Appendix 3-C. Water Level Sustainability Management Criteria

Contents

Groundwater Level Sustainability Measurable Criteria

This Appendix provides further background information for Section 3.4.1 Sustainable Management Criteria - Groundwater Elevation. The following provides additional figures and discussion to supplement the main text:

- The hydrographs used to set the minimum thresholds and measurable objectives.

- The process and figures of the well failure analysis.

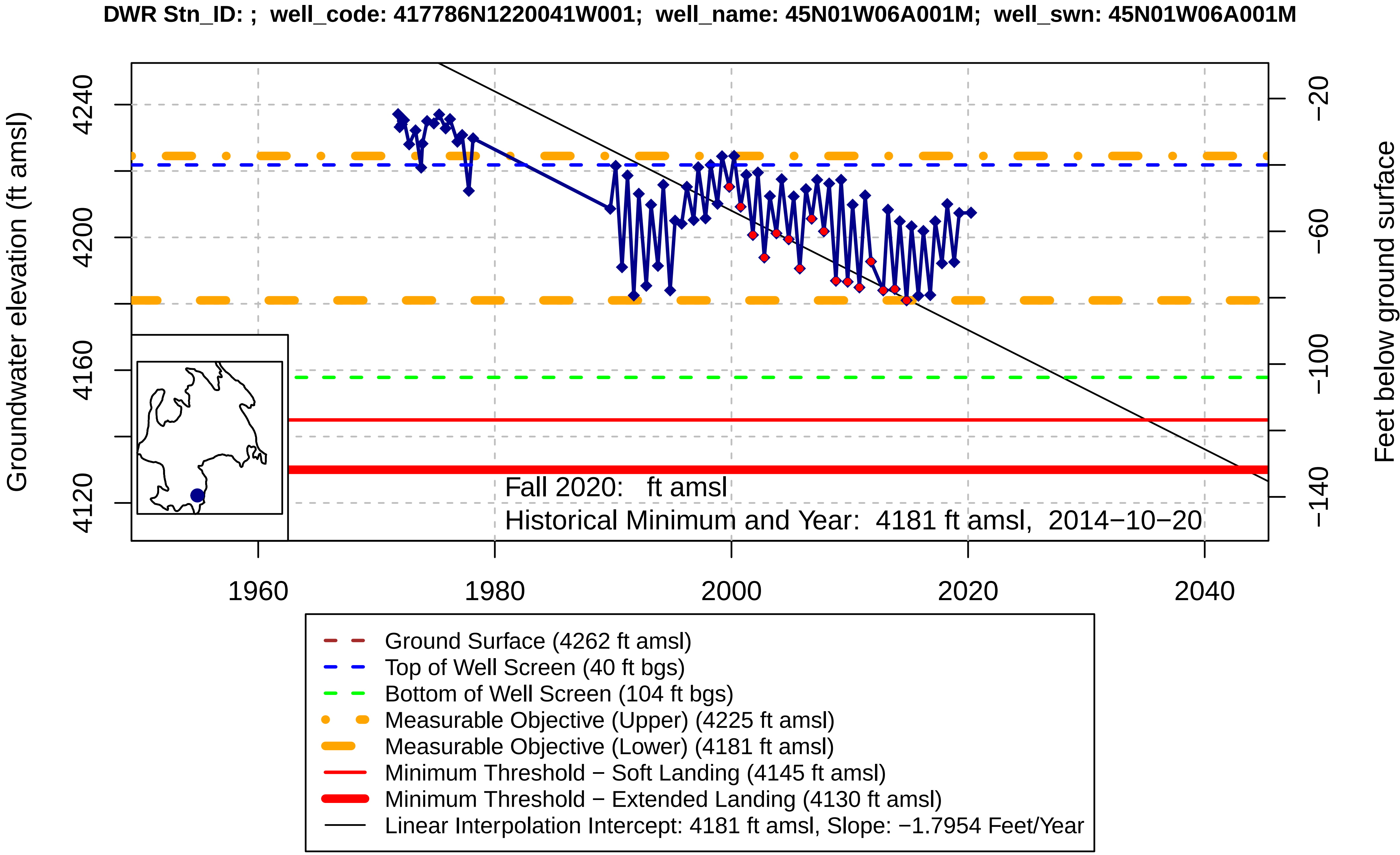
Hydrographs

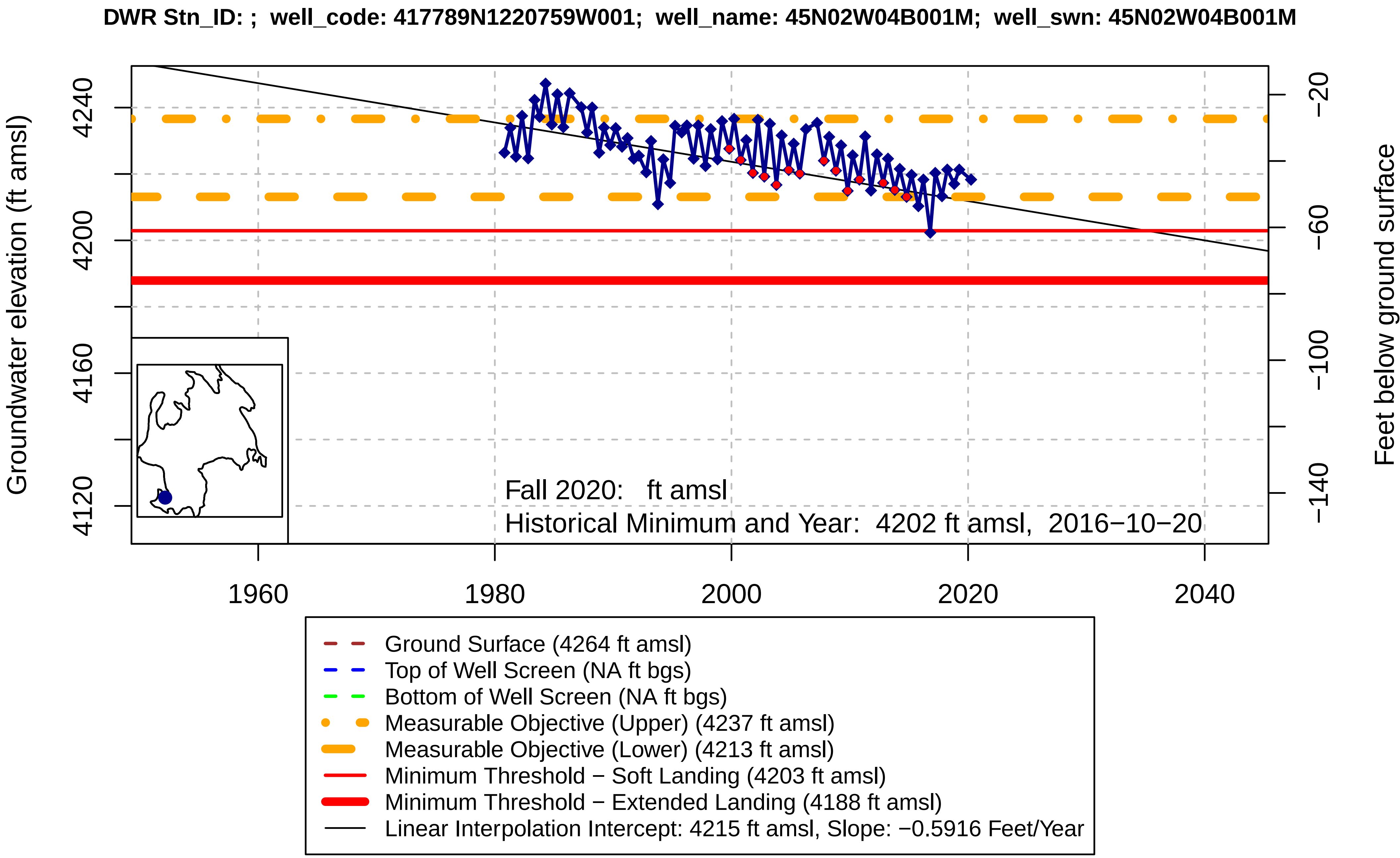
The hydrographs used to set the minimum thresholds and measurable objectives for each representative monitoring point are shown in the following figures. The groundwater level data used in the regression to calculate minimum thresholds have gone through a quality assurance and quality control (QAQC) process that removes data from the analysis for the following reasons:

- Oil or other foreign substances were floating at the groundwater surface inside the well and the data had high uncertainty as a result.
- The well was pumped recently.
- During the minimum threshold process and generation of a regression equation, a data point was deemed an outlier, which may result from the interference of drawdown from nearby wells.

Table 1: Removed groundwater level (WL) data from the regression analysis. The water level is in units of feet above mean sea level (ft amsl).

Well Name	Date	Removed WL	Reason
419451N1218967W001	2000-10-10	4157.23	Oil or foreign substance in casing
417944N1220350W001	2012-10-29	4203.73	Oil or foreign substance in casing
418512N1219183W001	1999-10-26	4208.79	Oil or foreign substance in casing
419451N1218967W001	1999-10-26	4159.73	Oil or foreign substance in casing
418512N1219183W001	2013-10-21	4194.69	Oil or foreign substance in casing
417944N1220350W001	2011-10-18	4189.83	Pumped recently
419755N1219785W001	2014-10-20	4172.7	Oil or foreign substance in casing
419451N1218967W001	2002-10-11	4138.73	Oil or foreign substance in casing
418661N1219587W001	1999-10-26	4204.5	Oil or foreign substance in casing
417789N1220759W001	2011-10-18	4215.01	Oil or foreign substance in casing
418948N1220832W001	2013-10-21	4197.37	Oil or foreign substance in casing
418948N1220832W001	2011-10-18	4197.57	Oil or foreign substance in casing
418948N1220832W001	2009-10-27	4202.07	Oil or foreign substance in casing
418948N1220832W001	1999-10-27	4204.27	Oil or foreign substance in casing
419451N1218967W001	2005-10-10	4153.73	Oil or foreign substance in casing
418661N1219587W001	2013-10-21	4193.7	Oil or foreign substance in casing
418512N1219183W001	2014-10-20	4191.99	Oil or foreign substance in casing
419451N1218967W001	2003-10-20	4139.63	Oil or foreign substance in casing
418948N1220832W001	2007-10-25	4205.57	Oil or foreign substance in casing
418948N1220832W001	2010-10-25	4199.97	Oil or foreign substance in casing
418948N1220832W001	2008-10-30	4205.07	Oil or foreign substance in casing
418948N1220832W001	2006-10-12	4204.87	Oil or foreign substance in casing
418948N1220832W001	2000-10-10	4201.67	Pumping
418948N1220832W001	2012-10-29	4197.97	Oil or foreign substance in casing
418948N1220832W001	2005-10-10	4200.07	Oil or foreign substance in casing
419451N1218967W001	2006-10-12	4149.93	Oil or foreign substance in casing
418948N1220832W001	2002-10-11	4202.37	Oil or foreign substance in casing
418948N1220832W001	2003-10-20	4203.07	Oil or foreign substance in casing
419451N1218967W001	2004-11-02	4136.23	Oil or foreign substance in casing
418948N1220832W001	2004-11-03	4204.37	Oil or foreign substance in casing
418512N1219183W001	2001-10-23	4182.69	Outlier
417789N1220759W001	2006-10-12	4204.81	Outlier


DWR Stn_ID: ; well_code: 417786N1220041W001; well_name: 45N01W06A001M; well_swn: 45N01W06A001M
Groundwater elevation (ft amsl)
Feet below ground surface
4120
4160
4200
4240
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4181 ft amsl, 2014−10−20
Ground Surface (4262 ft amsl)
Top of Well Screen (40 ft bgs)
Bottom of Well Screen (104 ft bgs)
Measurable Objective (Upper) (4225 ft amsl)
Measurable Objective (Lower) (4181 ft amsl)
Minimum Threshold − Soft Landing (4145 ft amsl)
Minimum Threshold − Extended Landing (4130 ft amsl)
Linear Interpolation Intercept: 4181 ft amsl, Slope: −1.7954 Feet/Year


DWR Stn_ID: ; well_code: 417789N1220759W001; well_name: 45N02W04B001M; well_swn: 45N02W04B001M
Groundwater elevation (ft amsl)
Feet below ground surface
4120
4160
4200
4240
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4202 ft amsl, 2016−10−20
Ground Surface (4264 ft amsl)
Top of Well Screen (NA ft bgs)
Bottom of Well Screen (NA ft bgs)
Measurable Objective (Upper) (4237 ft amsl)
Measurable Objective (Lower) (4213 ft amsl)
Minimum Threshold − Soft Landing (4203 ft amsl)
Minimum Threshold − Extended Landing (4188 ft amsl)
Linear Interpolation Intercept: 4215 ft amsl, Slope: −0.5916 Feet/Year

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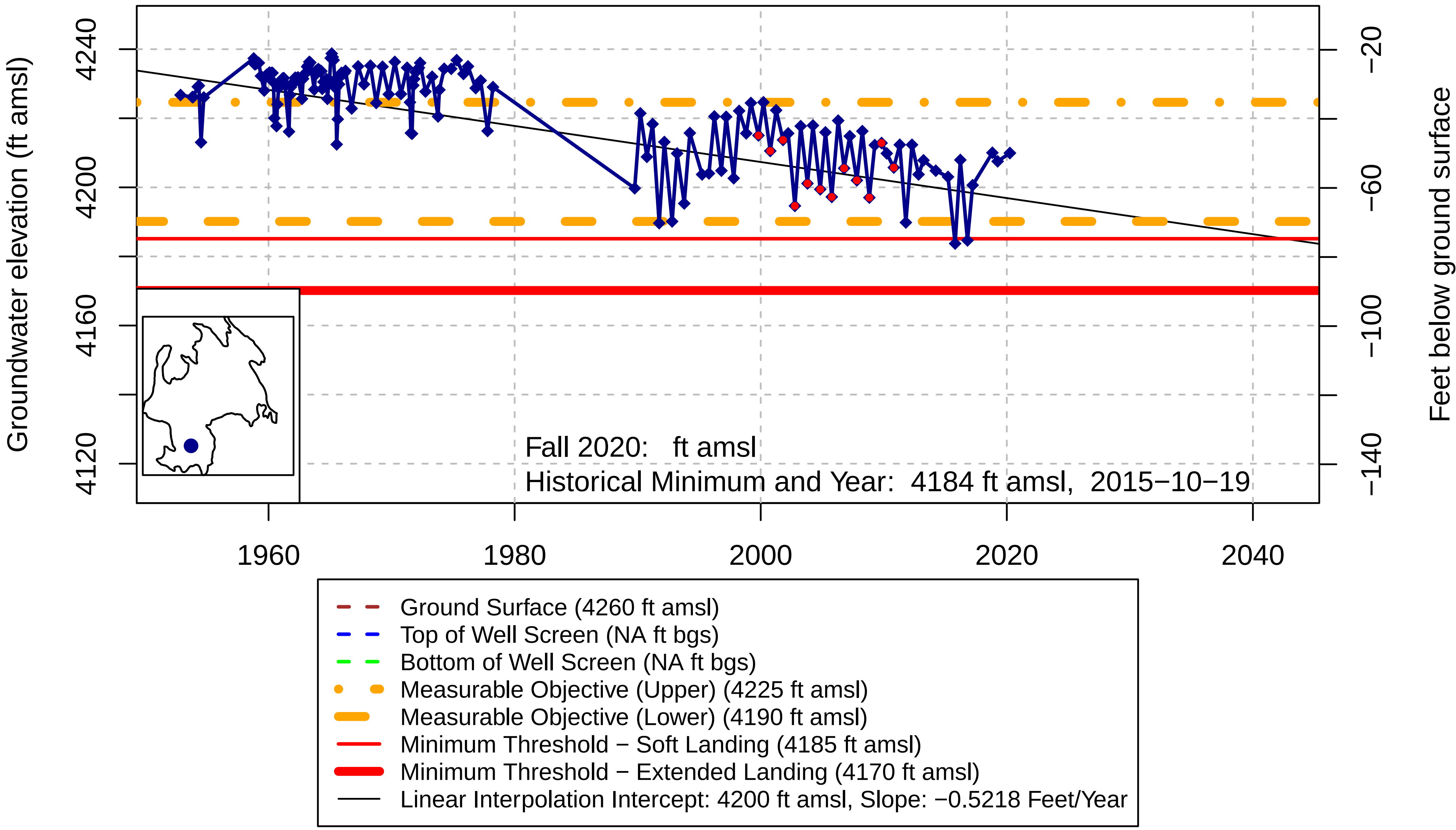
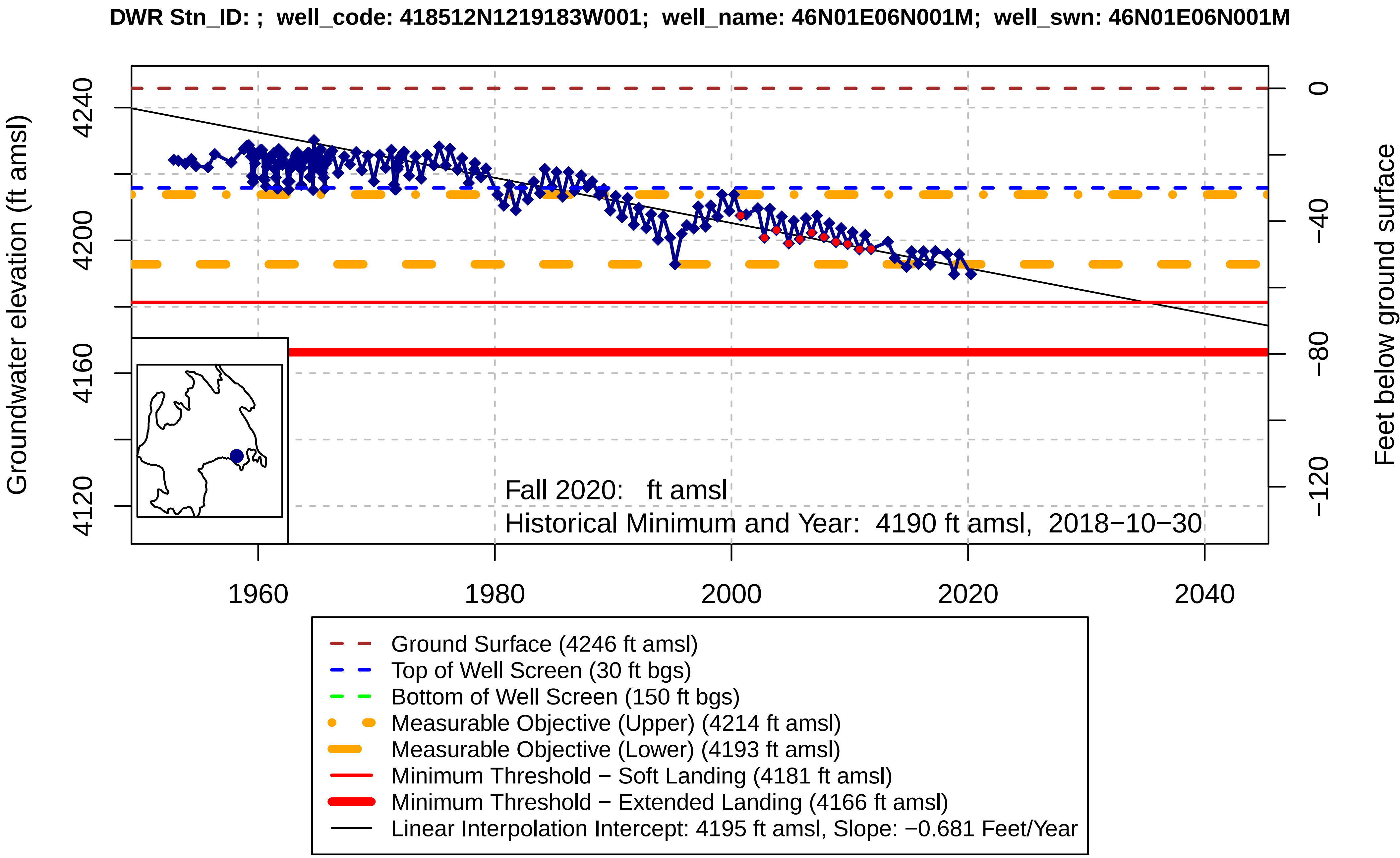
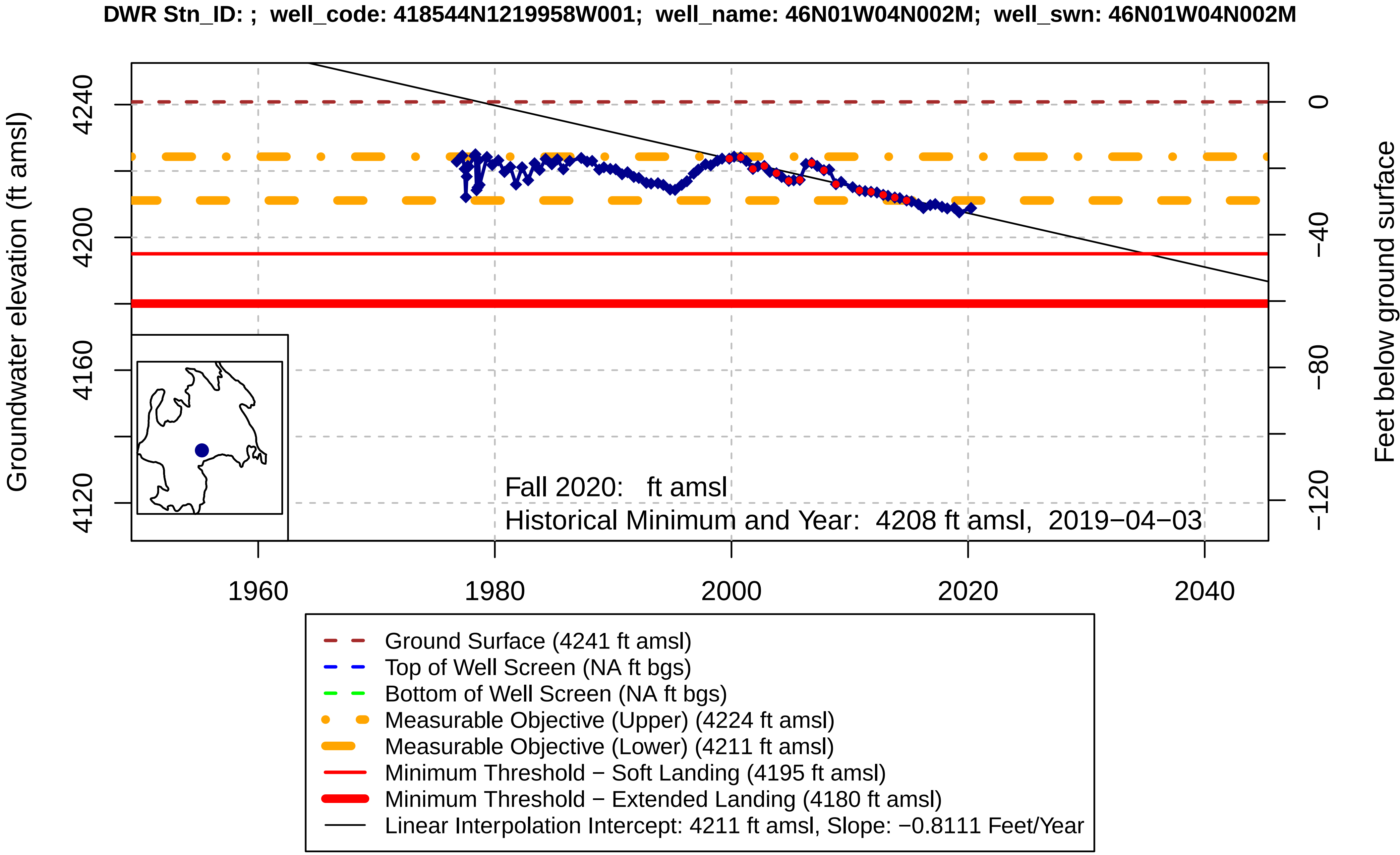


28



DWR Stn_ID: ; well_code: 418512N1219183W001; well_name: 46N01E06N001M; well_swn: 46N01E06N001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4190 ft amsl, 2018−10−30
Ground Surface (4246 ft amsl)
Top of Well Screen (30 ft bgs)
Bottom of Well Screen (150 ft bgs)
Measurable Objective (Upper) (4214 ft amsl)
Measurable Objective (Lower) (4193 ft amsl)
Minimum Threshold − Soft Landing (4181 ft amsl)
Minimum Threshold − Extended Landing (4166 ft amsl)
Linear Interpolation Intercept: 4195 ft amsl, Slope: −0.681 Feet/Year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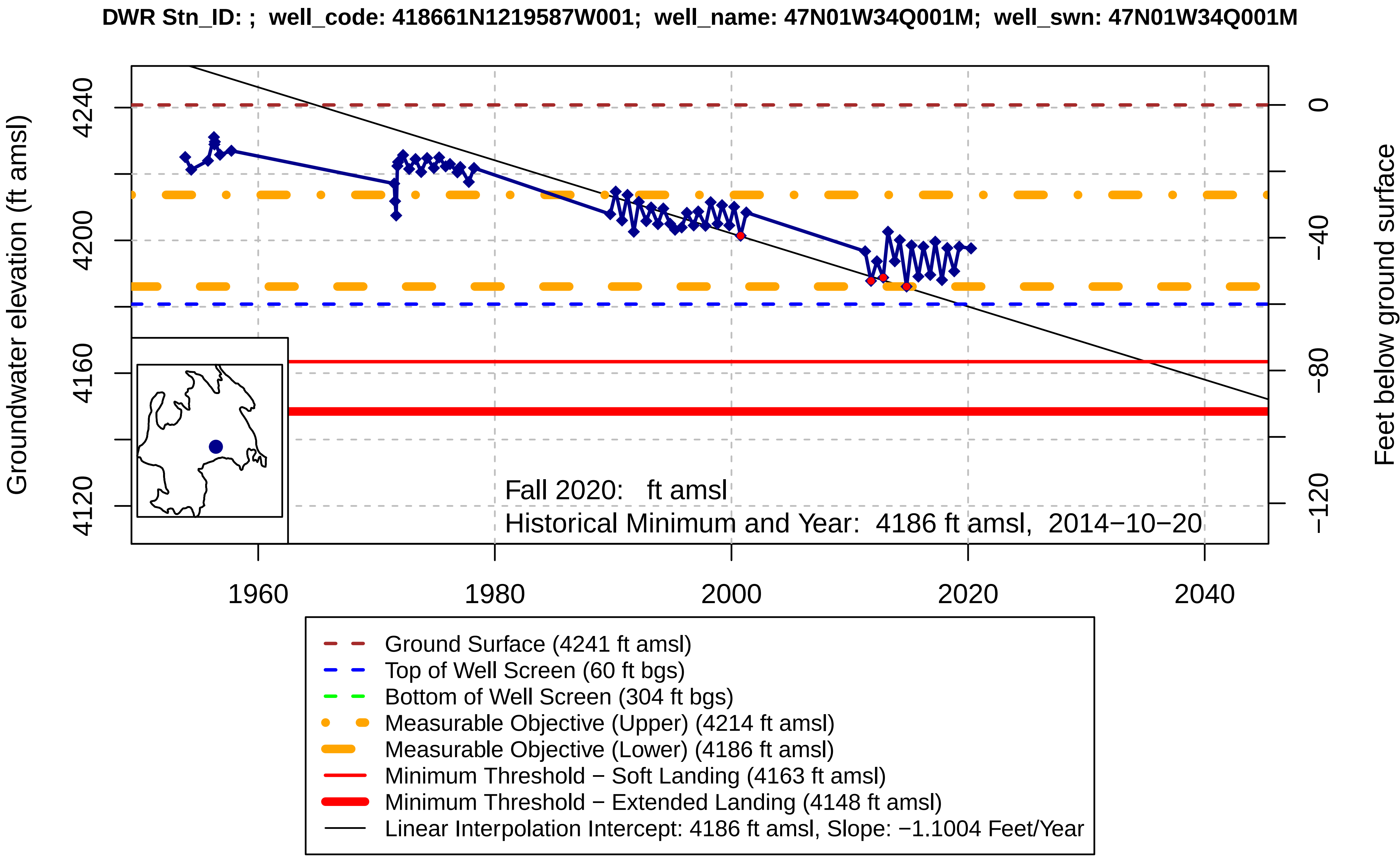
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4208 ft amsl, 2019−04−03
Ground Surface (4241 ft amsl)
Top of Well Screen (NA ft bgs)
Bottom of Well Screen (NA ft bgs)
Measurable Objective (Upper) (4224 ft amsl)
Measurable Objective (Lower) (4211 ft amsl)
Minimum Threshold − Soft Landing (4195 ft amsl)
Minimum Threshold − Extended Landing (4180 ft amsl)
Linear Interpolation Intercept: 4211 ft amsl, Slope: −0.8111 Feet/Year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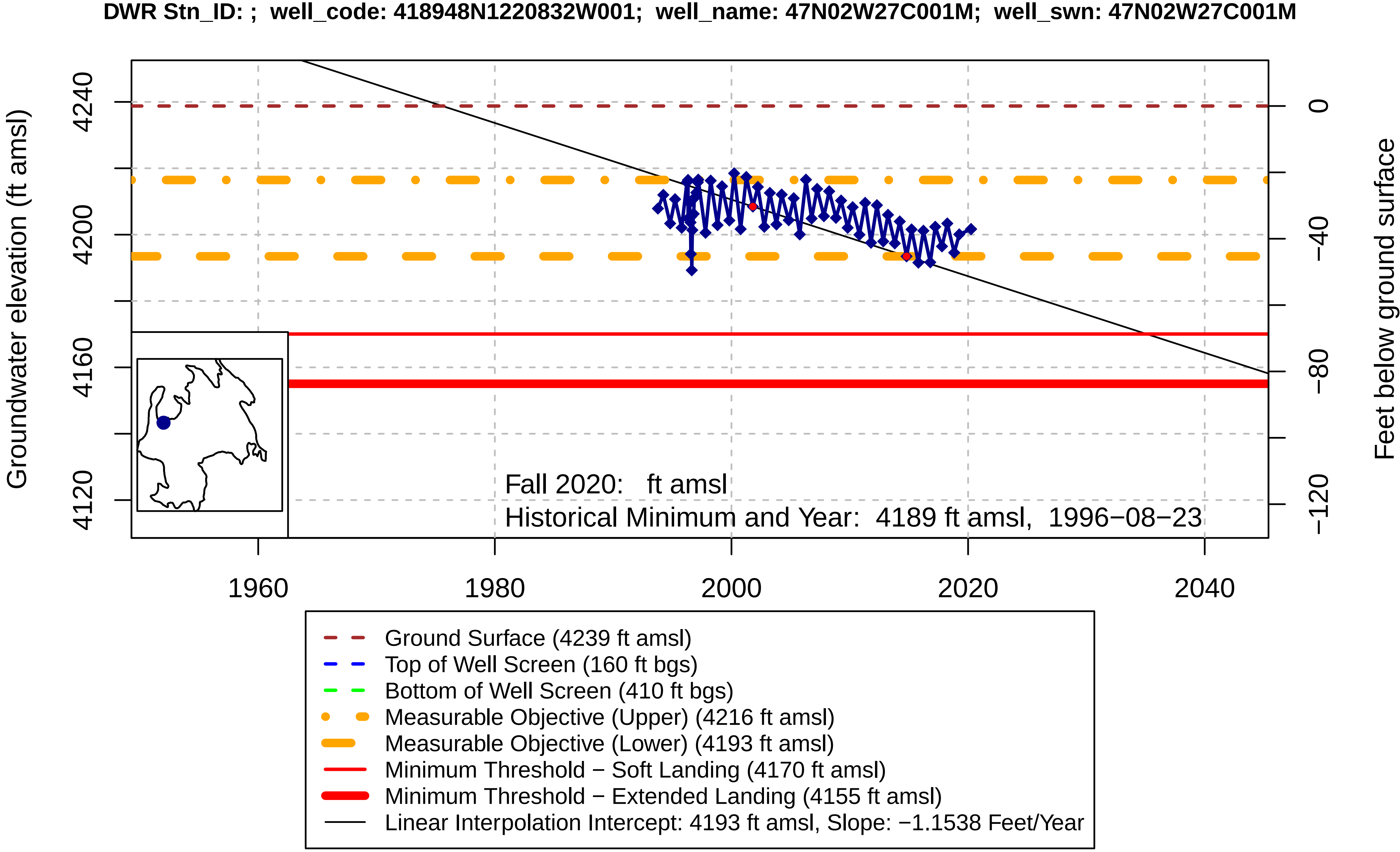
Groundwater elevation (ft amsl)
Feet below ground surface
4120
4160
4200
4240
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4186 ft amsl, 2014−10−20
Ground Surface (4241 ft amsl)
Top of Well Screen (60 ft bgs)
Bottom of Well Screen (304 ft bgs)
Measurable Objective (Upper) (4214 ft amsl)
Measurable Objective (Lower) (4186 ft amsl)
Minimum Threshold − Soft Landing (4163 ft amsl)
Minimum Threshold − Extended Landing (4148 ft amsl)
Linear Interpolation Intercept: 4186 ft amsl, Slope: −1.1004 Feet/Year


DWR Stn_ID: ; well_code: 418948N1220832W001; well_name: 47N02W27C001M; well_swn: 47N02W27C001M
Groundwater elevation (ft amsl)
Feet below ground surface
4120
4160
4200
4240
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4189 ft amsl, 1996−08−23
Ground Surface (4239 ft amsl)
Top of Well Screen (160 ft bgs)
Bottom of Well Screen (410 ft bgs)
Measurable Objective (Upper) (4216 ft amsl)
Measurable Objective (Lower) (4193 ft amsl)
Minimum Threshold − Soft Landing (4170 ft amsl)
Minimum Threshold − Extended Landing (4155 ft amsl)
Linear Interpolation Intercept: 4193 ft amsl, Slope: −1.1538 Feet/Year

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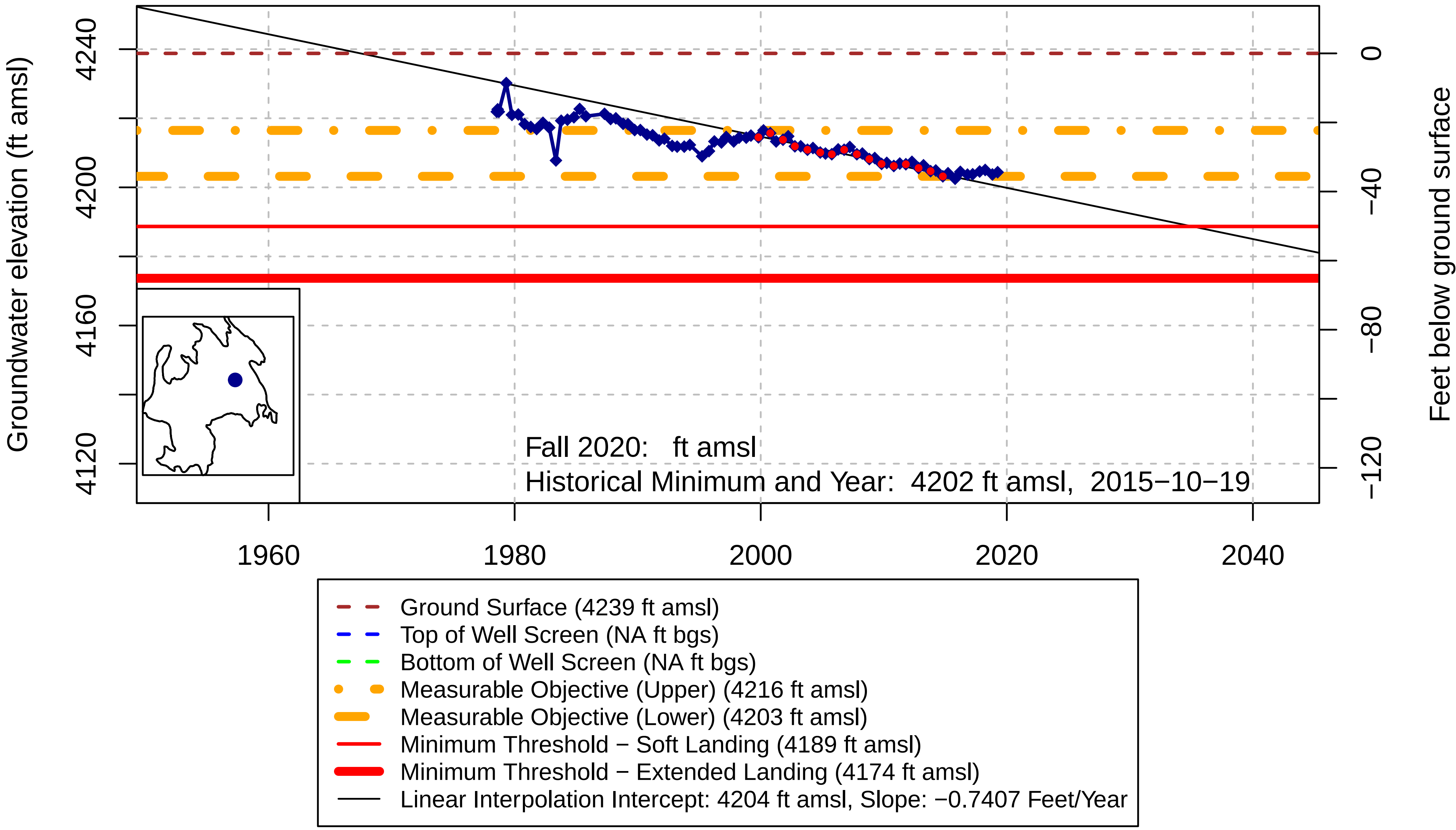

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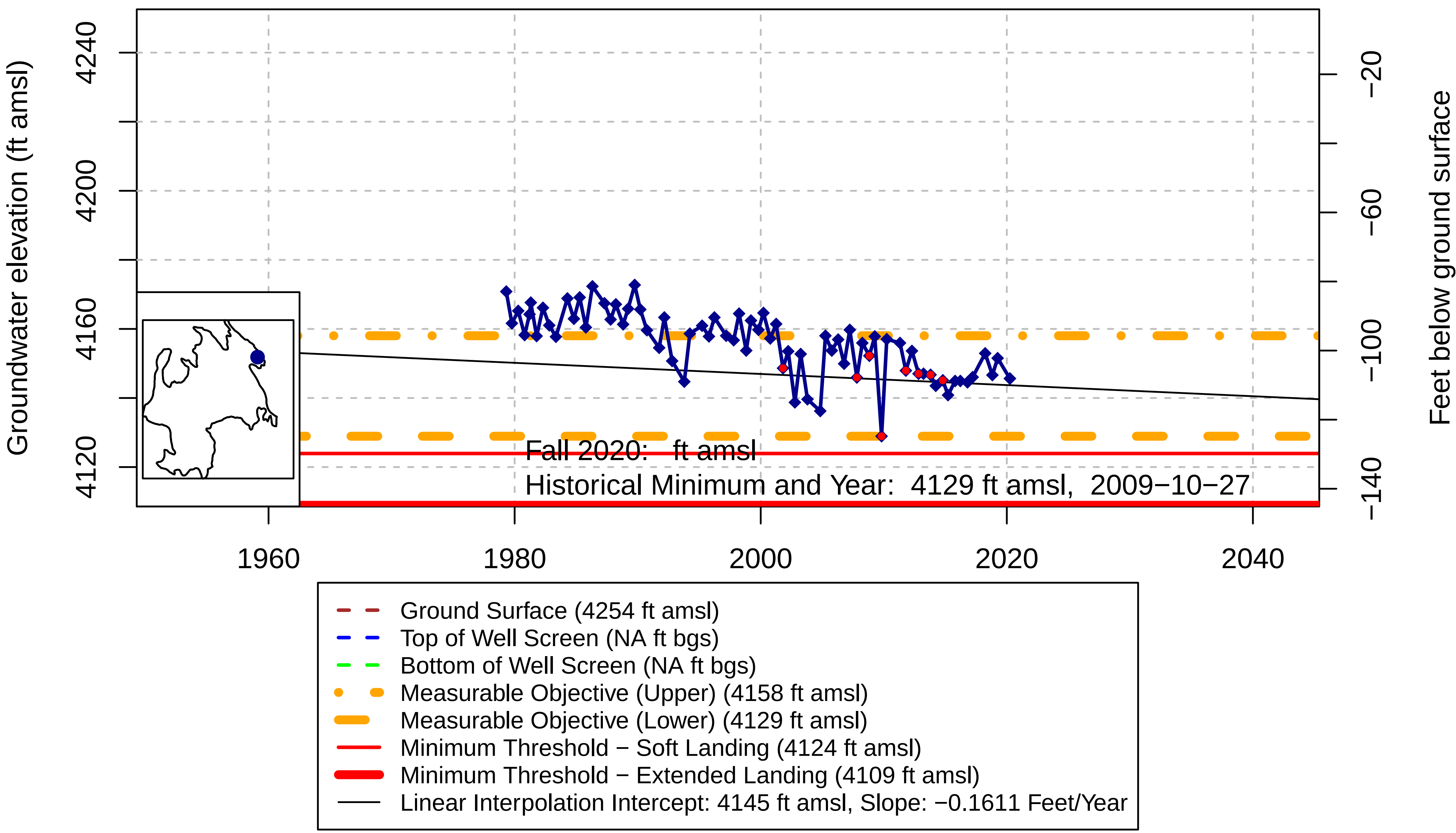
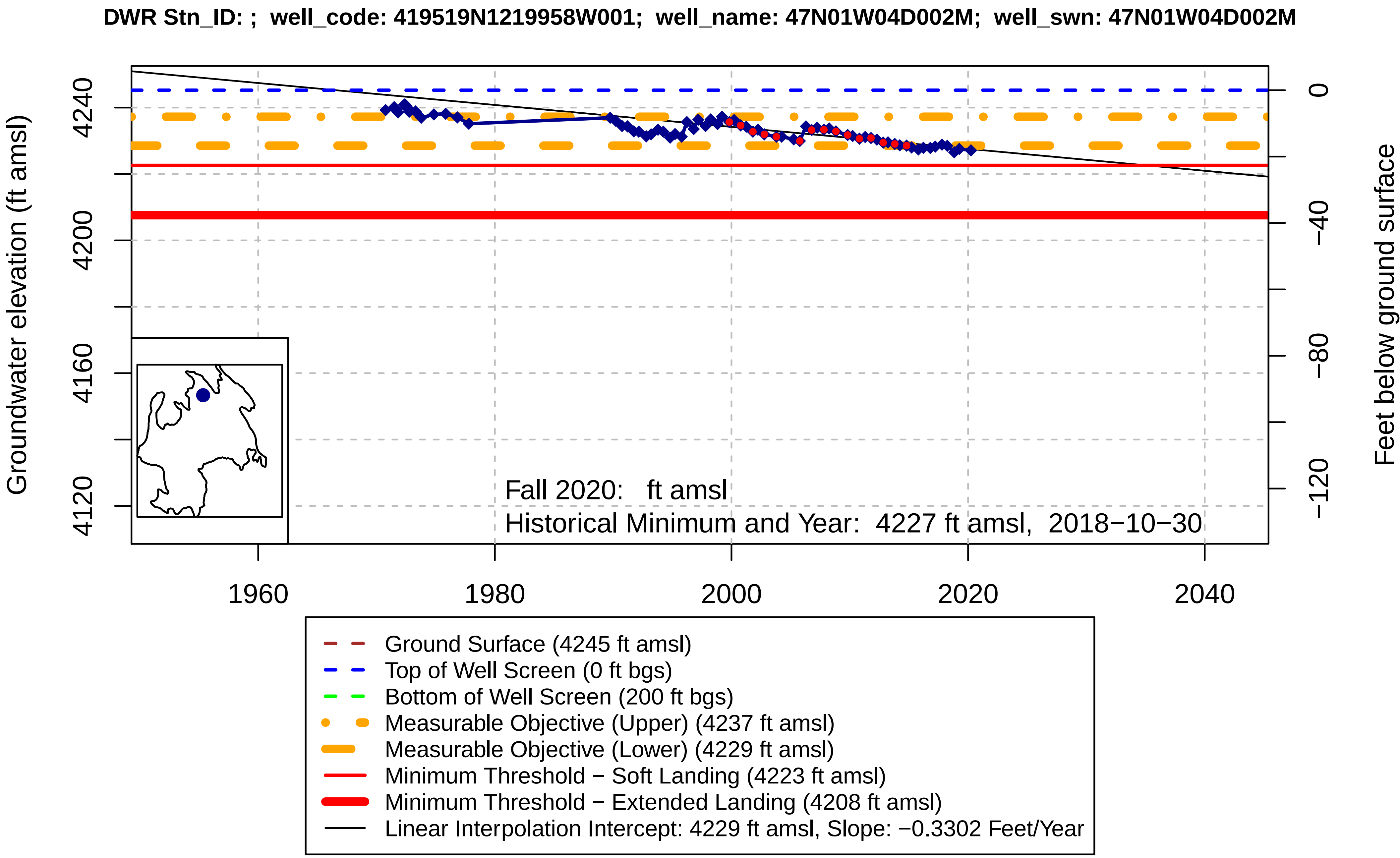


34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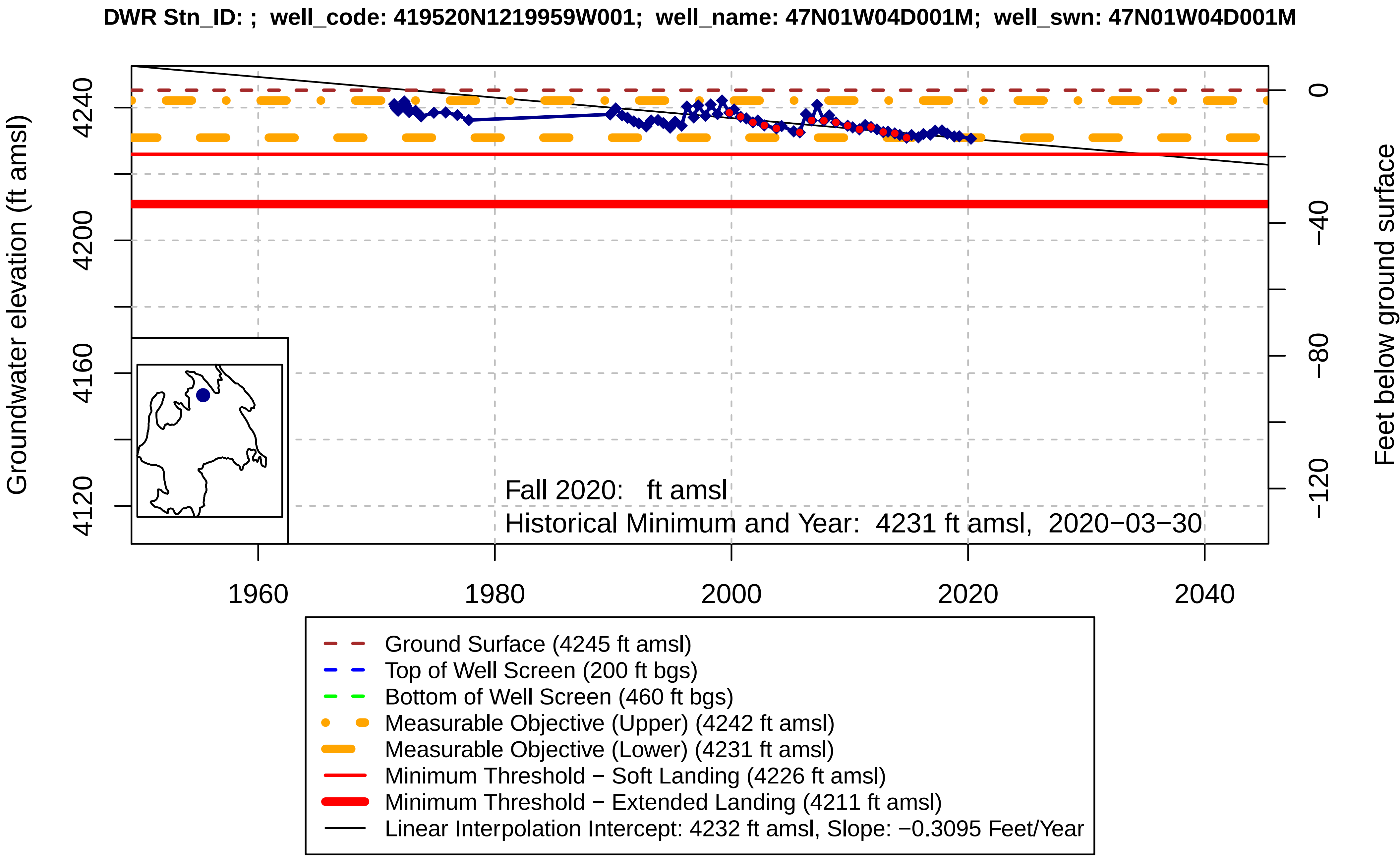
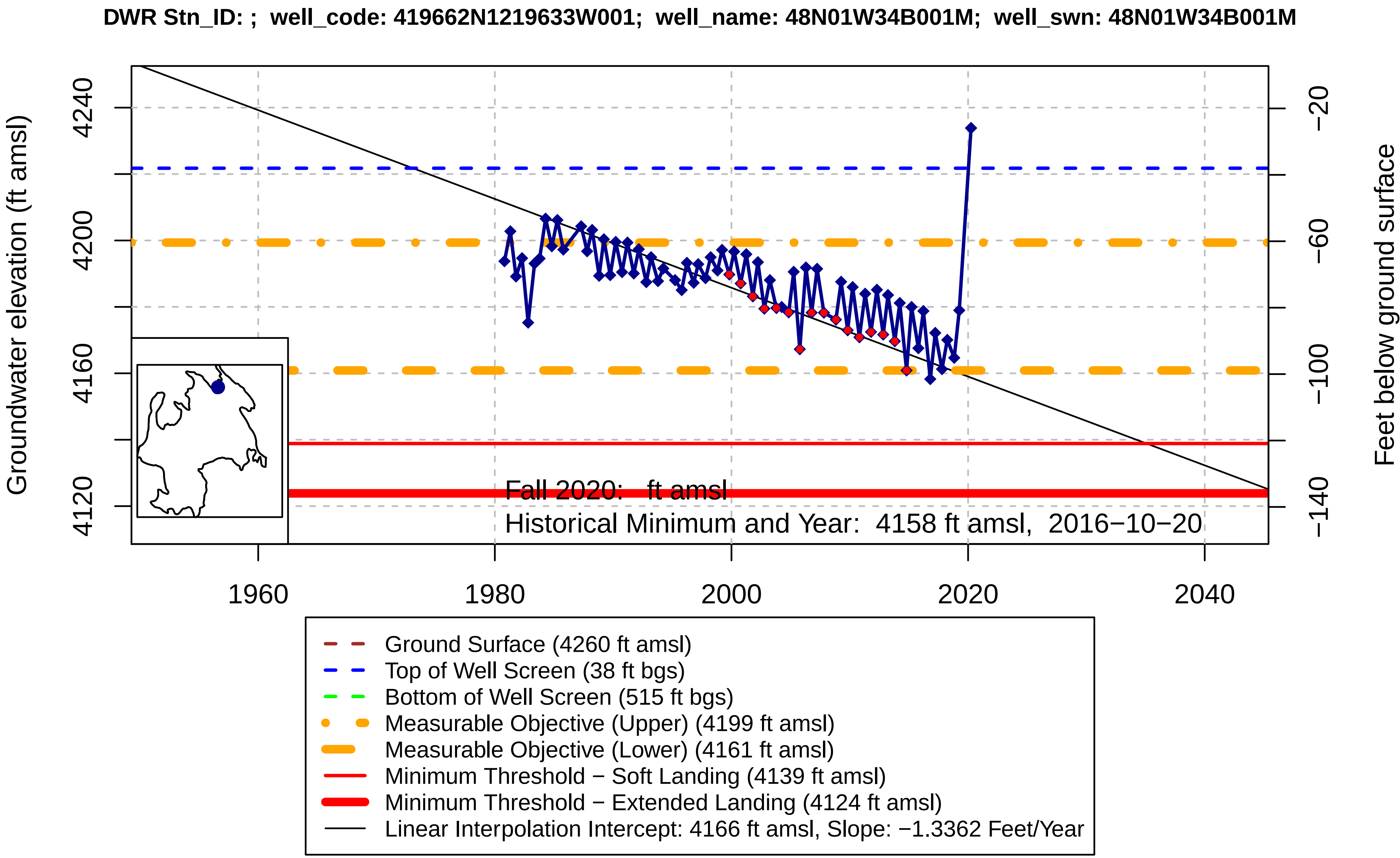
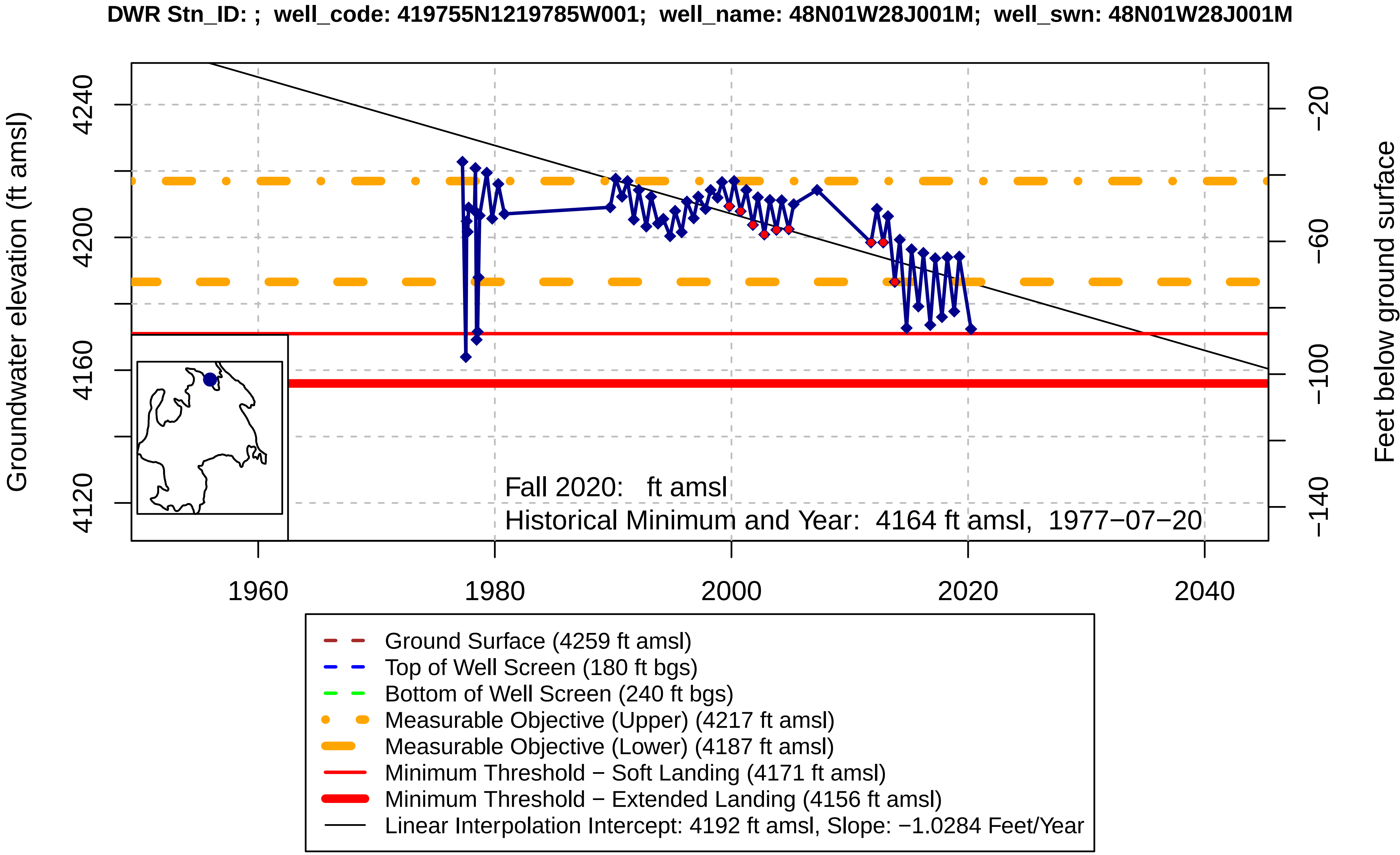
Groundwater elevation (ft amsl)
4120
4160
4200
4240
Feet below ground surface
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4227 ft amsl, 2018−10−30
Ground Surface (4245 ft amsl)
Top of Well Screen (0 ft bgs)
Bottom of Well Screen (200 ft bgs)
Measurable Objective (Upper) (4237 ft amsl)
Measurable Objective (Lower) (4229 ft amsl)
Minimum Threshold − Soft Landing (4223 ft amsl)
Minimum Threshold − Extended Landing (4208 ft amsl)
Linear Interpolation Intercept: 4229 ft amsl, Slope: −0.3302 Feet/Year


DWR Stn_ID: ; well_code: 419520N1219959W001; well_name: 47N01W04D001M; well_swn: 47N01W04D001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4231 ft amsl, 2020−03−30
Ground Surface (4245 ft amsl)
Top of Well Screen (200 ft bgs)
Bottom of Well Screen (460 ft bgs)
Measurable Objective (Upper) (4242 ft amsl)
Measurable Objective (Lower) (4231 ft amsl)
Minimum Threshold − Soft Landing (4226 ft amsl)
Minimum Threshold − Extended Landing (4211 ft amsl)
Linear Interpolation Intercept: 4232 ft amsl, Slope: −0.3095 Feet/Year



DWR Stn_ID: ; well_code: 419662N1219633W001; well_name: 48N01W34B001M; well_swn: 48N01W34B001M
Groundwater elevation (ft amsl)
Feet below ground surface
4120
4160
4200
4240
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4158 ft amsl, 2016−10−20
Ground Surface (4260 ft amsl)
Top of Well Screen (38 ft bgs)
Bottom of Well Screen (515 ft bgs)
Measurable Objective (Upper) (4199 ft amsl)
Measurable Objective (Lower) (4161 ft amsl)
Minimum Threshold − Soft Landing (4139 ft amsl)
Minimum Threshold − Extended Landing (4124 ft amsl)
Linear Interpolation Intercept: 4166 ft amsl, Slope: −1.3362 Feet/Year


DWR Stn_ID: ; well_code: 419755N1219785W001; well_name: 48N01W28J001M; well_swn: 48N01W28J001M
Groundwater elevation (ft amsl)
Feet below ground surface
4120
4160
4200
4240
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4164 ft amsl, 1977−07−20
Ground Surface (4259 ft amsl)
Top of Well Screen (180 ft bgs)
Bottom of Well Screen (240 ft bgs)
Measurable Objective (Upper) (4217 ft amsl)
Measurable Objective (Lower) (4187 ft amsl)
Minimum Threshold − Soft Landing (4171 ft amsl)
Minimum Threshold − Extended Landing (4156 ft amsl)
Linear Interpolation Intercept: 4192 ft amsl, Slope: −1.0284 Feet/Year

Well Failure Analysis

[Section Under Development]

Butte Valley Well Failure Discussion

Bill Rice

4/1/2021 (Draft)

Contents

About The Analysis

This analysis seeks to determine the number of wells that may fail due to declining groundwater levels. This assumes that wells have an operating life of approximately 40 years and are sensitive to water table declines where water levels drop too close to the top of the well screen interval. Additionally, the depth to the bottom of the well is considered due to the importance of the Butte Valley Basalt Formation and the frequency of wells with pumps set below the bottom of solid casing into open boreholes in that formation.

For this study it was necessary to hand-digitize well logs from scanned records. Although there were 441 wells from the California Online System for Well Completion Reports (OSWCR), they did not have enough data for an analysis. Of those wells, 55 had both screen perforation data and well diameter used to make maps shown below. Top of screen interval statistics only require top of well screen, however the OSCWR dataset has 72 wells with top of screen and no diameter of casing which could have been used for general statistics. Hand digitizing resulted in 480 wells available for analysis in the basin, of which 149 had both screen perforation data and well diameter. For general statistics there were 151 wells with only top of well screen data. For general statistics there were 461 wells with only completed well depth data. This hand processing resulted in a much larger dataset available for analysis.

Well failure risk was assessed by measuring the distance between the interpolated groundwater surface and the top of well screen. Well failure was considered a likely risk for agricultural and public wells if water levels dropped to the top of the screen interval. Domestic wells were considered at likely risk of failure if water levels dropped to less than 20 feet above the top of the well screen.

Modeled Conditions in Spring 2020

Spring 2020 Figure 1

Spring 2020 Screen Depth Relative to Water level Figure 2

Well Statistics

Percent of Total Number of Wells By Screen Depths Figure 3

Percent of Total Number of Wells By Total Depth Figure 4

Violin Plot of Top of Screen by Well Type, Log Y-Axis Figure 5

Violin Plot of Top of Screen by Well Type, Normal Y-Axis Figure 6

Distribution of Top of Screen Interval by Well Type - Horizontal Figure 7

Distribution of Top of Screen Interval by Well Type - Vertical Figure 8

Histogram of Top of the well screen Figure 9

Histogram of Bottom of wells Figure 10

Future Projections Based on Minimum Thresholds

Well Failure Map in 2042 Assuming Soft Landing Minimum Thresholds Figure 11

Well Failure Map in 2042 Assuming Extended Landing Minimum Thresholds Figure 12

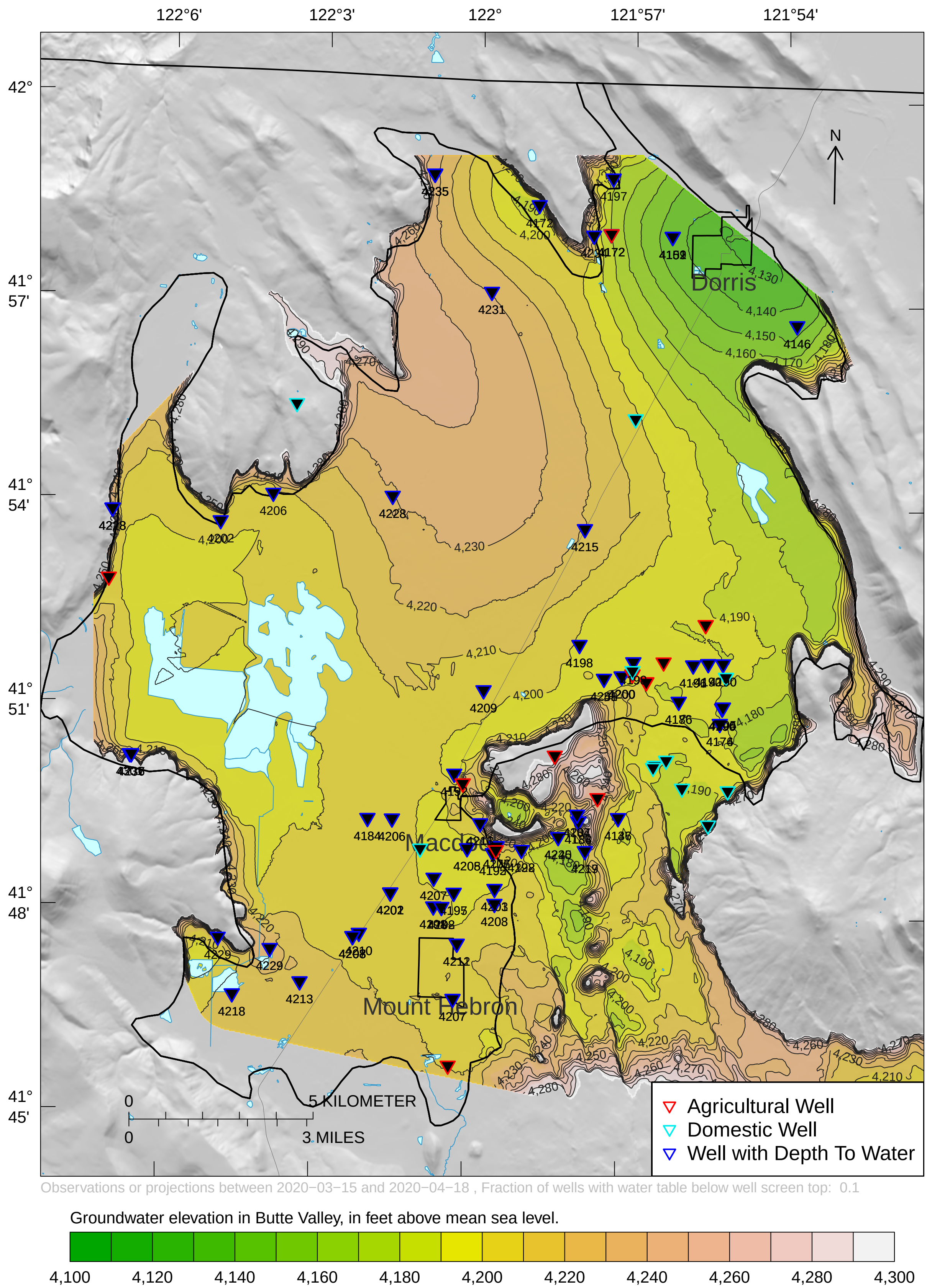


Figure 1: Butte Valley Groundwater Elevations, spring 2020 and well failure estimates based on recent water level observations. Well failures

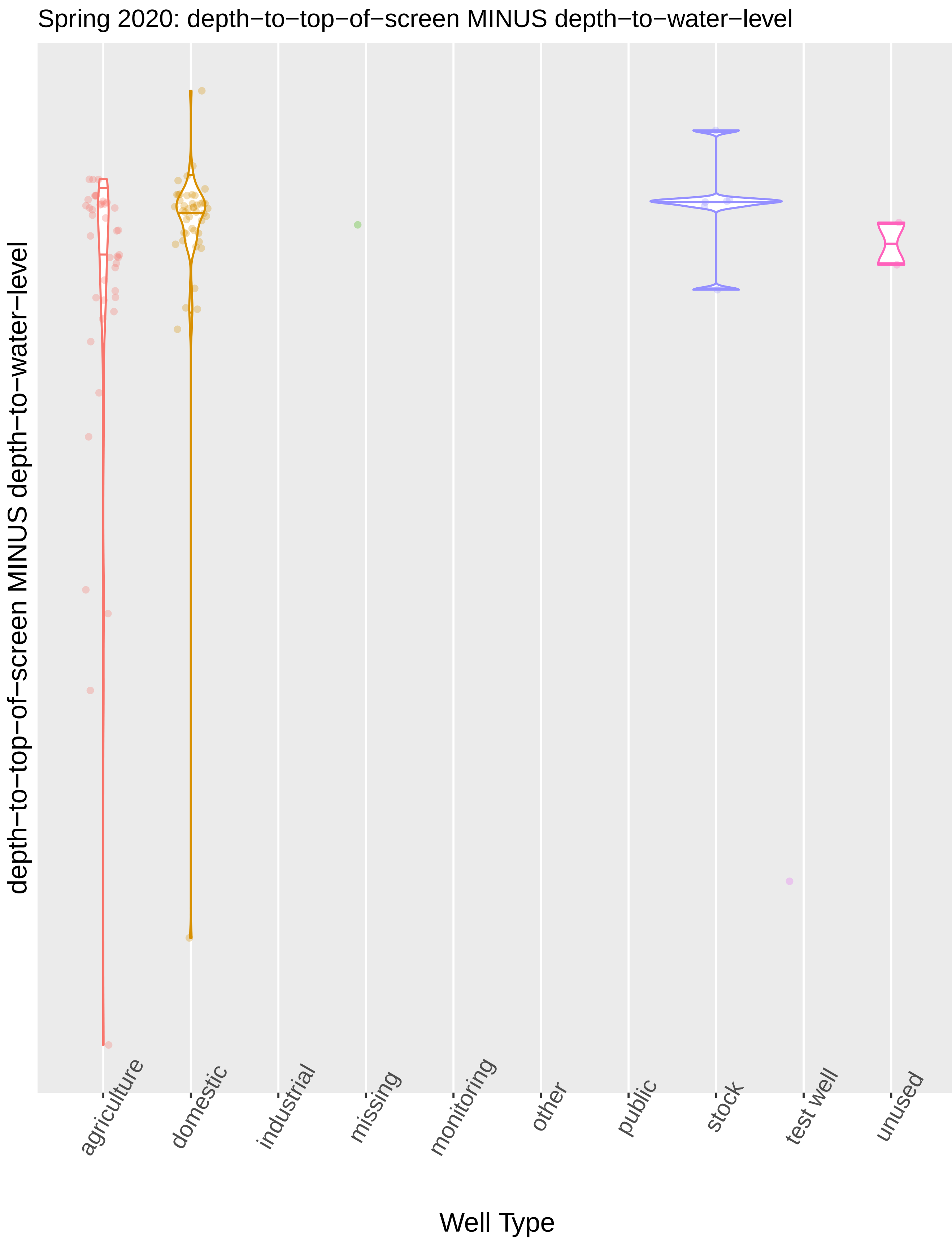


Figure 2: Butte Valley Groundwater Elevations, Depth To Top Of Screen, spring 2020. These wells already appear to be suffering well risk of well failure. Failure projections will assume these wells have already failed and not consider them as new wells under risk of failure.

45

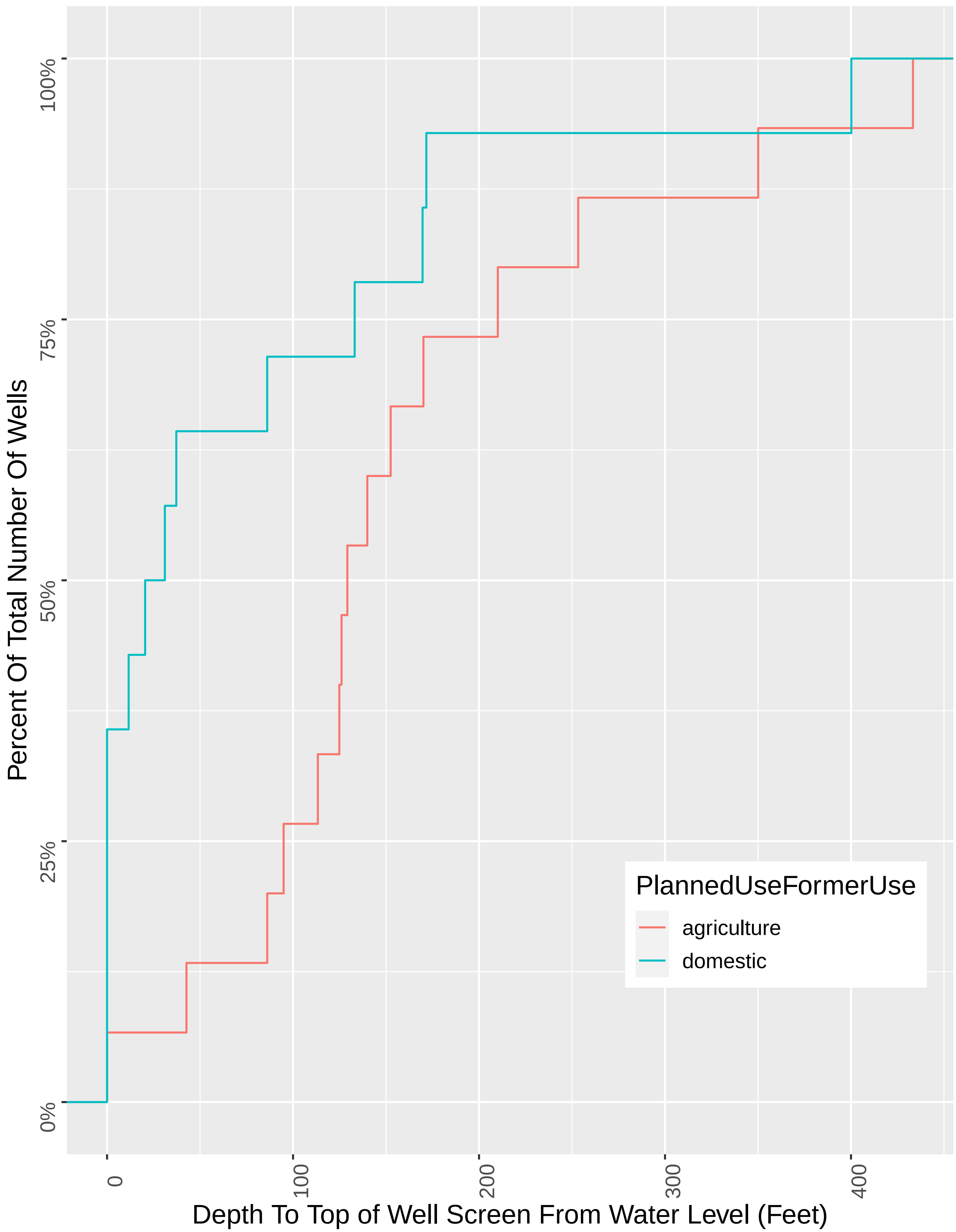


Figure 3: Cumulative distribution Of the total number Of Wells in Butte Valley relative to top Of well screen.

46

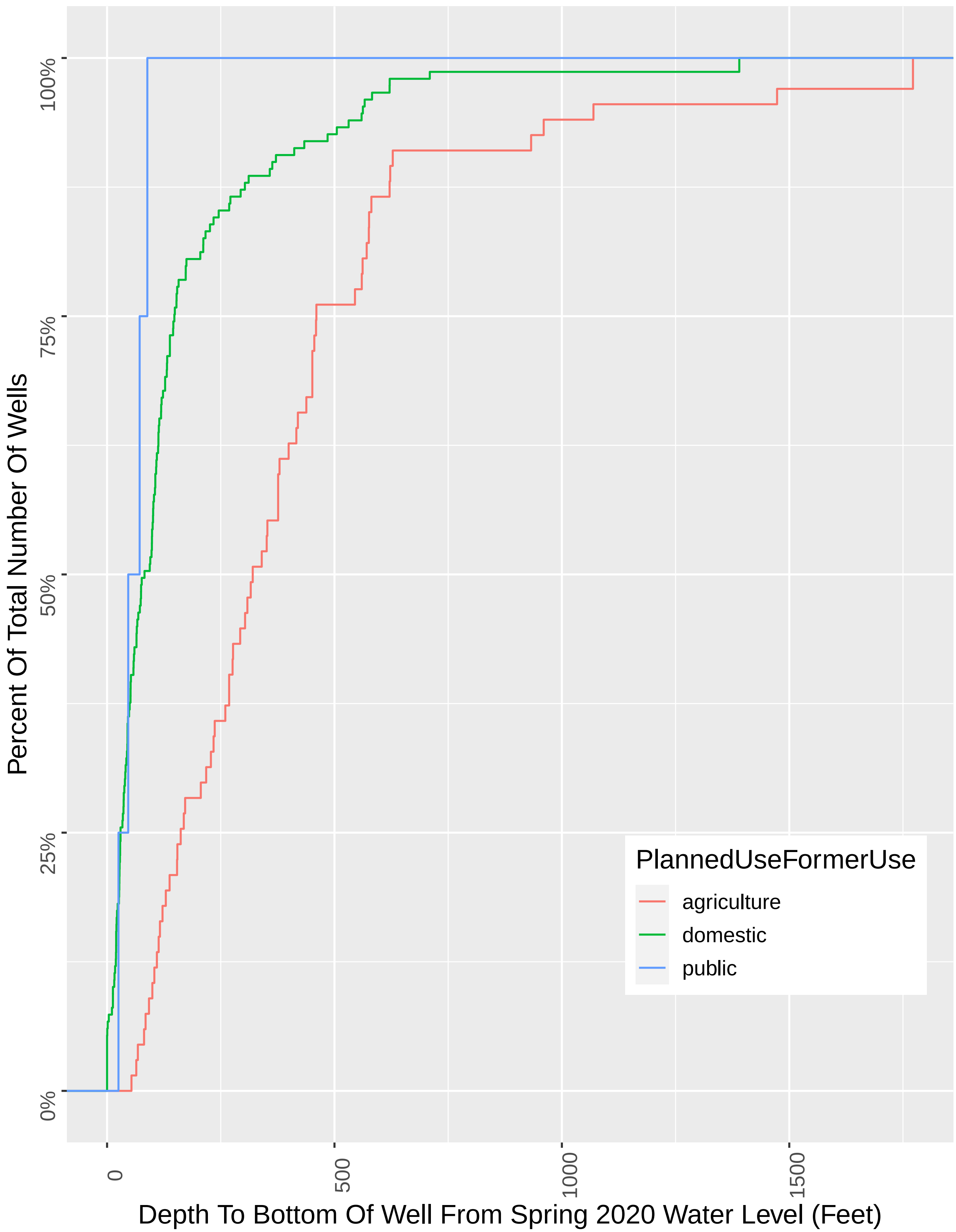


Figure 4: Cumulative distribuion of the total Number Of wells in Butte Valley relative to bottom Of the well.

47

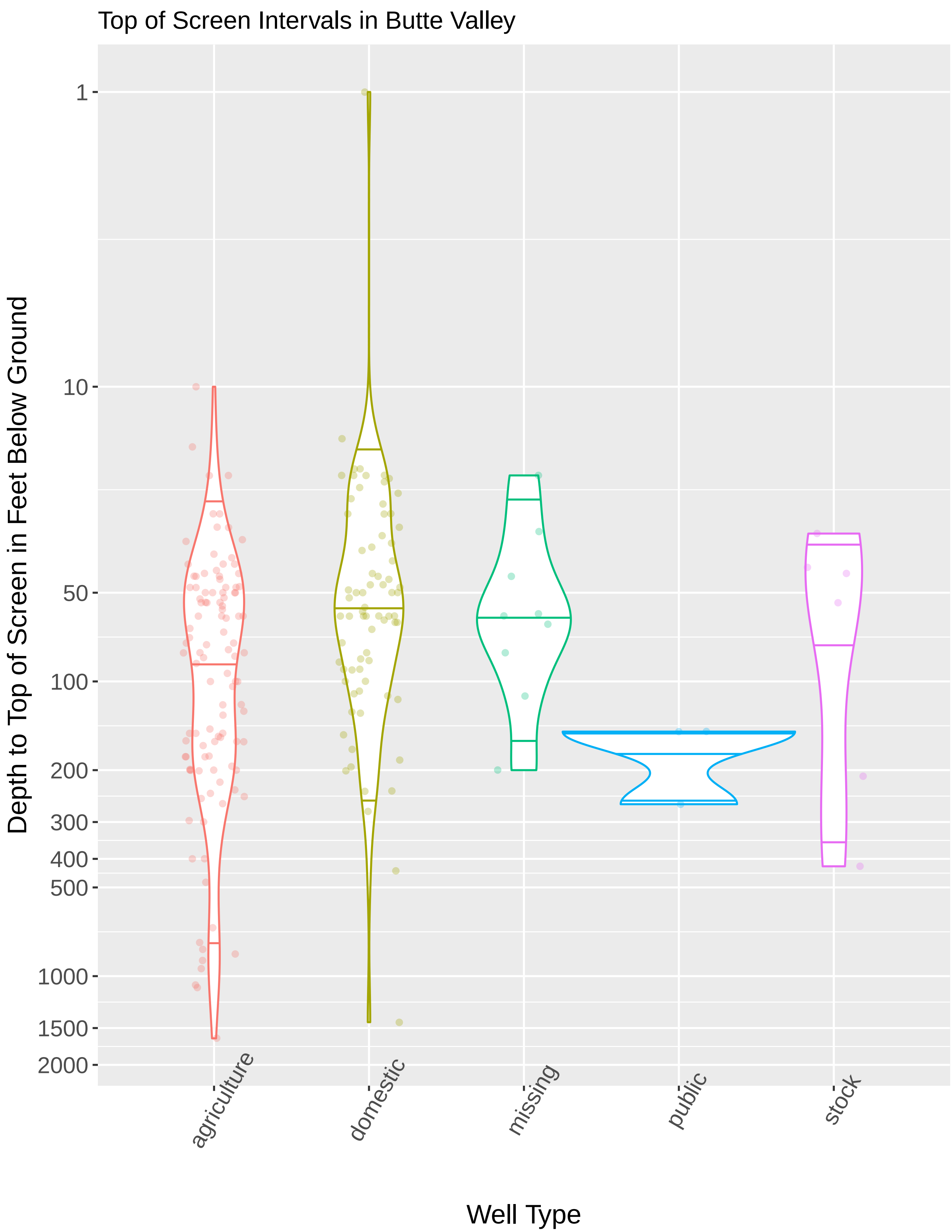


Figure 5: Violin plot with the y-axis in log space showing the top of well screens in Butte Valley. Thicker sections indicate more frequency. Points show individual wells in the dataset.

48

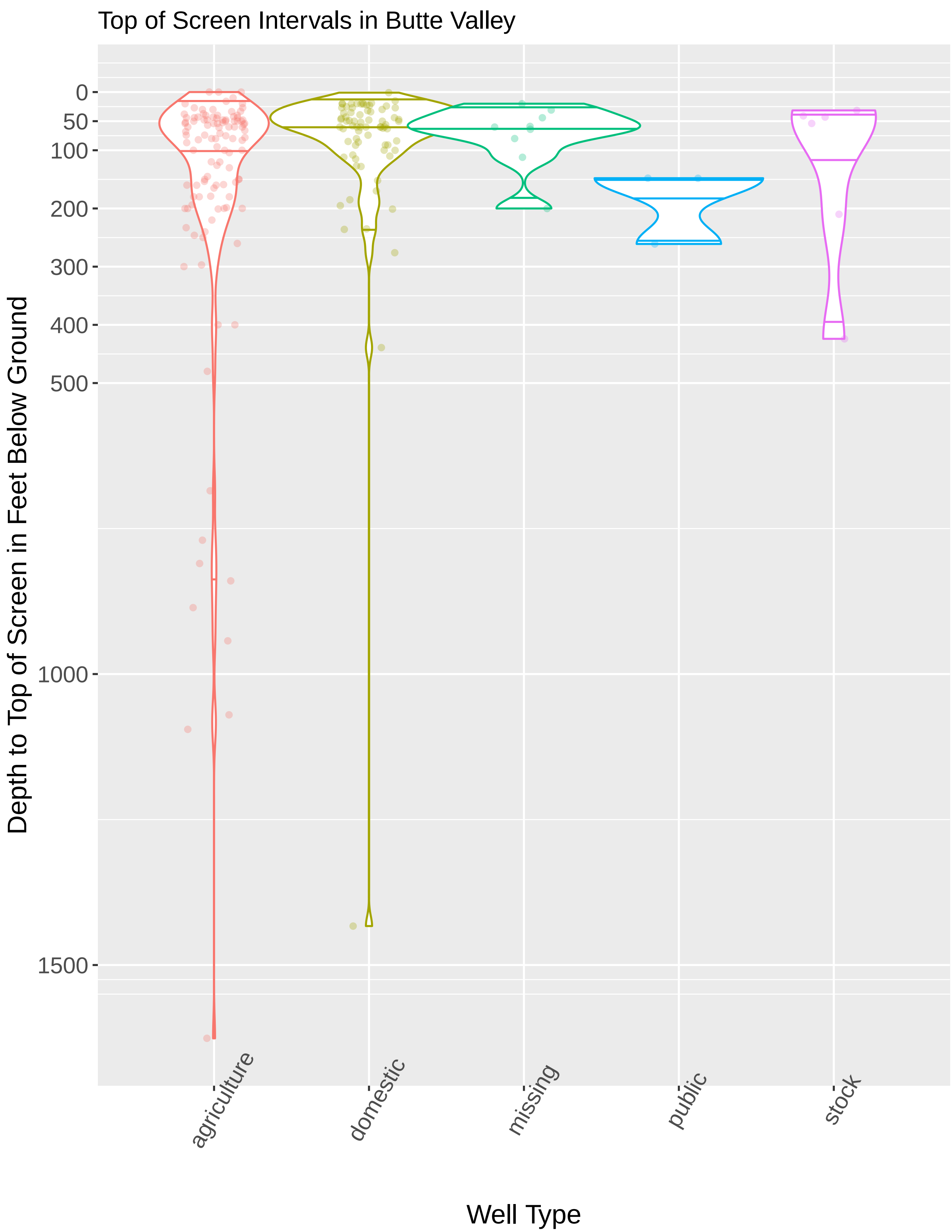


Figure 6: Violin plot with the y-axis in normal space showing the top of well screens in Butte Valley. Thicker sections indicate more frequency. Points show individual wells in the dataset.

49

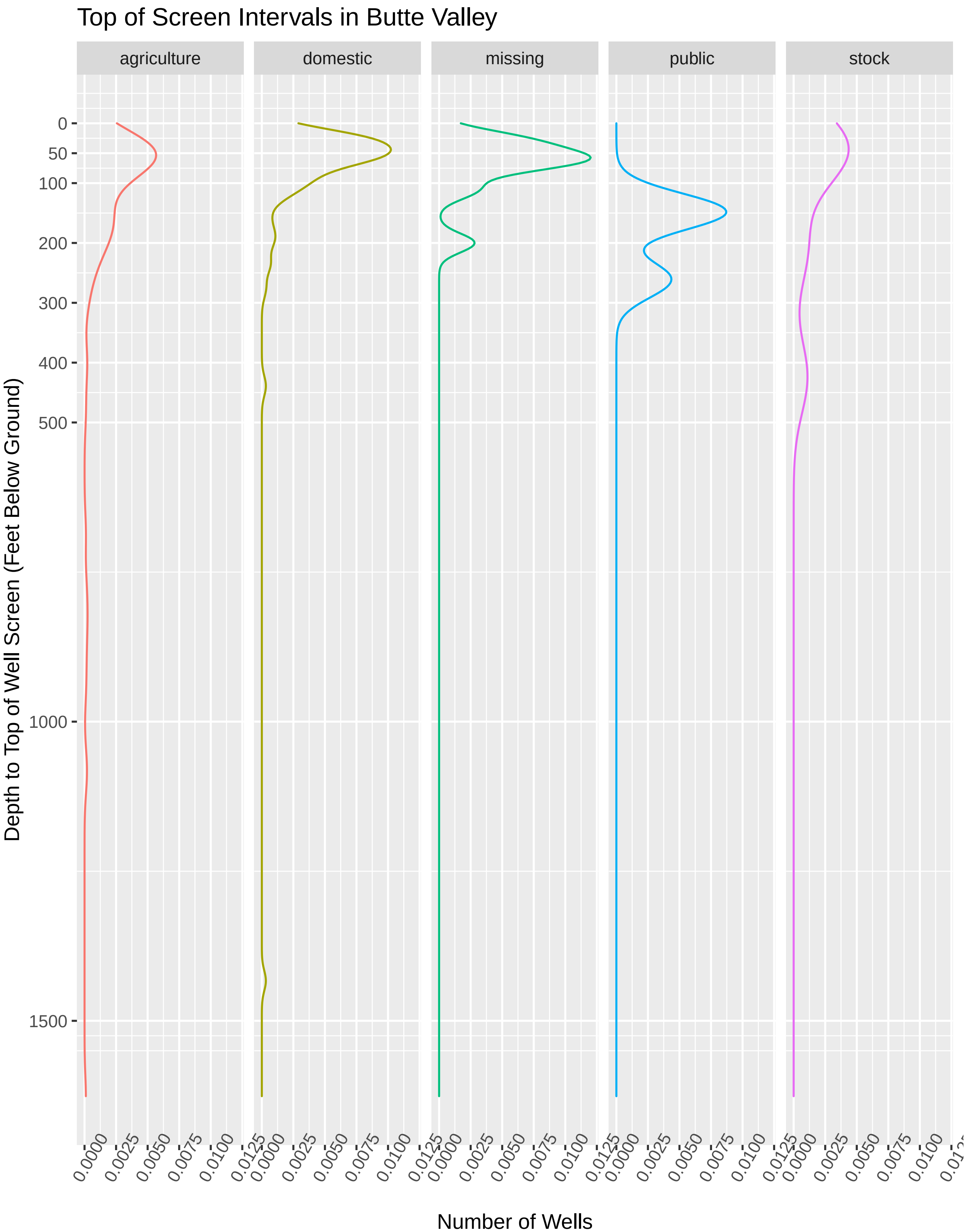


Figure 7: Distribution of the top of well screens in Butte Valley, plotted vertically.

50

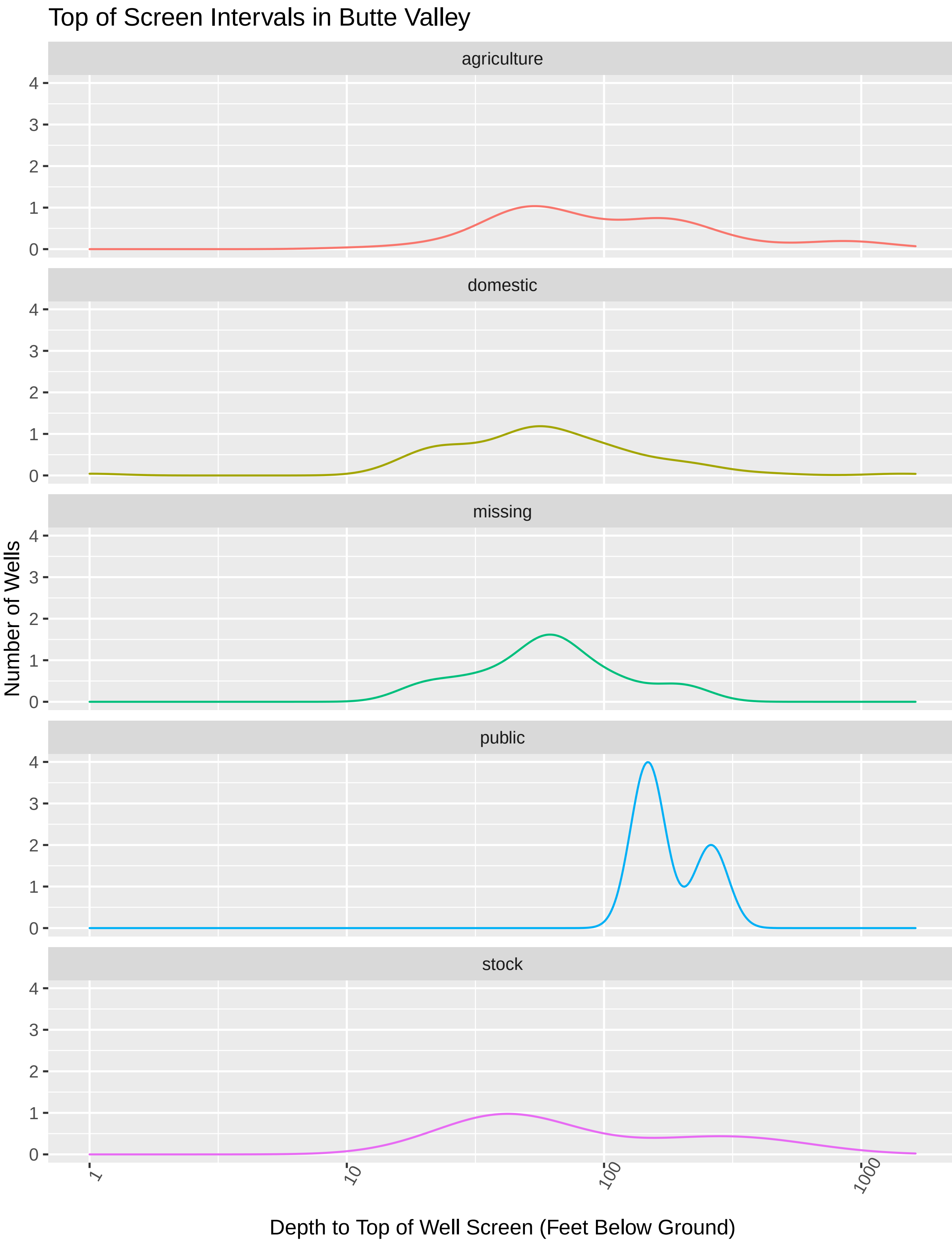


Figure 8: Distribution of the top of well screens in Butte Valley, plotted horizontally.

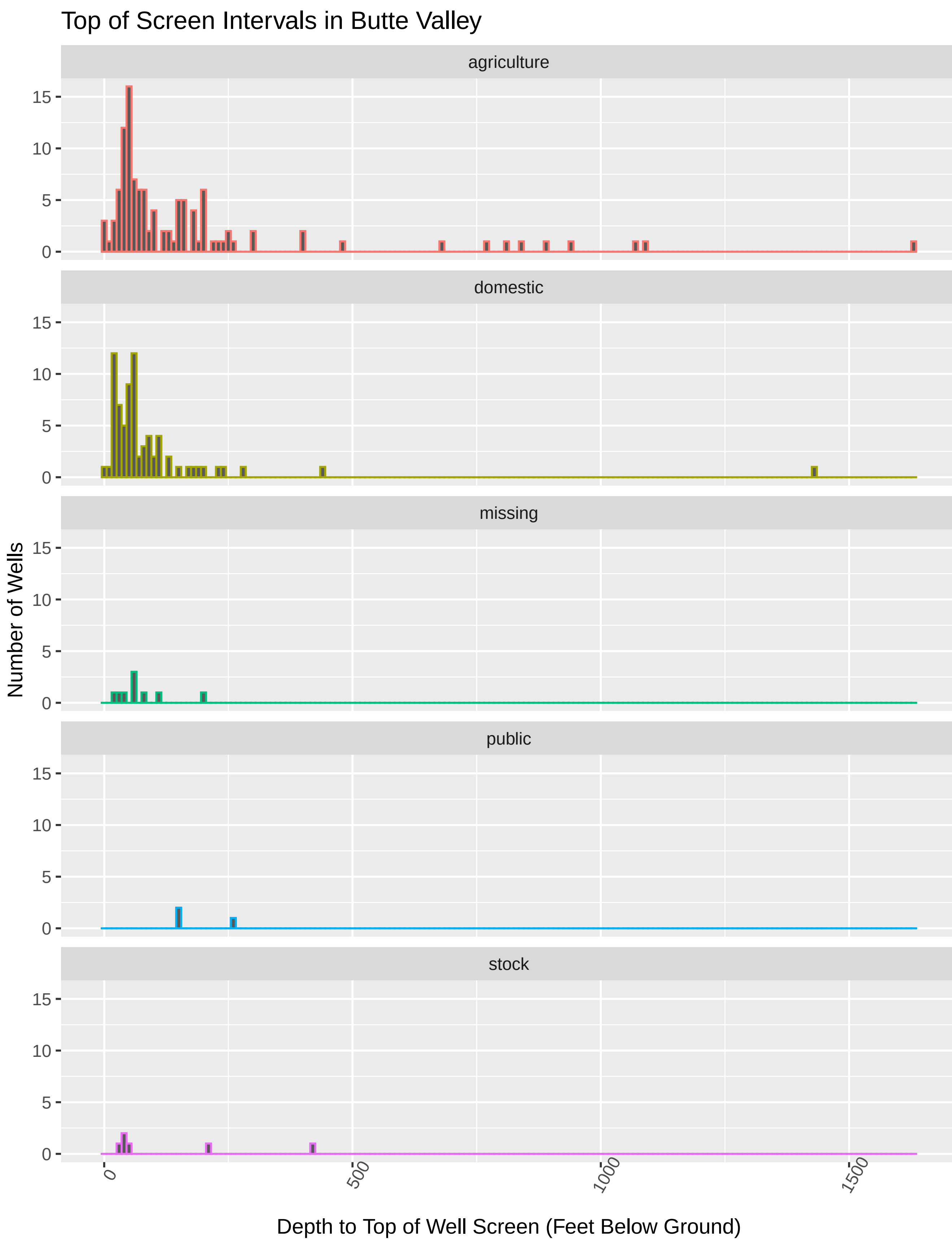


Figure 9: Histogram of Top of Well Screens in Butte Valley. Number of wells are shown on the y-axis with depth shown on the x-asis.

52

Figure 10: Histogram of Total Completed Depth in Butte Valley. Number of wells are shown on the y-axis with depth shown on the x-asis.

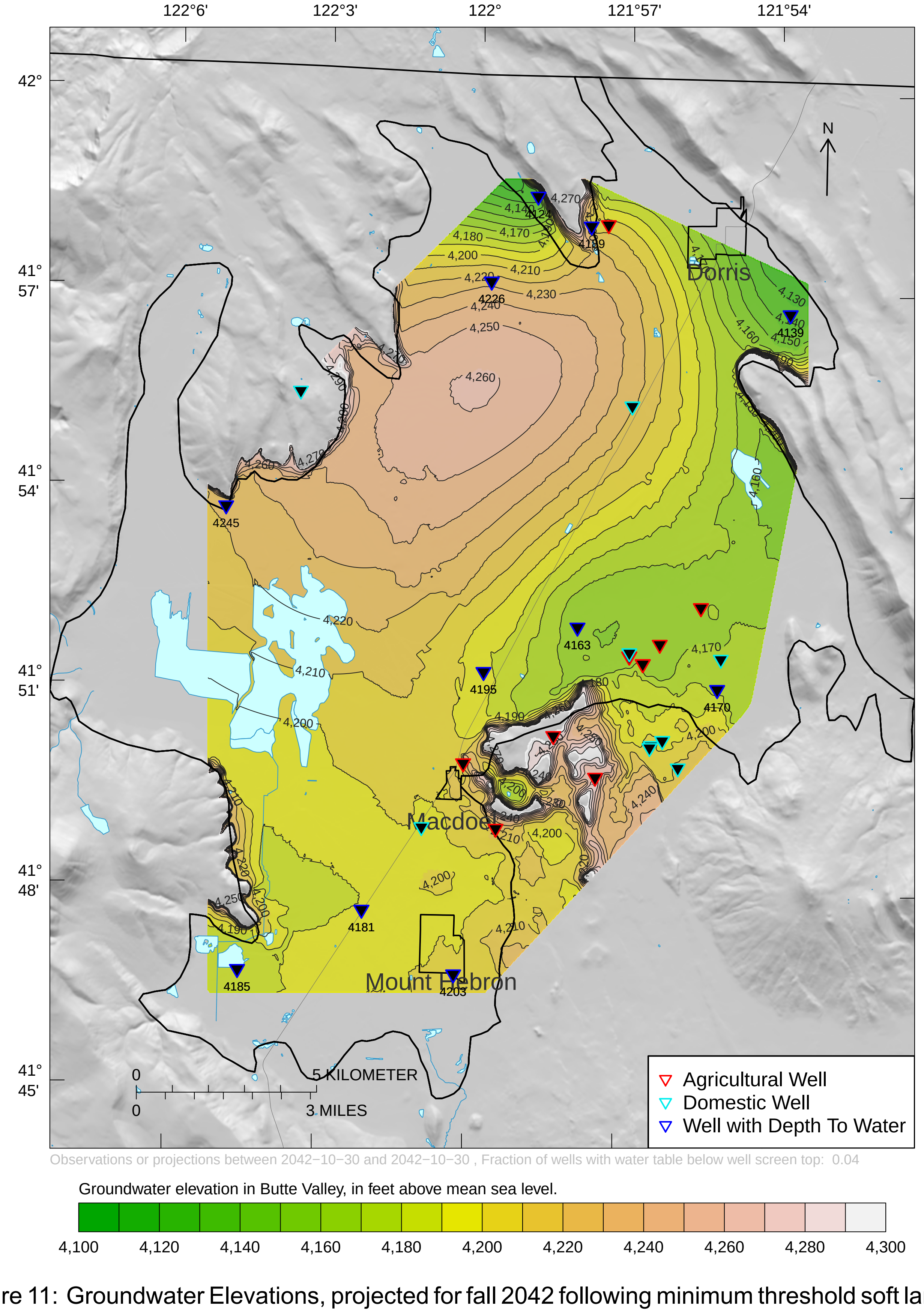


Figure 11: Groundwater Elevations, projected for fall 2042 following minimum threshold soft landing estimates. Butte Valley wells that are already in production in 2020. Only wells built between 1980 and 2020 are considered in this estimate.

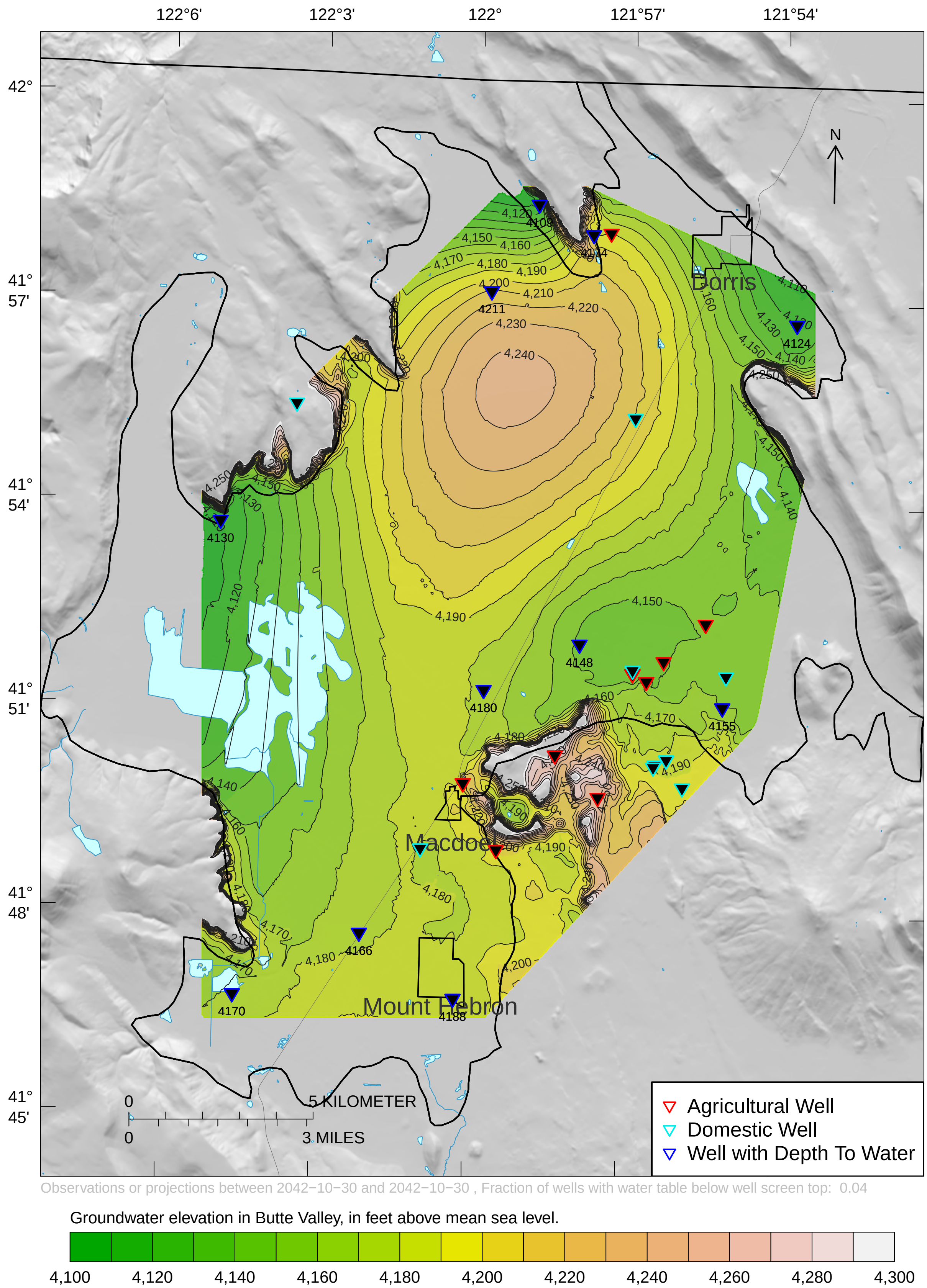


Figure 12: Groundwater Elevations, projected for fall 2042 following minimum threshold extended landing estimates. Butte Valley wells that are already in production in 2020. Only wells built between 1980 and 2020 are considered in this estimate.