

Groundwater Technical Review

Date: 09/10/2021
To: Randall Doneen, Conservation Assistance and Regulation Section Manager
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From: Amanda Yourd, Hydrogeologist
Subject: Rationale for Groundwater Permit Suspensions in Warren Area
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PROFESSIONAL GEOLOGIST

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Geologist under the Laws of the State of Minnesota.

License No: 50027 Signature: _____

Executive Summary

The Deep/Basal Confined aquifer in the Warren area is the primary source of drinking water for the City of Warren and the Marshall-Polk Rural Water System (MPRWS), which supplies a service area of over 1,000 square miles across three counties. In summer 2021, the rate of groundwater pumping was higher than ever before, and groundwater reached the lowest recorded level on record in all observation wells in the aquifer system. Groundwater levels had approached the pump in the City of Warren well (the pump was subsequently lowered) and were approaching the pump in the MPRWS West Wellfield. Consequently, four groundwater appropriation permits for agricultural irrigation were suspended on August 9, 2021 to protect the public water supply in the MPRWS West Wellfield.

Demand for groundwater continues to increase as agricultural irrigation expands and as MPRWS plans to add rural water lines to the City of Argyle in 2022.

Groundwater levels have been declining long-term in this aquifer system since the start of monitoring in 1956. Groundwater levels have also fallen below the top of the aquifer in DNR observation well 45000 during the 2021 irrigation season.

Water is being removed from the aquifer faster than it can be replenished (i.e., **the aquifer is over-allocated**). DNR and permit holders will continue to monitor the Warren area water levels; DNR is using this data to evaluate how much water the aquifer system can supply long-term.

Introduction

Drinking water for the City of Warren in Marshall County and rural residents across Marshall, Polk, and Kittson Counties comes from one main groundwater aquifer system, herein referred to as the Warren-area aquifer. The aquifer is of limited areal extent, which is why many rural residences get water piped to their house from the Marshall Polk Rural Water Supply (MPRWS; Figure 1). The aquifer is also used for agricultural irrigation. Groundwater use for agricultural irrigation has expanded over the past 10 years from one to four appropriators.

The Warren area experienced drought conditions during the 2021 irrigation season (U.S. Drought Monitor, 2021). As a result of low rainfall and higher-than-average groundwater use, water levels in the aquifer system have decreased steadily throughout the irrigation season, endangering public water supply at the City of Warren and MPRWS public water supply wells. On August 9, 2021, the four agricultural irrigation permits listed in Table 1 were suspended in order to protect the public water supplies of the City of Warren and MPRWS.

The purpose of this technical memo is to summarize the data that informed the decision to suspend irrigation permits. The permitted groundwater users and timeline of events leading to that decision are outlined below.

Permitted Groundwater Use

Permitted groundwater use in the area includes four agricultural irrigation permits and three public water supply permits for the City of Warren and Marshall Polk Rural Water Supply (MPRWS – East and West Wellfields) (Table 1; Figure 1). The City of Warren supplies water to 1,700 citizens, and MPRWS supplies water to numerous rural residents across Polk, Marshall, and Kittson Counties. MPRWS also has plans to extend their service area to the City of Argyle in 2022 (M. Walker, DNR, written commun., 2021, MPARS permit file [1981-1079](#)).

Three of the four irrigation permits (2011-0597, 2018-3270, 2019-0703; listed in Table 1) have permit conditions tied to water levels in the City of Warren (1981-1099) and MPRWS West Wellfield (1981-1079) wells. These conditions state that if water levels fall within 10 feet of the pumps in the Warren or MPRWS West public water supply wells, use from the irrigation wells associated with permits 2011-0597, 2018-3270, and 2019-0703 must stop. MPRWS East Wellfield (1976-1100) wells are not part of these permit conditions.

Timeline of events

- **July 6, 2021:** City of Warren reports to DNR that water levels have fallen to within eight feet of the pump in their water supply well (162389). The City reports that water levels were not recovering within 24 hours.
- **Week of July 12, 2021:** City of Warren adds 21 feet of drop pipe to their pump and has the well screen cleaned out by a well driller.

- **July 14, 2021:** DNR receives a verbal well interference complaint for two domestic wells owned by the same person near the 2019-0703 irrigation well. While investigating this complaint, DNR receives a second verbal complaint near the 1990-1151 irrigation well.
- **July 22, 2021:** DNR requests water use records from all the users listed in Table 1 for the well interference investigation.
- **July 26, 2021:** DNR receives a third verbal domestic well interference complaint near the 1990-1151 irrigation well.
- **July 27, 2021:** DNR receives water level data from City of Warren. Data shows that water levels are in danger of dropping with ten feet of the pump by early August.
- **July 27 through August 5, 2021:** DNR compiles monitoring and water use data from irrigators and finds:
 - Water levels are in danger of dropping within ten feet of the pump at MPRWS West Wellfield Well #6 by the end of August.
 - Water levels are dropping below the data logger in MPRWS Well #5 in the East Wellfield and the pump depths are unknown for all three wells (Wells #1, #2, and #5) in the East Wellfield.
 - Water use for agricultural irrigation is the highest on record, and 2021 water levels are at lowest recorded levels in all monitored wells.
 - Water levels are below top of aquifer in DNR observation well 45000 (location shown in Figure 1).
 - Permit 2018-3270 has exceeded permitted volume and acreage.
- **August 5, 2021:** City of Warren installs new pump and adds 42 feet of drop pipe. The longer drop pipe greatly reduced the risk of the City of Warren going out of water during the 2021 irrigation season.
- **August 5, 2021:** DNR makes decision to suspend irrigation permits to protect public water supply at the MPRWS West Wellfield. DNR contacts the four irrigators in Table 1 to tell them that their permits may be suspended.
- **August 9, 2021:** DNR sends letter to the four irrigation permittees listed in Table 1 to notify them that their permits are suspended immediately due to water supply concern for MPRWS.
- **August 10, 2021:** DNR sends letters to MPRWS and City of Warren to notify them of irrigation permit suspensions.

Setting

Geology

The Warren area is located near a transition from Glacial Lake Agassiz lake-bed sediments to the west and beach ridge systems to the east (Lindgren, 1996). There is approximately 250 to 400 feet of glacial sediments (including glacial outwash and till) overlying crystalline bedrock in the area (Champion, 2012).

Hydrogeology and Aquifer Information

An unconsolidated buried aquifer system is the main source aquifer in this area located east of the City of Warren. Glacial sand and gravel deposits make up this buried aquifer system confined by glacial till and Glacial Lake Agassiz lake sediments (Lindgren, 1996). Groundwater generally flows from east to the west (Lindgren, 1996). Bedrock in this area does not provide significant quantities of water.

Lindgren (1996) classifies the aquifers within this buried aquifer system based on the depth to the top of each confined aquifer. These aquifers are referred to as Shallow (<100 feet deep), Intermediate (100-200 feet), Deep (200-300 feet deep), and Basal Confined (>300 feet deep) aquifers (Figure 2). Regional studies indicate the buried sand and gravel aquifers are elongate in shape and trend in a north to south direction (Figure 2).

Most high capacity wells in the area are screened in the Deep/Basal Confined aquifer (the top of the aquifer is within the Deep Confined and the bottom is within the Basal Confined). The top of this aquifer is approximately 250 feet below land surface near the MPRWS West Wellfield and 400 feet below land surface near the MPRWS East Wellfield. The aquifer is up to 200 feet thick in the western area, and thins to the east (aquifer thickness listed in Table 2). In this area, the Deep/Basal Confined aquifer meets the criteria of a sole source aquifer as defined by the U.S. Environmental Protection Agency because it supplies at least 50 percent of the drinking water for the service area, and there are no reasonably available alternative drinking water sources should the aquifer become contaminated (EPA, 2021).

Wells screened in the Deep/Basal Confined aquifer include all of the Production wells listed in Table 1, with the exception of MPRWS East Wellfield Well #1 and Well #2. These two wells are screened in a shallower aquifer (Intermediate Confined) approximately 130 to 200 feet deep. This shallower aquifer appears to be less productive than the deeper aquifer because MPRWS Well #1 and Well #2 are consistently pumped at a lower rate (approximately 100 gpm) and produce lower volumes compared to East Wellfield Well #5, which is screened in the deeper part of the aquifer system (Basal Confined aquifer).

Groundwater level monitoring (described below) indicates that the shallower and deeper part of the aquifer system are connected. Further evaluation of geologic data needs to be completed to better understand the nature of this connection and define the extent of the aquifer system.

History of well interference

Prior to the 2021 irrigation season, there were three reported well interferences in the Warren area, none of which were found valid. These complaints are summarized in Lahti and Johnson (2019). During the 2021 irrigation season, the DNR received well interference complaints from three different complainants. One of these complaints was resolved by Jarod Peterson (2018-3270). One of the complaints is currently being investigated as part of the DNR well interference process. One of the complaints was a verbal complaint only and is not going through the DNR well interference process.

Data Analysis

Groundwater Level Monitoring

Groundwater levels are monitored at the wells listed in Table 2. These monitored wells include seven wells monitored by permittees, and one well monitored by DNR as part of the DNR observation well network.

In all monitored wells, year-over-year water levels have decreased since the start of monitoring, and 2021 irrigation season water levels are the lowest on record. On a long-term basis, this indicates that more water is removed from the aquifer system than is added (aquifer is over-allocated).

Water levels trends and observations for three areas marked in Figure 1 (Western, Eastern, and Northern) are outlined below.

Western Area

Long-term water level records from MPRWS West Wellfield (Well #6), City of Warren well, the 2018-3270 observation well, and the 2011-0597 irrigation well are shown in Figure 3. Water levels recorded during 2021 for these wells are shown in Figure 4. Permit 2019-0703 also has an observation well that was installed in 2020, but did not have a water level record for the majority of the 2021 irrigation season due to data logger malfunction. Observations from the data shown in Figure 3 and 4 are as follows:

- Starting in 2012, water levels have not been recovering fully in between irrigation seasons. This has led to approximately seven feet of year-over-year decline in winter water levels in MPRWS Well #6 between 2012 and 2021 (approximately 0.8 feet of head loss per year).
- Prior to the 2021 irrigation season, a maximum of approximately 30 feet of seasonal decline was observed during the irrigation season.
- There has been approximately 70 feet of seasonal decline in water levels in this area since the start of the 2021 irrigation season in late April 2021. This equates to four to five feet of water level decline **per week**.
- Irrigation season water levels were within 35 feet of the pump in MPRWS Well #6 in 2021. If groundwater use continued at the same rate, water levels would be within 10 feet of the MPRWS Well #6 pump by approximately the end of August.
- Before the City of Warren lowered the pump in their production well on August 5, 2021, water levels were projected to fall within 10 feet of the pump.

Eastern Area

Historic water levels from the MPRWS East Wellfield (Wells #1, #2, and #5) are shown in Figure 5, and 2021 water levels are shown in Figure 6. There are gaps in the data record for all three of these wells, but the record is sufficiently complete to identify trends. Observations from this monitoring record are as follows:

- Well #5 is screened within the deeper part of the aquifer system and Wells #1 and #2 are screened within the shallower part of the aquifer system. The shallower part of the system has higher head than the deeper part, indicating a downward hydraulic gradient.
- Starting in 2014, water levels in Well #5 have not been recovering fully in between irrigation seasons. This has led to more than 100 feet of year-over-year decline in winter water levels between 2014 and 2021 (approximately 14 feet per year head loss).

- There has been approximately 32 feet of seasonal decline in Well #5 levels in this area since the start of the 2021 irrigation season in late April 2021. This equates to approximately two feet of water level decline **per week**.
- Starting in mid-June of 2021, water levels started dropping below the data logger in the Well #5 (indicated by flat line at an elevation of approximately 762 feet on Figure 7). The depth of the pump in Well #5 is unknown.
- Since 2017, water levels in Well #1 have not been recovering fully between irrigation seasons. This has led to approximately five feet of year-over-year decline between 2017 and 2021 (1.25 feet of head loss per year). Water levels in Well #2 have increased by approximately five feet during this time period (1.25 feet of head increase per year).
- Water levels have fallen by approximately 16 feet in Well #1 and #2 during the 2021 irrigation season, and are at the lowest recorded level on record. The depth of the pumps in Wells #1 and #2 are unknown.
- The shallow part of the system (Wells #1 and #2) does not show the same magnitude of long-term decline as the deeper part of the system (Well #5). This shows there is some separation between the shallower and deeper parts of the aquifer system. However, Well #5 pumping cycles can be seen in Well #1 and #2 data, indicating that there is some connection between the deeper and shallow systems.

Northern Area

DNR observation well 45000 is located approximately six miles northeast of the City of Warren (Figure 1). DNR observation well 45000 has a water level record from 1956 to present. The City of Warren (1981-1099) pumped water from near the observation well until 1981, when the City stopped using that well field and began using the current wellfield (Figure 1). Historic water levels from DNR observation well 45000 are shown in Figure 7 and 2021 water levels are shown in Figure 8. Observations from this well are as follows:

- From 1956 to 1981, water levels declined by approximately 32 feet (approximately 1.3 feet of head loss per year).
- The top of the aquifer is 28 feet below land surface, the 25% aquifer threshold is at 22.5 feet below land surface, and the 50% aquifer threshold is 16.6 feet below land surface. Water levels trends since 1956 relative to these metrics are outlined below:
 - 1956 – 1958: apart from one measurement in 1956, water levels are consistently above the 50% threshold.
 - 1958 – 1966: most water levels fall below the 50% aquifer threshold, and water levels drop to the top of the aquifer once in 1961.
 - 1966 – 1981: water levels are consistently below the 50% threshold and the majority of water levels are below the 25% threshold. Water levels fall below the top of the aquifer seasonally during six years (1973, 1975, 1978-1981) until City of Warren stops pumping from the nearby wellfield in 1981.
 - 1981 – 1988: Water levels recover, but remain below the 50% threshold.

- 1988 – 2006: Most water levels are between the 50% and 25% threshold, but water levels start to fall below the 25% threshold.
 - 2006-2020: Water levels are consistently below the 25% threshold and drop below the top of the aquifer seasonally during six years (2012, 2013, 2017-2020).
 - 2021: water levels are the lowest and record and are consistently below the top of the aquifer starting in June 2021.
- According to [Minnesota Administrative Rules 6115.0630](#), safe yield is exceeded in this aquifer.

Water Use

Figure 9 shows water use from 1990 to 2021 along with water level data recorded in DNR observation well 45000. Water use for the 2021 irrigation season through late June/early August is shown in Figure 10. Observations from water use records include:

- Ten-year average total water use (public supply and agricultural irrigation) has increased since 1990 as follows:
 - 1990-1999 average water use: 152 MG
 - 200-2009 average water use: 172 MG
 - 2010-2020 average water use: 207 MG
- Water use for agricultural irrigation has increased since 1990, with the largest increase from 2012 to 2020.
- Use for agricultural irrigation was highest in 2021 (reported through late June to early August) than in any other year. This high use corresponds with a rapid water level decline in DNR observation well 45000 and the lowest water level on record during summer of 2021.
- Water levels in DNR observation 45000 well do not fully recover between irrigation seasons during some years, resulting in an overall declining trend in water levels. This declining trend is occurring with the relatively slow and modest decadal increase in water use. On a long-term basis, this indicates that more water is being removed from the aquifer system than is being added (aquifer is over-allocated).
- Permit 2018-3270 has exceeded permitted volume.

Conclusions

On August 9, 2021, four irrigation permits were suspended in order to protect public water supply. The facts that led to this decision are outlined below.

1. Groundwater pumping in the Warren aquifer system has lowered water levels below the top of the aquifer at DNR observation well 45000. Minnesota Administrative Rules 6115.0630 states that withdrawing groundwater from an aquifer system to a degree that converts the aquifer from artesian conditions to a water table condition exceeds the aquifer's safe yield.

2. At the City of Warren production well, groundwater levels have declined 70 feet since late April 2021. The City of Warren well was at risk of groundwater levels dropping below the pump intake by July 2021. As a result the City lowered their pump during the week of July 12, 2021 and again on August 5, 2021. Because the pump was lowered, the City well is no longer at risk of going out-of-water during the 2021 irrigation season.
3. At the Marshall-Polk Rural Water Supply's (MPRWS) West Wellfield, water levels have been dropping at a rate of approximately four to five feet per week since late April 2021. Water levels there are expected to be within 10 feet of the pump in the MPRWS west well by the end of August 2021 if irrigation continues at the same rate.
4. At the MPRWS East Wellfield Well #5, water levels have been dropping at a rate of approximately two feet per week since late April 2021. As of August 6, 2021, MPRWS does not know the depth of pumps in the East Wellfield wells (Wells #1, #2, and #5).
5. The rate of groundwater use in this aquifer system is higher this year than in any previous year. Water levels at all observation wells in the area are at their lowest recorded level. We do not have historical data with comparable rates of groundwater use or groundwater levels, which means we do not know when or how quickly groundwater levels will recover. If groundwater use for irrigation stops, groundwater levels may stabilize, may rise, or may continue declining because MPRWS and the City of Warren will need to continue pumping.
6. The Warren aquifer system is the only aquifer capable of supplying high-capacity wells in this area. There is not another viable water supply in the area.
7. Water levels at DNR observation well 45000 have fallen 30 feet over the period of record (which dates to 1956), i.e., there are year-over-year declines in groundwater levels. This data indicates that the aquifer is over-allocated.
8. Groundwater appropriation permits 2018-3270, 2019-0703, and 2011-0597 have permit conditions which require that they stop pumping if groundwater levels in the City of Warren supply well or Marshall-Polk Rural Water Supply West well fall to within 10 feet of the pump intake. The sharp rate of groundwater level declines in the Warren aquifer system, incomplete water-level recovery between pumping cycles, and the potential for continued drought conditions means that 10 feet is no longer adequately protective.

Recommendations

The following is recommended for the Warren area:

- DNR and permittees should continue groundwater level and water use monitoring.
- DNR complete a monitoring plan and annual monitoring summaries.

- DNR conduct further geologic and hydrogeologic study in the area to determine the size and shape of the Warren area aquifer.

DNR will use this information to determine where new monitoring points are needed and how much water the Warren aquifer system can supply long-term.

References

Champion, G. 2012. Permit Application 2011-0597. Minnesota Department of Natural Resources. Groundwater Technical Review Memo.

EPA, 2021. Sole Source Aquifer for Drinking Water. Environmental Protection Agency, website: <https://www.epa.gov/dwssa>. Accessed online on August 25, 2021.

Lahti and Johnson, 2019. Groundwater Technical Review Permit Application 2018-3270, Jarod Peterson, Polk County. Minnesota Department of Natural Resources. Groundwater Technical Review Memo.

Lindgren, R.J. 1996. Availability and Quality of Water from Drift Aquifers in Marshall, Pennington, Polk, and Red Lake Counties, Northwestern Minnesota. United States Geological Survey. Water Resource Investigations Report 95-4201.

MPARS permit files for all permits listed in Table 1 includes all the information reviewed for this document and is available at: <https://www.dnr.state.mn.us/mpars/index.html>.

U.S. Drought Monitor, 2021. National Drought Mitigation Center. University of Nebraska-Lincoln. Website: <https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?MN>. Accessed online on August 25, 2021

Tables

Table 1. Warren area groundwater appropriation permits

Permittee name (permit number)	Well Unique Number(s) (Well Name)	Use type	Permitted volume (MGY)*	Permitted Rate (gpm)*	Irrigated area (acres)	Irrigated inches/acre
MPRWS East Wellfield (1976-1100)	240757 (Well #1) 240758 (Well #2) 513019 (Well #5)	Public supply	110 <i>(combined)</i>	600 <i>(combined)</i>	Not applicable	Not applicable
MPRWS West Wellfield~ (1981-1079)	473633 (Well #6)	Public supply	107	800	Not applicable	Not applicable
City of Warren (1981-1099)	162389	Public supply	91	400	Not applicable	Not applicable
Jarod Peterson** (2018-3270)	832138	Irrigation	50	1200	266	6.9
Steve Goodwin (2011-0597)	777599	Irrigation	61	1500	260	8.6
Cole and Lucas Goodwin (2019-0703)	841819	Irrigation	50	800	130	14.2
Dean Peterson (1990-1151)	511095	Irrigation	88	1100	270	12.0

* gpm: gallons per minute; MGY: million gallons per year

**Permit amendment for 162.5 MGY and 798 acres is currently under review.

~There are two additional wells permitted to appropriate water under permit 1981-1079 (163384-Well #3 and 166210-Well #4). These two wells are located approximately 20 miles south of the MPRWS west wellfield and are test-pumped monthly, but are for emergency use only. These wells will not be discussed further in this report.

Table 2. Wells monitored in the Warren area

Permittee name (permit number)	Well Unique Number (Well Name)	Use type+	UTM Easting and Northing (meters)*	Ground Elevation* (ft NAVD88)	Well Depth (ft BGS)+	Aquifer Depth (ft BGS)	Aquifer Elevation (ft NAVD88)	Aquifer Thickness (feet)	Interpreted Aquifer (Lindgren, 1996)
MPRWS West Wellfield (1981-1079)	473633 (Well #6)	PWS	Not public information	884.1	391	253-391	631-493	138	Deep/Basal Confined
MPRWS East Wellfield (1976-1100)	513019 (Well #5)	PWS	Not public information	928.3	419	393-419	535-509	26	Basal Confined
MPRWS East Wellfield (1976-1100)	240757 (Well #1)	PWS	Not public information	925.2	171	137-202	788-723	65	Intermediate Confined
MPRWS East Wellfield (1976-1100)	240758 (Well #2)	PWS	Not public information	925.3	197	142-207	783-718	65	Intermediate Confined
City of Warren (1981-1099)	162389	PWS	Not public information	887.9	303	264-303	624-585	39	Deep Confined
Steve Goodwin (2011-0597)	777599	IR	E 227244 N 5341719	885.9	334	262-334	624-552	72	Deep/Basal Confined
Jarod Peterson (2018-3270)	848920	MW	E 225168 N 5340591	880.9	398	321-422**	561-460**	101**	Deep/Basal Confined
Not applicable	219329 (DNR Obwell 45000)	MW	E 228828 N 5352528	903.9	88~	28-57	879-847	29	Shallow Confined

*Well locations and elevations collected during DNR survey on 7/14/2021. Well 777599 location estimated using aerial imagery and elevation estimated using LiDAR.

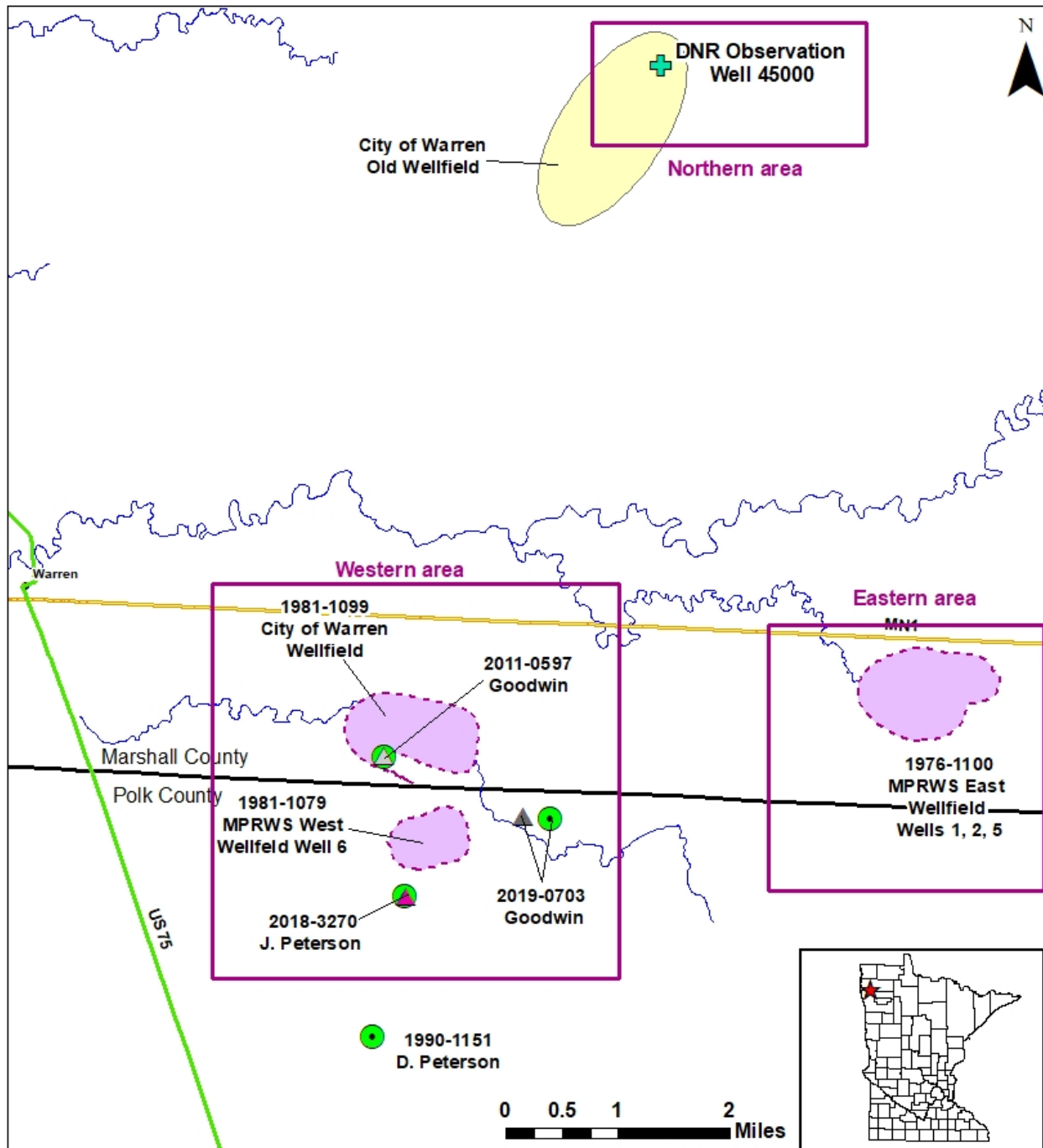
+PWS=public water supply; IR=irrigation; MW=monitoring well; BGS=below ground surface.

~Field-measured well depth was 44 feet BGS (measured in the field by DNR staff on 2/2/2021).

**Well log is not available for well 848920. Aquifer information presented is for 2018-3270 irrigation well 832138, which is 90 feet from well 848920 and similar in depth.

Figures

Figure 1. Warren area location map



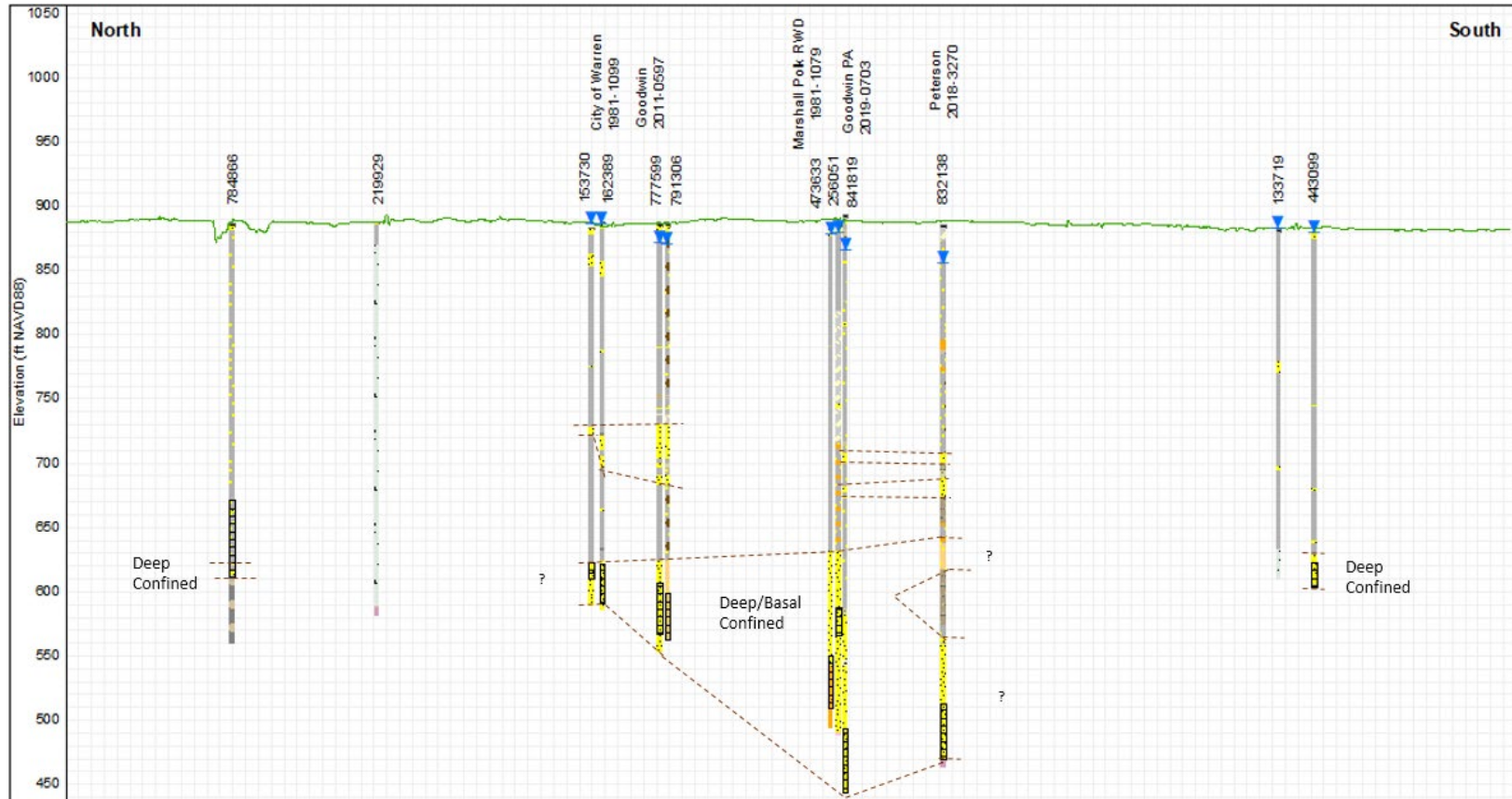
Well Type

- Permitted Irrigation Well
- ▲ Permittee Monitoring Well
- + DNR Observation Well 45000 (219329)
- ▲ Permittee Monitoring Well (not actively monitored - logger issue)
- ▲ Permittee Monitoring Well (not actively monitored - well plugged)

- Wellhead Protection Areas
- Public Water Watercourse



Figure 2. North to south hydrogeologic cross section



Legend

- | | | |
|------------------------|----------------------|-------------------------------|
| Topsoil | Sandy Clay with Rock | Sand and Gravel |
| Clay | Till | Gravel |
| Silty Clay | Clay with Sand | Coble |
| Silty Sandy Clay | Sand with Fines | Boulder |
| Sandy Clay | Sand with Coal | Sand with Decomposing Granite |
| Sandy Clay with Gravel | Sand | Granite |

Vertical Exaggeration x30

- Static Water Level
- Land Surface
- Screen

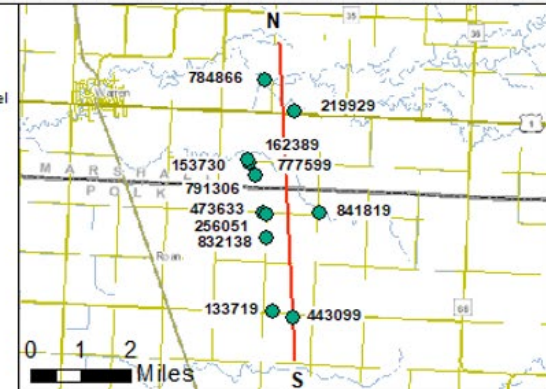


Figure 3. Western area: long-term water levels

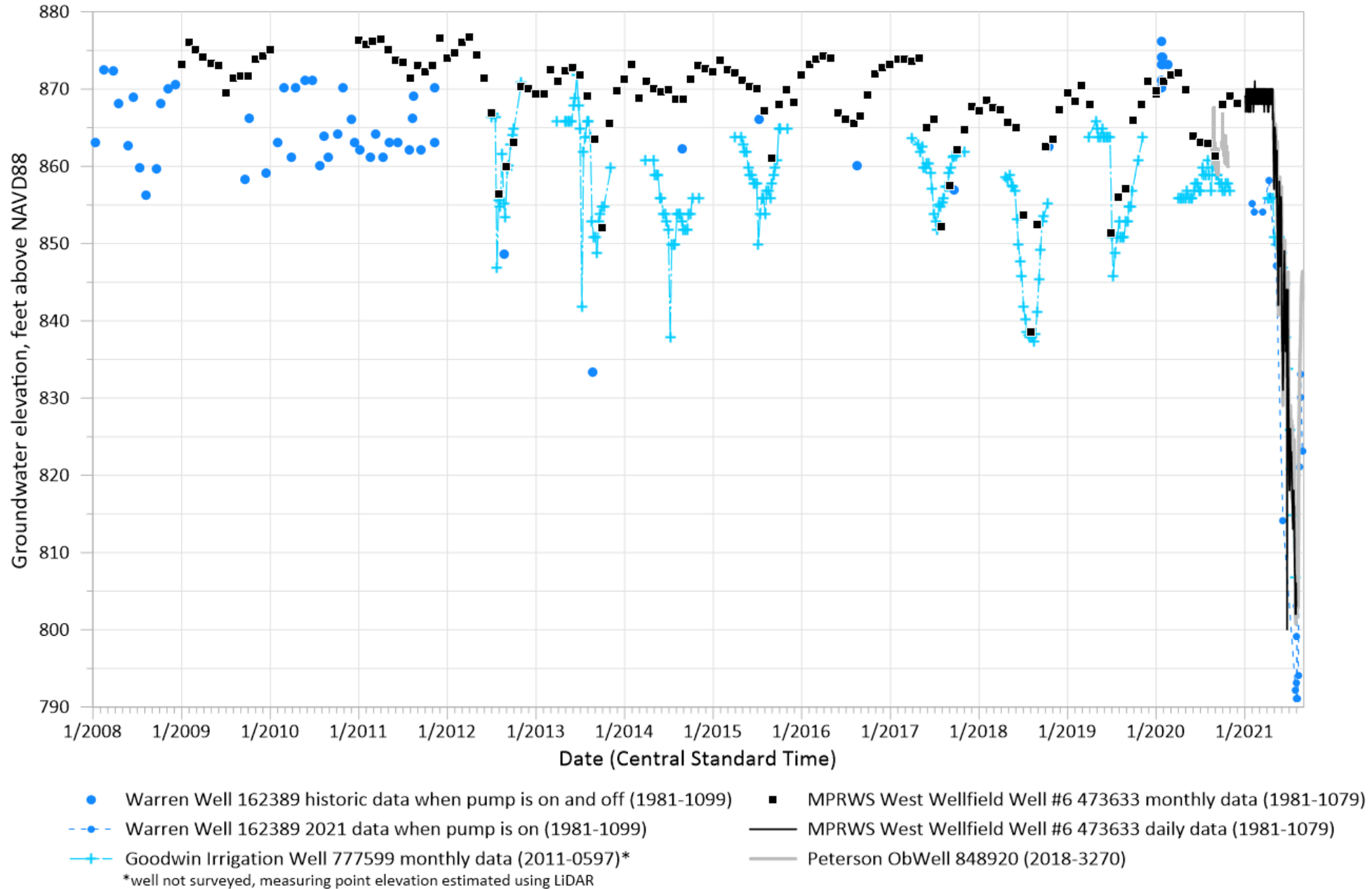


Figure 4. Western area: 2021 irrigation season water levels

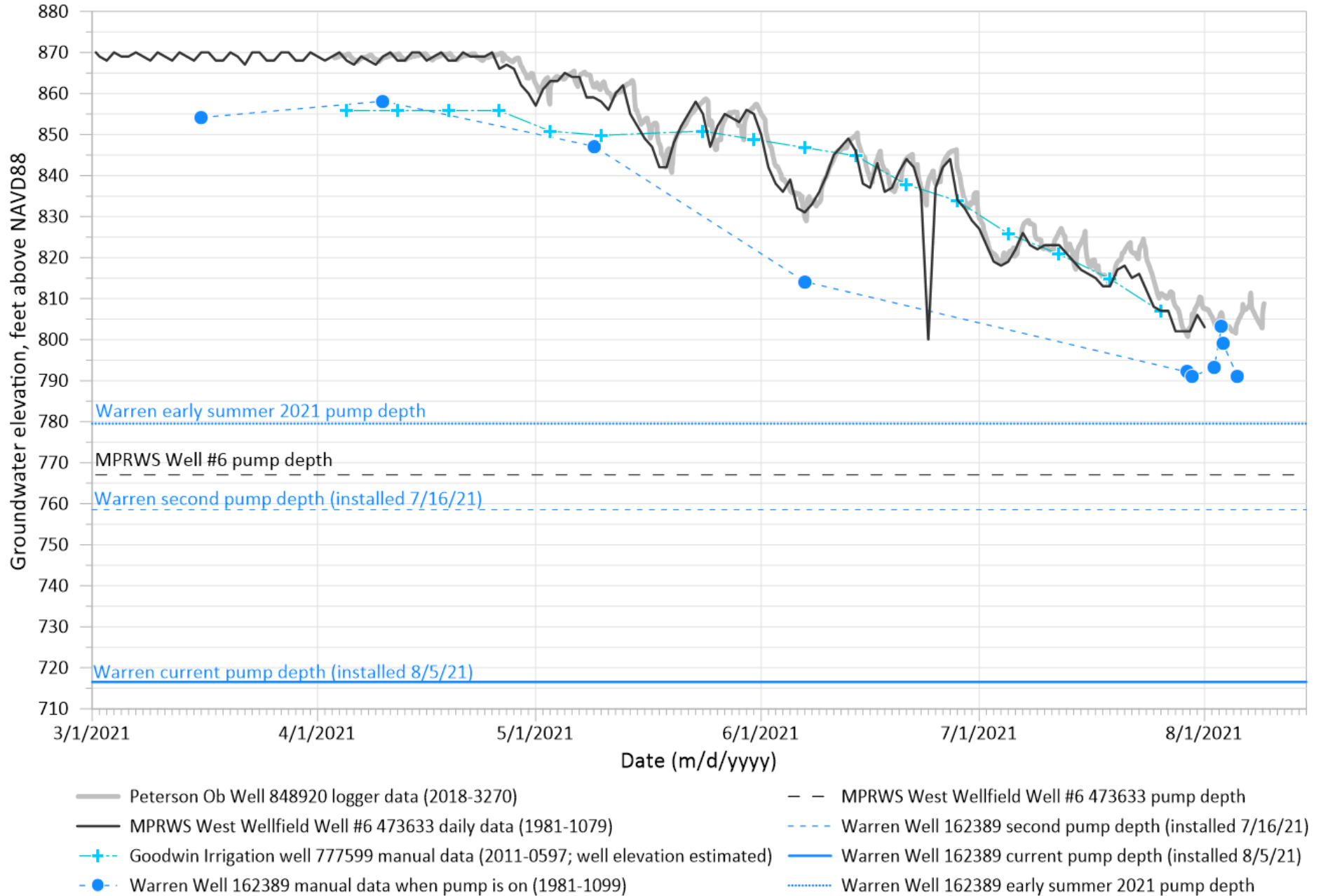


Figure 5. Eastern area: long-term water levels



Figure 6. Eastern area: 2021 water levels

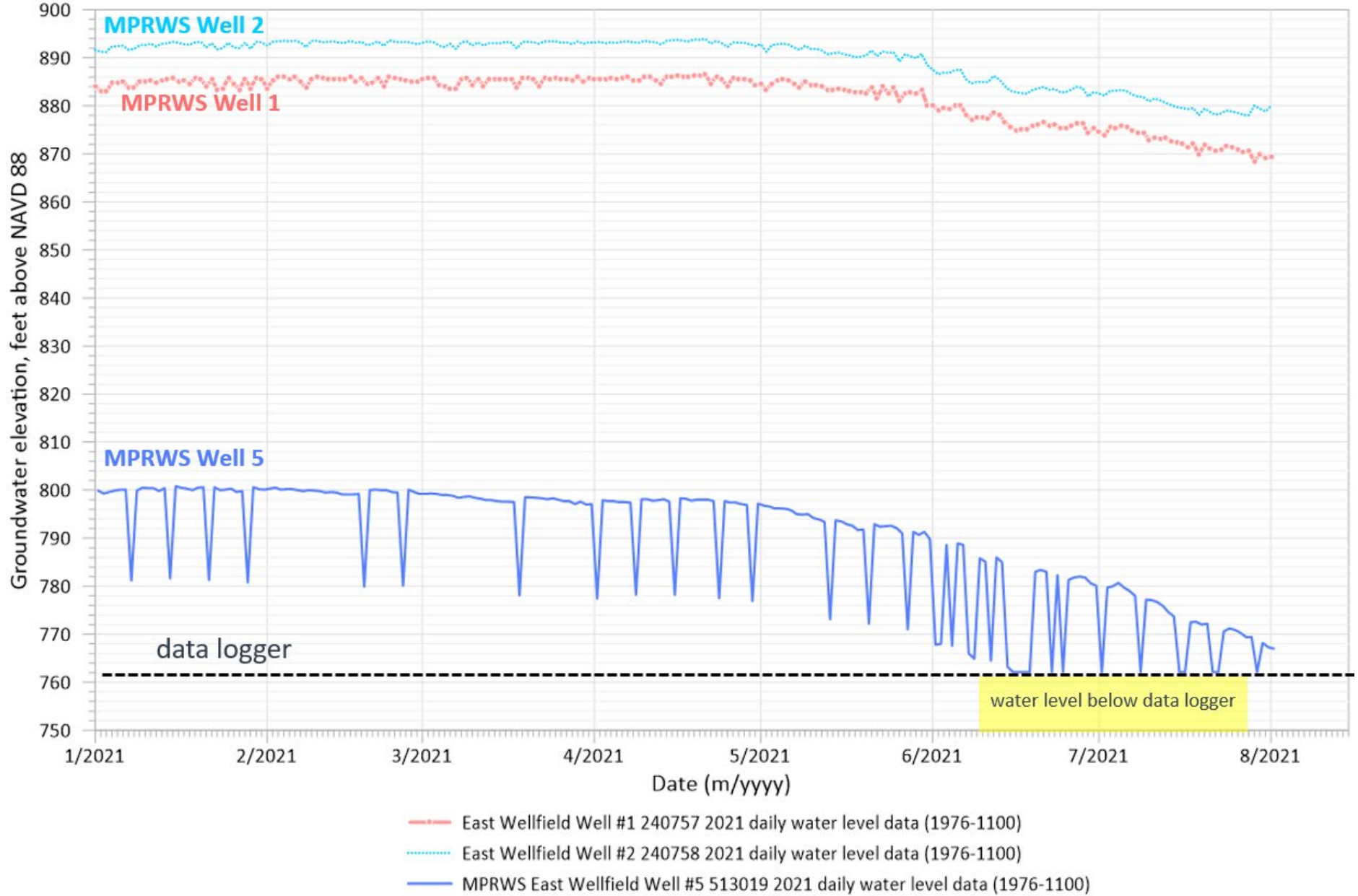


Figure 7. Northern area: long-term water levels

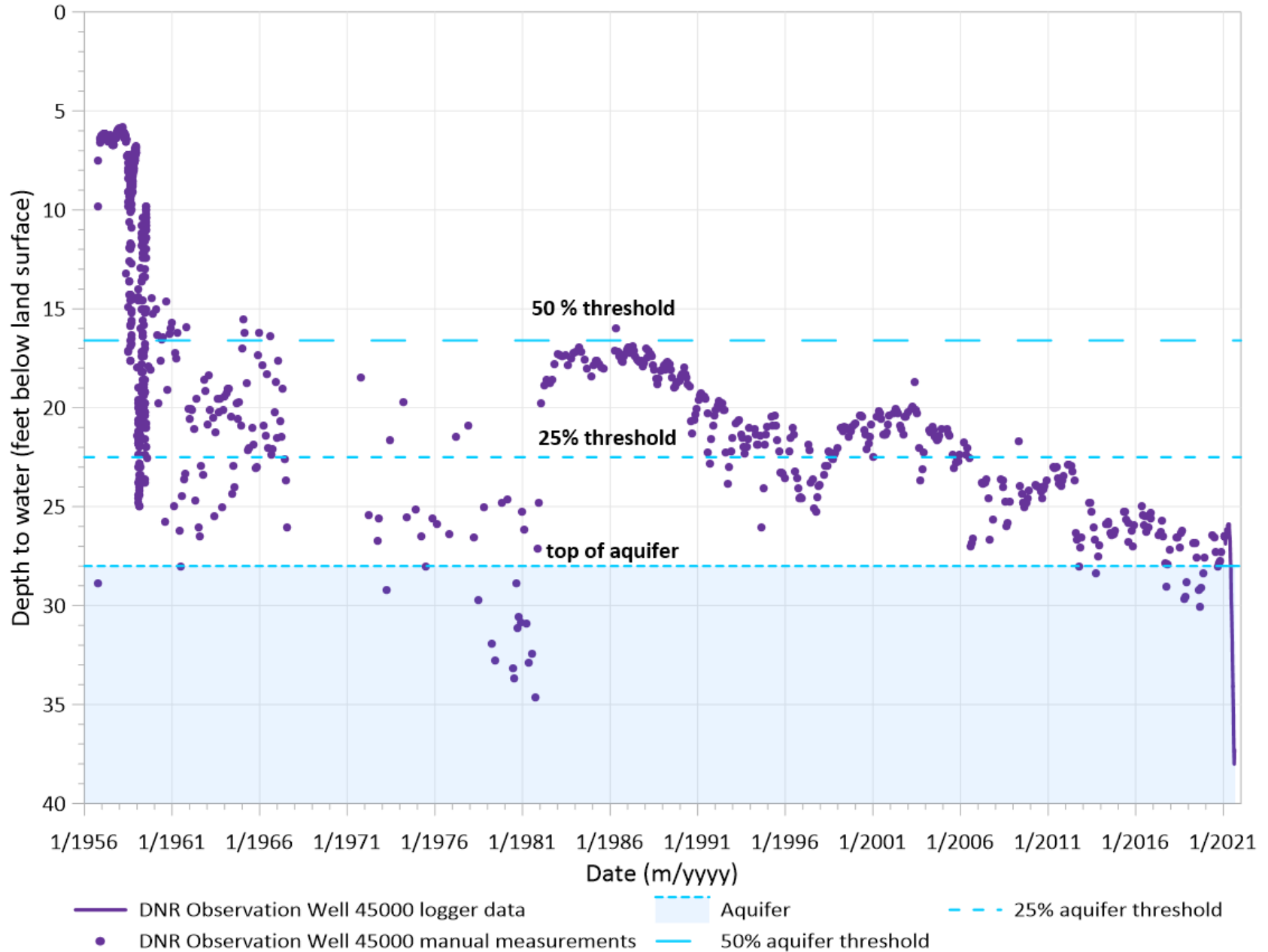


Figure 8. Northern area: 2021 water levels

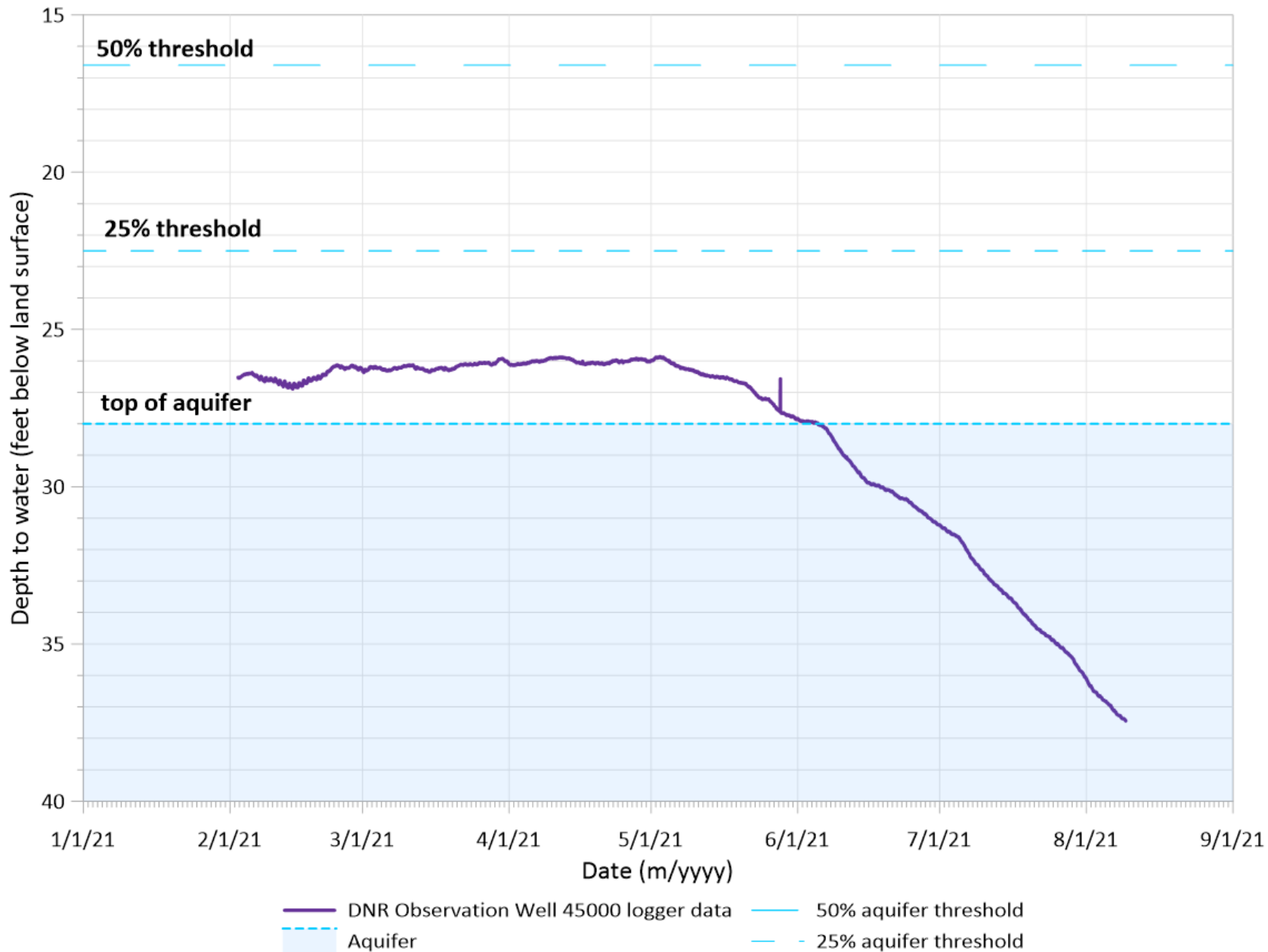


Figure 9. Historic water use and DNR observation well 45000 water levels

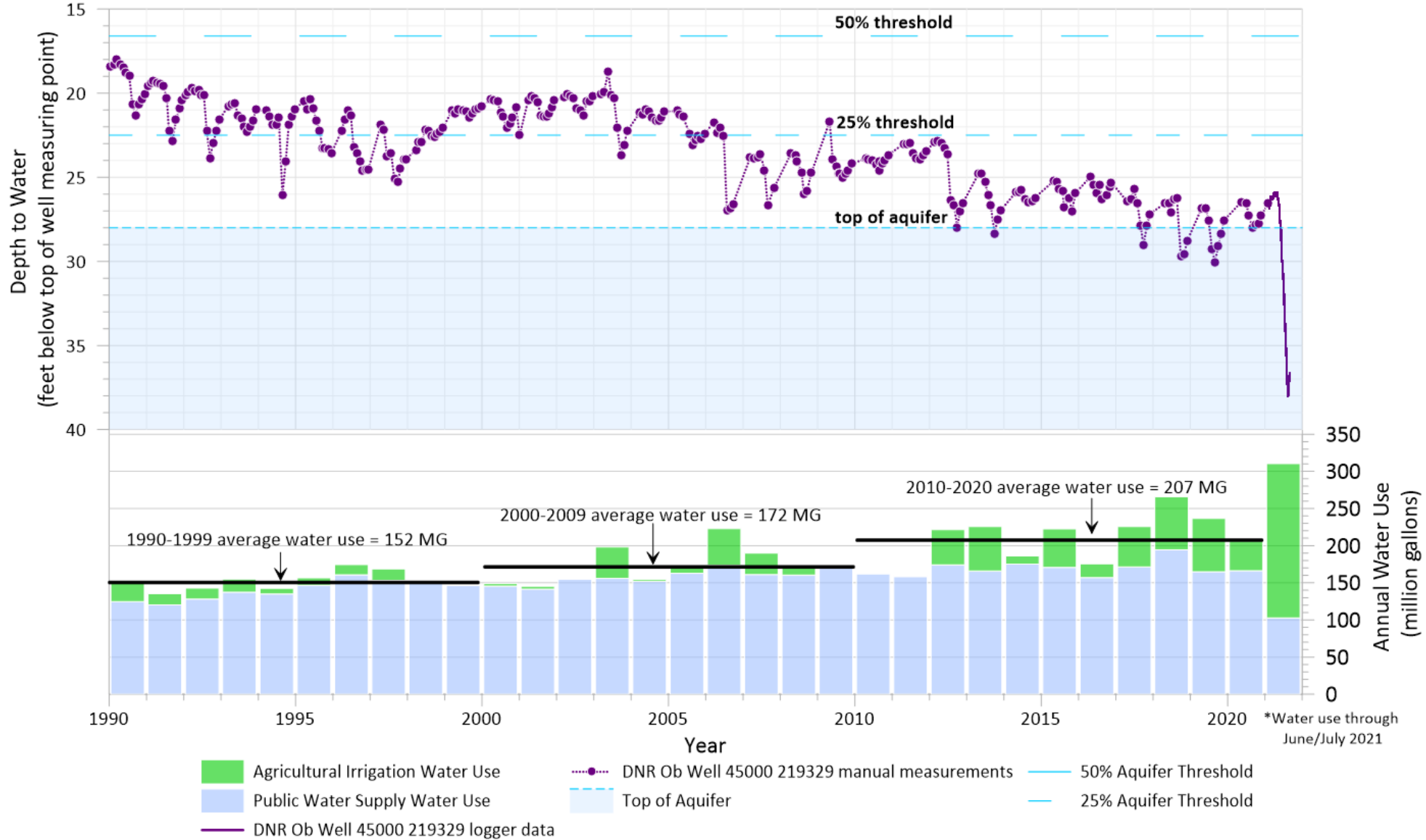


Figure 10. Water use for 2021

