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Verde Watershed CURRENTS

VERDE WATERSHED ASSOCIATION

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NEW USGS REPORTS ON POTENTIAL EFFECTS OF GROUNDWATER PUMPING ON SURFACE WATER AND RIPARIAN EVAPOTRANSPIRATION IN THE VERDE VALLEY

Two new reports published last summer by the U.S. Geological Survey (USGS) in cooperation with The Nature Conservancy provide important insight for water managers and other citizens on the potential effects of groundwater pumping and artificial recharge on surface water and riparian vegetation in the Verde Valley. These reports represent the first application of the completed and soon-to-be-published Northern Arizona Regional Groundwater Flow Model (NARGFM; Pool and others, in press) to critical water-management concerns in the Verde River watershed.

Critical observations and implications of these two reports for water-resource management in the Verde Valley sub-basin are:

(1) The aquifer system, the Verde River, its perennial tributaries, and the shallow groundwater that supports riparian vegetation in the vicinity of these waterways are connected.

(2) Pumping of groundwater within the Verde Valley sub-basin eventually depletes the flow of the Verde River and its perennial tributaries as well as the supply of shallow groundwater that supports riparian vegetation. Conversely, artificial recharge to the aquifer can offset some of the depletion.

(3) The NARGFM enables generalized prediction of the timing and location of pumpage-caused depletion of surface-water flow and consumptive use (evapotranspiration) of groundwater by riparian vegetation. Conversely, it also enables generalized prediction of the timing and location of augmentation, via artificial recharge, of surface-water flow and evapotranspiration.

(4) Past and current pumping has not yet fully affected river flow and evapotranspiration.

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(Continued from page 1) **NEW USGS REPORTS**

The two new USGS reports are: (1) a detailed scientific report (Leake and Pool, 2010; http://pubs.usgs.gov/sir/2010/5147/); and (2) a summary fact sheet (Leake and Haney, 2010; http://pubs.usgs.gov/fs/2010/3108/) prepared by Stan Leake (USGS) and Jeanmarie Haney (The Nature Conservancy) and directed at a more general audience. The purpose of this article is to call attention to these new USGS reports and their implications for water-management decisions that affect the viability of the Verde Valley's water resources and invaluable riparian habitat.

The USGS technical report (Leake and Pool, 2010) describes the process whereby the source of water pumped from a well changes through time from groundwater stored in the aquifer around the well to streams, springs, and riparian zones that are naturally supplied from the aquifer. The increased role of surface water through time in supplying the well necessarily results in diminished surface-water flow (Figs. 1 and 2). In other words: 100 percent of the initial supply of pumped water comes from groundwater storage, and 0 percent comes from reduced surface-water flow and evapotranspiration. With continued pumping, the contribution from groundwater storage change eventually approaches zero as the contribution supplied from reduced surface-water flow and evapotranspiration approaches 100 percent. At all times between the two extremes, the percentages of water supplied from groundwater storage and from surface-water flow plus evapotranspiration totals 100 percent. The timing of progression to supply of pumping by reduced surface-water flow and evapotranspiration is highly variable. For wells pumping near streams, reduction of surface-water and evapotranspiration as a source of pumped water may occur within a few years. For wells that are many tens of miles from streams, significant reduction of surface-water and evapotranspiration may not occur for decades or even centuries.

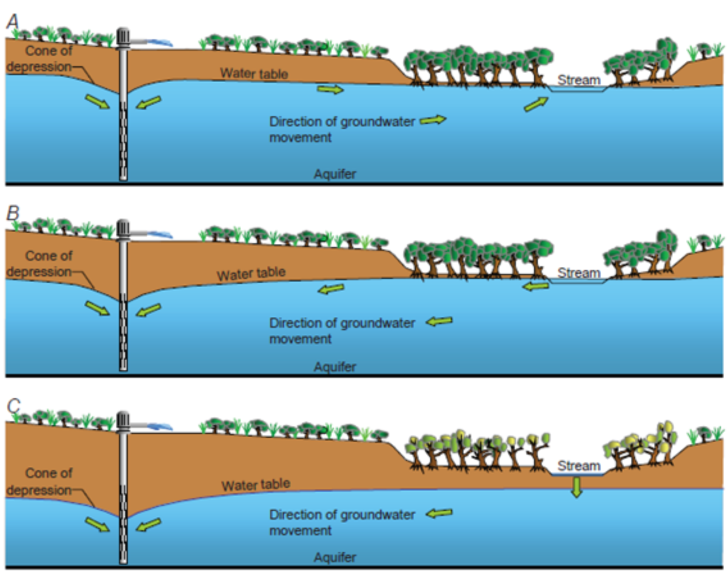

Figure 1. Stages of effects of pumping a well on a nearby stream. (A) A cone of depression has developed around the well, but groundwater still discharges to the steam. (B) After some time, the cone of depression has deepened and spread to the nearby stream, resulting in elimination of groundwater discharge to the stream and loss of water in the stream to the aquifer. (C) When the stream cannot supply the quantity of water pumped, the stream may eventually lose all of its water to the aquifer and become ephemeral and nearby riparian vegetation may also be affected. (Leake and Pool, 2010).

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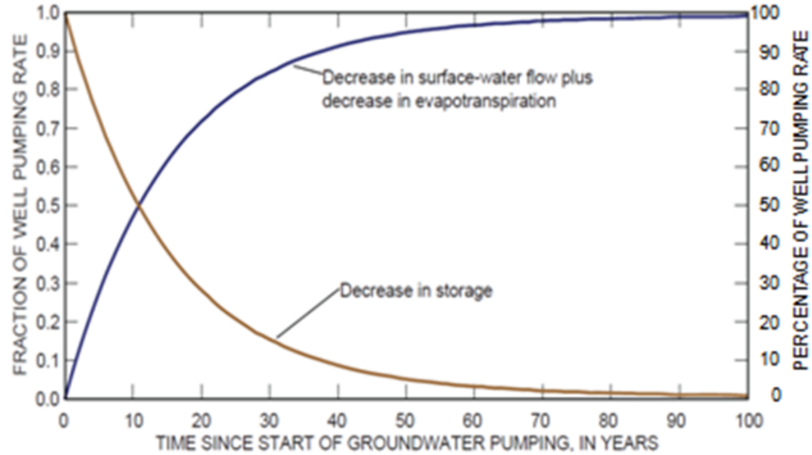

Figure 2. Sources of water to a pumped well through time (After Leake and Pool, 2010).

The NARGFM is ideally suited to support this kind of analysis. It synthesizes much of the important hydrologic and hydrogeologic information of northern Arizona into a powerful tool that can be used to evaluate water-resource issues. Although NARGFM simulates an area much larger than the Verde Valley, it was constructed as the best-available representation of the flow of water into, through, and out of the aquifer systems of the upper and middle Verde watersheds. That representation includes not only the amount of water that enters and exits the aquifers but also how the flow of water in the aquifer and the streams responds to stresses to the system such as withdrawals by wells. A technique developed by the USGS enables this use of the NARGFM to map the effects through time of groundwater pumping or artificial recharge on the flow of surface water as well as on riparian evapotranspiration in the Verde Valley.

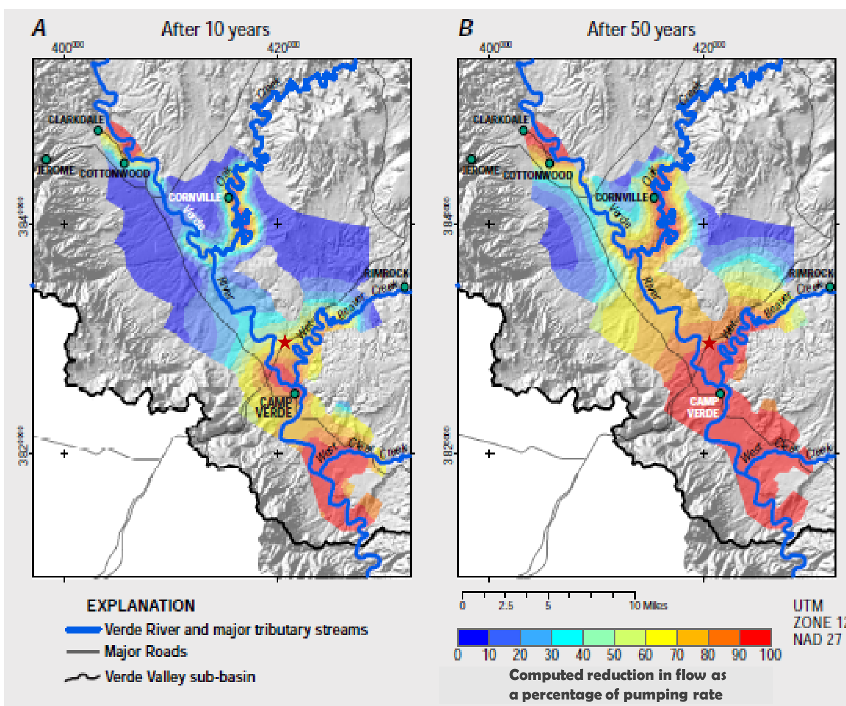

Figure 3. Computed reduction in stream flow and in connected riparian evapotranspiration as a percentage of pumping rate that would result from pumping groundwater from model layer 1 at a constant rate for 10 years (A) and 50 years (B). ★ , Location of hypothetical well discussed in text. (After Leake and Haney, 2010).

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(*Continued from page 3*) **NEW USGS REPORTS**

For example, pumpage of a single new hypothetical well (red star) located along Interstate 17 near exit 289, about 2.5 miles north of AZ 260, and pumped at a consistent annual rate from layer 1 would be estimated (Fig. 3) to reduce stream flow and evapotranspiration by between approximately 60 and 70 percent of the pumping rate after 10 years and by nearly 90 percent of the pumping rate after 50 years. To state it in an alternative way, after 10 years, an estimated 60 to 70 percent of the water being pumped from this hypothetical well would be supplied by capture of water from stream flow and riparian evapotranspiration; after 50 years, an estimated nearly 90 percent of the water being pumped from this hypothetical well would be supplied by capture of water from stream flow and riparian evapotranspiration. If the annual pumping rate of the hypothetical well was 10 acre-feet per year, the estimated reduction (Fig. 3) in stream flow and riparian evapotranspiration caused by this single well would be between 6 and 7 acre-feet per year after 10 years and close to 9 acre-feet per year after 50 years of pumping. Beyond 50 years, the rate of depletion of stream flow and evapotranspiration would continue to increase at an ever-slower rate, eventually approaching the value of 10 acre-feet per year of pumpage.

The colored area of figure 4 shows the area of layer 2, which consists largely of sand, gravel and volcanic rocks in the deeper part of the Verde Formation to the southwest and the saturated part of the sandstone and mudstone of the Supai Formation to the north and east. Note that layer 2 extends to the Mogollon Rim, far to the north and east of layer 1. Accordingly, the area of figure 4 is far larger than the area of figure 3. Layer1 overlies only the southwestern-most part of layer 2. Layer 2 ranges up to more than 4,000 feet in thickness, and its mean thickness is about 1,300 feet.

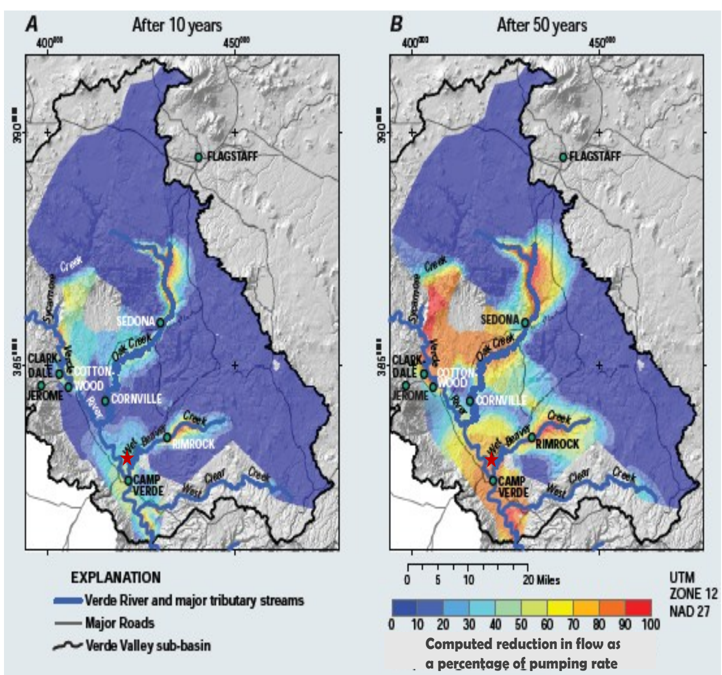

Figure 4. Computed reduction in stream flow and in connected riparian evapotranspiration as a percentage of pumping rate that would result from pumping groundwater from model layer 2 at a constant rate for 10 years (A) and 50 years (B). ★, Location of hypothetical well discussed in text. (After Leake and Haney, 2010).

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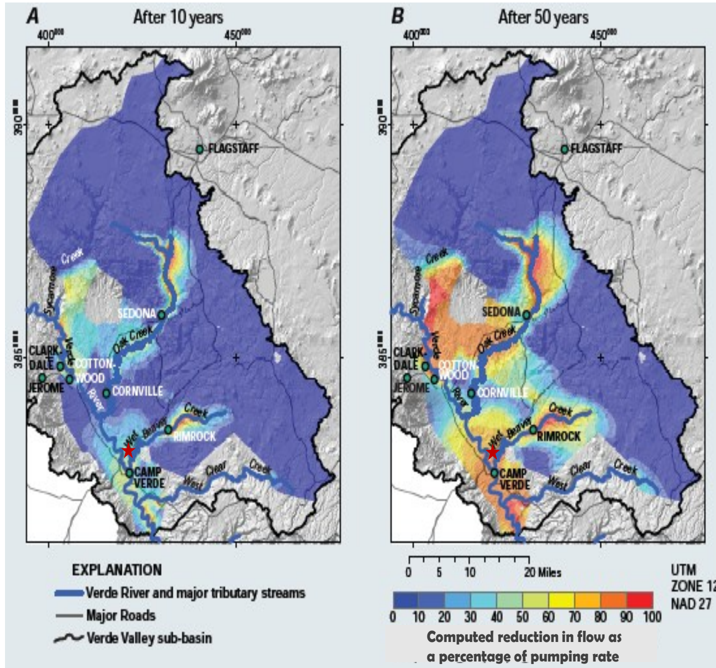

Figure 4. Computed reduction in stream flow and in connected riparian evapotranspiration as a percentage of pumping rate that would result from pumping groundwater from model layer 2 at a constant rate for 10 years (A) and 50 years (B). ★ , Location of hypothetical well discussed in text. (After Leake and Haney, 2010).

Pumpage of a single hypothetical new well (red star in figure 4) located along Interstate 17 near exit 289, at a consistent annual rate, in this example from only layer 2, would be estimated to reduce stream flow and riparian evapotranspiration by between approximately 40 and 50 percent of the pumping rate after 10 years and by between 70 and 80 percent of the pumping rate after 50 years. To state it in an alternative way, after 10 years, an estimated 40 to 50 percent of the water being pumped from this hypothetical well would be supplied by capture of water from stream flow and riparian evapotranspiration; after 50 years, an estimated 70 to 80 percent of the water being pumped from this hypothetical well would be supplied by capture of water from stream flow and riparian evapotranspiration. If the annual pumping rate of the hypothetical well, pumping from only layer 2, was 10 acre-feet per year, the estimated reduction in stream flow and riparian evapotranspiration caused by this single well would be between 4 and 5 acre-feet per year after 10 years and between to 7 and 8 acre-feet per year after 50 years of pumping. Beyond 50 years, the rate of depletion of stream flow and evapotranspiration would continue to increase at an ever-slower rate, eventually approaching the value of 10 acre-feet per year of pumpage.

Note that the postulated depletion of stream flow and evapotranspiration is proportional to the pumping rate whether the pumping rate is 10, or 1, or 0.5 acre-feet per year.

Layer 3 in the NARGFM represents the still deeper Redwall Limestone and Martin Formation—commonly referred to as the R aquifer—and the relatively impermeable basement rocks beneath them. The USGS reports did not evaluate the effects on stream flow and riparian evapotranspiration resulting from pumping groundwater from layer 3.

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(Continued from page 5) **NEW USGS REPORTS**

The rate of response of stream flow and riparian evapotranspiration to either pumping or artificial recharge at any locality depends upon both the distance of the pumping or artificial recharge from surface-water features and the local hydrologic properties of the aquifer. For example, Figure 3 shows that the Verde River is expected to respond much more rapidly to either pumping or artificial recharge that occurs within layer 1 near Camp Verde or Cottonwood than at comparable distances from the river in the reach due west of Cornville. Clearly, differences such as this reflect differing aquifer properties.

The aquifer system is doubtless more complex than portrayed in the NARGFM. Accordingly, Leake and Pool (2010) clearly state: "The results are intended to indicate general patterns over large areas. For site-specific projects, improved results may require detailed studies of local hydrologic conditions…" Further, the USGS reports do not evaluate effects of any existing wells on surface water in the Verde Valley. Nevertheless, the conclusions are unequivocal:
--The aquifer system and the Verde River and its perennial tributaries are connected and interactive.
--Extraction of groundwater by pumping in the Verde Valley sub-basin or, alternatively, augmentation of the groundwater by artificial recharge ultimately—and in some parts of the sub-basin on a time-scale of only a few years or a few decades—respectively, depletes or increases surface-water flow and riparian evapotranspiration.
--Much of the impact of recent and current groundwater pumping on stream flow—from the thousands of wells installed in the Verde Valley since the middle of the 20th century—has yet to materialize.
--There is no "free lunch". Pumping and consumption of groundwater in the Verde Valley sub-basin ultimately results in an equal depletion of Verde River flow plus riparian evapotranspiration.

References

Pool, D.R., Blasch, K.W., Callegary, J. and Graser, L, in press, Groundwater-flow model of the Redwall-Muav, Coconino, and Alluvial Basin aquifer systems of northern and central Arizona: U.S. Geological Survey Scientific Investigations Report 2010-5180.

Leake, S.A., and Pool, D.R., 2010, Simulated effects of groundwater pumping and artificial recharge on surface-water resources and riparian vegetation in the Verde Valley sub-basin, Central Arizona: USGS Scientific Investigations Report 2010-5147, 18 p.

Leake, S.A., and Haney, Jeanmarie, 2010, Possible effects of groundwater pumping on surface water in the Verde Valley: U.S. Geological Survey Fact Sheet 2010-3108.

Prepared by Ed Wolfe

Yavapai County Water Advisory Committee (WAC) Update

The Yavapai County Water Advisory Committee (WAC) is continuing with priority projects and embarking renewed strategic planning. The primary project focus is the Central Yavapai Highlands Water Resource Management Study (CYHWRMS) with the Arizona Department of Water Resources (ADWR) and U.S. Bureau of Reclamation. Additionally, the WAC is looking forward to evaluating and utilizing the USGS Northern Arizona Regional Groundwater Flow Model and the water-use scenario runs. Strategic planning will serve to evaluate the WAC's assumptions, objectives and tactics.

The CYHWRMS study team is now focusing on identifying and analyzing alternatives to meet unmet future water demands that were identified in earlier phases. The WAC website has information on the study in general and specific results of the early phases (http://www.co.yavapai.az.us/Content.aspx?id=20562)). We anticipate that the alternative development phase will continue throughout most of 2011. The alternative evaluation criteria include environmental, economic, legal and institutional analyses as well as Reclamation's four tests of viability (completeness, effectiveness, efficiency and acceptability). The Technical Working Group typically meets on the first Thursday of each month at 10:30 following the meeting of the Technical Committee of the WAC.

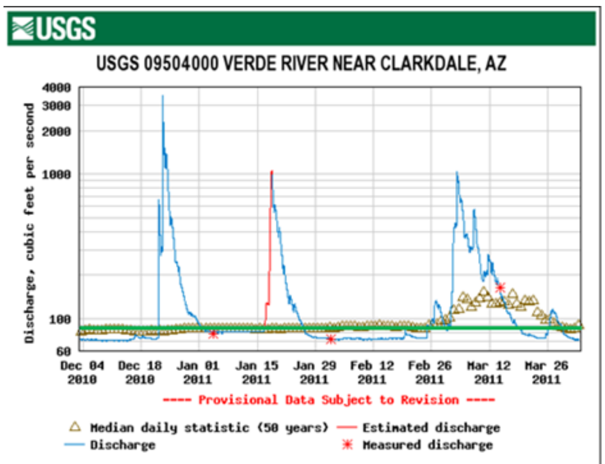
The Model Report for the current USGS Northern Arizona Regional Groundwater Flow Model is in the final publication process. The WAC has prepared a set of scenarios for the model that will investigate a range of groundwater pumping conditions in the Big Chino, Little Chino and Verde Valley areas. The results of these model runs should be available by spring 2011 and will be reported to the WAC upon completion. The WAC anticipates a focused effort to explore the model and results of the scenario runs in order to facilitate clear understanding of what the scenarios and studies are and are not. We also expect much discussion on the applicability of the model to water resource management.

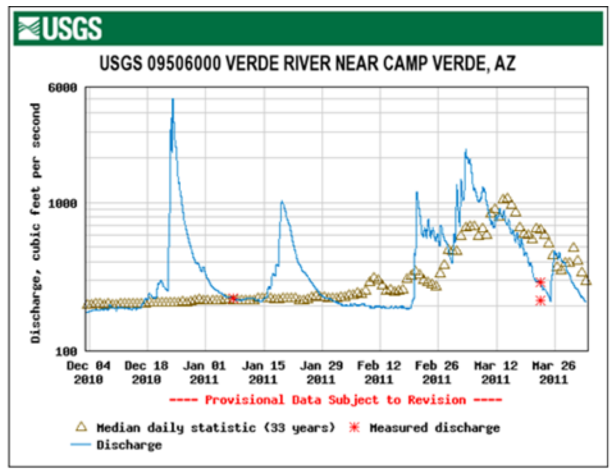
The WAC has begun to re-evaluate its written assessment of situational analysis, critical planning assumptions, key objectives and operational tactics. This evaluation will update an old WAC document and allow for WAC members to evaluate the assumptions and methods the organization has identified to fulfill its mission. Additionally, it will help bring newer WAC members "up to speed" on the WAC organization. The strategic planning effort is ultimately intended to provide a basis for evaluating the appropriateness of WAC projects and expenditures of funds and time. While at some level this will be an ongoing process, we expect the new planning document to be largely complete by summer 2011. The WAC welcomes input from other stakeholders and interested parties.

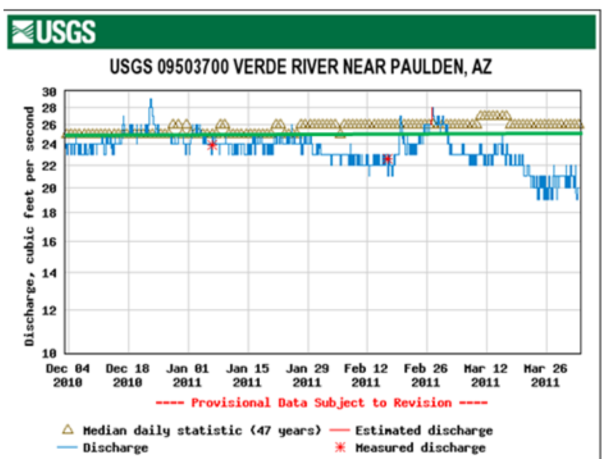
Please contact the WAC Coordinator, John Rasmussen, for meeting dates, details on any of the WAC activities or if you would like to be added to the WAC email-recipient list (john.rasmussen@co.yavapai.az.us or 928-442-5199).

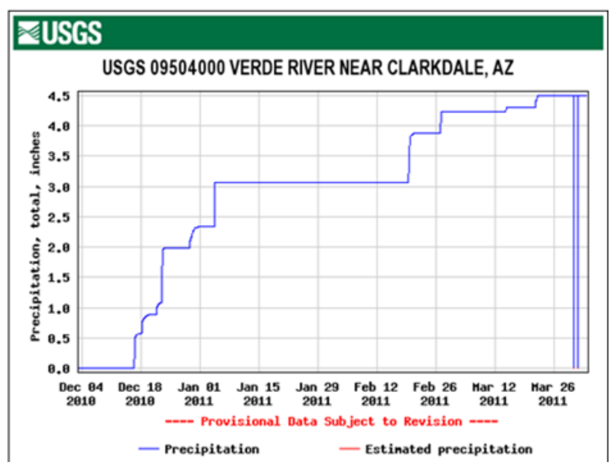
Prepared by John Rasmussen

VERDE RIVER DISCHARGE AND PRECIPITATION DECEMBER 2010 THROUGH MARCH 2011









Green bar in gage record for the Paulden and Clarkdale gages shows average winter base flow from Blasch, K.W., Hoffmann, J.P., Graser, L.F., Bryson, J.R., and Flint, A.L. 2006. Hydrogeology of the upper and middle Verde River watersheds, central Arizona: U.S.Geological Survey Scientific Investigations Report 2005-5198, 101 p., 3 plates.

Average winter base flow, Paulden gage = 25.1 cfs (for years 1964-2003)
Average winter base flow, Clarkdale gage = 83.5 cfs (for years 1966-2003)
Average base flow at Camp Verde gage is not shown.

The patterns of precipitation recorded at the Paulden gage and the Clarkdale gage are essentially identical, although they differ slightly in the magnitudes of recorded precipitation. Thus, only the precipitation record at the Clarkdale gage is shown. No precipitation event correlates with the mid- to late-January peak in discharge recorded at the Clarkdale and Camp Verde gages, but essentially unrecognizable at the Paulden gage. Temperature records from Prescott and Payson (http://ag.arizona.edu/AZMET/az-data.htm) suggest that a week or so of slightly elevated temperature could have caused a high-country snow-melting event that produced the mid-January episode of elevated river discharge.

VERDE AND SALT RIVER RESERVOIRS AS OF MARCH 31, 2011

As of March 31, reservoirs in the Salt River system are 94 percent full; reservoirs in the Verde River system are 54 percent full. Total system reservoir storage as of March 31 is 89 percent; last year on this date total system reservoir storage was 98 percent.

Data from SRP Daily Water Report (http://www.srpwater.com/dwr/).

Membership Form for Verde Watershed Association

Government units	$100 per year	Make Checks Payable to:
Business for profit	$100 per year	**Verde Watershed Association**
Civic groups and non-profits	$50 per year	**P.O. Box 4001**
Individuals	$25 per year	**Cottonwood, AZ 86326**

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