BIG CHINO SUB-BASIN DATA COLLECTION AND MONITORING PLAN

YAVAPAI COUNTY, ARIZONA

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PURPOSE & GOALS

The purpose of the Big Chino Sub-basin Data Collection and Monitoring Plan ("Plan") for the Big Chino sub-basin of the Verde River Groundwater Basin (Figure 1) is to collect additional hydrologic data for development of a numerical groundwater flow model and establish a long-term data collection program. The data are designed to:

1. provide hydrologic data for development of a numerical groundwater flow model of the Big Chino sub-basin and surrounding area,
2. monitor changes in the hydrologic system caused by proposed groundwater pumping and transport by Prescott and Prescott Valley (the Communities) from the Big Chino Water Ranch (BCWR) in the upper Big Chino sub-basin (Figure 2) that may indicate a potential impact upon the base flow of the upper Verde River,
3. monitor changes in the hydrologic system caused by other existing or proposed groundwater pumping in the Big Chino sub-basin that may indicate a potential impact upon the base flow of the upper Verde River, and

4. monitor changes in the hydrologic system caused by climatic variations.

The specific goals of the Plan are to develop a Big Chino sub-basin groundwater data collection and monitoring strategy that includes:

1. Improved understanding of the hydrologic relationship between groundwater and surface water in the upper Verde River area.
2. An early warning system for the Upper Verde Springs (UVS).
3. Collection of data that may be used to distinguish Communities' groundwater pumping impacts due to the Project from the impacts of groundwater pumping of others in the sub-basin, and natural system variability.
4. Ability to relate regional groundwater and surface water observations to future groundwater model calibration & verification
5. Recognition of the need for additional data collection which might include precipitation, surface water flows, groundwater withdrawals, and effects of artificial recharge

The Plan assumes that the Communities' will pump groundwater exclusively from lands on the Big Chino Water Ranch in the upper Big Chino sub-basin.[1]

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[1] There exists the potential that groundwater pumping for transportation may occur at other locations throughout the Big Chino sub-basin. This plan would be revised if additional pumping locations were to alter this assumption.

DATA NEEDS FOR GROUNDWATER FLOW MODEL

Under a separate scope of work, a groundwater flow model of the Big Chino sub-basin and the area surrounding the UVS will be developed. It is recognized that existing hydrologic data within the study are variable, both in quality and quantity. Data are more plentiful for some aspects of the hydrologic system than others. Some data needs have been identified that, if filled, are thought to significantly improve the ability of the groundwater flow model to simulate actual hydrologic conditions. It is further anticipated that as the groundwater flow model is developed and as data are collected and interpreted, new questions may arise so that additional data collection may be required. At this time, the following areas of additional data needs have been identified:

- hydrogeologic controls on water movement between the basin-fill and Paleozoic carbonate aquifers with particular emphasis on the area between Wineglass Ranch and the UVS,
- geologic structural controls on groundwater movement in the Paleozoic carbonate aquifer surrounding the UVS,
- aquifer parameters (transmissivity and storage coefficient) of the Paleozoic carbonate aquifer, and
- quantification and distribution of infiltration/runoff relationships.

It is anticipated that the current USGS Northern Arizona Regional Groundwater Flow Model (NARGFM) will be used to help guide some of the data collection activities.

DATA COLLECTION AND MONITORING PLAN COMPONENTS

The Plan is comprised of the following components:

1. City of Prescott Groundwater Monitor Wells for the Big Chino Water Ranch

Maintain the City of Prescott groundwater monitor wells for the Big Chino Water Ranch as provided in Attachment A: The City of Prescott monitor well plan for the BCWR consists of seven (7) monitor wells, six (6) of which are now in place. Two (2) of the wells were existing, four (4) were installed by the City and one is planned for future installation. Although six (6) monitor wells have been completed (Figure 3.), the City's consultant, Southwest Groundwater Consultants Inc. (SGC), was unable to complete the seventh, Boundary Monitoring Well #2 (BMW-2) due to drilling problems.

BMW-2 is important with respect to the monitoring of the Paleozoic carbonate aquifer and is planned for completion early in the program. The location of this well has been revised from the plan presented in Attachment A. The proposed new location is adjacent BMW-3 in order to facilitate the measurement of heads in the basin-fill and Paleozoic carbonate aquifers at the same geographic location. The new location is shown on Figure 3.

All of the installed BCWR monitor wells are or will be incorporated into the ADWR/USGS monitoring networks.

2. GWSI Wells in the Big Chino Sub-basin

ADWR GWSI index wells in the Big Chino sub-basin are shown on Figure 4. These wells are disproportionately concentrated in the upper portion of the sub-basin. It is proposed to add wells to the GWSI in the Williamson

Valley, middle and lower regions of the Big Chino sub-basin, and in the Paleozoic carbonate aquifer north of the upper Verde River. Approximately 10 to 20 wells will be added to the GWSI to achieve a density similar to the existing GWSI in the rest of the Big Chino sub-basin. Potential existing wells to be considered for inclusion in the GWSI are shown on Figure 4.

ADWR GWSI Index wells historically have been selected to provide good spatial distribution or coverage within a groundwater basin and to assess vertical gradients if possible. ADWR GWSI Index wells are selected based on guidelines developed by the USGS Office of Ground Water for the Collection of Basic Records (CBR) Program. Additional details can be found at: http://water.usgs.gov/ogw/CBR/Guidelns.html

Specific criteria for Index well selection can include at a minimum the following:

- Open to a single, known hydrogeologic unit
- Known well construction that allows good water-level measurements
- Located in unconfined aquifers or near-surface confined aquifers that respond to climatic fluctuations
- Minimally affected by pumpage and likely to remain so
- Essentially unaffected by irrigation, canals, and other potential sources of artificial recharge
- Long-term accessibility
- Well has never gone dry (not susceptible to going dry)

Additional desired characteristics:

- Representative of broad area (e.g., a regional aquifer)

- Complete characterization of the site is available
- A long record of water-level measurements exists
- Lithologic and geophysical logs available
- Alternative well identified for each site

Please note that selection criteria may vary for GWSI Index wells depending on area specific monitoring objectives. For example, wells may be selected that are located in confined conditions versus unconfined for specific data needs.

Monitoring of existing wells in Big Chino sub-basin is incorporated into the Big Chino Sub-basin Monitoring Plan, as described below.

a. In 2008 ADWR began semi-annual water level monitoring of 30-34 wells in the upper Big Chino sub-basin. It is unclear if ADWR will continue to monitor these wells on a semi-annual basis. However, it is recommended that water levels in these wells continue to be measured on a semi-annual basis until or until the data are sufficient to support a less frequent measuring period.

b. On a 4 to 5 year frequency, ADWR has conducted comprehensive water level measurement "sweeps" for many groundwater basins throughout the State. During these sweeps ADWR attempts to obtain water level measurements from as many wells as circumstances and scheduling allows. The last water level sweep for the Big Chino sub-basin occurred in 2009.

ADWR may not be able to continue its periodic all-inclusive sweep of existing wells in the Big Chino sub-basin to obtain water level measurements. However, if measurement sweeps are conducted, the data will be incorporated into the annual monitoring report as they become available.

3. Geophysical Surveys

The geology of the Big Chino sub-basin is complex. Understanding the relationships between the alluvial sediments (tertiary basin fill), volcanic interflows and intrusive events, and the Paleozoic carbonate rocks is essential to understanding both the movement of the groundwater from the area of the BCWR to the UVS and the potential effects of pumping in the upper Big Chino sub-basin on the base flow of the upper Verde River.

Geophysical surveys have been conducted to assess the general configuration of the Big Chino valley and major structural features (WRA 1990; USBR 1993; USGS 2000). Additional surveys are proposed to focus specifically on three key areas:

- Extent and distribution of coarse-grained and fine-grained aquifer materials in the middle portions of the sub-basin;
- Lithologic and structural conditions in the area between Wineglass Ranch and the UVS;
- Major (Mesa Butte and Big Chino faults) and lessor (fissure and solution zone) structural features in the Paleozoic carbonate rocks north of the UVS.

The primary geophysical tools are anticipated to be electrical methods (TEM and CSAMT). These may be supplemented with other methods such as seismic surveys in selected areas. Electrical geophysical methods (ground-based transient electromagnetic (TEM) and controlled source audio-magnetotelluric (CSAMT)) will be used in the three (3) specified areas to address specific questions in Big Chino sub-basin. The USGS Arizona Water Science Center will use Center equipment and experienced staff to carry out these surveys as part of a related project to construct a groundwater flow model of the Big Chino sub-basin. Targets of the electrical surveys will include the aquifer extent and lithology and geologic structures such as horsts and grabens. In particular, the distributions of productive aquifer materials, coarse-grained sediments and limestone, and poor aquifer materials, fine-grained sediments and crystalline rock, will be mapped. Depths of investigation will range from a few tens of meters to several hundred meters. Data processing will include subsurface electrical models. Additional methods that may be used to refine the electrical survey results, such as 2-dimensional electrical resistivity surveys and seismic reflection, will be considered after evaluation of the initial surveys.

The three (3) areas of interest for electrical geophysical surveys are discussed below:

a. The region of steep hydraulic gradients near Walnut Creek that appear to hydraulically compartmentalize the upper and lower parts of the alluvial basin including an area within the following region T19N R4W sec 9, 10, 11, 13, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 33, 34, 35, 36 and T19N R3W sec 19, 30, 31. The targets of surveys include the thickness, extent, and continuity of the alluvial and Paleozoic aquifers and the extent and thickness of the silt and clay body. Detailed CSAMT or TEM profiles will be use to map aquifer lithology and geologic structure. The specific location of profiles will be determined after evaluating available geologic information including drill logs, other geophysical data, and access to lands in the region.

b. Paleozoic aquifer that lies to the north of the Verde River above the Paulden gage T18N R2W sec 26 to T18N R1W sec 30, T18N R2W sec 35 to T18N R1W sec 32, T17N R2W sec 2 to T17N R1W sec 5. Targets of surveys include the thickness and extent of the Paleozoic aquifer including geologic structures that may limit or transmit groundwater flow. Detailed CSAMT profiles will be needed to map geologic structure in sufficiently useful detail. The specific locations of profiles will be determined after evaluating available geologic information, drill logs, other geophysical data, the hydrogeologic framework model of Fry (NAU Master's Thesis, 2006), and access to lands in the region. At least 3 profiles are proposed, 2 approximately W-E and 1 N-S, but more may be needed. The distribution of CSAMT soundings along profiles may be as small as 500 ft or as great as 1 mile between stations along multiple profiles.

c. North of Paulden and south of Big Black Mesa including areas within T18N R2W sec 16, 17, 20, 21, 26, 27, 28, 33, 34. The target of these surveys include the thickness and extent of the Paleozoic and alluvial aquifers including the Big Chino Fault. Detailed CSAMT or TEM profiles will be used to map geologic structure. The specific locations of profiles will be determined after evaluating available geologic information including drill logs, other geophysical data, and access to lands in the region.

4. New Groundwater Monitor Wells

Up to 10 new groundwater monitor wells are anticipated as part of this plan. New monitor wells will be constructed in a manner to allow for both water level measurement and collection of water quality samples. The following new monitor wells (Figure 5) are proposed to be added to the network, measured at least semi-annually or continuously, as appropriate. Final well locations will be based upon access, land availability and technical considerations, including the results of the geophysical surveys.

a. Existing wells will be reviewed and evaluated as potential monitor wells based upon ownership, access, construction and condition. It is anticipated that this would be done in conjunction with ADWR's assessment of its index well coverage of the Big Chino sub-basin (Task 2). This task will also benefit from a review of the soon to be published USGS Northern Arizona Regional Groundwater Flow Model (NARGFM), with emphasis on improving future model calibration and results.
b. Unless existing wells will suffice (see Section 2), three to five additional wells will be installed in Sections 13, 24 and 25 of T18N, R2W and Sections 16-33 of T18N, R1W (Figure 5). For initial cost estimation, it is anticipated three (3) wells would be installed to a depth of 300 feet below land surface (ft bls) and two (2) wells would be 700 ft bls.
c. A well will be installed in the E½ of Section 36, T18N, R2W, drilled into Paleozoic carbonate aquifer (Figure 5). The depth of the well is uncertain but the potentiometric surface is expected to be at an elevation higher than 4,300 feet (300 ft bls).

d. There are very few existing wells in the Big Chino sub-basin just above the Verde River headwaters. A well is proposed to be installed in the SE¼ NE¼ Section 11, T17N, R2W in the saddle between the two knobs in the NE¼ of this section. The well will be drilled into the Paleozoic carbonate aquifer to a depth of approximately 330 ft bls. This would put the bottom of the well 50 feet below the elevation of the Verde River (elevation approximately 4170).
e. It is important to establish the current and future piezometric head in the Paleozoic carbonate aquifer as close to the UVS as possible. A new groundwater monitor well is proposed in Section 12, T17N, R2W as close to the UVS as possible given site and ownership constraints.
f. The playa deposit in the middle of the Big Chino sub-basin potentially has a significant effect on groundwater movement. It is unclear whether existing wells (and their reported water levels) in and near the playa are penetrating a perched aquifer on top of the playa, the regional basin-fill aquifer, or both. A new dual piezometer monitor well screened in the shallow (perched) aquifer and deeper (regional) aquifer is proposed to investigate the presence of a perched aquifer. The well would be located in NW ¼ of Section 26 T18N, R4W and drilled to a total depth of approximately 400 ft bls.
g. A new Paleozoic carbonate aquifer exploration/monitor well is proposed near Wineglass Ranch (NW ¼ of Section 24 or SW ¼ of Section 25, T18N, R3W) to investigate the carbonate hydraulic head and aquifer parameters in the middle portion of the Big Chino sub-basin. The depth of this well would be 900-1,000 ft bls
h. .Continuous water level monitoring equipment will be installed in up to ten (10) new monitor wells (in addition to the six (6) existing wells with continuous recording devices).

i. SRP has installed water level monitoring equipment at the Gipe well, located in the NE¼ of the NE¼ of the NE¼ of Section 17, T18N, R1W, ADWR Registration number 55-511557, in cooperation with Drake Mining LLC. Water level data are being collected in real time and are available to the public. The Gipe well is completed in the Paleozoic carbonate aquifer (Figure 5). The well monitoring equipment is currently being maintained by SRP with hopes that it will be incorporated into the ADWR GWSI network.

j. Chino Valley has proposed a recharge facility to be located in the lower Big Chino sub-basin, NW¼ Section 4, T17N, R2W, at APN 306-40-008D. Any monitor wells associated with that recharge facility will be made part of this Plan.

5. <u>Paleozoic Carbonate Aquifer Testing</u>

Measured transmissivity and storage data for the Paleozoic carbonate aquifer in the Big Chino sub-basin are nonexistent. It is proposed to develop aquifer parameters at three geographically dispersed locations in the sub-basin as noted below.

a. at the new BMW-2 monitor well located adjacent to BMW-3 (see Attachment A),
b. at a new carbonate monitor well to be located in the vicinity of the Wineglass Ranch (Section 4g), and
c. at the new monitor well to be located near the UVS (Section 4d).

Each well will be geophysically logged when drilled. The logging suite will include at least two depths of penetration of resistivity measurement, spontaneous potential, natural gamma, neutron, porosity, gamma gamma density, sonic travel time, and borehole televiewer.

After the wells are completed, long-term pumping tests of at least seven (7) days duration will be conducted on each well. The length of each test will be adjusted in the field so that the length is adequate to test a sufficiently large volume of aquifer so that transmissivity adjacent to the borehole and aquifer transmissivity farther from the borehole can be estimated. Additionally, the tests will aid in understanding whether or not the aquifer at the location of the monitor wells is connected to an extensive network of fractures and/or solution features.

In order to balance cost and the need for aquifer data, wells will be designed to accommodate a pump capable of producing approximately 500 gpm. Well diameter is anticipated to be twelve (12) inches. It is understood that in areas of extensive solution fractures this pumping rate may not be adequate to stress the aquifer: in this event a qualitative assessment of aquifer transmissivity will made.

6. Water Quality Sampling

Groundwater quality monitoring usually has one of two purposes: 1) to detect movement of poor-quality water related to pumping, or 2) to detect presence or introduction of anthropogenic contaminants. Prescott will monitor groundwater quality of the planned BCWR production wells to ensure that all municipal water supply standards are met. However, outside the BCWR there seems to be little need for monitoring groundwater quality to detect changes with time.

There is, however, a need for additional chemical and isotopic data to improve understanding of the hydrogeology in Big Chino sub-basin. For example, data for arsenic (As) concentrations are particularly important given that high As concentrations in drinking water have human-health implications and arsenic concentrations have been shown to vary with depth near the BCWR, and very high (>100 μg/L) concentrations have been reported in 6-10 wells near the Wineglass Ranch.

There are essentially no water quality or stable isotopic data in the middle Big Chino sub-basin (T18N, R4W), even though this area may be within the main groundwater flow path from the upper to lower Big Chino sub-basin. Such data are also very sparse between Williamson Valley and Paulden. Water quality sampling is discussed below

a. **Existing wells with repeated sampling** - groundwater from three (3) wells has been sampled and analyzed from 2 to 10 different times. Well (B-17-2)4AAA was sampled in 1991 by ADWR, and in 2003 by USGS (Wirt et al, 2005). The two analyses, including trace elements, were nearly identical.

   Well (B-18-3)25CDA was sampled by ADWR ten times from 1990-1998. All constituents were very stable during that period. However, boron concentrations (averaging 135 mg/L) are 2 to 3 times larger than most basin-fill analyses; and silica concentrations (averaging 73 mg/L) are 2.5 to 4 times higher than most basin-fill aquifer analyses. Thus, this well may not be representative of basin-fill aquifer groundwater.

Well (B-19-4)4CAC) was sampled 7 times by ADWR from 1990 to 1998, and again by USGS in 2001. All analyses were essentially the same, with the exception of the 1993 analysis in which concentrations were about 60 percent higher for most constituents.

Given the consistency of the analyses for the above wells, the Cooperators do not plan to embark on a repeat sampling (monitoring) program unless analysis of new data or results from numerical groundwater flow modeling identify a reason for further sampling of these wells.

b. **Stable isotopes -** The ratio of stable isotopes of oxygen and hydrogen ($^{18}O/^{16}O$ and H^2/H^1) relative to a known standard are useful for identifying the source of water, as well as the season and elevation of recharge. Stable isotopes of water are also useful for calculating the proportions of source waters in a mixed water sample. To be useful, a stable isotope monitoring campaign must characterize the "end members", which can be called the pure source waters, the water for which source is of interest, as well as temporal variability in both of those sample types.

In the most general terms, the property of stable isotopes from which their utility derives is that the heavier isotope in water evaporates and condenses at a slower rate than the lighter isotope. This differential rate results in 'fractionation', or a separation of heavy from light isotopes. The result is that water termed isotopically heavy or light represents precipitation that condensed at different temperatures and altitudes.

Winter precipitation (and therefore groundwater recharged by winter precipitation) tends to be isotopically light. Similarly, precipitation that forms at high altitudes over mountains tends also to be isotopically light, resulting in the recharge of isotpically light groundwater in mountain blocks and fronts.

The existing data set for stable isotopes is so small that a large sampling effort would be required to obtain a regionally meaningful data set. A total of 32 stable isotope values for the Big Chino sub-basin are reported in the literature (Blasch 2006; Wirt 2005; and Wirt & Hjalmarson 2000) – this includes the 1996 ASU samples. Of the 32 values, 15 are located between the southern playa deposits and Upper Verde Springs (downstream end of sub-basin); eight (8) are in wells overlying the playa deposits; four (4) are in CV Ranch; three (3) are in Williamson Valley; and two (2) are six (6) to 10 miles NW of the BCWR. Like the water chemistry, there are no stable isotope data from BCWR to Paulden, except in the playa deposit area.

If the sparse data allowed for a generalized conclusion, the lightest groundwater is in Williamson Valley; followed, in order, by carbonates near Paulden; the wells on the playa deposits; the average of wells near the UVS; and the heaviest near the BCWR. Collecting additional stable isotope data from wells in the middle portion the valley may provide some additional insights on the hydrogeology.

The USGS is reportedly analyzing surface-water samples, collected by volunteers, for stable isotopes in drainages extending into the Juniper and Santa Maria Mountains. These isotope analyses may provide end member data required for interpreting mixing of isotopes from the mountains to the UVS.

c. **Wells to be sampled for water chemistry and stable isotopes** - The installation of new wells presents an opportunity to collect water samples that are well characterized with respect to the depth and aquifer from which the water derives. Water chemistry and stable isotope samples will be collected from all new monitor wells.

Water from approximately 10 existing wells will be sampled and analyzed from the central basin area between the BCWR and Paulden where no groundwater chemistry data currently exist. As the study proceeds other wells may be identified and sampled, as appropriate. Water chemistry analyses will include, at a minimum, common inorganic anions and cations plus trace metals and stable isotopes. The existing wells to be sampled will be chosen after further research into which wells have sufficient information (depths, perforation interval, logs, etc.) to warrant sampling.

7. Base flow water quality sampling

Other than during specific research activities (ASU 1996, Wirt 2005), surface water quality in the Big Chino sub-basin has been sampled only sporadically. Given the importance of understanding the relationship between ground and surface water in the Big Chino sub-basin regular water quality sampling of base flow at selected locations should be implemented, at least until a consistent baseline can be established. Therefore, it is proposed to sample base flow as follows:

1. at least quarterly at the USGS' Williamson Valley gage,

2. The Paulden and the SRP Campbell Ranch gage will be sampled at time of visits during base flow conditions for the first two years. At the same time a water sample of flow from the UVS will also be collected. This sample will be taken on the north side of the Verde River as close to the springs as is physically possible.

At a minimum, samples will be analyzed for common inorganic anions, cations, arsenic and stable isotopes. The USGS is conducting monthly stable isotope sampling at the Paulden gaging station. For this monitoring effort those monthly samples will be bolstered with quarterly sampling and analysis of inorganic anions, cations, and trace metals. A similar sampling regimen, plus stable isotopes will be instituted for the SRP Campbell Ranch gage and possibly upstream.

8. <u>Verde River Low Flow Measurement</u>

SRP will provide low-flow stream flow data on a monthly basis from the Campbell Ranch low flow stream gage. This stream gage is located on the Verde River down-gradient from the UVS (see Figure 2).

9. <u>Verde River Tributary and Verde River Flow Measurement</u>

Stream flow in Partridge Creek and Big Chino Wash are potential sources of recharge to the regional Big Chino sub-basin basin-fill aquifer. Neither of these surface water drainages is currently gaged. Measurement of stream flow in these drainages would aid in the quantification of recharge to the basin-fill aquifer.

Runoff from the Walnut Creek drainage traverses karstic Paleozoic carbonate rocks before entering the valley floor and flowing on the surface of the basin-fill aquifer. Monitoring ephemeral streamflow above and below the carbonate outcrops can assist in defining the distribution and quantity of recharge to the Paleozoic carbonate and basin-fill aquifers.

The following streamflow monitoring is proposed to be incorporated into the Plan:

a. **New streamflow gaging locations -** At least nine (9) new stream flow gages are proposed: one (1) on Partridge Creek, four (4) on Big Chino Wash, two (2) on Walnut Creek, one (1) on Pine Creek and one (1) on Williamson Valley Wash. Given the ephemeral nature of these streams Continuous Slope Area (CSA) gages are proposed. Field verification will be required to assess hydraulic, access and land ownership suitability of the proposed locations. Tentative locations of the proposed gages are shown on Figure 6.

b. **Existing streamflow gaging stations -** Flow data from the USGS Del Rio Springs gage near Chino Valley, (Station number 09502900), the Williamson Valley Wash gage near Paulden, (Station number 09502800), and the Paulden gage, (Station number 09503700) will be included in the annual monitoring report along with data from relevant Yavapai County Flood Control gages shown on Figure 6.

10. Climate Monitoring

The federal government (NOAA/NWS) and the Yavapai County Flood Control District operate weather stations within the study area, as shown on Figure 6. All of these stations measure precipitation; several also collect other climatological data (temperature, humidity, wind speed, etc.). Relevant data, including but not limited to precipitation, from these sites will be compiled and used in estimates of recharge and in assessing the impact of climatic changes on water levels and streamflow.

Blasch (2005) concludes that significant recharge to aquifers in the study area originates as precipitation on the Juniper Mountains and on Big Black Mesa. It is proposed to establish precipitation gages in these areas. There are two (2) existing, but currently inactive, gages in the Juniper Mountains that will be considered for the precipitation network. Two (2) new gages are proposed on Big Black Mesa in recharge source areas identified by Blasch, as shown on Figure 6.

Evapotranspiration can be monitored using a combination of point measurements and Basin Characterization Modeling (BCM). Until recently the USGS operated two (2) climate stations that estimated potential evapotranspiration in Chino Valley and near the Paulden streamflow gaging station. Additionally, basin ET estimates using satellite data were previously estimated during the Rural Watershed Study. These latter basin ET estimates should be continued. It is proposed to work with the USGS to evaluate the ability of the BCM to provide localized estimates of ET for the numerical model. If the use of satellite data and the BCM prove inadequate, additional vegetative water use analyses to estimate ET may be proposed.

11. Natural Recharge

Discriminating between the impacts of climate fluctuations and pumping withdrawals on changes in Verde River base flow is a more complicated step than monitoring changes in the aquifer attributed to withdrawals alone. This is primarily attributed to the various recharge mechanisms occurring within the sub-basin, time scale of recharge and attenuation of groundwater signals, and correlation between water withdrawals and precipitation. Precipitation monitoring is a necessary first step for the general understanding of water entering the sub-basin and was discussed in the previous section. Recharge rates are necessary to estimate the amount of water that is entering the groundwater system and deterministic models are necessary to determine the flow through the groundwater system. Multiple strategies will be employed to provide this information including:

a. Direct monitoring of channel recharge. Streamflow gages will be installed within the main channel and major tributaries to estimate infiltration (seepage) during runoff events (see Section 8).
b. Integration of recharge data into the existing BCM and existing and planned groundwater models (see Section 9).

12. Groundwater Storage

The response of the groundwater system in the Big Chino sub-basin to variations in groundwater withdrawals and natural recharge is poorly known. Monitoring of water-levels in wells in the two (2) primary aquifers will help in understanding hydraulic response. However, the relation of storage change to water-level change, aquifer-storage coefficient, is also poorly understood. Additional periodic monitoring of groundwater storage using gravity methods at several sites throughout the basin will help determine both aquifer storage coefficient and the spatial distribution of variations in recharge. The USGS currently operates several microgravity stations in the study area where data are collected quarterly. It is proposed to establish up to 20 additional microgravity stations. Many of the stations will be co-located at monitor wells where variations in water-level and gravity will be used to estimate storage coefficient. Some of the stations will also be located in expected recharge areas where wells are unavailable.

13. Groundwater Pumpage

Prescott will install flow meters on BCWR production wells. For the non-BCWR irrigation wells, an annual survey of crop type will be made along with annual estimates of irrigated acreage using current aerial photographs or satellite imagery. These data will be used to compute groundwater pumping rates for unmetered irrigation wells. Non-BCWR municipal pumping will be provided by ADWR. Estimates of domestic well pumping will be based upon the number of domestic wells in the sub-basin as annually updated by ADWR.

14. Big Chino Sub-basin Monitoring Plan Annual Report

An annual monitoring report summarizing the data generated will be prepared and made available.

PROPOSED IMPLEMENTATION SCHEDULE

The proposed schedule follows a phased approach with the specific points of implementation to be determined by the monitoring and/or modeling committees. In general, the schedule is as outlined below:

Year 1: Install 5 of 9 stream gages, add the GWSI wells and install precipitation stations

Year 2: Install 5 of 9 shallow monitoring wells

Year 3: Install remaining 4 stream gages, remaining 4 shallow wells, begin geophysical and aquifer storage monitoring and begin modeling

Year 4: Install 2 deep wells, complete geophysical monitoring

Year 5: Continue aquifer storage monitoring, model development and anylysis

Year 6: Complete Modeling Report

LIST OF FIGURES AND ATTACHMENTS

Attachment A

City of Prescott Groundwater Monitor Wells for the Big Chino Water Ranch

November 2008