Appendix C

Supporting Information for Aquifer Sampling Tubes

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Appendix C — Supporting Information for Aquifer Sampling Tubes

M.J. Hartman and C.A. Newbill

Aquifer tubes are small-diameter, flexible tubes that have a screen on one end. The tubes are installed in the aquifer along the Columbia River shoreline by driving a temporary steel casing into the ground adjacent to the river. The temporary casing is filled with water to keep sediments from coming up into the casing, then the drive-tip on the casing end is knocked out and the screened end of a tube is inserted into the casing (Figures C-1 and C-2). The steel casing is then pulled out, leaving the tube in place (Figure C-3). Water is withdrawn from the tube using a peristaltic pump. Most aquifer tube sites include two or three individual tubes monitoring different depths, from ~1 to 8 meters. The tube sites cover the Hanford Site shoreline, from just upstream of the 100-B/C Area to downstream at the 300 Area. Sites are more closely spaced along some segments where higher density spatial resolution of contaminant plumes is needed.

C.1 Sampling Metrics for 2010

A total of 562 aquifer tubes were installed on the Hanford Site between 1997 and 2010. A subset of tubes is selected for sampling. The Sampling and Analysis Plan for Aquifer Sampling Tubes (DOE/RL-2000-59) contains a list of tubes and constituents scheduled to be sampled in fiscal year (FY) 2009. The same list of tubes and constituents were scheduled for sampling in FY 2010 and FY 2011. The sampling and analysis plan also summarizes the history of Hanford Site aquifer tube installation and describes tube site nomenclature.

At most aquifer tube sites, if specific conductance of the water is less than 160 µS/cm, the conductance is recorded and water is not collected for laboratory analyses because the samples contain more river water than groundwater. These sampling trips are considered successful because they reflect representative conditions at the time. In some locations, notably the 100-N Area, samples are collected for laboratory analyses even when specific conductance is low.

Most of the tubes are sampled once per year, generally in the fall. For FY 2011, sampling was scheduled for October through December 2010, but sampling was delayed into calendar year (CY) 2011. As a result, fewer aquifer tubes were sampled in CY 2010 than usual. Most of the sampling for CY 2010 was for tubes that are on a semiannual, quarterly, or monthly sampling schedule.

Twenty-six new aquifer tubes were installed in CY 2010 to support remedial investigation studies in the River Corridor operable units. A total of 145 aquifer tubes were sampled in CY 2010 (Figure C-4). Many of the tubes were sampled more than once, for a total of 335 sampling trips. Table C-1 summarizes the total number of tubes and clusters in each segment of shoreline, the tubes installed in 2010, the number of tubes sampled, and the number of sampling trips in 2010. Table C-2 provides information on 2010 sampling dates and other supporting information (the aquifer tubes are listed in the table in order from upstream to downstream).

C.2 Sampling Dates and River Stage

The water in the Hanford Site's unconfined aquifer near the Columbia River represents a mixture of river water and groundwater. When the river stage is low in the fall of each year, aquifer tube samples typically contain the least amount of river water and contaminant concentrations are the highest.

The daily average river stage in 2010 (measured in each of the reactor areas and the 300 Area) and aquifer tube sample dates for 2010 are depicted in the following figures:

- 100-BArea (Figure C-5)
- 100-K Area (Figure C-6)
- 100-N Area (Figure C-7)
- 100-D Area (Figure C-8)

- 100-H Area (Figure C-9)
- 300 Area (Figure C-10).

The gauge in 100-F Area was not operating for the entire year, and a river stage gauge is not located in the 200-PO-1 Operable Unit shoreline segment; therefore, hydrographs are not provided for those segments.

C.3 Evaluation of Changes in Specific Conductance During Aquifer Tube Sampling

The question has been raised whether sampling aquifer tubes results in "short circuiting" (i.e., whether river water is being sucked through the sediment around the tube and into the screen). This problem would be more likely to occur during periods of high river stage when the entry point of the tube into the sediment is submerged. Evaluation of data collected before and after sampling indicates that river water is not pulled into the screen during routine sampling. Details are provided in the following discussion.

The maximum pumping rate for aquifer tube sampling is 650 milliliters per minute. Actual pumping rates are less and depend on factors such as depth to water, aquifer material surrounding the screen, and the voltage of the battery in the sampling pump. Typical screen depths are between 2.4 and 6 meters.

C.3.1 Approach

To determine if river water was being drawn into aquifer tubes during sampling, 333 pairs of specific conductance data (sampling dates January 4, 2009, through April 19, 2010) were analyzed to determine if there is a statistically significant difference between the first and second measurements. The first measurement is the specific conductance after the aquifer tube has been purged and specific conductance has stabilized (three consecutive measurements that differ by less than 10%). Once specific conductance is stable, the other field parameters are measured and sample bottles are filled. After all the sample bottles have been filled with water, specific conductance is measured again. The elapsed time (i.e., time pumping) between measurements ranged from 0 to 73 minutes. Because river water has a lower specific conductance than groundwater, successive aquifer tube samples would have decreasing conductance if river water were drawn in by the sampling process.

Three statistical tests were used to analyze the data: t-test, sign test, and signed-rank test. For each of the three tests, the percentage change from the first measurement to the second was analyzed. This avoided weighting large changes from high measurements more than small changes from low measurements.

C.3.2 Discussion

Changes in conductance ranged from a decrease of 299 µS/cm to an increase of 102 µS/cm (-50% to +37% change); however, such large changes were uncommon. The median change was 0% and the mean was -0.5% (Figures C-11 and C-12).

The largest percent decline in conductance was -50% in tube N116mArray-1A (conductance declined from 253 to 127 µS/cm). The lower conductance is more in line with previous trends in this tube. The sample was collected after nearby injections of apatite-forming chemicals into the aquifer, which likely temporarily increased the conductance.

The largest increase was 37% (from 276 to 378 µS/cm) in tube C5638, but this appears to be an anomaly as the elapsed time recorded was 0 minutes. The lower value is more in line with the trend in this tube.

The average relative percent difference in the 333 pairs of specific conductance measurements was 2.2%. The laboratory control limits for field duplicates is 20%. Only four pairs of samples (1.2%) exceeded 20%. Therefore, differences between samples were not significant relative to laboratory precision, which indicates insignificant evidence of river water intrusion.

C.3.3 Results of Statistical Tests

This section presents results of the t test and sign and sign ranked tests.

C.3.3.1 Results of t-Test

The hypothesis for the t-test in this application is that if there is no difference between the first and second measurements (i.e., insignificant river water influence), the average change in measurements should be close to zero, relative to the variability in the average changes. Table C-3 shows the average change and standard deviation in changes, as well as other pertinent values.

The average change from the first measurement to the second is a decrease of 0.50% (-0.0050). The standard deviation of the changes is 0.055. The t-test statistic is the departure of the average change from zero relative to the expected variability in the average change. The expected variability in the average change (standard error of the mean) is estimated by dividing the standard deviation of the changes by the square root of the number of sample pairs. Table C-4 shows the results of the t-test.

The computed t-statistic indicates that the average change from the first measurement to the second is 1.655 standard deviations of the mean from the expected value of zero. If these were drawn from a normal population with mean zero and standard deviation one, a larger difference from zero 9.88% of the time (P-value) would be expected. Therefore, the t-test on the 333 pairs of specific conductance measurements does not show significant river water influence at the 5% level but it does at the 10% level.

However, the t-test assumes the data set is drawn from a normal population. The large coefficient of variation (1,102%), large magnitudes in the skewness (-28) and kurtosis (163), and results of the Shapiro Wilk test (Table C-5) indicate that the changes in specific conductance are not normally distributed. The coefficient of variation should be less than 100%, skewness and kurtosis should be in the range of -2 to +2, and the P-value on the Shapiro-Wilk test should exceed 5%. This non normality indicates that the t test result for this data may be questionable.

C.3.3.2 Results of Sign and Signed-Rank Tests

Using the nonparametric (not based on an assumption of data normality) sign and signed-rank tests, the differences in measurements are not significant at the 5% level (Tables C-6 and C-7).

The sign test simply counts the number of times the first measurement exceeds the second. Assuming no difference between the measurements (equal probability of either being larger; a simple coin toss), this number should be about one-half the number of sample pairs (e.g., equal numbers of heads and tails in a coin toss). The amount by which this differs from the expected number is an indication of the likelihood that the two measurements really are different. In the specific conductance measurements, 54 of the 333 pairs had equal measurements, leaving 279 pairs for comparison. The first measurement exceeded the second 131 out of 279 times (e.g., equivalent to getting 131 heads and 148 tails in 279 tosses of a fair coin). Assuming equal probability of one exceeding the other, this amount of departure from an idealized split of 139/140 would occur 33.8% of the time. This indicates no statistically significant difference in the frequency at which the first measurement exceeds the second, or vice versa. Therefore, according to the sign test, there is no indication of river water intrusion.

Another test of significant differences between the measurements is the signed-rank test. In this test, the absolute values of the differences are ranked, with the smallest difference being ranked as 1, the next smallest difference ranked as 2, etc. Ties are assigned the average rank for the set of ties. After the measurements are ranked, the signs are restored to the rankings. The sum of the ranks for the negative (or positive) ranks is compared to the expected value of $n(n+1)/4$. Equivalently, the average negative or positive rank is compared to the expected average rank of $(n+1)/2$. The amount of departure from this expected value is an indication of the likelihood that the measurements really are different. The results of the signed-rank test are shown in Table C-7.

When the number of pairs exceeds 16, the test statistic is an approximate normal deviate. In this case, the sum of the signed ranks only differs by 0.094 standard deviations from the expected value. This is expected to be exceeded 92% of the time if there is no difference between the first and second measurements. Therefore, the signed-rank test also indicates no statistically significant difference between specific conductance measurements at the 5% level.

C.3.3.3 Conclusion

The t-test, sign test, and signed-rank tests performed on the percentage change from the first to the second measurements of 333 pairs of specific conductance measurements do not indicate statistically significant differences. In addition, the average relative percent difference among the pairs is well within laboratory control limits. Therefore, there is no statistical indication of river water effects on the measurements of specific conductance in aquifer tubes. This shows that there is no "short circuiting" of the system occurring during sample collection.

C.4 Reference

DOE/RL-2000-59, 2009, *Sampling and Analysis Plan for Aquifer Sampling Tubes,* Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Table C-1. Inventory of Hanford Site Aquifer Tubes as of December 31, 2010

Segment	Total Tubes/ Sites*	Tubes Not in Service	New Tubes CY 2010	Tubes Sampled, CY 2010	Sites Sampled, CY 2010	Tube Trips, CY 2010
100-B/C	53/21	1	9	9	3	9
100-K	70/28	0	3	19	10	44
100-N	84/40	10	8	42	23	141
100-D	97/37	10	4	27	11	84
100-H	97/41	11	2	23	12	30
100-F	81/29	16	0	1	1	1
200-PO-1	28/17	4	0	1	1	1
300 Area	52/25	3	0	23	12	25
Totals	**562/238**	**55**	**26**	**145**	**73**	**335**

* A tube site (cluster) contains one or more tube; multiple tubes monitor different depths.

Table C-2. Aquifer Tube Sampling Dates, Calendar Year 2010

Tube Name	Frequency	CY 2010 Sample Dates	Comments
100-BC Area Segment			
C7718	A	9/15/10	Installed 2010
C7719	A	9/15/10	Installed 2010
C7720	A	9/15/10	Installed 2010
C7724	A	9/15/10	Installed 2010
C7725	A	9/15/10	Installed 2010
C7726	A	9/15/10	Installed 2010
C7780	A	9/15/10	Installed 2010
C7781	A	9/15/10	Installed 2010
C7782	A	9/15/10	Installed 2010
100-K Area Segment			
AT-K-1-D	A	12/16/10	
C7641	Q	8/15/10	Installed 2010
	Q	8/29/10	Installed 2010
	Q	11/22/10	Installed 2010
	Q	12/19/10	Installed 2010
C7642	Q	8/15/10	Installed 2010
	Q	8/29/10	Installed 2010
	Q	11/22/10	Installed 2010
	Q	12/19/10	Installed 2010
C7643	Q	8/15/10	Installed 2010
	Q	8/29/10	Installed 2010
	Q	11/22/10	Installed 2010
	Q	12/19/10	Installed 2010
C6241	Q	2/1/10	
	Q	5/12/10	
	Q	8/15/10	
AT-K-2-D	A	12/16/10	
AT-K-3-D	A	12/16/10	
AT-K-3-S	A	1/12/10	
AT-K-3-M	A	1/12/10	
C6250	Q	2/1/10	
	Q	5/11/10	
	Q	8/15/10	
C6252	A	1/14/10	
C6253	A	1/12/10	
C6256*	A	1/14/10	Submerged 1/12/10
26-S	Q	2/1/10	Field readings only; SC low
	Q	5/11/10	Field readings only; SC low
	Q	8/15/10	
26-M	Q	2/1/10	Field readings only; SC low

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
	Q	5/11/10	Field readings only; SC low
	Q	8/15/10	Field readings only; SC low
26-D	Q	2/1/10	Field readings only; SC low
	Q	5/11/10	
	Q	8/15/10	
C6263	A	12/28/10	
	3	8/17/10	
	3	9/13/10	
C6264	A	12/28/10	
	3	8/17/10	
	3	9/13/10	
C6265	A	12/28/10	
	3	8/17/10	
	3	9/13/10	
100-N Area Segment			
C6317	Q	1/13/10	Field readings only
	Q	8/12/10	
	Q	9/13/10	
C6318	Q	1/13/10	Field readings only
	Q	8/12/10	
	Q	9/13/10	
C6319	Q	1/13/10	
	Q	8/12/10	
	Q	9/13/10	
C7934	Q	7/15/10	Installed 2010; under water 6/29/10
	Q	9/12/10	Installed 2010
	Q	12/28/10	Installed 2010
C7935	Q	7/15/10	Installed 2010; under water 6/29/10
	Q	9/12/10	Installed 2010
	Q	12/28/10	Installed 2010
C7936	Q	7/15/10	Installed 2010; under water 6/29/10
	Q	9/12/10	Installed 2010
	Q	12/28/10	Installed 2010
C7937	Q	7/15/10	Installed 2010; under water 6/29/10
	Q	9/12/10	Installed 2010
	Q	12/27/10	Installed 2010
C7938	Q	7/15/10	Installed 2010; under water 6/29/10
	Q	9/12/10	Installed 2010
	Q	12/27/10	Installed 2010
C7939	Q	7/15/10	Installed 2010; under water 6/29/10
	Q	9/12/10	Installed 2010

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
	Q	12/27/10	Installed 2010
C6320	Q	8/11/10	
	Q	9/9/10	
	Q	12/27/10	
C6321	Q	8/11/10	
	Q	9/9/10	
	Q	12/27/10	
C6322	Q	8/12/10	
	Q	9/9/10	
	Q	12/27/10	
C6352	A	1/14/10	Field readings only
C6132	Q	3/8/10	
	Q	9/16/10	
N116mArray-0A	Q/A	3/8/10	
	Q/A	6/28/10	Tube broken but sampleable
	Q/A	9/16/10	
C6135	Q	3/8/10	
	Q	6/29/10	
	Q	9/16/10	
N116mArray-1A	Q/A	3/8/10	
	Q/A	6/28/10	
	Q/A	9/16/10	
N116mArray-2A	Q/A	3/8/10	
	Q/A	6/28/10	
	Q/A	9/16/10	
N116mArray-3A	M/Q	2/1/10	
	M/Q	2/25/10	
	M/Q	3/8/10	
	M/Q	4/19/10	
	M/Q	5/11/10	
	M/Q	6/28/10	
	M/Q	7/12/10	
	M/Q	8/15/10	
	M/Q	9/16/10	
	M/Q	12/9/10	
N116mArray-4A	M/Q	2/1/10	
	M/Q	2/25/10	
	M/Q	3/8/10	
	M/Q	4/19/10	
	M/Q	5/11/10	
	M/Q	6/28/10	

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
	M/Q	7/12/10	
	M/Q	8/15/10	
	M/Q	9/16/10	
	M/Q	12/9/10	
NVP1-1	Q	5/12/10	No yield 3/5/10, 3/16/10
	Q	6/29/10	
NVP1-2	Q	1/13/10	No yield 12/19/09 or 12/29/09
	Q	5/12/10	No yield 3/5/10 or 3/16/10
	Q	6/29/10	
NVP1-3	Q	5/12/10	No yield 3/5/10 or 3/16/10
	Q	6/29/10	
NVP1-4	Q	3/5/10	
	Q	6/29/10	
NVP1-5	Q	3/5/10	
	Q	6/29/10	
	Q	9/16/10	
NVP2-116.3	Q	3/5/10	
	Q	6/29/10	
NVP2-116.0	M/Q	2/1/10	
	M/Q	2/25/10	
	M/Q	3/9/10	
	M/Q	4/19/10	
	M/Q	5/11/10	
	M/Q	6/29/10	
	M/Q	7/12/10	
	M/Q	8/15/10	
	M/Q	9/19/10	
	M/Q	12/9/10	
NVP2-115.7	Q	3/5/10	
	Q	6/29/10	
	Q	9/19/10	
NVP2-115.4	Q	3/5/10	
	Q	6/29/10	
	Q	9/19/10	
NVP2-115.1	Q	3/5/10	
	Q	6/29/10	
	Q	9/19/10	
N116mArray-6A	M	2/1/10	
	M	3/9/10	
	M	4/19/10	
	M	5/11/10	

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
	M	6/28/10	
	M	7/12/10	
	M	8/15/10	
	M	9/19/10	
	M	12/9/10	
N116mArray-8A	Q/A	3/8/10	
	Q/A	6/28/10	
	Q/A	9/19/10	
N116mArray-8.5A	Q/A	3/9/10	
	Q/A	6/28/10	
	Q/A	9/19/10	
N116mArray-9A	Q/A	3/9/10	
	Q/A	6/28/10	
N116mArray-10A	Q/A	3/16/10	No yield 3/9/10
	Q/A	6/28/10	
	Q/A	9/19/10	
N116mArray-11A	Q/A	3/16/10	No yield 3/9/10
	Q/A	6/28/10	
	Q/A	9/19/10	
N116mArray-12A	Q/A	3/9/10	
	Q/A	6/28/10	
N116mArray-13A	Q/A	3/9/10	
C6323	A	1/14/10	Field readings only
C6324	A	1/14/10	Field readings only
C6325	A	1/13/10	
N116mArray-14A	Q	3/9/10	
	Q	6/28/10	
N116mArray-15A	Q	3/16/10	No yield 3/9/10
	Q	6/28/10	
	Q	9/19/10	
100-D Area Segment			
C7645	Q	7/23/10	Installed 2010
	Q	8/29/10	Installed 2010
	Q	12/14/10	Installed 2010
C7646	Q	7/23/10	Installed 2010
	Q	8/29/10	Installed 2010
	Q	12/14/10	Installed 2010
C7647	Q	7/23/10	Installed 2010
	Q	8/29/10	Installed 2010
	Q	12/14/10	Installed 2010
C7648	Q	7/23/10	Installed 2010

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
	Q	8/29/10	Installed 2010
	Q	12/14/10	Installed 2010
C6266	Q	4/13/10	
	Q	8/19/10	
C6267	Q	4/13/10	
	Q	8/19/10	
C6268	Q/A	4/13/10	
	Q/A	8/19/10	
C6269	Q	4/13/10	
	Q	8/19/10	
C6270	Q	4/13/10	
	Q	8/19/10	
C6271	Q/A	4/13/10	
	Q/A	8/19/10	
DD-44-3	Q/A	2/2/10	
	Q/A	4/15/10	
	Q/A	9/20/10	
DD-44-4	Q/A	2/2/10	
	Q/A	4/15/10	
	Q/A	9/20/10	
DD-43-2	Q	2/2/10	
	Q	4/15/10	
	Q	9/20/10	
DD-43-3	Q/A	2/2/10	
	Q/A	4/15/10	
	Q/A	9/20/10	
DD-42-2	Q	1/21/10	Field readings only; low SC
	Q	4/15/10	
	Q	8/19/10	
DD-42-3	Q	1/21/10	
	Q	4/15/10	
	Q	8/19/10	
DD-42-4	Q/A	1/21/10	
	Q/A	4/15/10	
	Q/A	8/19/10	
DD-41-1	Q	1/21/10	Field readings only; low SC
	Q	4/13/10	Field readings only; low SC
	Q	8/19/10	Field readings only; low SC
DD-41-2	Q/A	8/19/10	
DD-41-3	Q	1/21/10	
	Q	4/13/10	

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
	Q	8/19/10	
REDOX-4-3.0	Q	1/21/10	
	Q	4/15/10	
REDOX-4-6.0	Q/A	1/21/10	
	Q/A	4/9/10	
REDOX-3-3.3	Q	1/21/10	
	Q	4/9/10	
	Q	9/19/10	
REDOX-3-4.6	Q/A	1/21/10	
	Q/A	4/9/10	
DD-39-1	Q	4/9/10	
	Q	8/17/10	
DD-39-2	Q	1/18/10	
	Q	4/9/10	
	Q	8/17/10	
DD-39-3	Q/A	1/18/10	
	Q/A	4/9/10	
	Q/A	8/17/10	
REDOX-2-3.0	Q	1/18/10	
	Q	4/9/10	
REDOX-2-6.0	Q/A	1/18/10	
	Q/A	4/9/10	
	Q/A	9/19/10	
REDOX-1-3.3	Q	2/2/10	Field readings only; low SC
	Q	4/19/10	
	Q	9/19/10	
REDOX-1-6.0	Q/A	2/2/10	Field readings only; low SC
	Q/A	4/19/10	
	Q/A	9/19/10	
36-S	A	11/10/10	
36-M	A	11/10/10	
38-M	A	11/10/10	
38-D	A	11/10/10	Scheduled for field readings only
100-H Area Segment			
C5632	A	1/4/10	Field readings only; low SC
C5633	A	1/4/10	
C5634	A	1/4/10	
C5635	A	1/4/10	Field readings only; low SC
C5636	A	1/4/10	
C5637	A	1/4/10	
C5638	A	1/6/10	

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
C5641	A	1/6/10	
C5673	A	1/6/10	Field readings only; low SC
C5674	A	1/6/10	
C5676	A	1/8/10	
C5677	A	1/8/10	
C5678	A	1/8/10	
C5679	A	1/4/10	
C5680	A	1/4/10	
C5681	A	1/4/10	
44-M	A	11/10/10	
45-S	A	1/8/10	
	A	11/10/10	
45-M	A	1/8/10	
	A	11/10/10	
45-D	A	1/8/10	
	A	11/10/10	
C7649	Q	8/10/10	Installed 2010
	Q	9/15/10	Installed 2010
	Q	12/16/10	Installed 2010
C7650	Q	8/10/10	Installed 2010
	Q	9/15/10	Installed 2010
	Q	12/16/10	Installed 2010
100-F Area Segment			
AT-F-2-M	A	1/29/10	
200-PO-1 Operable UnitSegment			
C6378	A	1/29/10	
300 Area Segment			
AT-3-1-S	A	1/11/10	
AT-3-1-M	SA	1/11/10	
	SA	3/10/10	
AT-3-1-D(1)	A	1/11/10	
AT-3-2-M	SA	3/10/10	
C6341	SA	3/10/10	
C6342	SA	3/10/10	
C6343	SA	3/10/10	
AT-3-3-S	SA	3/10/10	
AT-3-3-M	SA	3/10/10	
AT-3-3-D	SA	3/17/10	No yield 3/10/10
C6344	SA	1/11/10	
	SA	3/10/10	
AT-3-4-S	SA	3/10/10	

Table C-2. (Cont.)

Tube Name	Frequency	CY 2010 Sample Dates	Comments
AT-3-4-D	SA	3/10/10	
C6347	SA	3/11/10	
C6348	SA	3/11/10	
AT-3-5-S	SA	3/11/10	Stopped producing water; partial sample
C6350	SA	3/11/10	
C6351	SA	3/11/10	
AT-3-6-S	SA	3/11/10	
AT-3-6-D	SA	3/11/10	
AT-3-7-M	SA	3/11/10	
AT-3-7-D	SA	3/11/10	
AT-3-8-S	SA	3/11/10	

Notes: Aquifer tubes are listed in order, upstream to downstream. Alternating shaded and unshaded bands indicate tubes in clusters.

A = annually

M = monthly

Q = quarterly

SA = semiannually

SC = specific conductance

Table C-3. Summary Statistics for Percent Change in Specific Conductance

Count	333
Average	-0.00503
Standard deviation	0.055478
Coefficient of variation	-1102.47%
Minimum	-0.49802
Maximum	0.36957
Range	0.86759
Standard skewness	-27.9229
Standard kurtosis	162.846

Table C-4. Results of t-Test on Percentage Change

Null hypothesis	Mean = 0.0
Alternative	Not equal
Computed t statistic	-1.65522
P-value	0.0988239
Do not reject the null hypothesis for alpha = 0.05	

Table C-5. Shapiro-Wilk Test of Normality for Percent Change Conductivity

Test	Statistic	P-Value
Shapiro-Wilk	0.559484	0.0

Table C-6. Results of the Sign Test

Null hypothesis	Median = 0.0
Alternative	Not equal
Number of values below hypothesized median	131
Number of values above hypothesized median	148
Large sample test statistic (continuity correction applied)	0.957895
P-Value	0.338114
Do not reject the null hypothesis for alpha = 0.05	

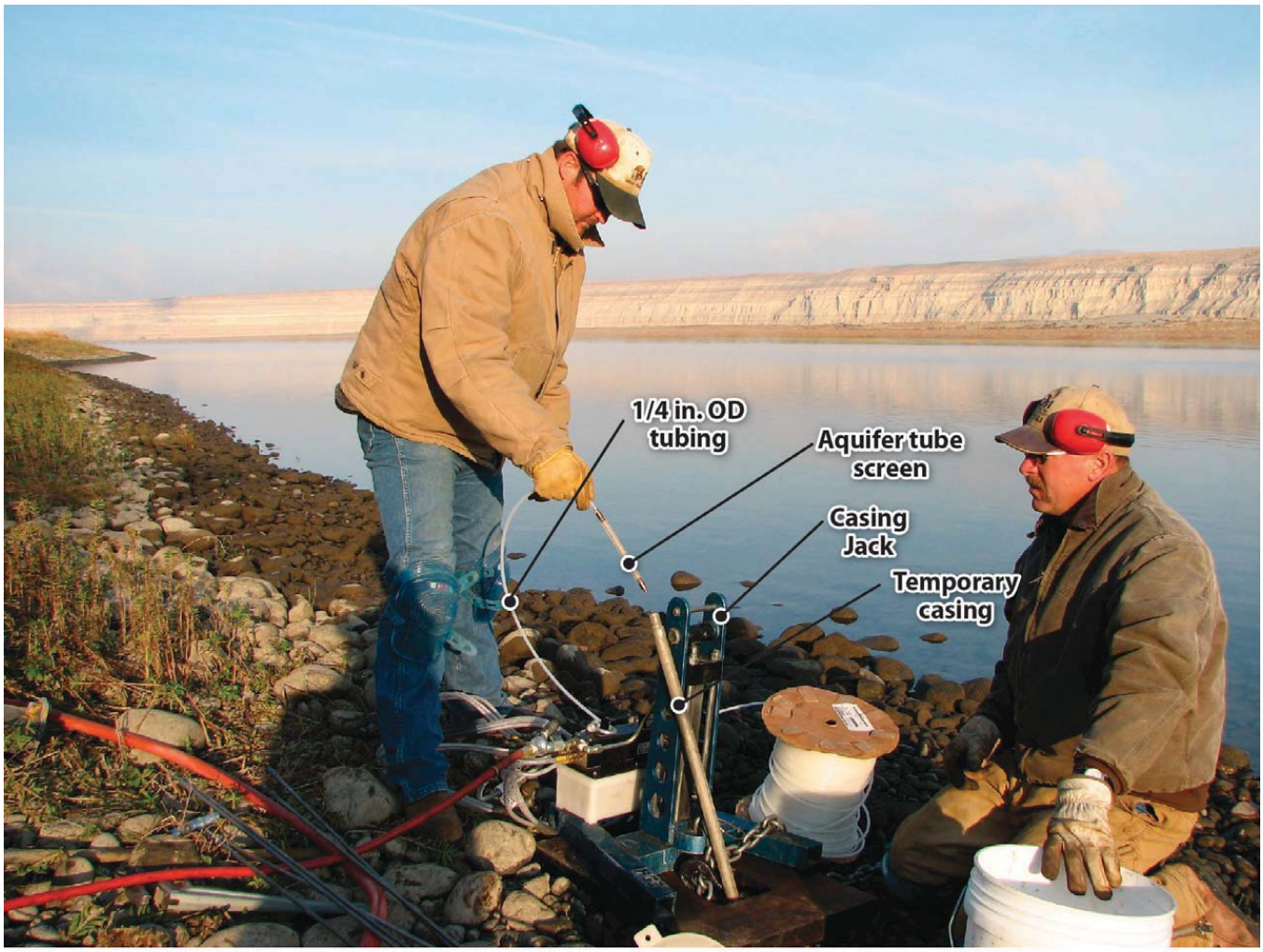
Table C-7. Results of the Signed-Rank Test

Null hypothesis	Median = 0.0
Alternative	Not equal
Average rank of values below hypothesized median	150.057
Average rank of values above hypothesized median	131.098
Large sample test statistic (continuity correction applied)	0.0941505
P-Value	0.924984
Do not reject the null hypothesis for alpha = 0.05	

Figure C-1. Driving the Temporary Casing for Aquifer Tube Installation

gwf10026

Figure C-2. Installation of Aquifer Tube and Screen



gwf10027

Figure C-3. Typical Aquifer Tube Completion

gwf10029

Figure C-4. Aquifer Tube Sampling Trips by Month, 2010

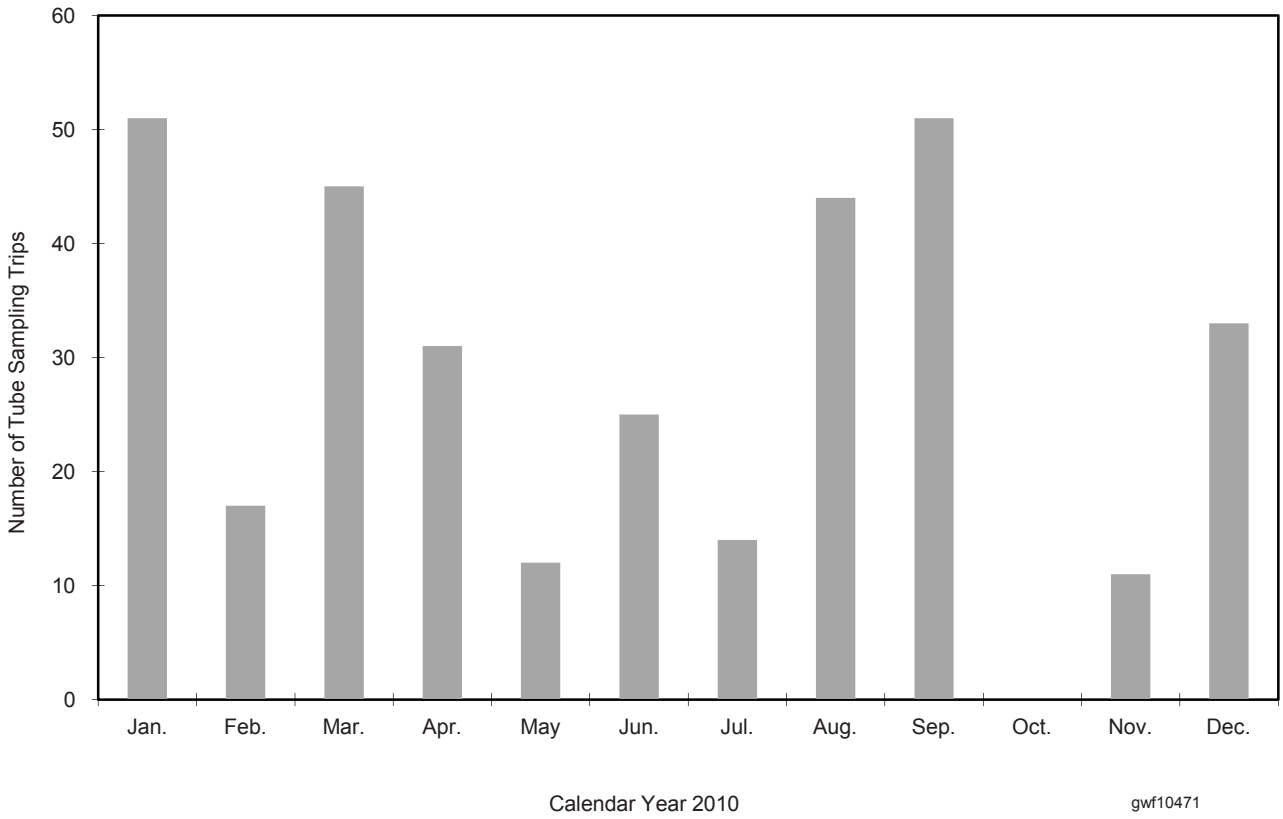


Figure C-5. 100-B/C Area River Stage and Aquifer Tube Sampling Dates, 2010

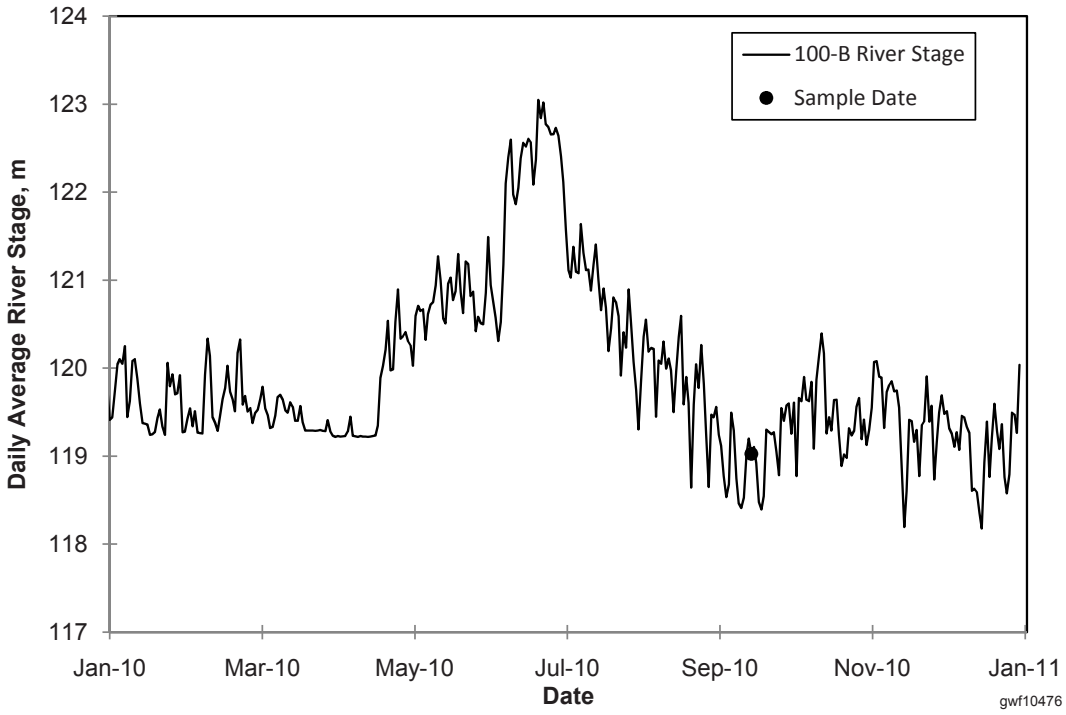


Figure C-6. 100-K Area River Stage and Aquifer Tube Sampling Dates, 2010

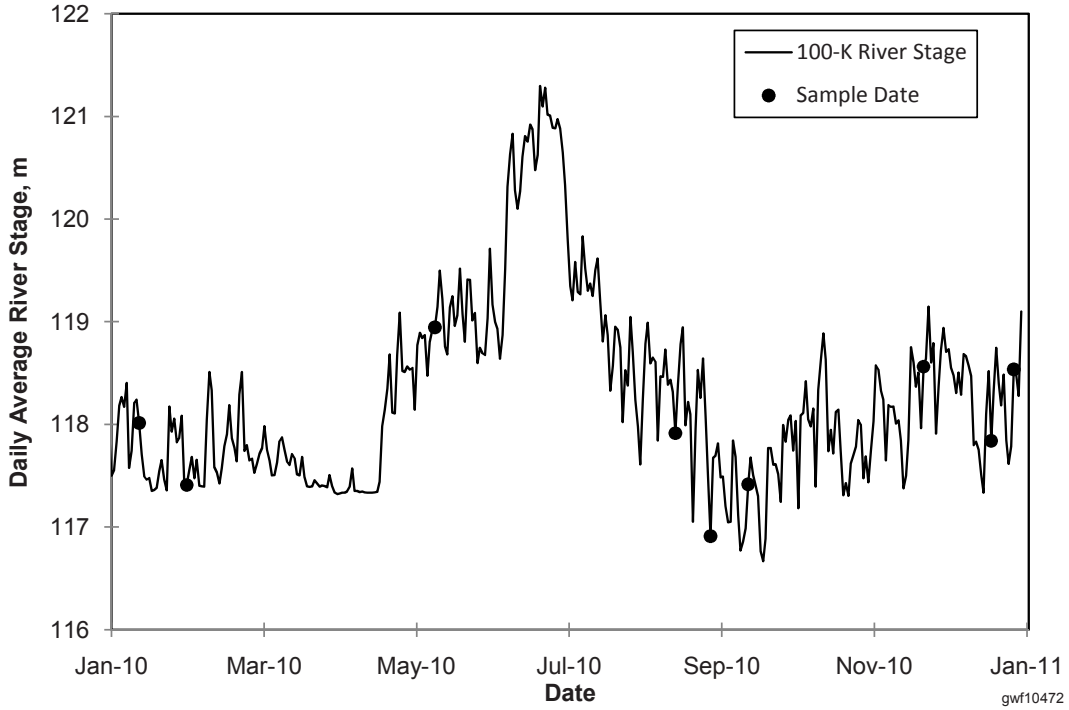


Figure C-7. 100-N Area River Stage and Aquifer Tube Sampling Dates, 2010

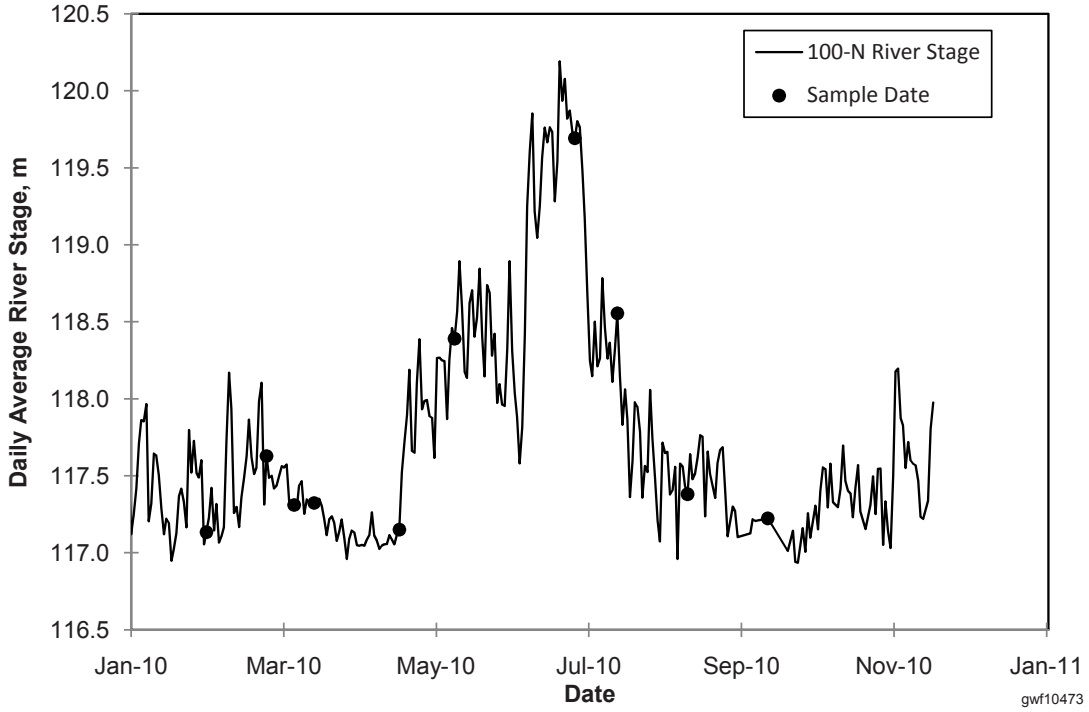


Figure C-8. 100-D Area River Stage and Aquifer Tube Sampling Dates, 2010

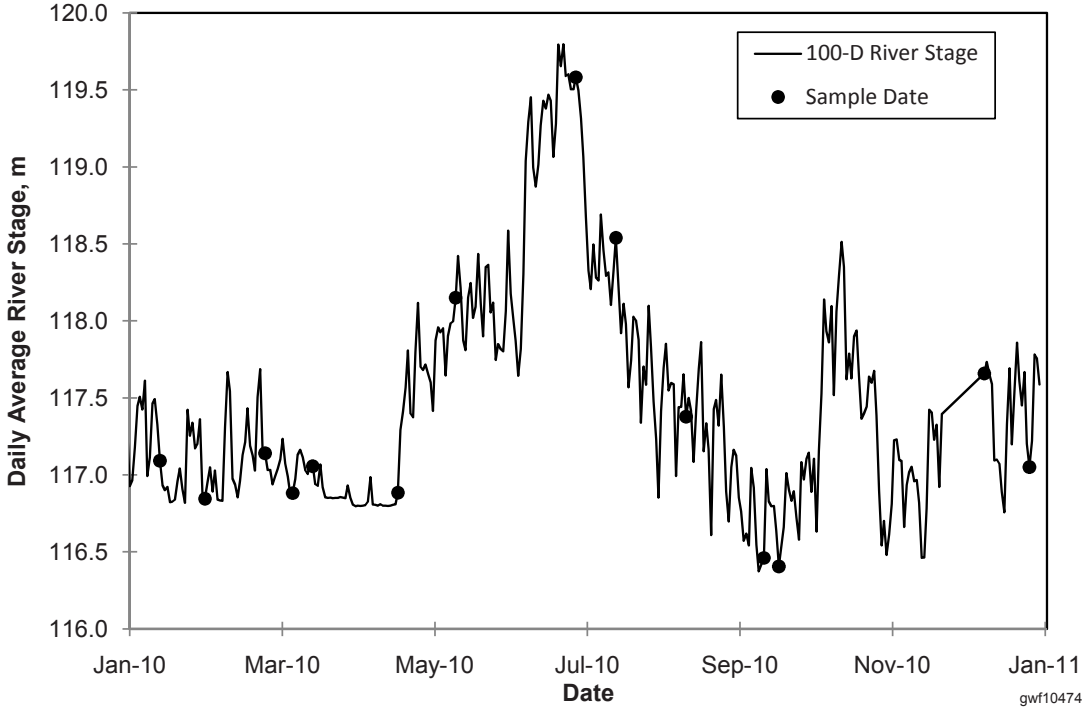


Figure C-9. 100-H Area River Stage and Aquifer Tube Sampling Dates, 2010

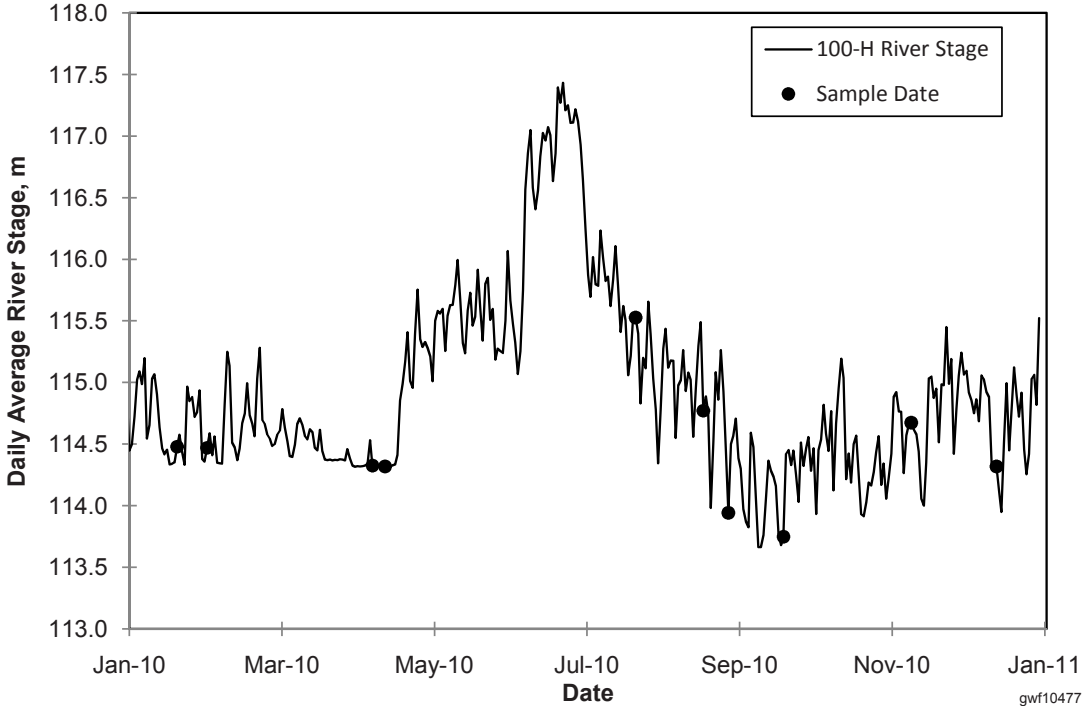


Figure C-10. 300 Area River Stage and Aquifer Tube Sampling Dates, 2010

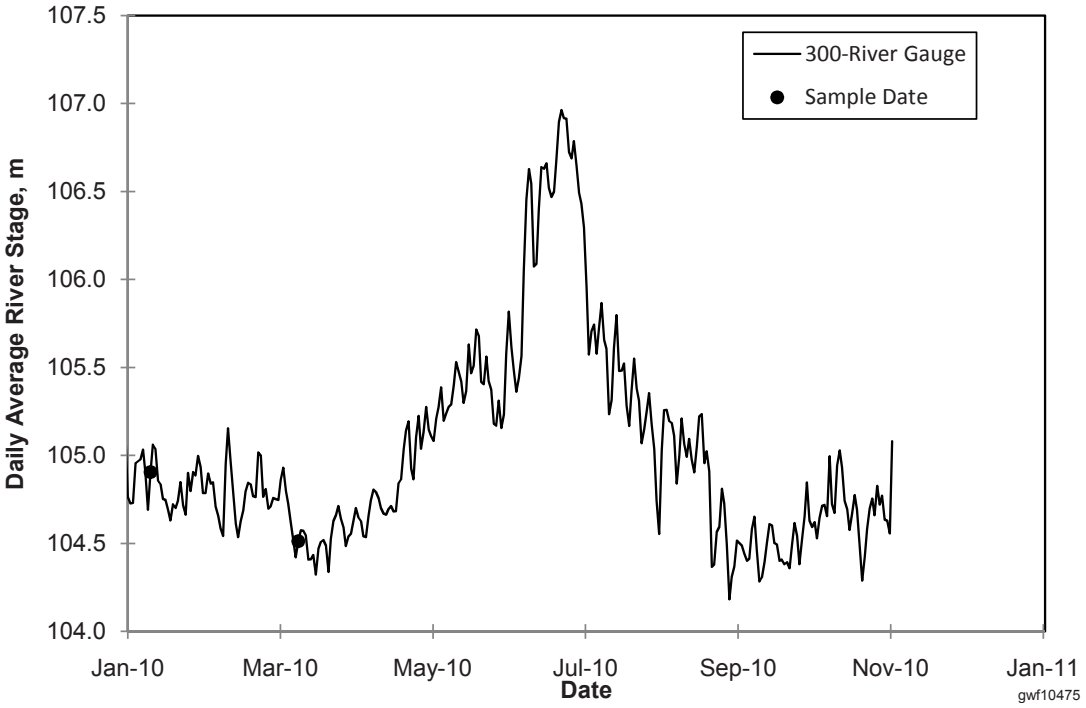


Figure C-11. Percent Change in Specific Conductance versus Elapsed Time Between Measurements

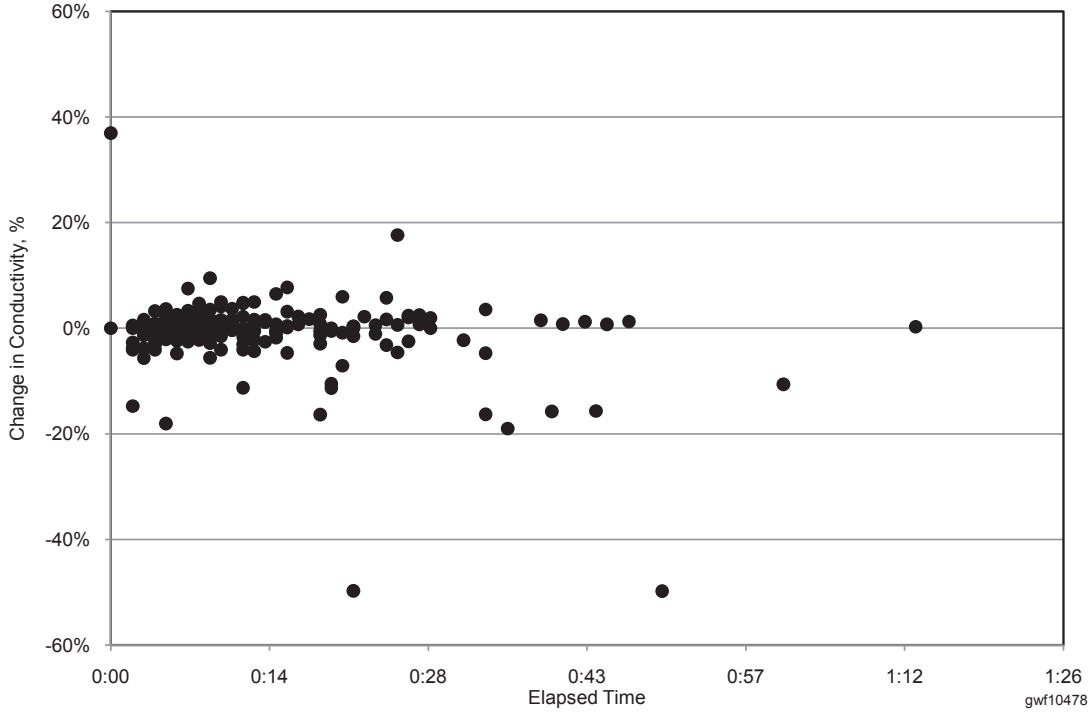
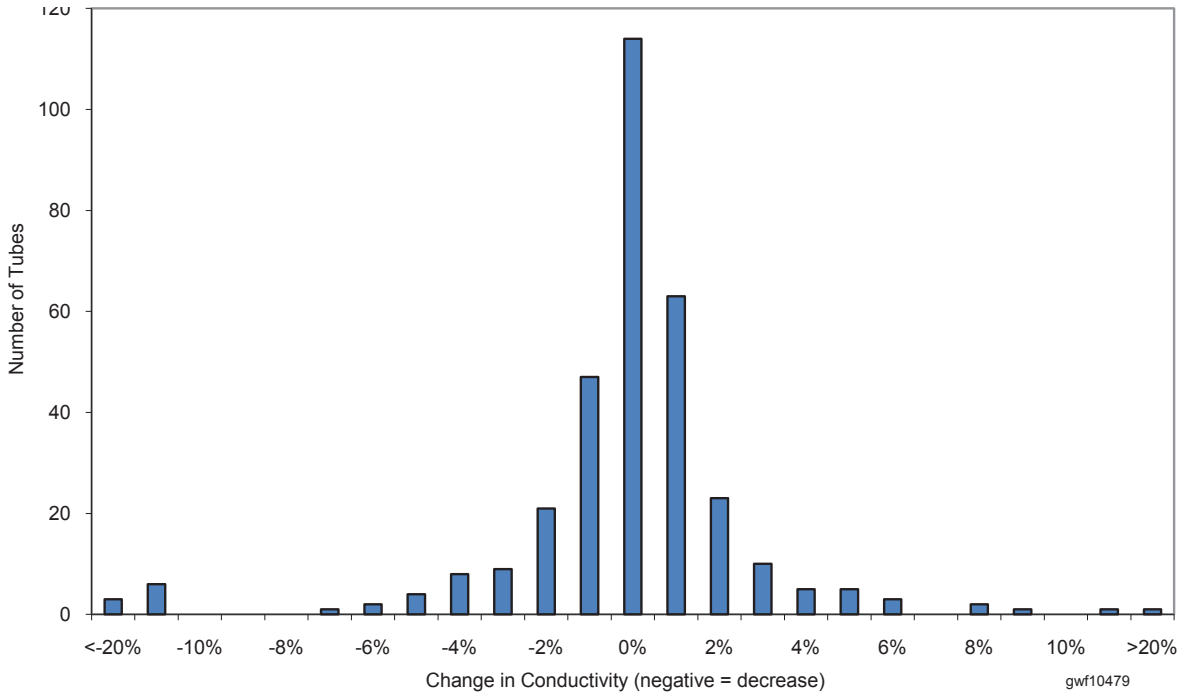


Figure C-12. Change in Specific Conductance in Aquifer Tubes



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