

Appendix 4. Regression analysis results for estimating total phosphorus concentration

All data were collected using U.S. Geological Survey (USGS) protocols and are stored in the USGS National Water Information System (NWIS) database (<http://waterdata.usgs.gov/nwis>). The regression models are based on measurements of turbidity and concurrent total phosphorus samples collected from November 2008 to September 2009. Continuous water-quality data were collected at 5-minute intervals using a YSI model 6920 V2 multiparameter water-quality monitor with a 6560 specific conductance and water temperature sensor, and

a 6136 optical turbidity sensor. Turbidity values are instantaneous unit values temporally corresponding to the collection of the total phosphorus samples. Samples were collected throughout the range of continuously observed hydrologic conditions. Summary statistics and the complete model-calibration dataset are provided. A comparison of cross-section mean and corresponding time-series monitor readings is archived at the Wisconsin Water Science Center and is available by request to Austin Baldwin (akbaldwi@usgs.gov).

Total phosphorus at Little Menomonee River near Freistadt, WI (04087050)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Little Menomonee River near Freistadt, WI.

$$\text{Log}_{10}(\text{Total Phosphorus}) = -1.37 + 0.486 \log_{10}(\text{Turb}),$$

Where:

Total Phosphorus = total phosphorus concentration in mg/L

Turb = Turbidity, (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 39,

Root-mean-squared error (RMSE) = 0.19

Model standard percentage error (MPSE) = +56 and -36 percent

90-percent prediction intervals (based on units in mg/L) = +/- 94 percent

Adjusted coefficient of determination ($\text{Adj } R^2$) = 0.75

Sum of squared error = 1.40

PRESS = 1.75

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.37	0.074	-18.49	<.0001
$\text{Log}_{10}(\text{Turb})$	0.486	0.045	10.82	<.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}(\text{Turb})$
Intercept	1.00	-0.908
$\text{Log}_{10}(\text{Turb})$	-0.908	1.00

Duan's bias correction factor = **1.13**

Table 4-1. Model-calibration dataset for Little Menomonee River near Freistadt, Wisconsin.

[mg/L, milligrams per liter; NTU, Nephelometric turbidity units]

Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)	Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)
11/20/2008	9:45	0.042	1.2	4/23/2009	9:45	0.038	2.1
12/17/2008	11:30	0.044	2.1	4/25/2009	15:10	0.24	100.0
12/27/2008	13:05	0.26	11.2	4/26/2009	5:30	0.55	180.0
12/28/2008	1:05	0.52	52.3	4/26/2009	19:30	0.56	200.0
12/28/2008	7:15	0.43	45.0	4/27/2009	1:30	0.32	80.0
1/20/2009	10:55	0.21	0.7	5/9/2009	7:25	0.26	81.0
2/7/2009	18:50	0.24	19.7	5/9/2009	13:30	0.23	54.0
2/9/2009	22:40	0.12	11.3	5/9/2009	19:30	0.11	15.0
2/10/2009	10:45	0.36	38.0	5/14/2009	2:30	0.68	270.0
2/10/2009	14:40	0.57	113.3	5/20/2009	9:00	0.076	4.5
2/10/2009	20:40	0.41	46.0	6/8/2009	5:20	0.32	120.0
2/11/2009	2:40	0.28	21.3	6/16/2009	8:45	0.11	12.0
3/2/2009	7:10	0.049	4.2	6/19/2009	2:50	0.56	290.0
3/7/2009	12:55	0.37	130.0	6/19/2009	8:50	0.37	89.0
3/7/2009	18:05	0.83	220.0	7/16/2009	10:05	0.14	19.0
3/8/2009	7:05	0.35	62.0	8/19/2009	10:00	0.085	8.8
3/8/2009	19:00	0.77	210.0	9/15/2009	9:30	0.066	10.0
3/9/2009	0:30	0.56	140.0	MINIMUM		0.04	0.7
3/10/2009	3:20	0.3	68.0	MAXIMUM		0.83	290.0
3/10/2009	8:15	0.43	94.0	MEAN		0.31	73.8
3/10/2009	20:15	0.25	51.0	MEDIAN		0.28	51.0
3/24/2009	10:40	0.043	2.8	STANDARD DEVIATION		0.21	79.0

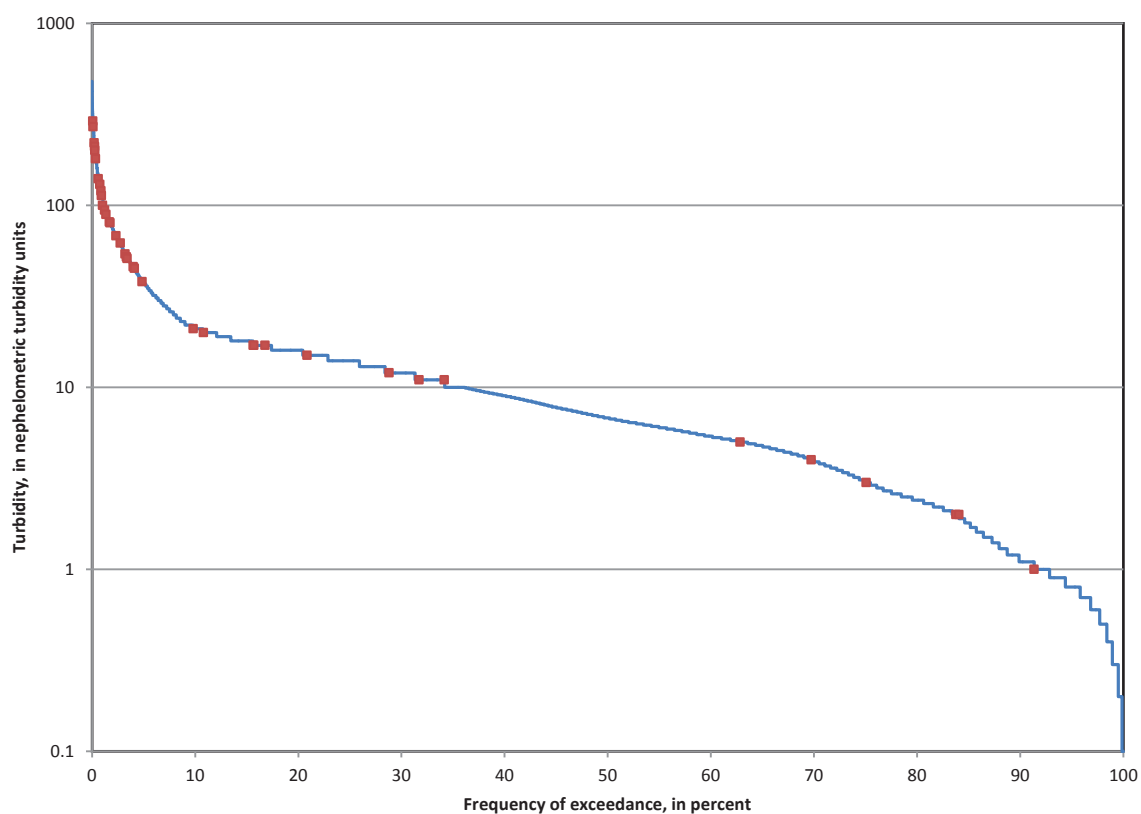


Figure 4-1. Duration curve for turbidity (November 2008–September 2010) and corresponding values associated with total phosphorus concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Little Menomonee River near Freistadt, Wisconsin.

Total phosphorus at Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2009

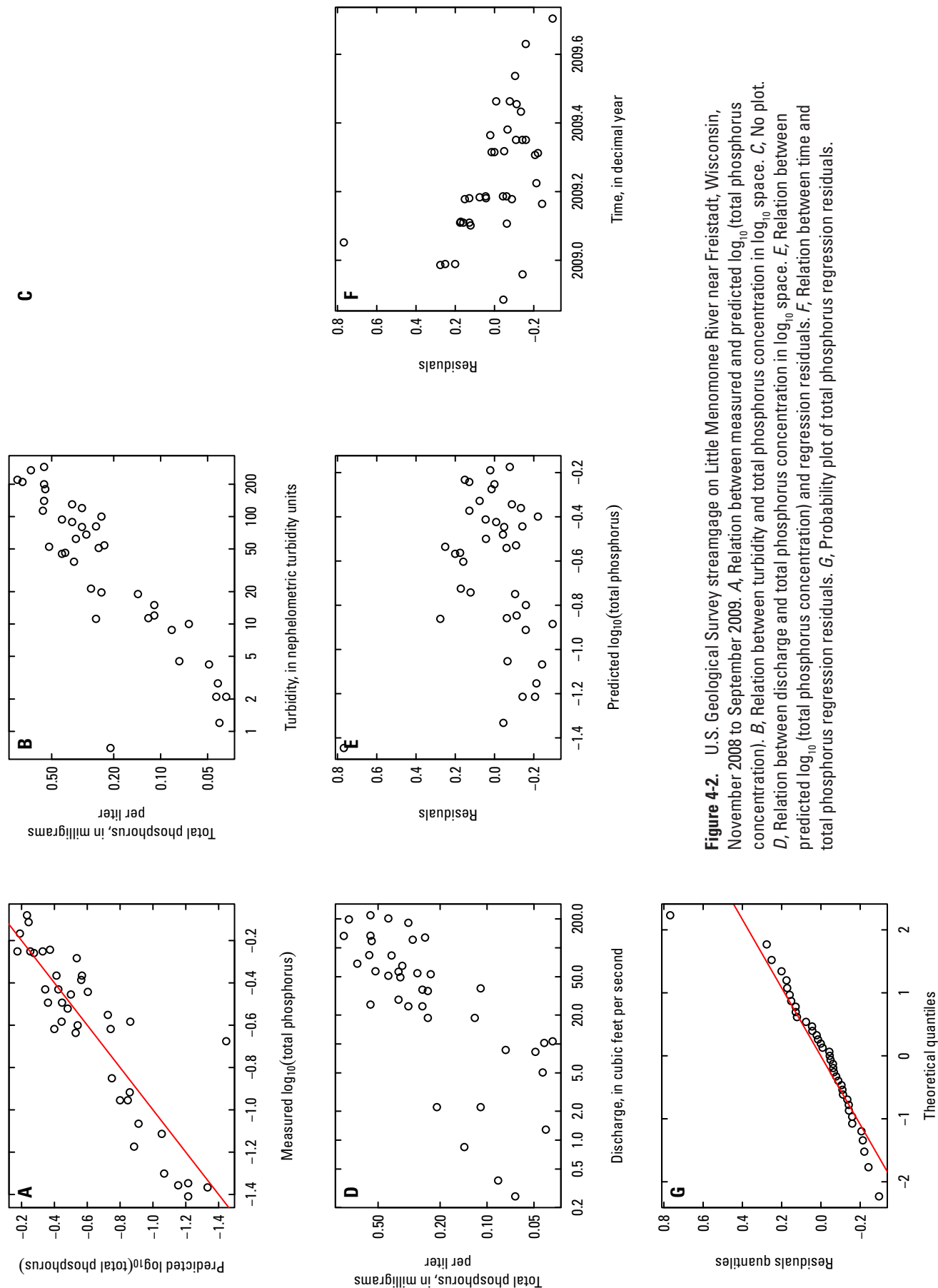


Figure 4-2. U.S. Geological Survey streamgauge on Little Menomonee River near Freistadt, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (total phosphorus concentration). *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space. *C*, No plot. *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (total phosphorus concentration) and regression residuals. *F*, Relation between time and total phosphorus regression residuals. *G*, Probability plot of total phosphorus regression residuals.

Total phosphorus at Menomonee River at Menomonee Falls, WI (04087030)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Menomonee River at Menomonee Falls, WI.

$$\text{Log}_{10}(\text{Total Phosphorus}) = -1.55 + 0.492 \log_{10}(\text{Turb}),$$

Where:

Total Phosphorus = total phosphorus concentration in mg/L

Turb = Turbidity, (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 59,

Root-mean-squared error (RMSE) = 0.207

Model standard percentage error (MPSE) = +61 and -38 percent

90-percent prediction intervals (based on units in mg/L) = +/- 101 percent

Adjusted coefficient of determination ($\text{Adj } R^2$) = 0.62

Sum of squared error = 2.45

PRESS = 2.67

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.55	0.077	-20.20	<0.0001
$\text{Log}_{10}(\text{Turb})$	0.492	0.050	9.83	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}(\text{Turb})$
Intercept	1	-0.936
$\text{Log}_{10}(\text{Turb})$	-0.936	1

Duan's bias correction factor = **1.14**

Table 4-2. Model-calibration dataset for Menomonee River at Menomonee Falls, Wisconsin.

[mg/L, milligrams per liter; NTU, Nephelometric turbidity units]

Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)	Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)
11/20/2008	9:15	0.041	3.6	5/10/2009	10:25	0.053	8.2
12/17/2008	12:00	0.036	2.7	5/13/2009	23:00	0.2	81.0
12/27/2008	0:35	0.23	18.0	5/20/2009	9:30	0.063	6.3
12/27/2008	6:15	0.27	49.0	6/8/2009	3:15	0.32	91.0
12/27/2008	14:20	0.42	100.7	6/8/2009	3:25	0.78	220.0
12/27/2008	20:20	0.35	39.7	6/8/2009	9:35	0.096	28.0
12/28/2008	8:20	0.33	45.3	6/16/2009	10:15	0.071	13.0
1/20/2009	9:55	0.24	2.5	6/19/2009	0:10	0.55	160.0
2/16/2009	11:00	0.054	3.1	6/19/2009	0:50	0.2	110.0
2/26/2009	15:05	0.22	86.0	6/19/2009	2:00	0.1	66.0
2/26/2009	18:15	0.24	81.0	6/20/2009	2:00	0.55	21.0
2/27/2009	0:15	0.17	30.0	7/16/2009	9:30	0.082	5.0
3/2/2009	7:15	0.068	3.2	8/7/2009	19:35	0.2	46.0
3/7/2009	9:30	0.13	31.0	8/8/2009	9:05	0.21	80.0
3/7/2009	15:30	0.17	29.0	8/19/2009	9:00	0.094	3.2
3/8/2009	10:30	0.18	26.0	8/25/2009	18:20	0.36	210.0
3/8/2009	14:00	0.27	69.0	8/25/2009	18:45	0.28	85.0
3/9/2009	2:00	0.2	34.0	8/26/2009	1:30	0.11	30.0
3/24/2009	10:00	0.038	4.1	8/26/2009	1:55	0.14	48.0
3/25/2009	5:25	0.057	16.0	9/15/2009	9:30	0.06	2.8
4/19/2009	23:00	0.1	23.0	9/22/2009	13:15	0.18	62.0
4/20/2009	11:15	0.043	12.0	9/22/2009	14:05	0.4	130.0
4/20/2009	23:15	0.038	11.0	9/22/2009	15:20	0.12	21.0
4/23/2009	9:15	0.034	3.8	9/27/2009	19:25	0.23	81.0
4/25/2009	10:50	0.18	71.0	9/27/2008	21:30	0.2	51.0
4/25/2009	11:00	0.38	170.0	9/28/2009	5:55	0.088	12.0
4/26/2009	5:00	0.1	27.0	MINIMUM		0.03	2.5
4/26/2009	16:00	0.12	34.0	MAXIMUM		0.78	220.0
4/27/2009	4:00	0.11	23.0	MEAN		0.19	49.8
5/9/2009	1:05	0.17	83.0	MEDIAN		0.17	30.0
5/9/2009	1:15	0.35	110.0	STANDARD DEVIATION		0.15	50.9
5/9/2009	10:25	0.077	12.0				
5/9/2009	22:25	0.066	14.0				

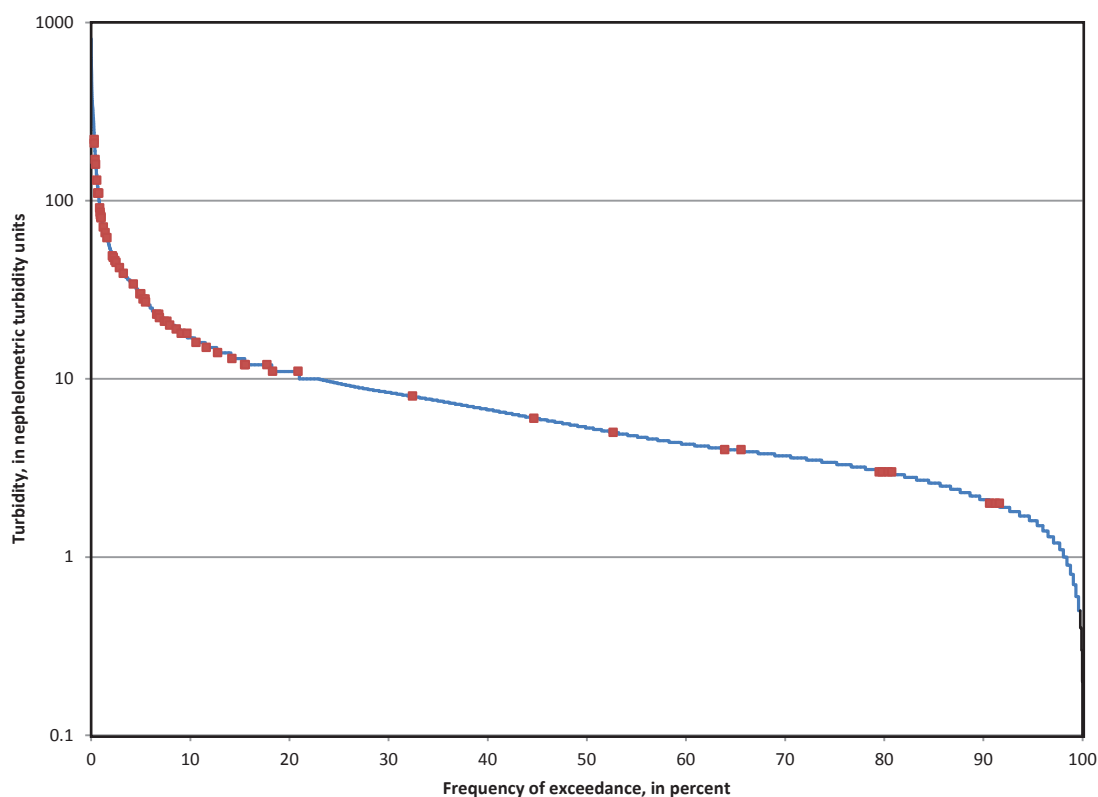


Figure 4-3. Duration curve for turbidity (November 2008–September 2010) and corresponding values associated with total phosphorus concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Menomonee River at Menomonee Falls, Wisconsin.

Total phosphorus at Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2009

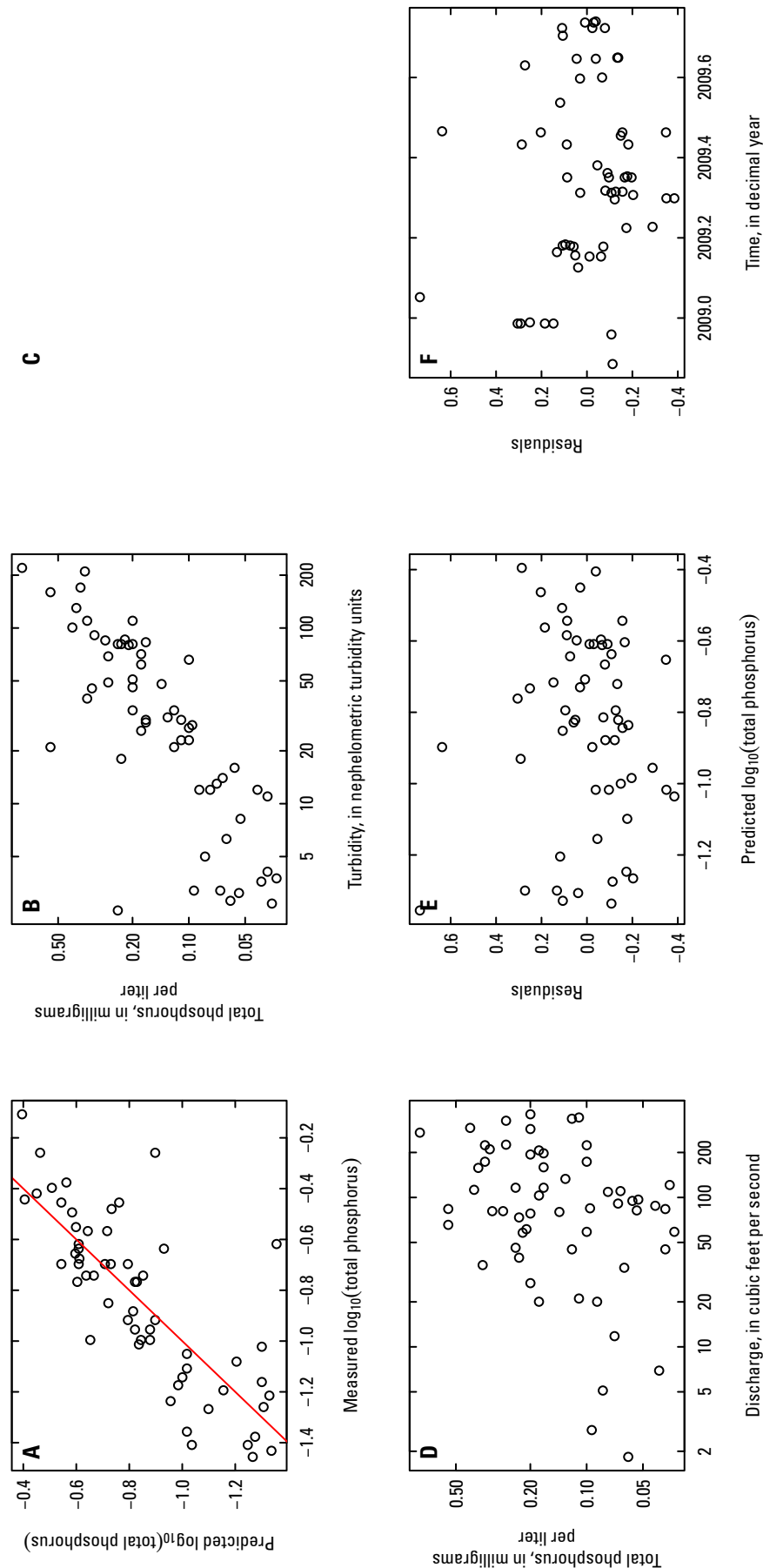


Figure 4-4. U.S. Geological Survey streamgauge on Menomonee River at Menomonee Falls, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (total phosphorus concentration). *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space. *C*, No plot. *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (total phosphorus concentration) and regression residuals. *F*, Relation between time and total phosphorus regression residuals. *G*, Probability plot of total phosphorus regression residuals.

Total phosphorus at Honey Creek at Wauwatosa, WI (04087119)

Sample data from 4/25/2009 at 12:40 through 4/26/2009, and sample data from 6/8/2009 were not used in the regression development because of excessive fouling of the data sonde. Sample data on 6/19/2009 were not used because of damage to the sonde and sampler line during an extreme flood event.

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Honey Creek at Wauwatosa, WI.

$$\text{Log}_{10}(\text{Total Phosphorus}) = -1.45 + 0.451 \log_{10}(\text{Turb}),$$

Where:

Total Phosphorus = total phosphorus concentration in mg/L

Turb = Turbidity, (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 66,

Root-mean-squared error (RMSE) = 0.22

Model standard percentage error (MPSE) = +66 and -40 percent

90-percent prediction intervals (based on units in mg/L) = +/- 108 percent

Adjusted coefficient of determination ($\text{Adj } R^2$) = 0.64

Sum of squared error = 3.08

PRESS = 3.35

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.45	0.075	-19.21	<.0001
$\text{Log}_{10}(\text{Turb})$	0.451	0.042	10.74	<.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}(\text{Turb})$
Intercept	1.00	-0.934
$\text{Log}_{10}(\text{Turb})$	-0.934	1.00

Duan's bias correction factor = 1.14

Table 4-3. Model-calibration dataset for Honey Creek at Wauwatosa, Wisconsin.

[mg/L, milligrams per liter; NTU, Nephelometric turbidity units]

Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)	Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)
12/17/2008	13:45	0.04	1.8	5/14/2009	0:55	0.3	130.0
1/20/2009	11:55	0.26	1.7	5/14/2009	2:40	0.28	120.0
2/10/2009	10:10	0.28	46.0	5/20/2009	11:00	0.035	2.7
2/10/2009	13:25	0.37	123.3	6/16/2009	11:00	0.051	2.7
2/10/2009	19:25	0.26	82.0	7/16/2009	11:00	0.13	4.0
2/11/2009	1:25	0.18	41.3	8/7/2009	17:10	0.3	27.0
2/11/2009	11:25	0.12	21.3	8/7/2009	20:20	0.83	170.0
2/11/2009	12:00	0.37	97.0	8/7/2009	23:05	0.27	28.0
2/11/2009	15:30	0.4	210.0	8/8/2009	9:10	0.71	240.0
2/12/2009	2:25	0.15	32.7	8/8/2009	9:30	0.7	300.0
2/16/2009	12:20	0.14	53.3	8/8/2009	19:55	0.13	59.0
3/7/2009	9:25	0.074	74.0	8/10/2009	1:50	0.49	210.0
3/7/2009	10:25	0.47	210.0	8/10/2009	4:10	0.21	100.0
3/7/2009	12:10	0.41	140.0	8/19/2009	12:40	0.086	1.3
3/7/2009	16:05	0.26	71.0	8/25/2009	20:55	0.28	63.0
3/7/2009	22:05	0.22	46.0	8/28/2009	22:05	0.51	206.7
3/8/2009	14:25	0.28	140.0	8/26/2009	4:05	0.28	34.0
3/9/2009	1:00	0.22	32.0	9/15/2009	10:45	0.054	1.6
3/10/2009	0:50	0.1	40.0	9/20/2009	20:20	0.14	44.0
3/10/2009	5:30	0.15	50.0	9/20/2009	21:55	0.88	190.0
3/10/2009	9:30	0.15	55.0	9/21/2009	3:55	0.3	34.0
3/10/2009	12:10	0.12	33.0	9/22/2009	13:25	0.33	84.0
3/10/2009	12:15	0.12	31.0	9/22/2009	14:05	0.7	210.0
3/24/2009	11:40	0.041	1.8	9/22/2009	22:40	0.16	44.0
3/25/2009	1:20	0.37	280.0	9/27/2009	20:20	0.35	110.0
3/25/2009	3:45	0.14	183.3	9/27/2009	21:00	0.6	272.5
3/31/2009	16:15	0.16	61.0	9/27/2009	23:35	0.4	99.0
3/31/2009	17:05	0.39	390.0	9/28/2009	2:30	0.16	88.0
4/1/2009	3:00	0.078	27.0	MINIMUM		0.03	1.3
4/19/2009	17:10	0.081	17.0	MAXIMUM		0.88	390.0
4/19/2009	18:15	0.36	117.5	MEAN		0.28	94.8
4/20/2009	2:30	0.12	34.3	MEDIAN		0.24	57.0
4/20/2009	17:20	0.045	18.5	STANDARD DEVIATION		0.21	91.3
4/23/2009	10:45	0.03	1.6				
4/25/2009	10:50	0.064	21.0				
5/13/2009	20:30	0.17	54.0				
5/13/2009	20:50	0.67	280.0				
5/13/2009	21:10	0.66	260.0				

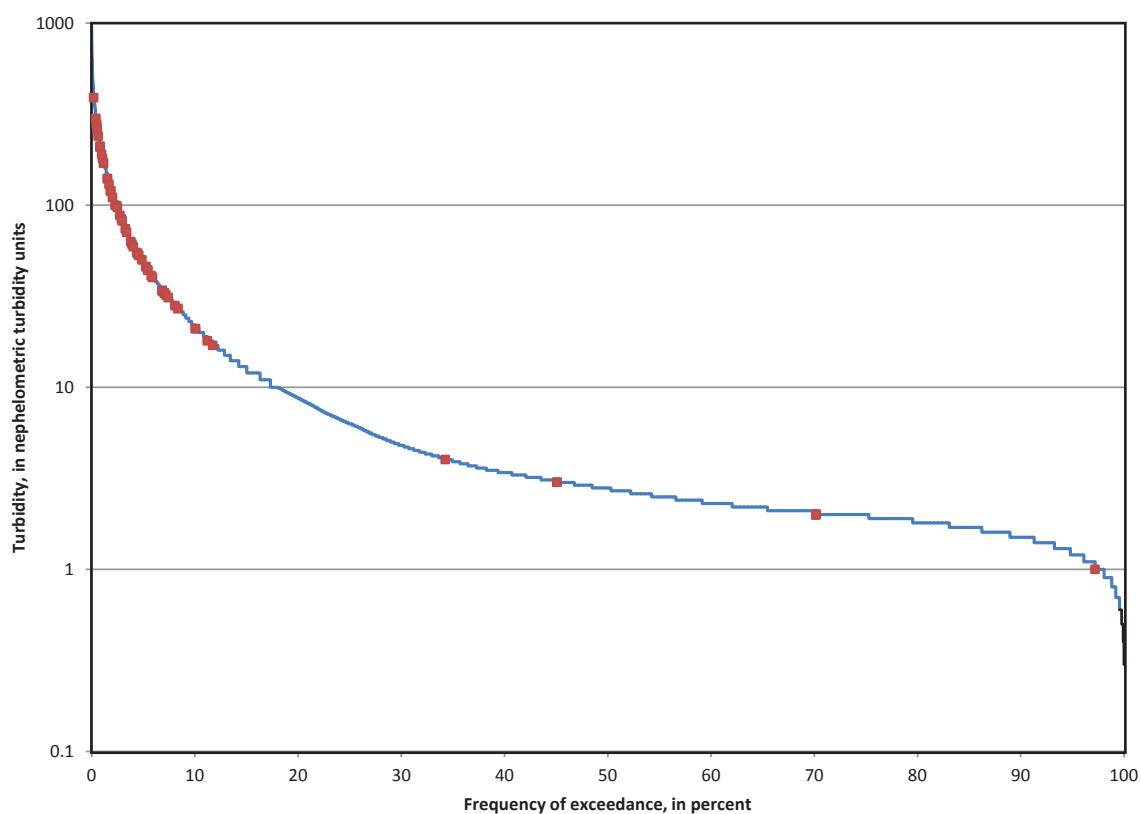


Figure 4-5. Duration curve for turbidity (November 2008–September 2010) and corresponding values associated with total phosphorus concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin.

Total phosphorus at Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2009

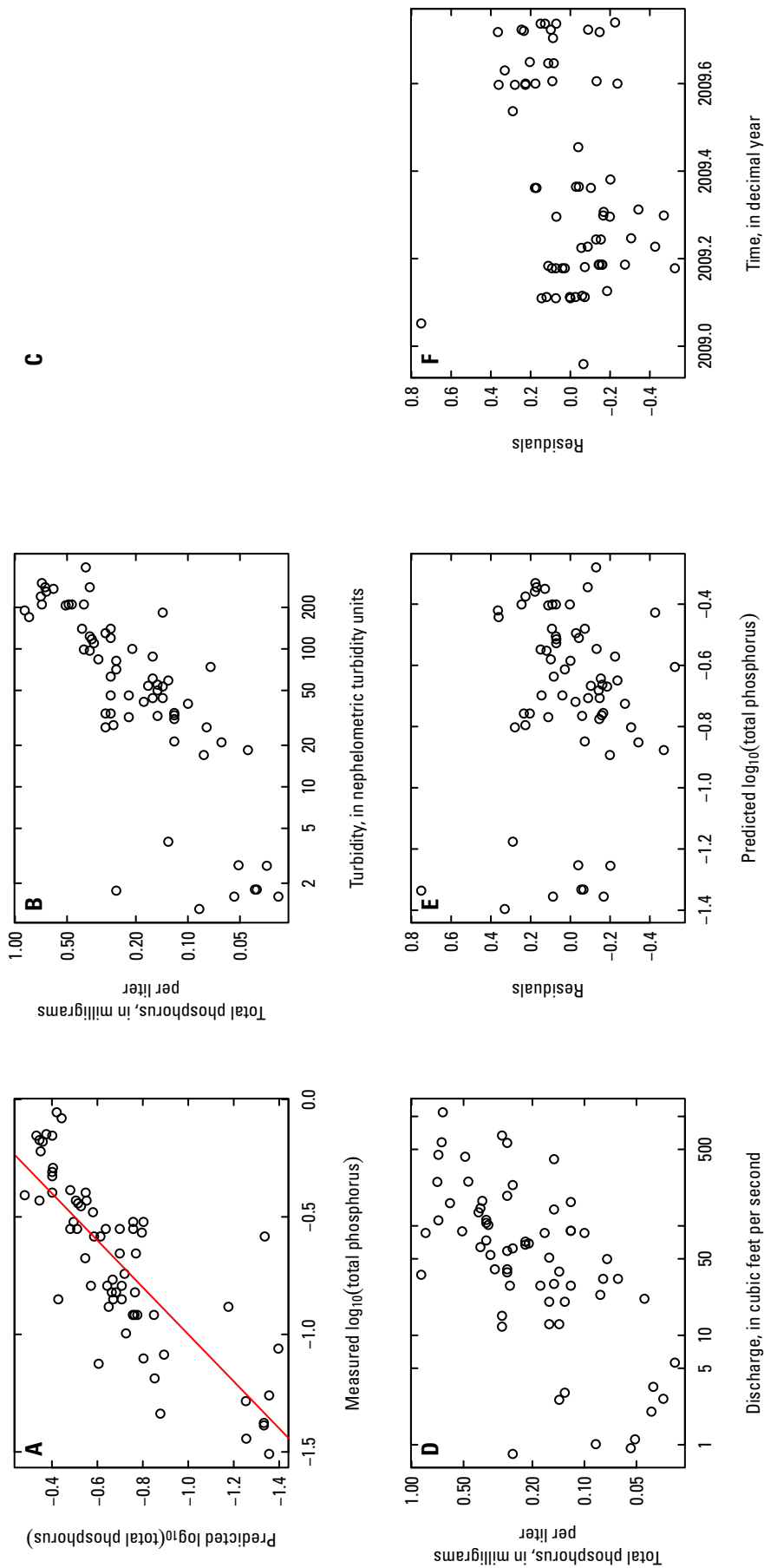


Figure 4-6. U.S. Geological Survey streamgauge on Honey Creek at Wauwatosa, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (total phosphorus concentration). *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space. *C*, No plot. *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (total phosphorus concentration) and regression residuals. *F*, Relation between time and total phosphorus regression residuals. *G*, Probability plot of total phosphorus regression residuals.

Total phosphorus at Menomonee River at Wauwatosa, WI (04087120)

Total phosphorus samples collected on 12/27/2008 at 06:05, 10:15, and 14:45, and on 12/28/2008 at 07:45 were not used in the regression analysis because the MMSD laboratory reported a qualified total phosphorus concentration of < 1.4 mg/L. Samples collected on 6/8–6/9 2009 were not used in the regression analysis because the turbidity sensor readings were spiking excessively and the data quality was thought to be poor.

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Menomonee River at Wauwatosa, WI.

$$\log_{10}(\text{Total Phosphorus}) = -1.42 + 0.431 \log_{10}(\text{Turb}),$$

Where:

Total Phosphorus = total phosphorus concentration in mg/L

Turb = Turbidity, (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 91,

Root-mean-squared error (RMSE) = 0.204

Model standard percentage error (MPSE) = +60 and -38 percent

90-percent prediction intervals (based on units in mg/L) = +/- 97 percent

Adjusted coefficient of determination (Adj R²) = 0.55

Sum of squared error = 3.72

PRESS = 3.96

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.42	0.068	-20.70	<0.0001
Log ₁₀ (Turb)	0.431	0.041	10.63	<0.0001

Correlation matrix of coefficients:

	Intercept	log ₁₀ (Turb)
Intercept	1	-0.950
Log ₁₀ (Turb)	-0.950	1

Duan's bias correction factor = 1.12

Table 4-4. Model-calibration dataset for Menomonee River at Wauwatosa, Wisconsin.

[mg/L, milligrams per liter; NTU, Nephelometric turbidity units]

Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)	Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)
11/20/2008	10:30	0.046	1.9	4/27/2009	0:30	0.14	76.0
12/17/2008	12:30	0.053	6.8	5/9/2009	0:30	0.15	37.0
12/27/2008	1:15	0.31	25.0	5/9/2009	9:30	0.083	17.0
12/27/2008	3:45	0.34	46.0	5/9/2009	15:50	0.065	15.0
12/27/2008	5:50	0.39	66.0	5/13/2009	20:40	0.28	68.0
12/27/2008	14:00	0.66	180.0	5/13/2009	21:05	0.46	150.0
1/20/2009	12:10	0.23	1.5	5/13/2009	22:00	0.37	140.0
2/7/2009	11:25	0.33	72.3	5/14/2009	3:15	0.2	86.0
2/7/2009	13:25	0.4	105.0	5/20/2009	11:15	0.11	4.8
2/7/2009	13:40	0.54	110.0	6/16/2009	11:50	0.089	9.6
2/7/2009	19:40	0.31	46.3	6/19/2009	9:15	0.35	84.0
2/8/2009	13:40	0.22	26.0	6/19/2009	18:15	0.17	52.0
2/9/2009	1:40	0.13	12.0	6/19/2009	21:20	0.22	150.0
2/9/2009	19:40	0.34	64.0	6/20/2009	3:10	0.18	45.0
2/9/2009	22:00	0.45	140.0	7/16/2009	11:45	0.082	3.5
2/9/2009	23:15	0.3	140.0	8/7/2009	18:00	0.26	32.0
2/10/2009	7:20	0.18	45.7	8/7/2009	20:40	0.29	60.0
2/10/2009	11:00	0.39	100.0	8/8/2009	0:55	0.2	37.0
2/10/2009	17:05	0.28	70.7	8/8/2009	8:50	0.23	74.0
2/10/2009	23:25	0.17	41.3	8/8/2009	9:45	0.56	210.0
2/16/2009	12:45	0.18	4.8	8/8/2009	19:50	0.14	48.0
2/26/2009	14:35	0.093	66.0	8/9/2009	19:50	0.19	39.0
2/26/2009	19:00	0.097	140.0	8/10/2009	2:00	0.25	110.0
2/26/2009	19:45	0.26	170.0	8/10/2009	4:20	0.16	99.0
2/26/2009	22:50	0.29	130.0	8/19/2009	12:20	0.11	2.7
2/27/2009	4:50	0.36	70.0	8/25/2009	20:50	0.3	68.0
3/2/2009	7:20	0.068	7.3	8/25/2009	21:25	0.34	110.0
3/10/2009	0:15	0.13	34.0	8/25/2009	21:30	0.37	96.0
3/10/2009	5:50	0.14	38.0	8/26/2009	3:30	0.2	47.0
3/10/2009	11:45	0.15	38.0	8/27/2009	3:35	0.11	18.0
3/10/2009	14:50	0.14	41.0	9/15/2009	11:00	0.067	2.8
3/11/2008	1:10	0.13	45.5	9/20/2009	21:40	0.41	69.0
3/24/2009	11:55	0.046	1.1	9/21/2009	3:40	0.26	51.0
3/25/2009	1:30	0.11	38.0	9/22/2009	13:30	0.31	56.0
3/31/2009	17:00	0.053	14.0	9/22/2009	13:40	0.56	71.0
3/31/2009	17:35	0.092	33.0	9/22/2009	21:50	0.49	56.0
4/1/2009	5:35	0.058	20.0	9/22/2009	23:10	0.19	53.0
4/19/2009	19:10	0.085	17.0	9/27/2009	20:35	0.37	100.0
4/20/2009	5:05	0.064	24.0	9/27/2009	21:05	0.49	150.0
4/21/2009	5:05	0.042	7.1	9/27/2009	21:20	0.54	180.0
4/23/2009	11:00	0.035	1.4	09/28/209	0:05	0.22	70.0
4/25/2009	11:15	0.082	22.0	9/28/2009	2:35	0.17	62.0
4/25/2009	12:40	0.48	160.0	9/28/2009	20:35	0.16	25.0
4/25/2009	21:35	0.17	77.0	MINIMUM		0.04	1.1
4/26/2009	2:35	0.18	68.0	MAXIMUM		0.66	210.0
4/26/2009	14:35	0.098	36.0	MEAN		0.23	64.6
4/26/2009	16:00	0.35	150.0	MEDIAN		0.20	52.0
4/26/2009	17:10	0.37	190.0	STANDARD DEVIATION		0.15	51.4

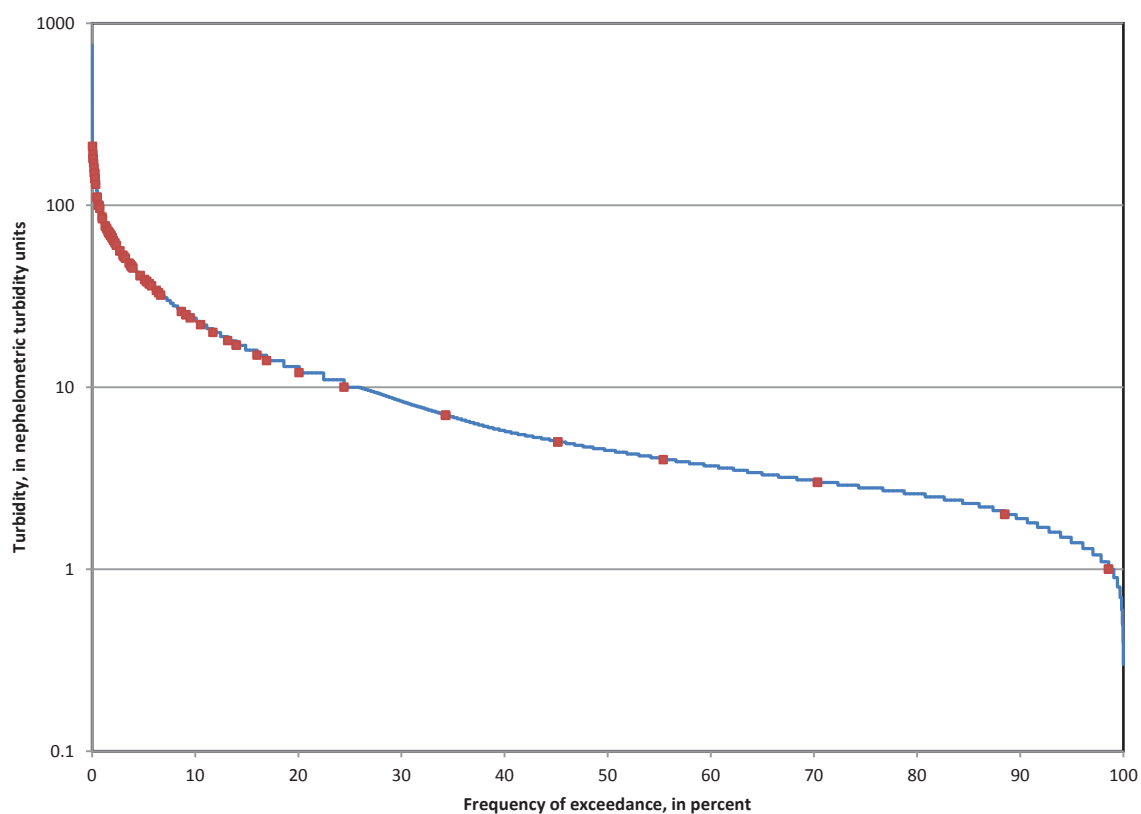


Figure 4-7. Duration curve for turbidity (November 2008–September 2010) and corresponding values associated with total phosphorus concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Menomonee River at Wauwatosa, Wisconsin.

Total phosphorus at Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2009

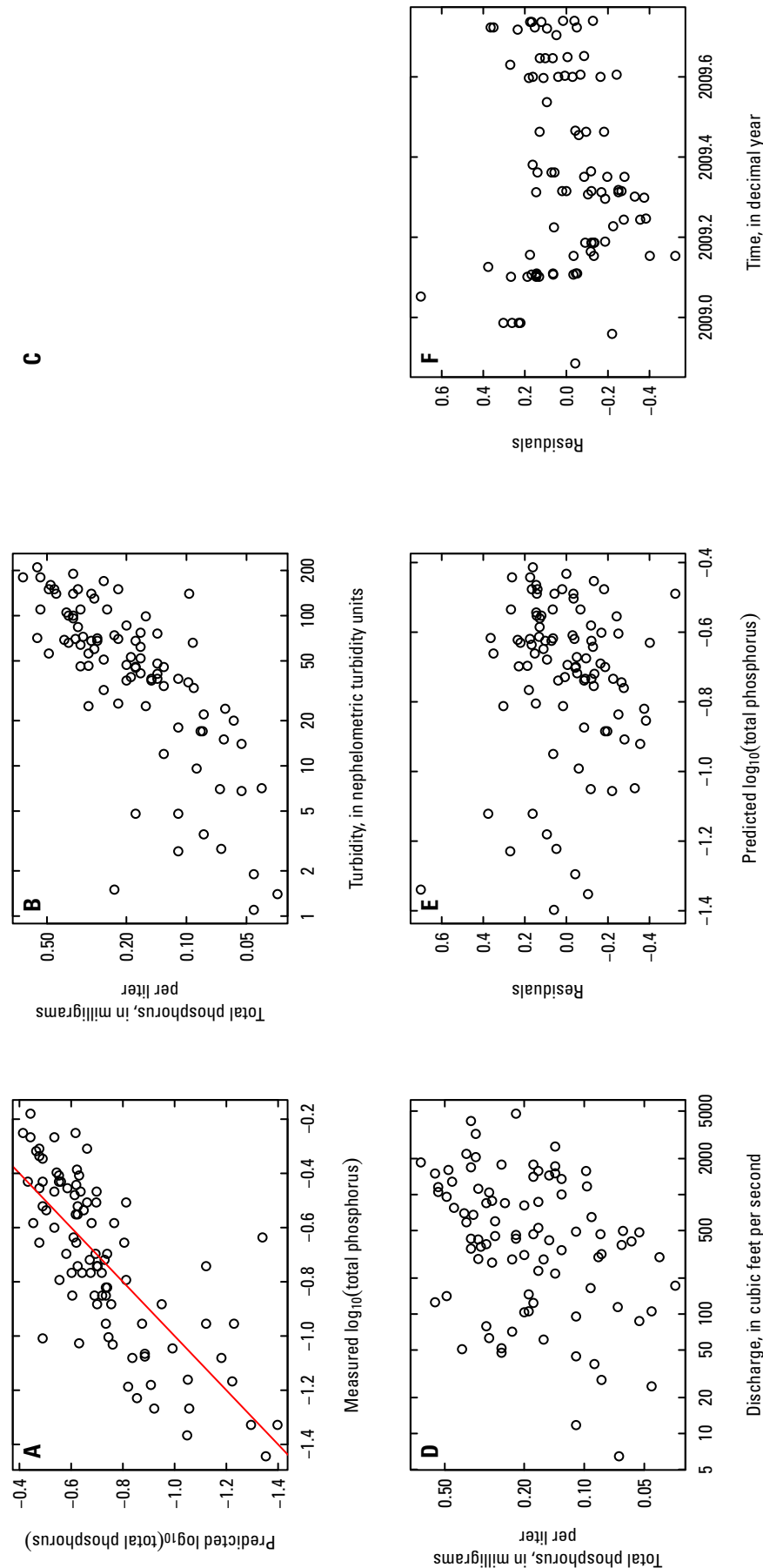


Figure 4-8. U.S. Geological Survey streamgauge on Menomonee River at Wauwatosa, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (total phosphorus concentration). *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space. *C*, No plot. *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (total phosphorus concentration) and regression residuals. *F*, Relation between time and total phosphorus regression residuals. *G*, Probability plot of total phosphorus regression residuals.

Total phosphorus at Menomonee River at 16th Street at Milwaukee, WI (04087142)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Menomonee River at 16th Street at Milwaukee, WI.

$$\text{Log}_{10}(\text{Total Phosphorus}) = -1.51 + 0.462 \log_{10}(\text{Turb}),$$

Where:

Total Phosphorus = total phosphorus concentration in mg/L

Turb = Turbidity, (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 77,

Root-mean-squared error (RMSE) = 0.192

Model standard percentage error (MPSE) = +56 and -36 percent

90-percent prediction intervals (based on units in mg/L) = +/- 89 percent

Adjusted coefficient of determination (Adj R²) = 0.61

Sum of squared error = 2.76

PRESS = 2.97

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.51	0.067	-22.46	<0.0001
Log ₁₀ (Turb)	0.462	0.042	10.93	<0.0001

Correlation matrix of coefficients:

	Intercept	log ₁₀ (Turb)
Intercept	1	-0.946
Log ₁₀ (Turb)	-0.946	1

Duan's bias correction factor = **1.11**

Table 4-5. Model-calibration dataset for Menomonee River at 16th Street at Milwaukee, Wisconsin.

[mg/L, milligrams per liter; NTU, Nephelometric turbidity units]

Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)	Date	Time	Total phosphorus (mg/L)	Turbidity (NTU)
11/20/2008	11:45	0.051	3.1	4/26/2009	14:00	0.095	39.0
12/17/2008	14:15	0.061	7.3	4/26/2009	16:25	0.26	82.0
12/27/2008	9:35	0.26	20.0	4/26/2009	17:10	0.52	210.0
12/27/2008	12:35	0.28	52.3	4/26/2009	19:30	0.38	210.0
12/27/2008	21:35	0.38	77.3	4/26/2009	19:35	0.38	190.0
12/28/2008	0:35	0.35	58.7	5/13/2009	22:05	0.14	35.0
1/20/2009	12:40	0.26	5.4	5/14/2009	0:35	0.17	67.0
2/7/2009	11:40	0.094	3.6	5/14/2009	1:45	0.21	93.0
2/7/2009	20:40	0.34	78.7	5/14/2009	3:35	0.16	70.0
2/8/2009	5:40	0.24	34.7	5/20/2009	11:45	0.12	5.0
2/8/2009	14:40	0.19	28.3	6/8/2009	12:40	0.1	42.0
2/8/2009	23:40	0.2	28.0	6/8/2009	15:30	0.12	50.0
2/9/2009	17:40	0.18	12.7	6/9/2009	2:35	0.087	32.7
2/10/2009	5:40	0.23	98.0	6/9/2009	5:00	0.088	31.3
2/11/2009	17:40	0.28	69.3	6/16/2009	13:00	0.11	5.3
2/16/2009	13:40	0.073	8.1	6/19/2009	0:55	1.8	530.0
2/26/2009	16:00	0.096	8.2	6/19/2009	1:10	1.2	400.0
2/26/2009	19:00	0.38	200.0	6/19/2009	1:45	0.96	340.0
2/26/2009	22:00	0.3	130.0	6/19/2009	9:35	0.2	95.0
2/27/2009	4:00	0.21	85.0	6/19/2009	20:45	0.27	160.0
2/27/2009	12:00	0.12	51.0	6/20/2009	2:25	0.19	84.0
2/28/2009	12:00	0.19	19.0	7/16/2009	12:30	0.1	4.9
3/7/2009	11:10	0.1	19.0	8/8/2009	22:30	0.14	24.0
3/7/2009	14:10	0.2	89.0	8/9/2009	10:30	0.1	17.0
3/7/2009	23:10	0.17	54.0	8/19/2009	13:30	0.076	4.7
3/8/2009	12:10	0.14	35.0	8/26/2009	7:05	0.11	15.0
3/8/2009	18:10	0.25	90.0	8/26/2009	17:00	0.099	13.0
3/9/2009	0:10	0.19	61.0	8/26/2009	23:45	0.1	14.0
3/10/2009	8:15	0.15	47.0	9/15/2009	11:30	0.074	2.9
3/10/2009	12:55	0.15	41.0	9/23/2009	7:10	0.11	7.1
3/10/2009	13:00	0.14	42.0	9/24/2009	7:00	0.095	9.2
3/10/2009	20:30	0.14	41.0	9/28/2009	12:05	0.11	28.0
3/11/2009	4:30	0.12	29.0	09/28/2009	18:05	0.12	30.0
3/24/2009	12:25	0.057	4.0	9/29/2009	0:05	0.11	30.0
4/1/2009	1:40	0.083	34.0	9/29/2009	3:05	0.1	17.0
4/20/2009	3:05	0.046	12.0	9/29/2009	5:00	0.11	16.0
4/20/2009	4:50	0.044	14.0	MINIMUM		0.04	2.9
4/23/2009	11:15	0.039	5.7	MAXIMUM		1.80	530.0
4/25/2009	13:20	0.073	30.0	MEAN		0.21	62.9
4/25/2009	20:00	0.097	61.0	MEDIAN		0.14	34.7
4/26/2009	8:00	0.1	48.0	STANDARD DEVIATION		0.25	88.9

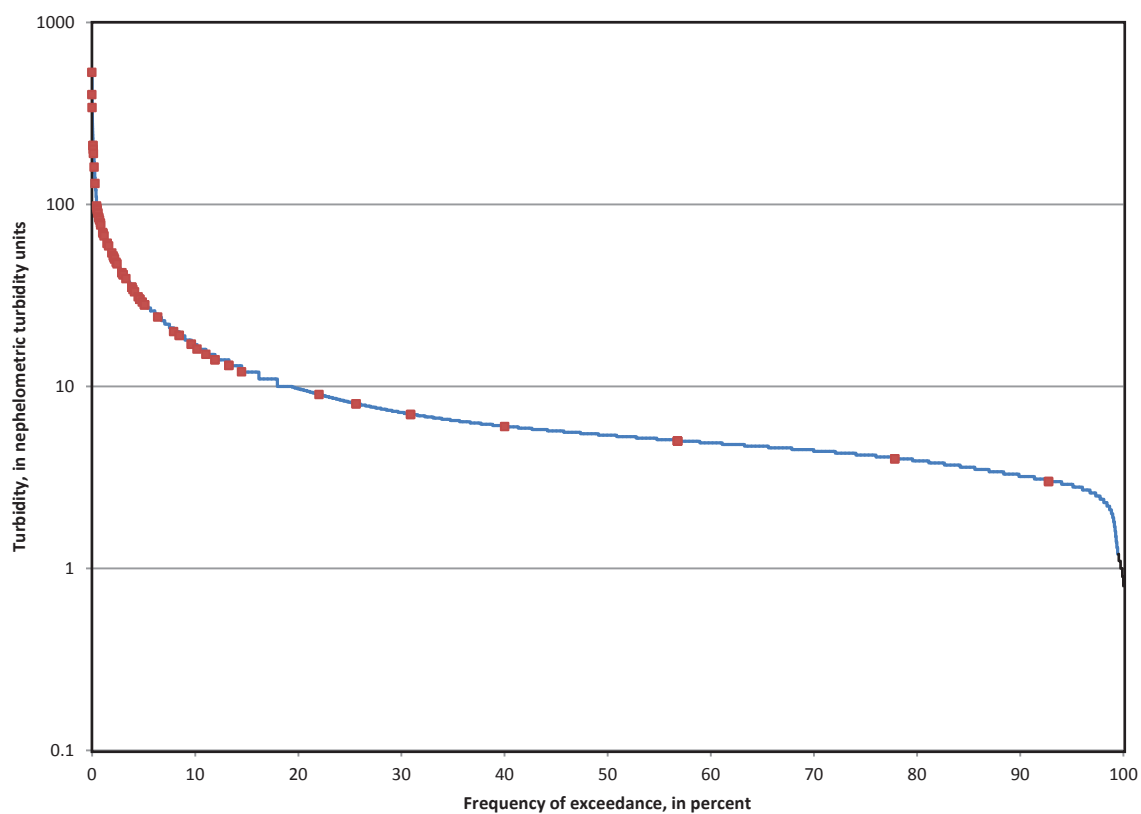


Figure 4-9. Duration curve for turbidity (November 2008–September 2010) and corresponding values associated with total phosphorus concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Menomonee River at 16th Street at Milwaukee, Wisconsin.

Total phosphorus at Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2009

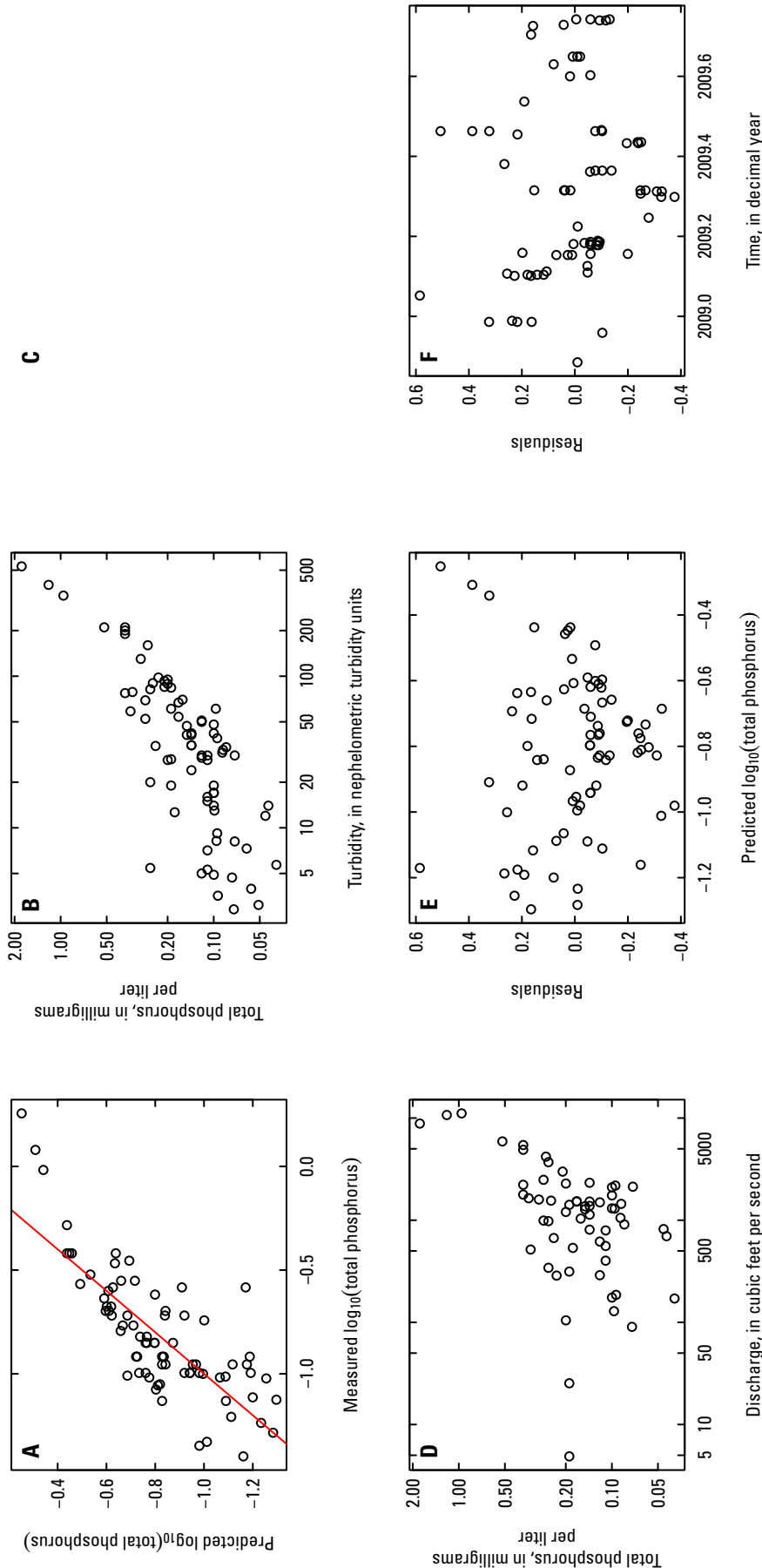


Figure 4-10. U.S. Geological Survey streamgauge on Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (total phosphorus concentration). *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space. *C*, No plot. *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (total phosphorus concentration) and regression residuals. *F*, Relation between time and total phosphorus regression residuals. *G*, Probability plot of total phosphorus regression residuals.

