Pacific Gas and
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July 27, 2017

Mr. Chris Guerre, PG, CHG
Senior Engineering Geologist
Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Subject: Responses to California Department of Toxic Substance Control's March 13, 2017 Memorandum

Dear Mr. Yue:

Pacific Gas and Electric (PG&E) is in receipt of the California Department of Toxic Substance Control (DTSC) memorandum dated March 13, 2017 regarding salinity stratification identified by conductivity profiling in monitoring wells at the PG&E Topock Compressor Station near Needles, California. Our response is provided in the attached memorandum.

To give the monitoring team time to coordinate field activities, we request your response by September 1, 2017. We would be glad to use weekly technical calls or ad hoc technical calls to facilitate your review.

Please contact me at (760) 791-5884 if you have any questions or comments regarding this response.

Sincerely,

Curt Russell
Topock Site Manager

cc: Aaron Yue/DTSC, Pam Innis/DOI

TECHNICAL MEMORANDUM

Response to DTSC *Well Salinity Stratification* Memorandum dated March 13, 2017 PG&E Topock Compressor Station

PREPARED FOR: Pacific Gas & Electric Co., Inc.

DATE: July 27, 2017

PROJECT NUMBER: 681899

REVIEWED BY: CH2M

Executive Summary

This technical memorandum presents a response to the California Department of Toxic Substance Control (DTSC) memorandum "Well Salinity Stratification Identified by Conductivity Profiling" dated March 13, 2017 (DTSC 2017). Stratification refers to a difference in conductivity with depth in the water column within the monitoring well casing and screen. This typically affects those wells with screen intervals near the bedrock contact, resulting in a difference between conductivity for water in the blank casing, the screen interval, and, where present, the sump below the screen. Stratification is present to varying degrees in the relatively small set of wells where conductivity profile data are available. This memorandum provides additional profile data as requested by DTSC and discusses the possible causes and effects of in-well stratification.

A general trend of increasing conductivity with depth is typical of the alluvial aquifer at the Topock site. In many but not all places, this trend is exaggerated in the interval just above bedrock, where a basal saline layer has been noted in the transition zone between alluvium and bedrock. The wells where the degree of stratification is greatest (MW-34-100, MW-45-95a, and MW-27-085) are located near the river and are constructed so that the bottom of the well screen is at or just above the bedrock surface. This construction results in these wells being screened within or near this basal saline layer, where the steep vertical gradient in conductivity results in relatively large differences in conductivity values between the top and bottom of the screened intervals. The lower conductivity water is lighter and tends to rise up into the blank casing above the screen, rendering the water in the casing above the screen similar to that of the upper screened interval, and less conductive than the average water in the screen. The opposite happens in the sump below the screen or in the bottom portion of the screen, where the heavier, higher conductivity water sinks and accumulates.

The possible effect of in-well stratification on groundwater sample quality was evaluated using existing data. The available conductivity profile data was compared to conductivity measurements made while sampling the same wells. The conductivity measured when profiling the screened interval was compared to the sample conductivity from the sampling event closest to the profile date. These two values are in 85% to 98% agreement (more than meeting the 80% agreement criterion applied to duplicate samples). This close agreement verifies that while the stratification is an interesting phenomenon, it does not have an impact on sample quality when sampling procedures are followed. Any water that is displaced downward when inserting the low flow sampling pump into the well is removed as the low flow purge continues until water quality parameters are stable and consistent with historical results. Trend plots for monitoring data were visually reviewed for changes since low flow sampling was adopted at most Topock monitoring wells, and the trends remain consistent.

Introduction

The DTSC memorandum "Well Salinity Stratification Identified by Conductivity Profiling" (DTSC 2017) notes that salinity stratification was identified in certain monitoring wells. The memorandum also states a concern about density stratification in the blank casing above monitoring well screens resulting from zones of water with differing salinity (which is proportional to conductivity). The concern being that well conductivity stratification is an indication of stagnant water above the monitoring well screen that could impact the quality of groundwater monitoring samples.

For consistency and clarity, the rest of this memorandum will discuss conductivity measurements and profiles, because conductivity is a direct measurement. The salinity value used in transducer work is calculated from conductivity, and in turn used with water temperature for density calculations and water level elevation corrections.

This technical memorandum responds to the DTSC requests for

- Information about conductivity profiling of monitoring wells,
- The occurrence of stratification at Topock well locations,
- Possible explanations for the observed stratification, and
- Recommendations, including steps to better understand the stratification phenomenon.

Well Profile Data and Stratification

The following presents information requested by DTSC.

Review of Conductivity Profile Data (2008-2016)

The following wells have conductivity profile data collected on multiple dates from 2008 to 2016, allowing for review of changes over time. These wells were profiled for density corrections on the water level data collected by transducers.

Floodplain monitoring wells

Monitoring Well	IM3 Key Gradient Well?	Well Diameter (inches)
MW-20-130	no	4
MW-27-85	yes	2
MW-31-135	yes	2
MW-33-150	yes	2
MW-34-100	yes	2
MW-45-95	yes	2

IM3 Injection Area monitoring wells

Monitoring Well	Well Diameter (inches)
OW-5D	2
OW-5M	2
CW-1D	2

Table 1 summarizes information about the floodplain key gradient monitoring wells shown in Attachment 1.

Plots for these wells are attached showing conductivity vs. depth below ground surface (Attachment 1). Each plot shows multiple sets of conductivity profile data, color coded by date. In some cases, the conductivity was logged both as the probe was lowered into the well and as it was raised out of the well, so the plots for those dates show two lines. The screened interval of each well is shown as a pattern overlaying the profile plots. For wells that are part of a nest or cluster, e.g., MW-20-130, the mid-point depth of other screens at the same monitoring well location is shown by a triangle and the conductivity measured at that screen in recent sampling events is shown as a text box. At many monitoring well locations, the deepest well was installed with a blank PVC sump to allow for cased hole geophysical logging. These sumps are indicated by profile data that extends to depths below the monitoring well's screened interval. The conductivity plots are discussed further in the following section.

Changes at Topock Monitoring Wells

There are several changes that have occurred over time at the floodplain and injection area locations with conductivity profiles shown in Attachment 1:

- IM3 has operated for 12 years (since 2005) with injection creating groundwater mounding and breakthrough of injected water at OW- and CW- monitoring wells. IM3 extraction pumping began in 2005 with PE-1 added in 20016, creating a cone of depression and landward hydraulic gradients in the Colorado River floodplain. In the central floodplain where MW-27, MW-34 and MW-45 are located, the River water geochemical and isotopic signature has migrated landward and the overall conductivity of the water in the shallow portion of the aquifer has decreased.
- The frequency of groundwater sampling decreased over time from initial monthly sampling at many monitoring wells to quarterly, semiannual or annual sampling.
- The sampling technique for many Topock monitoring wells including the floodplain wells in Attachment 1, changed from 3-volume purge to low flow sampling in late 2014. However, the sampling technique used at injection area OW- and CW- monitoring wells did not change and remains a 3-volume purge.

Observed Patterns and Trends of Conductivity vs. Depth in Monitoring Wells

Several patterns can be observed from these conductivity profile plots.

- A review of the conductivity profiles in Attachment 1 shows that wells exhibit varying degrees of stratification. Well stratification is defined as the relative difference between conductivity measured in blank casing and conductivity measured in a well's screened interval and sump. The degree of stratification appears to be reflective of vertical variability in conductivity that exists in the aquifer at the depth of the screened interval. Those wells that show the most stratification are MW-27-085, MW-34-100, and MW-45-095. All of these wells are screened near the depth where bedrock was encountered in their respective borings. There is a consistent trend of increasing salinity with proximity to bedrock all across the Topock site and the salinity gradient is often steeper in the zone near bedrock. In addition, these three wells are in an area where the IM-3 pumping has pulled low conductivity water from the river into the floodplain. The large contrast in conductivity between the overlying river water and the saline water associated with the bedrock surface results in a steep conductivity gradient within the screened intervals, and therefore a large proportion of the stratification observed in these three wells.

- Well stratification is present to a greater extent over time, increasing at most floodplain wells between 2008-2009 and 2012-2014, years before the late 2014 change from 3-volume purge to low flow sampling techniques. The frequency of sampling did decrease at some wells over this time period. This time period saw constant IM3 operations, with extraction pumping from the floodplain and injection in the upland. IM3 extraction caused the landward migration of a less saline Colorado River water signature at locations between extraction wells and the River (e.g., MW-34, MW-45, and MW-27 clusters), possibly increasing the salinity gradient in the screened intervals of these wells.
- Other floodplain wells shown in Attachment 1 include MW-20-130, MW-31-135, and MW-33-150. These three wells slow lesser degrees of stratification. Of the three, only MW-20-130 is screened near the bedrock contact. However at MW-20-130 there is evidently only a moderate gradient in conductivity across the screen. The water at the depth of the MW-20-130 screened interval appears to be in a relatively narrow range of conductivity between about 9,000 and 13,000 µS/cm. Wells MW-31-135 and MW-33-150 are not screened close to the bedrock contact and the vertical conductivity gradients in the aquifer at the depth of their screened intervals appear to be slight.
- Upland wells with profile data include CW-1D, OW-5M, and OW-5D. Of these, only OW-5D is screened near bedrock. There is some stratification in OW-5D, mainly between the sump and the rest of the well. Most of the water across the screened interval is similar to the water in the upper blank casing. CW-1D and OW-5M show very little stratification, which is consistent with the conceptual model that there should be less vertical stratification in conductivity in the aquifer at depths well above the bedrock contact.
- Several of the plots in Attachment 1 show a marked decrease in conductivity in the uppermost foot or two of the profile. This is likely due to condensation of water inside the well casing, which could, over time, add an increment of fresh water to the top of the water column. This condensation would be driven by the day-night temperature cycles present at Topock's desert location and the daily water level changes, which would periodically draw cool night air into the wells. Cool night air pulled in by falling water levels could cause the water vapor in the air inside the well to condense on the well casing and drip down into the well. Assuming the relative humidity in the well is 100% and the temperature of the uppermost meter of casing dropped by 10 degrees C (a common daily temperature range for Topock), approximately 0.5 cm (~0.2 inch) of water could be condensed in a year. This condensate would essentially be distilled water and could dramatically lower the conductivity of the uppermost layer of water in the well. The effect is evident in the profile plots of most of the floodplain wells near the river but not apparent in the upland wells, where daily water level fluctuations are less and there would limited air exchange in the casing.

Possible Mechanism for Observed Conductivity Stratification

The stratification in the wells is believed to result from density-driven separation of lighter, lower conductivity water into the upper section of the well and heavier, higher conductivity water into the lower section of the well. The water in the upper casing reflects the conductivity of the water near the top of the screened interval and the water in the sump (where present) reflects the conductivity of the water in the lower part of the screened interval. In wells where there is little vertical variation in conductivity within the screened interval, stratification is minimal. In wells where there is significant vertical variation in conductivity within the screened interval, the stratification is more prominent. Stratification is believed to occur as follows:

1. Lower conductivity water tends to be present in the upper portion of the screen and higher conductivity water is present in the deeper portion, reflecting the stratification in the aquifer.
2. The daily groundwater level fluctuations in response to river level changes surges some of the lower conductivity water up into the blank casing above the screen.
3. The higher conductivity water near the bottom of the screen settles into the sump, if one is present.
4. Over time, the conductivity of the water in the upper casing becomes similar to that in the upper portion of the screened interval and the conductivity in the sump becomes similar to the lower portion of the screen.

Review of Historical Data for Impacts on Groundwater Sampling

Table 1 shows a comparison between conductivity measured at the monitoring screened interval by profiling and conductivity measured when sampling, with the ratio between these measurements averaging 85% to 98%. These ratios are within the 20% relative percent difference used for acceptance of duplicate sample results. In addition, the trend plots for chromium concentrations in the same wells, (attachment 2) are consistent over time and do not show changes in trends with the change to low flow sampling techniques late in 2014, or the adjustments to PE-1 pumping rates beginning in 2016. The groundwater result trends don't correlate with changes over time to conductivity profiles shown in Attachment 1. This indicates that low flow sampling achieves laminar flow from target screened interval depths and is not impacted by the water column in blank casing above the screened interval. Stabilization of purge parameters before sampling indicates that any stagnant water displaced by pump insertion to the well screen was removed before sampling.

In sum, the mixing effects of 3-volume purge were not a critical preventative measure, because similar results are obtained from low flow sampling procedures. Low flow and 3-volume sampling procedures both already require that groundwater quality indicator parameters stabilize, and are also checked for consistency against historical results, before a purge is considered complete and groundwater samples are collected. Those steps protect against impact to sample quality from stagnant water in the bank casing.

Recommendations

The following actions are recommended:

- Continue low flow sampling: results do not indicate impacts on groundwater sample quality from conductivity stratification.
- Collect additional profile data. Perform a one-time conductivity profile of wells that have screened intervals near the bedrock contact to check for the presence of stratification. This data could be collected with an annual sampling event as a step before sampling each of these deeper wells. The profile data from the screen intervals could be compared to the sample purge conductivity measurements to repeat the comparison described above and shown in Table 1.
- Report on these activities with results and recommendations.

References

California Department of Toxic Substance Control (DTSC) 2017. *Well Salinity Stratification Identified by Conductivity Profiling and Potential Impacts to Groundwater Sampling Results. PG&E Topock Compressor Station, Needles, California*. March 13.

CH2M HILL 2008. *Summary Report for Hydraulic Testing in Bedrock Wells, PG&E Topock Compressor Station, Needles, California*. January.

CH2M HILL 2015. *SOP-A18: Purging and Sampling of Groundwater Monitoring Wells, Minimal Drawdown Method, Standard Operating Procedures for PG&E Topock Program*. September 28.

Table

Table 1 - Summary of Floodplain Key Gradient Well Information

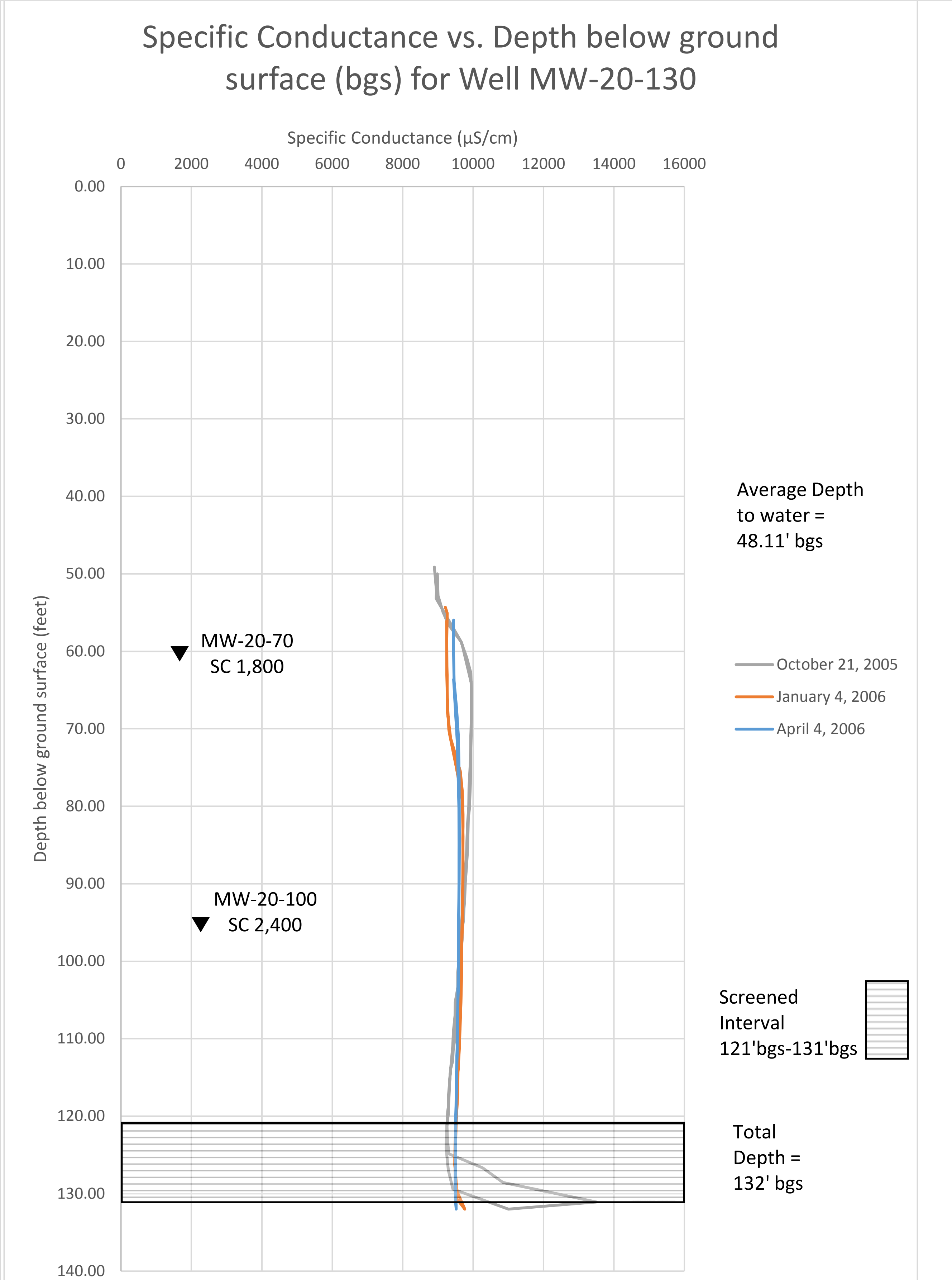
Well	Location	Screened Interval (ft bgs)	SC Profile Date	SC in blank casing	SC in well screen	SC from sampling event	Sampling event date	Sample SC % of Profile SC in screen	Approx. well distance from Colorado River (feet)	Duration of profile data record	Comments
MW-34-100	Floodplain, close to river	89.5-99.5							75	2009-2016	closest to Colorado River. Sump into bedrock
			21-Apr-09	22,000	23,000	16,900	4/30/2009	73%			
			25-Oct-12	17,000	18,000	19,000	10/1/2012	106%			
			23-Oct-14	16,000	18,000	17,000	10/2/2014	94%			
			7-Dec-15	13,000	17,000	17,459	12/3/2015	103%			
			7-Jan-16	13,000	17,000	14,100	2/25/2016	83%			
			12-Apr-16	9,000	12,000	15,500	4/26/2016	129%			
			7-Dec-16	9,000	17,000	16,000	12/6/2016	94%			
Average ratio of MW-34-100 sampling SC / profiling SC at screen								**97%**			
MW-27-85	Floodplain, close to river	77.5-87.5							100	2008-2016	Sump into bedrock
			22-Oct-08	14,000	15,000	16,000	4/30/2009	107%			
			13-Mar-12	11,000	13,000	12,000	10/1/2012	92%			
			23-Oct-14	10,000	12,000	8,500	11/4/2014	71%			
			7-Dec-15	10,000	11,000	9,975	12/3/2015	91%			
			7-Jan-16	9,000	12,000	--					
			12-Apr-16	9,000	11,000	11,700	4/25/2016	106%			
			7-Dec-16	10,000	12,000	9,400	12/6/2016	78%			
Average ratio of MW-27-85 sampling SC / profiling SC at screen								**91%**			
MW-45-95	Floodplain, next to PE-1	83-93							150	2006-2016	note MW-45-95 proximity to PE-1
			2-May-06	12,000	13,000	14,000	3/24/2006	108%			
			22-Oct-08	6,000	13,000	9,700	9/29/2009	75%			Closest date was 2009.
			12-Mar-12	8,500	12,000	9,000	12/13/2012	75%			
			23-Oct-14	4,000	10,000	8,400	12/2/2013	84%			Closest date was 2013
			7-Dec-15	2,000	10,000	--					
			7-Jan-15	1,000	10,000	--					
			12-Apr-16	1,000	8,000	--					
			7-Dec-16	1,000	11,000	--					
Average ratio of MW-45-95 sampling SC / profiling SC at screen								**85%**			

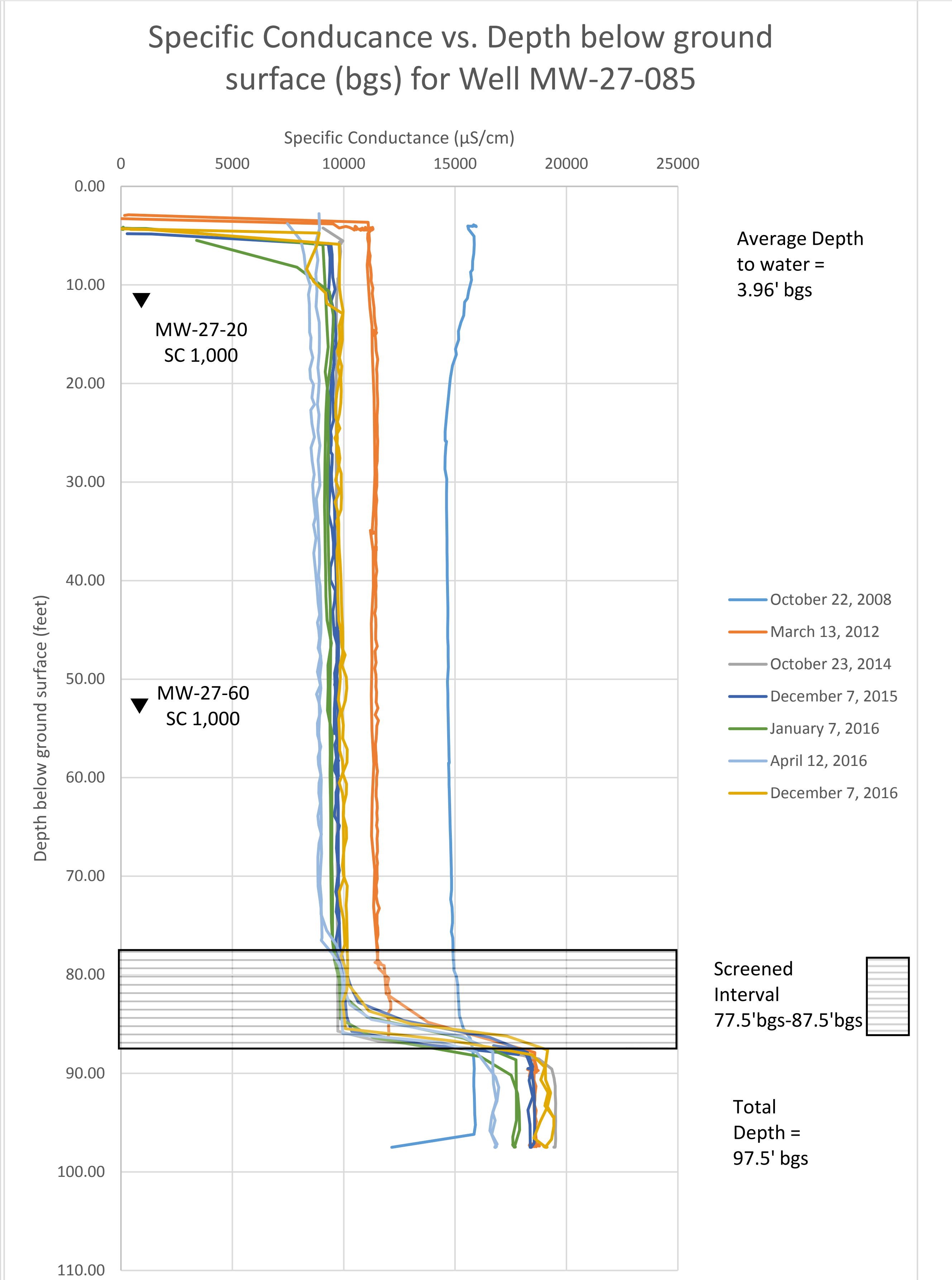
Table 1 - Summary of Floodplain Key Gradient Well Information

Well	Location	Screened Interval (ft bgs)	SC Profile Date	SC in blank casing	SC in well screen	SC from sampling event	Sampling event date	Sample SC % of Profile SC in screen	Approx. well distance from Colorado River (feet)	Duration of profile data record	Comments
MW-33-150	mid-Floodplain	132-152							250	2006-2016	
			3-Apr-06	18,000	NA	18,300	3/8/2006	102%			
			22-Oct-08	18,000	18,000	17,000	10/6/2008	94%			
			13-Mar-12	16,000	16,000	16,000	2/9/2012	100%			
			23-Oct-14	16,000	17,000	14,000	11/12/2014	82%			
			7-Dec-15	15,000	18,000	15,737	12/1/2015	87%			
			7-Jan-16	15,000	17,000	--					
			12-Apr-16	14,000	15,000	16,900	4/26/2016	113%			
			7-Dec-16	16,000	18,000	15,000	12/8/2016	83%			
Average ratio of MW-33-150 sampling SC / profiling SC at screen								**95%**			
MW-31-135	Floodplain landward edge	113-133							500	2008-2016	most distant from Colorado River
			22-Oct-08	11,000	12,000	11,000	10/6/2008	92%			
			13-Mar-12	10,000	11,000	12,000	11/15/2012	109%			
			23-Oct-14	10,000	12,000	10,000	11/5/2014	83%			
			7-Dec-15	10,000	11,000	12,693	12/7/2015	115%			
			7-Jan-16	10,000	11,000	--					
			12-Apr-16	9,000	12,000	--					
			7-Dec-16	10,000	12,000	11,000	12/9/2016	92%			
Average ratio of MW-31-135 sampling SC / profiling SC at screen								**98%**			

Attachments

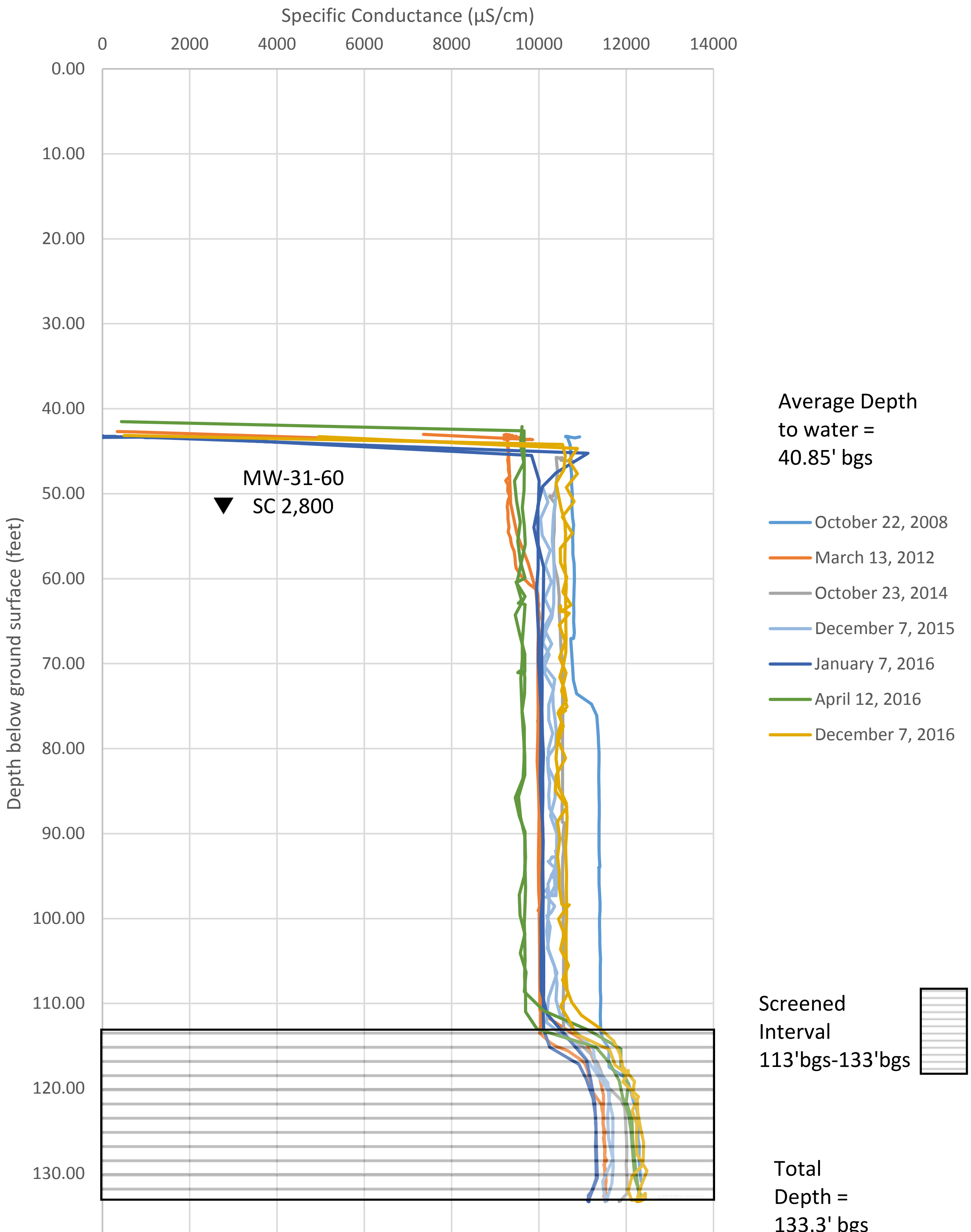
Attachment 1
Conductivity Profiles

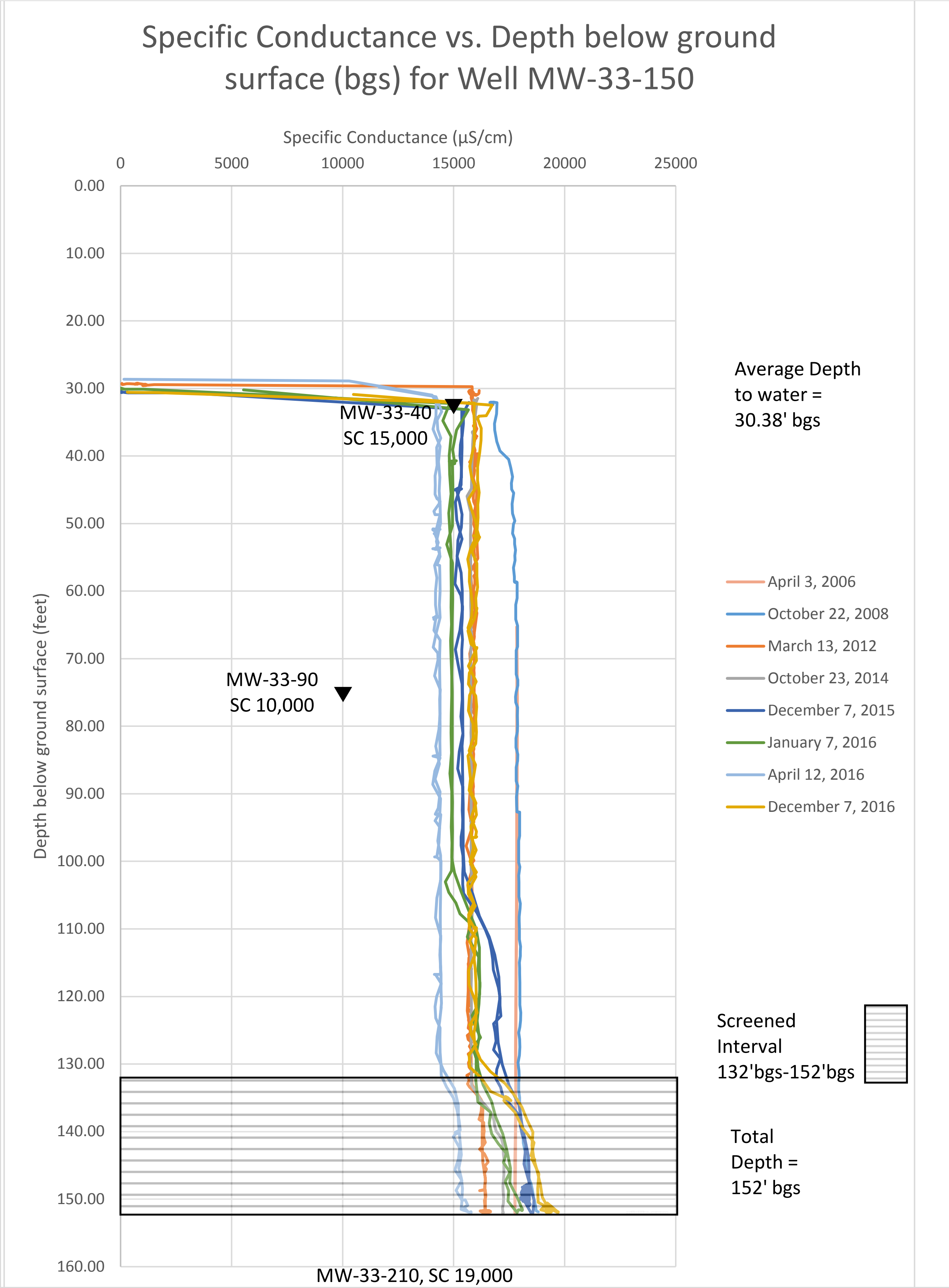

Specific Conductance vs. Depth below ground surface (bgs) for Well MW-20-130
Specific Conductance (µS/cm)
0
2000
4000
6000
8000
10000
12000
14000
16000
Depth below ground surface (feet)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
MW-20-70
SC 1,800
MW-20-100
SC 2,400
Average Depth to water = 48.11' bgs
October 21, 2005
January 4, 2006
April 4, 2006
Screened Interval 121'bgs-131'bgs
Total Depth = 132' bgs



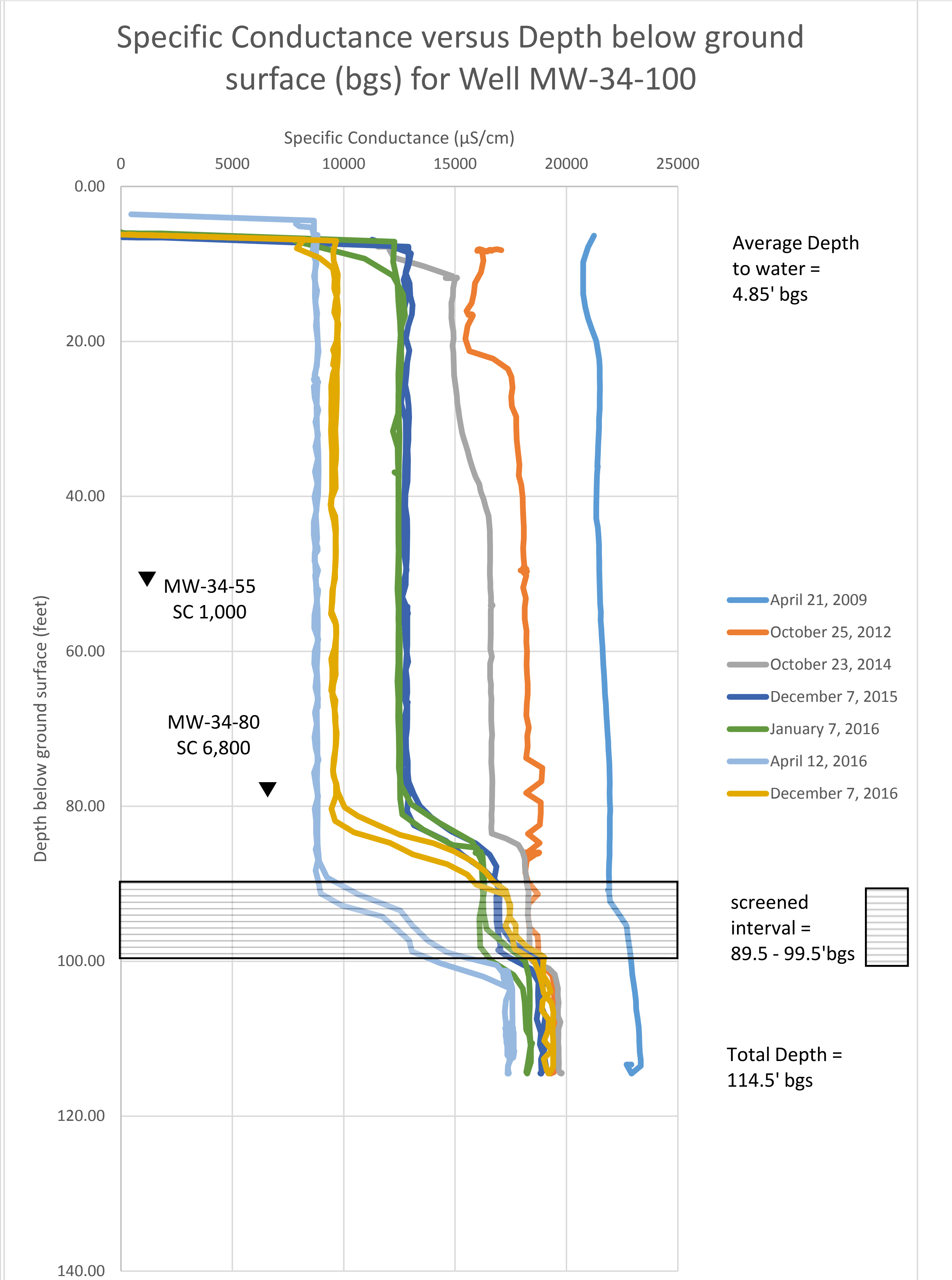
Specific Conducance vs. Depth below ground surface (bgs) for Well MW-27-085
Specific Conductance (µS/cm)
0
5000
10000
15000
20000
25000
Depth below ground surface (feet)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
MW-27-20
SC 1,000
MW-27-60
SC 1,000
Average Depth to water = 3.96' bgs
October 22, 2008
March 13, 2012
October 23, 2014
December 7, 2015
January 7, 2016
April 12, 2016
December 7, 2016
Screened Interval 77.5'bgs-87.5'bgs
Total Depth = 97.5' bgs

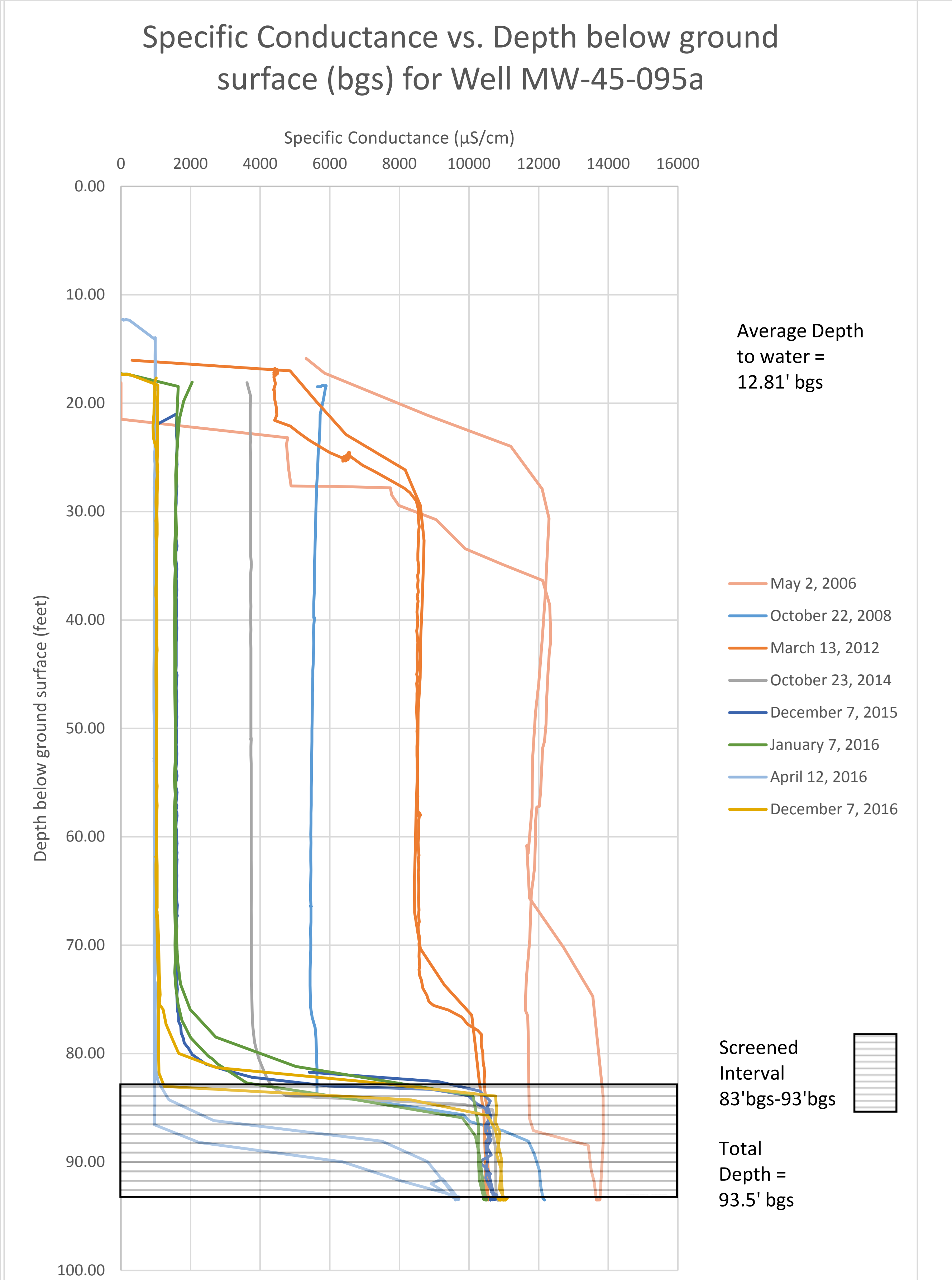
Specific Conductance vs. Depth below ground surface (bgs) for Well MW-31-135



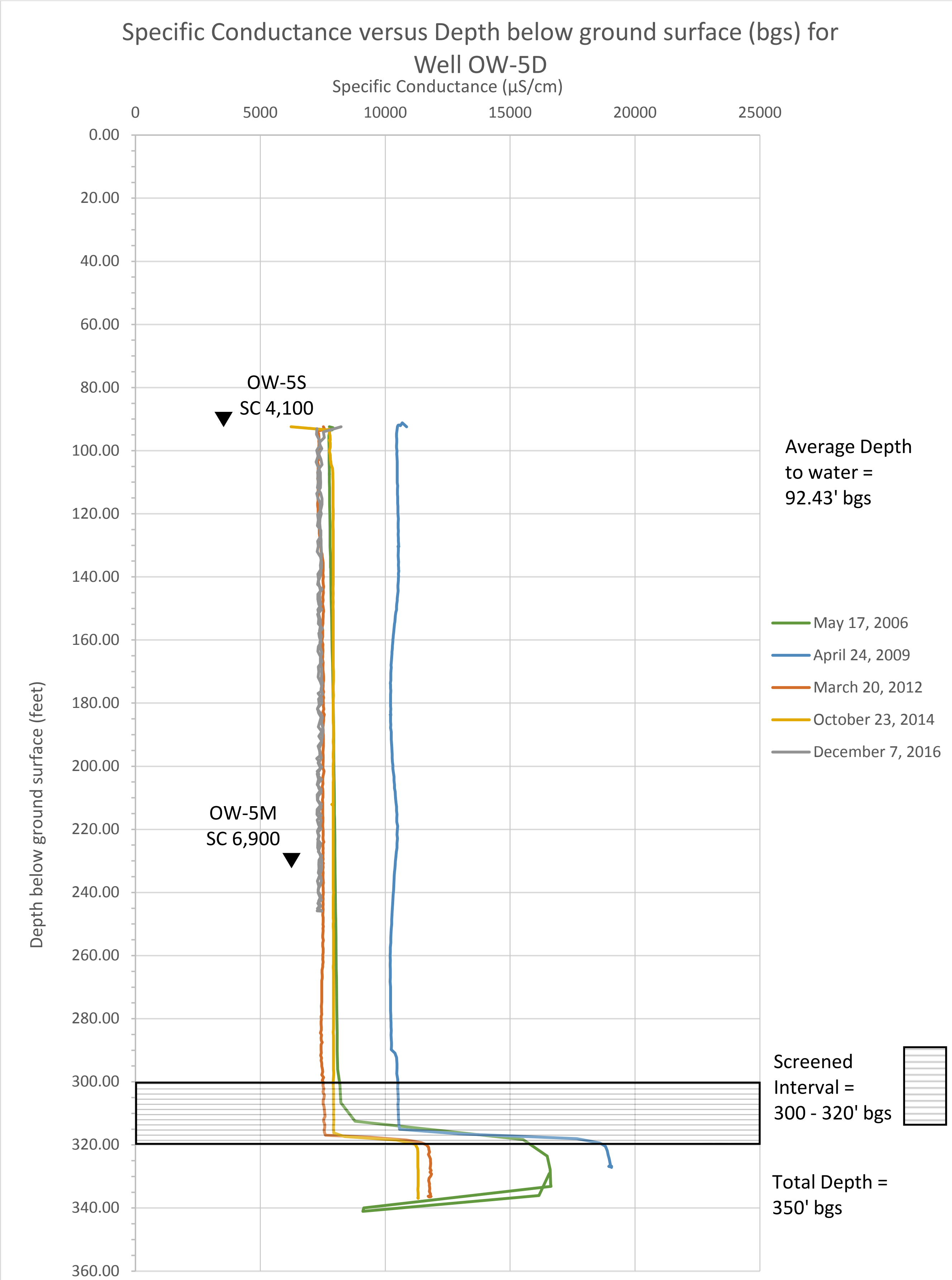


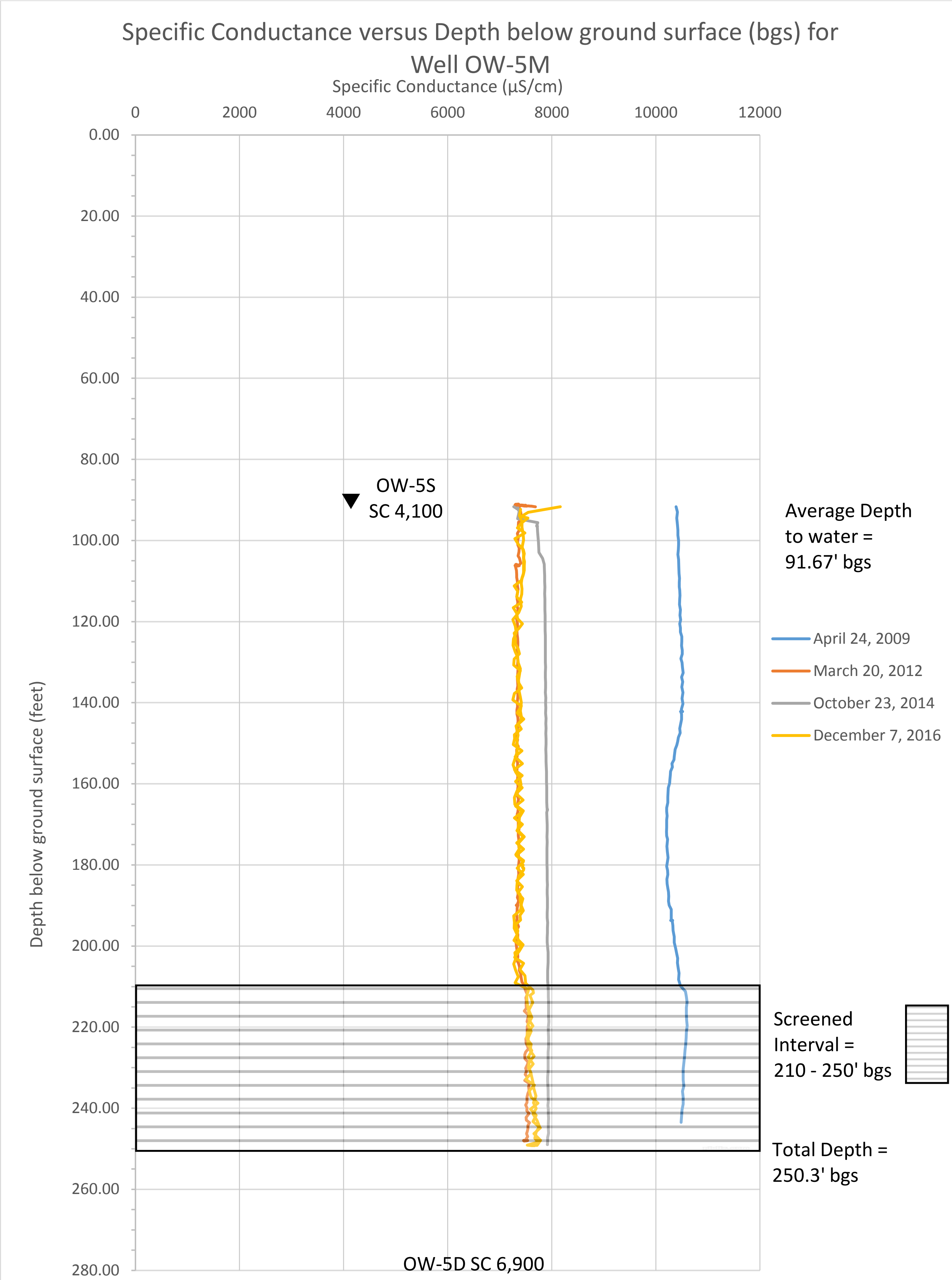
Specific Conductance vs. Depth below ground surface (bgs) for Well MW-33-150
Specific Conductance (µS/cm)
0
5000
10000
15000
20000
25000
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
Depth below ground surface (feet)
MW-33-40
SC 15,000
MW-33-90
SC 10,000
MW-33-210, SC 19,000
Average Depth to water = 30.38' bgs
April 3, 2006
October 22, 2008
March 13, 2012
October 23, 2014
December 7, 2015
January 7, 2016
April 12, 2016
December 7, 2016
Screened Interval 132'bgs-152'bgs
Total Depth = 152' bgs


Specific Conductance versus Depth below ground surface (bgs) for Well MW-34-100
Specific Conductance (µS/cm)
0
5000
10000
15000
20000
25000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Depth below ground surface (feet)
Average Depth to water = 4.85' bgs
MW-34-55 SC 1,000
MW-34-80 SC 6,800
April 21, 2009
October 25, 2012
October 23, 2014
December 7, 2015
January 7, 2016
April 12, 2016
December 7, 2016
screened interval = 89.5 - 99.5'bgs
Total Depth = 114.5' bgs

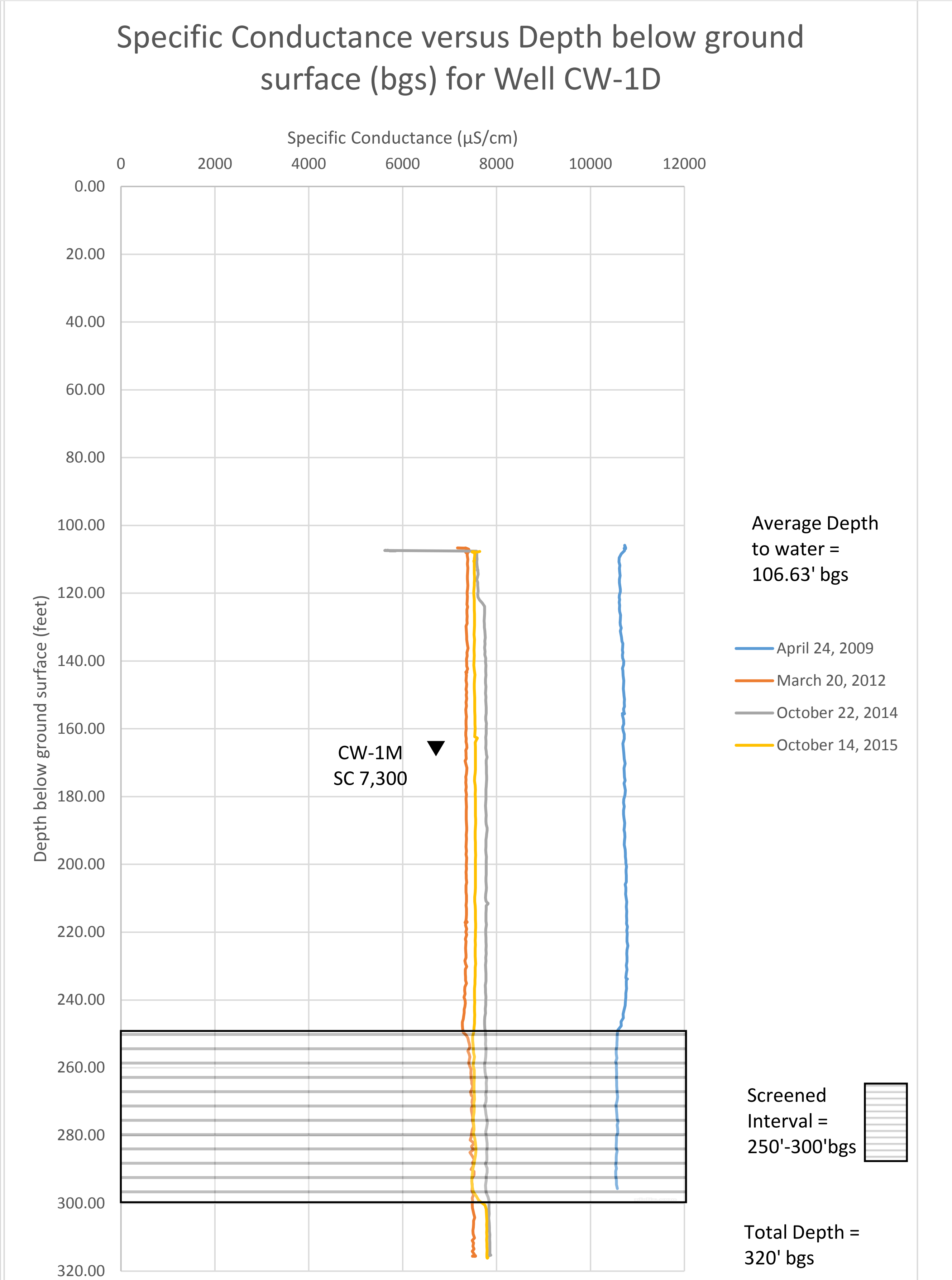


Specific Conductance vs. Depth below ground surface (bgs) for Well MW-45-095a
Specific Conductance (µS/cm)
0
2000
4000
6000
8000
10000
12000
14000
16000
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Depth below ground surface (feet)
Average Depth to water = 12.81' bgs
May 2, 2006
October 22, 2008
March 13, 2012
October 23, 2014
December 7, 2015
January 7, 2016
April 12, 2016
December 7, 2016
Screened Interval 83'bgs-93'bgs
Total Depth = 93.5' bgs


Specific Conductance versus Depth below ground surface (bgs) for Well OW-5D
Specific Conductance (µS/cm)
0
5000
10000
15000
20000
25000
Depth below ground surface (feet)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
240.00
260.00
280.00
300.00
320.00
340.00
360.00
OW-5S
SC 4,100
OW-5M
SC 6,900
Average Depth to water = 92.43' bgs
May 17, 2006
April 24, 2009
March 20, 2012
October 23, 2014
December 7, 2016
Screened Interval = 300 - 320' bgs
Total Depth = 350' bgs

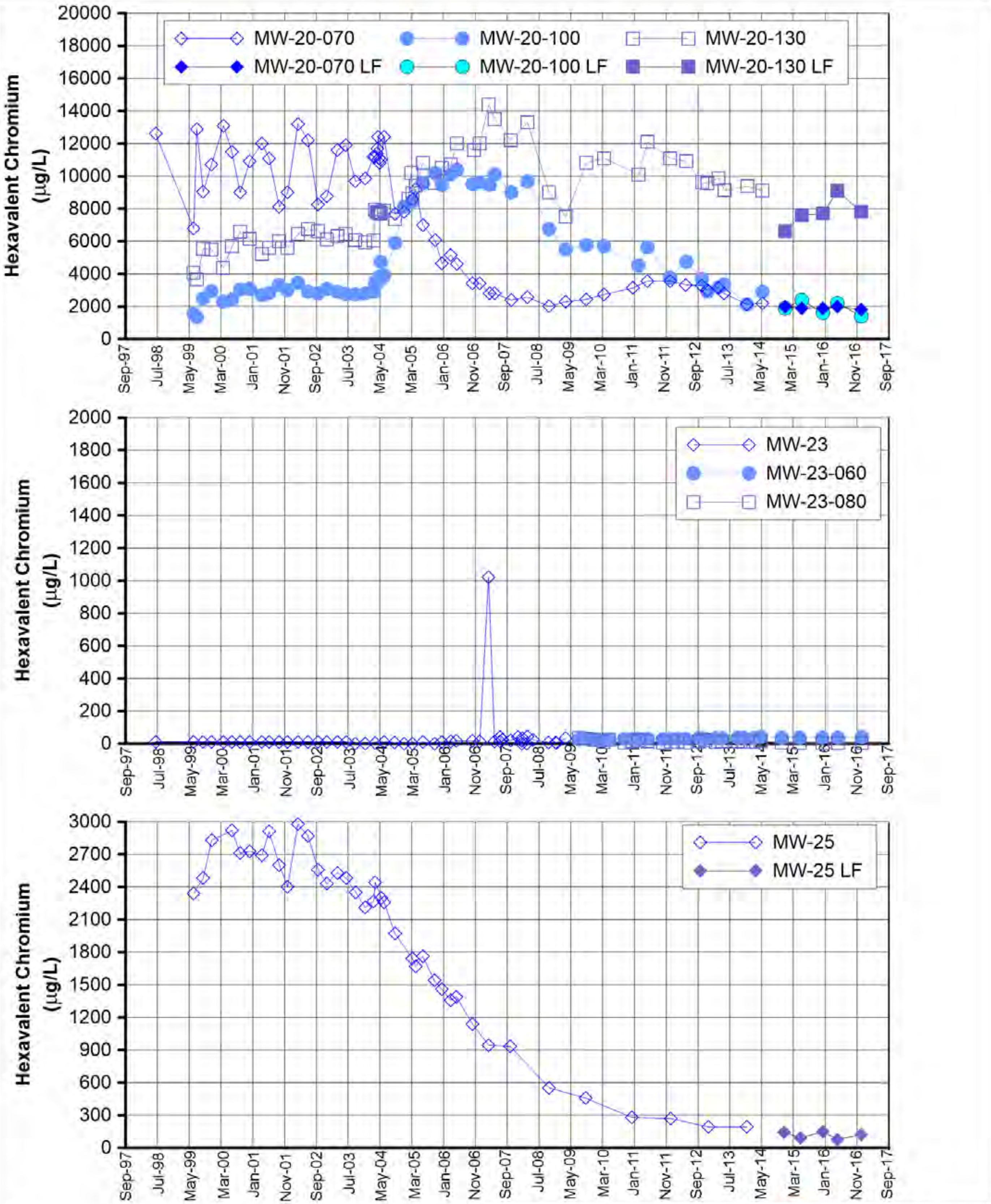


Specific Conductance versus Depth below ground surface (bgs) for Well OW-5M
Specific Conductance (µS/cm)
0
2000
4000
6000
8000
10000
12000
Depth below ground surface (feet)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
240.00
260.00
280.00
OW-5S
SC 4,100
Average Depth to water = 91.67' bgs
April 24, 2009
March 20, 2012
October 23, 2014
December 7, 2016
Screened Interval = 210 - 250' bgs
Total Depth = 250.3' bgs
OW-5D SC 6,900



Specific Conductance versus Depth below ground surface (bgs) for Well CW-1D
Specific Conductance (µS/cm)
0
2000
4000
6000
8000
10000
12000
Depth below ground surface (feet)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
240.00
260.00
280.00
300.00
320.00
CW-1M
SC 7,300
Average Depth to water = 106.63' bgs
April 24, 2009
March 20, 2012
October 22, 2014
October 14, 2015
Screened Interval = 250'-300'bgs
Total Depth = 320' bgs

Attachment 2
Chromium Trend Plots



Notes:

LF = low flow, hexavalent chromium sample collected using low flow sampling method. Data not indicated with (LF) was collected using the three-volume purge sampling method.

FIGURE C-3
HEXAVALENT CHROMIUM IN MW-20 AND MW-23 CLUSTERS AND MW-25

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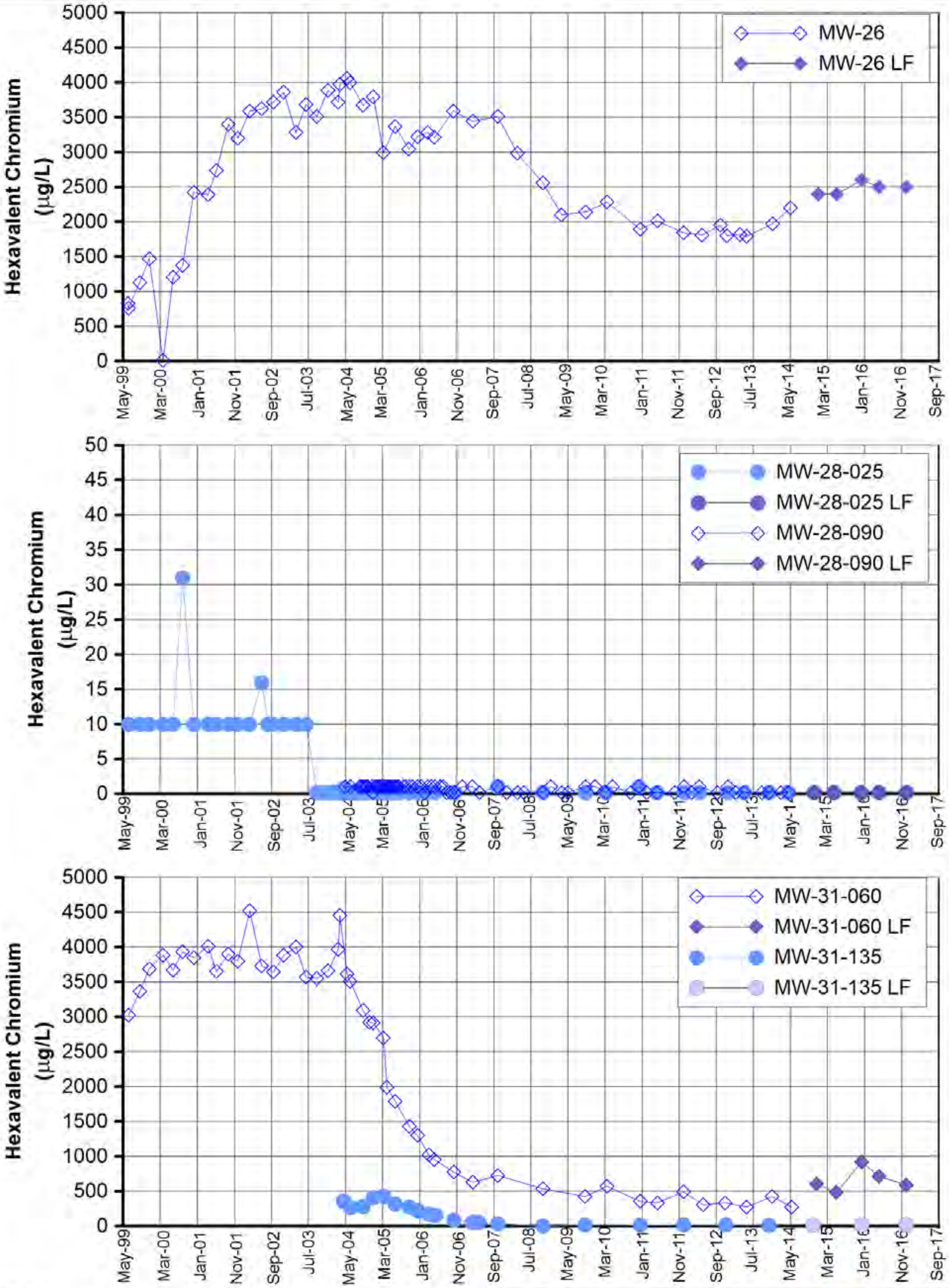
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA



Notes:

1) The IM Contingency Plan and hexavalent chromium [Cr(VI)] trigger levels were updated July 17, 2008 (DTSC, 2008b).

2) The trigger level for MW-28-090 is 20 μg/L.

LF = low flow, hexavalent chromium sample collected using low flow sampling method. Data not indicated with (LF) was collected using the three-volume purge sampling method.

FIGURE C-4
HEXAVALENT CHROMIUM IN MW-26, MW-28, AND MW-31 CLUSTERS

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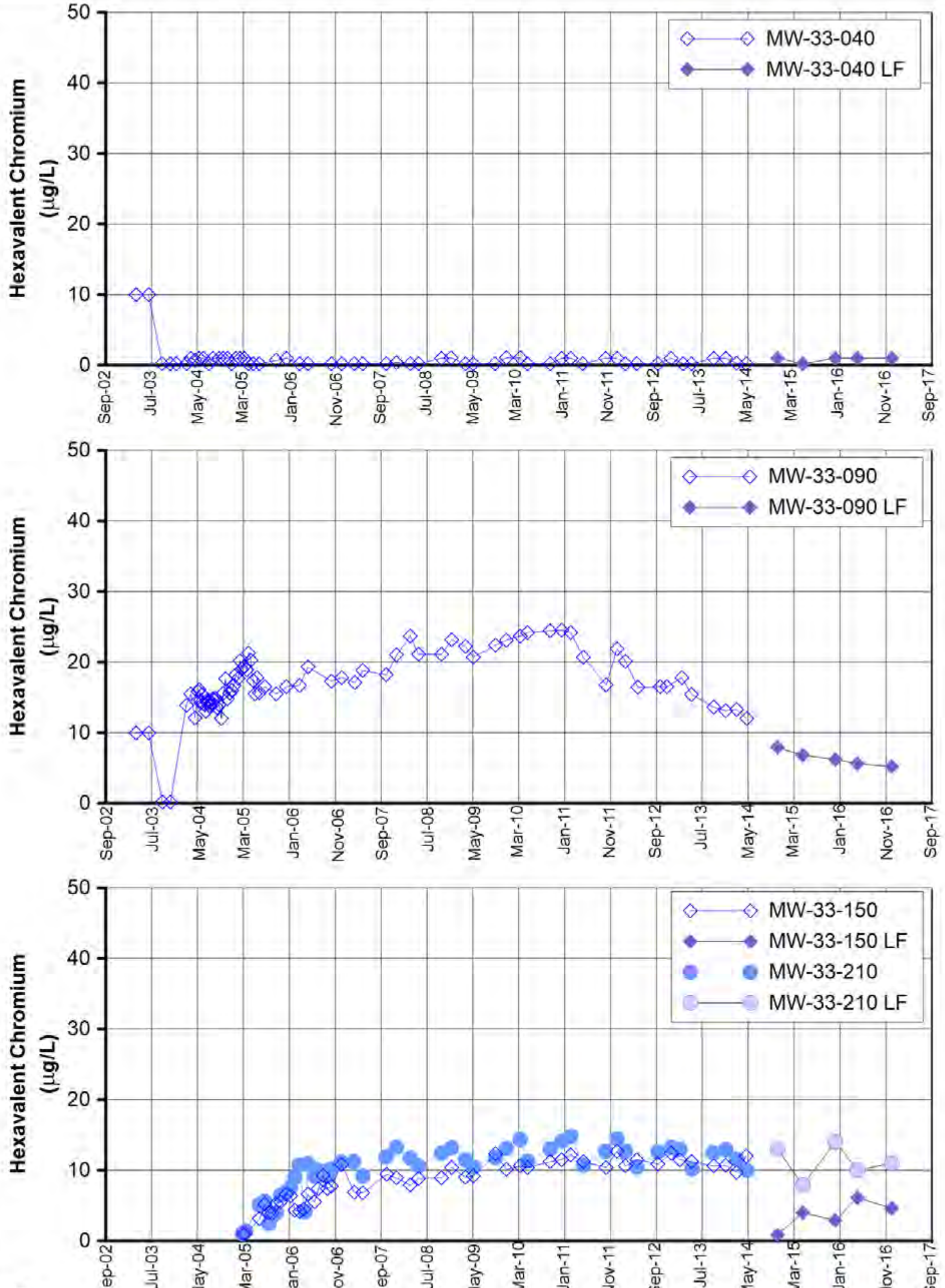

Notes:

1) The IM Contingency Plan and hexavalent chromium [Cr(VI)] trigger levels were updated July 17, 2008 (DTSC, 2008b).
2) The trigger level for MW-33-040 is 20 µg/L.
3) The trigger level for MW-33-090 is 25 µg/L.
4) The trigger level for MW-33-150 is 20 µg/L.
5) The trigger level for MW-33-210 is 20 µg/L.

LF = low flow, hexavalent chromium sample collected using low flow sampling method. Data not indicated with (LF) was collected using the three-volume purge sampling method.

FIGURE C-5
HEXAVALENT CHROMIUM IN MW-33 CLUSTER

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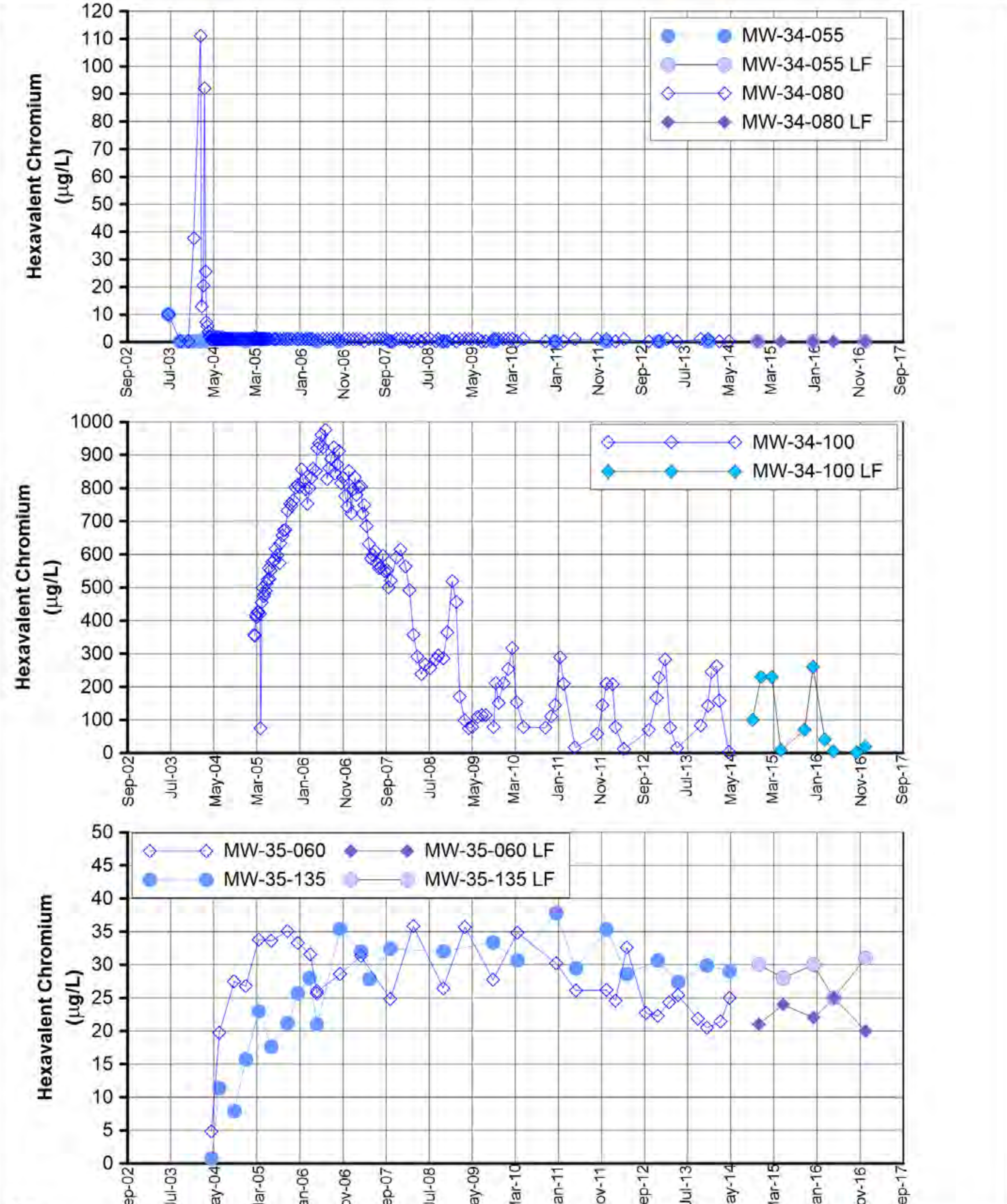

Notes:

1) The IM Contingency Plan and hexavalent chromium [Cr(VI)] trigger levels were updated July 17, 2008 (DTSC, 2008b).
2) The trigger level for MW-34-080 is 20 µg/L.
3) The trigger level for MW-34-100 is 750 µg/L.

LF = low flow, hexavalent chromium sample collected using low flow sampling method. Data not indicated with (LF) was collected using the three-volume purge sampling method.

FIGURE C-6
HEXAVALENT CHROMIUM IN MW-34 AND MW-35 CLUSTERS

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Attachment 3
SOP-A18, Purging and Sampling of Groundwater Monitoring Wells, Minimal Drawdown Procedure

SOP-A18

Purging and Sampling of Groundwater Monitoring Wells Minimal Drawdown Method Standard Operating Procedures for PG&E Topock Program

This standard operating procedure (SOP) addresses the procedures and equipment to be used for purging and sampling all groundwater monitoring wells approved for the minimal drawdown sampling approach. This SOP will be used for sampling groundwater monitoring wells using an adjustable rate, positive displacement pump.

REQUIRED DOCUMENTS:

- Event-specific planned sample table (PST).
- Applicable project work plan or monitoring plan. Refer to the Topock Program Sampling, Analysis, and Field Procedures Manual (Procedures Manual).
- Construction/Remedial Action Work Plan (C/RAWP) during the construction phase.
- Operation and Maintenance (O&M) Manual, and Quality Assurance Project Plan (QAPP) (Appendix B of the O&M Manual Volume 2, Sampling and Monitoring Plan) as required during the O&M phase.
- Topock Program Health and Safety Plan (HSP)
- Applicable SOPs may include:
  - SOP-A1, *Purging and Sampling of Groundwater Monitoring Wells, Well-Volume Method*
  - SOP-A2, *Purging and Sampling of 1-inch Diameter Groundwater Monitoring Wells, Modified Well-Volume Method*
  - SOP-A3, *Purging and Sampling of Active and Inactive Water Supply Wells*
  - SOP-A4, *Depth-Specific River Water Sampling*
  - SOP-A5, *Groundwater Sampling from Sonic Drilling Boreholes*
  - SOP-A6, *Field Filtration*
  - SOP-A7, *Water Level Measurements*
  - SOP-A8, *Field Water Quality Measurements Using a Flow-through Cell*
  - SOP-A9, *Calibration of Field Instruments*
  - SOP-A10, *Decontamination of Water Sampling Equipment*
  - SOP-A11, *Total Depth Measurements*
  - SOP-A12, *Field Water Quality Measurements for Grab Samples*
  - SOP-A13, *Spill Prevention, Containment, and Control Measures for Monitoring Well Sampling*
  - SOP-A14, *Pore Water Sampling*

- SOP-A16, *Access Routes*
- SOP-A19, *Sampling of Groundwater Monitoring Wells, Hydrasleeve No Purge Method*
- SOP-A23, *Sample Handling and Custody*
- SOP-C1, *Solinst Pressure Transducers*

- Well construction logs/specifications
- Mobile Integrated Sample Tracking (MIST) handheld database
- Previous sampling logs or tabular historic field data tables
- Current site access map
- Blank sampling logs, maps, sample labels, chains of custody (COC's), and the designated groundwater sampling field notebook

REQUIRED EQUIPMENT:

- 2 or more (i.e. one is backup) WQ instruments with flow through cells, or equivalent.
- Hach 2100P turbidimeter or equivalent.
- 200 foot (or longer as needed) water level indicator (WLI).
- Trimble Rugged Reader hand held instrument for MIST data collection.
- Two, 200 gallon capacity purge tanks.
- Utility vehicles (UTVs) as necessary.
- Honda 2000 watt generator or alternate power source.
- Adjustable-rate, positive-displacement pump
- Sample containers, cooler and ice

PREPARATION & SETUP:

- Review event-specific PST or event-specific field instructions, previous sampling logs, Procedures Manual, O&M Manual, HSP, and groundwater sampling supplies and equipment check list. (NOTE: the PST should also be reviewed for required "non-analytical event activities" such as water level measurements or other data collection that is planned in association with the groundwater sampling event).
- Acquire the existing field logbook for groundwater sampling and initiate entries.
- Inspect all equipment and verify that the field water quality (WQ) meters have been calibrated prior to use according to the manufacturer's instructions and SOP-A9, *Calibration of Field Instruments*.
- Inventory sample bottles, build sample sets for the required analytes at each sample location, ensure a sufficient supply of lab de-ionized water for equipment blanks, and confirm the lab courier schedule.

- Field-check sampling equipment and supplies: water level indicator (WLI), WQ meters, flow-through cell, pump controller, power supply, pump discharge/sampling tubing, N-dex gloves, deionized water sprayers, 5 gallon buckets, paper towels, 0.45 micron in-line filters, etc.

FIELD PROCEDURES:

- **Prior to opening any monitor well, remove all pens, lighters, calculators, or any other loose items from vest pockets, or from any other location where they could fall into the well.**
- Upon arrival at the monitoring well, at least 2 members of the sampling team must confirm the well ID. Wells should be clearly marked on the well monument. If the well cannot be positively identified by the marking, measure total depth of the well and compare to the well installation details to confirm the correct location. Report worn or unclear well markings to the on-site field coordinator.
- Place spill containment according to SOP-A13 *Spill Prevention, Containment, and Control Measures for Monitoring Well Development, Purging, and Sampling.*
- If using a transient pump, collect an "EB", equipment blank, ***prior to pump installation*** if necessary according to the PST.
- Open the protective casing lid and, ***prior to moving it***, note the exact configuration of the transducer installation if present. Measure static WL according to SOP-A7, *Water level Measurements,* moving the transducer if necessary, and record WL value in MIST and on the sampling log.
- If the well is equipped with a transducer and does not have a dedicated pump installed, remove the transducer from the well according to SOP-C1, *Solinst Pressure Transducers*.
- If the well does not have a dedicated pump installed, but does have dedicated sample tubing, attach the dedicated tubing to the appropriate pump and install decontaminated pump at the same intake/sampling depth as used in prior events. There is a marking on the purge tubing which corresponds with the monitor well top of casing (TOC) to facilitate this requirement. Purge and sample the well as described below.
- If the well does not have a dedicated pump ***or*** tubing, or has not been previously sampled, use new low-density polyethylene tubing and install the pump with the intake at approximately the midpoint of the well screen. Purge and sample the well as described below.
- If the well ***does*** have a dedicated pumping system, connect the discharge tubing and purge and sample the well as described below.
- Collect daily equipment blanks and duplicate samples as required by the PST and instructed by the field team leader.

PURGING AND SAMPLING PROCEDURES:

- Install the pump in the well. Slowly lower the pump (with the attached tubing and safety line) into the well to the desired depth. The pump will be set near the middle of the well screen, if possible. At a minimum, the pump intake will not be positioned lower than 2 feet from the bottom of the well. The depth to the pump intake will be recorded on the Groundwater Sampling Form. If there is less than 3 feet of available water, the groundwater well will be purged and sampled using a bottom-loading bailer.

- Measure the water level in the well after pump insertion. Leave the water level probe in the well to facilitate continued water level monitoring during purging activities.
- Start purging the well at a low flow rate between 0.2 and 0.5 liters per minute. Measure the purge rate using a container of known volume, and record this information on the Groundwater Sampling Form
- The water level should be monitored during purging, and ideally, the purge rate should equal the well recharge rate so there is limited drawdown in the well. (The water level should stabilize for the specific purge rate). The purge rate may be increased above 0.2 and 0.5 liters per minute as long as a constant water level in the well can be maintained, and the target drawdown of no more than 1 foot is being met. There should be at least 1 foot of water over the pump intake. This assures that there is no risk of the pump suction being broken, or of entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water on the field data sheet. If the target drawdown is not met, purge rates should be decreased to the minimum capabilities of the pump (0.1 to 0.2 liters per minute). If using a pulse style pump, measure the water level at the end of the pressure cycle when the water level has recovered as much as it will, before again filling the pump during the fill cycle. This method will generate consistent drawdown data.
- During purging, the water quality parameters will be measured periodically (every 3 to 5 minutes) until the parameters have stabilized as shown below. If parameter stabilization has not occurred after 4 hours, purging activities will be considered complete.

- pH	+/- 0.1 pH units
- Specific conductance	+/- 3%
- ORP	+/- 10 millivolts
- Turbidity	10% NTU units or less unless other parameters have stabilized during an extended purge and turbidity is trending flat if still over 10 NTU units. The target turbidity goal (but not a hard criterion) is 5 to 10 NTUs.
- Dissolved oxygen	+/- 0.3 mg/L
- Temperature	+/- 2^{o} Celsius

- When the requirements above have been satisfied and the purge cycle is complete, disconnect the flow through cell and prepare to collect samples directly from the pump discharge tubing for analyses according to event-specific PST. Prepare sample containers and collect gas-sensitive analytes first. The preferred collection order will be volatile organic compounds (VOCs), semi-volatile organic compound (SVOCs), metals (including hexavalent chromium [Cr(VI)] and total chromium [Cr(T)]; see SOP-A6), then general chemistry (cations, anions, stable isotopes).

- For filtered samples, attach a 0.45 micron in-line filter to the pump discharge and allow approximately 500 mL of sample to pass through the filter before beginning sample collection in accordance with SOP-A6 *Field filtration* and the QAPP.
- When sample collection is complete, record sample information, final WL, and purge volume data in MIST and on the field sampling log.
- If transient pump previously installed, remove the pump from the well, detach the dedicated tubing and carefully drain any residual water to the purge water tank. Fold both ends of the purge tubing and secure with wire ties as a further deterrent to leakage. Store the dedicated tubing in a sealed, labeled trash bag. Decontaminate the pump according to SOP-A10, *Decontamination of Water Sampling Equipment*.
- If well was equipped with a transducer, replace the transducer in exactly the same configuration in which it was found and in accordance with SOP-C1, *Solinst Pressure Transducers*.
- Close and secure well protection lid.
- Follow applicable SOPs, the Procedures Manual, and O&M Manual for sample handing and management, equipment decontamination, and investigation-derived waste (IDW) management (O&M Manual Volume 1, Section 6 during O&M or Appendix R of the C/RAWP during construction).