

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Customer #: 6000004581/AZ091
Agreement #: 16CMAZ02600
Project #: ZF00AD9
TIN #: 86-6007877
Fixed Cost Agreement YES

JOINT FUNDING AGREEMENT

FOR

WATER RESOURCES INVESTIGATIONS

THIS AGREEMENT is entered into as of the, 21st day of June, 2016 by the U.S. GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF THE INTERIOR, party of the first part, and the CITY OF COTTONWOOD, party of the second part.

1. The parties hereto agree that subject to availability of appropriations and in accordance with their respective authorities there shall be maintained in cooperation a program to for hydrologic data collection in the Middle Verde River Watershed as described in the attached workplan herein called the program. The USGS legal authority is 43 USC 36C; 43 USC 50; and 43 USC 50b.
 2. The following amounts shall be contributed to cover all of the cost of the necessary field and analytical work directly related to this program. 2(b) includes In-Kind Services in the amount of \$0.00
 - (a) by the party of the first part during the period

Amount	Date	to	Date
\$12,640.00	October 1, 2015		September 30, 2016
 - (b) by the party of the second part during the period

Amount	Date	to	Date
\$19,860.00	October 1, 2015		September 30, 2016

Total = \$32,500.00

 - (c) Contributions are provided by the party of the first part through other USGS regional or national programs, in the amount of: \$0.00

Description of the USGS regional/national program:
N/A
 - (d) Additional or reduced amounts by each party during the above period or succeeding periods as may be determined by mutual agreement and set forth in an exchange of letters between the parties.
 - (e) The performance period may be changed by mutual agreement and set forth in an exchange of letters between the parties.
3. The costs of this program may be paid by either party in conformity with the laws and regulations respectively governing each party.
4. The field and analytical work pertaining to this program shall be under the direction of or subject to periodic review by an authorized representative of the party of the first part.
5. The areas to be included in the program shall be determined by mutual agreement between the parties hereto or their authorized representatives. The methods employed in the field and office shall be those adopted by the party of the first part to insure the required standards of accuracy subject to modification by mutual agreement.
6. During the course of this program, all field and analytical work of either party pertaining to this program shall be open to the inspection of the other party, and if the work is not being carried on in a mutually satisfactory manner, either party may terminate this agreement upon 60 days written notice to the other party.

- 7. The original records resulting from this program will be deposited in the office of origin of those records. Upon request, copies of the original records will be provided to the office of the other party.
- 8. The maps, records, or reports resulting from this program shall be made available to the public as promptly as possible. The maps, records, or reports normally will be published by the party of the first part. However, the party of the second part reserves the right to publish the results of this program and, if already published by the party of the first part shall, upon request, be furnished by the party of the first part, at costs, impressions suitable for purposes of reproduction similar to that for which the original copy was prepared. The maps, records, or reports published by either party shall contain a statement of the cooperative relations between the parties.
- 9. USGS will issue billings utilizing Department of the Interior Bill for Collection (form DI-1040). Billing documents are to be rendered quarterly. Payments of bills are due within 60 days after the billing date. If not paid by the due date, interest will be charged at the current Treasury rate for each 30 day period, or portion thereof, that the payment is delayed beyond the due date. (31 USC 3717; Comptroller General File B-212222, August 23, 1983).

U.S. Geological Survey
United States
Department of the Interior

City of Cottonwood

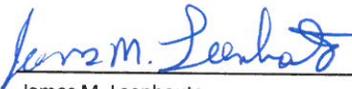
USGS Point of Contact

Customer Point of Contact

Name: James M. Leenhouts
Address: 520 N. Park Ave., Suite 221
Tucson, AZ 85719
Telephone: 520-670-6671 x278
Email: leenhout@usgs.gov

Name: Tom Whitmer
Address: 816 N. Main Street
Cottonwood, AZ 86326
Telephone: 928-340-2737
Email: twhitmer@cottonwoodaz.gov

Signatures and Date

Signature:		Date:	Signature:	Date:
Name:	James M. Leenhouts			
Title:	Director			

**USGS FY16–18 workplan to continue hydrologic data collection in support of
improving the understanding the hydrologic system of the Middle Verde River
Watershed (Verde Valley)**

Introduction

This workplan proposes to continue hydrologic monitoring that is providing critical data within the Verde Valley for use in future modeling and decision making. This workplan describes the second year of a 4-year monitoring plan and includes funds for 2 monitoring reports. In addition to continuing long-term groundwater and aquifer storage monitoring, the workplan also proposes to continue an investigation of current regional-aquifer contributions (as opposed to bank-storage and shallow-alluvial aquifer contributions) to flow in the Verde River and thus establish a metric from which to evaluate future changes.

Ongoing collection of basic hydrological data continues to improve understanding of the groundwater-flow system and provide valuable information that will assist in evaluation of the accuracy of the previously developed (Pool and others, 2010) or new groundwater-flow models. The ongoing data-collection tasks include continued operation of continuous groundwater-level stations, collection of stable isotopes of outflow from the groundwater system; and seasonal monitoring of aquifer-storage change (fig. 1). Long-term monitoring of groundwater levels defines the response of the groundwater system to variations in recharge and groundwater withdrawals. Monitoring of the stable isotopes in discharge waters helps define the distributions of recharge to the groundwater system. Monitoring of aquifer-storage change helps define the local hydrogeology and distributions of aquifer storage-coefficient throughout the major aquifers of Verde Valley.

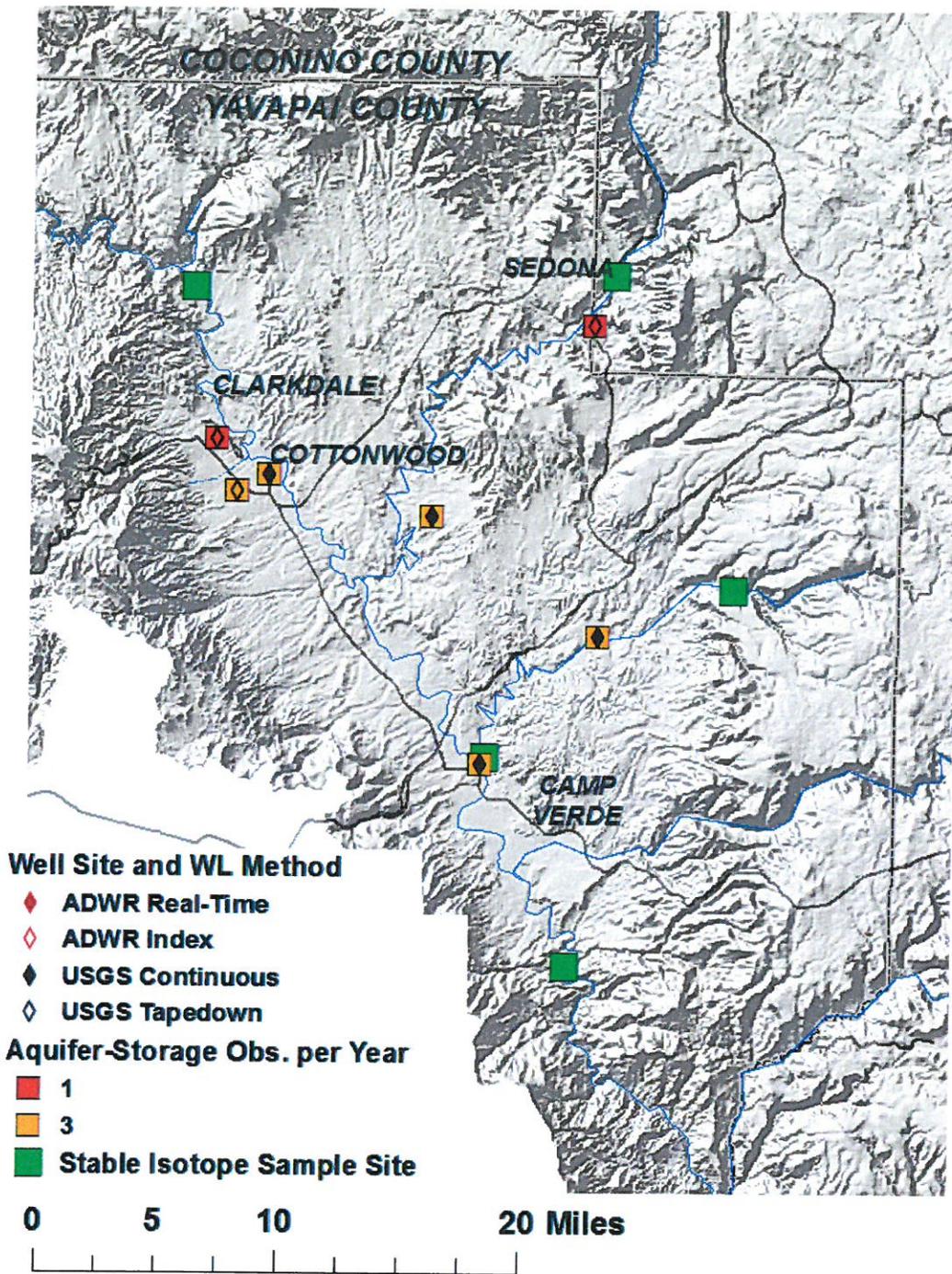


Figure 1. Proposed hydrologic monitoring in the Verde Valley.

Continuous Groundwater-Level Monitoring

USGS water-level monitoring compliments similar information collected by staff of the ADWR Field Services Program and provides a critical record of groundwater conditions that is essential for understanding both climate and human impacts on the groundwater-flow system. The monitored wells, in addition to other well sites that have long-term water-level records, can be used as calibration checks for any groundwater-flow model. Operation and maintenance of the monitoring well stations and periodic calibration of continuous monitoring equipment will be conducted through this task. The integrity of the data will be verified and the data populated into the USGS NWIS database.

USGS AzWSC has been continuously monitoring water levels in 4 or more wells in Verde Valley (Table 1) for several years. The sites are visited periodically (about 3 site visits per year) to service continuous water-level monitoring equipment (transducers and data loggers), download water-level data, and collect a manual depth-to-water observation (tapedown). The data are then uploaded to the web from office computers following each site visit. Currently four sites are instrumented to collect continuous water-level data. Two sites are monitored by seasonal water-level measurements.

Table 1. List of wells proposed for USGS water-level monitoring during FY16. Each continuous record site will be visited and water-level data downloaded approximately 3 times per year.

Site ID	Well Name	Depth to Water Data Frequency	Period of Record	Area
343409111511101	A-14-05 32BBB1	Continuous Hourly	Apr 00-present	Camp Verde
344302111532701	A-15-04 11AAB	Annual	Oct 01-present	Cornville
343850111460701	A-15-05 36DBD	Continuous Hourly	Feb 14-present	Rimrock
344544112025001	A-16-03 20DDC	Annual	Mar 00-present	Clarkdale
344428112004801	A-16-03 34ADC1	Continuous Hourly	Aug 14-present	Cottonwood
344354112014901	A-15-03 04ABA1	Continuous Hourly	New	Cottonwood

Data from the monitored wells can be accessed at:

<http://groundwaterwatch.usgs.gov/StateMaps/AZ.html>

Aquifer-Storage Monitoring

Aquifer-storage monitoring uses gravity methods to monitor the acceleration of gravity, which varies with the mass of water stored in the subsurface. The method is a direct

measure of subsurface changes in water mass that compliments water-level monitoring at co-located wells. Aquifer-storage change is often inferred from water-level change in a well; however, water-level change is a direct measure of hydraulic-head change, which is only an indirect indicator of storage change. Complimentary monitoring of storage change allows a better understanding of local hydrogeology at each site and often allows an estimate of aquifer storage coefficient, an important aquifer property that influences the response of the aquifer to changes in withdrawals and recharge. Aquifer storage coefficients are poorly defined throughout the aquifer systems in Yavapai County. Aquifer storage is a critical parameter in developing groundwater-flow models that realistically represent the timing of withdrawal and recharge effects on streamflow; accordingly, improved estimates will result in improved groundwater flow models.

The purpose of the aquifer-storage monitoring is to establish records for aquifer-storage change and develop estimates of aquifer storage coefficient at co-located wells where water-levels are also monitored. Initial observations at sites are completed with approximately 3 observations each year, to establish the typical range of variability and any trends that may be occurring at each site. The frequency of observations at each site is modified after trends are established. The frequency may be reduced to annual or less where no change is observed or a consistent multi-year trend is observed. The reduced frequency of observations allows expansion of the network of aquifer-storage monitoring to include more stations across a broader region. Complimentary observations of soil moisture in the upper 2 feet of soil are also made at aquifer-storage sites that have nearby exposed soils for the purpose of evaluating and correcting for the influence of near surface and non-aquifer variations in water storage on the gravity observations.

During 2009, USGS established aquifer-storage monitoring stations at 7 observation wells in Verde Valley and completed the initial observations. Each site was visited 3 times per year for a total of 21 observations annually. One site was discontinued in 2011 because observations indicated no substantial storage change was occurring in an area of confined aquifer and nothing more was expected to be learned from continued monitoring. In addition, observations at 3 sites are now limited to 2 observations per year because no seasonal variation has been observed. Discontinuation of sites and decrease visits at other sites has allowed expansion of the 21 observations per year to include an additional site for

this year. Suggestions for areas of interest and specific sites that might be included in monitoring are welcome. One additional site in Cottonwood was added to the network in 2011. Another site was added in 2014 to monitor a shallow aquifer in Cottonwood (fig. 1, table 2). A total of 8 sites are proposed for aquifer-storage monitoring during FY 2016. Five of the sites will be visited 3 times per year. Three sites will be visited twice per year.

Table 2. List of aquifer-storage monitoring sites proposed for monitoring in the Verde Valley during FY16

Local Well ID	Station Name	Water-Level Monitoring Agency	Obs. per Year	Period of Record	Area
A-15-03 04AAB	Cottonwood American Legion	ADWR Index Well and USGS Continuous	3	Mar 11-present	Cottonwood
A-16-03 34ADC1	Cottonwood Shallow	USGS continuous	3	Aug 14-present	Cottonwood
A-15-05 36DBD1	Weesner#2	USGS continuous	3	Feb 14-present	Rimrock
A-14-05 32BBB1	Camp Verde	USGS continuous	3	Oct 09-present	Camp Verde
A-15-04 11AAB	A-15-04 11AAB	USGS continuous	2	Oct 09-present	Cornville
A-17-06 E30BBB	Dori	ADWR index well	2	Oct 09-present	Sedona
A-16-03 20DDC	A-16-03 20DDC	USGS Tapedown	2	Oct 09-present	Clarkdale
TBD	TBD	TBD	3	New	TBD

Definition of sources of groundwater using geochemical methods

The USGS will continue collecting and processing repeat stable isotope measurements on a quarterly basis from the Verde River main stem and selected tributaries. These isotope measurements will continue a data set that began in 2009 to monitor changes in the sources of water to the river that may result from groundwater withdrawals or changes in recharge rates. Samples will be collected at gaging stations on the Verde River near Clarkdale, Camp Verde, and the head of perennial flow where Beaver Creek joins the Verde River. Samples will also be collected at gaging stations on Oak Creek near Sedona and Wet Beaver Creek near Rimrock. The integrity of the data will be verified and the data populated into the USGS database.

A dissolved gas isotope method of identifying areas of groundwater inflow to the Verde River, and of separating locally- from regionally-derived groundwater, was tested in FY15 and indicated areas of the Verde River within Mormon Pocket that had detectable Radon-222 (^{222}Rn) and high Helium-4 (^4He) concentrations which indicate a nearby source of groundwater contribution. This method has significant implications for understanding the watershed's water budget. In FY16, ten samples will be collected from the Verde River between Mormon Pocket and Clarkdale at locations guided by the results from FY15 and analyzed for ^{222}Rn , ^4He , other noble gases, water quality parameters and discharge. Two sites sampled in FY15 will be sampled again as part of the FY16 sample collection to understand annual variability in dissolved gas concentrations. Geochemical analysis to understand contribution of groundwater to the Verde River is needed to understand baseline conditions before any future changes to the system. Results from this analysis would be included in the proposed geochemical report in FY17.

Relevance and Benefits

This study addresses the science of groundwater hydrologic properties and water quality within the Verde River, Arizona, specifically related to assessing sources of groundwater. The study contributes to the goals of the USGS strategic science direction "A Water Census of the United States," as identified and described in the Strategic Science Plan of the USGS (U.S. Geological Survey, 2007, Facing tomorrow's challenges—U.S. Geological Survey Science in the Decade 2007-2017: U.S. Geological Survey Circular 1309, 69 p.)

Budget and Deliverable Products

The costs associated with the core project tasks in FY16 are included in table 3. The table also includes projected annual monitoring costs after 2016. The effectiveness of soil-moisture monitoring is being evaluated, which may result in proposed changes to that task including elimination or upgrading.

Personnel needed for the proposed work include two hydrologists, and additional support staff. USGS match funding will be used to support data collection and archiving.

Sufficient data have been collected to date to warrant publications of analyses of the data as well as a summary of what has been learned about the hydrologic system. Two reports are proposed: a water-level and storage report, and a geochemistry report. The costs of the reports are estimated in table 3, and publication dates would be FY17 for the geochemistry report and FY18 for the water-level and storage report.

All discrete groundwater-level measurement data that are collected pursuant to this agreement will be submitted to ADWR using the ADWR Online Water Level Data portal within three months of the end of the water year in which the data were collected. If the data portal is unavailable, the water level data should be submitted directly to the ADWR-Hydrology Division using the same electronic format required by the portal.

Table 3. Project costs and funding for regional groundwater and water quality monitoring in fiscal year 2016, and estimated project costs and funding for fiscal years 2017 and 2018 (Oct. 1, 2015 to Sept. 30, 2018). [the USGS cost share amount will be 39% of the total project cost.]

Item	FY16	FY17	FY18
Water-Level Monitoring	\$10,000	\$10,000	\$10,000
Aquifer-storage monitoring	\$20,000	\$20,000	\$20,000
Soil-moisture monitoring	\$1,500	\$1,500	\$1,500
Stable Isotopes - Verde flow	\$8,000	\$8,000	\$8,000
Groundwater inflow study	\$21,500	0	0
Water-Level and storage report	\$1,500	\$1,500	\$24,500
Geochemistry report	\$1,500	\$23,000	0
Miscellaneous supplies	\$1,000	\$1,000	\$1,000
TOTAL	\$65,000	\$65,000	\$65,000
Local Partners and ADWR	\$39,720	\$39,720	\$39,720
USGS Match	\$25,280	\$25,280	\$25,280