CWAG Feb. 14, 2015 Presentation

POTENTIAL FUTURE DECLINES IN BASE FLOW TO THE UPPER VERDE RIVER DUE TO GROUNDWATER EXTRACTION FROM THE BIG CHINO SUB-BASIN AND SURROUNDING AREAS – AN APPLICATION OF THE NARGFM

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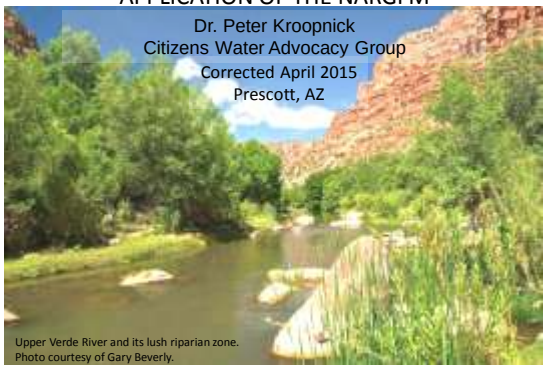
Citizens Water Advocacy Group
Corrected April 2015
Prescott, AZ



Upper Verde River and its lush riparian zone.
Photo courtesy of Gary Beverly.

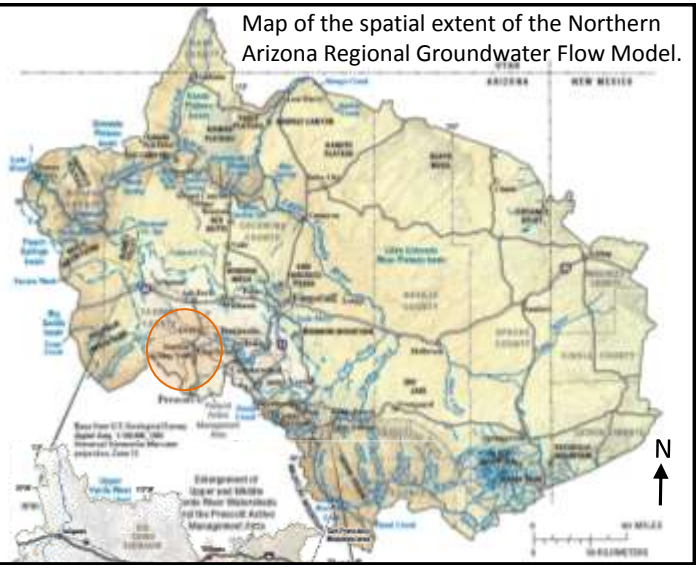
NARGFM. "Regional Groundwater-Flow Model of the Redwall-Muav, Coconino, and Alluvial Basin Aquifer Systems of Northern and Central Arizona" (USGS Scientific Investigations Report 2010-5180).

Acknowledgments:
Wayne Hood prepared many of the maps.
Ed Wolfe kindly shared the VRBP/USGS data.
Don Poole shared the NARGFM model files.
J. Zambrano, G. Beverly and CWAG

Photo courtesy of Gary Beverly.

http://www.cwagaz.org/home/188-kroopnick-nargfm-big-chino

Map of the spatial extent of the Northern Arizona Regional Groundwater Flow Model.



Regional Groundwater-Flow Model of the Redwall-Muav, Coconino, and Alluvial Basin Aquifer Systems of Northern and Central Arizona -- NARGFM

By D.R. Pool, Kyle W. Blasch, James B. Callegary, Stanley A. Leake, and Leslie F. Graser

Prepared in cooperation with the Arizona Department of Water Resources and Yavapai County.
USGS Scientific Investigations Report 2010–5180

- ✓ NARGFM is a numerical flow model (MODFLOW) of the groundwater flow system in the primary aquifers in northern Arizona.
- ✓ Developed to simulate interactions between the aquifers, perennial streams, and springs for predevelopment and transient conditions during 1910 through 2005.
- ✓ Only a regional model can simulate the effect of changes in any basin or sub-basin on another.
- ✓ Intended to be used by resource managers to help assess the adequacy of the regional groundwater supply and the potential effects of increased groundwater use, due to population growth, on water levels, streamflow, and riparian vegetation.

However, the communities of Prescott, Prescott Valley and Chino Valley objected to the use of this model as a management or planning tool, claiming the model is inaccurate in its ability to predict future water trends for the Big Chino Valley and the Prescott AMA.

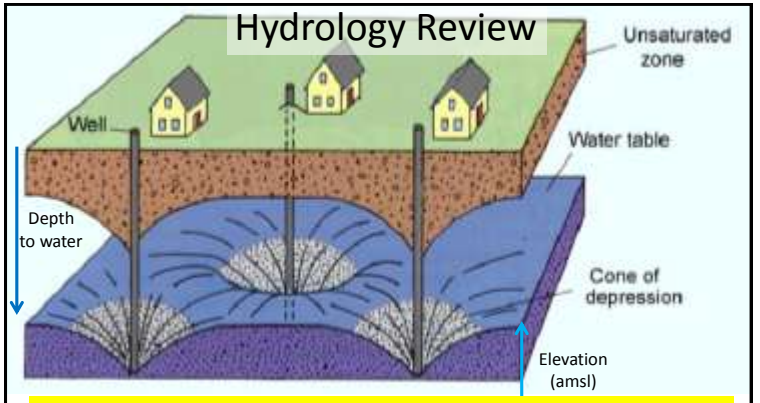
Meanwhile

- The USGS, in cooperation with the Verde River Basin Partnership and the Town of Clarkdale, used the NARGFM to explore the effects of past and possible future human stresses on the hydrologic system of the Verde Valley and northern Arizona. (Garner et. al., 2013. Human Effects on the Hydrologic System of the Verde Valley, …, USGS 2013-5029)
- The cities signed an agreement with SRP to collect more data and build a more detailed model with finer grid spacing and time resolution (~2020)

This presentation follows the example of Garner, but for the Big and Little Chino sub-basins.

- Use the NARGFM to calculate water budgets that include simulation of known natural and human stresses for 1910–2005.
- Apply three scenarios of hypothetical future human stresses for 2005–2110.

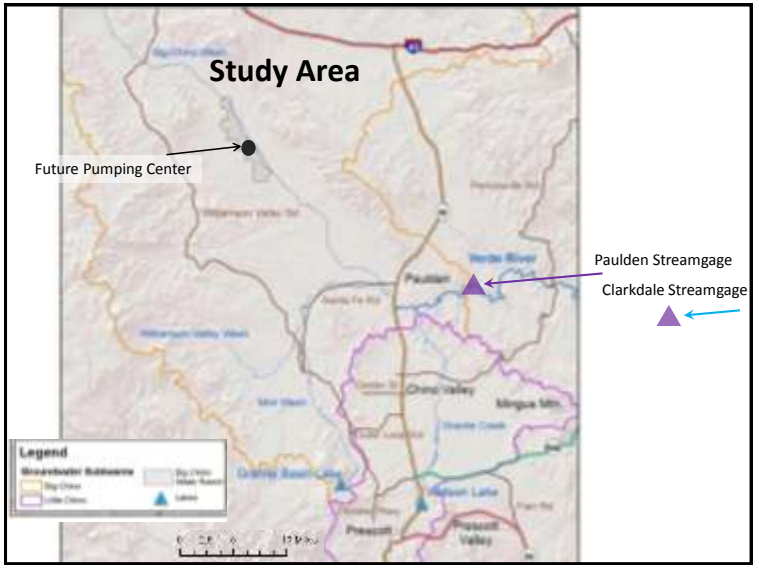
Hydrology Review

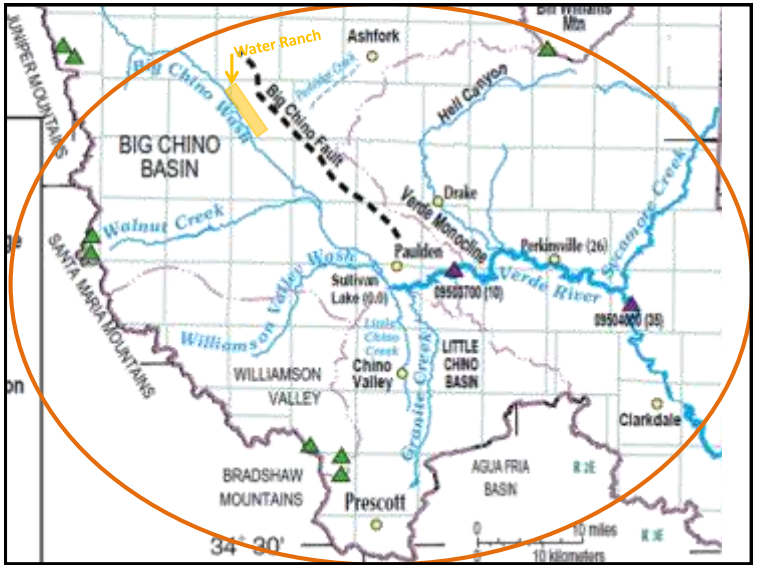


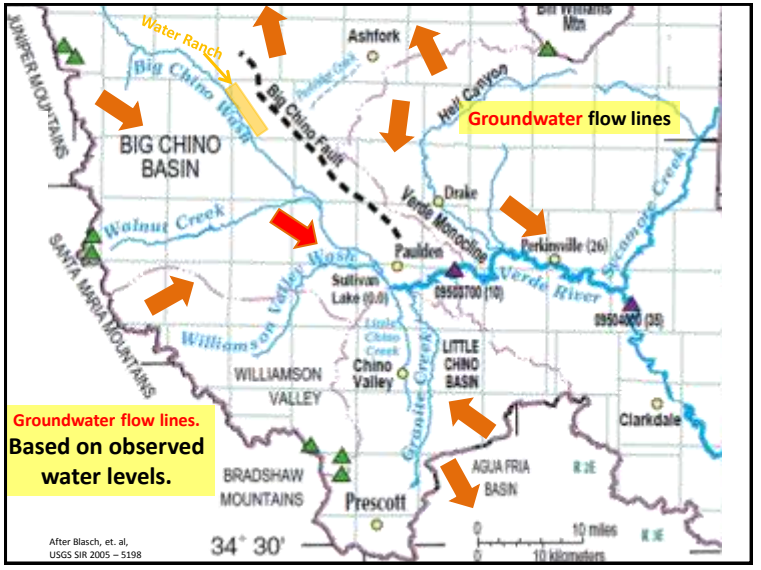
Acre-foot: The volume of water that would cover 1 acre to a depth of 1 foot = 325,850 gal.

Put into perspective, 100 gal per day = 0.07 gpm = 0.11 acre-ft. per year.

Cubic foot per second: 1 CFS = 724 ac-ft/yr.

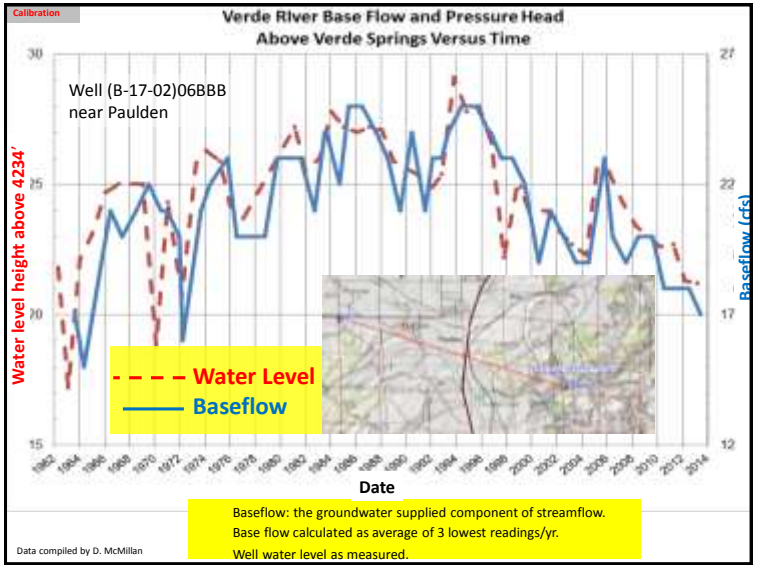






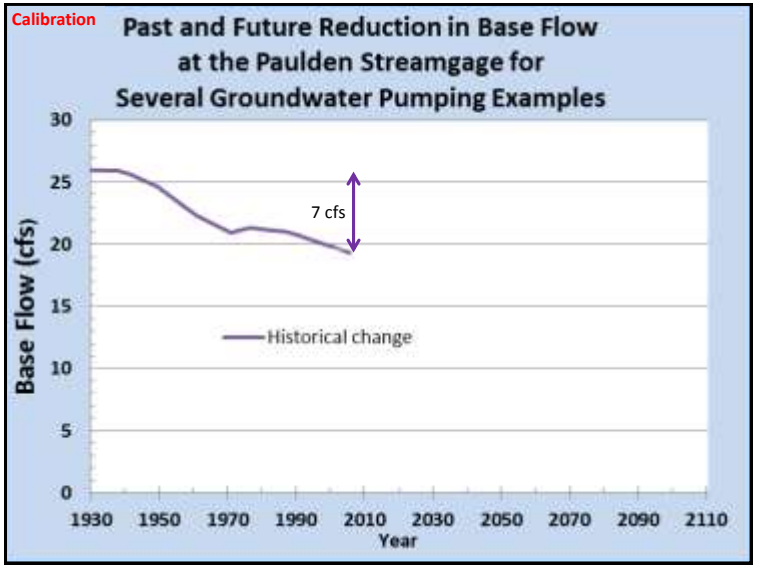
Spring flow contributing to origin of Verde River.

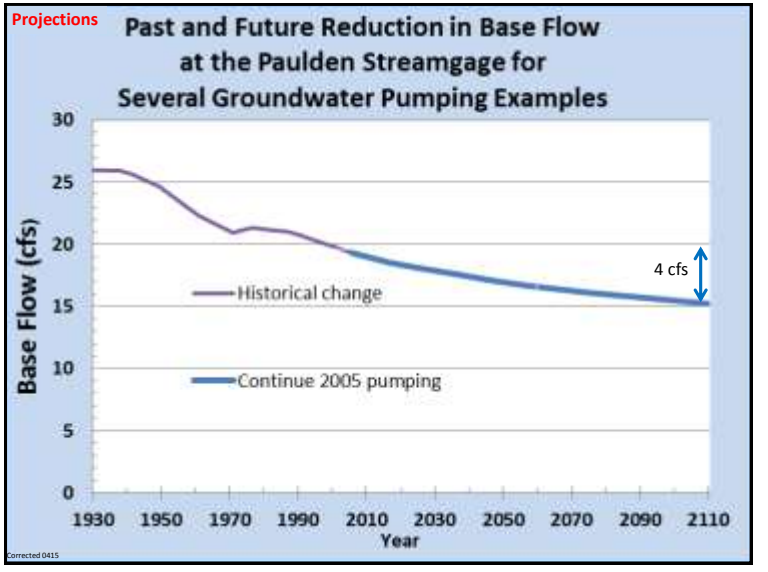
Groundwater and Surface water are connected.

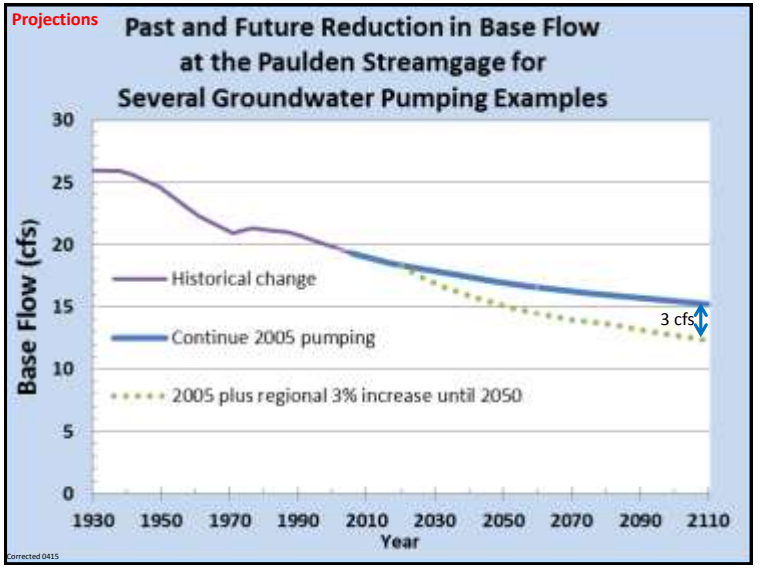


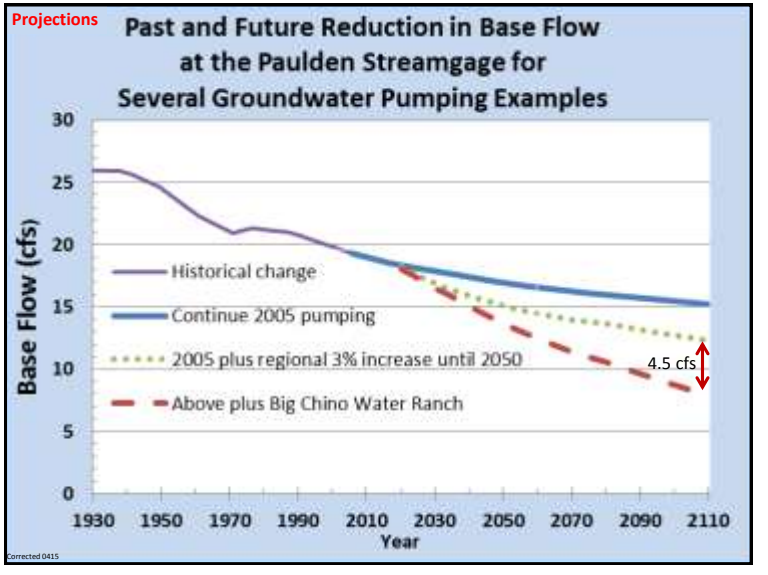
Projected changes – this work

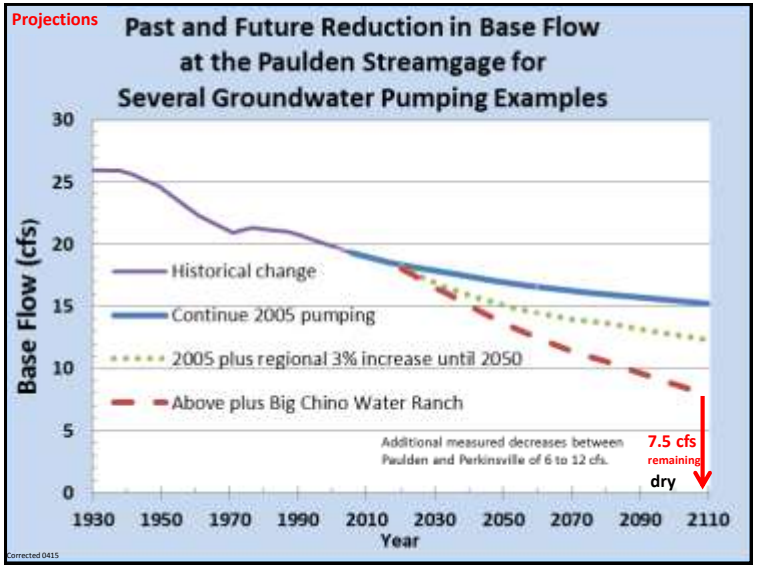
- Garner showed the historical changes in base flow at the USGS Paulden and Clarkdale streamgages – 1910 – 2005 (Garner et. al., 2013).
- Perform forward-looking simulations for the period 2005-2110 that evaluate potential effects on base flow in the upper Verde River resulting from:
  - (1) unchanged water demand from 2005 through 2110 – recharge average historical,
  - (2) increased water demand -- 3% per decade to 2060 for entire domain,
  - (3) extraction of the expected 12,000 acre-feet per year (ac-ft/yr) of groundwater from the Water Ranch beginning in 2020, and
  - (4) the cumulative effect of all of above.

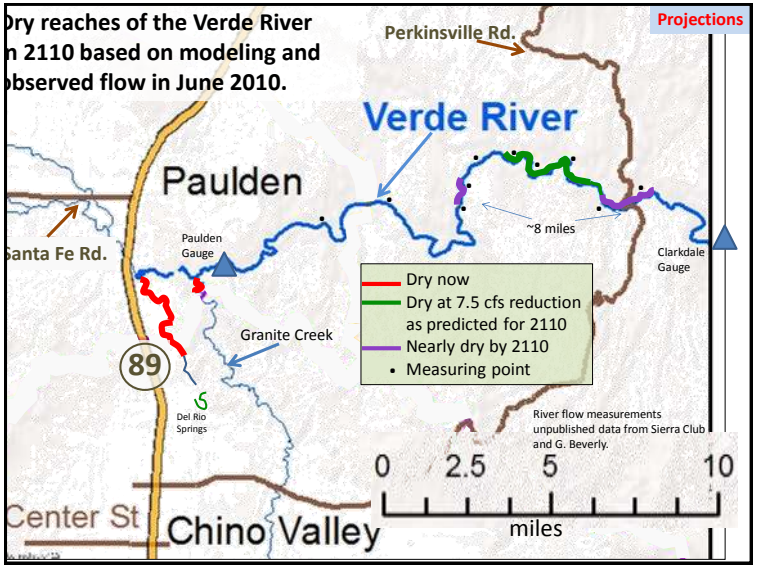

Calibration
Past and Future Reduction in Base Flow at the Paulden Streamgage for Several Groundwater Pumping Examples
Base Flow (cfs)
Year
7 cfs
Historical change

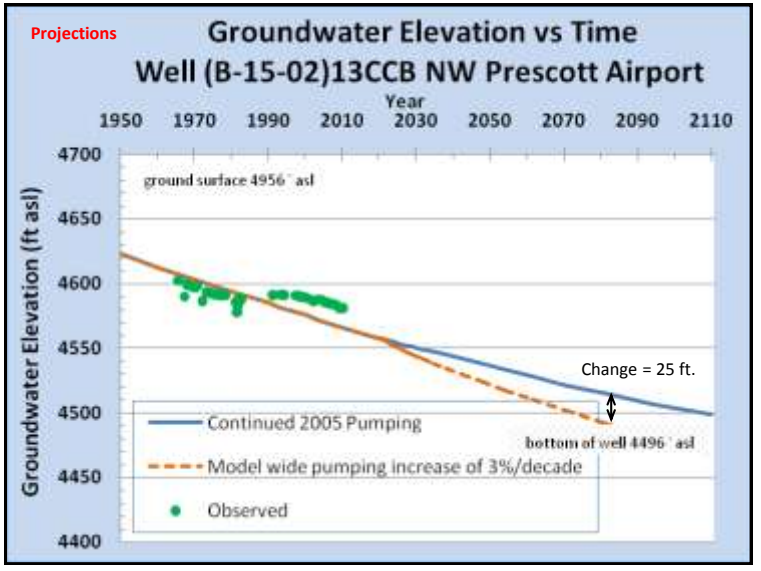

Projections
Past and Future Reduction in Base Flow at the Paulden Streamgage for Several Groundwater Pumping Examples
Base Flow (cfs)
Year
4 cfs
Historical change
Continue 2005 pumping

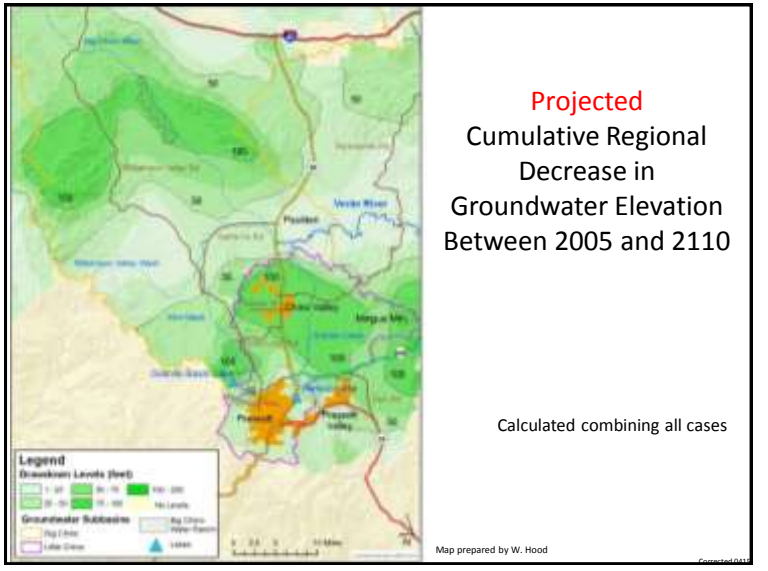

Projections
Past and Future Reduction in Base Flow at the Paulden Streamgage for Several Groundwater Pumping Examples
Base Flow (cfs)
Year
Historical change
Continue 2005 pumping
2005 plus regional 3% increase until 2050
3 cfs


Projections
Past and Future Reduction in Base Flow at the Paulden Streamgage for Several Groundwater Pumping Examples
Base Flow (cfs)
Year
Historical change
Continue 2005 pumping
2005 plus regional 3% increase until 2050
Above plus Big Chino Water Ranch
4.5 cfs


Projections
Past and Future Reduction in Base Flow at the Paulden Streamgage for Several Groundwater Pumping Examples
Base Flow (cfs)
Year
Historical change
Continue 2005 pumping
2005 plus regional 3% increase until 2050
Above plus Big Chino Water Ranch
Additional measured decreases between Paulden and Perkinsville of 6 to 12 cfs.
7.5 cfs remaining
dry


Dry reaches of the Verde River in 2110 based on modeling and observed flow in June 2010.
Projections
Perkinsville Rd.
Verde River
Paulden
Santa Fe Rd.
Paulden Gauge
~8 miles
Clarkdale Gauge
Dry now
Dry at 7.5 cfs reduction as predicted for 2110
Nearly dry by 2110
Measuring point
Granite Creek
89
Del Rio Springs
River flow measurements unpublished data from Sierra Club and G. Beverly.
0 2.5 5 10
miles
Center St
Chino Valley


Projections
Groundwater Elevation vs Time
Well (B-15-02)13CCB NW Prescott Airport
Year
Groundwater Elevation (ft asl)
ground surface 4956 ' asl
Change = 25 ft.
Continued 2005 Pumping
bottom of well 4496 ' asl
Model wide pumping increase of 3%/decade
Observed


Projected
Cumulative Regional Decrease in Groundwater Elevation Between 2005 and 2110
Calculated combining all cases
Map prepared by W. Hood

CONCLUSIONS

- ❖ Forward-looking simulations using the NARGFM show that the cumulative effect of increased water demand, and extraction of 12,000 ac-ft/yr (16.6 cfs) of groundwater from the Big Chino, will decrease the base flow to the Verde River by 11.5* cfs at the Paulden streamgage by the year 2110.
- ❖ Since the base flow at the Paulden streamgage in 2005 was approximately 19 cfs, this would leave only 7.5 cfs in the river.
- ❖ Sierra Club seepage runs for 2007 through 2010 show additional decreases of between 6 and 12 cfs between the Paulden and Perkinsville Bridge streamgages. Thus, it is likely that part of the Upper Verde River near and above Perkinsville would be dry by 2110 based on the cumulative effects discussed above.
- ❖ Groundwater level decreases greater than 100 ft. will occur in several areas.
- ❖ The scenarios shown here are conservative: constant recharge, low demand
- ❖ Mitigation?

**Not including drought reduction of 1.4 cfs. Seepage run data supplied by G. Beverly.*

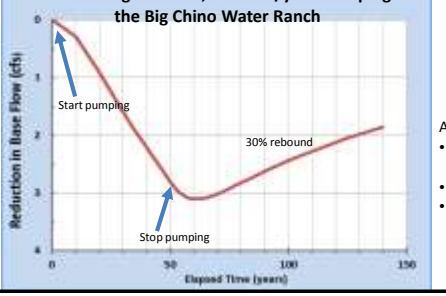
Projections

MITIGATION

- Prescott and Prescott Valley in conjunction with SRP, have pledged to mitigate the effects of pumping from the BC and are collecting data for a new model
- Dictionary: make less severe, serious, or painful.
  - alleviate, reduce, diminish, lessen, weaken, lighten, attenuate
- To me - Prevent any further reduction in stream flow of the upper Verde

HYDROLOGICAL CONSIDERATIONS

Calculated Reduction and Recovery of Base Flow at Paulden Gauge with 12,000 ac-ft/yr of Pumping at the Big Chino Water Ranch



Hypothetical test case using NARGFM

Assumptions:
- USGS pumping rates for historical time
- 2005 rates extended to future
- Constant recharge at long term average

Sierra Club Water Sentinels, June 1, 2013, unpublished data