FINAL TECHNICAL REPORT

OBSERVATION WELL INTEGRITY TESTING AND DRILLING OF TWO NEW OBSERVATION WELLS

Grant/Cooperative Agreement Number G18AC0074

James Raab, jim.raab@dnr.ohio.gov 614-265-6747

Michael Angle, mike.angle@dnr.ohio.gov, 614-265-67

Ohio Department of Natural Resources - Division of Geological Survey

2045 Morse Road, Bldg. C

Columbus, Ohio 43229

Term of Contract: July 3, 2018–July 2, 2020

September 30, 2020

The Groundwater Program of the Ohio Department of Natural Resources, Division of Geological Survey (DGS) is responsible for collecting, researching, interpreting, and disseminating hydrologic and groundwater resource information for the State of Ohio. An important component of this program is to characterize Ohio's groundwater resources through monitoring and evaluating long-term trends in groundwater level fluctuations throughout the state's various aquifer systems.

This grant project conducted 48 well integrity tests (slug tests) over a two-year period and contracted to drill two new observation wells in areas deficient of data. See Appendix A for a list of observation wells that were assessed. See Appendix B for the new well sites.

Project Description

Well Maintenance

Under Objective 4 – Well Maintenance, integrity tests (slug tests) were conducted on 48 existing observation wells. The last time any of the state's observation wells were slug tested was back in the late 1990s. The USGS recommends an integrity test cycle of every 5 years. With existing staffing levels, the DGS can test all 139 existing observation wells in six years. Slug test procedures outlined in USGS document *GWPD 17 – Conducting an Instantaneous Change in Head (Slug) Test with a Mechanical Slug and Submersible Pressure Transducer* were followed. Appendix A contains a list of the wells that were tested along with the results of each test.

For logistical and travel reasons, we modified the list of wells that were measured during this grant period. We did not decrease the total number of wells measured, but changed which wells were measured. This was submitted in our year 1 project summary report. Table 1 shows the well ID originally slated to be tested and the replacement well that was tested under this grant.

Table 1. List of well replacements

Well ID Listed in Grant Application	Replacement Well ID
B-3	TU-3
BU-3	BU-7
CH-3	Cl-7
FR-10	FR-19
PK-9	PK-4
RO-6	PI-2
S-3	CR-1
F-7	V-100

Since the project started, there has been several staffing changes. Mitch Valerio and Mark Pleasants have left the DGS. Current staff (Scott Kirk, Devon Goeller, Curtis Coe, Krista Hardin, Craig Nelson, Tom Valachovics, and Jim Raab) conducted most of the slug tests. The general tasks that were followed for slug testing included:

- Removal of the existing observation well equipment that is in the well
- Installation of the temporary pressure transducer
- Conducting the slug test
- Re-installation of the observation well equipment
- Analyzing the slug test data

Staff had three different options of slug tests that they could perform: water in, physical slug in and out, and pneumatic. Depending on the well diameter and physical site conditions, one or two of the methods were used for each well. The type of tests conducted on each well is listed in the table in Appendix A. The pneumatic technique could only be used on wells that were 5 to 8 inches in diameter and did not have any abrasions near the top of the casing that would damage the packer.

Most of the wells responded quickly to the slug test (see Appendix A for a table of the wells that were slug tested and the resulting aquifer properties). However, there were some wells that were slow to respond. This could be due to a clogging of the well screen or formation. The following wells listed in Table 2 did not respond quick enough to calculate aquifer properties and will be evaluated for either a clean-out or a re-drill in the next phase of this project.

Table 2. Observation wells that were slow to respond to slug test.

Well ID	**County**
BR-20	Brown
BU-7	Butler
FR-18	Franklin
M-2	Madison
MD-5	Medina
PI-2	Pike
R-4	Richland
SU-6	Summit
WY-1	Wyandot

The current plan is to submit a grant request in two years which will include the cleaning and redevelopment of these wells and any other wells that fail during the active grant that we are working on now.

As part of our analysis, we looked at the data from the previous slug tests conducted in the late 1990s. Table 3 is a list of the wells that were tested in the 1990s and during this grant.

Table 3. Comparison of hydraulic conductivity from late 1990s and current values

Well ID	**Aquifer Type**	**Confined/Unconfined**	**Hydraulic Conductivity 1996–1998 (ft/day)**	**Hydraulic Conductivity 2019 (ft/day)**
CR-1	Sand and Gravel	Unconfined	39.7	19.67
M-3	Limestone	Confined	8.99	33.22
M-4	Sand and Gravel	Confined	136.08	137
MN-2	Limestone	Confined	453.6	316
MN-4	Limestone	Confined	82.22	113.7
V-1	Sandstone	Confined	0.23	0.0014
BU-18	Sand and Gravel	Unconfined	62.37	78.38
CL-7	Sand and gravel	Unconfined	1.19	6.987
PK-4	Sand and Gravel	Unconfined	11.91	4.533
PK-7	Sand and Gravel	Unconfined	1.98	12
TU-4	Sand and Gravel	Unconfined	53.87	609
WN-7	Sand and Gravel	Unconfined	311.85	317.1

Most of the hydraulic conductivities were similar between the two rounds of slug tests. Of note is the increase in hydraulic conductivity in TU-4. Well V-1 is completed in a fine-grained sandstone and showed a lower hydraulic conductivity.

For the wells that show a lower hydraulic conductivity or that did not respond very fast to the slug test, we examined the period of record hydrograph for that well to see how it was responding to either nearby pumping or precipitation events. Examinations of changes were noted and compared to any changes in nearby pumping.

Well Drilling

Under Objective 5 – Well Drilling, two wells were drilled and equipped to measure groundwater level changes. One of the wells is located in southern Ohio (Scioto County) and the other well is located in northwest Ohio (Fulton County). Table 4 lists information on the new wells that were added to the NGWMN. Appendix B contains a summary of the wells and the locations relative to existing observation wells. Appendix B also contains the Request for Bid that was solicited for each well.

Table 4. New Wells Added to the Ohio Observation Well Network

Well ID	USGS Well ID	ODNR Well Log #	Total Depth	Aquifer Material	Principal Aquifer	Date Added to Network
SC-2	385702083013400	2076272	85	Sand and Gravel	Quaternary	11/5/2019
FN-9	413839084220101	1021507	150	Sand and Gravel	Quaternary	12/30/2019

The drilling of each well was contracted to a registered water well driller. The Ohio Environmental Protection Agency's (EPA) Technical Guidance Manual for Hydrogeologic Investigations and Groundwater Monitoring – Chapter 6 Drilling and Subsurface Sampling was used. After the wells were completed, staff equipped the wells with gauges to start collecting groundwater level data. These wells were added to the NGWMN registry.

New Well SC-2

The location for the new southern observation well is the rest area along the west side of U.S. Route 23 in Scioto County. This well was completed in the Scioto River Buried Valley Aquifer. Both municipalities and industries utilize this highly productive aquifer, which previous studies determined a yield per river mile up to 29 million gallons per day. The surrounding bedrock formations are poor producing so the Scioto River Buried Valley Aquifer is utilized as a regional water supply. Observation well PI-2, located approximately eight miles to the north, is becoming plugged and the current owner of the land has been reluctant to allow ODNR to bring in a drilling rig to the site to clean out the well or re-drill a well at that site, so this new well could replace observation well PI-2.

Observation well SC-2 was drilled on October 11, 2019. DGS staff installed monitoring equipment on the well on November 5, 2019 and we have been collecting hourly data since then.

New Well FN-9

While scouting for a new well location completed in the shallow sand aquifer in Fulton County in northwest Ohio, we found that a professor from the University of Toledo had maintained one of our inactive observation wells, FN-4, which is completed in the Oak Openings sand aquifer. We had monitored this well from 1955 to June 1974. In June, 2019, we conducted slug tests on this well and concluded that it was still open to the shallow sand aquifer. Later that month, we installed a SDR data logger in well FN-4 and have added it to our active well list.

During the past couple years, we have had an increased concern from land owners about a proposed wellfield located in western Fulton County. Projected water withdrawal could be as high as 14 million gallons per day from the sand and gravel aquifer. This sand and gravel aquifer is actually a series of sand and gravel formations known as the "Michindoh" aquifer. The Indiana, Ohio, and Michigan offices of the USGS have been involved in inquiries from the public and from legislators. The Indiana DNR and the USGS Indiana office have already added two observation wells near the Ohio border to their monitoring network. The USGS Ohio Water Science Center is in contract with the Ohio EPA to conduct a study of the aquifer in Ohio. At that time, we did not have any observation wells within 15 miles of the proposed production well. Therefore, we located the new observation well in western Fulton County on ODNR property. This will allow us to reactivate the shallow sand aquifer in FN-4 on the east side of Fulton County and add a deeper sand and gravel aquifer on the western side of Fulton County. New observation well FN-9 was drilled on December 10, 2019. DGS staff installed monitoring equipment on the well on December 30, 2019 and we have been collecting hourly data on this well since then.

The USGS Ohio Water Science Center conducted a camera survey and gamma ray log on SC-2 (10/22/2019) and FN-9 (06/11/2020). The camera survey confirmed the condition of the screens and the gamma log confirmed the geologic breaks between the fine and course materials. These logs were added to the observation well files and will be used for further evaluations of each well.

Data collected from the new wells SC-2 and FN-9, and reactivated well FN-4 will be shared with the USGS Ohio Water Science Center using the existing data transfer procedure. No changes were made to the ODNR web services or data transfer procedures.

The DGS has been in contact with the company Aquatic Informatics concerning the purchase of the Aquarius software program. The USGS Ohio Water Science Center uses this program and it looks like a good fit for Ohio. But because of the current spending freeze in Ohio, we do not know when we can proceed with this purchase. The use of Aquarius would make the data transfer process seamless with the USGS.

Appendix A

Table of Slug Test Data

Well ID	Slug Test ID	Slug Test Date	Slug Test Type	Conclusion	Solution Method	Dampening	Kr	Ss	Kv/Kr
AT-5	AT5-2019-1	11-Jun-19	Water In	Pass					
					Bouwer-Rice	Over dampened	50.21		0.02163
					Bouwer-Rice		50.21		0.02163
					KGS Model w/skin		55.5	2.484E-07	0.02317
AT-6	AT6-2019-1	11-Jun-19	Water In	Pass					
					Bouwer-Rice		198.2		0.002065
					Springer-Gelhar	Over dampened	185.2		
					KGS Model w/skin		129.4	7.277E-09	0.2344
AT-6	AT6-2019-2	11-Jun-19	Slug In	Pass					
AT-6	AT6-2019-3	11-Jun-19	Slug Out	Pass					
AT-6	AT6-2019-4	11-Jun-19	Pneumatic	Pass					
AU-3	AU3-2020-1	09-Jul-20	Water In	Pass					
					KGS Model	Under dampened	0.0001053	0.0002188	1
					Bouwer-Rice	Under dampened	0.00303		
AU-4	AU4-2020-1	17-Jun-20	Slug In	Pass					
					Butler	Under dampened	0.1933		
					Bouwer-Rice	Under dampened	0.1442		
					KGS Model w/skin	Under dampened	0.2669	9.15E-13	0.1023
AU-4	AU4-2020-2	09-Jul-20	Slug In	Pass					
					KGS Model	Under dampened	0.3069	0.000008396	1
					Bouwer-Rice	Under dampened	0.244		
					Butler		0.3398		
AU-4	AU4-2020-4	09-Jul-20	Slug Out	Pass					
					Butler	Under dampened	0.2825		

					KGS Model w/skin	Under dampened	0.2537	4.107E-07	1
					Bouwer-Rice	Under dampened	0.2017		
BR-20	BR20-1998-1	05-May-98	Water In	Fail (Field)					
BR-20	BR20-2019-1	15-Aug-19	Water In	Fail (Field)					
BU-18	BU18-1996-1	27-Mar-96	Water In	Pass					
					Bouwer-Rice		62.37		
BU-18	BU18-2019-1	10-Sep-19	Water In	Pass					
					KGS Model w/skin		102	6.349E-13	0.009441
					Bouwer-Rice		78.38		1
					Springer-Gelhar	Critically Dampened	76.34		
BU-18	BU18-2019-2	10-Sep-19	Slug In	Pass					
					Bouwer-Rice		94.74		1
					Springer-Gelhar	Over dampened	108.8		
					KGS Model w/skin		197.9	0.000005659	1
BU-18	BU18-2019-3	10-Sep-19	Slug Out	Pass					
					Bouwer-Rice		102.2		1
					KGS Model w/skin		178.1	0.0005659	1
					Springer-Gelhar	Critically Dampened	112.3		
BU-18	BU18-2019-4	10-Sep-19	Pneumatic	Pass					
					Springer-Gelhar	Critically Dampened	93.99		
					Bouwer-Rice		83.76		0.5957
					KGS Model w/skin		93.99	5.595E-13	0.5957
BU-3	BU3-1996-1	25-Mar-96	Water In	Pass					
BU-3	BU3-2019-1	10-Sep-19	Water In	Pass					

					Springer-Gelhar	Over dampened	37.26		
					Bouwer-Rice		20.48		1
					KGS Model		30.99	0.000005988	1
BU-3	BU3-2019-2	10-Sep-19	Water In	Pass					
					Springer-Gelhar	Over dampened	21.38		
					Bouwer-Rice		12.3		1
					KGS Model w/skin		21.38	0.00007199	1
BU-7	BU7-2020-1	01-Jul-20	Water In	Fail (Field)					
BU-8	BU8-2020-1	21-Jul-20	Water In	Pass					
					Bouwer-Rice	Under dampened	0.004752		
					Butler	Under dampened	0.004139		
					KGS Model w/skin	Under dampened	0.004752	6.015E-13	1
CL-10	CL10-2019-1	15-May-19	Water In	Pass					
					Springer-Gelhar	Critically Dampened	229.4		
					KGS Model w/skin		231.6	0.00000133	0.5
					Bouwer-Rice		229.4		1
CL-10	CL10-2019-2	15-May-19	Slug In	Pass					
					Bouwer-Rice		271.2		1
					Springer-Gelhar	Under dampened	472.7		
CL-10	CL10-2019-3	15-May-19	Slug Out	Pass					
					Springer-Gelhar	Under dampened	472.7		
CL-10	CL10-2019-4	15-May-19	Water In	Pass					
					Springer-Gelhar	Under dampened	371.9		
CL-7	CL7-1996-1	19-Mar-96	Water In	Pass					
					Bouwer-Rice		1.19		
CL-7	CL7-2019-1	15-May-19	Water In	Pass					

					KGS Model w/skin		9.275	2.024E-11	1
CL-7	CL72019-4	15-May-19	Pneumatic	Pass					
					Bouwer-Rice		6.987		1
					Springer-Gelhar	Over dampened	6.987		
CR-1	CR1-2019-1	09-Aug-19	Water In	Pass					
					Bouwer-Rice		12.62		1
					KGS Model w/skin		19.67	5.143E-08	1
					Butler	Over dampened	16.63		
CR-1	CR-1996-1	01-Apr-96	Water In	Pass					
					Bouwer-Rice		12.62		
CS-4	CS4-2019-1	20-Sep-19	Water In	Pass					
					Springer-Gelhar	Critically Dampened	368		
					Bouwer-Rice		673		1
CS-4	CS4-2019-2	20-Sep-19	Slug In	Pass					
					Bouwer-Rice		1629		1
					Springer-Gelhar	Under dampened	1076.3		
CS-4	CS4-2019-3	20-Sep-19	Slug Out	Pass					
					Springer-Gelhar	Under dampened	1205.8		
					Bouwer-Rice		1101.9		1
FN-4	FN4-2019-1	04-Jun-19	Water In	Pass					
					Bouwer-Rice		4.987		1
FN-4	FN4-2019-2	04-Jun-19	Slug In	Pass					
					Bouwer-Rice		0.5765		1
FN-4	FN4-2019-3	04-Jun-19	Slug Out	Pass					
					Bouwer-Rice		3.707		0.007
					KGS Model w/skin		9.951	0.000004179	0.002818
					Springer-Gelhar	Over dampened	11.05		

FR-18	FR18-2019	24-Apr-19	Slug In	Fail (Field)					
FR-19	FR19-2019-1	24-Apr-19	Slug In	Pass					
					Bouwer-Rice		1.928		645
					KGS Model w/skin		1.33	0.0000048	0.006457
					Butler	Over dampened	2.647		
H-2	H2-2020-1	30-Jun-20	Slug In	Pass					
					Butler	Under dampened	1.79		
					Bouwer-Rice	Under dampened	2.035		
					KGS Model	Under dampened	2.004	1.271E-12	1
H-2	H2-2020-2	30-Jun-20	Water In	Pass					
					Bouwer-Rice	Under dampened	2.061		
					Butler	Under dampened	1.769		
					KGS Model w/skin	Under dampened	2.031	1.271E-12	1
H-4	H4-2020-1	14-Jul-20	Water In	Pass					
					Butler	Under dampened	1.214		
					Bouwer-Rice	Under dampened	1.531		
					KGS Model w/skin	Under dampened	1.214	1.271E-12	1
H-4	H4-2020-2	14-Jul-20	Slug In	Pass					
					KGS Model w/skin	Under dampened	1.613	0.001271	1
					Bouwer-Rice	Under dampened	1.864		
					Butler	Under dampened	1.5818		
H-4	H4-2020-3	14-Jul-20	Slug Out	Pass					
					Bouwer-Rice	Under dampened	1.221		
					Butler	Under dampened	1.142		
					KGS Model w/skin	Under dampened	1.11	1.271E-12	0.5
H-6	H6-2020-1	01-Jul-20	Water In	Pass					

					KGS Model w/skin				
					Bouwer-Rice	Under dampened	0.00276		
HN-1	HN1-2020-1	07-Jul-20	Water In	Pass					
					Bouwer-Rice	Under dampened	0.00115		
					KGS Model	Under dampened	0.00115	0.00003663	1
LI-5	LI5-2018-1	28-Sep-18	Slug In	Pass					
					Butler	Over dampened	174.8		
					Bouwer-Rice		140.9		1
					KGS Model w/skin		140.7	0.000108	0.003236
LI-6	LI6-2019-1	27-Sep-18	Slug In	Pass					
					Butler	Over dampened	189.8		
					KGS Model w/skin		454.8	3.37E-13	0.02089
					Bouwer-Rice		94.79		1
M-2	M2-2019-1	07-Oct-19	Water In	Fail (Analyzed)					
					Bouwer-Rice		0.06489		0.03758
					KGS Model w/skin		0.1077	1.48E-08	0.03758
					Butler	Over dampened	0.07115		
M-3	M3-1996-1	18-Mar-96	Water In	Pass					
					Bouwer-Rice		33.22		
M-3	M3-2019-1	07-May-19	Water In	Pass					
					Butler	Critically Dampened	106.5		
					Bouwer-Rice		33.79		1
					KGS Model		33.79	0.000000296	0.006457
M-3	M3-2019-2	07-May-19	Water In	Pass					
					Bouwer-Rice		73.66		1
					Butler	Critically Dampened	106.5		

M-4	M4-1996-1	20-Mar-96	Water In	Pass					
					Bouwer-Rice		136.08		
M-4	M4-2019-2	07-May-19	Water In	Pass					
					KGS Model w/skin		137	0.00243	1
					Bouwer-Rice		137		1
					Butler	Over dampened	143.5		
M-5A	M5A-2019-1	07-May-19	Water In	Pass					
					Bouwer-Rice		192.2		1
					Butler	Over dampened	349.8		
					KGS Model w/skin		290.2	0.00127	1
M-5A	M5A-2019-2	07-May-19	Pneumatic	Pass					
					Butler	Critically Dampened	810		
					KGS Model w/skin		290.2	0.001274	1
					Bouwer-Rice		520.9		1
MD-1A	MD1A-2019-1	19-Jun-19	Water In	Pass					
					Butler	Over dampened	42.77		
					KGS Model w/skin		40.43	0.000009311	0.9661
					Bouwer-Rice		37.7		0.9661
MD-5	MD5-2019-1	19-Jun-19	Water In	Fail (Analyzed)					
					Bouwer-Rice		0.01277		1
MN-2	MN2-2019-1	09-Aug-19	Water In	Pass					
					Bouwer-Rice		407.9		1
					KGS Model w/skin		852.3	4.348E-12	0.8128
					Butler	Over dampened	435.6		
MN-4	MN4-1996-1	02-Apr-96	Water In	Pass					

					Bouwer-Rice		82.22		
MN-4	MN4-2019-1	09-Aug-19	Water In	Pass					
					Butler	Critically Dampened	66.42		
					Bouwer-Rice		59.2		1
MN-4	MN4-2019-2	09-Aug-19	Water In	Pass					
					Bouwer-Rice		125.3		0.1972
					Butler	Under dampened	131.2		
MR-2	MR2-2020-1	23-Jul-20	Water In	Pass					
					KGS Model w/skin	Under dampened	8029	5.747E-13	1
					Bouwer-Rice	Under dampened	0.006326		
					Springer-Gelhar	Under dampened	0.006287		
MR-2	MR2-2020-2	23-Jul-20	Water In	Pass					
					KGS Model	Under dampened	0.002436	0.000529	1
					Bouwer-Rice	Under dampened	0.00526		
MR-2	MR2-2020-3	23-Jul-20	Slug Out	Pass					
					KGS Model w/skin	Under dampened	0.009028	1.273E-08	1
					Bouwer-Rice	Under dampened	0.008271		
					Springer-Gelhar	Under dampened	0.008143		
MT-3	MT3-2019-1	15-May-19	Water In	Pass					
					Bouwer-Rice		0.6543		1
					Springer-Gelhar	Over dampened	0.5967		
					KGS Model w/skin		0.5967	3.394E-10	1
MT-49	MT49-2020-1	21-Jul-20	Water In	Pass					
					KGS Model w/skin	Under dampened	0.4849	5.03E-13	1
					Springer-Gelhar	Under dampened	0.04944		
					Bouwer-Rice	Under dampened	0.05661		
MT-49	MT49-2020-2	21-Jul-20	Slug In	Pass					

					Bouwer-Rice	Under dampened	0.03382		
					Springer-Gelhar	Under dampened	0.03716		
					KGS Model w/skin	Under dampened	0.6216	2.171E-07	1
MT-49	MT49-2020-3	21-Jul-20	Slug Out	Pass					
					Springer-Gelhar	Under dampened	0.06334		
					KGS Model w/skin	Under dampened	0.5709	5.03E-13	1
					Bouwer-Rice	Under dampened	0.0345		
MU-1A	MU1A-2019-1	11-Jun-19	Water In	Pass					
					KGS Model w/skin		12	9.985E-08	0.002723
MU-1A	MU1A-2019-2	11-Jun-19	Slug In	Pass					
					KGS Model		9.393	0.0001735	0.05309
					Bouwer-Rice		7.323		1
MU-1A	MU1A-2019-3	11-Jun-19	Slug Out	Pass					
					KGS Model w/skin		7.269	0.00000821	1
					Springer-Gelhar	Under dampened	7.269		
					Bouwer-Rice		7.269		1
PI-2	PI2-2019-1	15-Aug-19	Slug In	Fail (Field)					
PK-4	PK4-1996-1	16-Oct-96	Water In	Pass					
					Bouwer-Rice		11.09		
PK-4	PK4-2019-1	01-May-19	Slug In	Pass					
					Springer-Gelhar	Over dampened	4.369		
					KGS Model w/skin		3.477	0.00001235	1
					Bouwer-Rice		4.533		1
PK-4	PK4-2019-2	01-May-19	Slug Out	Pass					
					Bouwer-Rice		3.477		1

					Springer-Gelhar	Over dampened	4.428		
PK-7	PK7-1996-1	20-Mar-96	Water In	Pass					
					Bouwer-Rice		1.98		
PK-7	PK7-2019-1	01-May-19	Slug In	Pass					
					KGS Model w/skin		12.06	2.145E-09	0.02239
					Bouwer-Rice		12.06		0.0239
PK-7	PK7-2019-2	01-May-19	Slug Out	Pass					
					Bouwer-Rice		8.273		1
PK-7	PK7-2019-3	01-May-19	Pneumatic	Pass					
					Springer-Gelhar	Over dampened	8.525		
					Bouwer-Rice		8.525		1
R-3	R3-2019-1	21-May-19	Water In	Pass					
					Butler	Over dampened	4.603		
					KGS Model w/skin		7.731	1.619E-12	-0.9661
					Bouwer-Rice		4.285		1
R-4	R4-3019-1	21-May-19	Water In	Fail (Field)					
SC-2	SC2-2019-1	22-Oct-19	Water In	Pass					
					Bouwer-Rice		169		1
					KGS Model w/skin		131.5	2.174E-12	0.1135
					Springer-Gelhar	Over dampened	120.8		
SC-2	SC2-2019-2	10-Oct-19	Slug In	Pass					
					Springer-Gelhar	Over dampened	153.5		
					Bouwer-Rice		153.5		1
					KGS Model w/skin		153.5	0.00002174	1
SC-2	SC2-2019-3	22-Oct-19	Slug Out	Pass					
					Bouwer-Rice		147.9		1

					KGS Model w/skin		147.9	2.029E-11	0.8414
					Springer-Gelhar	Over dampened	136.4		
SC-2	SC2-2019-4	22-Oct-19	Pneumatic	Pass					
					KGS Model w/skin		123.3	0.0009489	0.8318
					Springer-Gelhar	Over dampened	102.5		
					Bouwer-Rice		98.67		1
SC-2	SC2-2019-5	22-Oct-19	Pneumatic	Pass					
					Springer-Gelhar	Over dampened	103.4		
					KGS Model w/skin		132.3	0.000007713	0.2291
					Bouwer-Rice		91.52		1
SU-6	SU6-2019-1	19-Jun-19	Water In	Fail (Analyzed)					
					Bouwer-Rice		0.1035		1
					Springer-Gelhar	Over dampened	0.1035		
					KGS Model w/skin		0.1035	0.0000129	1
AU-3	TEST-1	09-Jul-20	Water In	Pass					
TU-3	TU3-2019-1	20-Sep-19	Water In	Pass					
					Springer-Gelhar	Under dampened	112.9		
					KGS Model w/skin		114.8	1.963E-12	1
					Bouwer-Rice		182.1		1
TU-3	TU3-2019-2	20-Sep-19	Slug In	Pass					
					Springer-Gelhar	Over dampened	217.3		
					Bouwer-Rice		217.3		1
					KGS Model w/skin		217.3	0.000001963	1
TU-3	TU3-2019-3	20-Sep-19	Slug Out	Pass					

					KGS Model w/skin		202.9	2.177E-12	0.2344
					Springer-Gelhar	Under dampened	175.6		
					Bouwer-Rice		250.6		1
TU-4	TU4-1996-1	08-Apr-96	Water In	Pass					
					Bouwer-Rice		53.87		
TU-4	TU4-2019-1	20-Sep-19	Water In	Pass					
					KGS Model w/skin		526	3.287E-12	0.5
					Springer-Gelhar	Over dampened	559.7		
					Bouwer-Rice		628		1
TU-4	TU4-2019-2	20-Sep-19	Slug In	Pass					
					Bouwer-Rice		609.2		1
					Springer-Gelhar	Over dampened	609.2		
					KGS Model w/skin		609.2	0.00000328	1
TU-4	TU4-2019-3	20-Sep-19	Slug Out	Pass					
					Springer-Gelhar	Critically Dampened	685.3		
					Bouwer-Rice		701.1		1
					KGS Model w/skin		679.6	3.287E-12	0.6823
TU-8	TU8-2019-1	20-Sep-19	Water In	Pass					
					Springer-Gelhar	Under dampened	671		
					Bouwer-Rice		439.6		1
					KGS Model w/skin		439.6	2.58E-12	1
TU-8	TU8-2019-2	20-Sep-19	Slug In	Pass					
					Springer-Gelhar	Under dampened	654.3		
					KGS Model		1037	1.015E-12	1
					Bouwer-Rice		583.1		1

TU-8	TU8-2019-3	20-Sep-19	Slug Out	Pass					
					KGS Model w/skin		389.5	5.91E-12	0.1349
					Bouwer-Rice		531.8		1
					Springer-Gelhar	Under dampened	824.6		
V-100	V100-2019-1	20-Aug-19	Water In	Pass					
					KGS Model w/skin		1.87	3.096E-08	0.08318
					Bouwer-Rice		1.267		1
					Butler	Over dampened	1.749		
V-100	V100-2019-2	20-Aug-19	Slug In	Pass					
V-1	V1-1996-1	25-Mar-96	Water In	Pass					
					Bouwer-Rice		0.23		
V-1	V1-2019-1	20-Aug-19	Water In	Pass					
					Butler	Over dampened	0.001491		
					Bouwer-Rice		0.001424		1
					KGS Model w/skin		0.0005936	0.00001053	1
W-5	W5-2020-1	14-Jul-20	Water In	Pass					
					Butler	Under dampened	5.251		
					Bouwer-Rice	Under dampened	4.101		
					KGS Model w/skin	Under dampened	4.448	0.00008655	1
W-5	W5-2020-2	14-Jul-20	Water In	Pass					
					KGS Model w/skin	Under dampened	4.377	0.00006635	1
					Bouwer-Rice	Under dampened	4.077		
WN-2A	WN2A-2019-3	06-Jun-19	Slug In	Pass					
					KGS Model w/skin		2489000	0.000002898	0.06095
					Bouwer-Rice		1788.2		1

					Butler	Under dampened	2357		
WN-6	WN6-2019-2	06-Jun-19	Water In	Pass					
					Bouwer-Rice		9.817		1
					KGS Model w/skin		18.91	1.596E-08	0.001
					Springer-Gelhar	Over dampened			
WN-7	WN7-1996-1	13-Jun-96	Water In	Pass					
					Bouwer-Rice		311.85		
WN-7	WN7-2019-2	06-Jun-19	Pneumatic	Pass					
					KGS Model w/skin		308.1	1.067E-12	1
					Bouwer-Rice		363.9		1
					Springer-Gelhar	Critically Dampened	317.1		
WY-1	WY1-2019-1	09-Aug-19	Water In	Fail (Analyzed)					
					Springer-Gelhar	Over dampened	0.02528		
					Bouwer-Rice		0.02306	1.478E-08	1

Appendix B

Information on New Observation Wells SC-2 and FN-9

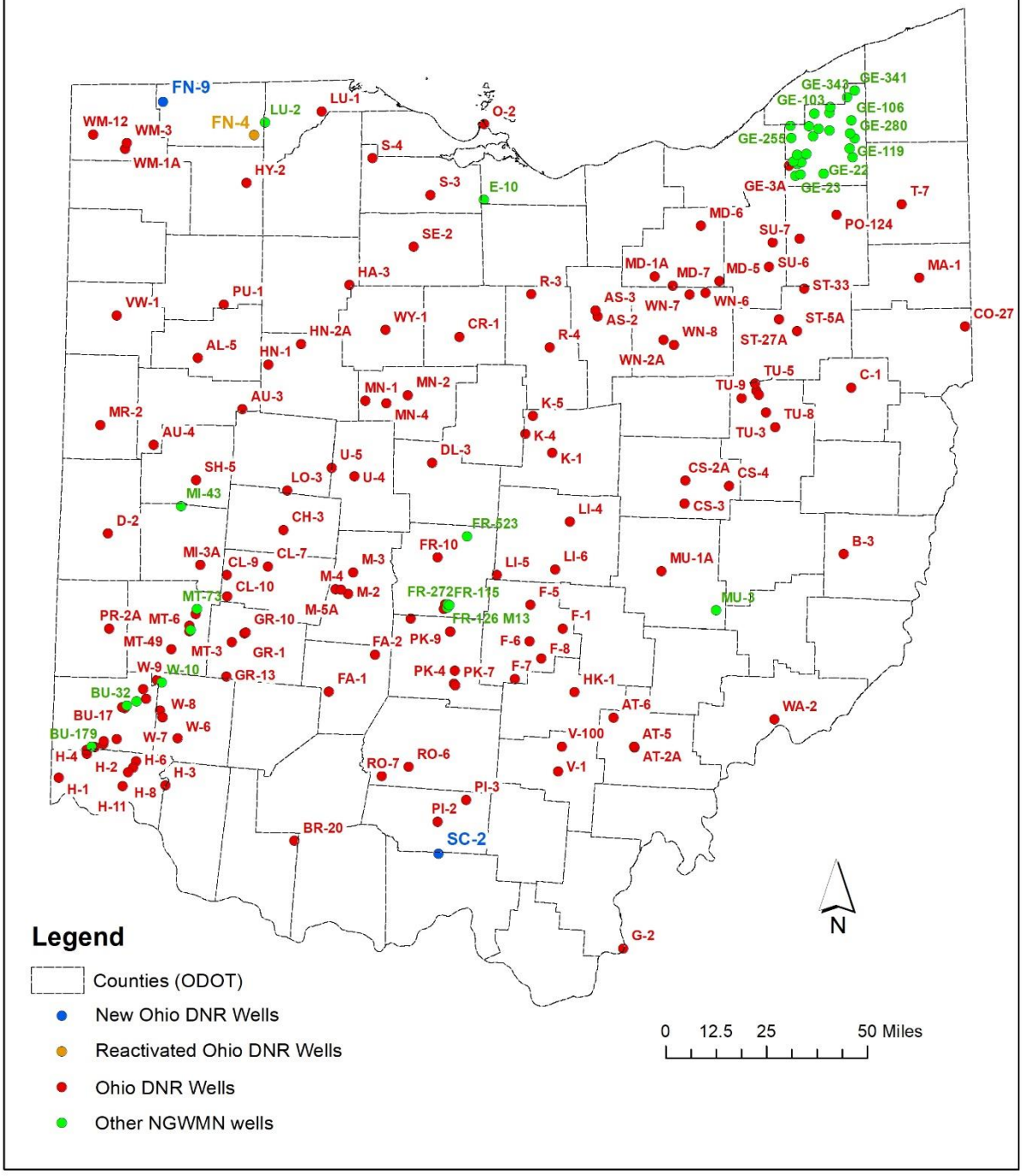
Map of New and Reactivated Observation Wells

Well Logs and Drilling Reports for New Wells

And

Drilling Specifications for Each New Observation Well

Locations of New and Reactivated Observation Wells



Scioto County Well Log – Well SC-2

DNR 7802.05e

WELL LOG AND DRILLING REPORT

Ohio Department of Natural Resources
Division of Water, 2045 Morse Road, Columbus, Ohio 43229-6605
Voice (614) 265-6740 Fax (614) 265-6767

Well Log Number: 2076272

Page 1 of 1 for this record.

WELL LOCATION

County SCIOTO Township VALLEY

ODNR-DIVISION OF GEOLOGICAL SURVEY
Owner/Builder

USRT 23
Address of Well Location

City WAKEFIELD Zip Code +4

Permit No. Section; and or Lot No.

Use of Well OBSERVATION

Coordinates of Well (Use only one of the below coordinate systems)

State Plane Coordinates

N ☐ X +/- ft.

S ☐ Y +/- ft.

Latitude, Longitude Coordinates

Latitude: 38.950556 Longitude: -83.026111

Elevation of Well in feet: 560 +/- 150 ft.

Datum Plane: ☐ NAD27 ☒ NAD83 Elevation Source MAP-OTHERS

Source of Coordinates: MAP-OTHERS

Well location written description:

Comments on water quality/quantity and well construction:

WELL TEST *

Pre-Pumping Static Level 39.4 ft. Date 10/11/2019

Measured from TOP OF CASING

Pumping test method PUMPING

Test Rate 10 gpm Duration of Test 1 hrs.

Feet of Drawdown 2.9 ft. Sustainable Yield 10 gpm

*(Attach a copy of the pumping test record, per section 1521.05, ORC)

Is Copy Attached? ☐ Yes ☒ No Flowing Well? ☐ Yes ☒ No

PUMP/PITLESS

Type of pump Capacity gpm

Pump set at ft. Pitless Type

Pump installed by

I hereby certify the information given is accurate and correct to the best of my knowledge.

Drilling Firm SMITH 'S WELL DRILLING LLC

Address 29417 RD Old SR 75

City, State, Zip MCARTHUR OH 45651

Signed NEWTON SMITH (Filed Electronically) Date 10/21/2019

ODH Registration Number 0763

CONSTRUCTION DETAILS

Drilling Method: MUD ROTARY

BOREHOLE/CASING (Measured from ground surface)

1 Borehole Diameter 9.5 inches Depth 85 ft.
Casing Diameter 6 in. Length 80 ft. Thickness 0.28 in.

2 Borehole Diameter inches Depth ft.
Casing Diameter in. Length ft. Thickness in.

Casing Height Above Ground 2 ft.

Type 1: Steel
2:

Joints 1: Threaded
2:

SCREEN

Diameter 6 in. Slot Size 0.05 in. Screen Length 5 ft.

Type CONTINOUS WIRE WOUND Material STAINLESS STEEL

Set Between 80 ft. and 85 ft.

GRAVEL PACK (Filter Pack)

Material/Size 1/4" X 3/8" Vol/Wt. Used 1000 POUNDS

Method of Installation Poured (gravity)

Depth: Placed From: 85 ft. To: 80 ft.

GROUT

Material Bentonite/polymer slurry Vol/Wt. Used 6 50#BAGS@24GALH2OPB

Method of Installation Pumped w/Tremie pipe

Depth: Placed From: 80 ft. To: 0 ft.

DRILLING LOG*

FORMATIONS INCLUDE DEPTH(S) AT WHICH WATER IS ENCOUNTERED.

Color	Texture	Formation	From	To
BROWN		CLAY	0	9
		SAND AND GRAVEL	9	85
		Water Encountered At	80	85

Aquifer Type (Formation producing the most water.) SAND & GRAVEL

Date of Well Completion 10/11/2019 Total Depth of Well 85 ft.

Completion of this form is required by section 1521.05, Ohio Revised Code - file within 30 days after completion of drilling.
Distribute copies of this record to Customer, and Local Health Deptartment.

Fulton County well log – Well FN-9

WELL LOG AND DRILLING REPORT

1021507

OHIO DEPARTMENT OF NATURAL RESOURCES
Division of Water, 1939 Fountain Square Drive
Columbus, Ohio 43224-9971 Voice: (614) 265-6739 Fax: (614) 265-6767

WELL LOCATION

County: FULTON Township: GORHAM
Owner/Builder: Odnr - Geo Survey
Well Location: 26246 HARRISON LAKE RD
City: FAYETTE Zip +4: 43521
Permit #: Section: Lot:
Location in State Plane Use of well: OBSERVATION
X +/- Feet
Y +/- Feet
Elevation of Well: +/- Feet
Datum Plain: Elevation Source:
Source of Coordinates:

Map Sketch Latitude: 41.644199 Longitude: -84.366862

Observation Well FN-9

CONSTRUCTION DETAILS

Drilling Method: Rotary

BORE HOLE/CASING (Measured from ground surface)

1 Borehole Diameter: 9.88 Inches Depth: 200.00 Feet
Casing Diameter: 6.00 Inches Length: 145 Ft Thickness: 0.280 In
2 Borehole Diameter: Inches Depth: Feet
Casing Diameter: Inches Length: Ft Thickness: In
Casing Height above Ground: 3 Feet
Type 1 Steel - galvanized
2
Joints 1 Threaded & cou
2

SCREEN

Diameter: 6 In pipe size Slot size: 20 Length: 5 Ft.
Type & Material: Stainless steel-wire
Set between: 145 Ft. an 150 Ft.

GRAVEL PACK

Material/Size: peastone Volume/Weight Used 375.00 Pounds
Method of Installation: Gravity Pour
Depth: Placed From 150 Feet To: 135 Feet

GROUT

Material: HolePlug/Bensal #Volume/Weight Used 50 Pounds
Method of installation: Grout pipe outside casing + poured
Depth: Placed From 135 Feet To: 132 Feet 1 bag Hole Plug
152' 0' 11 bags Bensal
220 gal water

WELL TEST*

Pre-pumping Static Level: 30.5 ft Date 2/12/2019
Measured from: Ground Level
Test Method: Air / Pump Test
Test Rate: 2.00 gpm Duration of Test 1 hrs
@ 52 gpm
Ft of Drawdown: 7.9 Feet Sustainable Yield: gpm
Attach a copy of the pumping test record, per section 1521.05, ORC
Is Copy Attached?: YES Flowing Well: No
Water Quality: FRESH & CLEAR

PUMP/PITLESS

DRILLING LOG

	From	To
Topsoil	0	2
Yellow Sandy Clay	2	5
Yellow Sand	5	7
Yellow Sandy Clay	7	12
Yellow Clay & Gravel	12	19
Gray Clay & Gravel	19	31
Gray Clay & Gravel 50/50	31	34.5
Fine Sand & Gravel	34.5	39
Sand & Gravel	39	47
Gray Silty Clay / some gravel	47	79
Fine Sand Silty	79	109
Gray Clay & Gravel	109	126
Medium Sand / finer gravel	126	142
Medium Gravel	142	150
Hardpan	150	200

Backfilled from 200' – 150' with peastone

I hereby certify the information given is accurate and correct to the best of my knowledge.
Drilling Firm: Watson Well Drilling, Inc.
Address: 13580 County Road C
City, State, Zip: Bryan, OH 43506

Signed Cathy Watson Date 12-13-19
Registered Representative
ODH Registration Number: 823

Date of Well Completion: 12/10/2019 Total Depth of Well: 150 Feet

Completion of this form is required by section 1521.05,Ohio Revised Code - File within 30 days after completion of drilling.
ORIGINAL COPY TO ODNR, Division of Water, 1939 Fountain Square Drive, Columbus, OHIO 43224-9971
Submit copies to Customer, Local Health Department, Company

DRILLING SPECIFICATIONS FOR NEW OBSERVATION WELL IN SCIOTO COUNTY

Description of Work

The purpose of the work is to construct a new sand and gravel well at the ODOT rest area along US Route 23 in northern Scioto County. The approximate latitude and longitude are 38.950614 degrees latitude and -83.025948 degrees longitude. This well will be used by the ODNR Division of Geological Survey for the collection of data on groundwater level fluctuations. This well will be incorporated into the Statewide Observation Well Network. The work consists of drilling, casing, developing and otherwise constructing a six-inch diameter well that is responsive to water level changes in the sand and gravel aquifer and that will accommodate installation of recording equipment. The expected maximum well depth is 90 feet.

Performance Requirements

The contractor shall perform all the work and furnish all labor, materials, equipment, fuel, lubricants, etc., necessary for completion of the work in the manner and under the conditions specified.

The Contractor shall be responsible to do whatever is required to move the drilling equipment on and off the site and shall take the necessary measures to minimize damage to property. Particular care shall be taken during wet weather.

The Contractor shall be responsible for determining or verifying the location of any underground utilities prior to drilling.

During the period of construction, protection of the well shall be a prime concern of the Contractor. If the well is filled in with debris or otherwise damaged by vandals during the course of construction, correction of the damage shall be accomplished by the Contractor.

The well log and drilling report form shall be submitted to the ODNR Project Representative.

Quality Assurance

All installation procedures shall conform to applicable sections of ANSI/AWWA A100, ASTM A53-57, APA Spec 5CT (Steel Casing), NSF materials for casing, grout, lubricants, and screens, and manufacturers' instructions for mixing and use of grouting materials.

Only approved, uncontaminated, potable quality water shall be utilized for drilling purposes to avoid contamination of the aquifer.

The Contractor shall render all necessary assistance to the ODNR Project Representative and shall promptly respond to all directives of the ODNR Project representative to ensure that the work is accomplished in accordance with these specifications and industry standards.

Qualifications

The Contractor shall be a recognized water well drilling contractor operating in the State of Ohio and shall have consistently met the requirements of ORC 1521.05.

The well driller shall be registered with the Ohio Department of Health and have no previous history of registration revocations, suspensions, or cited violations within the past 5 years.

The well driller shall have installed wells within the last two years. For the last five jobs, provide project name, location, contact person, telephone number and date when work was completed.

Regulatory Requirements

The Contractor is responsible for compliance with all regulatory requirements relative to safety, operation, and movement of equipment to and from the drilling site.

Delivery, Storage, and Handling

The Contractor shall be responsible for the delivery, storage, and handling of all products and materials and shall use all means necessary to protect these products and materials before and during installation.

All materials shall be neatly stored on service trucks during transportation to the site and maintained in "as manufactured" condition. If materials or products are off-loaded at the site, care shall be taken to ensure that they do not become damaged or otherwise compromised.

All grouting materials in paper bags shall be covered with waterproof tarps or sheeting and care shall be taken to ensure bags do not become torn or wet prior to use.

Equipment

The Contractor shall have equipment of adequate size and reliability for proper and timely execution of drilling and well construction. The drilling equipment used for the work shall be in first-class condition and be of the size, capacity, etc. that the work can be done properly and expeditiously. The equipment shall include, but is not limited to:

1. Cable tool or rotary drilling rig
2. Service truck with mobile water tank separate from the drilling rig
3. Grout pump
4. Tremie pipe
5. Bailer/sand pump

Materials

Casing. Permanent seamless steel casing pipe shall be new steel pipe meeting ASTM 53 quality standards and specifications and the requirements of the American Pipe Institute (API) "Steel Water Well Pipe". Casing shall be threaded and coupled carbon steel pipe of nominal 20-foot lengths, with a nominal diameter of 6 inches, and a wall thickness of 0.28 inch.

Well Screen. The well screen shall be up to five feet in length and be type 304 stainless steel wire wound continuous slot screen as manufactured by US Filter/Johnson Screens or approved equal specifications. Said screen shall be furnished or provided with the necessary fittings to close the bottom and provide a watertight seal between the top of the screen and the well casing. For rotary installations, screens shall be 6-inch diameter pipe size provided with NPT threads. For cable tool installations, the screen shall be 6-inch diameter telescoping with the top equipped with a K-packer. A maximum of five feet of screen shall be used.

Formation Stabilizer. Pure silica sand shall be used as a formation stabilizer to be placed in the annular space between the borehole and the well screen for rotary installations. Formation stabilizer material shall have a uniformity coefficient of 2.5 or less and have a 90 percent retained size equal to or greater than the slot size of the screen to be installed. The material shall be disinfected prior to placement with a hypochlorite solution of 150-200 parts per million.

Grout Material. Only bentonite or sealant that meets NSF standards shall be accepted as a sealing material. Bentonite shall be clay material containing at least 85 percent of the mineral montmorillonite, which meets API specification standard 13-A 91985. Bentonite slurry shall be a mixture of bentonite and potable water with no less than 2 pounds of bentonite for each gallon of water. All bentonite grout materials shall be mixed and used in accordance with the manufacturer's specifications. Neat cement shall consist of cement conforming to ASTM C150 and potable water, mixed with 4 pounds of bentonite and not more than 6 gallons of water per 80-pound sack of cement.

Drilling Fluid. Drilling fluid additives used to stabilize the borehole when drilling through unconsolidated material shall be high quality bentonite. The viscosity of the drilling mud shall be sufficient to carry the heaviest cuttings to the surface and shall meet API Marsh funnel viscometer discharge requirements of one quart per 32 to 38 seconds. Mud density as measured by a mud balance shall be less than 9.0 pounds per gallon. Drilling mud shall be mixed in accordance with manufacturer's instructions.

Well Cap. No well cap will be required. The ODNR Representative will secure the top of the well casing.

Well Installation

All drilling equipment shall be inspected prior to arrival at the site to ensure that it is free of oil leaks, mud or other potential contaminants, and shall be cleaned and/or repaired as necessary. All down-hole equipment shall be steam cleaned or power washed and disinfected with a sodium hypochlorite solution of 50 ppm prior to drilling to prevent bacterial contamination of the aquifer.

All casing shall be free of cutting oils and disinfected with a sodium hypochlorite solution of 50 ppm prior to installation.

INSTALLATION BY ROTARY DRILLING

The borehole shall be drilled at least 9 inches in diameter through unconsolidated materials until water-bearing sand and gravel is encountered. Total depth anticipated will be less than 100 feet. Once the ODNR Project Representative-approved depth to set the well screen has been reached, the hole will be circulated to ensure removal of all drill cuttings and obstructions and then the bit and drill stem shall be removed.

Samples of the water bearing material shall be taken to determine the slot size by removing from the discharge fluid a representative sample of the formation with a bucket and allowing the sample to settle out. The penetration of the bit shall stop at the bottom of the sample interval for such time as is required for all the cuttings from the last drill section of the hole to be removed. A cutting sample then shall be collected from the sampling point.

The well screen and casing shall be lowered by the drilling machine utilizing clamps, slips, elevators, or other mechanical devices of adequate capacity. The screen shall be centered and set gently on the bottom of the hole while maintaining the weight of the casing string suspended by the drilling rig.

The formation stabilizer shall be placed around the screen by pouring it into the annular space at a rate not to exceed 3 minutes per 50-pound bag until the stabilizer is at least three feet above the top of the well screen. The pouring process shall be halted occasionally in order to lower a weighted measuring tape into the annular space to check the fill level.

At least one foot of bentonite pellets or chips shall be poured into the annular space on top of the formation stabilizer. Grout shall be pumped into the annular space by use of a tremie pipe of no less than one inch in diameter. The tremie pipe shall be lowered to the top of the bentonite pellets/chips and grout shall be pumped from the bottom until pure grout is circulated to the surface in one continuous operation.

The finished well casing shall extend 3 feet above the ground elevation.

INSTALLATION BY CABLE TOOL DRILLING

The hole shall be advanced by driving, drilling, and bailing until water-bearing sand and gravel formations have been encountered. As the casing is advanced, the annular space around the drive pipe shall be sealed by the dry-driven grout method. Granular bentonite of not more than 40 mesh size shall be used. The depth of the well shall be approved by the ODNR Project Representative but shall not exceed 90 feet.

Samples of the water-bearing material shall be taken to determine the slot size by use of a sand pump or flat bottom bailer. In stable materials, samples may be taken before or after driving the casing to the bottom of the sample interval. In unstable materials, the casing shall be driven ahead of the hole and the sample shall be taken with the sand pump. The Contractor is responsible to ensure that a sufficient supply of potable water is on hand to control heaving sand should such a condition be encountered.

After the casing has been driven to the proper depth, any sediment that has entered or settled with the casing shall be carefully removed, and the screen shall be lowered to the bottom of the well. The drill string or a weight attached to the sand line shall be placed on the bottom of the screen while the casing is pulled back to ensure that the screen remains in position. The casing shall be pulled back to expose the screen using the casing line, block and tackle, or hydraulic jacks as may be required.

The finished well casing shall extend 3 feet above the ground elevation.

Well Development

ROTARY DRILLED WELL: The well shall be developed until the water is clear and free of sediment. Development shall be done by air surging starting with the drill rods in the hole with the appropriate size bit at the top of the screen and working downward. Airflow and surging shall begin gently at first and be increased in intensity and duration to break down the mud cake between the formation stabilizer and the natural formation. Development shall continue until little or no sand can be removed from the well.

At the end of development, the Contractor shall ensure that the bottom of the screen is free of sediment. Final development may be completed with the test pump. The final degree of development shall be approved by the ODNR Project Representative.

CABLE TOOL DRILLED WELL: The well shall be developed until water is clear and free of sediment. The well shall be developed by mechanical surging. The surge tool shall be lowered into the well until it is 10-15 feet beneath the static water level. The initial surging motion shall be gentle, allowing fine material to go into suspension and enter the well. As water begins to move into and out of the screen more readily, the surge tool shall be lowered to just above the top of the screen and the force of the surging motion may be increased. Development within the screen shall move progressively downward based on observed results. Surging shall continue until little or no sand can be removed from the well. The Contractor may apply other techniques such as air surging or jetting if deemed appropriate. The final degree of development shall be approved by the ODNR Project Representative.

Testing

The contractor shall furnish a test pump with a capacity of 20 gallons per minute (gpm) at a pumping level of 50 feet. The pump intake shall be set at least 3 feet above the top of the screen. The pump shall be a submersible type powered by an electric generator. A control valve and discharge line shall be installed to convey the water to a natural drainage point.

The well shall be pumped for one hour at a rate of 10 gpm. If the well cannot sustain 10 gpm, the well shall be pumped at a rate that can be sustained for at least one hour. The rate shall be measured using a flow meter or orifice weir that is approved by the ODNR Project Representative. All fines shall be removed from the well prior to beginning the well pump test.

During the pumping test, the Contractor shall measure water levels to the nearest 0.01 foot using an electric tape and record the measurements on the test data sheet provided by the ODNR Project Representative. Measurements shall be taken at 5-minute intervals for the first 30 minutes and 10-

minute intervals for the last 30 minutes of the test. The test shall not be started sooner than one hour after completion of development to measure and record a static water level.

Restoration

After completion of the work, the Contractor shall restore the site to the original condition or better, to include grading and seeding. All excess materials and debris generated as a result of the work shall be removed. Drill cuttings may be broadcast on-site if they are not extensive and can be incorporated into restoration (grading and seeding) of the well site. If the drill cuttings are too extensive to be left at the location, they must be containerized for transportation and proper disposal.

DRILLING SPECIFICATIONS FOR NEW OBSERVATION WELL IN FULTON COUNTY

Description of Work

The purpose of the work is to construct a new sand and gravel well at Harrison Lake State Park located in Gorham Township, Fulton County. The approximate latitude and longitude are 41.644199 degrees latitude and -84.366862 degrees longitude. This well will be used by the ODNR Division of Geological Survey for the collection of data on groundwater level fluctuations. This well will be incorporated into the Statewide Observation Well Network. The work consists of drilling, casing, developing and otherwise constructing a six-inch diameter well that is responsive to water level changes in the sand and gravel aquifer and that will accommodate installation of recording equipment. The expected maximum well depth is 200 feet.

Performance Requirements

The contractor shall perform all the work and furnish all labor, materials, equipment, fuel, lubricants, etc., necessary for completion of the work in the manner and under the conditions specified.

The Contractor shall be responsible to do whatever is required to move the drilling equipment on and off the site and shall take the necessary measures to minimize damage to property. Particular care shall be taken during wet weather.

The Contractor shall be responsible for determining or verifying the location of any underground utilities prior to drilling.

During the period of construction, protection of the well shall be a prime concern of the Contractor. If the well is filled in with debris or otherwise damaged by vandals during the course of construction, correction of the damage shall be accomplished by the Contractor.

The well log and drilling report form shall be submitted to the ODNR Project Representative.

Quality Assurance

All installation procedures shall conform to applicable sections of ANSI/AWWA A100, ASTM A53-57, APA Spec 5CT (Steel Casing), NSF materials for casing, grout, lubricants, and screens, and manufacturers' instructions for mixing and use of grouting materials.

Only approved, uncontaminated, potable quality water shall be utilized for drilling purposes to avoid contamination of the aquifer.

The Contractor shall render all necessary assistance to the ODNR Project Representative and shall promptly respond to all directives of the ODNR Project representative to ensure that the work is accomplished in accordance with these specifications and industry standards.

Qualifications

The Contractor shall be a recognized water well drilling contractor operating in the State of Ohio and shall have consistently met the requirements of ORC 1521.05.

The well driller shall be registered with the Ohio Department of Health and have no previous history of registration revocations, suspensions, or cited violations within the past 5 years.

The well driller shall have installed wells within the last two years. For the last five jobs, provide project name, location, contact person, telephone number and date when work was completed.

Regulatory Requirements

The Contractor is responsible for compliance with all regulatory requirements relative to safety, operation, and movement of equipment to and from the drilling site.

Delivery, Storage, and Handling

The Contractor shall be responsible for the delivery, storage, and handling of all products and materials and shall use all means necessary to protect these products and materials before and during installation.

All materials shall be neatly stored on service trucks during transportation to the site and maintained in "as manufactured" condition. If materials or products are off-loaded at the site, care shall be taken to ensure that they do not become damaged or otherwise compromised.

All grouting materials in paper bags shall be covered with waterproof tarps or sheeting and care shall be taken to ensure bags do not become torn or wet prior to use.

Equipment

The Contractor shall have equipment of adequate size and reliability for proper and timely execution of drilling and well construction. The drilling equipment used for the work shall be in first-class condition and be of the size, capacity, etc. that the work can be done properly and expeditiously. The equipment shall include, but is not limited to:

1. Cable tool or rotary drilling rig
2. Service truck with mobile water tank separate from the drilling rig
3. Grout pump
4. Tremie pipe
5. Bailer/sand pump

Materials

Casing. Permanent seamless steel casing pipe shall be new steel pipe meeting ASTM 53 quality standards and specifications and the requirements of the American Pipe Institute (API) "Steel Water Well Pipe". Casing shall be threaded and coupled carbon steel pipe of nominal 20-foot lengths, with a nominal diameter of 6 inches, and a wall thickness of 0.28 inch.

Well Screen. The well screen shall be up to five feet in length and be type 304 stainless steel wire wound continuous slot screen as manufactured by US Filter/Johnson Screens or approved equal specifications. Said screen shall be furnished or provided with the necessary fittings to close the bottom and provide a watertight seal between the top of the screen and the well casing. For rotary installations, screens shall be 6-inch diameter pipe size provided with NPT threads. For cable tool installations, the screen shall be 6-inch diameter telescoping with the top equipped with a K-packer. A maximum of five feet of screen shall be used.

Formation Stabilizer. Pure silica sand shall be used as a formation stabilizer to be placed in the annular space between the borehole and the well screen for rotary installations. Formation stabilizer material shall have a uniformity coefficient of 2.5 or less and have a 90 percent retained size equal to or greater than the slot size of the screen to be installed. The material shall be disinfected prior to placement with a hypochlorite solution of 150-200 parts per million.

Grout Material. Only bentonite or sealant that meets NSF standards shall be accepted as a sealing material. Bentonite shall be clay material containing at least 85 percent of the mineral montmorillonite, which meets API specification standard 13-A 91985. Bentonite slurry shall be a mixture of bentonite and potable water with no less than 2 pounds of bentonite for each gallon of water. All bentonite grout materials shall be mixed and used in accordance with the manufacturer's specifications. Neat cement shall consist of cement conforming to ASTM C150 and potable water, mixed with 4 pounds of bentonite and not more than 6 gallons of water per 80-pound sack of cement.

Drilling Fluid. Drilling fluid additives used to stabilize the borehole when drilling through unconsolidated material shall be high quality bentonite. The viscosity of the drilling mud shall be sufficient to carry the heaviest cuttings to the surface and shall meet API Marsh funnel viscometer discharge requirements of one quart per 32 to 38 seconds. Mud density as measured by a mud balance shall be less than 9.0 pounds per gallon. Drilling mud shall be mixed in accordance with manufacturer's instructions.

Well Cap. No well cap will be required. The ODNR Representative will secure the top of the well casing.

Well Installation

All drilling equipment shall be inspected prior to arrival at the site to ensure that it is free of oil leaks, mud or other potential contaminants, and shall be cleaned and/or repaired as necessary. All down-hole equipment shall be steam cleaned or power washed and disinfected with a sodium hypochlorite solution of 50 ppm prior to drilling to prevent bacterial contamination of the aquifer.

All casing shall be free of cutting oils and disinfected with a sodium hypochlorite solution of 50 ppm prior to installation.

INSTALLATION BY ROTARY DRILLING

The borehole shall be drilled at least 9 inches in diameter through unconsolidated materials until water-bearing sand and gravel is encountered. Total depth anticipated will be less than 200 feet. Once the ODNR Project Representative-approved depth to set the well screen has been reached, the hole will be circulated to ensure removal of all drill cuttings and obstructions and then the bit and drill stem shall be removed.

Samples of the water bearing material shall be taken to determine the slot size by removing from the discharge fluid a representative sample of the formation with a bucket and allowing the sample to settle out. The penetration of the bit shall stop at the bottom of the sample interval for such time as is required for all the cuttings from the last drill section of the hole to be removed. A cutting sample then shall be collected from the sampling point.

The well screen and casing shall be lowered by the drilling machine utilizing clamps, slips, elevators, or other mechanical devices of adequate capacity. The screen shall be centered and set gently on the bottom of the hole while maintaining the weight of the casing string suspended by the drilling rig.

The formation stabilizer shall be placed around the screen by pouring it into the annular space at a rate not to exceed 3 minutes per 50-pound bag until the stabilizer is at least three feet above the top of the well screen. The pouring process shall be halted occasionally in order to lower a weighted measuring tape into the annular space to check the fill level.

At least one foot of bentonite pellets or chips shall be poured into the annular space on top of the formation stabilizer. Grout shall be pumped into the annular space by use of a tremie pipe of no less than one inch in diameter. The tremie pipe shall be lowered to the top of the bentonite pellets/chips and grout shall be pumped from the bottom until pure grout is circulated to the surface in one continuous operation.

The finished well casing shall extend 3 feet above the ground elevation.

INSTALLATION BY CABLE TOOL DRILLING

The hole shall be advanced by driving, drilling, and bailing until water-bearing sand and gravel formations have been encountered. As the casing is advanced, the annular space around the drive pipe shall be sealed by the dry-driven grout method. Granular bentonite of not more than 40 mesh size shall be used. The depth of the well shall be approved by the ODNR Project Representative but shall not exceed 200 feet.

Samples of the water-bearing material shall be taken to determine the slot size by use of a sand pump or flat bottom bailer. In stable materials, samples may be taken before or after driving the casing to the bottom of the sample interval. In unstable materials, the casing shall be driven ahead of the hole and the sample shall be taken with the sand pump. The Contractor is responsible to ensure that a sufficient supply of potable water is on hand to control heaving sand should such a condition be encountered.

After the casing has been driven to the proper depth, any sediment that has entered or settled with the casing shall be carefully removed, and the screen shall be lowered to the bottom of the well. The drill string or a weight attached to the sand line shall be placed on the bottom of the screen while the casing is pulled back to ensure that the screen remains in position. The casing shall be pulled back to expose the screen using the casing line, block and tackle, or hydraulic jacks as may be required.

The finished well casing shall extend 3 feet above the ground elevation.

Well Development

ROTARY DRILLED WELL: The well shall be developed until the water is clear and free of sediment. Development shall be done by air surging starting with the drill rods in the hole with the appropriate size bit at the top of the screen and working downward. Airflow and surging shall begin gently at first and be increased in intensity and duration to break down the mud cake between the formation stabilizer and the natural formation. Development shall continue until little or no sand can be removed from the well.

At the end of development, the Contractor shall ensure that the bottom of the screen is free of sediment. Final development may be completed with the test pump. The final degree of development shall be approved by the ODNR Project Representative.

CABLE TOOL DRILLED WELL: The well shall be developed until water is clear and free of sediment. The well shall be developed by mechanical surging. The surge tool shall be lowered into the well until it is 10-15 feet beneath the static water level. The initial surging motion shall be gentle, allowing fine material to go into suspension and enter the well. As water begins to move into and out of the screen more readily, the surge tool shall be lowered to just above the top of the screen and the force of the surging motion may be increased. Development within the screen shall move progressively downward based on observed results. Surging shall continue until little or no sand can be removed from the well. The Contractor may apply other techniques such as air surging or jetting if deemed appropriate. The final degree of development shall be approved by the ODNR Project Representative.

Testing

The contractor shall furnish a test pump with a capacity of 20 gallons per minute (gpm) at a pumping level of 100 feet. The pump shall be a submersible type powered by an electric generator. A control valve and discharge line shall be installed to convey the water to a natural drainage point.

The well shall be pumped for one hour at a rate of 10 gpm. If the well cannot sustain 10 gpm, the well shall be pumped at a rate that can be sustained for at least one hour. The rate shall be measured using a flow meter or orifice weir that is approved by the ODNR Project Representative. All fines shall be removed from the well prior to beginning the well pump test.

During the pumping test, the Contractor shall measure water levels to the nearest 0.01 foot using an electric tape and record the measurements on the test data sheet provided by the ODNR Project Representative. Measurements shall be taken at 5-minute intervals for the first 30 minutes and 10-

minute intervals for the last 30 minutes of the test. The test shall not be started sooner than one hour after completion of development to measure and record a static water level.

Restoration

After completion of the work, the Contractor shall restore the site to the original condition or better, to include grading and seeding. All excess materials and debris generated as a result of the work shall be removed. Drill cuttings may be broadcast on-site if they are not extensive and can be incorporated into restoration (grading and seeding) of the well site. If the drill cuttings are too extensive to be left at the location, they must be containerized for transportation and proper disposal.