

Appendix 6. Model Archive Summary for Suspended-Sediment Concentration at U.S. Geological Survey Site 07179750, Neosho River at Burlingame Road near Emporia, Kansas, during May 2, 2015, through December 31, 2019

This model archive summary summarizes the suspended-sediment concentration (SSC) model developed to compute hourly or daily SSC during May 2, 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: 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 section 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 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 May 2, 2015.

Date model was created: January 15, 2020

Model calibration data period: May 18, 2015, through March 14, 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). 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 23 measurements of discretely collected SSC samples and continuously measured turbidity collected during May 18, 2015, through March 14, 2019. Discrete 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 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 three to eight 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 May 2, 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 collection 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. 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 2,300; minimum 2.29; mean 50.6; 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) compared to 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 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 SSC regression analysis at site 07179750:
SSC-based model:

$$\text{Log}_{10}(\text{SSC}) = 1.12 \times \text{Log}_{10}(\text{TurbEXO}) + 0.0799$$

where

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

TurbEXO = turbidity, YSI 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 1.02 for this model and the formula for the retransformed model accounting for BCF is as follows:

$$\text{SSC} = 1.23 \times \text{TurbEXO}^{1.12}$$

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

No previously published model

Model Statistics, Data, and Plots

Model

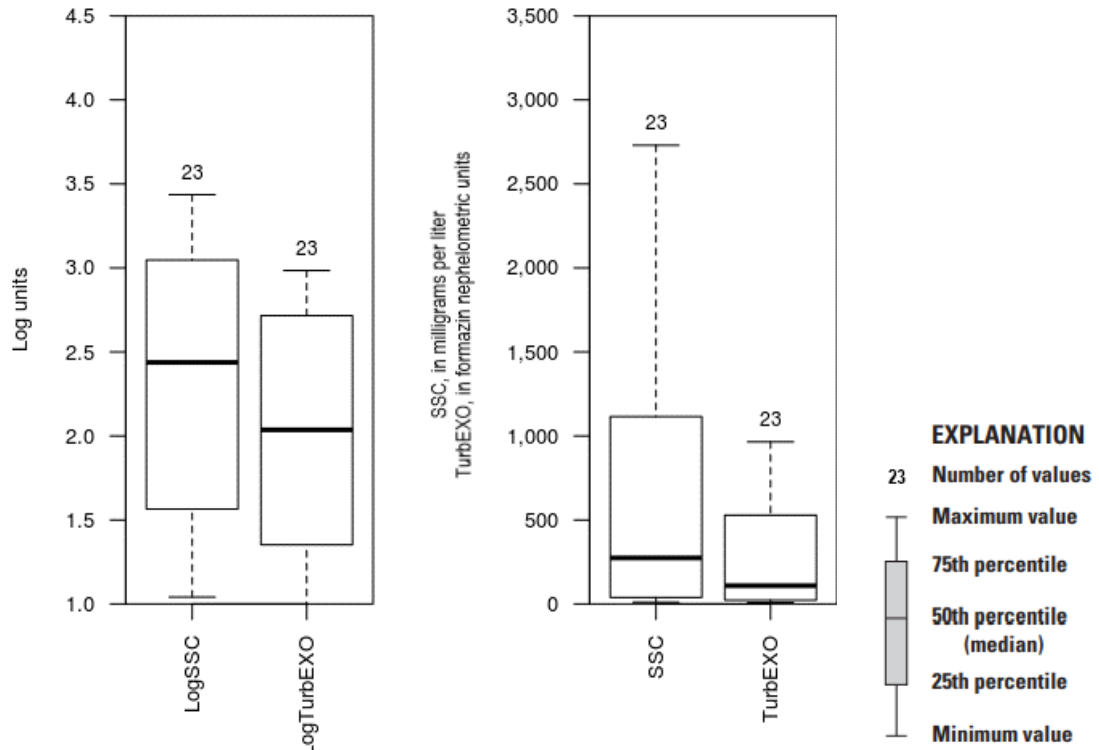
$$\text{Log}(\text{SSC}) = + 1.12 * \text{Log}(\text{TurbEXO}) + 0.0799$$

Variable Summary Statistics

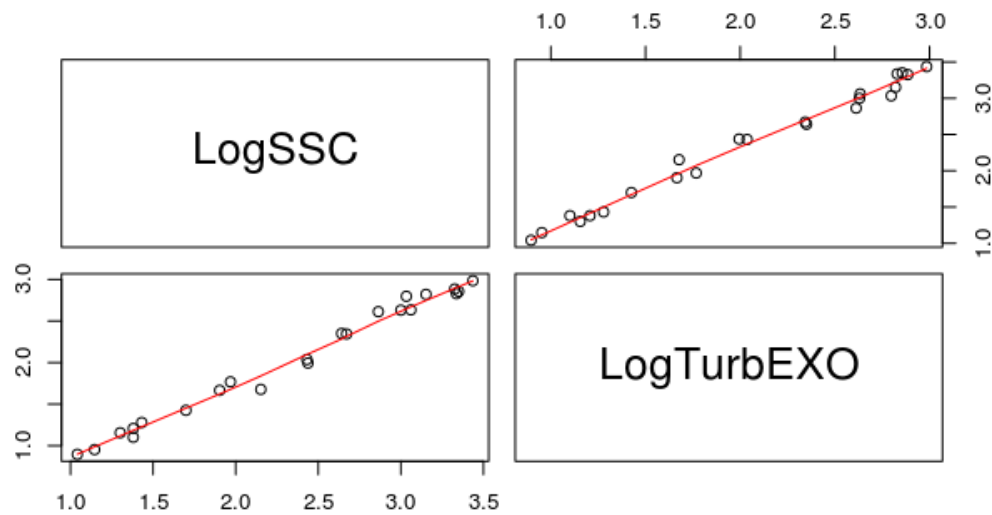
	LogSSC	SSC	LogTurbEXO	TurbEXO
Minimum	1.04	11	0.896	7.87

1st Quartile	1.43	27	1.280	19.00
Median	2.44	274	2.040	109.00
Mean	2.35	721	2.040	286.00
3d Quartile	3.06	1150	2.800	627.00
Maximum	3.44	2730	2.980	965.00

Box Plots



Exploratory Plots



Basic Model Statistics

Number of Observations	23
Standard error (RMSE)	0.0895
Average Model standard percentage error (MSPE)	20.7
Coefficient of determination (R^2)	0.988
Adjusted Coefficient of Determination (Adj. R^2)	0.988
Bias Correction Factor (BCF)	1.02

Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t)
(Intercept)	0.0799	0.0571	1.4	1.76e-01
LogTurbEXO	1.1200	0.0264	42.2	8.73e-22

Correlation Matrix

	Intercept	E.vars
Intercept	1.000	-0.945
E.vars	-0.945	1.000

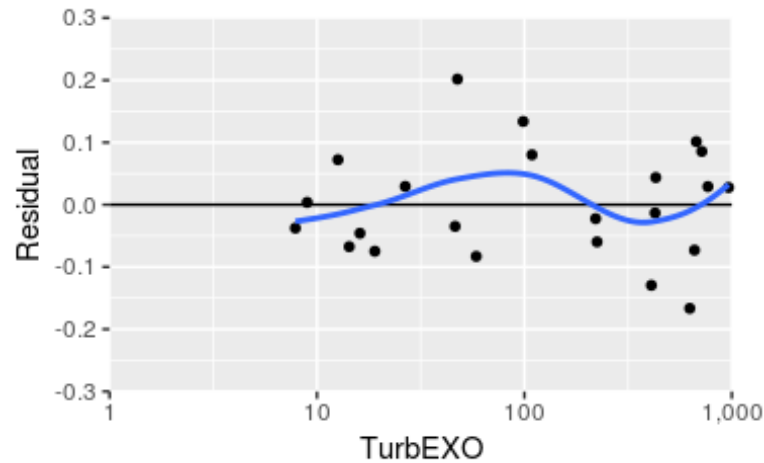
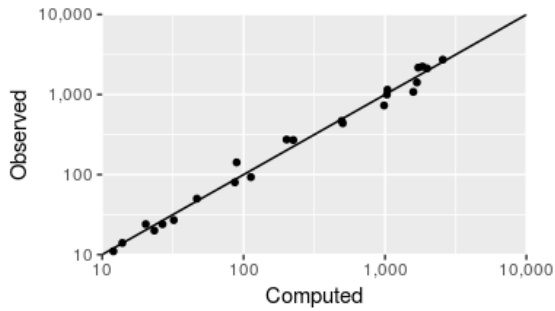
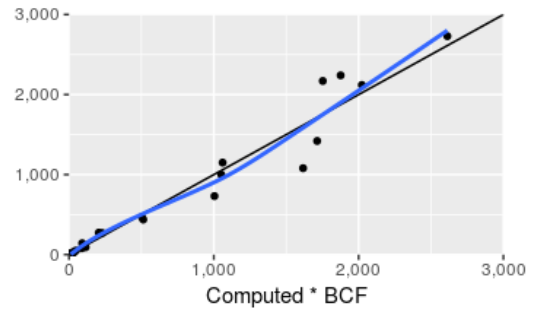
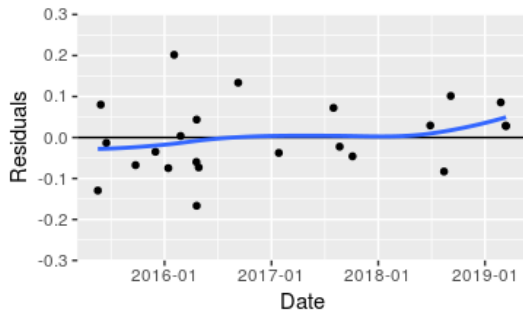
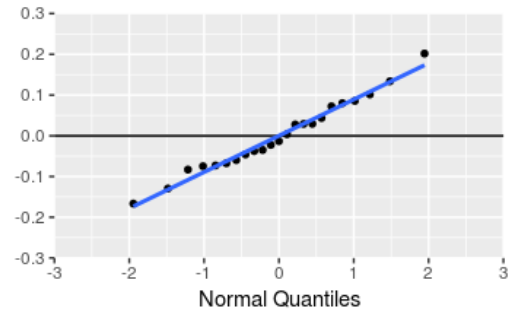
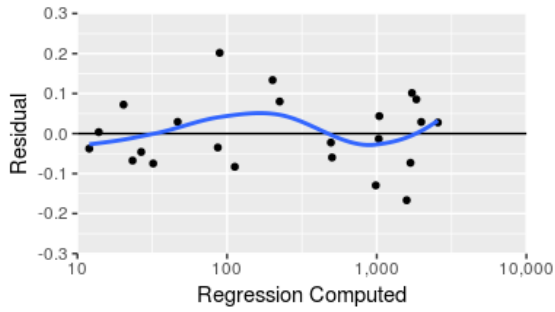
Outlier Test Criteria

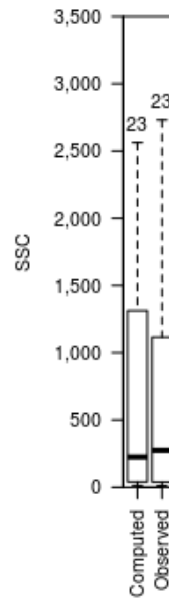
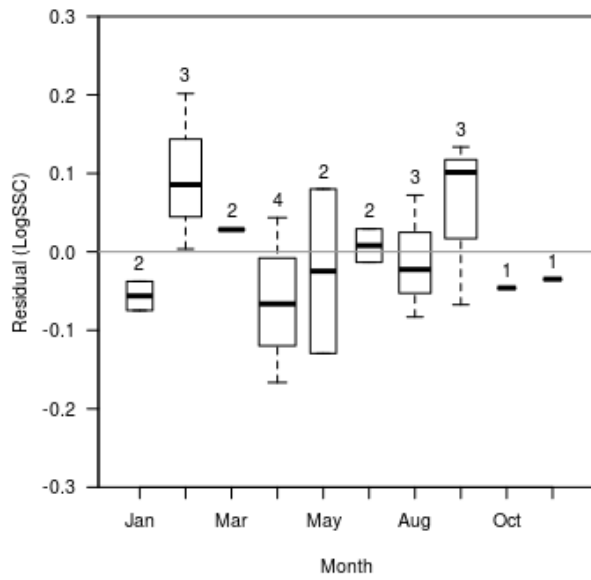
Leverage	Cook's D	DFFITS
0.261	0.193	0.590

Flagged Observations

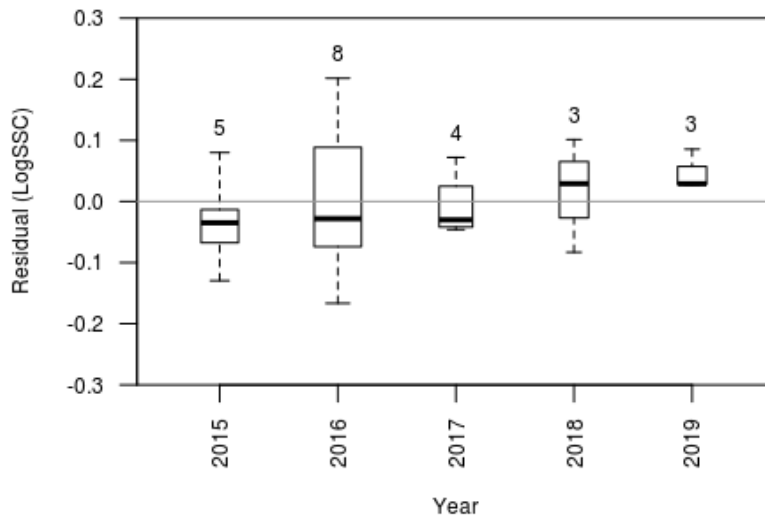
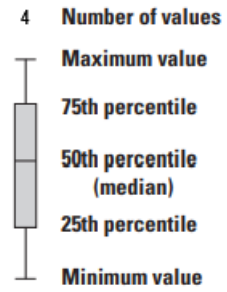
	LogSSC Estimate	Residual	Standard Residual	Studentized Residual	Leverage	Cook's D	DFFITS
2/3/2016 11:10	2.15	1.95	0.202	2.32	2.63	0.0549	0.156
4/20/2016 14:50	3.03	3.20	-0.167	-1.96	-2.11	0.0937	0.198

Statistical Plots

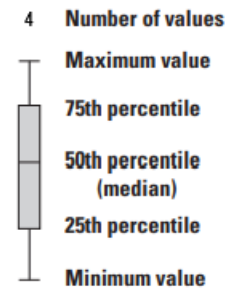




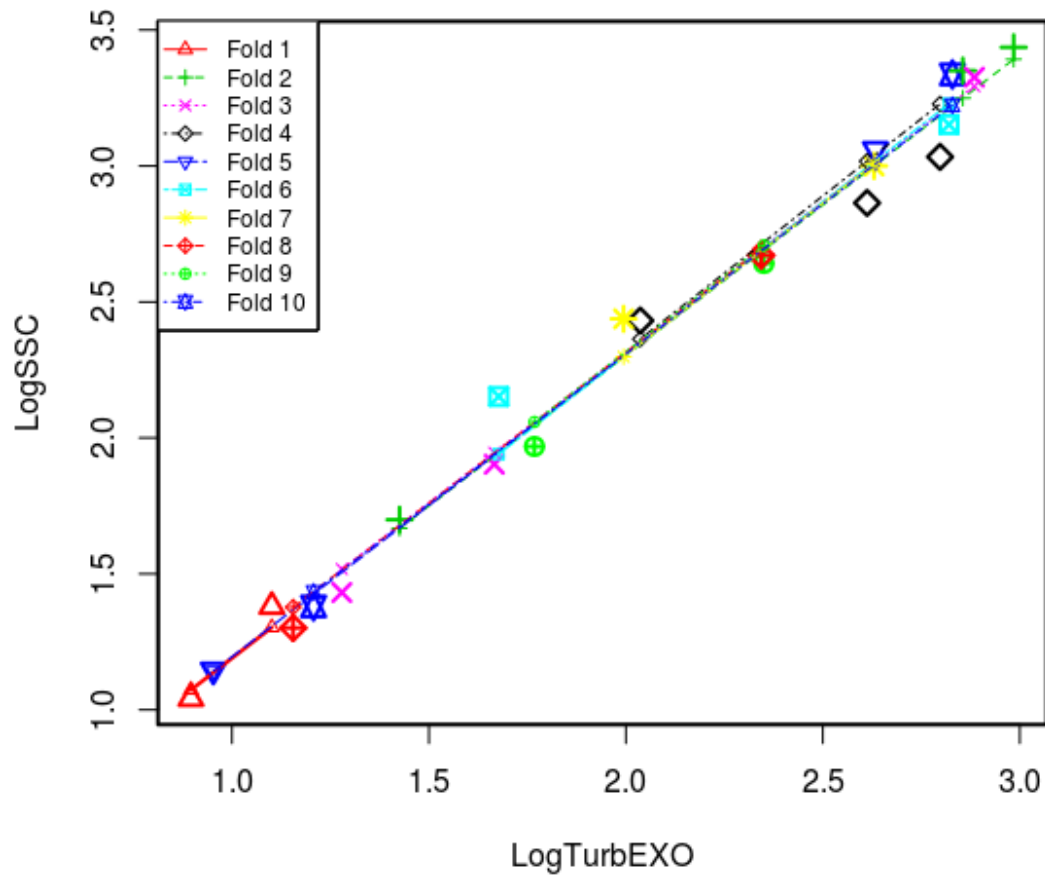
EXPLANATION



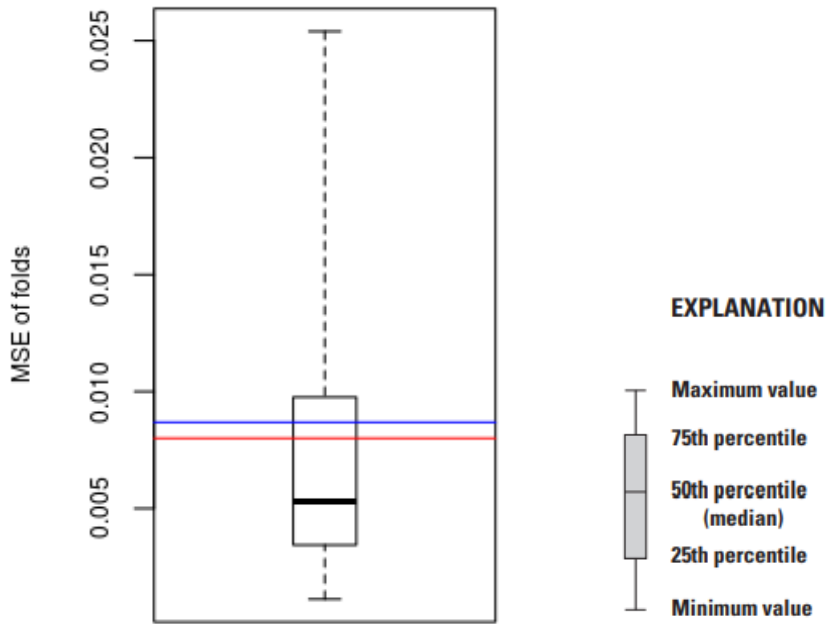
EXPLANATION



Cross Validation



Minimum mean squared error (MSE) of folds: 0.00112
Mean MSE of folds: 0.00869
Median MSE of folds: 0.00530
Maximum MSE of folds: 0.02540
(Mean MSE of folds) / (Model MSE): 1.09000



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	2015-05-18	2.86	2.61	731	409	2.99	1000	-0.129	-1.48	--
2	2015-06-16	3	2.63	1000	427	3.01	1050	-0.0133	0	--
3	2015-05-28	2.43	2.04	270	109	2.35	229	0.0801	0.848	--
4	2015-09-24	1.3	1.16	20	14.3	1.37	23.8	-0.0675	-0.702	--
5	2015-12-01	1.9	1.67	80	46.3	1.94	88.4	-0.0348	-0.218	--
6	2016-01-14	1.43	1.28	27	19	1.51	32.7	-0.0748	-1.01	--
7	2016-02-03	2.15	1.68	142	47.6	1.95	91	0.202	1.95	--
8	2016-02-25	1.15	0.953	14	8.97	1.14	14.2	0.00371	0.108	--
9	2016-04-19	2.64	2.35	438	224	2.7	513	-0.0597	-0.57	--
10	2016-04-20	3.06	2.63	1150	430	3.02	1060	0.0436	0.57	--
11	2016-04-20	3.03	2.8	1080	627	3.2	1620	-0.167	-1.95	--
12	2016-04-27	3.15	2.82	1420	661	3.23	1710	-0.073	-0.848	--
13	2016-09-09	2.44	1.99	274	98.7	2.3	205	0.134	1.48	--
14	2017-01-26	1.04	0.896	11	7.87	1.08	12.2	-0.0376	-0.33	--
15	2017-08-22	2.67	2.34	469	221	2.69	504	-0.0225	-0.108	--
16	2017-08-01	1.38	1.1	24	12.6	1.31	20.7	0.0723	0.702	--
17	2017-10-05	1.38	1.21	24	16.1	1.43	27.2	-0.046	-0.447	--
18	2018-06-28	1.7	1.43	50	26.6	1.67	47.7	0.0293	0.447	--
19	2018-08-14	1.97	1.77	93	58.6	2.05	115	-0.083	-1.22	--
20	2018-09-06	3.34	2.83	2170	674	3.24	1750	0.101	1.22	--
21	2019-02-24	3.35	2.86	2240	717	3.26	1880	0.0856	1.01	--
22	2019-03-13	3.33	2.88	2120	767	3.3	2020	0.0291	0.33	--
23	2019-03-14	3.44	2.98	2730	965	3.41	2610	0.0276	0.218	--

Definitions

Adj R²: 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

R²: 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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