



Middle Verde Water Resources Analysis

What? How? Why?

USGS-VRBP Sept 2010 – Feb 2012

photo by Kim Schonek

Verde River at Shield Ranch

USGS-VRBP Verde Valley Water-Resource Analysis

18-month study: September 2010 – February 2012

- Fulfills first report required under Title II of Public Law 109-110, The Northern Arizona Land Exchange, Title II And Verde River Basin Partnership Act Of 2005
- ***water-budget analysis of the portion of the Verde River Basin within the Verde Valley***
 - *inflow and outflow of surface water and groundwater*
 - *annual consumptive water use*
 - *changes in groundwater storage*
 - *analysis of potential long-term consequences of various water-use scenarios on groundwater levels and Verde River flows*

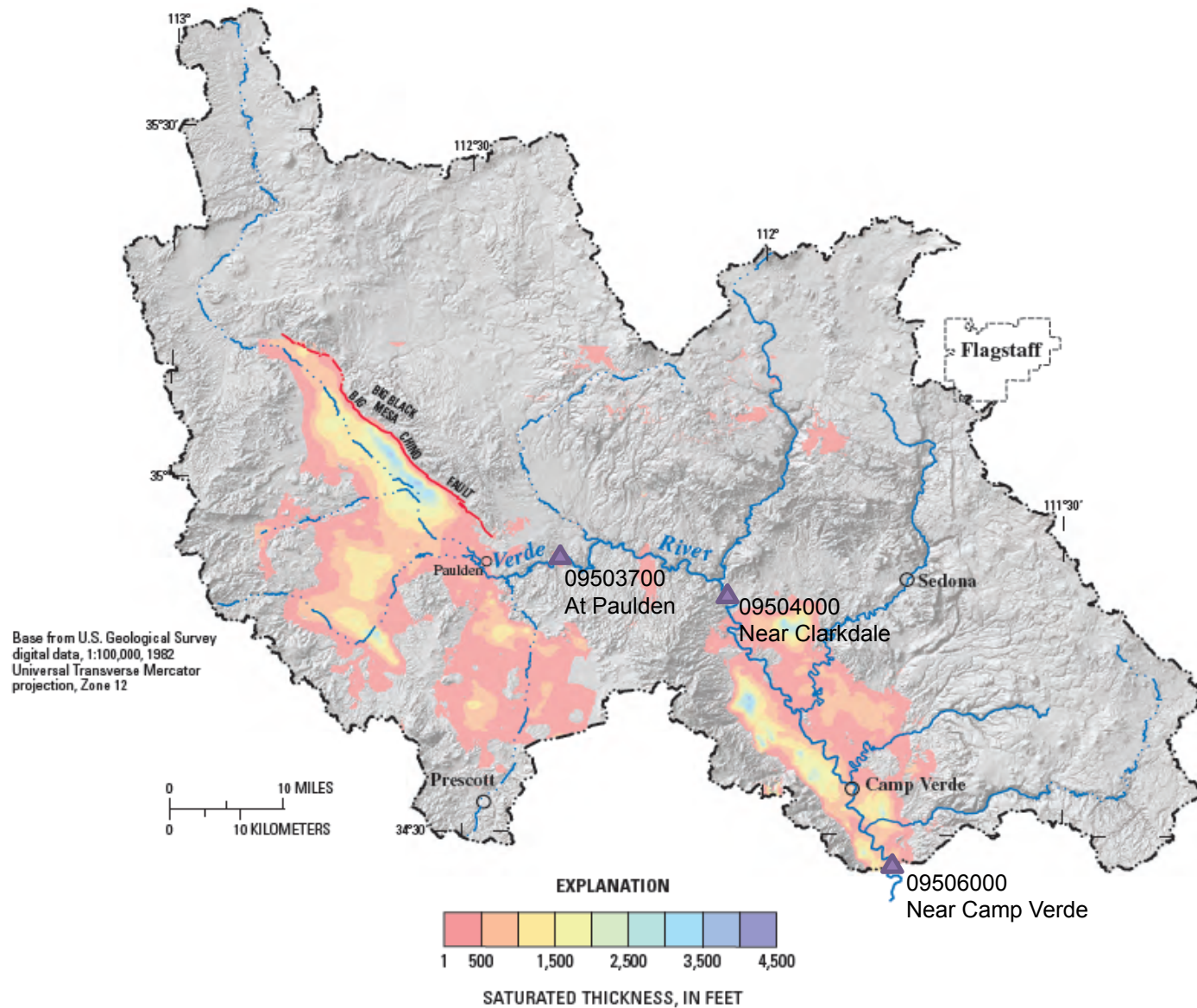


Figure 22. Thickness of saturated Cenozoic sediments and volcanic rocks, upper and middle Verde River watersheds, central Arizona. Thickness data from Langenheim and others, 2005.

Sources of Funding

- \$300,000 Project
 - \$250,000 from Walton Family Foundation
 - \$50,000 in-kind support from USGS
- WFF grant supports the USGS work
 - town of Clarkdale administers grant
 - receives funds from the foundation
 - pays the USGS
 - carries out grant accounting and verification



Tasks



- A. Compilation and interpretation of existing published information with specific focus on Verde Valley**
- B. Use of NARGFM* to provide specific water-budget information for Verde Valley**
- C. Use of NARGFM for evaluation of potential long-term consequences of water-use scenarios**
- D. Data collection to refine Verde Valley water budget**
- E. Reporting of results**

***USGS Northern Arizona Regional Groundwater Flow Model**

Northern Arizona Regional Groundwater Flow Model (NARGFM)

- **Developed by USGS with support of WAC**
- **Best available representation of flow of water through Aquifer systems of Northern Arizona**
- **Quantifies:**
 - ✓ **movement of water into, through, and from the aquifers (part of the water budget)**
 - ✓ **how the movement of groundwater into streams and rivers changes in response to stresses in the system such as withdrawal by wells**

Northern Arizona Regional Groundwater Flow Model



Application to Verde Valley water budget:

- ✓ Smaller geographic subset for determining Verde Valley water budget is readily extracted for this purpose
- ✓ Inflow and outflow of surface water and groundwater
- ✓ Changes in groundwater storage

Northern Arizona Regional Groundwater Flow Model

Application of NARGFM to estimate responses of aquifer system to groundwater pumping

Current project (USGS report released August 2010):

- ✓ Verde Valley maps by USGS in cooperation with The Nature Conservancy that plot the calculated fraction of captured surface water in the output of hypothetical wells after 10 and 50 years of pumping

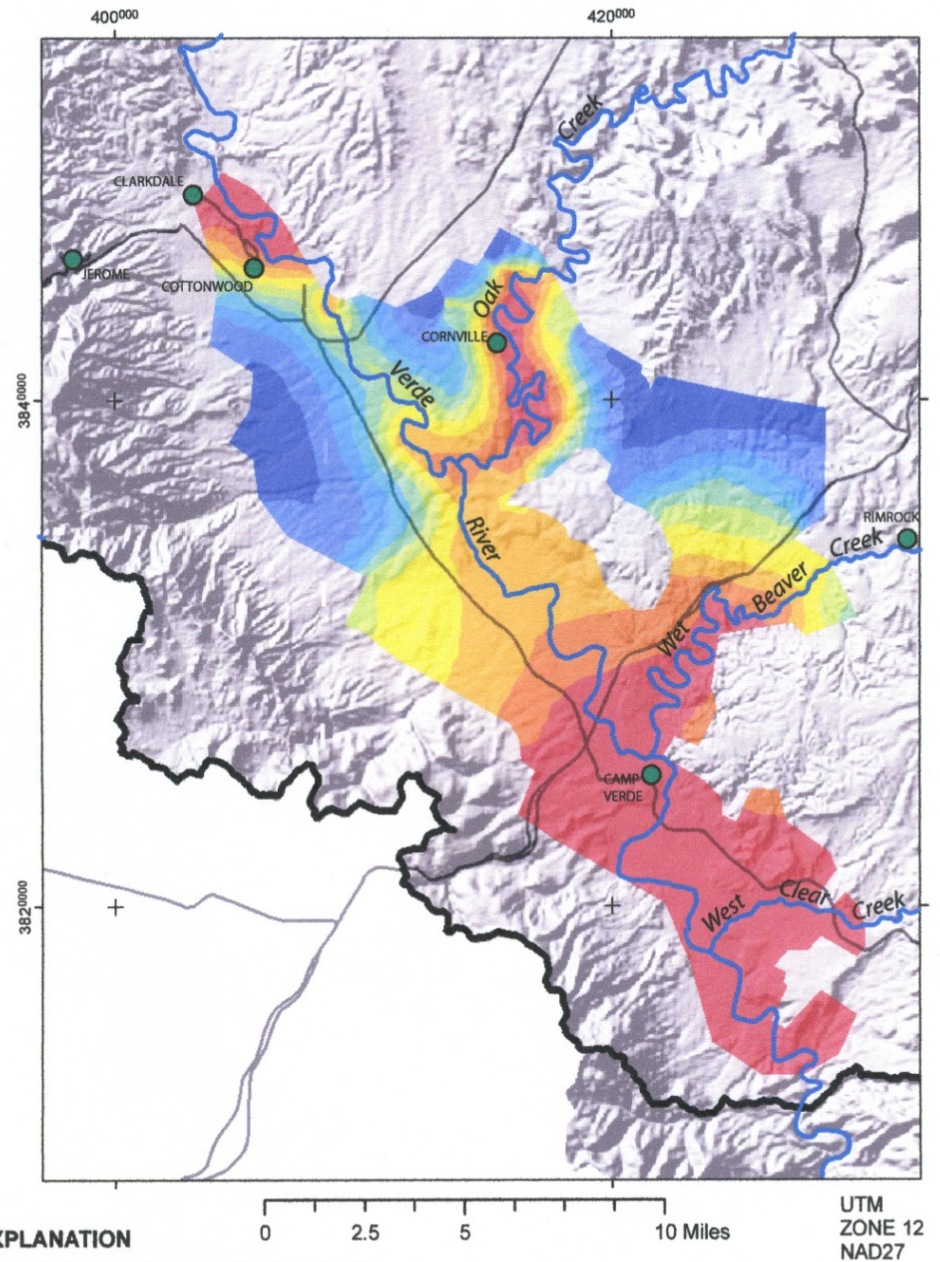
For USGS-VRBP Project:

- ✓ Time horizon of response maps will be extended to 100 years and maps will be included in report

Surface-Water Capture Middle Verde

Layer 1
50 Years

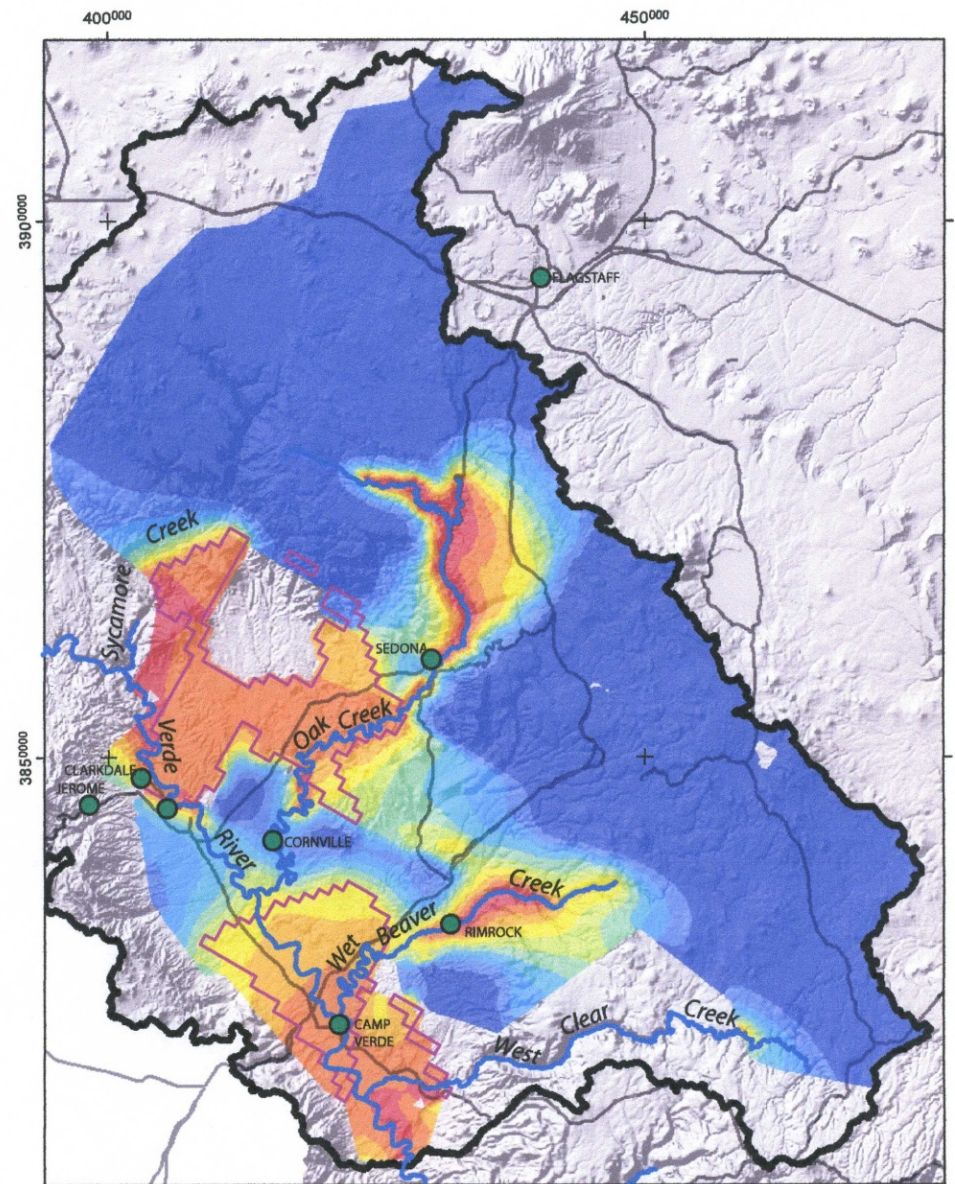
From Leake and Pool, 2010



Surface-Water Capture Middle Verde

Layer 2 50 Years

From Leake and Pool, 2010



EXPLANATION

- Verde River and major tributary streams
- Major Roads
- Verde Valley sub-basin
- Area where hydraulic conductivity along rows in layer 2 is greater than 5 feet per day

0 5 10 20 Miles UTM ZONE 12 NAD 27

Total reduced flow as a fraction of pumping rate at 50 years



Northern Arizona Regional Groundwater Flow Model

Application of NARGFM to evaluation of potential long-term consequences of water-use scenarios

Current project:

- ✓ analysis through 2050 by USGS for WAC of basin-wide system responses to three pumping scenarios provided by WAC

USGS-VRBP project:

- ✓ emphasis will be on middle Verde River watershed and long-term impacts on Verde Valley water resources
- ✓ Scenarios will be run for 100 years (to 2110) with 2050 pumping values held constant for remaining years

Northern Arizona Regional Groundwater Flow Model

Application of NARGFM to evaluation of potential long-term consequences of water-use scenarios

- Critical limiting factor for Verde Valley water resources is base flow passing the Paulden gage
- NARGFM allows estimation of Verde River base flow that may result from past and future pumping throughout both the upper and middle Verde watersheds

New Water-Budget Data

- **NAU quantification of Verde Valley irrigation diversions**
 - ✓ New quantifying data (supported by WAC) to be employed insofar as possible in refining Verde Valley water budget
- **Evapotranspiration by riparian vegetation and crops**
 - ✓ Analysis of MODIS spectral satellite data, 250-m resolution, uses established correlation of spectral data to ground measurement to estimate evapotranspiration
 - ✓ Good temporal resolution: satellite pass every 16 days
 - ✓ Verde valley MODIS data compiled for 2000 – 2007 and analysis partly done
 - ✓ USGS will update data sets and analysis, focusing in detail on evapotranspiration in Verde Valley

New Water-Budget Data

- **Evapotranspiration by riparian vegetation and crops (cont)**



- **Field verification and analysis of crops, on the ground, by USGS**
 - ✓ **Crop types, acreage, irrigation methods**
 - ✓ **Mapped into GIS database using high-res air photos**
 - ✓ **Consumptive use calculated considering latitude, average monthly temperature, total monthly precipitation, crop type, planting and harvesting dates**

New Water-Budget Data

Winter base-flow analysis (seepage run)

- ✓ Late fall 2010, Clarkdale gage to gage below Camp Verde (Chasm Cr.)
- ✓ Snapshot—locations and amounts of water entering and leaving stream along its length
- ✓ Includes both stream-aquifer interactions and ag diversions and returns
- ✓ Evapotranspiration and irrigation diversions are at a minimum
- ✓ Complements 2007 summer base-flow analysis of the same reach when evapotranspiration and irrigation diversions were at peak
- ✓ Will better constrain knowledge of inflows and outflows of surface water and groundwater along the river

Reports

Two reports are planned:

1. Technical report: methods, data, and conclusions

2. Report written for general audience

- Including stakeholders in VRBP and resource managers
- Emphasizes interpretation of conclusions + implications for strengths and limitations of Verde Valley water resources over the long term



Why does it matter?



Why does it matter?

Verde River may be threatened as never before

1. increased water demand
2. climate change (not considered in this study)



CYHWRMS* phase 1 conclusions

Population: 2006 vs 2050

- ✓ Full CYHWRMS study area (PRAMA, Big Chino sub-basin, middle Verde sub-basin):
 - **3x increase: approx. 200,000 to 600,000**
- ✓ Verde Valley:
 - **2.6x increase: approx. 70,000 to 180,000**

*Central Yavapai Highlands Water Resources Management Study
(BOR, WAC, and ADWR)

Why does it matter?



CYHWRMS phase 1 conclusions:

Unmet water demand in 2050

- Study area (PRAMA, Big Chino sub-basin, middle Verde sub-basin)
➤ **45,279 af/yr** (additional 62%)
- Big Chino and Williamson Valleys
➤ **3,148 af/yr** (omits exportation to PrAMA)
- Verde Valley
➤ **10,136 af/yr** (14 cfs; additional 30%)

Why does it matter?

Water demand in 2050

- **Big Chino sub-basin**

- **Population increase from 9,124 in 2006*
to 58,379 in 2050***

	<u>2006</u>	<u>2050</u>
➤ Non-ag pumpage (af/yr)	1,688*	8,997*
➤ Ag consumptive use	8,324*	0
➤ Exportation to PrAMA (af/yr)		<u>~18,000</u>
➤ Total (af/yr)	10,012*	26,997

Assumes
all Ag
retired

- **Increased groundwater demand 2006 to 2050 = 16,985 af/yr
(23.4 cfs/yr)**

* From CYHWRMS

Why does it matter?

- Groundwater in the upper and middle Verde River watersheds flows under the force of gravity, exiting at the Verde River
- Before development, groundwater exited the watershed only by
 - evapotranspiration and
 - exiting to the river and its tributaries
- Before development:
Discharge to et + discharge to river \approx natural recharge
- The groundwater exiting to the river is the base flow, which is the consistent low flow that makes the river perennial
- Removal of groundwater by pumping intercepts water that was en route to the river and eventually reduces the base flow
- Without its base flow, the river would be a dry wash that flows only in direct response to storms and snowmelt

Why does it matter?



**Summer base flow in the Upper Verde River:
~20 cfs (At Paulden Gage)**

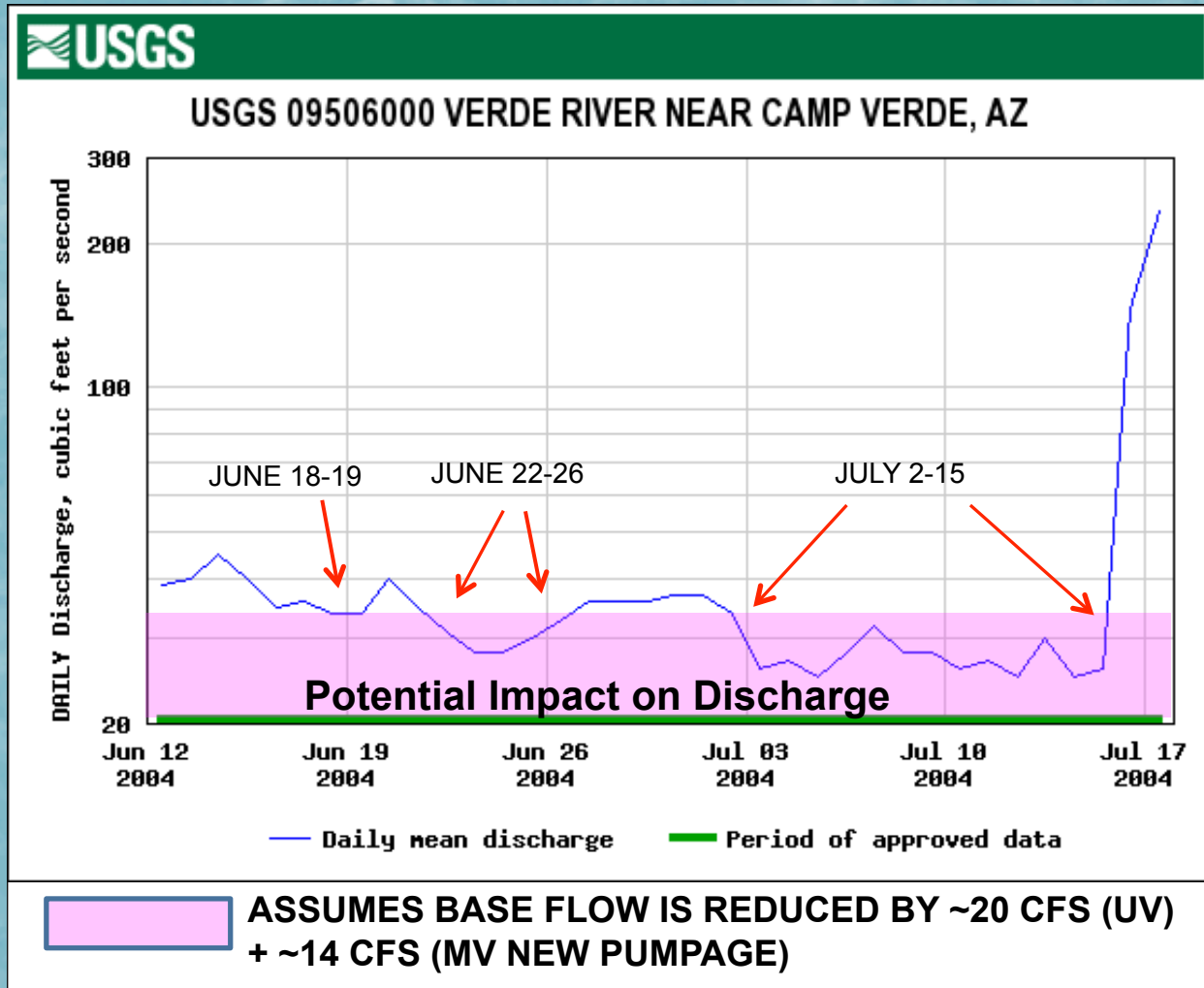
**Unmet demands for 2050 in the Big Chino:
Exceed The Base Flow**

**Unmet demands for 2050 in the Verde Valley:
10,136 Af/Yr or 14 cfs**

**Summer base-flow reduction in the
Verde Valley of:
~34 cfs (20 cfs +14 cfs)**

**Resulting in dry reaches of the Verde River
for weeks to months every summer**

USGS Gage below Camp Verde ~ Summer 2004 (Near Chasm Creek)

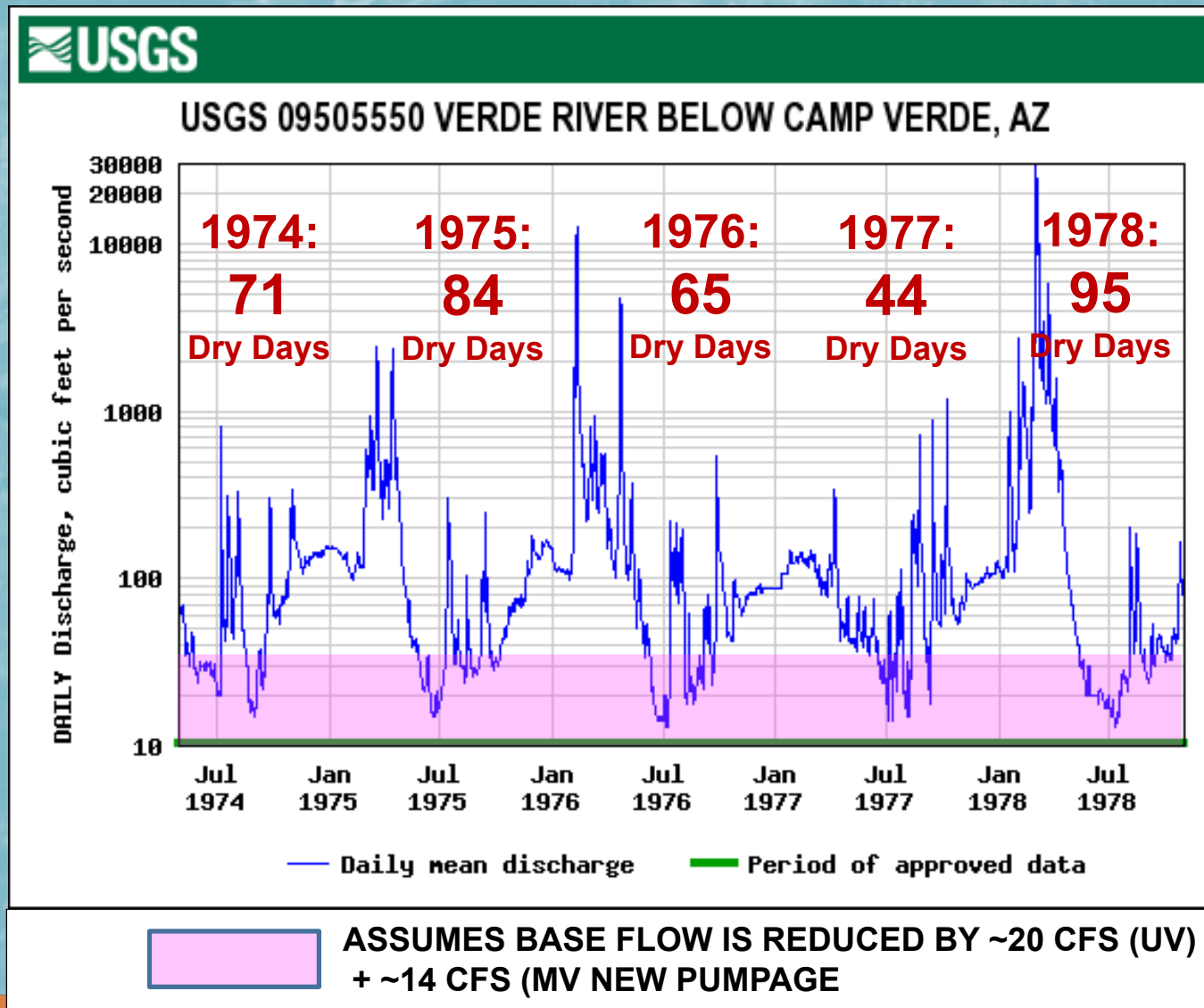


INFERRED 23 DAYS OF NO FLOW, JUNE & JULY 2004

ALSO 8 DAYS IN 2007 AND 4 DAYS IN 2009

Gage near Camp Verde (White Bridge)

(at hwy 260; active late 1971 through 1978)



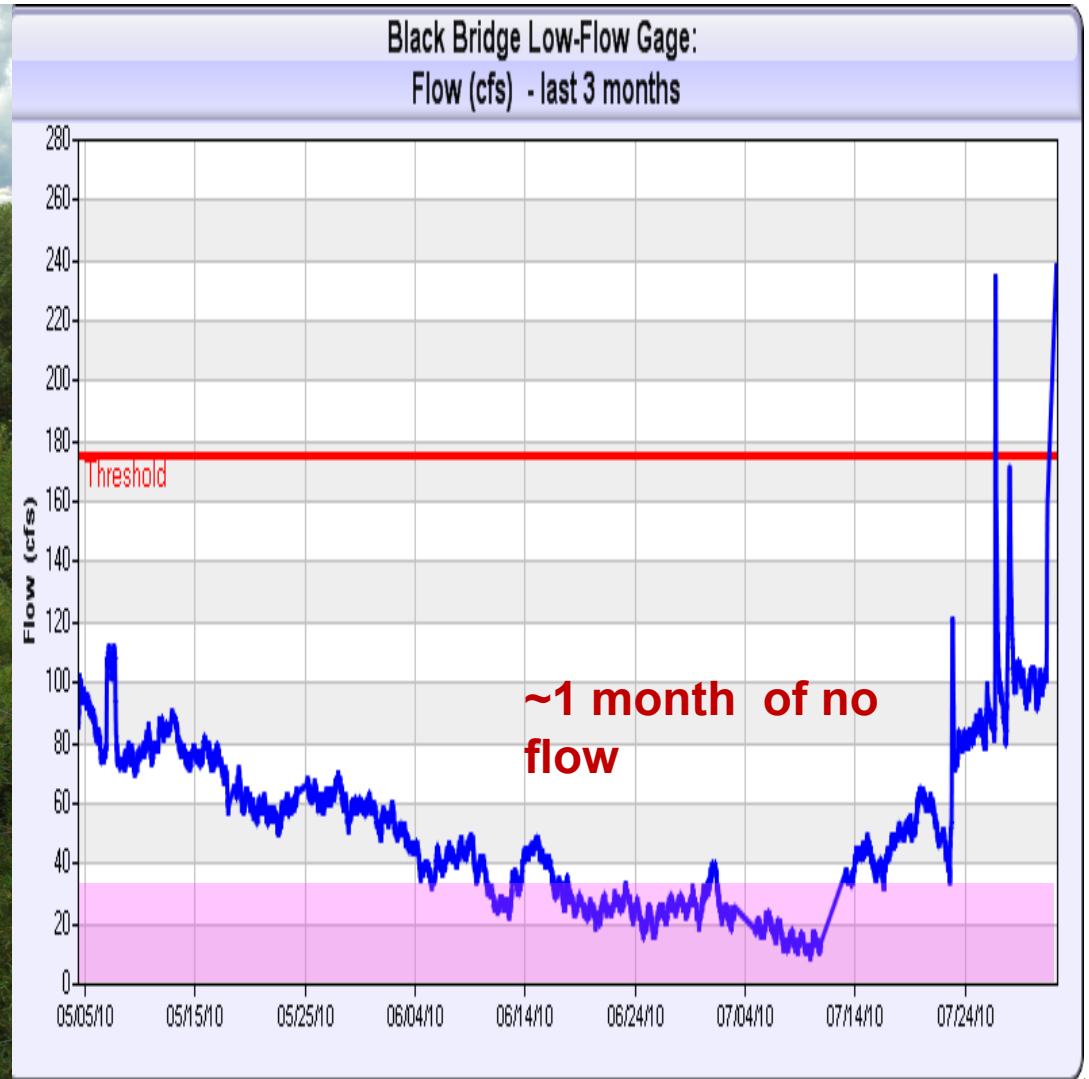
View downstream
From White Bridge



Photo by Steve Ayers
Aug. 27, 2010

View upstream from
Black Bridge

~40 cfs



**ASSUMES BASE FLOW IS REDUCED BY
~20 CFS (UV)
+ ~14 CFS (MV NEW PUMPAGE)**

Photo by Steve Ayers
Aug. 27, 2010

Expected Results

- **Refine these inferences with new data and analysis**
- **Address long-term consequences of water-management scenarios**
- **Document, explain, and formalize the strengths and limitations of long-term water resources, including the flow of the Verde River**
- **Provide scientifically sound science to guide public officials and the citizens they represent in the management of the Valley's water resources**
- **Define data needs for future groundwater modeling**

QUESTIONS?

