TECHNICAL MEMORANDUM

New Residential Well Remedial Alternative, Ault Field, Naval Air Station Whidbey Island, Coupeville, Washington

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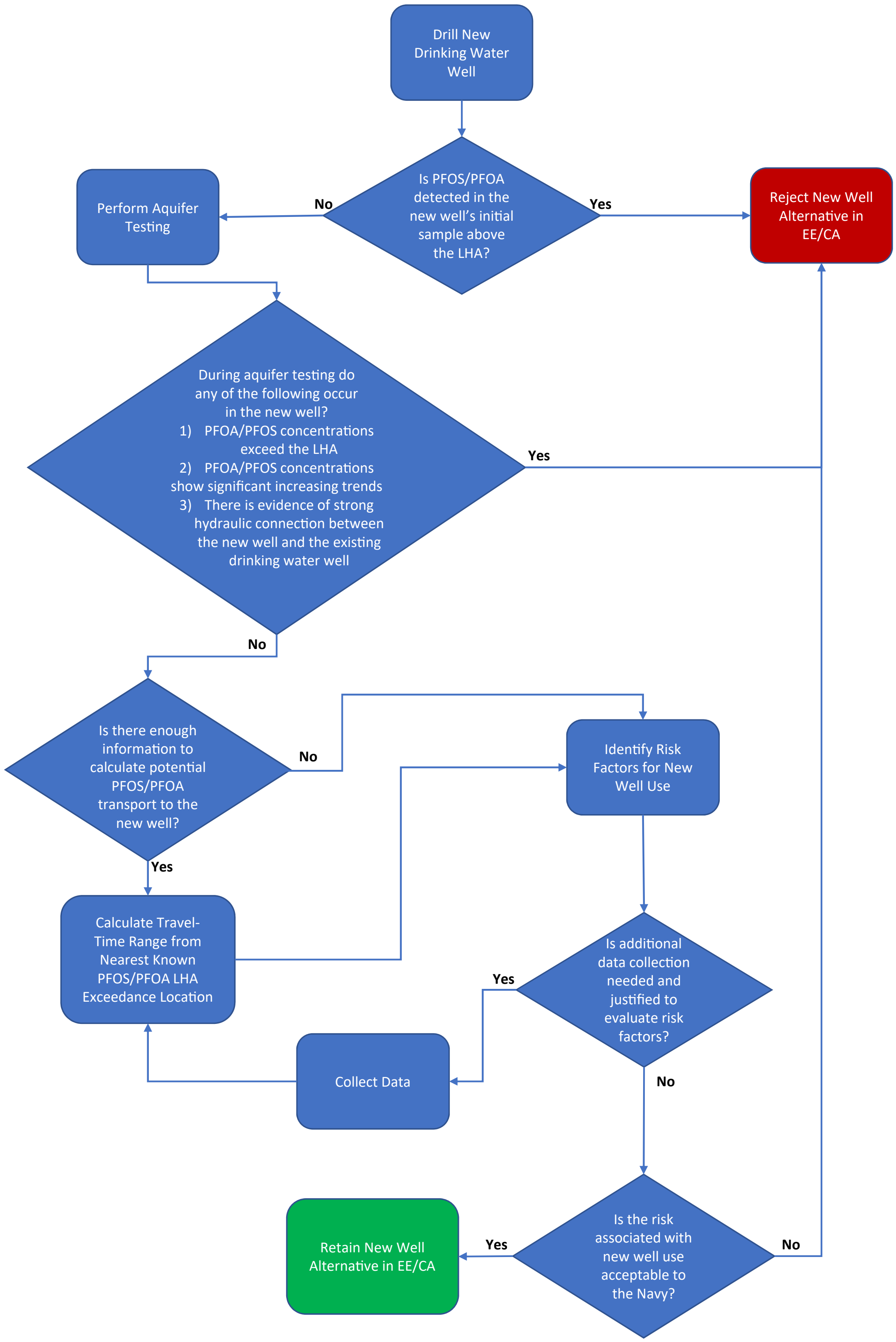
Introduction and Background

Ault Field is located on Whidbey Island near Oak Harbor, Washington, and is one of three Naval Air Station Whidbey Island installations. A Phase 1 Site Investigation was performed in January and February 2018 that included drilling two off-Base wells, WI-AF-MW-611 (MW-611) and WI-AF-MW-615 (MW-615). The Site Investigation included collecting information to support the evaluation of the new drinking water wells as long-term solutions for two residential parcels (**Figure 1**) near Ault Field where per- and poly-fluoroalkyl substances (PFAS) have been detected in drinking water above the United States Environmental Protection Agency (USEPA) Lifetime Health Advisory (LHA) of 70 parts per trillion (ppt).

Field activities to perform aquifer testing and groundwater sampling at these two residences were conducted with the primary objective to assess the potential risk that long-term pumping from the new wells may induce horizontal or vertical migration of the shallow PFAS contamination at each location into the screened interval of the new wells. A secondary objective of the testing program was to quantify aquifer properties in each area to assess potential migration rates for PFAS in groundwater to support development of a water quality monitoring program. Note that this secondary objective will only be applicable to sites where aquifer testing results indicate use of the replacement well as long-term water supply is viable. If aquifer testing results suggest that the potential replacement supply well at either residence is not suitable for long-term supply, then these analyses will not be required.

A decision tree (**Figure 2**) was developed outlining the activities recommended to determine whether the new wells would serve as a long-term solution for water supply at either residence. The purpose of this technical memorandum (TM) is to summarize the aquifer testing and groundwater sampling activities performed at each residence and provide the primary conclusions obtained from the aquifer testing program.



Notes:

EE/CA = Engineering Evaluation/Cost Analysis

LHA = U.S. Environmental Protection Agency Lifetime Health Advisory

PFOA = perfluorooctanoic acid

PFOS = perfluorooctane sulfonate

Figure 2.
Ault Field New Residential Well Remedial Alternative Decision Tree
Naval Air Station Whidbey Island
Oak Harbor, Washington

Aquifer Testing

Aquifer testing was conducted in June and July 2018. Yellow Jacket Drilling provided field services including pump installation and investigation-derived waste management. A variable rate (step) test (operating the well pump at different rates) and constant rate test (operating the well pump at a single rate) were completed on the new potential supply wells at each of the two residences as described in **Table 1** and discussed further in subsequent sections. Site layouts for each residence are included as **Figures 3 and 4.**

Table 1. Aquifer Testing Summary

Location	Potential Supply Well (New)	Observation Wells	Variable Rate (Step) Test	Constant Rate Test
Residence 1	MW-611	Residence 1 Existing Supply Well (EXR1) Community Well[a]	2 gpm for 2 hours 4 gpm for 2 hours 6 gpm for 2 hours 8 gpm for 2 hours 8.3 gpm for 1 hour	8 gpm for 16 hours 0 gpm for 8 hours (repeat three times)
Residence 2	MW-615	Residence 2 Existing Supply Well (EXR2) WI-AF-MW-614 (MW-614)	2 gpm for 2 hours 4 gpm for 2 hours 6 gpm for 2 hours 8 gpm for 2 hours	8 gpm for 72 hours

Notes:
[a.] Initially planned to monitor water levels during testing. Transducer was installed from July 2, 2018 at 13:30 and removed July 2, 2018 at 19:49 because of community concerns.
gpm = gallon(s) per minute

Baseline Monitoring

At least 1 week before aquifer testing, In Situ Level TROLL 700 data logging pressure transducers were installed in the new potential supply wells (MW-611 and MW-615) and select observation wells as listed in **Table 1**. The pressure transducers were equipped with vented cables to account for atmospheric pressure variations. A Baro TROLL was also installed in the existing residential wells to monitor atmospheric pressure variations. All transducers were programmed to record data at 1-minute intervals. Baseline data are presented for Residence 1 and Residence 2 in **Figures 5 through 9**. The following observations are made about the baseline data:

- There is a correlation between the barometric pressure and water levels observed in MW-611 at Residence 1. However, the same correlation is not observed in EXR1.
- Water levels in the Community Well are relatively stable at approximately 21 feet below ground surface (bgs), indicating the pump was operating continuously during the baseline monitoring period. Drawup was observed in the water levels on July 2, 2018 at 16:36, which correlates to Bob's Pumps arriving onsite to troubleshoot pump operations. A water line leak and low water pressure were reported by residents. This may explain why the pump was operating continuously versus cycling on and off to meet demands, but this explanation is unconfirmed.
- A drawdown in groundwater levels of approximately 0.25 feet was observed in EXR1 starting late on July 5, 2018, correlating to the Community Well pump being replaced and resuming normal operation.
- There is a correlation between the barometric pressure and water levels observed in MW-615 at Residence 2 and the MW-614 observation well.

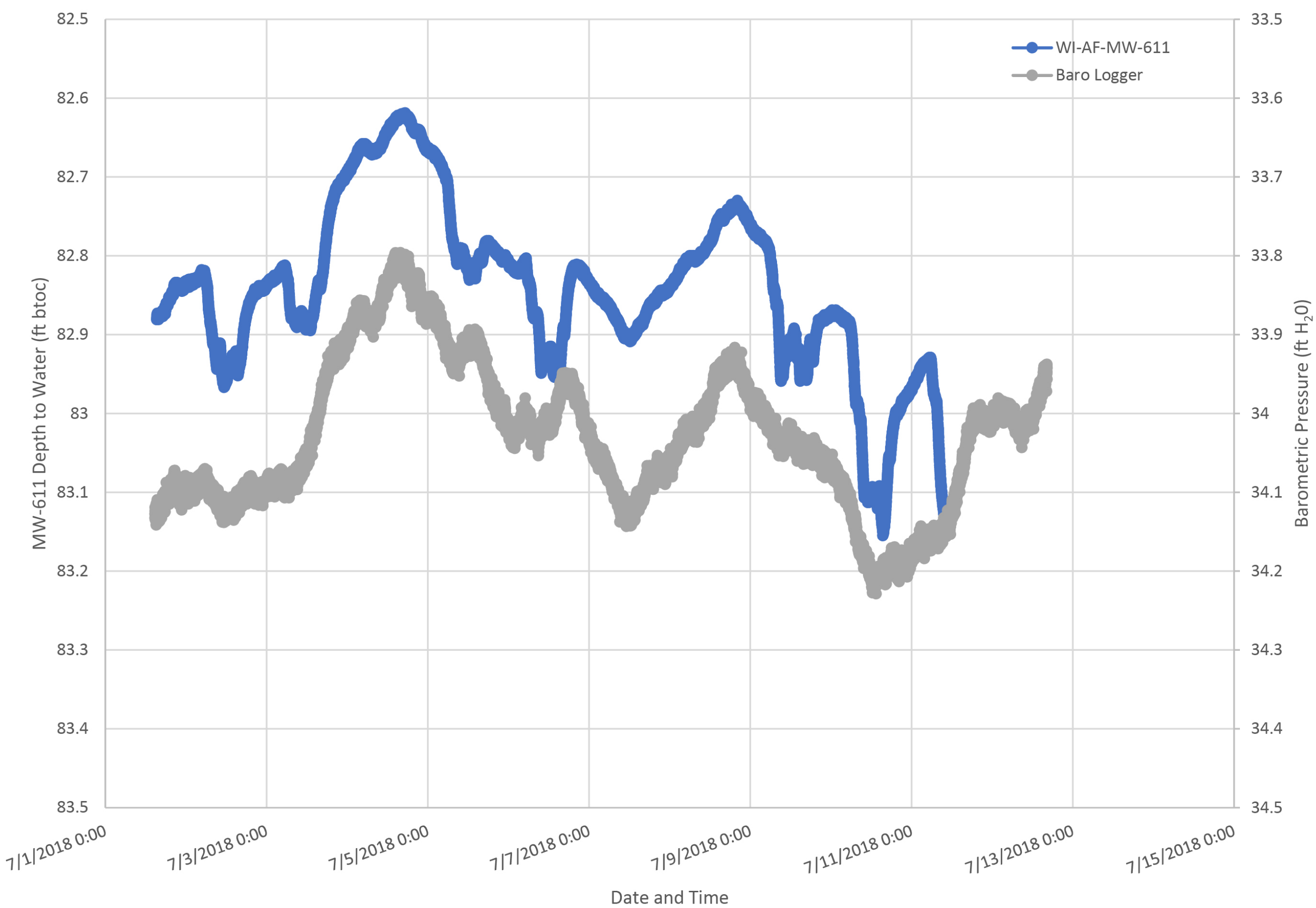


Figure 5.
Residence 1 Baseline Data – MW-611
Naval Air Station Whidbey Island
Oak Harbor, Washington

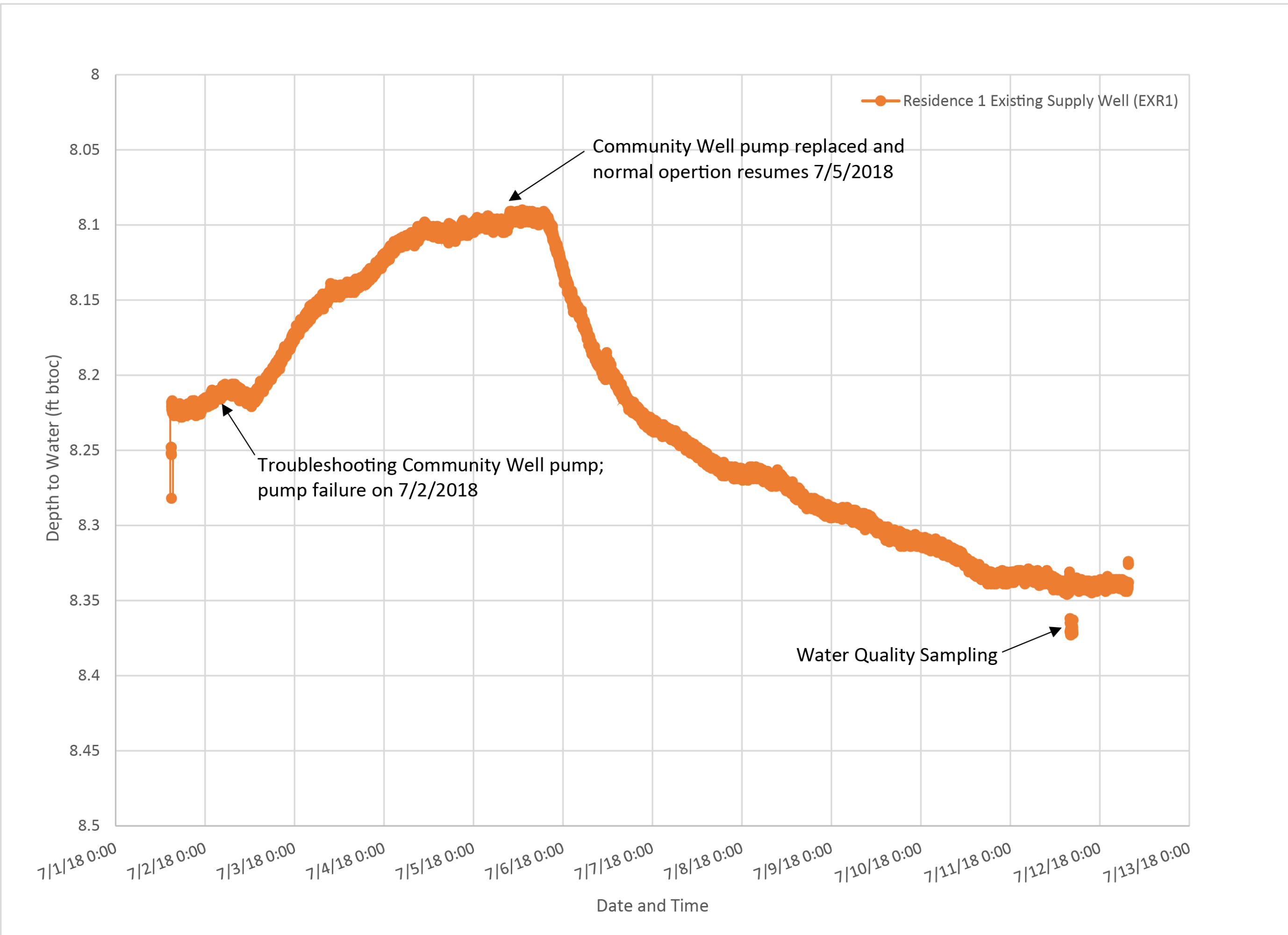


Figure 6.
Residence 1 Baseline Data – Existing Supply Well
Naval Air Station Whidbey Island
Oak Harbor, Washington

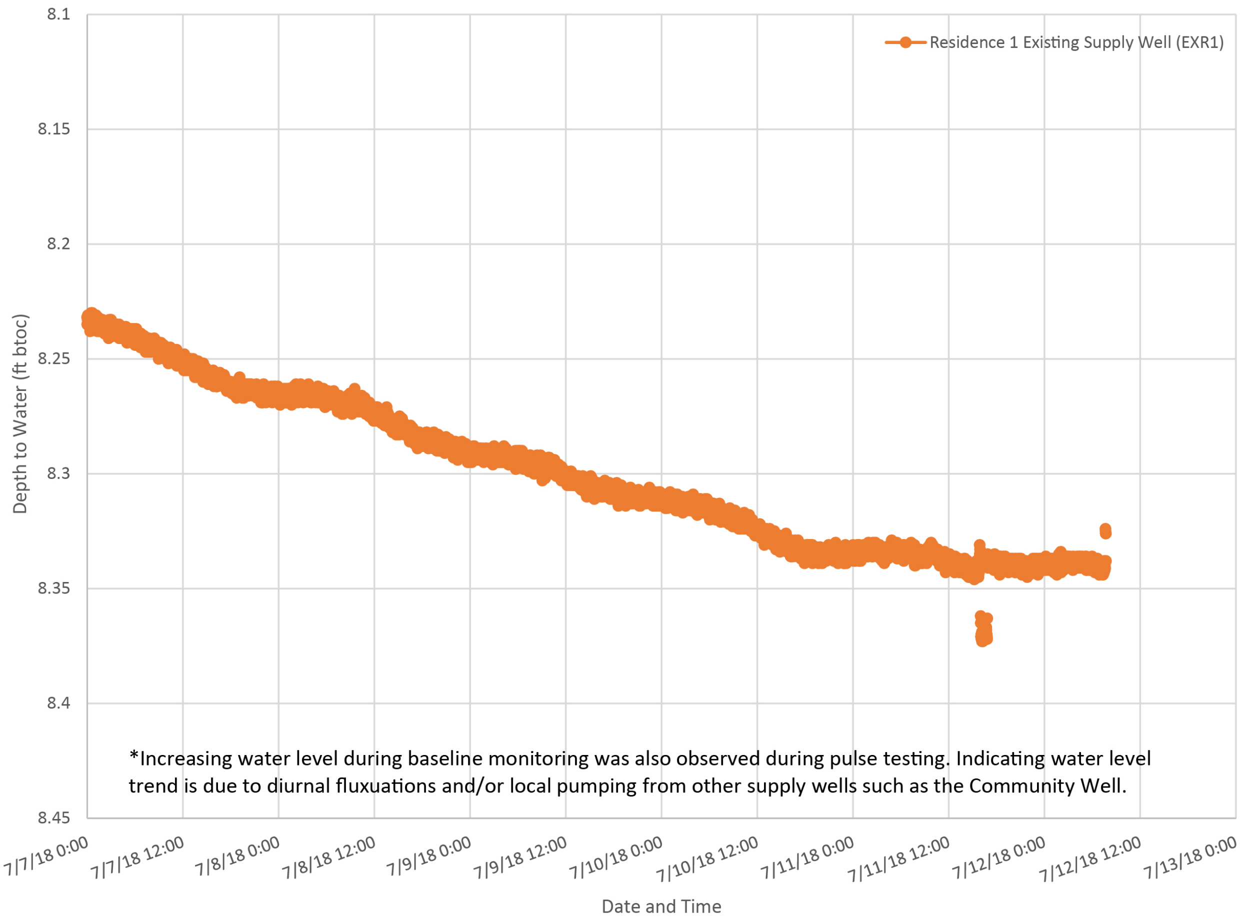


Figure 7.
Residence 1 Baseline Data – Existing Supply Well
Naval Air Station Whidbey Island
Oak Harbor, Washington

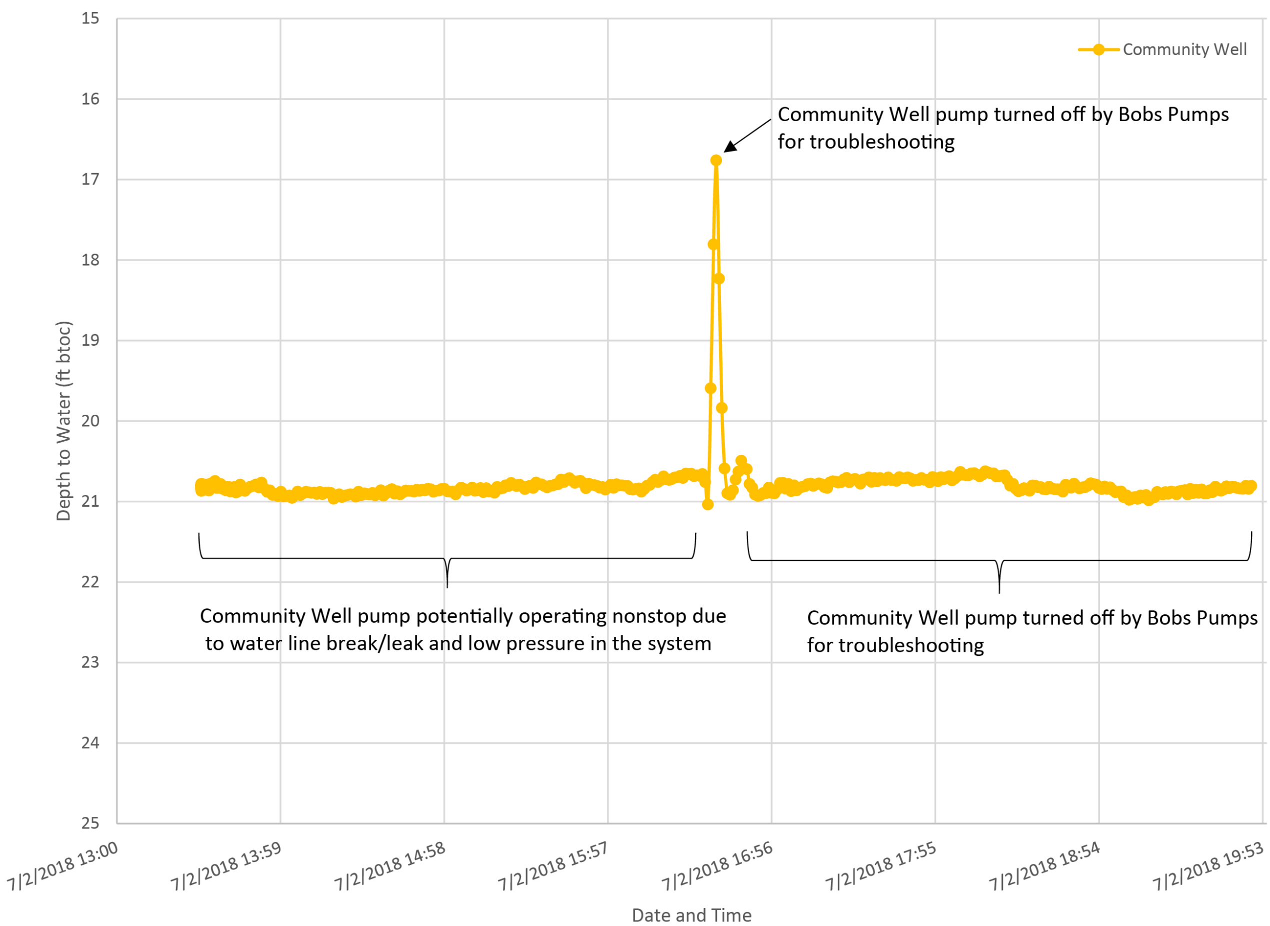


Figure 8.
Residence 1 Baseline Data – Community Well
Naval Air Station Whidbey Island
Oak Harbor, Washington

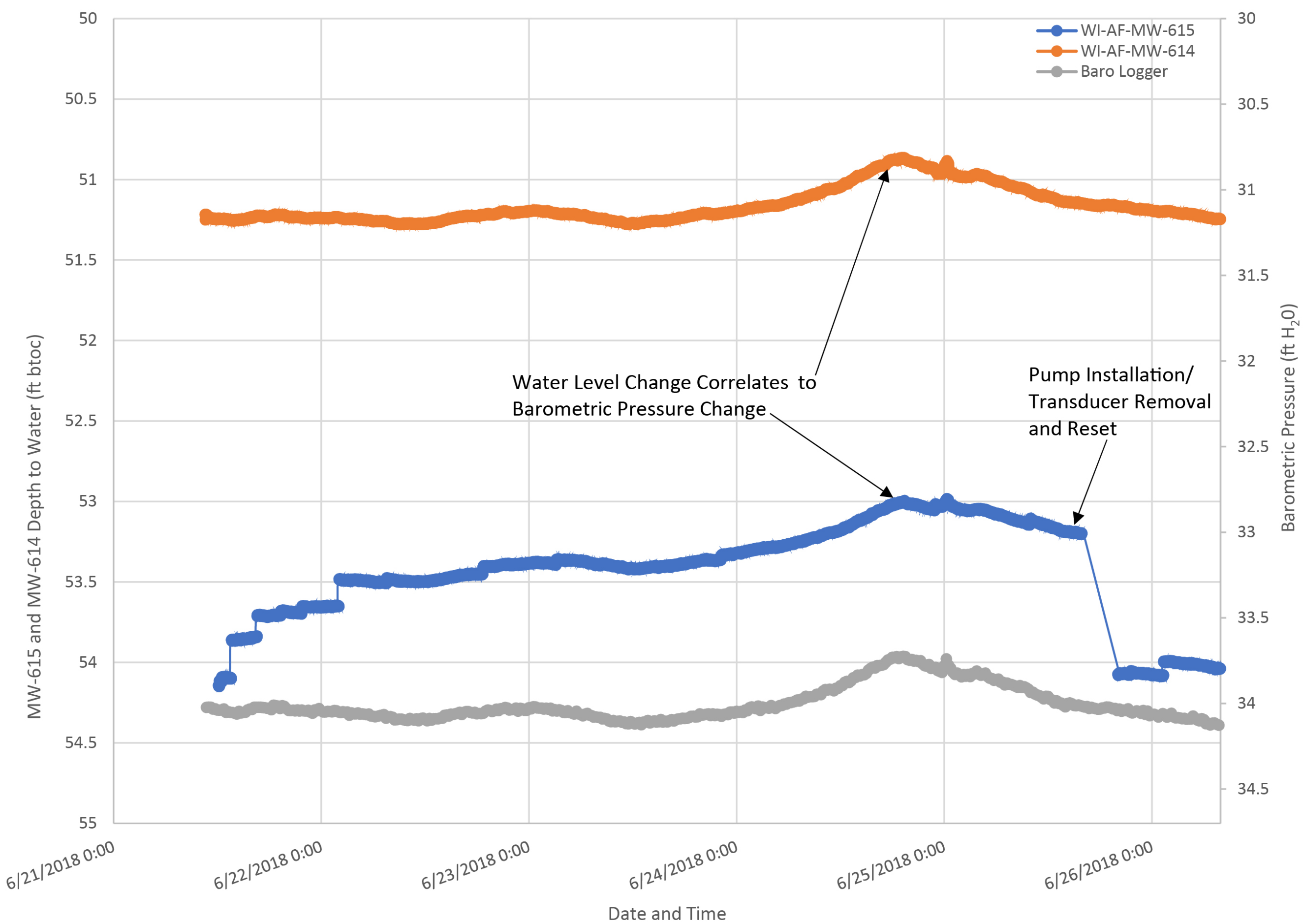


Figure 9.
Residence 2 Baseline Data
Naval Air Station Whidbey Island
Oak Harbor, Washington

Variable Rate (Step) Test

An 8-hour variable-rate (step) test was conducted on the new potential supply wells with water levels monitored both manually and by data logging pressure transducers in the new wells and select observation wells (**Table 1**).

The step test consisted of operating the pump at four different flow rates (steps), for 2 hours at each rate, starting with the lowest rate. At Residence 1, the pump was operated for an additional hour to test one additional higher-flow rate that coincided with the maximum yield that could be obtained from the submersible pump system.

Pressure transducers were programmed to record groundwater levels logarithmically at 1-minute intervals for the duration of each step. Water levels were manually measured and recorded in the new potential supply wells and observation wells to confirm the water levels measured by the pressure transducers. Manual water level measurements were generally recorded at the following frequency:

- 0 to 10 minutes, every minute
- 10 to 20 minutes, every 5 minutes
- 20 to 30 minutes, every 15 minutes
- 30 to 120 minutes, every 30 minutes

Step test data is presented for Residence 1 and Residence 2 in **Figures 10 and 11**, respectively. The following observations are made about the step test data:

- Static water levels in EXR1 are significantly shallower than static water levels in MW-611.
- Water levels in EXR1 were not affected from pumping MW-611 during the step test.
- Water levels in EXR2 showed approximately 0.2 feet of drawdown while water levels in MW-614 were not affected from pumping MW-615 during the step test.

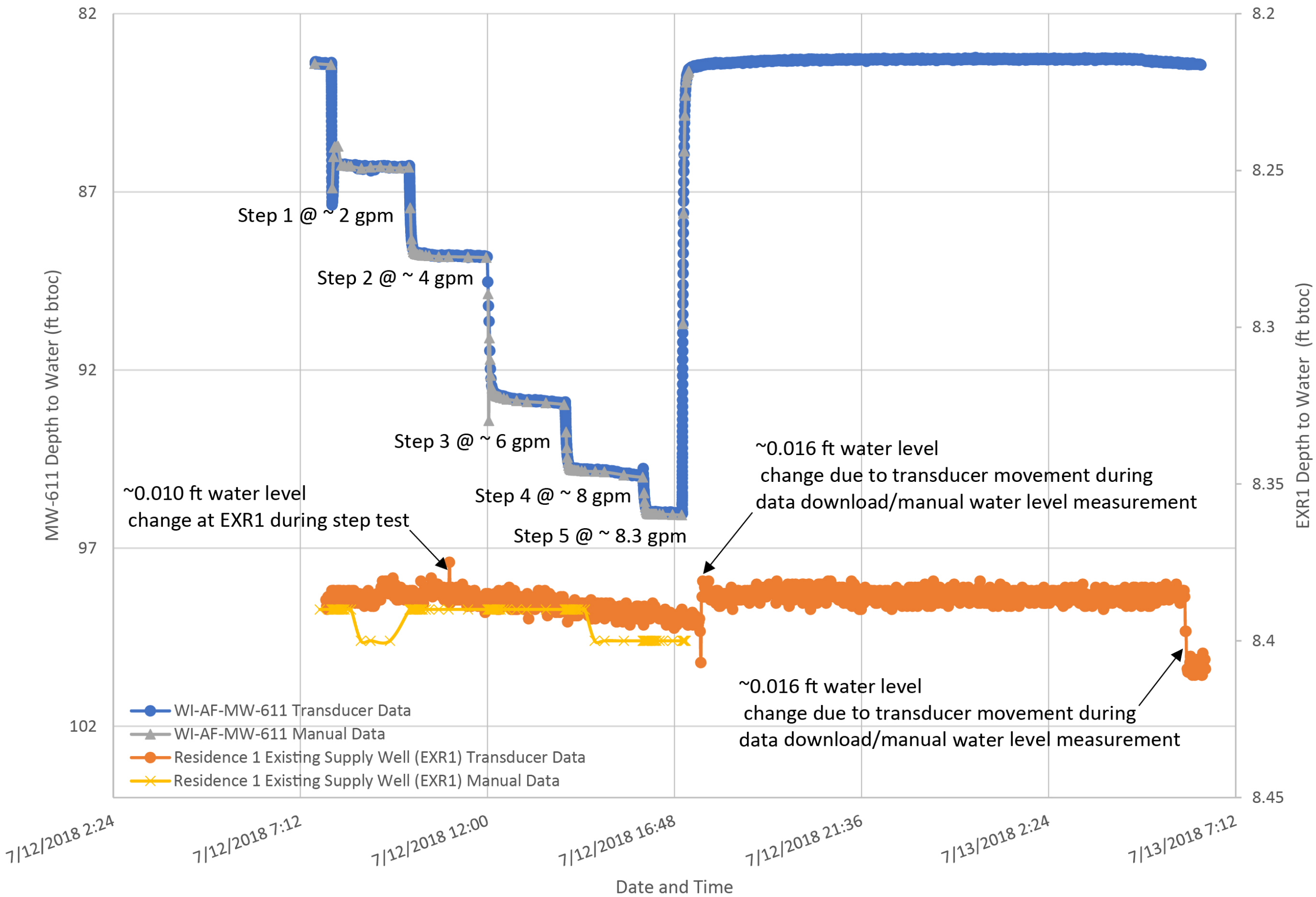


Figure 10.
Residence 1 Step Test Data
Naval Air Station Whidbey Island
Oak Harbor, Washington

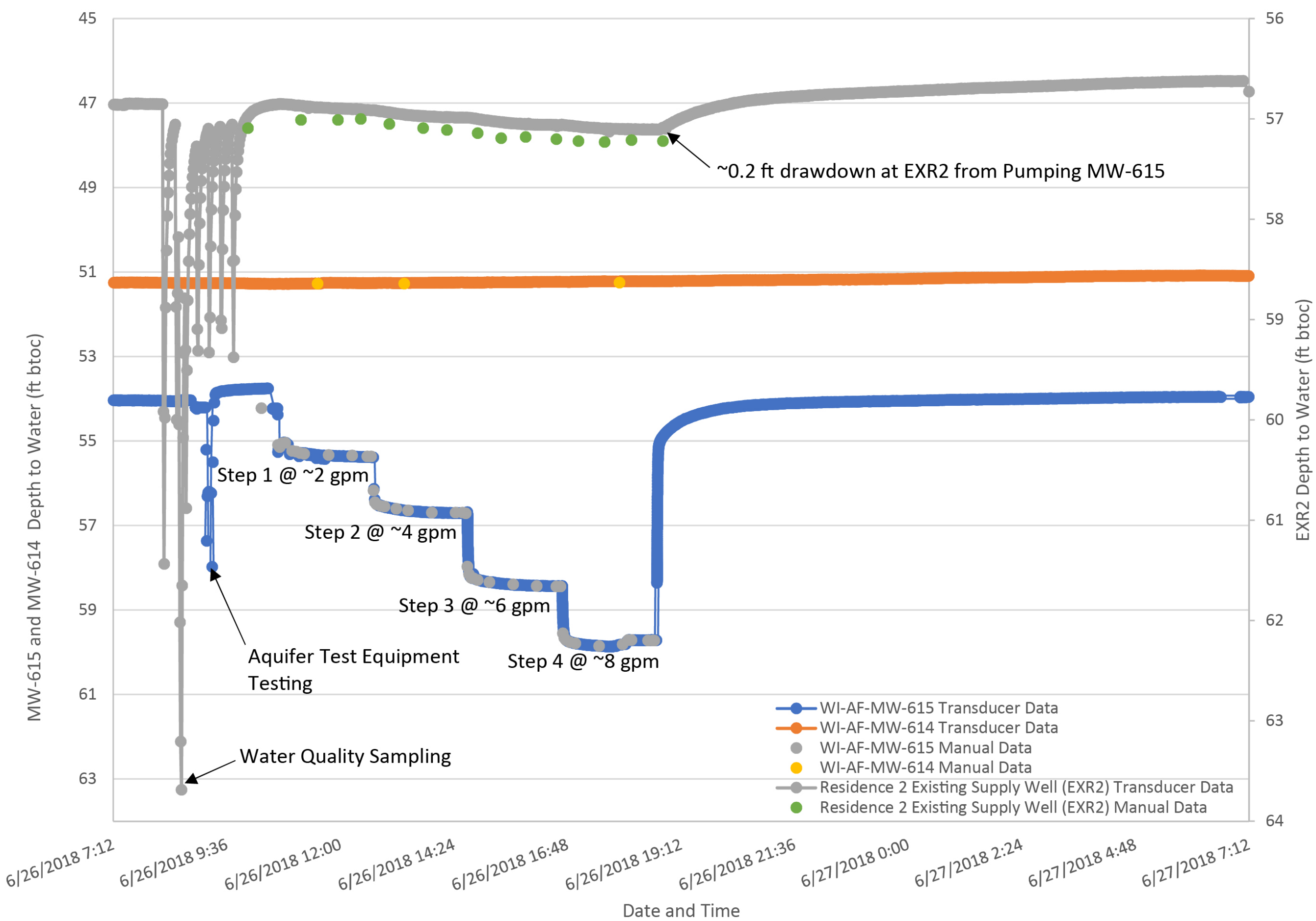


Figure 11.
Residence 2 Step Test Data
Naval Air Station Whidbey Island
Oak Harbor, Washington

Constant Rate Test

The results of the step test were used to select the pumping rate for the constant rate test. The planned constant rate test procedure consisted of operating the pump for 72 hours at a constant rate while monitoring water levels in the new pumping well and associated observation wells. Following shutdown, water levels were monitored for a 24-hour recovery period.

This procedure was followed for the Residence 2 constant rate test between June 27 and 30, 2018 with recovery between June 30, 2018 and July 1, 2018.

The testing procedure was modified for the Residence 1 site because of the lack of observation wells at this site, the inability to take the Community Well out-of-service during the testing period, and the inability to monitor water levels in the Community Well. The 72-hour constant rate test procedure was modified to a pulse test consisting of pumping MW-611 for 16 hours followed by shutdown and recovery for 8 hours and was repeated for three cycles. The goal of the pulse test was to create a defined period of pumping and not pumping that would be reflected in the groundwater levels and could be differentiated from water level changes because of operation of the Community Well or other residential wells that may be operating in the area. Constant rate and pulse test data is presented for Residence 1 and Residence 2 in **Figures 12 through 14.** The following observations are made about the constant rate and pulse test data:

- Water levels in EXR1 decline over the duration of pulse testing and continue to decline following shutdown by approximately 0.05 feet, indicating the drawdown is not because of pumping of MW-611. There is no correlation between the barometric pressure and water levels. The change in water levels is likely because of regional groundwater fluctuations or local pumping from residential wells in the area.
- Water levels in EXR2 decline by approximately 0.6 feet over the duration of the 72-hour constant rate test and recovered relatively quickly following shutdown of pumping well MW-615, indicating the drawdown is because of pumping of MW-615.
- Water levels in MW-614 decline by approximately 0.3 feet over the duration of the 72-hour constant rate test, suggesting the drawdown may be because of pumping MW-615.

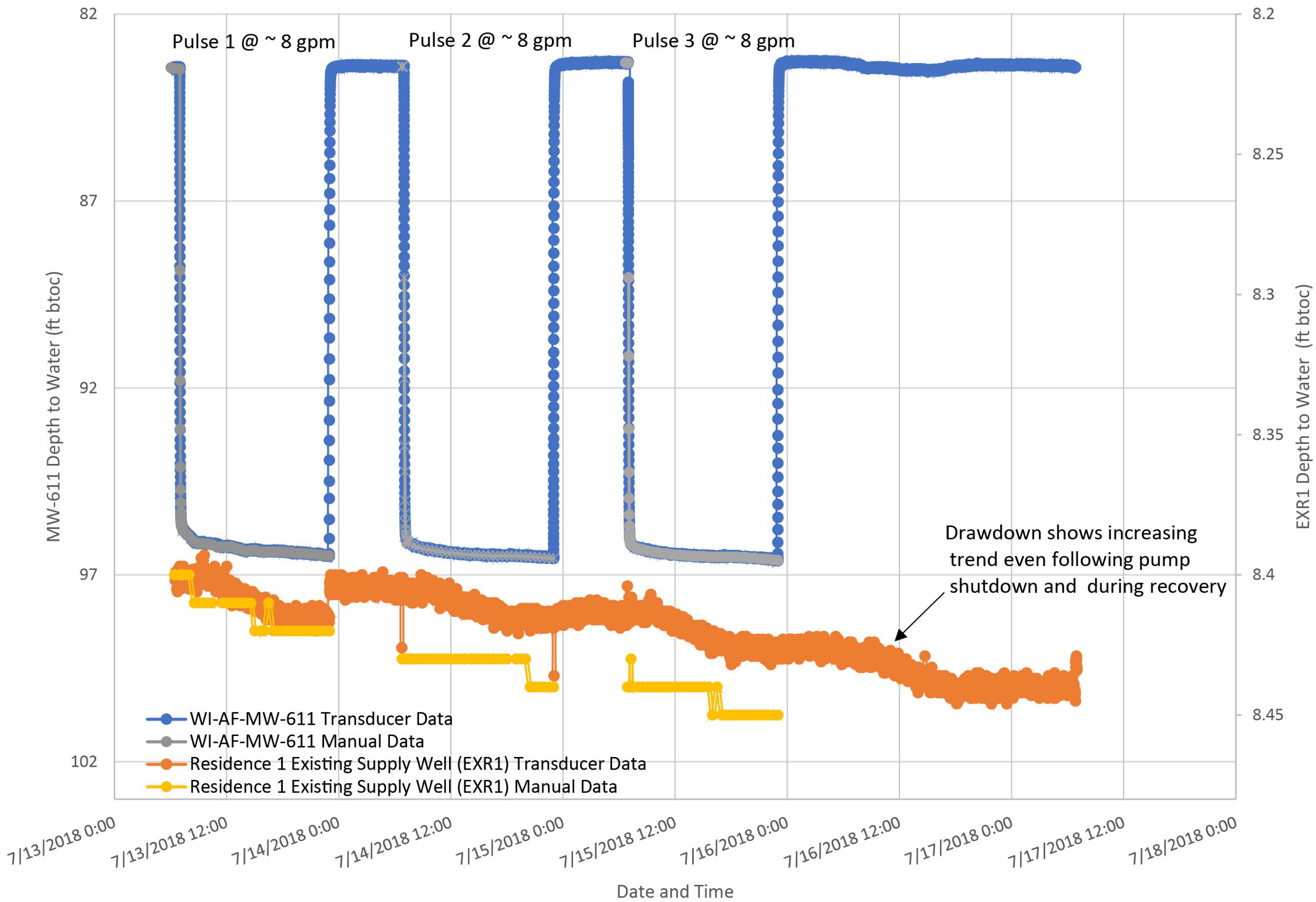


Figure 12.
Residence 1 Constant Rate Data – MW-611 and Existing Supply Well
Naval Air Station Whidbey Island
Oak Harbor, Washington

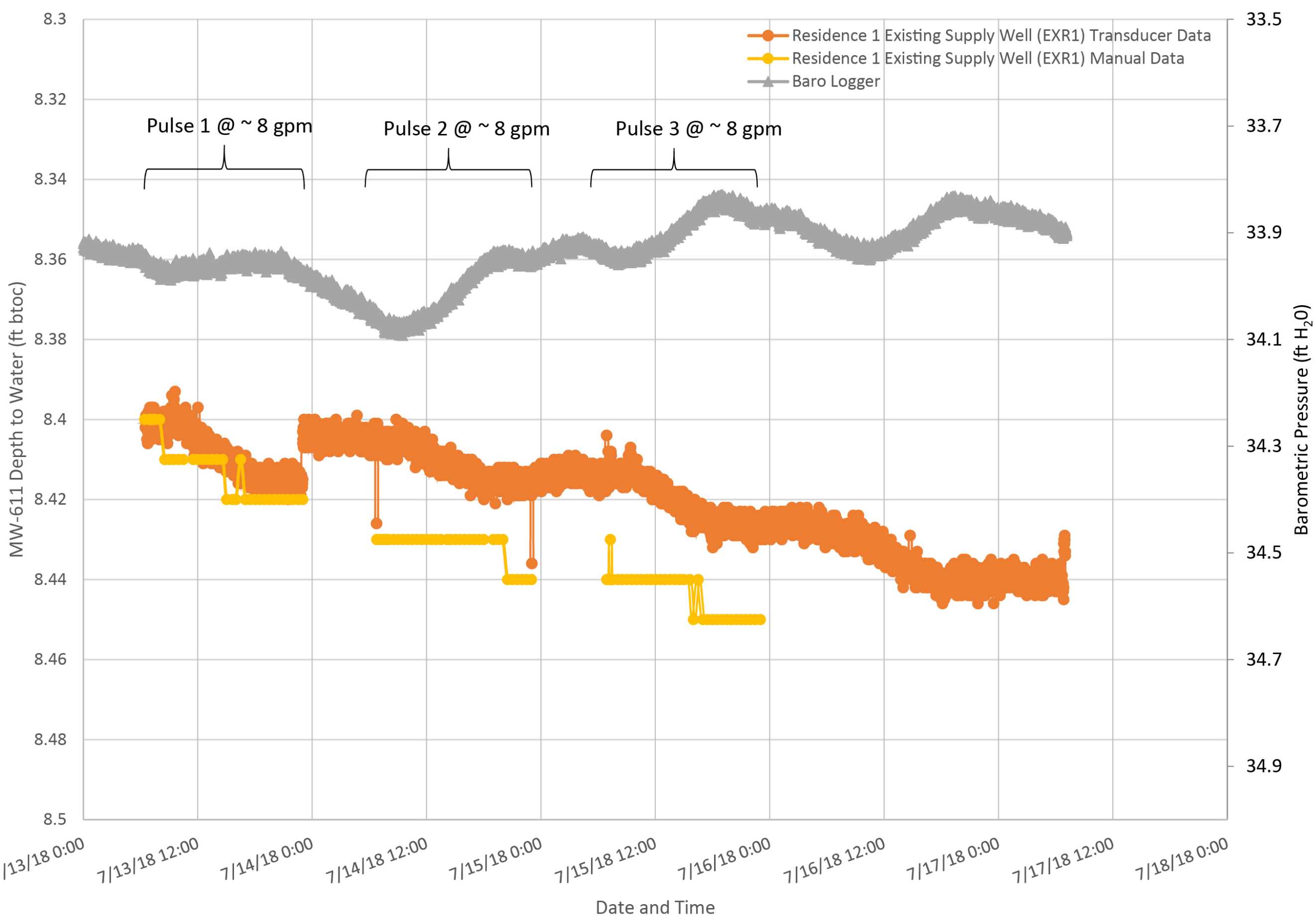


Figure 13.
Residence 1 Constant Rate Data – Existing Supply Well
Naval Air Station Whidbey Island
Oak Harbor, Washington

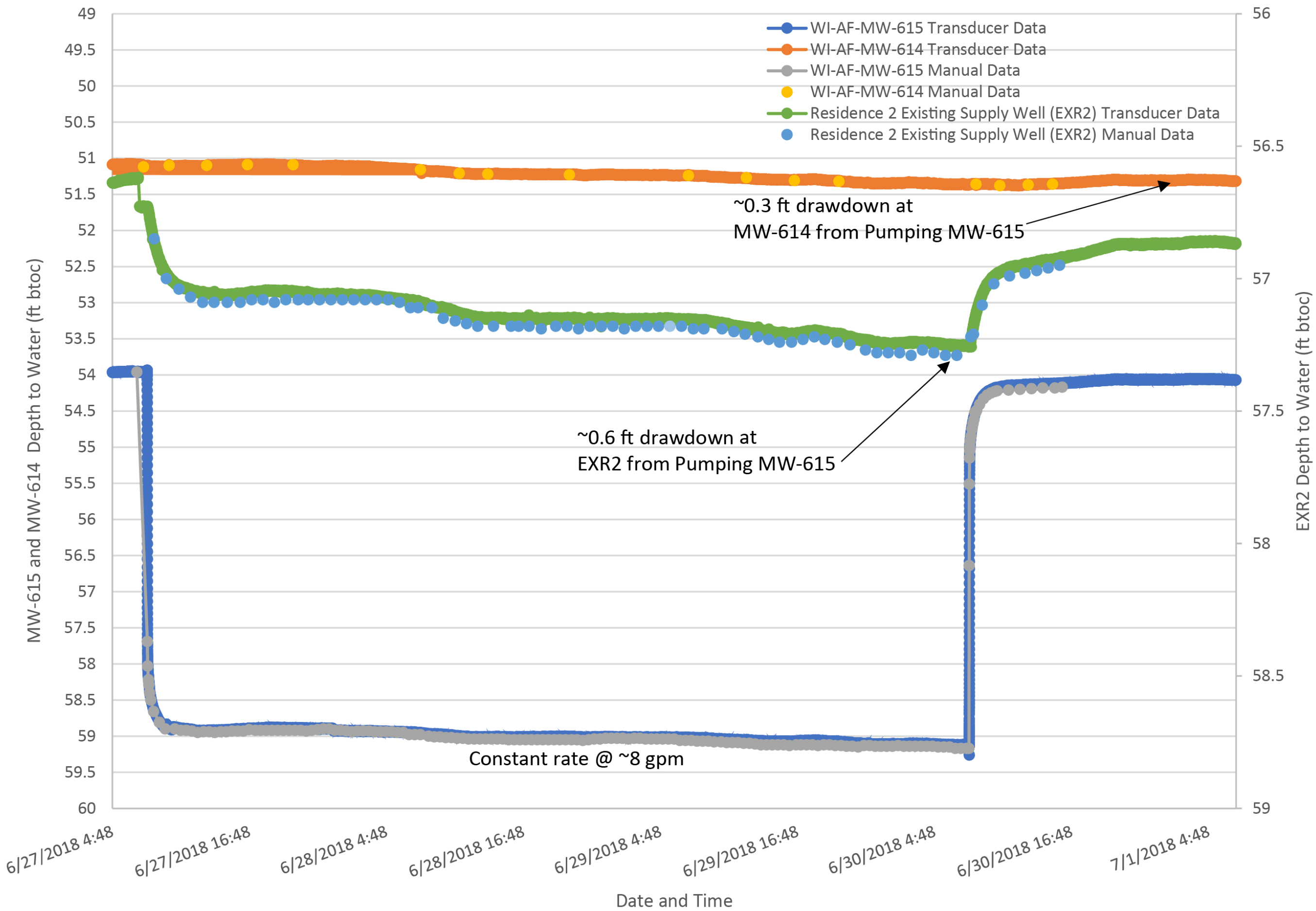


Figure 14.
Residence 2 Constant Rate Data
Naval Air Station Whidbey Island
Oak Harbor, Washington

Water Quality Results and Evaluation

Water quality samples were collected in the existing residential supply wells, new potential supply wells, and observation wells at each site before aquifer testing, during aquifer testing, and following aquifer testing for evaluation of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) concentrations. PFOA/PFOS are fluorinated organic chemicals that are a part of the larger group of chemicals referred to as PFAS. Results are summarized in **Table 2**. A summary table including all 14 compounds, where sampled, is included as **Appendix A**.

Table 2. Aquifer Testing Summary

Sample Location	Sample Point	Sample Date	PFOA (ppt)	PFOS (ppt)	Combined PFOA + PFOS (ppt)	Sampling Description
Residence 1	Spigot	February 2017	140	44	184	Phase 2 Drinking Water Sampling -Existing Residential Well
	Spigot	October 2017	73.1	ND	73.1	Drinking Water Sampling for Periodic Monitoring -Existing Residential Well
	Spigot	March 2018	35.2	1.1	36.3	Drinking Water Sampling for Periodic Monitoring -Existing Residential Well
	Spigot[a]	July 2018	34.6	ND	34.6	*EXR1A* Pre-Aquifer Test Sample - Existing Residential Well
	Spigot[a]	July 2018	38.3	ND	38.3	*EXR1C* Post-Aquifer Test Sample -Existing Residential Well
	Well	March 2018	ND	ND	ND	*MW-611* Phase 1 SI Groundwater Sample - New Well
	Well[a]	July 2018	ND	ND	ND	*MW-611A* Pre-Aquifer Test Sample -New Well
	Well[a]	July 2018	ND	ND	ND	*MW-611B* During Aquifer Test Sample - New Well
	Well[a]	July 2018	ND	ND	ND	*MW-611C* Post-Aquifer Test Sample -New Well
Community Well	Spigot	February 2017	32	49	81	Phase 2 Drinking Water Sampling Existing Well
	Spigot	October 2017	30.3	ND	30.3	Drinking Water Sampling for Periodic Monitoring Existing Well
	Spigot	March 2018	33.6	ND	33.6	Drinking Water Sampling for Periodic Monitoring Existing Well
	Spigot[a]	July 2018	31.3	ND	31.3	*EXC1A* Pre-Aquifer Test Sample - Existing Community Well
	Spigot[a]	July 2018	33.8	ND	33.8	*EXC1B* During Aquifer Test Sample -Existing Community Well

Table 2. Aquifer Testing Summary

Sample Location	Sample Point	Sample Date	PFOA (ppt)	PFOS (ppt)	Combined PFOA + PFOS (ppt)	Sampling Description
	Spigot[a]	July 2018	32.1	ND	32.1	*EXC1C* Post Aquifer Test Sample -Existing Community Well
Residence 2	Spigot	February 2017	23	3,800	3,823	Phase 2 Drinking Water Sampling Existing Well
	Spigot	October 2017	5.99	538	543.99	Drinking Water Sampling for Periodic Monitoring Existing Well
	Spigot	March 2018	46.1	8,030	8,076.1	Drinking Water Sampling for Periodic Monitoring Existing Well
	Spigot[a]	June 2018	147	23,900	24,047	*EXR2A* Pre-Aquifer Test Sample - Existing Residential Well
	Spigot[a]	July 2018	142	25,900	26,042	*EXR2C* Post-Aquifer Test Sample -Existing Residential Well
	Well	March 2018	7.85	3.37	11.22	*MW-615* Phase 1 SI Groundwater Sample - New Well
	Well[a]	June 2018	7.4	ND	7.4	*MW-615A* Pre-Aquifer Test Sample -New Well
	Well[a]	June 2018	10.8	ND	10.8	*MW-615B* During Aquifer Test Sample - New Well
	Well[a]	June 2018	7.52	ND	7.52	*MW-615C* Post-Aquifer Test Sample -New Well

Notes:
[a.] Data has not been validated
N/A = not applicable
ND = non-detect

Aquifer Test Results and Analysis

Residence 1

The drawdown data from the 72-hour pulsed aquifer test performed at Residence 1 was evaluated using a simple three-layer numerical tool developed using MODFLOW-2005. The model was constructed with a uniform grid with total dimensions of 5,000 feet by 5,000 feet and a uniform cell size of 25 feet by 25 feet. The model was configured using three layers to reflect the observed lithology of the area. Layer 1 represents the shallow aquifer system that extends from ground surface to a depth of 50 feet. Layer 2 represents the clay aquitard observed during drilling of MW-611 that extends from 50 feet bgs to 100 feet bgs. Finally, Model Layer 3 is represented by a deeper aquifer unit that underlies the clay aquitard and extends to the total depth of well MW-611 at 165 feet bgs. The model grid was oriented parallel to an assumed groundwater flow direction to the north, based on local topography in the area and the presence of the Clover Valley Creek discharge area north of the residence. A horizontal hydraulic gradient of 0.001 foot/foot was assumed in the model. The hydraulic gradient was induced in the model by imposition of constant head cells along the northern and southern model boundaries. The model was developed with the following objectives:

- Estimating the aquifer properties of the lower aquifer in the vicinity of well MW-611.
- Estimating the travel time between contamination in the upper aquifer in the vicinity of well EXR1 and well MW-611, which is screened in the deeper aquifer. The travel time estimates will be used to inform the development of a long-term monitoring program for well MW-611, if it is chosen for use as a water supply well to Residence 1.

Aquifer parameters in the groundwater model were obtained by simulating the 72-hour pulsed aquifer test performed on well MW-611 in the model and adjusting the aquifer hydraulic conductivities and storage properties of the three model layers until the simulated drawdown in pumping well MW-611 (assuming a well efficiency of 70 percent) match the drawdown observed during the aquifer test. This analysis resulted in the following estimated aquifer hydraulic conductivities:

- Layer 1 (Upper Aquifer) = 10 feet per day (feet/day) horizontal, 1 feet/day vertical
- Layer 2 (Aquitard) = $1x10^{-5}$ centimeter per second (cm/s) (0.028 feet/day) vertical and horizontal
- Layer 3 (Lower Aquifer) = 2 feet/day horizontal, 0.2 feet/day vertical

The aquifer storage properties estimated from the modeling analysis are as follows:

- Layer 1 specific yield (Upper Aquifer) = 0.01 (dimensionless)
- Layer 2 and 3 specific storage (Aquitard/Lower Aquifer) = $2x10^{-6}$ feet

The results of the modeling analysis suggest that to sustain greater than 70 feet in groundwater level elevation difference between the upper and lower aquifers observed in wells MW-611 and EXR1, the aquitard unit must have a hydraulic conductivity of $1x10^{-5}$ cm/s or lower. Given this assumption, along with the stratigraphically lower aquifer hydraulic properties obtained from the pulsed aquifer test data, contamination present in the upper aquifer in the vicinity of well EXR1 is unaffected by pumping from MW-611 at reasonable rates for a domestic well serving a single residence (less than 5 gpm). Groundwater in Layer 1 near well EXR1 instead flows horizontally to the north toward Clover Valley Creek. These results assume that the aquitard unit is laterally continuous across the model domain, although significant uncertainty exists regarding the lateral continuity of the aquitard in the area. However, model simulations assuming relatively small "holes" in the aquitard (on the order of 50 feet by 50 feet square) in the vicinity of the contaminated area, yield simulated drawdown in the shallow aquifer at well EXR1 that exceeds the drawdown rates observed in the field. Further, for the aquitard to sustain 70 feet of water level elevation difference between the shallow and deep aquifers, it suggests that the aquitard represents a substantial barrier to groundwater exchange between the aquifer units. However, for the purposes of obtaining a rough estimate of the potential travel time for PFAS contamination present in the upper aquifer to reach the Well MW-611, a calculation was performed assuming the aquifer properties estimated through the modeling process. These calculations assume PFAS present in the upper aquifer moves vertically downward through the aquitard unit into the lower aquifer near Well MW-611. The results of this calculation suggest that the travel time through the aquitard is approximately 6 years. It should be noted that the actual travel time for PFAS to move from the upper to the lower aquifer is highly uncertain because the more likely pathway would be through gaps in the aquitard, if present. As previously mentioned, the lateral continuity of the aquitard unit in this area is unknown, and therefore estimates of PFAS travel time are highly uncertain.

Residence 2

The drawdown data from the 72-hour aquifer test performed at Residence 2 was evaluated using a simple single-layer numerical tool developed using MODFLOW-2005. The 2D model was constructed with a uniform grid with total dimensions of 4,000 feet by 4,000 feet and a uniform cell size of 40 feet by 40 feet. The grid was oriented parallel to groundwater flow directions defined by data from the nearby MW-614 (**Figure 4**), which suggest a flow direction to the northeast and a horizontal hydraulic gradient of 0.0004 foot/foot. The hydraulic gradient was induced in the model by imposition of constant head cells on the northeastern and southwestern model boundaries. The tool was developed with the following objectives:

- Estimating the aquifer properties in the vicinity of well MW-615.
- Estimating the extent of the hydraulic capture zone generated by long-term pumping of MW-615 as a water supply well.

Aquifer parameters in the groundwater model were obtained by simulating the 72-hour aquifer test performed on well MW-615 in the model and adjusting the aquifer hydraulic conductivity and storage properties until the simulated drawdown in well EXR2 match the drawdown observed during the aquifer test. This analysis resulted in an estimated aquifer hydraulic conductivity of 18 feet/day and a vertical hydraulic conductivity of 1.8 feet/day. The aquifer-specific yield assumed in the model was 0.001, which is lower than the typical 0.10 specific yield often assumed for unconfined aquifers of this type. Lower specific-capacity values are often required to accurately match results from short-term aquifer tests because of the relatively short duration of pumping not fully draining the drainable porosity of the aquifer matrix.

The final model was then used to evaluate the capture zone that would be created by long-term operation of MW-615 as a water supply well. This analysis was performed by conducting numerous steady-state simulations at varying flow rates from well MW-615. Since these simulations assumed steady-state conditions, the flow rate assumed for well MW-615 represents the long-term average flow rate from the well, not the instantaneous flow rate when the well is operating. A summary of the information obtained from this analysis is presented in **Figure 15**. This figure summarizes the simulated downgradient extent of the capture zone for varying long-term well MW-615 pumping rates. The location of well EXR2, where concentration of PFOS exceed 25,000 ppt, is shown in **Figure 15** by the dashed red vertical line approximately 410 feet downgradient from well MW-615. These data suggest that if the long-term flow rate from MW-615 exceeds approximately 3.7 gpm, the capture zone generated by pumping the well will extend to the location of well EXR2, and contamination at this location will eventually be pulled into well MW-615. At lower long-term average flow rates, the capture zone will extend a shorter distance downgradient from well MW-615; however, the distribution of PFOS between wells EXR2 and well MW-615 is currently unknown. MW-615 is a single family domestic well, which typically has a usage of approximately 300 to 400 gpd (0.2 to 0.28 gpm). However, at Residence 2, water pumped from the well is also used for irrigation of a garden and large lawn; therefore, the average useage is likely somewhat greater than that of a typical single family domestic well.

Therefore, operation of well MW-615 as a long-term supply well is not recommended, especially given that recent sampling of that well has shown detection of PFOA on the order of 7 to 10 ppt.

Limitations

Mathematical models can only approximate processes of physical systems. Models are inherently inexact because the mathematical description of the physical system is imperfect, the understanding of interrelated physical processes is incomplete, and many of the model input parameters (such as the PFAS source area extents) are not well constrained. Although the model simulations are non-unique, the models described in this TM represent screening-level tools that can provide useful insight into processes within the physical system. However, such models are no substitute for continued monitoring of PFAS trends at available wells to ensure protectiveness for exposure of residents to drinking water containing PFAS compounds at levels the USEPA LHA of 70 ppt.

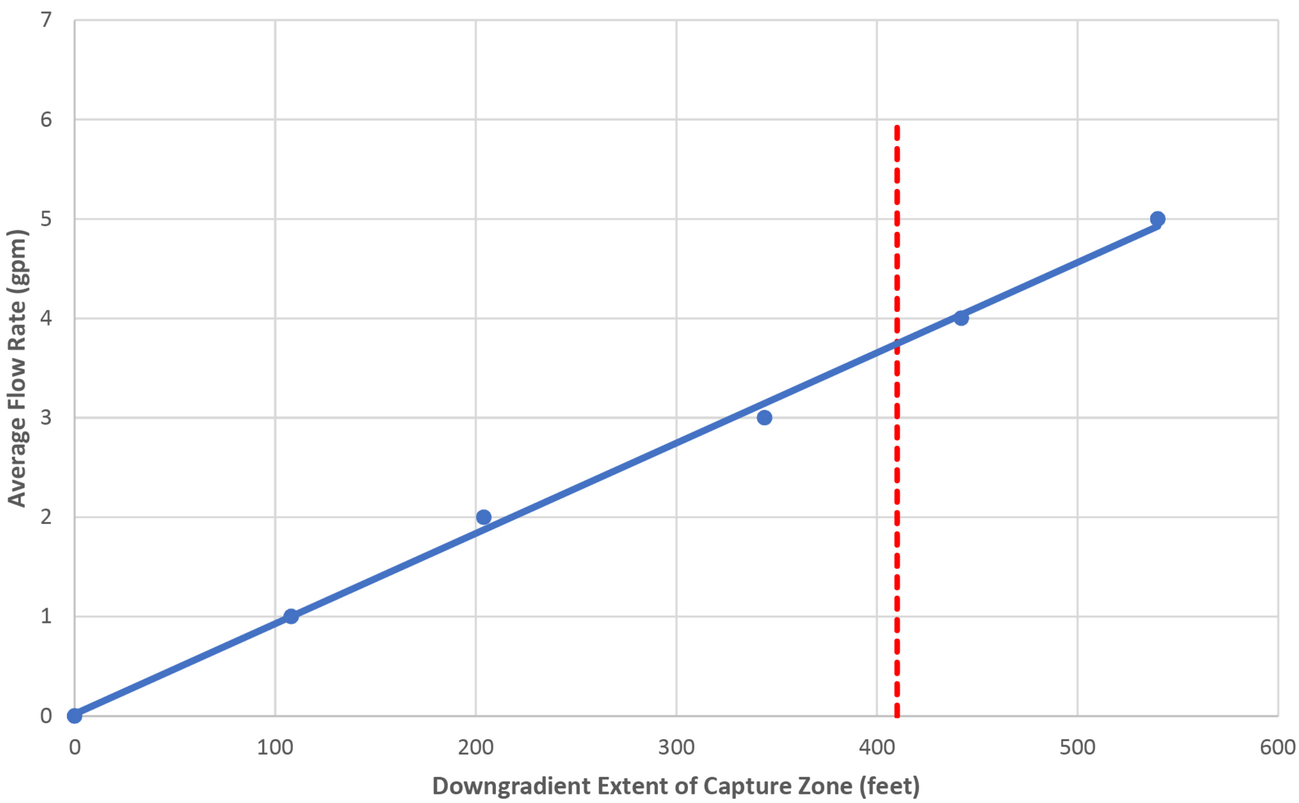


Figure 15.
Residence 2 Capture Zone Extent
Naval Air Station Whidbey Island
Oak Harbor, Washington

Conclusions

Based on the results from the analyses described in this TM, the following conclusions can be made for each residence.

Residence 1

- PFOA/PFOS was detected in EXR1 during drinking water sampling.
- A new well MW-611 was drilled and constructed as a potential alternative water supply for Residence 1.
- PFOS/PFOA was non-detect in the new potential supply well MW-611.
- An aquifer test was conducted on MW-611 and water quality samples collected.
- PFOA was detected at approximately the same concentrations pre-and post-aquifer testing and do not show significant increasing trends during aquifer testing at well MW-611.
- PFOA/PFOS was non-detect in the new potential supply well, MW-611, during testing and post aquifer testing.
- Water levels monitored in EXR1 do not show strong evidence of a hydraulic connection between the MW-611 and EXR1.
- Groundwater modeling results, as well as the 70-foot head difference between static water levels in the shallow and deep aquifers, suggest that the aquitard present between the shallow and deep aquifers in the area represents a barrier to groundwater exchange between the aquifer systems.
- Based on this information, along with the modeling analysis results discussed herein, well MW-611 may represent a potential long-term water supply solution for Residence 1.

Residence 2

- PFOA/PFOS was detected in EXR2 during drinking water sampling.
- A new well MW-615 was drilled and constructed as a potential alternative water supply for Residence 2.
- PFOA was detected in the new well MW-615 at concentrations ranging from 7 to 10 ppt.
- An aquifer test was conducted on the MW-615 and water quality samples collected.
- PFOA was detected in both well MW-615 and EXR2 at approximately the same concentrations pre- and post-aquifer testing and do not show significant increasing trends during aquifer testing.
- Static groundwater levels monitored in wells MW-615 and EXR2 are similar, suggesting potential hydraulic connection between the new potential supply well and EXR2.
- Groundwater modeling analyses indicate that pumping well MW-615 at a long-term average of greater than 3.7 gpm will result in a generation of a capture zone that extends downgradient beyond well EXR2, that currently has a PFOS concentration exceeding 25,000 ppt.
- The distribution of PFOS concentrations in groundwater between wells MW-615 and EXR2 are currently unknown; therefore, use of well MW-615 as a primary water supply for Residence 2 presents an unacceptable risk of potential exposure of residents to drinking water containing PFAS compounds at levels exceeding the USEPA LHA of 70 ppt.

Recommendations

Based on the analysis presented herein, it is recommended that MW-611 should be considered as a long-term water supply option for Residence 1, as long as a robust groundwater quality monitoring program for well MW-611 is implemented. A long-term monitoring program for Residence 1 is currently under development.

Based on the results of the analysis for Residence 2, it is not recommended that well MW-615 be considered as a long-term drinking water solution for Residence 2. Results of this assessment suggest that use of well MW-615 as a drinking water supply may pose a future unacceptable risk to human exposure because of the hydraulic connection between the existing and new wells, detection of PFOA in the new well, and evidence that the hydraulic capture zone of the new well will likely extend into areas of PFAS-contaminated groundwater. Based on these results, development of a water quality monitoring program to support use of local groundwater as a long-term supply for this parcel will not be performed.

Appendix A

Sample ID Sample Date	USEPA Lifetime Health Advisory (May 2016)	USEPA Tapwater RSL HQ = 1.0 (November 2017)	WI-AF-1RW28-0217 2/20/17	WI-AF-1RW28-1017 10/14/17	WI-AF-1RW28-0318 3/20/18	WI-AF-1RW32-0217 2/21/17	WI-AF-1RW32-1017 10/11/17	WI-AF-1RW32-0318 3/19/18
Chemical Name								
Semivolatile Organic Compounds (NG/L)								
Perfluorobutanesulfonic acid (PFBS)	--	400,000	110 U	2.12 J	2.55 J	130	64.5	213 J
Perfluoroheptanoic acid (PFHpA)	--	--	NS	3.67 J	3.5 J	NS	4.34 J	15.7
Perfluorohexanesulfonic acid (PFHxS)	--	--	NS	7.07 J	8.53 J	NS	156	1,230
Perfluorohexanoic Acid (PFHxA)	--	--	NS	5.2 U	5.15 J	NS	40.8	141
Perfluorooctane Sulfonate (PFOS)	70	--	49 U	5.2 U	5.25 U	**3,800**	**538**	**8,030**
Perfluorooctanoic acid (PFOA)	70	--	32	30.3	33.6	23 J	5.99 J	46.1
PFOA+PFOS	70	--	32	30.3	33.6	**3,823**	**544**	**8076**

Notes:

U - The material was analyzed for, but not detected

J - Analyte present. Value may or may not be accurate or precise

NG/L - Nanograms per liter

NS - Not sampled

Shading indicates detection

Bold indicates USEPA LHA exceedance

<u>Underline indicates USEPA Tapwater RSL HQ = 1.0 exceedance</u>

* indicates sample is unvalidated

Sample ID Sample Date	USEPA Lifetime Health Advisory (May 2016)	USEPA Tapwater RSL HQ = 1.0 (November 2017)	WI-AF-1RW28-0217 2/20/17	WI-AF-1RW28-1017 10/14/17	WI-AF-1RW40-0217 2/24/17	WI-AF-1RW40P-0217 2/24/17	WI-AF-1RW40-1017 10/18/17	WI-AF-1RW40-0318 3/28/18
Chemical Name								
Semivolatile Organic Compounds (NG/L)								
Perfluorobutanesulfonic acid (PFBS)	--	400,000	110 U	2.12 J	100 U	100 U	3.87 J	4.02 J
Perfluoroheptanoic acid (PFHpA)	--	--	NS	3.67 J	NS	NS	3.99 J	4.3 J
Perfluorohexanesulfonic acid (PFHxS)	--	--	NS	7.07 J	NS	NS	23.2	15.6
Perfluorohexanoic Acid (PFHxA)	--	--	NS	5.2 U	NS	NS	4.92 U	6.85 J
Perfluorooctane Sulfonate (PFOS)	70	--	49 U	5.2 U	44 U	45 U	4.92 U	1.1 J
Perfluorooctanoic acid (PFOA)	70	--	32	30.3	**140**	**120**	**73.1**	35.2
PFOA+PFOS	70	--	32	30.3	**140**	**120**	**73.1**	36.3

Notes:

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Sample ID Sample Date	USEPA Lifetime Health Advisory (May 2016)	USEPA Tapwater RSL HQ = 1.0 (November 2017)	WI-AF-1RW28-0217 2/20/17	WI-AF-1RW28-1017 10/14/17	WI-AF-EXC1A-0718* 7/11/18	WI-AF-EXC1B-0718* 7/15/18	WI-AF-EXC1C-0718* 7/15/18	WI-AF-EXR1A-0718* 7/11/18
Chemical Name								
Semivolatile Organic Compounds (NG/L)								
Perfluorobutanesulfonic acid (PFBS)	--	400,000	110 U	2.12 J	3.16 J	3.23 J	3.1 J	4.61 J
Perfluoroheptanoic acid (PFHpA)	--	--	NS	3.67 J	4.27 U	4.27 U	3.37 J	4.46 U
Perfluorohexanesulfonic acid (PFHxS)	--	--	NS	7.07 J	7.74 J	8.84	8.36 J	14.1
Perfluorohexanoic Acid (PFHxA)	--	--	NS	5.2 U	4.89 J	4.27 U	5.05 J	4.46 U
Perfluorooctane Sulfonate (PFOS)	70	--	49 U	5.2 U	4.27 U	4.27 U	4.2 U	4.46 U
Perfluorooctanoic acid (PFOA)	70	--	32	30.3	31.3	33.8	32.1	34.6
PFOA+PFOS	70	--	32	30.3	31.3	33.8	32.1	34.6

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Sample ID Sample Date	USEPA Lifetime Health Advisory (May 2016)	USEPA Tapwater RSL HQ = 1.0 (November 2017)	WI-AF-1RW28-0217 2/20/17	WI-AF-1RW28-1017 10/14/17	WI-AF-EXR1C-0718* 7/17/18	WI-AF-EXR2C-0718* 7/1/18	WI-AF-MW-611-0318 3/1/18	WI-AF-MW-611A-0718* 7/12/18
Chemical Name								
Semivolatile Organic Compounds (NG/L)								
Perfluorobutanesulfonic acid (PFBS)	--	400,000	110 U	2.12 J	4.94 J	517	5.63 U	4.27 U
Perfluoroheptanoic acid (PFHpA)	--	--	NS	3.67 J	4.27 U	51.9	5.63 U	4.27 U
Perfluorohexanesulfonic acid (PFHxS)	--	--	NS	7.07 J	19.1	4,770	5.63 U	4.27 U
Perfluorohexanoic Acid (PFHxA)	--	--	NS	5.2 U	6.48 J	463	5.63 U	4.27 U
Perfluorooctane Sulfonate (PFOS)	70	--	49 U	5.2 U	4.27 U	**25,900**	5.63 U	4.27 U
Perfluorooctanoic acid (PFOA)	70	--	32	30.3	38.3	**142**	5.63 U	4.27 U
PFOA+PFOS	70	--	32	30.3	38.3	**26,042**	ND	ND

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Sample ID Sample Date	USEPA Lifetime Health Advisory (May 2016)	USEPA Tapwater RSL HQ = 1.0 (November 2017)	WI-AF-1RW28-0217 2/20/17	WI-AF-1RW28-1017 10/14/17	WI-AF-MW-611B-0718* 7/15/18	WI-AF-MW611C-0718* 7/15/18	WI-AF-MW-615-0318 3/1/18	WI-AF-MW-615A-0618* 6/26/18
Chemical Name								
Semivolatile Organic Compounds (NG/L)								
Perfluorobutanesulfonic acid (PFBS)	--	400,000	110 U	2.12 J	4.27 U	4.24 U	89.1	91.2
Perfluoroheptanoic acid (PFHpA)	--	--	NS	3.67 J	4.27 U	4.24 U	8.41 J	7.25 J
Perfluorohexanesulfonic acid (PFHxS)	--	--	NS	7.07 J	4.27 U	4.24 U	123	123
Perfluorohexanoic Acid (PFHxA)	--	--	NS	5.2 U	4.27 U	4.24 U	51.7	53.7
Perfluorooctane Sulfonate (PFOS)	70	--	49 U	5.2 U	4.27 U	4.24 U	3.37 J	4.63 U
Perfluorooctanoic acid (PFOA)	70	--	32	30.3	4.27 U	4.24 U	7.85 J	7.4 J
PFOA+PFOS	70	--	32	30.3	ND	ND	11.22	7.4

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Sample ID Sample Date	USEPA Lifetime Health Advisory (May 2016)	USEPA Tapwater RSL HQ = 1.0 (November 2017)	WI-AF-1RW28-0217 2/20/17	WI-AF-1RW28-1017 10/14/17	WI-AF-MW-615B-0618* 6/28/18	WI-AF-MW-615C-0618* 6/30/18	WI-AF-MW-615CP-0618* 6/30/18	WI-AF-MW-EXR2A-0618* 6/26/18
Chemical Name								
Semivolatile Organic Compounds (NG/L)								
Perfluorobutanesulfonic acid (PFBS)	--	400,000	110 U	2.12 J	111	118	113	496
Perfluoroheptanoic acid (PFHpA)	--	--	NS	3.67 J	8.75	9.42	9.78	51.4
Perfluorohexanesulfonic acid (PFHxS)	--	--	NS	7.07 J	187	169	167	5,420
Perfluorohexanoic Acid (PFHxA)	--	--	NS	5.2 U	63.7	70.5	67.4	481
Perfluorooctane Sulfonate (PFOS)	70	--	49 U	5.2 U	4.24 U	4.5 U	4.35 U	**23,900**
Perfluorooctanoic acid (PFOA)	70	--	32	30.3	10.8	7.52 J	9.46	**147**
PFOA+PFOS	70	--	32	30.3	10.8	7.52	9.46	**24,047**

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