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October 26, 2018

Mr. Aaron Yue
Project Manager
California Environmental Protection Agency,
Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Subject: Conductivity Profile Results from Topock Compressor Station Monitoring Wells

Dear Mr. Yue:

This letter presents specific conductivity profiles measured at Groundwater Monitoring Program (GMP) and Construction Monitoring Program (CMP) monitoring wells at the Topock Compressor Station (TCS) in Needles, California, as requested by DTSC. Collection of this profile data was identified as a condition of Agency approvals for low-flow sampling or sampling trials in 2017 correspondence and related discussions (DTSC, 2017a-c).

As requested, profiles or plots of specific conductance (conductivity) vs. depth are presented for two groups of data: historical data where multiple profiles were measured in a monitoring well over time, and a set of data collected site-wide during the fourth quarter (4Q) 2017 annual monitoring event when a specific conductivity profile was measured in as many GMP and CMP monitoring wells as practical. A total of 134 wells were profiled before sampling during the 4Q 2017 event.

A series of maps (for the shallow, mid-depth, and deep groundwater zones) is also attached that summarizes the 4Q 2017 results showing the conductivity range observed in each well (i.e., the difference in conductivity between the blank casing above the screen and the bottom of the screen interval measured using a downhole conductivity probe), as well as the measured conductivity in each well from groundwater samples collected after the profiling (see Figure 1). The following discussion presents the background for this work, conductivity profiles, summary map and interpretation, conclusions, and recommendations.

Background

Conductivity profiles were measured and used to calculate average salinity over the water column in Topock monitoring wells instrumented with transducers for continuous water level measurements. The average salinity is used for a density correction to the transducer groundwater elevation data.

When reviewing conductivity profiles for monitoring wells, the DTSC noted that stratification in the water column (the gradient or change in conductivity with depth) varied between different monitoring wells, and that early in Interim Measure No. 3 (IM-3) operations efforts were made to mix the monitoring well water column by purging the wells while raising and lowering the pump. Later, the standard procedure for three-volume purge sampling placed the pump closer to the top of the water column, effectively mixing the water column when the wells were sampled. With the approval of minimal drawdown (MD) or low-flow groundwater sampling methods, the sampling pump was placed at mid-screen or specific depths within the well screen and the wells were no longer mixed during the sampling purge. The DTSC was concerned about an increase in conductivity stratification over time

without well mixing by pumping the entire water column, and DTSC asked for the profiles and interpretation presented in this letter.

Conductivity Profile Plots

A total of 134 wells were profiled during December 2017 before the wells were purged for sampling, and the conductivity profiles are provided in graphical form in Attachment 1. A tabular listing of all data collected in the December 2017 profiling is provided in Table 1, including the conductivity range observed in the profile, conductivity measurement from the 4Q 2017 sampling event, and depth to bedrock from the mid-screen interval for each well. The last two columns of the table summarize profiling history for wells with previous profile data.

Several wells could not be profiled: wellhead configuration prevented profiling at PE-01, PM-03, PM-04, TW-2S, and TW-2D. Access restriction prevented profiling at MW-40 and MW-68. Difficulty using the sonde with installed pumps prevented profiling at MW-24BR, MW-66BR-270, PGE-07BR, PGE-08BR, and TW-01. There was too little water in MW-30-30 to achieve a meaningful profile, and MW-57-050 and MW-58-065 were dry. Finally, the slant wells MW-52, MW-53, and MW-56 could not be profiled with a vertical sonde.

Of the 134 wells profiled, 25 had multiple profiles taken in their history, and an additional 13 wells had one previous profile run. The remaining 96 wells were profiled for the first time in December 2017. Most wells with multiple previous profiles had 2017 results that were consistent with previous data. Exceptions to this were wells MW-31-135, MW-34-080, MW-42-065, OW-1S, OW-2S, and OW-5S, which showed either higher or lower conductivity in December 2017 than in previous events. These wells are all affected by the IM-3 activity, either from extraction at the floodplain or injection at the East Mesa, and conductivity and water quality in general would be expected to vary in some wells of these areas. For the wells with only one prior profile, 12 showed a significant difference, but the previous profile for these wells was from 2005 or 2006, with no other event until 2017. There are not enough data for these wells to assess a historical trend.

The December 2017 profiles represent conditions after many months without purging or sampling, so they serve as a unique sitewide snapshot of conductivity vs. depth in the majority of site monitoring wells. The approximate range of conductivity was recorded for each well (Table 1), from the upper part of the water column to the bottom of the screen interval. The profiles in Attachment 1 show irregular conductivity readings in the first few inches of water, and in some cases very high conductivity in the sump below the screen interval – these data were not considered in calculating the conductivity range.

Map of Specific Conductivity Ranges and Values

Figure 1 presents maps of the 2017 specific conductivity profile results that provide an aerial view of specific conductivity ranges measured in the monitoring wells; it includes maps of the wells in the Upper, Middle, and Lower aquifer zones (consistent with maps in GMP reports). The wells profiled included 43 wells in the Upper aquifer zone (designated the Shallow Zone on Figure 1), 20 wells in the Middle zone (Mid-Depth Zone on Figure 1), and 51 and 18 wells in the Lower aquifer and Bedrock zones (Deep Zone of Figure 1), respectively.

The colored dot for each well on Figure 1 shows two values:

- The color expresses the range of conductivity (the difference in values measured in groundwater in blank casing above the screen, to the bottom of the screened interval). The conductivity ranges from profile data collection were divided into five color categories, based on magnitude, and plotted on the map.

- The size of the dot expresses the magnitude of the field measurement of specific conductivity recorded during groundwater sample collection. The diameter of the color dot at each well is one of three sizes corresponding to three conductivity ranges into which the field measurement falls (less than 5,000 microsiemens per centimeter [µS/cm], 5,000 to 15,000 µS/cm, and greater than 15,000 µS/cm) to indicate the relative magnitude of the Q4 2017 conductivity field measurement collected during groundwater sampling, after the profile data collection.

The highest conductivity ranges in the profiles, represented by the red dots on Figure 1, range from 5,000 to 20,000 µS/cm (Table 1). The majority of these wells are located in the IM-3 extraction area, the TCS area, and the East Ravine. The vertical patterns of the high-conductivity-range wells vary (Attachment 1): for some, much of the range is from low-conductivity water near the top of the water column, and for others it is from a large increase in conductivity with depth across the screen interval. For the latter group of wells, the large increase at the bottom is commonly due to the proximity of the basal saline unit, directly overlying the bedrock surface. As an illustration of this relationship, Figure 2 shows a plot of the mid-screen interval distance from bedrock vs. the conductivity range.

Specific Conductivity Range and Screen Distance from Bedrock

Figure 2 plots the depth to bedrock from the mid-screen interval vs. the conductivity range for all wells profiled in Q4 2017. For the wells with ranges greater than 5,000 µS/cm, nearly all are from deep wells close to the bedrock surface. These wells are located primarily in the TCP and IM-3 extraction areas. Exceptions in this group are MW-29 and MW-32-20, which are labeled on Figure 2. Well MW-29 likely represents perched, stagnant water, as this well does not respond to river fluctuations despite its close proximity to the Colorado River. The same is true for MW-32-20, which is located on the southern floodplain in an area of heavy salt cedar vegetation and former dredge spoils where saline soil led to corrosion and replacement of the MW-32 well monuments. The deeper well in this cluster, MW-32-035, shows essentially no range in conductivity (Table 1, Attachment 1). Also labeled on Figure 2 are TW-04 and TW-05 which are longer-screen, 4-inch-diameter test wells with a specific conductivity range of approximately 6,000 µS/cm. Aside from these exceptions, the wells that exhibit a conductivity range greater than 5,000 µS/cm are screened in the lower unconsolidated aquifer (deep zone Figure 1) or in bedrock.

The high ranges of other wells in the IM-3 pumping area may reflect the influence of groundwater extraction, with significant vertical gradients created by historical extraction at MW-2D/3D and at PE-01. Some of the bedrock wells in the East Ravine in the southeast portion of the maps in Figure 1 also show high ranges (Table 1, Figures 1 and 2). Bedrock wells in the East Ravine area set in crystalline bedrock are screened in a different hydrogeologic regime than the wells screened in alluvium and Miocene conglomerate bedrock across the floodplain and uplands over most of the area shown in Figure 1. For example, East Ravine bedrock wells MW-61, MW-64 and MW-72 show a high range of specific conductivity in shallow zone screens and are the three bedrock (yellow) points in Figure 2 clustered near a conductivity range of 10,000 to 12,000 µS/cm.

Conclusions

When exceptions such as East Ravine bedrock wells, hydraulically isolated wells such as MW-29, and wells in salty surface soil locations such as MW-32 are considered, there are patterns in conductivity range observed in 4Q 2017 profiles that relate to map location and distance from bedrock. The patterns of the sample conductivity value (sampling data) and profile conductivity range (profile data) make sense in the larger context across the site of the IM-3 injection area, the IM-3 extraction area and the lower conductivity Colorado River, and a more general increase in groundwater specific conductivity with depth (and with proximity to the basal saline layer of groundwater generally present above bedrock).

Figure 1 shows several patterns by location. First, at the IM-3 injection area, associated with wells designated “OW-“ and “CW-“, lower profile conductivity ranges are seen in monitoring wells at the injection area at all depth zones. The relatively low and uniform sample conductivity values are interpreted as the result of IM-3 injection breakthrough at all depths in this area.

Another pattern is seen on the floodplain area of Figure 1, located immediately west of the Colorado River, including the IM-3 extraction pumping area. As discussed above, some shallow floodplain wells such as MW-32 have higher conductivity sample values and profile ranges attributed to salt-tolerant vegetation and former dredge spoils at the well locations. Wells that are closer to IM-3 extraction pumping influence, such as the cluster of wells between MW-20 and MW-34 on Figure 1 including MW-27 and MW-44, have lower sample conductivity values that may reflect a long-term trend to an increased river water signature in this area, resulting from landward hydraulic gradients and downward vertical hydraulic gradients induced by extraction pumping. These wells have low profile conductivity ranges in the shallow and mid-depth zones, but high conductivity profile ranges in the deep zone, where well screens are close to the basal saline layer at the alluvium/Miocene bedrock interface. The deep zone sample conductivity values are higher for wells more distant from IM-3 extraction pumping, such as MW-43, MW-46, MW-47 or MW-49.

Finally, in the TCS area of Figure 1, both the sample conductivity value and the profile conductivity range increase with depth (or with proximity to bedrock and the basal saline layer).

The low-flow sampling purge with the pump in the screened interval creates laminar flow to collect a sample representative of groundwater conditions at the pump depth. Because of that, it is our assertion that while the patterns seen in the sample value and profile range of conductivity are of some interest in relation to the existing site conceptual model, these patterns do not have a practical impact on the use of low-flow sampling. Comparison of the December 2017 specific conductivity profiles in Attachment 1 with the specific conductivity values in Table 1 measured at the December 2017 groundwater sampling event conducted a few days after profiling the wells reveals close agreement between the two values (a difference of 20 percent or less) in the screened interval of each well. While water in the blank casing may differ in specific conductivity from the groundwater below, within the screened interval the agreement between profiled and sampled conductivity values indicates that low-flow sampling near mid-screen is not affected by the water above the well screen.

Key gradient wells are corrected with density profiles in a rigorous effort to remove sources of groundwater elevation measurement error. Other wells in the larger site-wide groundwater elevation network are not as rigorously corrected for density throughout the water column; however, the resulting error is too small to affect site wide groundwater elevation maps.

Recommendations

PG&E does not recommend or seek any change to pumping or sampling methods based on this study.

No repeat site-wide conductivity profile data collection is recommended, other than ongoing profile data collection that is related to key gradient well density corrections.

Because low-flow sampling methods create laminar flow to collect groundwater from the screened interval where the pump is set, PG&E does not recommend any new program for mixing wells to homogenize conductivity throughout the water column.

Please contact me at 760-791-5884 if you have any questions about this.

Sincerely,

Curt Russell
Topock Project Manager

Enclosures:

Table 1 – Specific Conductivity Profile Data Summary, December 2017

Figure 1 – Specific Conductivity Range in Vertical Profiles of Monitoring Wells, December 2017
Figure 2 – Depth to Bedrock from Mid-Screen vs. Specific Conductivity Range in Profile

Attachment 1 – Specific Conductivity Profile Plots for 134 Monitoring Wells

cc: Chris Guerre/DTSC
Karen Baker/DTSC
Pam Innis/DOI

References

California Department of Toxic Substances Control (DTSC). 2017a. *Memorandum. "Proposal for Alternative Groundwater Sampling Trial; Pacific Gas and Electric Company (PG&E) Topock Compressor Station Site, Needles, California (EPA ID No. CAT080011729)."* April 6.

California Department of Toxic Substances Control (DTSC). 2017b. *Memorandum. "Response to Comments on Proposal for Alternative Groundwater Sampling Trial; Pacific Gas and Electric Company (PG&E) Topock Compressor Station Site, Needles, California (EPA ID No. CAT080011729)."* October 20.

California Department of Toxic Substances Control (DTSC). 2017c. *Memorandum. "Response to Pacific Gas and Electric Company (PG&E) Comments on Well Salinity Stratification, Topock Compressor Station Site, Needles, California (EPA ID No. CAT080011729)."* November 1.

Table

Table 1. Specific Conductance Profile Data Summary, December 2017

Topock Compressor Station, Needles, California

Well Name	Aquifer Zone	Approximate Profile Conductivity Range (µS/cm)	Distance to Bedrock from Middle of Screen Interval (ft)	Field Conductivity (µS/cm)	First Profile Date	Total Number of Profiles
CW-01D	Lower UA	300	83.0	7,000	05/03/05	17
CW-01M	Lower UA	300	192.6	7,000	05/03/05	16
CW-02D	Lower UA	0	70.0	7,300	05/03/05	16
CW-02M	Lower UA	0	199.9	7,300	05/03/05	16
CW-03D	Lower UA	0	64.5	7,400	05/03/05	16
CW-03M	Middle UA	0	162.5	8,000	05/03/05	16
CW-04D	Lower UA	0	76.0	7,300	05/03/05	14
CW-04M	Lower UA	0	189.9	7,200	05/03/05	13
MW-09	Upper UA	250	4.1	3,990	12/06/17	1
MW-10	Upper UA	750	65.3	3,100	12/06/17	1
MW-11	Upper UA	250	123.3	3,100	12/07/17	1
MW-12	Upper UA	2,600	12.6	8,880	12/08/17	1
MW-13	Upper UA	0	218.3	3,310	12/08/17	1
MW-14	Upper UA	1,200	219.2	3,720	12/11/17	1
MW-15	Upper UA	600	69.2	2,010	12/12/17	1
MW-16	Upper UA	0	75.4	1,240	12/12/17	1
MW-17	Upper UA	0	267.9	1,380	12/11/17	1
MW-18	Upper UA	600	253.5	1,600	12/11/17	1
MW-19	Upper UA	0	173.3	2,320	12/07/17	1
MW-20-070	Upper UA	0	90.1	2,580	12/07/17	1
MW-20-100	Middle UA	0	55.5	2,880	12/07/17	1
MW-20-130	Lower UA	7,300	24.1	9,790	07/01/05	8
MW-21	Upper UA	0	11.1	19,200	12/08/17	1
MW-22	Upper UA	0	4.2	26,300	12/04/17	1
MW-23-060	Bedrock	0	N/A	17,500	12/08/17	1
MW-23-080	Bedrock	1,200	N/A	17,800	12/08/17	1
MW-24A	Upper UA	0	112.9	2,170	12/06/17	1
MW-24B	Lower UA	9,300	21.8	21,600	12/07/17	1
MW-25	Upper UA	500	126.5	2,110	12/07/17	1
MW-26	Upper UA	0	61.4	5,030	12/07/17	1
MW-27-020	Upper UA	0	74.8	1,030	12/04/17	1
MW-27-060	Middle UA	0	34.1	1,020	12/04/17	1
MW-27-085	Lower UA	10,000	3.9	10,300	07/19/05	22
MW-28-025	Upper UA	0	181.9	1,260	12/06/17	1
MW-28-090	Lower UA	3,900	119.9	6,920	12/06/17	1
MW-29	Upper UA	10,000	336.0	1,790	12/06/17	1
MW-30-050	Upper UA	0	61.4	1,110	12/05/17	1
MW-31-060	Upper UA	800	133.6	3,510	12/08/17	1
MW-31-135	Lower UA	2,100	62.1	13,200	05/06/05	25

Table 1. Specific Conductance Profile Data Summary, December 2017

Topock Compressor Station, Needles, California

Well Name	Aquifer Zone	Approximate Profile Conductivity Range (µS/cm)	Distance to Bedrock from Middle of Screen Interval (ft)	Field Conductivity (µS/cm)	First Profile Date	Total Number of Profiles
MW-32-020	Upper UA	20,000	20.1	31,800	12/04/17	1
MW-32-035	Upper UA	0	3.9	9,810	12/04/17	1
MW-33-040	Upper UA	2,100	188.0	14,900	12/06/17	1
MW-33-090	Middle UA	600	143.0	10,400	12/06/17	1
MW-33-150	Lower UA	2,900	80.0	15,000	05/05/05	24
MW-33-210	Lower UA	0	22.0	19,800	12/06/17	1
MW-34-055	Middle UA	0	47.9	1,020	12/05/17	1
MW-34-080	Lower UA	5,600	20.1	7,910	08/17/04	13
MW-34-100	Lower UA	5,800	3.4	11,900	02/08/05	26
MW-35-060	Upper UA	3,300	317.1	7,010	12/06/17	1
MW-35-135	Lower UA	2,000	242.2	11,000	12/06/17	1
MW-36-020	Upper UA	0	82.5	5,400	12/05/17	1
MW-36-040	Upper UA	0	62.7	1,070	12/05/17	1
MW-36-050	Upper UA	0	49.3	1,100	12/05/17	1
MW-36-070	Middle UA	0	32.5	1,040	12/05/17	1
MW-36-090	Lower UA	0	12.7	5,720	12/05/17	1
MW-36-100	Lower UA	15,200	4.8	8,180	12/05/17	1
MW-37D	Lower UA	0	37.7	18,400	12/07/17	1
MW-37S	Middle UA	3,700	153.5	8,760	12/07/17	1
MW-38D	Lower UA	0	12.0	24,000	12/06/17	1
MW-38S	Upper UA	400	99.8	1,770	12/06/17	1
MW-39-040	Upper UA	0	73.2	1,250	12/04/17	1
MW-39-050	Middle UA	0	58.6	1,070	12/04/17	1
MW-39-060	Middle UA	0	54.3	1,210	12/04/17	1
MW-39-070	Middle UA	500	43.2	1,960	12/04/17	1
MW-39-080	Lower UA	0	33.1	5,140	12/04/17	1
MW-39-100	Lower UA	18,100	18.3	14,300	12/04/17	1
MW-41D	Lower UA	0	18.9	22,900	12/12/17	1
MW-41M	Lower UA	0	120.1	16,000	12/12/17	1
MW-41S	Upper UA	0	250.4	6,970	12/12/17	1
MW-42-030	Upper UA	2,900	50.6	2,770	12/04/17	1
MW-42-055	Middle UA	0	22.7	1,090	12/04/17	1
MW-42-065	Lower UA	11,200	8.8	2,060	02/10/05	10
MW-43-025	Upper UA	0	69.1	1,390	12/04/17	1
MW-43-075	Lower UA	4,000	19.0	11,800	12/04/17	1
MW-43-090	Lower UA	5,500	4.0	18,000	07/27/05	2
MW-44-070	Middle UA	900	58.0	1,460	04/03/06	2
MW-44-115	Lower UA	500	13.7	11,400	04/03/06	2
MW-44-125	Lower UA	17,000	5.0	14,200	04/03/06	2

Table 1. Specific Conductance Profile Data Summary, December 2017

Topock Compressor Station, Needles, California

Well Name	Aquifer Zone	Approximate Profile Conductivity Range (µS/cm)	Distance to Bedrock from Middle of Screen Interval (ft)	Field Conductivity (µS/cm)	First Profile Date	Total Number of Profiles
MW-45-095	Lower UA	8,900	7.0	N/A	04/03/06	22
MW-46-175	Lower UA	0	41.0	18,900	04/03/06	2
MW-46-205	Lower UA	0	10.0	23,400	04/03/06	2
MW-47-055	Upper UA	1,500	230.0	4,810	04/03/06	2
MW-47-115	Lower UA	2,700	170.0	14,200	04/03/06	2
MW-48	Bedrock	500	N/A	22,700	12/08/17	1
MW-49-135	Lower UA	0	240.0	13,900	12/06/17	1
MW-49-275	Lower UA	4,600	100.0	26,200	12/06/17	1
MW-49-365	Lower UA	1,500	9.0	37,000	12/07/17	1
MW-50-095	Middle UA	3,000	137.0	6,060	12/07/17	1
MW-50-200	Lower UA	2,400	34.0	22,000	12/07/17	1
MW-51	Middle UA	2,100	8.5	15,800	12/07/17	1
MW-54-085	Middle UA	3,800	148.1	10,700	12/12/17	1
MW-54-140	Lower UA	700	97.1	13,700	12/12/17	1
MW-54-195	Lower UA	0	40.0	20,300	12/12/17	1
MW-55-045	Middle UA	400	89.0	1,530	12/12/17	1
MW-55-120	Lower UA	3,000	18.0	8,600	12/12/17	1
MW-57-070	Bedrock	0	N/A	2,630	12/08/17	1
MW-57-185	Bedrock	0	N/A	20,200	12/08/17	1
MW-58BR	Bedrock	200	N/A	9,290	12/11/17	1
MW-59-100	Upper UA	4,400	15.4	18,100	12/06/17	1
MW-60-125	Bedrock	2,600	N/A	13,100	12/06/17	1
MW-60BR-245	Bedrock	0	N/A	20,700	12/12/17	1
MW-61-110	Bedrock	9,600	N/A	21,300	12/05/17	1
MW-62-065	Bedrock	600	N/A	8,300	12/05/17	1
MW-63-065	Bedrock	1,900	N/A	6,940	12/12/17	1
MW-64BR	Bedrock	10,000	N/A	17,200	12/06/17	1
MW-65-160	Upper UA	300	73.0	N/A	12/05/17	1
MW-65-225	Lower UA	14,500	8.0	N/A	12/05/17	1
MW-66-165	Upper UA	1,600	81.0	N/A	12/05/17	1
MW-66-230	Lower UA	6,700	10.0	N/A	12/05/17	1
MW-67-185	Upper UA	2,100	89.0	N/A	12/04/17	1
MW-67-225	Middle UA	4,500	53.6	N/A	12/04/17	1
MW-67-260	Lower UA	4,700	16.1	N/A	12/04/17	1
MW-69-195	Bedrock	0	N/A	N/A	12/04/17	1
MW-70-105	Bedrock	1,800	N/A	N/A	12/08/17	1
MW-70BR-225	Bedrock	0	N/A	14,000	12/08/17	1
MW-72-080	Bedrock	12,000	N/A	17,900	12/05/17	1
MW-72BR-200	Bedrock	16,700	N/A	17,500	12/05/17	1

Table 1. Specific Conductance Profile Data Summary, December 2017

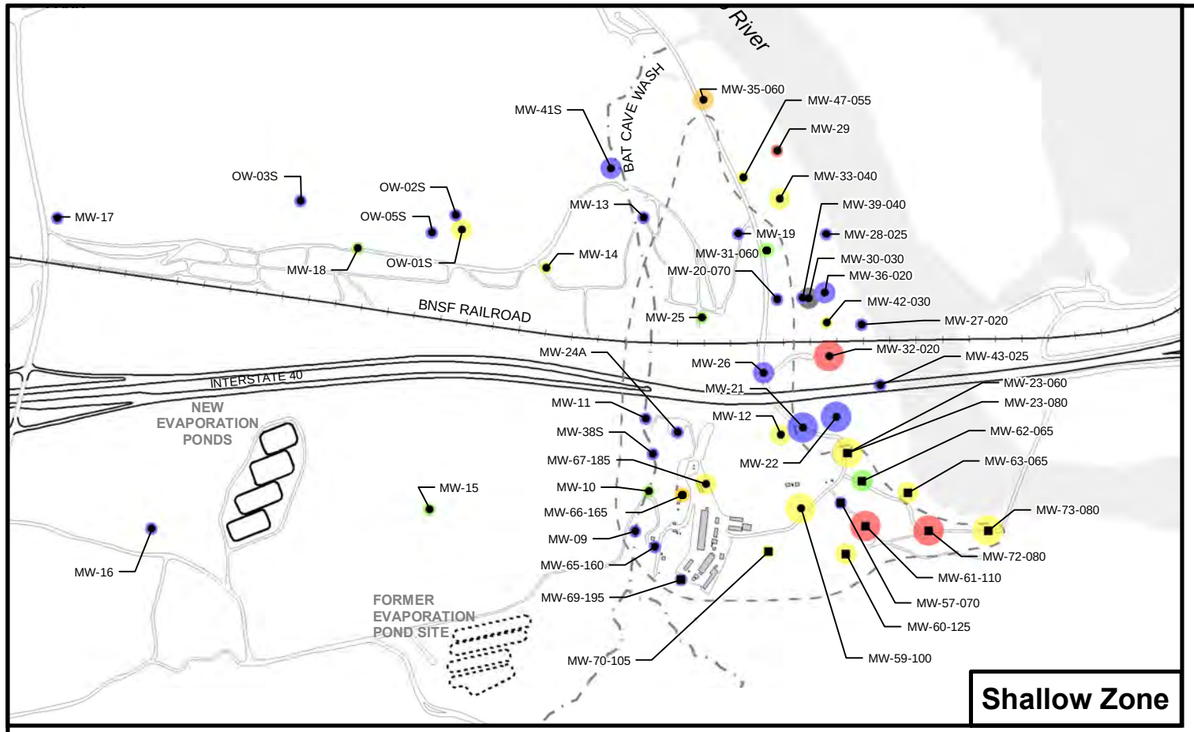
Topock Compressor Station, Needles, California

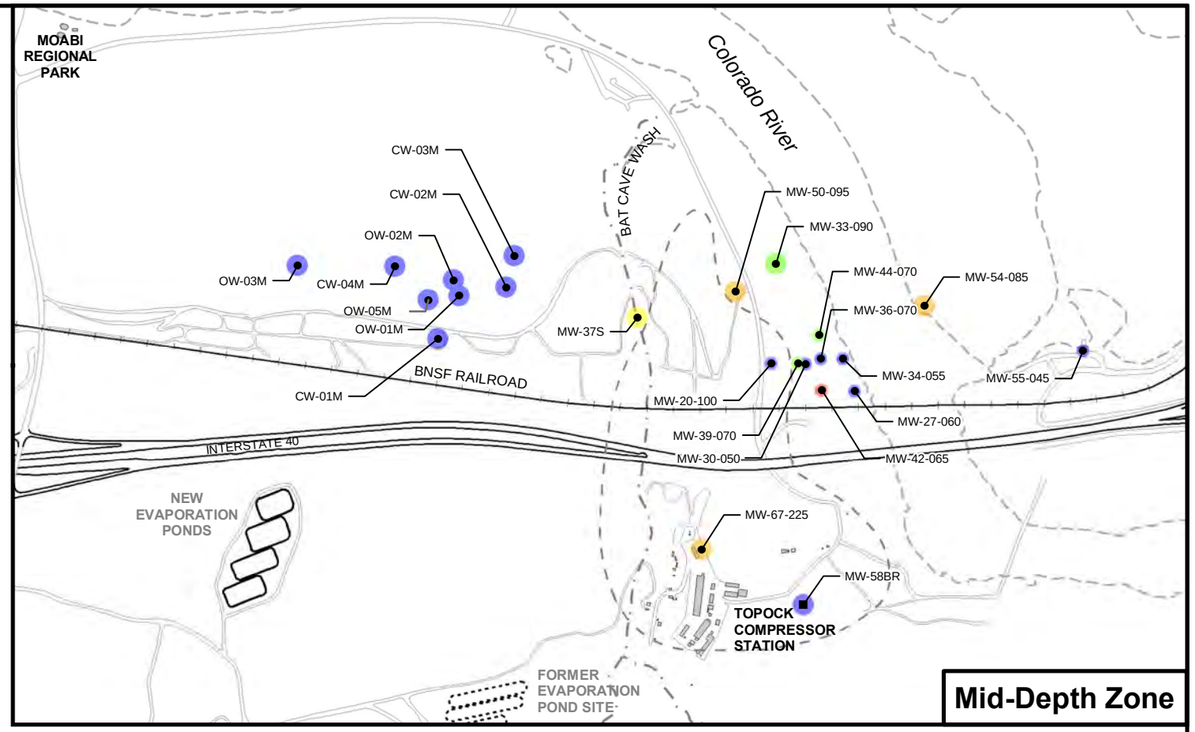
Well Name	Aquifer Zone	Approximate Profile Conductivity Range (µS/cm)	Distance to Bedrock from Middle of Screen Interval (ft)	Field Conductivity (µS/cm)	First Profile Date	Total Number of Profiles
MW-73-080	Bedrock	2,500	N/A	15,200	12/05/17	1
MW-74-240	Bedrock	0	N/A	N/A	12/04/17	1
OW-01D	Lower UA	200	72.8	6,900	04/14/05	17
OW-01M	Middle UA	0	164.7	6,900	04/14/05	16
OW-01S	Upper UA	1,700	241.1	5,500	04/14/05	18
OW-02D	Lower UA	0	38.7	7,100	04/14/05	15
OW-02M	Middle UA	0	157.9	7,000	04/14/05	13
OW-02S	Upper UA	0	272.2	2,900	10/28/08	12
OW-03D	Lower UA	1,900	123.9	10,000	04/14/05	2
OW-03M	Middle UA	0	186.2	6,860	04/14/05	2
OW-03S	Upper UA	0	274.8	1,640	04/14/05	2
OW-05D	Lower UA	400	36.0	7,000	04/14/05	15
OW-05M	Lower UA	500	115.5	7,000	04/14/05	13
OW-05S	Upper UA	0	255.6	4,400	04/14/05	14
PE-01	Lower UA	NM	NM	NM	07/27/05	2
TW-04	Lower UA	6,000	50.0	25,400	04/03/06	2
TW-05	Lower UA	6,000	98.9	14,900	12/12/17	1

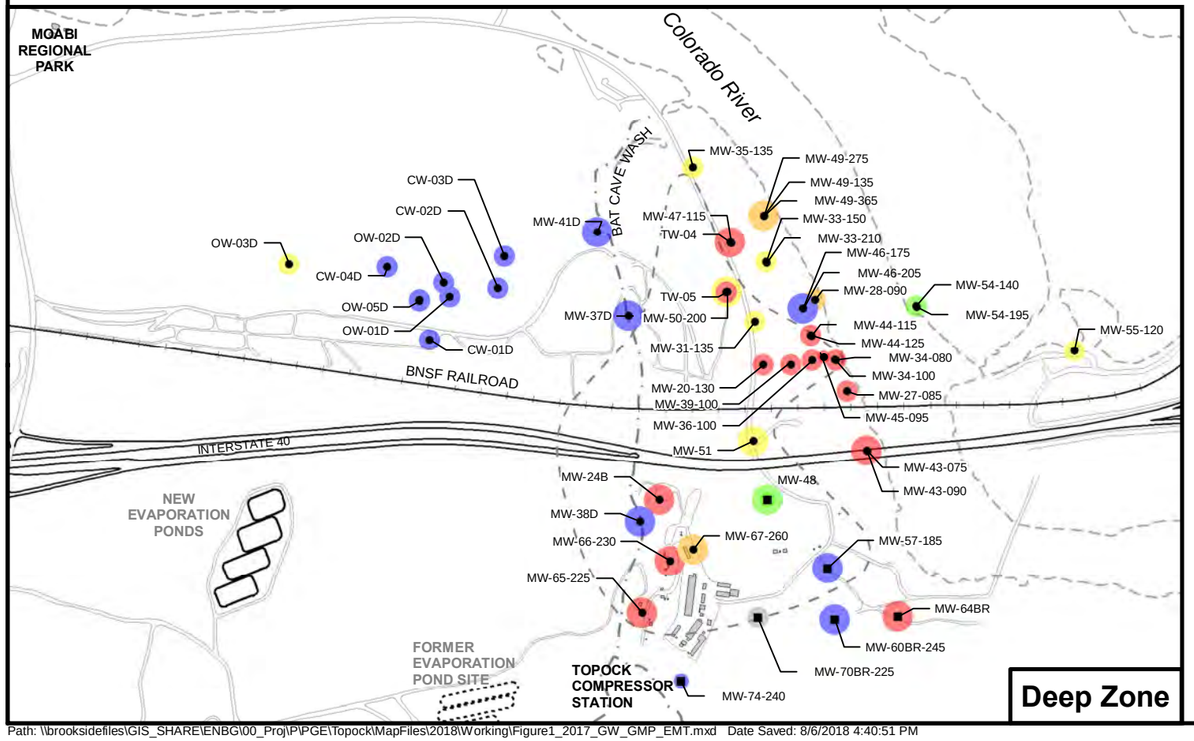
Notes:

µS/cm	microsiemens per centimeter
ft	feet
Bedrock	bedrock aquifer zone
Lower UA	lower unconsildated aquifer zone
Middle UA	middle unconsildated aquifer zone
Upper UA	upper unconsildated aquifer zone
N/A	not available
NM	not measured in 2017

Figures







LEGEND

- Groundwater well completed in Alluvial Aquifer
- Groundwater well completed in bedrock

Conductivity Range for December 2017 (values in µS/cm)

- <500
- 500 - 1000
- 1000 - 3000
- 3000 - 5000
- >5000

Symbol Size based on field measurements of Conductivity of Sample(s) Collected from Well (values in µS/cm)

- <5000
- 5000-15000
- >15000

NOTES:
1. Conductivity range represents approximate difference in conductivity between blank casing above screen and the bottom of the screen interval measured using a downhole conductivity probe.
2. For co-located wells, the well with highest conductivity range was used for the symbol category.

N

FIGURE 1
SPECIFIC CONDUCTIVITY RANGE IN VERTICAL PROFILES OF MONITORING WELLS, DECEMBER 2017

PG&E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

JACOBS

Path: \\brooksidefiles\GIS_SHARE\ENBG\00_Proj\P\PGE\Topock\MapFiles\2018\Working\Figure1_2017_GW_GMP_EMT.mxd Date Saved: 8/6/2018 4:40:51 PM

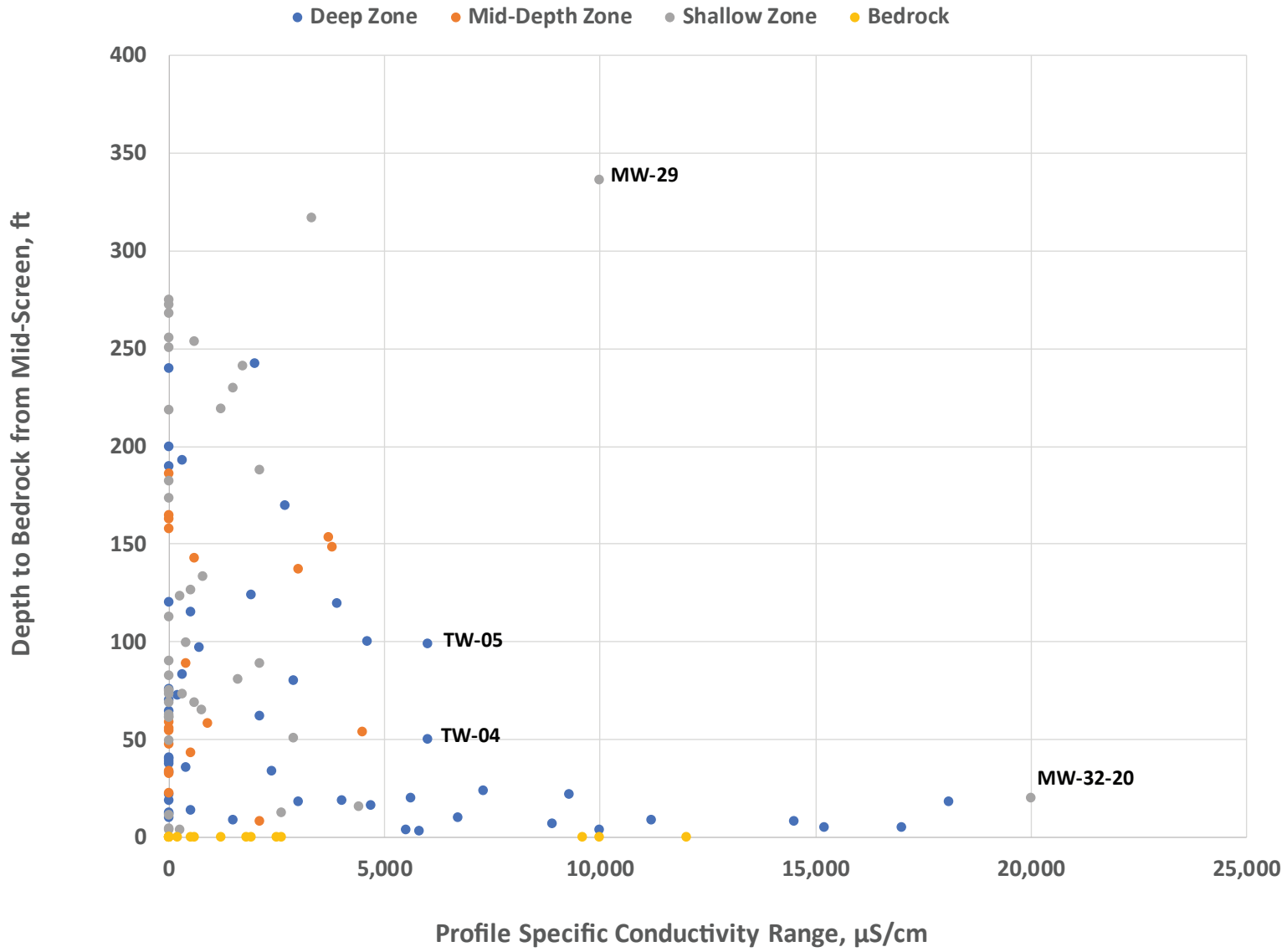
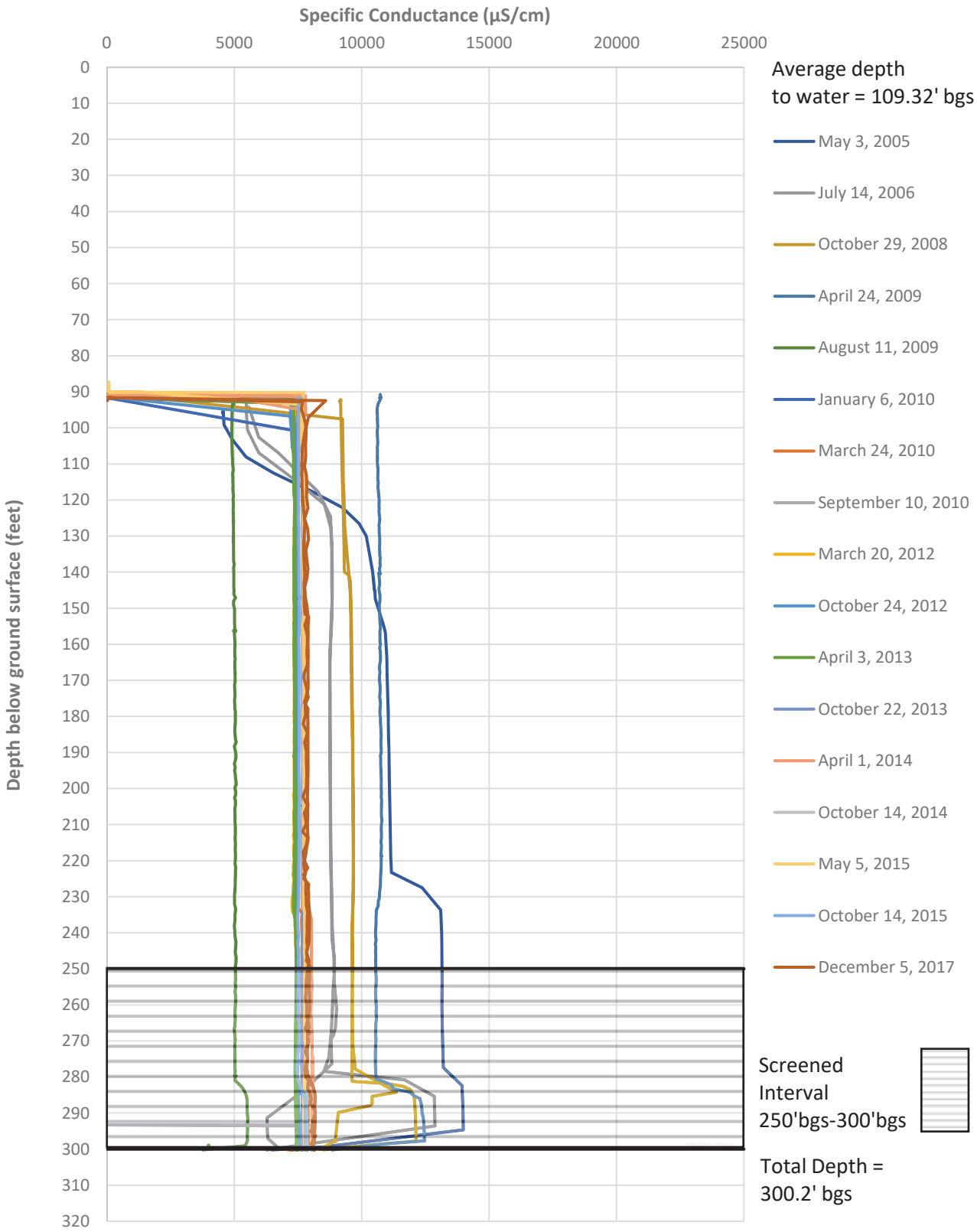


FIGURE 2
DEPTH TO BEDROCK FROM MID-SCREEN vs. SPECIFIC CONDUCTIVITY RANGE IN PROFILE
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

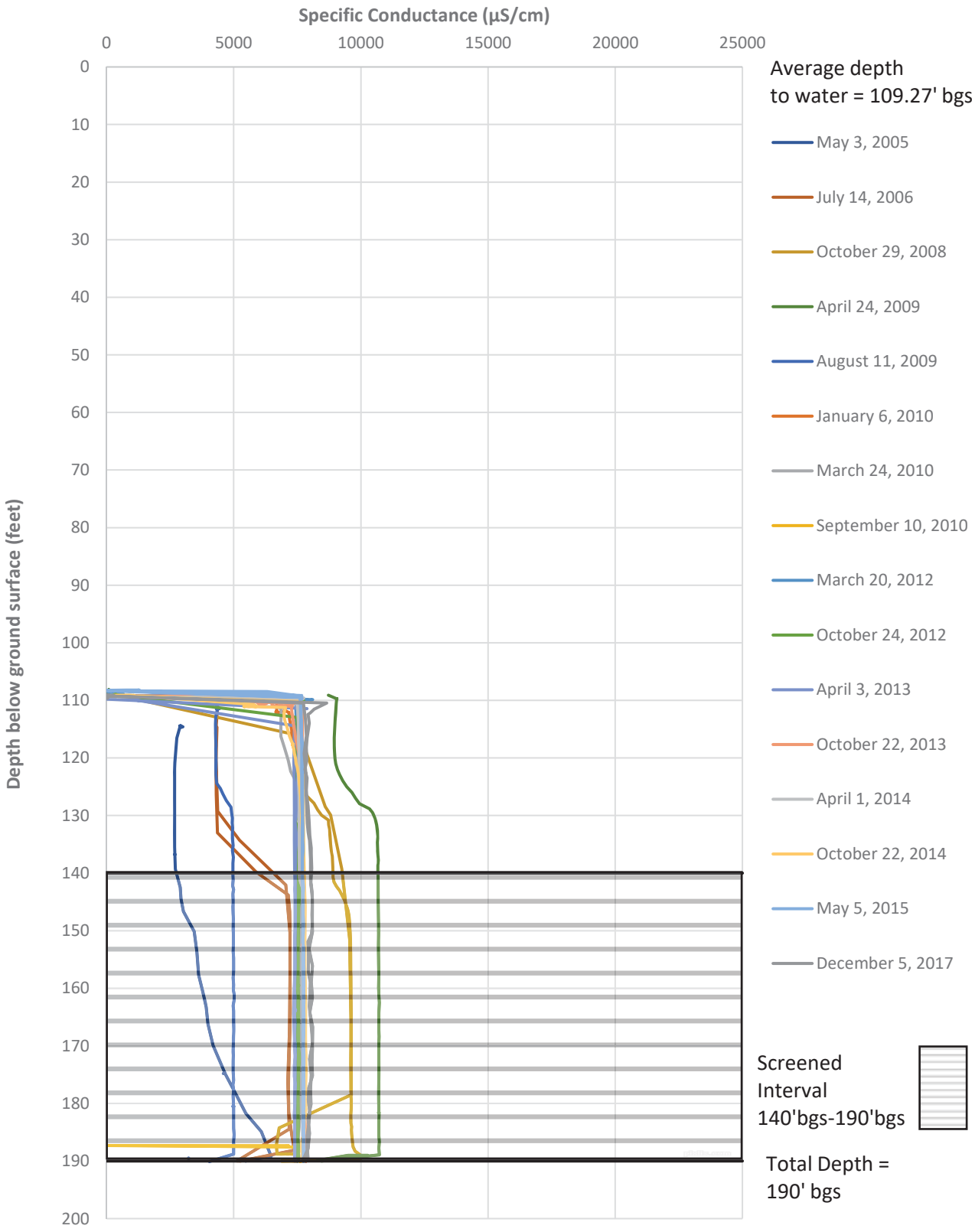
JACOBS

Attachment 1
Specific Conductivity Profile Plots for 134 Monitoring Wells

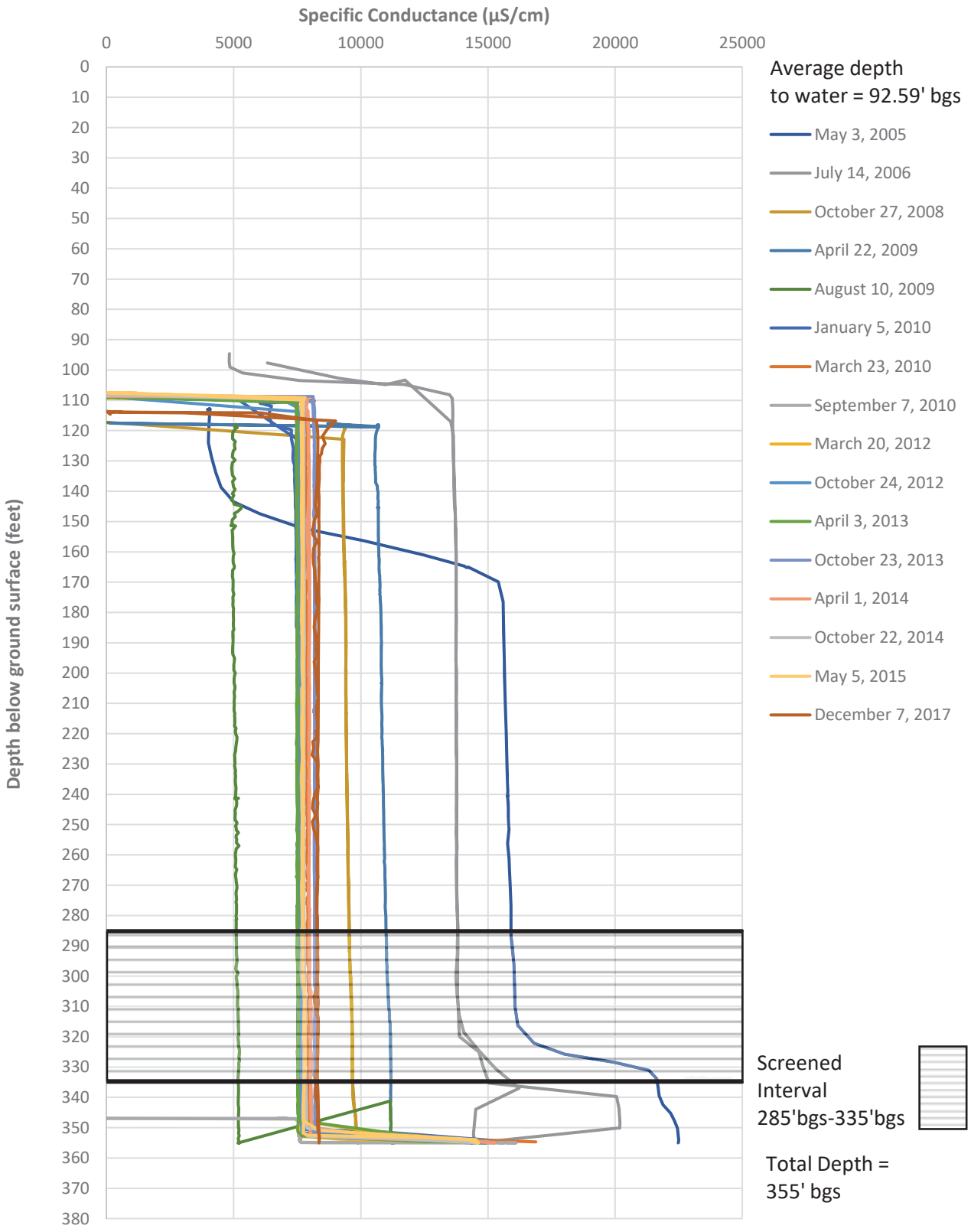
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-01D



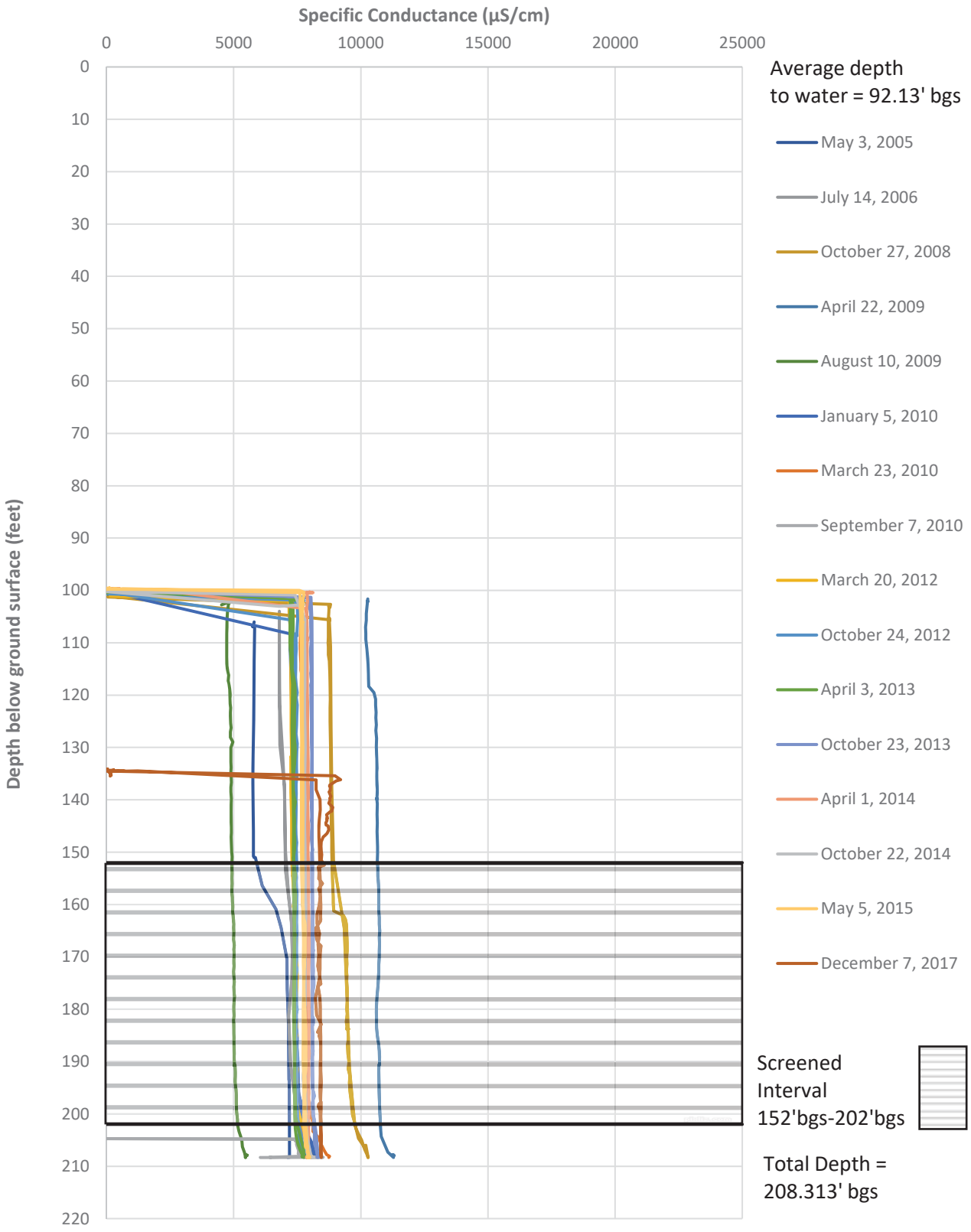
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-01M



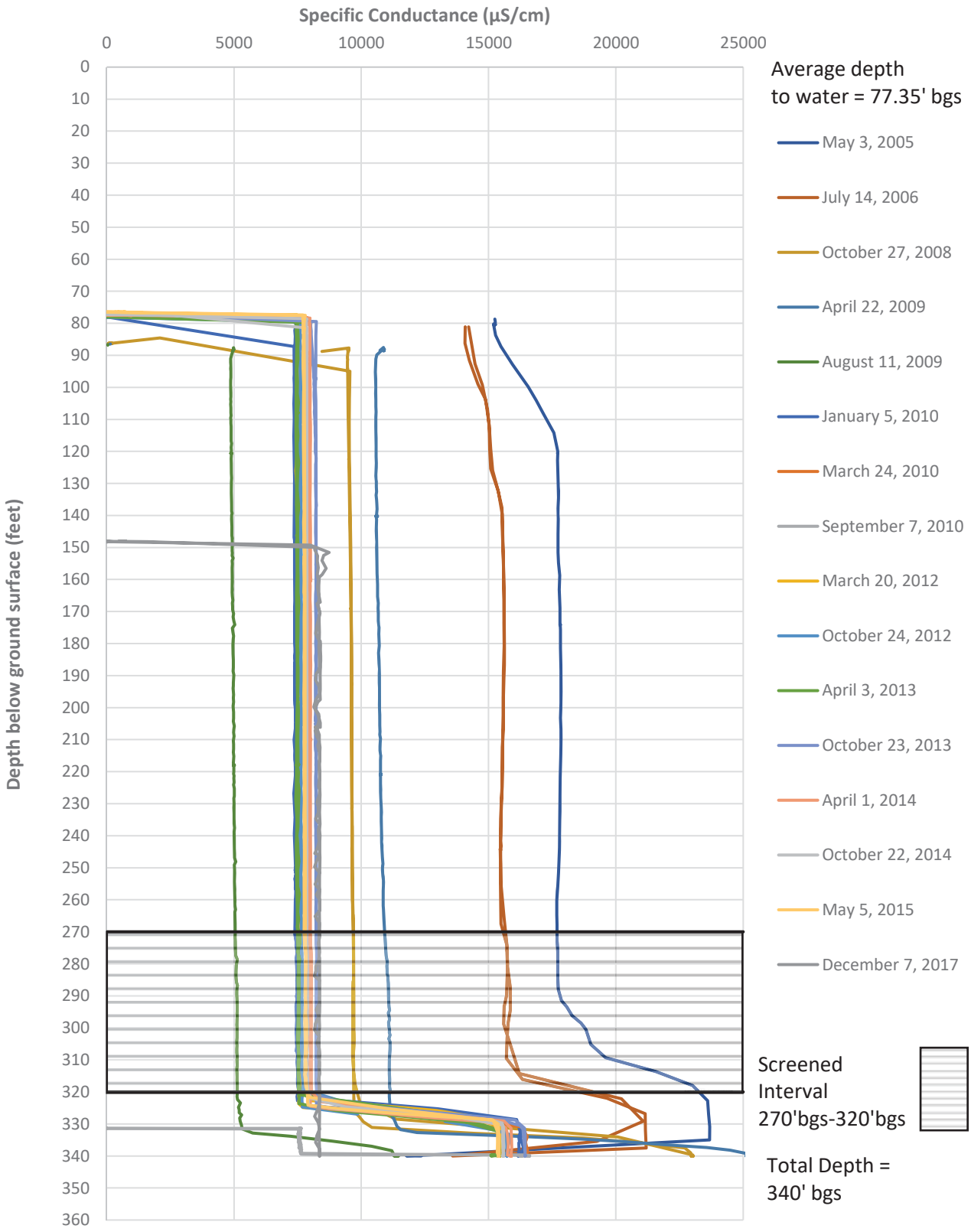
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-02D



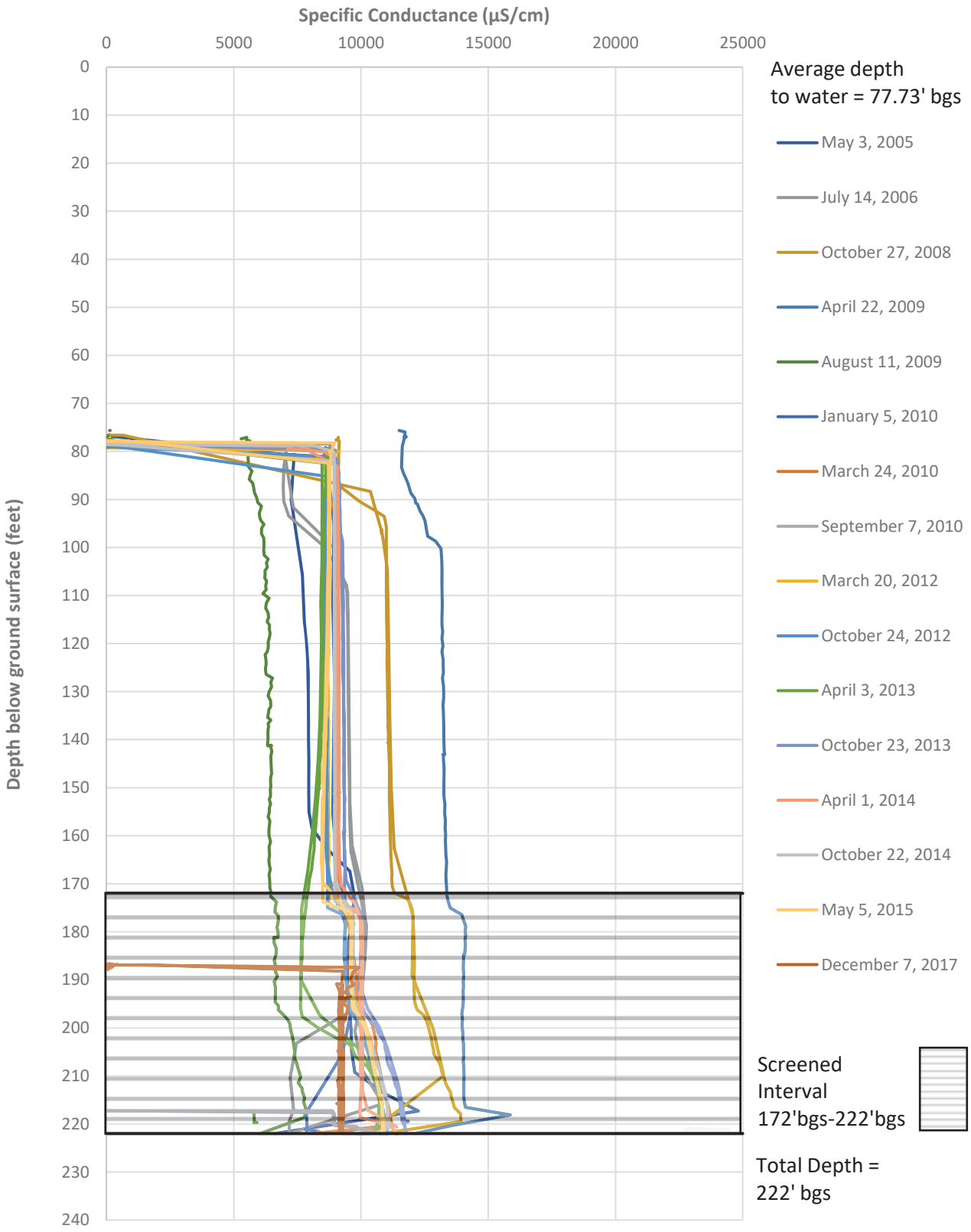
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-02M



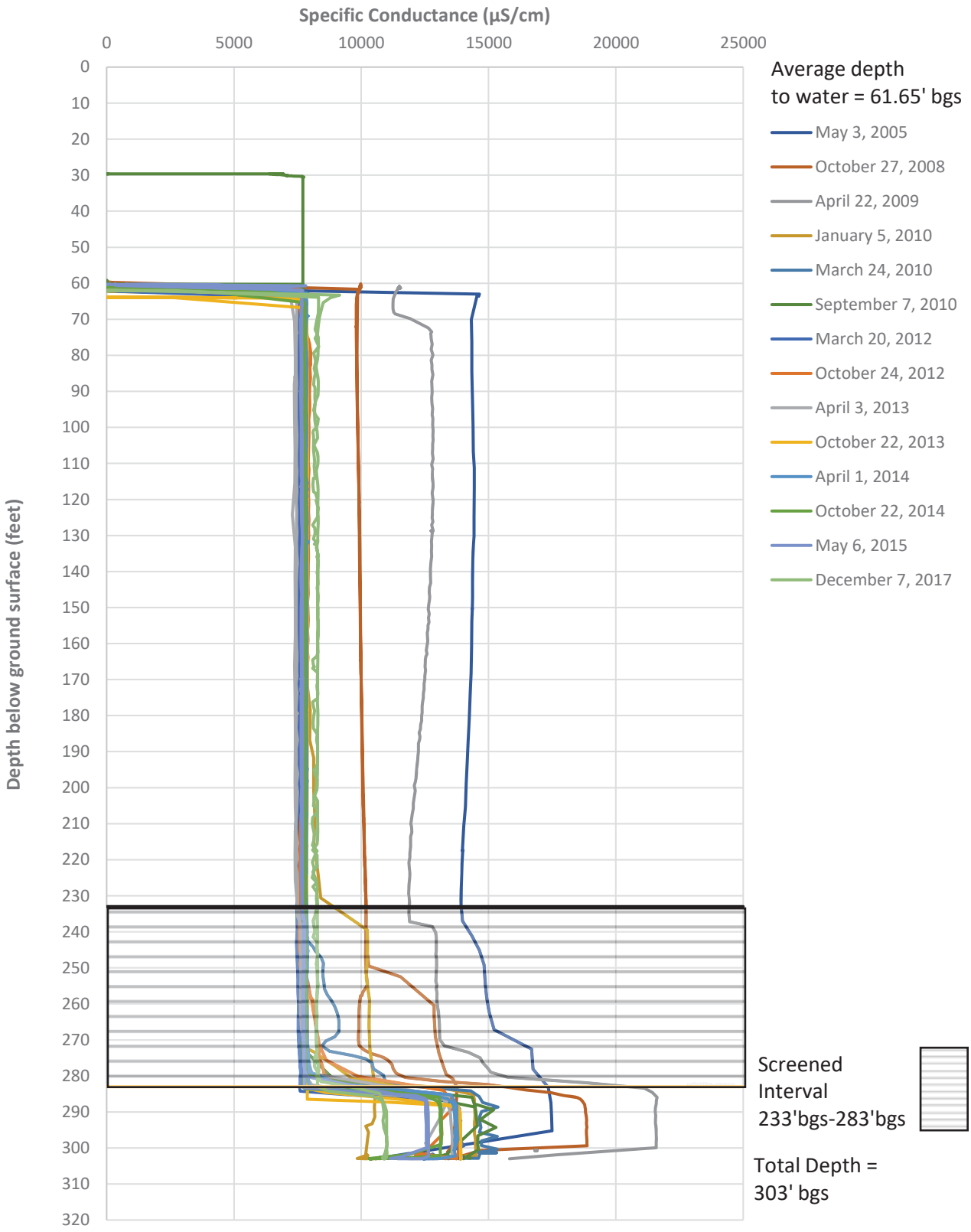
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-03D



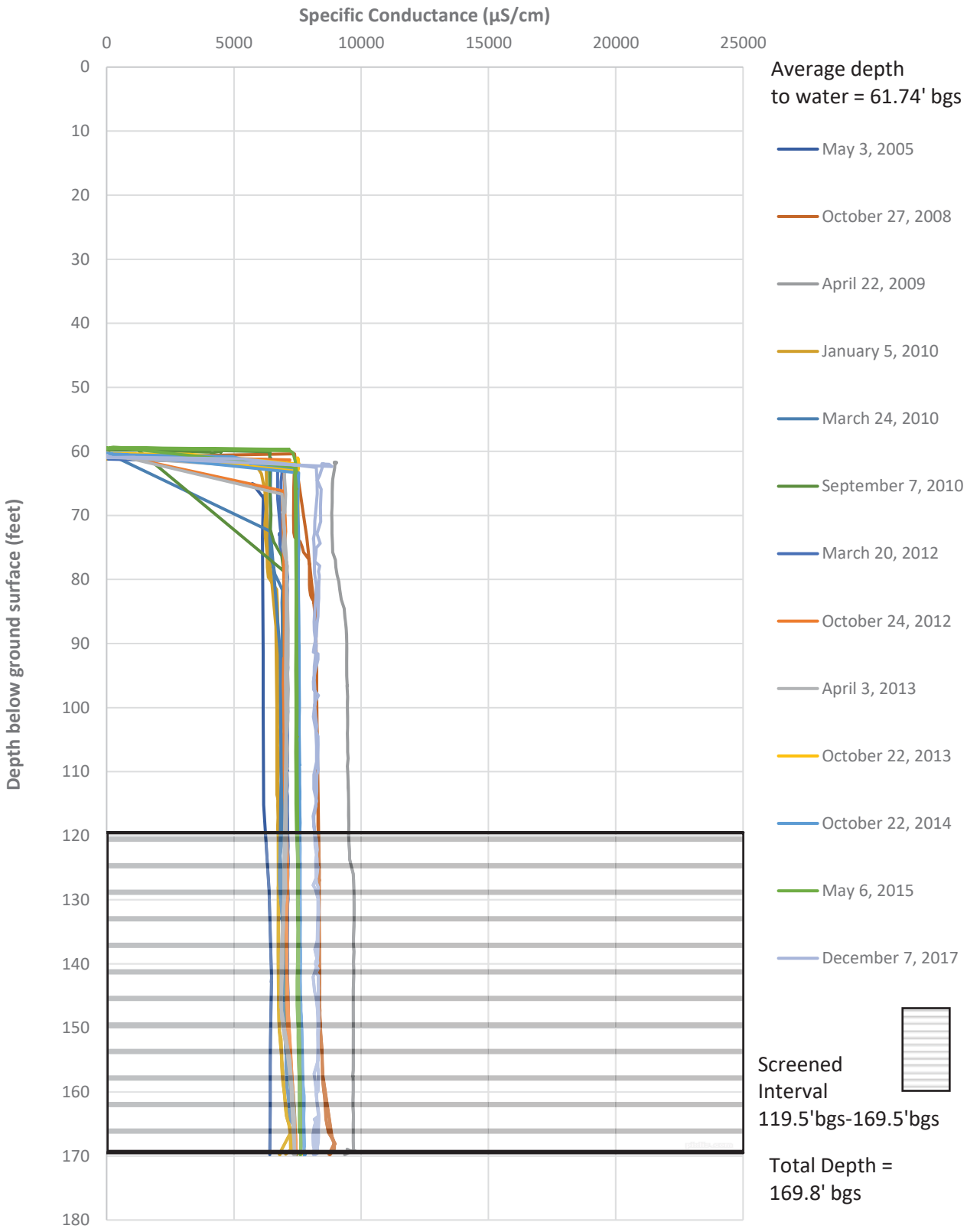
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-03M



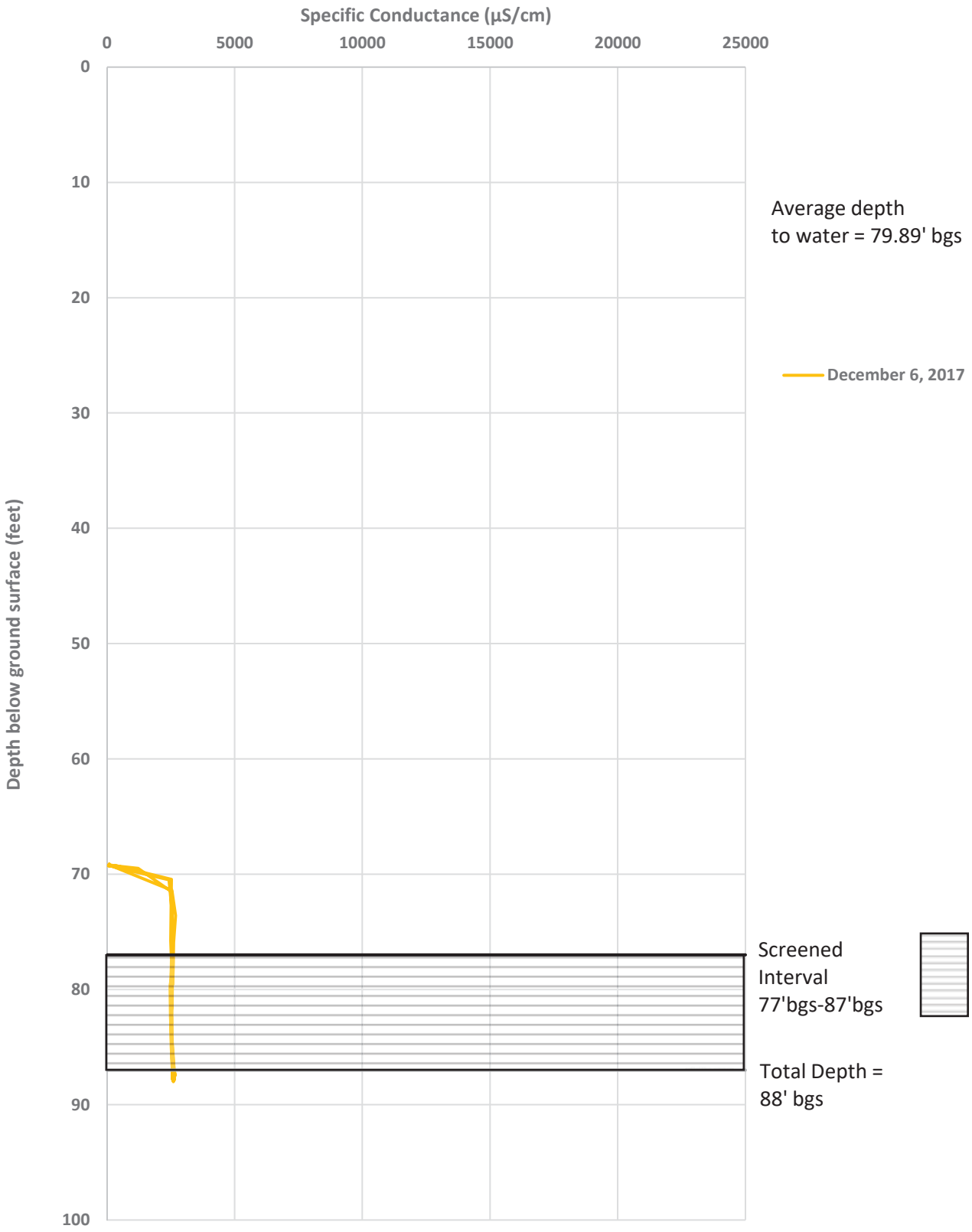
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-04D



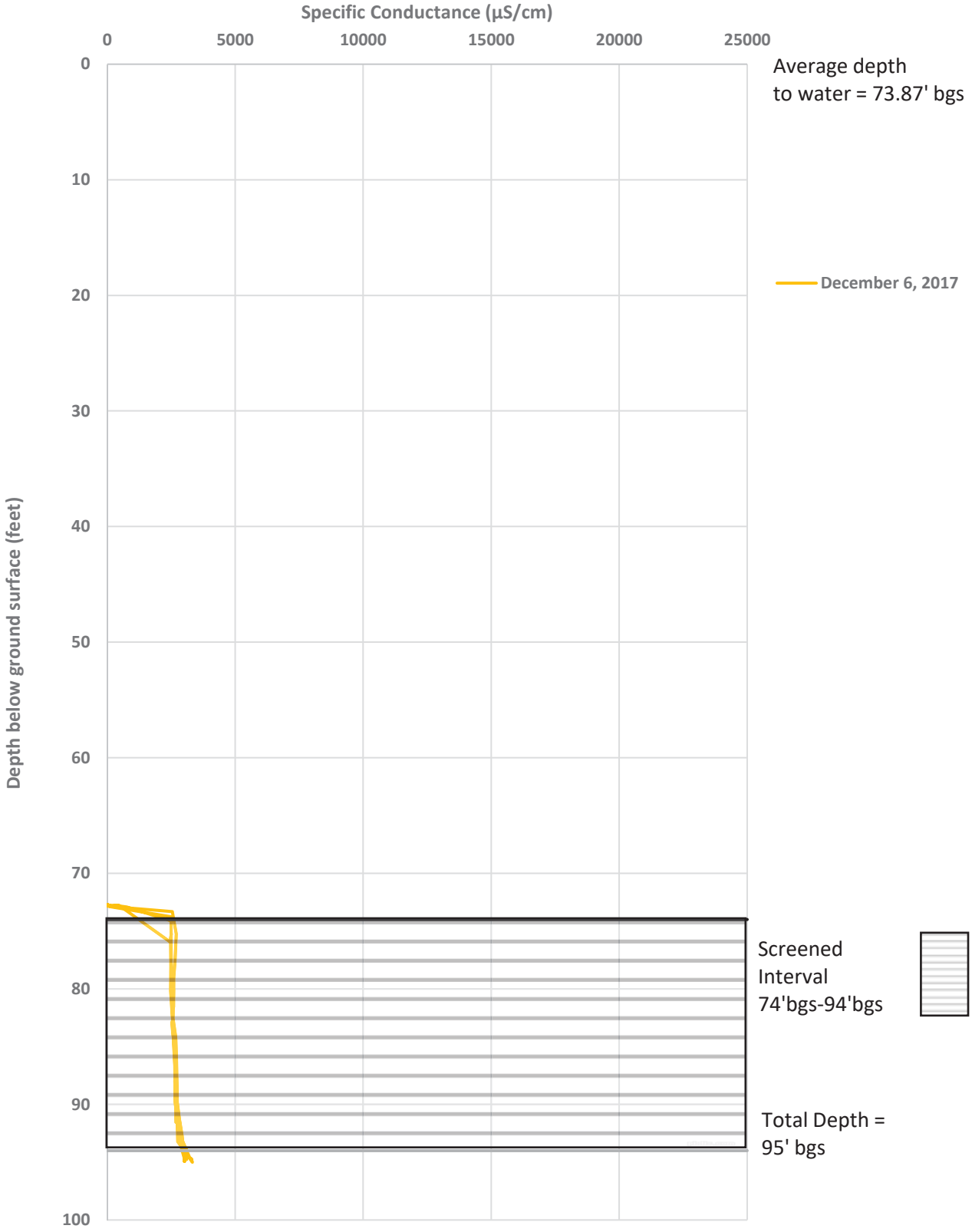
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well CW-04M



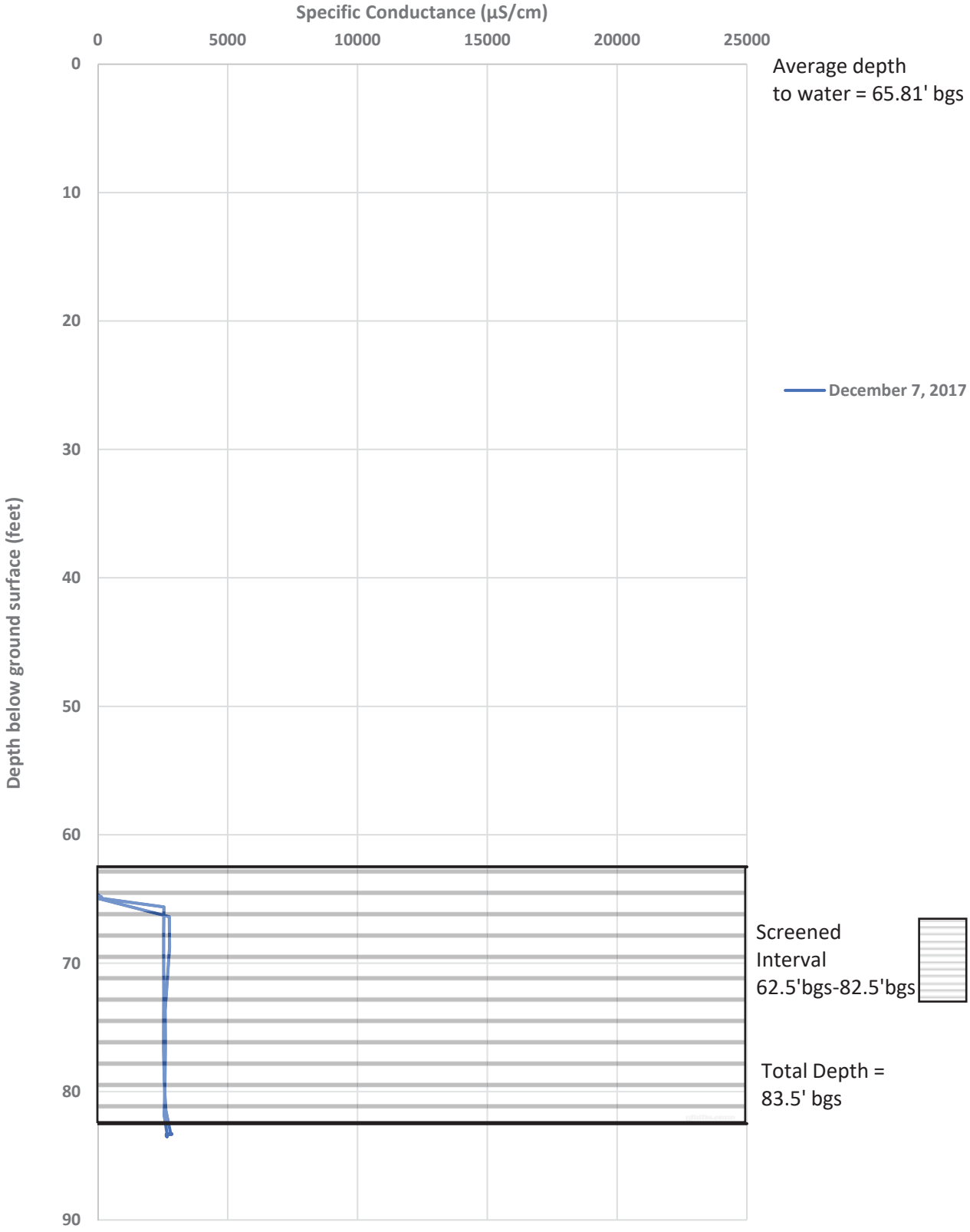
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-09



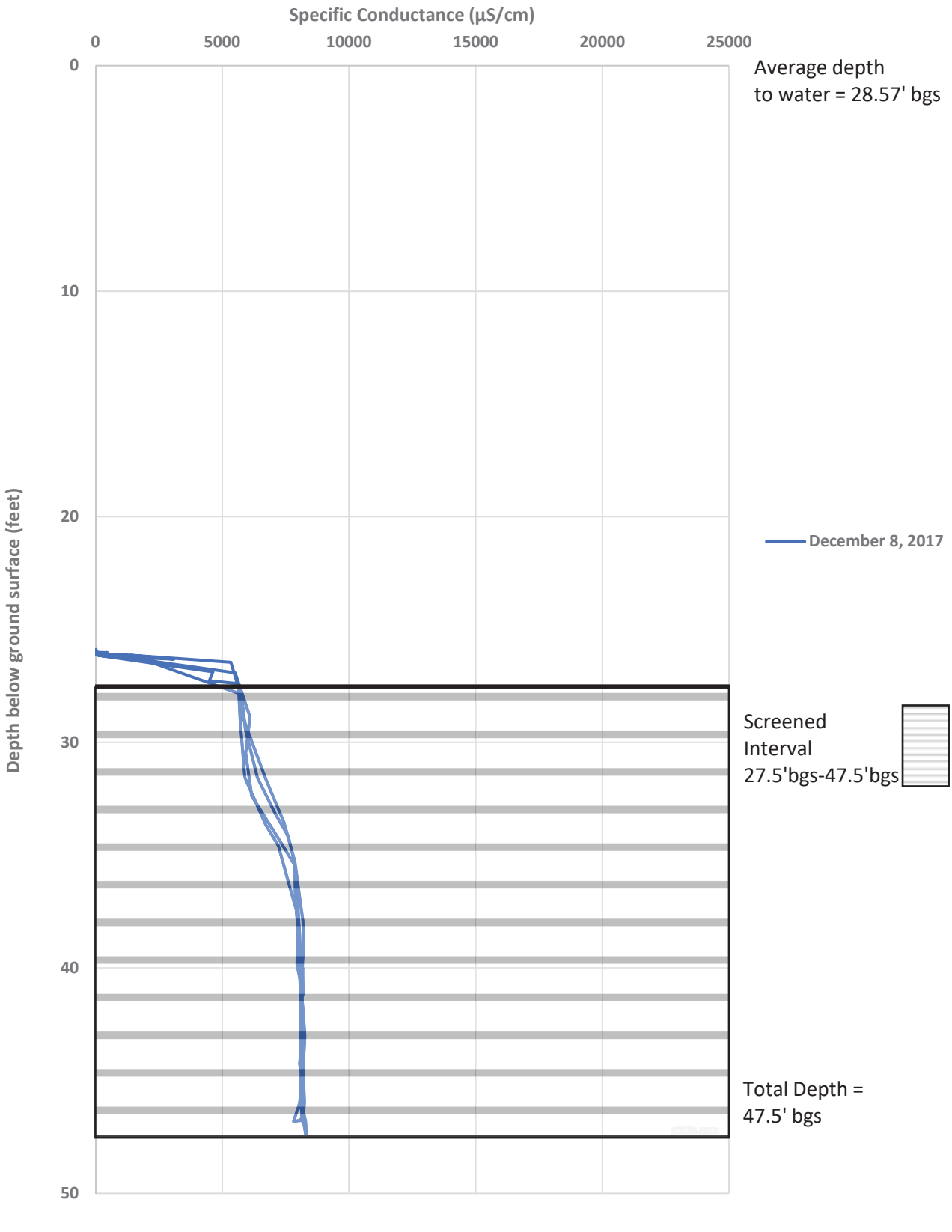
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-10



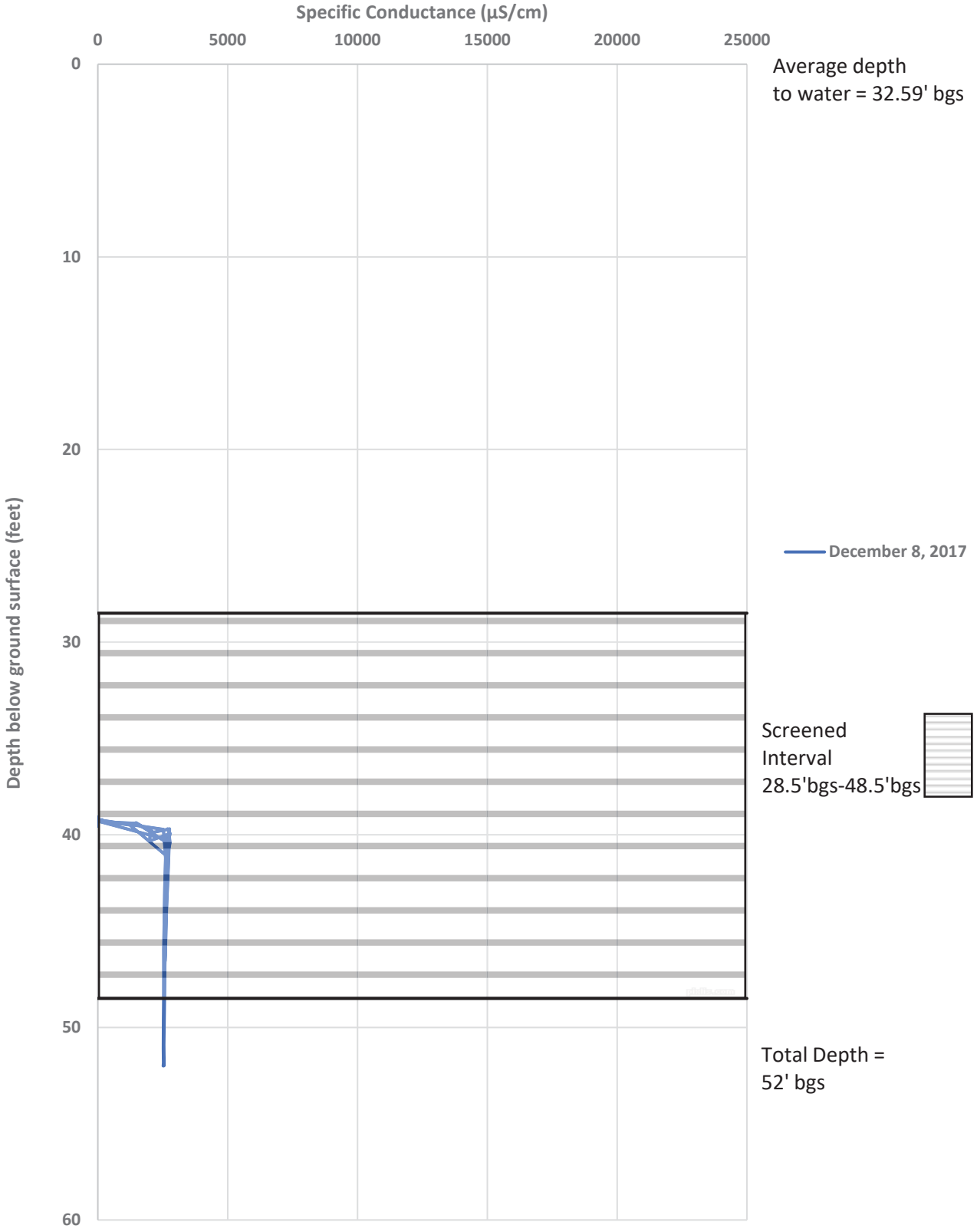
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-11



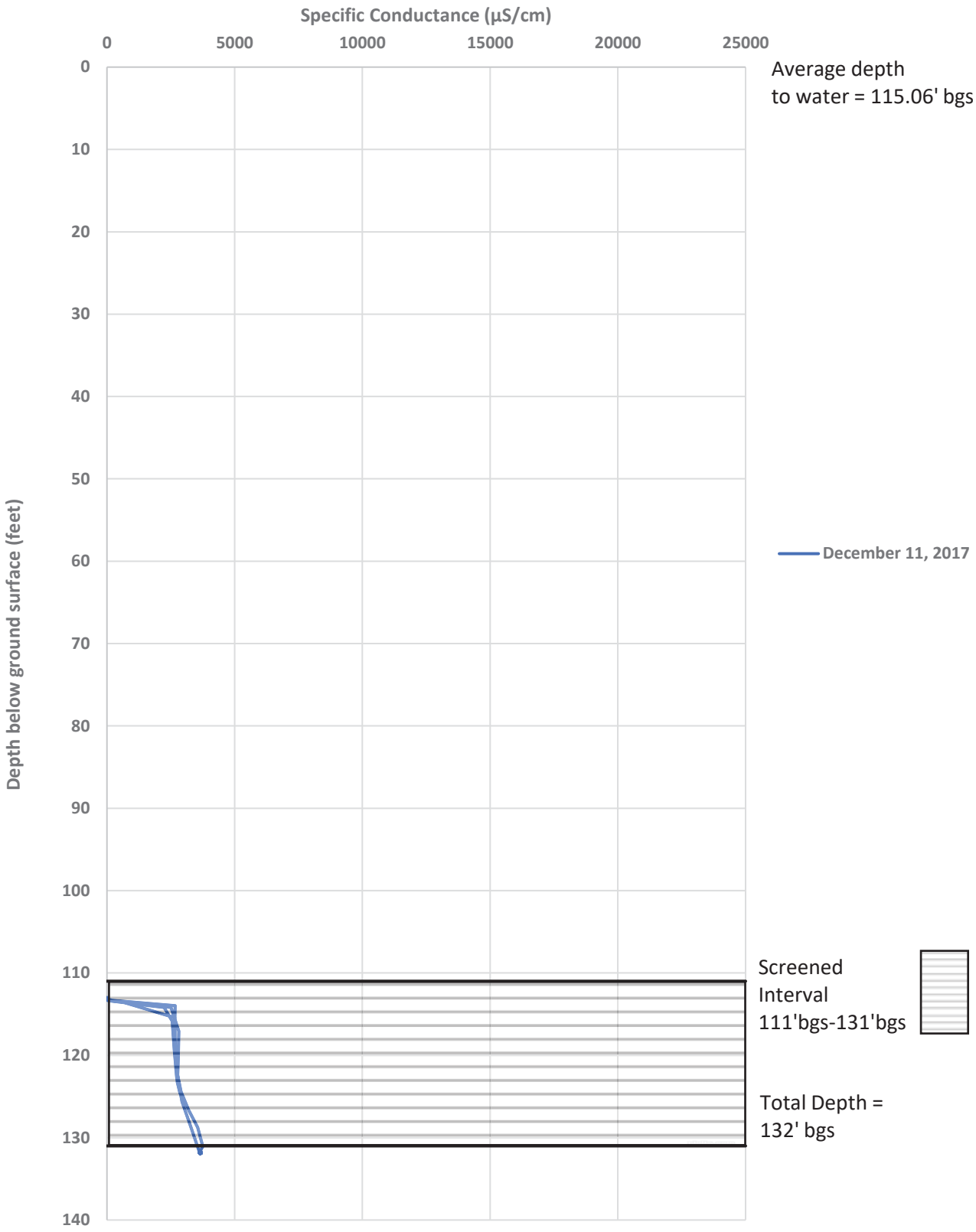
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-12



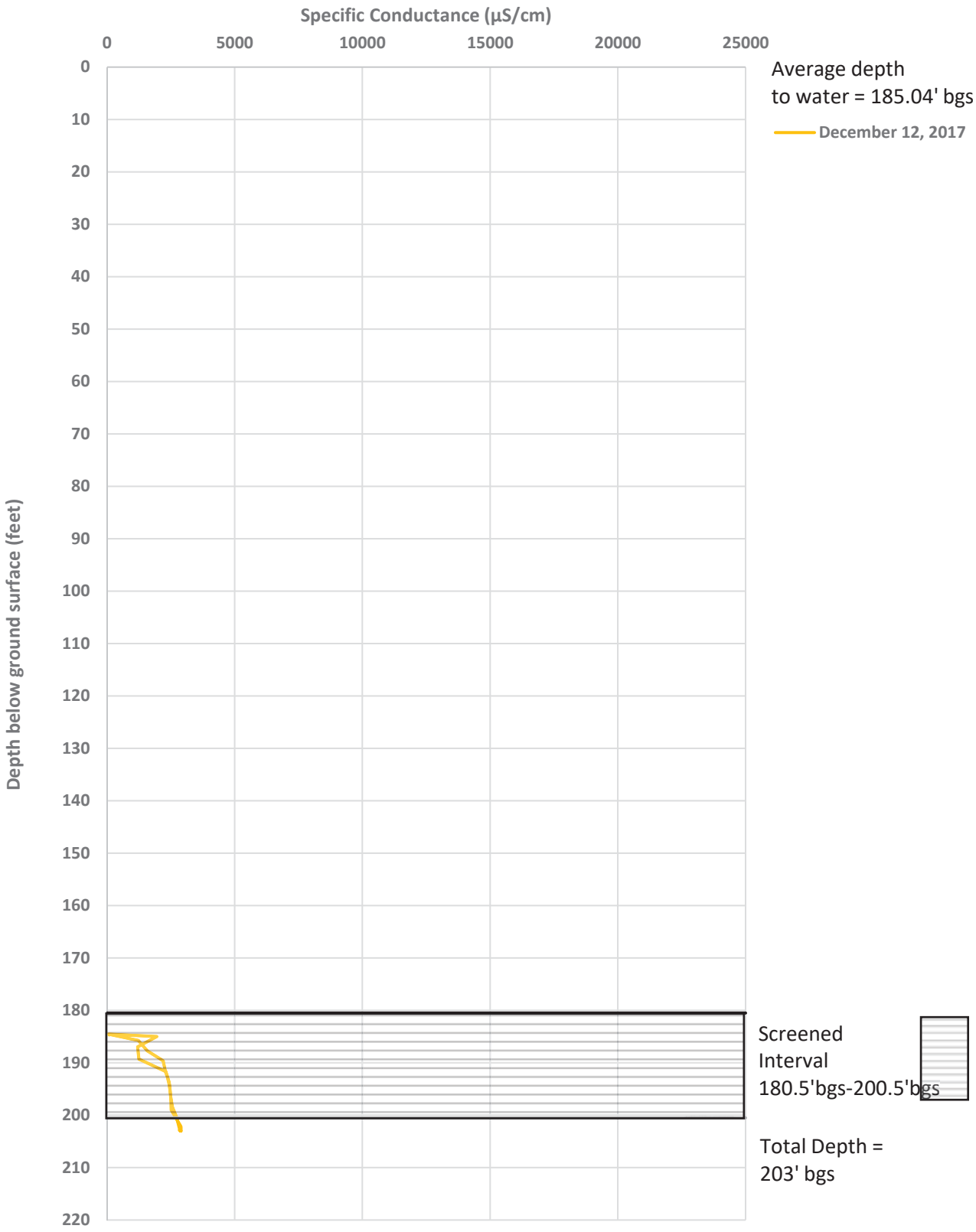
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-13



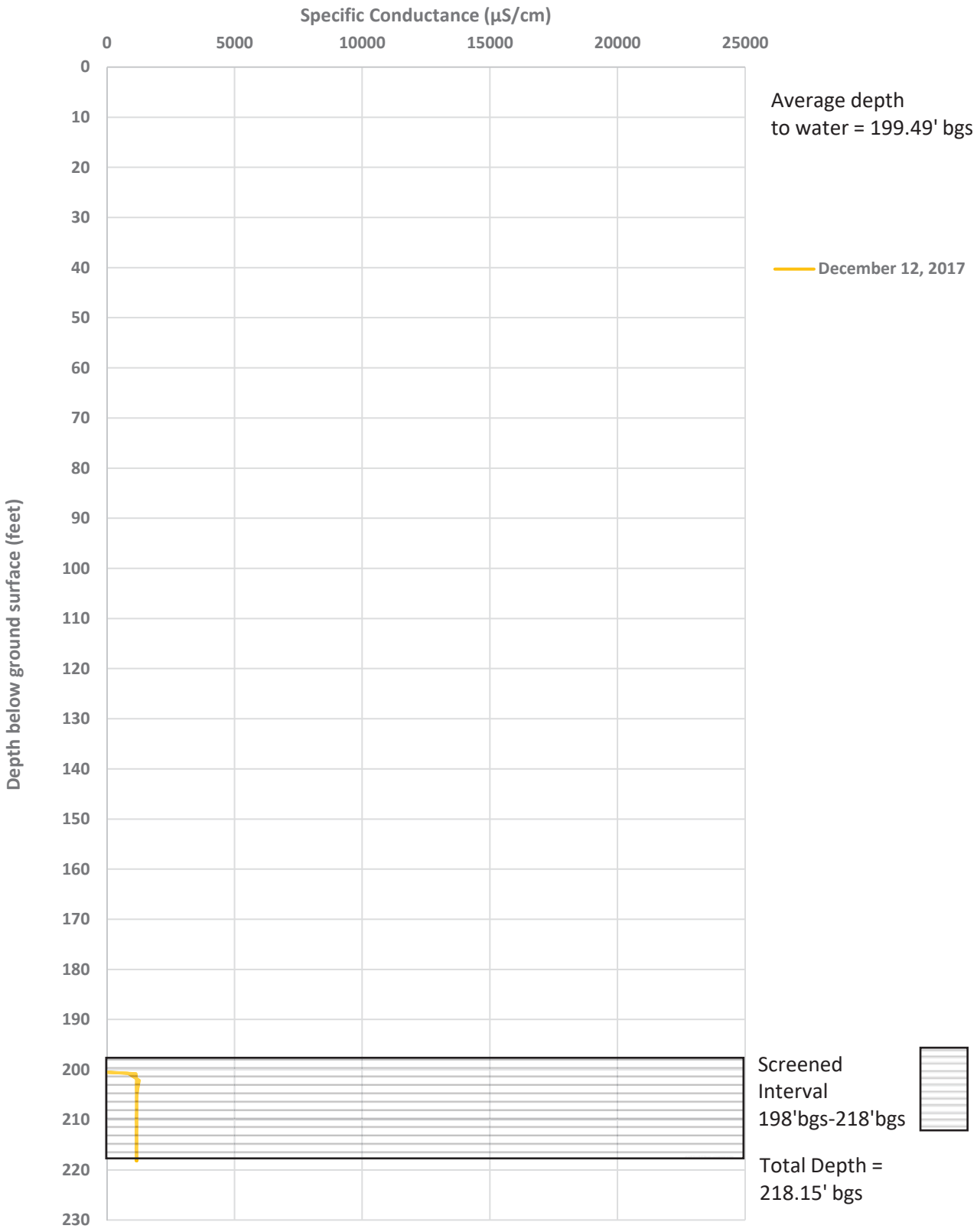
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-14



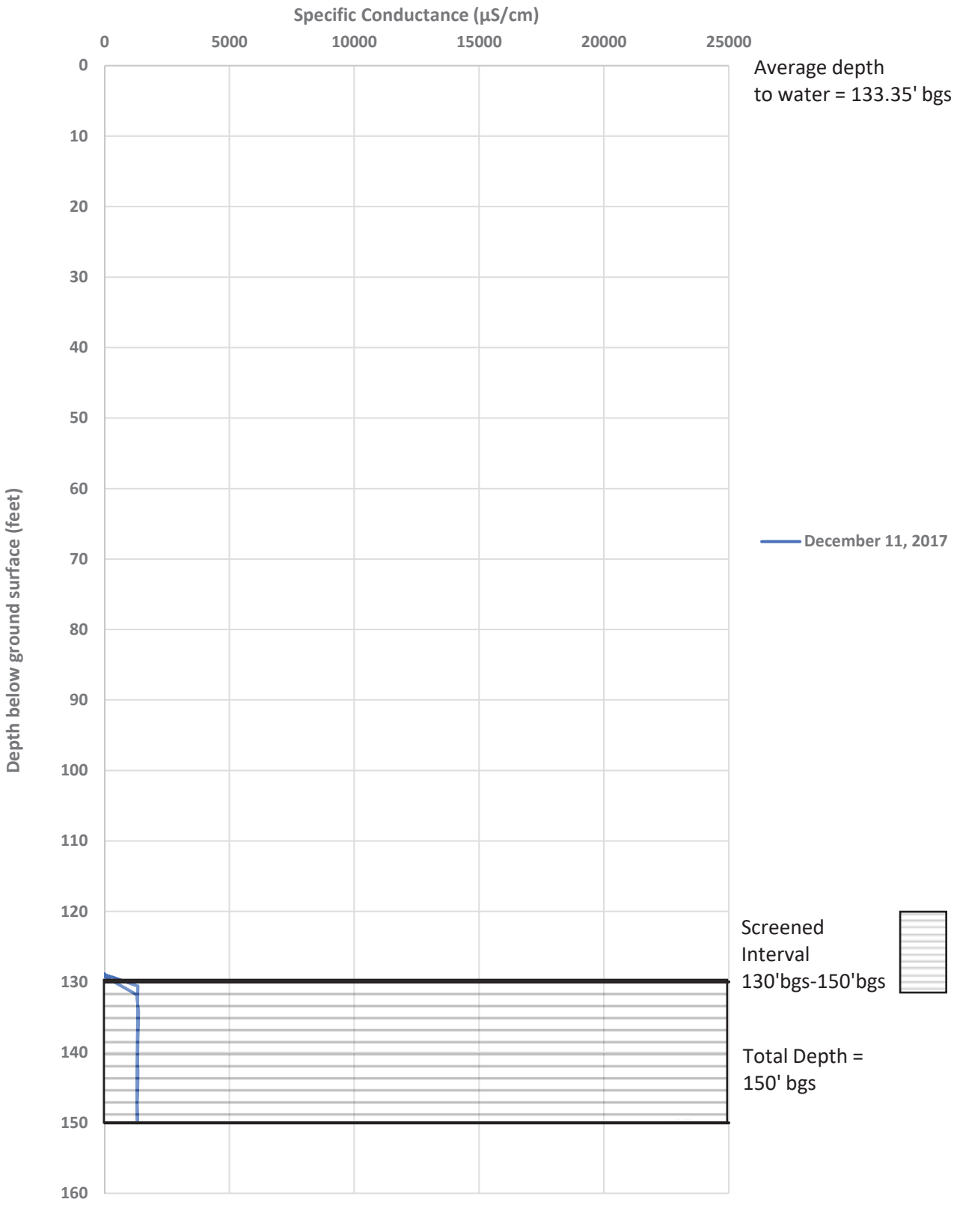
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-15



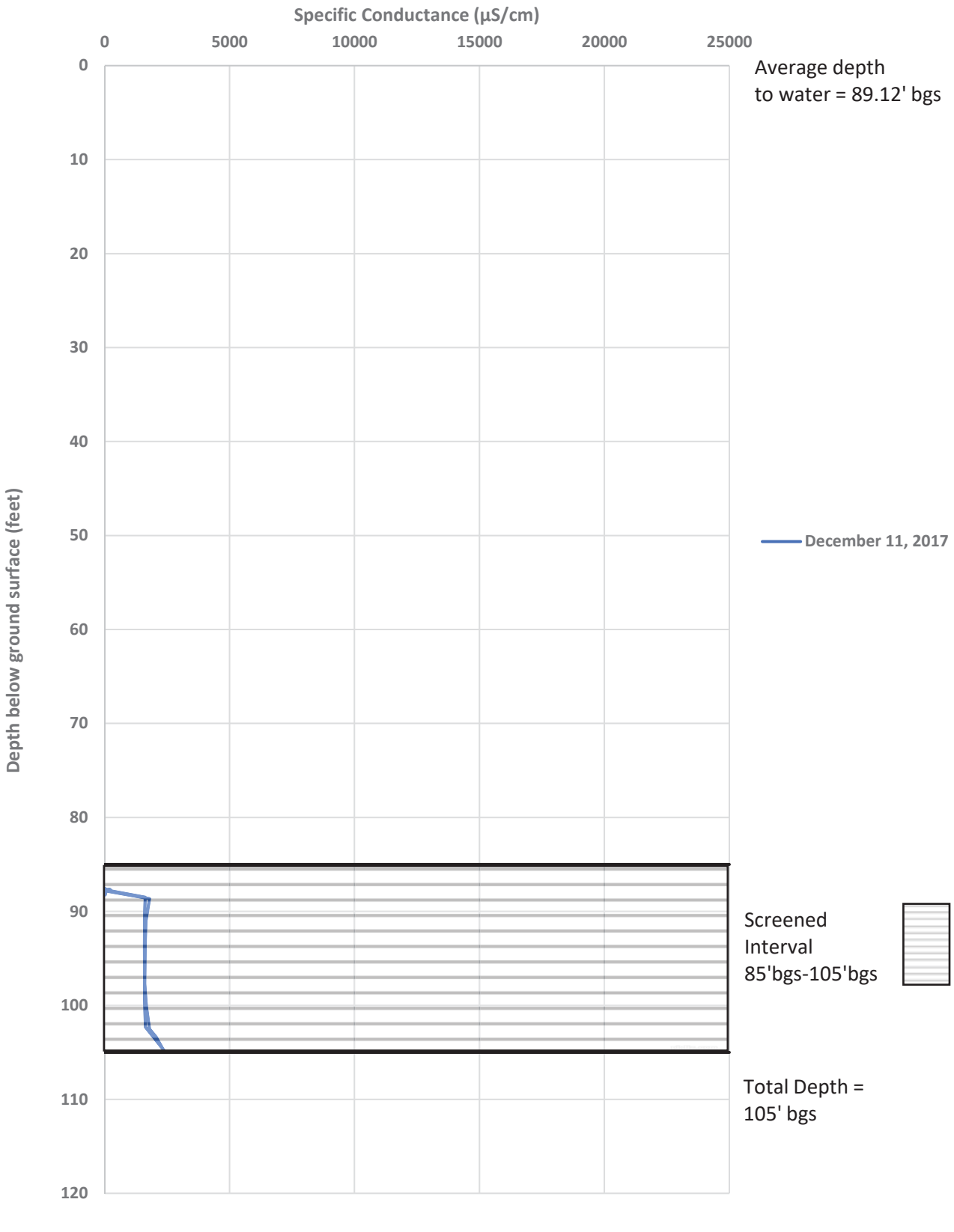
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-16



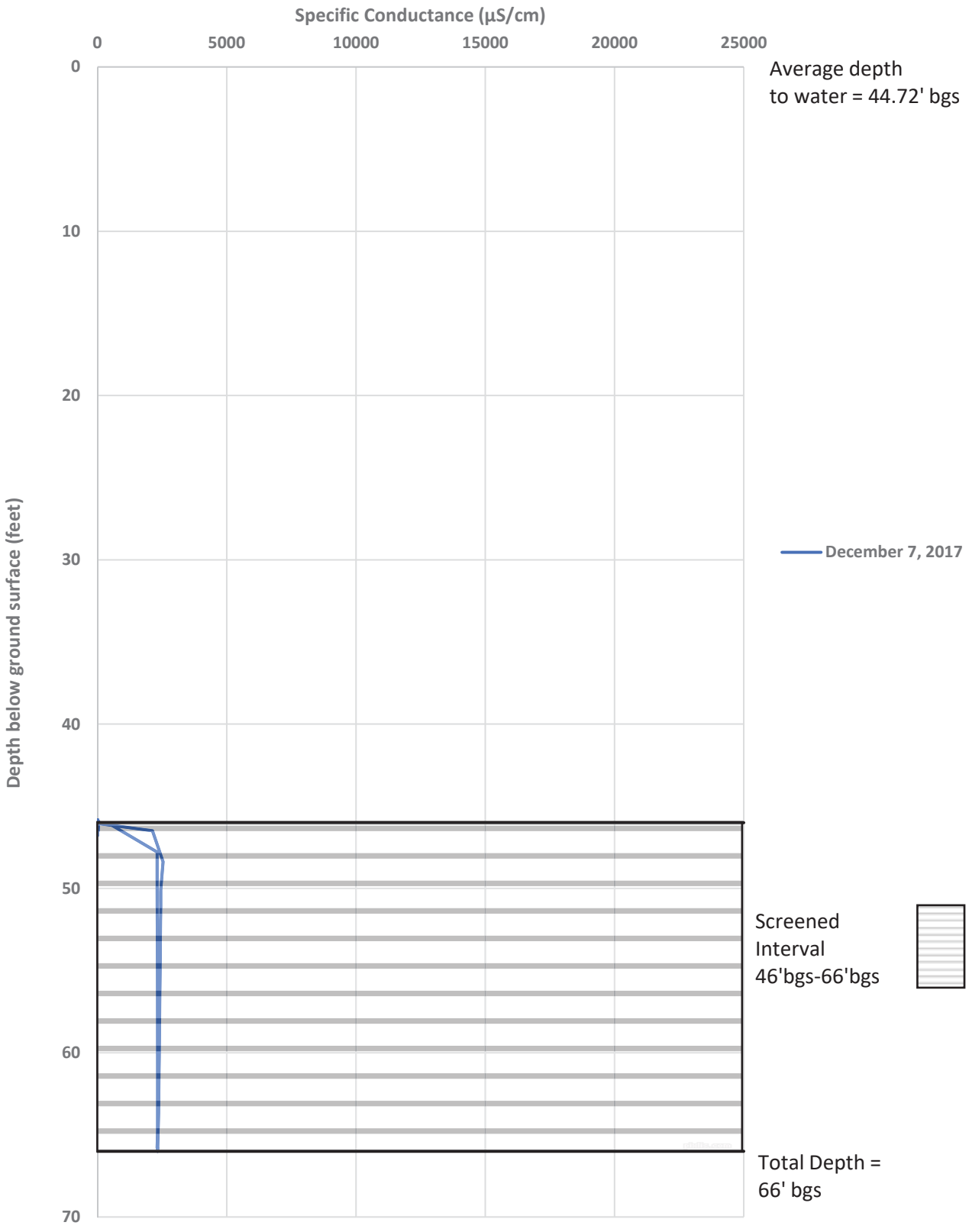
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-17



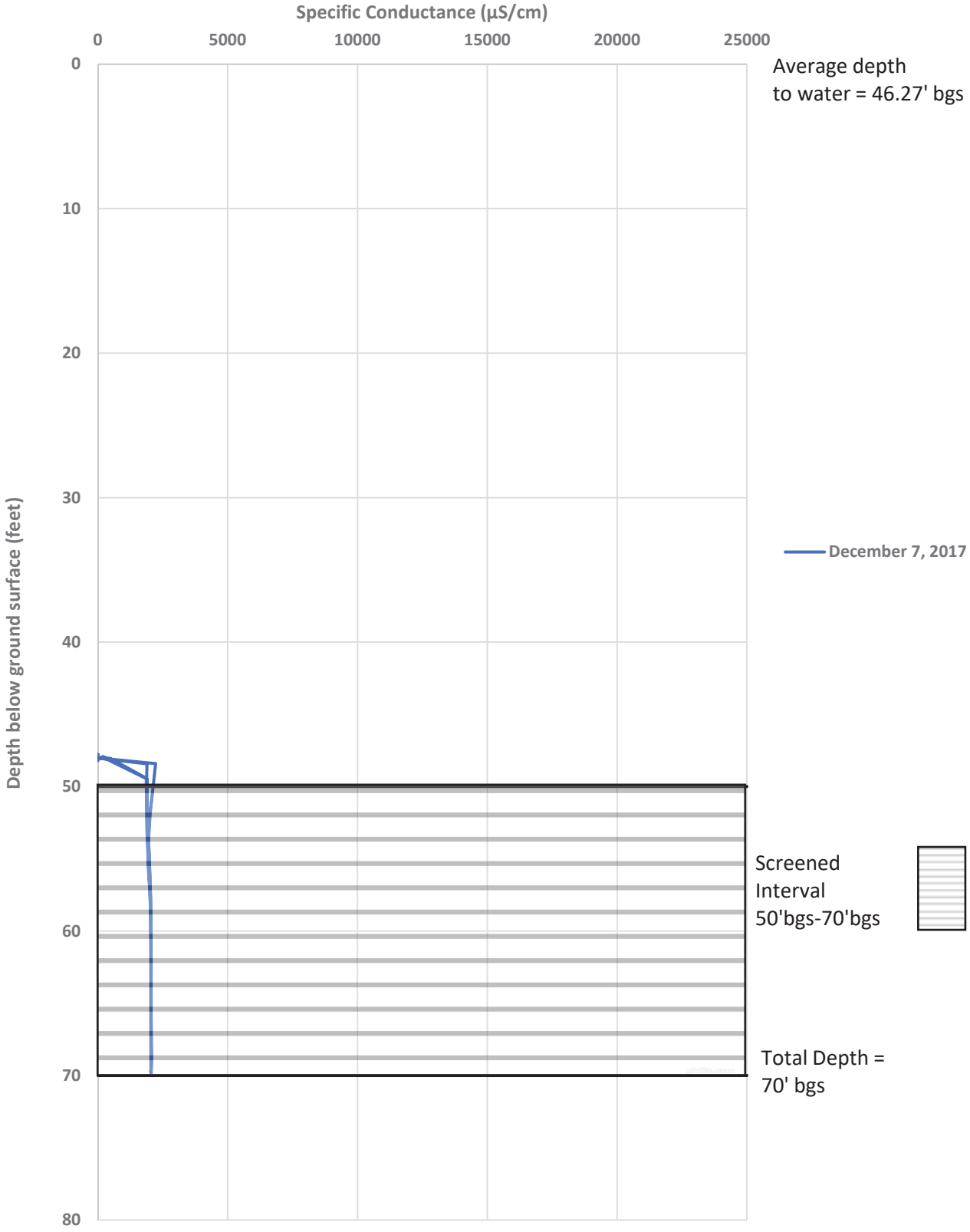
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-18



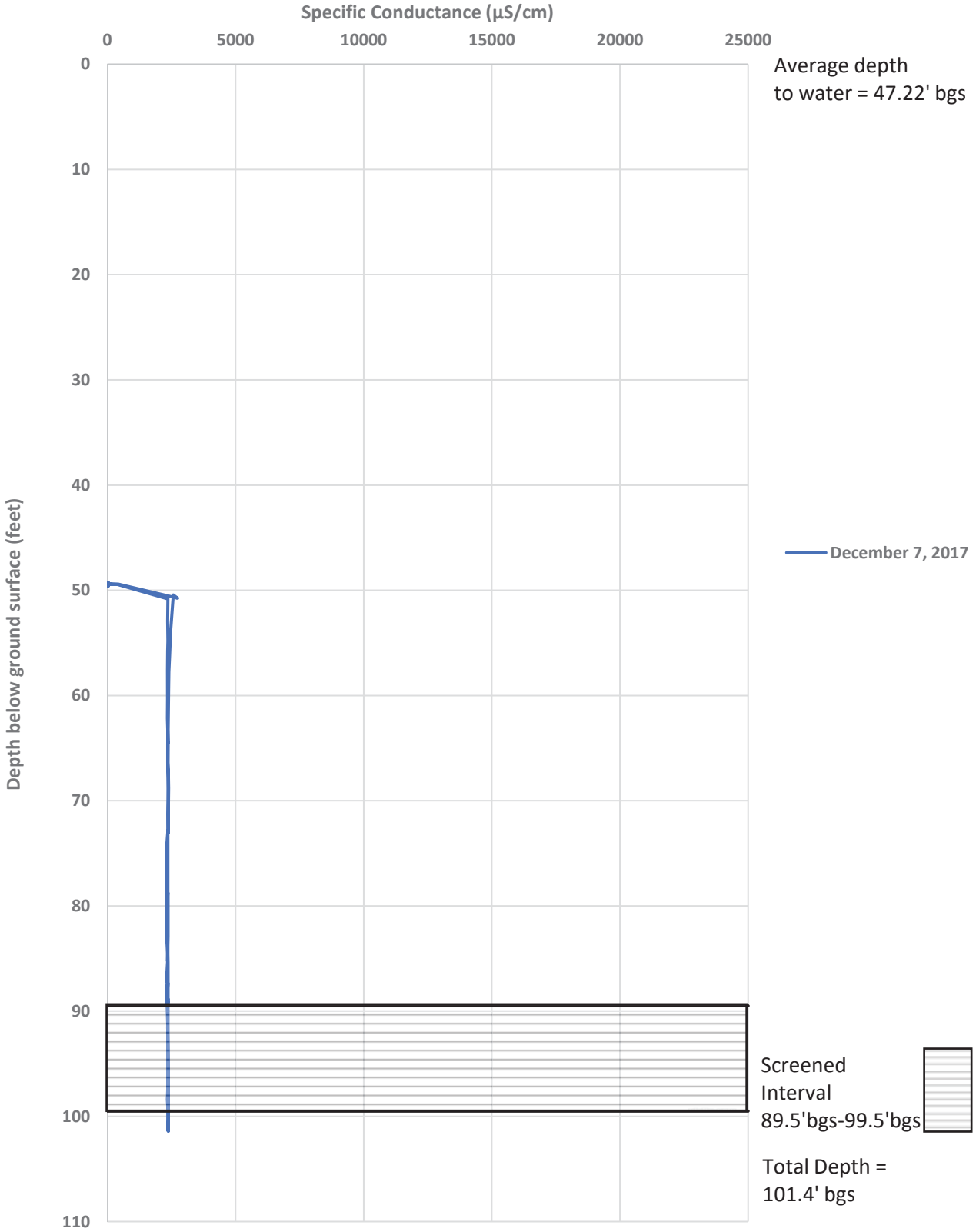
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-19



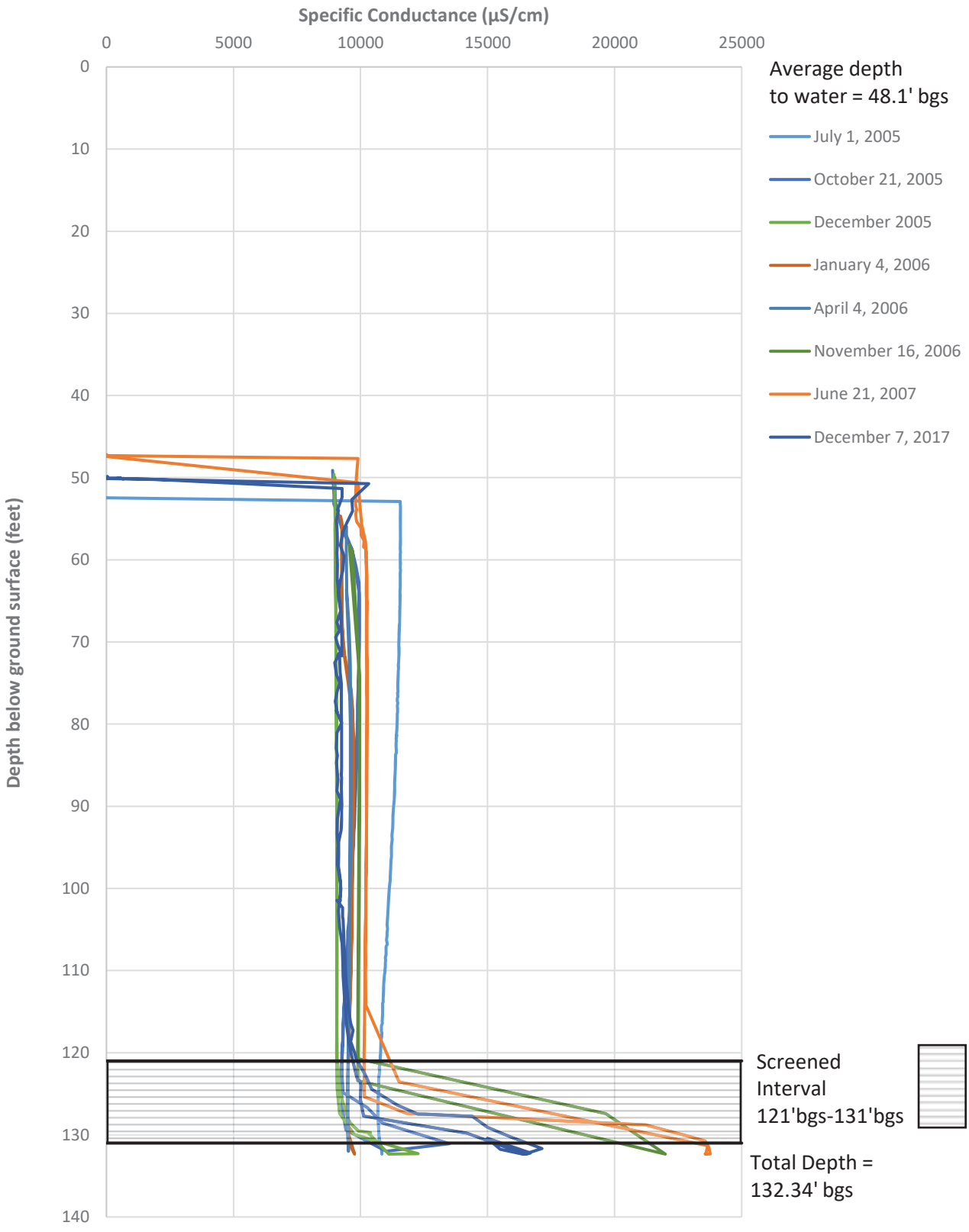
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-20-070



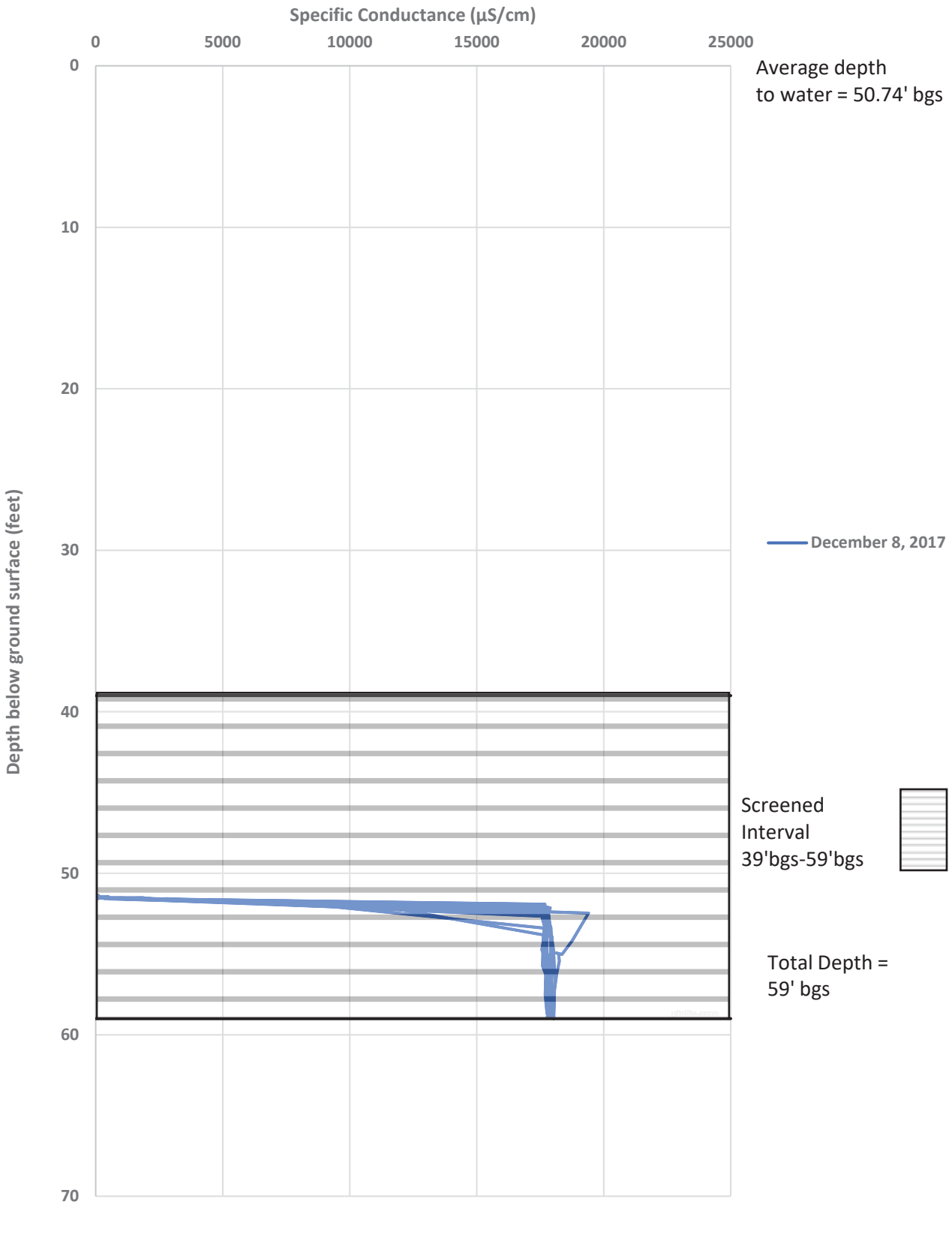
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-20-100



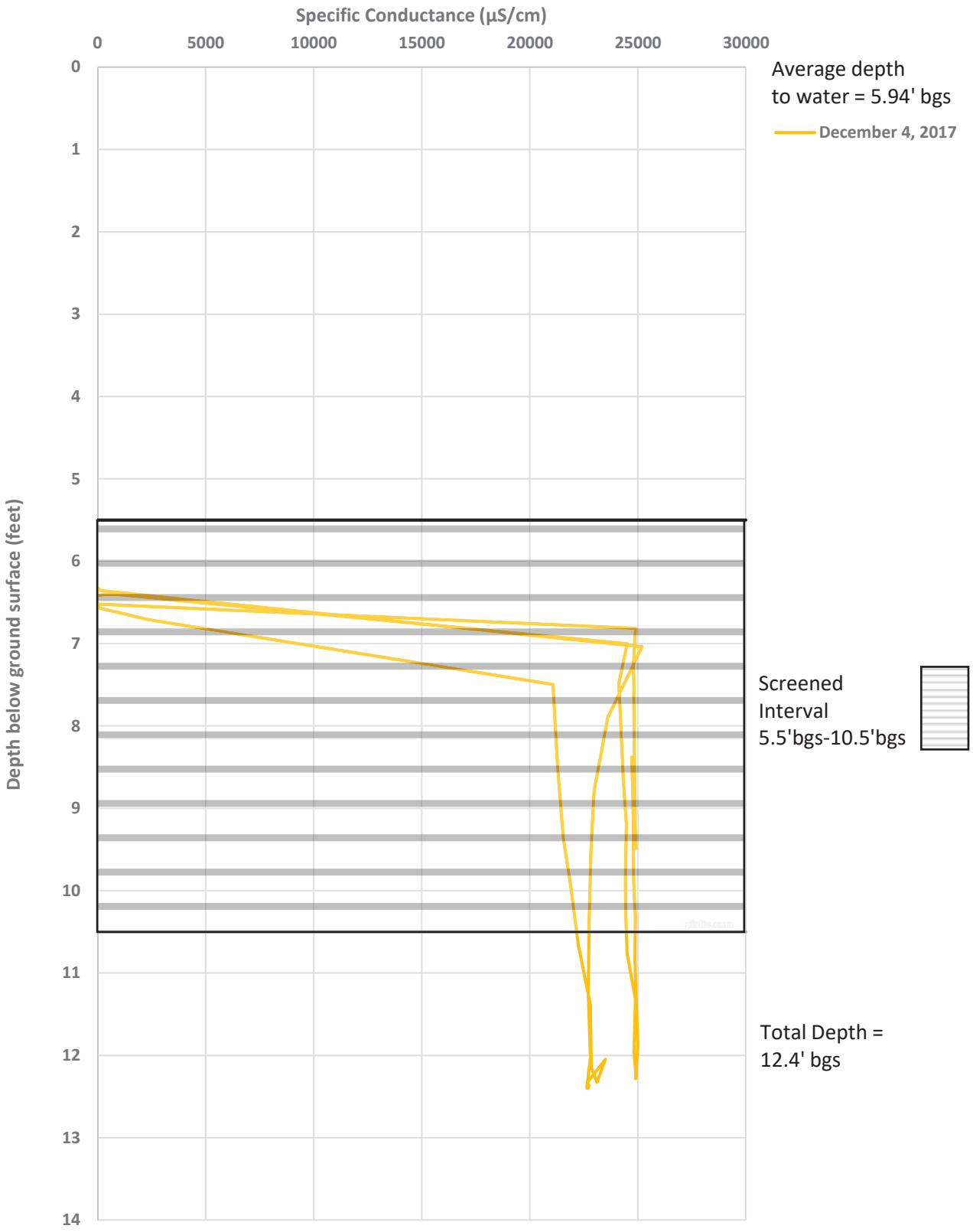
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-20-130



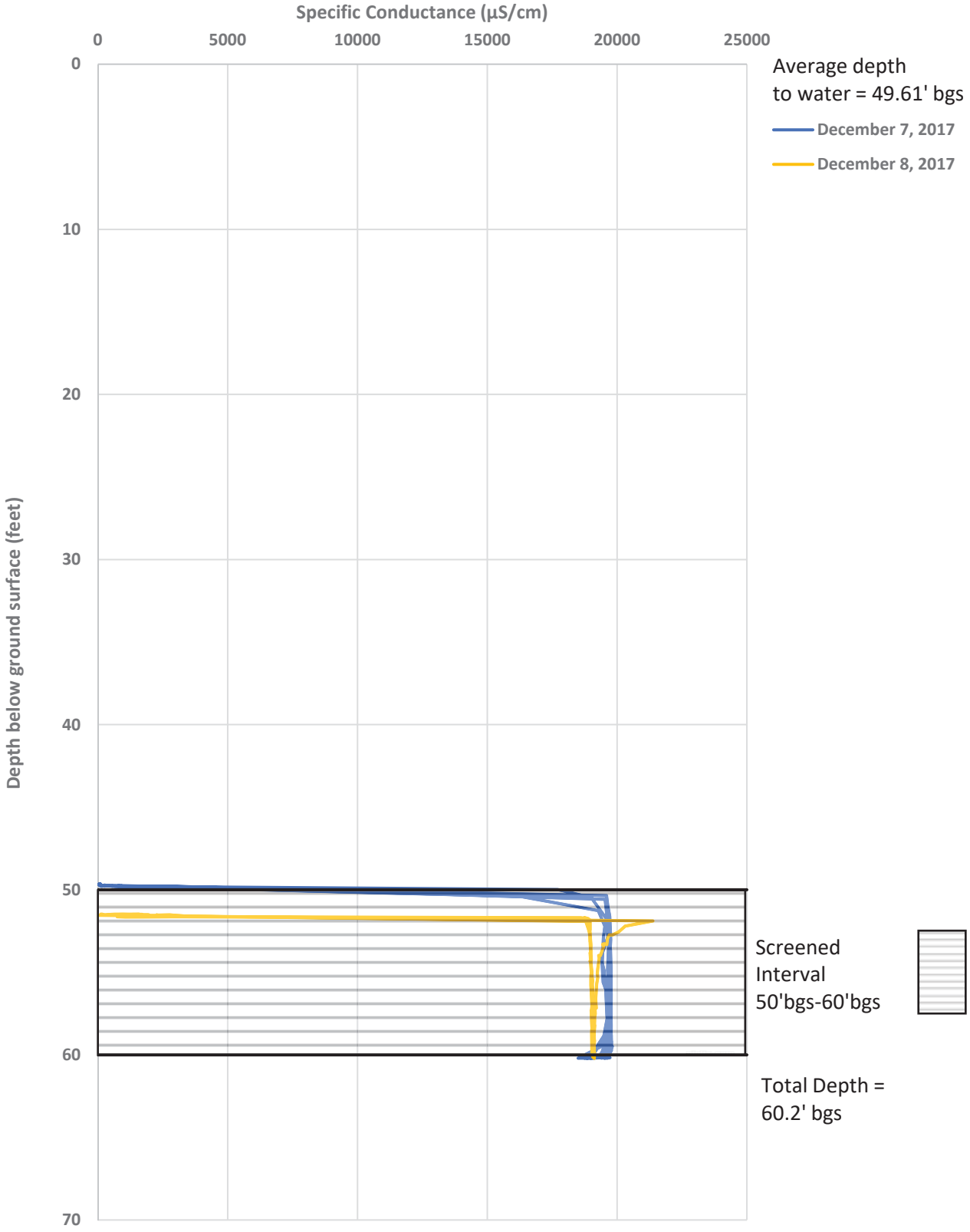
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-21



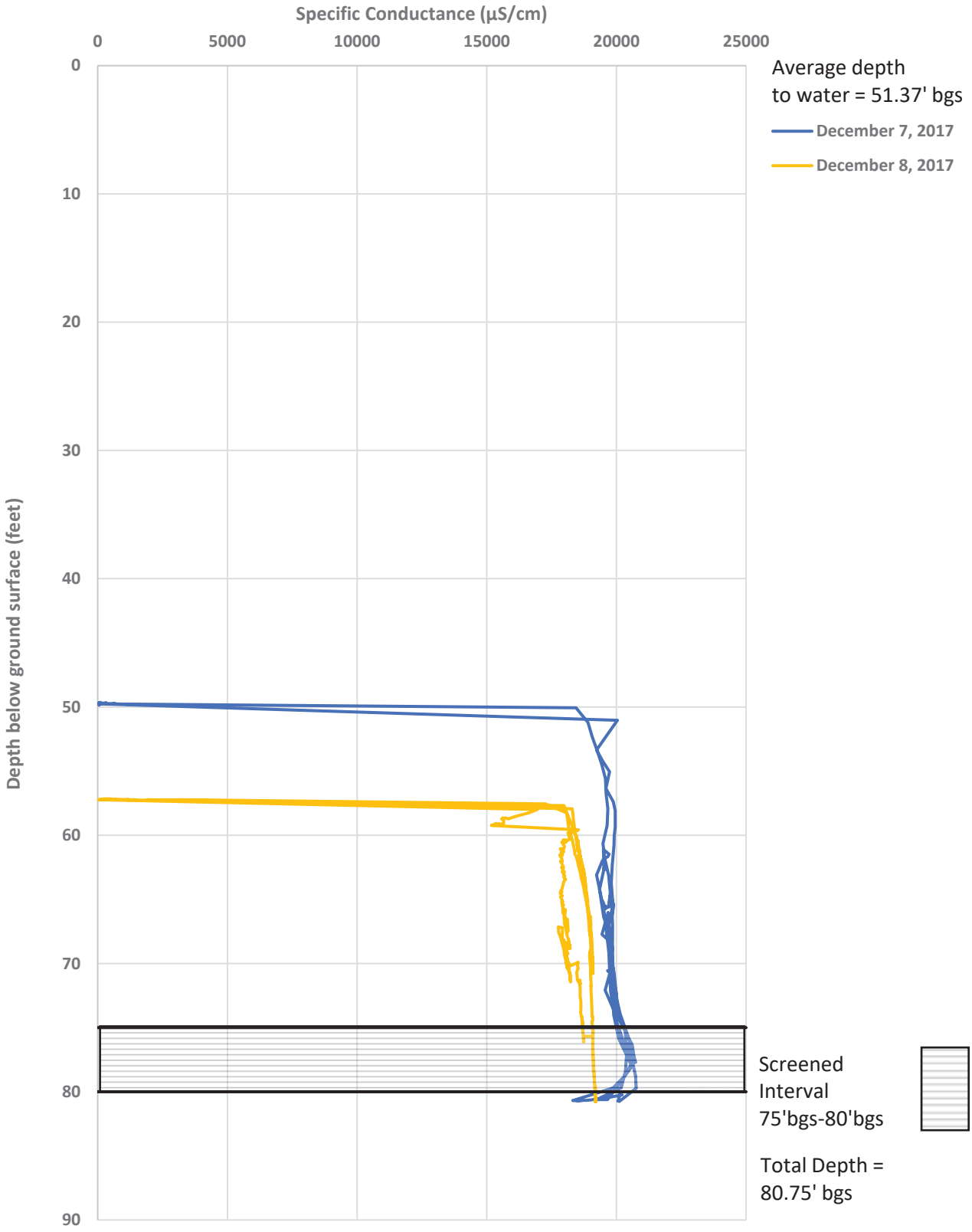
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-22



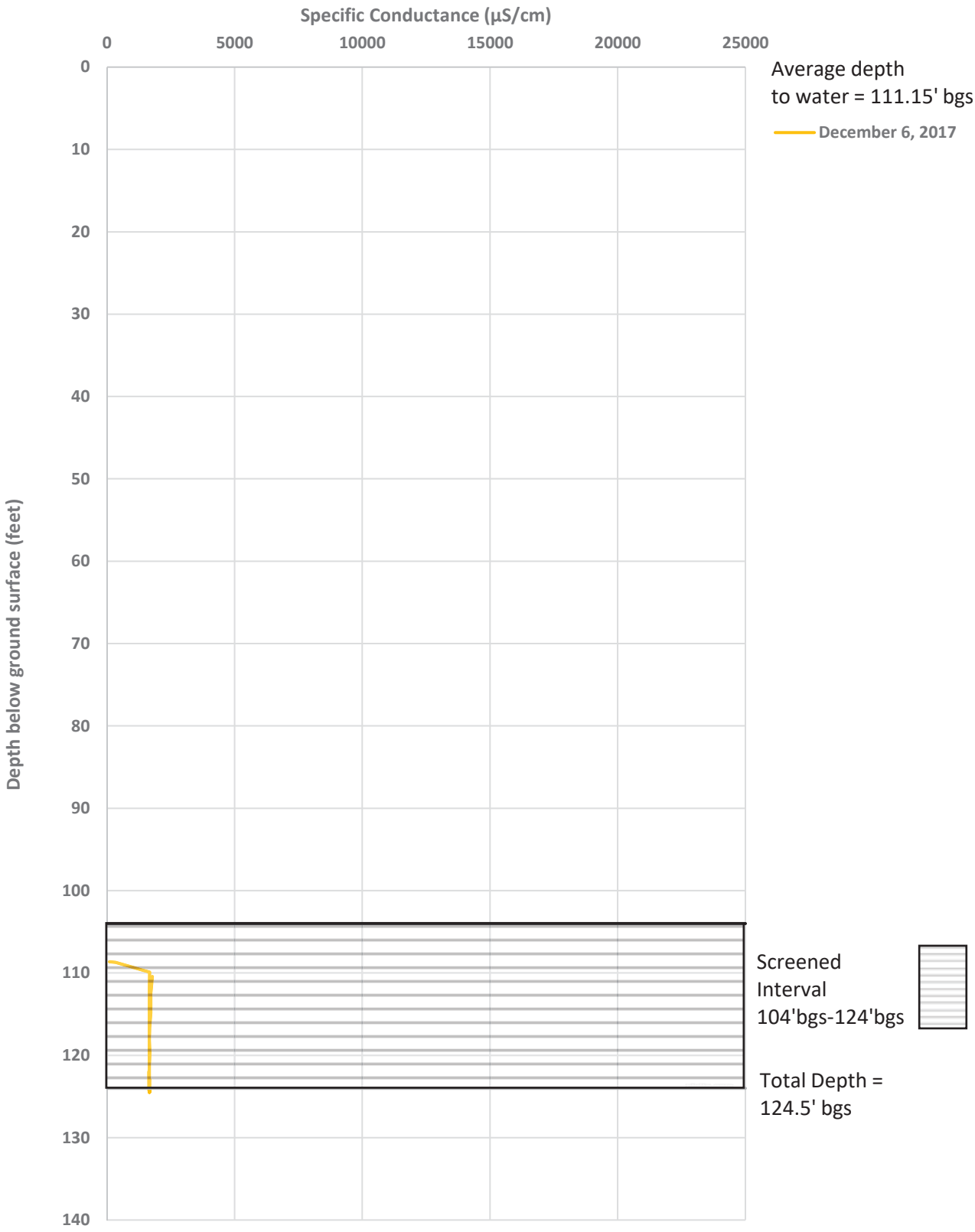
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-23-060



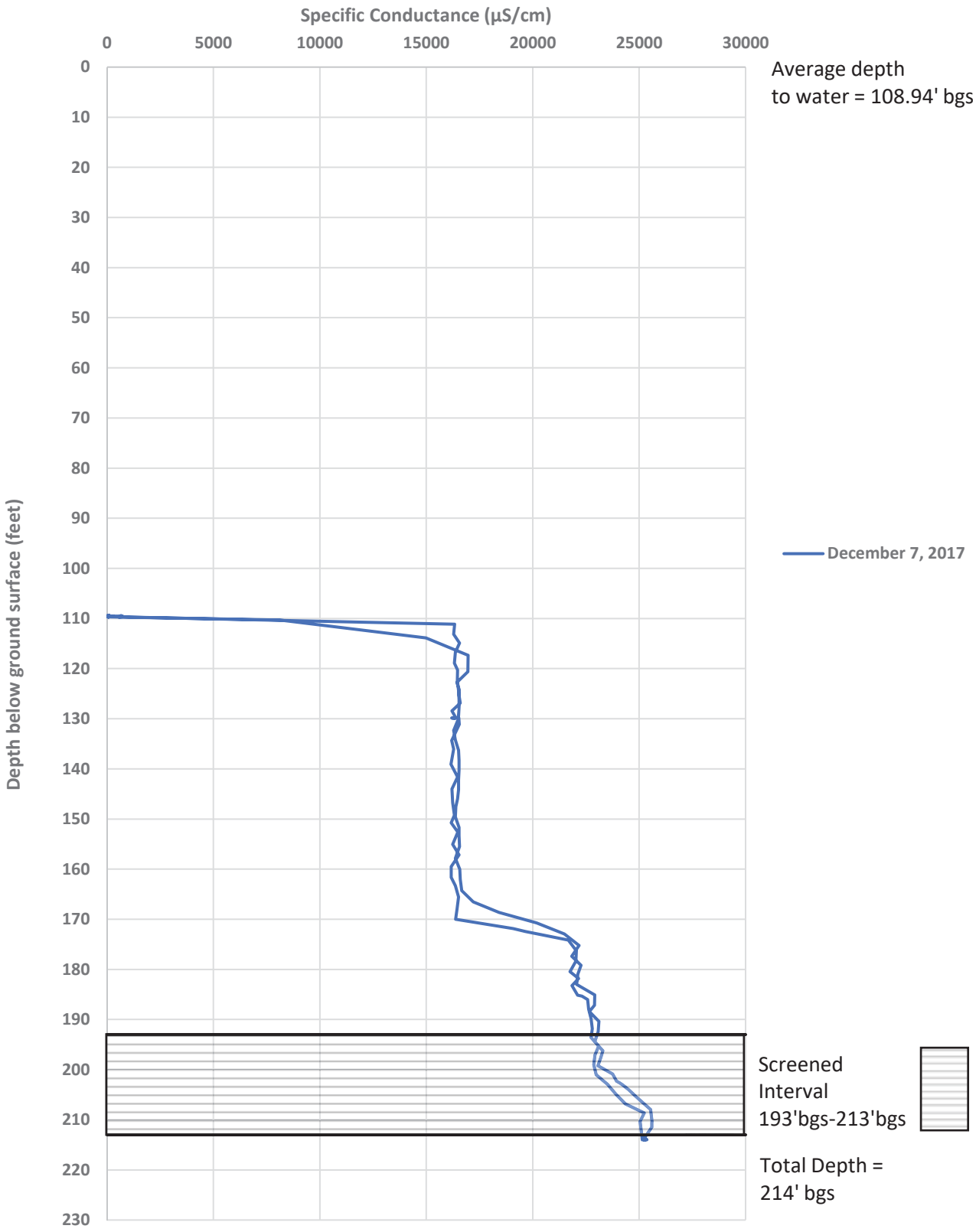
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-23-080



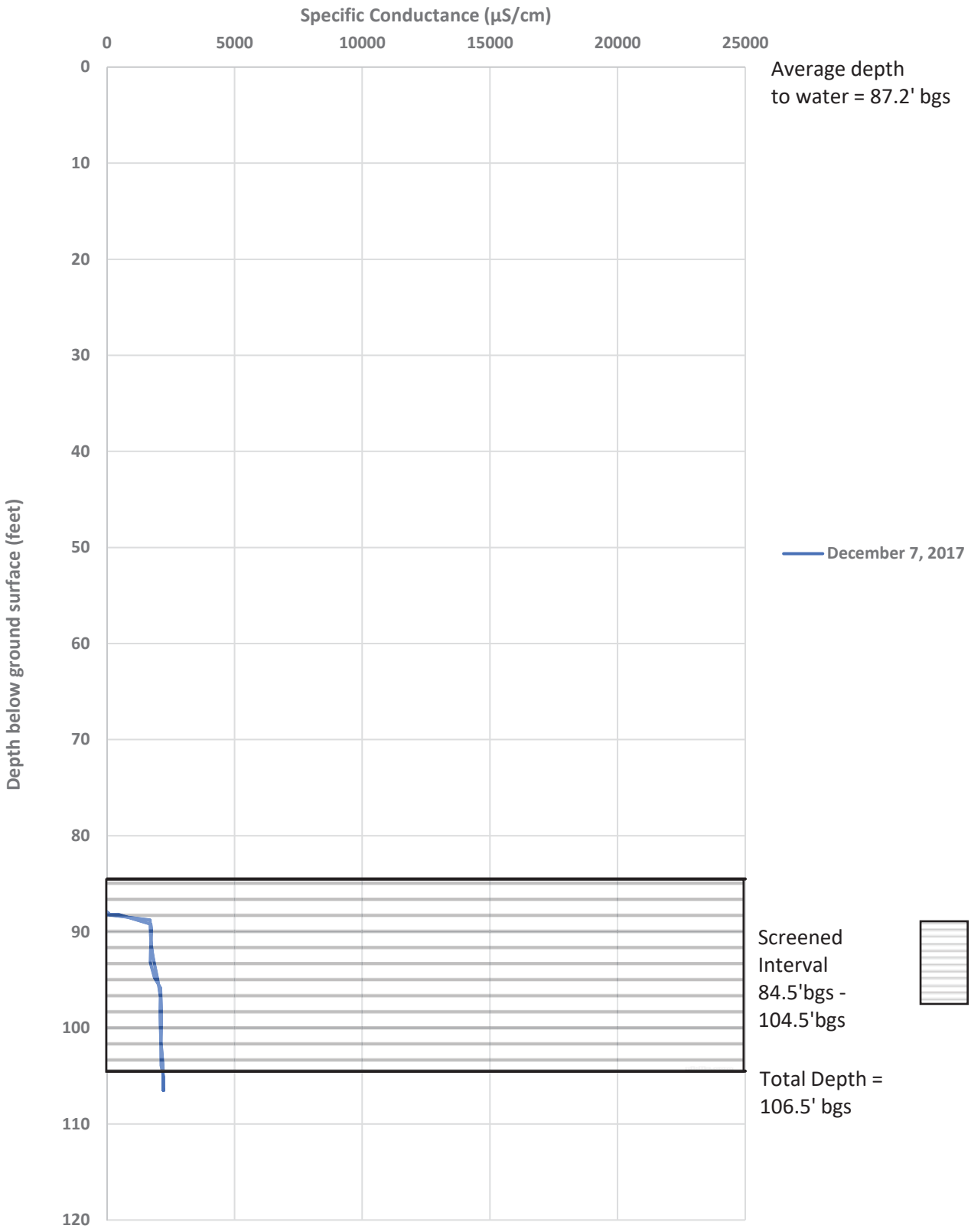
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-24A



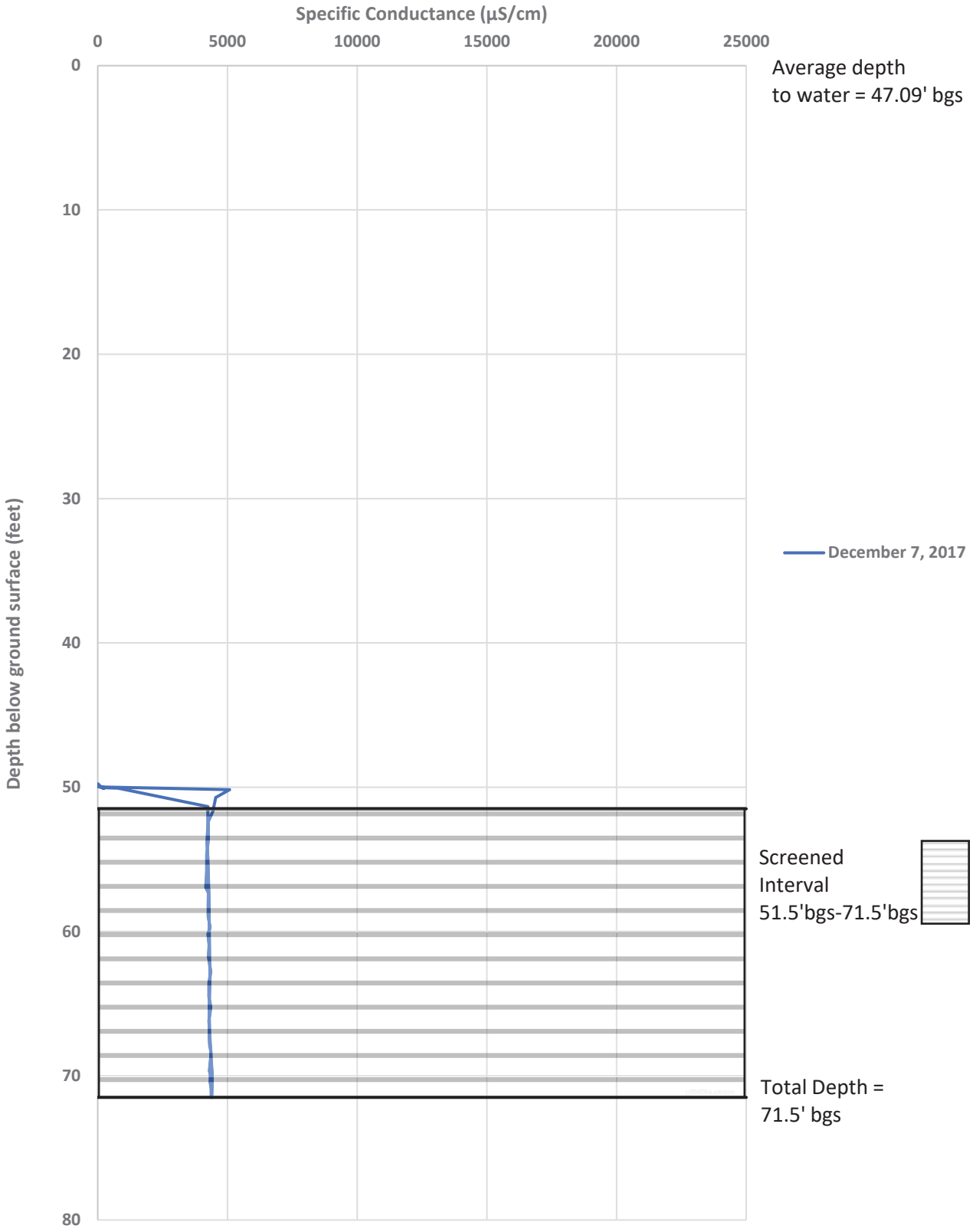
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-24B



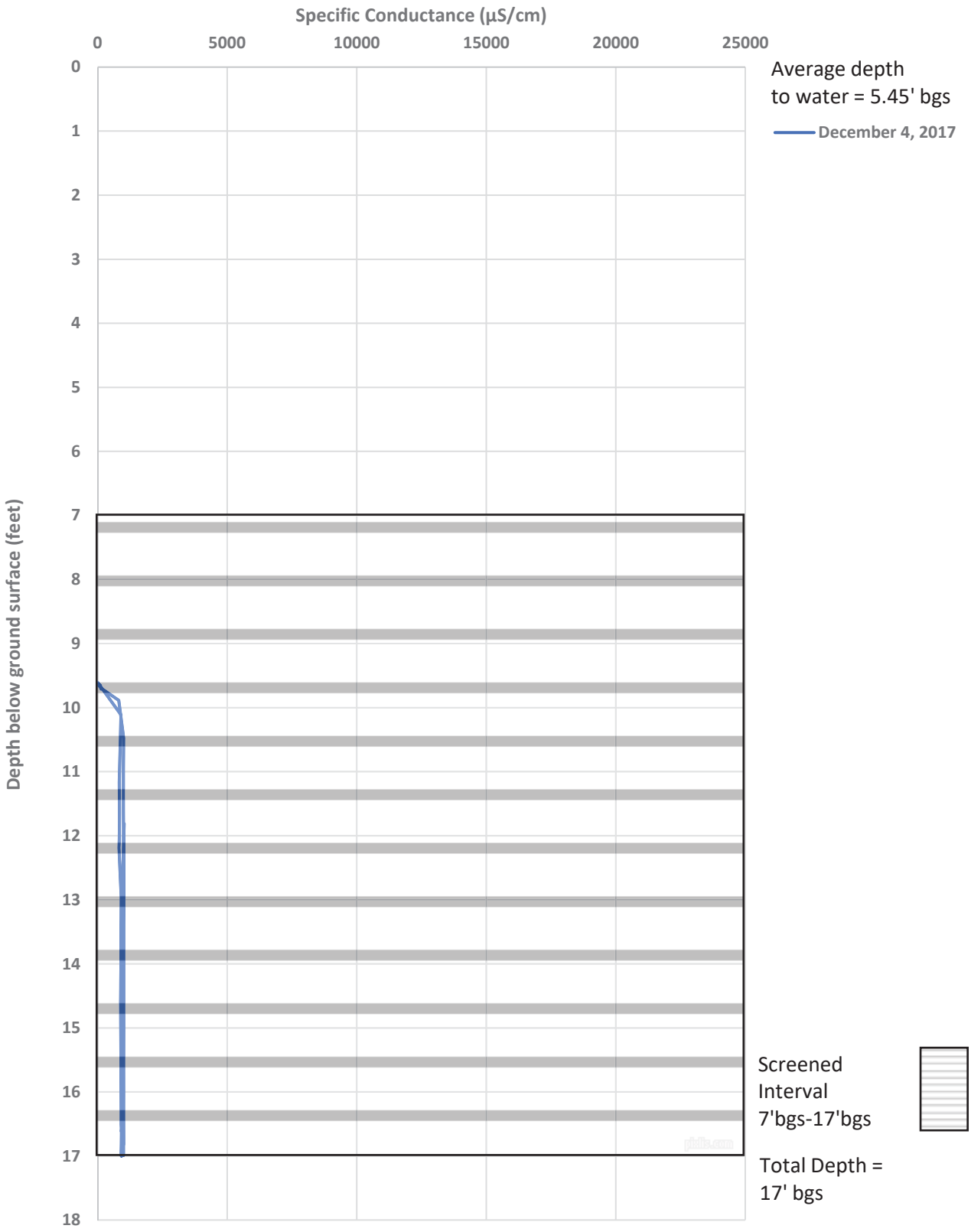
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-25



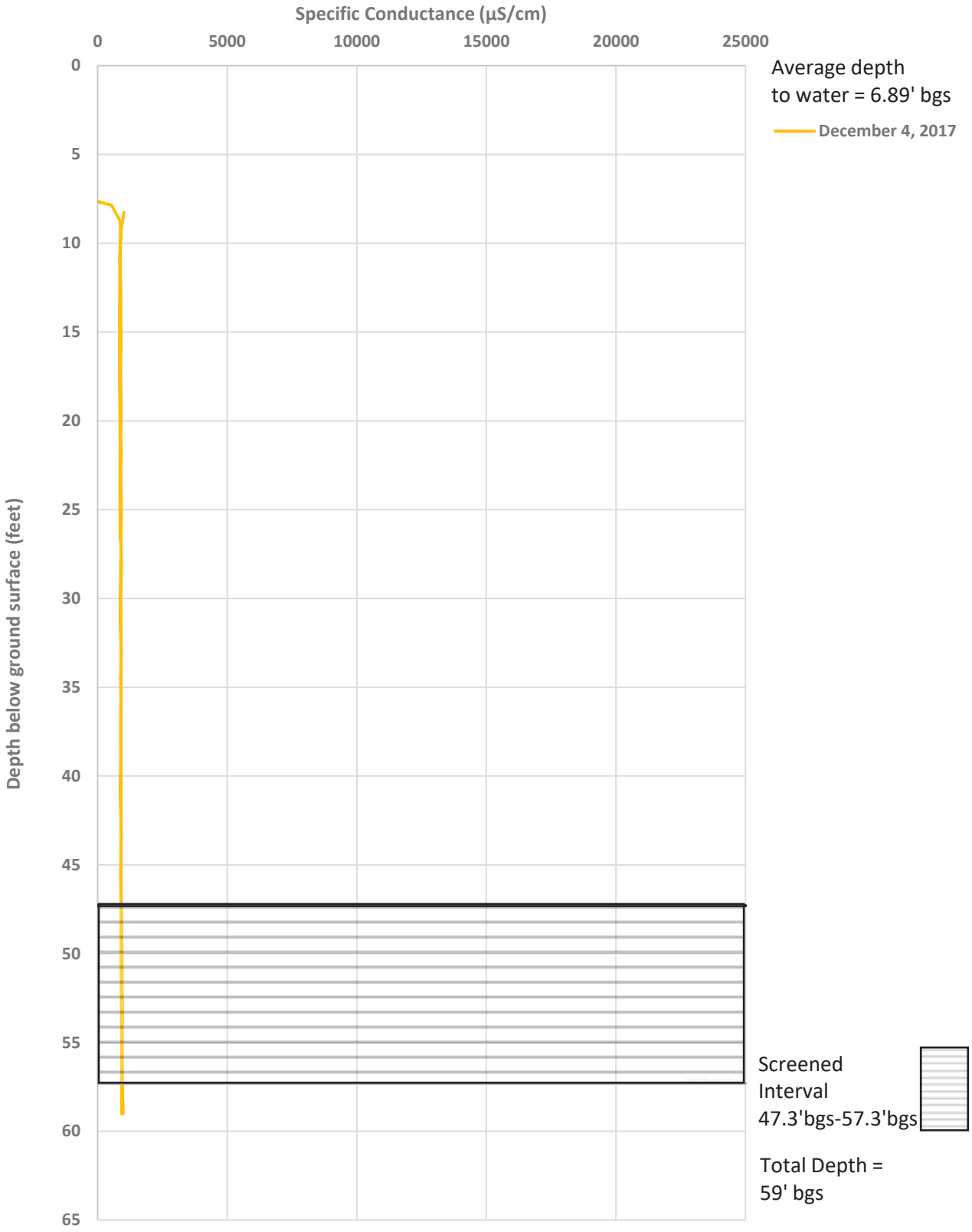
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-26



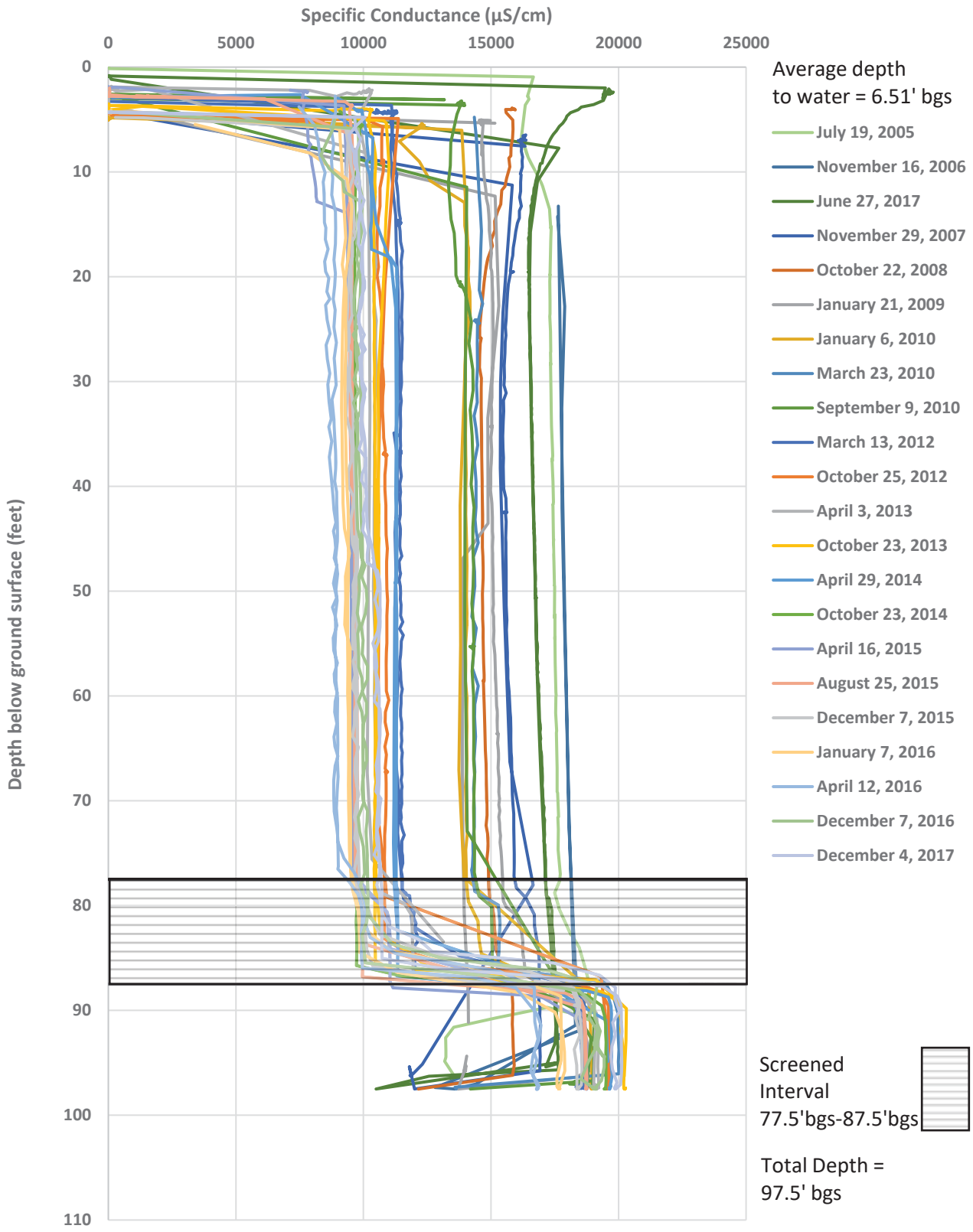
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-27-020



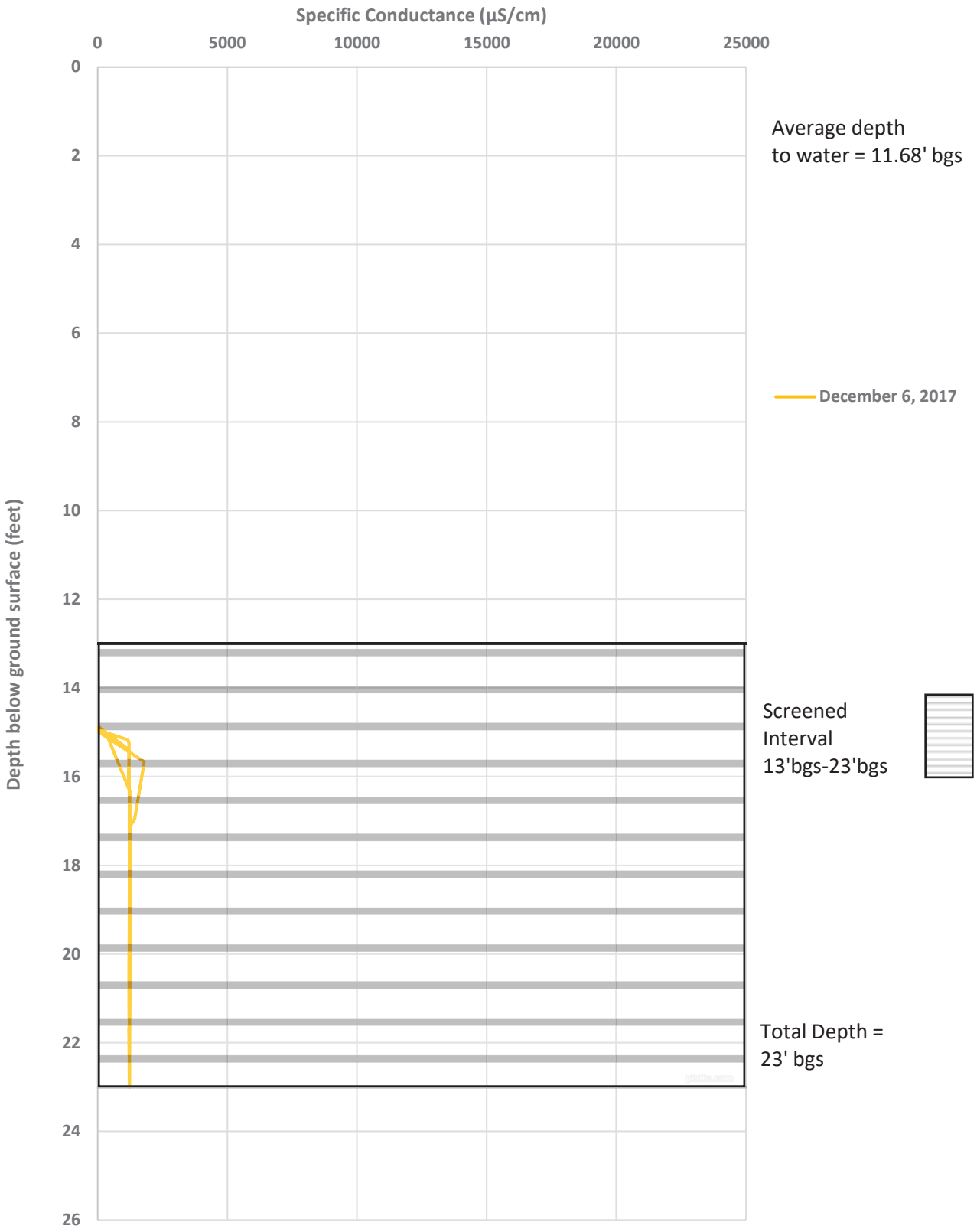
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-27-060



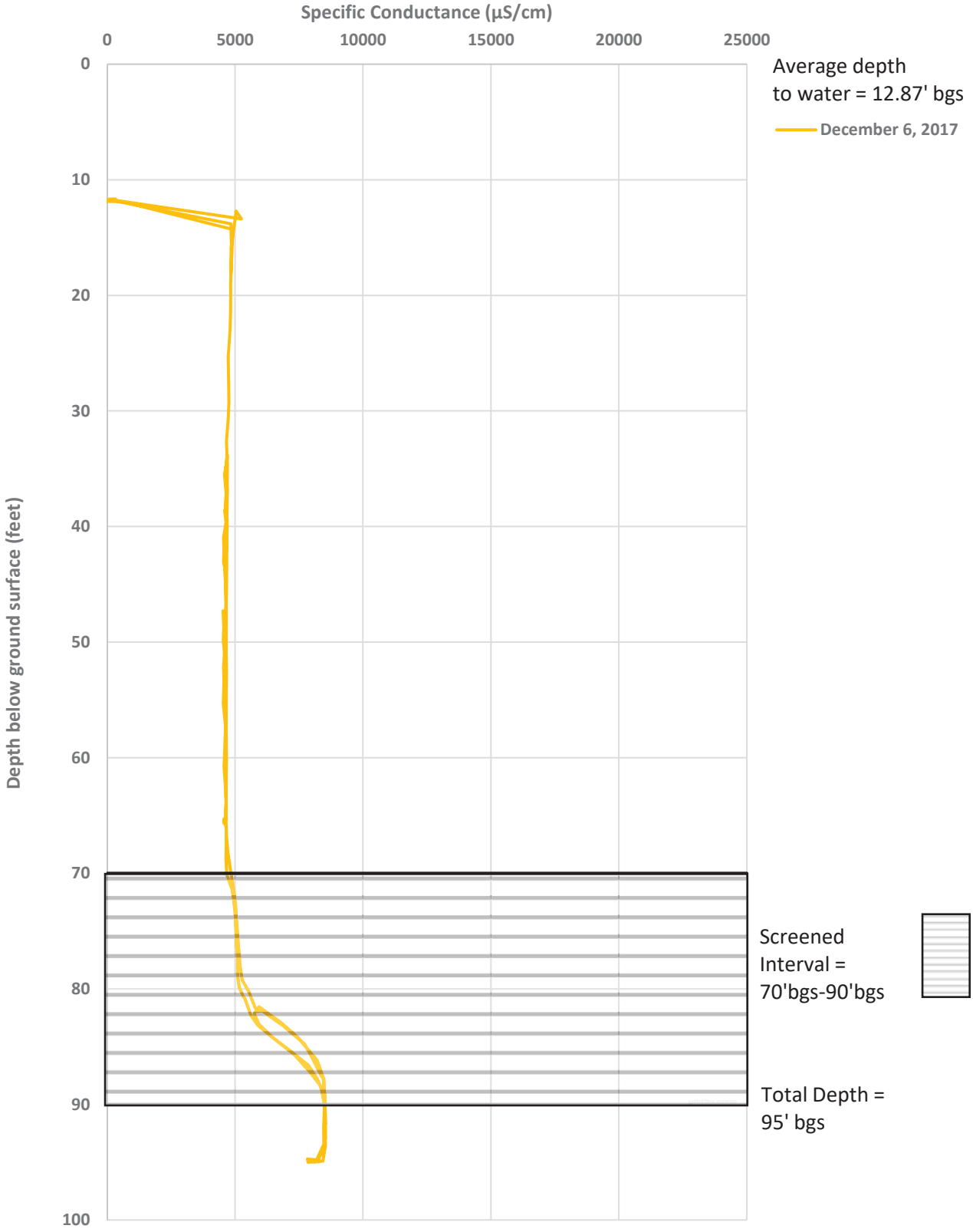
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-27-085



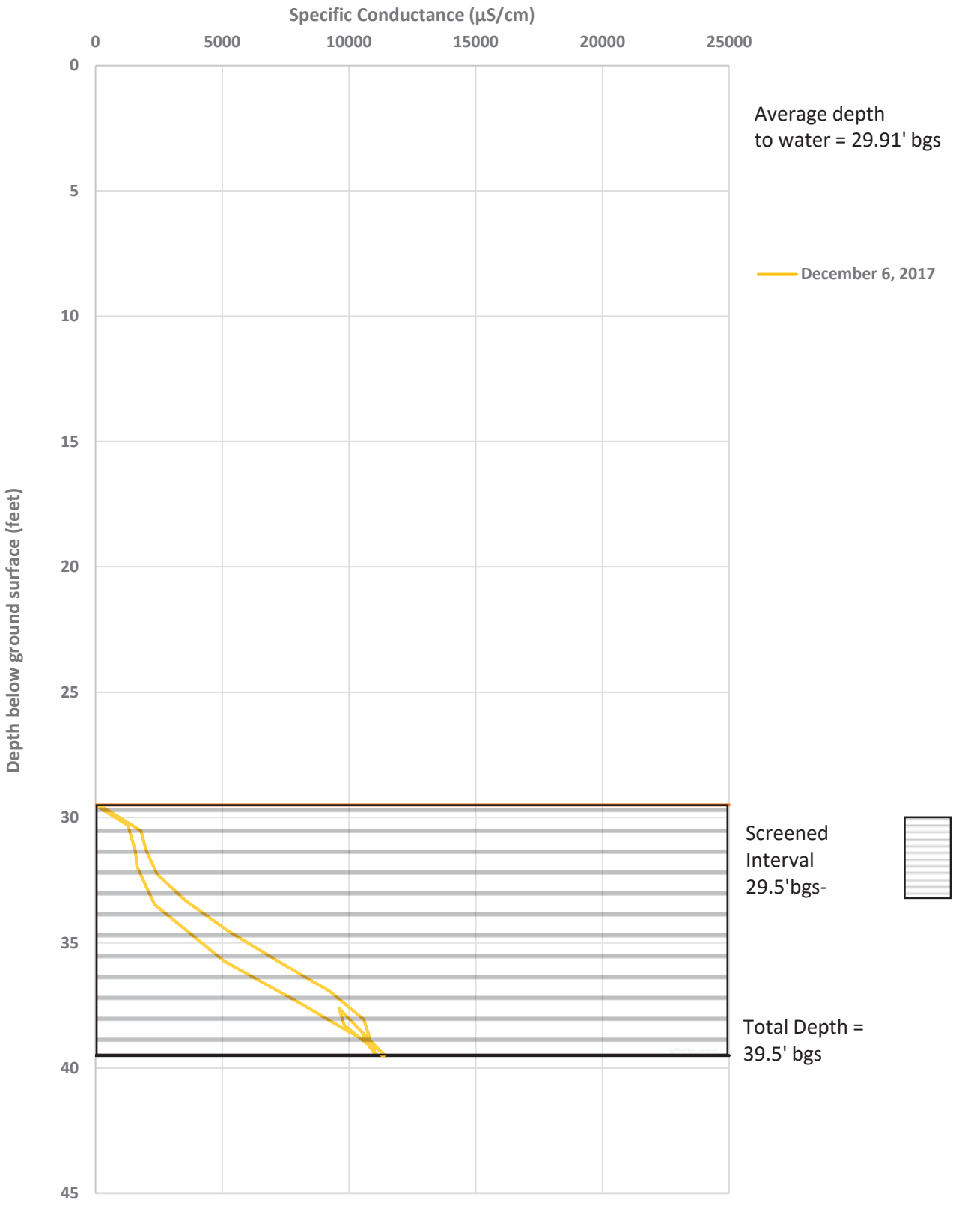
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-28-025



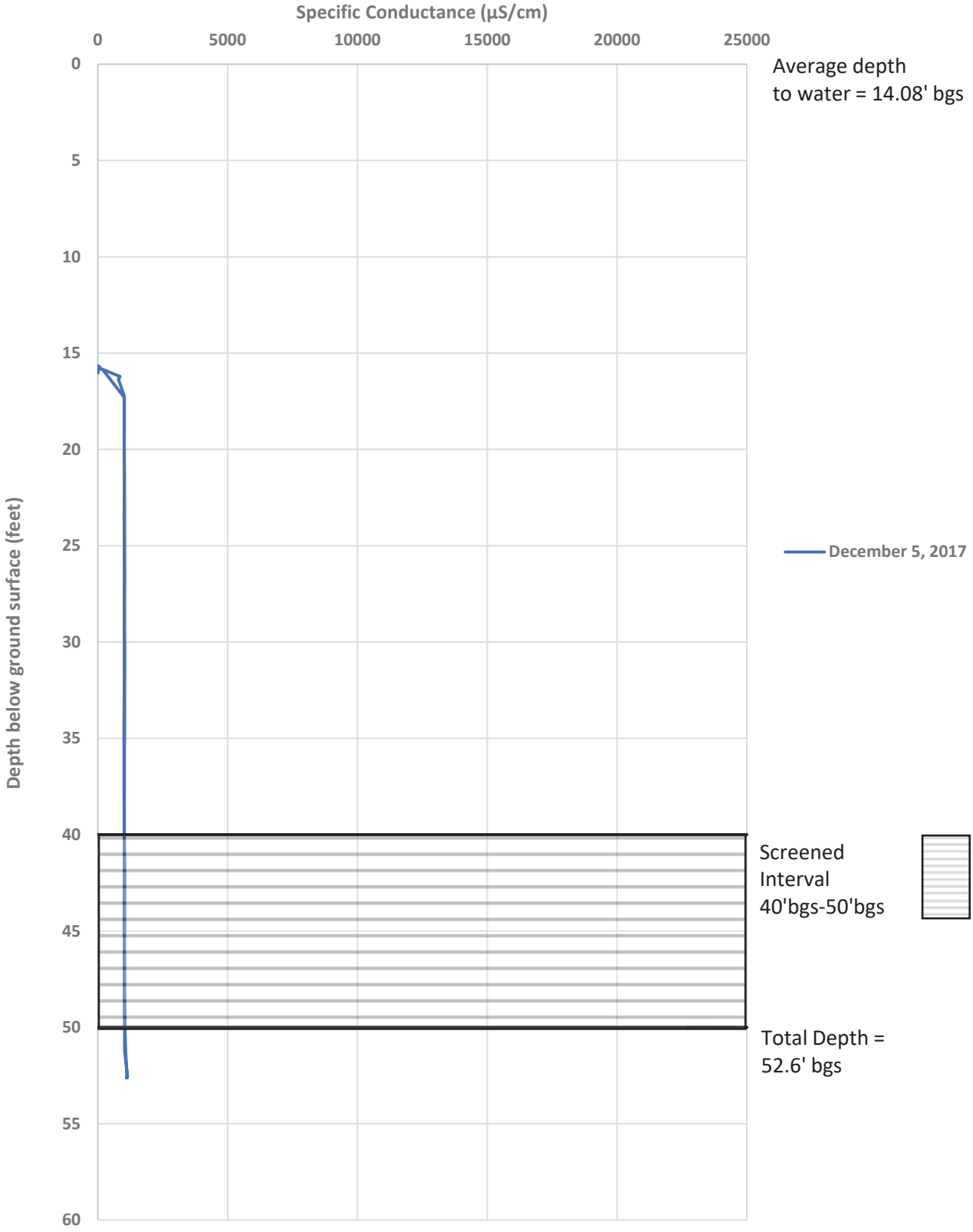
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-28-090



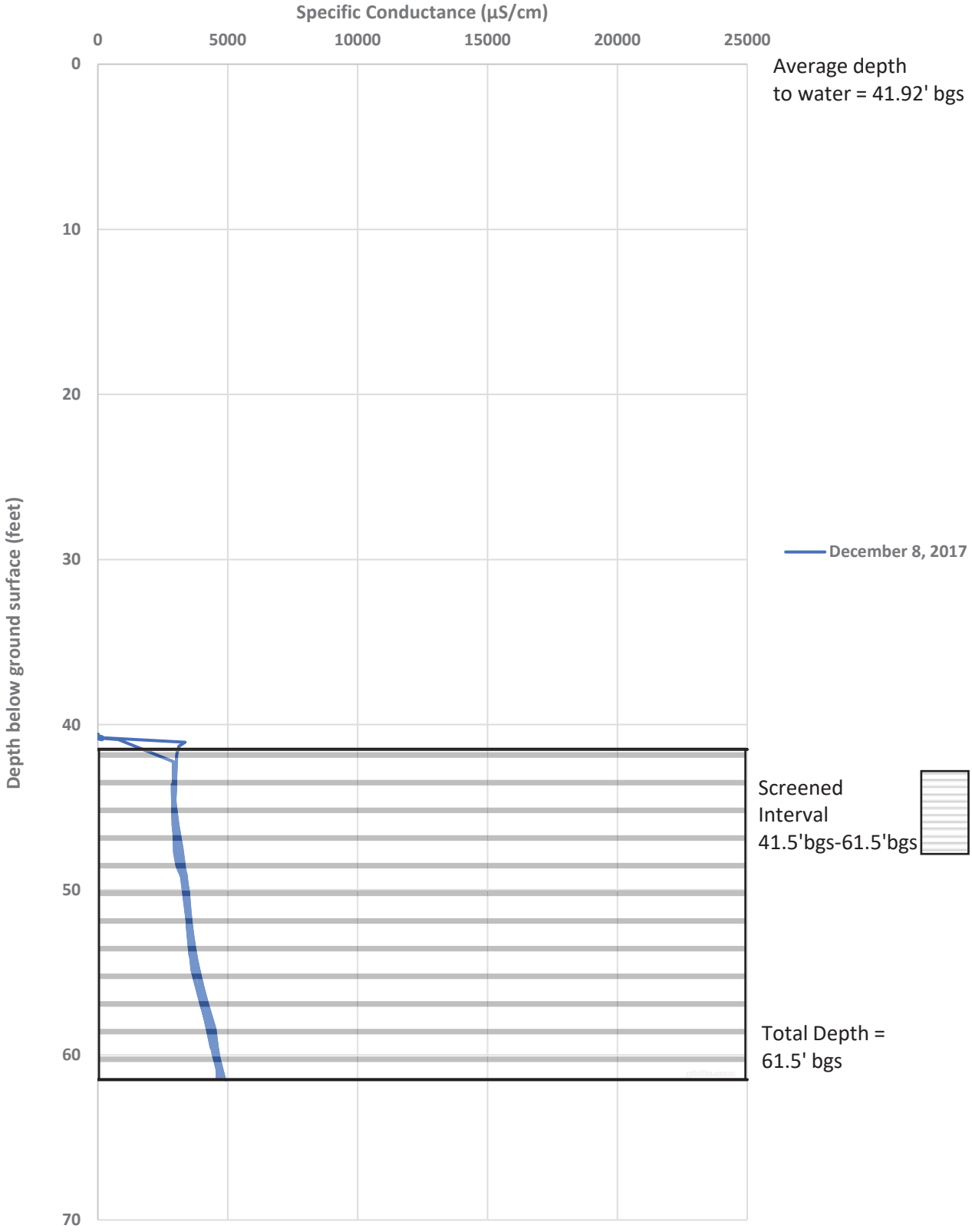
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-29



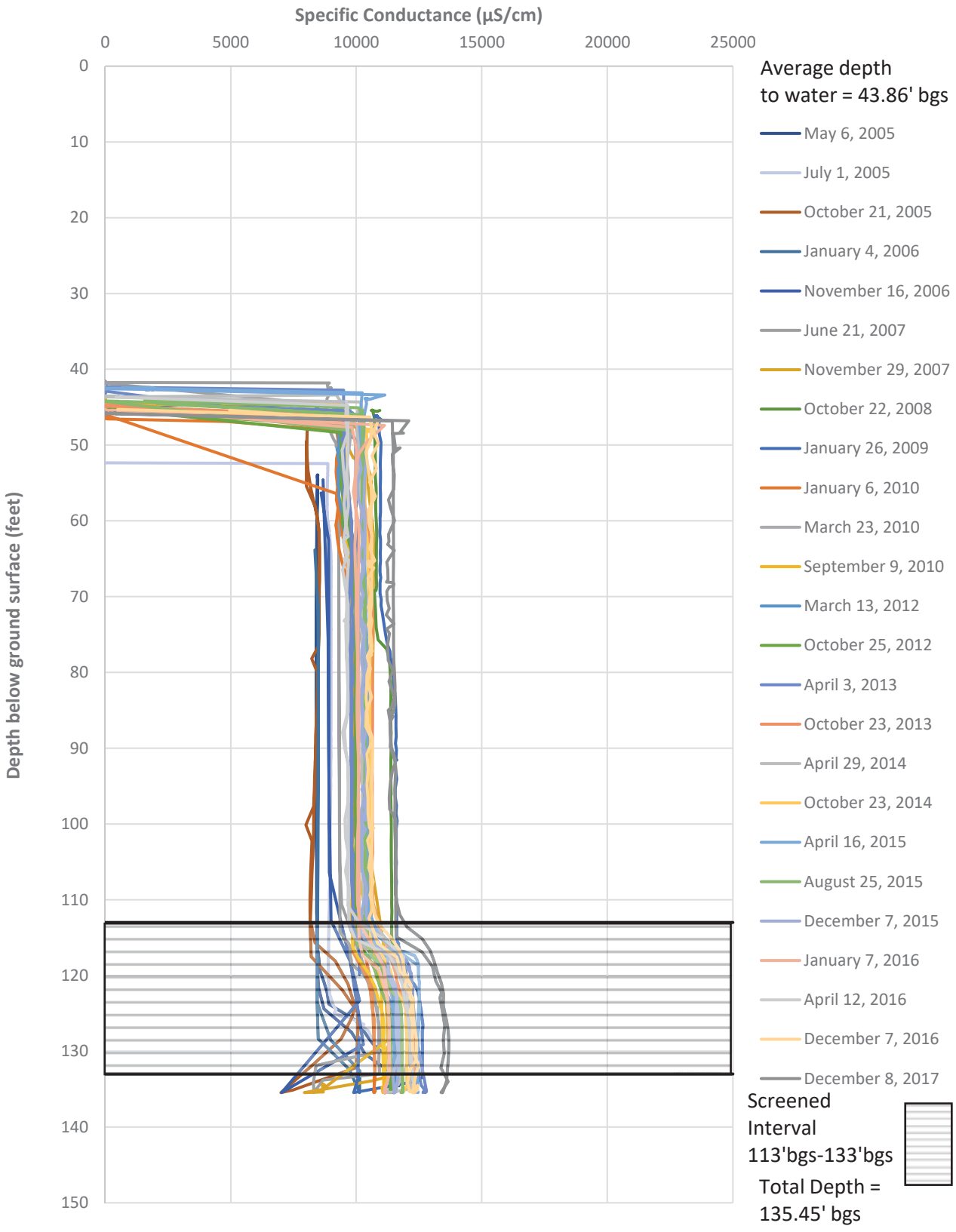
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-30-050



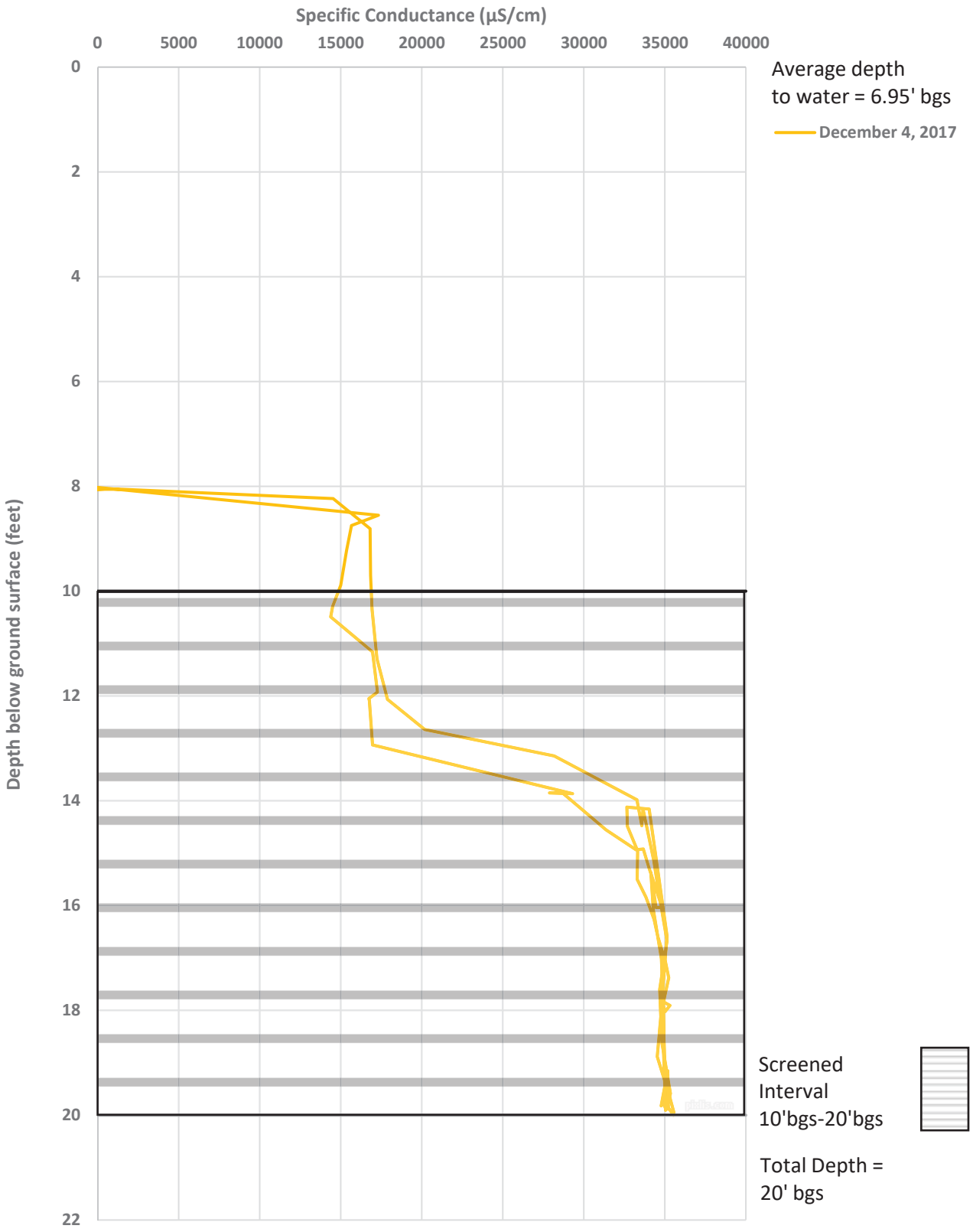
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-31-060



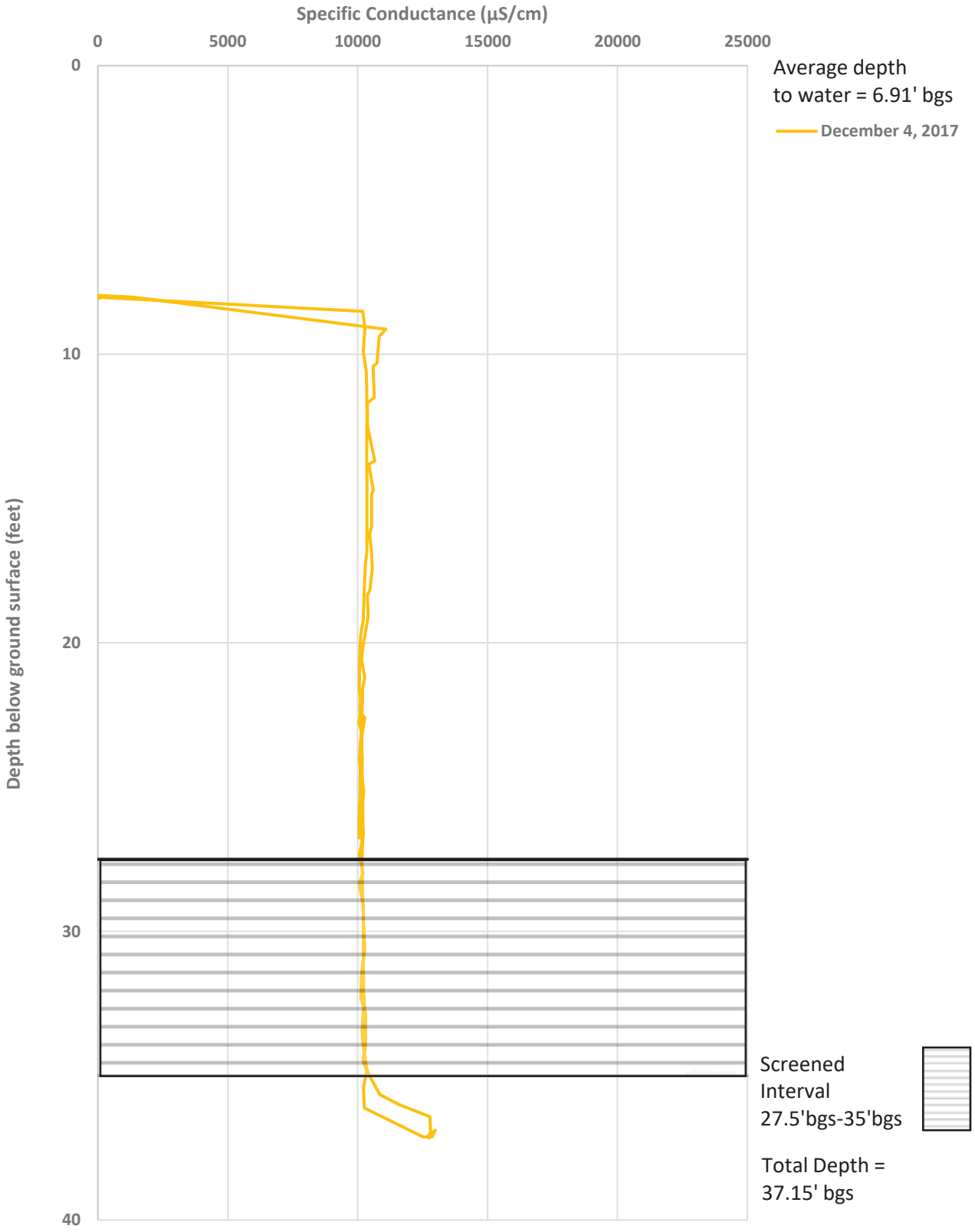
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-31-135



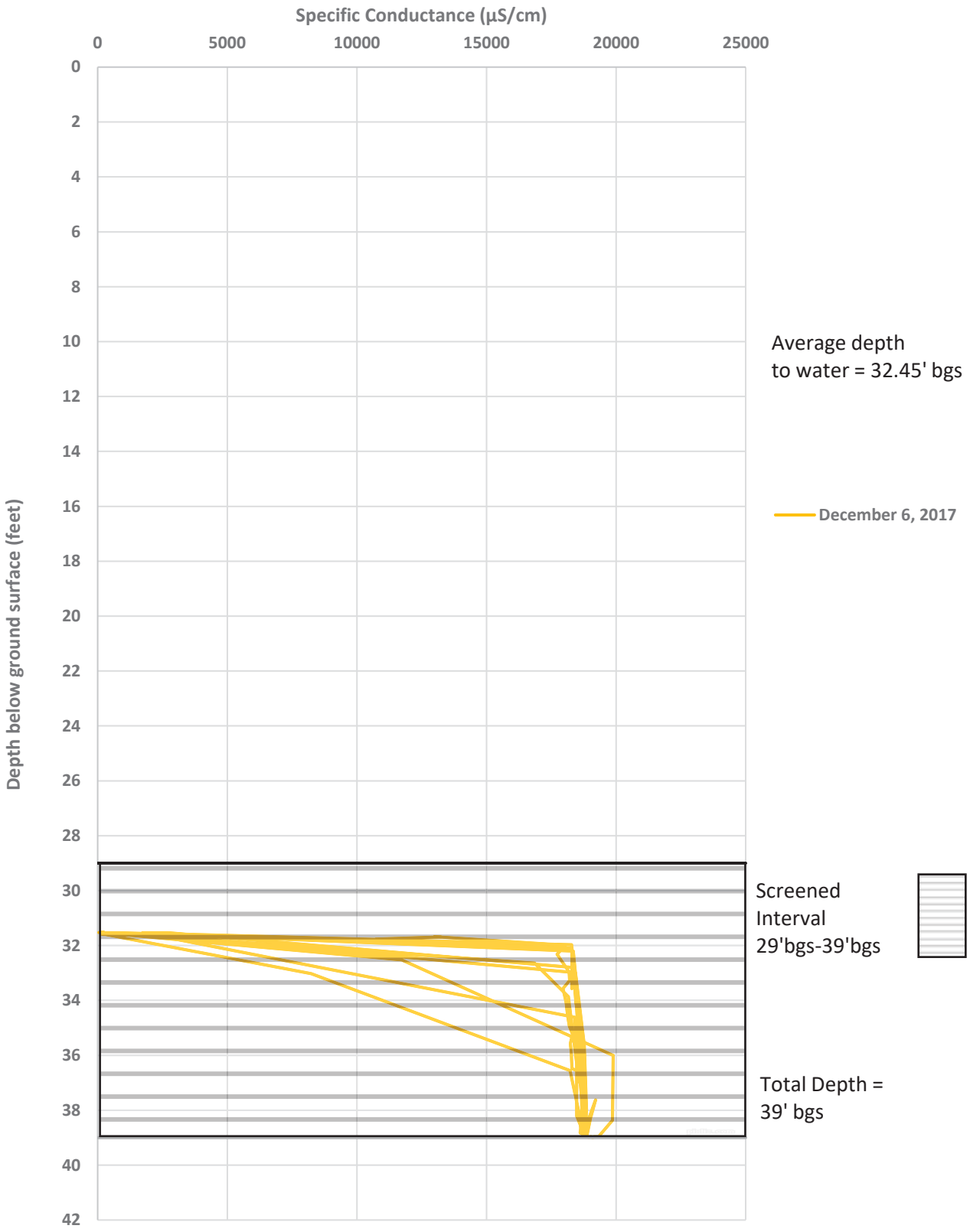
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-32-020



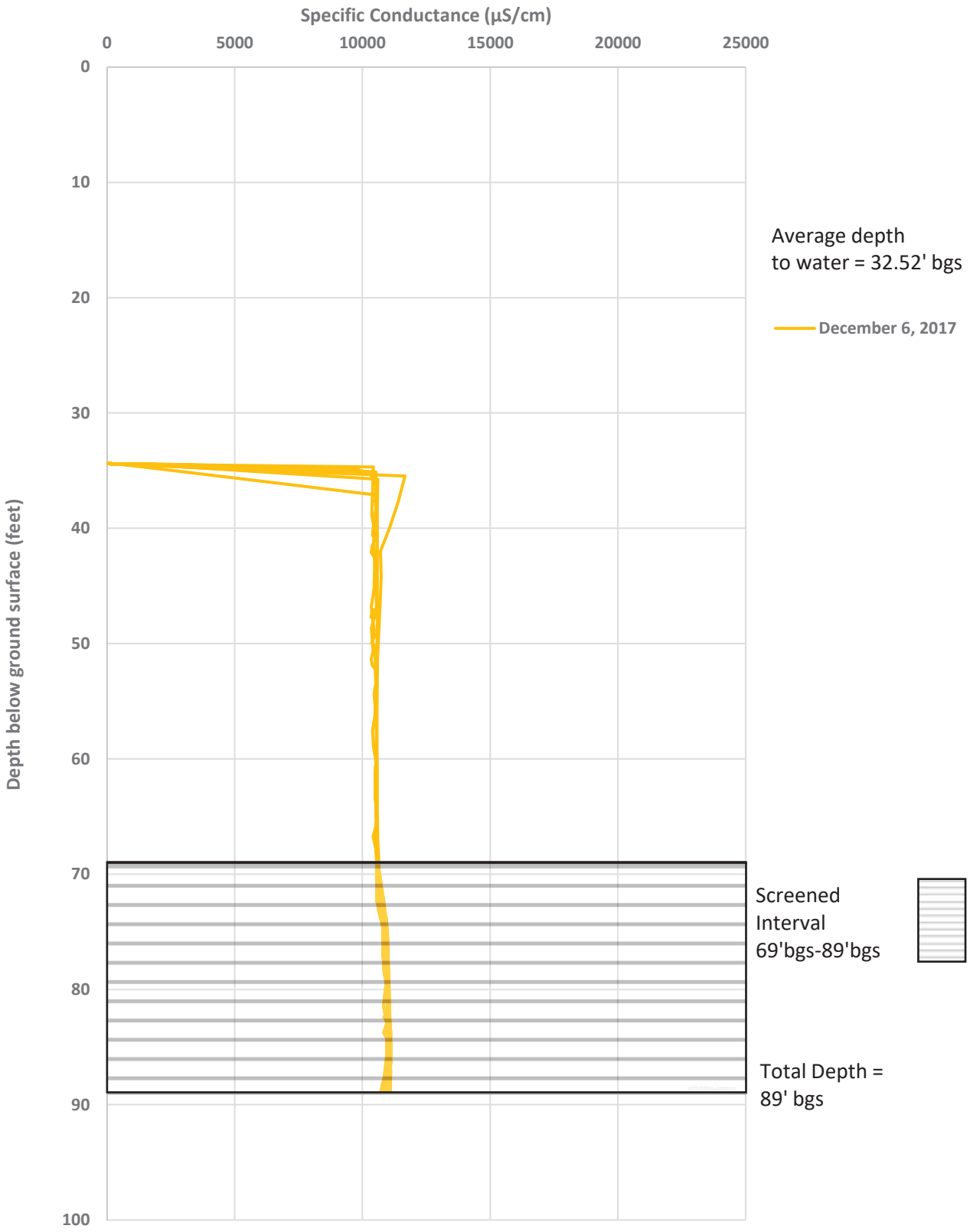
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-32-035



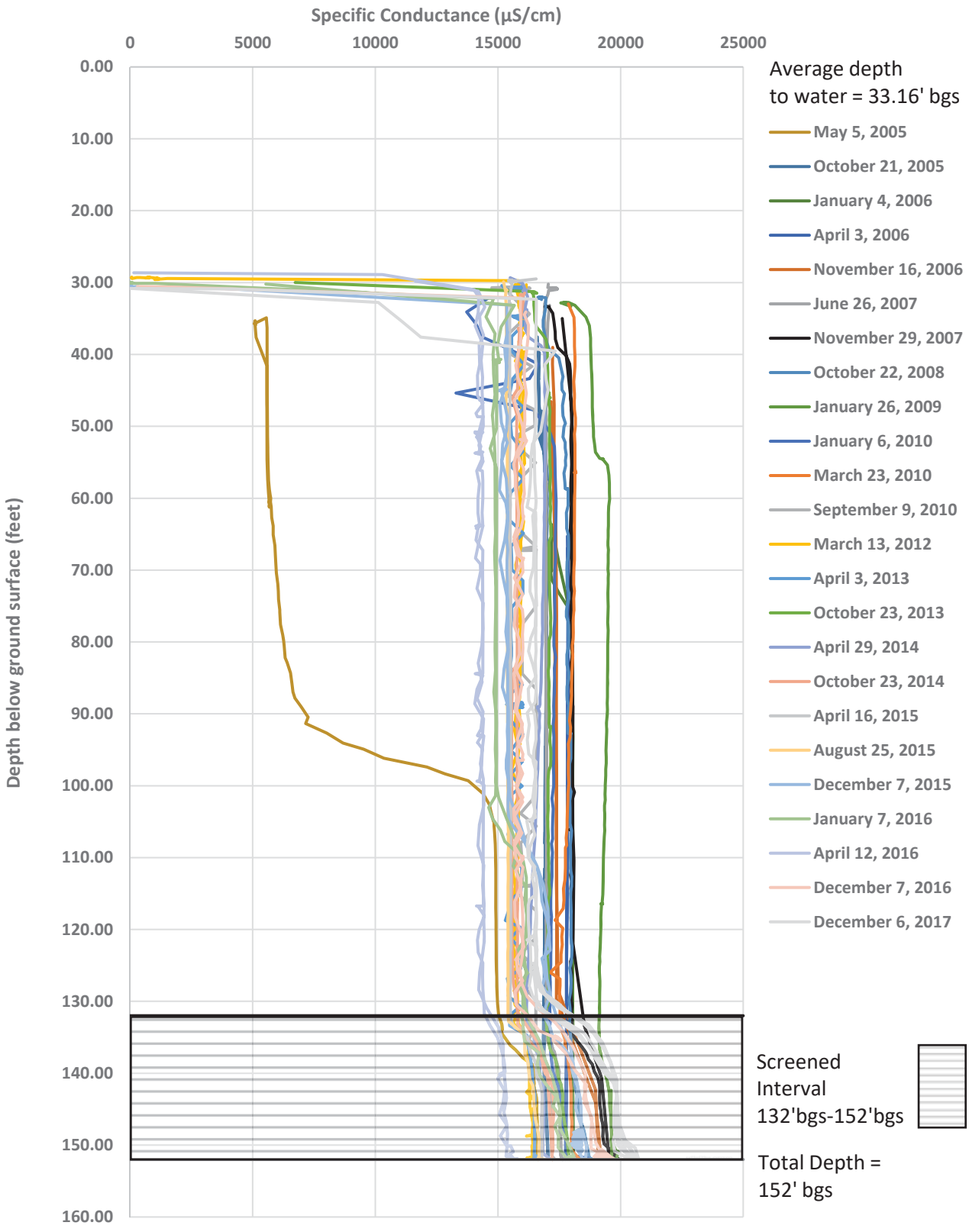
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-33-040



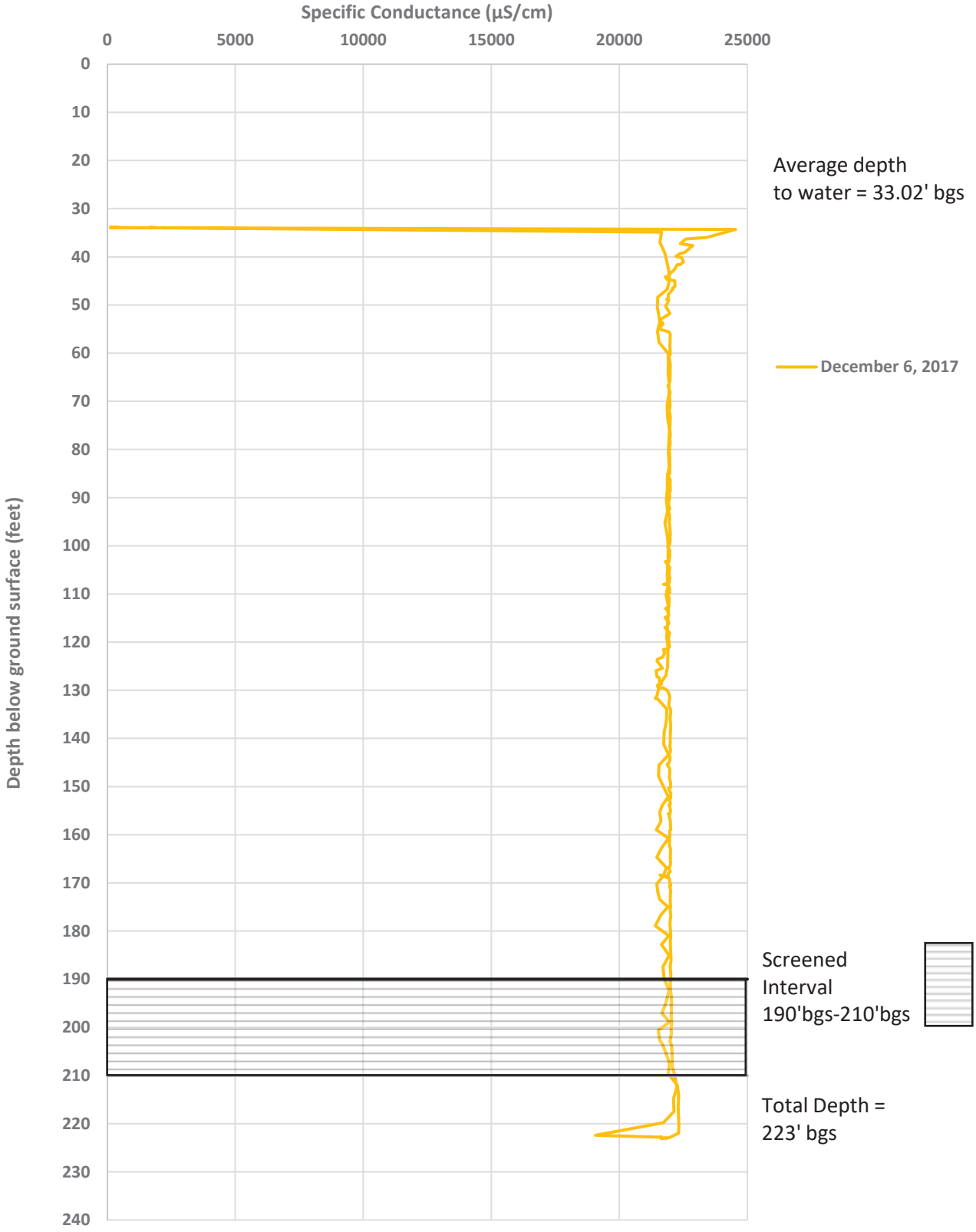
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-33-090



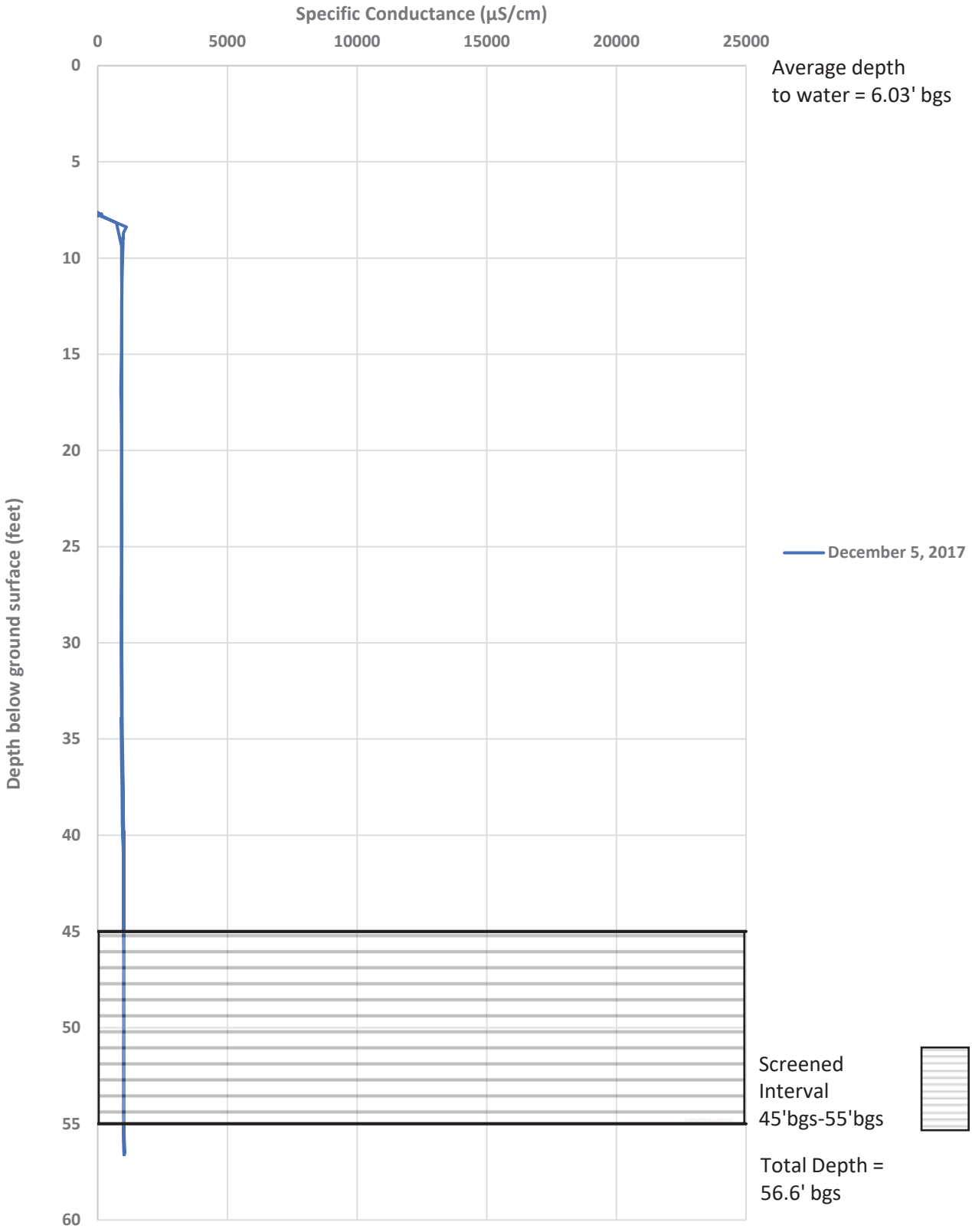
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-33-150



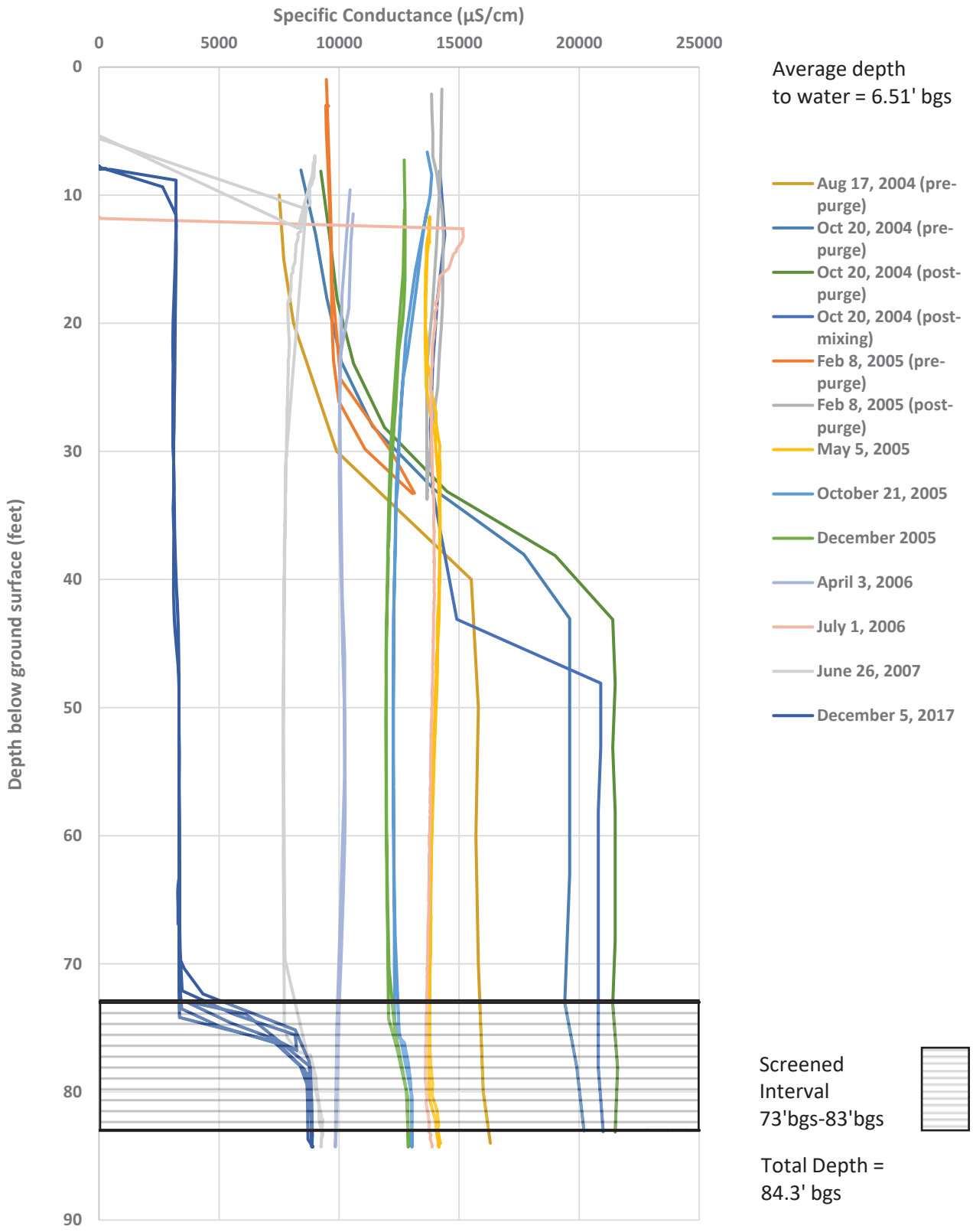
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-33-210



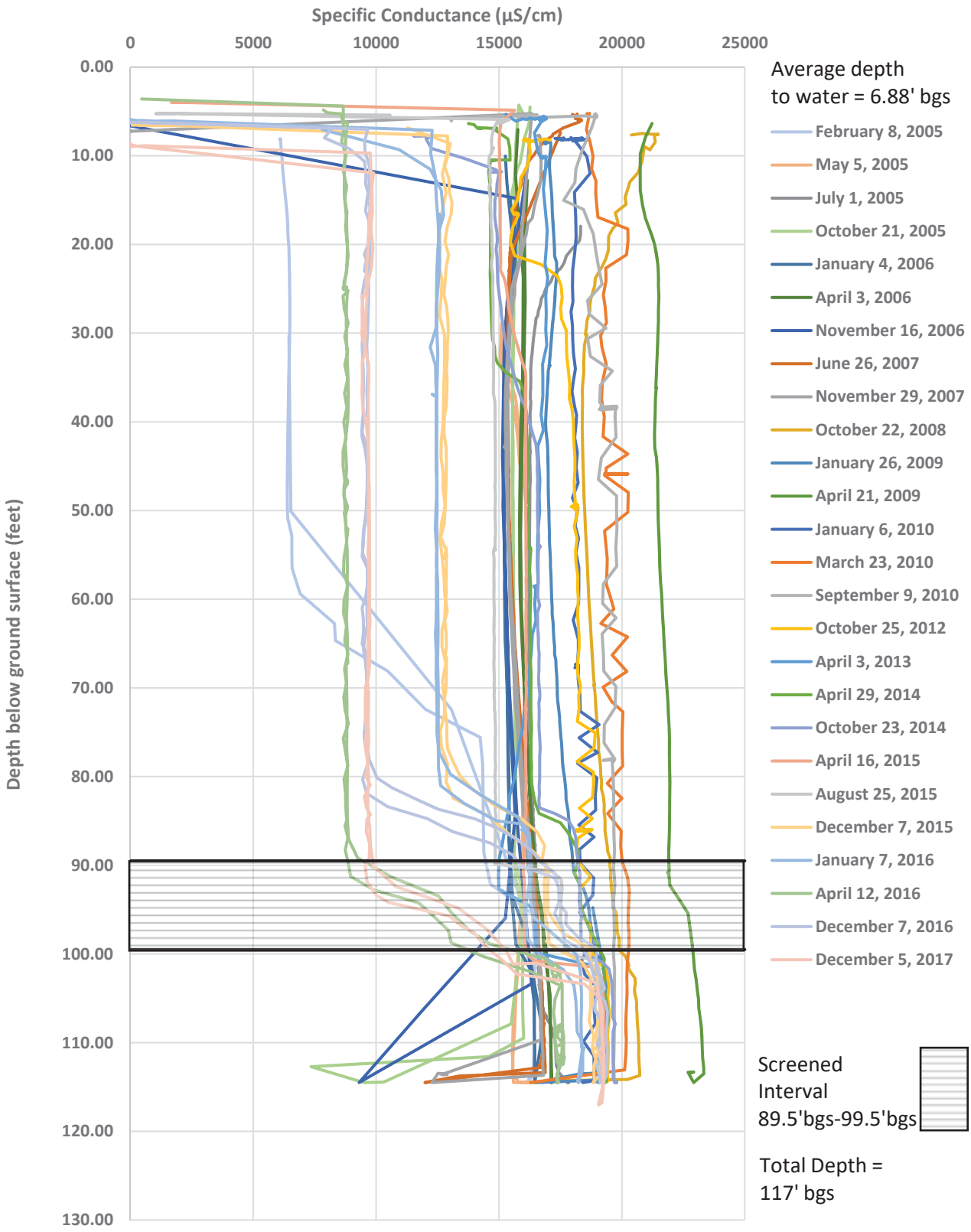
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-34-055



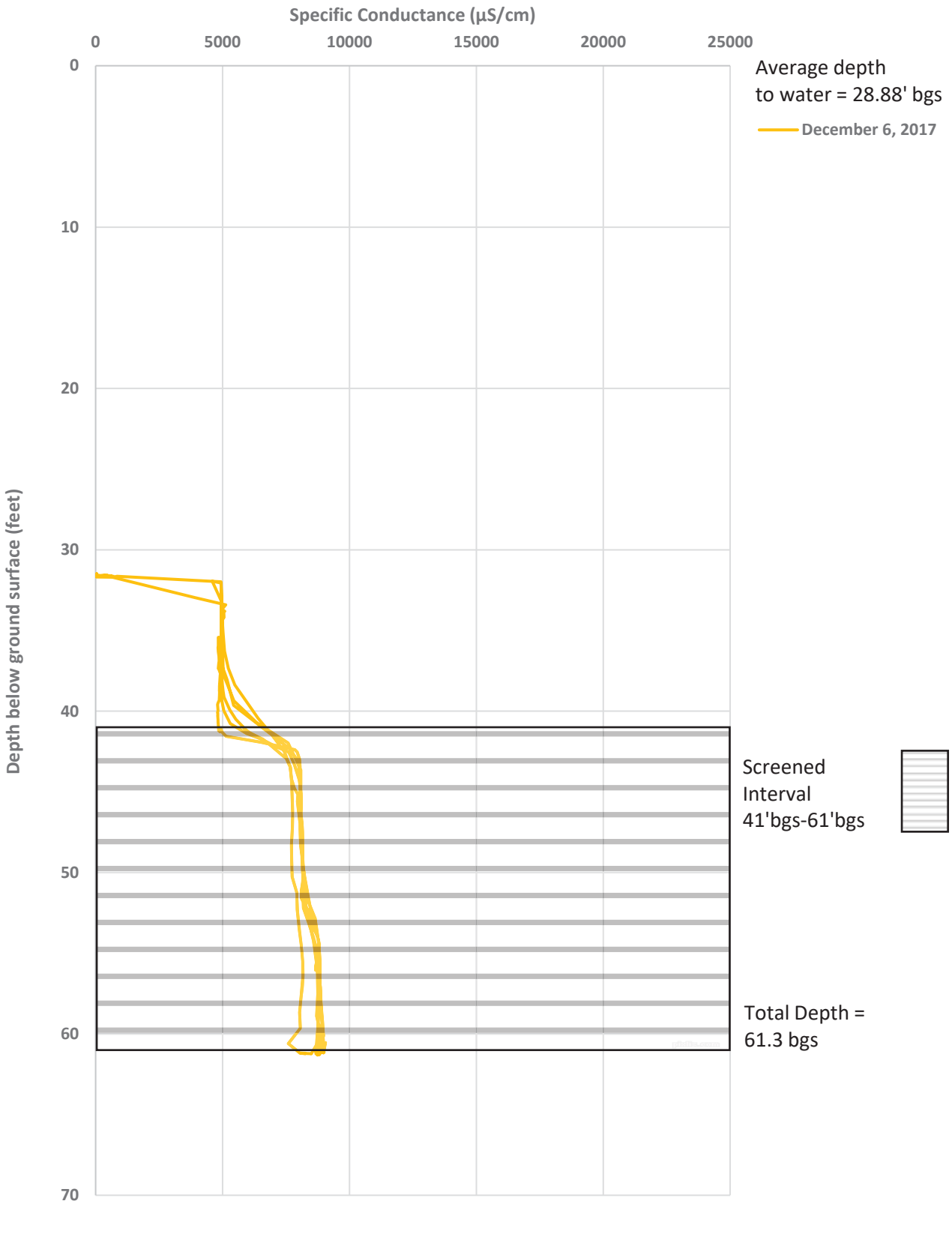
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-34-080



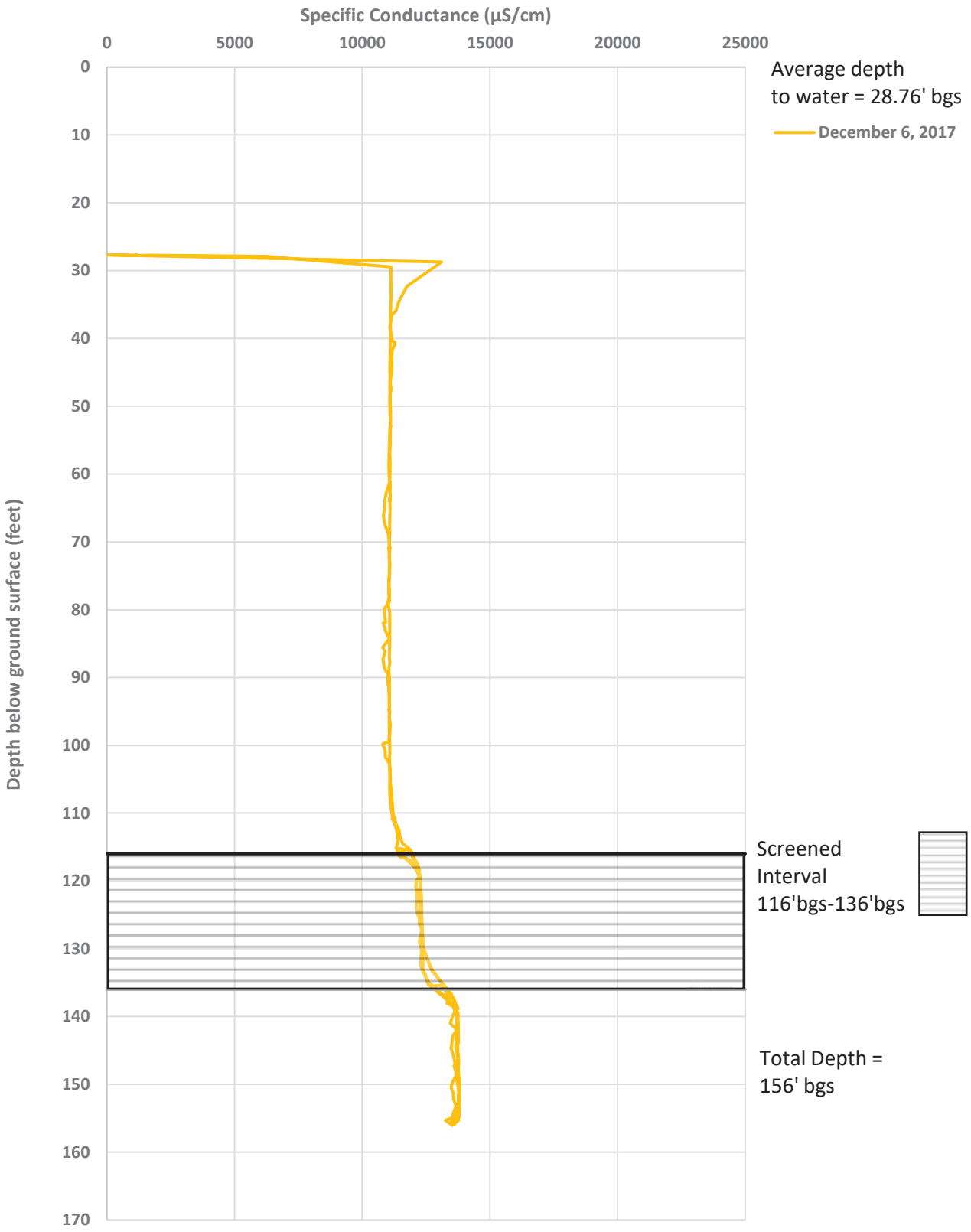
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-34-100



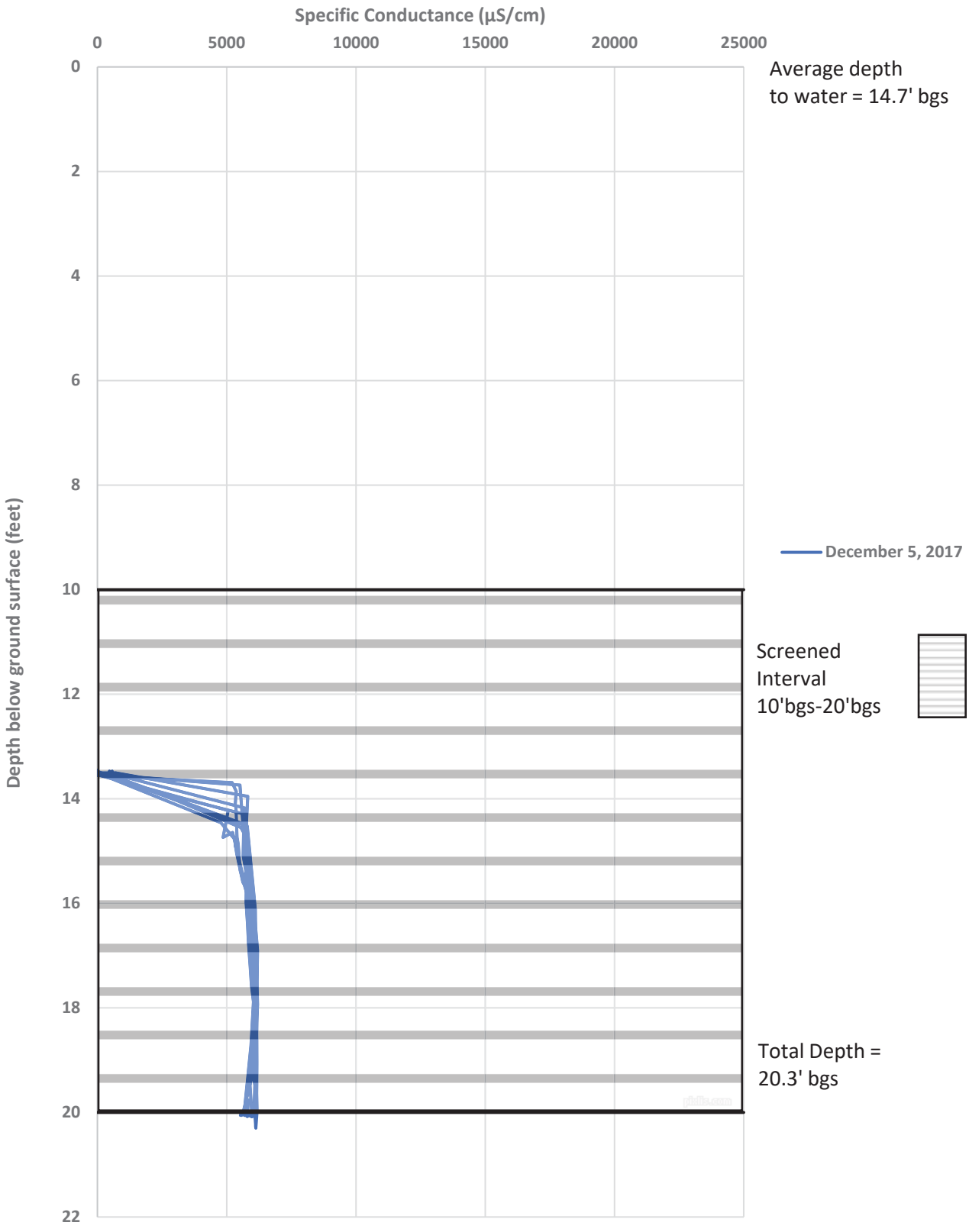
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-35-060



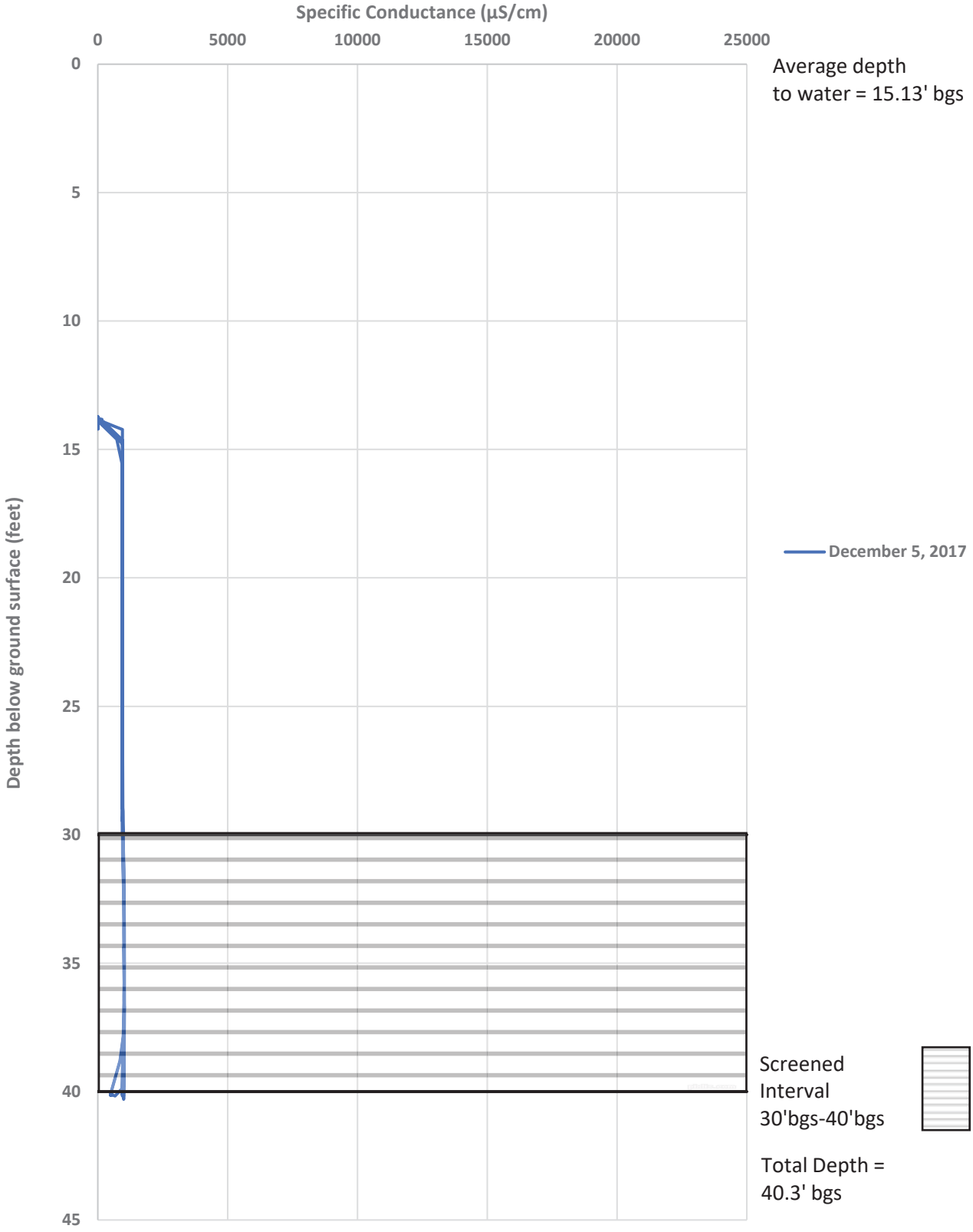
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-35-135



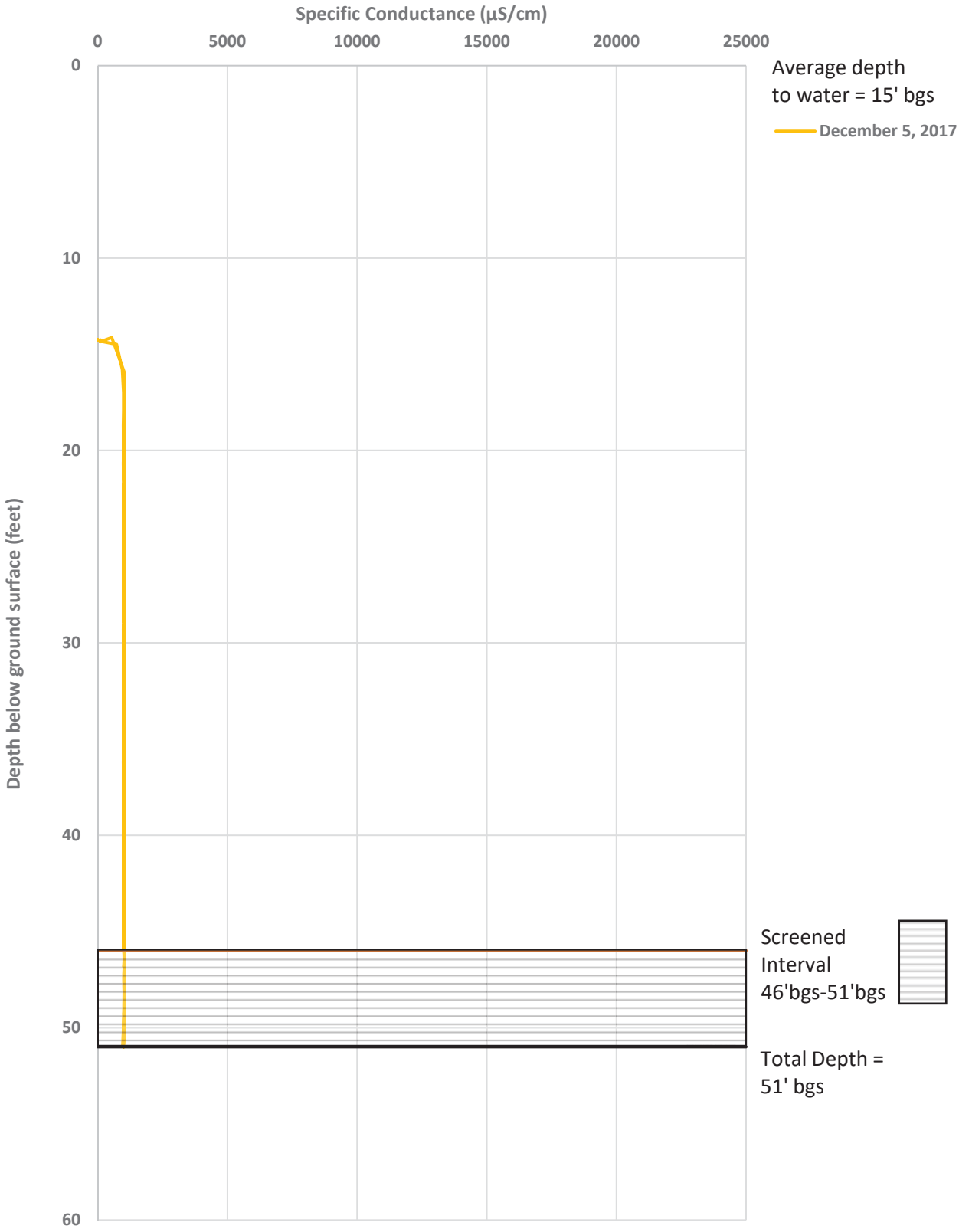
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-36-020



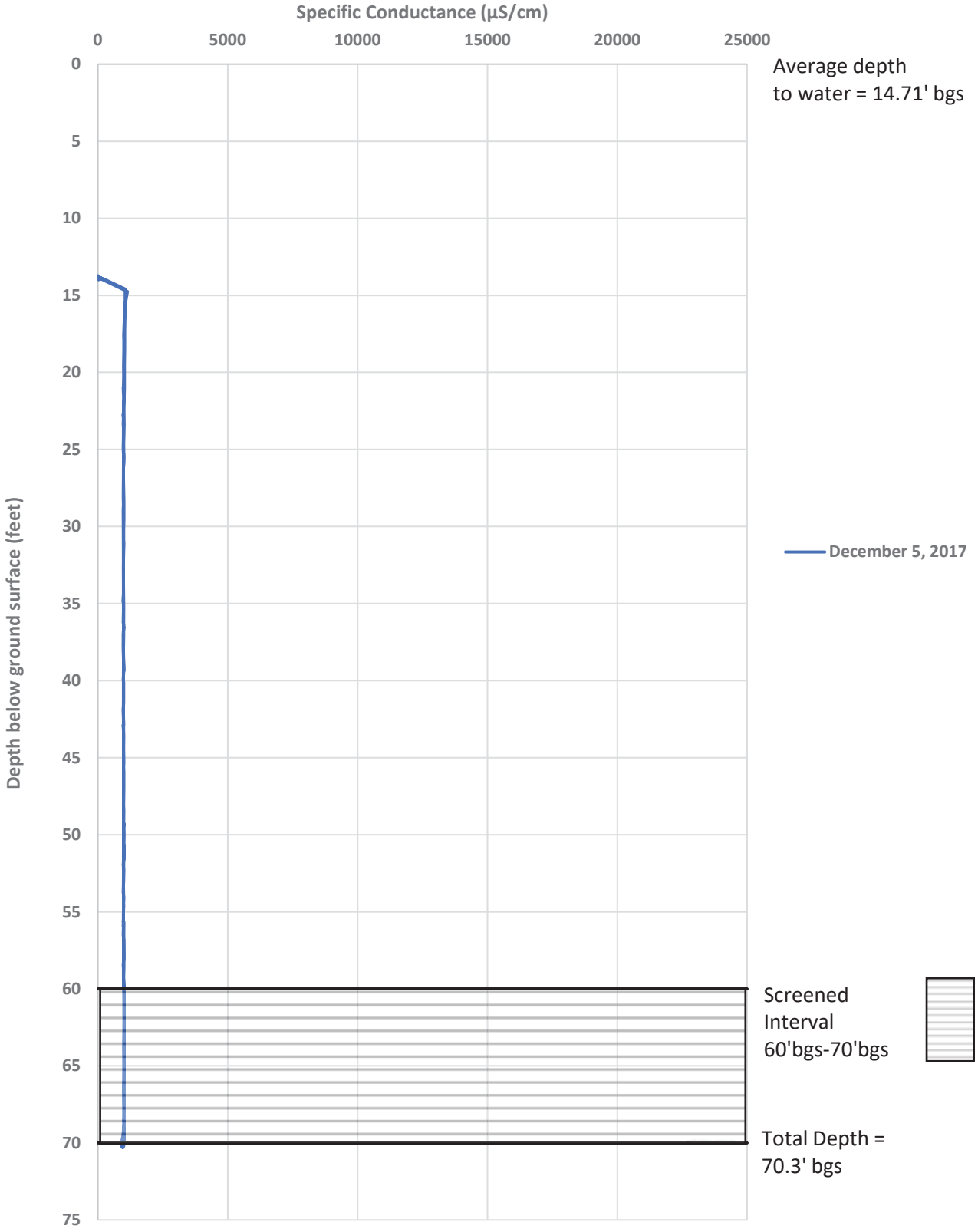
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-36-040



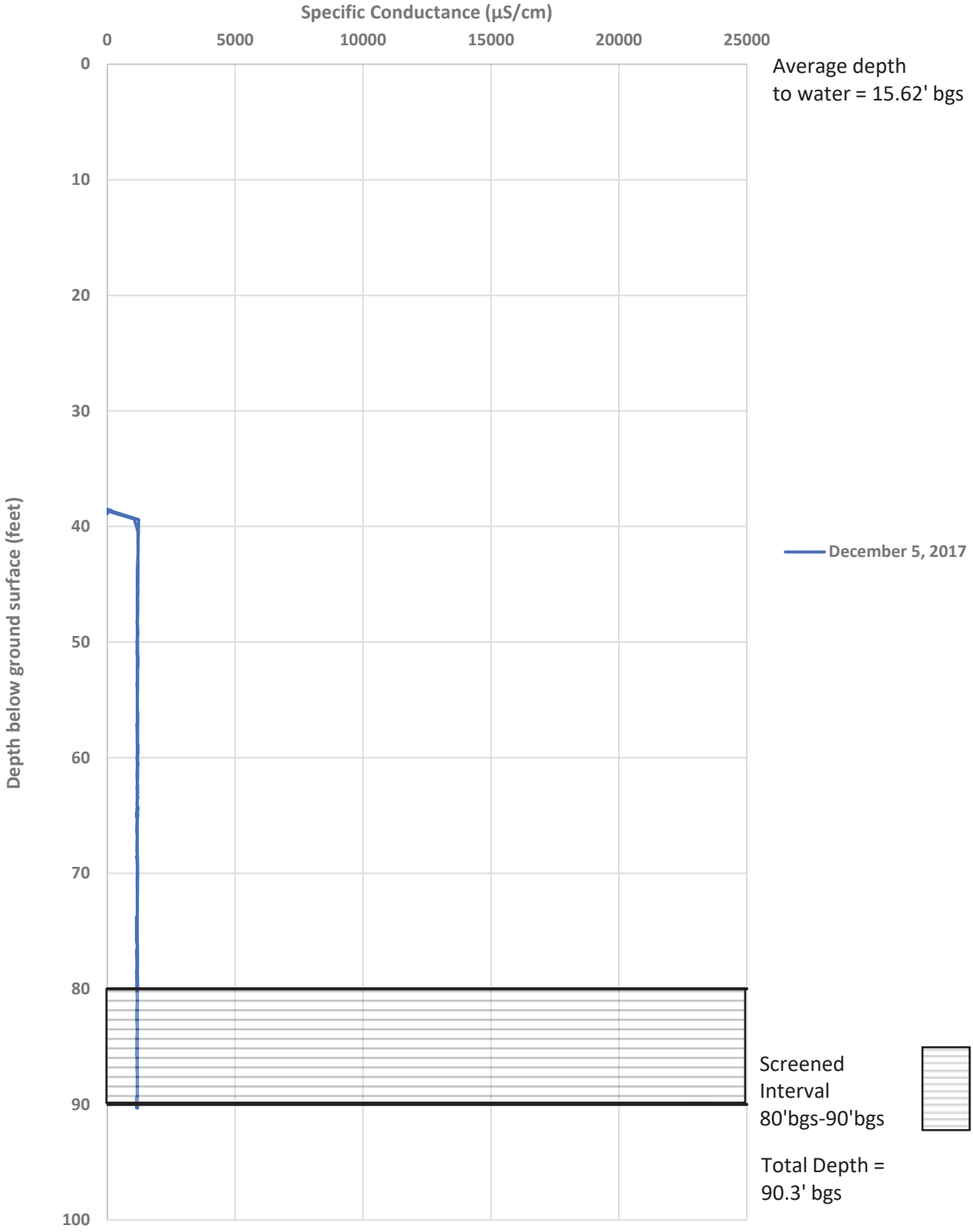
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-36-050



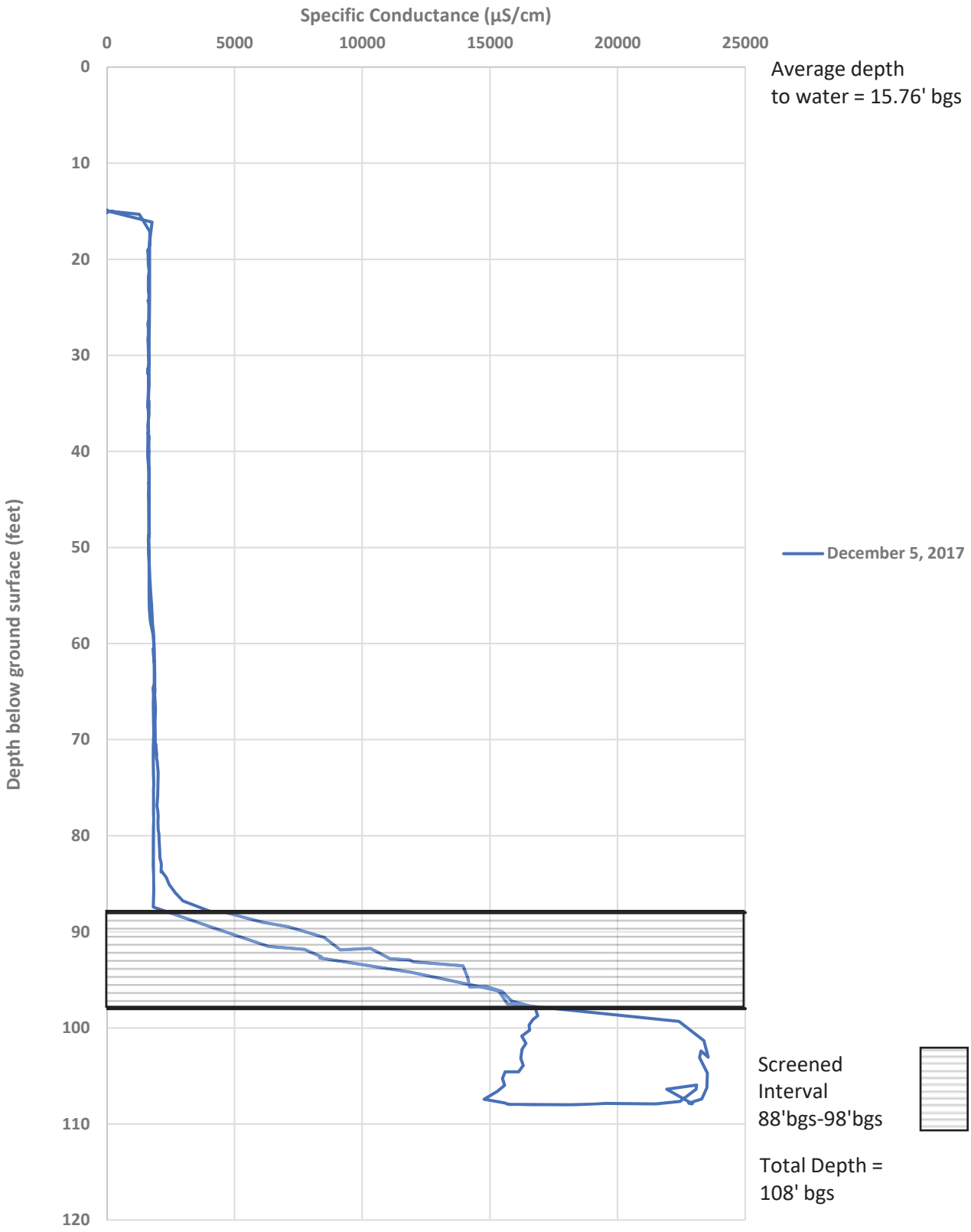
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-36-070



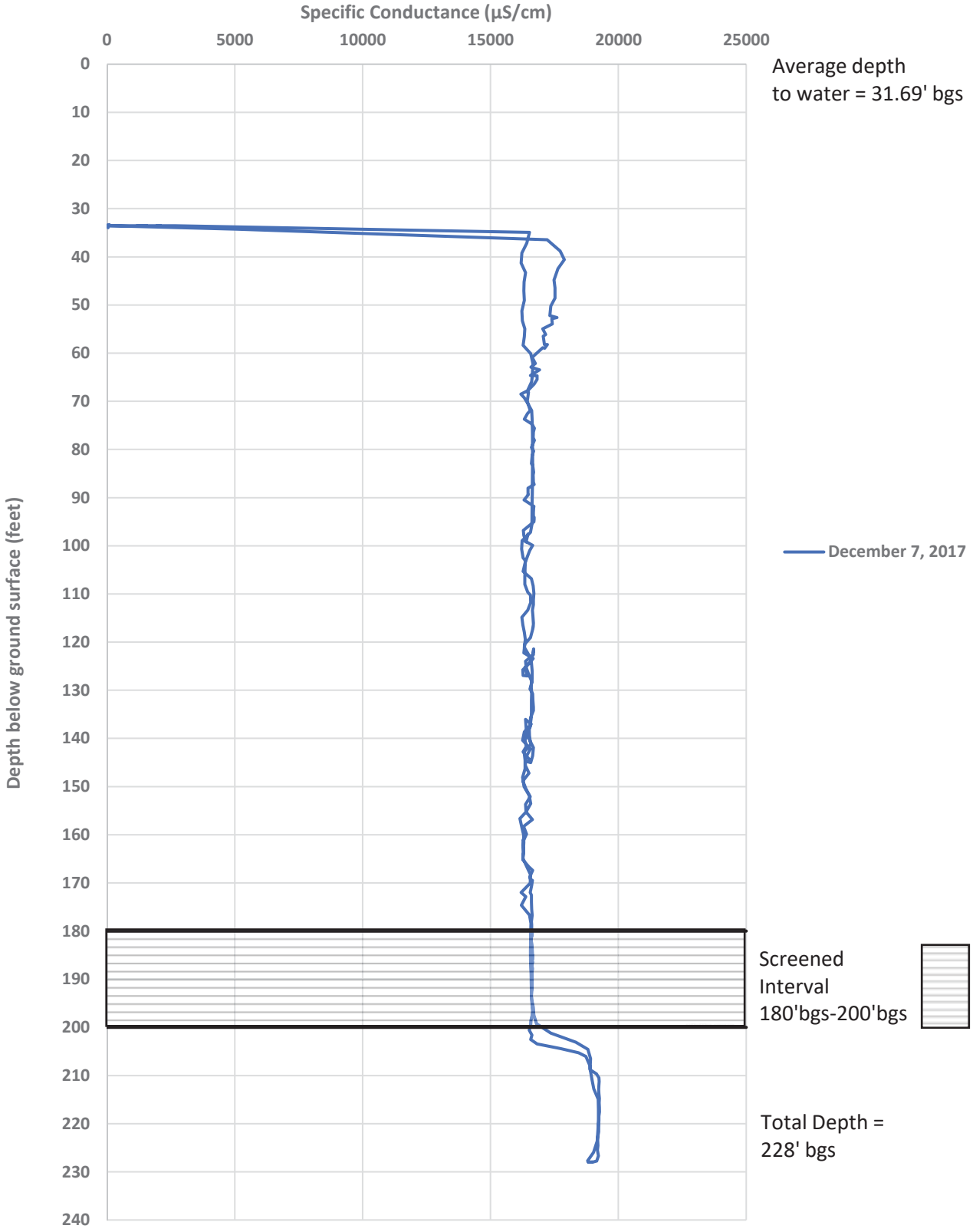
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-36-090



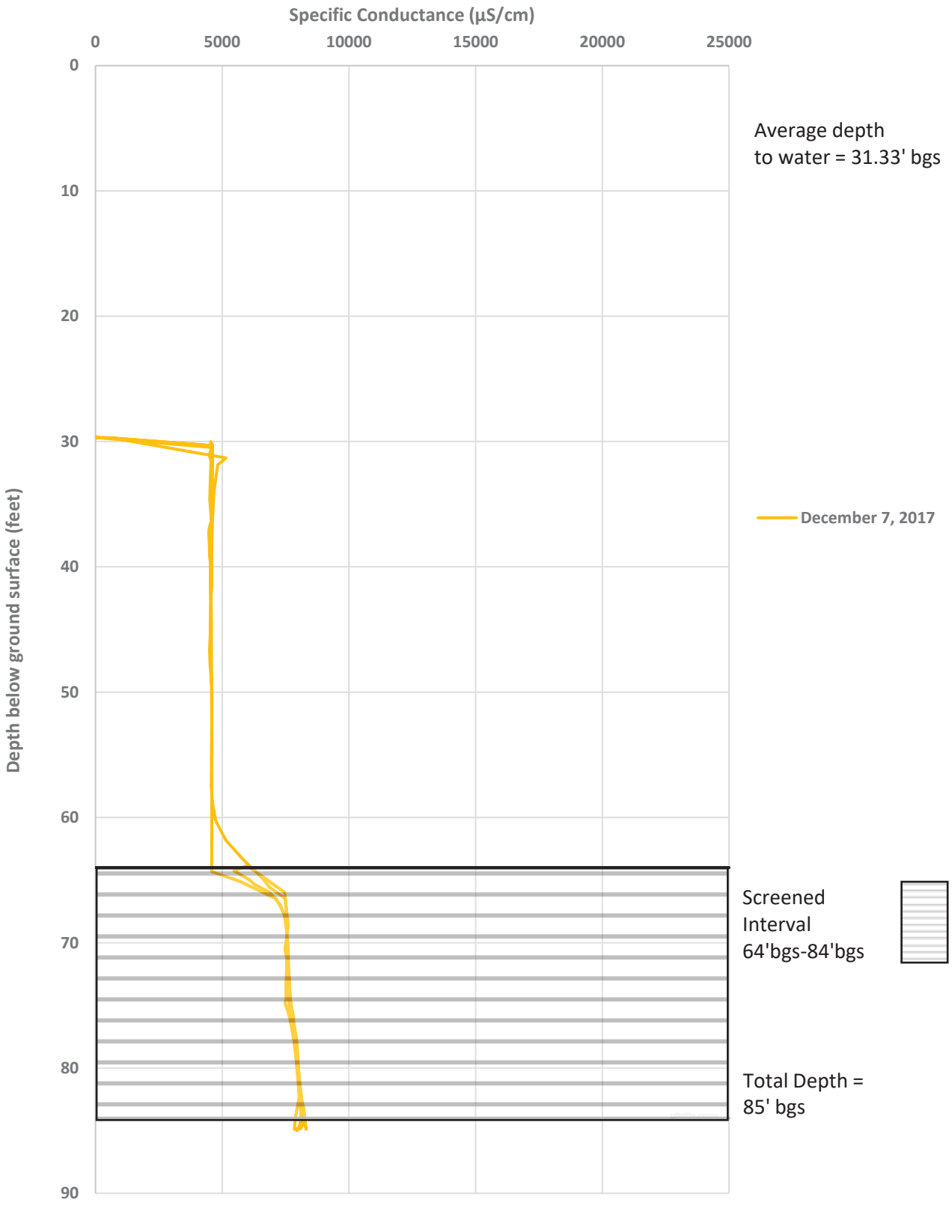
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-36-100



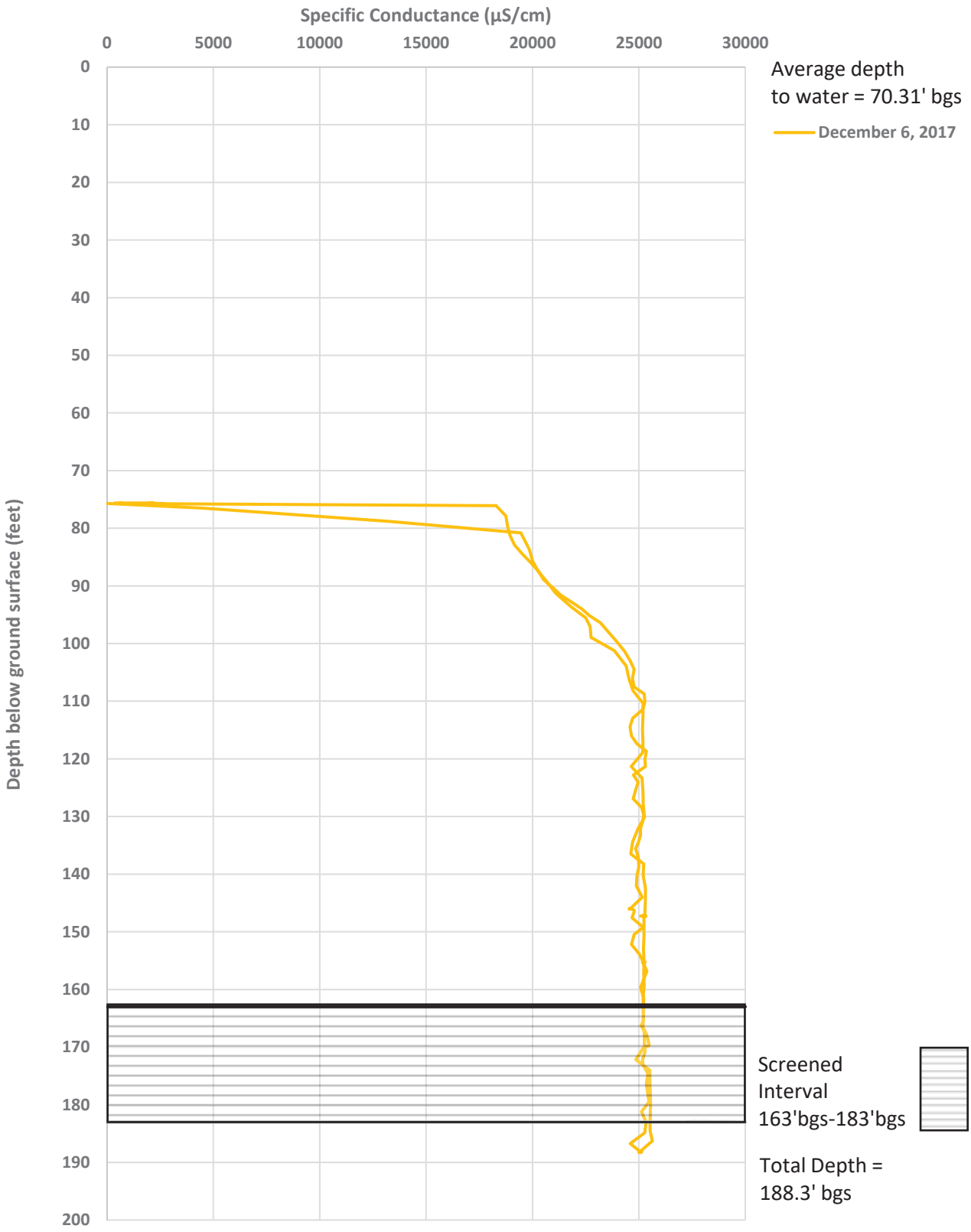
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-37D

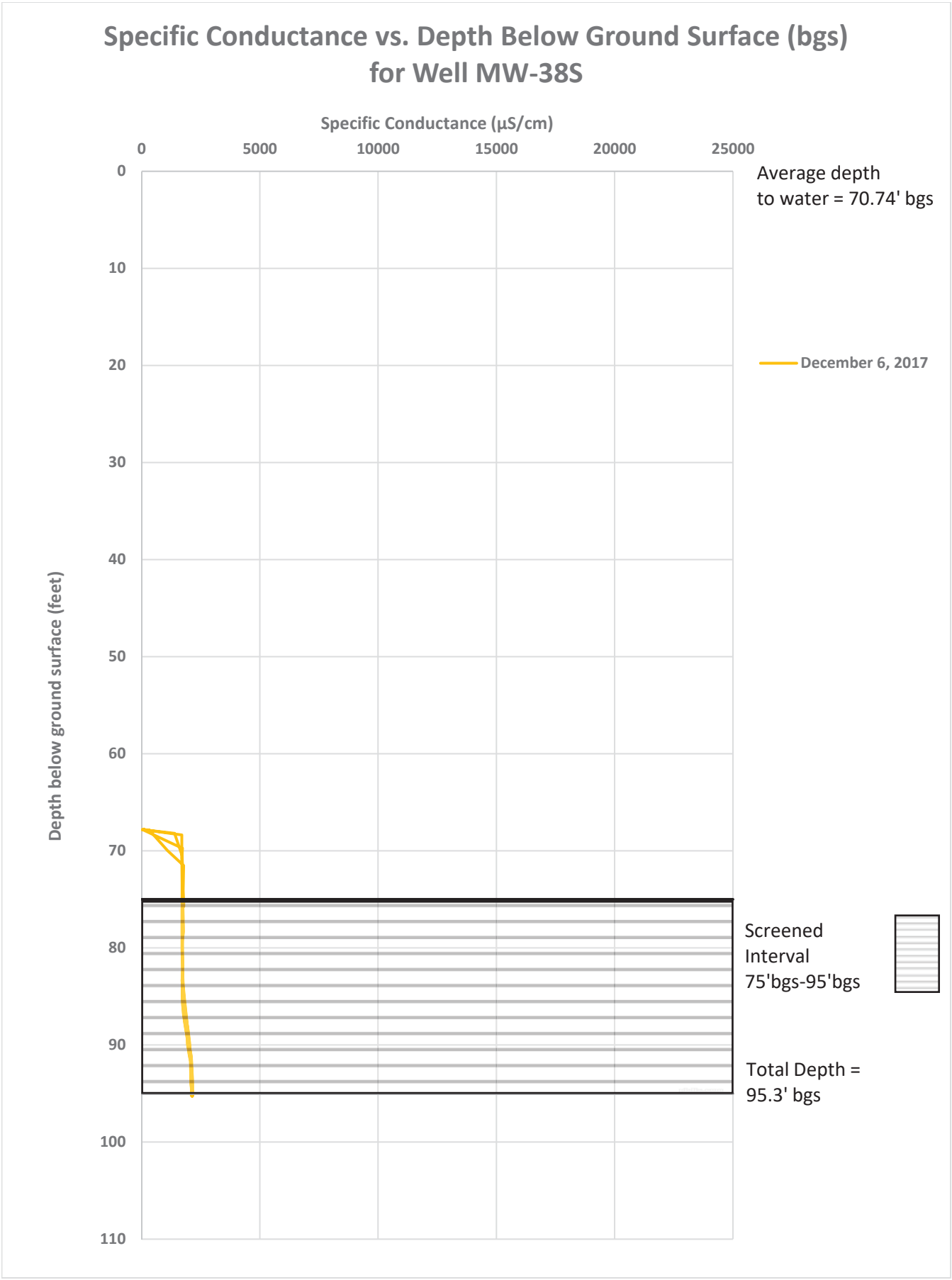


Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-37S

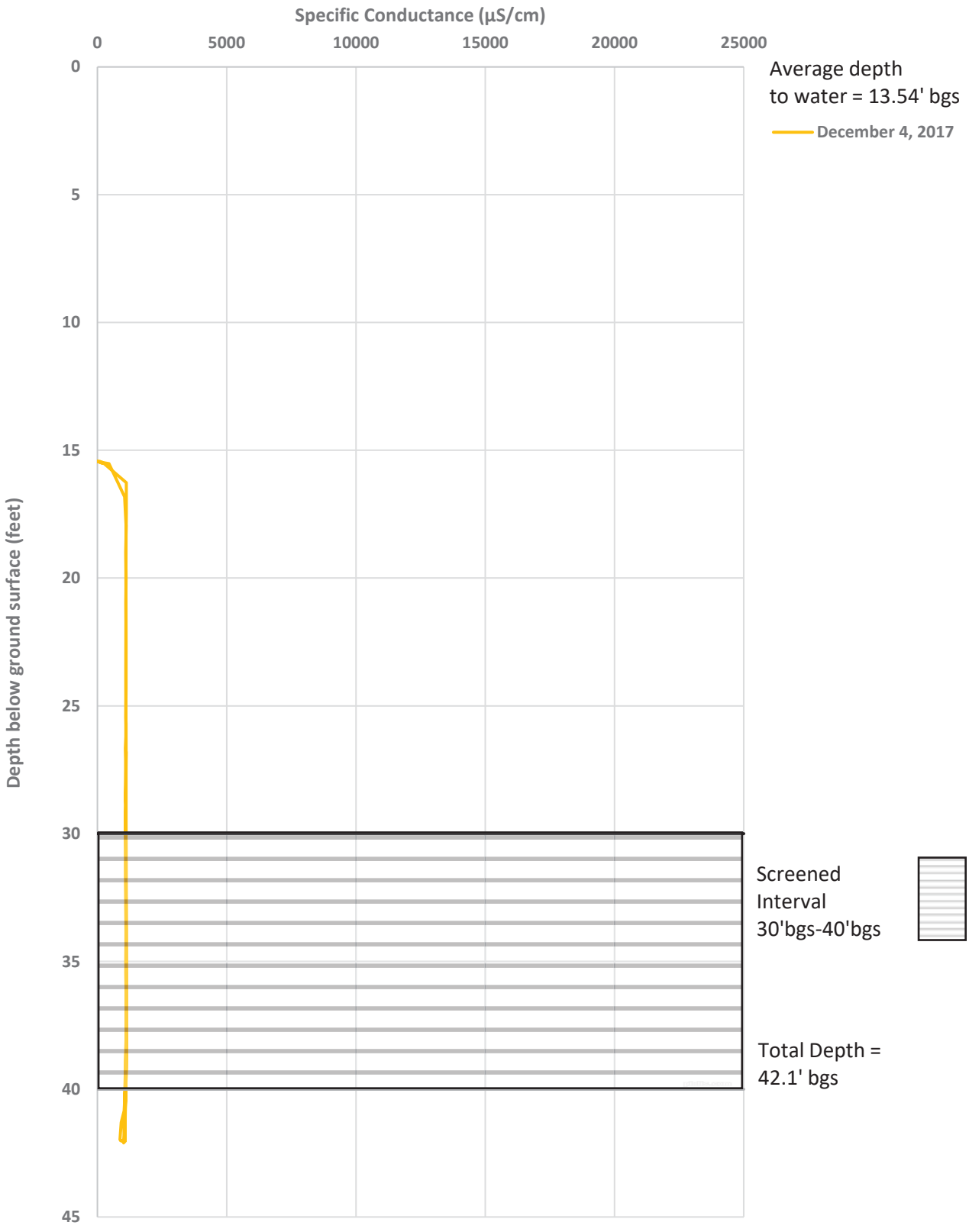


Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-38D

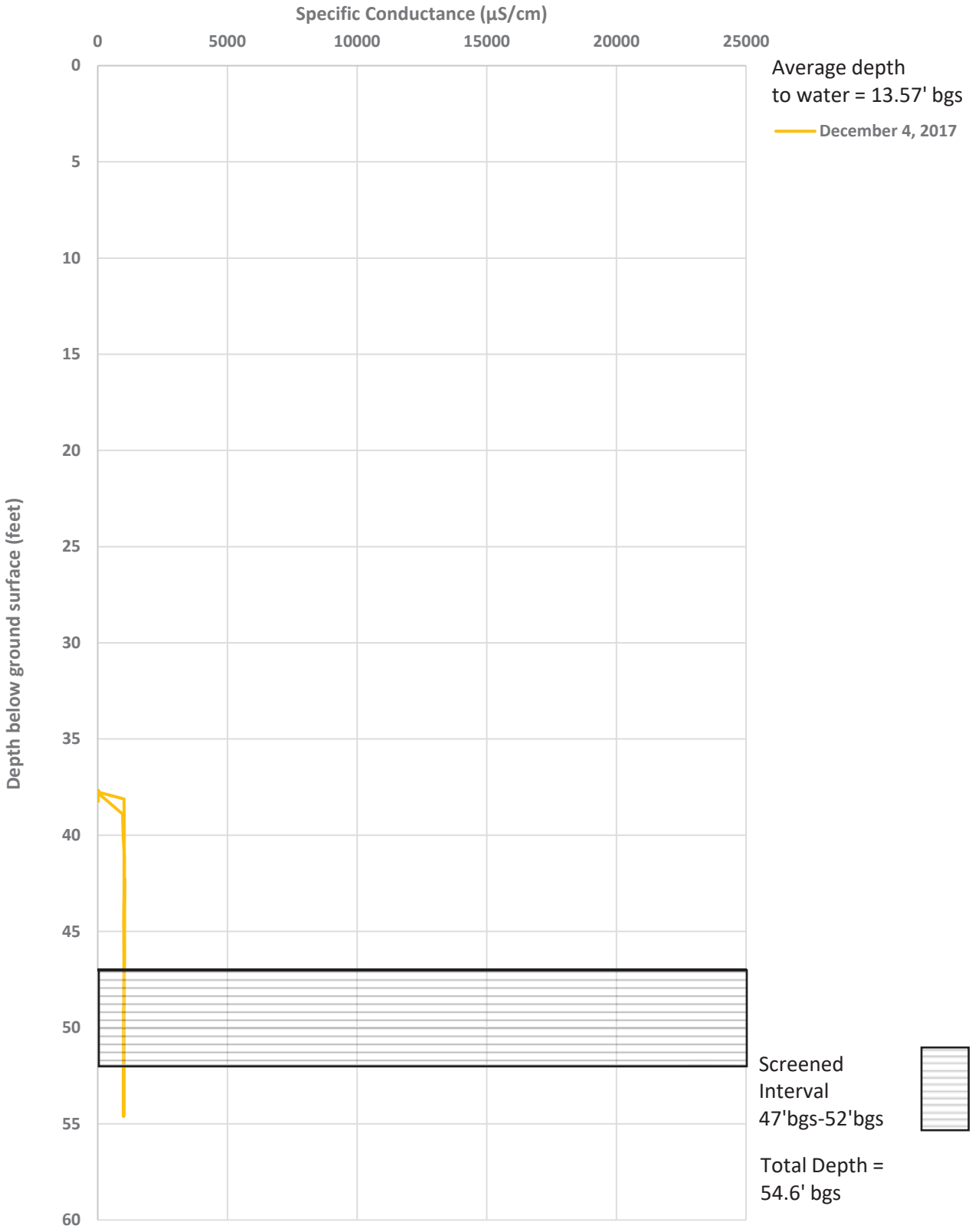



Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-38S
Specific Conductance (µS/cm)
0
5000
10000
15000
20000
25000
Depth below ground surface (feet)
0
10
20
30
40
50
60
70
80
90
100
110
Average depth to water = 70.74' bgs
December 6, 2017
Screened Interval 75'bgs-95'bgs
Total Depth = 95.3' bgs

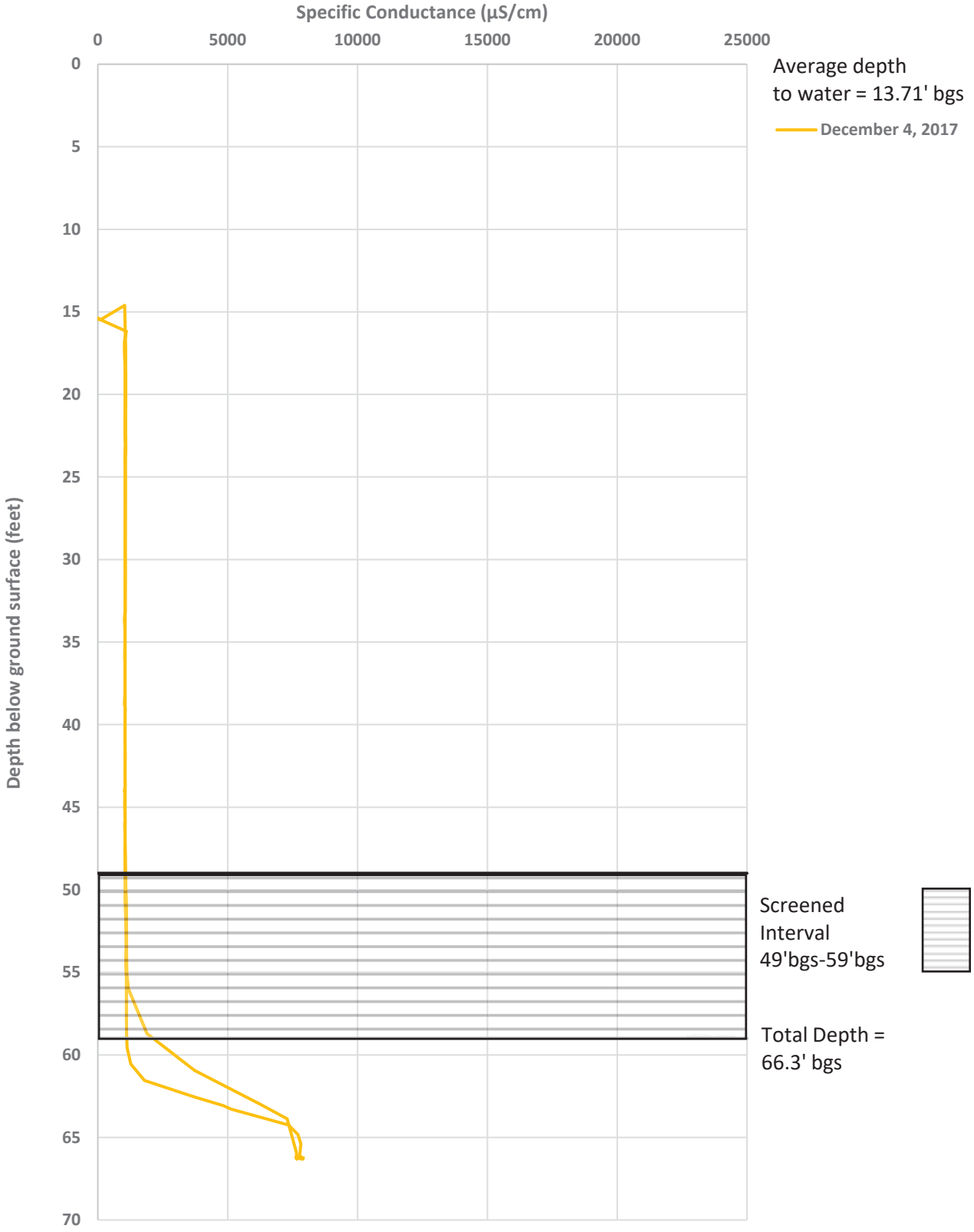
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-39-040



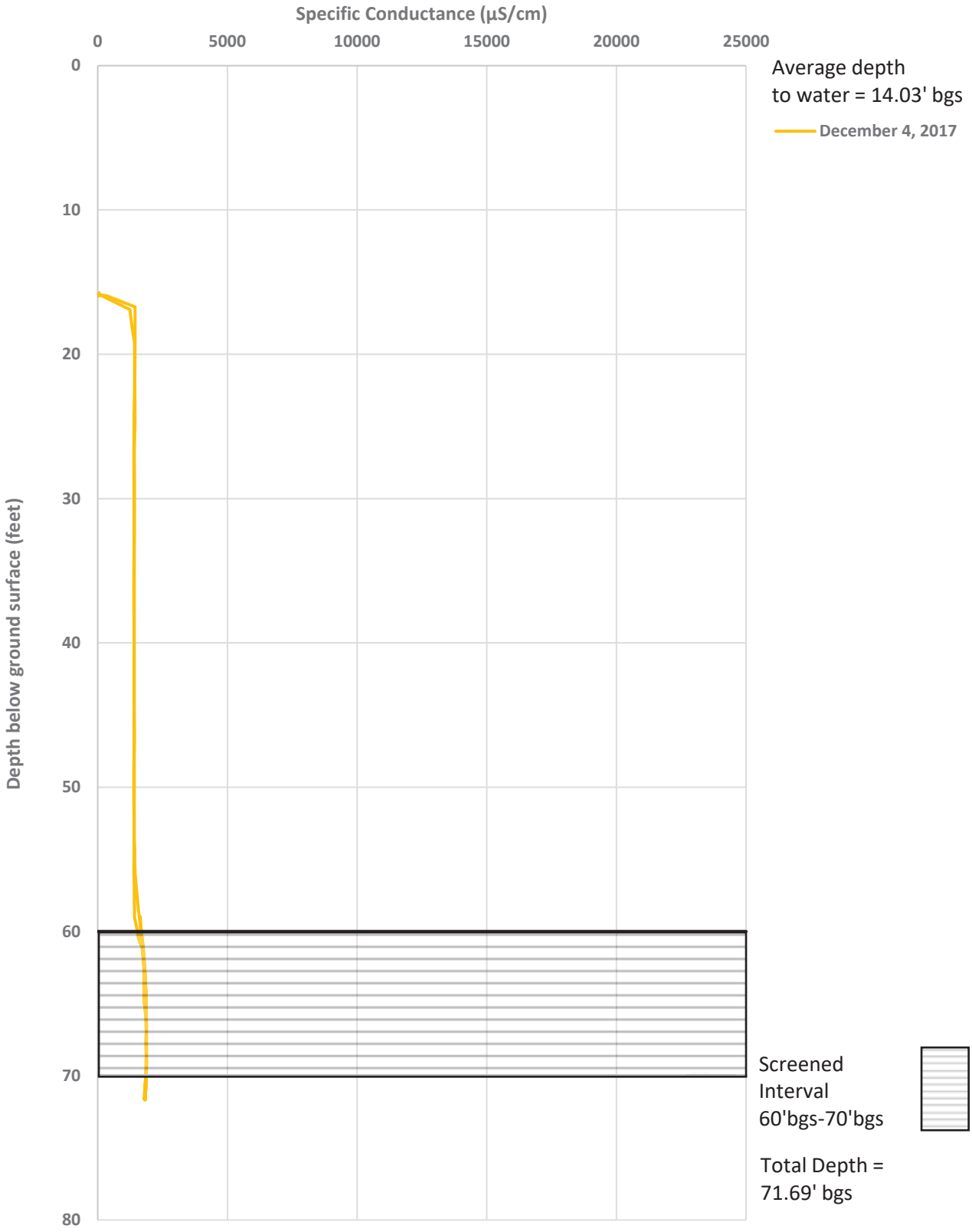
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-39-050



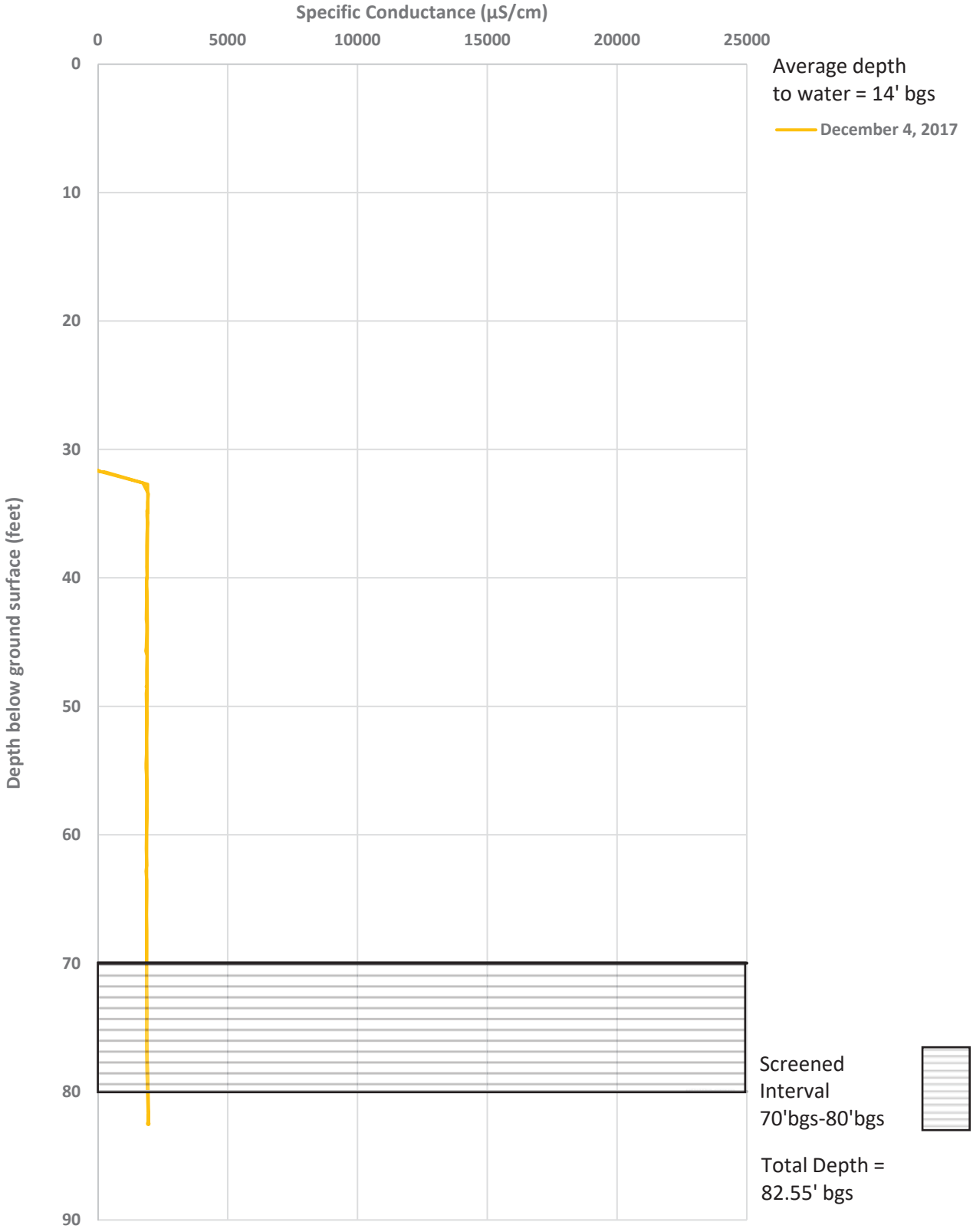
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-39-060



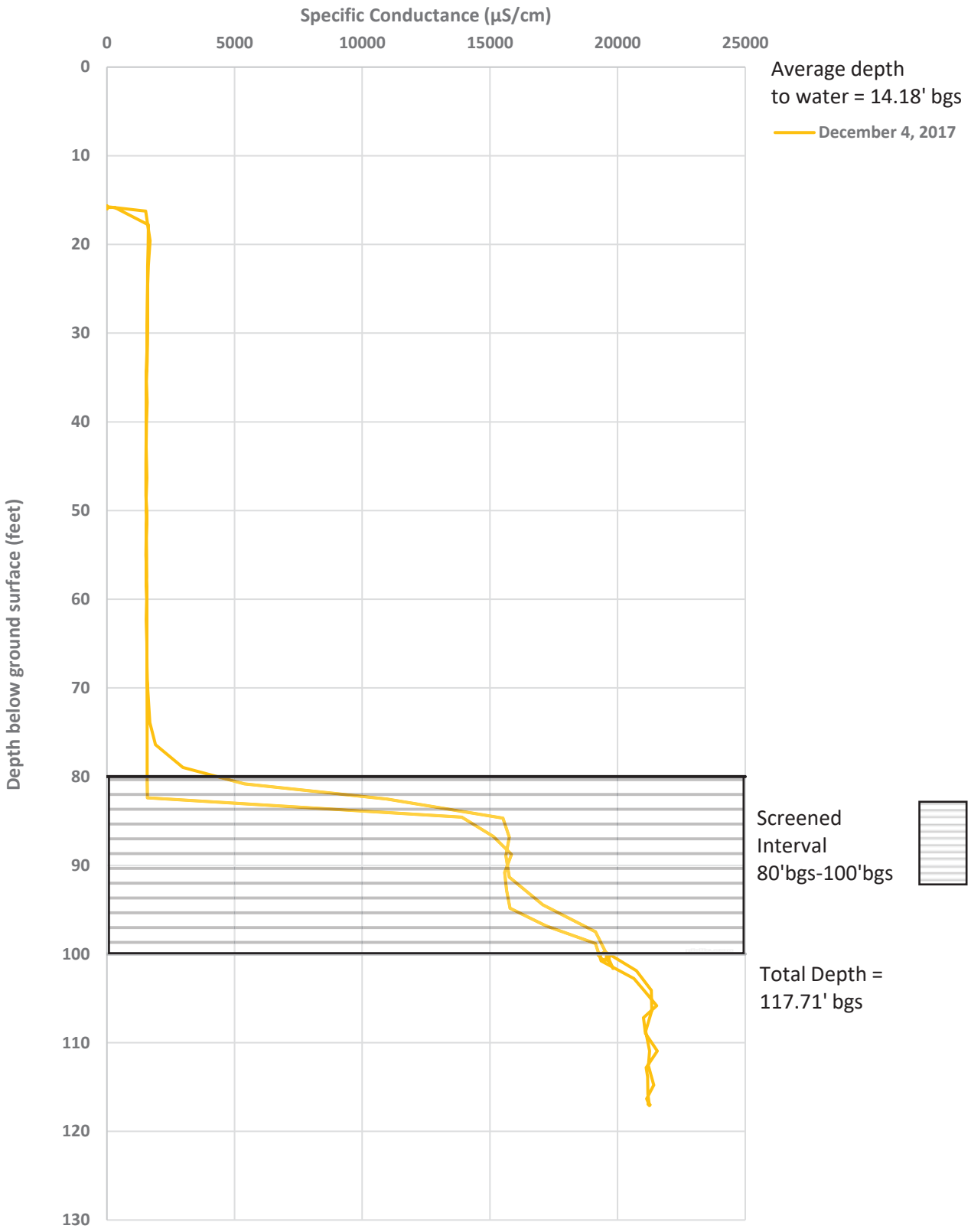
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-39-070



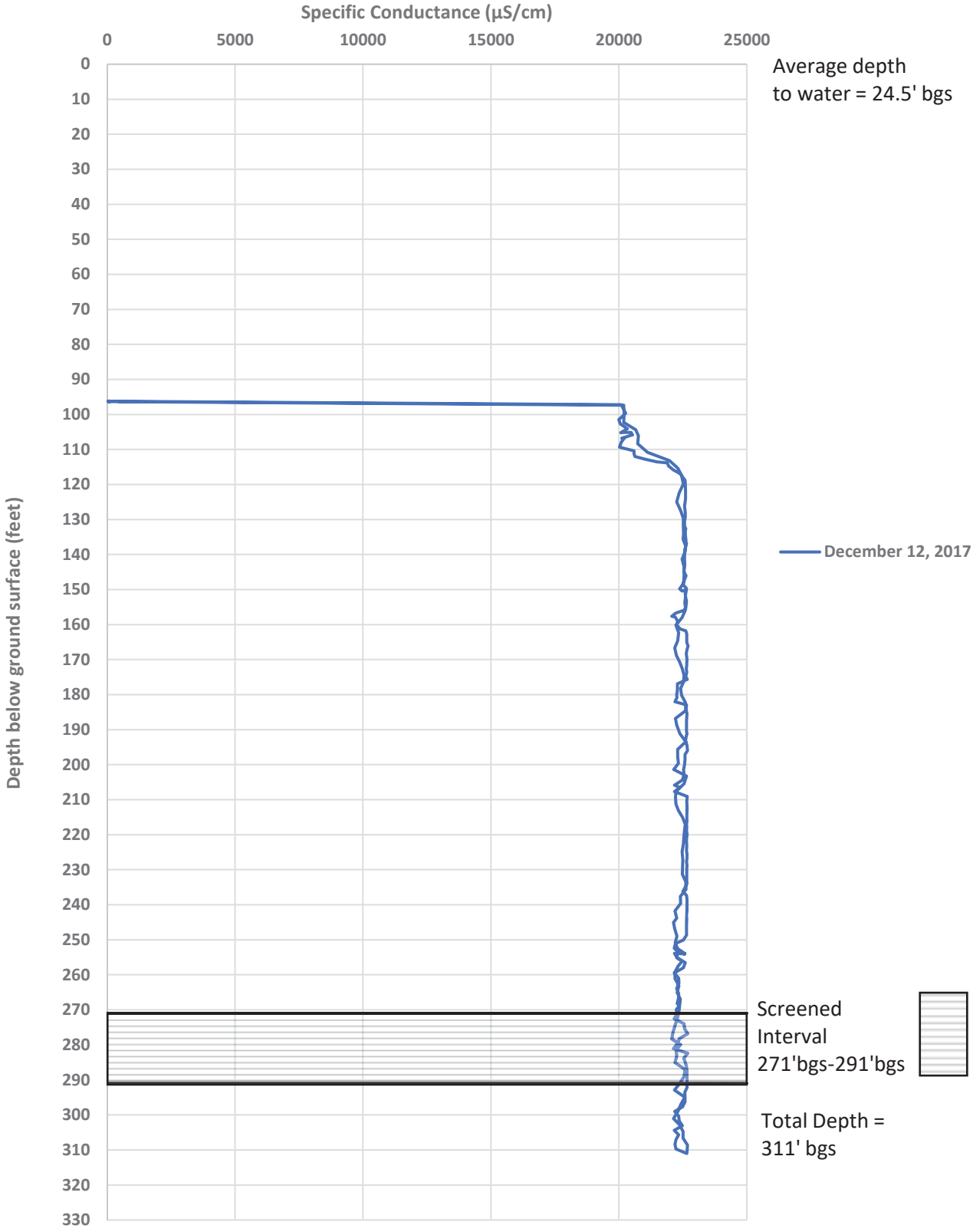
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-39-080



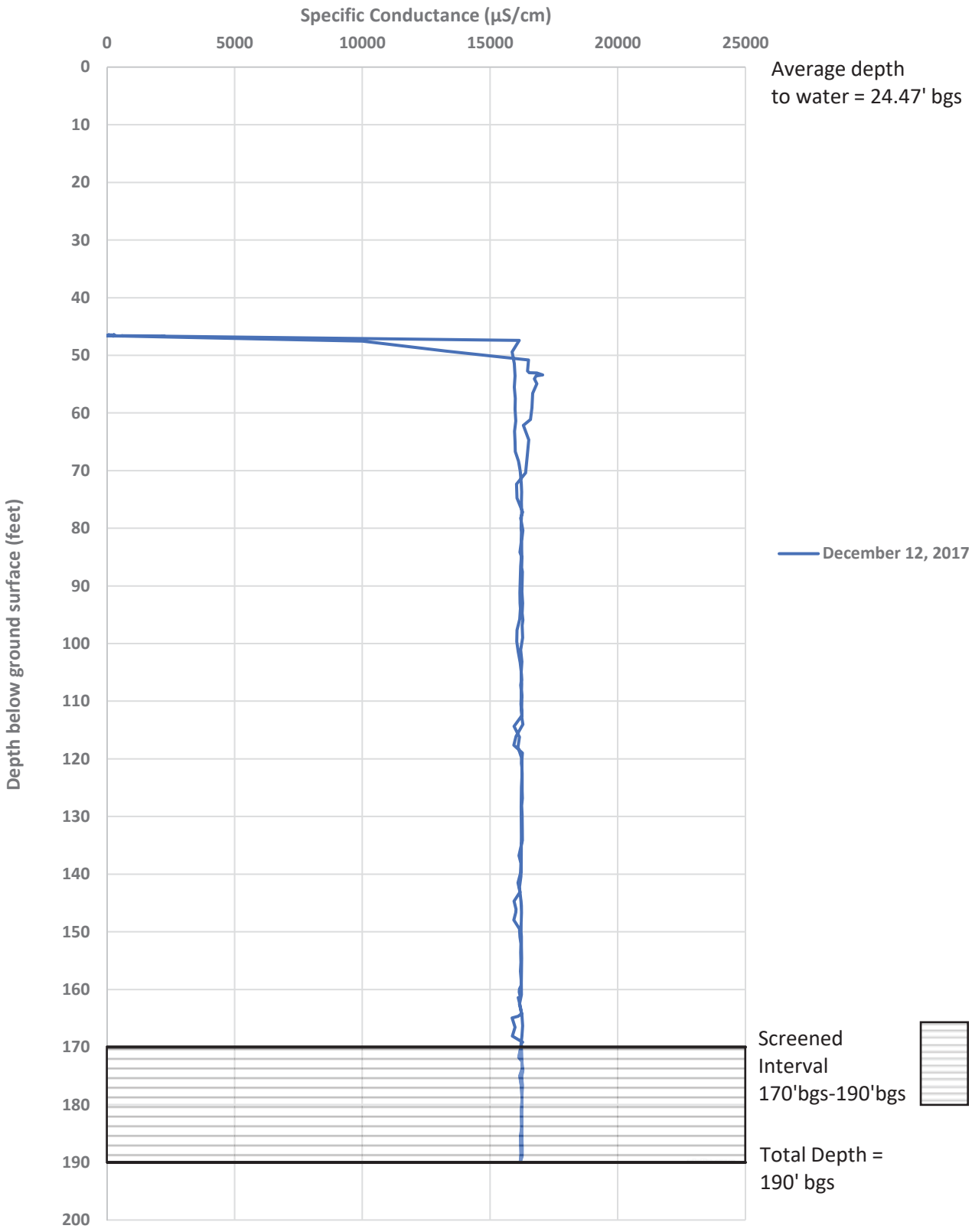
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-39-100



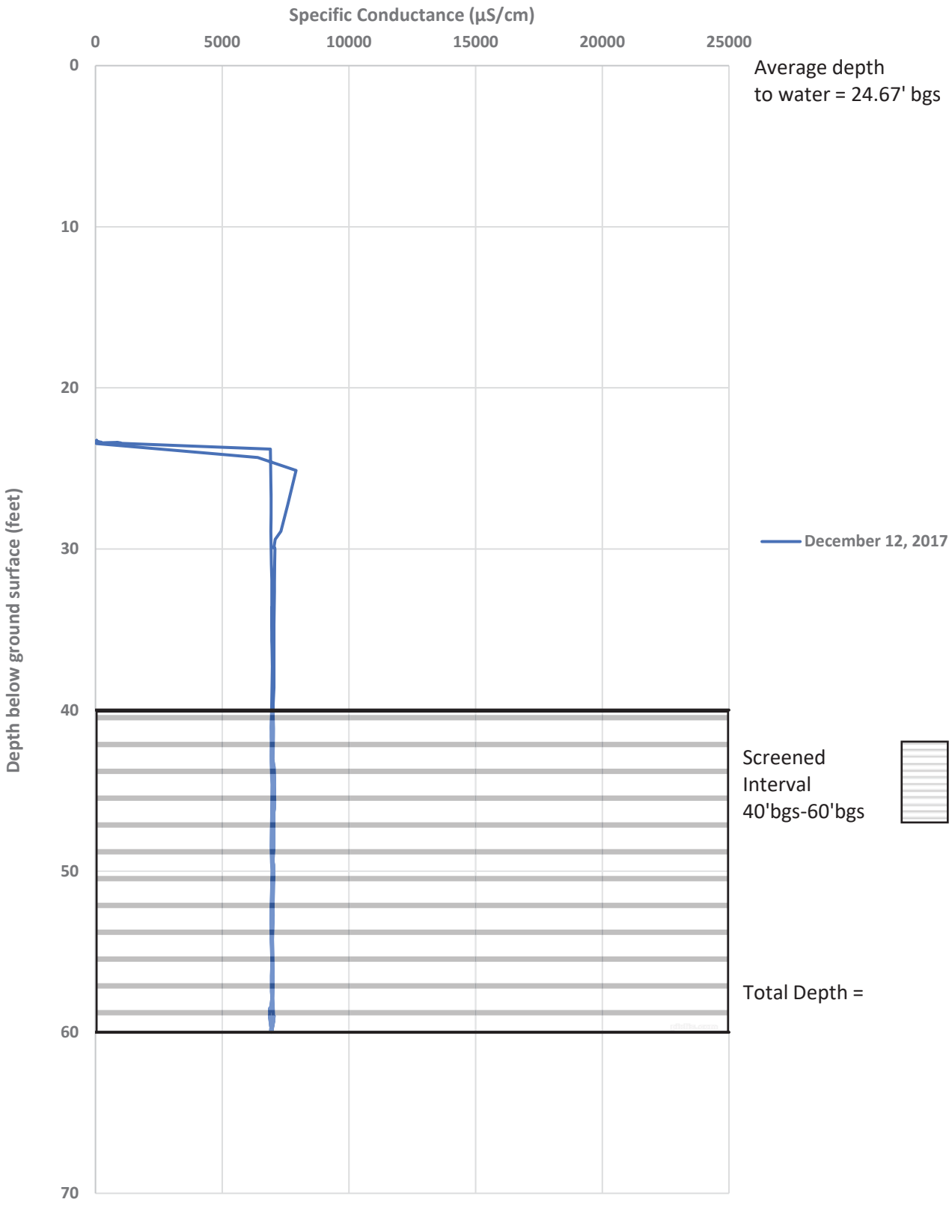
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-41D



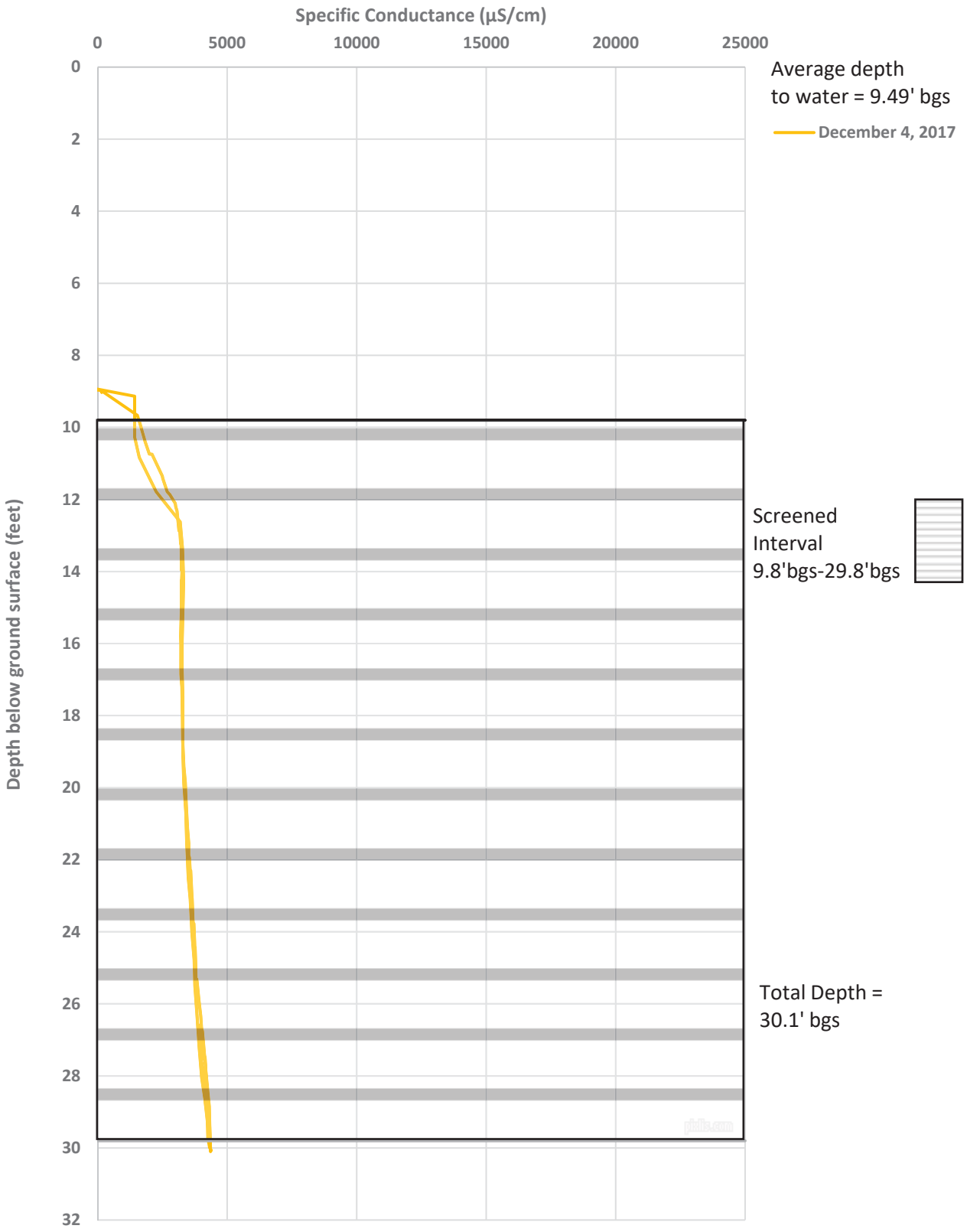
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-41M



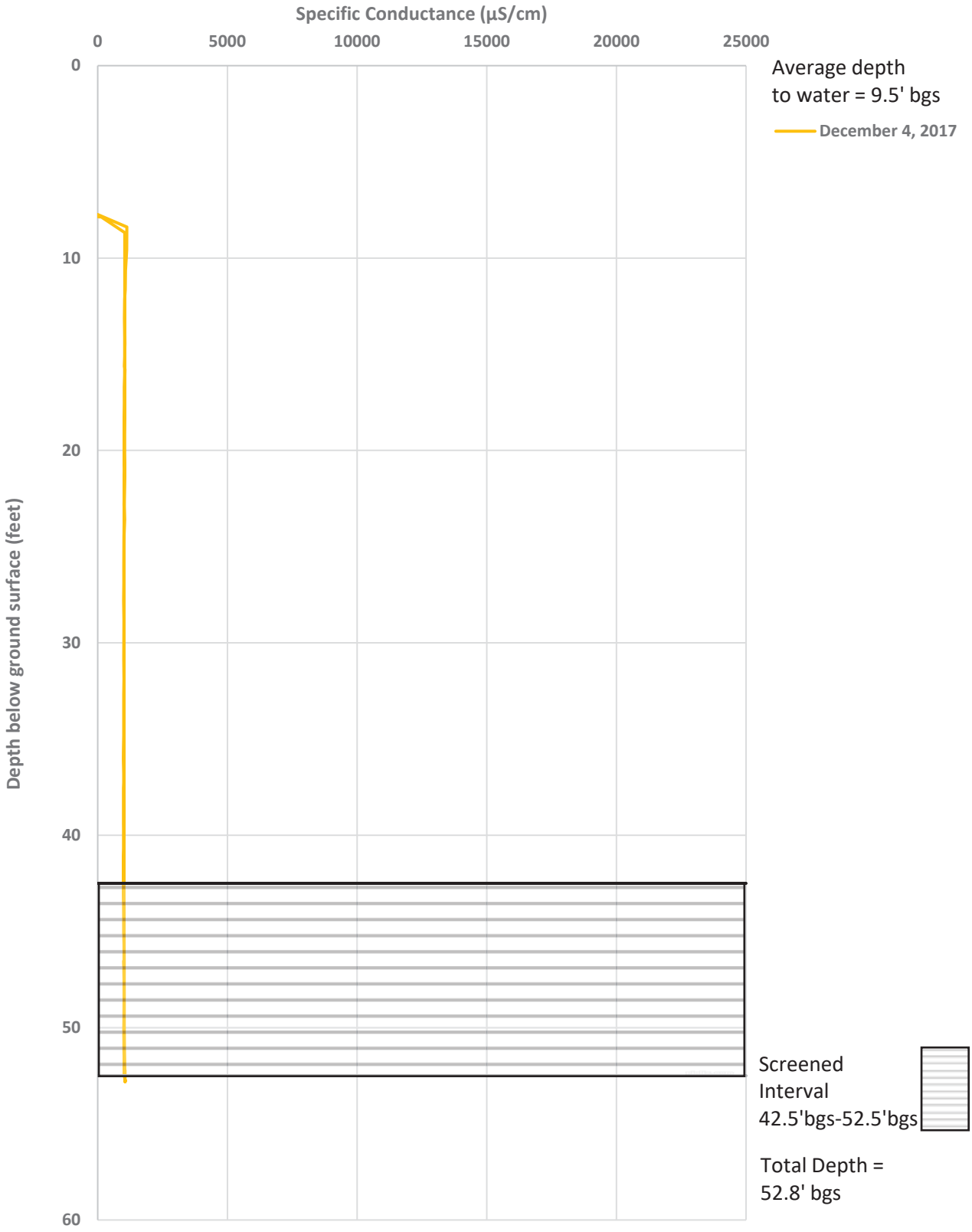
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-41S



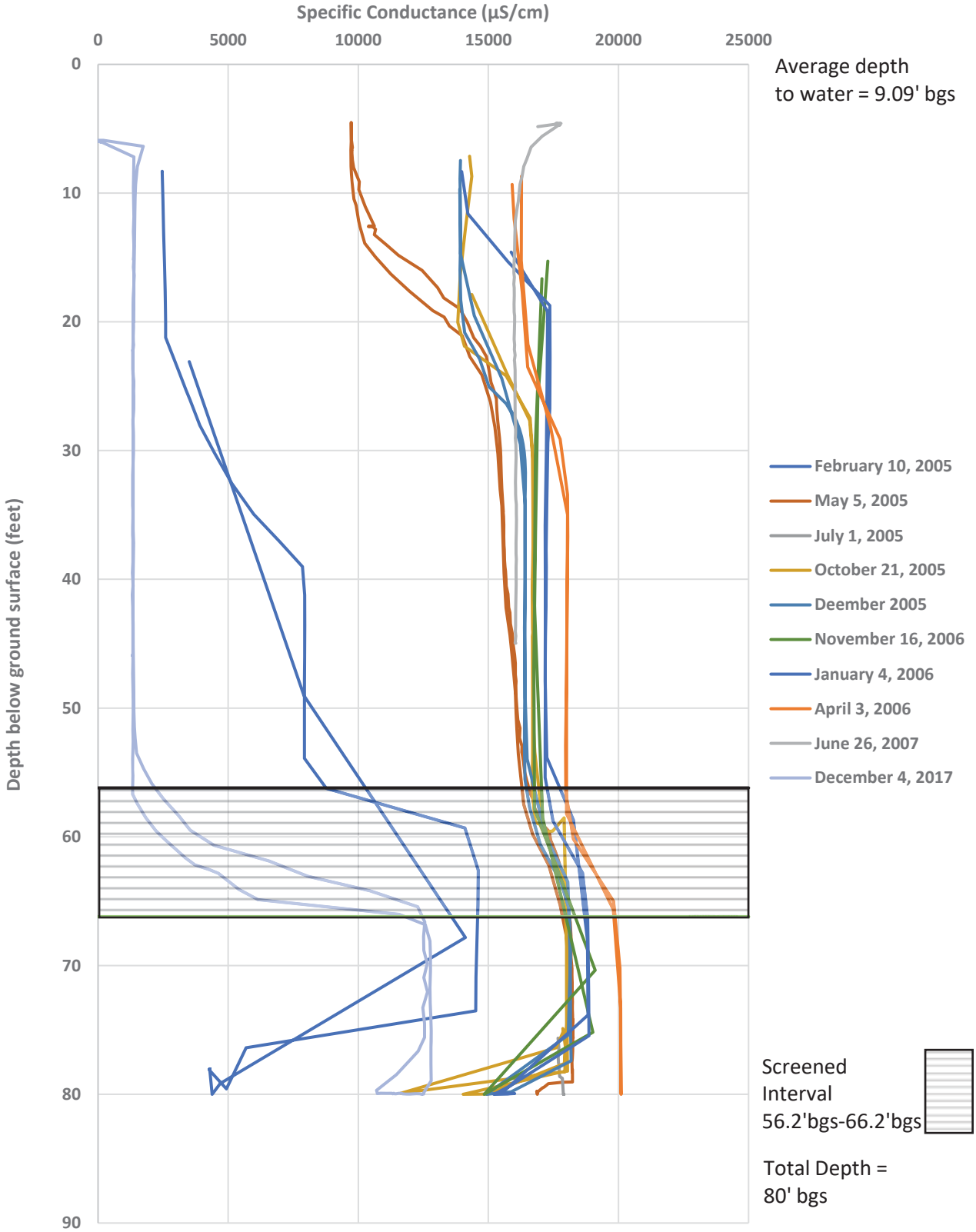
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-42-030



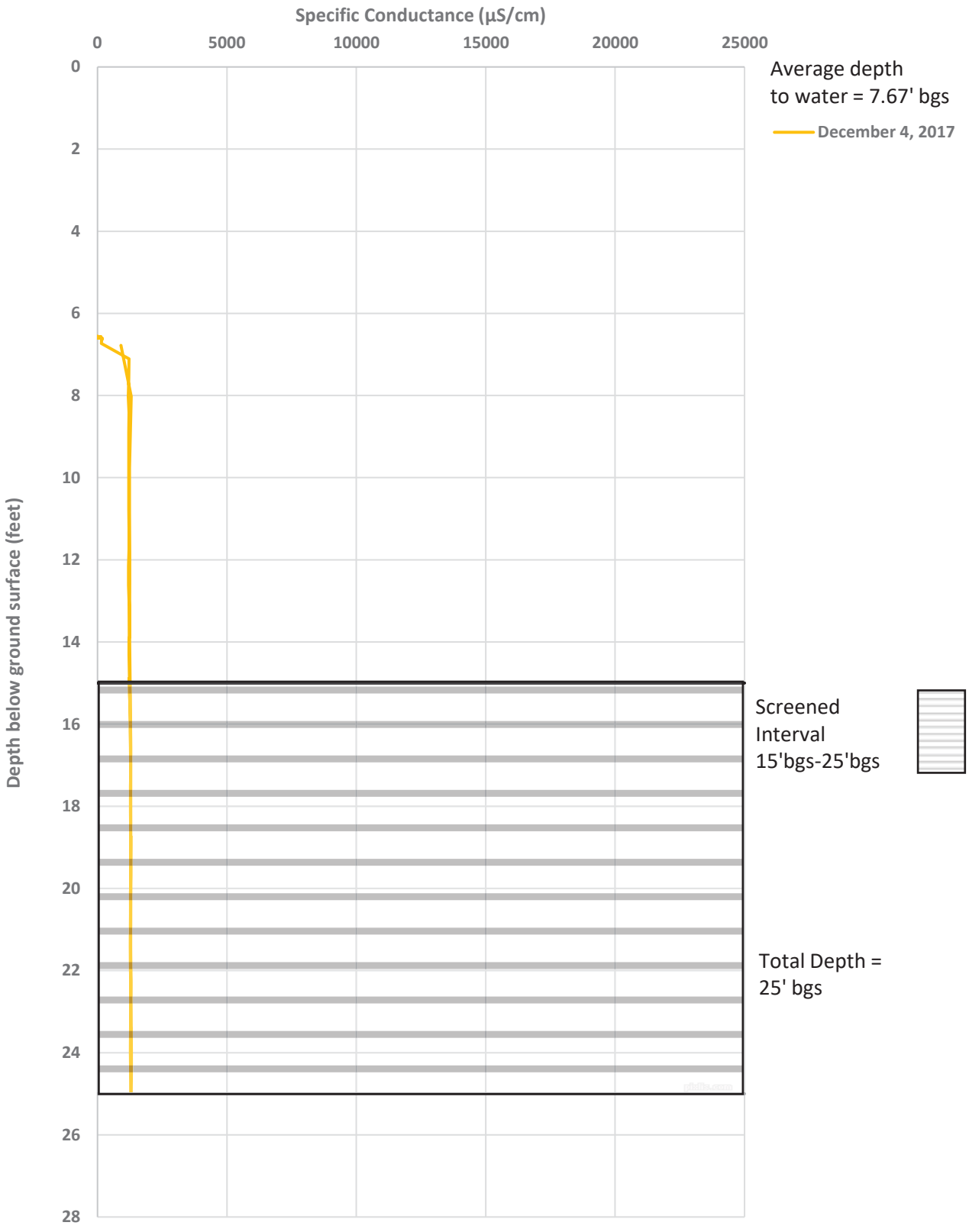
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-42-055



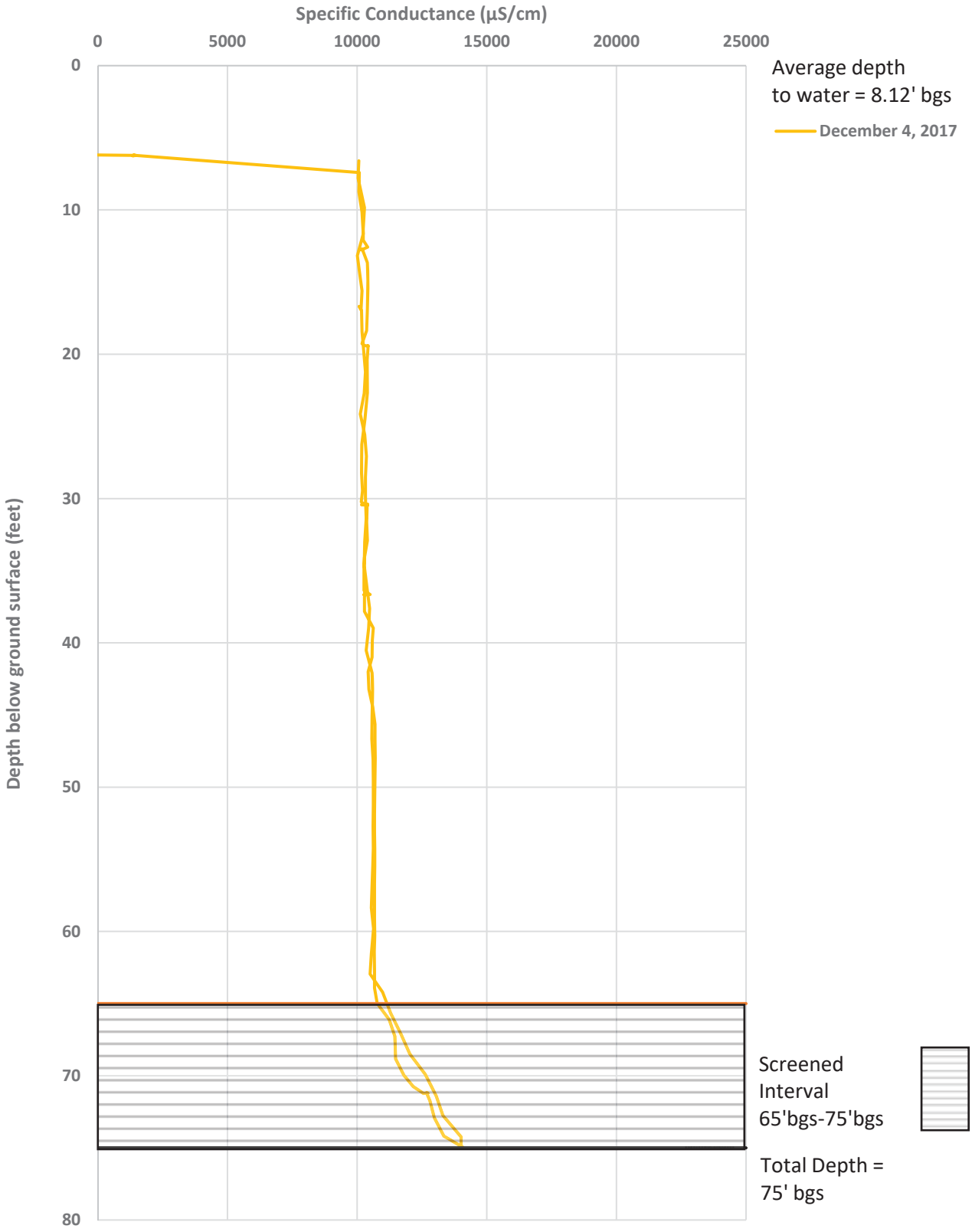
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-42-065



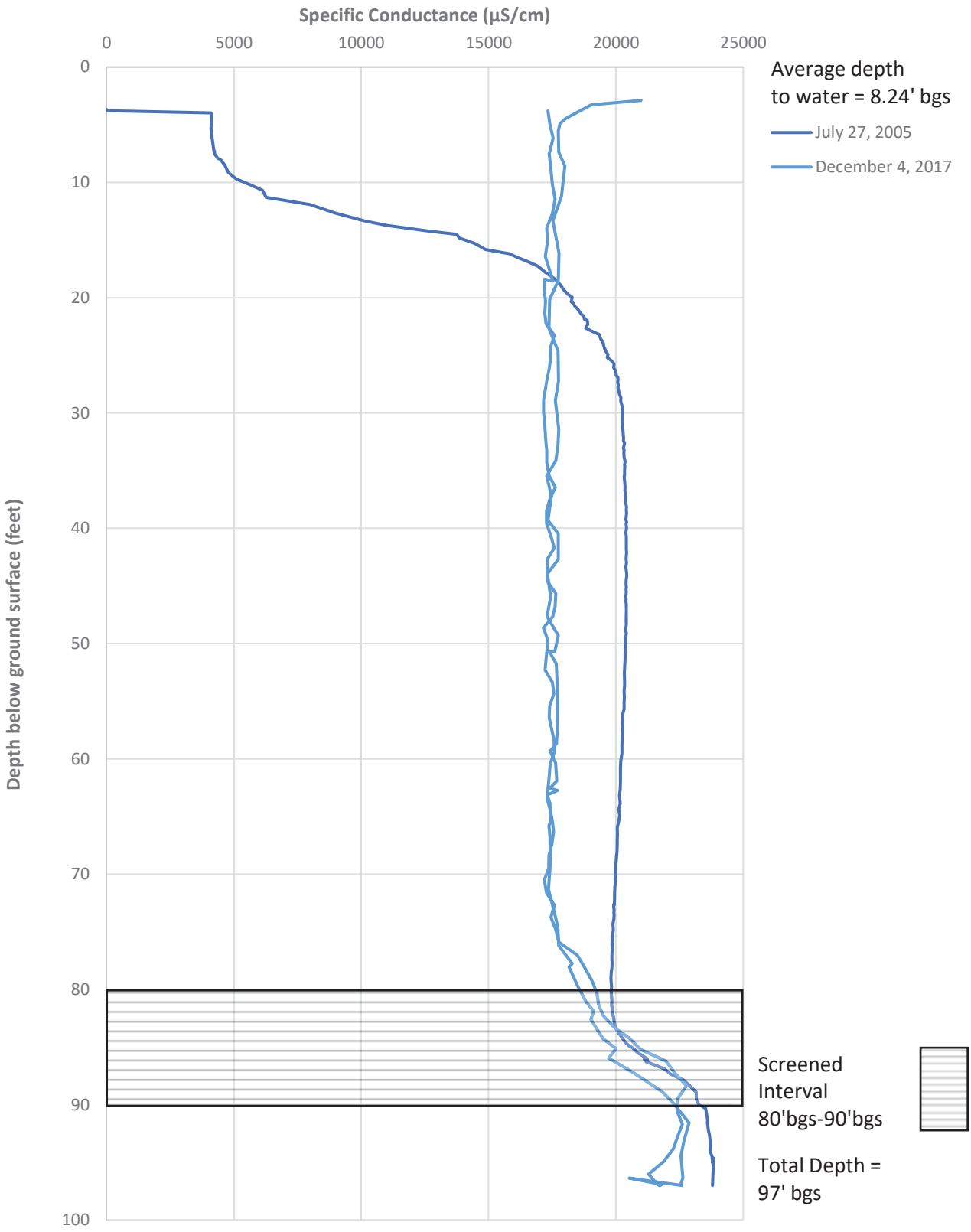
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-43-025



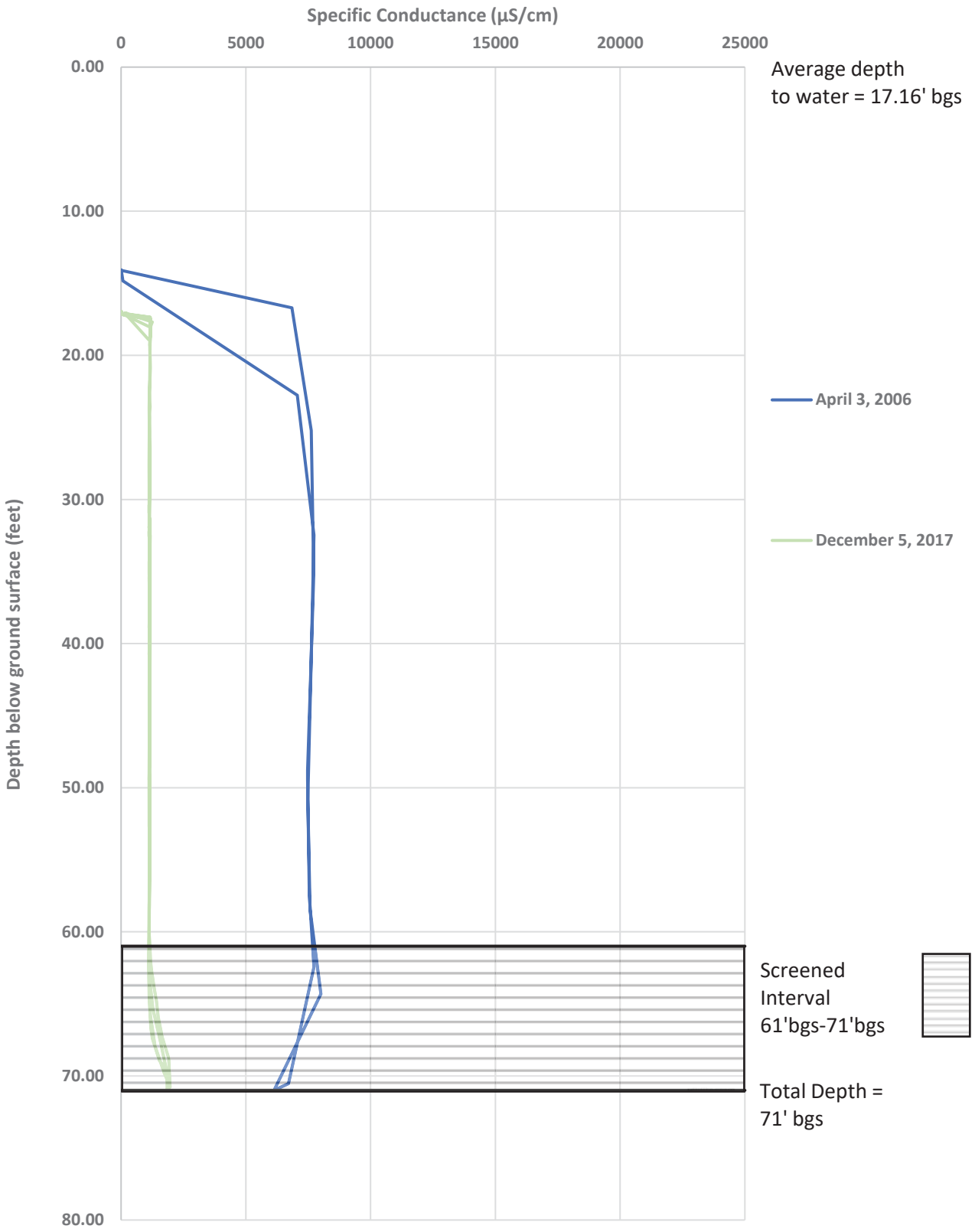
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-43-075



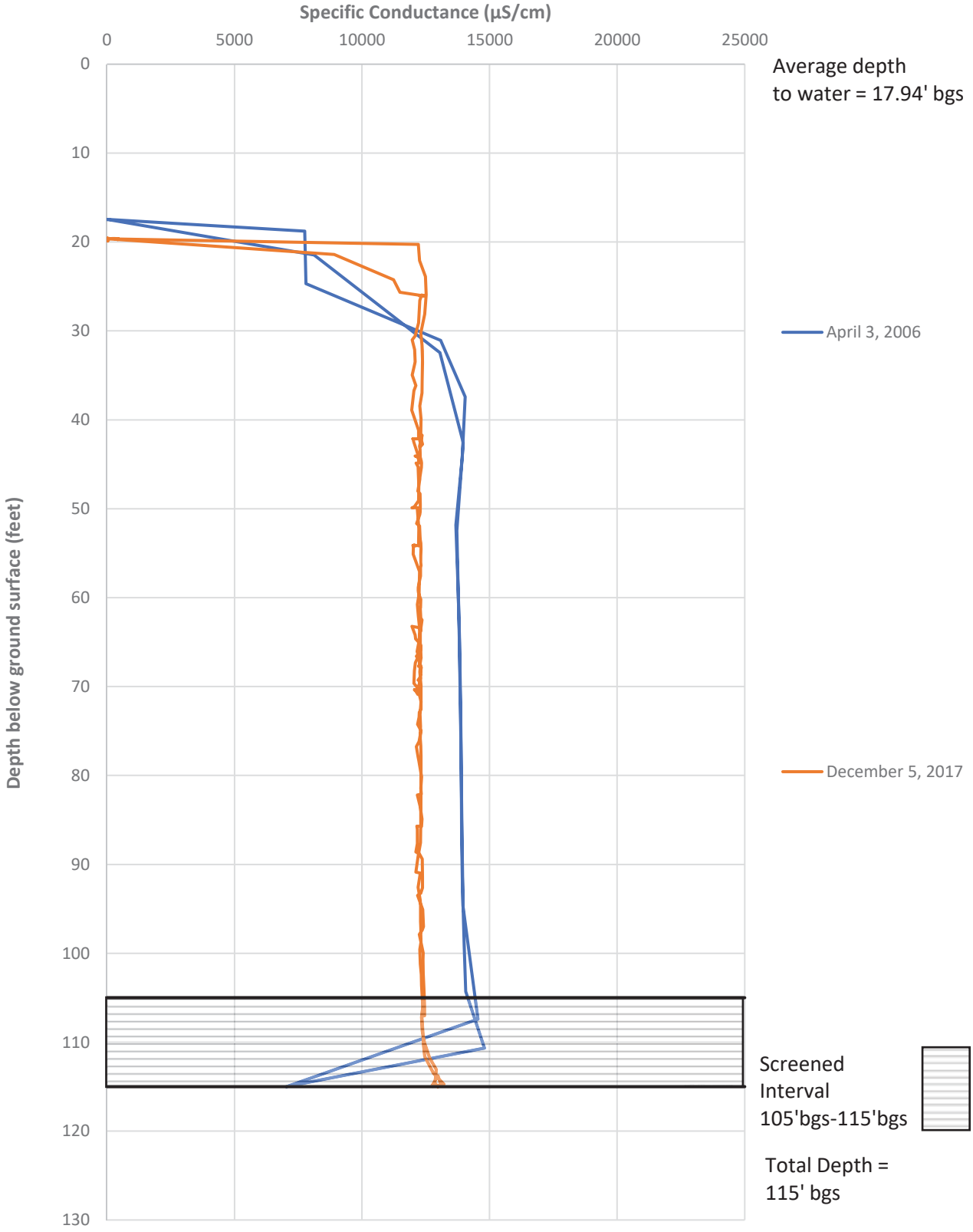
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-43-090



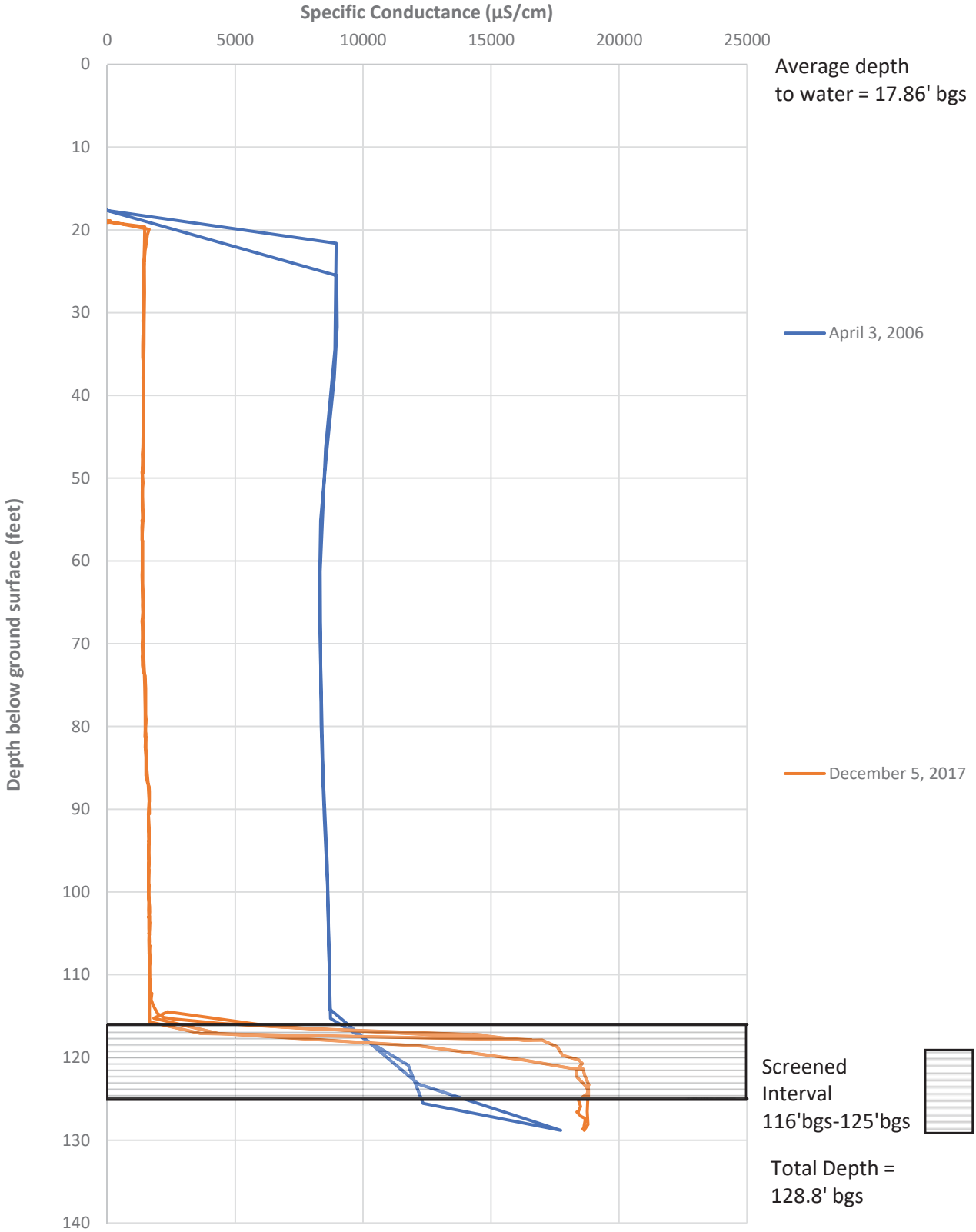
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-44-070



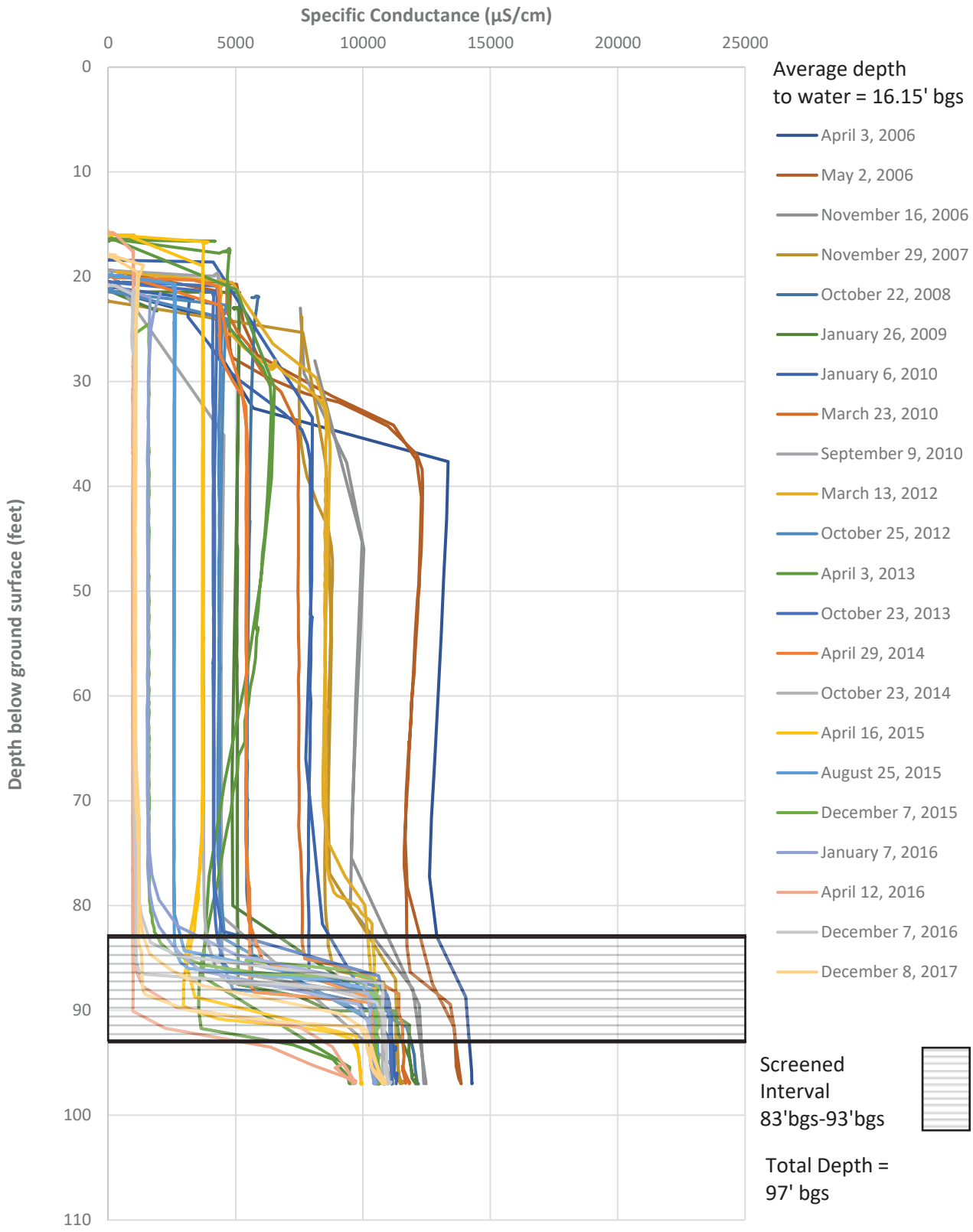
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-44-115



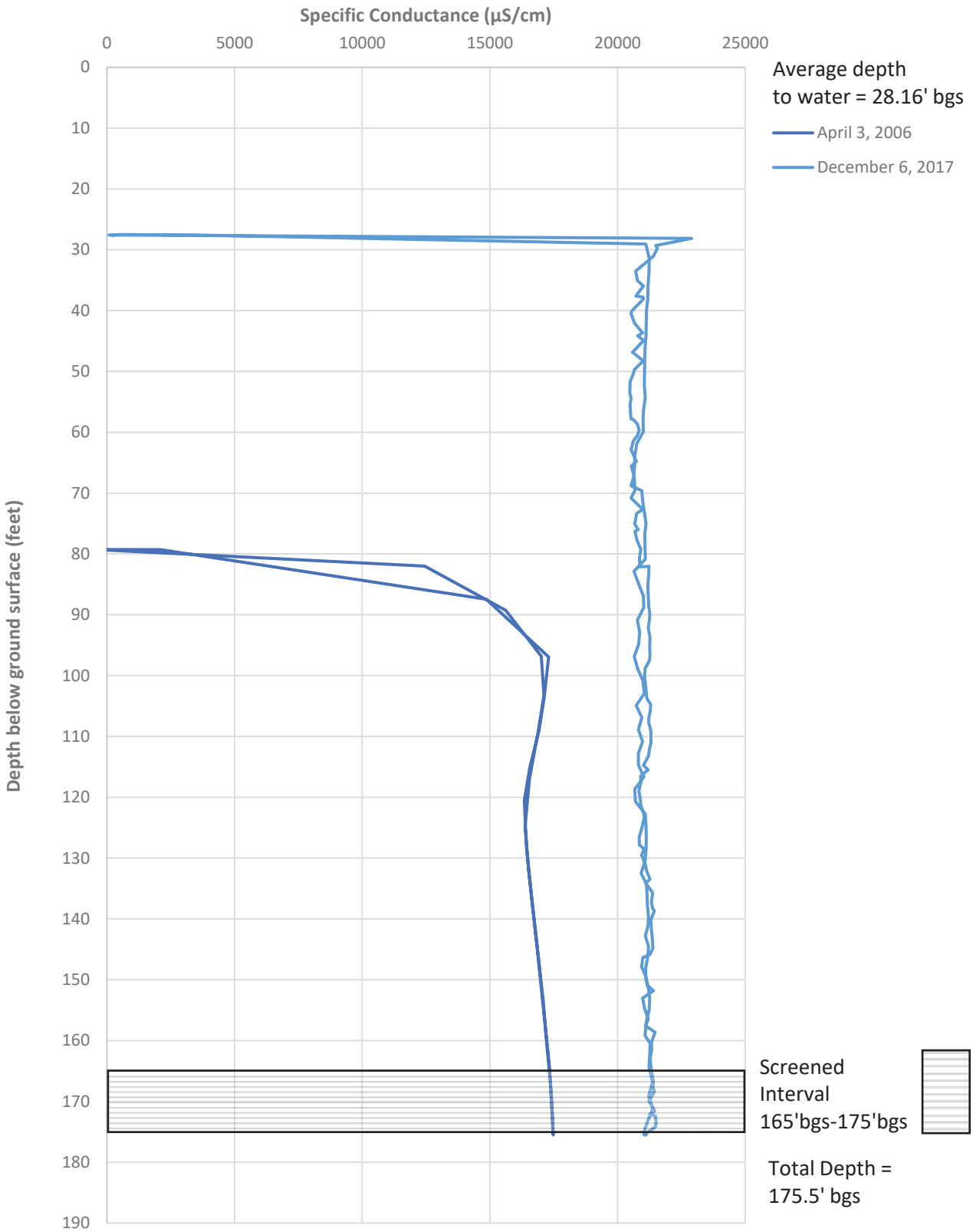
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-44-125



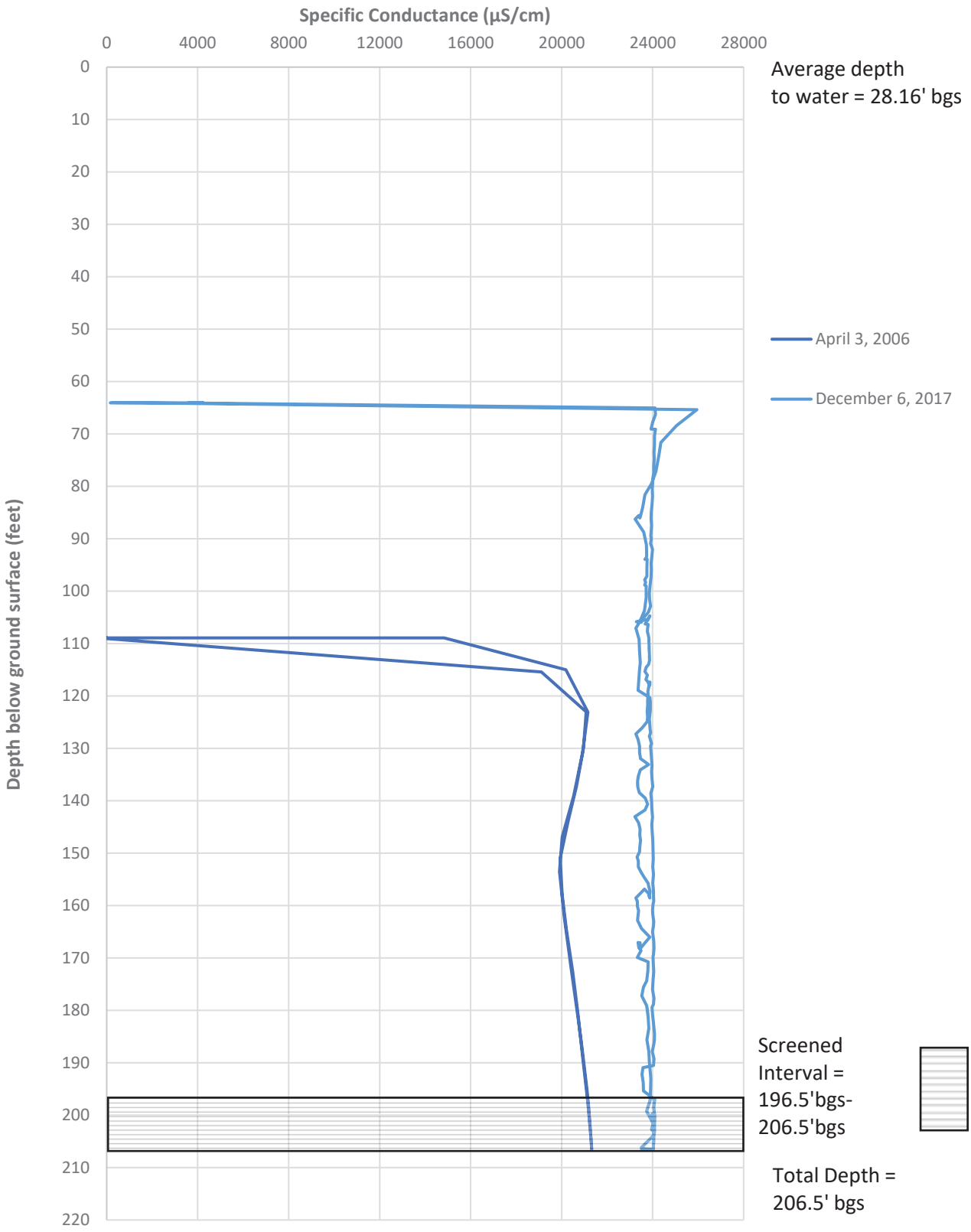
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-45-095a



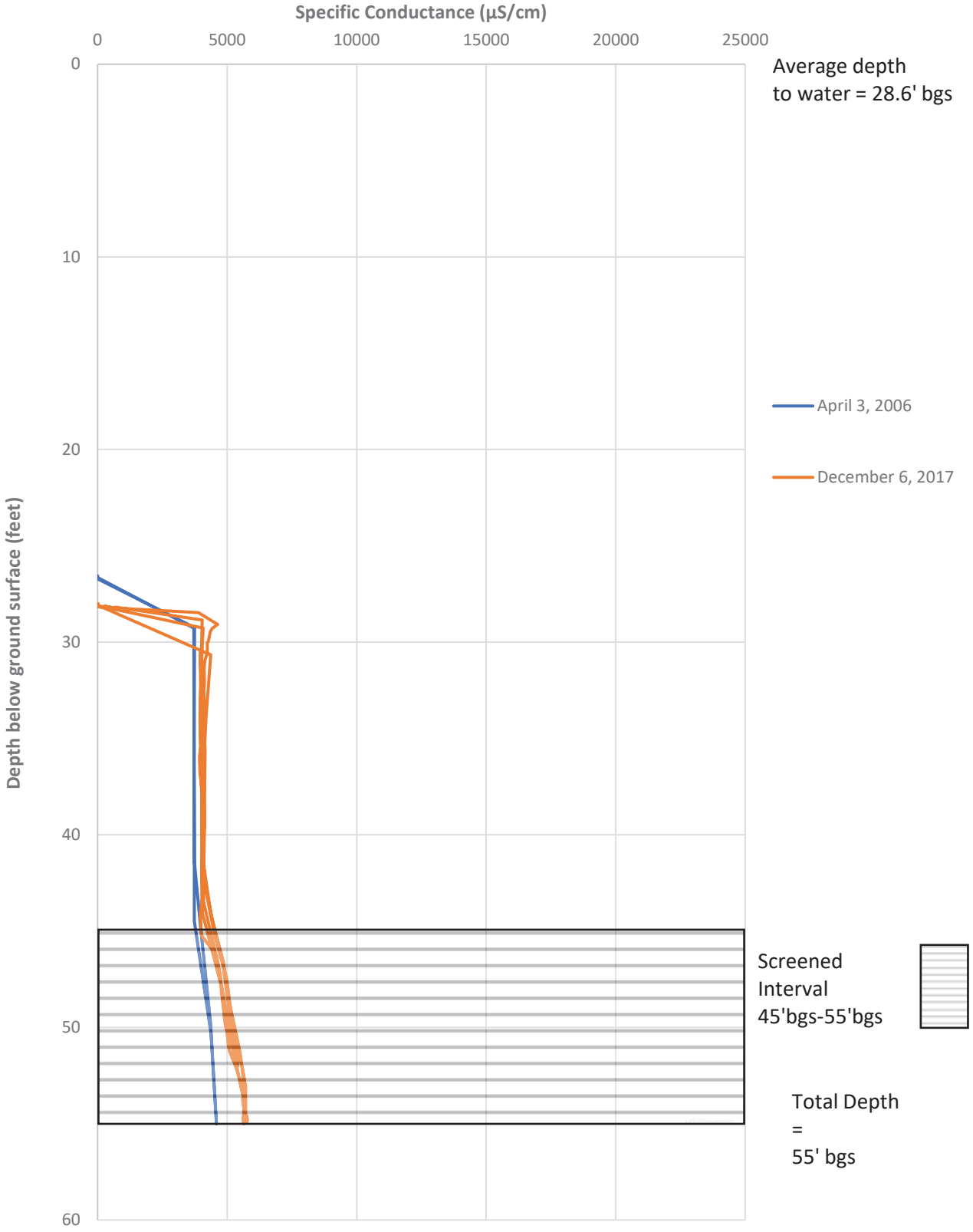
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-46-175



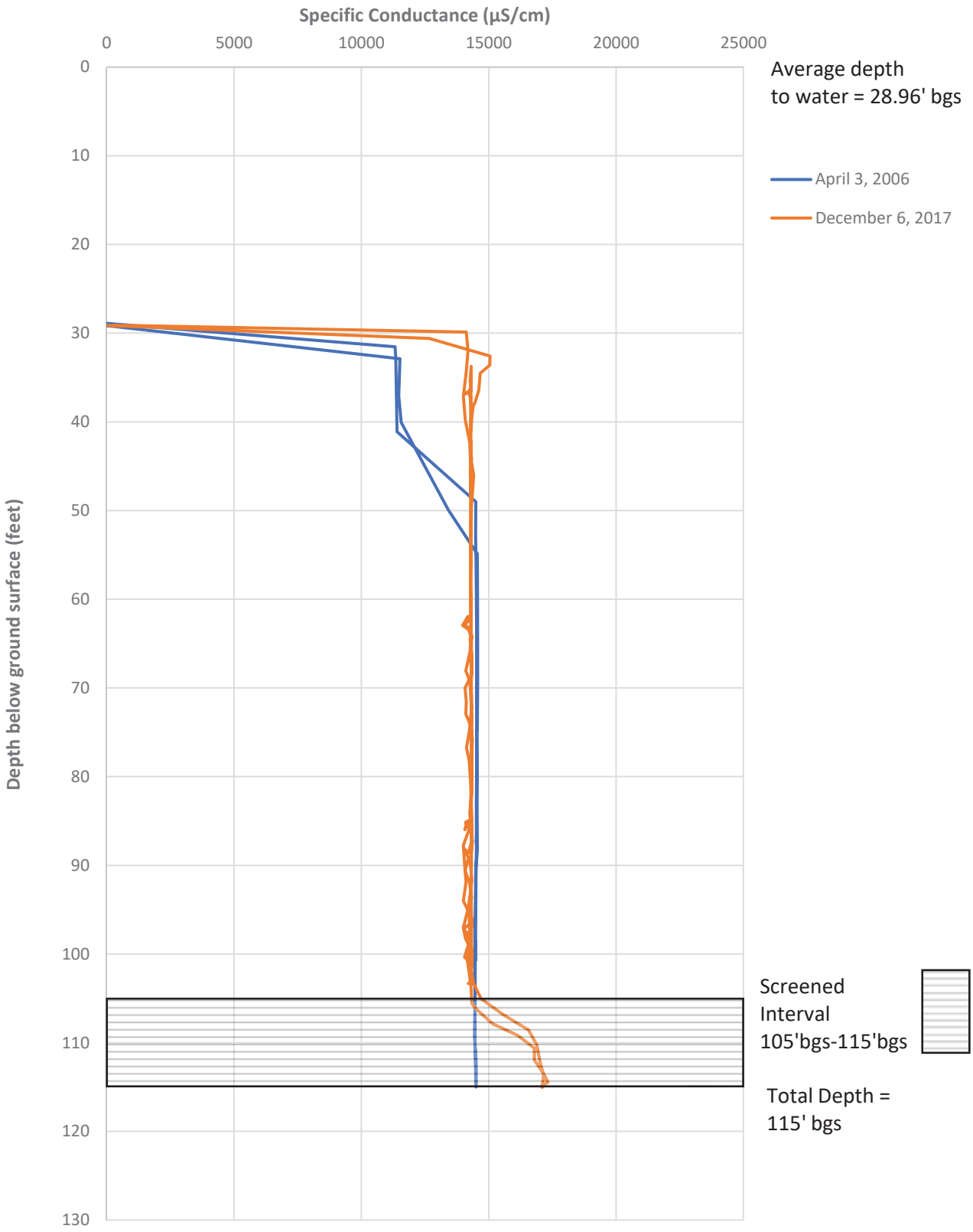
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-46-205



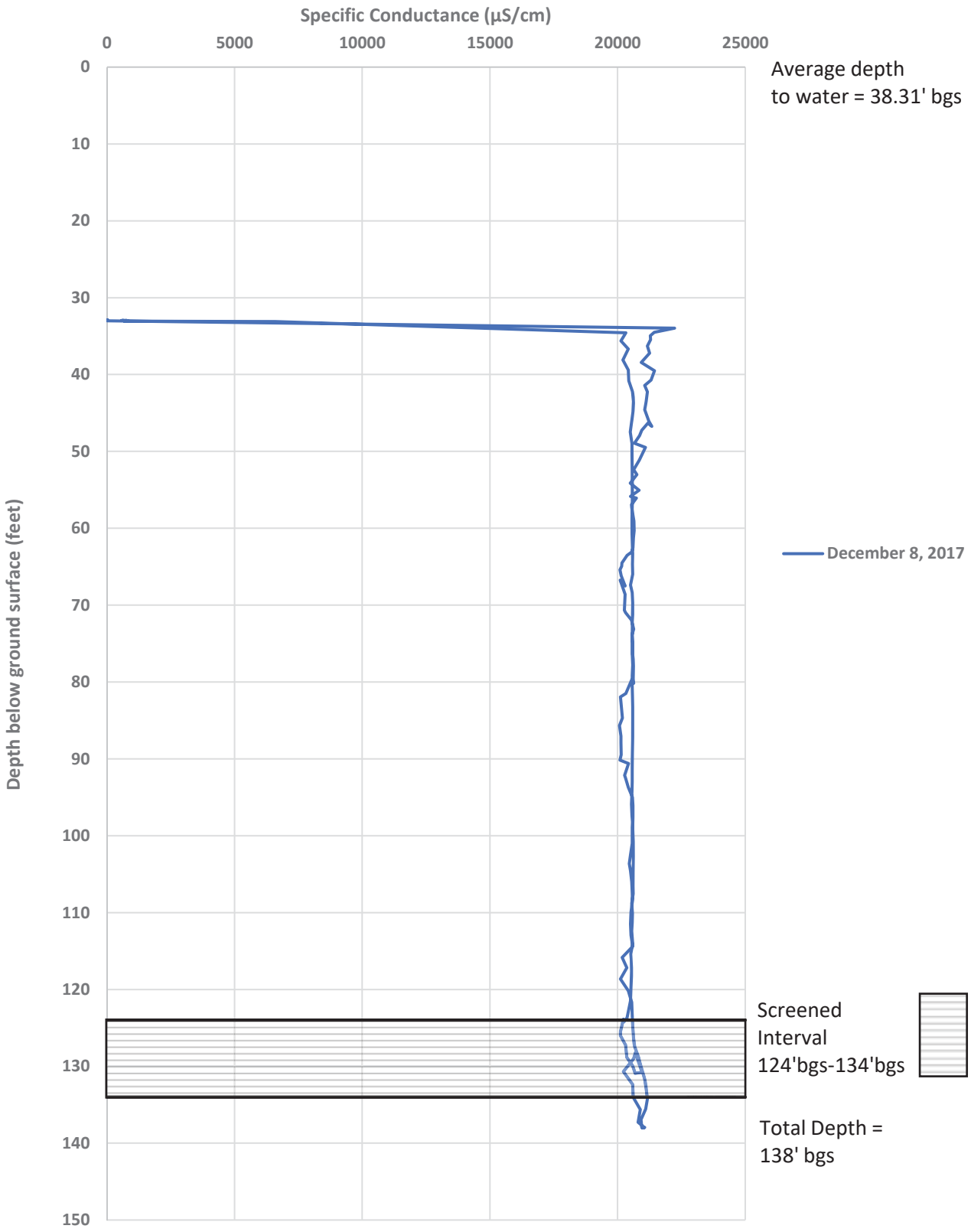
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-47-055



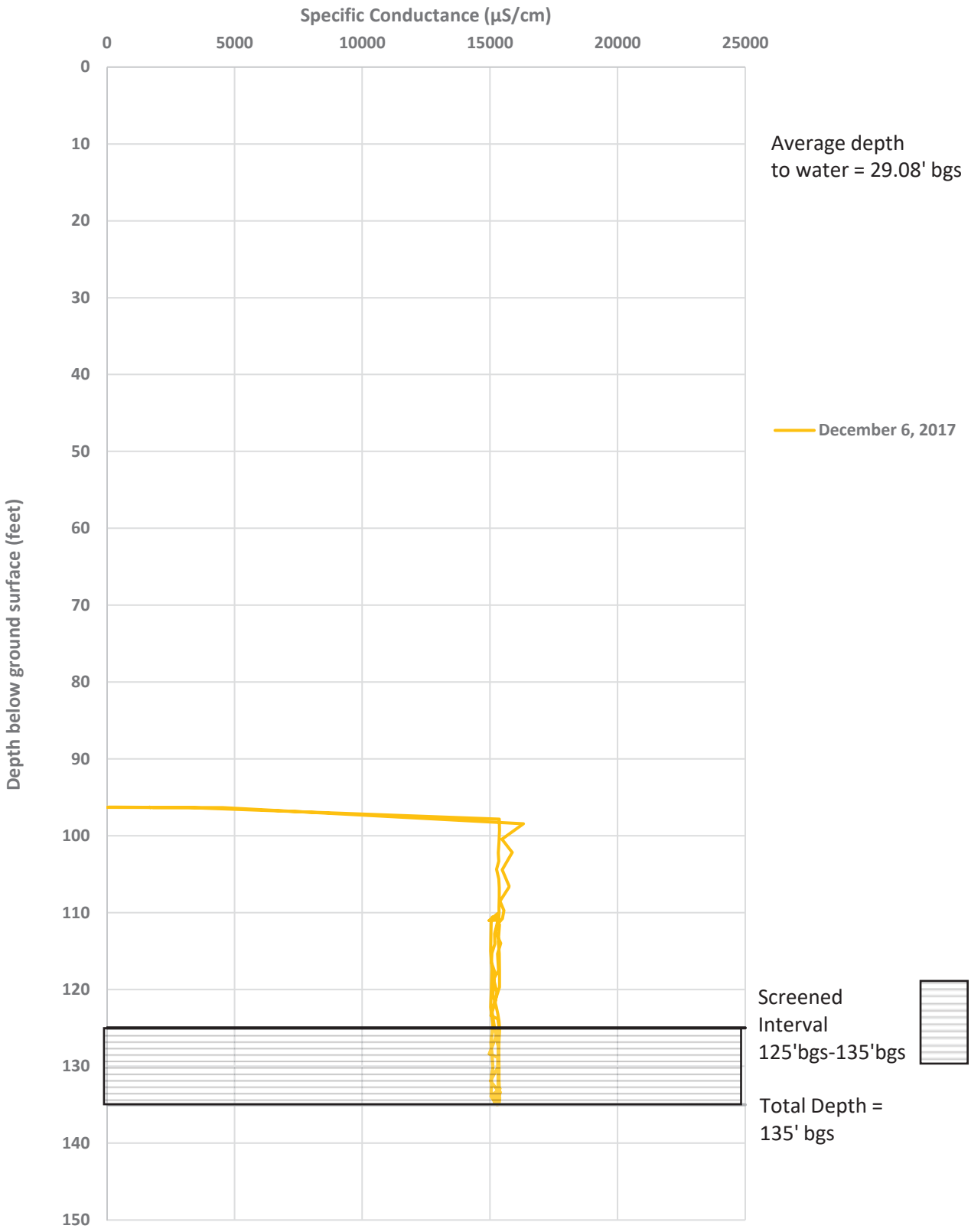
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-47-115



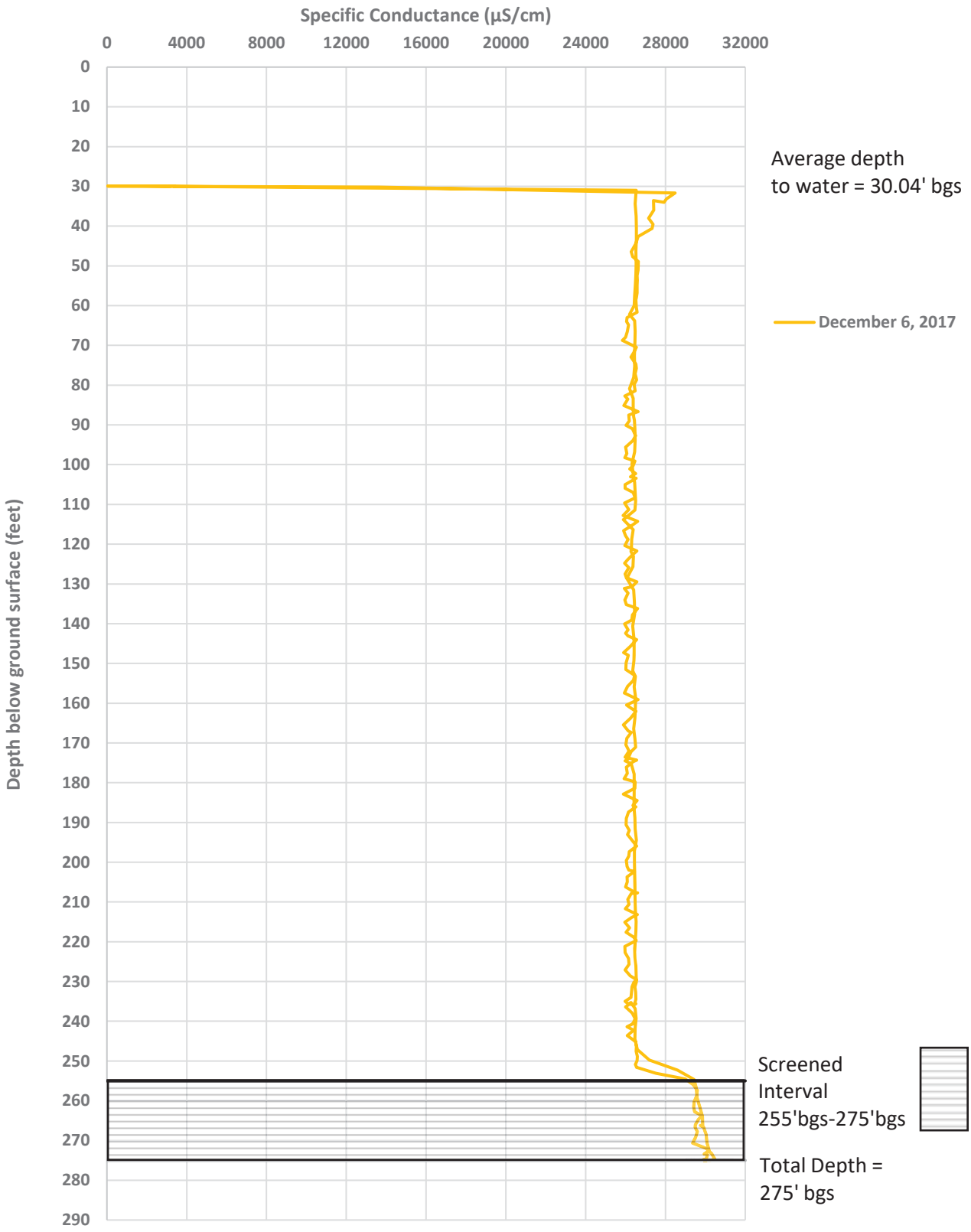
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-48



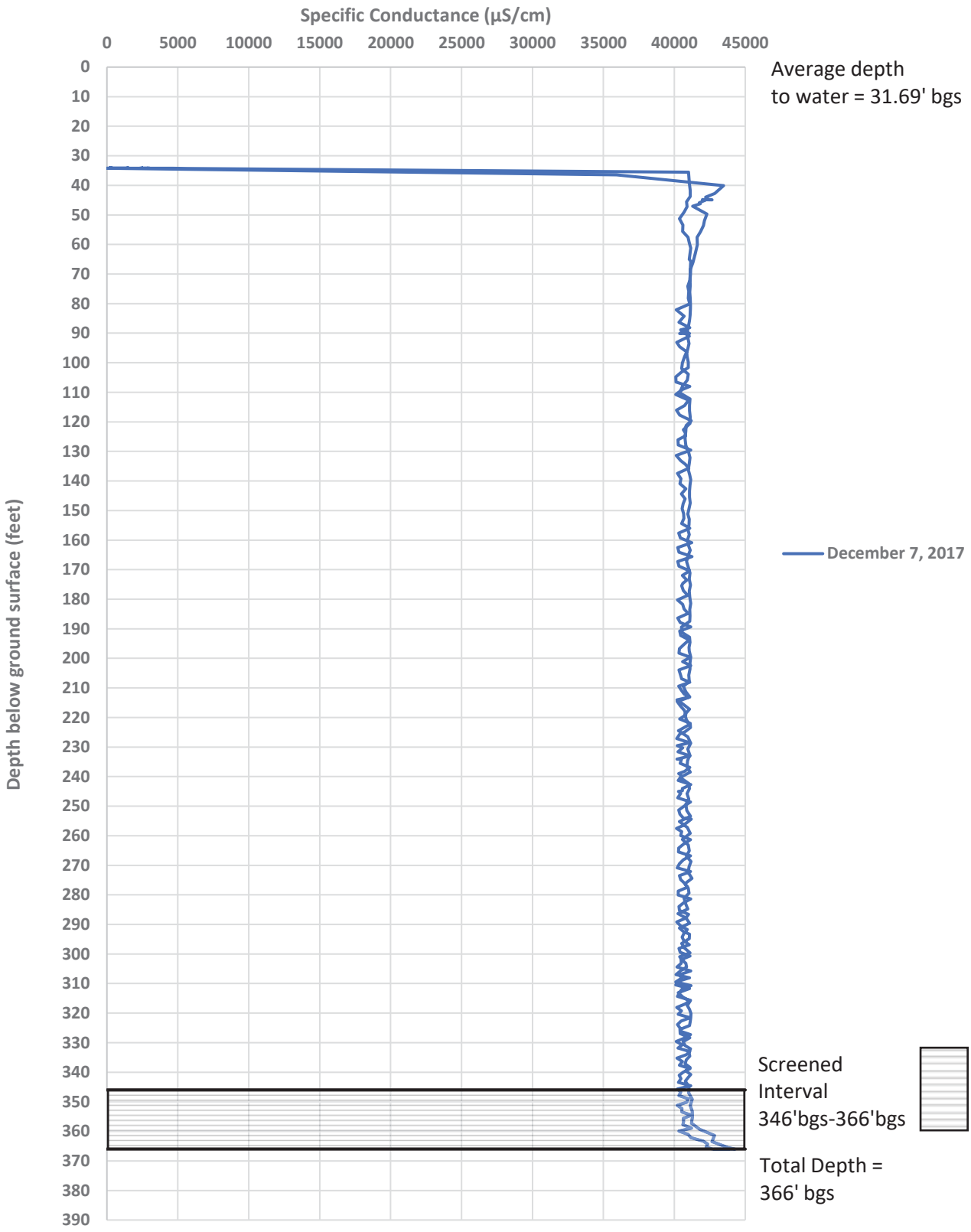
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-49-135



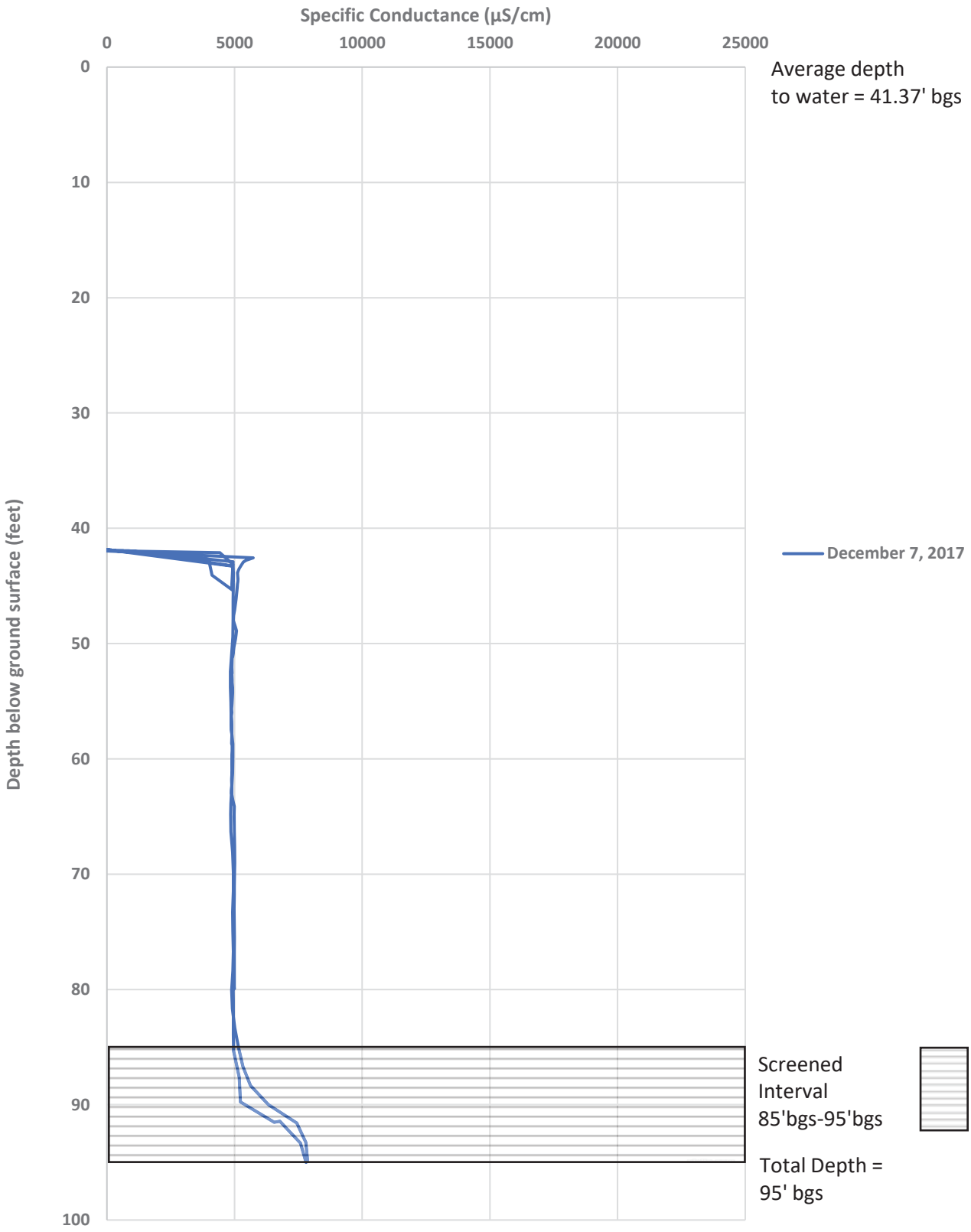
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-49-275



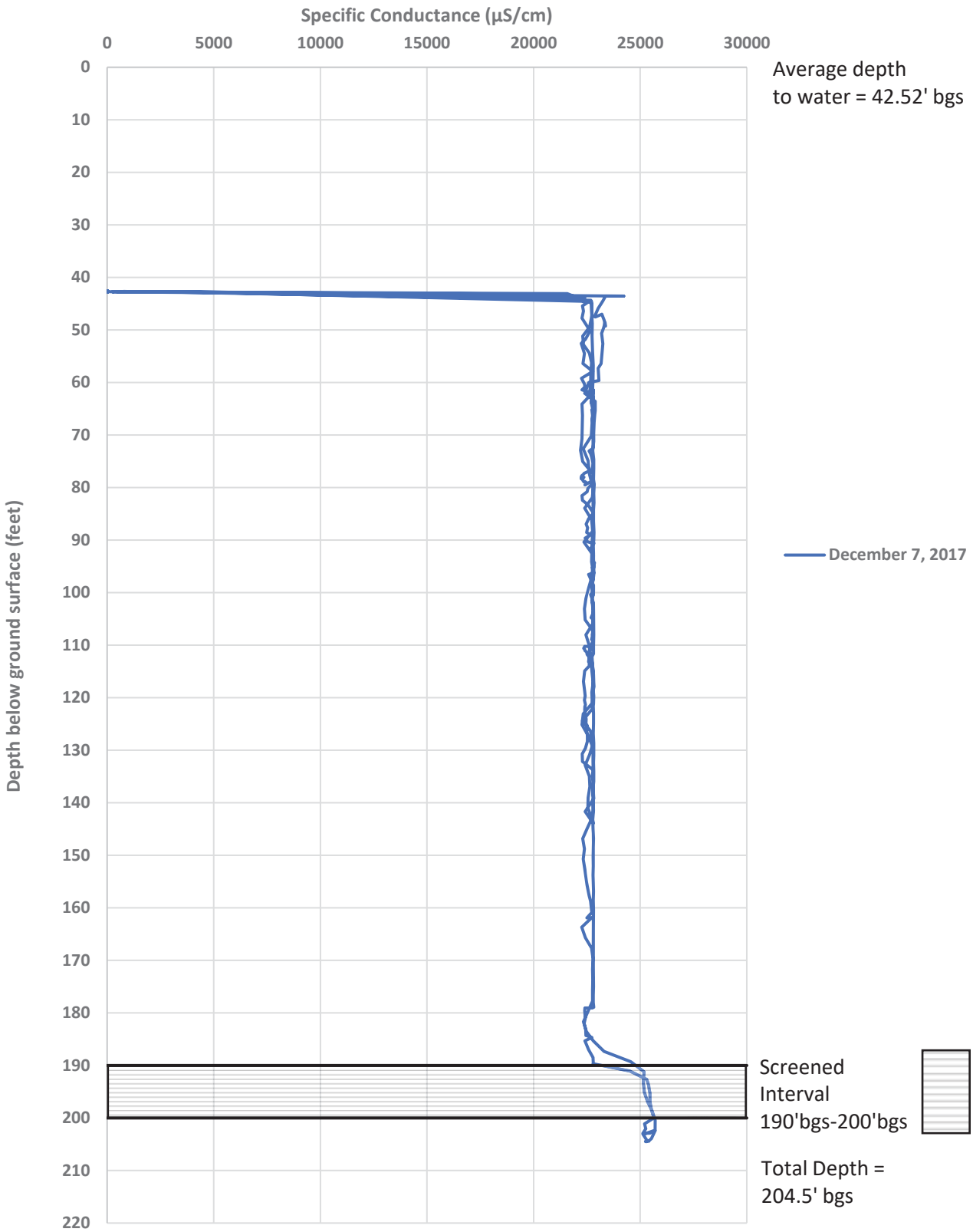
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-49-365



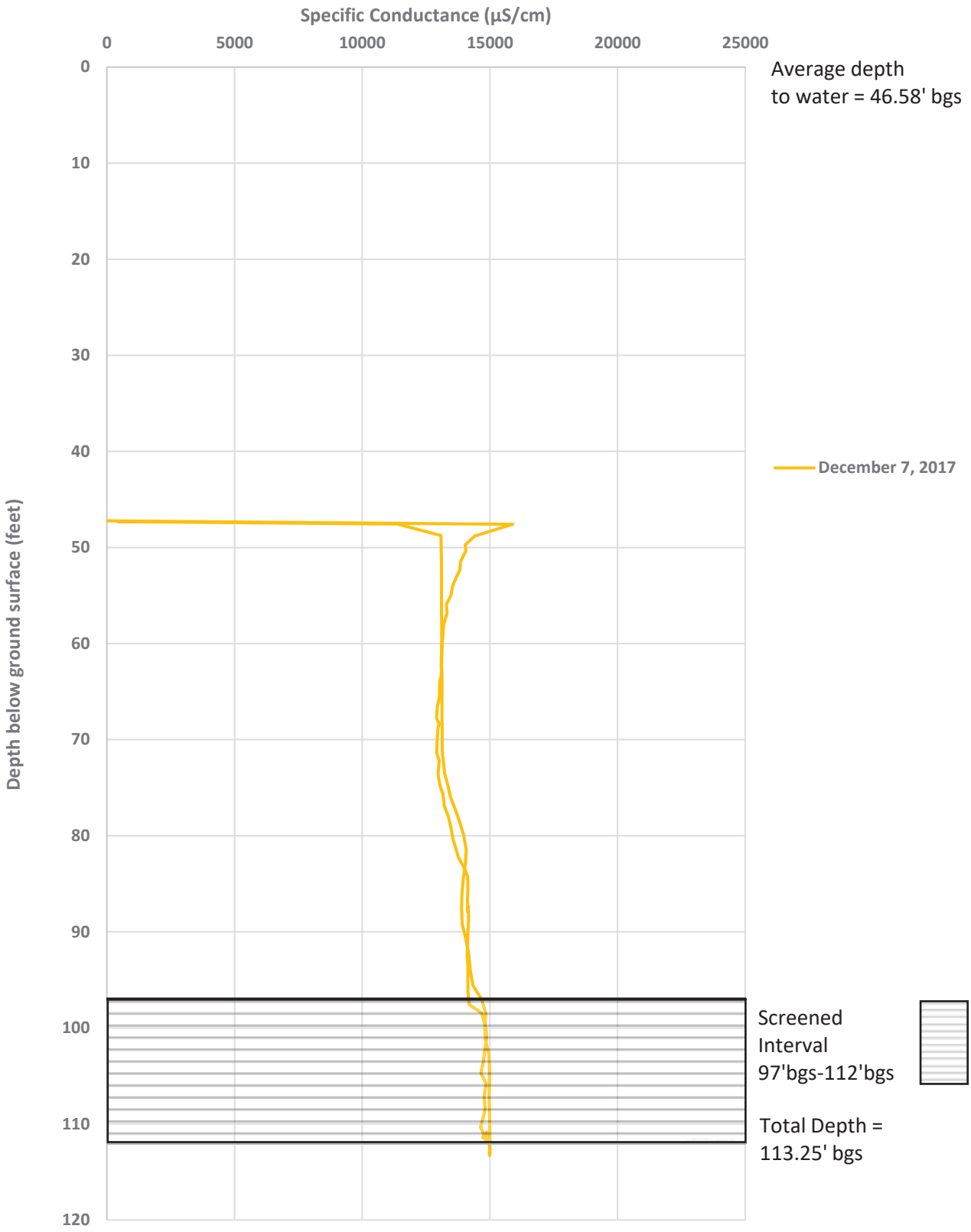
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-50-095



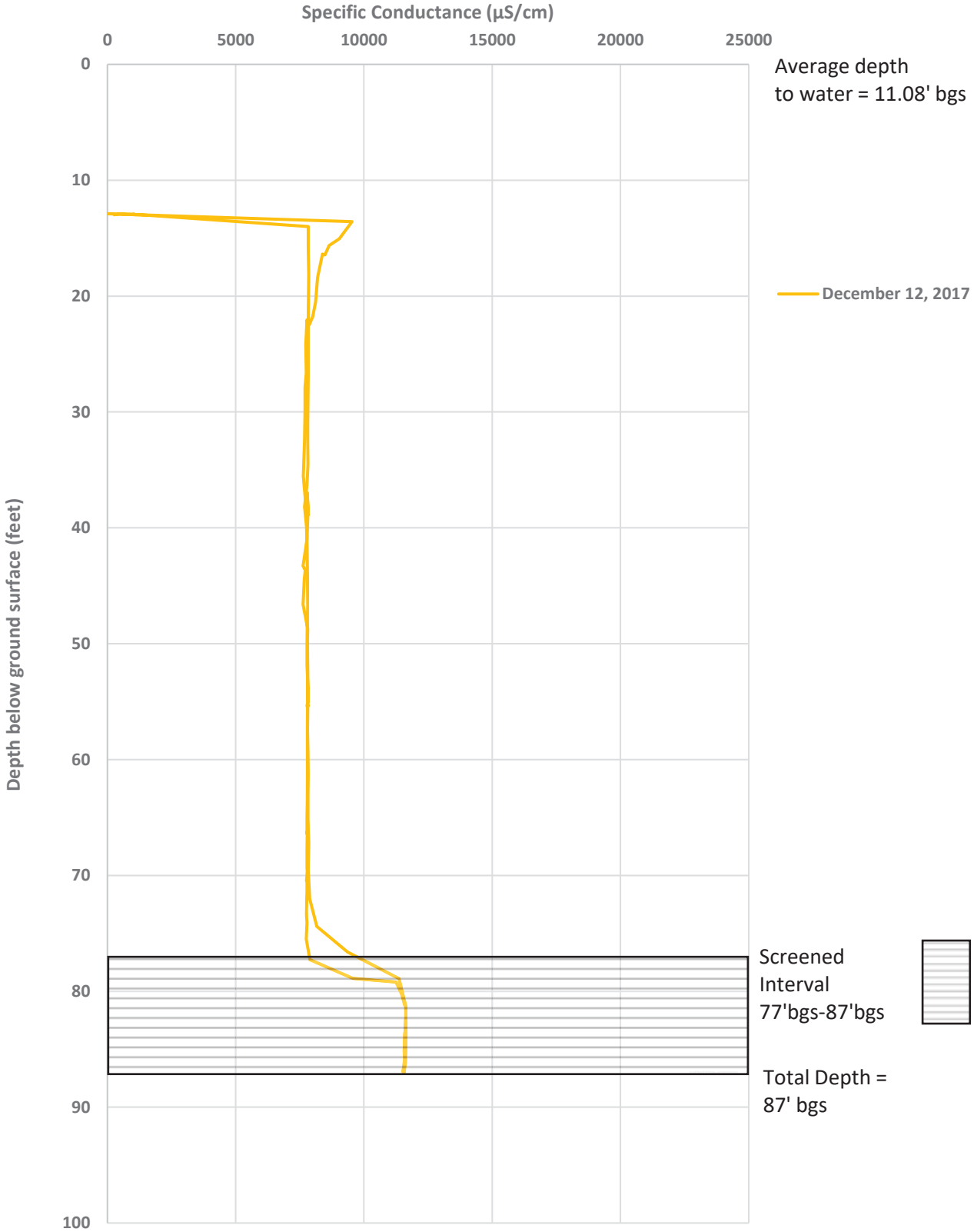
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-50-200



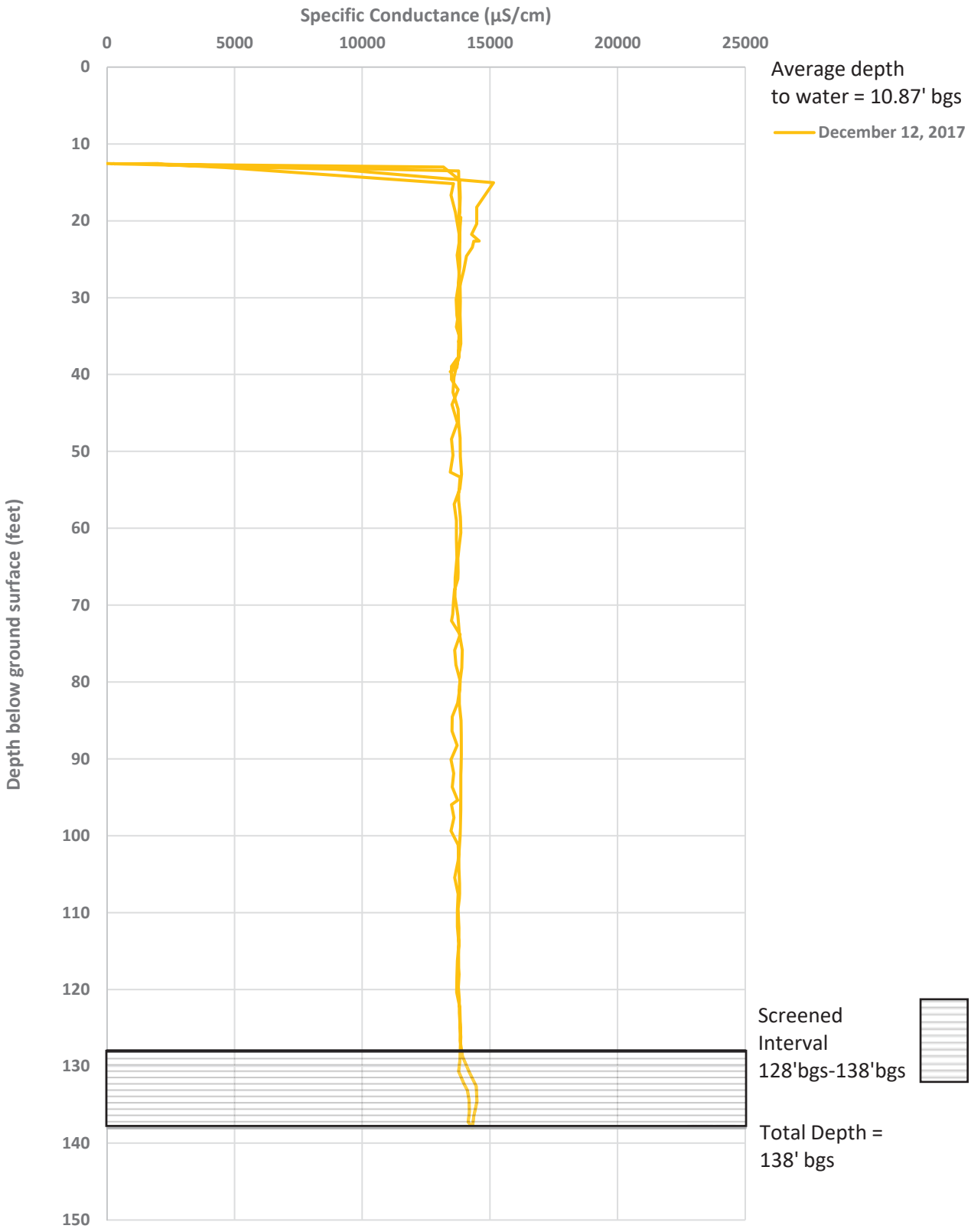
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-51



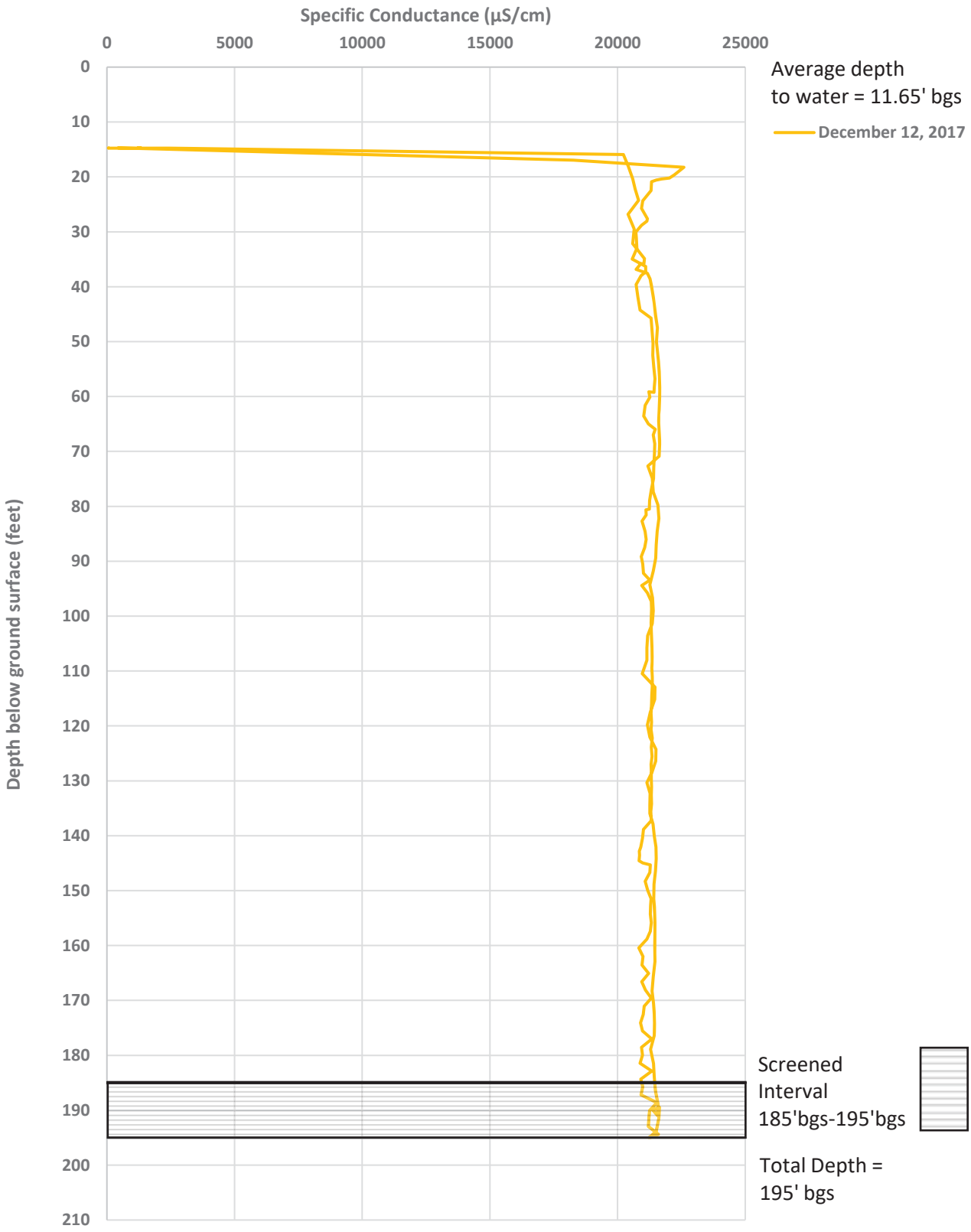
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-54-085



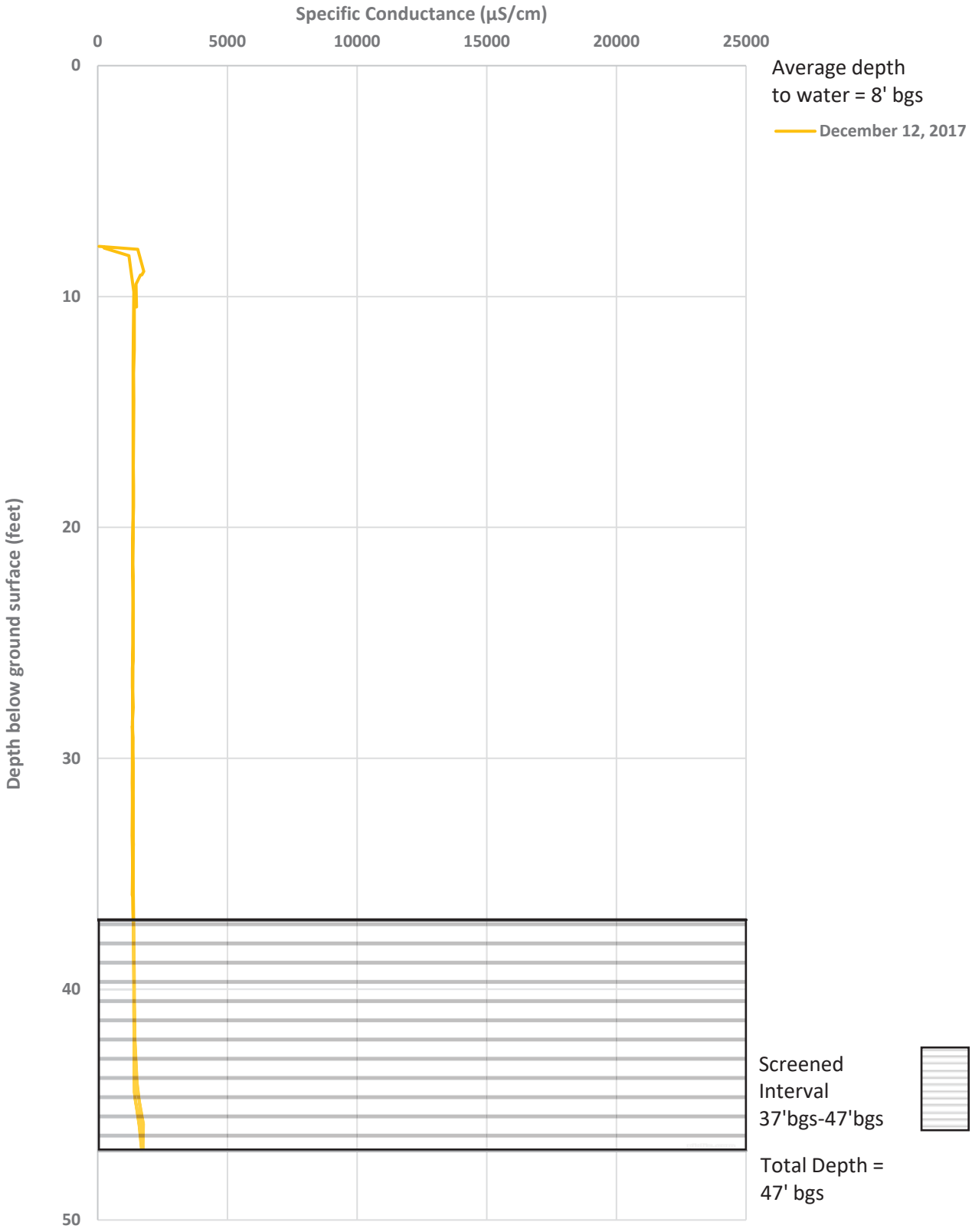
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-54-140



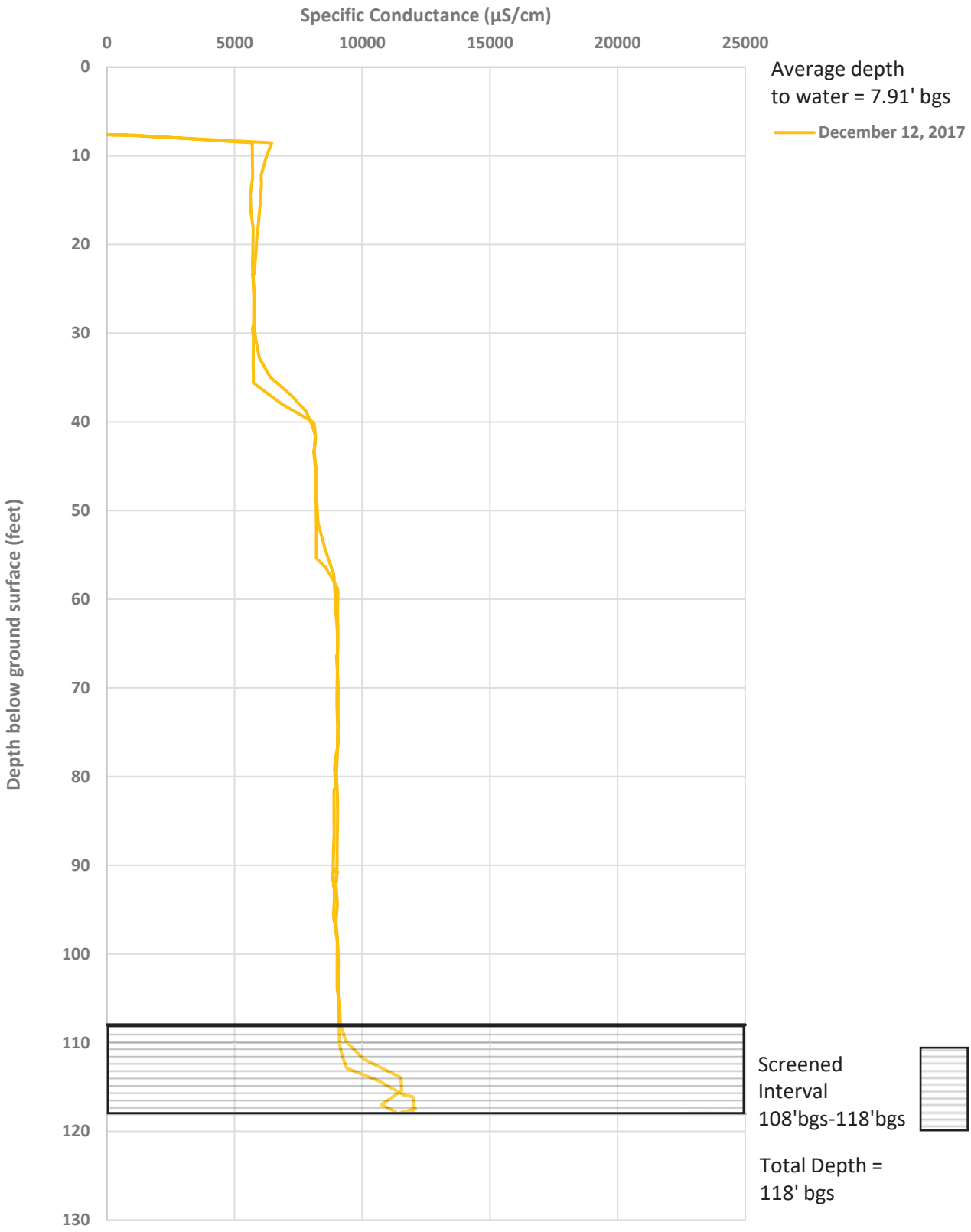
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-54-195



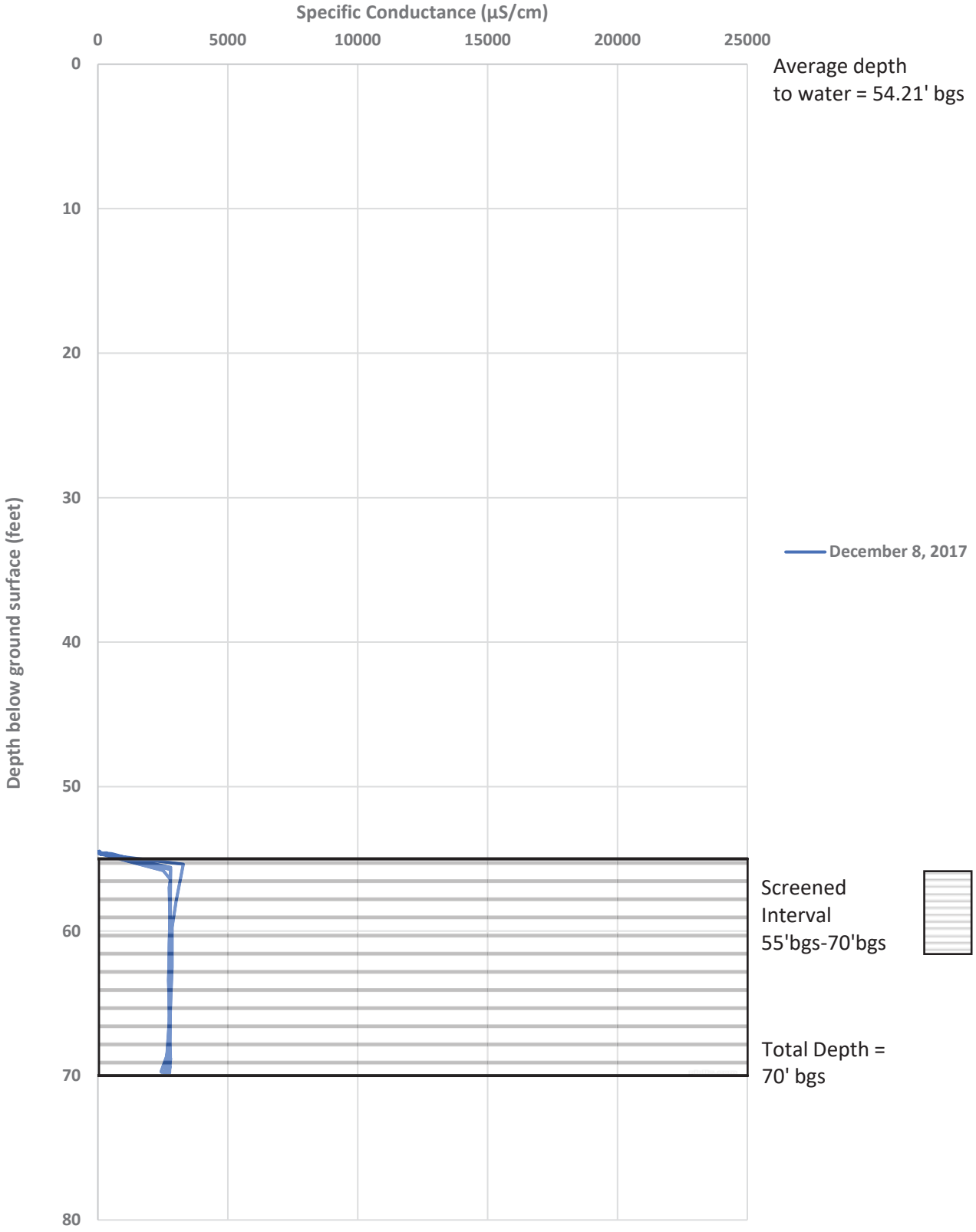
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-55-045



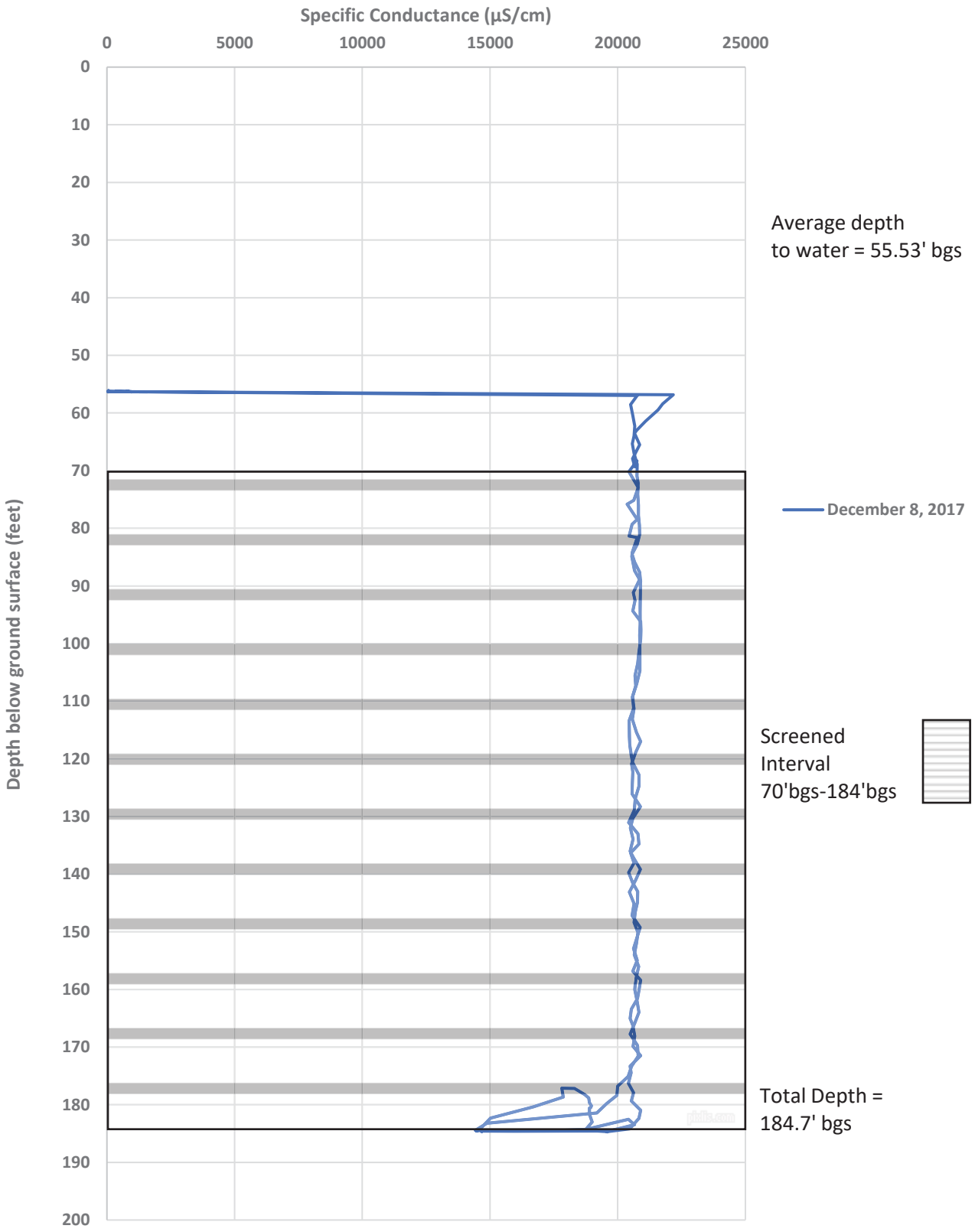
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-55-120



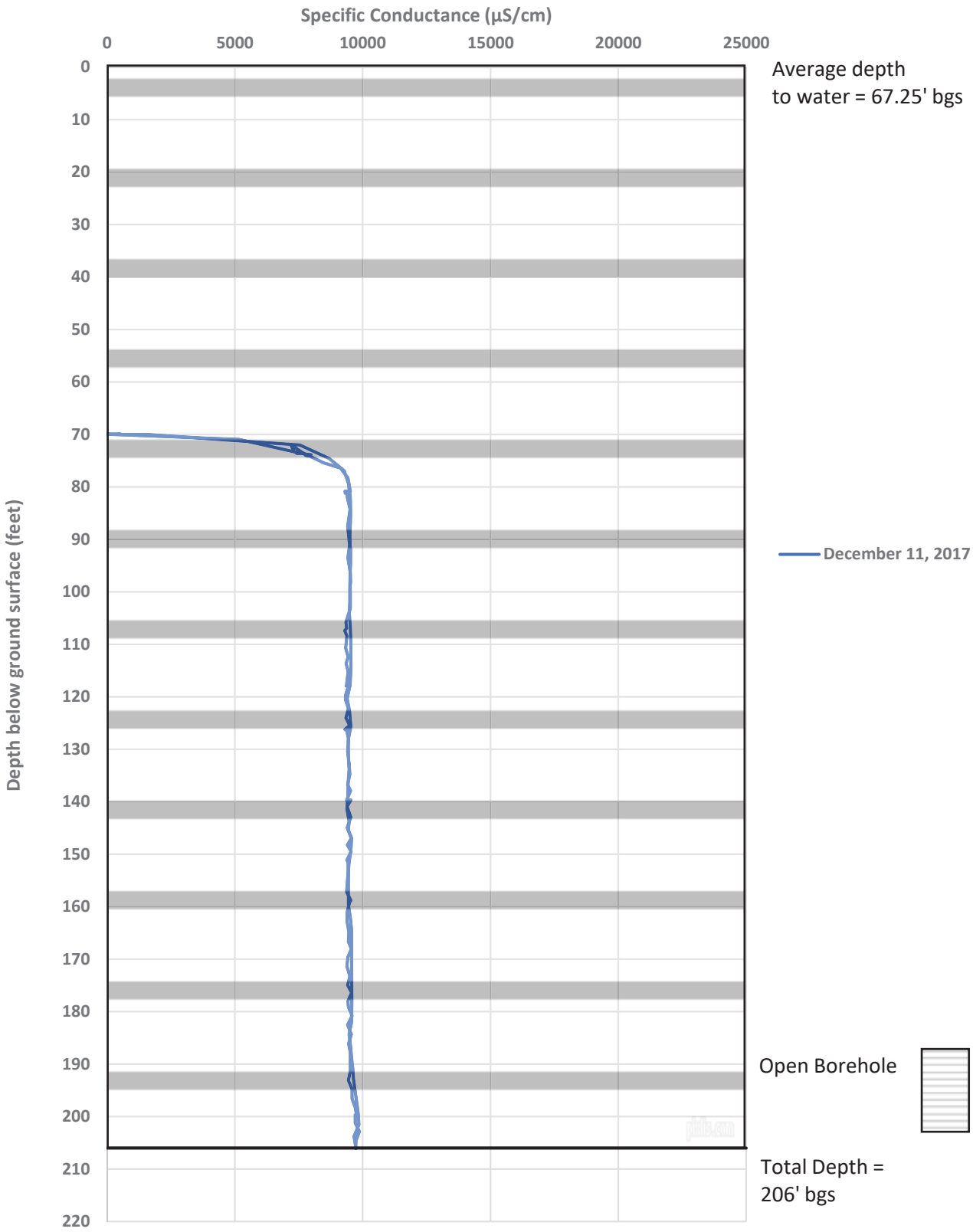
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-57-070



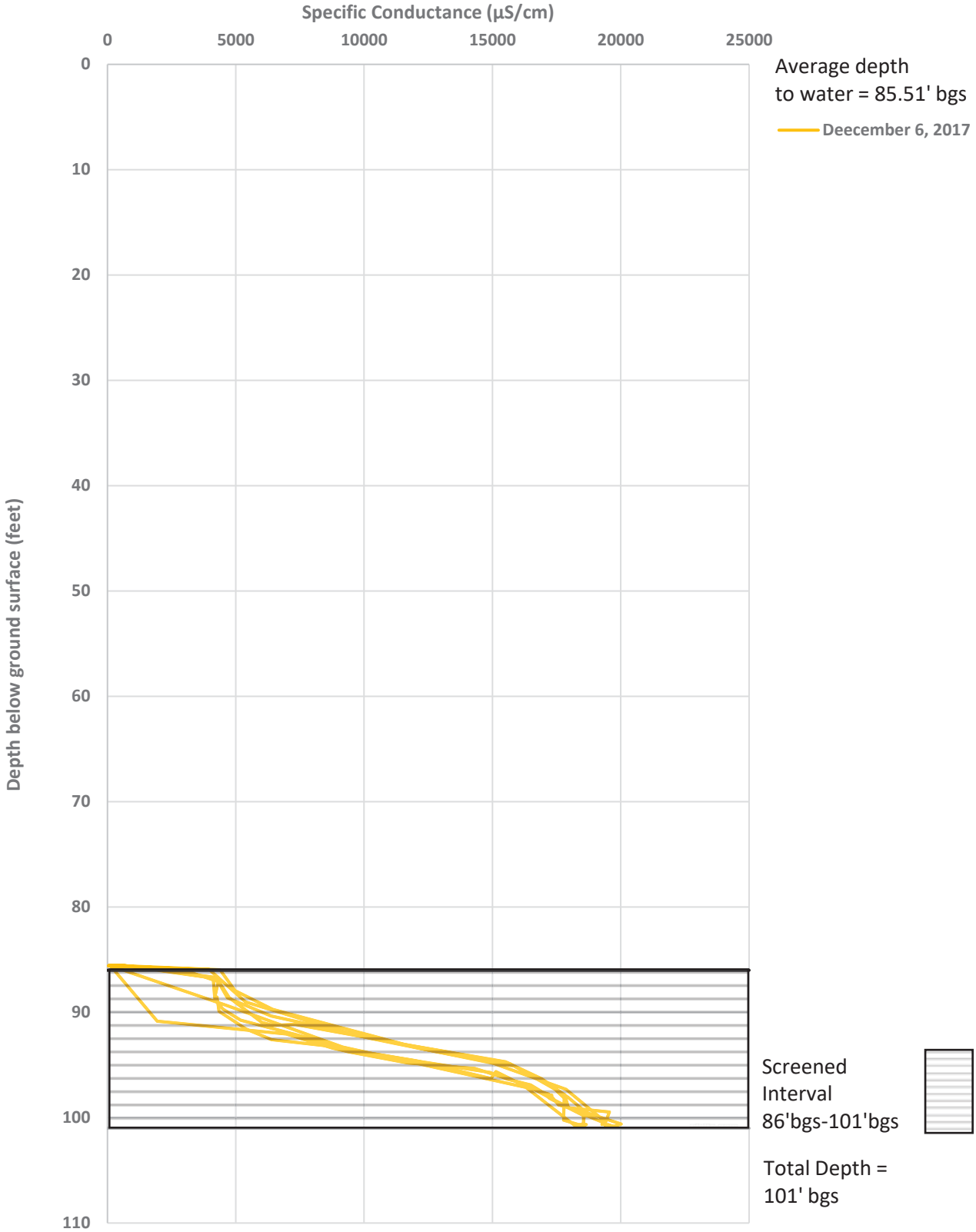
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-57-185



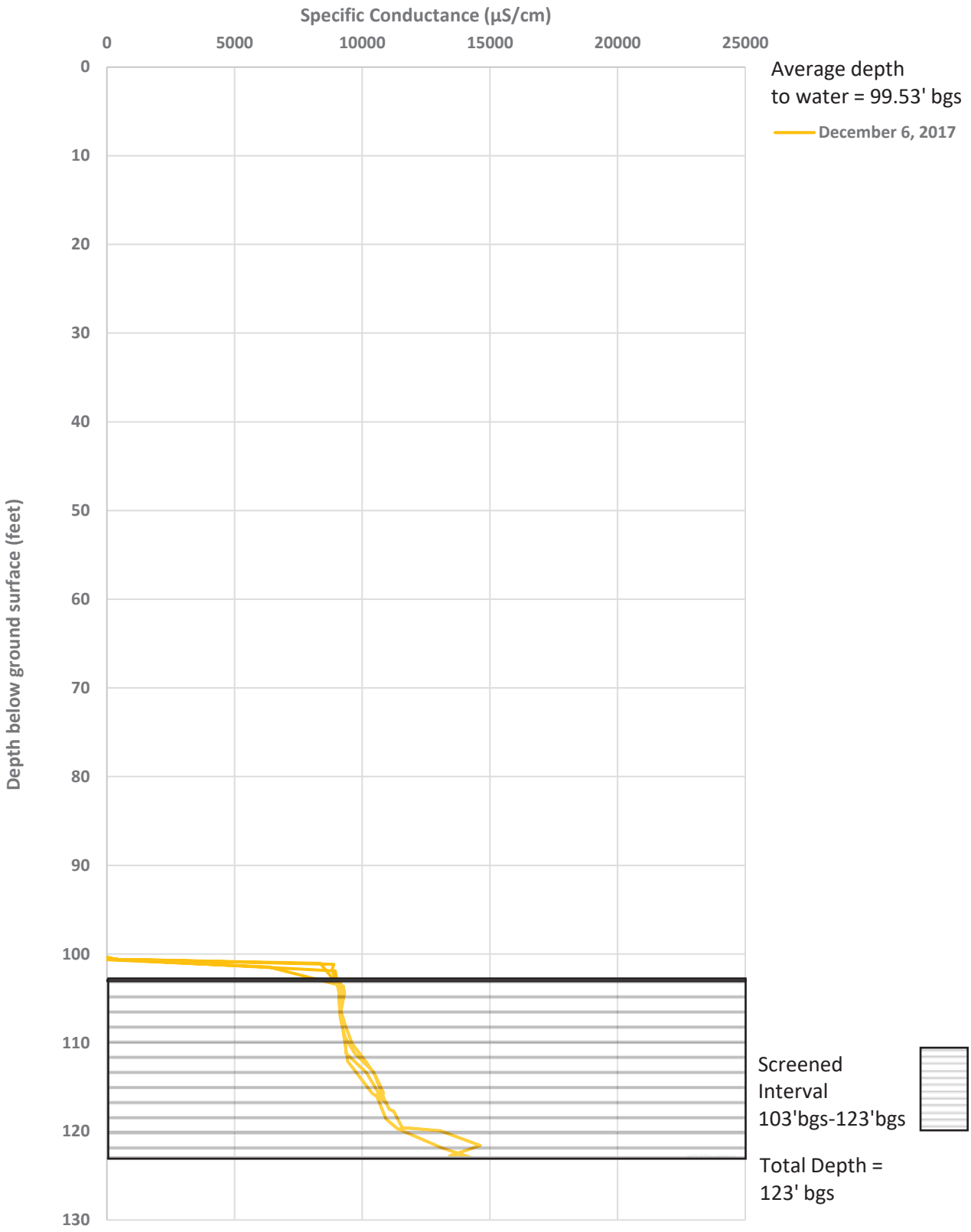
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-58BR



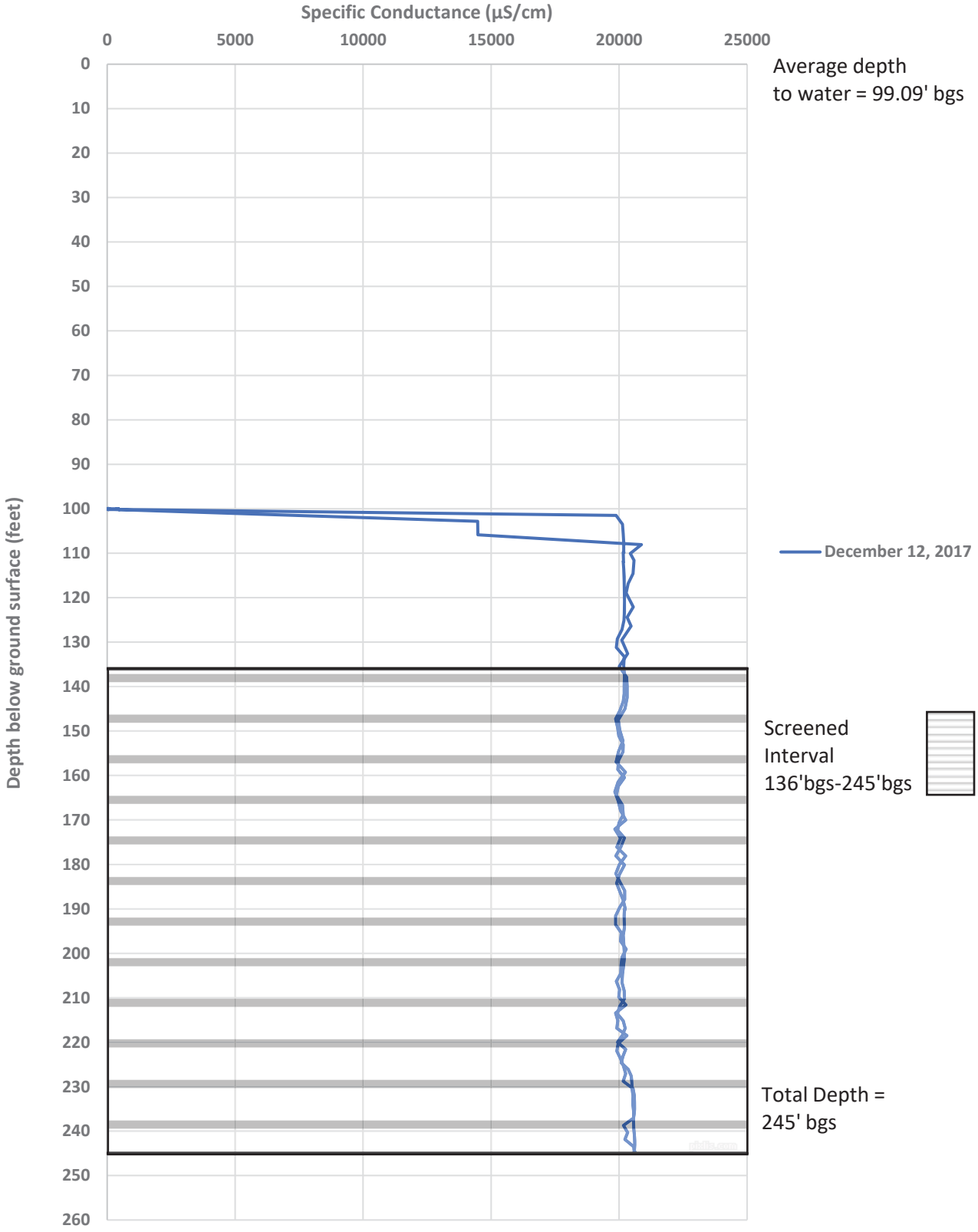
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-59-100



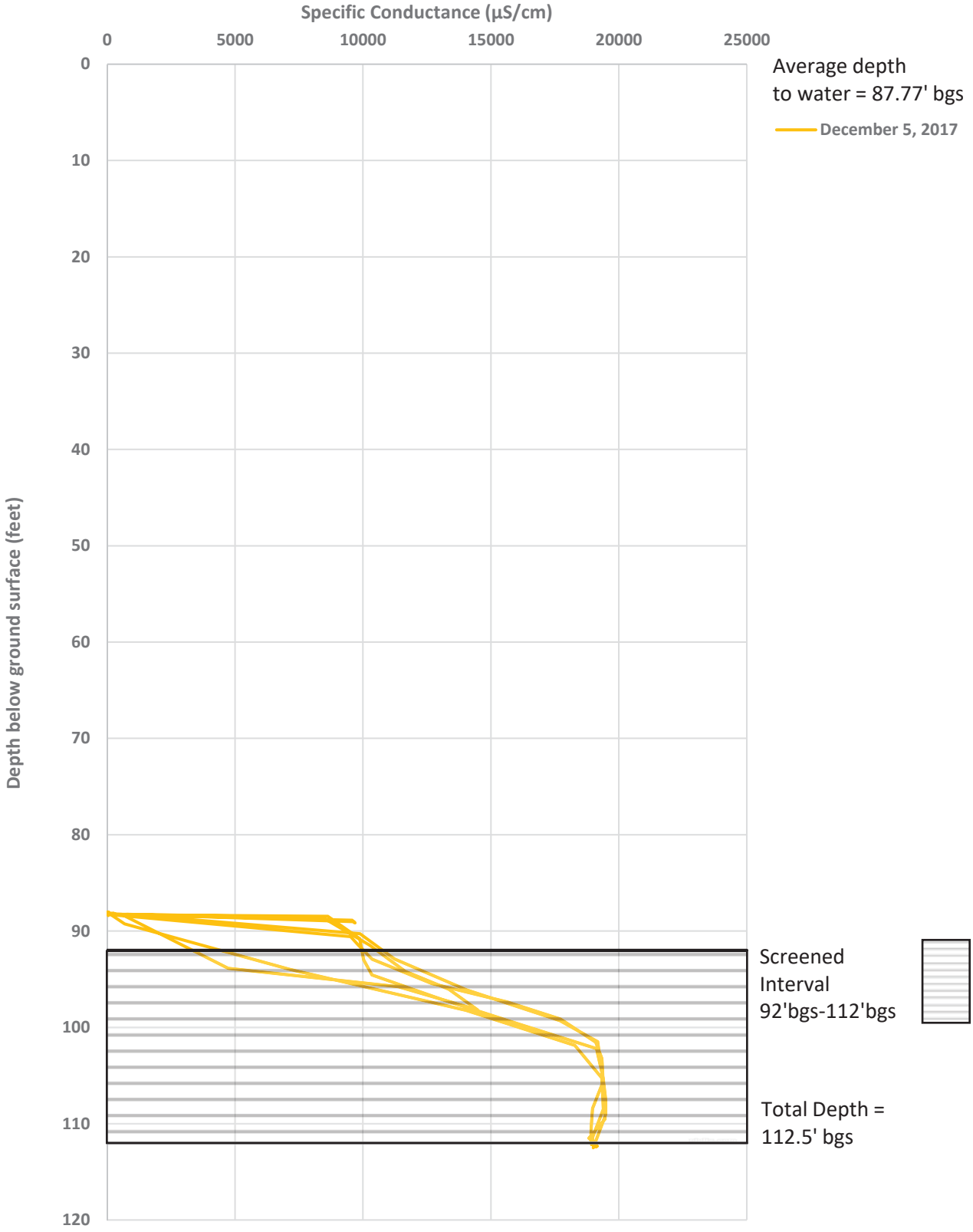
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-60-125



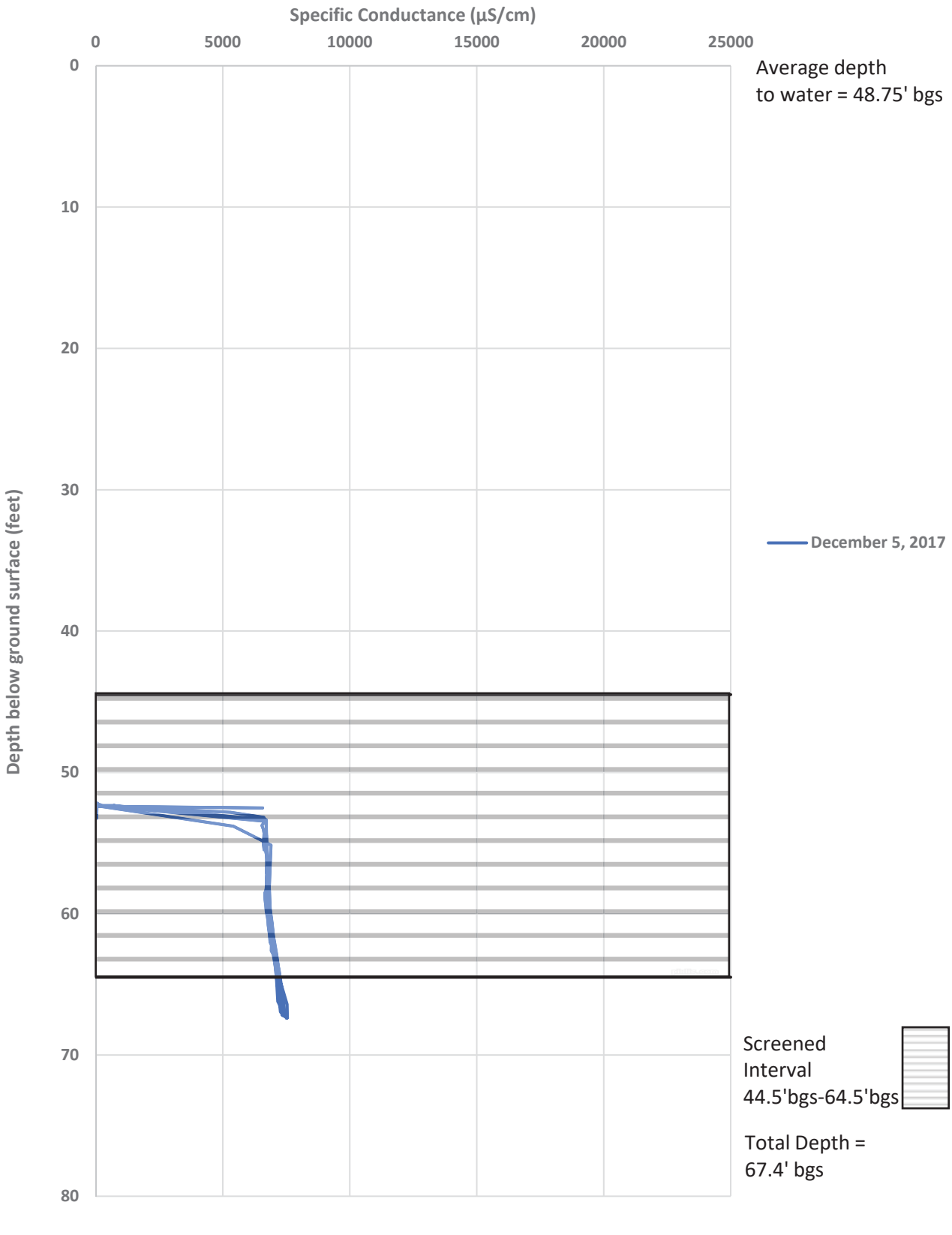
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-60BR-245



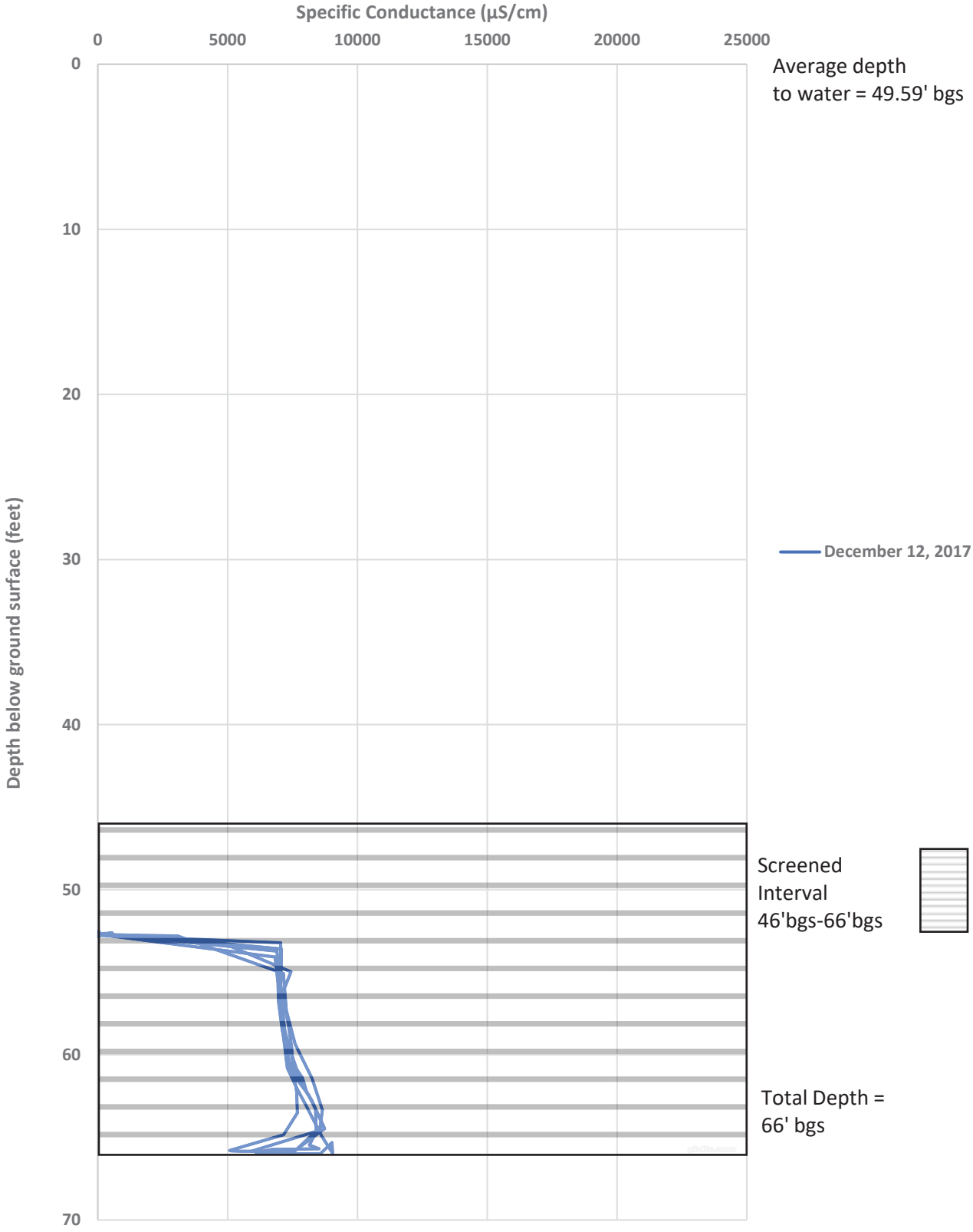
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-61-110



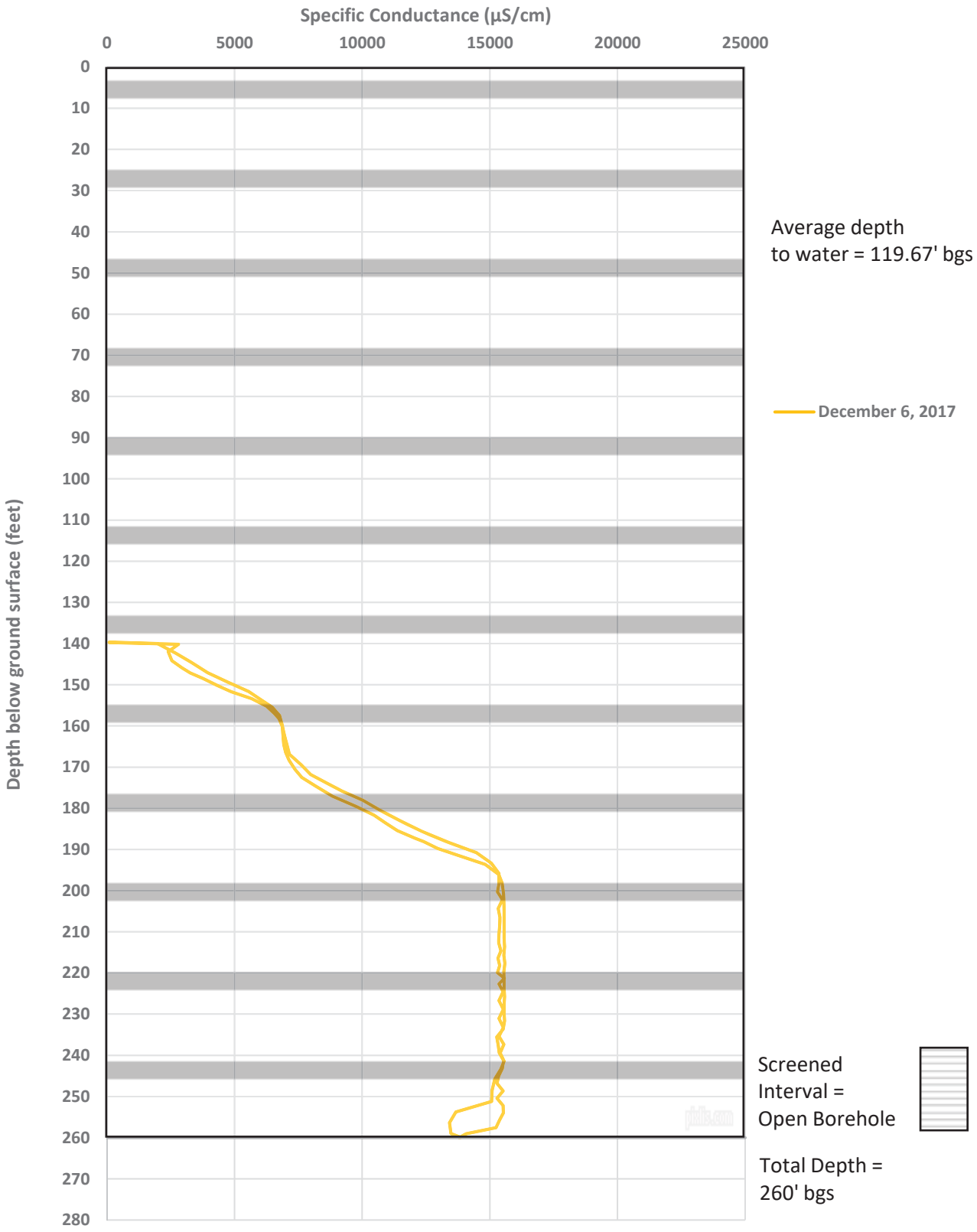
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-62-065



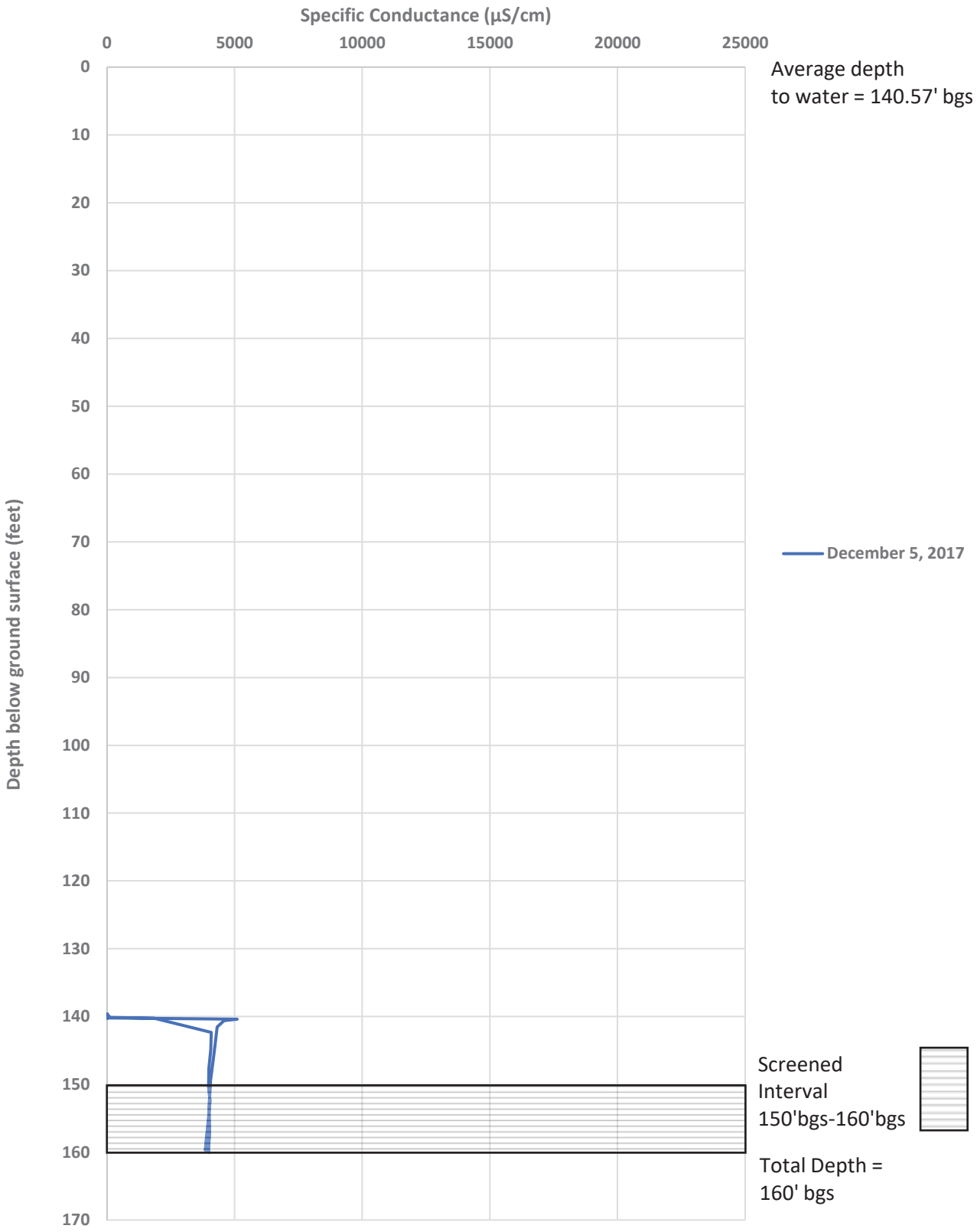
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-63-065



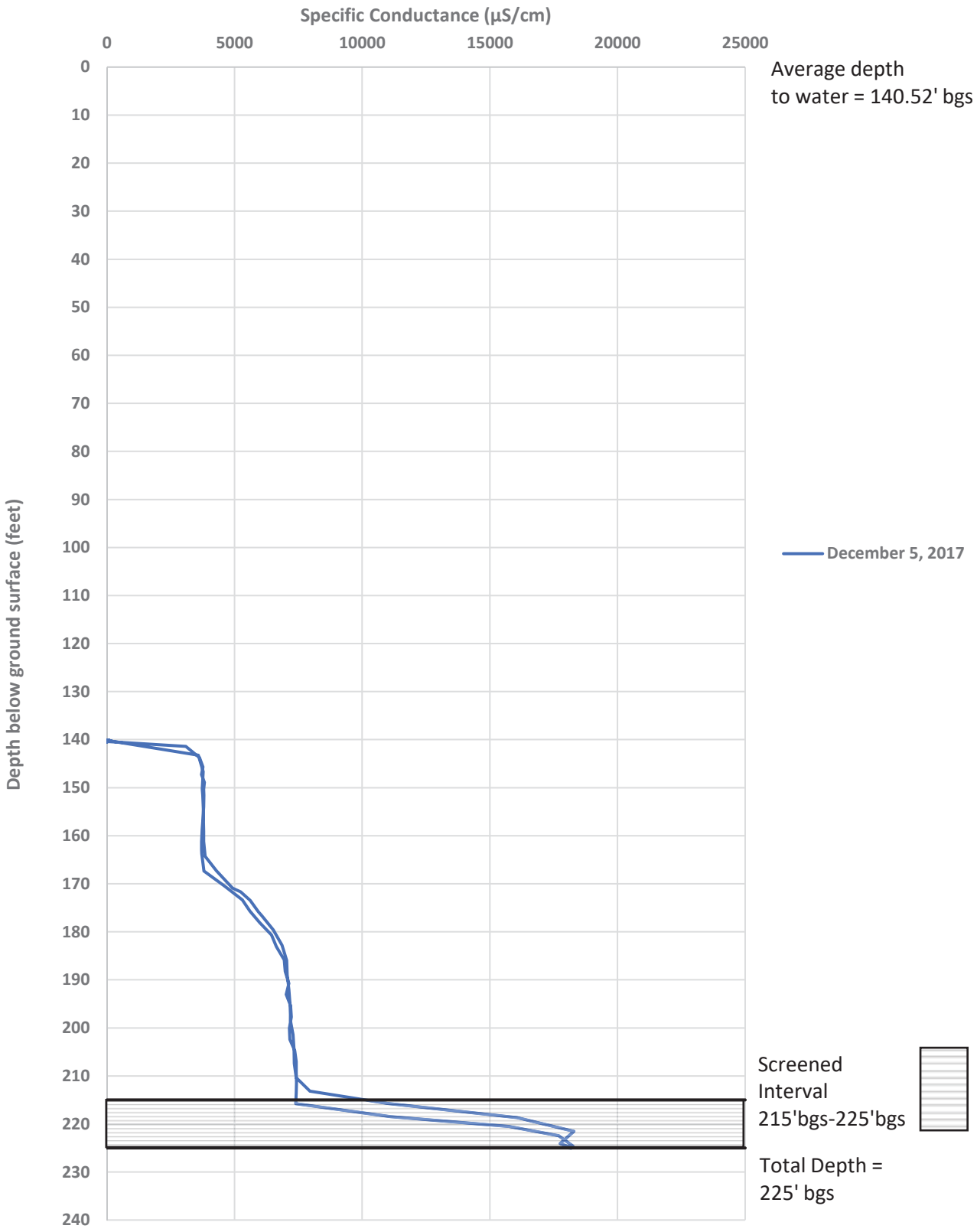
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-64BR



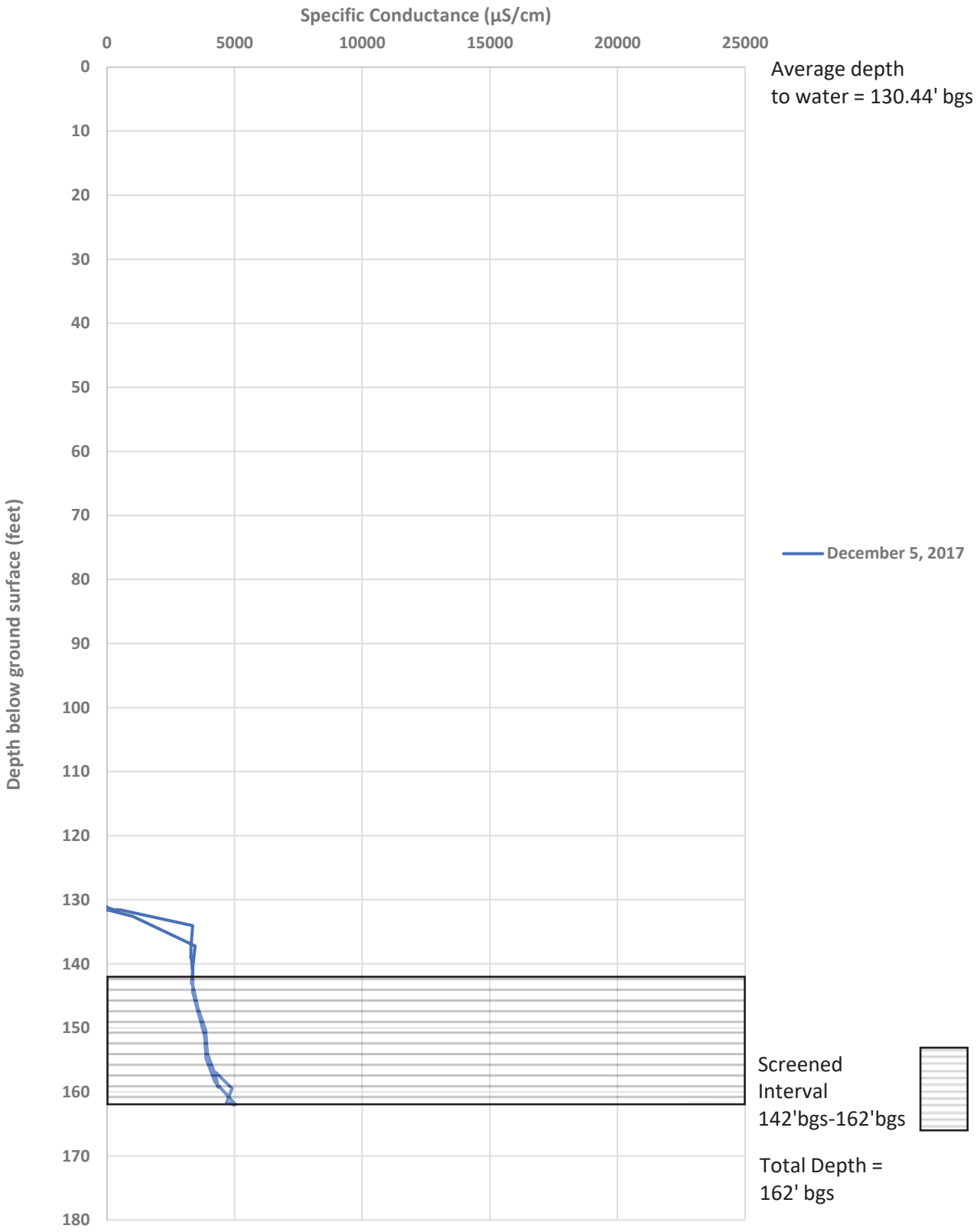
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-65-160



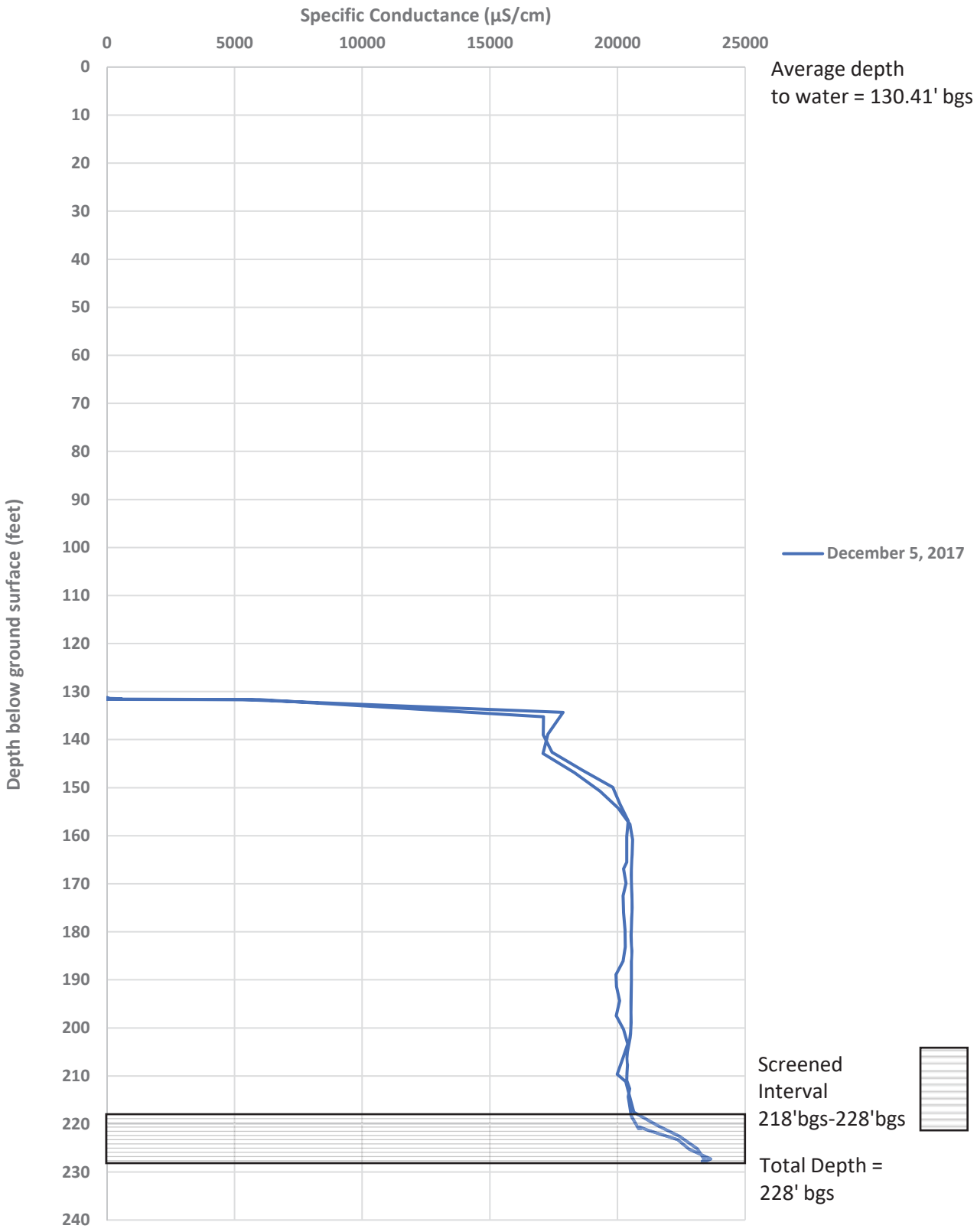
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-65-225



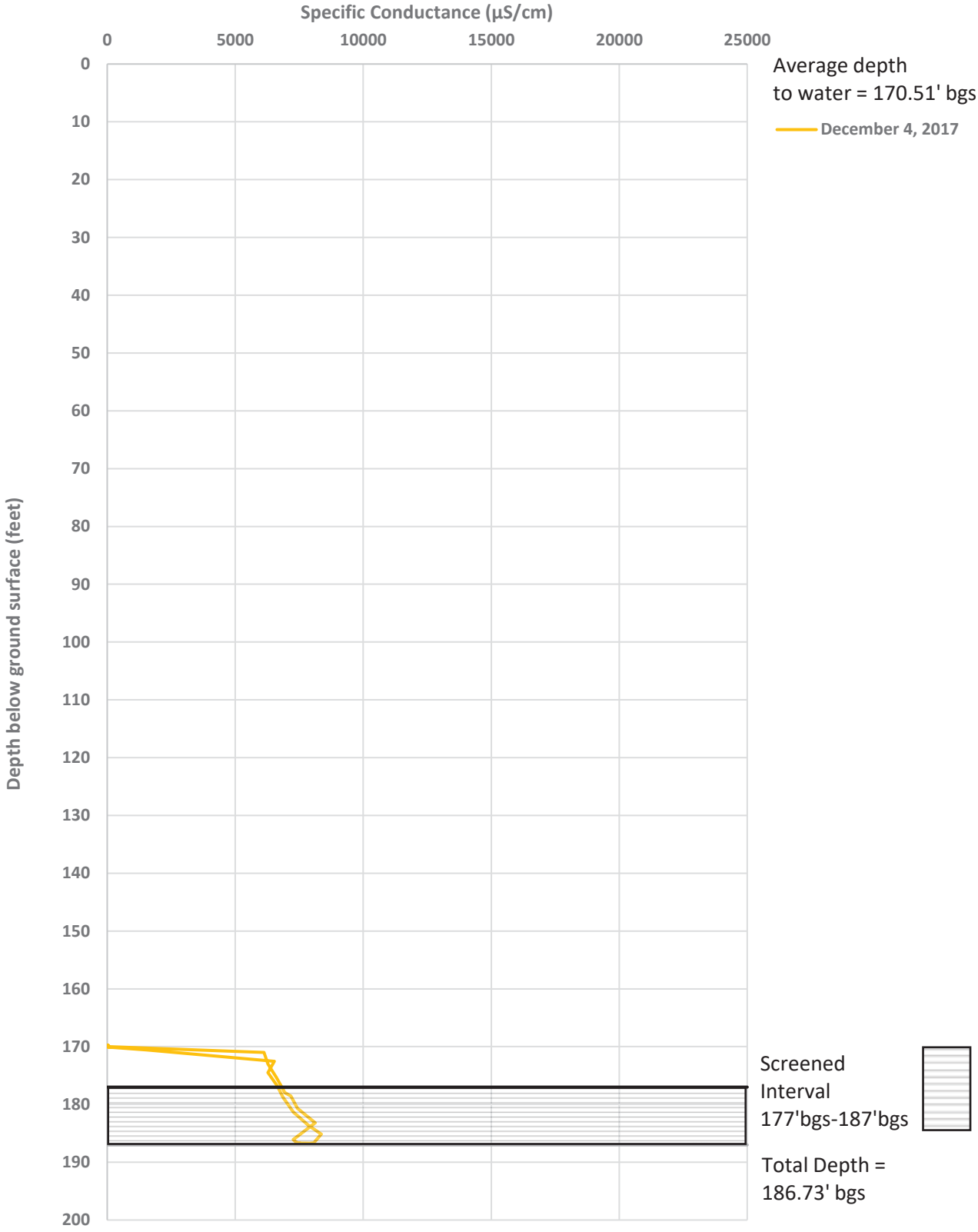
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-66-165



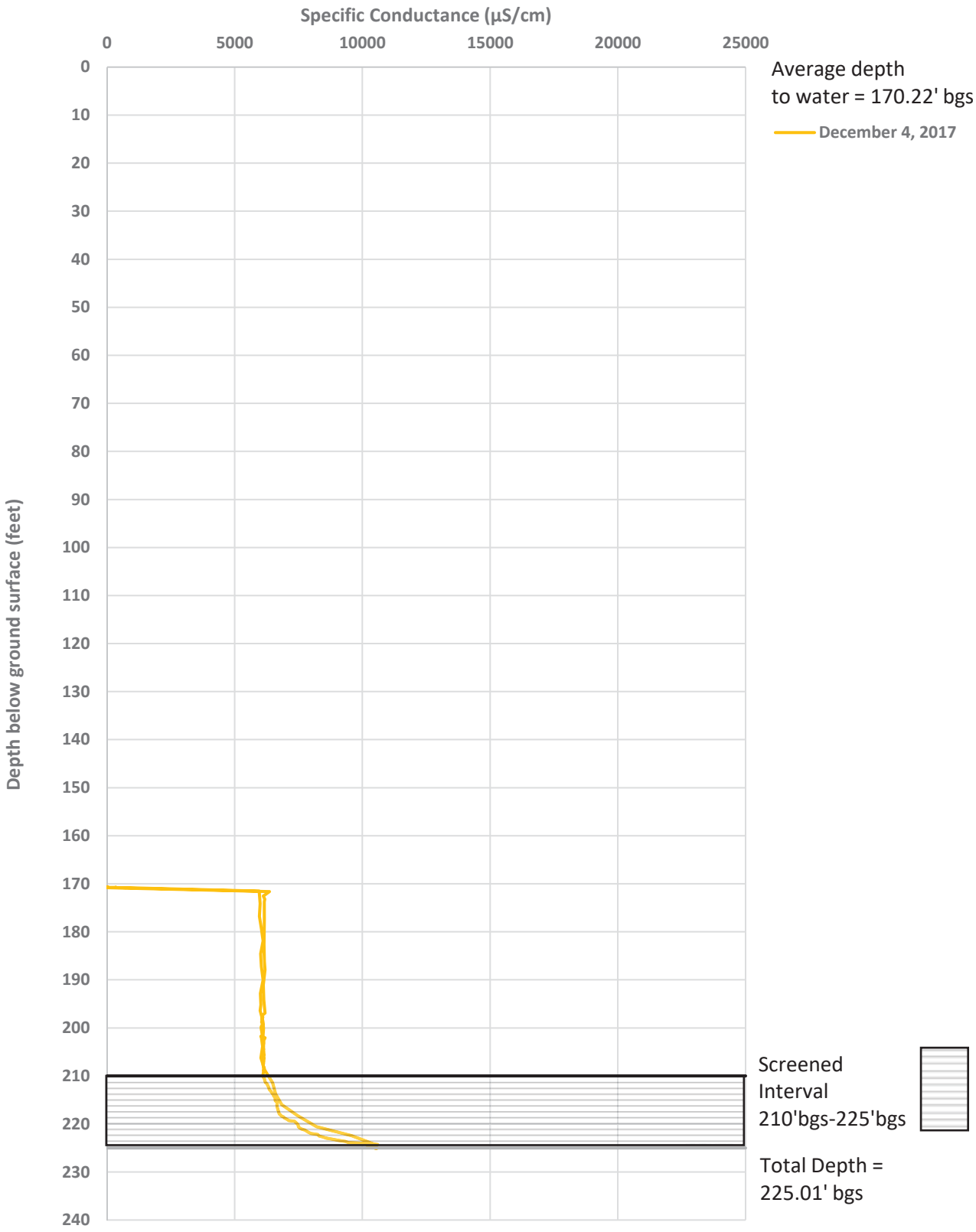
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-66-230



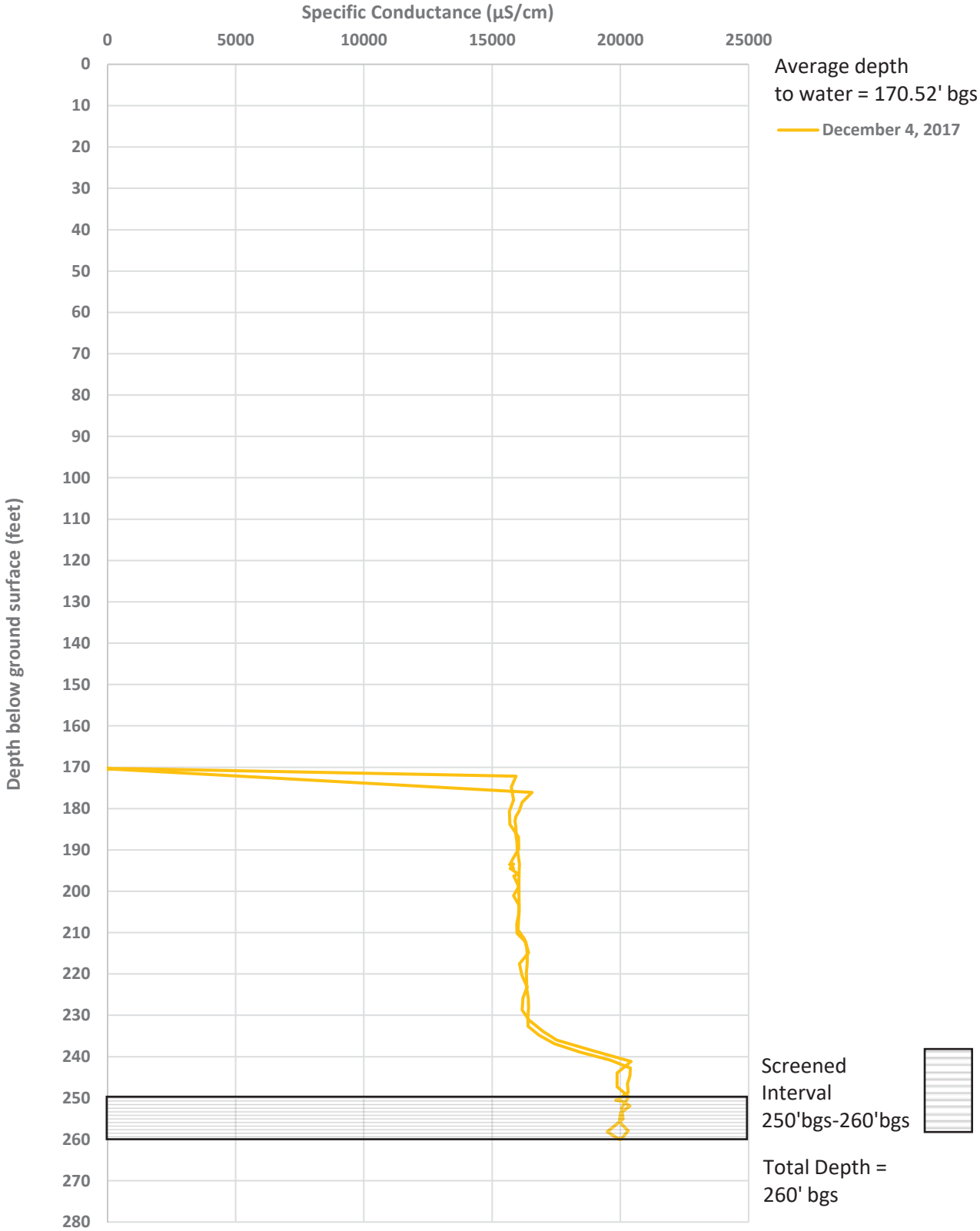
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-67-185



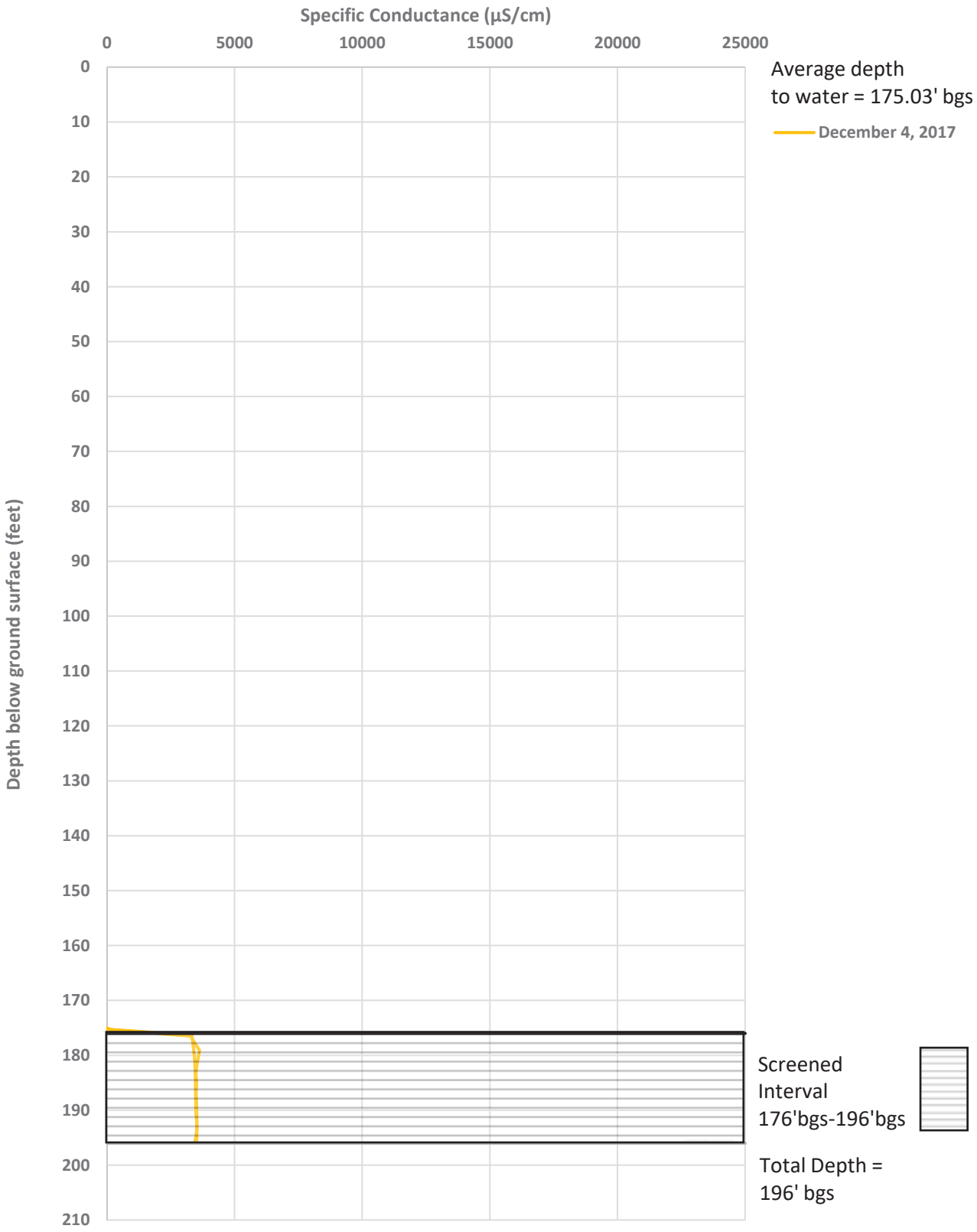
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-67-225



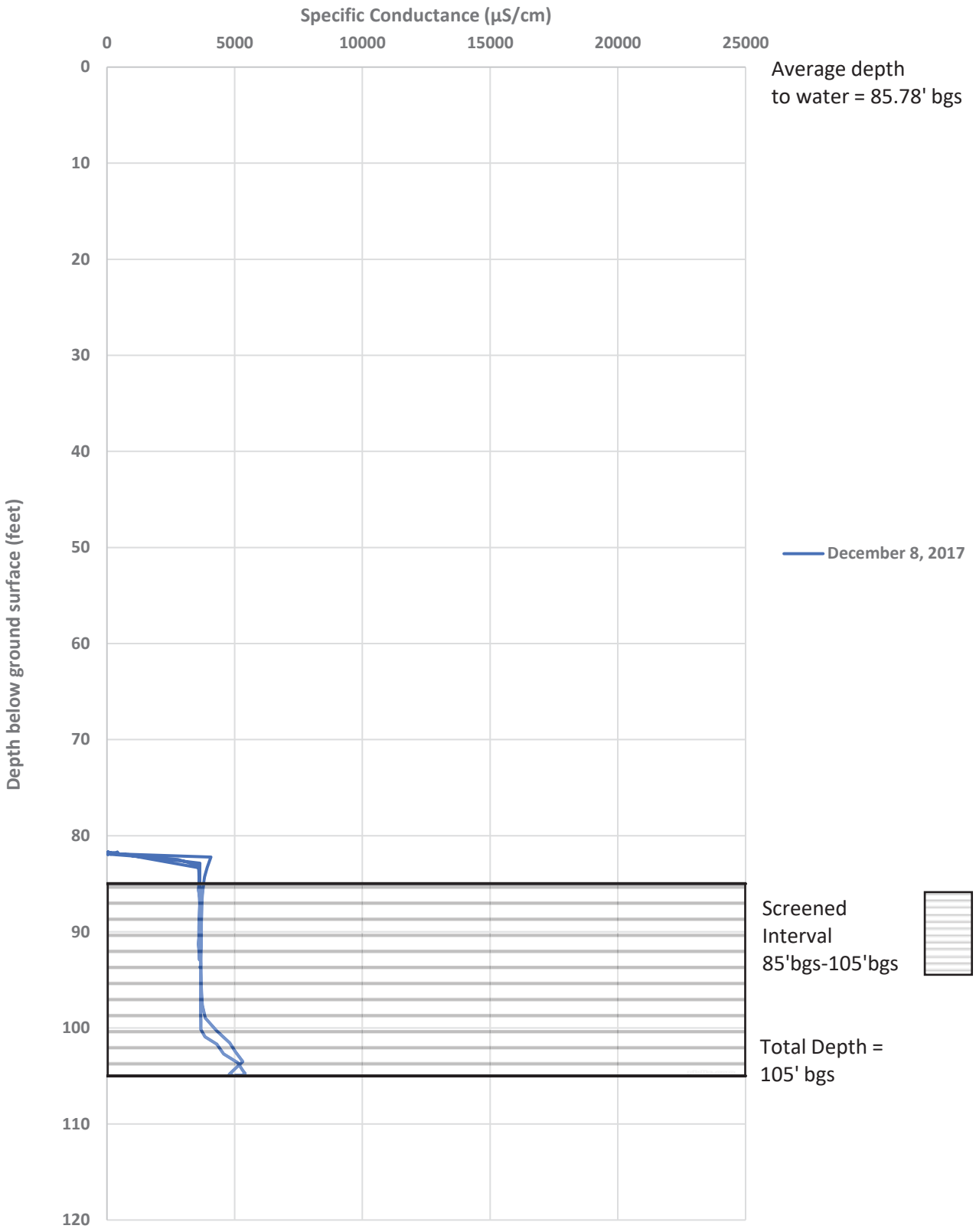
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-67-260



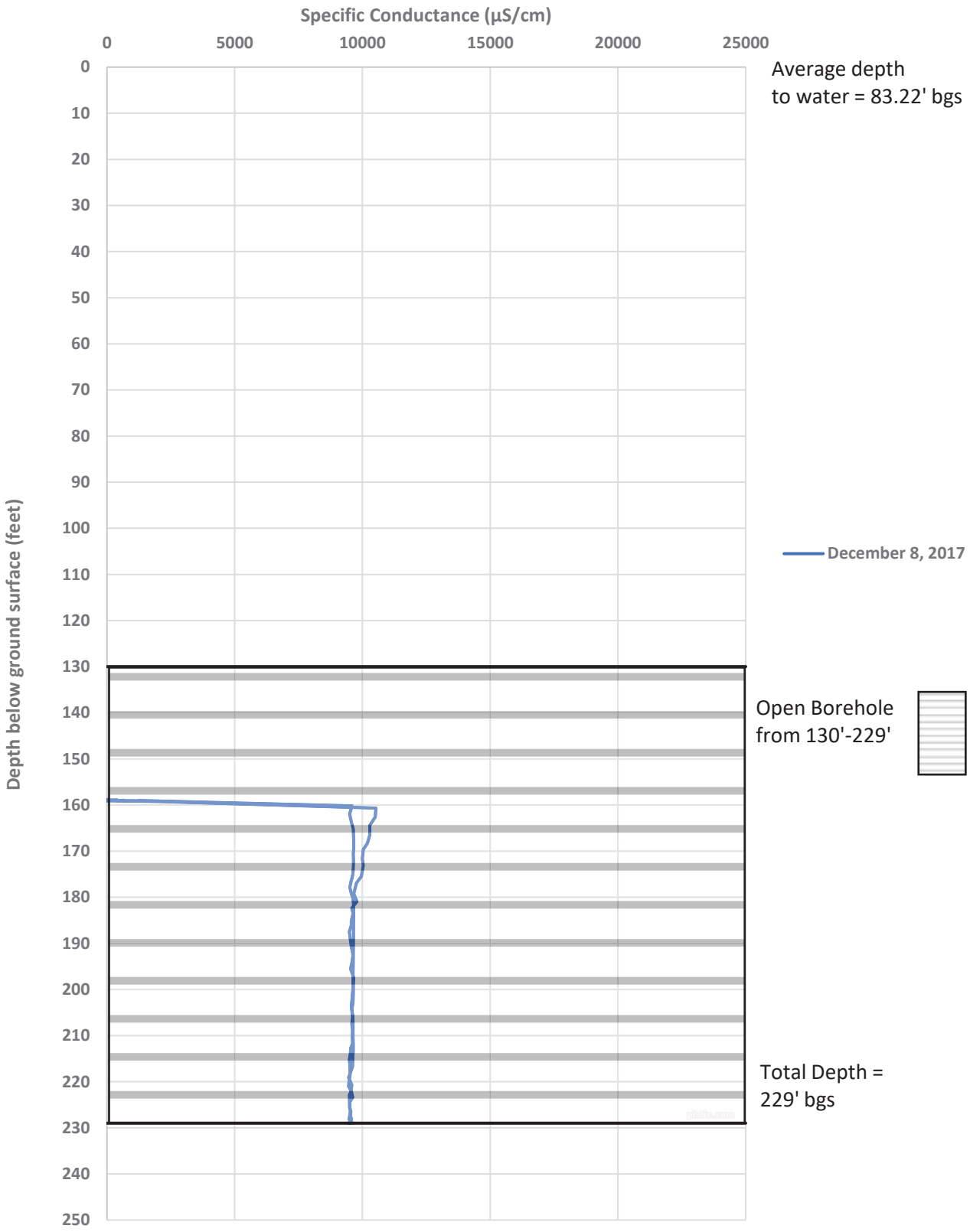
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-69-195



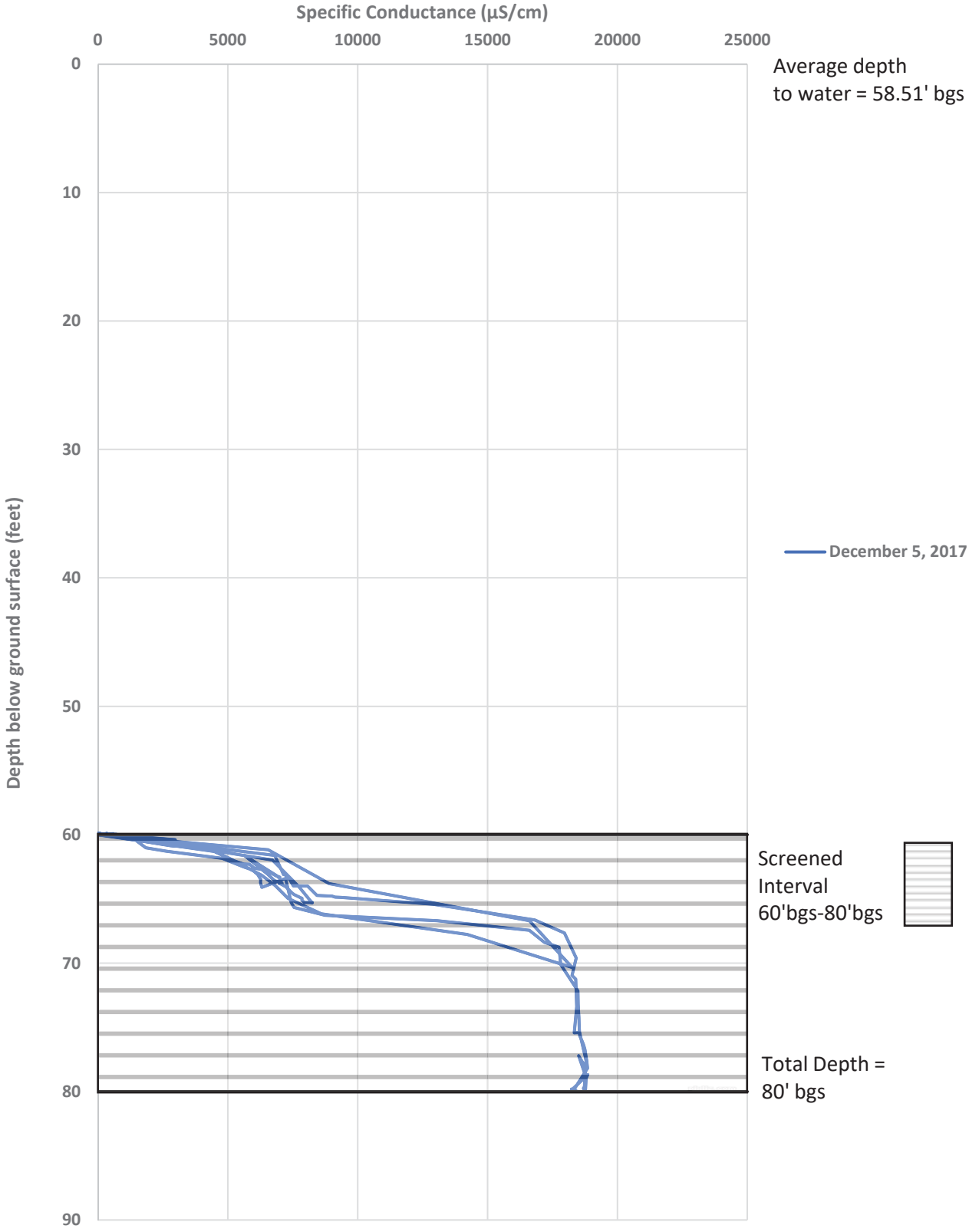
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-70-105



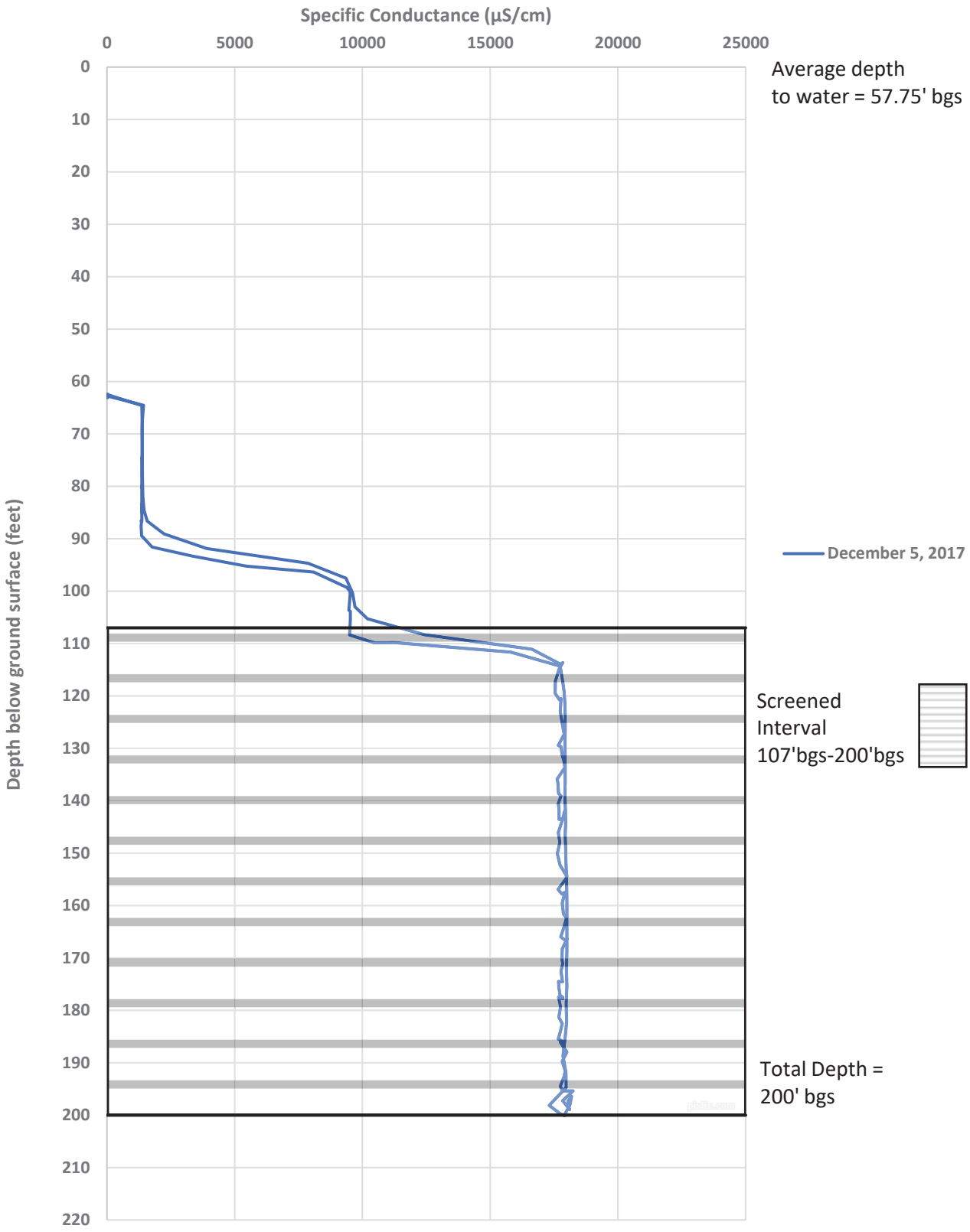
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-70BR-225



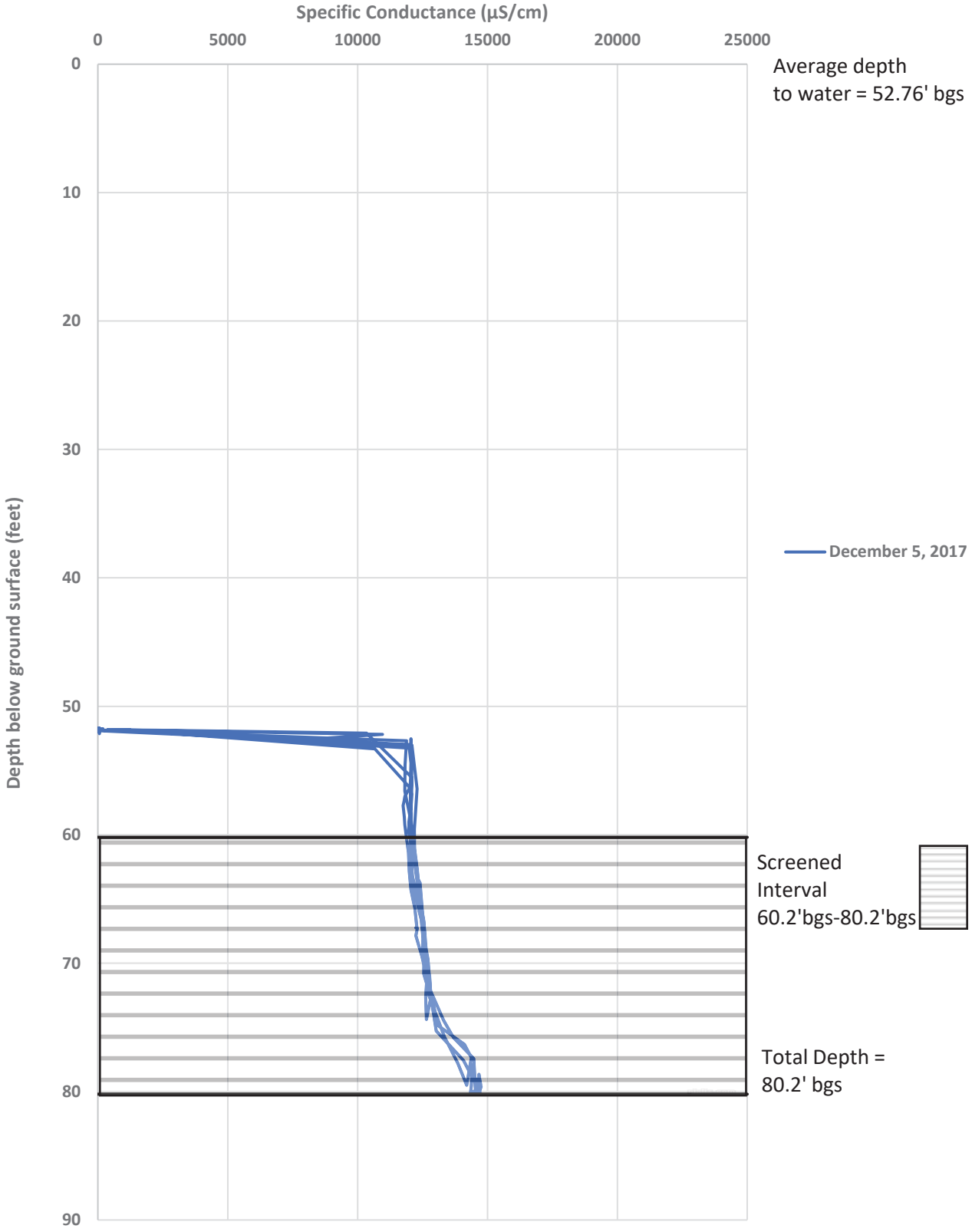
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-72-080



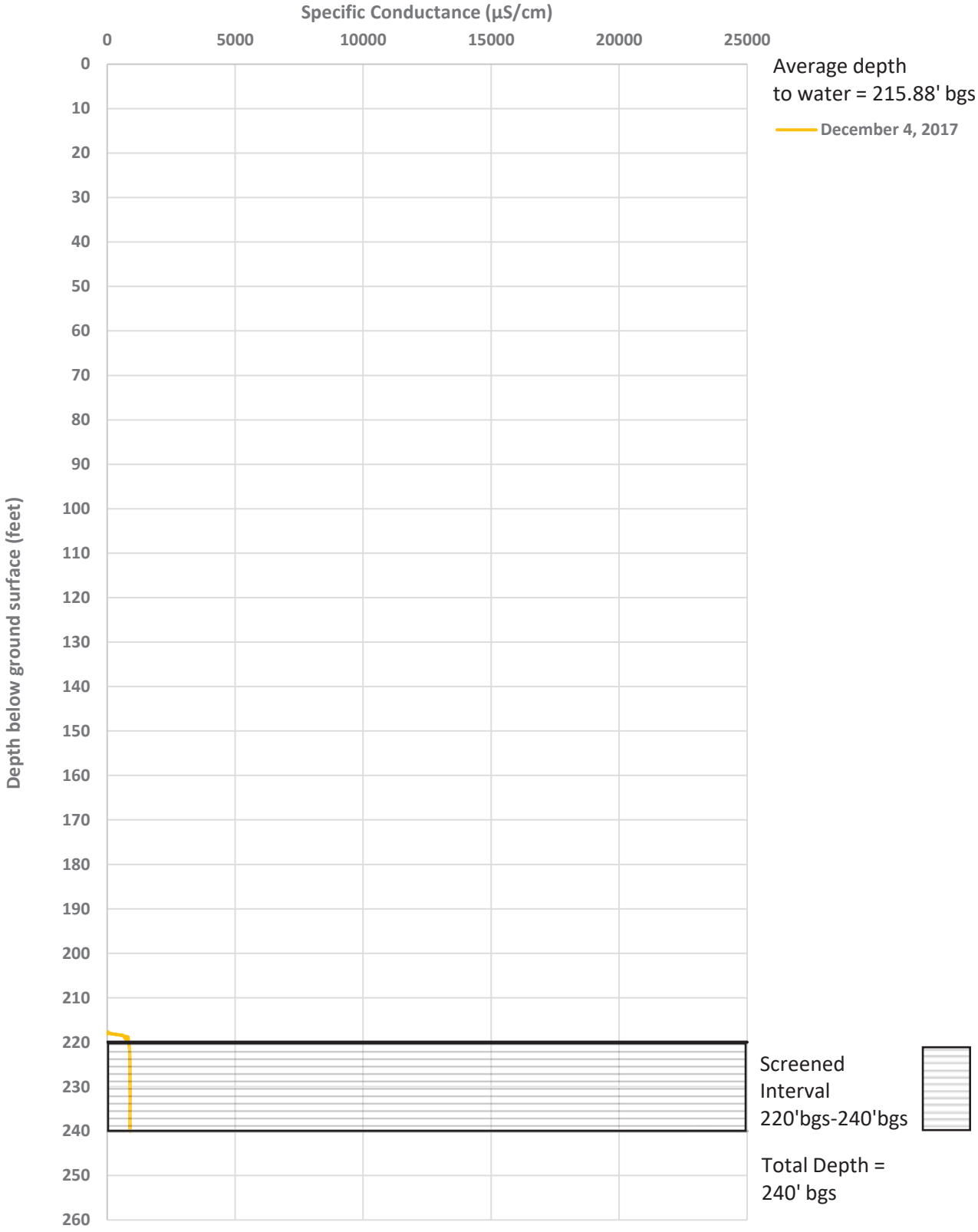
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-72BR-200



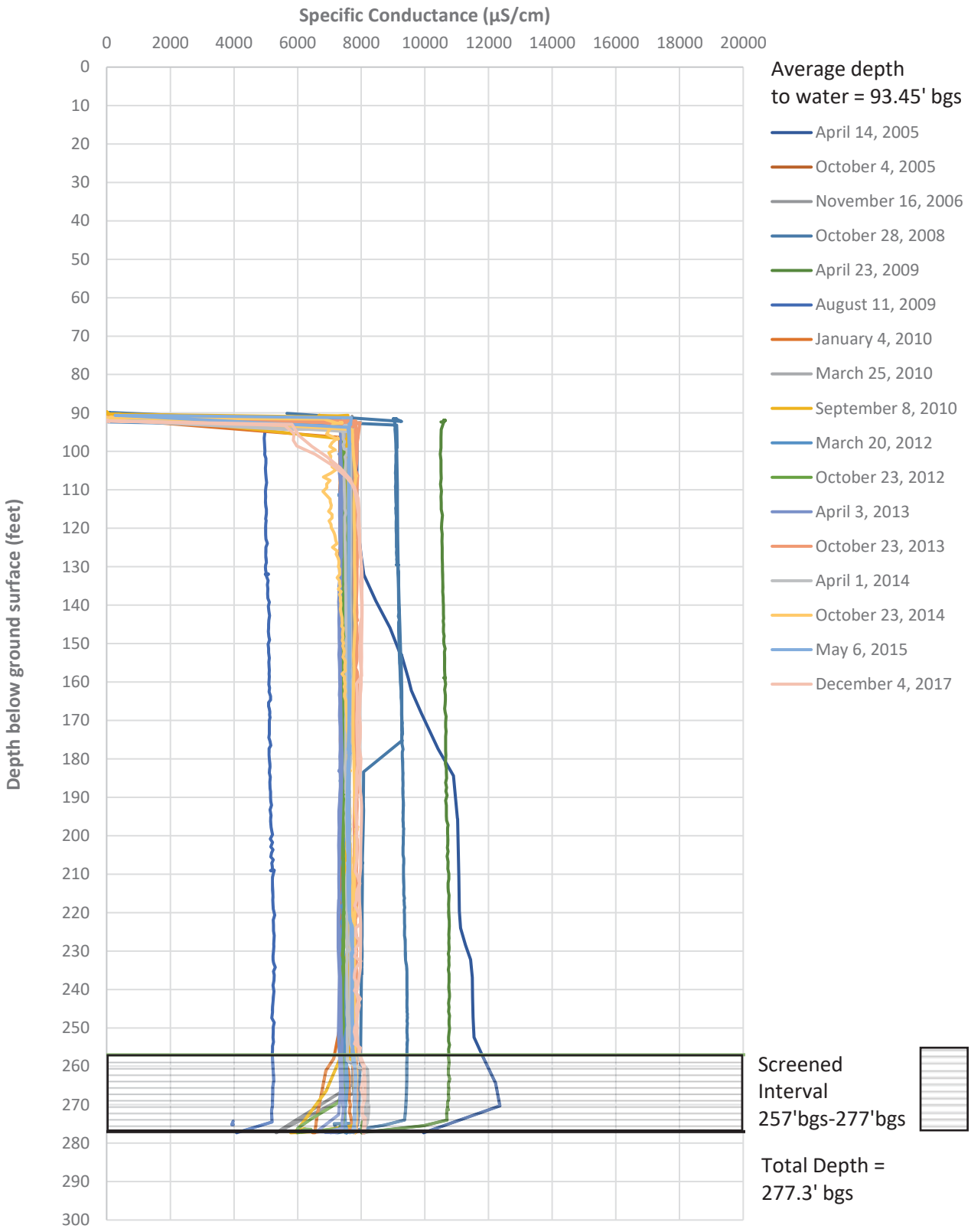
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-73-080



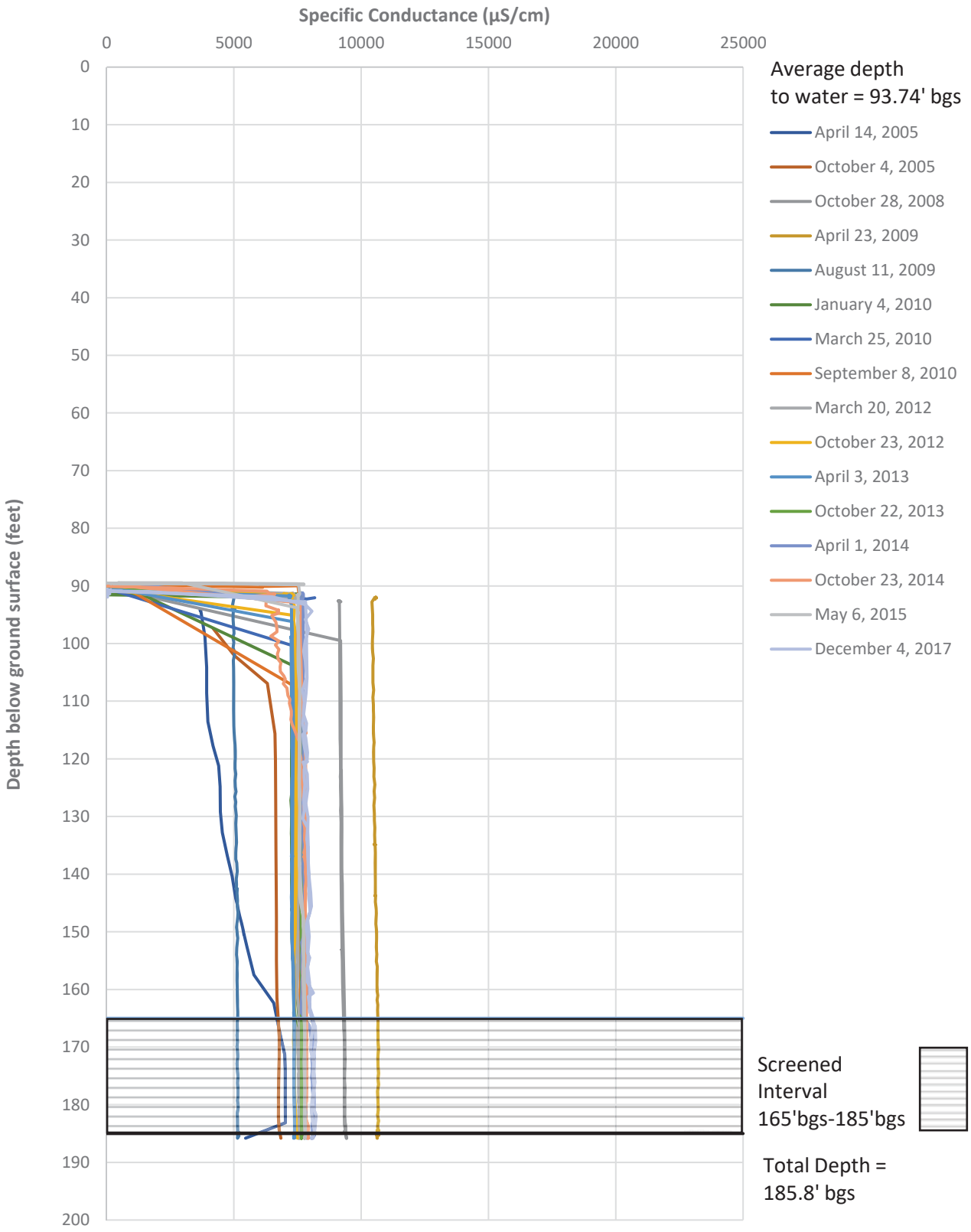
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well MW-74-240



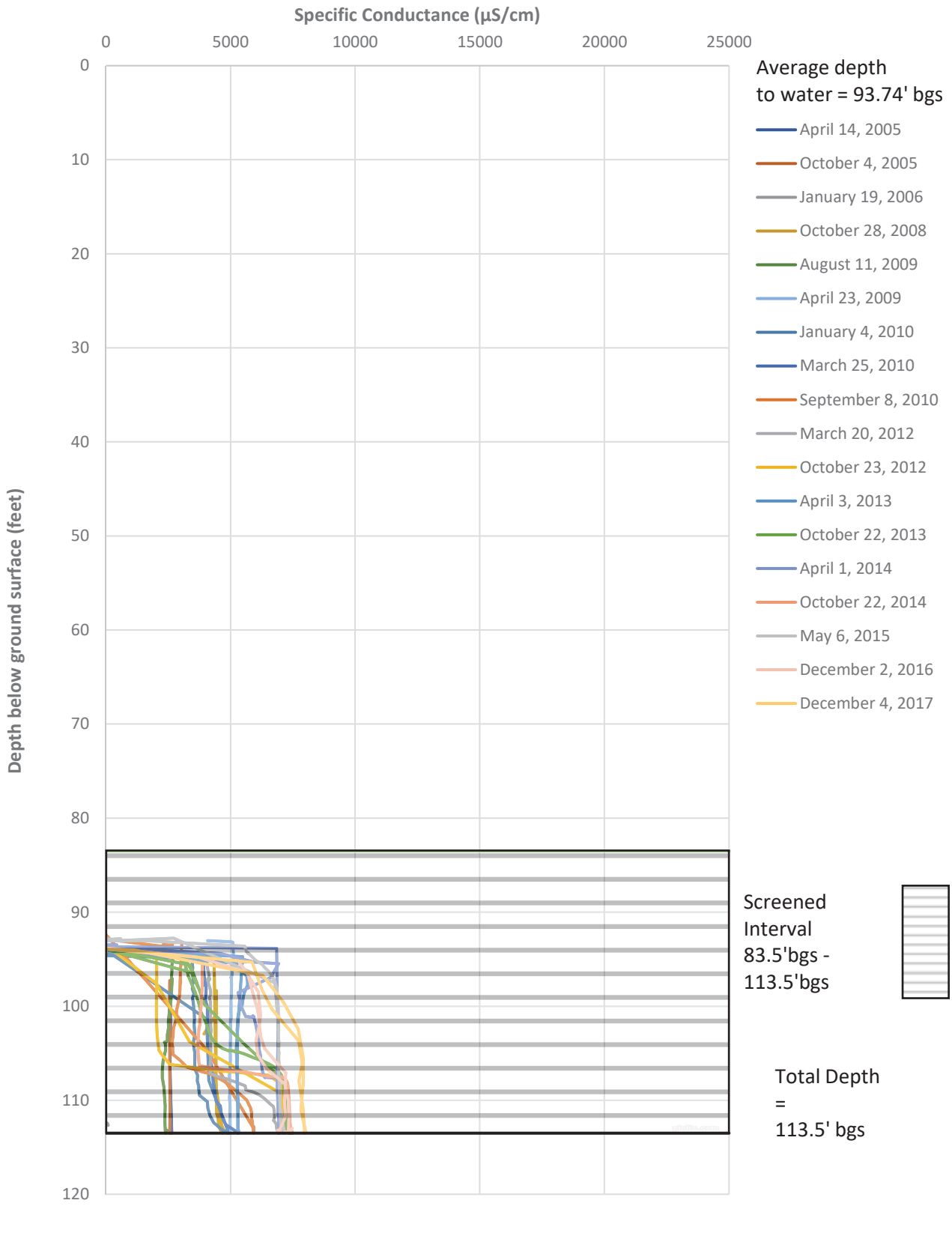
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-01D



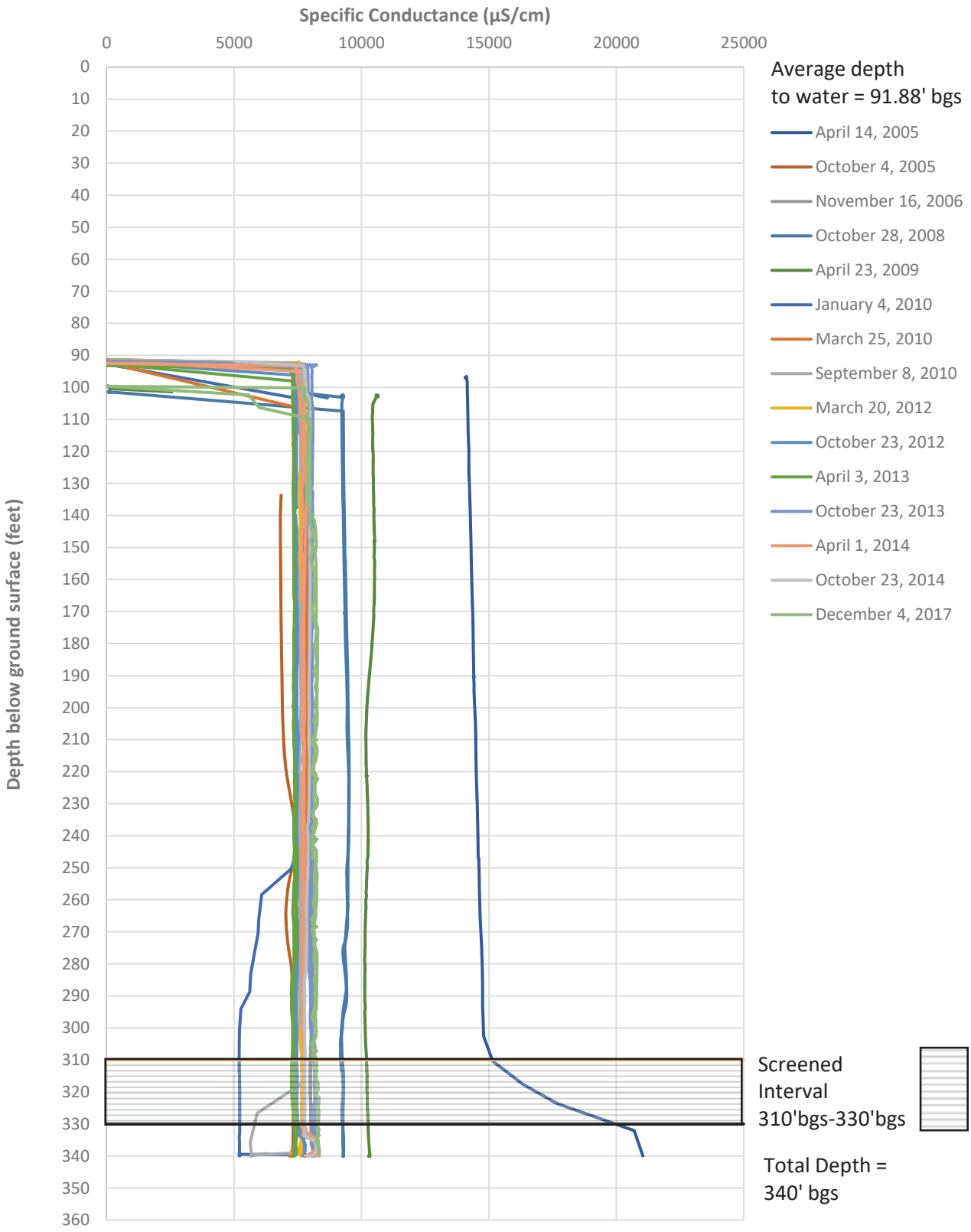
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-01M



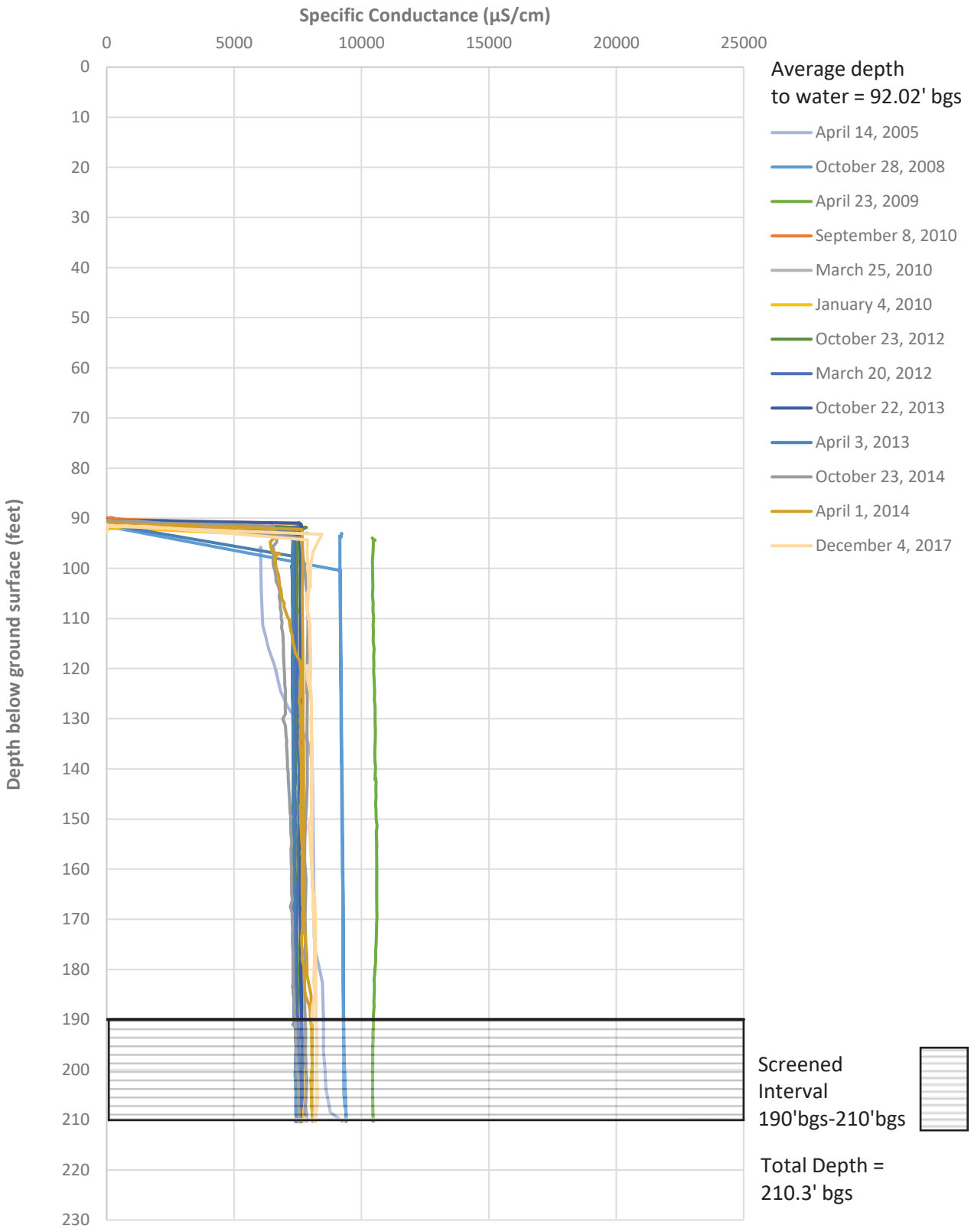
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-01S



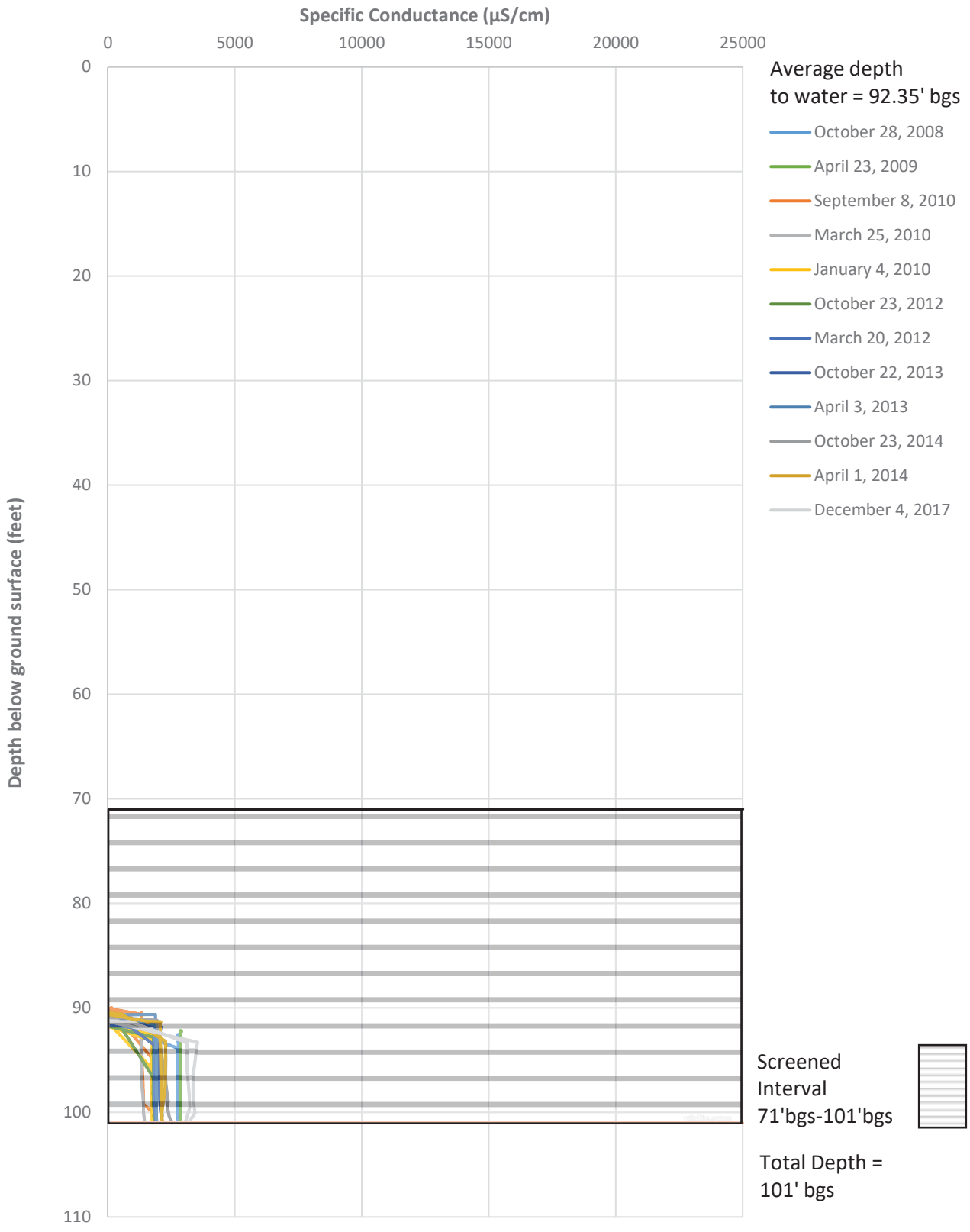
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-02D



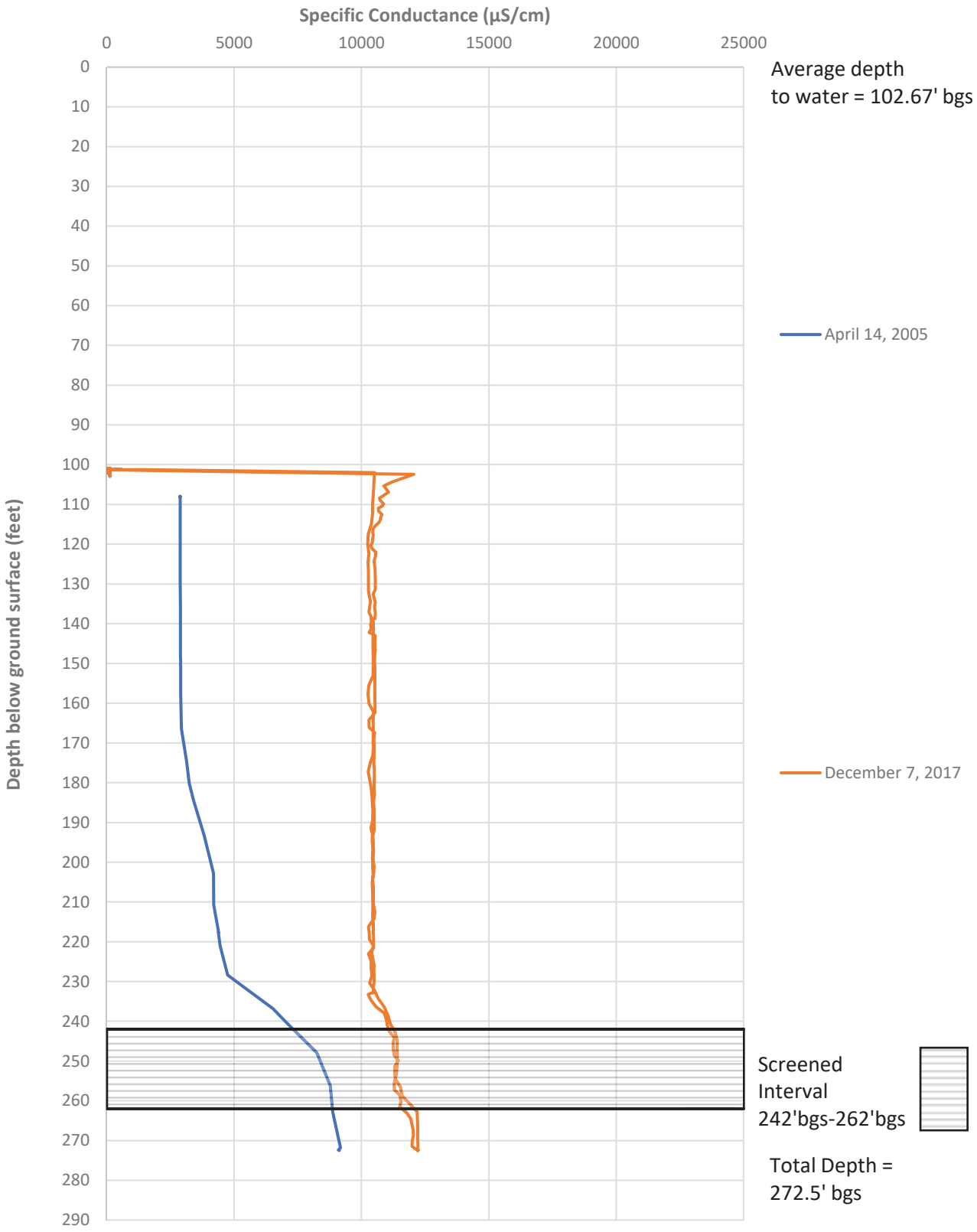
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-02M



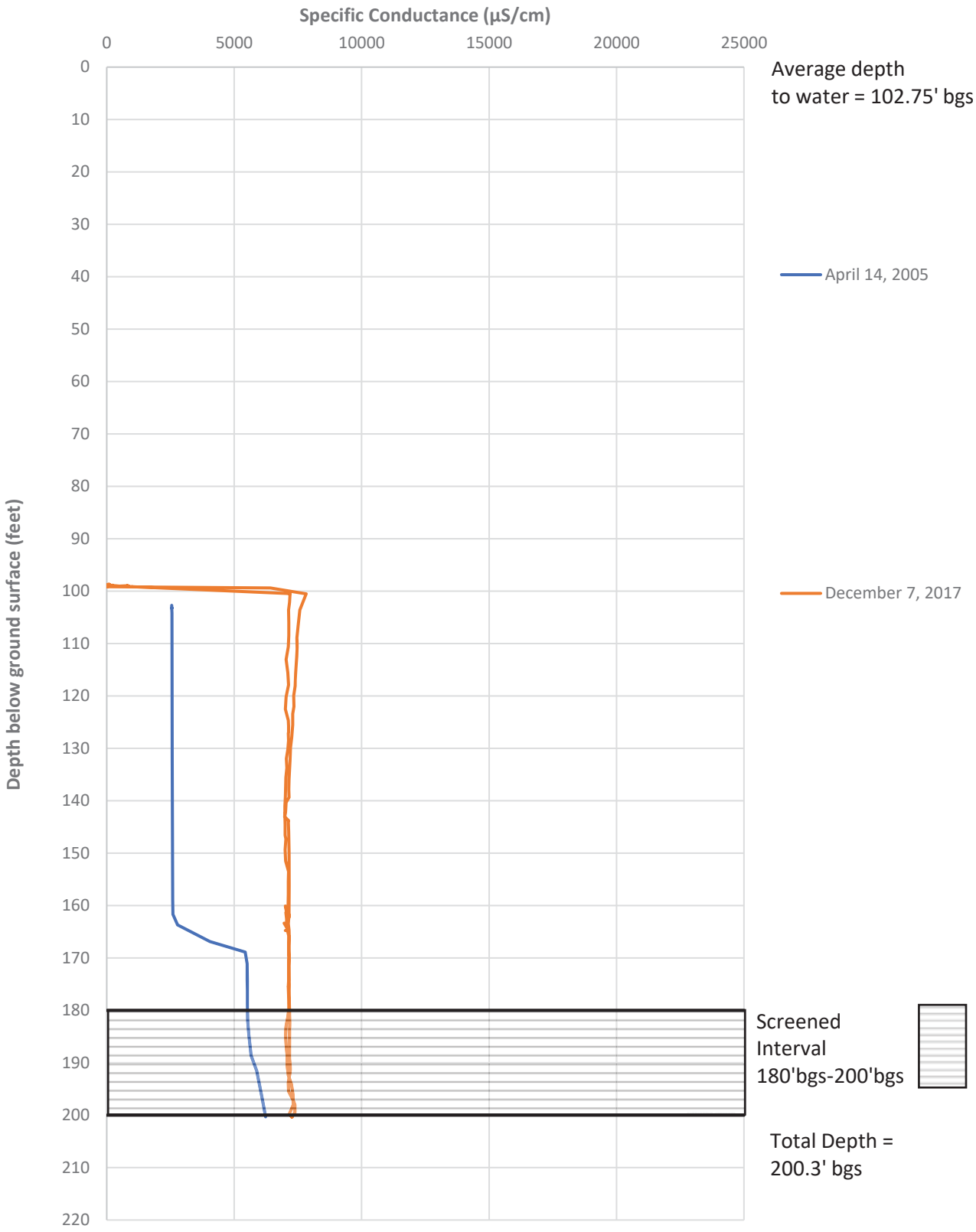
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-02S



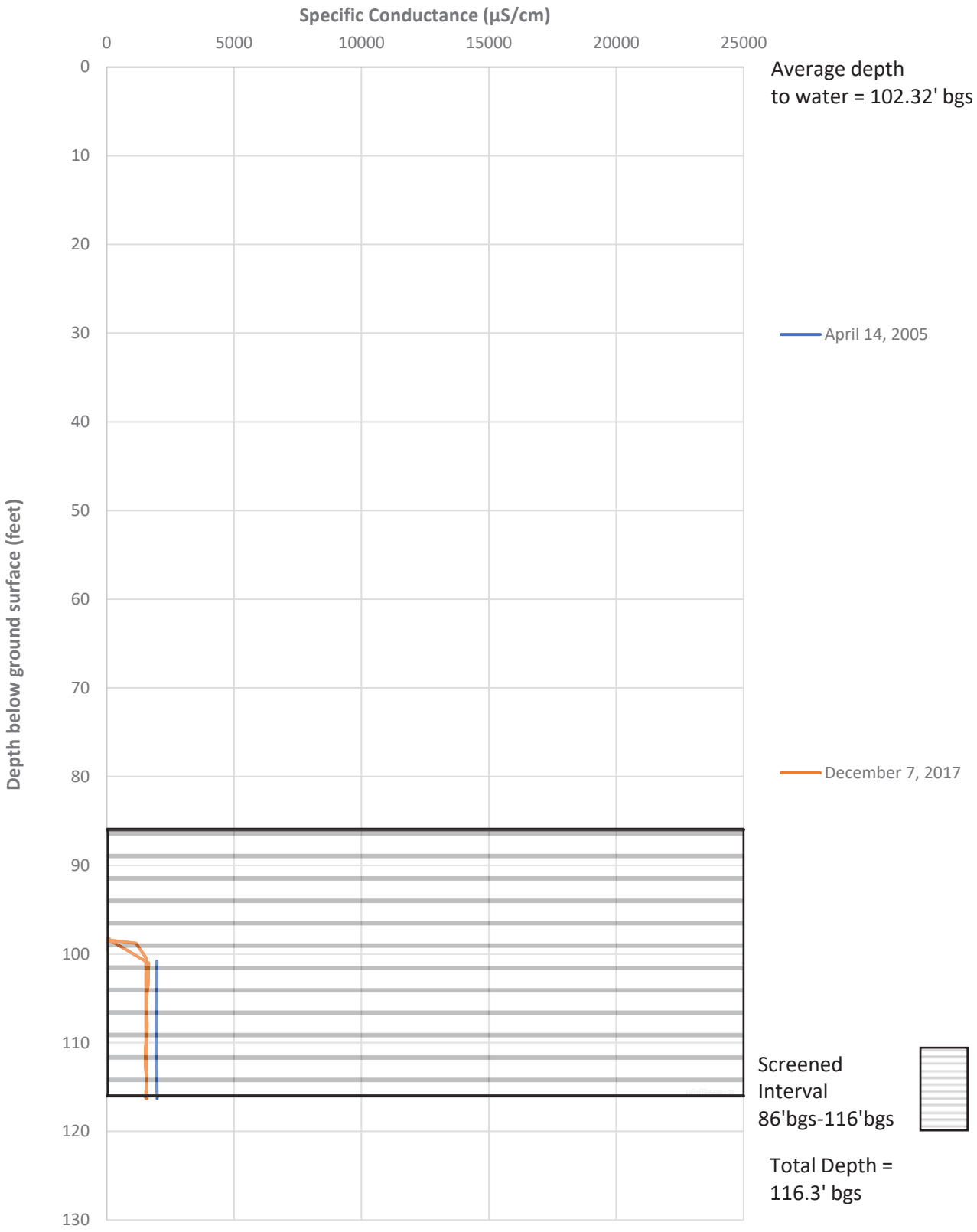
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-03D



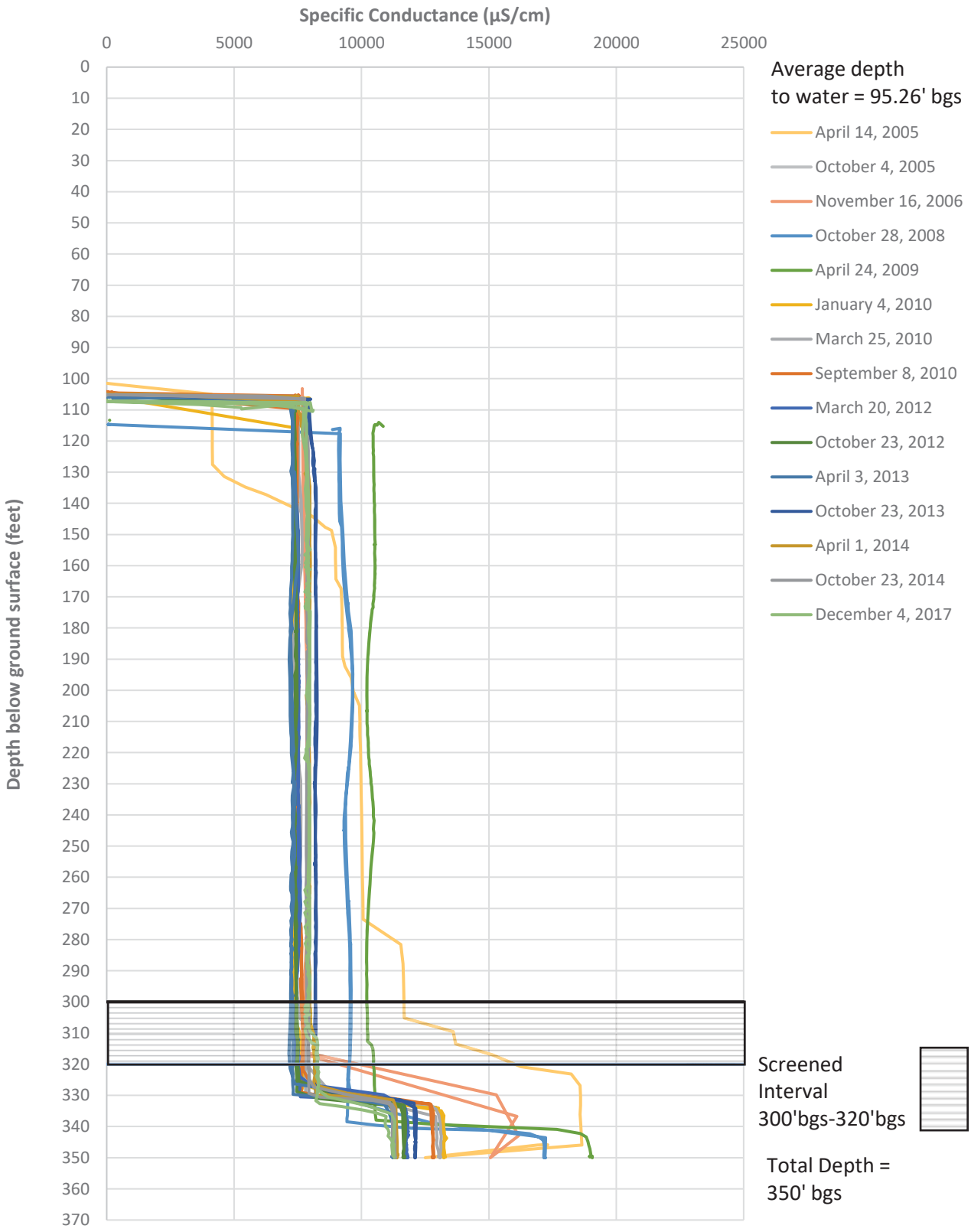
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-03M



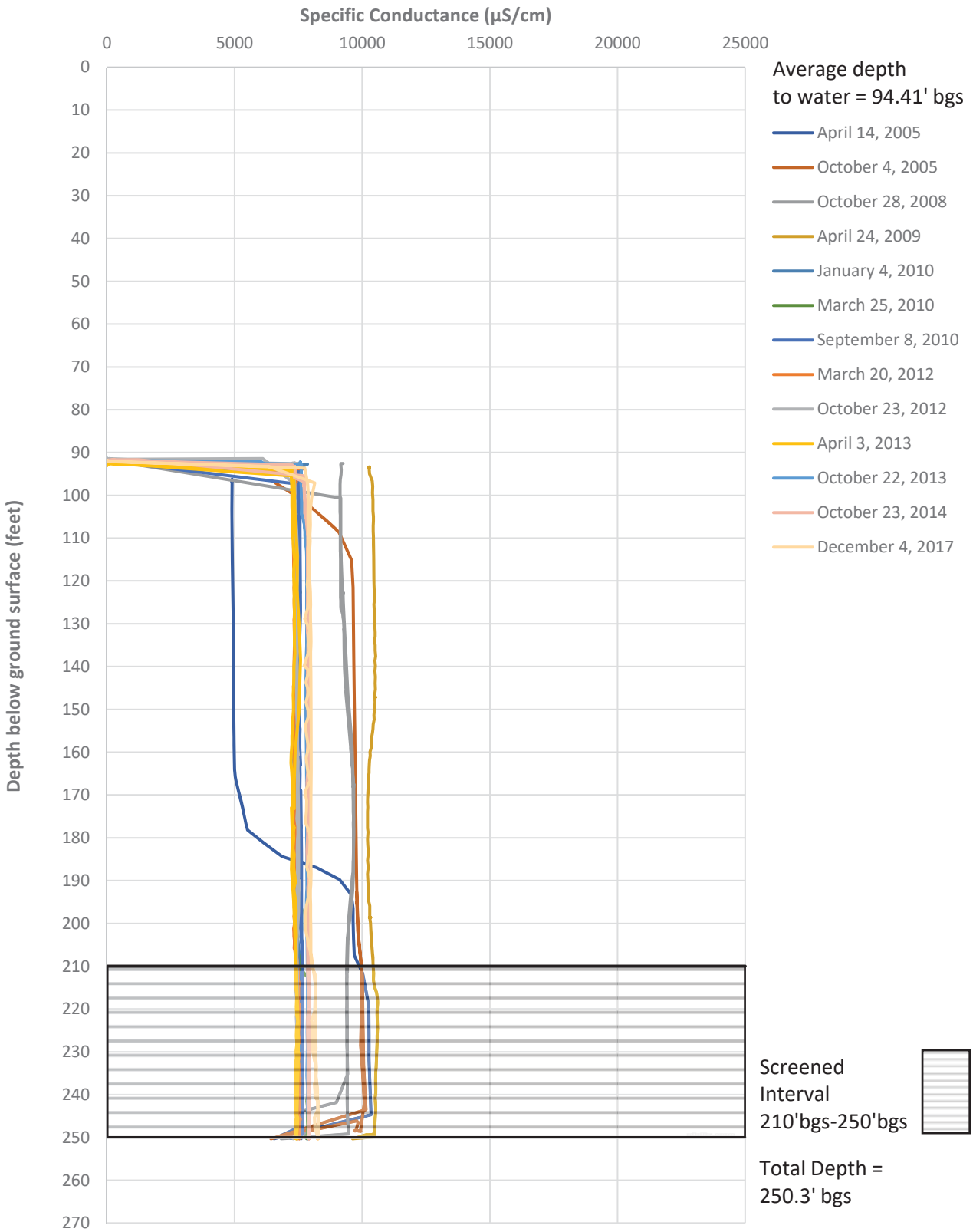
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-03S



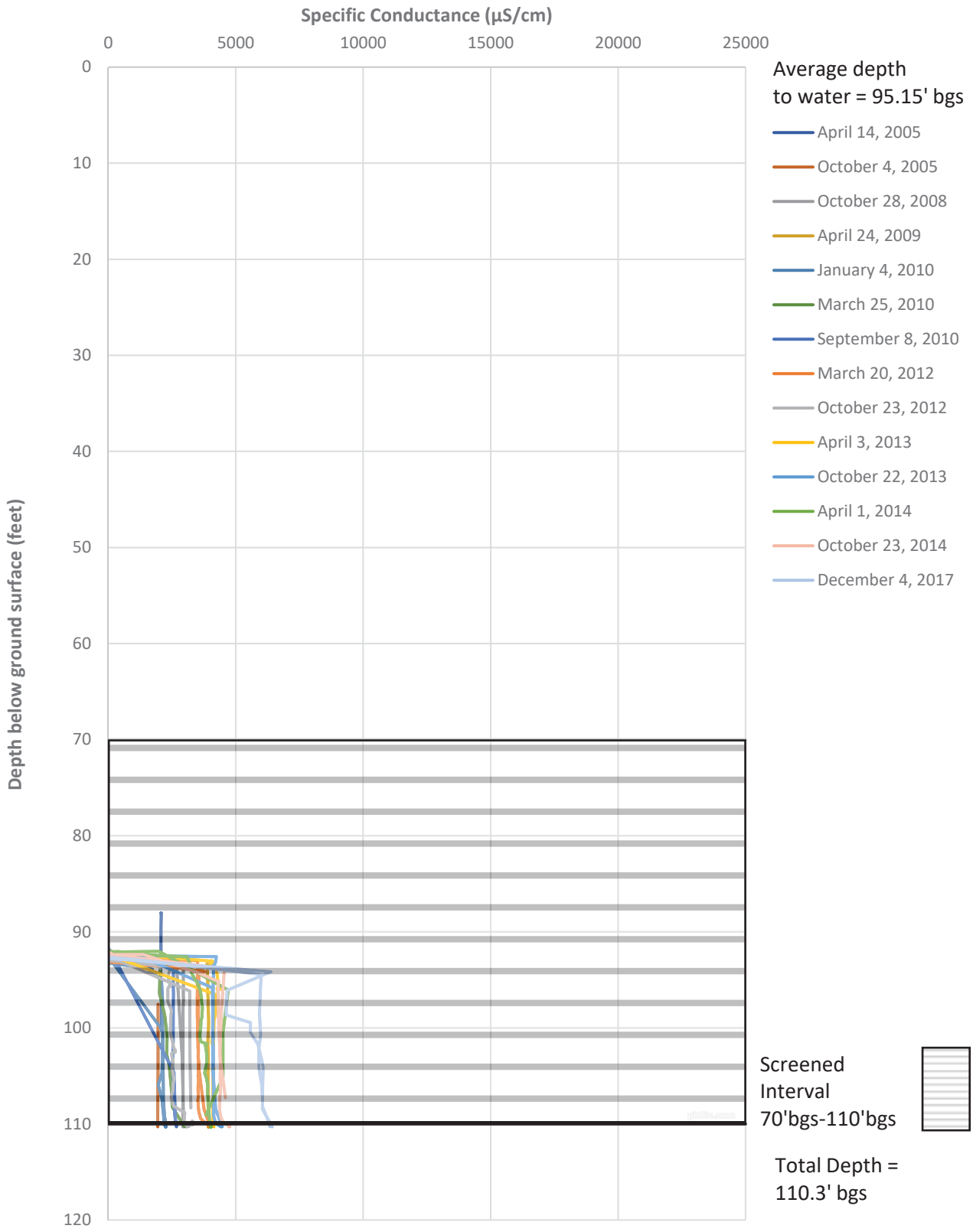
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-05D



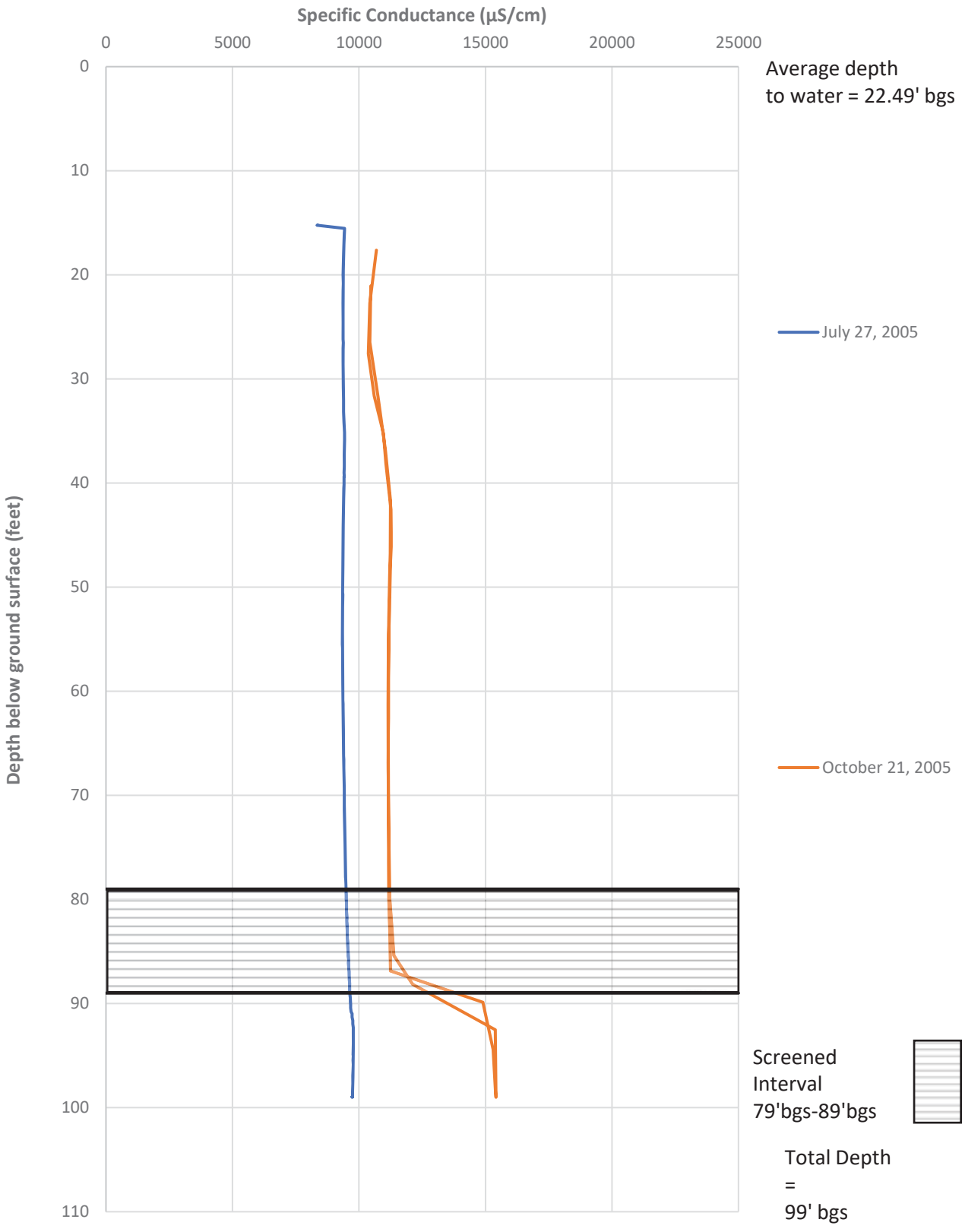
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-05M



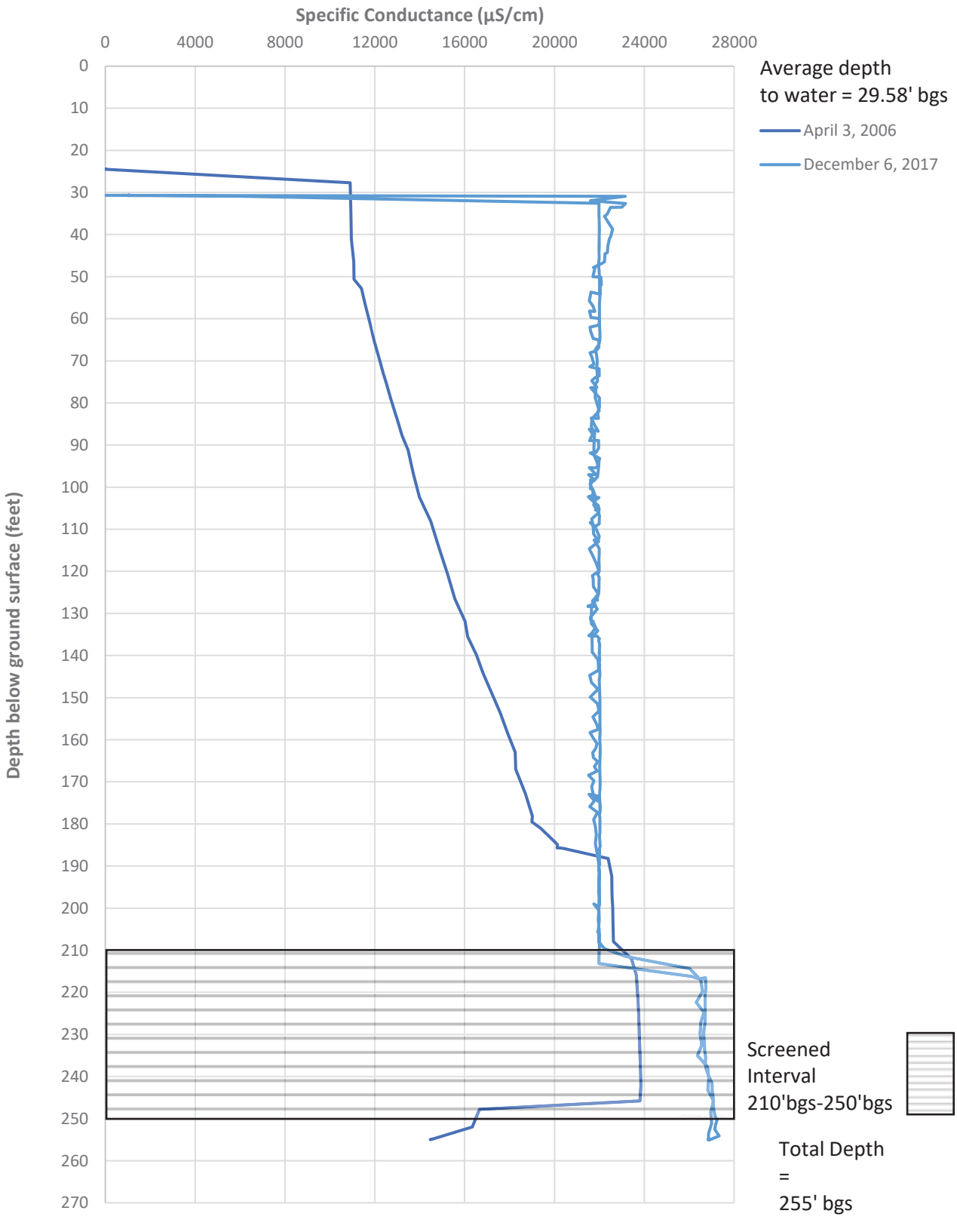
Specific Conductance vs. Depth Below Ground Surface (bgs) for Well OW-05S



Specific Conductance vs. Depth Below Ground Surface (bgs) for Well PE-01



Specific Conductance vs. Depth Below Ground Surface (bgs) for Well TW-04



Specific Conductance vs. Depth Below Ground Surface (bgs) for Well TW-05