiple designations (see Figure 3 for the number of designations on stream reaches in this region). Having many designations on one reach can be an indication of an area with significant environmental resources. Different designations provide different types of protections for environmental flows, but having three designations does not necessarily mean the reach is better protected than a reach with only one designation.

***Table 1a*: Data Coverage for Flow Demands in Colorado River Region Streams**

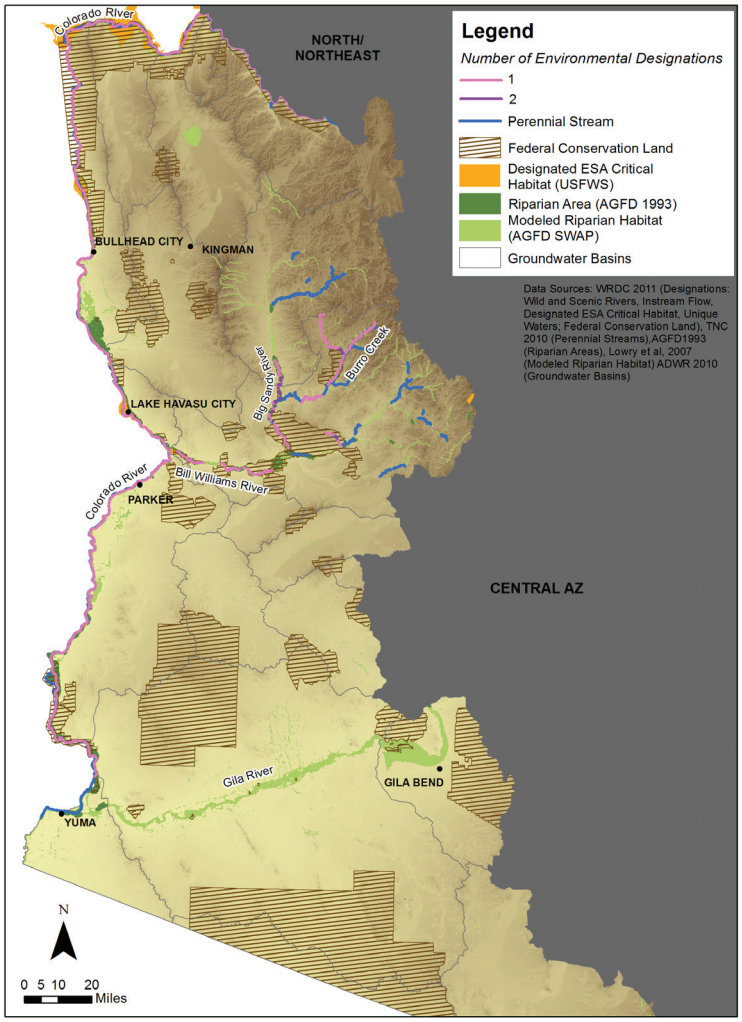
% Area Perennial/ Intermittent	% Total Studied	% Perennial Streams Studied	% Intermittent Streams Studied
(Miles)			
46%/53% *(700/810)*	35% *(530)*	69% *(480)*	6% *(50)*

***Table 1b*: Quantified Flow Components Studied and Information Gaps for Perennial Streams in the Colorado River Arizona Region**

River Name	Magnitude	Duration	Frequency	Timing of Flow	Rate of Change
	(% of the Stream Reach Studied)				
Bill Williams River	S	S	S	S	S
Colorado River	S	NS	S	S	NS
Gila River	S (30%)	NS	NS	NS	NS
Santa Maria River	S	NS	NS	S	NS

S= Entire stream surveyed, S= Reach (% of stream surveyed), NS= Not surveyed
Data Source: WRRC 2013

***Figure 3:* Environmental Resources and Designations in the Colorado River Region**



Colorado River at Imperial National Wildlife Refuge, Arizona
Photo Credit: Arizona Department of Water Resources

Statewide, ecosystem-level flow requirements remain poorly understood. Small scale studies that prescribe flows for a single reach exist for some areas, but cannot be applied across basins or regions. 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.

The Colorado River Region has a wealth of natural resources in its streams, springs, and riparian areas. Overall, water demands of the environment in this region are not well understood. Where known, various environmental flow demands, such as species-specific water demands, can be compared with current conditions to identify areas needing protection or restoration.

Information available in the region on the relationships between components of flow and biological factors can be used for considering potential impacts of future water decisions. These pages present a brief overview of the information available for the Colorado River Region; more detailed information to help inform planning efforts throughout this region is available by contacting the WRRC.

How Can This Information be Applied?

1. **Determine how environmental flows interact with other demand sectors**
2. **Identify factors putting environmental flows at risk**
3. **Identify studies needed to address key information gaps about environmental flows**
4. **Determine local priorities for ecosystems**
5. **Develop scenario analyses for water planning that incorporates the environment**

Next Steps: EnWaP Roadmap Development

The WRRC is developing Arizona's first ever roadmap for if and when environmental water demands should be considered in statewide water management and planning decisions. This process is being guided by a diverse Steering Committee with statewide representatives from agency, agricultural, environmental, industry, mining, municipal, tribal, and research interests. A series of statewide focus group meetings will begin in fall 2013 to learn how water using stakeholders value their water and where consideration for environmental demands may correspond with their interests. Contact us to participate in an upcoming focus group. This collective effort is designed to produce a roadmap document that describes "avenues" of opportunities for considering the environment in water decision making, which can be pursued and refined at the local level in ways that meet the needs and reflect the priorities of water users.

Contact Info

The **EnWaP Database** and electronic copies of the **Environmental Flows and Water Demands** bulletin series are available for download on the EnWaP project website:

wrrc.arizona.edu/Water-for-the-Environment

To participate in the **Roadmap development** process or an upcoming **focus group** contact:

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Phone: (520) 621-3826

WRRC offers public presentations about this information as well as direct support for water planning processes.

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