Appendix 2. Model Archive Summary for Suspended-Sediment Concentration at U.S. Geological Survey Site 07179750, Neosho River at Burlingame Road near Emporia, Kansas, during January 1, 2010, through December 16, 2012

This model archive summary summarizes the suspended-sediment concentration (SSC) model developed to compute hourly or daily SSC during January 1, 2010, through December 16, 2012. This model supersedes all prior models used during this period. The methods used follow U.S. Geological Survey (USGS) guidance as referenced in relevant Office of Surface Water/Office of Water Quality Technical Memoranda and USGS Techniques and Methods, book 3, chapter C4, and the policy and guidance for approval of surrogate regression models for computation of time series SSCs and loads (Rasmussen and others, 2009; U.S. Geological Survey, 2016).

Site and Model Information

Site number: 07179750
Site name: Neosho River at Burlingame Road near Emporia, Kansas
Location: Latitude 38°25'43", Longitude 96°09'29" referenced to North American Datum of 1927, in NE 1/4 SW 1/4 NE 1/4 sec.02, T.19 S., R.11 E., Lyon County, Kans., hydrologic unit 11070201, on left downstream side of bridge at Burlingame Road, 1.5 miles north of Interstate Highway 35, and at mile 391.8.

Equipment: A YSI 6600 water-quality monitor equipped with sensors for water temperature, specific conductance, and turbidity (YSI model 6136 turbidity sensor). The YSI 6600 water-quality monitor was in operation during July 31, 2009, through December 16, 2012.

Date model was developed: January 16, 2020
Model calibration data period: June 17, 2009, through September 27, 2012

Model Data

All data were collected using USGS protocols (Wagner and others, 2006; Sauer and Turnipseed, 2010; Turnipseed and Sauer, 2010; U.S. Geological Survey, variously dated) and are stored in the National Water Information System (NWIS) database (https://doi.org/10.5066/F7P55KJN; U.S. Geological Survey, 2020). Explanatory variables were evaluated individually and in combination. Potential explanatory variables included streamflow,

water temperature, specific conductance, and turbidity. Seasonal components (sine and cosine variables) were also evaluated as explanatory variables.

The regression model is based on 27 concomitant values of discretely measured SSC samples and continuously measured turbidity during June 17, 2009, through September 27, 2012. Discrete samples were collected over a range of streamflows and turbidity conditions. No samples had concentrations below laboratory detection limits. Identification of potential outliers included any values that exceeded the Cook's D test (Cook, 1977) and any point for which the studentized residual was greater than 3 or less than −3. None of the samples in this dataset were deemed outliers or removed from the model calibration dataset.

Suspended-Sediment Sampling Details

Discrete samples were collected from the downstream side of the bridge or instream within 350 feet of the bridge using equal-width-increment, multiple vertical, single vertical, or grab-dip methods following U.S. Geological Survey (2006) and Rasmussen and others (2014). Discrete samples were collected on a semifixed to event-based schedule ranging from four to nine samples per year with a Federal Interagency Sediment Project U.S. D–77, DH–95 or D–95 with a Teflon bottle, cap, and nozzle depth-integrating sampler, a D–96 bag sampler, a DH–81 with a Teflon bottle, cap, and nozzle hand sampler, DH–48 or a grab sample with a Teflon bottle depending on sample location. Samples were analyzed for SSC, loss on ignition, and occasionally five-point grain size by the USGS Sediment Laboratory in Iowa City, Iowa.

Continuous Data

Turbidity was measured using a YSI model 6136 sensor installed during July 31, 2009, through December 16, 2012 (U.S. Geological Survey, 2018). Concomitant turbidity values were time interpolated. If continuous data were not available (2 or more hours of specific conductance values bracketing the sample collected time were missing) because of fouling, changes in equipment, or unsuitable site conditions, then the field monitor turbidity value measured during sampling was substituted. If neither concomitant continuous data nor field monitor data were available, the sample was not included in the dataset. The range of continuous turbidity data of the YSI model 6136 sensor (in formazin nephelometric units) was as follows: maximum 2,450; minimum 0.700; mean 52.2; median 24.0.

Model Development

Ordinary least squares regression analysis was done using R programming language (R Core Team, 2019) to relate discretely collected SSC to turbidity and other continuously measured data. The distribution of residuals was examined for normality and plots of residuals (the difference between the measured and model calculated values) were compared to model calculated SSC and were examined for homoscedasticity (departures from zero did not change

substantially over the range of model calculated values). Previously published explanatory variables were also strongly considered for continuity however, the best explanatory variable(s) was ultimately selected.

Turbidity was selected as the best predictor of logarithm base 10 ($\log_{10}$) (SSC) based on residual plots, relatively high coefficient of determination (R^2), and relatively low model standard percentage error (MSPE).

Model Summary

Summary of final SSC regression analysis at site 07179750:
SSC-based model:

$$\log_{10}(SSC) = 1.10 \times \log_{10}(Turb6136) + 0.00834$$

where

SSC = suspended-sediment concentration, in milligrams per liter, and
Turb6136 = turbidity, YSI model 6136, in formazin nephelometric units.

The use of turbidity as an explanatory variable is appropriate physically and statistically. Turbidity makes sense physically because suspended sediment is composed of particles that scatter light in water. The relation between turbidity and SSC can vary given varying concentrations of organic suspended particles that increase turbidity but are not included in the SSC analysis.

The log-transformed model may be retransformed to the original units to calculate SSC directly. A bias is introduced in the calculated constituent during retransformation and may be corrected using the Duan's bias correction factor (BCF; Duan, 1983). The calculated BCF is 1.08 for this model and the formula for the retransformed model accounting for BCF is as follows:

$$SSC = 1.10 \times Turb6136^{1.1}$$

Suspended-Sediment Concentration Record

The SSC record that is being used in this regression model is stored at the National Real-Time Water Quality (NRTWQ) website (https://nrtwq.usgs.gov/ks).

Previously Published Model

$$\log_{10}(SSC) = 1.07 \times \log_{10}(Turb) + 0.11$$

Model author: Foster (2014)
Model data period: June 17, 2009, through September 27, 2012

Model Statistics, Data, and Plots

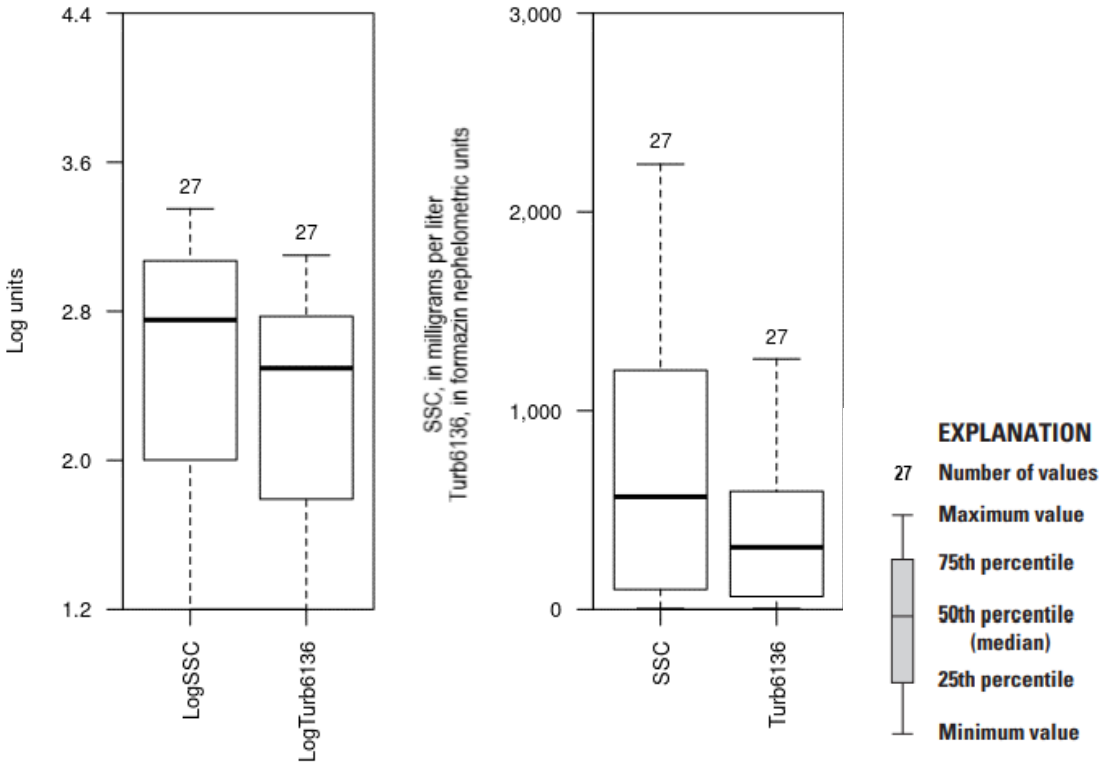
Model

$$\text{Log}(SSC) = + 1.10 * \text{Log}(Turb6136) + 0.00834$$

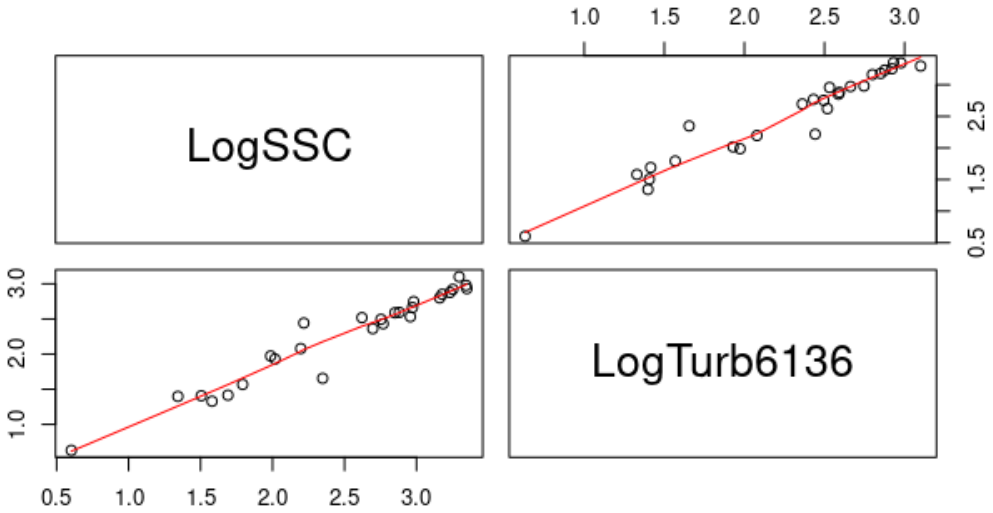
Variable Summary Statistics

	LogSSC	SSC	LogTurb6136	Turb6136
Minimum	0.602	4	0.631	4.27
1st Quartile	1.990	97	1.660	45.20
Median	2.750	567	2.500	313.00
Mean	2.500	747	2.270	371.00
3d Quartile	3.160	1450	2.800	630.00
Maximum	3.350	2240	3.100	1260.00

Box Plots



Exploratory Plots



Basic Model Statistics

Number of Observations	27
Standard error (RMSE)	0.174
Average Model standard percentage error (MSPE)	41.2
Coefficient of determination (R^2)	0.945
Adjusted Coefficient of Determination (Adj. R^2)	0.943
Bias Correction Factor (BCF)	1.08

Explanatory Variables

	Coefficients	Standard Error	t value	Pr(>|t|)
(Intercept)	0.00834	0.125	0.0669	9.47e-01
LogTurb6136	1.10000	0.053	20.8000	2.77e-17

Correlation Matrix

	Intercept	E.vars
Intercept	1.000	-0.963
E.vars	-0.963	1.000

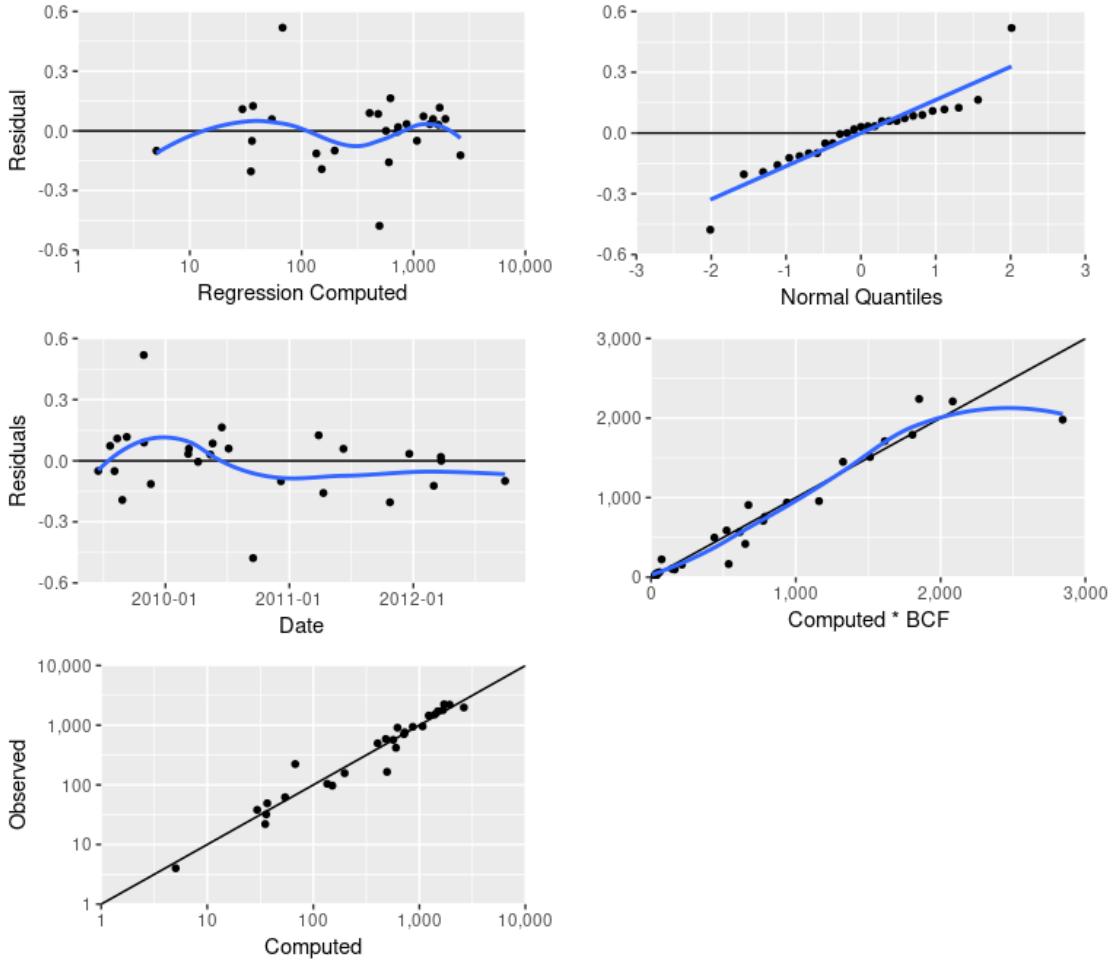
Outlier Test Criteria

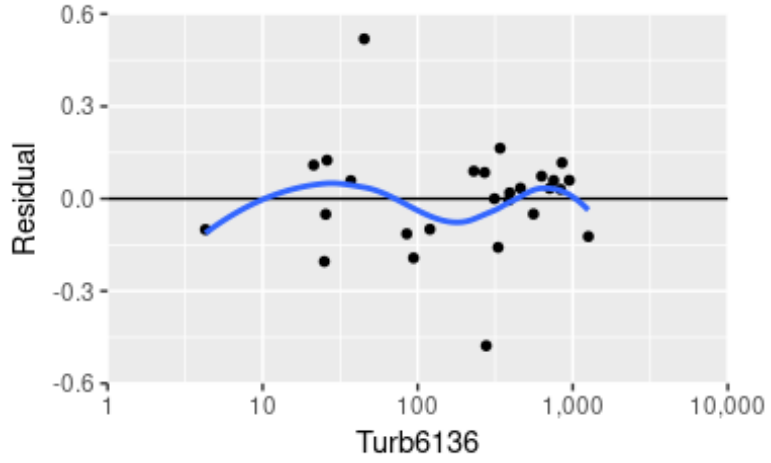
Leverage	Cook's D	DFFITS
0.222	0.193	0.544

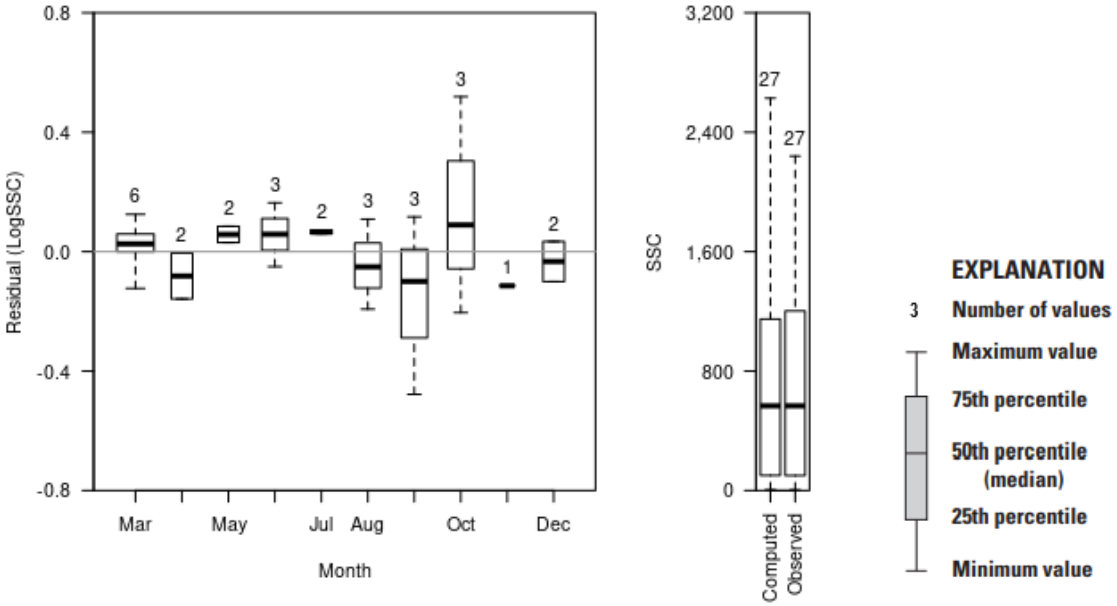
Flagged Observations

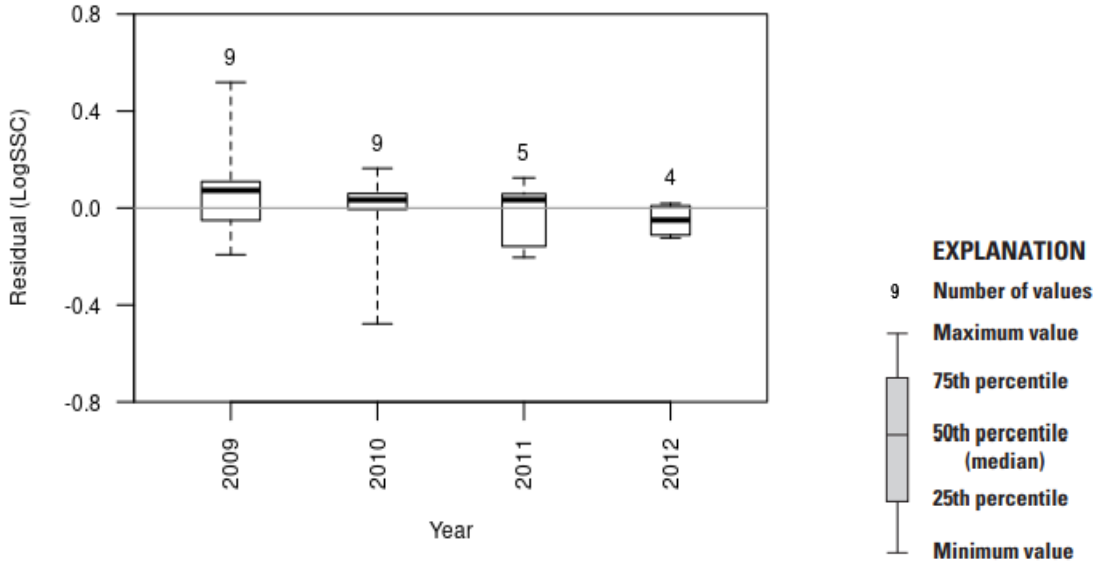
	LogSSC	Estimate	Residual	Standard Residual	Studentized Residual	Leverage	Cook's D	DFFITS
10/29/2009 12:35	2.350	1.830	0.519	3.100	3.860	0.0718	0.3700	1.070
9/16/2010 12:10	2.220	2.700	-0.478	-2.800	-3.310	0.0399	0.1630	-0.675
12/7/2010 12:30	0.602	0.702	-0.100	-0.682	-0.674	0.2850	0.0927	-0.426

Statistical Plots

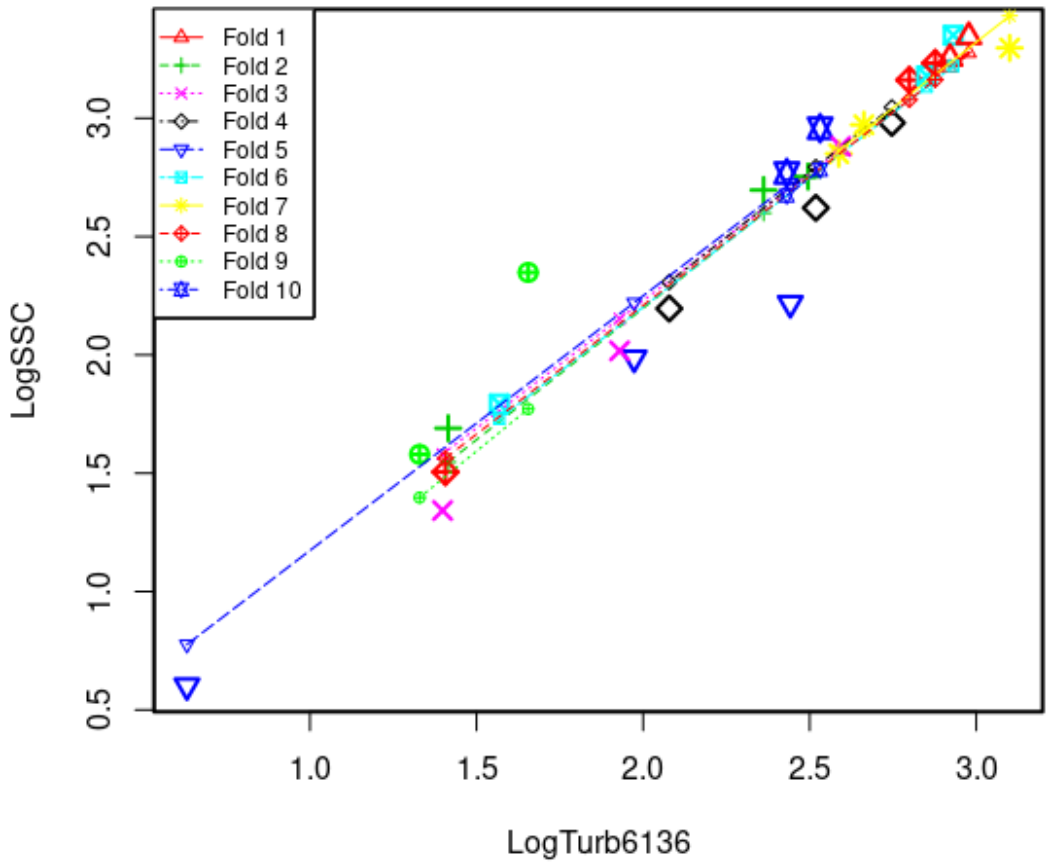



0.6
0.3
0.0
-0.3
-0.6
Residual
1
10
100
1,000
10,000
Turb6136


0.8
0.4
0.0
-0.4
-0.8
Residual (LogSSC)
6
2
2
3
2
3
3
3
1
2
Mar
May
Jul
Aug
Oct
Dec
Month
3,200
2,400
1,600
800
0
SSC
27
27
Computed
Observed
EXPLANATION
3
Number of values
Maximum value
75th percentile
50th percentile
(median)
25th percentile
Minimum value



Cross Validation



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 Minimum mean squared error (MSE)  of folds:  0.0031
                          Mean MSE of folds:  0.0390
                        Median MSE of folds:  0.0128
                       Maximum MSE of folds:  0.1830
          (Mean MSE of folds) / (Model MSE):  1.2900
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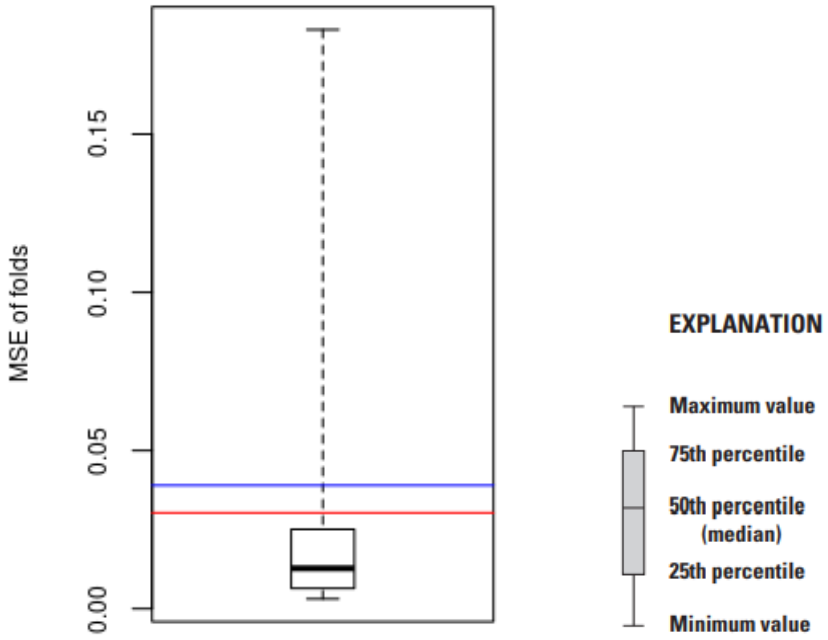


```
Red line - Model MSE

Blue line - Mean MSE of folds
```

Model-Calibration Dataset

	Date	LogSSC	LogTurb6136	SSC	Turb6136	Computed LogSSC	Computed SSC	Residual	Normal Quantiles	Censored Values
1	2009-06-17	2.98	2.75	956	558	3.03	1160	-0.05	-0.377	--
2	2009-07-22	3.16	2.8	1450	630	3.09	1330	0.0729	0.585	--
3	2009-08-04	1.51	1.41	32	25.5	1.56	38.9	-0.0508	-0.478	--
4	2009-08-12	1.58	1.33	38	21.3	1.47	32	0.109	0.958	--
5	2009-08-27	1.99	1.97	97	94	2.18	163	-0.193	-1.31	--
6	2009-09-09	3.35	2.93	2240	853	3.23	1850	0.117	1.12	--
7	2009-10-29	2.35	1.66	223	45.2	1.83	73	0.519	2.01	--
8	2009-10-30	2.7	2.36	497	230	2.61	438	0.0894	0.821	--
9	2009-11-19	2.02	1.93	104	85	2.13	146	-0.114	-0.821	--
10	2010-03-09	3.18	2.85	1510	710	3.15	1510	0.0334	0.0923	--
11	2010-03-11	3.23	2.88	1710	753	3.17	1610	0.0591	0.377	--
12	2010-04-07	2.85	2.59	708	387	2.86	775	-0.00513	-0.28	--
13	2010-05-13	3.25	2.92	1790	834	3.22	1810	0.0304	0	--
14	2010-05-20	2.77	2.43	587	270	2.68	522	0.0851	0.698	--
15	2010-06-16	2.96	2.53	907	340	2.79	673	0.164	1.56	--
16	2010-07-06	3.34	2.98	2210	950	3.28	2080	0.0597	0.478	--
17	2010-09-16	2.22	2.44	165	277	2.7	536	-0.478	-2.01	--

18	2010-12-07	0.602	0.631	4	4.27	0.702	5.45	-0.1	-0.698	--
19	2011-03-28	1.69	1.41	49	26	1.57	39.8	0.125	1.31	--
20	2011-04-11	2.62	2.52	418	330	2.78	651	-0.158	-1.12	--
21	2011-06-09	1.79	1.57	62	37	1.73	58.6	0.0586	0.28	--
22	2011-10-24	1.34	1.4	22	25	1.55	38.1	-0.204	-1.56	--
23	2011-12-20	2.97	2.66	938	460	2.94	938	0.0341	0.185	--
24	2012-03-01	3.3	3.1	1980	1260	3.42	2840	-0.123	-0.958	--
25	2012-03-22	2.88	2.59	760	392	2.86	787	0.019	-0.0923	--
26	2012-03-23	2.75	2.5	567	313	2.75	614	-0.000121	-0.185	--
27	2012-09-27	2.2	2.08	157	120	2.3	213	-0.0993	-0.585	--

Definitions

Adj R^2: Adjusted coefficient of determination

BCF: Bias correction factor

DFFITS: Studentized difference in fits

Log: logarithm base 10

MSE: Mean squared error

MSPE: Model standard percentage error

R^2: Coefficient of determination

RMSE: Root mean square error

SSC: Suspended-sediment concentration, in milligrams per liter (80154)

Turb6136: Turbidity, in formazin nephelometric units (63680)

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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