

SITE NUMBER—07144100

SITE NAME—Little Arkansas River near Sedgwick

DATE CREATED—4/10/2013

MODEL DEVELOPMENT DATA PERIOD—5/1/1998 – 9/22/2011

MODEL-CALIBRATION DATASET—All data were collected using U.S. Geological Survey (USGS) protocols and are stored in National Water Information System (NWIS) database. The regression model is based on 156 concurrent measurements of sulfate and specific conductance samples collected from 05-01-1998 through 09-22-2011. Samples were collected throughout the range of continuously observed hydrologic and specific conductance conditions. Specific conductance values are time-averaged, approved unit values corresponding with the duration of sample collection. Summary statistics and complete model-calibration dataset are provided. No sulfate values were deemed outliers.

MODEL DEVELOPMENT—Regression analysis was done using S-PLUS, R, and a spreadsheet macro that examined specific conductance as an explanatory variable for estimating sulfate. Different combinations of untransformed and \log_{10} -transformed data were evaluated. Specific conductance and sulfate were selected as the best model based on residual plots, model standard percentage error (*MSPE*), adjusted R^2 , prediction error sum of squares (*PRESS*), and Mallows' C_p . Model spreadsheet is archived and can be found at <http://nrtwq.usgs.gov/ks> for review, and contains all relevant sample data and more in-depth statistical information.

MODEL SUMMARY—Summary of final regression analysis for sulfate concentration at site number 07144100.

Specific conductance-based model:

$$\log_{10}(SO_4) = 1.13 \times \log_{10}(SC) - 1.59,$$

where

SO_4 = sulfate, in milligrams per liter; and

SC = specific conductance, in microsiemens per centimeter at 25 degrees Celsius.

The use of specific conductance as an explanatory variable makes sense both physically and statistically. It makes physical sense because sulfate is a major ion that affects the conductivity of water, which specific conductance measures. This results in a clear correlation between specific conductance and sulfate. Specific conductance makes statistical sense as an explanatory variable because it resulted in a model with low Mallows' C_p and *PRESS* values, and high adjusted R^2 values.

SULFATE RECORD— The record is computed using the regression model in the National Real-Time Water Quality (NRTWQ) website. Data are computed at hourly intervals. The record is complete for the year except as noted. The specific conductance monitor was removed during winter months because of below freezing conditions. A more in-depth description of the water quality record can be found at –

<http://nrtwq.usgs.gov/ks>

REMARKS—

- Site location, equipment, and other stream-gaging station information can be found in the Site Information Management System (SIMS).

Computed: Aaron King

Reviewed: Patrick Rasmussen

07144100 - Little Ark near Sedgwick - Sulfate

Model Form

$$\log(\text{SO}_4) = 1.13 * \log(\text{SC}) - 1.59$$

Explanatory variable summary statistics

	log(SC)	SC
Minimum	1.944	88.0
1st Quartile	2.451	283
Median	2.773	593
Mean	2.681	588
3rd Quartile	2.941	872
Maximum	3.126	1340

Notes:

Dependent variable summary statistics

	log(SO ₄)	SO ₄
Minimum	0.6990	5.00
1st Quartile	1.176	15.0
Median	1.544	35.0
Mean	1.444	36.4
3rd Quartile	1.758	57.3
Maximum	1.903	80.0

Notes:

Model Calibration

Basic Data

Number of Measurements:	156
Standard Error:	0.0910
MSPE (Upper)	+23.32
MSPE (Lower)	-18.91
R ²	0.93
Adj R ²	0.93
Duan BCF:	1.02

Explanatory Variables

Variable	Value	Standard Error
Intercept	-1.59	0.0658
log(SC)	1.13	0.0244

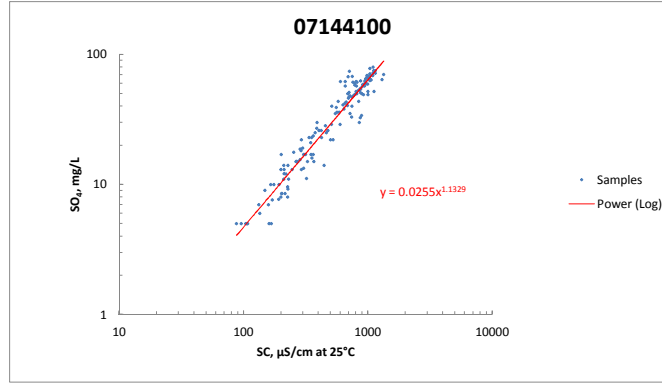
Notes:

Covariance Matrix

	Intercept	log(SC)
Intercept	1	-0.994
log(SC)	-0.994	1

Test Criteria

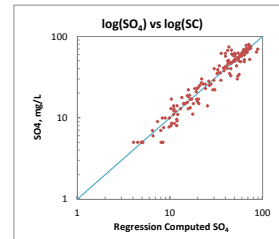
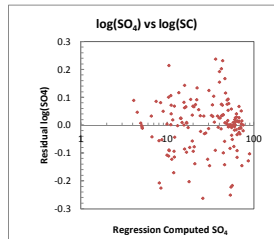
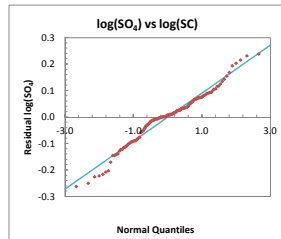
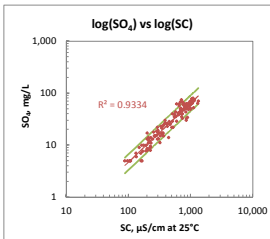
Leverage	Cook's D	DFITS
0.0385	0.792	0.226



Observations exceeding at least one test criterion

Observation	Observed log(SO ₄)	Predicted log(SO ₄)	Residuals	Standardized Residuals	Studentized Residuals	Leverage	Cook's D	DFITS
1	1.51	1.74	-0.223	-2.46	-2.51	0.0112	0.0343	-0.266
13	1.23	1.02	0.214	2.37	2.41	0.0167	0.0478	0.314
14	0.699	0.609	0.0898	1.01	1.01	0.0454	0.0243	0.220
51	0.699	0.652	0.0468	0.525	0.524	0.0415	0.00597	0.109
64	0.903	1.07	-0.170	-1.89	-1.90	0.0141	0.0254	-0.227
106	1.15	1.41	-0.262	-2.88	-2.96	0.00649	0.0271	-0.239
107	0.699	0.925	-0.226	-2.51	-2.56	0.0215	0.0693	-0.379
109	0.699	0.907	-0.208	-2.31	-2.35	0.0226	0.0617	-0.356
133	1.87	1.64	0.231	2.55	2.60	0.00850	0.0279	0.241
153	1.53	1.75	-0.216	-2.39	-2.43	0.0115	0.0334	-0.263
154	1.48	1.73	-0.250	-2.76	-2.82	0.0109	0.0419	-0.296

Notes:



Date	SC, µS/cm at 25°C	Streamflow, ft ³ /sec	SO ₄ , mg/L	log(SO ₄)	log(SC)	Regression	Residual log(SO ₄)	Normal Quantiles	90% P.L.	90% P.L.
						Computed SO ₄			Lower	Upper
5/1/1998	868	729	32.6	1.51	2.94	54.4	-0.222	-2.00	38.5	77.0
5/6/1998	803	143	51.8	1.71	2.91	49.8	0.017	-0.218	35.2	70.5
5/11/1998	911	128	58.8	1.77	2.96	57.5	0.010	0.105	40.6	81.3
5/14/1998	322	1947	11.1	1.05	2.51	17.7	-0.202	-1.73	12.5	25.0
5/27/1998	844	100	43.5	1.64	2.93	52.7	-0.083	-0.880	37.3	74.6
6/16/1998	877	43.5	50.6	1.70	2.94	55.1	-0.037	-0.644	38.9	77.9
6/24/1998	598	413	29.0	1.46	2.78	35.7	-0.090	-0.953	25.2	50.5
7/10/1998	211	1360	11.0	1.04	2.32	11.0	0.002	-0.088	7.7	15.5
7/13/1998	316	243	17.0	1.23	2.50	17.3	-0.008	-0.352	12.2	24.5
7/20/1998	558	44.8	39.0	1.59	2.75	33.0	0.073	0.928	23.3	46.7
8/6/1998	819	28.7	61.0	1.79	2.91	51.0	0.078	1.03	36.0	72.1
9/15/1998	877	14.5	54.0	1.73	2.94	55.1	-0.008	-0.369	38.9	77.9
9/22/1998	201	913	17.0	1.23	2.30	10.4	0.215	2.13	7.3	14.7
9/25/1998	88.0	6590	5.00	0.699	1.94	4.07	0.090	1.15	2.9	5.8
10/5/1998	108	7490	5.00	0.699	2.03	5.13	-0.011	-0.404	3.6	7.3
10/22/1998	425	104	23.0	1.36	2.63	24.2	-0.023	-0.529	17.1	34.3
11/5/1998	200	8776	8.00	0.903	2.30	10.3	-0.110	-1.21	7.3	14.6
1/12/1999	1101	113	72.0	1.86	3.04	71.2	0.005	-0.024	50.4	100.8
2/1/1999	306	4676	17.0	1.23	2.49	16.7	0.008	0.040	11.8	23.6
2/19/1999	1041	119	65.0	1.81	3.02	66.9	-0.012	-0.421	47.3	94.6
3/16/1999	1337	110	70.0	1.85	3.13	88.8	-0.103	-1.15	62.7	125.6
3/23/1999	1095	98.1	69.0	1.84	3.04	70.8	-0.011	-0.387	50.0	100.1
4/7/1999	404	1651	26.0	1.42	2.61	22.9	0.056	0.704	16.2	32.4
4/16/1999	200	5410	13.0	1.11	2.30	10.3	0.101	1.32	7.3	14.6
5/5/1999	802	239	50.0	1.70	2.90	49.8	0.002	-0.056	35.2	70.4
5/24/1999	211	1664	14.0	1.15	2.32	11.0	0.106	1.40	7.7	15.5
6/18/1999	300	410	19.0	1.28	2.48	16.3	0.066	0.767	11.5	23.1
6/21/1999	220	2223	12.0	1.08	2.34	11.5	0.019	0.235	8.1	16.3
7/20/1999	176	3521	10.0	1.00	2.25	8.92	0.049	0.644	6.3	12.6
8/3/1999	149	4238	9.00	0.954	2.17	7.39	0.086	1.12	5.2	10.5
8/19/1999	924	88.8	49.0	1.69	2.97	58.4	-0.076	-0.811	41.3	82.6
9/28/1999	212	1915	12.1	1.08	2.33	11.0	0.041	0.605	7.8	15.6
2/9/2000	1113	84.4	74.8	1.87	3.05	72.1	0.016	0.202	51.0	102.0

07144100 - Little Ark near Sedgwick - Sulfate

3/7/2000	286	1151	18.7	1.27	2.46	15.5	0.082	1.09	10.9	21.9
3/28/2000	254	4559	17.7	1.25	2.41	13.5	0.117	1.49	9.6	19.1
5/19/2000	1064	98.6	63.7	1.80	3.03	68.5	-0.032	-0.605	48.4	96.9
5/31/2000	456	203	28.3	1.45	2.66	26.2	0.033	0.439	18.5	37.1
6/28/2000	364	1165	17.0	1.23	2.56	20.3	-0.078	-0.833	14.4	28.8
7/28/2000	353	160	23.0	1.36	2.55	19.6	0.069	0.856	13.9	27.8
8/16/2000	749	23.5	47.0	1.67	2.87	46.0	0.009	0.056	32.5	65.1
9/8/2000	846	19.1	53.0	1.72	2.93	52.9	0.001	-0.105	37.4	74.8
9/25/2000	855	20.9	53.0	1.72	2.93	53.5	-0.004	-0.251	37.8	75.7
10/26/2000	228	6524	14.0	1.15	2.36	12.0	0.068	0.833	8.5	16.9
11/8/2000	514	82.5	40.0	1.60	2.71	30.1	0.124	1.54	21.2	42.5
12/4/2000	1086	46.2	69.0	1.84	3.04	70.1	-0.007	-0.318	49.6	99.2
3/14/2001	336	1932	23.0	1.36	2.53	18.6	0.093	1.25	13.1	26.3
4/13/2001	565	415	36.0	1.56	2.75	33.5	0.032	0.404	23.6	47.3
4/26/2001	982	98.2	67.0	1.83	2.99	62.6	0.030	0.387	44.2	88.5
5/8/2001	660	155	57.0	1.76	2.82	39.9	0.155	1.73	28.2	56.4
6/4/2001	292	1050	22.0	1.34	2.47	15.8	0.143	1.66	11.2	22.4
6/6/2001	96.0	8962	5.00	0.699	1.98	4.49	0.047	0.624	3.2	6.4
6/23/2001	165	4251	10.0	1.00	2.22	8.29	0.081	1.06	5.9	11.7
7/11/2001	811	49.1	57.0	1.76	2.91	50.4	0.054	0.684	35.6	71.3
8/2/2001	765	24.4	48.0	1.68	2.88	47.2	0.008	0.024	33.3	66.7
8/28/2001	788	31.2	58.0	1.76	2.90	48.8	0.075	0.979	34.5	69.0
9/20/2001	135	4178	6.00	0.778	2.13	6.61	-0.042	-0.664	4.7	9.3
10/31/2001	853	27.3	53.0	1.72	2.93	53.3	-0.003	-0.235	37.5	75.5
1/10/2002	1040	36.4	63.0	1.80	3.02	66.8	-0.025	-0.548	47.2	94.5
2/21/2002	1100	42.0	80.0	1.90	3.04	71.2	0.051	0.664	50.3	100.7
4/9/2002	961	93.5	65.0	1.81	2.98	61.1	0.027	0.369	43.2	86.4
4/22/2002	265	1480	15.0	1.18	2.42	14.2	0.024	0.268	10.0	20.1
5/22/2002	422	142	26.0	1.42	2.63	24.0	0.034	0.475	17.0	34.0
6/6/2002	388	244	27.0	1.43	2.59	21.9	0.092	1.21	15.4	30.9
6/13/2002	226	5868	8.00	0.903	2.35	11.9	-0.171	-1.66	8.4	16.8
7/9/2002	720	29.6	35.0	1.54	2.86	44.0	-0.100	-1.12	31.1	62.3
8/15/2002	744	750	40.0	1.60	2.87	45.7	-0.058	-0.789	32.3	64.6
9/19/2002	720	15.2	48.0	1.68	2.86	44.0	0.038	0.567	31.1	62.3
12/18/2002	1300	41.1	64.0	1.81	3.11	86.0	-0.128	-1.40	60.8	121.6
3/20/2003	292	6285	13.0	1.11	2.47	15.8	-0.086	-0.904	11.2	22.4
4/17/2003	1150	69.9	71.5	1.85	3.06	74.8	-0.020	-0.511	52.9	105.9
4/23/2003	642	296	38.0	1.58	2.81	38.7	-0.007	-0.335	27.3	54.7
5/14/2003	369	1709	15.0	1.18	2.57	20.6	-0.139	-1.45	14.6	29.2
5/29/2003	479	193	26.0	1.42	2.68	27.7	-0.028	-0.567	19.6	39.2
6/11/2003	656	96.5	42.0	1.62	2.82	39.6	0.025	0.318	28.0	56.0
6/24/2003	1000	57.0	49.0	1.69	3.00	63.9	-0.115	-1.28	45.2	90.3
7/30/2003	894	7.73	50.0	1.70	2.95	56.3	-0.051	-0.704	39.8	79.6
9/3/2003	265	578	15.0	1.18	2.42	14.2	0.024	0.285	10.0	20.1
10/14/2003	193	1077	10.0	1.00	2.29	9.91	0.004	-0.040	7.0	14.0
12/11/2003	1120	46.2	52.0	1.72	3.05	72.6	-0.145	-1.60	51.3	102.7
3/9/2004	212	1819	13.0	1.11	2.33	11.0	0.072	0.880	7.8	15.6
3/30/2004	999	292	59.0	1.77	3.00	63.8	-0.034	-0.624	45.1	90.2
4/26/2004	986	50.6	69.0	1.84	2.99	62.9	0.040	0.585	44.4	88.9
5/13/2004	265	1153	15.0	1.18	2.42	14.2	0.024	0.301	10.0	20.1
5/26/2004	1040	49.7	78.0	1.89	3.02	66.8	0.067	0.811	47.2	94.5
6/16/2004	788	56.1	60.0	1.78	2.90	48.8	0.090	1.18	34.5	69.0
6/22/2004	273	1042	15.0	1.18	2.44	14.7	0.010	0.088	10.4	20.8
7/27/2004	133	5855	7.00	0.845	2.12	6.50	0.032	0.421	4.6	9.2
1/27/2005	348	172	21.0	1.32	2.54	19.3	0.036	0.529	13.7	27.3
3/23/2005	227	5855	9.60	0.982	2.36	11.9	-0.093	-1.06	8.4	16.8
5/10/2005	587	203	35.8	1.55	2.77	34.9	0.011	0.121	24.7	49.4
5/27/2005	305	743	13.3	1.12	2.48	16.6	-0.097	-1.09	11.8	23.5
6/6/2005	291	1957	18.2	1.26	2.46	15.8	0.062	0.746	11.1	22.3
8/31/2005	363	112	23.6	1.37	2.56	20.3	0.066	0.789	14.3	28.7
2/9/2006	872	32.5	62.5	1.80	2.94	54.7	0.058	0.725	38.7	77.4
5/2/2006	743	122	32.9	1.52	2.87	45.6	-0.142	-1.49	32.3	64.5
6/8/2006	1000	25.5	51.8	1.71	3.00	63.9	-0.091	-0.979	45.2	90.3
6/26/2006	286	114	15.5	1.19	2.46	15.5	0.001	-0.153	10.9	21.9
7/27/2006	693	3.12	67.2	1.83	2.84	42.2	0.203	2.00	29.8	59.6
8/15/2006	658	6.99	62.0	1.79	2.82	39.8	0.193	1.89	28.1	56.2
8/23/2006	576	15.2	43.5	1.64	2.76	34.2	0.105	1.36	24.2	48.4
9/27/2006	751	6.99	67.9	1.83	2.88	46.2	0.167	1.80	32.6	65.3
1/10/2007	873	13.8	54.9	1.74	2.94	54.8	0.001	-0.121	38.7	77.5
2/5/2007	974	15.2	59.6	1.78	2.99	62.0	-0.017	-0.475	43.8	87.7
3/12/2007	708	19.1	51.0	1.71	2.85	43.2	0.072	0.904	30.5	61.1
3/21/2007	698	51.0	46.0	1.66	2.84	42.5	0.034	0.493	30.0	60.0
3/27/2007	446	164	14.0	1.15	2.65	25.6	-0.262	-2.67	18.1	36.2
4/2/2007	167	2886	5.00	0.699	2.22	8.41	-0.226	-2.13	5.9	11.9
4/18/2007	231	861	11.0	1.04	2.36	12.1	-0.043	-0.684	8.6	17.2
7/11/2007	161	1927	5.00	0.699	2.21	8.07	-0.208	-1.80	5.7	11.4
8/16/2007	686	59.3	40.4	1.61	2.84	41.7	-0.014	-0.457	29.5	59.0
9/6/2007	952	25.5	62.0	1.79	2.98	60.4	0.011	0.137	42.7	85.5
11/26/2007	815	28.9	50.0	1.70	2.91	50.7	-0.006	-0.285	35.8	71.7
12/6/2007	906	29.5	56.9	1.76	2.96	57.1	-0.002	-0.202	40.4	80.8
3/6/2008	305	979	17.0	1.23	2.48	16.6	0.009	0.072	11.8	23.5
4/14/2008	465	484	25.0	1.40	2.67	26.8	-0.031	-0.585	19.0	38.0
5/29/2008	216	2895	8.50	0.929	2.33	11.3	-0.122	-1.36	8.0	15.9
6/30/2008	356	877	16.0	1.20	2.55	19.8	-0.093	-1.03	14.0	28.0
8/5/2008	708	24.9	47.0	1.67	2.85	43.2	0.037	0.548	30.5	61.1
4/6/2009	669	187	43.0	1.63	2.83	40.5	0.026	0.335	28.6	57.3
4/13/2009	548	851	35.0	1.54	2.74	32.3	0.035	0.511	22.8	45.7
4/28/2009	202	6190	8.50	0.929	2.31	10.4	-0.089	-0.928	7.4	14.8
6/16/2009	511	661	29.0	1.46	2.71	29.9	-0.013	-0.439	21.1	42.2
9/9/2009	159	3141	7.00	0.845	2.20	7.95	-0.055	-0.746	5.6	11.2
9/24/2009	246	333	13.0	1.11	2.39	13.0	-0.001	-0.169	9.2	18.4
11/3/2009	327	328	15.0	1.18	2.52	18.0	-0.079	-0.856	12.7	25.5
11/19/2009	780	65.0	49.0	1.69	2.89	48.2	0.007	-0.008	34.1	68.2
12/1/2009	921	54.7	58.0	1.76	2.96	58.2	-0.001	-0.186	41.1	82.3
12/17/2009	1030	58.7	68.0	1.83	3.01	66.1	0.013	0.153	46.7	93.4
1/6/2010	1150	94.5	75.0	1.88	3.06	74.8	0.001	-0.137	52.9	105.9
1/19/2010	1040	79.7	71.0	1.85	3.02	66.8	0.027	0.352	47.2	94.5
2/4/2010	949	63.9	63.0	1.80	2.98	60.2	0.020	0.251	42.6	85.2
2/23/2010	997	69.3	66.0	1.82	3.00	63.7	0.016	0.186	45.0	90.1
3/10/2010	712	547	74.0	1.87	2.85	43.5	0.231	2.32	30.7	61.5
4/14/2010	1040	52.7	69.0	1.84	3.02	66.8	0.014	0.169	47.2	94.5
4/23/2010	601	228	62.0	1.79	2.78	35.9	0.238	2.67	25.4	50.8
5/13/2010	349	544	17.0	1.23	2.54	19.4	-0.057	-0.767	13.7	27.4
6/9/2010	170	2448	7.60	0.881	2.23	8.58	-0.053	-0.725	6.1	12.1
6/10/2010	228	3345	9.20	0.964	2.36	12.0	-0.114	-1.25	8.5	16.9
6/13/2010	106	7905	5.00	0.699	2.03	5.02	-0.002	-0.218	3.6	7.1
6/14/2010	107	15162	5.00	0.699	2.03	5.08	-0.007	-0.301	3.6	7.2
6/15/2010	192	6480	7.70	0.887	2.28	9.85	-0.107	-1.18	7.0	13.9
6/16/2010	203	4806	8.50	0.929	2.31	10.5	-0.091	-1.01	7.4	14.8

07144100 - Little Ark near Sedgwick - Sulfate

7/6/2010	104	13387	5.00	0.699	2.02	4.92	0.007	0.008	3.5	7.0
8/19/2010	632	60.8	41.0	1.61	2.80	38.0	0.033	0.457	26.8	53.7
8/25/2010	524	770	22.0	1.34	2.72	30.7	-0.145	-1.54	21.7	43.4
11/16/2010	500	262	22.0	1.34	2.70	29.1	-0.122	-1.32	20.6	41.2
3/7/2011	759	50.8	61.0	1.79	2.88	46.7	0.116	1.45	33.0	66.1
3/16/2011	806	48.0	62.0	1.79	2.91	50.0	0.093	1.28	35.4	70.8
4/6/2011	957	37.6	61.0	1.79	2.98	60.8	0.002	-0.072	43.0	86.0
4/18/2011	942	32.8	59.0	1.77	2.97	59.7	-0.005	-0.268	42.2	84.4
5/2/2011	937	28.8	57.0	1.76	2.97	59.3	-0.017	-0.493	41.9	83.9
6/7/2011	691	21.9	50.0	1.70	2.84	42.0	0.076	1.01	29.7	59.4
6/21/2011	890	110	34.0	1.53	2.95	56.0	-0.217	-1.89	39.6	79.2
6/22/2011	854	46.2	30.0	1.48	2.93	53.4	-0.251	-2.32	37.8	75.6
8/15/2011	376	25.5	25.0	1.40	2.58	21.1	0.074	0.953	14.9	29.8
9/22/2011	391	42.9	30.0	1.48	2.59	22.0	0.134	1.60	15.6	31.2