

## **Award: G16AC00020**

Oklahoma Water Resources Board

“Oklahoma NGWMN”

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## Background

The Oklahoma Water Resources Board (OWRB) exists to manage and improve the state's water resources. Its primary duties and responsibilities include water use appropriation and permitting, water quality monitoring and standards, financial assistance for water/wastewater systems, dam safety, floodplain management, water supply planning, technical studies and research, and water resource mapping. The OWRB has historically maintained an annual groundwater level measurement program that began in the 1950s with an expansion in the 1970s. This annual measurement program has varied in size but has continued uninterrupted since its inception, mainly informing drought monitoring in the state and allocation of water rights. USGS Principal Aquifers that have been historically monitored include the Ada-Vamoosa (began in 1995), Arbuckle Simpson (began 1994), Blaine (began 1950), Central Oklahoma (began 1977), High Plains (began 1966), Rush Springs (began 1976), and Trinity (began 1981) Aquifers. With the initiation of the Groundwater Monitoring and Assessment Program (GMAP) in 2013, this annual monitoring network's density has been improved. The Ada-Vamoosa currently has 34 annual monitoring sites, Arbuckle Simpson has 21 sites, Blaine has 25, Central Oklahoma has 50, High Plains has 217, Rush Springs has 88, and Trinity has 32 sites.

The Groundwater Monitoring and Assessment Program (GMAP) includes water quality sampling and water level measurement networks, aiming to characterize both the ambient quality and quantity of the state's major aquifers. The baseline monitoring network for each aquifer is a comprehensive water level and water quality sampling event tentatively scheduled for every 5<sup>th</sup> year. In general, this network strives for a density of 1 quality site per 100-150 km<sup>2</sup> and 1 quantity site per 50-100 km<sup>2</sup>, dependent on the areal extent of the aquifer. Baseline evaluations have been completed for the Ada-Vamoosa (2014), Arbuckle Simpson (2015), the Central Oklahoma (2014), the southern non-Panhandle portion of the High Plains (2013), the panhandle portion of the High Plains (2016), the Rush Springs (2013), and the Trinity (2015) Aquifers. A baseline evaluation is scheduled for the Ozark Plateaus in 2017. The Blaine (2015) was scheduled for a water level-only evaluation.

GMAP also collects data multiple times a year through a trend network to recognize seasonal changes, changes due to climate, and/or changes due to usage over time. The Water Level Trend monitoring network is implemented after baseline evaluation is completed and measures sites three times a year. This network consists of about 50% of the baseline water level sites, and GMAP strives to include historic wells in order to continue long-term water level records. The Ada-Vamoosa currently has 16 trend monitoring sites, Arbuckle Simpson has 11 trend sites, Blaine has 12, Central Oklahoma has 27, the southern non-Panhandle portion of the High Plains has 21, Rush Springs has 38, and the Trinity has 13 trend sites. Water Level Trend networks are scheduled for implementation in the panhandle portion of the High Plains (2017), and the Ozark Plateaus (2018) Aquifers. To facilitate this effort, many wells across the state have been equipped with water level data loggers. Water Quality Trend networks, to consist of about 20% of the baseline sites and to be sampled twice a year, are not scheduled for implementation until 2018.

This scope of work for this award included selection of sites for the NGWMN Water Level Network, classification of sites, documentation of field and data-management practices, and investigation into forming a connection from OWRB Aquarius database to the NGWMN portal. OWRB's Water Quality Division, with the help of the Aquarius Database Manager, focused on constructing a web-service to allow NGWMN connection and exploring how best to transfer OWRB data to the NGWMN Data Portal.

## Site Selection & Classification

Upon evaluating GMAP's current water level network and NGWMN goals, continuous data recorder sites in each Principal Aquifer should be able to fulfill the NGWMN minimum density goal based on area for the trend network of 1 site per 1,000 mi<sup>2</sup>. With the addition of OWRB trend water level sites, manually measured three times

per year, density goals for the NGWMN trend network based on usage and development of the Principal Aquifers could potentially be met. The OWRB's annual water level sites should be able to fulfill density goals for the NGWMN surveillance network. Due to limited staff time and the unknown variables involved with connecting to the NGWMN through web-services, only continuous recorder sites in two principal aquifers were targeted. Ten continuous recorder sites were identified for the NGWMN registry; five sites in the Rush Springs Aquifer and five sites in the Central Oklahoma (known locally as Garber-Wellington) Aquifer. A few recorders in each aquifer are located at Oklahoma Mesonet sites that concurrently collect meteorological data.

GMAP selects sites to install recorders through a multi-step evaluation process. Once well location and placement in the correct aquifer is verified, landowners are contacted for permission to access their property and their well. Upon receiving permission, reconnaissance visits to each site are made to verify location, depth, and diameter of well casing. Staff also makes note of other construction details, if the well was functioning, and any potential sources of contamination nearby. If a site is currently unused, the owner has no plans for use in the near future, and the site is secure from the public but accessible by OWRB staff, then it is considered a candidate for continuous monitoring. Wells with a period of record prior to GMAP were also considered. Final selection are made by the Groundwater Quality Manager. Some recorder sites in the GMAP program are inherited from the OWRB's Planning & Management (P&M) section. At the end of an intensive aquifer study, P&M staff will recommend sites that they have good data from as candidates for long-term continuous recorders through the GMAP program. Final selection is done through collaboration between the P&M and the Groundwater Quality managers.

Each of the ten continuous recorder sites would fall under the NGWMN monitoring category of Trend. They are dedicated wells, continuously measuring water levels, and sites can fulfill the requested density of 1/1,000 mi<sup>2</sup> in the principal aquifers. Metadata concerning construction & lithology for most sites should be complete.

In order to determine the subnetwork category, GMAP staff first noted the period of record for each well and when a continuous recorder was installed. Most recorder sites were measured manually for years prior to installation. Staff examined land use, major landmarks, surface waters, and proximity to cities within 3 miles of the site using GIS, aerial maps, and site field notes. Staff also noted the number of reported well records within those 3 miles, along with any permits for groundwater usage and stream water diversion. Each site was examined individually and all of the above information was used to determine the classification.

Utilizing the tip sheets and well registry guidance provided by the NGWMN, sites and their metadata were compiled and then entered into the online registry.

## **Web Services**

Continuous recorder water-level data is housed in Aquatic Informatics' Aquarius Time-Series software. Lithologic, well construction, and manual water-level data is currently housed in the OWRB Driller's Database. Both of these systems are internal access, but this award solely focused on setting up web services to connect to Aquarius software for the continuous water level data.

The Oklahoma Water Resources Board Water Quality staff gathered business and technical requirements for the web service and outlined a plan for connection. Examples of connection to the NGWMN from other states and the Aquarius user guide & support were essential to this process. The assigned OWRB IT application developer built a representational state (REST) web service that will receive USGS queries for the most recent groundwater well levels from OWRB monitored Oklahoma wells that are part of the NGWMN. The REST web service then translates the request into the proper format for searching the Aquatics Informatics, Inc. Aquarius Time Series Server database at OWRB that stores all values collected from OWRB monitored groundwater wells in Oklahoma. The REST web service will then format the results of the query into an XML statement that is returned via http to the USGS IT mechanism or web service that is designated to receive the results.

The high level technical configuration of this web service system is as follows. The REST web service utilizes application programming interface calls from components of the Aquarius Time Series server software development kit. The web service is designed to be a .Net web service of Internet Information Server version 8 within a Windows 2012 Standard server. The Aquarius Time Series database is an Oracle 11G database.

OWRB IT employees completed internal proof-of-concept testing of the web service they created. They demonstrated that a properly formed query for the most current well levels send to the web service will return a properly formatted XML statement with answers to the query. The water levels web service has been tested by the USGS and is ready to go. The USGS are in the process of incorporating the OWRB web service into the NGWMN data portal. The OWRB has met and completed its contractual obligations to provide a web service that will display water level data housed in its Aquarius data base to the USGS data portal; for select wells currently in the USGS-Oklahoma well registry list.

## **Field Techniques**

Data collection procedures were reviewed and compared to Appendix 5 of the NGWMN Framework Report. These field techniques can be found in OWRB's SOP GMAP Continuous Recorder Program document. Staff identified gaps in the program's post-field data flow and approval processes, which were then addressed. A multi-step plan for correcting and improving these processes has begun. OWRB staff anticipates full implementation of this plan during calendar year 2017.

## **Data Processing**

Continuous recorder managers upload the collected data from field handheld devices or laptops into Aquarius. Site visits with any measurement activities are manually entered into Aquarius. QA for completeness on this process is done three times per year by either the Groundwater Quality Manager or someone he designates, checking against the field data sheets.

Continuous recorder managers apply instrument drift corrections and grades to the data series as they upload data into Aquarius Time-Series software. Staff also looks for suspicious values or slopes in the data, investigating any irregularities. The Groundwater Quality Manager looks at the corrected and graded data to either approve it as Final Data, viewable to the public, or return it to staff for any irregularities.

Calibration corrections are applied as needed for specific time periods. Datum corrections will be applied on periodic basis determined by the Groundwater Quality Manager and the OWRB Data Manager. Programmed QC checks by Aquarius Time-Series for suspicious values and slopes at each site are planned for the future of the program.

All data is stored and archived in Aquatic Informatics' Aquarius Time-Series software. This software preserves the original, raw data. When a site is taken offline, any recorder data is kept in the software.

## **Summary**

Required elements for the well registry hosted by USGS NGWMN were complete for all sites, except for altitude. Altitude data could not be verified on some sites and so was not uploaded. The OWRB anticipates gathering corrected data and updating these sites during calendar year 2017.

Web services constructed by IT staff are operational providing a connection between the NGWMN data portal and the Aquarius Time Series database. The USGS is in the process of incorporating the OWRB web service into the NGWMN data portal. The OWRB will maintain this web service for the foreseeable future, as award funding allows.

As the Aquarius software becomes more widely utilized, the OWRB looks forward to sharing the connection built with other data providers to the NGWMN. The State of Wyoming is already in contact with OWRB IT for guidance in anticipation of applying during the next grant application period.