BOARD OF SUPERVISORS AGENDA ITEM REPORT
CONTRACTS / AWARDS / GRANTS

◯ Award ◉ Contract ◯ Grant

Requested Board Meeting Date: 10/06/2020

or Procurement Director Award ☐

**** = Mandatory, information must be provided***

***Contractor/Vendor Name/Grantor (DBA):**
Dept of Interior US Geological Survey

***Project Title/Description:**
Joint Funding Agreement for Water Resource Investigations

***Purpose:**
This JFA is a funding contribution from the Pima County Regional Flood Control District to this USGS project The purpose of this JFA between the USGS, Department of the Interior is to monitor changes in water stored in the Aquifer and evaluate land surface change, which may impact infrastructure, cause subsidence and land fissures.

***Procurement Method:**
This IGA is a non-Procurement contract and not subject to Procurement rules.

***Program Goals/Predicted Outcomes:**
Improve our knowledge of existing water resources and threats to infrastructure from loss of water in the Aquifer and subsequent land-surface elevation change.

***Public Benefit:**
Obtain a better capacity to estimate risks from land-surface changes to roads, sewer lines, and foundations, as well as knowledge of changes in water resource volume availability and physical location.

***Metrics Available to Measure Performance:**
Annually, the USGS, Department of the Interior will provide us with interpretive maps, a presentation on the updated data, and periodic technical reports.

***Retroactive:**
This is jointly funded by other parties, some of which began their support on October 3, 2020. All parties to the agreement were not available to sign on 10/3/2020.

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To: COB - 9.28.20
Ver. - 1
Pgs - 16 (1)
Addendum

Procure Dept 09/28/'20 AM10:50

Contract / Award Information

Document Type: CT Department Code: FC Contract Number (i.e.,15-123): 21-179

Commencement Date: 10/03/2020 Termination Date: 06/30/2024 Prior Contract Number (Synergen/CMS): ______

☒ **Expense Amount: $*** 65,811.00 ☐ Revenue Amount: $ ______

***Funding Source(s) required:** Flood Control Ops

Funding from General Fund? ○ Yes ◉ No If Yes $ ______ % ______

Contract is fully or partially funded with Federal Funds? ☐ Yes ☒ No

If Yes, is the Contract to a vendor or subrecipient? ______

Were insurance or indemnity clauses modified? ☐ Yes ☒ No

If Yes, attach Risk's approval.

Vendor is using a Social Security Number? ☐ Yes ☒ No

If Yes, attach the required form per Administrative Procedure 22-10.

Amendment / Revised Award Information

Document Type: ______ Department Code: ______ Contract Number (i.e.,15-123): ______

Amendment No.: ______ AMS Version No.: ______

Commencement Date: ______ New Termination Date: ______

Prior Contract No. (Synergen/CMS): ______

○ Expense or ○ Revenue ○ Increase ○ Decrease Amount This Amendment: $ ______

Is there revenue included? ○ Yes ○ No If Yes $ ______

***Funding Source(s) required:**

Funding from General Fund? ○ Yes ○ No If Yes $ ______ % ______

Grant/Amendment Information (for grants acceptance and awards) ○ Award ○ Amendment

Document Type: ______ Department Code: ______ Grant Number (i.e.,15-123): ______

Commencement Date: ______ Termination Date: ______ Amendment Number: ______

☐ Match Amount: $ ______ ☐ Revenue Amount: $ ______

***All Funding Source(s) required:**

***Match funding from General Fund?** ○ **Yes** ○ **No** **If Yes $** ______ **%** ______

***Match funding from other sources?** ○ **Yes** ○ **No** **If Yes $** ______ **%** ______

***Funding Source:** ______

***If Federal funds are received, is funding coming directly from the Federal government or passed through other organization(s)?** ______

Contact: Evan Canfield (Martha Guzman for P/U 4-4611)

Department: Regional Flood Control District Telephone: (520) 724-4678

Department Director Signature/Date: 9/25/2020

Deputy County Administrator Signature/Date: 9/25/2020

County Administrator Signature/Date: 9/25/2020

(Required for Board Agenda/Addendum Items)

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Arizona Water Science Center
520 North Park
Tucson, AZ 85719

September 23, 2020

Mr. Evan Canfield
Civil Engineering Manager
Pima County Regional Flood Control District
201 N. Stone Ave.
9th Floor, Ste. 7
Tucson, AZ 85701

Dear Mr. Canfield:

Enclosed is a signed original of our standard joint-funding agreement for the Aquifer-Storage Change and Land-Surface Elevation Change Monitoring in the Tucson Active Management Area project, during the period October 3, 2020 through June 30, 2024, in the amount of $65,811 from your agency. U.S. Geological Survey contributions for this agreement are $47,253 for a combined total of $113,064. Please sign and return one fully-executed original to Autumn Henson at the address above.

Federal law requires that we have a signed agreement before we start or continue work. Please return the signed agreement by **October 3, 2020**. If, for any reason, the agreement cannot be signed and returned by the date shown above, please contact Elizabeth (Libby) Kahler by phone number (520) 670-3335 or email ekahler@usgs.gov to make alternative arrangements.

This is a fixed cost agreement to be billed quarterly via Down Payment Request (automated Form DI-1040). Please allow 30-days from the end of the billing period for issuance of the bill. If you experience any problems with your invoice(s), please contact Alexis Lopez at phone number (520) 670-3339 or email at aslopez@usgs.gov.

The results of all work performed under this agreement will be available for publication by the U.S. Geological Survey. We look forward to continuing this and future cooperative efforts in these mutually beneficial water resources studies.

Sincerely,

JAMES LEENHOUTS
Digitally signed by JAMES LEENHOUTS
Date: 2020.09.23 17:34:43 -07'00'

James M Leenhouts
Director

Enclosure
21ZFJFA0800 (2)

Contract No: CT-FC-21-179 Amendment No: ______

This number must appear on all correspondence and documents pertaining to this contract

Form 9-1366
(May 2018)

U.S. Department of the Interior
U.S. Geological Survey
Joint Funding Agreement
FOR
Water Resource Investigations

Customer #: 6000000793
Agreement #: 21ZFJFA0800
Project #: ZF009EF
TIN #: 86-6000543

Fixed Cost Agreement YES[X] NO[ ]

THIS AGREEMENT is entered into as of the October 3, 2020, by the U.S. GEOLOGICAL SURVEY, Arizona Water Science Center, UNITED STATES DEPARTMENT OF THE INTERIOR, party of the first part, and the Pima County Regional Flood Control District party of the second part.

1. The parties hereto agree that subject to the availability of appropriations and in accordance with their respective authorities there shall be maintained in cooperation Water Resource Investigations (per attachment), 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) include In-Kind-Services in the amount of $0.00

(a) $47,253 by the party of the first part during the period October 3, 2020 to June 30, 2024

(b) $65,811 by the party of the second part during the period October 3, 2020 to June 30, 2024

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

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 cost, 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. The Parties acknowledge that scientific information and data developed as a result of the Scope of Work (SOW) are subject to applicable USGS review, approval, and release requirements, which are available on the USGS Fundamental Science Practices website (https://www.usgs.gov/about/organization/science-support/science-quality-and-integrity/fundamental-science-practices).

Form 9-1366
(May 2018)

U.S. Department of the Interior
U.S. Geological Survey
Joint Funding Agreement
FOR
Water Resource Investigations

Customer #: 6000000793
Agreement #: 21ZFJFA0800
Project #: ZF009EF
TIN #: 86-6000543

9. Billing for this agreement will be rendered **quarterly**. Invoices not paid within 60 days from the billing date will bear Interest, Penalties, and Administrative cost at the annual rate pursuant the Debt Collection Act of 1982, (codified at 31 U.S.C. § 3717) established by the U.S. Treasury.

USGS Technical Point of Contact

Name:	Elizabeth (Libby) Kahler Hydrologist
Address:	520 N. Park Ave Tucson, AZ 85719
Telephone:	(520) 670-3335
Fax:	
Email:	ekahler@usgs.gov

Customer Technical Point of Contact

Name:	Evan Canfield Pima County Regional Flood Control District
Address:	201 N. Stone Ave. 9th Floor, Ste. 7 Tucson, AZ 85701
Telephone:	(520) 724-4636
Fax:	
Email:	evan.canfield@pima.gov

USGS Billing Point of Contact

Name:	Alexis Lopez Budget Technician
Address:	520 N. Park Ave Tucson, AZ 85719
Telephone:	(520) 670-3339
Fax:	
Email:	aslopez@usgs.gov

Customer Billing Point of Contact

Name:	Evan Canfield Pima County Regional Flood Control District
Address:	201 N. Stone Ave. 9th Floor, Ste. 7 Tucson, AZ 85701
Telephone:	(520) 724-4636
Fax:	
Email:	evan.canfield@pima.gov

U.S. Geological Survey
United States
Department of Interior

Signature

By JAMES LEENHOUTS Digitally signed by JAMES LEENHOUTS Date: 2020.09.23 17:35:14 -07'00' **Date:**

Name: James M Leenhouts

Title: Director

Pima County Regional Flood Control District

Signatures

By____________________ **Date:** ________

Name:

Title:

By [signature] **Date:** 9/25/2020

Name:

Title:

By Kell Olson Digitally signed by Kell Olson Date: 2020.09.24 17:26:09 -07'00' **Date:**

Name: Kell Olson, as to form

Title: Deputy County Attorney

Aquifer-Storage Change and Land-Surface Elevation Change Monitoring in the Tucson Active Management Area, October 3, 2020 to June 30, 2024

Prepared by: Libby Kahler, U.S. Geological Survey, AZ Water Science Center
Date: July 23, 2020

Introduction

The U.S. Geological Survey (USGS) has been monitoring aquifer-storage change within the Tucson Active Management Area (AMA) since the late 1990s, in cooperation with local and state agencies. The extent of monitoring has varied through time, depending on the number of active cooperators in each funding cycle and their interests, but on average has involved monitoring changes in gravity at over 100 benchmarks in the Tucson AMA, annually to biannually. A number of reports have been published based on data collected through this project, including the most recent report with results from 2003 to 2016 (Carruth and others, 2018). Results from that report for the monitoring period from 2014 to 2016 indicate that basin-wide positive aquifer storage change occurred for the first time in the Tucson Basin and continues to occur in Avra Valley (fig. 1). Data collected between 2016 and 2018 however indicate negative storage change to the south of the Tucson Basin (fig. 2), and continuing net storage loss from the Tucson Basin.

Over the course of this project, development in the Tucson AMA has led to a loss of monitoring stations. Continued monitoring will require construction of stations to replace those lost, and to increase the resolution of the network in critical areas. Stations should also be added in areas of interest to project cooperators, including at new artificial recharge facilities, groundwater savings facilities, or locations where development and increased pumping may be occurring. Additionally, the highly variable nature of natural recharge resulting from precipitation continues to be of interest and increasing the number of stations along ephemeral channels would aid in identifying storage changes due to such infiltration. This proposal includes construction of additional station to capture changes occurring in these areas and increase the density of stations across the whole monitored area.

This project has relied on two LaCoste and Romberg D-type relative gravimeters for relative data collection since the project beginning. These meters are more than thirty years old and are less stable than newer relative gravimeters, resulting in longer collections times per measurement, and increased personnel hours to complete a network survey. A ZLS Burris relative gravimeter that belongs to the USGS Southwest Gravity Program (SGP) is currently being utilized, to increase the efficiency of data collection, but this limits the ability of other SGP projects to collect data for the duration of the Tucson gravity surveys. For this reason, the SGP is planning on purchasing a new relative gravimeter, to help support both this project and all other current gravity monitoring projects. A portion of the cost for this new equipment is factored into the budget for this funding cycle, proportional to the amount of usage of that equipment by this project.

Finally, the funding cycle for this project has historically been three years but is proposed here as four years. The timing of surveys in this proposal includes surveys of the full network every other year, beginning in the first year, and partial surveys at critical locations in years that full surveys are not completed. Changing the length of the project to four-year intervals allows enough time after the last full survey to publish and communicate results to cooperators, and discuss future needs the project can address.

This proposal outlines a new scope of work for continued and expanded monitoring of aquifer-storage change and continued monitoring of land-surface elevation change in the Tucson AMA for the period of October 3, 2020 through June 30, 2024.

Problem

Aquifer-Storage Change

The volume of water artificially recharged or pumped from an aquifer is easily measured. Estimations based on indirect methods must be used for other groundwater-budget components, including withdrawals by small capacity (<35 gallon per minute) wells, evapotranspiration, groundwater underflow from adjacent basins, incidental recharge from effluent recharge and other sources, and natural recharge from many sources including mountain fronts and ephemeral streams. This estimation of several groundwater-budget components results in large uncertainty in the groundwater budget. The greatest uncertainty can be attributed to a lack of information about natural recharge and groundwater-storage change. Estimates of the natural recharge rates are highly uncertain and depend on accurate measurements of annual precipitation and streamflow, which have high interannual variation (Pool, 2005). Estimates of groundwater-storage change are also highly uncertain when computed as residuals in the water budget equations because the storage term includes the cumulative uncertainty of all other components.

Water levels in wells have been monitored to estimate aquifer-storage changes. However, use of water-level variations entails significant assumptions about the hydraulic properties of the aquifer system. One difficulty is the heterogeneity of hydrologic properties of the aquifer; the alluvial sediments of the aquifer vary in lithology and texture, both laterally and with depth. Thus, hydraulic properties estimated from water levels in individual wells may not adequately represent aquifer characteristics at distances away from the well. A second difficulty is monitor- well design; particularly when water levels are measured in deep wells that tap multiple aquifers, most of which are confined and have accordingly low storage properties. Water levels in these deep wells open to multiple aquifers represent a composite of water levels from several aquifer units. When these composite water levels are used to estimate storage changes, the hydrologic properties used in the calculation typically do not reflect the range of aquifer materials over which the well is screened. Water-level responses also depend on the geometry and lithology of the hydrogeologic units that constitute the aquifer system that wells sample. This information often is incomplete, or uncertain. Because of these complexities and requisite assumptions, use of water-level variations as the only indicators of storage change can be uncertain, and cannot be reliably extrapolated beyond the well location.

Aquifer-storage can be monitored by measuring changes in gravity alone. As water is added or removed from the aquifer, there is a change in mass and a corresponding measurable change in gravity. The repeat microgravity method, developed primarily at the University of Arizona and the U.S. Geological Survey (USGS) Arizona Water Science Center, is an established method for monitoring aquifer-storage changes in alluvial basins. The method has successfully been used to track the dispersal of water recharged through the channel of an ephemeral stream in Tucson, Arizona (Pool, 1997). Monitoring of gravity and groundwater levels in the Tucson Basin has shown that large changes in groundwater storage, as much as several feet of water, have occurred that were not reflected in comparable water-level changes (Carruth and others, 2018). Gravity monitoring of a spreading-basin artificial recharge facility in Avra Valley, Arizona, showed preferential groundwater flow, as storage accumulated to the west of three recharge basins but not to the east (Kennedy, 2016). Also at that facility, gravity data proved useful for identifying hydraulic conductivity and storage parameters in a MODFLOW groundwater model (Kennedy and others, 2016). The method is presently in use by the USGS Southwest Gravity Program (http://go.usa.gov/xqBnQ) for several projects across New Mexico, Arizona, and California.

Land-Surface Elevation Change

Permanent land subsidence can occur in alluvial basins when water is removed from aquifer systems (Galloway and others, 1999). Aquifer systems in unconsolidated rocks such as those in the Tucson AMA are supported by the granular skeleton and the pore-fluid pressure. When groundwater is withdrawn and the pore-fluid pressure is reduced, the granular skeleton is compressed, causing some lowering of the land surface. Both the aquifers (sand and gravel) and aquitards (clay and silt) of aquifer systems are deformed as a result of changes to the pore-fluid pressure and skeleton, but to different degrees. Most permanent subsidence occurs due to the irreversible compression of aquitards during the slow process of aquitard drainage (over a number of years).

Permanent subsidence, seasonal elastic deformation, and uplift have been observed in Tucson Basin and Avra Valley. Rates of compaction in Tucson Basin in relation to water-level decline have been less than 0.5 foot per 100 feet of water-level decline. Comparison with the Eloy and Phoenix areas (greater than 1 foot per 100 feet of decline) suggests that compaction to date in the Tucson region has been largely elastic and recoverable. Compaction and land subsidence can be slowed or stopped, and in areas having appropriate geologic conditions, reversed to some extent by eliminating groundwater withdrawals or through artificial recharge.

The City of Tucson has increased delivery of recharged, recovered, and blended Central Arizona Project (CAP) water, while reducing pumping from the Central Well Field. This appears to have reduced or stopped water-level declines an induced recovery in most areas. However, subsidence due to previous levels of pumping and maximum water-level declines will continue in some areas into the future. Continued monitoring of areas having the greatest potential for subsidence will provide information that resource managers can use in the development and implementation of mitigation efforts.

Objectives

The objectives of this project are to monitor aquifer-storage change and land-surface elevation change within the Tucson AMA. The updates to the network proposed here would enable better estimates of storage change occurring in sensitive areas, such as the southern portion of the Tucson Basin. Additional stations near ephemeral channels and in the Catalina foothills would increase the resolution of storage changes that may be related to variations in natural recharge.

Data releases published after every full survey (every other year) will be used to produce an interpolated map of storage changes across the monitored area, which will be presented to the cooperators and the community and be made publicly available online.

Relevance and Benefits

This study directly contributes to the USGS Water Science Strategy goal to "Provide society the information it needs regarding the amount...of water in all components of the water cycle at high temporal and spatial resolution, nationwide" with the specific objective of advancing hydrologic monitoring networks and techniques (Evenson and others, 2013).

Aquifer-storage monitoring

Microgravity surveys are an efficient, noninvasive means of measuring changes in the amount of groundwater in Southwestern alluvial basins. Monitoring changes in groundwater storage in the Tucson AMA is a means to monitor the status of the basin aquifers and to track the progress toward the statutory goals of the 1980 Groundwater Management Act. This will be of value as water-supply entities in eastern Pima County address needs to manage and augment groundwater resources.

Water-level data entail assumptions about aquifer and well properties; thus, monitoring of gravity changes as pumping decreases in the basin currently is the only way to measure attendant changes in the amount of water in the aquifer and determine if and when aquifer recovery is occurring. This information conceivably will serve as part of a basis for decisions regarding distribution of groundwater withdrawals to help in mitigating land subsidence or aquifer storage losses in particular areas.

Aquifer-storage change is one of the three components of the groundwater budget. The other two are inflow to and outflow from the aquifer system. Measurement of aquifer-storage change and measures and estimates of outflow enable better estimation of recharge and development of a more reliable groundwater budget for the basin. Measures of aquifer-storage change increase the reliability and utility of groundwater flow and management models. Use of storage-change data to improve model calibration enables additional reduction in the uncertainty of model results. The improved understanding of the movement, distribution, volume, and availability of ground water, to which storage monitoring contributes, enables more effective water management in the Tucson AMA and in other areas of the State.

Surveys in the Tucson AMA since 1998 have provided previously unavailable data quantifying recharge and storage changes. For example, the results of aquifer-storage change monitoring in the Tucson Basin between 1998 and 2012 indicate that storage change and recharge can vary considerably from year to year (Carruth and others, 2018). It is possible that just a few years may account for the majority of recharge to southwestern aquifers for an entire decade or more. These data are being used to improve the understanding of the aquifer systems and to improve groundwater flow models that will be used in resource planning.

Land-surface elevation change monitoring

Some types of infrastructure are more sensitive to changes in land slope than other types. Sewer systems are largely gravity driven and are designed and constructed at slopes of about 2 feet per 1,000 feet. Small slope changes can cause operational problems under some conditions. Accurate determination of the rates, amounts, and distribution of land subsidence, together with delineation of higher-risk areas, will provide data upon which mitigation and protection plans can be based. Subsidence rates will increase when the stress threshold between elastic and inelastic compaction is exceeded. Because it is not possible to reliably estimate when the threshold might be exceeded in the Tucson AMA, and infrastructure damage becomes more likely, subsidence monitoring also provides a means to identify the type of compaction that is occurring.

Groundwater withdrawals from the city's Central Well Field has been substantially decreased as CAP recharge and recovery reaches full capacity. However, regional subsidence in response to previous pumping is unlikely to end in the near future. It will continue until the aquifer system reaches pressure equilibrium. Observation of the timing and magnitude of aquifer responses will further improve the understanding of land subsidence and of how the aquifer systems function. Monitoring data also will contribute to a better understanding of the responses of the aquifer systems to withdrawals and will provide additional insight in future plans for well-site selection, recharge efforts, and water-management programs.

Differential subsidence refers to a relatively large amount of subsidence over a relatively short distance and can cause focused effects. For example, localized subsidence of as little as one-half inch can necessitate rebuilding a highway overpass. Differential subsidence has the potential to separate pipe joints of sewer and water lines—this can lead to system disruptions and roadway damage. Also vulnerable are the concrete lining sections of engineered channels that rely on the integrity of expansion joints to prevent flood damage. Costs to address such infrastructure failures are high. Awareness of the distribution and magnitude of differential subsidence can help to guide the design and implementation of maintenance and monitoring schedules, selection of monitoring methods, and the design and construction of future infrastructure.

Approach

Repeat microgravity surveys in Southwest alluvial basins are useful for detecting local changes in the gravitational field of the Earth attributed to water mass change (Pool, 2008). As water is added to or removed from the aquifer, there is a change in mass and a corresponding measurable change in gravity. Two instruments are used for microgravity surveys, the relative-gravity meter and the absolute-gravity meter. The highly portable relative-gravity meter is used to measure relative gravity differences between stations. The absolute-gravity meter is used at a smaller number of stations to provide "benchmark values" of absolute gravity. These measurements are combined (post-processed) in a manner similar to how height differences and elevations are used in geodetic levelling surveys. This combination of relative- and absolute-gravity meters provides the highest-possible accuracy and represents a unique capability of the USGS Southwest Gravity Program.

Proposed locations for additional gravity stations are shown in figure 4. The final configuration of stations will utilize existing infrastructure where possible, and depend on permission to access some locations. The location of some of the proposed stations is based on the result of monitoring in previous time periods. Specifically, increasing the number of stations in the eastern foothills of the Catalina Mountains is intended to better capture storage changes due to infiltrated runoff resulting from precipitation; new stations in the southern part of the Tucson Basin will increase certainty related to long-term negative storage changes often observed in that area. The number of absolute gravity stations is also increased, to support the larger network and to include a greater proportion of stations as datum observations.

Land-surface elevation change is monitored across the Tucson AMA by measuring changes in land surface elevation over time (approximately annually) with Interferometric Synthetic Aperture Radar (InSAR). These data come from the Arizona Department of Water Resources (ADWR), which has an InSAR program in the Tucson AMA. InSAR is a technique that utilizes interferometric processing to compare the amplitude and phase signals received during one pass of the satellite-based SAR platform over the AMA with the amplitude and phase signals received during a second pass of the platform over the same area but at a different time.

Data Management Plan

Gravity data for the project will be collected using a Micro-g Lacoste A-10 absolute gravity meter and relative-gravity meters made by Lacoste and Romberg and ZLS Corporation. All gravity data will be collected by trained personnel using techniques consistent with published methodologies for using microgravity to investigate and monitor aquifer-storage change and land subsidence (Carruth and others, 2018; Kennedy and others, *in press*).
Data will be archived in the Arizona Water Science Center gravity data archive. All data will be published as one or more formal data releases at the USGS Southwest Gravity Program ScienceBase website (http://go.usa.gov/xqBnQ). Data collected during each year of a full survey will be published online within five months of final data collection.

All gravity data for the project will be processed, reviewed, approved, and published following QA/QC protocols established by the USGS Southwest Gravity Program (Kennedy and others, *in press*). Gravity data will be processed by USGS personnel in the office within 3 months of data collection. An experienced reviewer will review and check the data for accuracy. Data releases will be peer-reviewed and include complete metadata. Once published, data will be publicly accessible.

GPS data of station positions will be archived at the Arizona Water Science Center. Data will be processed using the National Geodetic Survey Online Positioning User Service or Project Networks and (or) OPUS projects service.

Products and Timeline

The schedule of work is based on ADWR's fiscal year, which begins July 1 and ends June 30, and is contingent on receiving signed agreements from the cooperators listed below by 9/30/2020. Gravity surveys of the entire network will be completed every other year (ADWR fiscal years 2020-2021 and 2022-2023) followed by a data release, and a partial survey will be completed in each of the off years. A coverage map of storage-change will be generated from published data and shared with cooperators following full surveys. Partial surveys in the off years will not result in maps of storage change but will provide a snapshot of change in different parts of the network and allow for annual monitoring at critical locations. Similarly, partial surveys will not result in a data release, however, cooperator meetings or updates may be requested after partial surveys.

Calendar Year	2020		2021				2022				2023				2024	
State Fiscal Year	FY 20-21				FY 21-22				FY 22-23				FY 23-24			
State Fiscal Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
USGS Fiscal Year		*FY 2021*				*FY 2022*				*FY 2023*				*FY 2024*		
Network planning and permitting																
Station construction																
Gravity survey																
Cooperator meeting																
Data release publication																
Purchase equipment																

Table 1. Project timeline by quarter.

The project budget shown in Table 2 represents tentatively approved contributions from the cooperators listed. Proportional costs to different cooperators are roughly based on the number of monitoring stations that are of interest to the cooperator and are informed by prior contributions to this project by each cooperator. The proposed monitoring network shown in figure 4 depends on signed agreements from all the cooperators listed.

Costs in the state fiscal year of 21-22 include a proportional contribution to the planned purchase of a new relative gravimeter and includes the costs of doing a meter comparison to ensure a seamless transition between meters moving forward.

State FY	FY 20-21		FY 21-22		FY 22-23		FY 23-24	
	Cooperator	USGS match	Cooperator	USGS match	Cooperator	USGS match	Cooperator	USGS match
ADWR	$ 19,965	$ 14,040	$ 25,573	$ 18,380	$ 26,162	$ 18,945	$ 19,422	$ 14,064
Pima County	$ 14,420	$ 10,140	$ 18,470	$ 13,274	$ 18,895	$ 13,682	$ 14,026	$ 10,157
Marana	$ 4,430	$ 3,181	$ 4,429	$ 3,181	$ 4,429	$ 3,181	$ 4,429	$ 3,181
Tucson Water	$ 4,991	$ 3,510	$ 6,394	$ 4,595	$ 6,541	$ 4,737	$ 4,855	$ 3,515
Totals	$ 43,806	$ 30,871	$ 54,866	$ 39,430	$ 56,027	$ 40,545	$ 42,732	$ 30,917

Table 2. Project budget by state fiscal year. FY 20-21 is 7/1/2020 – 6/30/2021, but work, and therefore billing, would not begin until 10/3/2020. Budget is based on agreements being signed by 10/3/2020. Pima County stands for Pima County Regional Flood Control District.

Figures

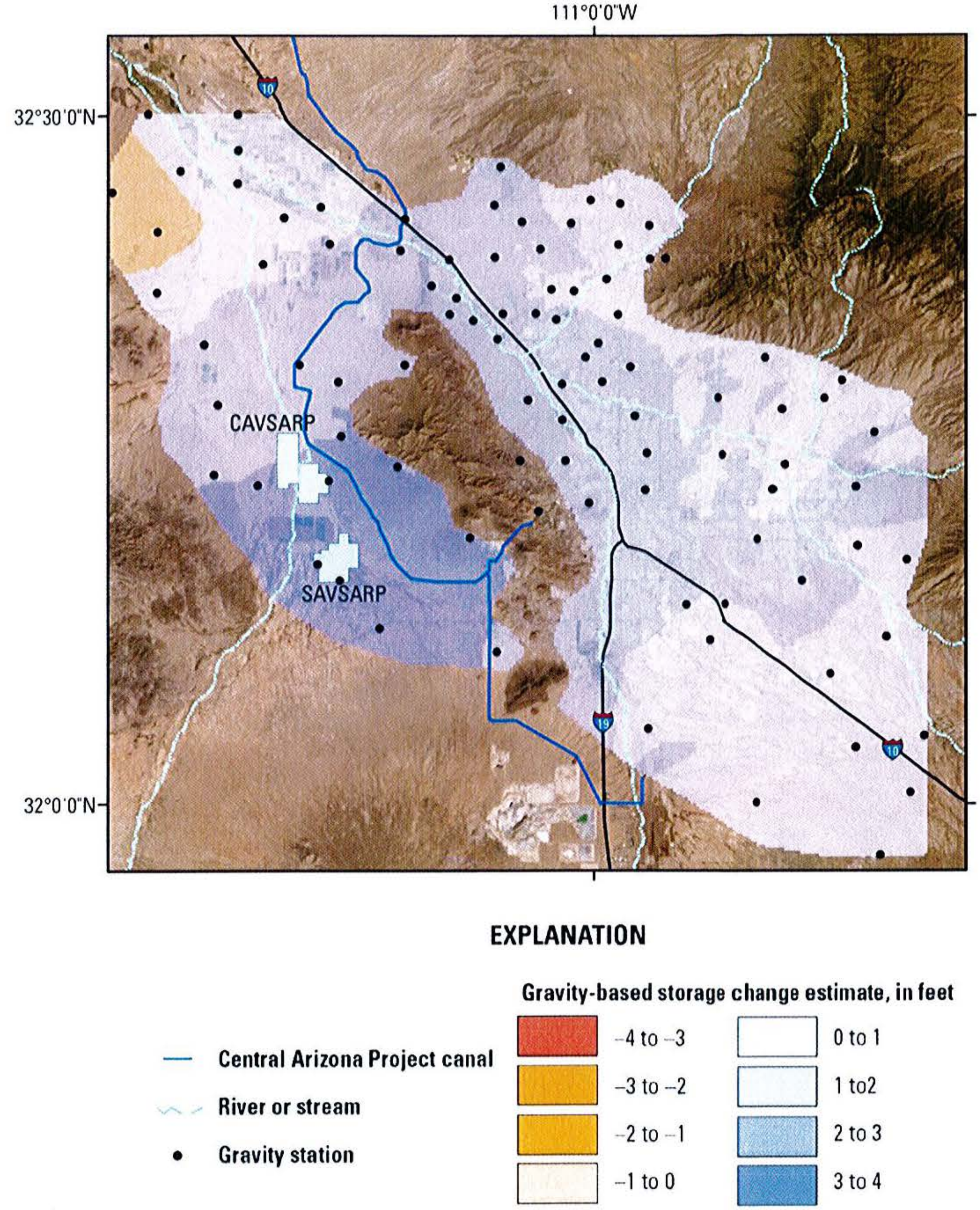

Figure 1. Storage-change from 2014 to 2016 was positive over almost the entire monitored area.

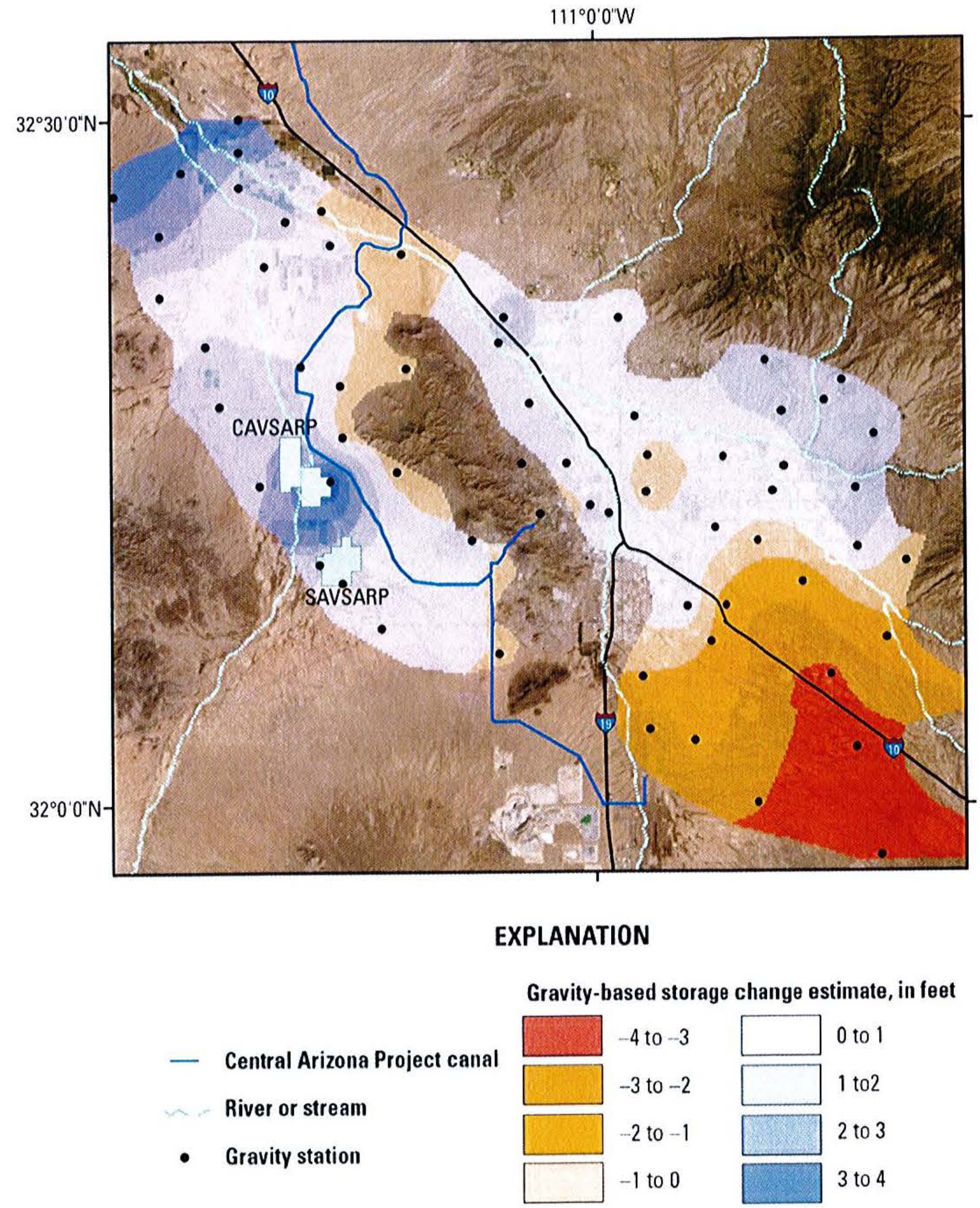

Figure 2. Negative storage change between 2016 and 2018 in the southern part of the Tucson Basin is more typical throughout this project's history.

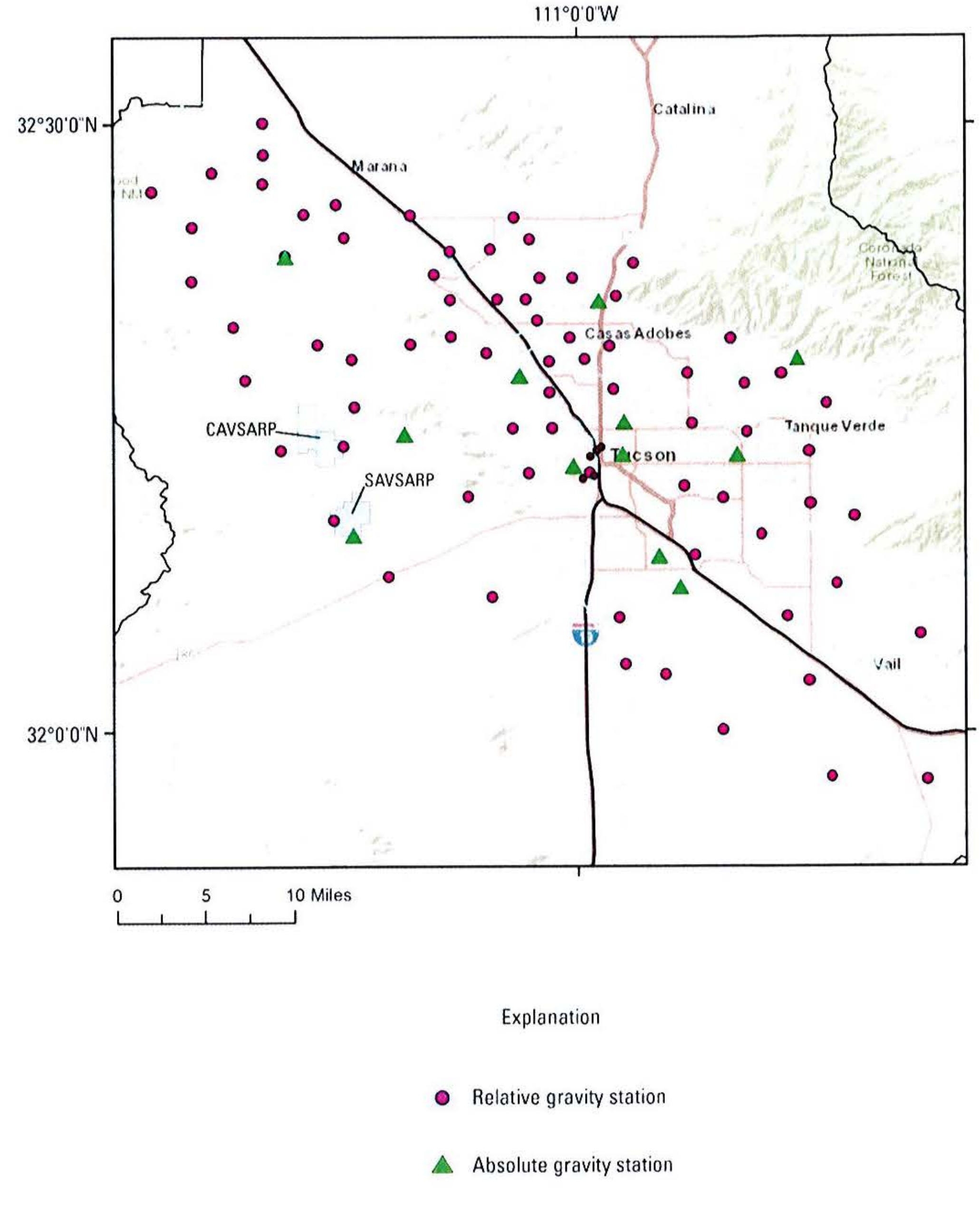

Figure 3. Current relative and absolute gravity stations in the network. Benchmarks have been lost over time, largely due to development but also as a result of aging benchmarks deteriorating and becoming unstable.

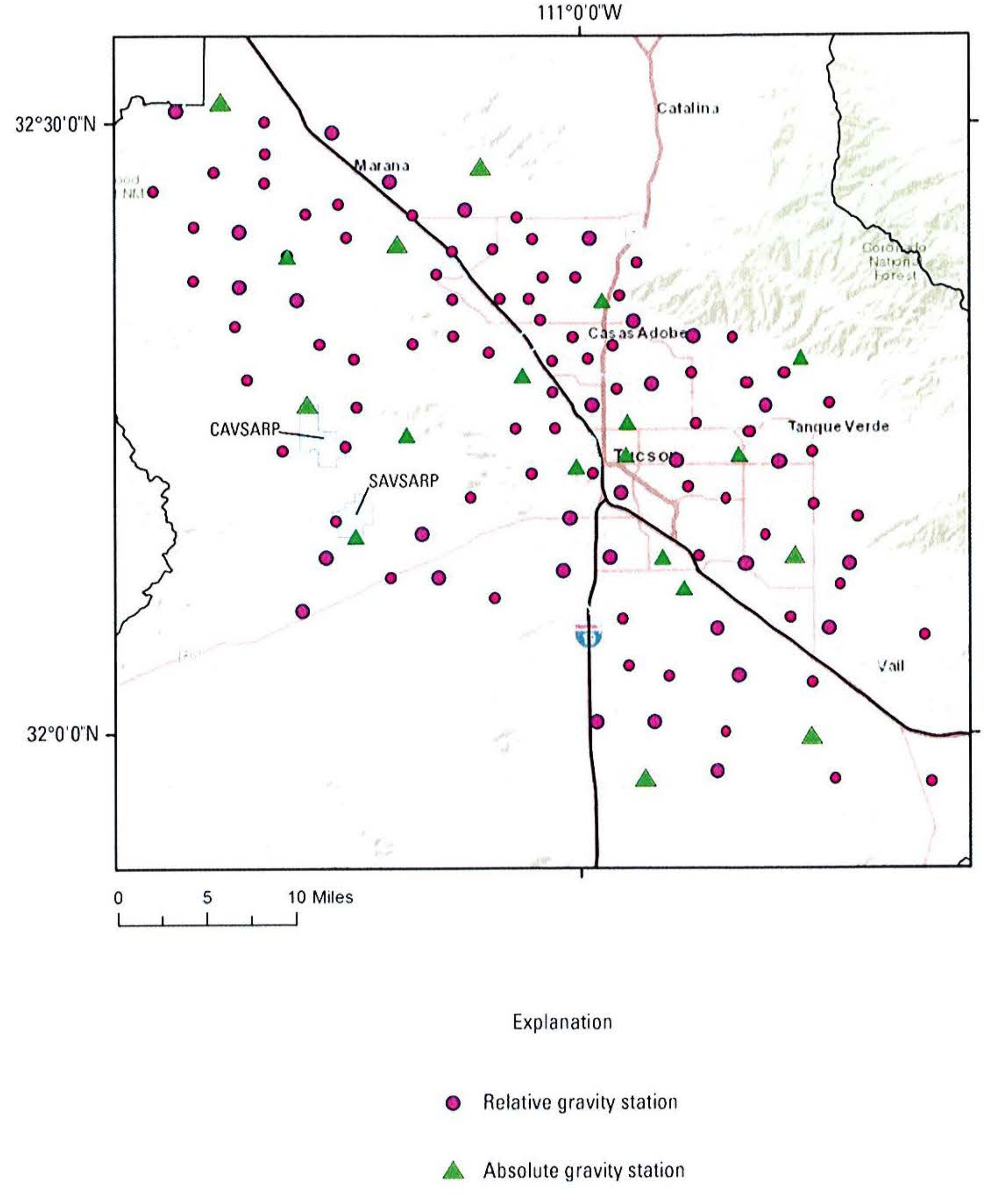

Figure 4. New stations proposed here are shown as slightly larger than the existing stations. There are 7 additional absolute stations and 31 additional relative stations shown here. The final distribution of new stations depends on access to roads and some private areas, and on

measurement quality concerns such as background noise near roads. This proposed network is based on obtaining signed agreements with the budget shown in Table 2.

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