

Appendix 5. Regression analysis results for estimating *Escherichia coli* (*E. coli*) bacteria 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 water temperature and concurrent *E. coli* bacteria 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 and water temperature values are instantaneous unit values temporally corresponding to the collection of the *E. coli* bacteria 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).

***Escherichia coli* (*E. coli*) bacteria at Little Menomonee River near Freistadt, WI (04087050)**

Sample data on 2/16/2009 were not used in the regression analysis because there was no sonde data. Sample data on 2/26/2010 was not used because it was believed the samples at 09:50 and 15:20 were switched and the concentration may be in error.

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

$$\text{Log}_{10} (E. coli) = 1.81 + 0.025 (WT) + 0.693 \log_{10} (\text{Turb}),$$

Where:

E. coli = Most Probable Number of *E. coli* per 100 ml (MPN/100ml)

WT = Water Temperature in °C

Turb = Turbidity (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 37,

Root-mean-squared error (RMSE) = 0.45

Model standard percentage error (MPSE) = +182 and -65 percent

90-percent prediction intervals (based on units in MPN/100ml) = +/- 573 percent

Adjusted coefficient of determination ($\text{Adj } R^2$) = 0.58

Sum of squared error = 6.90

PRESS = 8.17

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.81	0.182	9.91	<.0001
WT	0.025	0.012	2.12	0.041
Log ₁₀ (Turb)	0.693	0.106	6.57	<.0001

Correlation matrix of coefficients:

	Intercept	WT	log ₁₀ (Turb)
Intercept	1.00	-0.296	-0.821
WT	-0.296	1.00	-0.125
Log ₁₀ (Turb)	-0.821	-0.125	1.00

Duan's bias correction factor = 2.05

Table 5-1. Model-calibration dataset for Little Menomonee River near Freistadt, Wisconsin.

[MPN/100 mL, most probable number per 100 milliliters; NTU, Nephelometric turbidity units; °C, degrees Celsius]

Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)	Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)
11/20/2008	9:45	51	1.2	1.6	4/26/2009	5:30	4,500	180.0	7.1
12/17/2008	11:30	120	2.1	0.0	4/26/2009	19:30	4,000	200.0	9.7
12/28/2008	1:05	1,100	52.3	0.1	4/27/2009	1:30	2,200	80.0	9.6
1/20/2009	10:55	10	0.7	0.1	5/9/2009	7:25	3,400	81.0	11.7
2/7/2009	18:50	860	19.7	0.0	5/9/2009	13:30	8,700	54.0	11.6
2/9/2009	22:40	1,700	11.3	0.2	5/9/2009	19:30	2,200	15.0	12.0
2/10/2009	10:45	1,300	38.0	0.3	5/14/2009	2:30	6,000	270.0	13.8
2/10/2009	14:40	830	113.3	0.5	5/20/2009	9:00	140	4.5	14.0
2/10/2009	20:40	1,600	46.0	0.3	6/8/2009	5:20	3,800	120.0	11.5
2/11/2009	2:40	15,000	21.3	0.2	6/16/2009	8:45	260	12.0	14.0
3/2/2009	7:10	230	4.2	0.0	6/19/2009	2:50	9,600	290.0	17.4
3/7/2009	12:55	400	130.0	1.8	6/19/2009	8:50	25,000	89.0	17.4
3/7/2009	18:05	1,500	220.0	1.3	7/16/2009	10:05	1,100	19.0	16.2
3/8/2009	7:05	760	62.0	1.0	8/19/2009	10:00	250	8.8	16.0
3/8/2009	19:00	2,600	210.0	0.2	9/15/2009	9:30	730	10.0	16.5
3/9/2009	0:30	1,500	140.0	0.3	MINIMUM		10	0.7	0.0
3/10/2009	3:20	570	68.0	1.9	MAXIMUM		25,000	290.0	17.4
3/10/2009	8:15	840	94.0	1.1	MEAN		2,839	76.3	6.3
3/10/2009	20:15	610	51.0	2.2	MEDIAN		1,100	52.3	2.2
3/24/2009	10:40	110	2.8	4.0	STANDARD DEVIATION		4,870	80.3	6.4
4/23/2009	9:45	610	2.1	6.4					
4/25/2009	15:10	860	100.0	10.7					

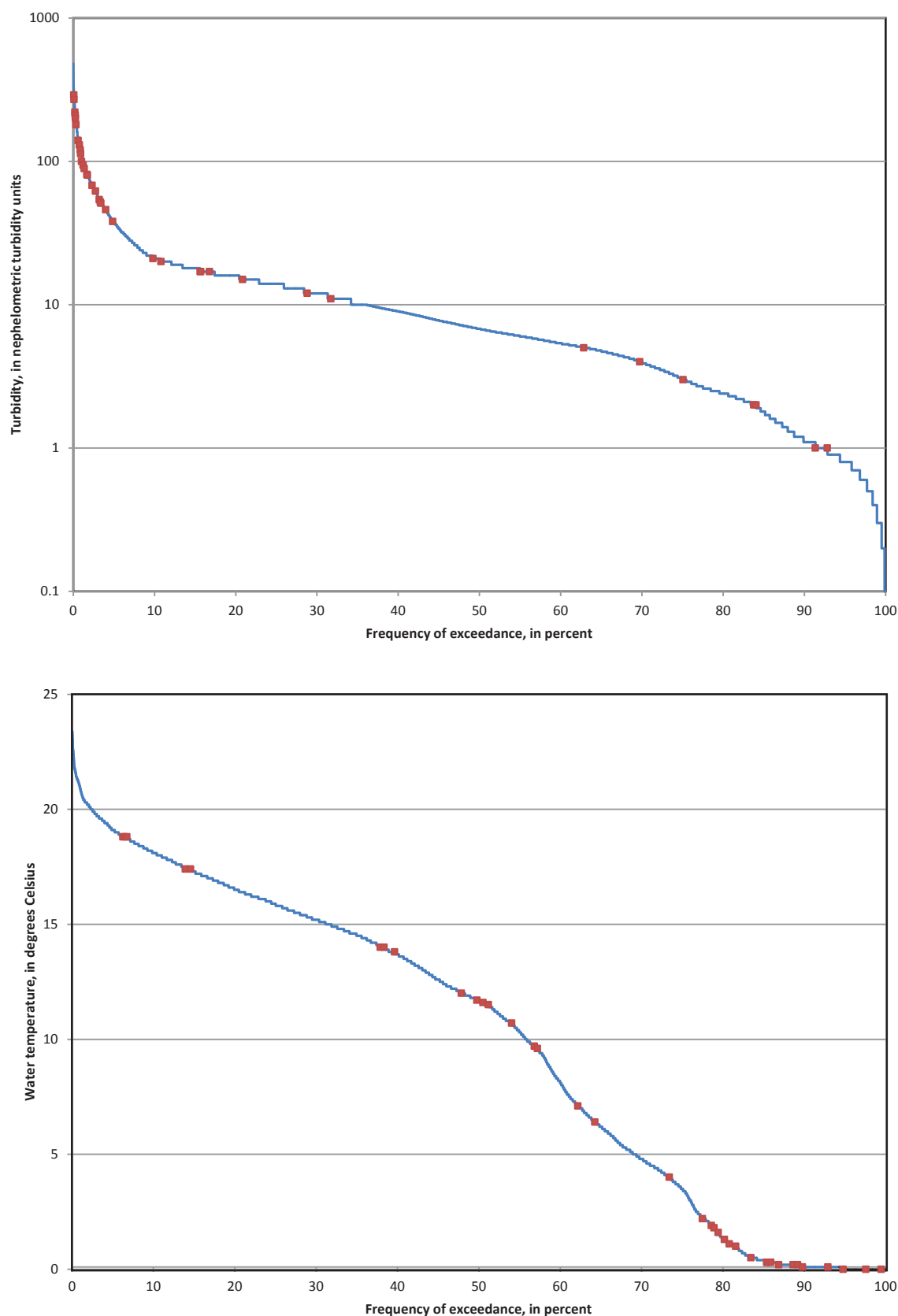


Figure 5-1. Duration curves for turbidity and water temperature (November 2008–September 2010) and corresponding values associated with *Escherichia coli* (*E. coli*) concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Little Menomonee River near Freistadt, Wisconsin.

***Escherichia coli* at Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2009**

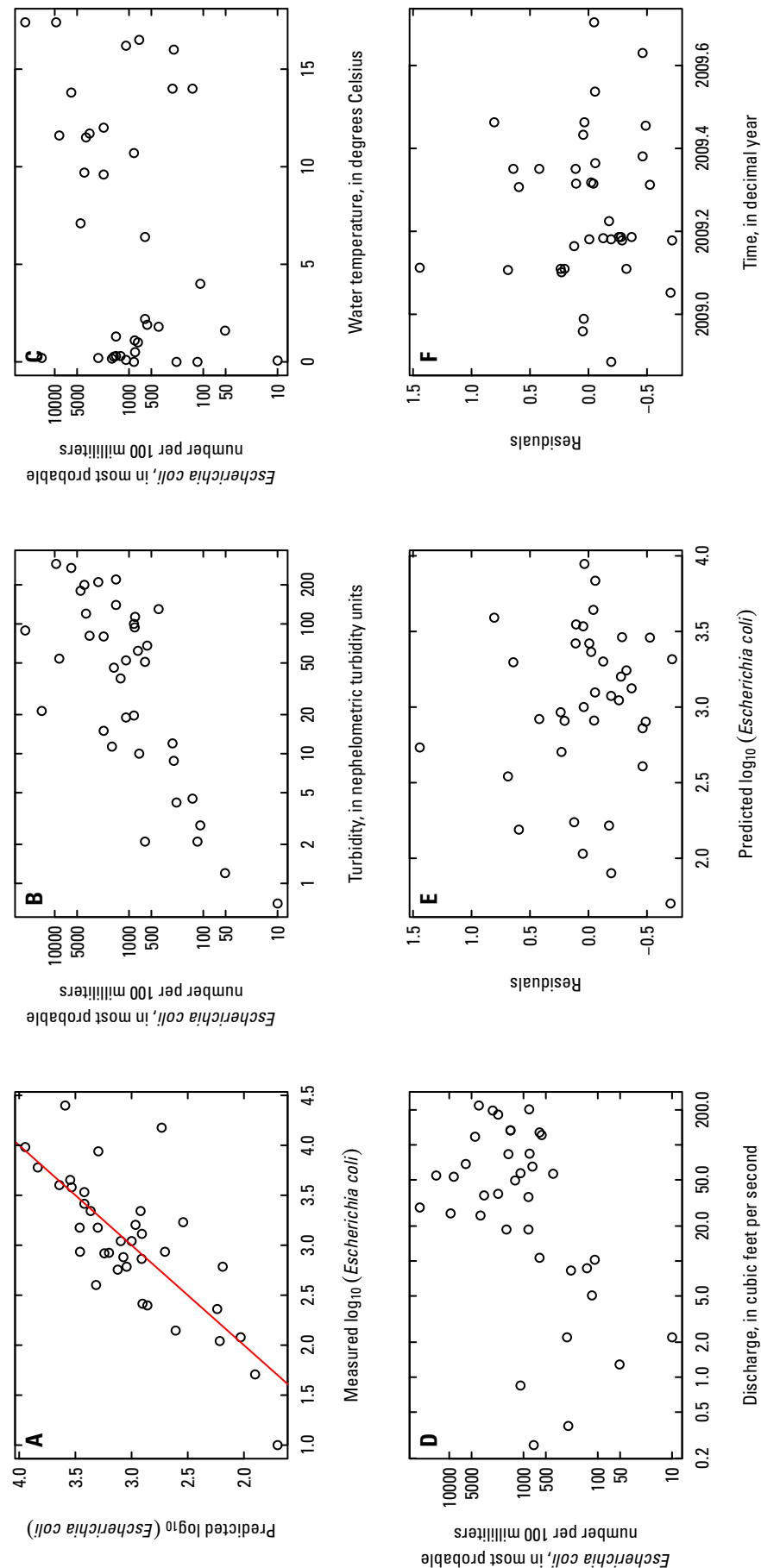


Figure 5-2. U.S. Geological Survey streamgauge on Little Menomonee River near Freistadt, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (*Escherichia coli* (*E. coli*) concentration). *B*, Relation between turbidity and *E. coli* concentration in $\log_{10}$ space. *C*, Relation between water temperature and *E. coli* concentration in $\log_{10}$ space. *D*, Relation between discharge and *E. coli* concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (*E. coli* concentration) and regression residuals. *F*, Relation between time and *E. coli* regression residuals. *G*, Probability plot of *E. coli* regression residuals.

***Escherichia coli* (*E. coli*) bacteria at Menomonee River at Menomonee Falls, WI (04087030)**

MODEL SUMMARY—Summary of final regression results for estimating *E. coli* concentrations at Menomonee River at Menomonee Falls, WI.

$$\text{Log}_{10} (E. coli) = 1.30 + 0.057 (WT) + 0.674 \log_{10} (\text{Turb}),$$

Where:

E. coli = Most Probable Number of *E. coli* per 100 ml (MPN/100ml)

WT = Water Temperature in °C

Turb = Turbidity (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 55,

Root-mean-squared error (RMSE) = 0.556

Model standard percentage error (MPSE) = +259 and -72 percent

90-percent prediction intervals (based on units in MPN/100ml) = +/- 768 percent

Adjusted coefficient of determination (Adj R²) = 0.60

Sum of squared error = 16.05

PRESS = 17.84

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.30	0.213	6.13	<0.0001
WT	0.057	0.010	5.75	<0.0001
Log₁₀ (Turb)	0.674	0.143	4.73	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	log₁₀ (Turb)
Intercept	1	-0.250	-0.771
WT	-0.250	1	-0.326
Log₁₀ (Turb)	-0.771	-0.326	1

Duan's bias correction factor = **1.84**

Table 5-2. Model-calibration dataset for Menomonee River at Menomonee Falls, Wisconsin.

[MPN/100 mL, most probable number per 100 milliliters; NTU, Nephelometric turbidity units; °C, degrees Celsius]

Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)	Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)
11/20/2008	9:15	63	3.6	1.1	6/8/2009	3:15	1,800	91.0	14.0
12/17/2008	12:00	230	2.7	0.0	6/8/2009	3:25	12,000	220.0	13.5
12/27/2008	14:20	490	100.7	0.1	6/8/2009	9:35	4,600	28.0	13.4
1/20/2009	9:55	41	2.5	2.0	6/16/2009	10:15	70	13.0	19.1
2/16/2009	11:00	50	3.1	0.2	6/19/2009	0:10	4,000	160.0	21.2
2/26/2009	15:05	300	86.0	0.1	6/19/2009	0:50	4,000	110.0	21.1
2/26/2009	18:15	730	81.0	0.2	6/19/2009	2:00	8,800	66.0	20.9
2/27/2009	0:15	550	30.0	0.0	6/20/2009	2:00	3,600	21.0	20.1
3/2/2009	7:15	70	3.2	0.0	7/16/2009	9:30	5,200	5.0	20.4
3/7/2009	9:30	160	31.0	1.9	8/7/2009	19:35	20,000	46.0	20.2
3/7/2009	15:30	160	29.0	2.0	8/8/2009	9:05	12,000	80.0	20.5
3/8/2009	10:30	150	26.0	0.7	8/19/2009	9:00	430	3.2	20.1
3/8/2009	14:00	370	69.0	0.8	8/25/2009	18:20	8,100	210.0	23.1
3/9/2009	2:00	260	34.0	0.0	8/25/2009	18:45	34,000	85.0	23.1
3/24/2009	10:00	190	4.1	4.1	8/26/2009	1:30	8,600	30.0	22.3
3/25/2009	5:25	130	16.0	5.1	8/26/2009	1:55	6,300	48.0	22.4
4/19/2009	23:00	410	23.0	10.5	9/15/2009	9:30	140	2.8	18.8
4/20/2009	11:15	100	12.0	8.4	9/22/2009	13:15	18,000	62.0	18.9
4/20/2009	23:15	200	11.0	8.3	9/22/2009	14:05	52,000	130.0	19.3
4/23/2009	9:15	150	3.8	7.3	9/22/2009	15:20	19,000	21.0	18.4
4/25/2009	10:50	750	71.0	14.6	9/27/2009	19:25	11,000	81.0	18.0
4/25/2009	11:00	850	170.0	14.3	9/27/2008	21:30	12,000	51.0	17.1
4/26/2009	5:00	410	27.0	8.9	9/28/2009	5:55	3,900	12.0	15.2
4/26/2009	16:00	520	34.0	9.8	MINIMUM		10	2.5	0.0
4/27/2009	4:00	520	23.0	10.2	MAXIMUM		52,000	220.0	23.1
5/9/2009	1:05	160	83.0	16.9	MEAN		4,778	50.7	11.9
5/9/2009	1:15	1,000	110.0	16.7	MEDIAN		520	30.0	14.0
5/9/2009	10:25	1,200	12.0	14.0	STANDARD DEVIATION		9,252	52.6	8.0
5/9/2009	22:25	400	14.0	13.5					
5/10/2009	10:25	350	8.2	11.9					
5/13/2009	23:00	2,300	81.0	15.8					
5/20/2009	9:30	10	6.3	16.5					

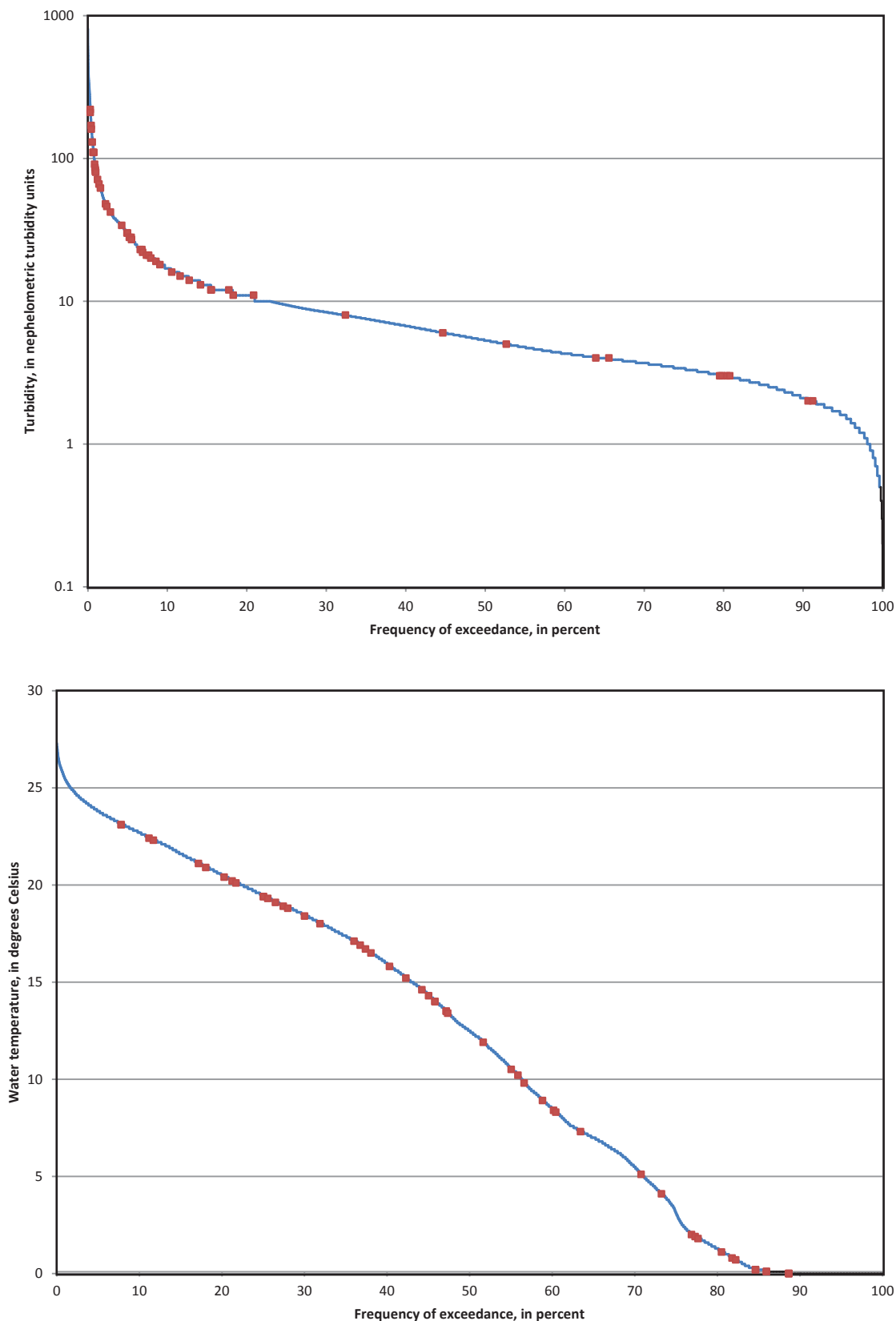


Figure 5-3. Duration curves for turbidity and water temperature (November 2008–September 2010) and corresponding values associated with *Escherichia coli* (*E. coli*) concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Menomonee River at Menomonee Falls, Wisconsin.

Escherichia coli at Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2009

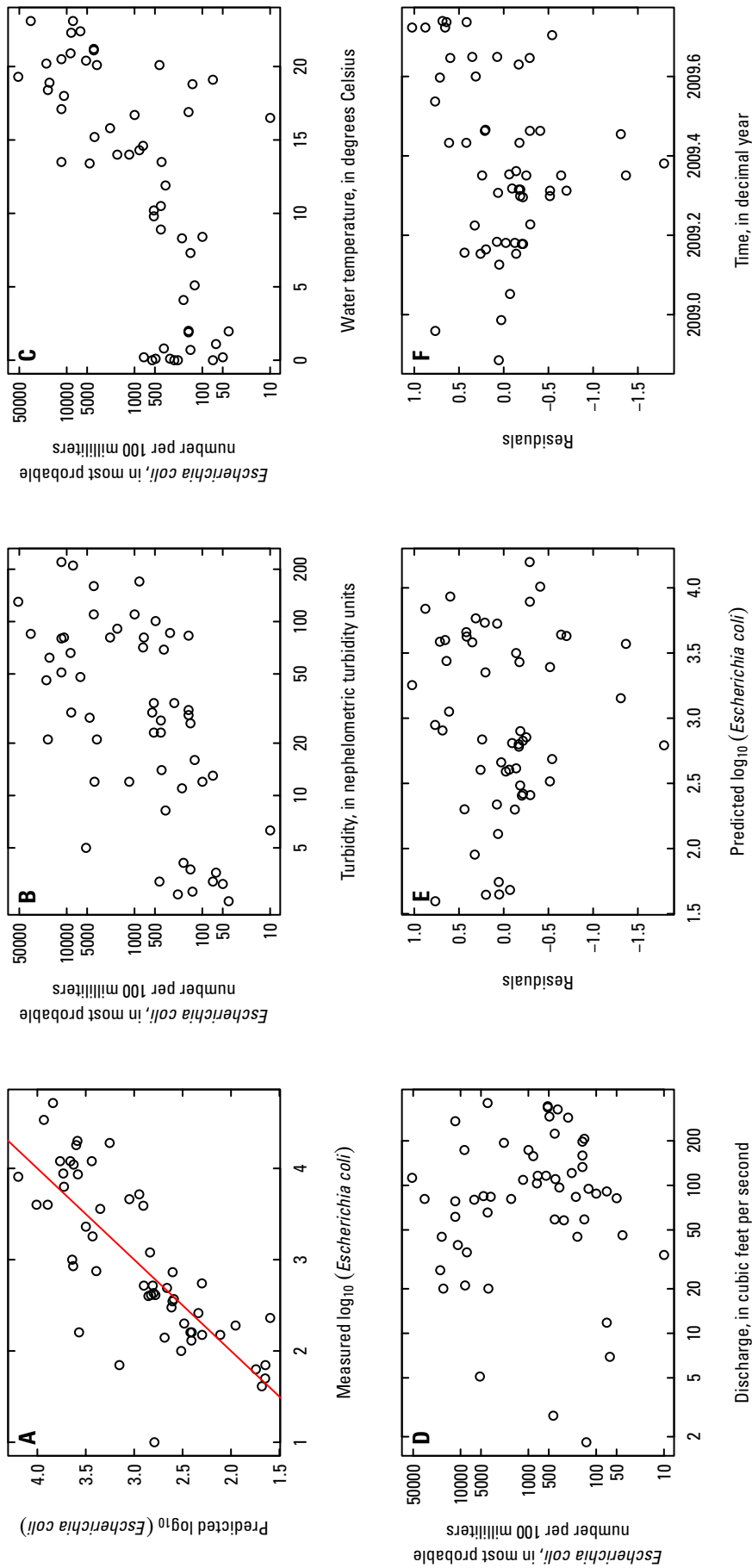
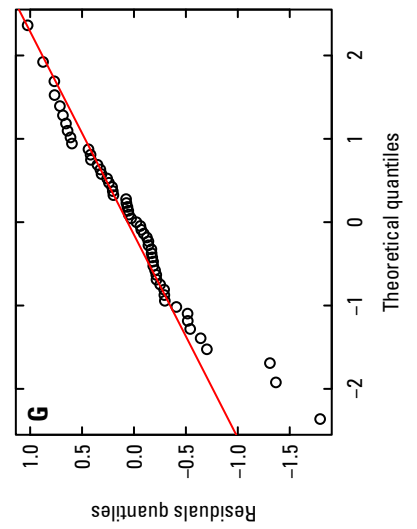


Figure 5-4. U.S. Geological Survey streamgauge on Menomonee River at Menomonee Falls, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (*Escherichia coli* (*E. coli*) concentration). *B*, Relation between turbidity and *E. coli* concentration in $\log_{10}$ space. *C*, Relation between water temperature and *E. coli* concentration in $\log_{10}$ space. *D*, Relation between discharge and *E. coli* concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (*E. coli* concentration) and regression residuals. *F*, Relation between time and *E. coli* regression residuals. *G*, Probability plot of *E. coli* regression residuals.



Escherichia coli (E. coli) bacteria 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 *E. coli* concentrations at Honey Creek at Wauwatosa, WI.

$$\text{Log}_{10} (E. coli) = 1.68 + 0.071 (WT) + 0.626 \log_{10} (\text{Turb}),$$

Where:

E. coli = Most Probable Number of *E. coli* per 100 ml (MPN/100ml)

WT = Water Temperature in °C

Turb = Turbidity (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 66,

Root-mean-squared error (RMSE) = 0.480

Model standard percentage error (MPSE) = +202 and -67 percent

90-percent prediction intervals (based on units in MPN/100ml) = +/- 610 percent

Adjusted coefficient of determination (Adj R²) = 0.69

Sum of squared error = 14.50

PRESS = 16.22

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.68	0.177	9.50	<0.0001
WT	0.071	0.008	9.12	<0.0001
Log ₁₀ (Turb)	0.626	0.092	6.77	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	log ₁₀ (Turb)
Intercept	1	-0.367	-0.816
WT	-0.367	1	-0.124
Log ₁₀ (Turb)	-0.816	-0.124	1

Duan's bias correction factor = 1.98

Table 5-3. Model-calibration dataset for Honey Creek at Wauwatosa, Wisconsin.

[MPN/100 mL, most probable number per 100 milliliters; NTU, Nephelometric turbidity units; °C, degrees Celsius]

Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)	Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)
12/17/2008	13:45	640	1.8	0.2	5/14/2009	0:55	7,300	130.0	16.2
1/20/2009	11:55	500	1.7	0.0	5/14/2009	2:40	9,800	120.0	15.2
2/10/2009	10:10	3,300	46.0	1.7	5/20/2009	11:00	250	2.7	14.6
2/10/2009	13:25	1,400	123.3	2.5	6/16/2009	11:00	620	2.7	15.4
2/10/2009	19:25	580	82.0	1.2	7/16/2009	11:00	200	4.0	18.6
2/11/2009	1:25	750	41.3	1.9	8/7/2009	17:10	24,000	27.0	18.3
2/11/2009	11:25	530	21.3	2.7	8/7/2009	20:20	24,000	170.0	19.6
2/11/2009	12:00	1,100	97.0	2.9	8/7/2009	23:05	24,000	28.0	19.5
2/11/2009	15:30	1,200	210.0	3.3	8/8/2009	9:10	24,000	240.0	20.4
2/12/2009	2:25	690	32.7	2.3	8/8/2009	9:30	10,000	300.0	20.7
2/16/2009	12:20	270	53.3	0.0	8/8/2009	19:55	17,000	59.0	21.4
3/7/2009	9:25	1,200	74.0	3.2	8/10/2009	1:50	24,000	210.0	21.9
3/7/2009	10:25	1,300	210.0	2.9	8/10/2009	4:10	24,000	100.0	21.5
3/7/2009	12:10	680	140.0	3.0	8/19/2009	12:40	300	1.3	18.9
3/7/2009	16:05	530	71.0	3.7	8/25/2009	20:55	10,000	63.0	21.0
3/7/2009	22:05	400	46.0	3.0	8/28/2009	22:05	21,000	206.7	21.9
3/8/2009	14:25	570	140.0	2.0	8/26/2009	4:05	16,000	34.0	21.5
3/9/2009	1:00	600	32.0	2.0	9/15/2009	10:45	510	1.6	19.0
3/10/2009	0:50	620	40.0	3.3	9/20/2009	20:20	11,000	44.0	17.8
3/10/2009	5:30	260	50.0	2.6	9/20/2009	21:55	87,000	190.0	17.8
3/10/2009	9:30	450	55.0	2.8	9/21/2009	3:55	200,000	34.0	18.2
3/10/2009	12:10	1,300	33.0	3.1	9/22/2009	13:25	98,000	84.0	17.0
3/10/2009	12:15	910	31.0	3.1	9/22/2009	14:05	160,000	210.0	19.7
3/24/2009	11:40	310	1.8	4.6	9/22/2009	22:40	46,000	44.0	19.4
3/25/2009	1:20	17,000	280.0	7.1	9/27/2009	20:20	160,000	110.0	18.0
3/25/2009	3:45	9,200	183.3	7.1	9/27/2009	21:00	130,000	272.5	17.4
3/31/2009	16:15	2,800	61.0	5.0	9/27/2009	23:35	39,000	99.0	17.1
3/31/2009	17:05	2,400	390.0	5.0	9/28/2009	2:30	17,000	88.0	16.4
4/1/2009	3:00	720	27.0	4.1	MINIMUM		200	1.3	0.0
4/19/2009	17:10	2,300	17.0	9.1	MAXIMUM		200,000	390.0	21.9
4/19/2009	18:15	3,800	117.5	8.8	MEAN		19,240	94.8	10.8
4/20/2009	2:30	310	34.3	8.3	MEDIAN		1,850	57.0	9.0
4/20/2009	17:20	740	18.5	8.5	STANDARD DEVIATION		41,203	91.3	7.7
4/23/2009	10:45	250	1.6	7.6					
4/25/2009	10:50	520	21.0	12.3					
5/13/2009	20:30	3,900	54.0	14.0					
5/13/2009	20:50	9,800	280.0	16.6					
5/13/2009	21:10	11,000	260.0	16.9					

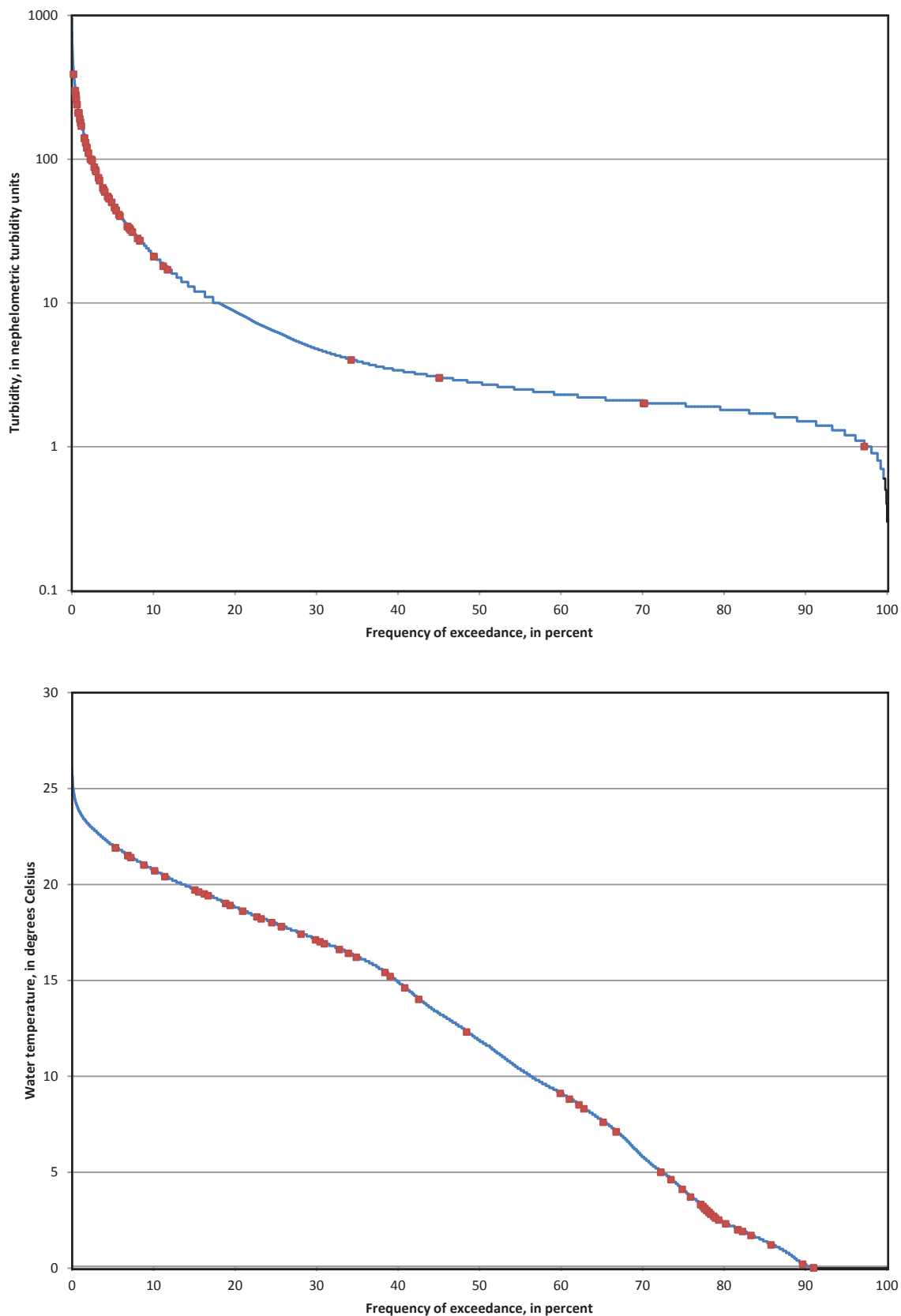


Figure 5-5. Duration curves for turbidity and water temperature (November 2008–September 2010) and corresponding values associated with *Escherichia coli* (*E. coli*) concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin.

Escherichia coli at Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2009

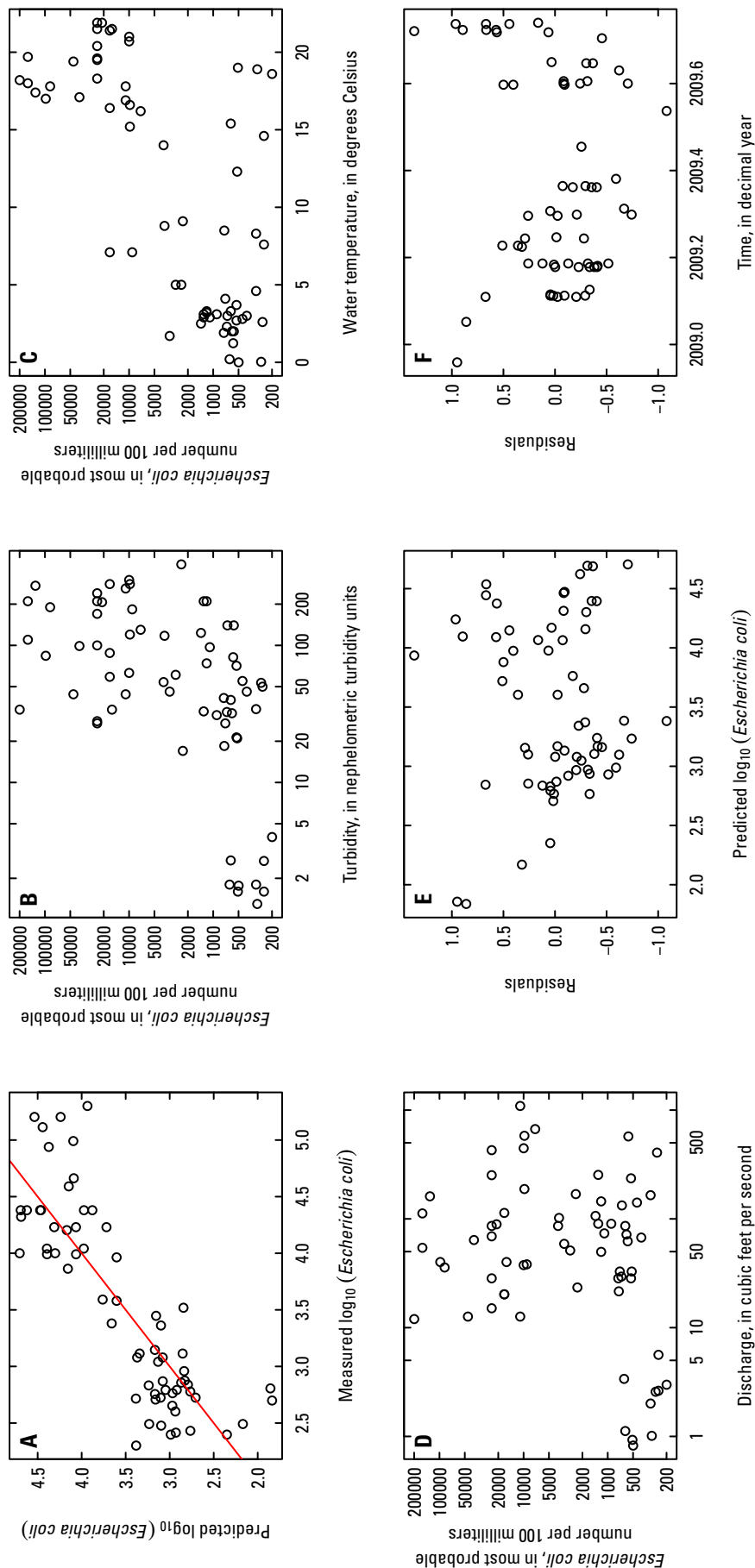


Figure 5-6. U.S. Geological Survey streamgauge on Honey Creek at Wauwatosa, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (*Escherichia coli* (*E. coli*) concentration). *B*, Relation between turbidity and *E. coli* concentration in $\log_{10}$ space. *C*, Relation between water temperature and *E. coli* concentration in $\log_{10}$ space. *D*, Relation between discharge and *E. coli* concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (*E. coli* concentration) and regression residuals. *F*, Relation between time and *E. coli* regression residuals. *G*, Probability plot of *E. coli* regression residuals.

***Escherichia coli* (*E. coli*) bacteria at Menomonee River at Wauwatosa, WI (04087120)**

Samples collected on 4/21/2009, 6/08/2009 – 6/09/2009, 08/07/2009 - 8/8/2009 at 09:45, 8/09/2009, and 9/22/2009 at 13:40 were not used in the regression analysis because of extreme fouling or because the MMSD laboratory qualified the results.

MODEL SUMMARY—Summary of final regression results for estimating *E. coli* concentrations at Menomonee River at Wauwatosa, WI.

$$\text{Log}_{10} (E. coli) = 1.28 + 0.063 (WT) + 0.884 \log_{10} (\text{Turb}),$$

Where:

E. coli = Most Probable Number of *E. coli* per 100 ml (MPN/100ml)

WT = Water Temperature in °C

Turb = Turbidity (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 81,

Root-mean-squared error (RMSE) = 0.528

Model standard percentage error (MPSE) = +237 and -70 percent

90-percent prediction intervals (based on units in MPN/100ml) = +/- 807 percent

Adjusted coefficient of determination (Adj R²) = 0.66

Sum of squared error = 21.74

PRESS = 23.37

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.28	0.191	6.68	<0.0001
WT	0.063	0.007	9.07	<0.0001
Log₁₀ (Turb)	0.884	0.109	8.14	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	log₁₀ (Turb)
Intercept	1	-0.303	-0.878
WT	-0.303	1	-0.071
Log₁₀ (Turb)	-0.878	-0.071	1

Duan's bias correction factor = **2.18**

Table 5-4. Model-calibration dataset for Menomonee River at Wauwatosa, Wisconsin.

[MPN/100 mL, most probable number per 100 milliliters; NTU, Nephelometric turbidity units; °C, degrees Celsius]

Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)	Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)
11/20/2008	10:30	74	1.9	2.2	4/27/2009	0:30	1,600	76.0	10.2
12/17/2008	12:30	500	6.8	0.0	5/9/2009	0:30	700	37.0	16.6
12/27/2008	10:15	1,700	89.0	0.0	5/9/2009	9:30	990	17.0	14.6
12/28/2008	7:45	1,200	36.0	0.0	5/9/2009	15:50	510	15.0	14.7
1/20/2009	12:10	86	1.5	0.0	5/13/2009	20:40	2,400	68.0	15.2
2/7/2009	11:25	3,400	72.3	0.0	5/13/2009	21:05	8,700	150.0	15.6
2/7/2009	13:25	1,800	105.0	0.0	5/13/2009	22:00	5,500	140.0	15.9
2/7/2009	13:40	2,400	110.0	0.0	5/14/2009	3:15	2,800	86.0	15.4
2/7/2009	19:40	1,200	46.3	0.0	5/20/2009	11:15	73	4.8	17.4
2/8/2009	13:40	340	26.0	0.0	6/16/2009	11:50	130	9.6	18.8
2/9/2009	1:40	430	12.0	0.0	6/19/2009	9:15	9,600	84.0	19.6
2/9/2009	19:40	320	64.0	0.0	6/19/2009	18:15	12,000	52.0	20.4
2/9/2009	22:00	1,500	140.0	0.0	6/19/2009	21:20	9,300	150.0	20.5
2/9/2009	23:15	2,100	140.0	0.1	6/20/2009	3:10	9,300	45.0	19.7
2/10/2009	7:20	760	45.7	0.0	7/16/2009	11:45	2,600	3.5	21.8
2/10/2009	11:00	880	100.0	0.1	8/8/2009	19:50	24,000	48.0	21.8
2/10/2009	17:05	750	70.7	0.5	8/10/2009	2:00	24,000	110.0	22.3
2/10/2009	23:25	570	41.3	0.2	8/10/2009	4:20	17,000	99.0	21.4
2/16/2009	12:45	60	4.8	0.3	8/19/2009	12:20	320	2.7	21.9
2/26/2009	14:35	120	66.0	0.4	8/25/2009	20:50	87,000	68.0	22.3
2/26/2009	19:00	320	140.0	0.7	8/25/2009	21:25	32,000	110.0	22.4
2/26/2009	19:45	1,900	170.0	0.7	8/25/2009	21:30	20,000	96.0	21.9
2/26/2009	22:50	1,700	130.0	0.6	8/26/2009	3:30	34,000	47.0	21.5
2/27/2009	4:50	1,100	70.0	0.0	8/27/2009	3:35	3,500	18.0	20.0
3/2/2009	7:20	220	7.3	0.0	9/15/2009	11:00	130	2.8	20.0
3/10/2009	0:15	290	34.0	2.3	9/20/2009	21:40	92,000	69.0	18.0
3/10/2009	5:50	200	38.0	2.1	9/21/2009	3:40	200,000	51.0	17.8
3/10/2009	11:45	370	38.0	1.9	9/22/2009	13:30	200,000	56.0	18.3
3/10/2009	14:50	240	41.0	1.9	9/22/2009	21:50	200,000	56.0	19.5
3/11/2008	1:10	150	45.5	2.2	9/22/2009	23:10	49,000	53.0	19.0
3/24/2009	11:55	62	1.1	4.9	9/27/2009	20:35	46,000	100.0	17.8
3/25/2009	1:30	2,200	38.0	6.2	9/27/2009	21:05	37,000	150.0	18.0
3/31/2009	17:00	2,000	14.0	5.1	9/27/2009	21:20	69,000	180.0	18.1
3/31/2009	17:35	1,900	33.0	5.2	9/28/2009	0:05	55,000	70.0	17.1
4/1/2009	5:35	610	20.0	4.3	9/28/2009	2:35	22,000	62.0	16.4
4/19/2009	19:10	1,300	17.0	11.4	9/28/2009	20:35	8,000	25.0	14.8
4/20/2009	5:05	1,400	24.0	9.1	MINIMUM		60	1.1	0.0
4/23/2009	11:00	85	1.4	8.2	MAXIMUM		200,000	190.0	22.4
4/25/2009	11:15	1,100	22.0	14.2	MEAN		16,476	63.7	10.1
4/25/2009	12:40	3,700	160.0	13.8	MEDIAN		1,700	52.0	10.2
4/25/2009	21:35	1,200	77.0	11.1	STANDARD DEVIATION		40,762	49.6	8.5
4/26/2009	2:35	2,200	68.0	9.6					
4/26/2009	14:35	850	36.0	8.9					
4/26/2009	16:00	1,300	150.0	10.0					
4/26/2009	17:10	1,800	190.0	10.5					

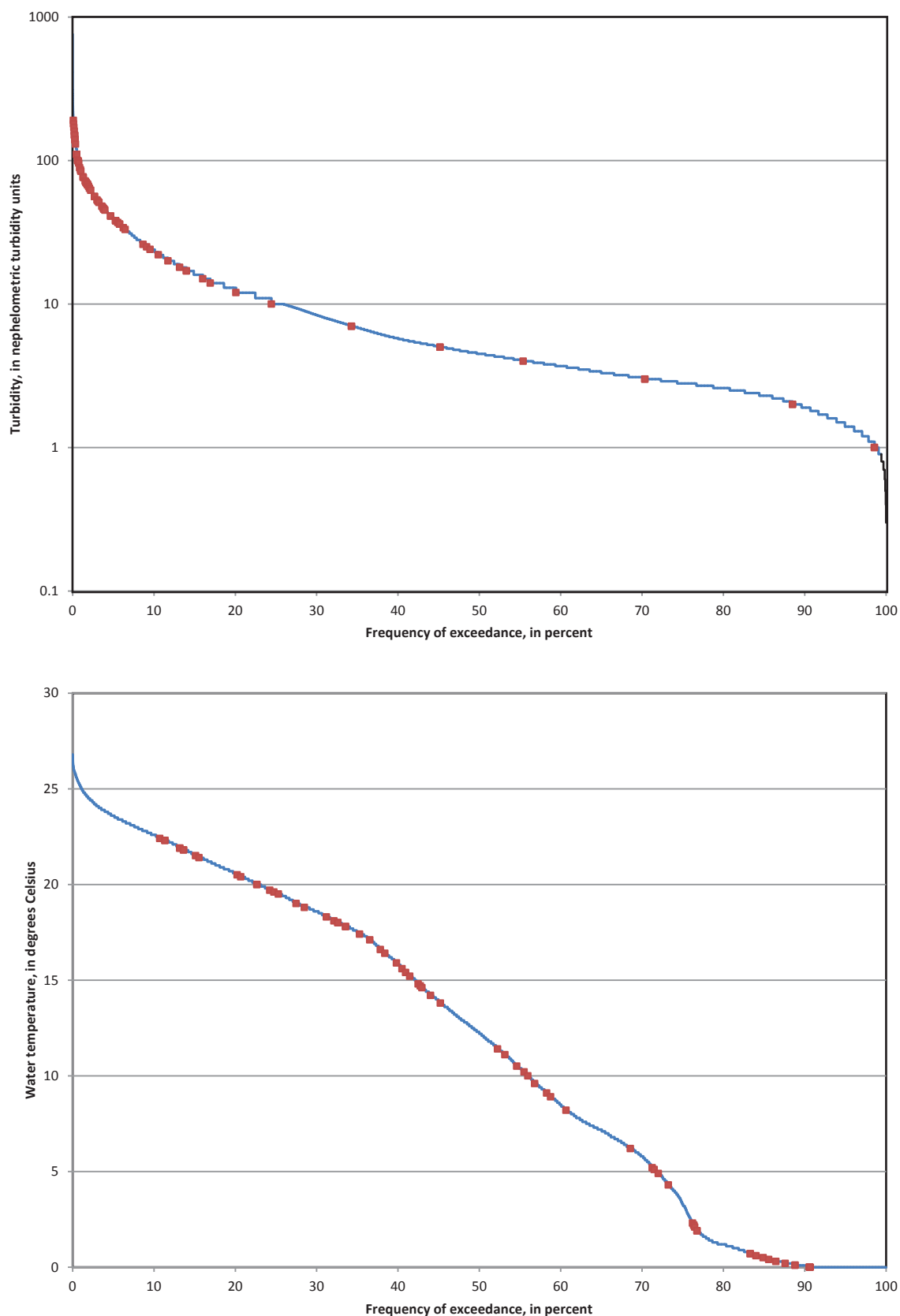


Figure 5-7. Duration curves for turbidity and water temperature (November 2008–September 2010) and corresponding values associated with *Escherichia coli* (*E. coli*) concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgauge on Menomonee River at Wauwatosa, Wisconsin.

***Escherichia coli* at Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2009**

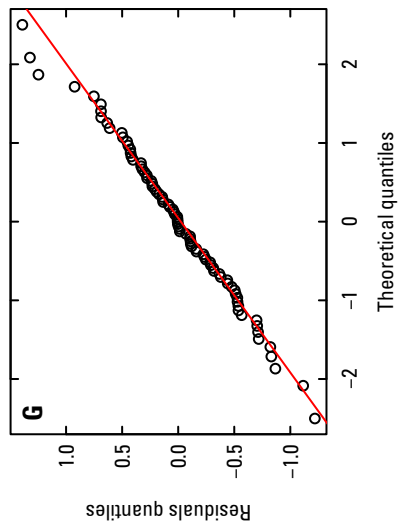
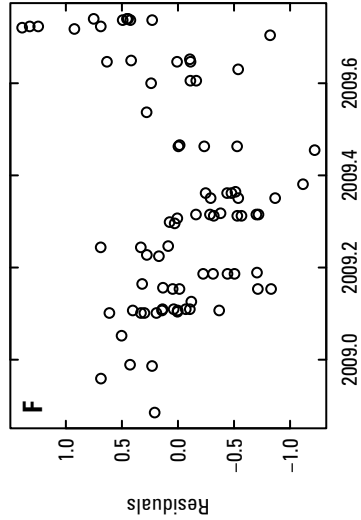
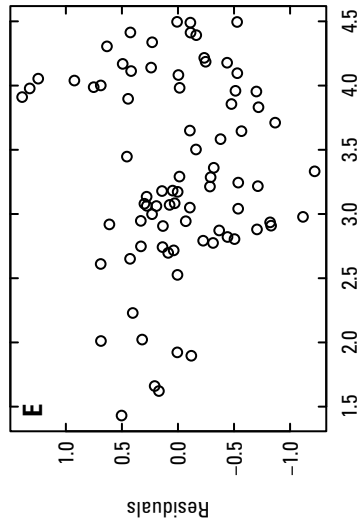
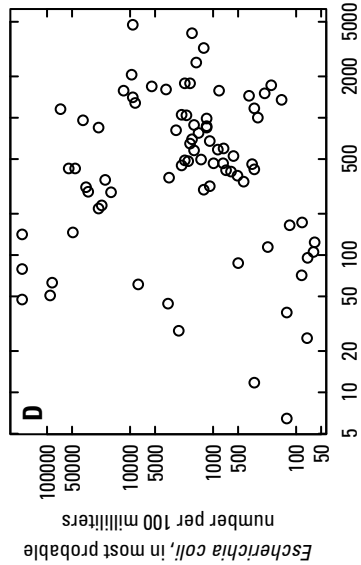
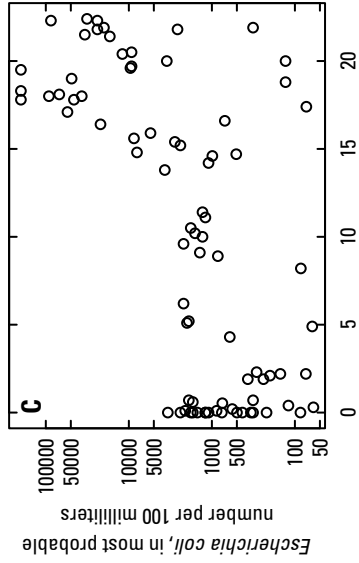
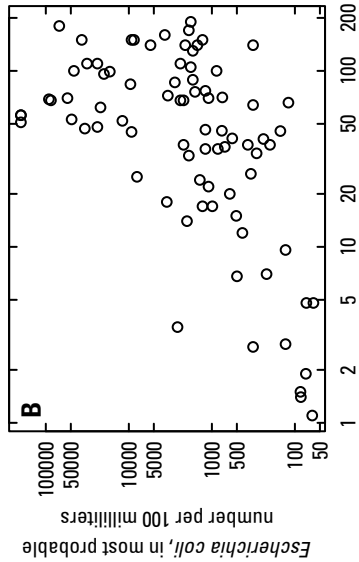
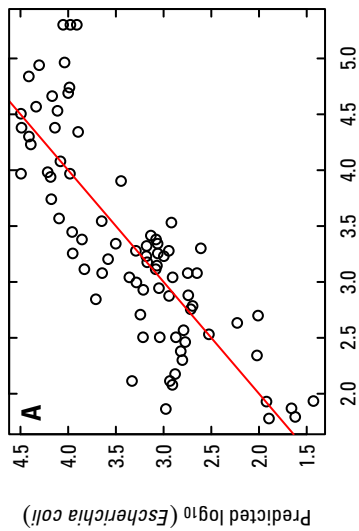


Figure 5-8. U.S. Geological Survey streamgauge on Menomonee River at Wauwatosa, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (*Escherichia coli* (*E. coli*) concentration). *B*, Relation between turbidity and *E. coli* concentration in $\log_{10}$ space. *C*, Relation between water temperature and *E. coli* concentration in $\log_{10}$ space. *D*, Relation between discharge and *E. coli* concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (*E. coli* concentration) and regression residuals. *F*, Relation between time and *E. coli* regression residuals. *G*, Probability plot of *E. coli* regression residuals.

***Escherichia coli* (*E. coli*) bacteria at Menomonee River at 16th Street at Milwaukee, WI (04087142)**

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

$$\text{Log}_{10} (E. coli) = 1.29 + 0.059 (WT) + 0.886 \log_{10} (\text{Turb}),$$

Where:

E. coli = Most Probable Number of *E. coli* per 100 ml (MPN/100ml)

WT = Water Temperature in °C

Turb = Turbidity (YSI 6136), in NTU

Model Information (in log units unless otherwise specified):

Number of measurements = 76,

Root-mean-squared error (RMSE) = 0.542

Model standard percentage error (MPSE) = +248 and -71 percent

90-percent prediction intervals (based on units in MPN/100ml) = +/- 926 percent

Adjusted coefficient of determination (Adj R²) = 0.54

Sum of squared error = 21.45

PRESS = 24.05

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.29	0.222	5.82	<0.0001
WT	0.059	0.008	7.78	<0.0001
Log ₁₀ (Turb)	0.886	0.122	7.26	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	log ₁₀ (Turb)
Intercept	1	-0.513	-0.895
WT	-0.513	1	0.191
Log ₁₀ (Turb)	-0.895	0.191	1

Duan's bias correction factor = **2.34**

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

[MPN/100 mL, most probable number per 100 milliliters; NTU, Nephelometric turbidity units; °C, degrees Celsius]

Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)	Date	Time	<i>Escherichia coli</i> (MPN/100 mL)	Turbidity (NTU)	Water temperature (°C)
11/20/2008	11:45	160	3.1	9.7	4/26/2009	16:25	11,000	82.0	9.6
12/17/2008	14:15	440	7.3	0.0	4/26/2009	17:10	16,000	210.0	10.3
12/27/2008	12:35	1,500	52.3	0.3	4/26/2009	19:30	3,700	210.0	10.9
12/28/2008	0:35	2,400	58.7	1.5	4/26/2009	19:35	3,200	190.0	10.9
12/28/2008	6:35	930	44.0	0.5	5/13/2009	22:05	3,300	35.0	15.2
1/20/2009	12:40	63	5.4	8.2	5/14/2009	0:35	5,200	67.0	16.4
2/7/2009	11:40	52	3.6	5.7	5/14/2009	1:45	3,100	93.0	16.4
2/7/2009	20:40	1,500	78.7	0.0	5/14/2009	3:35	4,100	70.0	16.0
2/8/2009	5:40	1,100	34.7	0.0	5/20/2009	11:45	120	5.0	18.4
2/8/2009	14:40	730	28.3	0.8	6/8/2009	12:40	3,600	42.0	13.1
2/8/2009	23:40	1,100	28.0	0.0	6/8/2009	15:30	3,100	50.0	13.6
2/9/2009	17:40	780	12.7	0.1	6/9/2009	2:35	5,200	32.7	14.3
2/10/2009	5:40	1,100	98.0	0.0	6/9/2009	5:00	7,100	31.3	14.3
2/11/2009	17:40	1,100	69.3	1.5	6/16/2009	13:00	60	5.3	22.7
2/16/2009	13:40	70	8.1	0.1	6/19/2009	0:55	27,000	530.0	20.1
2/26/2009	16:00	610	8.2	8.9	6/19/2009	1:10	16,000	400.0	20.0
2/26/2009	19:00	3,300	200.0	0.2	6/19/2009	1:45	26,000	340.0	20.1
2/26/2009	22:00	1,500	130.0	0.7	6/19/2009	9:35	18,000	95.0	19.6
2/27/2009	4:00	1,400	85.0	0.6	6/19/2040	20:45	24,000	160.0	21.1
2/27/2009	12:00	210	51.0	0.1	6/20/2009	2:25	20,000	84.0	19.8
2/28/2009	12:00	990	19.0	0.0	7/16/2009	12:30	11,000	4.9	24.4
3/7/2009	11:10	460	19.0	2.9	8/8/2009	22:30	17,000	24.0	21.6
3/7/2009	14:10	1,200	89.0	2.9	8/9/2009	10:30	8,700	17.0	22.1
3/7/2009	23:10	360	54.0	2.6	8/19/2009	13:30	240	4.7	22.1
3/8/2009	12:10	430	35.0	1.2	8/26/2009	7:05	98,000	15.0	21.6
3/8/2009	18:10	1,000	90.0	1.6	8/26/2009	17:00	16,000	13.0	22.0
3/9/2009	0:10	570	61.0	0.9	8/26/2009	23:45	7,500	14.0	21.8
3/10/2009	8:15	380	47.0	2.3	9/15/2009	11:30	41	2.9	26.3
3/10/2009	12:55	280	41.0	2.1	9/23/2009	7:10	140,000	7.1	24.3
3/10/2009	13:00	400	42.0	2.1	9/24/2009	7:00	18,000	9.2	23.7
3/10/2009	20:30	160	41.0	2.2	9/28/2009	12:05	17,000	28.0	16.3
3/11/2009	4:30	170	29.0	2.0	09/28/209	18:05	12,000	30.0	15.6
3/24/2009	12:25	63	4.0	12.0	9/29/2009	0:05	7,000	30.0	15.1
4/1/2009	1:40	1,900	34.0	5.1	9/29/2009	3:05	6,200	17.0	16.8
4/20/2009	3:05	520	12.0	10.9	9/29/2009	5:00	7,000	16.0	17.2
4/20/2009	4:50	1,700	14.0	9.6	MINIMUM		41	2.9	0.0
4/23/2009	11:15	110	5.7	12.5	MAXIMUM		140,000	530.0	26.3
4/25/2009	13:20	2,000	30.0	14.2	MEAN		7,937	63.0	10.4
4/25/2009	20:00	2,400	61.0	11.8	MEDIAN		1,550	34.8	10.6
4/26/2009	8:00	1,600	48.0	8.8	STANDARD		19,897	89.4	8.4
4/26/2009	14:00	980	39.0	8.8	DEVIATION				

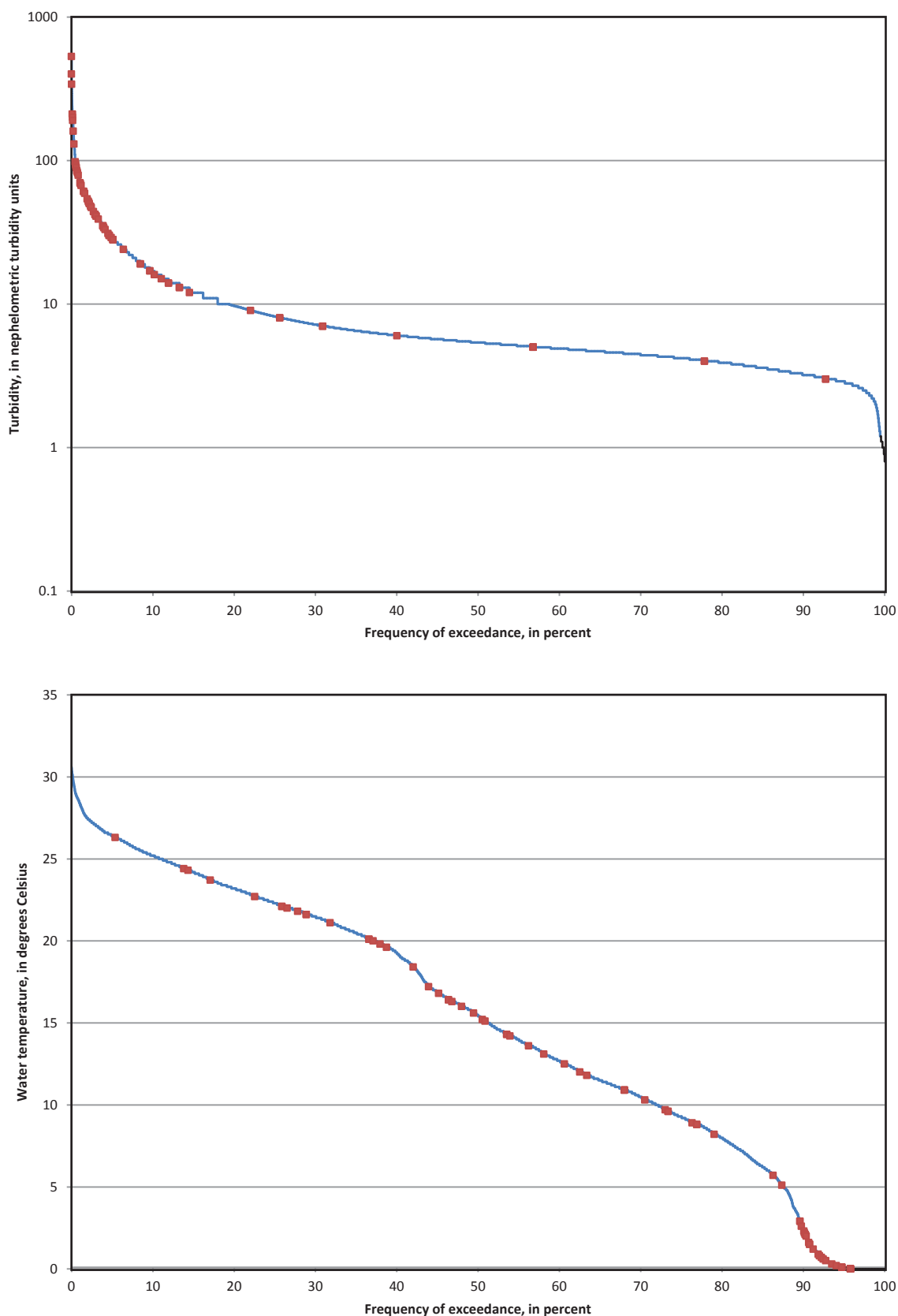


Figure 5-9. Duration curves for turbidity and water temperature (November 2008–September 2010) and corresponding values associated with *Escherichia coli* (*E. coli*) concentration samples collected November 2008 to September 2009 at U.S. Geological Survey streamgauge on Menomonee River at 16th Street at Milwaukee, Wisconsin.

***Escherichia coli* at Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2009**

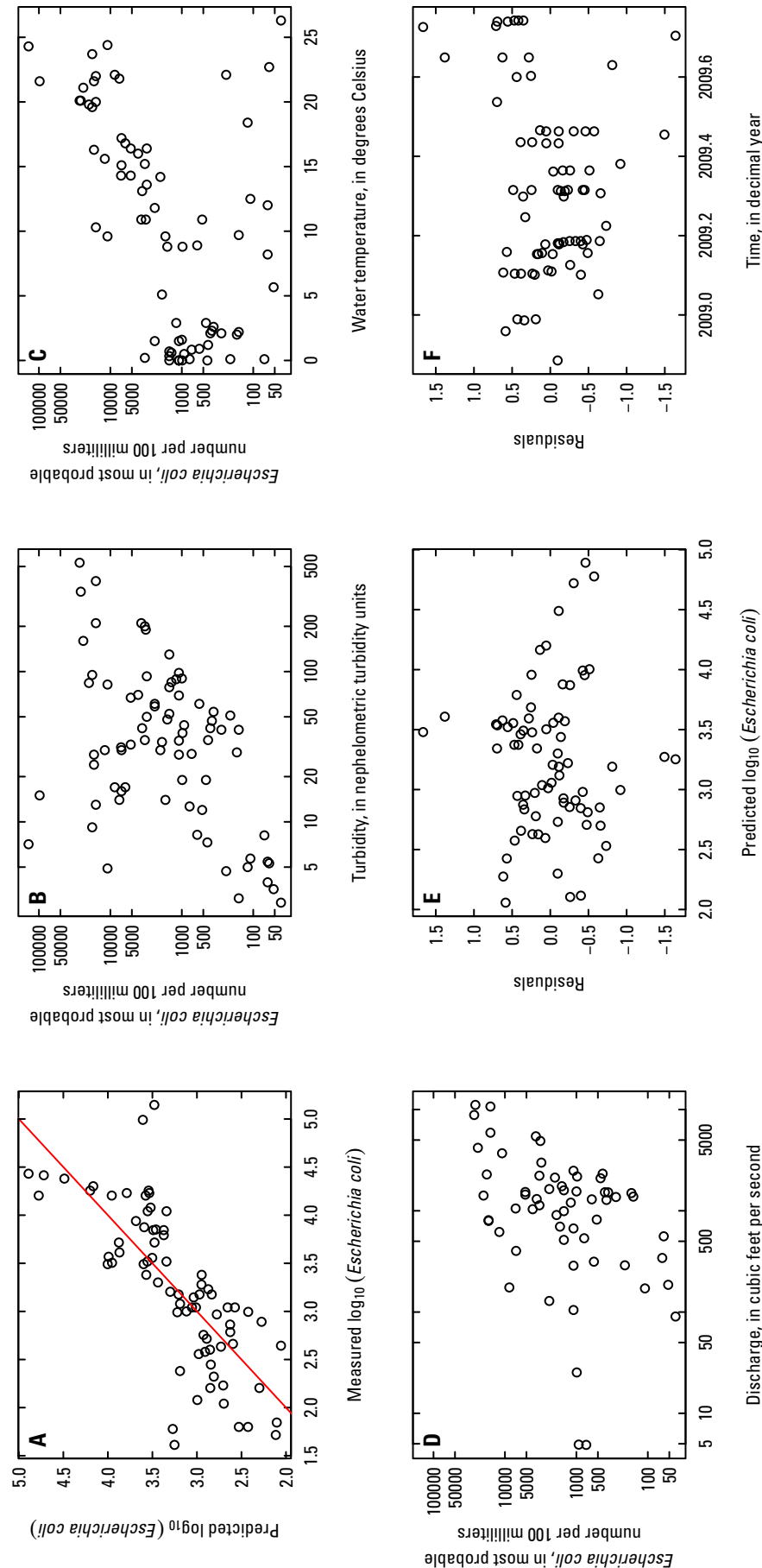


Figure 5-10. U.S. Geological Survey streamgauge on Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008 to September 2009. *A*, Relation between measured and predicted $\log_{10}$ (*Escherichia coli* (*E. coli*) concentration). *B*, Relation between turbidity and *E. coli* concentration in $\log_{10}$ space. *C*, Relation between water temperature and *E. coli* concentration in $\log_{10}$ space. *D*, Relation between discharge and *E. coli* concentration in $\log_{10}$ space. *E*, Relation between predicted $\log_{10}$ (*E. coli* concentration) and regression residuals. *F*, Relation between time and *E. coli* regression residuals. *G*, Probability plot of *E. coli* regression residuals.

