

Appendix 2.19. Model Archive Summary for Total Organic Nitrogen Concentration at U.S. Geological Survey site 07144100; Little Arkansas River near Sedgwick, Kansas, during October 2014 through December 2019

This model archive summary summarizes the total organic nitrogen model developed to compute hourly or daily total organic nitrogen. Model development methods follow U.S. Geological Survey (USGS) guidance from Office of Surface Water/Office of Water Quality Technical Memoranda and USGS Techniques and Methods, book 3, chap. C4 (Rasmussen and others, 2009).

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Site and Model Information

Site Number: 07144100

Site Name: Little Arkansas River near Sedgwick, Kansas

Location: Latitude 37°52'59", longitude 97°25'27" referenced to North American Datum of 1927, in NE 1/4 NW 1/4 NW 1/4 sec.15, T.25 S., R.1 W., Sedgwick County, Kansas; hydrologic unit 11030012.

Equipment: A Sutron Satlink II High Data Rate Collection Platform and a Design Analysis Water Log H350/355 nonsubmersible pressure transducer transfers real-time stage and water-quality data via satellite. The primary reference gage is a Type-A wire-weight gage located on the downstream bridge handrail. Check-bar elevation is 33.614 feet. The orifice is enclosed in a well-screen and attached to a concrete pier on the left downstream side of the bridge. Gage height was measured during October 2014 through December 2019. A YSI 6600 water-quality monitor equipped with water temperature, specific conductance (SC), pH, dissolved oxygen, and turbidity (a YSI Model 6026 [September 1998 through December 2006] and YSI Model 6136 [July 2004 through March 2015]) sensors collected data during April 1998 through March 2015. A YSI EXO2 water-quality monitor equipped with water temperature, specific conductance, pH, dissolved oxygen, turbidity, and fluorescent dissolved organic matter sensors collected data during September 2014 through December 2019. A Hach Nitratex monitor collected nitrate data during March 2012 through December 2019.

Date model was developed: June 1, 2020

Model calibration data period: October 14, 2014 through December 11, 2019

Model Data

All data were collected using USGS protocols (U.S. Geological Survey, variously dated; Wagner and others, 2006; Sauer and Turnipseed, 2010; Turnipseed and Sauer, 2010) and are stored in the National Water Information System (NWIS) database (U.S. Geological Survey, 2021). Explanatory variables were evaluated individually and in combination. Potential explanatory variables included streamflow, water temperature, specific conductance, pH, dissolved oxygen, YSI EXO2 turbidity, nitrate, and fluorescent dissolved organic matter. Seasonal components (sine and cosine variables) also were evaluated as explanatory variables.

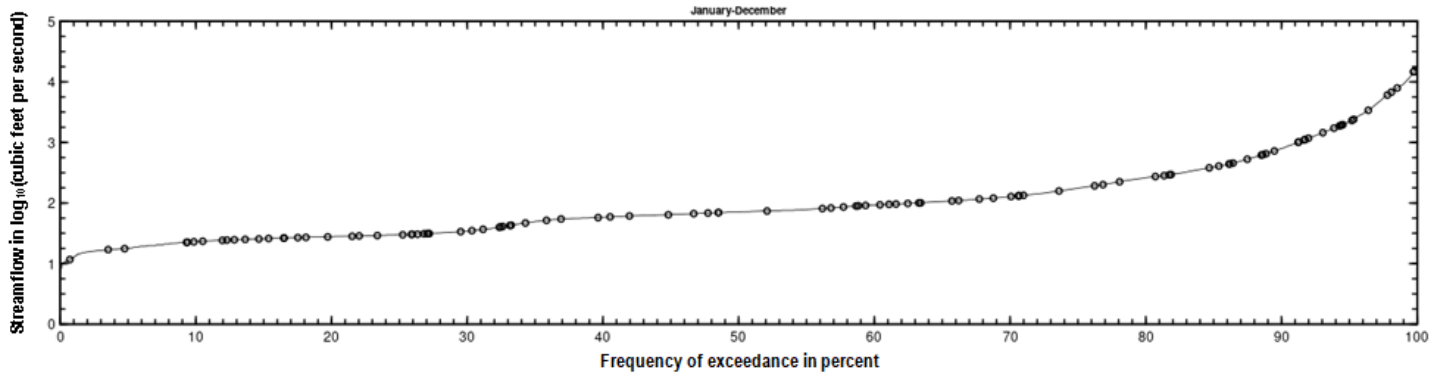
The regression model is based on 111 concomitant values of discretely collected total organic nitrogen and continuously measured turbidity during October 2014 through December 2019. Discrete samples were collected over a range of streamflow and turbidity conditions. No samples had concentrations that were below laboratory detection limits. Summary statistics and the complete model-calibration dataset are provided below. Outliers and influential points were identified using studentized residuals, DFITS, Cook's D (Cook, 1977), and leverage. Outliers in previously published versions of this model (Christensen and others, 2003; Rasmussen and others, 2016) were examined and retained in the dataset if there were no clear issues, explanations, or conditions that would cause a result to be invalid for model calibration. All samples were retained in the dataset.

Total Organic Nitrogen

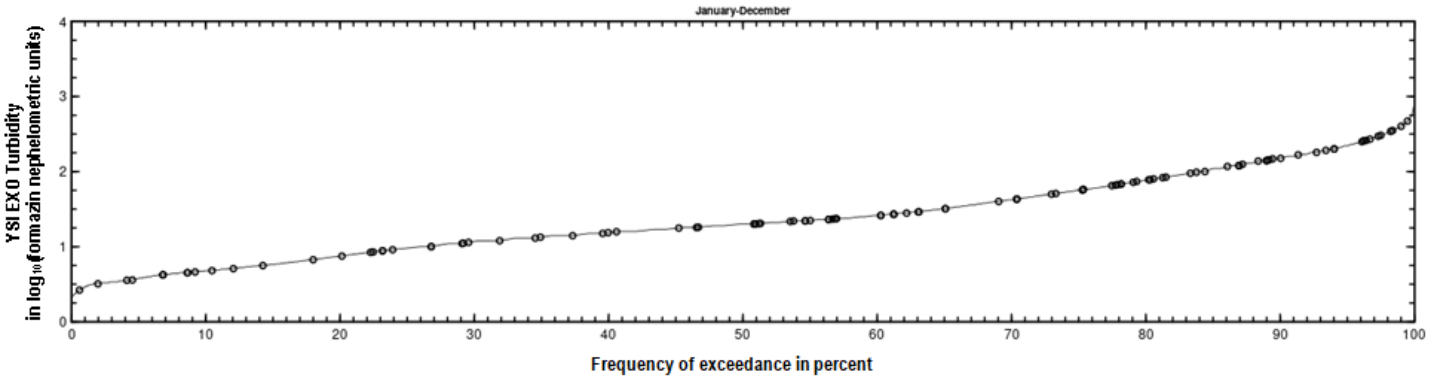
Discrete samples were collected from the downstream side of the bridge or instream within 50 feet of the bridge using equal-width-increment, multi-vertical, single vertical or grab-dip methods following U.S. Geological Survey (variously

dated) and Rasmussen and others (2014). Discrete samples were collected on a semifixed to event-based schedule ranging from 4 to 22 samples per year with a FISP US DH-95 or D-95 with a Teflon bottle, cap, and nozzle depth-integrating sampler, a DH-81 with a Teflon bottle, cap, and nozzle hand sampler or a grab sample with a Teflon bottle depending on sample location. Samples were analyzed for total organic nitrogen by the USGS National Water Quality Laboratory according to standard methods (American Public Health Association and others, 1995).

Total Organic Nitrogen Samples Plotted on Streamflow Duration Curve



Total Organic Nitrogen Samples Plotted on YSI EXO Turbidity Duration Curve



Continuous Data

Concomitant turbidity values were time interpolated. If no concomitant continuous data were available within 2 hours of sample collection, the sample was not included in the dataset.

Model Development

Ordinary least squares regression analysis was done using R (version 4.0.0) programming language (R Core Team, 2020) to relate discretely collected total organic nitrogen 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-computed total organic nitrogen 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) were ultimately selected.

Turbidity was selected as the best predictor of total organic nitrogen based on residual plots, high coefficient of determination (R^2), and low model standard percentage error (MSPE). Turbidity was positively correlated with total organic nitrogen because turbidity measures light scattered by particulates in water.

Model Summary

Summary of final total organic nitrogen regression analysis at USGS site number 07144100:

Total organic nitrogen-based model:

$$\log_{10}(TKN) = 0.419 \times \log_{10}(TBY) - 0.66$$

where,

\log_{10} = logarithm base 10;

TKN = total organic nitrogen, in milligrams per liter (mg/L); and

TBY = turbidity, in formazin nephelometric units (FNU)

The log-transformed model may be retransformed to original units so that TKN can be calculated directly. The retransformation introduces a bias in the calculated constituent. This bias may be corrected using Duan's bias correction factor (BCF; Duan, 1983). For this model, the calculated BCF is 1.03. The retransformed model, accounting for BCF is:

$$TKN = 0.2253 \times TBY^{0.419}$$

Model Statistics, Data, and Plots

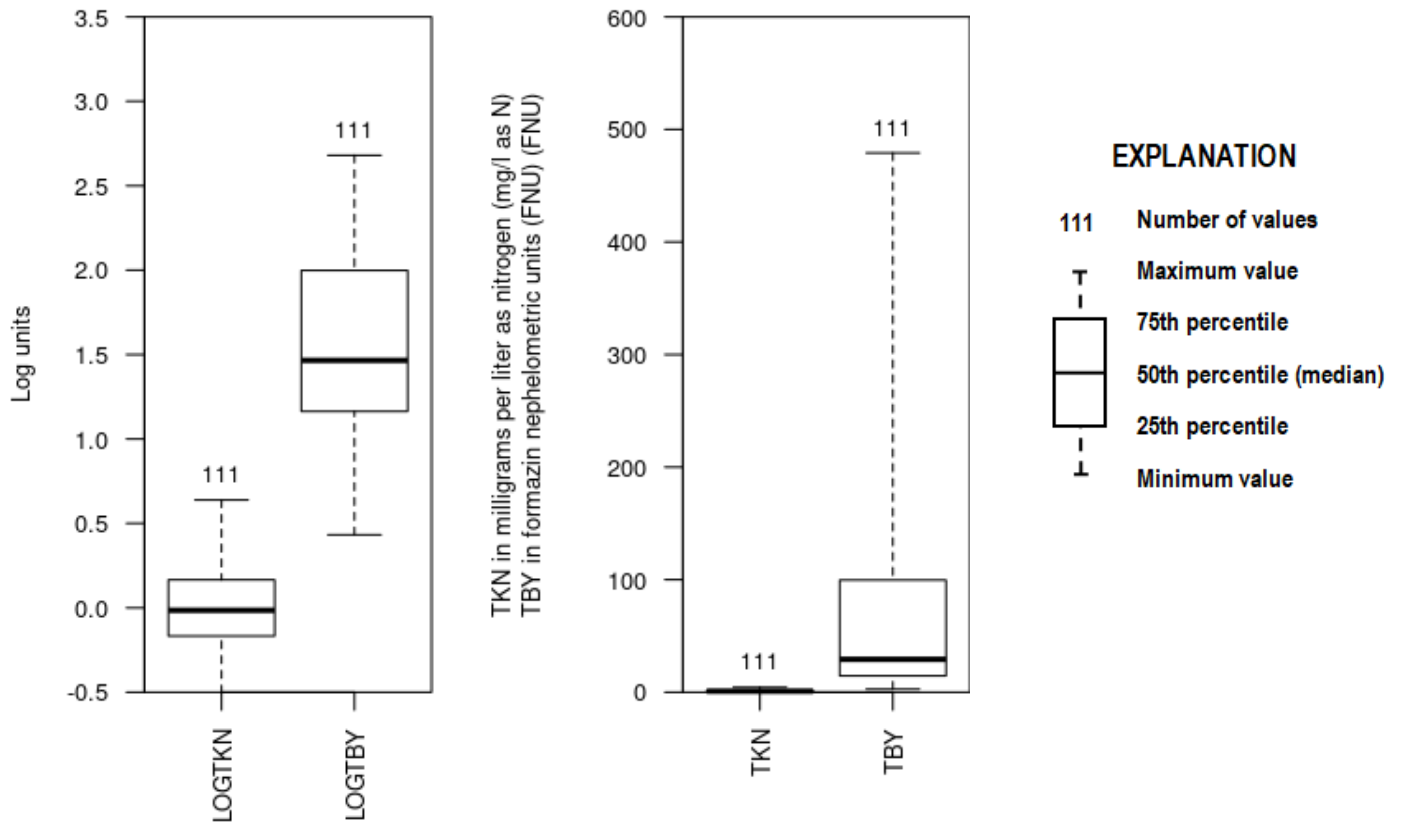
Model

$$\text{LOGTKN} = + 0.419 * \text{LOGTBY} - 0.66$$

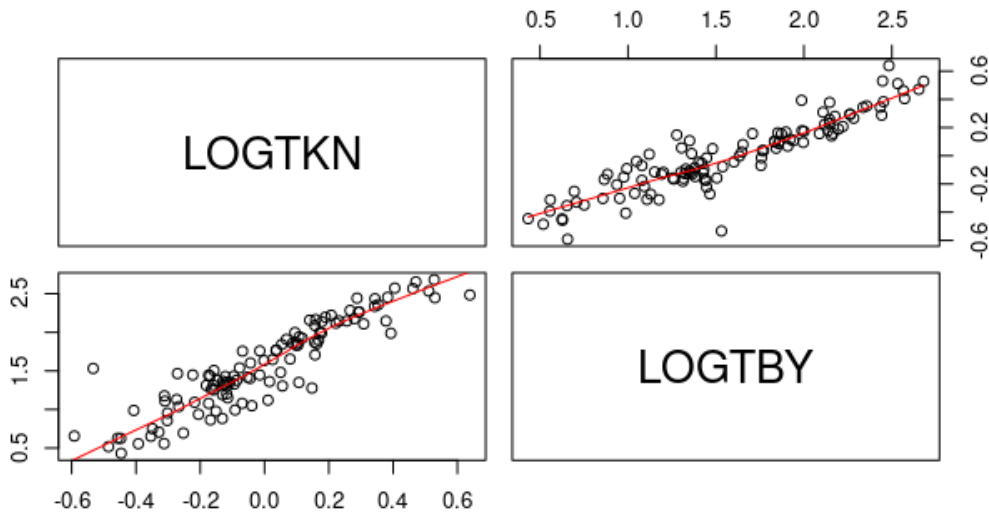
Variable Summary Statistics

	LOGTKN	TKN	LOGTBY	TBY
Minimum	-0.59200	0.256	0.432	2.71
1st Quartile	-0.16800	0.679	1.150	14.20
Median	-0.01500	0.966	1.470	29.20
Mean	-0.00234	1.190	1.570	79.20
3rd Quartile	0.16800	1.470	2.000	100.00
Maximum	0.63900	4.350	2.680	479.00

Box Plots



Exploratory Plots



Basic Model Statistics

Number of Observations	111
Standard error (RMSE)	0.105
Average Model standard percentage error (MSPE)	24.5
Coefficient of determination (R ²)	0.834
Adjusted Coefficient of Determination (Adj. R ²)	0.833
Bias Correction Factor (BCF)	1.03

Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t)
(Intercept)	-0.660	0.0298	-22.1	3.75e-42
LOGTBY	0.419	0.0179	23.4	2.31e-44

Correlation Matrix

	Intercept	E.vars
Intercept	1.000	-0.942
E.vars	-0.942	1.000

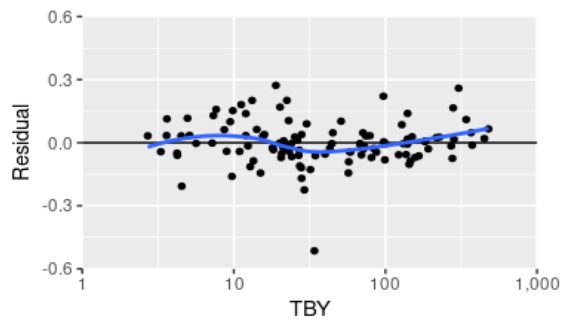
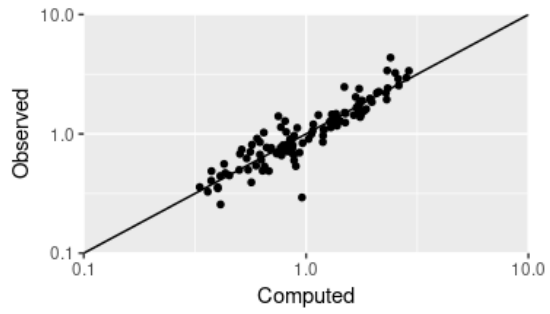
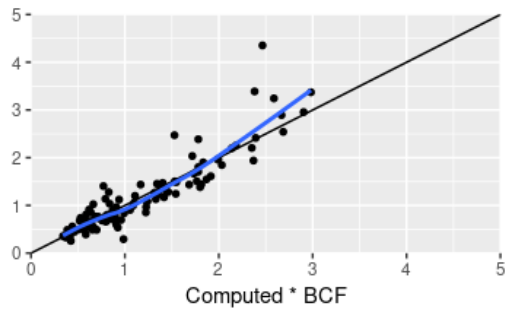
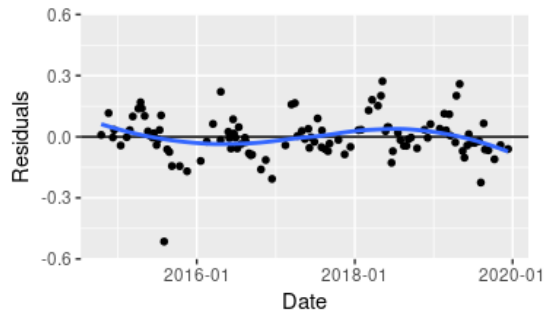
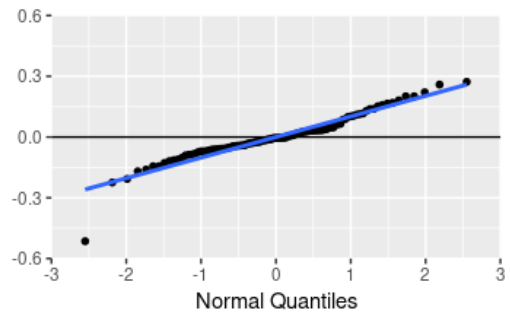
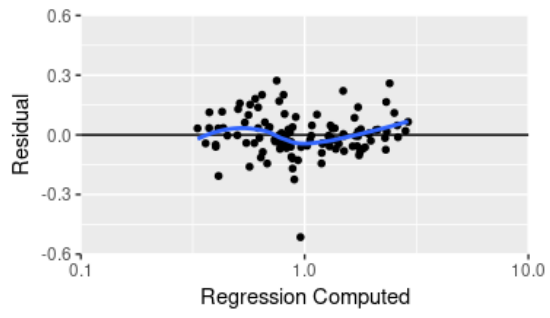
Outlier Test Criteria

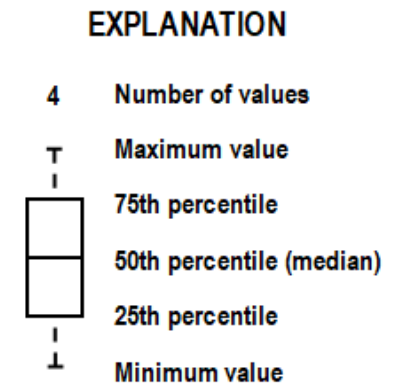
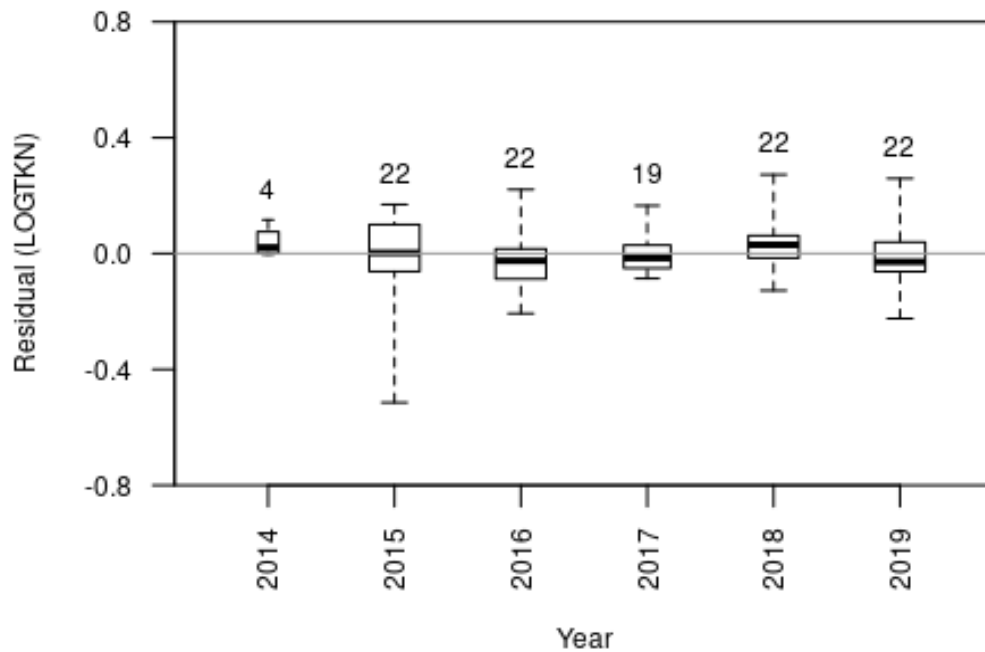
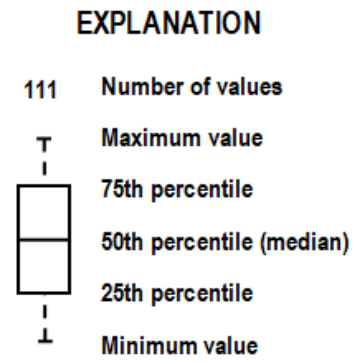
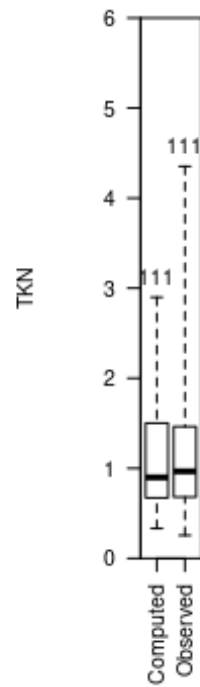
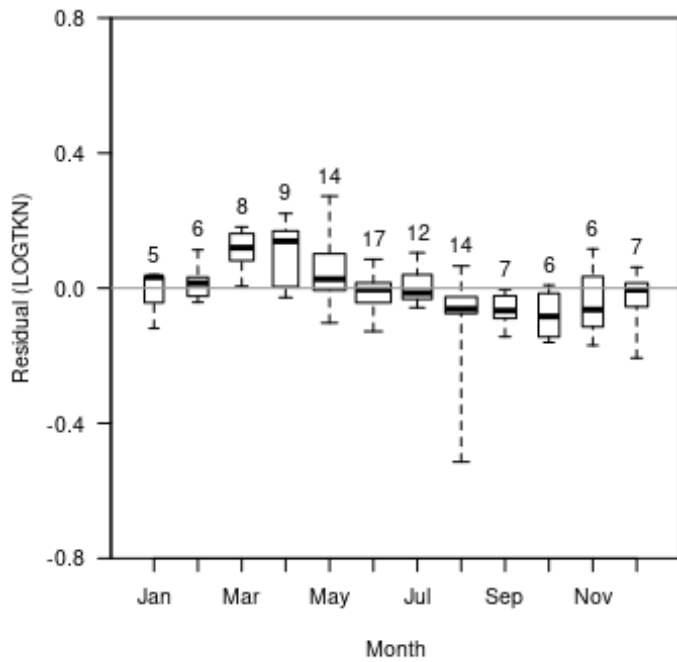
Leverage	Cook's D	DFFITS
0.0541	0.1944	0.2685

Flagged Observations

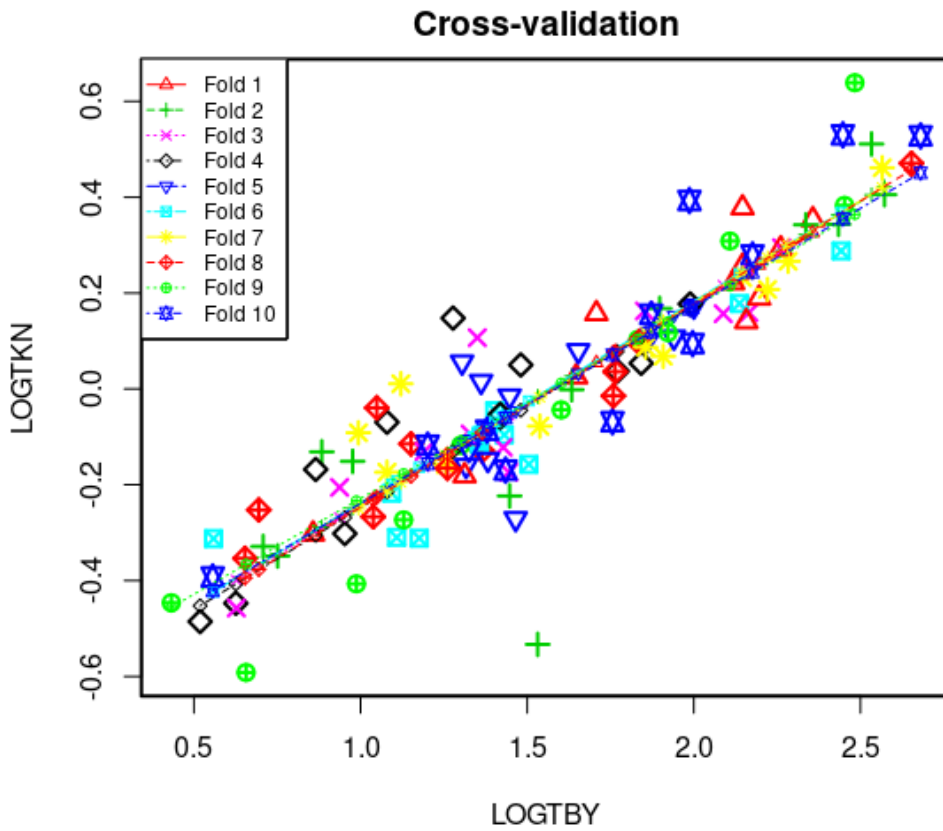
	LOGTKN	Estimate	Residual	Standard Residual	Studentized Residual	Leverage	Cook's D	DFFITS
8/3/2015 8:30	-0.533	-0.0186	-0.515	-4.9	-5.52	0.00905	0.11	-0.528
12/14/2016 10:20	-0.592	-0.385	-0.207	-1.99	-2.02	0.033	0.0678	-0.373
3/30/2017 13:45	0.53	0.365	0.165	1.59	1.6	0.0311	0.0406	0.287
5/9/2018 10:30	0.148	-0.125	0.273	2.6	2.67	0.0115	0.0392	0.288
5/1/2019 13:10	0.639	0.38	0.259	2.5	2.56	0.0329	0.106	0.472

Statistical Plots

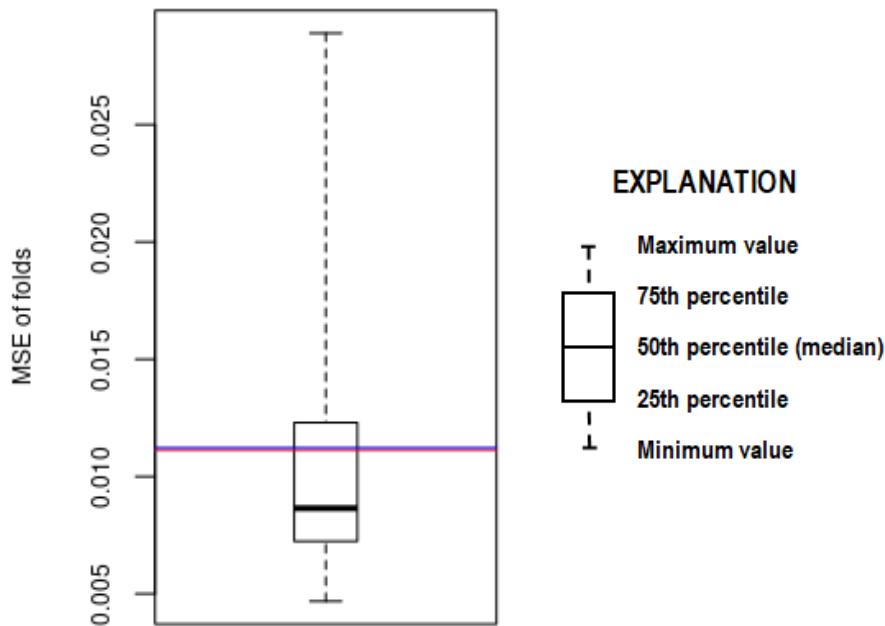




Cross Validation



Minimum MSE of folds: 0.00468
Mean MSE of folds: 0.01120
Median MSE of folds: 0.00864
Maximum MSE of folds: 0.02890
(Mean MSE of folds) / (Model MSE): 1.01000



Red line - Model MSE

Blue line - Mean MSE of folds

Model-Calibration Dataset

	Date	LOGTKN	LOGTBY	TKN	TBY	Computed LOGTKN	Computed TKN	Residual	Normal Quantiles
1	10/16/2014	-0.0942	1.33	0.805	21.3	-0.103	0.811	0.0091	0.227
2	11/19/2014	-0.253	0.695	0.559	4.95	-0.369	0.44	0.116	1.16
3	12/9/2014	-0.349	0.751	0.448	5.64	-0.345	0.464	-0.0035	0.0903
4	12/15/2014	-0.174	1.08	0.67	12	-0.208	0.637	0.034	0.57
5	1/14/2015	-0.485	0.519	0.327	3.3	-0.443	0.371	-0.0429	-0.518
6	2/11/2015	-0.303	0.857	0.498	7.2	-0.301	0.515	-0.00202	0.136
7	2/25/2015	-0.354	0.653	0.443	4.5	-0.386	0.423	0.0326	0.518
8	3/11/2015	-0.151	0.976	0.706	9.47	-0.251	0.577	0.0998	0.965
9	4/6/2015	-0.0696	1.08	0.852	12	-0.208	0.637	0.138	1.26
10	4/16/2015	0.0558	1.3	1.14	20.2	-0.114	0.792	0.169	1.56
11	4/22/2015	0.378	2.15	2.39	140	0.239	1.78	0.139	1.31
12	5/5/2015	0.157	1.71	1.44	51	0.0551	1.17	0.102	1
13	5/20/2015	0.353	2.36	2.25	228	0.327	2.18	0.0262	0.369
14	5/27/2015	0.295	2.26	1.97	183	0.288	1.99	0.00698	0.204
15	6/10/2015	0.103	1.83	1.27	68	0.107	1.32	-0.00395	0.0677
16	6/17/2015	0.256	2.15	1.8	140	0.239	1.78	0.0173	0.297
17	6/29/2015	-0.129	1.36	0.743	23.2	-0.0883	0.839	-0.0407	-0.418
18	7/6/2015	-0.108	1.35	0.78	22.3	-0.095	0.826	-0.0129	-0.113
19	7/13/2015	0.168	1.9	1.47	79	0.135	1.4	0.0332	0.544
20	7/20/2015	0.0154	1.36	1.04	23	-0.0896	0.837	0.105	1.04
21	8/3/2015	-0.533	1.53	0.293	34	-0.0186	0.985	-0.515	-2.55
22	8/17/2015	-0.0778	1.54	0.836	34.5	-0.0159	0.991	-0.0619	-0.83
23	8/27/2015	0.288	2.44	1.94	277	0.363	2.37	-0.0747	-1.04
24	9/8/2015	-0.0685	1.76	0.854	57	0.0753	1.22	-0.144	-1.56
25	10/14/2015	-0.312	1.18	0.488	15	-0.167	0.7	-0.144	-1.64
26	11/17/2015	-0.223	1.45	0.598	28	-0.0539	0.908	-0.169	-1.85
27	1/19/2016	-0.174	1.44	0.67	27.8	-0.055	0.906	-0.119	-1.42
28	2/16/2016	-0.158	1.26	0.695	18	-0.134	0.755	-0.0238	-0.227
29	3/16/2016	-0.115	1.15	0.768	14.2	-0.178	0.683	0.0631	0.83
30	4/20/2016	0.103	1.86	1.27	72.7	0.119	1.35	-0.0167	-0.181
31	4/21/2016	0.393	1.99	2.47	97	0.172	1.53	0.221	1.99
32	5/26/2016	0.342	2.34	2.2	217	0.318	2.14	0.0244	0.345
33	5/31/2016	0.232	2.15	1.71	140	0.239	1.78	-0.0067	-0.0451
34	6/7/2016	0.0535	1.84	1.13	69.5	0.111	1.33	-0.0579	-0.738
35	6/17/2016	0.309	2.11	2.04	128	0.223	1.72	0.0857	0.896
36	6/21/2016	0.383	2.45	2.41	283	0.367	2.39	0.0161	0.274
37	6/28/2016	0.0253	1.65	1.06	44.3	0.0297	1.1	-0.00435	0.0225
38	7/6/2016	0.157	2.09	1.43	123	0.214	1.68	-0.0576	-0.709
39	7/13/2016	0.0795	1.65	1.2	45	0.0324	1.11	0.0472	0.738
40	7/25/2016	-0.0958	1.43	0.802	27	-0.0605	0.895	-0.0353	-0.393
41	8/11/2016	0.173	2	1.49	100	0.178	1.55	-0.00492	0
42	8/16/2016	-0.00174	1.63	0.996	43	0.0241	1.09	-0.0258	-0.274
43	8/29/2016	0.0945	2	1.24	99.2	0.176	1.54	-0.0815	-1.08
44	9/7/2016	-0.0146	1.76	0.967	57.3	0.0764	1.23	-0.091	-1.21
45	9/13/2016	0.159	2.17	1.44	146	0.247	1.81	-0.0877	-1.16
46	10/24/2016	-0.407	0.988	0.392	9.72	-0.246	0.583	-0.16	-1.74
47	11/15/2016	-0.31	1.11	0.49	12.8	-0.196	0.655	-0.114	-1.36
48	12/14/2016	-0.592	0.656	0.256	4.53	-0.385	0.424	-0.207	-1.99
49	2/14/2017	-0.267	1.04	0.541	10.9	-0.225	0.612	-0.0417	-0.467
50	3/14/2017	-0.131	0.884	0.739	7.65	-0.29	0.528	0.158	1.42
51	3/30/2017	0.53	2.45	3.39	280	0.365	2.38	0.165	1.49
52	4/11/2017	0.177	1.99	1.5	97.5	0.173	1.53	0.00433	0.158
53	5/1/2017	0.279	2.18	1.9	150	0.251	1.83	0.0282	0.418

54	5/15/2017	0.0969	1.83	1.25	68.3	0.108	1.32	-0.0114	-0.0677
55	5/31/2017	-0.015	1.45	0.966	28	-0.0539	0.908	0.0389	0.652
56	6/5/2017	-0.0438	1.6	0.904	40	0.011	1.05	-0.0548	-0.652
57	6/13/2017	-0.117	1.3	0.763	20	-0.115	0.789	-0.00244	0.113
58	6/28/2017	-0.116	1.36	0.765	22.8	-0.0916	0.833	-0.0248	-0.251
59	7/13/2017	0.05	1.48	1.12	30.2	-0.0399	0.938	0.0899	0.93
60	7/31/2017	-0.16	1.32	0.692	20.7	-0.109	0.801	-0.0513	-0.624
61	8/2/2017	-0.131	1.19	0.74	15.5	-0.161	0.71	0.0304	0.442
62	8/16/2017	-0.122	1.43	0.755	26.8	-0.0618	0.892	-0.0602	-0.799
63	8/30/2017	-0.181	1.31	0.659	20.5	-0.11	0.798	-0.0707	-0.965
64	9/6/2017	-0.166	1.26	0.683	18.2	-0.132	0.759	-0.0336	-0.369
65	10/17/2017	-0.218	1.09	0.606	12.4	-0.202	0.646	-0.0155	-0.136
66	11/15/2017	-0.273	1.13	0.533	13.5	-0.187	0.669	-0.0864	-1.12
67	12/12/2017	-0.447	0.626	0.357	4.22	-0.398	0.412	-0.0496	-0.597
68	1/18/2018	-0.446	0.432	0.358	2.71	-0.479	0.342	0.0326	0.493
69	1/31/2018	-0.393	0.556	0.405	3.6	-0.427	0.385	0.0342	0.597
70	3/6/2018	-0.168	0.865	0.679	7.33	-0.297	0.519	0.129	1.21
71	3/22/2018	-0.0395	1.05	0.913	11.2	-0.221	0.619	0.181	1.64
72	4/18/2018	-0.0915	0.993	0.81	9.85	-0.244	0.587	0.152	1.36
73	5/2/2018	0.0107	1.12	1.02	13.2	-0.19	0.663	0.201	1.74
74	5/9/2018	0.148	1.28	1.4	18.9	-0.125	0.771	0.273	2.55
75	5/23/2018	-0.0453	1.4	0.901	25.3	-0.0725	0.87	0.0273	0.393
76	6/1/2018	0.461	2.57	2.89	367	0.414	2.67	0.0473	0.768
77	6/6/2018	0.163	1.85	1.45	71.1	0.116	1.34	0.047	0.709
78	6/20/2018	-0.157	1.51	0.696	32	-0.0296	0.961	-0.128	-1.49
79	6/26/2018	0.0682	1.91	1.17	80.9	0.139	1.42	-0.0709	-1
80	7/19/2018	0.471	2.65	2.96	450	0.451	2.9	0.0199	0.321
81	7/31/2018	0.343	2.43	2.21	272	0.359	2.35	-0.0158	-0.158
82	8/16/2018	0.037	1.77	1.09	58.9	0.0813	1.24	-0.0443	-0.544
83	8/28/2018	0.108	1.94	1.28	87.2	0.153	1.46	-0.0447	-0.57
84	9/6/2018	0.405	2.57	2.54	373	0.417	2.69	-0.0118	-0.0903
85	9/18/2018	-0.0862	1.38	0.82	24	-0.0822	0.851	-0.00404	0.0451
86	10/16/2018	0.178	2.14	1.51	137	0.235	1.77	-0.0566	-0.68
87	11/19/2018	-0.329	0.708	0.469	5.1	-0.363	0.445	0.0346	0.624
88	12/4/2018	0.222	2.12	1.67	131	0.227	1.73	-0.00512	-0.0225
89	12/17/2018	-0.206	0.937	0.623	8.65	-0.267	0.556	0.0619	0.799
90	1/29/2019	-0.117	1.2	0.763	15.9	-0.157	0.717	0.0393	0.68
91	2/19/2019	-0.312	0.559	0.487	3.62	-0.426	0.386	0.113	1.12
92	2/27/2019	0.156	1.87	1.43	74.5	0.124	1.37	0.0317	0.467
93	3/14/2019	0.511	2.53	3.24	341	0.401	2.59	0.11	1.08
94	3/19/2019	0.292	2.26	1.96	182	0.287	1.99	0.00558	0.181
95	4/11/2019	0.117	1.92	1.31	83.7	0.145	1.44	-0.0278	-0.297
96	4/16/2019	0.107	1.35	1.28	22.4	-0.0944	0.827	0.201	1.85
97	5/1/2019	0.639	2.48	4.35	304	0.38	2.47	0.259	2.19
98	5/15/2019	0.189	2.2	1.55	157	0.26	1.87	-0.07	-0.93
99	5/23/2019	0.141	2.16	1.38	144	0.243	1.8	-0.103	-1.26
100	6/5/2019	0.0358	1.76	1.09	58	0.0787	1.23	-0.0428	-0.493
101	6/12/2019	-0.0531	1.42	0.885	26.3	-0.0656	0.884	0.0126	0.251
102	6/24/2019	0.266	2.28	1.85	192	0.296	2.03	-0.0296	-0.321
103	7/10/2019	0.0871	1.86	1.22	71.7	0.117	1.35	-0.03	-0.345
104	7/30/2019	-0.127	1.32	0.747	21.1	-0.105	0.808	-0.0217	-0.204
105	8/7/2019	-0.271	1.47	0.536	29.2	-0.0462	0.925	-0.225	-2.19
106	8/20/2019	0.528	2.68	3.37	479	0.462	2.98	0.0654	0.862
107	8/26/2019	0.207	2.22	1.61	166	0.27	1.92	-0.0627	-0.862
108	9/11/2019	-0.148	1.38	0.712	24.1	-0.0811	0.853	-0.0664	-0.896
109	10/9/2019	-0.169	1.44	0.677	27.2	-0.0589	0.898	-0.11	-1.31

110	11/6/2019	-0.302	0.953	0.499	8.97	-0.261	0.564	-0.041	-0.442
111	12/11/2019	-0.457	0.627	0.349	4.24	-0.397	0.412	-0.0601	-0.768

Definitions

TKN: Kjeldahl nitrogen in mg/L as N (00625)

TBY: Turbidity in FNU (63680)

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