

# **Appendix 8. Model Archive Summary for Suspended-Sediment Concentration at U.S. Geological Survey Site 07182510, Neosho River at Burlington, Kansas, during October 23, 2015, through December 31, 2019**

This model archive summary summarizes the suspended-sediment concentration (SSC) model developed to compute hourly or daily SSC during October 23, 2015, through December 31, 2019. 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: 07182510

Site name: Neosho River at Burlington, Kansas

Location: Lat 38°11'40", long 95°44'06" referenced to North American Datum of 1927, in NE 1/4 SW 1/4 sec.26, T.21 S., R.15 E., Coffey County, Kans., hydrologic unit 11070204, on right bank at upstream side of county highway bridge at Burlington, 0.3 mile upstream from Rock Creek, and at mile 338.4.

Equipment: A YSI EXO2 water-quality monitor equipped with sensors for water temperature, specific conductance, and turbidity. The YSI EXO2 water-quality monitor recorded readings every 15 minutes and transmitted hourly via satellite using a Sutron Satlink 2 high data rate collection platform. The EXO2 water-quality monitor began operation during October 23, 2015.

Date model was created: January 16, 2020

Model calibration data period: November 23, 2015, through March 15, 2019.

## **Model Data**

All data were collected using approved 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) and is available for public use. Explanatory variables were evaluated individually and in combination. Potential explanatory variables included streamflow, water temperature, specific conductance and turbidity.

The regression model is based on 18 measurements of discretely collected SSC samples and continuously measured turbidity collected during November 23, 2015, through March 15, 2019. Samples were collected over a range of streamflow 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 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 one to five samples per year with a Federal Interagency Sedimentation Project U.S. DH-95 or D-95 with a Teflon bottle, cap, and nozzle depth-integrating sampler, a D-96 bag sampler, or a DH-81 with a Teflon bottle, cap, and nozzle hand sampler. 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

Continuously monitored turbidity was measured using a YSI EXO turbidity sensor installed during October 23, 2015, through December 31, 2019 (U.S. Geological Survey, 2018). Concomitant turbidity values were time interpolated. If continuous data were not available (2 or more hours of turbidity 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 EXO2 sensor (in formazin nephelometric units) was as follows: maximum 1,640; minimum 3.30; mean 28.2; median 23.0.

## 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) compared to model calculated SSC were examined for homoscedasticity (departures from zero did not change substantially over the range of model calculated values).

Turbidity was selected as the best predictors 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 SSC regression analysis at site 07182510:

SSC-based model:

$$\text{Log}_{10}(\text{SSC}) = 0.896 \times \text{Log}_{10}(\text{TurbEXO}) + 0.382$$

where

*SSC* = suspended-sediment concentration, in milligrams per liter, and

*TurbEXO* = turbidity, YSI model EXO, in formazin nephelometric units.

The use of turbidity as an explanatory variable is appropriate physically and statistically. In a physical sense, particles comprised of suspended solids scatter light which affects turbidity. In a statistical sense using turbidity resulted in a model with a low standard error and high  $R^2$  values. 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 1.03 for this model and the formula for the retransformed model accounting for BCF is as follows:

$$\text{SSC} = 2.48 \times \text{TurbEXO}^{0.896}$$

## Suspended-Sediment Concentration Record

The data are computed at 15-minute intervals and the computed 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

No previously published model.

## Model Statistics, Data, and Plots

### Model

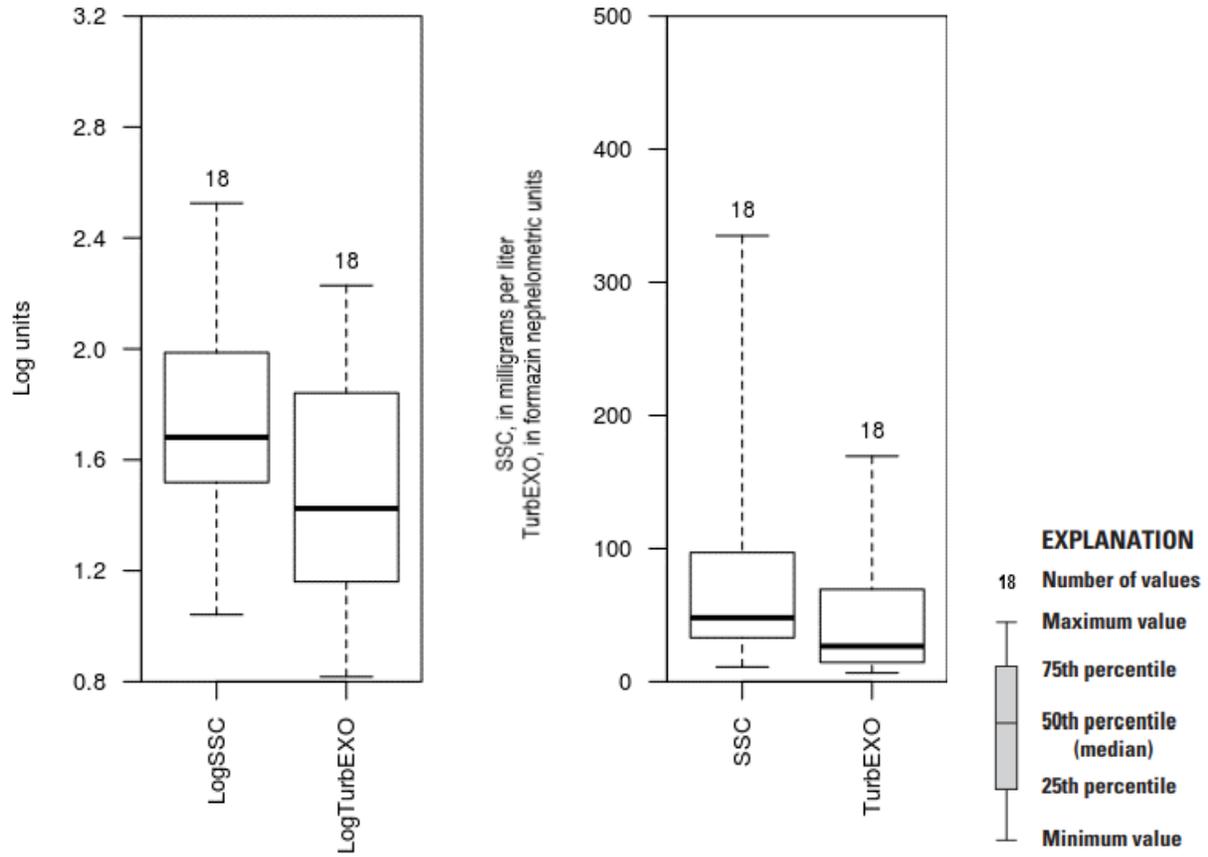
$$\text{Log}(\text{SSC}) = + 0.896 * \text{Log}(\text{TurbEXO}) + 0.382$$

### Variable Summary Statistics

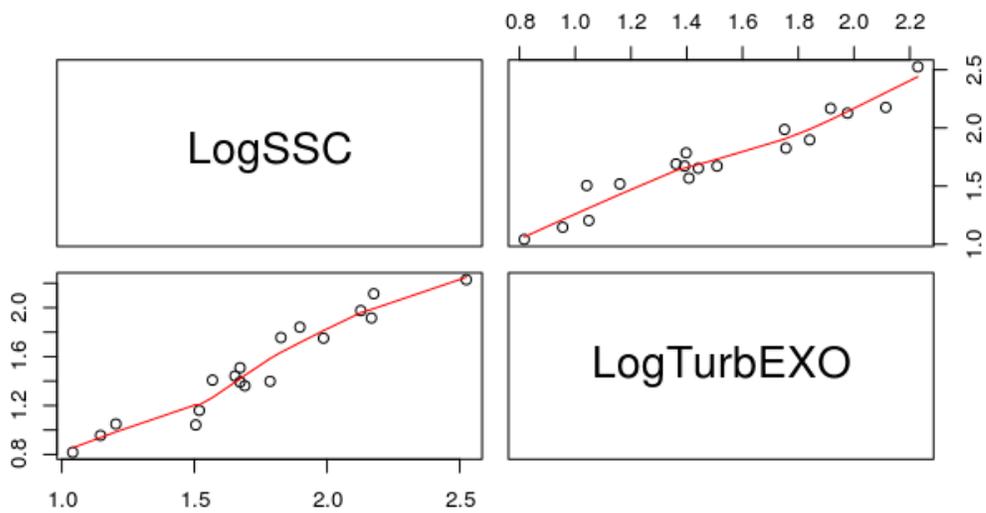
	LogSSC	SSC	LogTurbEXO	TurbEXO
Minimum	1.04	11.0	0.817	6.57
1st Quartile	1.52	33.0	1.160	14.50
Median	1.68	48.0	1.420	26.60

Mean	1.73	77.8	1.510	48.30
3d Quartile	1.99	97.0	1.840	69.30
Maximum	2.53	335.0	2.230	169.00

## Box Plots



## Exploratory Plots



## Basic Model Statistics

Number of Observations	18
Standard error (RMSE)	0.108
Average Model standard percentage error (MSPE)	25.2
Coefficient of determination ( $R^2$ )	0.925
Adjusted Coefficient of Determination (Adj. $R^2$ )	0.921
Bias Correction Factor (BCF)	1.03

## Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t )
(Intercept)	0.382	0.0992	3.84	1.43e-03
LogTurbEX0	0.896	0.0637	14.10	1.98e-10

## Correlation Matrix

	Intercept	E.vars
Intercept	1.000	-0.966
E.vars	-0.966	1.000

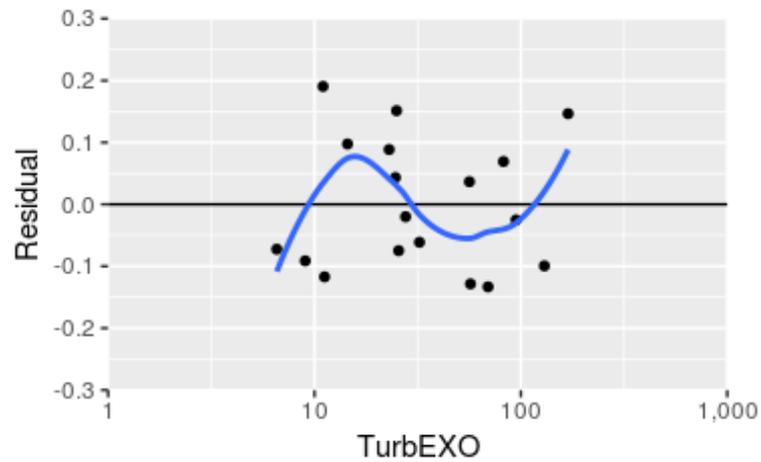
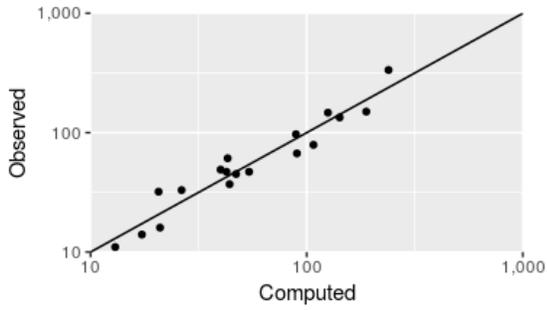
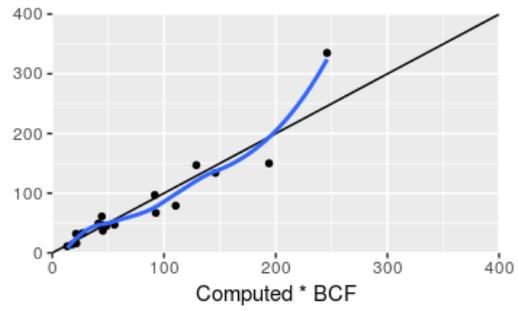
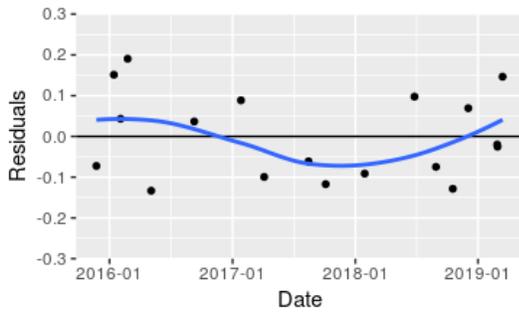
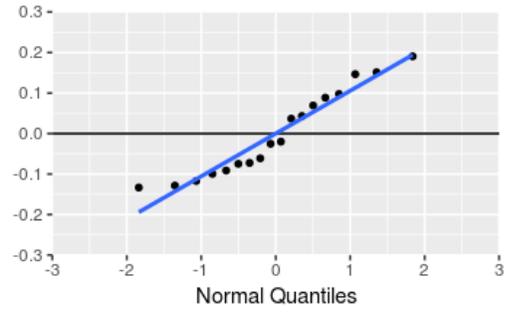
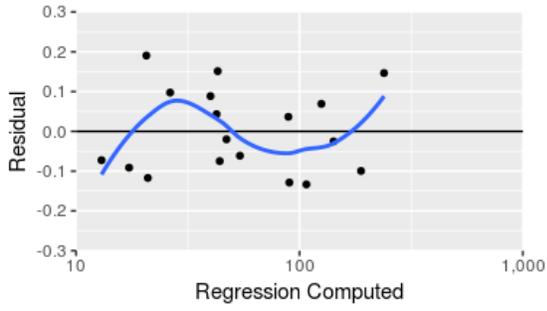
## Outlier Test Criteria

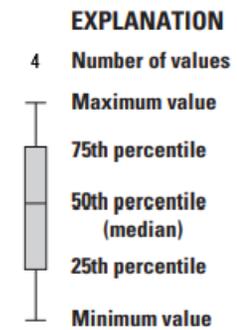
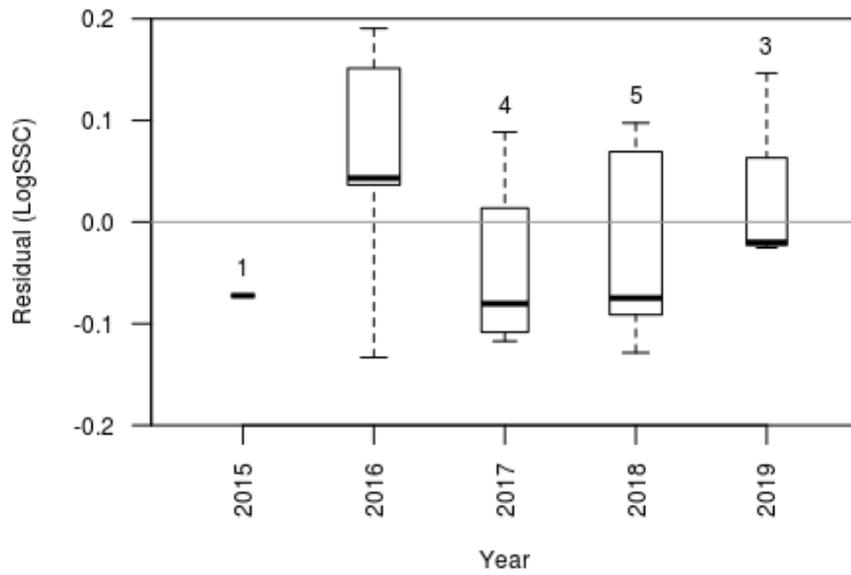
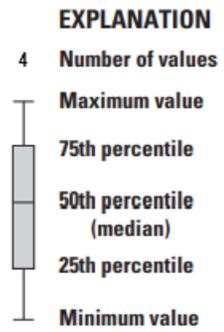
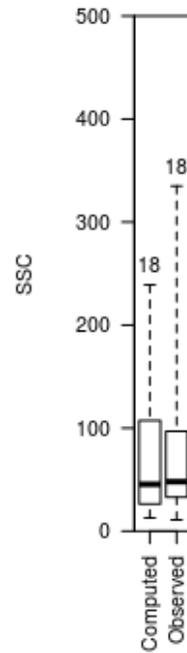
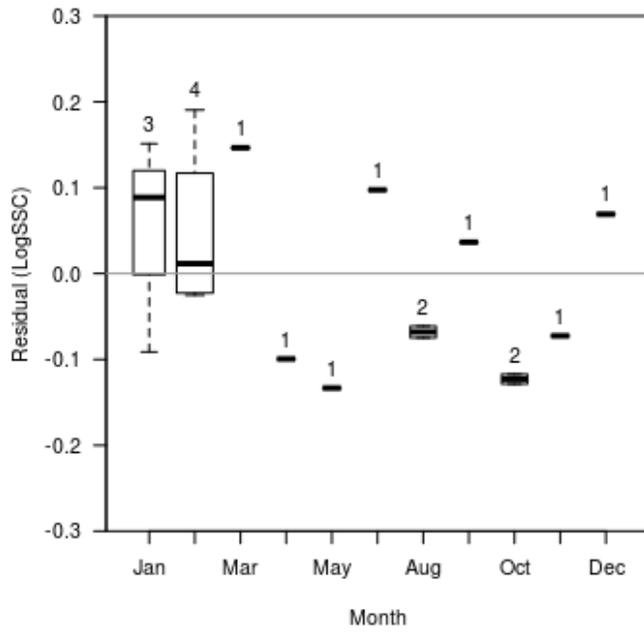
Leverage	Cook's D	DFFITS
0.333	0.192	0.667

## Flagged Observations

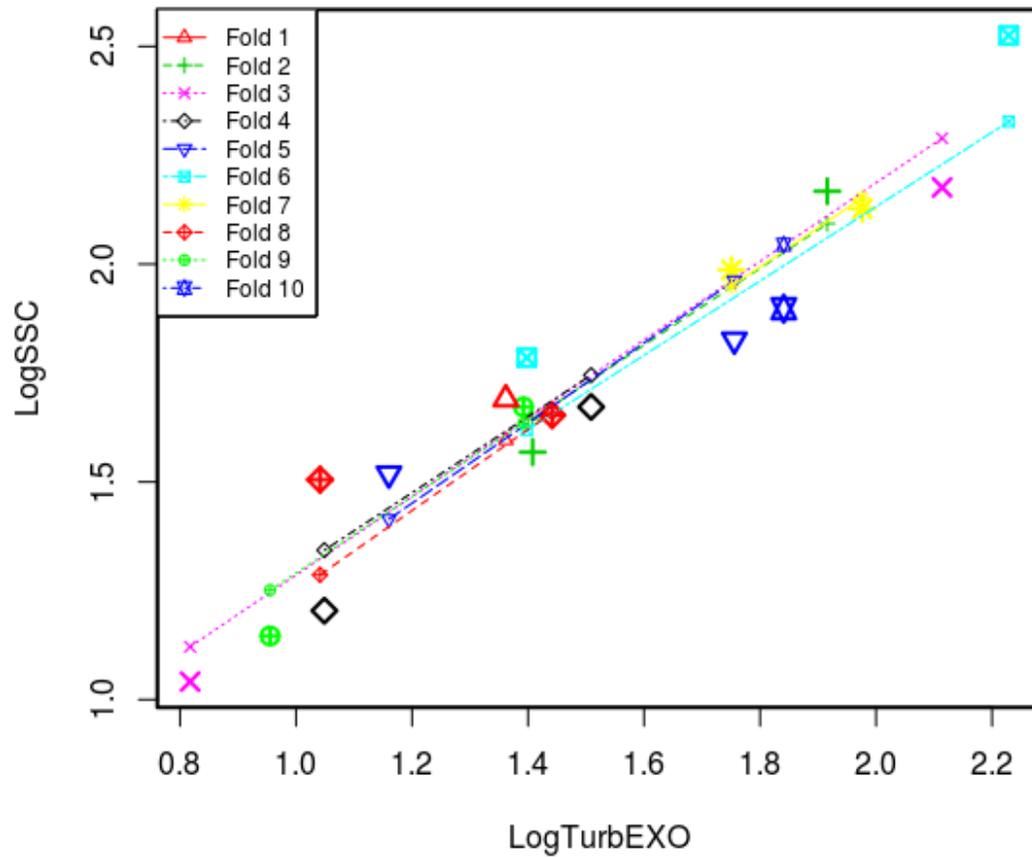
	LogSSC	Estimate	Residual	Standard Residual	Studentized Residual	Leverage	Cook's D	DFFITS
2/24/2016 13:00	1.51	1.31	0.191	1.89	2.07	0.130	0.266	0.801
3/15/2019 10:30	2.53	2.38	0.146	1.55	1.62	0.236	0.369	0.901

# Statistical Plots





## Cross Validation



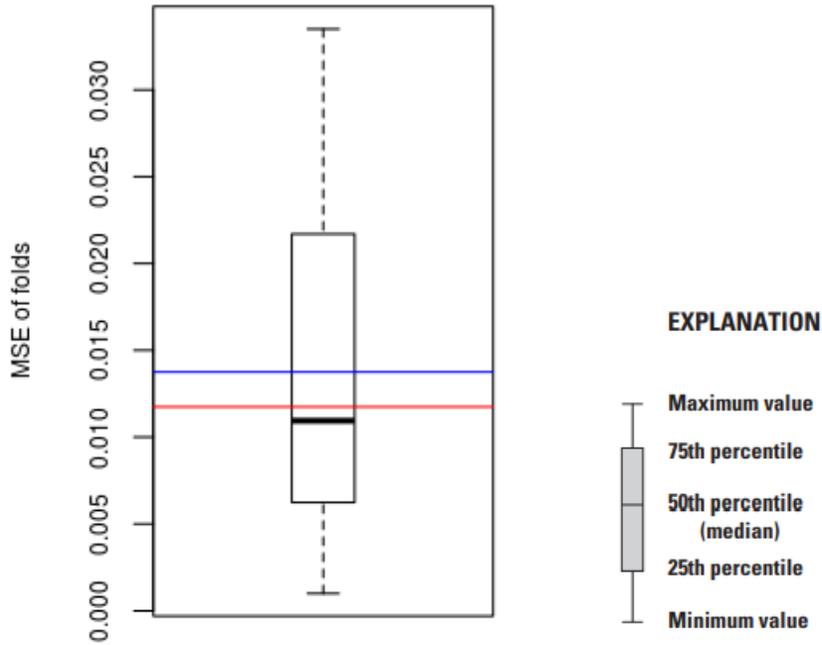
Minimum mean squared error (MSE) of folds: 0.000998

Mean MSE of folds: 0.013800

Median MSE of folds: 0.010900

Maximum MSE of folds: 0.033500

(Mean MSE of folds) / (Model MSE): 1.170000



Red line - Model MSE  
 Blue line - Mean MSE of folds

### Model-Calibration Dataset

	Date	LogSSC	LogTurbEXO	SSC	TurbEXO	Computed LogSSC	Computed SSC	Residual	Normal Quantiles	Censored Values
0										
1	2015-11-23	1.04	0.817	11	6.57	1.11	13.4	-0.0725	-0.351	--
2	2016-01-14	1.79	1.4	61	25	1.63	44.3	0.151	1.35	--
3	2016-02-03	1.67	1.39	47	24.7	1.63	43.8	0.0433	0.351	--
4	2016-02-24	1.51	1.04	32	11	1.31	21.2	0.191	1.84	--
5	2016-05-04	1.9	1.84	79	69.3	2.03	110	-0.133	-1.84	--
6	2016-09-09	1.99	1.75	97	56.3	1.95	91.7	0.0366	0.208	--
7	2017-01-26	1.69	1.36	49	23	1.6	41.1	0.0886	0.666	--
8	2017-04-05	2.18	2.11	150	130	2.28	194	-0.0995	-0.849	--
9	2017-08-15	1.67	1.51	47	32.3	1.73	55.7	-0.0612	-0.208	--
10	2017-10-05	1.2	1.05	16	11.2	1.32	21.6	-0.117	-1.07	--
11	2018-01-29	1.15	0.955	14	9.02	1.24	17.8	-0.0913	-0.666	--
12	2018-06-26	1.52	1.16	33	14.5	1.42	27.1	0.0975	0.849	--
13	2018-08-29	1.57	1.41	37	25.6	1.64	45.2	-0.0748	-0.502	--
14	2018-10-18	1.83	1.76	67	57	1.95	92.7	-0.129	-1.35	--
15	2018-12-03	2.17	1.92	147	82.4	2.1	129	0.0692	0.502	--
16	2019-02-27	1.65	1.44	45	27.6	1.67	48.5	-0.02	0.0689	--
17	2019-02-28	2.13	1.98	134	94.7	2.15	146	-0.0252	-0.0689	--
18	2019-03-15	2.53	2.23	335	169	2.38	246	0.146	1.07	--

## Definitions

Adj R<sup>2</sup>: 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<sup>2</sup>: Coefficient of determination

RMSE: Root mean square error

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

TurbEXO: 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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