

Model Archive Summary for Total Dissolved Solids at Station 07143672; Little Arkansas River at Highway 50 near Halstead, Kansas

This model archive summary (MAS) summarizes the total dissolved solids (DS) model developed to compute hourly DS from January 1, 2007 onward. This model supersedes all models used from 1999 to 2007.

Site and Model Information

Site number: 07143672

Site name: Little Arkansas River at Highway 50 near Halstead, Kansas

Location: Latitude 38°01'43", longitude 97°32'25" referenced to North American Datum of 1927, in NW 1/4 NE 1/4 NE 1/4 sec.28, T.23 S., R.2 W., Harvey County, Kansas, Hydrologic Unit 11030012.

Equipment: A YSI 6600 water-quality monitor equipped with sensors for water temperature, specific conductance (SC), dissolved oxygen, and pH, and a YSI Model 6136 turbidity sensor. The monitor is housed in a 4-inch plastic pipe. Readings from the YSI 6600 are recorded every 30 minutes and transmitted by way of satellite, hourly.

Date model was created: April 17, 2015

Model calibration data period: May 12, 1998 – August 28, 2014

Model application date: January 1, 2007 onward

Model Data

All data were collected using U.S. Geological Survey (USGS) protocols and are stored in the National Water Information System (NWIS) database. The regression model is based on 150 concurrent measurements of total dissolved solids, streamflow, and specific conductance collected from May 12, 1998 through August 28, 2014. Samples were collected throughout the range of continuously observed hydrologic conditions. There were no samples below laboratory reporting levels. Summary statistics and the complete model-calibration dataset are provided below. Potential outliers were identified where the Studentized residual was greater than 3 or less than negative 3 and the Cook's D value exceeded the outlier test criteria. Samples collected March 13, 2001 and May 26, 2005 were deemed outliers and were removed from the dataset.

Sampling Details

Cross-section samples are collected either from the downstream side of the bridge or instream, upstream of the bridge. Depending on stream depths and velocities, the equal-width-increment or multi-vertical method, or on occasion a single-point vertical, is used, and samples typically are composited for analysis. Cross-section samples are obtained during all discrete sample collections approximately every 2-3 months and during selected runoff events. A FISP US D-95 with a teflon bottle, cap, and nozzle depth integrating sampler is used from the bridge; and the DH-81 with a teflon bottle, cap, and nozzle hand sampler or a grab sample with a teflon bottle for wading samples. Samples are analyzed at the USGS National Water Quality Laboratory in Lakewood, Colorado; the Wichita Municipal Water and Wastewater Laboratory, Wichita, Kansas; the USGS Ohio Microbiology Lab in Columbus, Ohio; the USGS Organic Lab in Lawrence, Kansas; and ALS Environmental at various locations in the U.S.

Model Development

Regression analysis was done using R by examining SC, streamflow, and other continuously measured data as explanatory variables for estimating total dissolved solids. A variety of models that predict DS and models that predict $\log_{10}(\text{DS})$ were evaluated. The distribution of residuals was examined for normality, and plots of residuals (the difference between the measured and predicted values) as compared to predicted DS were examined for homoscedasticity (meaning that their departures from zero did not change substantially over the

range of predicted values). This comparison led to the conclusion that the most appropriate and reliable model would be one that estimated DS.

Specific conductance was selected as the best predictor of DS based on residual plots, relatively high adjusted coefficient of determination (adjusted R^2) and relatively low model standard percentage error ($MSPE$), prediction error sum of squares ($PRESS$), and Mallow's C_p . Values for all of the aforementioned statistics and metrics were computed for various models and are included below along with all relevant sample data and more in-depth statistical information.

Model Summary

Summary of final regression analysis for total dissolved solids at site number 07143672.

Total dissolved solids-based model:

$$DS = 0.566 \times SC + 18.6$$

where

DS = total dissolved solids in milligrams per liter (mg/L); and,

SC = specific conductance in microsiemens per centimeter at 25 degrees Celsius ($\mu S/cm$).

Specific conductance makes physical and statistical sense as an explanatory variable for dissolved solids. It makes physical sense because dissolved solids are partially comprised of ions and salts, which affect the conductivity of the water. This correlates well with SC because SC is a measure of the conductivity of water. Specific conductance makes statistical sense as an explanatory variable because it resulted in a model with low standard error, Mallow's C_p and $PRESS$ values, and high R^2 values. The model selected was the simplest model (one explanatory variable) even though some of the other models were marginally better statistically.

Previous Models

<u>Model</u>	<u>Start year</u>	<u>End year</u>	<u>Model</u>
1.0	1999	2006	$DS = 0.551 \times SC + 25.3$
1.1	2007	--	$DS = 0.566 \times SC + 18.6$

Total Dissolved Solids Record

The DS record is computed using this regression model and stored at the National Real-Time Water Quality (NRTWQ) Web site. Data are computed at hourly intervals. The complete water-quality record can be found at <http://nrtwq.usgs.gov/ks>.

Remarks

None

Computed: Patrick Eslick

Reviewed: Patrick Rasmussen

Model Statistics, Data, and Plots

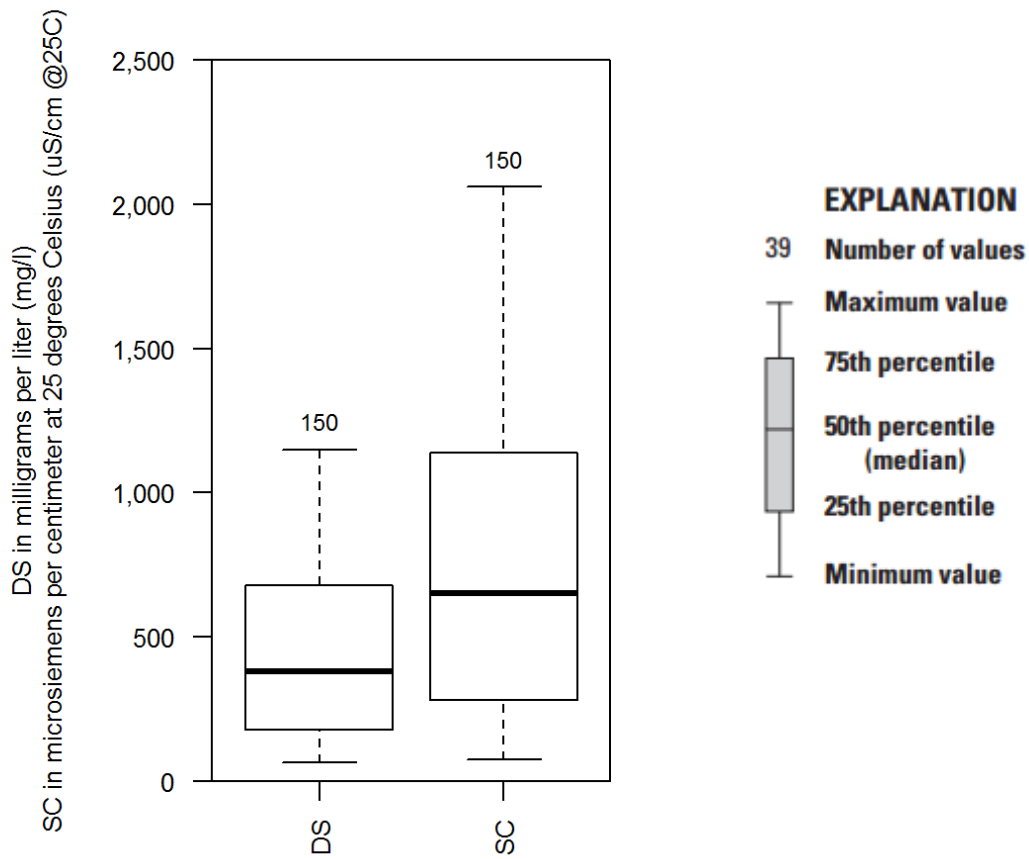
Model

$$DS = + 0.566 * SC + 18.6$$

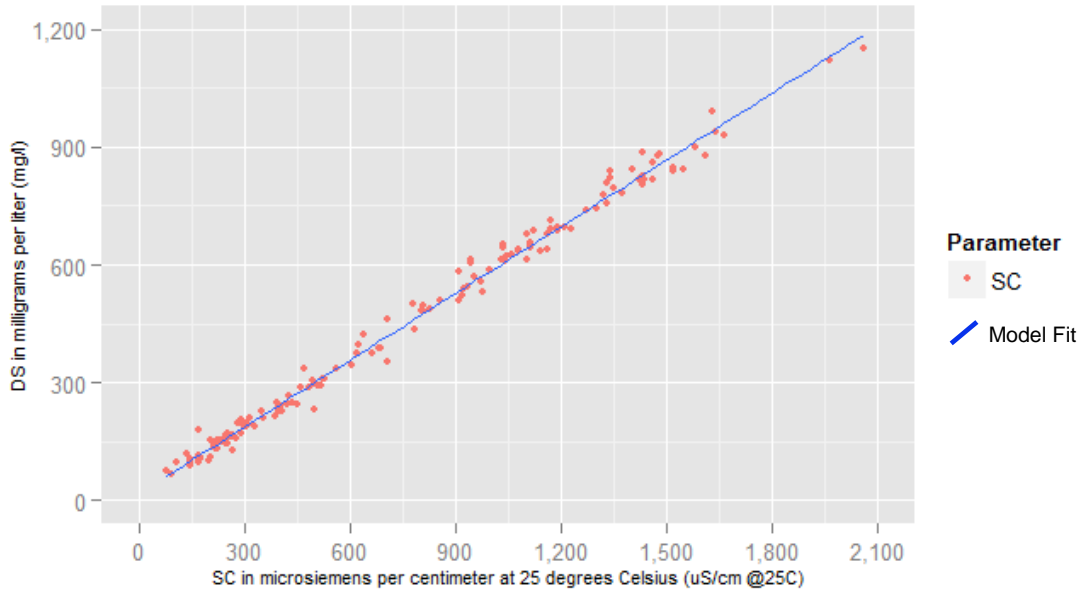
Variable Summary Statistics

	DS	SC
Minimum	66	75.7
1st Quartile	178	282.0
Median	382	651.0
Mean	441	746.0
3rd Quartile	680	1140.0
Maximum	1150	2060.0

Box Plots



Exploratory Plot



Basic Model Statistics

Number of Observations	150
Standard error (RMSE)	24.5
Upper Model standard percentage error (MSPE)	5.55
Lower Model standard percentage error (MSPE)	5.55
Coefficient of determination (R^2)	0.992
Adjusted Coefficient of Determination (Adj. R^2)	0.992

Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t)
(Intercept)	18.600	3.65000	5.1	1.04e-06
SC	0.566	0.00409	138.0	1.85e-158

Correlation Matrix

	Intercept	E.vars
Intercept	1.000	-0.836
E.vars	-0.836	1.000

Outlier Test Criteria

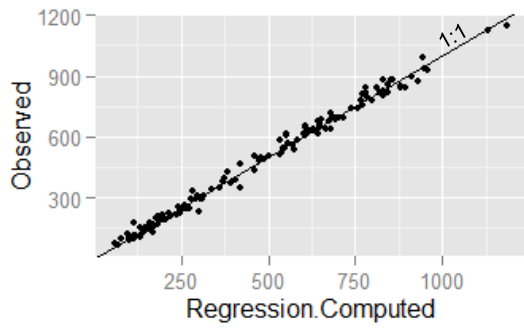
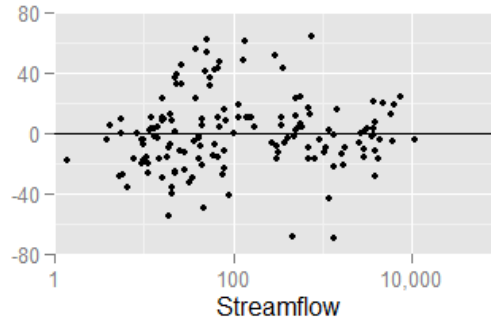
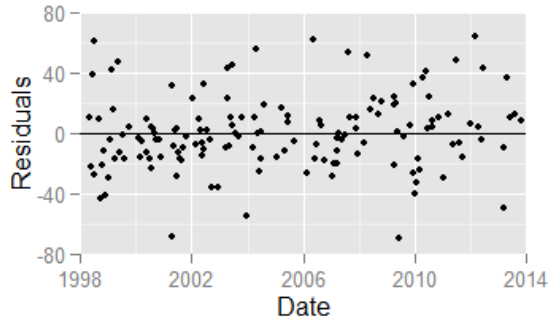
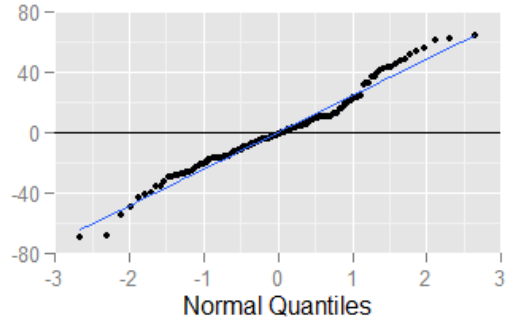
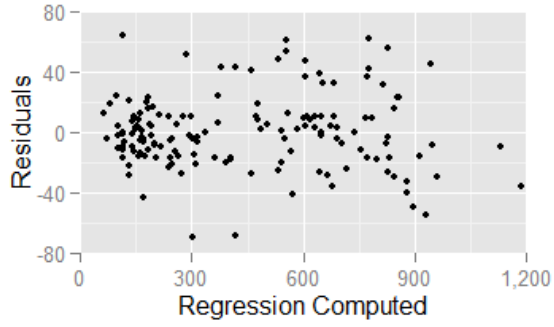
Leverage	Cook's D	DFFITS
0.0200000	0.1054351	0.1632993

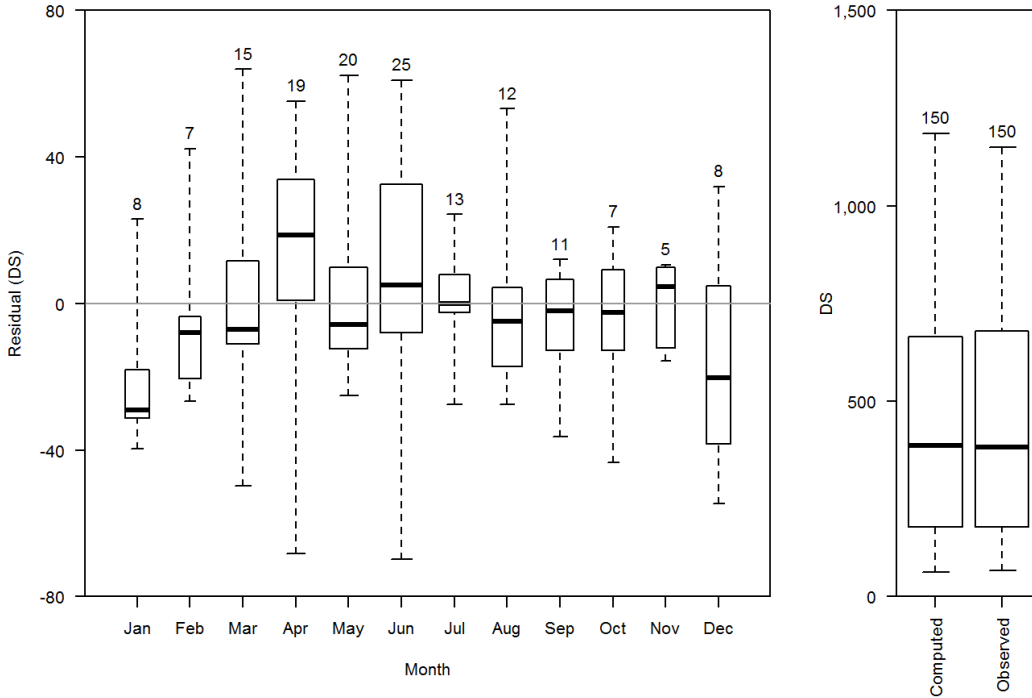
Flagged Observations

	DS Estimate	Residual	Standard Residual	Studentized Residual	Leverage	Cook's D	DFFITS	
6/25/1998 10:31	615	554.0	61.050	2.5010	2.5470	0.007767	0.024480	0.22530
10/1/1998 11:21	127	170.4	-43.430	-1.7840	-1.7980	0.013050	0.021050	-0.20670

1/6/1999 10:51	930	959.8	-29.850	-1.2370	-1.2390	0.030020	0.023680	-0.21800
2/19/1999 10:16	820	777.7	42.280	1.7400	1.7520	0.016490	0.025380	0.22690
3/11/1999 11:11	860	844.7	15.340	0.6327	0.6314	0.020800	0.004251	0.09201
5/20/1999 12:31	652	605.0	46.970	1.9260	1.9440	0.008992	0.016820	0.18510
11/30/2000 11:11	898	913.7	-15.680	-0.6485	-0.6472	0.026050	0.005623	-0.10580
4/12/2001 11:51	351	419.4	-68.360	-2.7990	-2.8670	0.006709	0.026460	-0.23560
4/26/2001 10:11	844	812.7	31.250	1.2880	1.2900	0.018650	0.015750	0.17790
5/9/2001 9:56	939	947.3	-8.292	-0.3434	-0.3424	0.028910	0.001755	-0.05907
1/9/2002 9:51	880	857.0	22.970	0.9477	0.9474	0.021680	0.009950	0.14100
12/17/2002 10:11	1150	1186.0	-35.600	-1.4940	-1.5010	0.054800	0.064740	-0.36130
4/16/2003 11:31	877	854.3	22.710	0.9370	0.9366	0.021480	0.009636	0.13880
6/24/2003 9:26	988	942.7	45.260	1.8740	1.8900	0.028510	0.051520	0.32380
12/11/2003 9:46	876	930.7	-54.680	-2.2630	-2.2950	0.027470	0.072300	-0.38570
4/26/2004 10:31	884	828.7	55.290	2.2790	2.3120	0.019700	0.052200	0.32780
5/2/2006 10:41	840	777.7	62.280	2.5630	2.6130	0.016490	0.055080	0.33840
8/13/2007 11:00	606	552.8	53.180	2.1790	2.2070	0.007745	0.018530	0.19500
4/14/2008 10:05	335	283.2	51.760	2.1220	2.1480	0.008843	0.020080	0.20280
6/16/2009 10:21	232	301.9	-69.860	-2.8630	-2.9360	0.008360	0.034560	-0.26960
1/6/2010 10:11	840	879.7	-39.690	-1.6390	-1.6490	0.023360	0.032130	-0.25500
1/19/2010 11:46	847	879.7	-32.690	-1.3500	-1.3540	0.023360	0.021800	-0.20940
4/13/2010 9:21	809	772.1	36.940	1.5200	1.5270	0.016170	0.018980	0.19570
1/19/2011 9:46	816	845.7	-29.700	-1.2250	-1.2270	0.020870	0.015990	-0.17910
6/20/2011 10:01	583	534.6	48.400	1.9830	2.0030	0.007421	0.014690	0.17320
3/1/2012 10:01	178	114.1	63.940	2.6310	2.6850	0.015980	0.056200	0.34220
3/12/2013 9:31	844	893.8	-49.750	-2.0560	-2.0790	0.024450	0.052960	-0.32910
3/13/2013 11:51	1120	1130.0	-9.968	-0.4169	-0.4157	0.047870	0.004369	-0.09322

Statistical Plots





Models Considered

Model Formula	Number of Variables	Standard Error	R2	Adjusted R2	Cp	PRESS	VIF	MSPE
DS ~ SC	1	20.4	98.8	98.8	4.02	90100	<NA>	± 5.6
DS ~ logSC	1	56.3	90.7	90.6	1430	695000	<NA>	± 15
DS ~ logQ	1	116	60.1	59.9	6790	2940000	<NA>	± 32
DS ~ SC + logQ	2	20.3	98.8	98.8	2.41	89600	2.46	± 5.5
DS ~ SC + logSC	2	20.5	98.8	98.8	5.98	90800	12	± 5.6
DS ~ Q + SC	2	20.5	98.8	98.8	6.01	90700	1.57	± 5.6
DS ~ Q + SC + logQ	3	20.3	98.8	98.8	3.12	89700	2.21	± 5.5
DS ~ SC + logSC + logQ	3	20.3	98.8	98.8	3.45	90000	12.5	± 5.5
DS ~ Q + SC + logSC	3	20.5	98.8	98.8	7.96	91400	3.35	± 5.6
DS ~ Q + SC + logSC + logQ	4	20.3	98.8	98.8	5	90400	3.57	± 5.6

Model-Calibration Data Set

	Date	DS	SC	Computed DS	Residual	Normal Quantiles	Censored Values
0							
1	1998-05-12	658	1110	647.4	10.6	0.673	--
2	1998-05-14	111	202	133	-22	-1.06	--
3	1998-06-15	680	1100	641.8	38.2	1.34	--
4	1998-06-25	615	945	554	61	2.11	--
5	1998-07-13	246	450	273.5	-27.5	-1.26	--
6	1998-09-14	611	1030	602.1	8.89	0.495	--
7	1998-10-01	127	268	170.4	-43.4	-1.87	--
8	1998-10-22	226	404.5	247.8	-21.8	-1.03	--
9	1998-11-06	104	172	116.1	-12.1	-0.514	--
10	1998-12-03	532	978.5	573	-41	-1.78	--
11	1999-01-06	930	1661	959.8	-29.8	-1.47	--

12	1999-02-01	165	265.3	168.9	-3.93	-0.125	--
13	1999-02-19	820	1340	777.7	42.3	1.42	--
14	1999-03-11	860	1458	844.7	15.3	0.828	--
15	1999-04-07	344	603.6	360.6	-16.6	-0.738	--
16	1999-05-20	652	1035	605	47	1.64	--
17	1999-05-24	133	224.6	145.8	-12.8	-0.572	--
18	1999-07-19	113	169	114.4	-1.35	0.00834	--
19	1999-08-04	98	170.6	115.3	-17.3	-0.828	--
20	1999-09-28	105	145	100.8	4.25	0.314	--
21	2000-02-08	826	1431	829.1	-3.08	-0.0919	--
22	2000-03-06	143	247.5	158.8	-15.8	-0.673	--
23	2000-03-27	156	252	161.4	-5.4	-0.244	--
24	2000-05-19	776	1320	766.4	9.61	0.514	--
25	2000-05-30	244	420.6	256.9	-12.9	-0.592	--
26	2000-06-26	187	326.9	203.8	-16.8	-0.782	--
27	2000-07-19	610	1038	606.4	3.56	0.262	--
28	2000-07-27	213	385.2	236.8	-23.8	-1.09	--
29	2000-08-15	633	1080	630.4	2.57	0.193	--
30	2000-09-07	647	1110	647.4	-0.427	0.0417	--
31	2000-09-25	688	1190	692.7	-4.75	-0.176	--
32	2000-10-27	241	399.6	245	-3.97	-0.142	--
33	2000-11-30	898	1580	913.7	-15.7	-0.653	--
34	2001-04-12	351	707.4	419.4	-68.4	-2.3	--
35	2001-04-26	844	1402	812.7	31.3	1.16	--
36	2001-05-09	939	1639	947.3	-8.29	-0.367	--
37	2001-06-01	585	996.4	583.1	1.9	0.142	--
38	2001-06-11	159	242.9	156.2	2.8	0.227	--
39	2001-06-22	103	198.6	131.1	-28.1	-1.34	--
40	2001-07-12	556	971.2	568.8	-12.8	-0.553	--
41	2001-08-01	755	1330	772.2	-17.2	-0.805	--
42	2001-08-30	780	1375	797.7	-17.7	-0.901	--
43	2001-09-18	107	172.7	116.4	-9.42	-0.403	--
44	2001-10-30	645	1110	647.4	-2.43	-0.025	--
45	2002-01-09	880	1480	857	23	1.06	--
46	2002-02-20	815	1420	823	-8.04	-0.349	--
47	2002-04-10	793	1350	783.4	9.61	0.533	--
48	2002-04-22	151	230.2	149	2	0.159	--
49	2002-05-14	310	526.1	316.6	-6.65	-0.279	--
50	2002-05-23	292	509.5	307.3	-15.3	-0.632	--
51	2002-06-06	714	1170	681.4	32.6	1.22	--
52	2002-06-17	90	144.7	100.6	-10.6	-0.476	--
53	2002-07-09	489	826.6	486.9	2.13	0.176	--
54	2002-08-20	297	500	301.8	-4.84	-0.21	--
55	2002-09-18	641	1163	677.3	-36.3	-1.64	--
56	2002-12-17	1150	2060	1186	-35.6	-1.58	--
57	2003-03-24	208	351.5	217.7	-9.74	-0.421	--
58	2003-04-16	877	1475	854.3	22.7	1.03	--
59	2003-04-22	462	707	419.1	42.9	1.47	--
60	2003-05-15	193	323.8	202	-9.04	-0.385	--
61	2003-05-28	307	491.5	297.1	9.93	0.553	--
62	2003-06-10	508	855	503	5.03	0.367	--
63	2003-06-24	988	1631	942.7	45.3	1.58	--
64	2003-07-30	738	1270	738.1	-0.0664	0.0752	--
65	2003-09-02	189	304.4	191.1	-2.08	-0.00834	--
66	2003-10-15	155	222	144.4	10.6	0.695	--
67	2003-12-11	876	1610	930.7	-54.7	-2.11	--
68	2004-03-09	131	216	141	-10	-0.458	--

69	2004-03-29	693	1172	682.5	10.5	0.632	--
70	2004-04-26	884	1430	828.7	55.3	1.98	--
71	2004-05-13	336	560.3	336	-0.00183	0.0919	--
72	2004-05-26	509	910.2	534.2	-25.2	-1.16	--
73	2004-06-16	541	921.4	540.6	0.403	0.109	--
74	2004-06-21	227	398.5	244.4	-17.4	-0.852	--
75	2004-07-26	97	105.7	78.48	18.5	0.901	--
76	2005-01-28	249	435.5	265.3	-16.3	-0.716	--
77	2005-03-25	212	313	195.9	16.1	0.876	--
78	2005-05-11	743	1300	755.1	-12.1	-0.533	--
79	2005-06-07	226	346.3	214.8	11.2	0.738	--
80	2005-06-14	147	214	139.8	7.16	0.421	--
81	2005-08-31	239	398	244.1	-5.08	-0.227	--
82	2006-02-07	615	1100	641.8	-26.8	-1.22	--
83	2006-05-02	840	1340	777.7	62.3	2.3	--
84	2006-06-08	388	683	405.5	-17.5	-0.876	--
85	2006-06-26	193	322	201	-8.03	-0.331	--
86	2006-07-28	167	248.1	159.1	7.86	0.439	--
87	2006-08-23	265	425.8	259.8	5.16	0.385	--
88	2006-09-27	389	685.3	406.8	-17.8	-0.926	--
89	2007-01-10	636	1140	664.4	-28.4	-1.38	--
90	2007-01-30	520	919.8	539.7	-19.7	-0.952	--
91	2007-03-12	374	662.3	393.8	-19.8	-0.979	--
92	2007-03-21	311	522.6	314.7	-3.65	-0.109	--
93	2007-03-27	171	290.2	183	-12	-0.495	--
94	2007-04-02	114	169	114.4	-0.351	0.0584	--
95	2007-04-18	163	260	165.9	-2.93	-0.0752	--
96	2007-05-25	66	92	70.73	-4.73	-0.159	--
97	2007-07-11	138	213	139.3	-1.28	0.025	--
98	2007-08-13	606	943	552.8	53.2	1.87	--
99	2007-09-05	620	1043	609.7	10.3	0.592	--
100	2007-11-27	641	1080	630.4	10.6	0.653	--
101	2007-12-04	696	1190	692.7	3.25	0.244	--
102	2007-12-12	147	251.1	160.9	-13.9	-0.612	--
103	2008-03-04	163	267.2	170	-6.97	-0.296	--
104	2008-04-14	335	467.1	283.2	51.8	1.78	--
105	2008-05-29	200	292.2	184.1	15.9	0.852	--
106	2008-06-30	206	291	183.5	22.5	1.01	--
107	2008-09-16	173	251.4	161	12	0.76	--
108	2008-10-17	154	202	133	21	0.979	--
109	2009-04-01	291	517.9	312	-21	-1.01	--
110	2009-04-06	496	809.7	477.3	18.7	0.926	--
111	2009-04-13	397	625	372.7	24.3	1.12	--
112	2009-04-30	198	282.5	178.6	19.4	0.952	--
113	2009-05-12	168	261.8	166.9	1.08	0.125	--
114	2009-06-16	232	500	301.9	-69.9	-2.65	--
115	2009-07-30	290	483.4	292.5	-2.49	-0.0417	--
116	2009-11-02	191	296.3	186.5	4.52	0.349	--
117	2009-12-01	685	1120	653.1	31.9	1.19	--
118	2009-12-17	802	1430	828.7	-26.7	-1.19	--
119	2010-01-06	840	1520	879.7	-39.7	-1.71	--
120	2010-01-19	847	1520	879.7	-32.7	-1.52	--
121	2010-02-11	815	1435	831.6	-16.6	-0.76	--
122	2010-02-23	691	1230	715.4	-24.4	-1.12	--
123	2010-04-13	809	1330	772.1	36.9	1.3	--
124	2010-06-01	501	779.3	460.1	40.9	1.38	--
125	2010-06-15	150	227	147.2	2.78	0.21	--

126	2010-07-07	120	136	95.68	24.3	1.09	--
127	2010-08-19	484	806.6	475.6	8.42	0.476	--
128	2010-08-25	155	234.3	151.4	3.64	0.279	--
129	2010-11-16	250	390.9	240	9.96	0.572	--
130	2011-01-19	816	1460	845.7	-29.7	-1.42	--
131	2011-03-07	570	951	557.4	12.6	0.805	--
132	2011-05-16	695	1207	702.4	-7.36	-0.314	--
133	2011-06-20	583	910.8	534.6	48.4	1.71	--
134	2011-08-11	111	173.8	117.1	-6.08	-0.262	--
135	2011-09-22	158	274.5	174.1	-16.1	-0.695	--
136	2011-12-21	376	619.8	369.8	6.24	0.403	--
137	2012-03-01	178	168.5	114.1	63.9	2.65	--
138	2012-04-18	196	306.1	192	3.98	0.296	--
139	2012-05-29	543	934.2	547.8	-4.84	-0.193	--
140	2012-06-18	424	639.8	381.1	42.9	1.52	--
141	2013-03-12	844	1545	893.8	-49.8	-1.98	--
142	2013-03-13	1120	1962	1130	-9.97	-0.439	--
143	2013-04-29	642	1036	605.4	36.6	1.26	--
144	2013-06-03	289	458.5	278.4	10.6	0.716	--
145	2013-07-30	74	75.73	61.51	12.5	0.782	--
146	2013-10-30	627	1060	619.1	7.9	0.458	--
147	2014-04-09	680	1160	675.8	4.25	0.331	--
148	2014-06-04	485	805	474.6	10.4	0.612	--
149	2014-06-12	98	145	100.8	-2.75	-0.0584	--
150	2014-08-28	434	782	461.6	-27.6	-1.3	--

Definitions

DS: Total dissolved solids in mg/l (70300)

SC: Specific conductance in uS/cm @25C (00095)