Appendix D

Hydraulic Testing Results

AECOM
30 Knightsbridge Road
Building 5, Suite 520
Piscataway, New Jersey 08854

732-564-3600 tel
732-369-0120 fax

Technical Memorandum

To	Shannon Gleason	Page 1
CC		
Subject	Summary of Hydraulic Testing Results for Bedrock Groundwater Remedial Investigation Garfield Avenue Group Sites, City of Jersey City, Hudson County, New Jersey	
From	Frederik Schuele, Bill Spronz, Dave Estrella	
Date	February 27, 2023 (updated February 6, 2025[1])	

Introduction

This Technical Memorandum presents the results of hydraulic testing conducted at select monitoring wells as part of the bedrock groundwater Remedial Investigation (RI) at the Garfield Avenue (GA) Group Sites in Jersey City, New Jersey (the Site).

Background

Bedrock groundwater investigation activities have been conducted at the Site since 2006. Four bedrock wells (114-MW4D, 114-MW6D, 114-MW7D, and 114-MW16B) were installed during RI activities conducted in 2006 and 2007. Four bedrock wells (114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D) were installed during RI activities conducted in 2020 and 2021. More recently (later in 2021 and in 2022), a limited bedrock groundwater investigation was conducted in the southwestern portion of Site 114 and northern portions of Site 143 and Site 132 to complete the delineation requirements of the New Jersey Department of Environmental Protection (NJDEP) Technical Requirements for Site Remediation (NJDEP, 2018), as per the recommendations presented in the *Final Groundwater Remedial Investigation Report* for the Site (AECOM, 2022a).

Two scopes of work for the limited bedrock groundwater investigation were submitted to the NJDEP on April 22, 2021 and on January 25, 2022, respectively. Field activities included bedrock well installation (114-MW71D and 114-MW72D), deepening of existing bedrock wells 114-MW4D, 114-MW-61D, and 114-MW66D, well development, borehole geophysical logging, groundwater elevation gauging, groundwater sampling, hydraulic testing, and installation of multi-port water FLUTe™ systems at select open borehole bedrock wells (114-MW52D, 114-MW66D, and 114-MW72D). In addition, as requested by the NJDEP, hydraulic testing was conducted at three wells screened in the basal till (114-MW52C, 114-MW56C, 114-MW65C), one well screened in basal till/weathered bedrock (114-MW61C), and two wells screened in weathered bedrock (114-MW53C and 114-MW57C).

[1]Only the conclusions were updated on February 6, 2025, pursuant to comments received from NJDEP on the February 27, 2023 memorandum.

A summary of well details is provided in **Table 1** and well locations are shown on **Figure 1**.

Field Activities

Key field activities that relate to hydraulic testing are presented below.

Borehole Geophysics

Borehole geophysical logging was conducted in the open bedrock portions of the boreholes for wells 114-MW4D, 114-MW6D, 114-MW52D, 114-MW57D, 114-MW61D, 114-MW66D, 114-MW71D, and 114-MW72D. The borehole geophysical suite included heat-pulse flow meter (HPFM) logging to identify water bearing fractures and to assess upward or downward flow between the fracture zones in the open borehole section of each well. The HPFM logs were run under both static and pumping conditions in most of the wells. The HPFM detects flow as low as 0.01 gallons per minute (gpm).

Bedrock Well Development

Groundwater elevation data collected during well development activities conducted at wells 114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D in January 2021 were used to evaluate for potential hydraulic connection between these wells and other bedrock wells (114-MW4D, 114-MW6D, and 114-MW7D) existing at the Site at that time. The results of this evaluation are presented in a Technical Memorandum previously submitted to NJDEP and included as **Attachment 1.** As noted in the memorandum, evaluation of the water level data indicated that no hydraulic connection exists between the wells that were pumped and monitored during well development activities.

Specific Capacity Testing

Specific capacity testing was performed in December 2021 at monitoring wells 114-MW52C, 114-MW52D, 114-MW53C, 114-MW56C, 114-MW57C, 114-MW57D, 114-MW61C, 114-MW65C, and 114-MW66D in accordance with the project operating procedure (POP) for specific capacity testing prepared by AECOM and reviewed by the New Jersey Department of Environmental Protection (NJDEP), included as **Attachment 2**. Specific capacity testing was performed to:

- estimate hydraulic conductivity (K) values for the materials within which the wells were completed, and
- evaluate potential hydraulic connection between the tested wells.

Vented Level Troll 700 pressure transducers, provided by In-Situ, Inc. of Fort Collins, CO, were deployed in the wells two days prior to the testing to provide continuous water-level monitoring data. Continuous water level monitoring data were collected prior to, and after, completion of the specific capacity test at each well. Manual water level readings were collected during the specific capacity tests.

During specific capacity testing, low flow rates had to be employed to achieve stable water levels at wells 114-MW52C, 114-MW53C, 114-MW56C, 114-MW57C, 114-MW61C, and 114-MW65C. Flow rates at which stabilization was achieved ranged from 0.033 to 0.4 gallons per minute (gpm). Use of higher flow rates yielded unstable drawdowns. Based on well behavior during development, continued pumping at higher flow rates could have caused the wells to go dry.

Stable water levels could not be achieved at bedrock wells 114-MW52D, 114-MW57D, and 114-MW66D even at very low pumping rates. Therefore, the hydraulic testing procedure for these wells was modified to a pump down and recovery test. During the pump down and recovery test, the water level in each well was quickly lowered by approximately 15 feet using a submersible pump. The pump was then shut off and the water level in each well was allowed to recover while being monitored using a pressure transducer. The recovery data were analyzed as rising head slug tests using AQTESOLV, a commercial software for the analysis of aquifer tests (Duffield, 2007).

Results

Results of hydraulic testing activities are presented below.

Borehole Geophysics

Results of the HPFM logging conducted in September 2020 and January 2021 are presented in the *Final Groundwater Remedial Investigation Report* for the Site (AECOM, 2022a) and results of the HPFM logging conducted in November 2021 are presented in Appendix E of the *Addendum to Groundwater Remedial Investigation Report and Groundwater Remedial Action Work Plan for Bedrock Water-Bearing Zone* (AECOM, 2022b). Key findings are summarized below[2]:

- 114-MW4D
    - September 2020: No flow detected under ambient or stressed conditions.
    - November 2021: Flow up the borehole at up to 0.02 gpm under stressed conditions.
- 114-MW6D: No flow detected under ambient or stressed conditions.
- 114-MW52D: Flow up the borehole at up to 0.02 gpm under stressed conditions.
- 114-MW57D: Flow up the borehole at up to 0.04 gpm under stressed conditions.
- 114-MW61D
    - January 2021: Flow up the borehole at up to 0.04 gpm under stressed conditions.
    - November 2021: Flow up the borehole at up to 0.01 gpm under stressed conditions.
- 114-MW66D
    - January 2021: Flow up the borehole at up to 0.05 gpm under stressed conditions.
    - November 2021: Flow up the borehole at up to 0.02 gpm under stressed conditions.
- 114-MW71D: Flow up the borehole at up to 0.03 gpm under stressed conditions.
- 114-MW72D: Flow up the borehole at up to 0.01 gpm under stressed conditions.

Specific Capacity Testing

Graphs depicting water level data collected at each well are included in **Attachment 3**. Analysis of specific capacity data from wells 114-MW52C, 114-MW53C, 114-MW56C, 114-MW57C, 114-

[2]Stressed conditions indicate that the well was either pumped or was recovering from well development activities.

MW61C, and 114-MW65C using the protocols described in the POP for specific capacity testing[3] yielded unreasonable results that do not compare with field observations. For example, at well 114-MW52C a stable drawdown of 0.2 feet was achieved at a flow rate of 0.11 gpm. Using the POP formula, this yields a specific capacity estimate of 0.55 gpm per foot of drawdown in the well. However, pumping this well at 0.5 gpm during well development caused the well to go dry, therefore this is not a realistic estimate of the well's specific capacity. Similar conditions were observed at other wells. Based on this finding, an alternate method for analysis of the specific capacity testing data was employed.

Specific capacity data were used to derive estimated values of K for wells 114-MW52C, 114-MW53C, 114-MW56C, 114-MW57C, 114-MW61C, and 114-MW65C using the methodology described in *Determining Hydraulic Conductivity Using Pumping Data from Low-Flow Sampling* (G.A. Robbins, et al, 2009), as detailed in **Attachment 4**. **Attachment 4** includes specific capacity testing results (flow rate and drawdown at which stabilization occurred in each well) and the input variables used to solve for K for each test. Estimated K values from these analyses are presented in **Table 2**.

Pump Down and Recovery Tests

Two methods were used to analyze the recovery data from bedrock wells 114-MW52D, 114-MW57D, and 114-MW66D:

- the Kansas Geological Survey (KGS) Model for slug test response in fully or partially penetrating wells in a homogeneous anisotropic confined aquifer, and;
- the Barker-Black Model for analyzing slug tests in a fractured aquifer; a dual porosity model that assumes slab-fissured matrix blocks.

Attachment 5 presents AQTESOLV plots for the bedrock well recovery data. Based on the Conceptual Site Model, which assumes that the bedrock behaves as a single porosity system with limited to no matrix permeability and flow primarily via fractures or bedding planes, the KGS model was initially used to estimate hydraulic conductivity (K) for the bedrock. The Barker-Black dual porosity model was then used to calculate transmissivity (T) for the fractures and hydraulic conductivity of the rock matrix (K'). Results of these analyses are presented in **Table 3**. Analysis results indicate very low conductivity for the rock matrix (i.e., contribution of flow from the rock matrix is negligible), demonstrating that the bedrock behaves as a single porosity system with flow primarily along fractures and bedding planes. Both the KGS and the Barker-Black models yielded similar estimates of K for the bedrock, indicating that the assumption of a single porosity system is valid.

Conclusions

The following conclusions are based on the results of the hydraulic testing activities conducted at select monitoring wells as part of the bedrock groundwater RI for the Site:

[3]The POP for specific capacity testing specifies that the following formula should be used to estimate the specific capacity of a well:

SC = Q/s

where:
SC = specific capacity in gpm/foot
Q = flow rate in gpm
s = drawdown in feet

- Based on HPFM logging data, flow in bedrock wells ranges from 0.01 gpm to 0.05 gpm. This indicates that the bedrock has very low permeability and that groundwater movement within the bedrock occurs slowly along fractures or bedding planes.
- The low flow rates required to achieve stabilized drawdowns during specific capacity testing at wells screened in the basal till provide conclusive evidence that the bulk permeability of the basal till is lower than suggested by the K estimates derived for these wells, which are representative of the higher permeability intervals within the basal till. Therefore, the estimated values of K presented herein for wells screened in the basal till are not representative of the bulk permeability of the basal till which is expected to be several orders of magnitude lower.
- During specific capacity testing, hydraulic influence was observed at the following wells, suggesting a hydraulic connection between wells screened in the basal till and weathered bedrock in the southwestern quadrant of Site 114:
    - 114-MW52C while pumping at well 114-MW61C,
    - 114-MW56C while pumping at wells 114-MW61C and 114-MW52C,
    - 114-MW57C while pumping at well 114-MW52C, and
    - 114-MW65C while pumping at well 114-MW53C.
- Based on the estimated hydraulic conductivity values for the weathered bedrock (Lockatong Formation) at wells 114-MW53C and 114-MW57C, weathered portions of the Lockatong Formation in the southwestern quadrant of Site 114 are permeable. The thickness of the weathered rock at these wells ranges from 2.5 to 4.5 feet (AECOM, 2022a). Based on the concentration of total chromium detected at these wells (AECOM, 2022a) and the results of the specific capacity testing, weathered bedrock in this area is hydraulically connected to the overlying overburden with chromium-impacted groundwater migrating from the overburden into the weathered rock.
- Permeability in the bedrock is within fractures and bedding planes, not the rock matrix. Estimated hydraulic conductivity values for fractures or bedding planes are very low, averaging approximately 0.03 ft/day, and water transfer within the bedrock is very slow.
- No hydraulic influence between bedrock wells was evident during development of bedrock wells 114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D.

References

AECOM, 2022a. *Groundwater Remedial Investigation Report, Final.* PPG Garfield Avenue Group, Hudson County Chromium Sites, Jersey City, New Jersey. January 2022.

AECOM, 2022b. *Addendum to Groundwater Remedial Investigation Report and Groundwater Remedial Action Work Plan for Bedrock Water-Bearing Zone.* PPG Garfield Avenue Group, Hudson County Chromium Sites, Jersey City, New Jersey. 2022.

Barker, J. A. and J.H. Black, 1983. *Slug tests in fissured aquifers*, Water Resources Research, vol.19, no. 6, pp. 1558-1564.

Duffield, G. M., 2007. AQTESOLV for Windows Version 4.5, HydroSOLVE, Inc., Reston, Virginia.

Gary A. Robbins, Alejandra T. Aragon-Jose, and Andres Romero, 2009. *Determining Hydraulic Conductivity Using Pumping Data from Low-Flow Sampling*, Groundwater, Volume 47, Number 2, pages 271-276, March-April 2009.

NJDEP, 2018. *N.J.A.C., 7.26E: Technical Requirements for Site Remediation.* August 6, 2018.

Tables

Table 1
Construction Details for Select Monitoring Wells
Bedrock Groundwater Remedial Investigation
Garfield Avenue Group Sites
PPG, Jersey City, New Jersey

Well ID	Water-Bearing Zone	Total Depth (ft bgs)	Screened Interval (ft bgs)	Ground Surface Elevation (ft NAVD88)	Top of Inner Casing Elevation (ft NAVD88)	Inner Casing Material	Inner Casing Diameter (inches)
114-MW4D	Bedrock (Open Borehole)[2] - Diabase, Lockatong	125	87-125	13.1	15.77	Steel	6
114-MW6D	Bedrock (Open Borehole) - Lockatong	111	86-111	12.6	12.69	Steel	6
114-MW7D	Bedrock[3] - Indeterminate	90	85-90	12.4	11.92	PVC	6
114-MW16B	Bedrock[3] - Diabase	35.5	30.5-35.5	16.1	15.53	PVC	2
114-MW52C	Basal Till	79	68-73	14	15.85	PVC	2
114-MW52D	Bedrock (Open Borehole)[1] - Lockatong	105	80-105	13.9	15.64	Steel	6
114-MW53C	Weathered bedrock - Lockatong	55	46-47.5	13.9	15.08	PVC	2
114-MW56C	Basal Till	80	67-72	14	16.04	PVC	2
114-MW57C	Weathered bedrock - Lockatong	75	68.5-70	12.9	14.55	PVC	2
114-MW57D	Bedrock (Open Borehole) - Lockatong	112.5	85-112.5	12.7	14.70	Steel	6
114-MW61C	Basal Till/Weathered Bedrock	75	62.5-68	14	16.67	PVC	2
114-MW61D	Bedrock (Open Borehole)[2,3] - Diabase, Lockatong	135	110-135	14.3	17.12	PVC	2
114-MW65C	Basal Till	72	60-65	12.4	14.20	PVC	2
114-MW66D	Bedrock (Open Borehole)[1,2] - Lockatong	140	90-140	13.9	16.20	Steel	6
114-MW71D	Bedrock (Open Borehole) - Diabase, Lockatong	141	115-141	14.2	15.96	Steel	6
114-MW72D	Bedrock (Open Borehole)[1] - Lockatong	125	100-125	12.3	14.41	Steel	6

Notes:
[1]Open borehole converted to FLUTe multi-port system
[2]Deepening of existing borehole
[3]Open borehole completed with 2-inch PVC screen and casing
bgs - below ground surface
ft - feet
NAVD88 - North American Vertical Datum of 1988
PVC - polyvinyl chloride

Table 2
Summary of Hydraulic Conductivity Values Estimated from Hydraulic Testing
Bedrock Groundwater Remedial Investigation
Garfield Avenue Group Sites
PPG, Jersey City, New Jersey

Well ID	Screen Zone	K (ft/day)	K (cm/sec)
114-MW52C	Basal Till	21.21	7.48E-03
114-MW56C	Basal Till	1.2	4.24E-04
114-MW65C	Basal Till	7.15	2.52E-03
114-MW53C	Weathered Bedrock (Lockatong)	52.11	1.84E-02
114-MW57C	Weathered Bedrock (Lockatong)	28.57	1.01E-02
114-MW61C	Basal Till/Weathered Bedrock (Diabase)	12.32	4.35E-03

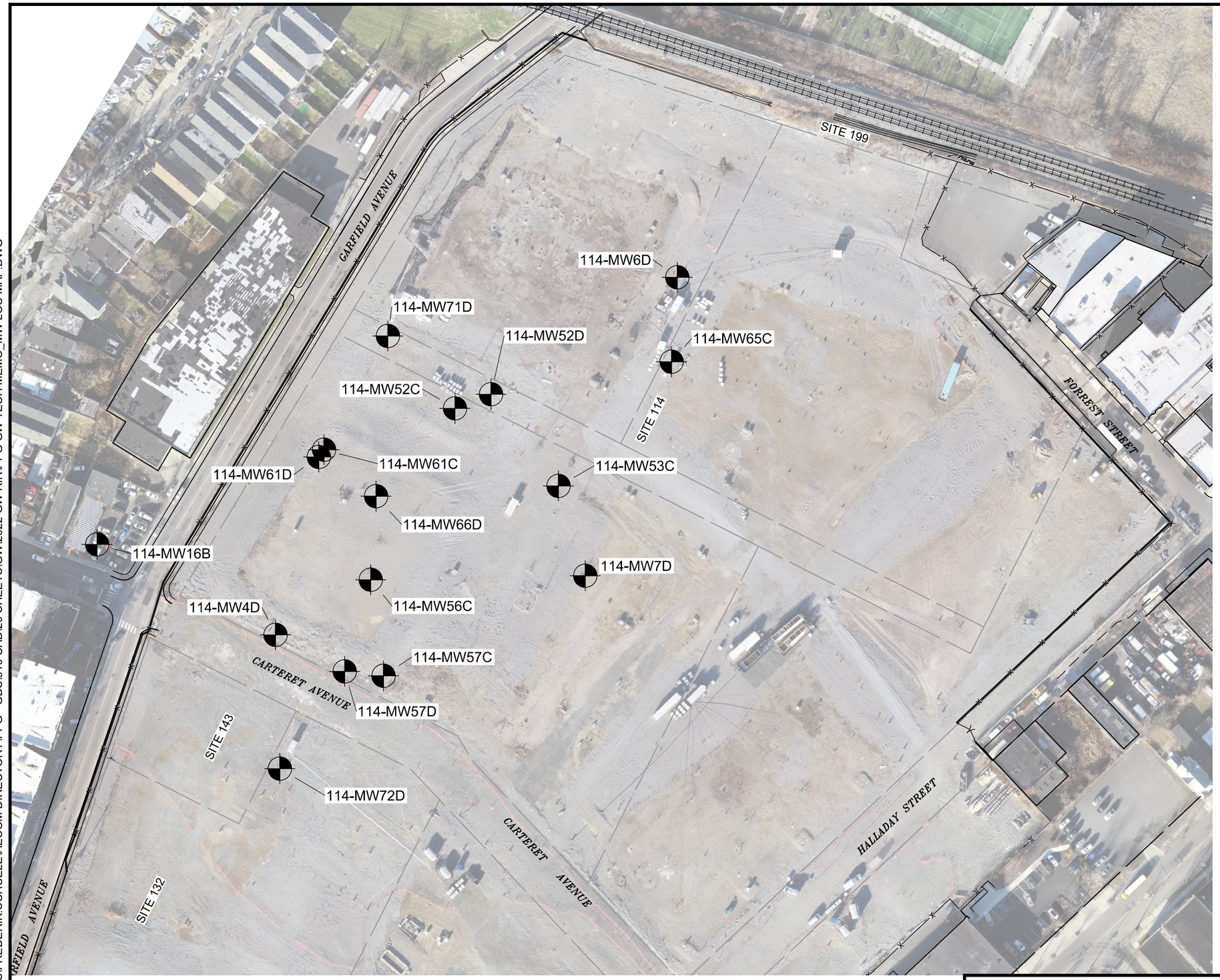
Notes:
cm - centimeters
ft - feet
K - hydraulic conductivity

Table 3
Summary of Hydraulic Conductivity Values Estimated for Bedrock Wells
Bedrock Groundwater Remedial Investigation
Garfield Avenue Group Sites
PPG, Jersey City, New Jersey

Well ID	Screen Zone	KGS Model	Barker-Black Model		
		K (ft/day)	T (ft^2/day)	K' (ft/day)	K (ft/day)
114-MW52D	Bedrock (Lockatong)	0.00155	0.0339	1.00E-10	0.00136
114-MW57D	Bedrock (Lockatong)	0.0125	0.272	1.00E-10	0.00987
114-MW66D	Bedrock (Lockatong)	0.0831	3.83	1.00E-10	0.0767
Average		0.032	1.38	NA	0.0293
Geometric Mean		0.012	0.328	NA	0.0101

Notes:
ft - feet
K - hydraulic conductivity of fractures within the rock matrix
K' - hydraulic conductivity of the rock matrix
T - transmissivity
NA - not applicable

Figures



LEGEND

- PROPERTY LINE
- SHEET PILE
- NEW JERSEY TRANSIT LIGHT RAIL
- 114-MW72D — MONITORING WELL ID
- MONITORING WELL LOCATION

Map Sources:

1. New Jersey State Plane North American Datum 1983 Coordinates, U.S. Survey Feet.

60 0 120

GRAPHIC SCALE IN FEET

N

AECOM

PPG
GARFIELD AVENUE GROUP
JERSEY CITY, NEW JERSEY

MONITORING WELL LOCATIONS

DATE: 09/12/2022 | DRWN: GET | FIGURE 1

File: C:\USERS\FREDERIK.SCHUELE\AECOM DIRECTORY\PPG - GDS\910 CAD\20 SHEETS\GW2022 GW RIR\PPG GW TECH MEMO_MW LOC MAP.DWG

Attachment 1

AECOM
30 Knightsbridge Road
Piscataway, New Jersey 08854
www.aecom.com

732 564 3600 tel
732 369 0122 fax

Technical Memorandum

To	Dave Doyle, NJDEP Dave Van Eck, NJDEP	Page	1 of 3
CC	Ron Ricco, Site Administrator Jim Ray, Site Administrator PM Nancy Colson, Site Administrator Assistant Rob Schmitt, Hampshire Peter Sorge, JM Sorge Chris Daggett, Hampshire Dave Spader, ERFS Nick Strasser, Jersey City Counsel Peter Baker, Jersey City Counsel Chris Fiore, Jersey City Redevelopment Agency Bhavini Doshi, Jersey City Redevelopment Agency Counsel Eric Tomaszewsk, Jersey City Redevelopment Agency Counsel Prabal Amin, WESTON Ralph Costa, WESTON Talley Zhang, WESTON Jody Overmyer, PPG Mark Terril, PPG Rich Feinberg, PPG Dorothy Laguzza, PPG Counsel - K&L Gates Joe Lagrotteria, PPG Counsel - K&L Gates Shannon Gleason, AECOM Shree Ravi, AECOM Bill Spronz, AECOM		
Subject	Bedrock Well Development Groundwater Elevation Monitoring Data Groundwater Remedial Investigation PPG Garfield Avenue Group, Hudson County Chromium Sites, Jersey City, New Jersey		
From	Maya Desai, Frederik Schuele		
Date	July 29, 2021		
Attachments	Figure 1 – Bedrock Well Locations Figure 2 – Water Level Response to Development at 114-MW52D Figure 3 – Water Level Response to Development at 114-MW57D Figure 4 – Water Level Response to Development at 114-MW61D Figure 5 – Water Level Response to Development at 114-MW66D Attachment A – Well Development Records		

Introduction

On behalf of PPG, AECOM is hereby providing to the New Jersey Department of Environmental Protection (NJDEP) the well development records and groundwater elevation data collected during development of bedrock wells 114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D, which were installed for the groundwater Remedial Investigation (RI) in December 2020 and January 2021. This information was requested by NJDEP via comments provided on June 16, 2021 regarding the April 21, 2021 Technical Memorandum entitled *Additional Bedrock Investigation Scope of Work for Groundwater Remedial Investigation, PPG Garfield Avenue Group, Hudson County Chromium Sites, Jersey City, New Jersey* (GW-102).

Summary of Monitoring Well Development Activities

Between January 5 and 13, 2021, AECOM completed development of newly installed open-borehole bedrock wells 114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D. Well locations are shown on **Figure 1**. Well development activities were conducted in accordance with the New Jersey Department of Environmental Protection Field Sampling Procedures Manual (FSPM; NJDEP, 2005) and PPG's Field Sampling Plan/Quality Assurance Project Plan (FSP-QAPP; AECOM, 2010) and included pumping and surging techniques to establish good communication with the bedrock aquifer and to remove solids from the open borehole. Due to the low yield of the wells, the wells were pumped dry and allowed to recover multiples times. In addition, fresh (potable) water was used to flush the wells and aid in the development of the wells. In accordance with the FSP-QAPP, if fresh water was added to a well a minimum of 1.5 times the volume of fresh water added was purged from the well. Purging of the proper volume of water from each well was confirmed by Weston in the field. Water quality indicator parameters, including temperature, pH, specific conductivity, dissolved oxygen, oxidation-reduction potential, and turbidity were recorded during well development activities. Well development records are included in **Attachment A**.

During well development activities, unvented LevelTROLL 400 series pressure transducers were deployed for the collection of continuous water elevation data at newly-installed bedrock wells 114-MW52D, 114-MW57D, 114-MW61D, 114-MW66D, and at existing bedrock wells 114-MW4D, 114-MW6D, and 114-MW7D. For each well that was developed, the pressure transducer was removed from the well during development activities. A BaroTROLL data logger was deployed during well development activities to collect barometric pressure data for atmospheric compensation of the pressure transducer data. Upon completion of well development activities, data from the pressure transducers were compiled, corrected using In-Situ's Baro Merge software to eliminate barometric effects from the measurements, and converted to groundwater elevations based on the surveyed measuring point at each well. Manual groundwater elevation readings were also collected during well development activities using an electronic water level meter. Hydrographs developed from the pressure transducer data and the manual groundwater elevation gauging data are presented on **Figure 2, Figure 3, Figure 4,** and **Figure 5**. On each figure, the dashed vertical line denotes the beginning of development activities at the subject well.

Conclusions

The collected groundwater elevation data were used to evaluate for potential hydraulic connection between bedrock wells during development activities conducted at wells 114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D. This evaluation concluded that there is a lack of observable water level responses during well development activities, indicating that there is no evidence of a hydraulic connection between the monitored bedrock wells.

References

AECOM, 2010. *Updated Field Sampling Plan-Quality Assurance Field Sampling Plan / Quality Assurance Project Plan Non-Residential Chromium Sites, Hudson County, New Jersey.* June 2010.

NJDEP, 2005. *Field Sampling Procedures Manual.* August 2005.

Figures

FRENCH PARK WAREHOUSE

JERSEY AUTO REPAIR

FORREST STREET

FORREST S PROPERT

HALLADAY STREET

CARTERET AVENUE

Site 114

Site 143

Site 132

114-MW50C -48.6
114-BSB-02 -48.0
114-MW62C -58.0
114-MW63C -50.5
114-MW6D -64.3
114-MW45C -59.5
114-MW51C -64.8
114-MW25C -44.6
SB-24A -67.3
114-MW67C -69.8
114-MW65C -53.6
114-BSB-03 -62.1
114-MW52D -54.1
114-MW52C -59.0
114-MW55C -56.9
114-MW61C -49.0
114-MW61D -48.6
EF-37 -3.6
GT-15 -38.8
114-MW66D -62.9
114-MW53C -31.6
114-MW16B -2.9
GT-14 -22.7
114-MW68C -59.2
114-MW56C -58.0
GT-9C -53.5
114-MW7D -64.1
MW-4F -64.1
114-MW58C -62.8
114-MW22B -22.9
114-MW4D -74.1
GT-10A -54.4
114-MW54C -66.2
SB-57 -61.3
114-MW57D -54.3
114-MW57C -55.1
114-MW69C -57.2
SB-58 -55.9
B-2 -56.3
SB-23 -73.0
114-MW59C -80.4
B-1 -61.2
114-MW64C -82.2
114-MW20C -71.6
137-MW1C -59.5
SB-25 -80.8
114-MW60C -108.5
SB-30 -65.7

LEGEND

- GARFIELD AVENUE GROUP SITES
- HUDSON COUNTY PARCELS
- FORMER MORRIS CANAL
- REMOVED SHEET PILE
- IN PLACE SHEET PILE
- RAILROAD TRACKS
- -90 TOP OF BEDROCK SURFACE (ELEVATION IN FEET NAVD88)
- -90 INFERRED TOP OF BEDROCK SURFACE (ELEVATION IN FEET NAVD88)
- INFERRED LIMIT OF THE DEEP WATER-BEARING ZONE
- INVESTIGATION LOCATION

Label:

135-MW1C
-93.1
Location ID
Top of Bedrock Elevation (feet NAVD88)

- EXISTING BEDROCK WELL

ROCK TYPE

- IGNEOUS - DIABASE
- INDETERMINATE
- SEDIMENTARY
- SEDIMENTARY - LOCKATONG
- SEDIMENTARY - STOCKTON

Map Sources:
1. New Jersey State Plane North American Datum 1983 Coordinates, U.S. Survey Feet.
2. Vertical Elevations are in North American Vertical Datum of 1988 (NAVD88), U.S. Survey Feet.
3. Parcels of Hudson County, New Jersey State Plane NAD83, Hudson County Department of Planning, Jersey City, New Jersey, May 21, 2013.

Notes:
1. Data used to develop the interpreted top of bedrock surface was obtained from historical investigations conducted by PPG and Public Service Electric and Gas Company (PSEG), as well as bedrock investigations and monitoring well installations on Site 114 as part of the groundwater remedial investigation.
2. The bedrock type for 114-MW7D, B-1, and B-2 is noted as indeterminate based on review of Project Area data and published bedrock geology for this area. Information for the bedrock interval noted on the boring logs for these wells is inconsistent with the information compiled for the Project Area.

AECOM

50 0 100
GRAPHIC SCALE IN FEET

PPG
GARFIELD AVENUE GROUP SITES
JERSEY CITY, NEW JERSEY

DATE: 07/19/21 | DRWN: FS

BEDROCK WELL LOCATIONS

FIGURE 1

Figure 2. Water level response to Development of 114-MW52D

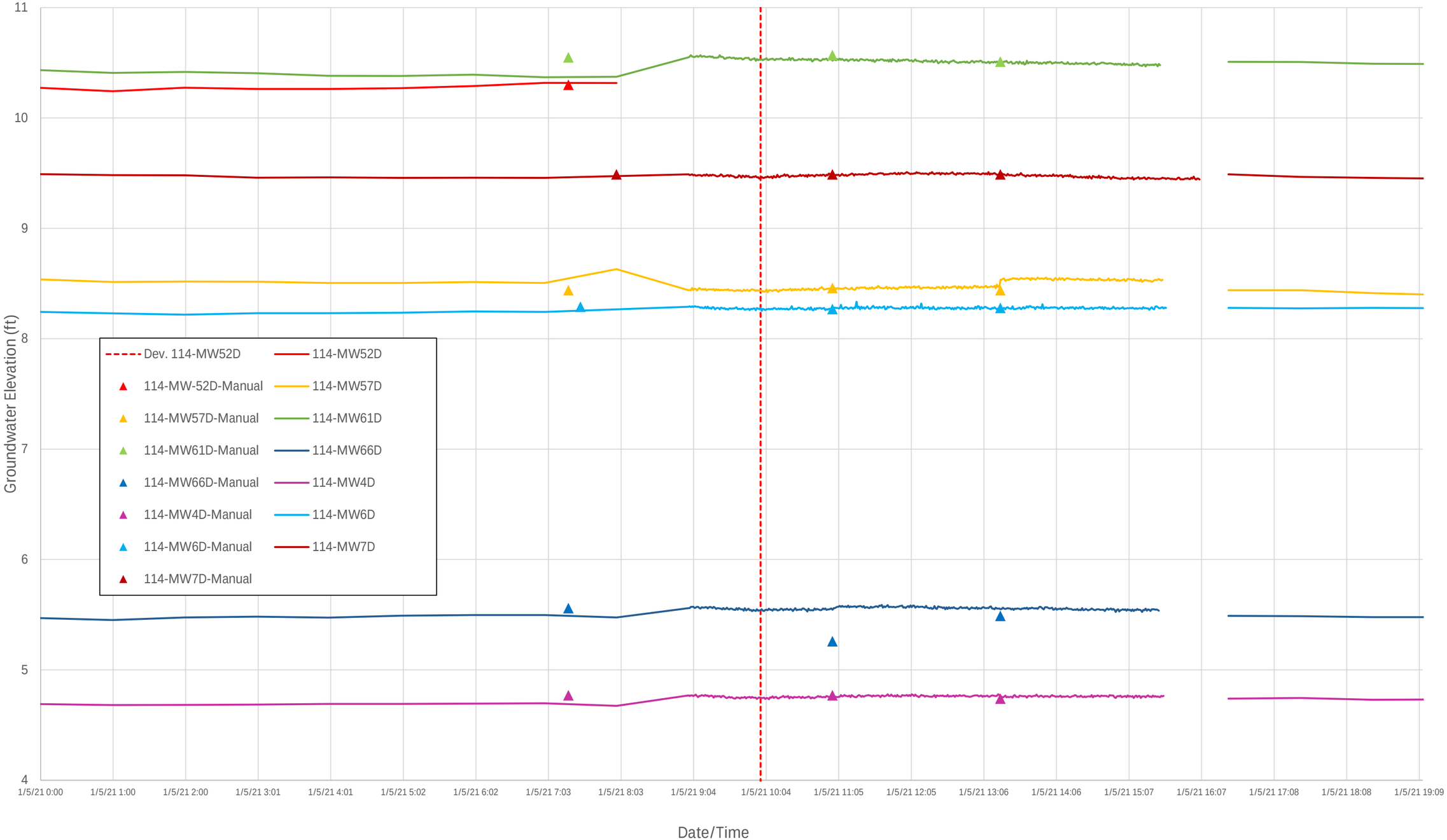


Figure 3. Water level response to Development of 114-MW57D

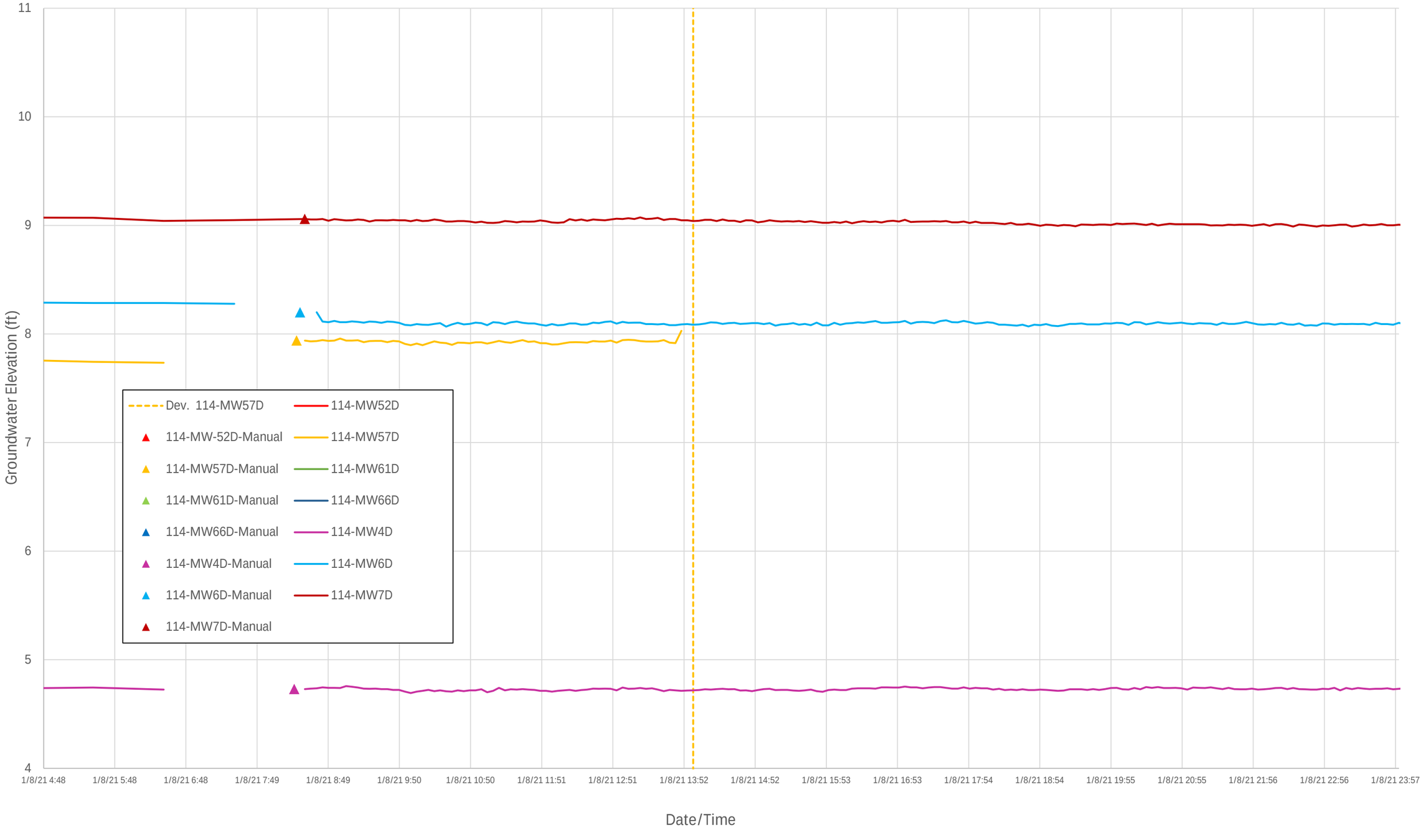


Figure 4. Water level response to Development of 114-MW61D

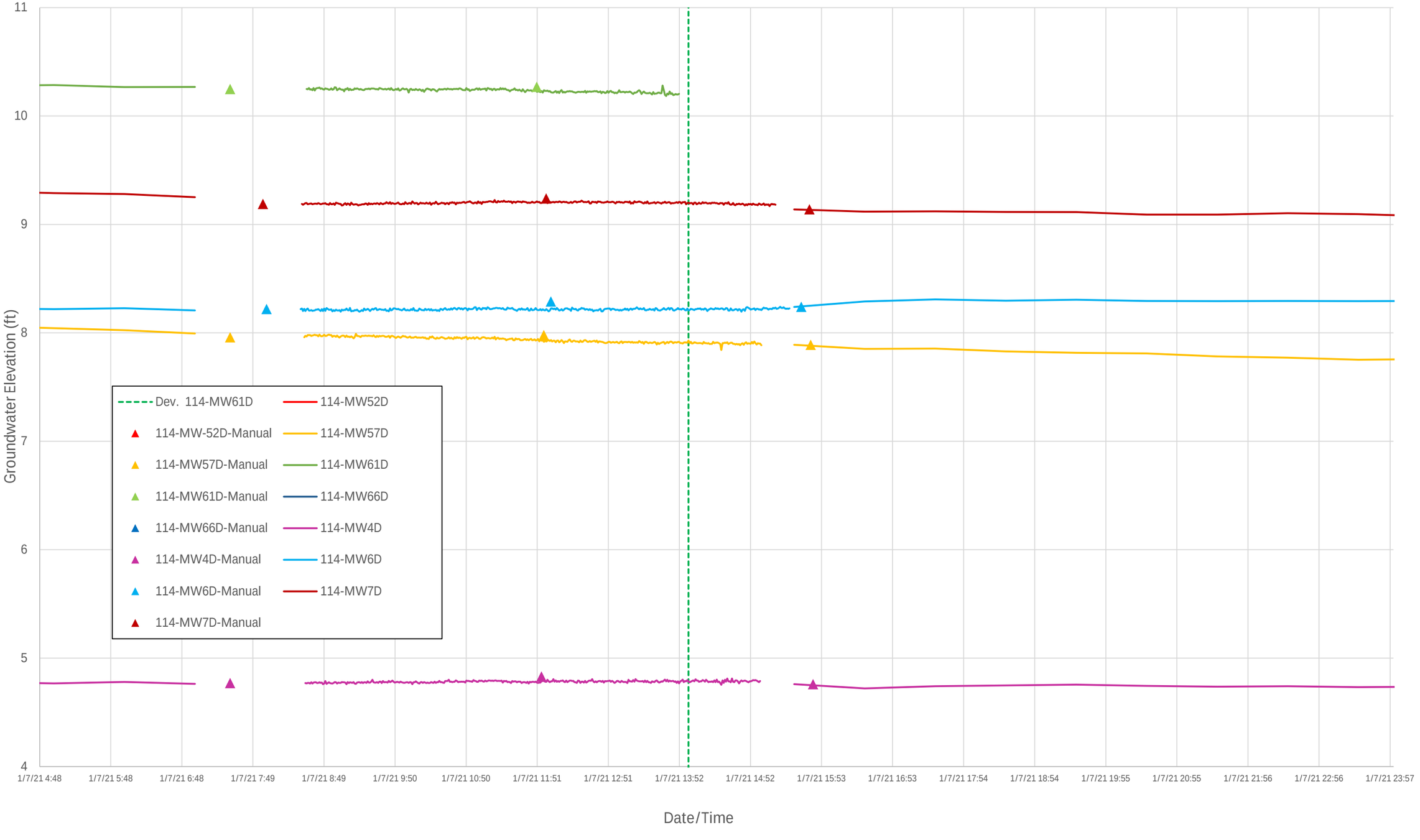
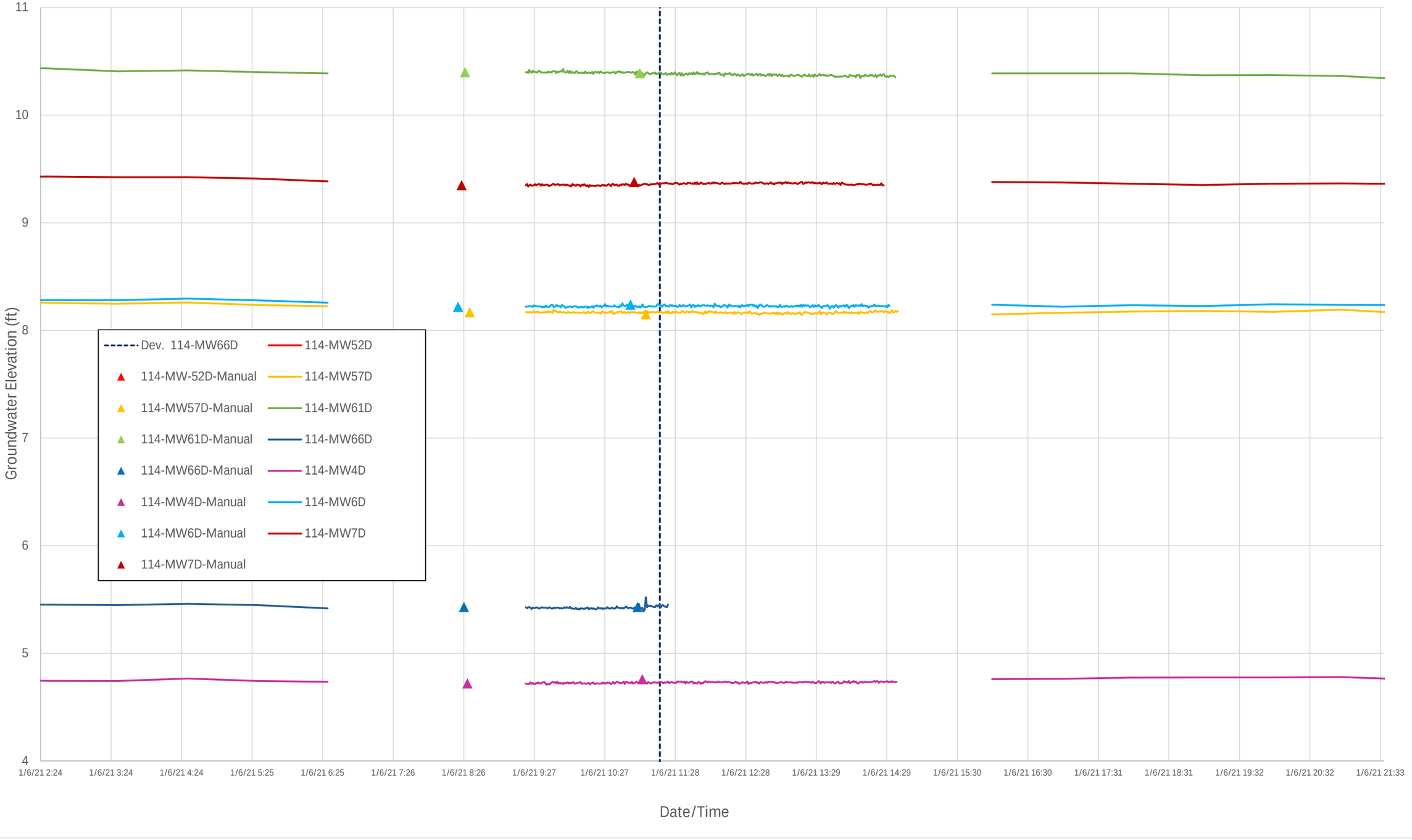


Figure 5. Water level response to Development of 114-MW66D



Attachment A

Well Development Records

PPG Garfield Avenue Group Sites
Well Development Field Data Sheet

AECOM

Well ID: 114-MW61D
Date: 1/7/21
Casing Diameter (inner): _____ inch
Weather Conditions: SUNNY 40's
Screened Interval: _____ ft to _____ ft OPEN BOREHOLE 85' - 115
AECOM Personnel: E. ACI S ELKINGTON
Subcontractor: ADI
Start Time (24 Hr): 1406 1/7/21
Project Manager: Shannon Gleason
End Time (24 Hr): _____

Pre-Development Measurements:

Depth to Water = 6.34 ft, below TOIC
Depth to Bottom = 111.2 ft, below TOIC
Well Bottom Quality (circle one): Soft / Hard / Unknown
Length of Water Column = 104.86 ft
Calculated Well Volume = 154.04 gal *
=> Required Purge Volume (3 Well Volumes) 462.12 gal

Post-Development Measurements:

Depth to Water = 9.72 ft, below TOIC
Depth to Bottom = 111.2 ft, below TOIC
Well Bottom Quality (circle one): Soft / (Hard) / Unknown
Total Volume Pumped = 1,720 gal
Final Turbidity = 26.2 NTU

*** Reference Table for Well Volume:**

Volume / Linear Ft. of Pipe	
Inner Diameter (in.)	Gallons
2	0.1632
4	0.6528
6"	1.469

Equipment Used:

Type	Make	Model	Serial #
1) WATER LIFT WITH DOUBLE DIAPHRAM PUMP			(1/7-8/21) (1100 GAL IN AND OUT)
2) PUMP WELL DOWN TO DRY (1/8/21) (150 GAL)			

Description of Purge Water (color, odor, etc.): CLEAR NO COLOR TO WATER

Other Comments or Observations:
FLUSHED 4 TIMES WITH FRESH WATER, THEN PUMP DRY 4 TIMES

Signature of AECOM Personnel: _____ Date: 1/9/21

MW-61D

	WATER IN	WATER OUT	
1/7/21	275	275	FLUSHING
	275	275	FLUSHING
1/8/21	275	275	FLUSHING
	275	275	FLUSHING
1/[illegible]	—	150	USING PUMP PUMP WELL DRY
1/12/21	—	175	USING PUMP PUMP WELL DRY
1/13/21	—	120	USING PUMP PUMP WELL DRY
1/14/21	—	175	USING PUMP PUMP WELL DRY

	1/12/21			1/13/21			1/14/21		
	9:55	10:15	10:45	9:40	9:55	10:10	8:55	9:15	9:27
TEMP	14.98	15.39	15.57	14.22	14.64	15.38	14.65	15.39	15.24
COND	1.526	2.525	3.574	1.119	1.633	2.873	0.604	0.980	1.284
DO%	47.6	49.2	37.6	14.5	16.6	7.8	17.5	11.2	10.1
DO	4.35	4.31	3.57	1.47	0.68	0.76	1.73	1.12	1.01
PH	11.45	11.85	12.04	11.12	11.83	12.31	10.17	11.62	-26.4
ORP	0.8	-67.4	-112.6	21.0	-29.9	-52.4	75.6	57.3	8.4
TURB	26.7	12.27	13.60	29.2	14.2	19.8	24.43	18.1	26.2
	175 gal			120 gal			175 gal		

PPG Garfield Avenue Group Sites
Well Development Field Data Sheet

AECOM

Well ID: 114-MW52D
Date: 1/5/21
Casing Diameter (inner): 6 inch
Weather Conditions: CLOUDY 40'
Screened Interval: ~~ft to ft~~ OPEN BOREHOLE 88-105'
AECOM Personnel: E.ACS S ELKINGTON
Subcontractor: ADT
Start Time (24 Hr): 10:00 1/5/21
Project Manager: Shannon Gleason
End Time (24 Hr): 1200 1/6/21

Pre-Development Measurements:

Depth to Water = 5.34 ft, below TOIC
Depth to Bottom = 107.33 ft, below TOIC
Well Bottom Quality (circle one): Soft / (Hard) / Unknown
Length of Water Column = 109.99 ft
Calculated Well Volume = 149.82 gal *
=> Required Purge Volume (3 Well Volumes) 449.46 gal

Post-Development Measurements:

Depth to Water = 8.32 ft, below TOIC
Depth to Bottom = 107.5 ft, below TOIC
Well Bottom Quality (circle one): Soft / (Hard) / Unknown
Total Volume Pumped = 750 gal
Final Turbidity = 3.04 NTU

*** Reference Table for Well Volume:**

Volume / Linear Ft. of Pipe	
Inner Diameter (in.)	Gallons
2	0.1632
4	0.6528
6"	1.469

Equipment Used:

Type	Make	Model	Serial #
1) 1" AIR LIFT USING COMPRESSOR (1-2 GPM) (1/6/21)			
2) WHALE PUMP (LESS THAN 1 GPM AT DEPTH) (1/6/21)			
3) WATERLIFT WITH DOUBLE DIAPHRAM PUMP (275 GAL IN 4 HRS OUT)			
4) PUMPED WITH A PUMP TO DRY WELL (1/12/21) (1/13/21)			

Description of Purge Water (color, odor, etc.): SLIGHT YELLOW COLOR TO WATER

Other Comments or Observations:

AFTER 2 HRS OF PUMPING AND GETTING ONLY ~150 GALLON, IT WAS DECIDED BY AECOM TO FILL THE WELL WITH FRESH WATER AND PUMP THAT OUT AGAIN THIS WAS DONE THREE TIMES THEN IT WAS PUMPED DOWN TILL THE NEXT DAY

Signature of AECOM Personnel: [signature]
Date: 1/15/21

MW 52D

	WATER IN	Water removed	
1/5/21	150 gal	150 gal	Flush well
	150 gal	150 gal	Flush well
1/5/21	—	150 gal	pump well dry
1/8/21	125 gal	125 gal	Flush well
1/12/21	—	150 gal	pumped well dry
1/13/21	—	25 gal	pump well dry

	1/12/21			1/13/21	
	1245	1313	1325	805	812
TEMP	15.26	15.53	15.67	14.13	15.02
COND	13.74	16.14	16.58	11.41	12.53
DO%	28.2	24.6	20.9	22.2	24.2
DO	2.69	2.29	1.94	2.21	2.33
PH	12.64	12.71	12.77	12.99	13.15
ORP	-116.8	-135.6	-133.0	80.1	-120.6
TURB	14.6	5.33	6.30	2.93	3.04
		127 gal		25 gal	

PPG Garfield Avenue Group Sites
Well Development Field Data Sheet

AECOM

Well ID: 114 - MW 57D
Date: 1/8/21
Casing Diameter (inner): 6 inch
Weather Conditions: CLOUDY 30's
Screened Interval: 85 - 110' ft to ft OPEN BOREHOLE
AECOM Personnel: E. ACS S. ELKINGTON
Subcontractor: ADT
Start Time (24 Hr): 1400 1/8/21
Project Manager: Shannon Gleason
End Time (24 Hr):

Pre-Development Measurements:

Depth to Water = 6.98 ft, below TOIC
Depth to Bottom = 106.2 ft, below TOIC
Well Bottom Quality (circle one): (Soft) / Hard / Unknown
Length of Water Column = 99.22 ft
Calculated Well Volume = 145.75 gal *
=> Required Purge Volume (3 Well Volumes) 437.25 gal

Post-Development Measurements:

Depth to Water = 9.98 ft, below TOIC
Depth to Bottom = 114.5 ft, below TOIC
Well Bottom Quality (circle one): Soft / (Hard) / Unknown
Total Volume Pumped = 2,225 gal
Final Turbidity = 31.8 NTU

*** Reference Table for Well Volume:**

Volume / Linear Ft. of Pipe	
Inner Diameter (in.)	Gallons
2	0.1632
4	0.6528
6"	1.469

Equipment Used:

Type	Make	Model	Serial #
1) WATER LIFT WITH DOUBLE DIAPHRAM PUMP (1/9/21 - 1/11/21)			
2) AIR LIFT WITH COMPRESSOR (1/11/21)			
3) DEVELOPE WITH PUMP - PUMPED DRY - (1/12/21, 1/13/21, 1/14/21, 1/18/21)			

Description of Purge Water (color, odor, etc.): YELLOW COLOR TO WATER

Other Comments or Observations:

FLUSHED WELL 5 TIMES WITH FRESH WATER, THEN PUMPED DRY 5 TIMES

Signature of AECOM Personnel: [signature] Date: 1/18/21

MW-57D

	WATER IN	WATER OUT	
1/8/21	275 gal	275 gal	WATER FLUSH
1/11/21	275 gal	275 gal	
	275 gal	275 gal	
	275 gal	275 gal	
	275 gal	275 gal	
	100 gal	100 gal	— AIR LIFT W NATIVE WATER
	—	175 gal	← AIRLIFT W NAT WATER
1/12/21	—	175 gal	← PUMPING NAT WATER (W PUMP)
1/13/21	—	125 gal	— pumped Nat water — Well Dry
1/14/21	—	100 gal	— pumped Nat. water — well Dry
1/18/21	—	175 gal	— pumped Nat. water — well Dry

	1/12/21			1/13/21			1/14/21			1/18/21			
	8:10	8:35	8:55	10:05	10:35	10:42	8:00	8:15	8:20	8:55	9:12	9:35	9:40
TEMP	13.44	14.74	14.86	14.22	15.42	15.52	13.98	15.49	15.81	13.56	15.02	15.82	15.61
COND	3.556	4.490	5.162	2.915	4.147	4.361	1.793	2.093	2.424	1.698	1.915	2.758	2.806
DO%	92.5	52.7	45.3	13.2	5.7	3.7	20.3	15.2	9.1	20.4	10.4	3.5	2.7
DO	9.49	5.19	4.34	1.34	0.53	0.36	2.07	1.58	0.90	2.01	1.09	0.34	0.27
PH	10.05	10.62	10.42	10.27	9.95	9.85	9.10	9.38	9.44	9.58	8.77	8.46	8.54
ORP	156.2	77.5	19.2	32.7	40.8	34.5	181.7	137.1	119.8	184.0	147.8	-109.0	-69.9
TURB	40.2	51.5	59.9	27.0	30.2	51.7	16.9	25.1	33.7	22.8	21.8	28.3	31.8
	175 gal			125 gal			100 gal			175 gal			

PPG Garfield Avenue Group Sites
Well Development Field Data Sheet

AECOM

Well ID: 114 - MW66D

Date: 1/6/21

Casing Diameter (inner): 6 inch

Weather Conditions: SUNNY 40'

Screened Interval: ____ ft to ____ ft OPEN BOREHOLE
90' - 117'

AECOM Personnel: E. ACO S ELKINGTON

Subcontractor: ADT

Start Time (24 Hr): 11:15 1/6/21

Project Manager: Shannon Gleason

End Time (24 Hr): 1

Pre-Development Measurements:

Depth to Water = 10.77 ft, below TOIC

Depth to Bottom = 117.2 ft, below TOIC

Well Bottom Quality (circle one): (Soft) / Hard / Unknown

Length of Water Column = 106.43 ft

Calculated Well Volume = 156.34 gal *

=> Required Purge Volume (3 Well Volumes) 469.02 gal

Post-Development Measurements:

Depth to Water = 9.76 ft, below TOIC

Depth to Bottom = 117.2 ft, below TOIC

Well Bottom Quality (circle one): Soft / (Hard) / Unknown

Total Volume Pumped = 1203 gal

Final Turbidity = 29.1 NTU

*** Reference Table for Well Volume:**

Volume / Linear Ft. of Pipe	
Inner Diameter (in.)	Gallons
2	0.1632
4	0.6528
6"	1.469

Equipment Used:

Type	Make	Model	Serial #
1) 6" AIR LIFT	USING COMPRESSOR (1/6/21)		
2) WATER LIFT WITH DOUBLE DIAPHRAM PUMP (1/7/21) (1100 GAL IN AND OUT)			
3) PUMP WELL DOWN TO DRY (1/8/21) 1/12/21 115 GALLONS EACH (1/13/21) 78 GALLONS			
4)			

Description of Purge Water (color, odor, etc.): YELLOW COLOR TO WATER

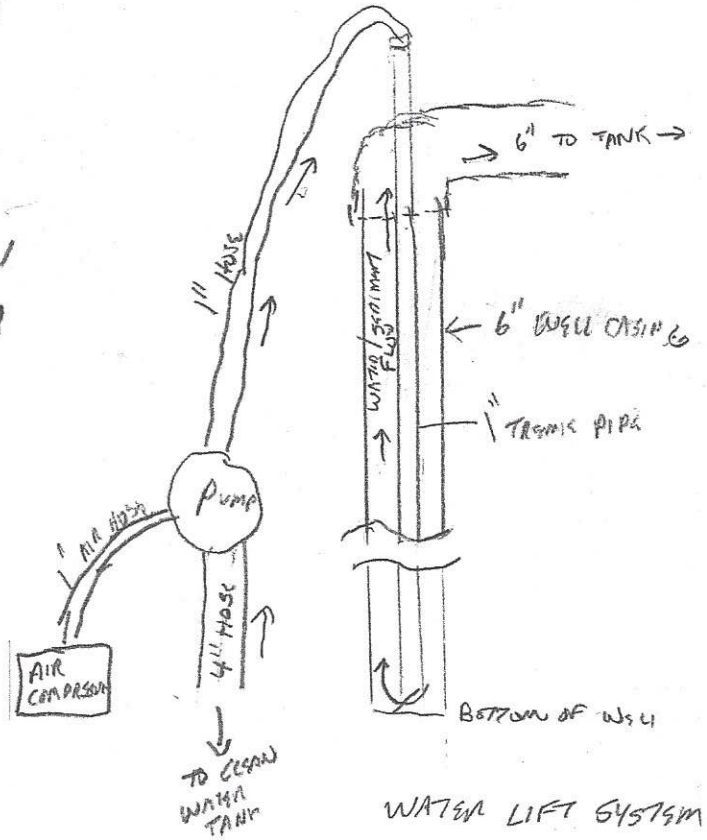
Other Comments or Observations:

FLUSHED WELL 4 TIMES WITH FRESH WATER THEN PUMPED WELL DRY 3 TIMES

Signature of AECOM Personnel: _____ Date: 1/6/21

MW-66D

	WATER IN	WATER OUT
1/7/21	225 gal	225 gal
	275 gal	275 gal
	275 gal	275 gal
	275 gal	275 gal
1/8/21	—	175 gal
1/12/21	—	175 gal
1/13/21	—	78 gal



WATER LIFT SYSTEM

	1/12/21			1/13/21		
	11:20	11:42	12:10	8:45	9:00	9:12
TEMP	15.43	15.88	16.12	13.52	15.20	15.16
COND	2.368	3.339	3.495	1.467	1.264	1.430
DO%	34.5	18.0	15.7	23.9	14.2	10.9
DO	3.16	1.71	1.48	2.38	1.27	1.08
PH	10.01	9.78	9.74	10.08	10.19	10.17
ORP	-64.0	-160.5	-158.5	75.5	24.2	15.1
TURB	54.1	62.1	73.6	21.1	19.6	29.1
		175 GAL			78 gal	

Attachment 2

Well Specific Capacity Testing Procedure

Procedure Number: PPG 030

Revision No.: 1

Revision Date: October 2021

Frederik Schuele, Bill Spronz	Date:	October 13, 2021
POP Author		
Shannon Gleason	Date:	October 13, 2021
Project Manager		

Annual review of this POP has been performed
and the POP still reflects current practice.

Initials: _____ Date: _____
Initials: _____ Date: _____

Contents

1.0 Definition and Applicability 1

2.0 Health and Safety Considerations 1

3.0 Equipment and Materials 1

4.0 Procedure 1

5.0 Analysis 2

6.0 References 3

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1.0 Definition and Applicability

This Project Operating Procedure (POP) describes a procedure for conducting a specific capacity test, computing the specific capacity of a water well (e.g., monitoring well or injection well), and estimating the transmissivity of the aquifer screened by the well. Specific capacity is defined as the well yield per unit drawdown at an identified time after pumping started and can be calculated as the pumping rate in gallons per minute (gpm) divided by the drawdown (in feet [ft]) observed after a defined period of pumping at the control well (ASTM D5472).

2.0 Health and Safety Considerations

The health and safety considerations for the work associated with this POP, including both potential physical and chemical hazards, are addressed in the site-specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Equipment and Materials

The following equipment and materials are required for this procedure:

- A water pump powered by an electrical energy source and tubing, with a valve at the end to control the flow rate. The pump must be appropriately sized to fit into the well and provide the necessary flow rate needed to conduct the test.
- A large container (vessel or plastic tote) to capture the well purge water.
- A stopwatch, timer, or a watch to measure elapsed time.
- A large bucket that has calibration marks in gallons.
- An electronic water level indicator accurate to the hundredths of a foot.
- A field book or notepad.

4.0 Procedure

The following procedures should be followed for collecting the data necessary for calculating the specific capacity of the targeted well:

- Open the well to be tested.
- Measure the depth to the static water level from the top of the inner well casing to the hundredths of a foot and record it and the time of collection.
- Install tubing on the pump and lower the pump to the bottom of the well, then pull it up no less than one foot above the bottom of the well. Anchor the pump such that is does not move within the well.

- Place the flow control valve on the end of the tubing and place the discharge end into the large container.
- Start the pump by connecting the electrical source and record the time at which the pump was started. Set the flow rate by adjusting the valve such that the well does not go dry. The flow of water out of the well should equal the flow of water into the container. Record the time.
- Let the pump run for a minimum of 20 minutes to stabilize the water level in the well. During this time the water level should be checked at least every 5 minutes with the electronic water level meter and the reading recorded (note time and depth to water to the hundredths of a foot). The objective is to achieve a stable water level within the well during pumping. Therefore, adjust flow rate as necessary to achieve stabilization.
- Once the water level has stabilized and the well has been pumped for 10 additional minutes at a stable flow rate, measure the discharge rate using the calibrated bucket and stopwatch/timer/watch. Measure the time it takes to fill one gallon in the calibrated bucket in seconds and record this value. Convert the value in seconds to minutes by dividing by 60 and record this value. Then, divide one (one gallon) by the time in minutes; this is the well flow rate (Q) in gpm. Record the flow rate.
- Stop the pump and let the water level in the well recover to its static (pre-pumping) level. Record the time at which the pump was stopped.
- Once the water level in the well has recovered, measure the depth to the static water level from the top of the inner well casing to the hundredths of a foot and record it and the time of collection.
- Initiate the specific capacity test by turning the pump on and setting the flow to the well flow rate (Q) at which stabilization was observed above. Record the time at which the pump was started. Continue pumping until the water level in the well stabilizes.
- Once the water level in the well has stabilized, measure the depth to the stabilized water level within the well using the electronic water level meter and record the reading to the hundredths of a foot and the time of collection. Subtract this value from the initial static water level; this is the drawdown (s) in ft in the well at which stabilization has been reached at the final pumping rate.
- Using the well flow rate (Q) in gpm and the drawdown(s) in ft, calculate the well's specific capacity (SC) via the following formula:
    - $SC = Q/s$

      where:

      SC = specific capacity in gpm/ft

      Q = flow rate in gpm

      s = drawdown in ft

5.0 Analysis

Transmissivity (T) of an aquifer is the rate at which groundwater is transmitted through the aquifer under a unit width and a unit hydraulic gradient; it is equal to the aquifer's hydraulic conductivity (K)

times the aquifer thickness (b) (Istok & Dawson, 1991). An estimate of an aquifer's T can be calculated using the SC value derived from a specific capacity test. The following equations can be used to estimate T for an aquifer, based on the specific capacity test results (Driscoll, 1986):

- T = 1500 * SC (for unconfined aquifers)
- T = 2000 * SC (for confined aquifers)

where:

SC = specific capacity in gpm/ft

T = Transmissivity in gallons per day (GPD) per ft (GPD/ft)

Hydraulic conductivity is the volume of water at the existing kinematic viscosity that will move in a unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow (ASTM D5472). An estimate of K for the aquifer screened by the well can be obtained from the T value calculated for the aquifer using the following formula (ASTM D5472):

- K = T/7.48/b/1440

where:

K = hydraulic conductivity in feet per minute (ft/min)

T = Transmissivity in GPD/ft

b = aquifer thickness in ft

7.48 = conversion factor, cubic feet per 1 gallon

1440 = conversion factor, minutes per 1 day

For the well at which the specific capacity test was performed, b should be assumed to be the saturated aquifer thickness screened by the well.

6.0 References

Istok, J. & Dawson, K., 1991. *Aquifer Testing: Design and Analysis of Pumping and Slug Tests*.

ASTM D5472/D5472M-20, Standard Practice for Determining Specific Capacity and Estimating Transmissivity at the Control Well, ASTM International, West Conshohocken, PA, 2020.

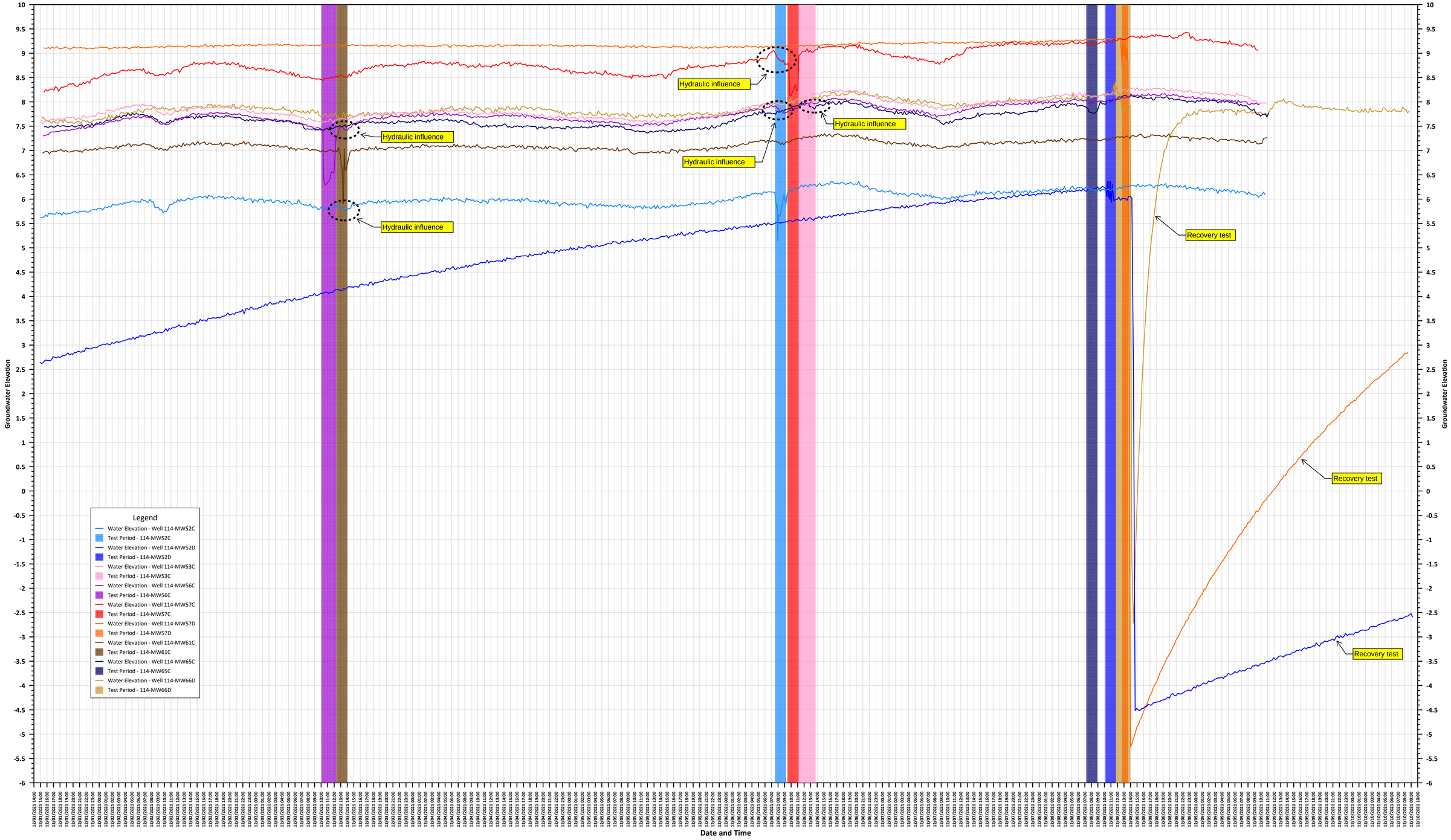
Driscoll, F.G, 1986. *Groundwater and Wells, Second Edition*, Johnson Filtration Systems Inc.

7.0 Revision History

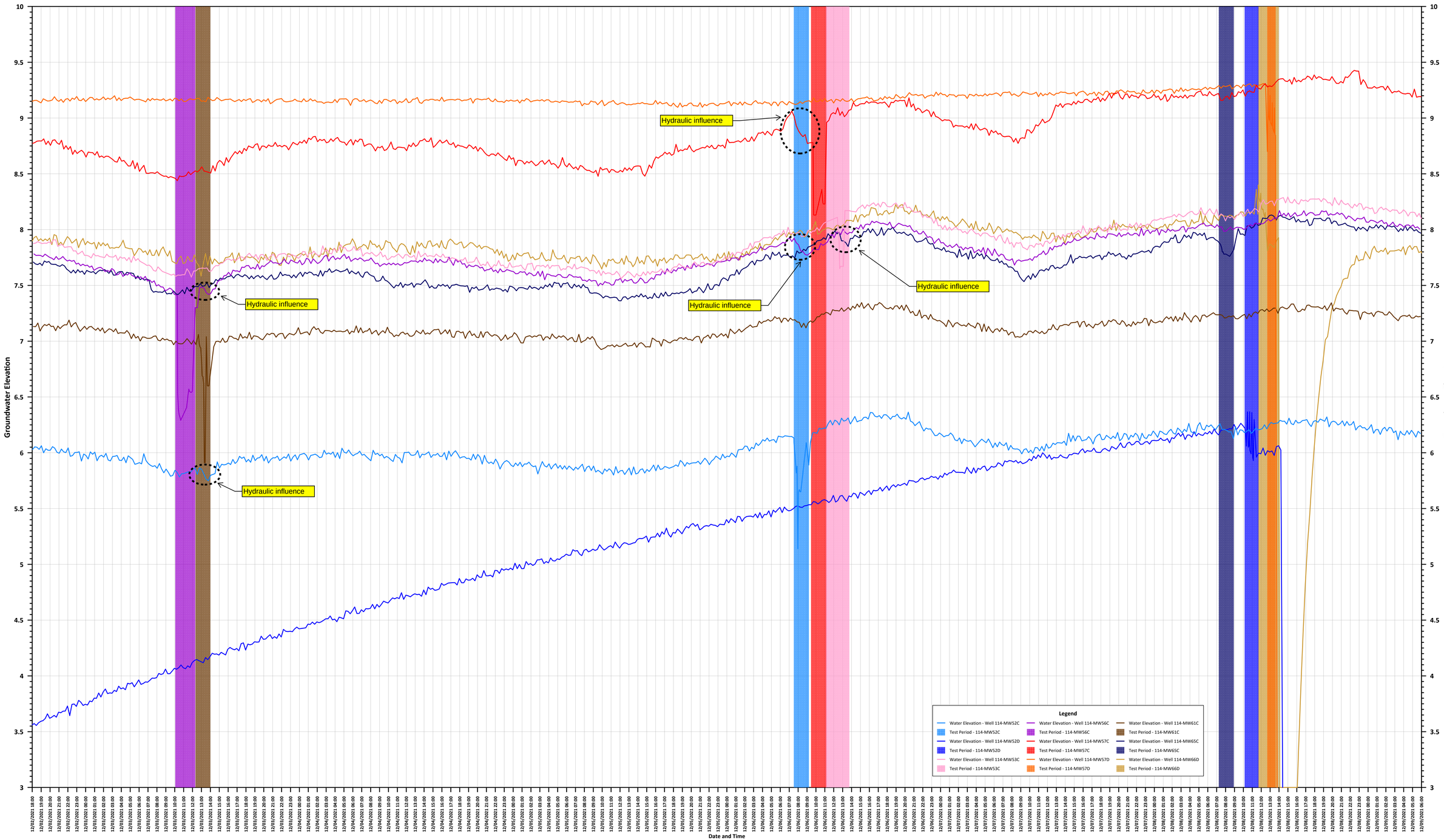
Revision	Date	Changes
1	October 13, 2021	Added details regarding conditioning procedure.
0	August 13, 2021	Original POP

Attachment 3

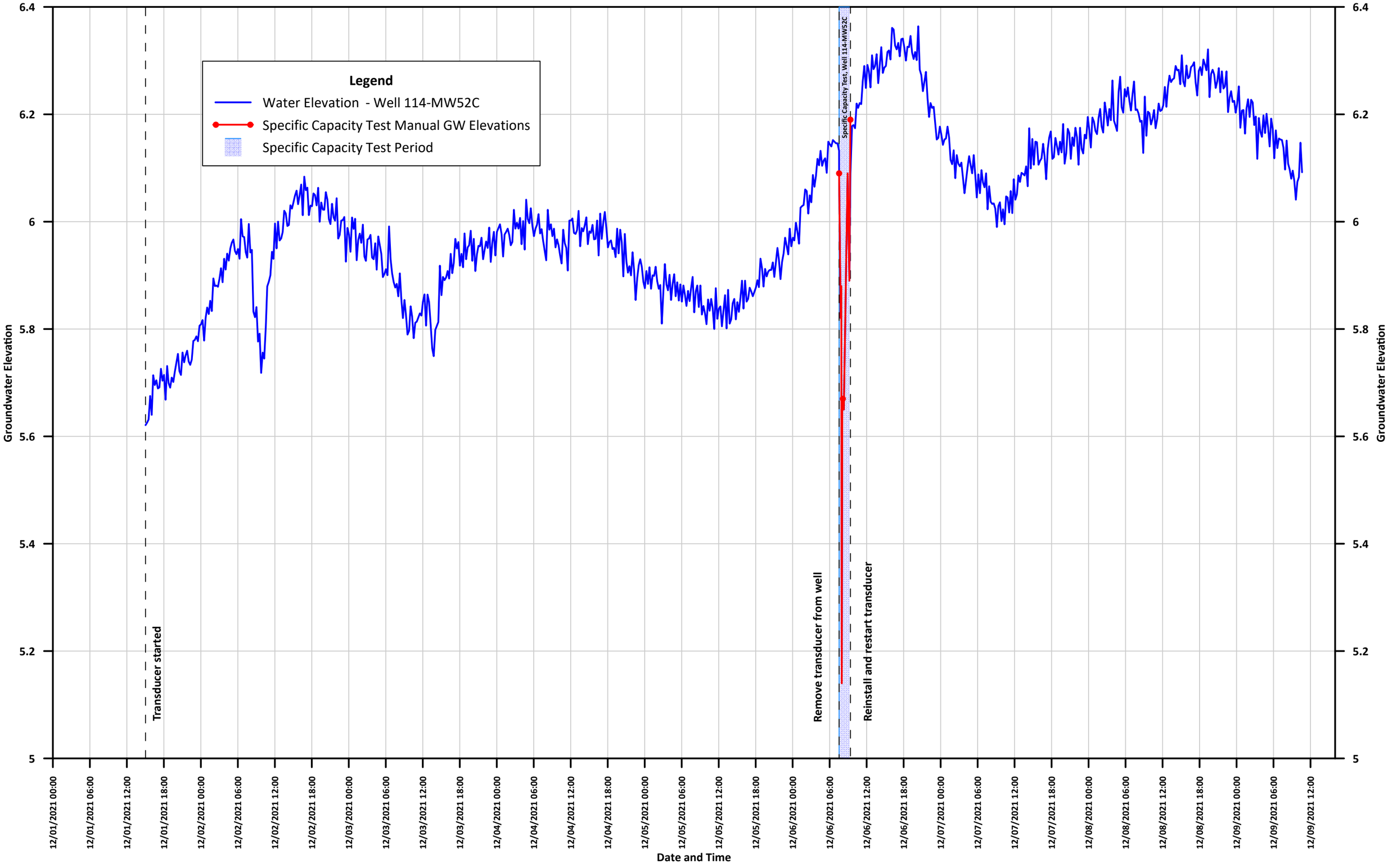
All Specific Capacity Test Wells



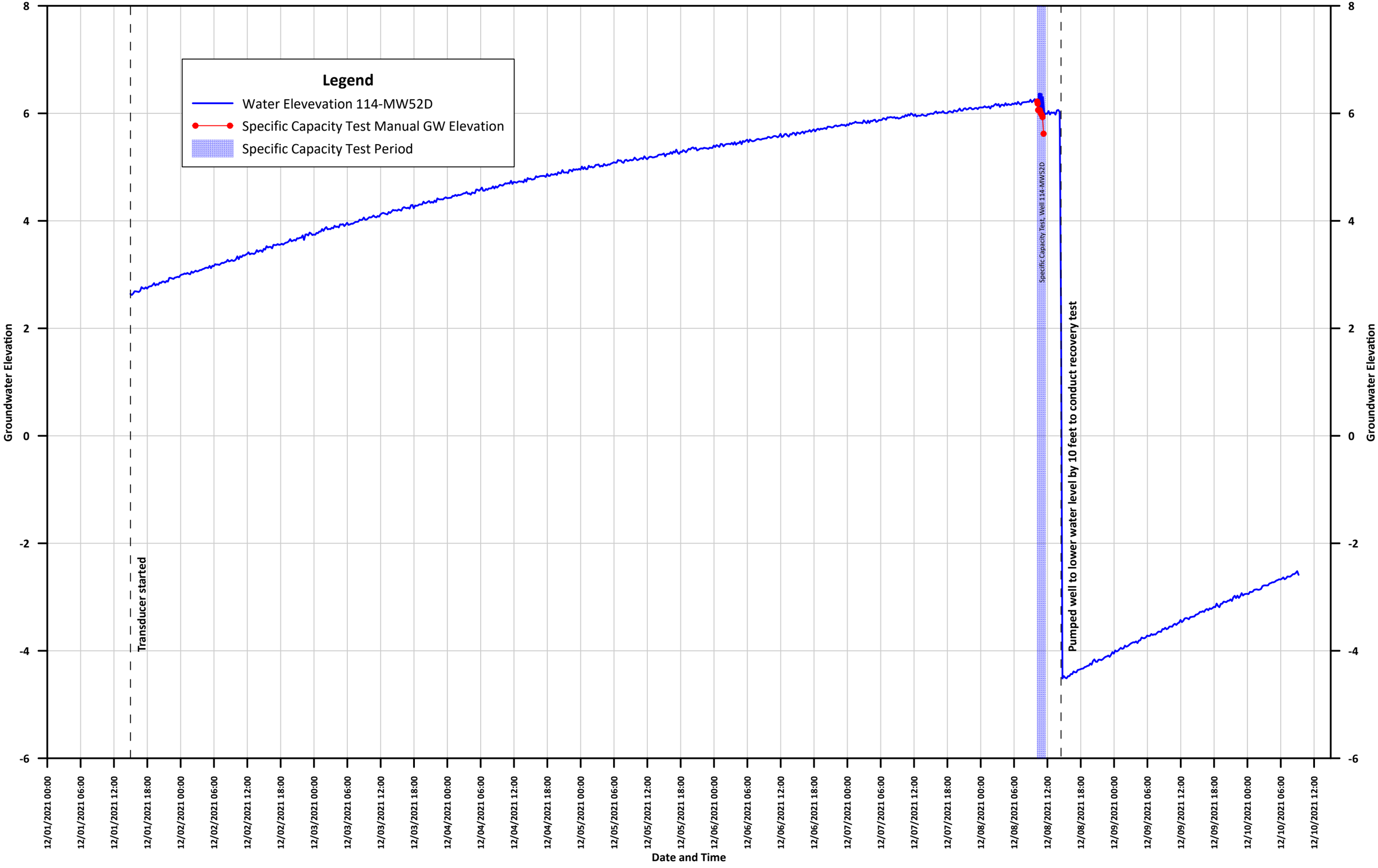
All Specific Capacity Test Wells



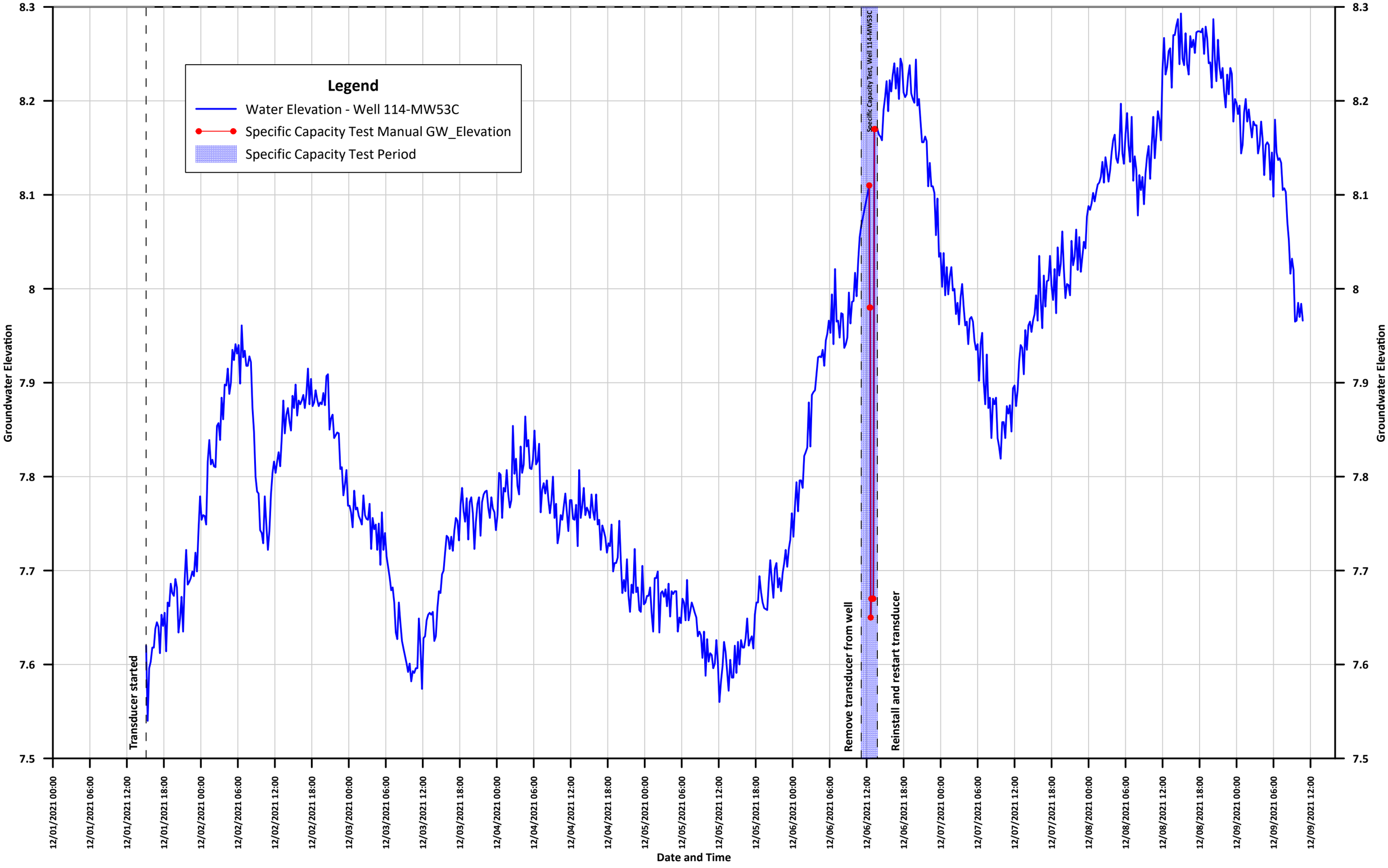
Well 114-MW52C



Well 114-MW52D



Well 114-MW53C



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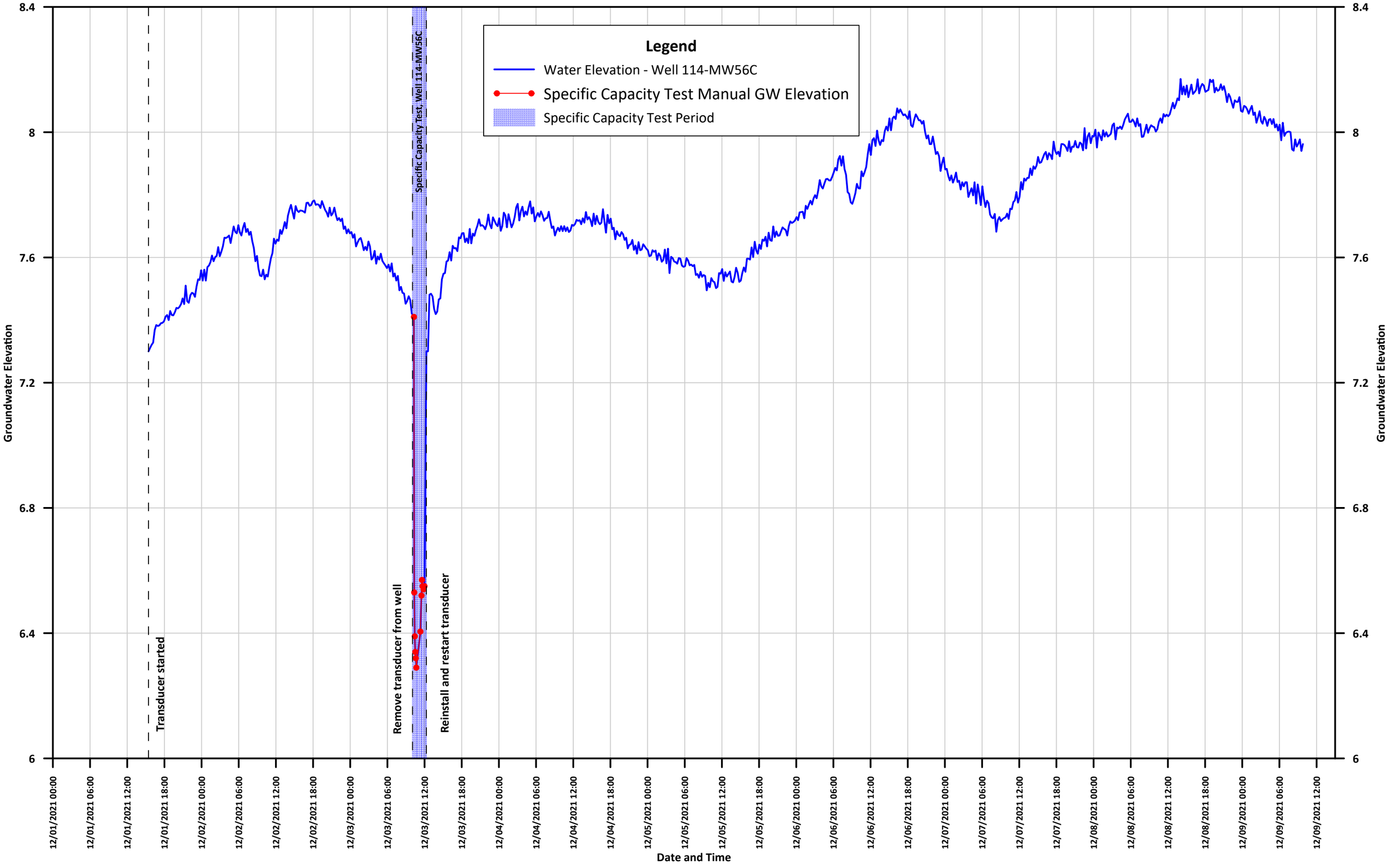
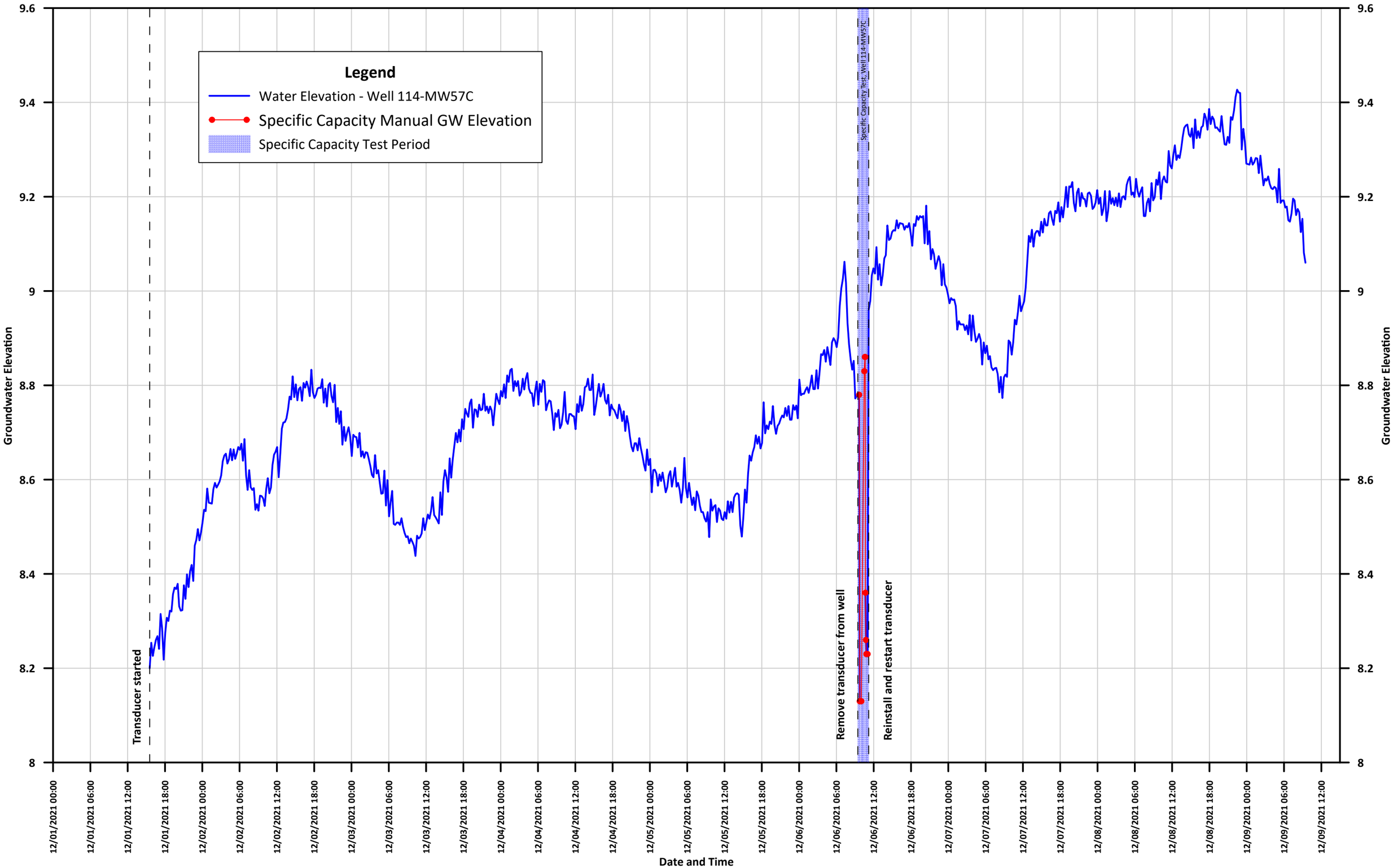
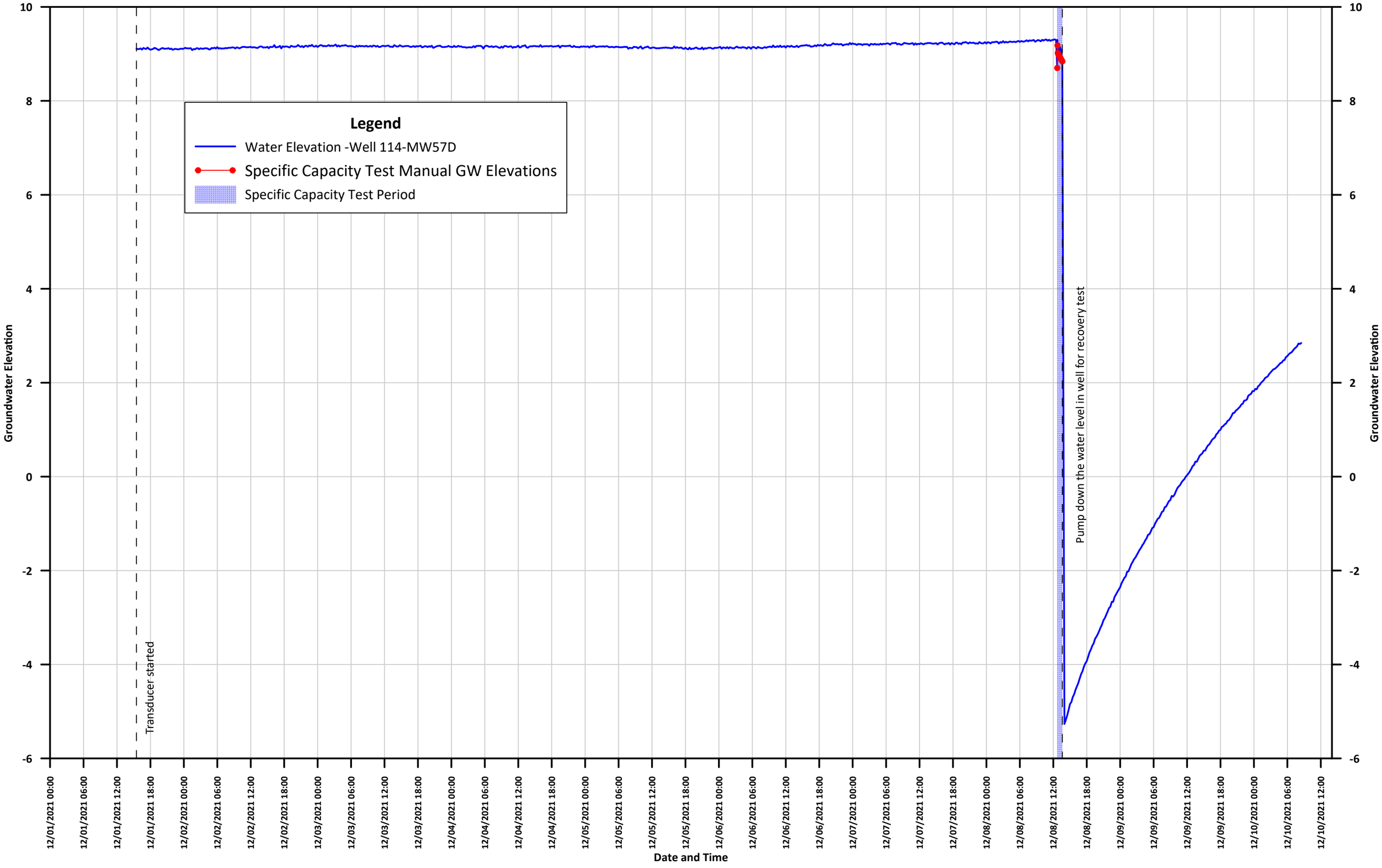


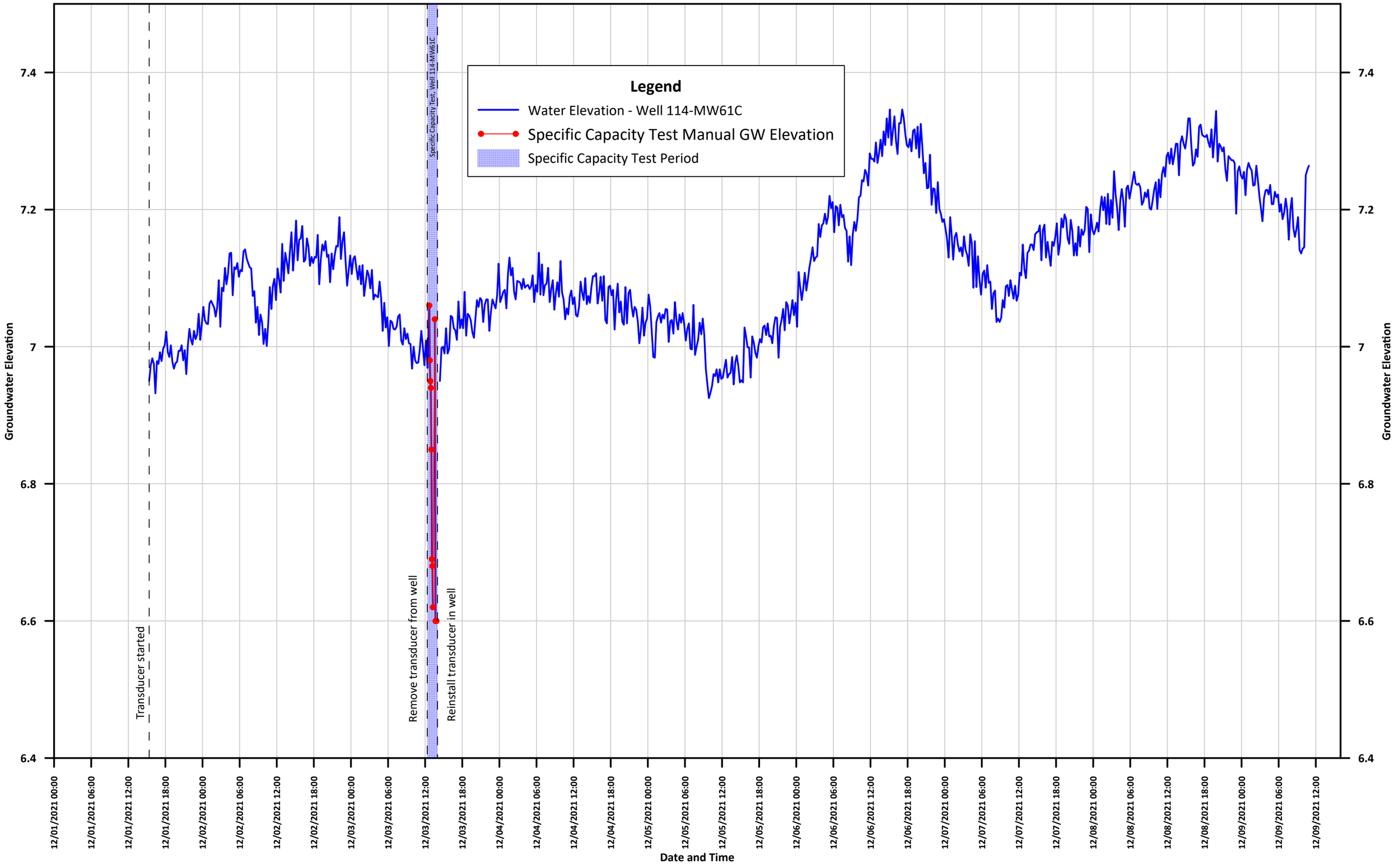
Well 114-MW57C



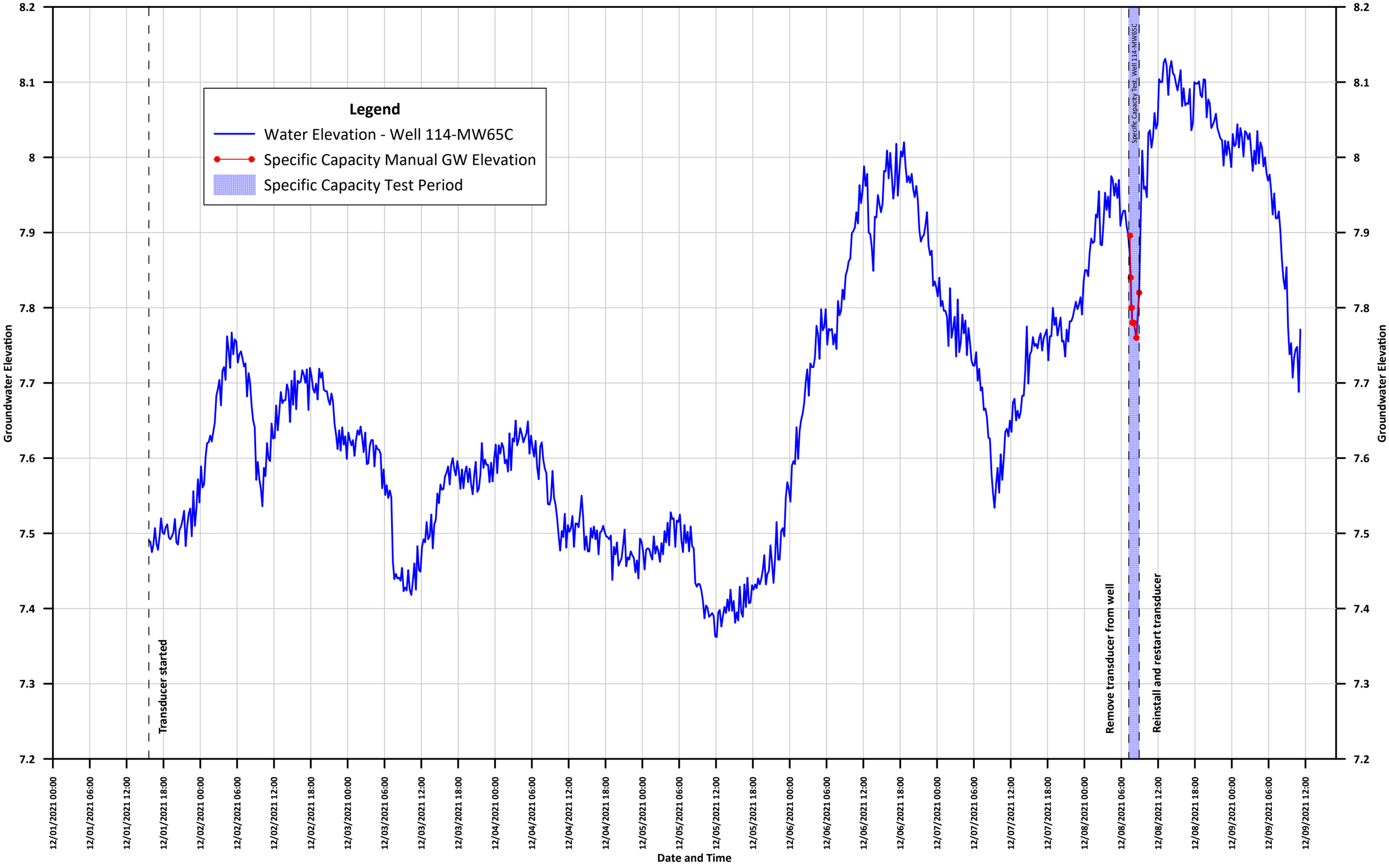
Well 114-MW57D



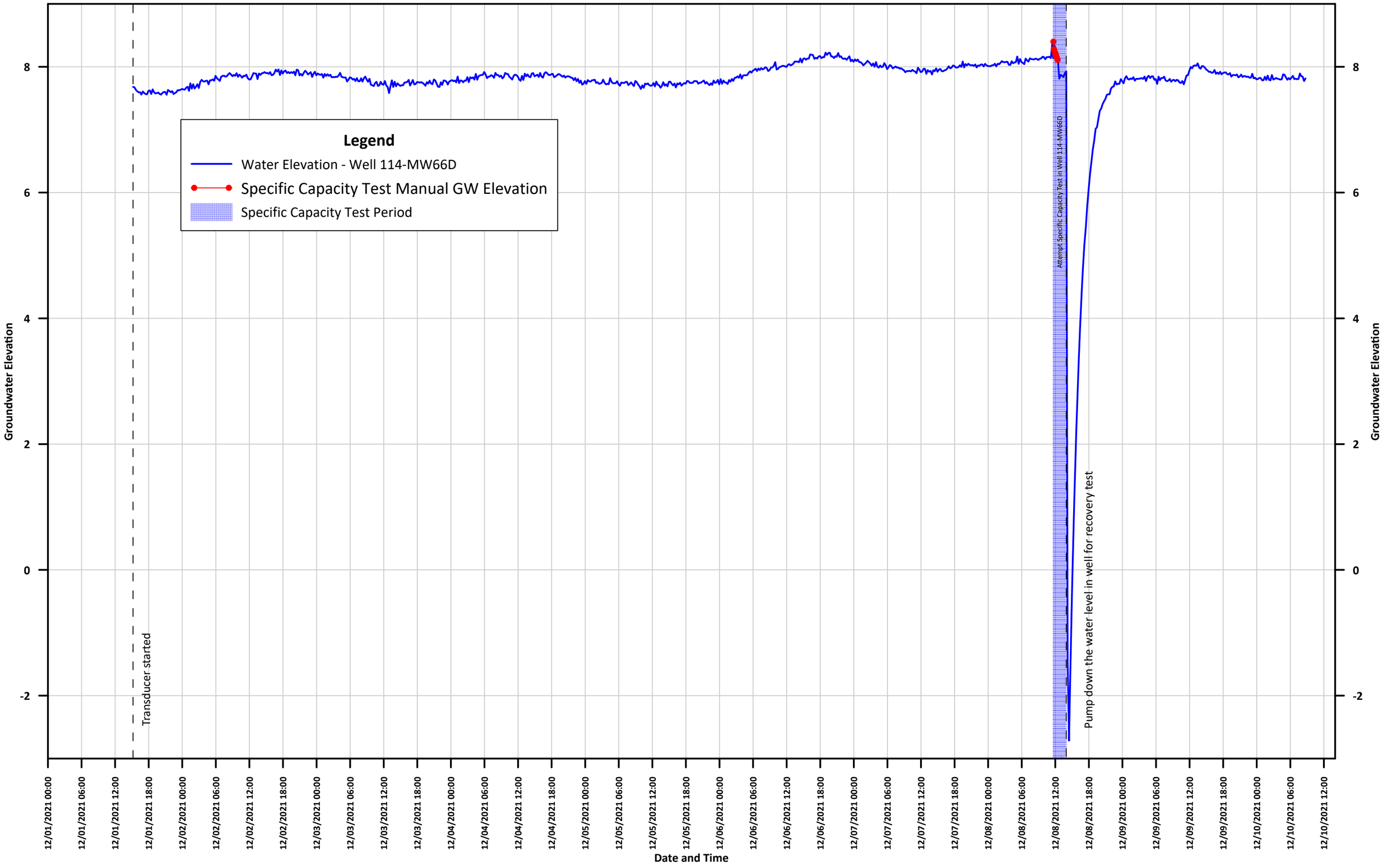
Well 114-MW61C



Well 114-MW65C



Well 114-MW66D

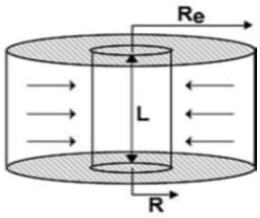


Attachment 4

The equation from Muskat (1937) was used to solve for K assuming radial flow to a fully penetrating well.

RADIAL FLOW

Muskat (1937)



Where:
- Q = steady state flow rate
- L = intake length
- K = hydraulic Conductivity
- H = steady state drawdown
- R = intake radius
- D = intake diameter
- R_e = radius of influence

$$Q = \frac{2\pi LKH}{2.303\log[R_e/R]}$$

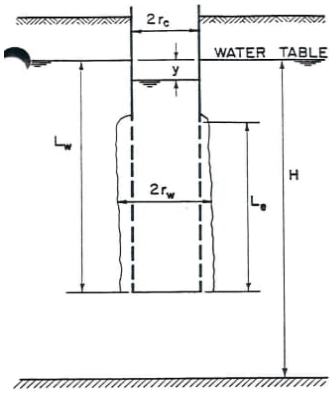
Values for Re were calculated from Equation 5, with values of C estimated from the "C" line in Figure 2 (Bouwer and Rice 1976; Bouwer 1989).

The results of the analog analyses to evaluate R_e for various system geometries were expressed in terms of the dimensionless ratio $\ln(R_e/r_w)$. The data could be fitted into two equations, one for the case where $L_w < H$, and one where $L_w = H$. The resulting equations were, respectively,

$$\ln\frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ln[(H - L_w)/r_w]}{L_e/r_w}\right]^{-1} \quad (4)$$

and

$$\ln\frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{C}{L_e/r_w}\right]^{-1} \quad (5)$$



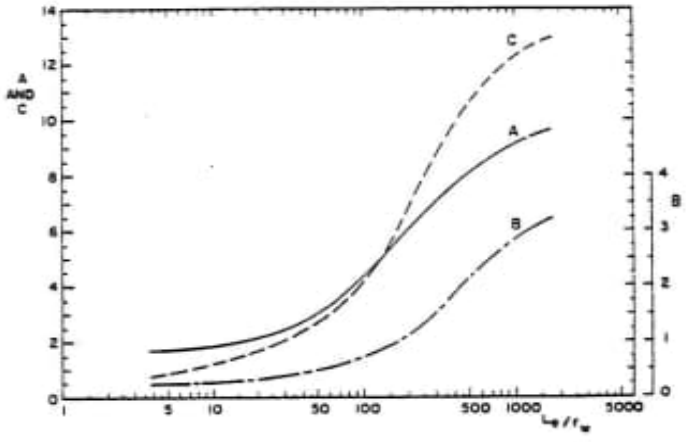


Fig. 2. Dimensionless parameters A, B, and C as a function of L_e/r_w for calculation of $\ln(R_e/r_w)$.

References:

Bouwer, H., and R.C. Rice. 1976. *A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells* . Water Resources Research 12, no. 3: 423–428.

Bouwer, H. 1989. *The Bouwer and Rice slug test—An update* . Ground Water 27, no. 3: 304–309.

Gary A. Robbins, Alejandra T. Aragon-Jose, and Andres Romero, 2009. *Determining Hydraulic Conductivity Using Pumping Data from Low-Flow Sampling* , Groundwater, Volume 47, Number 2, pages 271-276, March-April 2009.

Muskat, M. 1937. *The Flow of Homogeneous Fluids through Porous Media* . New York: McGraw-Hill Book Co.

Estimate of Hydraulic Conductivity from Specific Capacity Testing
Groundwater Remedial Investigation
Garfield Avenue Group Sites PPG, Jersey City, New Jersey

AECOM

Well ID:	114-MW52C	Ground Surface Elevation (ft NAVD88):	14.0
Screen Zone:	Basal Till	Depth to Bottom of Well Screen (ft bgs)	73
Initial Depth to water (ft btc):	9.76	Groundwater Elevation (ft NAVD88):	6.09
Final Depth to water (ft btc):	9.96	Bottom of Well Screen Elevation (ft NAVD88):	-59.00
Water Level Reference Elevation (ft NAVD88):	15.85	Drawdown (ft)	0.20

Key
User Input
Input from Graph
Calculated

Field Data Inputs						
Symbol	Description	Value	Unit	Value	Unit	Source
Q	Flow Rate	0.11	gpm	21.175	ft^3/day	Field Data Sheet
L or Le	Screen Length	5	ft	5	ft	Well Construction Diagram
Lw	Saturated Thickness	-	-	65.09	ft	Groundwater Elevation - Bottom of Screen Elevation
H	Stabilized Drawdown	-	-	0.2	ft	Initial Depth to Water - Final Depth to Water
R	Well Casing Radius	2	inches	0.17	ft	Well Construction Diagram
rw	Borehole Radius	6	inches	0.50	ft	Boring Log

Graphical Input						
Symbol	Description	-	-	Value	Unit	Source
Le/rw	Ratio of Le to rw	-	-	10	-	Calculated from Values Above
C	Chart Value	-	-	1.4	-	Obtain Value from C line on Fig 2

Output						
Symbol	Description	-	-	Value	Unit	Source
ln(Re/R)	Calculated from Equation 5, assumes Lw=H.	-	-	2.73	-	https://www.csus.edu/indiv/h/hornert/geol_210_summer_2012/week%203%20readings/bouwer%201989.pdf
K	Hydraulic Conductivity	-	-	21.21	ft/day	Equation for Radial Flow from Muskat 1937
K	Hydraulic Conductivity	-	-	7.48E-03	cm/sec	

Notes:
bgs = below ground surface
btc = well top of well casing
cm = centimeters
ft = feet
gpm = gallons per minute
NAVD88 = North Americal Vertical Datum of 1988
sec = seconds

Estimate of Hydraulic Conductivity from Specific Capacity Testing
Groundwater Remedial Investigation
Garfield Avenue Group Sites PPG, Jersey City, New Jersey

AECOM

Well ID:	114-MW53C	Ground Surface Elevation (ft NAVD88):	13.9
Screen Zone:	Weathered Bedrock (Lockatong)	Depth to Bottom of Well Screen (ft bgs)	47.5
Initial Depth to water (ft btc):	6.91	Groundwater Elevation (ft NAVD88):	8.17
Final Depth to water (ft btc):	7.41	Bottom of Well Screen Elevation (ft NAVD88):	-33.60
Water Level Reference Elevation (ft NAVD88):	15.08	Drawdown (ft)	0.50

Key
User Input
Input from Graph
Calculated

Field Data Inputs						
Symbol	Description	Value	Unit	Value	Unit	Source
Q	Flow Rate	0.23	gpm	44.275	ft^3/day	Field Data Sheet
L or Le	Screen Length	1.5	ft	1.5	ft	Well Construction Diagram
Lw	Saturated Thickness	-	-	41.77	ft	Groundwater Elevation - Bottom of Screen Elevation
H	Stabilized Drawdown	-	-	0.5	ft	Initial Depth to Water - Final Depth to Water
R	Well Casing Radius	2	inches	0.17	ft	Well Construction Diagram
rw	Borehole Radius	6	inches	0.50	ft	Boring Log

Graphical Input						
Symbol	Description	-	-	Value	Unit	Source
Le/rw	Ratio of Le to rw	-	-	3	-	Calculated from Values Above
C	Chart Value	-	-	0.5	-	Obtain Value from C line on Fig 2

Output						
Symbol	Description	-	-	Value	Unit	Source
ln(Re/R)	Calculated from Equation 5, assumes Lw=H.	-	-	2.41	-	https://www.csus.edu/indiv/h/hornert/geol_210_summer_2012/week%203%20readings/bouwer%201989.pdf
K	Hydraulic Conductivity	-	-	52.11	ft/day	Equation for Radial Flow from Muskat 1937
K	Hydraulic Conductivity	-	-	1.84E-02	cm/sec	

Notes:
bgs = below ground surface
btc = well top of well casing
cm = centimeters
ft = feet
gpm = gallons per minute
NAVD88 = North Americal Vertical Datum of 1988
sec = seconds

Estimate of Hydraulic Conductivity from Specific Capacity Testing
Groundwater Remedial Investigation
Garfield Avenue Group Sites PPG, Jersey City, New Jersey

AECOM

Well ID:	114-MW56C	Ground Surface Elevation (ft NAVD88):	14.0
Screen Zone:	Basal Till	Depth to Bottom of Well Screen (ft bgs)	72
Initial Depth to water (ft btc):	8.44	Groundwater Elevation (ft NAVD88):	7.6
Final Depth to water (ft btc):	9.5	Bottom of Well Screen Elevation (ft NAVD88):	-58.00
Water Level Reference Elevation (ft NAVD88):	16.04	Drawdown (ft)	1.06

Key
User Input
Input from Graph
Calculated

Field Data Inputs						
Symbol	Description	Value	Unit	Value	Unit	Source
Q	Flow Rate	0.033	gpm	6.353	ft^3/day	Field Data Sheet
L or Le	Screen Length	5	ft	5	ft	Well Construction Diagram
Lw	Saturated Thickness	-	-	65.6	ft	Groundwater Elevation - Bottom of Screen Elevation
H	Stabilized Drawdown	-	-	1.06	ft	Initial Depth to Water - Final Depth to Water
R	Well Casing Radius	2	inches	0.17	ft	Well Construction Diagram
rw	Borehole Radius	6	inches	0.50	ft	Boring Log

Graphical Input						
Symbol	Description	-	-	Value	Unit	Source
Le/rw	Ratio of Le to rw	-	-	10	-	Calculated from Values Above
C	Chart Value	-	-	1.4	-	Obtain Value from C line on Fig 2

Output						
Symbol	Description	-	-	Value	Unit	Source
ln(Re/R)	Calculated from Equation 5, assumes Lw=H.	-	-	2.74	-	https://www.csus.edu/indiv/h/hornert/geol_210_summer_2012/week%203%20readings/bouwer%201989.pdf
K	Hydraulic Conductivity	-	-	1.20	ft/day	Equation for Radial Flow from Muskat 1937
K	Hydraulic Conductivity	-	-	4.24E-04	cm/sec	

Notes:
bgs = below ground surface
btc = well top of well casing
cm = centimeters
ft = feet
gpm = gallons per minute
NAVD88 = North Americal Vertical Datum of 1988
sec = seconds

Estimate of Hydraulic Conductivity from Specific Capacity Testing
Groundwater Remedial Investigation
Garfield Avenue Group Sites PPG, Jersey City, New Jersey

AECOM

Well ID:	114-MW57C	Ground Surface Elevation (ft NAVD88):	12.9
Screen Zone:	Weathered Bedrock (Lockatong)	Depth to Bottom of Well Screen (ft bgs)	70
Initial Depth to water (ft btc):	5.69	Groundwater Elevation (ft NAVD88):	8.86
Final Depth to water (ft btc):	6.32	Bottom of Well Screen Elevation (ft NAVD88):	-57.10
Water Level Reference Elevation (ft NAVD88):	14.55	Drawdown (ft)	0.63

Key
User Input
Input from Graph
Calculated

Field Data Inputs						
Symbol	Description	Value	Unit	Value	Unit	Source
Q	Flow Rate	0.15	gpm	28.875	ft^3/day	Field Data Sheet
L or Le	Screen Length	1.5	ft	1.5	ft	Well Construction Diagram
Lw	Saturated Thickness	-	-	65.96	ft	Groundwater Elevation - Bottom of Screen Elevation
H	Stabilized Drawdown	-	-	0.63	ft	Initial Depth to Water - Final Depth to Water
R	Well Casing Radius	2	inches	0.17	ft	Well Construction Diagram
rw	Borehole Radius	6	inches	0.50	ft	Boring Log

Graphical Input						
Symbol	Description	-	-	Value	Unit	Source
Le/rw	Ratio of Le to rw	-	-	3	-	Calculated from Values Above
C	Chart Value	-	-	0.5	-	Obtain Value from C line on Fig 2

Output						
Symbol	Description	-	-	Value	Unit	Source
ln(Re/R)	Calculated from Equation 5, assumes Lw=H.	-	-	2.55	-	https://www.csus.edu/indiv/h/hornert/geol_210_summer_2012/week%203%20readings/bouwer%201989.pdf
K	Hydraulic Conductivity	-	-	28.57	ft/day	Equation for Radial Flow from Muskat 1937
K	Hydraulic Conductivity	-	-	1.01E-02	cm/sec	

Notes:
bgs = below ground surface
btc = well top of well casing
cm = centimeters
ft = feet
gpm = gallons per minute
NAVD88 = North Americal Vertical Datum of 1988
sec = seconds

Estimate of Hydraulic Conductivity from Specific Capacity Testing
Groundwater Remedial Investigation
Garfield Avenue Group Sites PPG, Jersey City, New Jersey

AECOM

Well ID:	114-MW61C	Ground Surface Elevation (ft NAVD88):	14.0
Screen Zone:	Basal Till/ Weathered Bedrock (Diabase)	Depth to Bottom of Well Screen (ft bgs)	68
Initial Depth to water (ft btc):	9.63	Groundwater Elevation (ft NAVD88):	7.04
Final Depth to water (ft btc):	10.77	Bottom of Well Screen Elevation (ft NAVD88):	-54.00
Water Level Reference Elevation (ft NAVD88):	16.67	Drawdown (ft)	1.14

Key
User Input
Input from Graph
Calculated

Field Data Inputs

Symbol	Description	Value	Unit	Value	Unit	Source
Q	Flow Rate	0.4	gpm	77	ft^3/day	Field Data Sheet
L or Le	Screen Length	5.5	ft	5.5	ft	Well Construction Diagram
Lw	Saturated Thickness	-	-	61.04	ft	Groundwater Elevation - Bottom of Screen Elevation
H	Stabilized Drawdown	-	-	1.14	ft	Initial Depth to Water - Final Depth to Water
R	Well Casing Radius	2	inches	0.17	ft	Well Construction Diagram
rw	Borehole Radius	6	inches	0.50	ft	Boring Log

Graphical Input

Symbol	Description	-	-	Value	Unit	Source
Le/rw	Ratio of Le to rw	-	-	11	-	Calculated from Values Above
C	Chart Value	-	-	1.5	-	Obtain Value from C line on Fig 2

Output

Symbol	Description	-	-	Value	Unit	Source
ln(Re/R)	Calculated from Equation 5, assumes Lw=H.	-	-	2.74	-	https://www.csus.edu/indiv/h/hornert/geol_210_summer_2012/week%203%20readings/bouwer%201989.pdf
K	Hydraulic Conductivity	-	-	12.32	ft/day	Equation for Radial Flow from Muskat 1937
K	Hydraulic Conductivity	-	-	4.35E-03	cm/sec	

Notes:
bgs = below ground surface
btc = well top of well casing
cm = centimeters
ft = feet
gpm = gallons per minute
NAVD88 = North Americal Vertical Datum of 1988
sec = seconds

Estimate of Hydraulic Conductivity from Specific Capacity Testing
Groundwater Remedial Investigation
Garfield Avenue Group Sites PPG, Jersey City, New Jersey

AECOM

Well ID:	114-MW65C	Ground Surface Elevation (ft NAVD88):	12.4
Screen Zone:	Basal Till	Depth to Bottom of Well Screen (ft bgs)	65
Initial Depth to water (ft btc):	5.44	Groundwater Elevation (ft NAVD88):	8.76
Final Depth to water (ft btc):	6.35	Bottom of Well Screen Elevation (ft NAVD88):	-52.60
Water Level Reference Elevation (ft NAVD88):	14.2	Drawdown (ft)	0.91

Key
User Input
Input from Graph
Calculated

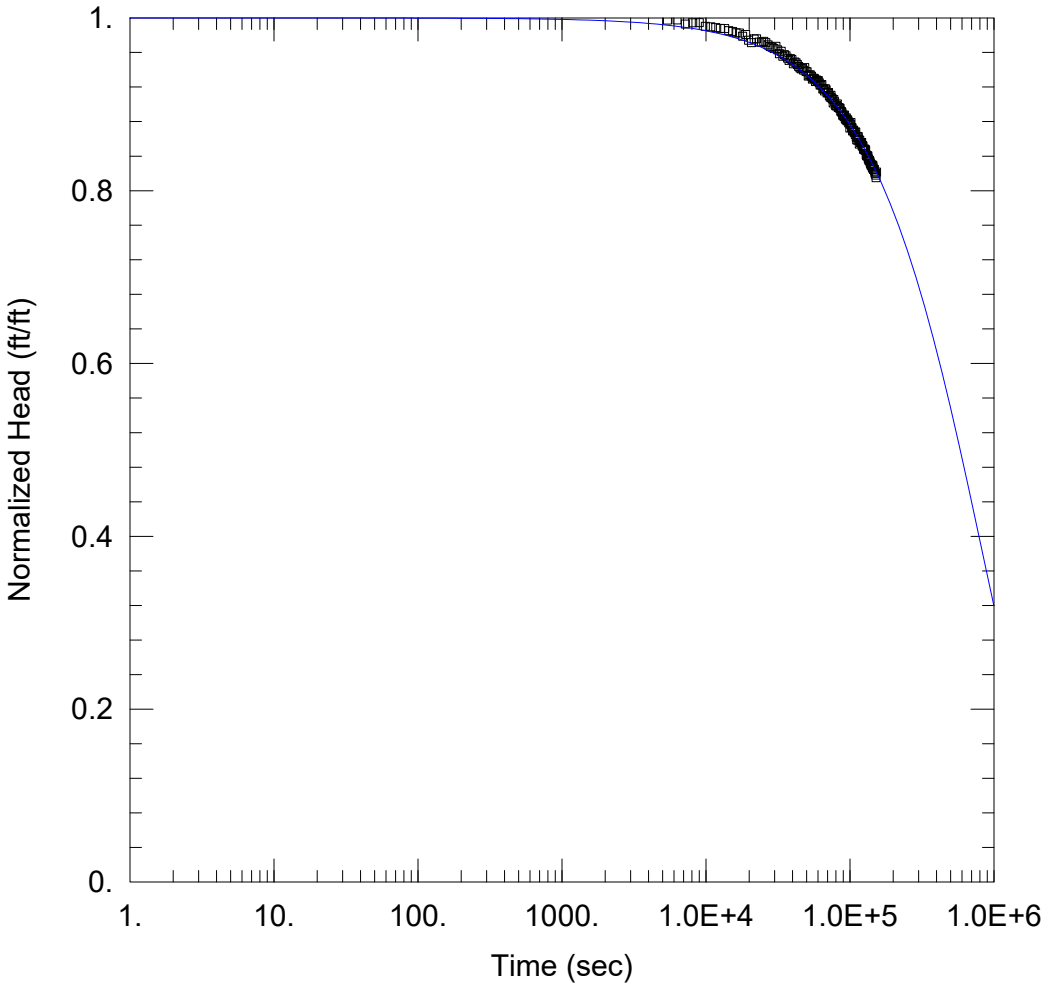
Field Data Inputs						
Symbol	Description	Value	Unit	Value	Unit	Source
Q	Flow Rate	0.17	gpm	32.725	ft^3/day	Field Data Sheet
L or Le	Screen Length	5	ft	5	ft	Well Construction Diagram
Lw	Saturated Thickness	-	-	61.36	ft	Groundwater Elevation - Bottom of Screen Elevation
H	Stabilized Drawdown	-	-	0.91	ft	Initial Depth to Water - Final Depth to Water
R	Well Casing Radius	2	inches	0.17	ft	Well Construction Diagram
rw	Borehole Radius	6	inches	0.50	ft	Boring Log

Graphical Input						
Symbol	Description	-	-	Value	Unit	Source
Le/rw	Ratio of Le to rw	-	-	10	-	Calculated from Values Above
C	Chart Value	-	-	1.4	-	Obtain Value from C line on Fig 2

Output						
Symbol	Description	-	-	Value	Unit	Source
ln(Re/R)	Calculated from Equation 5, assumes Lw=H.	-	-	2.71	-	https://www.csus.edu/indiv/h/hornert/geol_210_summer_2012/week%203%20readings/bouwer%201989.pdf
K	Hydraulic Conductivity	-	-	7.15	ft/day	Equation for Radial Flow from Muskat 1937
K	Hydraulic Conductivity	-	-	2.52E-03	cm/sec	

Notes:
bgs = below ground surface
btc = well top of well casing
cm = centimeters
ft = feet
gpm = gallons per minute
NAVD88 = North Americal Vertical Datum of 1988
sec = seconds

Attachment 5



RISING HEAD TEST

Data Set: X:\...\114-MW52D_HydCondTest_Disp_DE.aqt
Date: 09/01/22 Time: 09:48:02

PROJECT INFORMATION

Company: AECOM
Client: PPG
Location: Site 114
Test Well: 114-MW52D
Test Date: 12/8/2021

AQUIFER DATA

Saturated Thickness: 25. ft Anisotropy Ratio (Kz/Kr): 1.

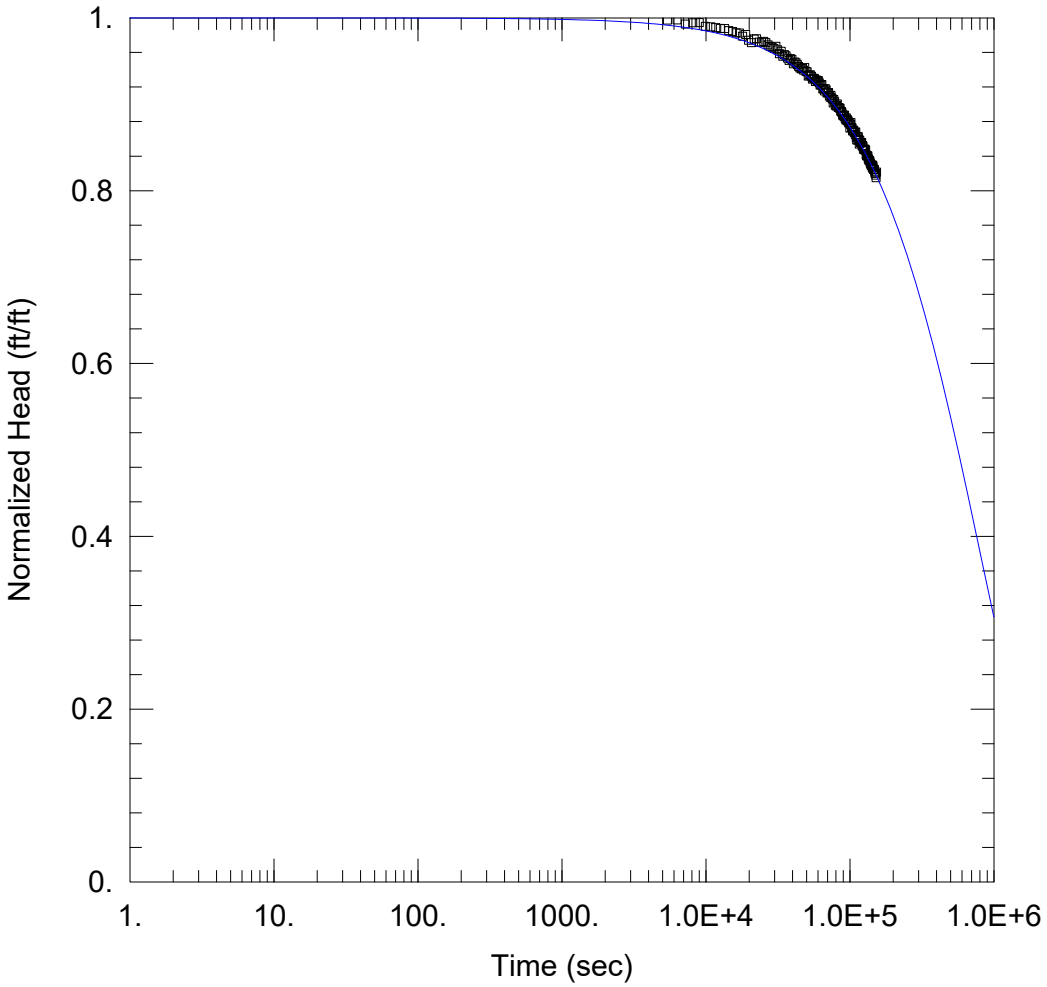
WELL DATA (114-MW52D)

Initial Displacement: 10.5 ft
Total Well Penetration Depth: 25. ft
Casing Radius: 0.25 ft
Static Water Column Height: 95.4 ft
Screen Length: 25. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Fractured
Solution Method: Barker-Black

T = 0.03392 ft^2/day
K' = 1.0E-10 ft/day
S = 2.794E-10
Ss' = 1.072E-10 ft^{-1}



RISING HEAD TEST

Data Set: X:\...\114-MW52D_HydCondTest_Disp_KGS.aqt
Date: 09/01/22 Time: 09:48:54

PROJECT INFORMATION

Company: AECOM
Client: PPG
Location: Site 114
Test Well: 114-MW52D
Test Date: 12/8/2021

AQUIFER DATA

Saturated Thickness: 25. ft

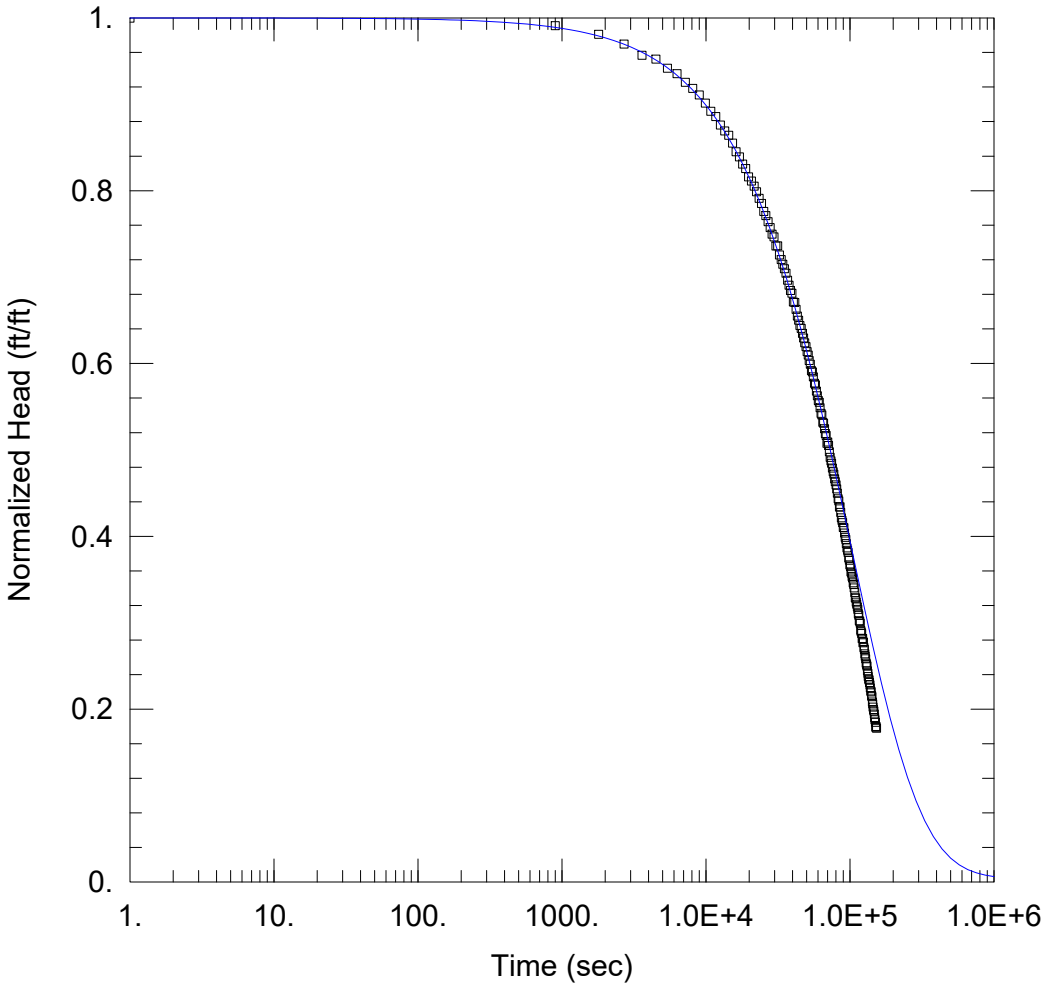
WELL DATA (114-MW52D)

Initial Displacement: 10.5 ft
Total Well Penetration Depth: 25. ft
Casing Radius: 0.25 ft
Static Water Column Height: 95.4 ft
Screen Length: 25. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.001547 ft/day
Kz/Kr = 0.09886
Ss = 1.525E-11 ft^{-1}



WELL TEST ANALYSIS

Data Set: X:\...\114-MW57D_HydCondTest_Disp.aqt
Date: 09/01/22 Time: 09:49:19

PROJECT INFORMATION

Company: AECOM
Client: PPG
Location: Site 114
Test Well: 114-MW57D
Test Date: 12/8/2021

AQUIFER DATA

Saturated Thickness: 27.5 ft Anisotropy Ratio (Kz/Kr): 1.

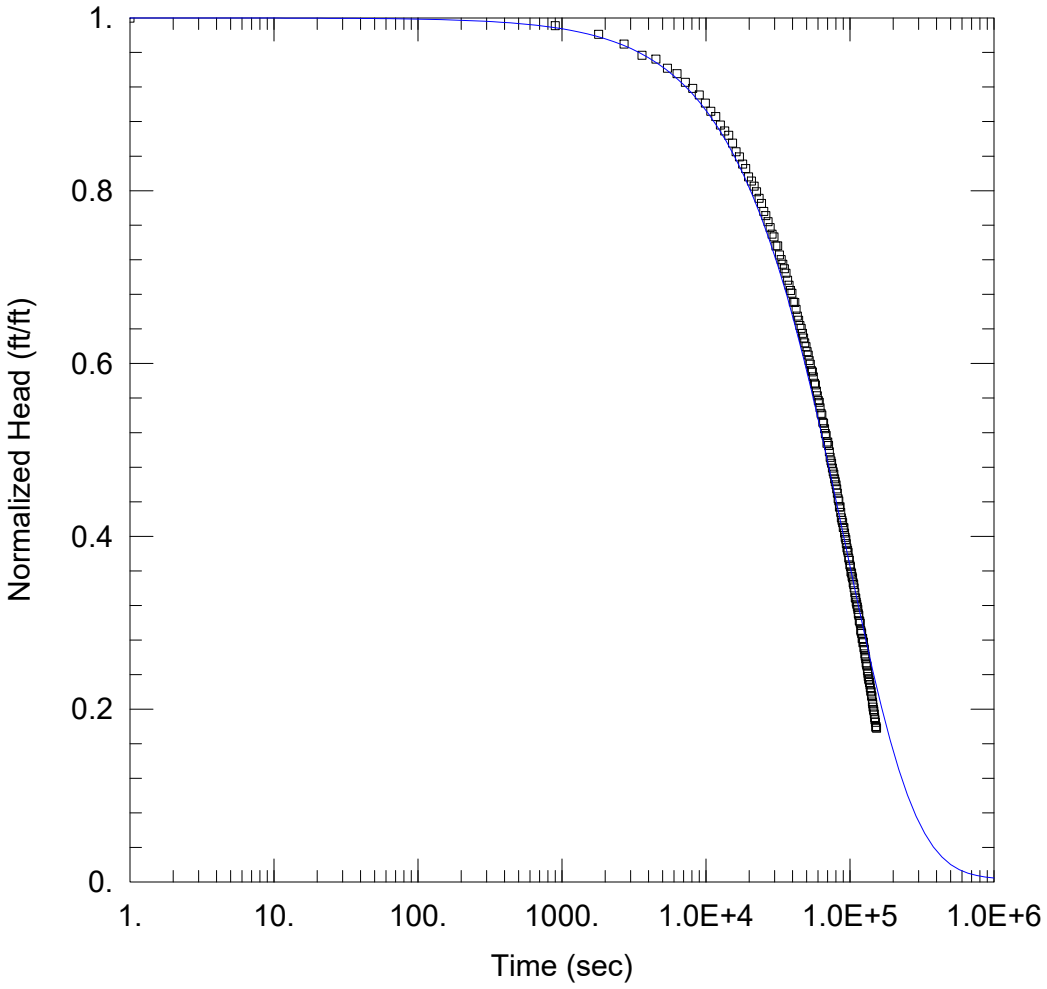
WELL DATA (114-MW57D)

Initial Displacement: 9.87 ft
Total Well Penetration Depth: 27.5 ft
Casing Radius: 0.25 ft
Static Water Column Height: 102.4 ft
Screen Length: 27.5 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Fractured
Solution Method: Barker-Black

T = 0.2715 ft^2/day
K' = 1.0E-10 ft/day
S = 1.0E-10
Ss' = 1.0E-10 ft^{-1}



WELL TEST ANALYSIS

Data Set: X:\...\114-MW57D_HydCondTest_Disp_KGS.aqt
Date: 09/01/22 Time: 09:49:47

PROJECT INFORMATION

Company: AECOM
Client: PPG
Location: Site 114
Test Well: 114-MW57D
Test Date: 12/8/2021

AQUIFER DATA

Saturated Thickness: 27.5 ft

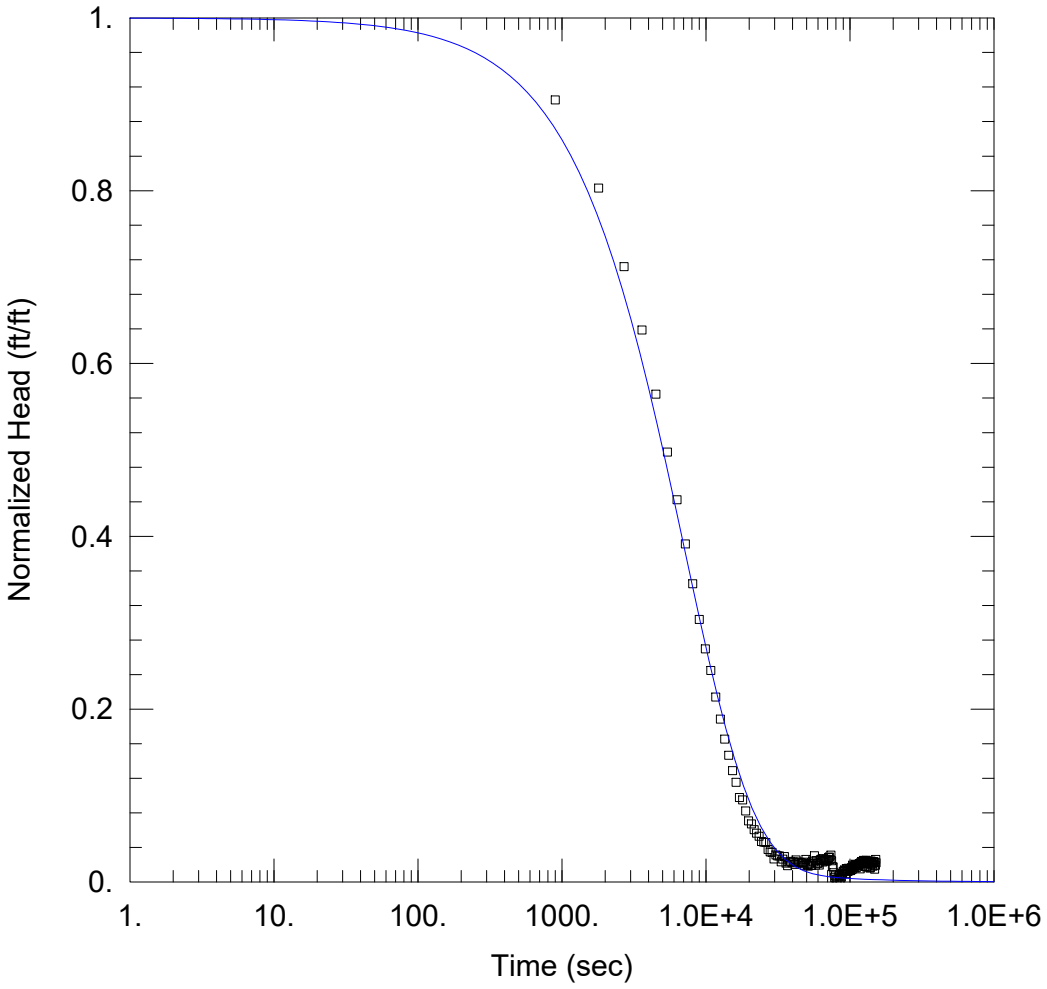
WELL DATA (114-MW57D)

Initial Displacement: 9.87 ft
Total Well Penetration Depth: 27.5 ft
Casing Radius: 0.25 ft
Static Water Column Height: 102.4 ft
Screen Length: 27.5 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01248 ft/day
Kz/Kr = 1.
Ss = 3.636E-12 ft^{-1}



WELL TEST ANALYSIS

Data Set: X:\...\114-MW66D_HydCondTest_Disp.aqt
Date: 09/01/22 Time: 09:50:25

PROJECT INFORMATION

Company: AECOM
Client: PPG
Location: Site 114
Test Well: 114-MW66D
Test Date: 12/8/2021

AQUIFER DATA

Saturated Thickness: 50. ft Anisotropy Ratio (Kz/Kr): 1.

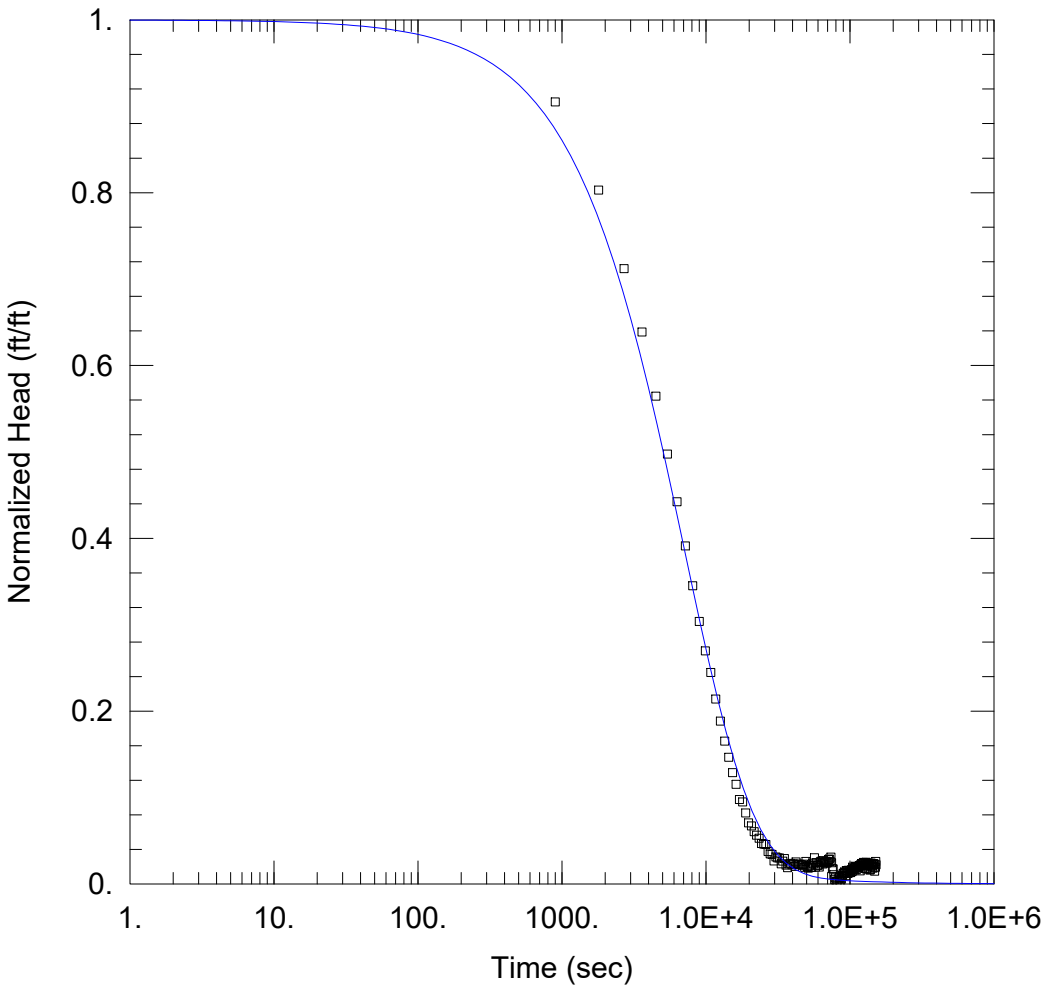
WELL DATA (114-MW66D)

Initial Displacement: 10.62 ft
Total Well Penetration Depth: 50. ft
Casing Radius: 0.25 ft
Static Water Column Height: 131.7 ft
Screen Length: 50. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Fractured
Solution Method: Barker-Black

T = 3.834 ft^2/day
K' = 1.0E-10 ft/day
S = 1.0E-10
Ss' = 1.0E-10 ft^{-1}



WELL TEST ANALYSIS

Data Set: X:\...\114-MW66D_HydCondTest_Disp_KGS.aqt
Date: 09/01/22 Time: 09:50:50

PROJECT INFORMATION

Company: AECOM
Client: PPG
Location: Site 114
Test Well: 114-MW66D
Test Date: 12/8/2021

AQUIFER DATA

Saturated Thickness: 50. ft

WELL DATA (114-MW66D)

Initial Displacement: 10.62 ft
Total Well Penetration Depth: 50. ft
Casing Radius: 0.25 ft
Static Water Column Height: 131.7 ft
Screen Length: 50. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.08305 ft/day
Kz/Kr = 1.
Ss = 1.765E-11 ft^{-1}