Hydraulic testing of select NGWMN wells by the Iowa Geological Survey

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INTRODUCTION

The National Ground-Water Monitoring Network (NGWMN), which was established to assess long-term water-level and water-quality trends at a national scale, provides a unique opportunity to collect and share date from different states, agencies, and others. The Iowa Geological Survey (IGS) at the University of Iowa joined the NGWMN in 2017. The IGS contributes 40 wells, completed in the Cambrian-Ordovician (USGS national code S300CAMORD), Cretaceous (N300lLCRTCS), Mississippian (N500MSSPPI), and Silurian-Devonian (N400SLRDVN) aquifers, where quarterly static water level measurements are made to the NGWMN.

Many of the IGS wells are decades old and lack documentation of when (or if) water was last purged or if hydraulic tests were ever conducted. Through U.S. Geological Survey (USGS) Award # G20AC00180 the IGS received funding to pump water and conduct hydraulic tests on four selected NGWMN sites. This report describes the work performed and results obtained under this award.

WELLS

The IGS received funding to pump water and conduct hydraulic tests on four selected NGWMN sites. Figure 1 shows the locations of the selected wells. Appendix A contains more detailed information on the wells. BS-2G (NGWMN ID 86249) is completed in the Cambrian-Ordovician aquifer, D-24 (ID 25525) and D-29 (ID 64073) are completed in the Cretaceous (Dakota) aquifer, and Parkers Grove (ID 23336) is completed in the Silurian-Devonian aquifer.

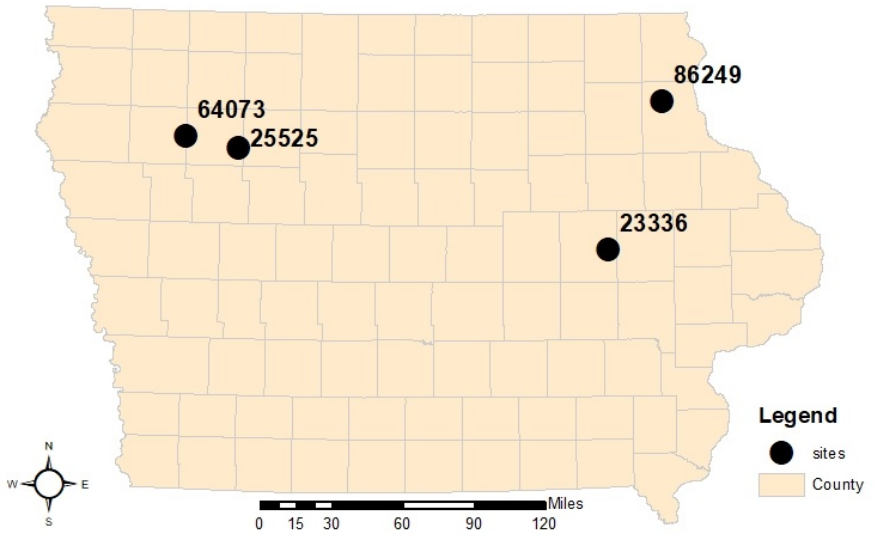

Figure 1. Location of wells selected for pumping and hydraulic testing.

According to IGS paper records, Parkers Grove was last pumped in 1974, D-24 in 1978, D-29 in 1980, and BS-2G in 1988. IGS paper records do not indicate if slug or other hydraulic tests have ever been conducted on the wells.

Deep static water levels in most of the wells necessitated modifications to the IGS drill rig. The static water levels in BS-2G, D-29, and Parkers Grove are >150 feet below the surface. The drill's winch was upgraded and spooled with 300 feet of steel cable to allow the IGS pumps to be lowered deeper than the deepest anticipated pumping water level.

WELL PUMPING

Water was purged from Parkers Grove in the fall 2020 and the remaining sites in spring 2021. Water was purged until either the water's specific conductance readings stabilized or three well volumes of water had been removed. D-29 was pumped using a 3" submersible pump. BS2-G and Parkers Grove were pumped with a 1½" Grundfos Redi-Flo submersible pump. D-24 was bailed with a PVC bailer due to its small casing size.

All wells pumped clear water by the end of the purging. BS2-G and D-29 initially pumped black water; Parkers Grove initially pumped light orange water. The water in all cleared are several minutes of pumping.

HYDRAULIC TESTING

Mechanical slug tests were conducted at all sites. The slug tests followed procedures established in the USGS' groundwater technical procedure document (GWPD) 17 (Cunningham and Schalk, 2011). A 2½ inch diameter, 2 foot long slug was used in the BS2-G, D-29, and Parkers Grove wells. A 3/4 inch diameter, 2 foot long slug was used in D-24. A minimum of four slug tests were conducted at most sites (two slug in and two slug out tests). Additional slug in or slug out tests were conducted at sites if any of the original tests seemed anomalous.

Water levels during the slug tests were collected using a pressure transducer with a built-in data logger (In-Situ Level TROLL 700). The data collection interval varied from 0.25 to 5 seconds depending on the anticipated response of the aquifer to the slug's introduction and removal. Data from the slug tests was processed in Microsoft Excel and analyzed using the AquiferTest 7.0 software (Waterloo Hydrogeologic). Two separate test methods were used to analyze the slug tests and determine hydraulic conductivity (K): Hvorslev (1951) and Butler et al. (2003). The Hvorslev method was used in wells where the water level response to the introduction/removal of the slug had minimal oscillations. The Butler method was used in wells where the water level response to the introduction/removal of the slug produced significant oscillations.

Slug test results are presented in Table 1. Hydraulic conductivities varied considerably between wells with average K ranging from 0.02 to 100 feet/day. Unfortunately, no previous estimates of hydraulic conductivity exists to compare the current results. The current results will be used as the baseline to compare future hydraulic conductivities against.

The results of the slug test on D-24 suggest a very poor connection to the aquifer. D-24 is completed in the Dakota sandstone. A single 'slug in' test was conducted at D-24. The water level in this well displayed an anomalously slow recovery to the static water level during the test. After consultations with IGS hydrogeologists Mike Gannon and Greg Brennan, the test was

stopped after 2 hours instead of waiting for the water level to return to the static level. The hydraulic conductivity calculated from this dataset was 0.02 feet/day. The slug tests in D-29, also completed in the Dakota sandstone, resulted in hydraulic conductivities ranging from 10 to 30 feet/day. Nearby public wells completed in the Dakota sandstones report hydraulic conductivities ranging from 12 to 86 feet/day. D-24's hydraulic conductivity is 3 orders of magnitude lower than other wells. The IGS will investigate options to establish a better connection to the aquifer in D-24, including options that may require a future funding request.

Table 1. Results from slug tests conducted on the NGWMN wells.

Location (NGWMN ID)	Hydraulic Conductivity (feet/day)		Method
	Average	Range	
BS2-G (86249)	2	1 to 3	Horslev
D-24 (25525)	0.02	0.02	Horslev
D-29 (64073)	18	10 to 30	Horslev
Parkers Grove (23336)	100	100 to 100	Butler

The raw data and analysis results of the slug tests have been entered into IGS Pump Test (https://www.iihr.uiowa.edu/igs/pump-test/) to allow public access. Entries into IGS Pump Test are screened randomly to ensure data standards are maintained.

WEBSERVICE AND DATABASES

The IGS did not encounter any problems with its web services transferring data to the NGWMN data portal in this contract period. IIHR Research Computing (RCS) staff noted the systems the IGS uses to manage, display, and transfer data were out-of-date. RCS staff transferred all IGS databases to a new server with new hardware. All services the IGS uses, including PHP, Apache, MySQL, and phpMyAdmin, we updated to the latest version. The upgrade ensures the IGS will have a reliable databases and web servers to serve data for years to come. The IGS verified all existing NGWMN web services functioned after the upgrade, ensuring data transfers to the NGWMN continues without incident

The IGS' water-level web service is currently being modified to use WaterML2 data standards. The prototype water-level web service is currently lacking information regarding the method used to collect the measurements. Development of this web service is ongoing with a goal to have an updated water-level web service operational and in use in 2021.

SUMMARY

The IGS has achieved all of the project goals. Specifically, we pumped water from four NGWMN wells sites to ensure the wells were still in connection with the aquifer. Mechanical slug tests were conducted at all sites to establish baseline hydraulic conductivity for future comparison. The raw data and analysis results of the slug tests have been entered into IGS Pump Test for public access.

References

Butler Jr, J. J., Garnett, E. J., and Healey, J. M., 2003, Analysis of Slug Tests in Formations of High Hydraulic Conductivity, Groundwater, 41(5), 620-631.

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater Technical Procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p.

Hvorslev, M. J., 1951, Time Lag and Soil Permeability in Ground-Water Observations, Vicksburg, MS: U.S. Army Waterways Experiment Station.

APPENDIX A
DETAILED WELL INFORMATION

NGWMN ID	Name	County	Latitude	Longitude	Accuracy	Drill Date	Well Depth	Aquifer
86249	BS2-G	Clayton	42.959880	-91.439090	GPS +/- 10 m.	7/20/1988	343	Cambrian-Ordovicain
25525	D-24	Buena Vista	42.669170	-94.954400	GPS +/- 10 m.	11/9/1978	357	Cretaceous (Dakota)
64073	D-29	Cherokee	42.729780	-95.387710	GPS +/- 10 m.	9/12/1979	340	Cretaceous (Dakota)
23336	Parkers Grove	Benton	42.055400	-91.903060	GPS +/- 10 m.	7/29/1974	590	Siurian-Devonian

NGWMN ID	Purge Method	Hyperlink
86249	Pump	https://www.iihr.uiowa.edu/igs/geosam/well/86249/general-information
25525	Bailed	https://www.iihr.uiowa.edu/igs/geosam/well/25525/general-information
64073	Pump	https://www.iihr.uiowa.edu/igs/geosam/well/64073/general-information
23336	Pump	https://www.iihr.uiowa.edu/igs/geosam/well/23336/general-information