FINAL TECHNICAL REPORT

OBSERVATION WELL INTEGRITY TESTING AND GEOPHYSICAL SURVEYS

Grant/Cooperative Agreement Number G23AC00312-00

Ohio Department of Natural Resources

Division of Geological Survey

2045 Morse Road, Bldg. B-2

Columbus, Ohio 43229

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Term of Contract: July 1, 2023–June 30, 2024

October 21, 2024

The Groundwater Program of the Ohio Department of Natural Resources, Division of Geological Survey (ODNR-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 the monitoring and evaluating of long-term trends in groundwater-level fluctuations throughout the state's aquifers. To do this, ODNR-DGS operates a network of State observation wells, which record groundwater-level measurements and, for some wells, transmit this data in real-time via satellite.

This grant project included work under two National Groundwater Monitoring Network (NGWMN) Objectives: Objective 3 – Filling Gaps in Information at NGWMN Sites and Objective 4 – Well Maintenance. Under Objective 3, this project filled data gaps for 17 NGWMN sites in Ohio by determining well construction and aquifer lithologies from downhole camera and geophysical logging surveys. Under Objective 4, it completed the round of well-integrity testing of ODNR-DGS's 141 active observation wells started in Ohio's 2018 NGWMN grant. Fieldwork mostly took place between August 2023 and June 2024, though several rescheduled and makeup days occurred after the conclusion of the contract period due to equipment issues, staffing delays, and weather-related postponements. Rescheduling had no effect on the project deliverables or budget.

Project Description

Filling Gaps in Information at NGWMN Sites

Under Objective 3 – Filling Gaps in Information at NGWMN Sites, downhole camera and geophysical (gamma ray) surveys were completed on 17 NGWMN wells that had neither an identifiable ODNR well log or documented, reliable construction information. Several of the 17 sites had well-service records that reported limited information or the results of previous camera, slug test, or well-sounding studies, but most consisted of pre-2000 data and were incomplete or considered generally unreliable or out-of-date. All 17 sites were consolidated (rock) wells with open boreholes where lithological information could be feasibly gathered via downhole camera footage and/or gamma ray data. Table 1 shows the list of wells that were surveyed as part of this grant.

Well Surveyed	County
AU-3	Auglaize
B-3	Belmont
GE-3A	Geauga
HN-1	Hardin
HY-2	Henry
LU-1	Lucas

M-2	Madison
M-3	Madison
MA-1	Mahoning
MN-1	Marion
MN-2	Marion
MN-4	Marion
MR-2	Mercer
S-3	Sandusky
S-4	Sandusky
VW-1	Van Wert
WY-1	Wyandot

Table 1. List of wells surveyed

A Laval Underground Surveys R-CAM 1000/1300 XLT downhole camera owned by ODNR-DGS was used for the downhole camera surveys. Video was captured both up- and downhole as MPEG-2 .ts video files. Notes were taken in the field and then compared to the camera footage for analysis. For most sites, camera footage was only sufficient in determining the well total depth, casing length, and some qualitative characteristics of the casing or borehole such as the presence of fractures, scaling, etc. At several sites, borehole collapses were noted. In others, lost equipment was encountered (e.g., at B-3, an old metal float-and-counterweight tape was found coiled up at the bottom of the well). Lithological determinations were difficult from camera footage alone due to the age and weathering of the boreholes, though in some wells, lithological changes were indeed noted. These were generally either corroborated or superseded by the geophysical survey data.

A Mount Sopris 32 GR Slim Natural Gamma Probe, a Mount Sopris MATRIX Data Logger, and a Mount Sopris Mini-series portable winch were used for geophysical surveys. Originally, ODNR-DGS intended to perform these surveys with its own equipment it had planned to purchase, but procurement issues dramatically delayed the equipment acquisition, and the surveys had to be performed in conjunction with United States Geological Survey (USGS) staff from the Ohio-Kentucky-Indiana USGS office, using USGS equipment. Each well was gamma logged immediately following the completion of its downhole camera survey. Gamma log data were converted into .las files and sent to the ODNR-DGS by USGS staff. Visualization and analysis of the .las files were performed by ODNR-DGS staff using Schlumberger's DataView and Advanced Logic Technology's WellCAD software.

On most field days, due to the distances of the wells from ODNR-DGS's central office and the time required to perform the tests, only one well was surveyed. On others, the proximity of the sites to one another allowed them to be completed together. Figure 1 shows the location of the surveyed wells in Ohio:

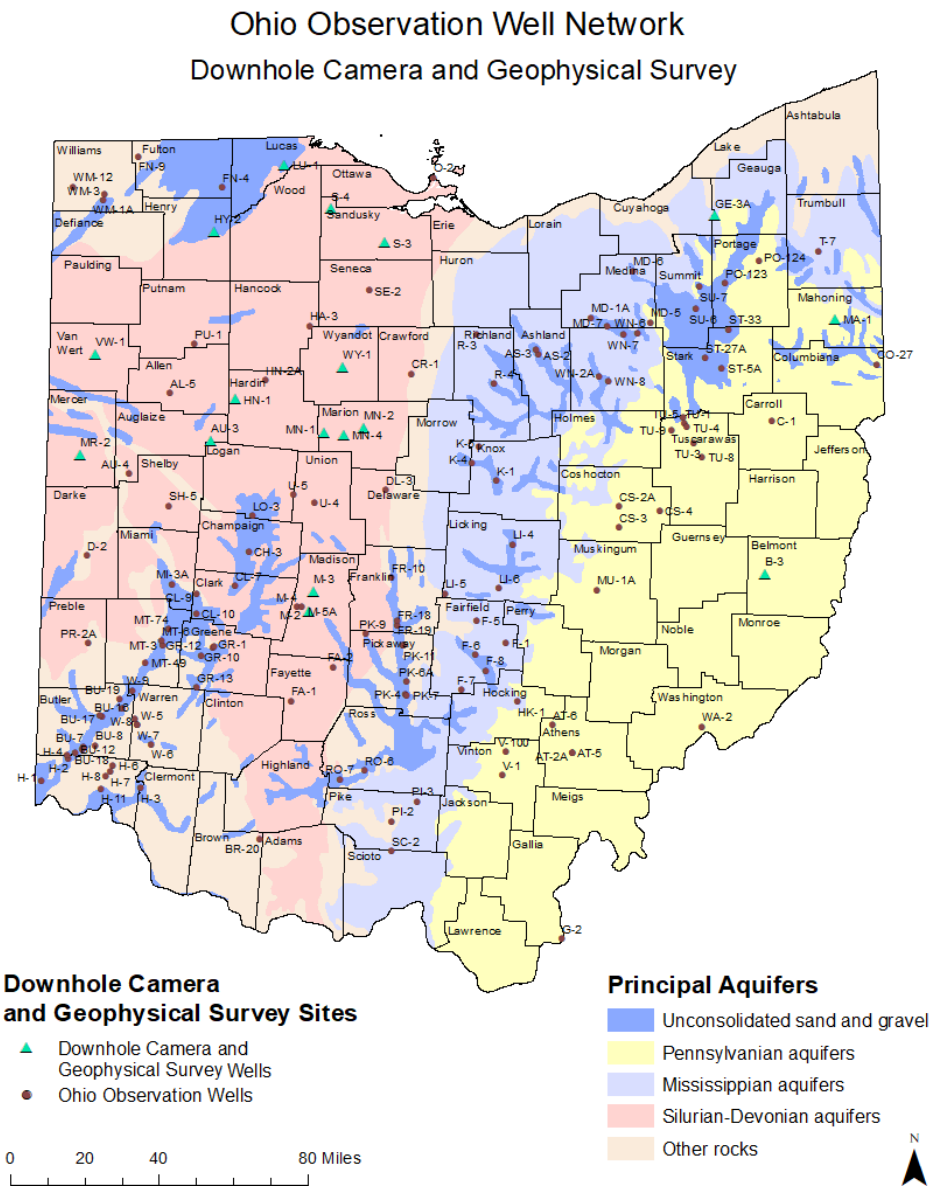


Figure 1. Location of wells surveyed

The results of the downhole camera and geophysical surveys were used to update each site's well construction information in AQUARIUS, ODNR-DGS's observation well data platform. For some sites, such as AU-3 and B-3, the results were used to link an existing ODNR well log to the site (see Appendix A, right). For others, the survey was used to update the ODNR well log with previously missing information (see Appendix A, left). At some sites, the camera and geophysical data allowed for the filing of a surrogate ODNR well log (see Appendix B). At all sites, the data were used to improve or fill gaps in critical site attributes such as total depth or casing length. Casing length data was added or updated to most sites based on the downhole camera footage. Current total depth was also updated for several sites, including M-2, MN-2, and WY-1, which revealed borehole collapses, and MR-2, which showed significant "silting-in" (sedimentation) at 234 feet. The key attributes added or updated for each site are shown in Table 2:

Well ID	Total Depth (ft.)	Casing Type	Casing Length (ft.)	Casing Height (ft.)	Casing Diameter (in.)	Screen (if present) Type	Screen Length (ft.)	Notes
AU-3	380	Steel	52	1.11	12	-	-	Confirmed well log: 421514
B-3	119	Steel	119	3.75	6	Perforated	40	Confirmed well log: 616226
GE-3A	92	Steel	21	3	6	-	-	
HN-1	40	Steel	38.6	1.45	6	-	-	
HY-2	300	Steel	45	2.92	12	-	-	
LU-1	523	Steel	96	3.32	10	-	-	
M-2	205	Steel	185	1.06	12	-	-	Collapse at 205 ft.
M-3	290	Steel	145	3.01	12	-	-	Partial collapse at 282, confirmed: CPBR-29
MA-1	170	Steel	99	2.55	8	-	-	
MN-1	50	Steel	50	3.15	4	-	-	Collapse at 50 ft.
MN-2	61	Steel	54	1.92	12	-	-	Collapse at 61 ft.
MN-4	290	Steel	33	2.85	12	-	-	
MR-2	234	Steel	54	1.35	6	-	-	Silted in/sedimentation at 234 ft.
S-3	121	Steel	93	2.85	12	-	-	
S-4	263	Steel	Unknown	1.2	8	-	-	
VW-1	340	Steel	70	3.43	8	-	-	
WY-1	67	Steel	66	2.85	5	-	-	Collapse at 67 ft.

Table 2. Updated site attributes following geophysical surveys

All collected geophysical data will be uploaded into AQUARIUS and attached to the associated ODNR well log (if available). At some sites, the geophysical data was not definitive enough to facilitate the filing of a surrogate ODNR well log. For these sites, the raw geophysical data will still be made available in AQUARIUS.

Well Maintenance

Under Objective 4 – Well Maintenance, integrity tests (slug tests) were conducted on 25 existing observation wells, completing the full round of well-integrity testing of ODNR-DGS's 141 active observation wells started during the 2018 NGWMN grant cycle. The last time ODNR's wells were slug tested was in the late 1990s. The USGS recommends an integrity test cycle of every 5 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. Table 3 shows the list of wells that were tested as part of this grant. Appendix C shows the full results of each test.

Well Tested	County
AT-2A	Athens
B-3	Belmont
BU-12	Butler
BU-16	Butler
BU-17	Butler
BU-19	Butler
CH-3	Champaign
FA-2	Fairfield
FN-9	Fulton
FR-10	Franklin
H-7	Hamilton
HK-1	Hocking
K-5	Knox
LO-3	Logan
MT-74	Montgomery
PK-10	Pickaway
PK-11	Pickaway
PK-6A	Pickaway

PK-9	Pickaway
RO-6	Ross
RO-7	Ross
W-6	Warren
W-7	Warren
W-8	Warren
W-9	Warren

Table 3. List of wells slug tested

Figure 2 shows the final status of slug testing by grant cycle:

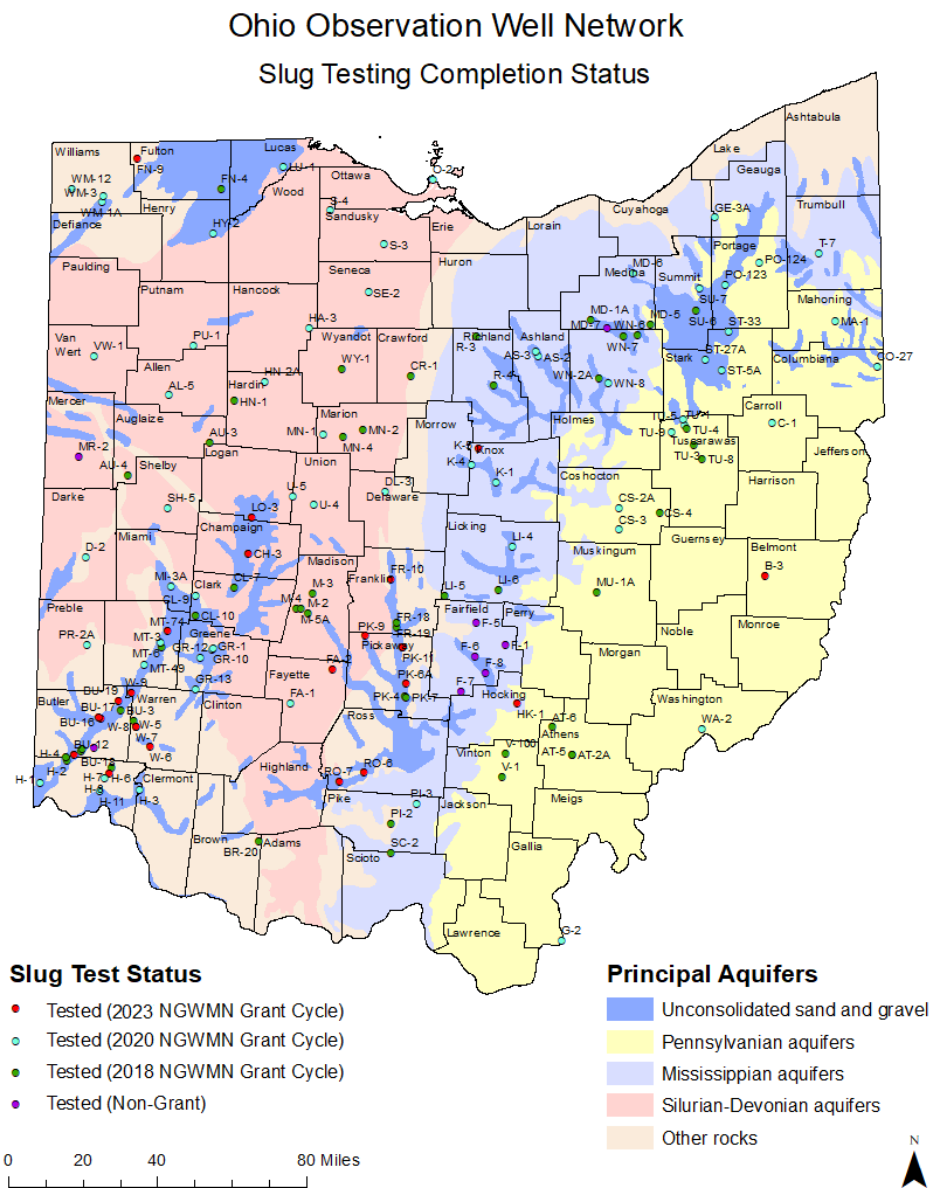


Figure 2. Status of slug testing

Since this grant's slug testing started, there have been several staffing changes. Curtis Coe retired from state service after the completion and analysis of all but three slug tests. Group Supervisor Craig Nelson analyzed the remaining tests. Mark Potucek and Alexis Lanier were reassigned to other projects. Devon Goeller, Scott Kirk, and Curtis Coe conducted most of the slug tests, with some assistance from junior staff member Maria Scaccia. 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 four types of slug tests they could perform: water in, physical slug in, physical slug out, and pneumatic. Depending on the well diameter and physical site conditions, one or more of the methods were used for each well. The type of test conducted on each well for its best solution is listed in the table in Appendix C. The pneumatic technique was not used during this grant cycle.

Most of the wells responded rapidly to the slug tests (see Appendix C 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 a degradation of the formation. The following wells listed in Table 4 did not respond quickly enough to calculate aquifer properties:

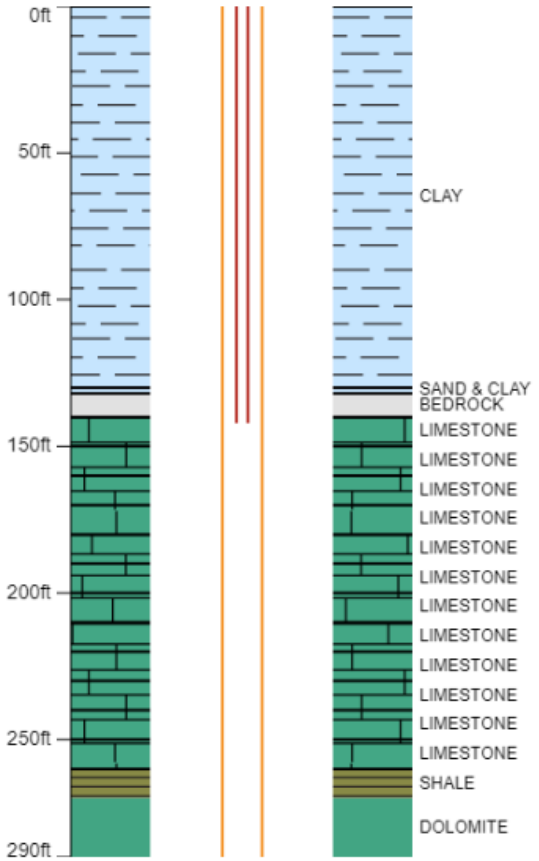
Well ID	County
B-3	Belmont
BU-12	Butler
H-7	Hamilton
HK-1	Hocking
PK-9	Pickaway

Table 4. Observation wells that were slow to respond to testing

Wells in Table 4 and the other slow-responding wells from previous NGWMN grant cycle ODNR-DGS slug-testing projects will be evaluated for cleanouts or sealed and decommissioned. At some sites, replacement wells may be drilled.

The conclusion of this testing program represents a significant achievement in ensuring the integrity of ODNR-DGS's NWGMN site wells throughout Ohio.

Appendix A: Example ODNR Well Logs Updated from Results of Geophysical Surveys



Updated well diagram for NGWMN Site well M-3

ODNR Org. Well AU-3 (CMW)

ORIGINAL

WELL LOG AND DRILLING REPORT

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

No. 421514
No 5 well

County Auglaize Township Goshen Section of Township 5
Owner Harold Stocker Address
Location of property Dosden Rd.

CONSTRUCTION DETAILS

Casing diameter 12 Length of casing 52
Type of screen Length of screen
Type of pump Turbine
Capacity of pump 500
Depth of pump setting 300
Date of completion 5-24-71

BAILING OR PUMPING TEST (Specify one by circling)

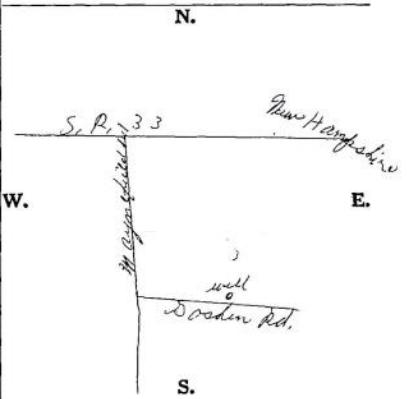
Test Rate 480 G.P.M. Duration of test 24 hrs.
Drawdown 151 ft. Date 5-24-71
Static level-depth to water 12 ft.
Quality (clear, cloudy, taste, odor) Clear
Pump installed by Stoffel Drilling Co

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay	0 Feet	6 Ft.
Sand & Gravel	6	48
Limestone	48	245
White Lime	245	340
Brown shale	340	380
Water at	95	ft.
	115	"
	205	"
	245	380

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.

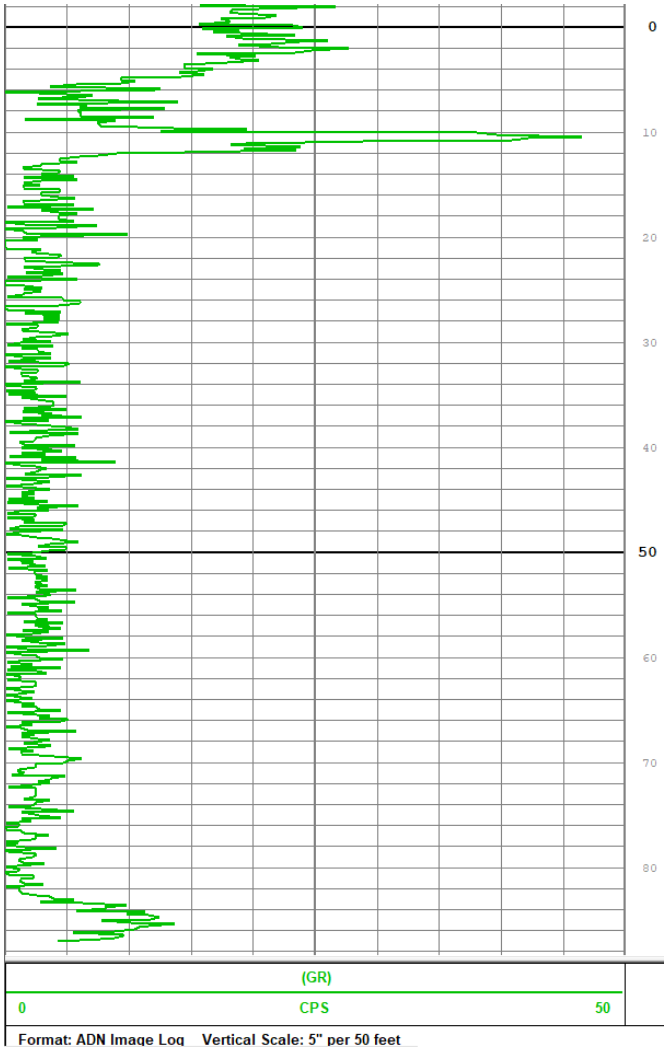


Drilling Firm Stoffel Drilling Co Date 5-24-71
Address R. R. 4 Ottawa O Signed John L Stoffel

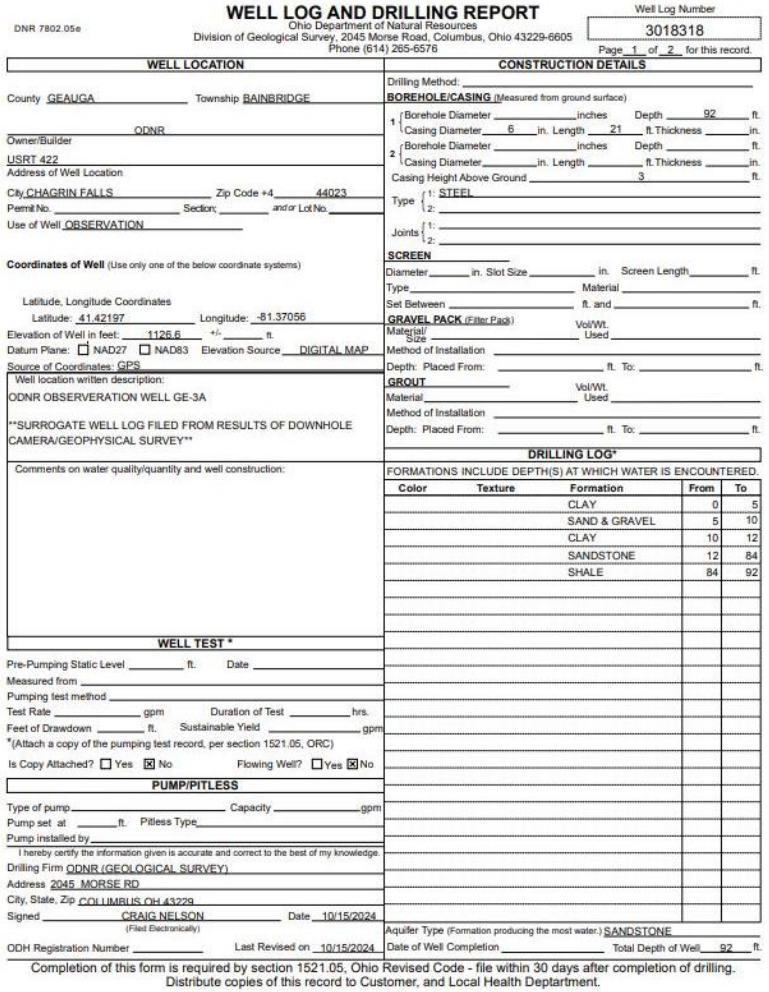
*If additional space is needed to complete well log, use next consecutive numbered form.

Updated well log for NGWMN Site well AU-3

Appendix B: Example geophysical log and its associated surrogate ODNR well log



Gamma probe .las file for well GE-3A viewed in DataViewer



DNR 7802.05e

WELL LOG AND DRILLING REPORT

Ohio Department of Natural Resources
Division of Geological Survey, 2045 Morse Road, Columbus, Ohio 43229-6605
Phone (614) 265-6576

Well Log Number: 3018318

Page 1 of 2 for this record.

WELL LOCATION

County GEAUGA Township BAINBRIDGE

ODNR
Owner/Builder

USRT 422
Address of Well Location

City CHAGRIN FALLS Zip Code +4 44023

Permit No. Section; and/or Lot No.

Use of Well OBSERVATION

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

Latitude, Longitude Coordinates

Latitude: 41.42197 Longitude: -81.37056

Elevation of Well in feet: 1126.6 +/- ft.

Datum Plane: ☐ NAD27 ☐ NAD83 Elevation Source DIGITAL MAP

Source of Coordinates: GPS

Well location written description:

ODNR OBSERVERATION WELL GE-3A

SURROGATE WELL LOG FILED FROM RESULTS OF DOWNHOLE CAMERA/GEOPHYSICAL SURVEY

Comments on water quality/quantity and well construction:

WELL TEST *

Pre-Pumping Static Level ft. Date

Measured from

Pumping test method

Test Rate gpm Duration of Test hrs.

Feet of Drawdown ft. Sustainable Yield 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 ODNR (GEOLOGICAL SURVEY)

Address 2045 MORSE RD

City, State, Zip COLUMBUS, OH 43229

Signed CRAIG NELSON (Filed Electronically) Date 10/15/2024

ODH Registration Number Last Revised on 10/15/2024

CONSTRUCTION DETAILS

Drilling Method:

BOREHOLE/CASING (Measured from ground surface)

1 Borehole Diameter inches Depth 92 ft.
Casing Diameter 6 in. Length 21 ft. Thickness in.

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

Casing Height Above Ground 3 ft.

Type 1: STEEL
2:

Joints 1:
2:

SCREEN

Diameter in. Slot Size in. Screen Length ft.

Type Material

Set Between ft. and ft.

GRAVEL PACK (Filter Pack) Vol/Wt.

Material/Size Used

Method of Installation

Depth: Placed From: ft. To: ft.

GROUT Vol/Wt.

Material Used

Method of Installation

Depth: Placed From: ft. To: ft.

DRILLING LOG*

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

Color	Texture	Formation	From	To
		CLAY	0	5
		SAND & GRAVEL	5	10
		CLAY	10	12
		SANDSTONE	12	84
		SHALE	84	92

Aquifer Type (Formation producing the most water.) SANDSTONE

Date of Well Completion Total Depth of Well 92 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.

Surrogate ODNR well log generated from geophysical survey results

Appendix C: Table of Slug Test Data

Well ID	Date of Test	Test Type	Conclusion	Solution Method	Aquifer Type	Hydraulic Conductivity (ft./day)	Specific Storage (ft^{-1})
AT-2A	8/15/2023	Water In	Pass	KGS Model w/skin	Sand and Gravel	25.23	3.48E-06
B-3	6/13/2024	Water In	Fail (Field)	-	Shale	-	-
BU-12	8/23/2023	Water In	Fail (Analyzed)	KGS Model w/skin	Sand and Gravel	0.02	7.27E-06
BU-16	8/22/2023	Water In	Pass	Springer-Gelhar	Sand and Gravel	5.78	-
BU-17	8/22/2023	Water In	Pass	KGS Model w/skin	Sand and Gravel	2.15	5.56E-13
BU-19	8/23/2023	Slug In	Pass	Butler	Sand and Gravel	11.44	-
CH-3	8/1/2023	Slug Out	Pass	Springer-Gelhar	Sand and Gravel	0.33	-
FA-2	9/14/2023	Water In	Pass	Butler	Limestone	0.99	-
FN-9	8/29/2023	Slug Out	Pass	KGS Model w/skin	Unspecified	5.81	8.95E-05
FR-10	1/16/2024	Water In	Pass	KGS Model w/skin	Sand and Gravel	0.12	2.50E-11
H-7	6/12/2024	Water In	Fail (Field)	-	Sand and Gravel	-	-
HK-1	8/15/2023	Water In	Fail (Analyzed)	KGS Model w/skin	Sand and Gravel	0.11	1.45E-12
K-5	8/16/2023	Slug Out	Pass	Springer-Gelhar	Sand and Gravel	3.45	
LO-3	8/30/2023	Slug In	Pass	KGS Model w/skin	Sand and Gravel	3.27	1.64E-12
MT-74	8/2/2023	Water In	Pass	Butler	Sand and Gravel	0.28	-
PK-10	11/8/2023	Slug In	Pass	Bouwer-Rice	Sand and Gravel	6.93	-
PK-11	11/8/2023	Slug In	Pass	Springer-Gelhar	Sand and Gravel	3.90	-
PK-6A	9/14/2023	Water In	Pass	Springer-Gelhar	Sand and Gravel	1.35	-
PK-9	11/8/2023	Water In	Fail (Field)	-	Sand and Gravel	-	-
RO-6	10/3/2023	Water In	Pass	Springer-Gelhar	Sand and Gravel	4.69	-
RO-7	10/3/2023	Slug In	Pass	KGS Model w/skin	Sand and Gravel	0.29	1.09E-03
W-6	6/12/2024	Water In	Pass	KGS Model w/skin	Sand and Gravel	6.50	1.08E-03
W-7	11/7/2023	Water In	Pass	Springer-Gelhar	Sand and Gravel	0.07	-
W-8	11/7/2023	Water In	Pass	KGS Model w/skin	Sand and Gravel	0.22	4.63E-13
W-9	8/30/2023	Slug Out	Pass	KGS Model w/skin	Gravel	7.56	9.26E-13