# APPENDIX A

## D.O. MODEL DESCRIPTION FOR THE MIDDLE CUYAHOGA RIVER

## A. Introduction

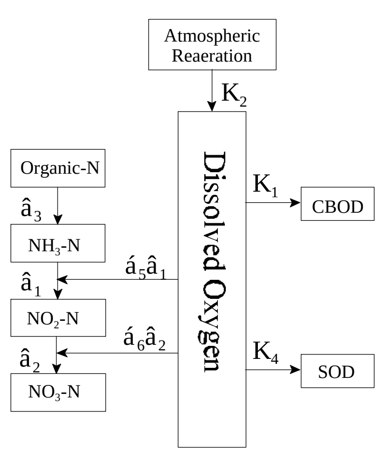
This section describes the methods used in the modeling analysis of D.O. in the middle Cuyahoga TMDL. It is intended to be used as a supplement to the TMDL report and relies on the report to provide a description of the study area, project objectives and results. The purpose of this section is to: 1) document the steps and decisions made in the modeling process; and 2) strengthen the level of confidence in the TMDL calculations.

### A.1 Model Structure and Approach

Dissolved oxygen was modeled using QUAL2E-UNCAS (Brown and Barnwell, 1987). It is a one-dimensional (the D.O. gradient is significant only in the main direction of flow), steady-state (the D.O. profile represents an equilibrium situation where inputs are assumed constant) model which was used to simulate D.O., CBOD and the nitrogen series. QUAL2E uses a mass balance approach as its basic premise; this approach divides each reach in the study area into computational elements which represent a series of linked completely mixed reactors. Each element is a separate system which has an initial external input and internal interactions that either add to or reduce the dissolved oxygen. The final output is the summation of the input and these interactions and it represents the input into the next element. The major constituent interactions used in the middle Cuyahoga model are depicted in Figure 5.

The Cuyahoga mainstem was divided into 18 reaches; each reach was further divided into computational elements with a length of 0.1 mile. The model representation of the stream network showing the computational elements and reaches is presented in Figure 6. Table 8 lists the sampling stations by river mile and year and indicates the type of data that was collected at each site.

Figure 5. Constituent Interactions for the Middle Cuyahoga TMDL



## A.2 Calibration and Verification

Calibration and verification of the middle Cuyahoga River D.O. model was conducted using data from six stream surveys conducted by the Ohio EPA during the summers of 1989, 1996 and 1998. The study area was divided into three segments so that an individual field survey would have a manageable data collection work load; each field survey targeted one of these three sections. The three sections include the upper portion of the study area (Rockwell to Kent), the lower portion (Kent to Cuyahoga Falls) and Breakneck Creek. A QUAL2E model was constructed for each section and calibrated and verified with the appropriate field data. The two mainstem models were then merged resulting in a total of 18 reaches and the results of the Breakneck model were input to the mainstem model as required.

The calibration was begun by constructing an initial data set populated only by measured values from the field survey selected for calibration. A range of values for each unknown input was then estimated using the field survey data and literature values. Initial estimates of the unquantified inputs based on the predefined ranges were then incorporated into the data set. The model results were compared to the observed data and the estimated inputs adjusted accordingly. The inputs to adjust were selected by performing a first-order error analysis on the data set to determine which inputs the model was most sensitive to. Then a sensitivity analysis was performed for these inputs and a final value was selected based on the sensitivity analysis results. The model was calibrated in stages for all values simulated by the model. The hydraulic simulations were calibrated first followed by the nitrogen series (organic, ammonia, nitrite and nitrate nitrogens), CBOD and dissolved oxygen. The final calibration graphs are included in Appendix B.

Kinetic coefficients developed in the calibration were applied to another field data set for model verification. Fine tuning of the coefficients was done as necessary and both the calibration and validation data sets were re-run until the comparison of the predicted results compared reasonably well to the observed data for both data sets. The validation graph for dissolved oxygen is in Appendix B, graph B.14. After calibration and verification, a simulation representing the current situation under critical conditions was run to estimate the deviation of the current conditions from the desired target (D.O. water quality criteria). Implementation option simulations were then run for selected remediation scenarios under critical conditions to determine TMDLs that would meet the D.O. criteria. The model results from some of these selected scenarios are presented in section 4 of the main report, Figure 4.

## A.3 Sources of Data

The majority of the data used in the modeling was field data collected by Ohio EPA (Table 10). The types of data that were collected include:

- time of travel studies to measure stream velocity
- chemical sampling including grab and 24-hr composites samples
- flow measurements of the mainstem and tributaries
- D.O., pH, temperature and conductivity hourly recordings over 48 hour time periods
- cross-sectional measurements
- sediment oxygen demand measurements

All point sources including effluents and tributaries were sampled for water quality and flow to quantify their contributions to the Cuyahoga for calibration and validation purposes. Other datasources include the effluent data collected by the dischargers as required by their NPDES permits. This data is collected over time and is more representative of the effluent quality than the 'snapshot picture' that is measured during a field survey. This data was used in the critical condition simulations for facilities that did not have a permit limit for a particular substance. Additionally, water temperature and flow data collected at USGS stream gage stations (USGS, 1981) were used to define the critical ambient stream temperature and flow values for the simulations.

## A.4 Description of Inputs

Forcing Functions

Forcing functions are the user-specified inputs that drive the system being modeled (Brown and Barnwell, 1987). The middle Cuyahoga River D.O. model has three applicable types of forcing functions. These functions and a description of the source of the input data are as follows:

1. Headwater Inputs - The Lake Rockwell release is the headwater input. The average of all the chemical samples taken from the release was used as the headwater quality in the critical condition simulations.

2. Point Sources and Withdrawals – The point source effluents and tributaries were sampled during each stream survey and the appropriate water quality was input for the calibration or validation data sets. The critical simulations assumed that the entities were discharging at their design flows and monthly average concentration limits if applicable or at their $75^{th}$ percentile values as calculated from the discharger's self-reported data if no permit limit applied. Tributary concentrations for the critical simulations were based on the average of all data collected at the mouth. The water quality of Breakneck was based on the predicted concentrations from a QUAL2E model of the tributary. The withdrawals in the study area are not metered and the withdrawal amount was estimated to be the intake pumps' capacities for the critical simulations. Critical flow conditions for the tributaries were input as the lowest 7-day average flow that has occurred in any 10-year period.

3. Incremental Inflows – Nonpoint sources such as drains, tiles and groundwater inflows were included as incremental inflows and were assumed to occur uniformly over the entire length of the reaches. Incremental inflow rates were estimated by calculating an incremental flow rate per mile based on differences in the upstream and downstream flow sites. The length of the reach multiplied by the flow rate/mile gave the total inflow per reach. All field-collected flow data sets had unaccounted flow after subtracting the upstream measured flow and all other known flow sources from the downstream flow site. This supports the assumption that there are nonpoint inflows even during lower flow conditions. The critical simulations used the inflow rates from the data survey conducted during the lowest flow conditions. The water quality of the incremental inflows was set to Lake Rockwell background concentrations.

Table 12 summarizes the input data for the forcing functions.

Hydraulics Data

Hydraulic data includes stream flow, velocity and water depth. Velocity was measured using a Rhodamine dye time of travel survey and the water depths were calculated from cross-sectional data measured at representative sites. This data was used to establish depth and velocity relationships with flow. Flow dependent depth and velocity functions are used to predict the depths and velocities of the stream that would occur under different stream flows than they were measured at. These relationships were established using the following power functions:

$$\text{Depth} = aQ^b$$
$$\text{Velocity} = cQ^d$$

Where:
- Q = Stream flow
- a,c = Stream constants for depth and velocity
- b,d = Depth and velocity coefficients

The constants and coefficients were calculated from log-log plots of the stream velocity or depth data where sufficient field data existed to determine such relationships. Where only limited data existed, the coefficients were assumed as follows:

b = 0.6 for free flowing reaches
= 0.21 for pooled reaches

d = 0.4 for free flowing reaches
= 0.79 for pooled reaches

Graphs B.1, B.2, B.7 and B.8 show that the constants and the coefficients preform reasonably well under the calibration conditions. Graph B.2 shows an expected increase in the predicted width of the stream as it nears the Kent Dam (RM 54.8); however, no width data was available in this reach to confirm the calibration. Graph B.8 shows that the model under predicts the width of the Munroe Falls Dam pool close to the dam. QUAL2E uses the following equation to predict width:

$$W = Q / (V * D)$$

Where:
- W = Width (ft)
- Q = Flow ($ft^3/s$)
- V = Velocity (ft/s)
- D = Depth (ft)

There is no reason to suspect the field data collected for flow, velocity or depth. All measurements were consistent and the measured widths in the Munroe Falls dam pool increase as would be expected. Therefore, the relationship between area, velocity and flow does not seem to accurately apply to this dam pool.

Dispersion

QUAL2E assumes that complete mixing occurs from side to side and top to bottom in a river. Mixing also occurs as the water travels down the river due mainly to the horizontal and vertical velocity gradients and river channel changes (Thomann and Mueller, 1987). This mixing is referred to as longitudinal dispersion. The time of travel dye studies were used to estimate the longitudinal dispersion using the following equation:

$$E_x = M * (2 A s_p)^{-2} * (ð t_p)^{-1}$$

Where:
- $E_x$ = Longitudinal dispersion coefficient for reach x
- $M$ = Mass of dye introduced to the stream
- $A$ = Average cross-sectional area of reach x
- $s_p$ = Peak concentration of the dye in reach x
- $t_p$ = Time to peak concentration of the dye for reach x

QUAL2E requires that a value for the longitudinal dispersion *constant* be used. The dispersion constant is a dimensionless value which relates the dispersion coefficient to the depth and shear velocity. The relationship is expressed as:

$$K = E_x / (D * U^*)$$

Where:
- $K$ = Dispersion constant
- $U^*$ = Shear velocity

Model Coefficients and Constants

The constants and coefficients selected during model calibration are shown in Table 8. The coefficients $á_5$ and $á_6$ represent the oxygen uptake per unit of oxidized ammonia and nitrite. The values used are recommended by U.S. EPA (1985) and are based on the stoichiometry of the reactions. The Manning's roughness factor used in the model was based on the lowest value recommended in the QUAL2E manual (Brown and Barnwell, 1987) for natural river channels that are winding with pools and shoals.

Field data downstream of the Fishcreek WWTP were used to determine the rate constant for the biological oxidation of nitrite to nitrate ($â_2$). The instream nitrite concentrations were plotted against the time of travel on semi-log paper, and the slope of the regression line represented the value of $â_2$. This value resulted in a fair calibration of both the upper and lower sections of the mainstem. The measured ammonia concentrations did not exhibit any decay in the study area; however, a first order error analysis of the model indicated that both the predicted ammonia and nitrite concentrations were sensitive to $â_1$. A sensitivity analysis was conducted on ammonia and nitrite by varying the value of $â_1$ and seeing how the predicted ammonia and nitrite concentrations compared to the observed ones. The value of $â_1$ that gave the best fit for both ammonia and nitrite and remained in the range of suggested values in the QUAL2E manual (Brown and Barnwell, 1987) was selected. The value of $â_1$ that gave the best fit did not lie in this range, so the value used was the maximum suggested value. Field measurements of organic nitrogen did exhibit a decay; however, the predicted organic nitrogen and ammonia concentrations did not calibrate well with the observed data when the field estimated value of $â_3$ was used. Instead, a sensitivity analysis was performed to determine what value gave the best predicted concentrations of ammonia and organic nitrogen when compared with observed values.

The instream measured concentrations of CBOD did not exhibit any conclusive decay patterns. An empirical relationship between the CBOD decay rate ($K_1$) and depth (D) has been observed. The equation, $K_1 = 0.2\,(D/8)^{-0.434}$, gave the best predicted fit for CBOD and D.O. and was used to determine $K_1$ for the entire study area. No settling was observed for either CBOD or the nitrogen series; therefore, all settling constants were assumed zero.

The stream reaeration rate was calculated using predictive equations selected based on stream slope and flow as suggested by Ohio EPA guidance (Division of Surface Water, 1984). The recommended predictive equation for the upper portion of the study area was the Parkhurst-Pomeroy equation. Both the Krenkel-Orlob and the Negelescu-Rojanski reaeration equations were recommended for the lower section of the study area. The portion upstream of the Munroe Falls Dam pool was best predicted by the Negelescu-Rojanski equation whereas the dam pool section had the best fit with the Krenkel-Orlob equation. The D.O. profiles of other predictive equations were graphically compared to the D.O. profile resulting from the above selections; however, the three equations applied to the specified stream sections gave the best fit to the observed data.

Sediment oxygen demand (SOD) is a measure of the oxygen consumed by biochemical decompositions of organic matter in stream sediments and is represented by the rate coefficient $K_4$. SOD measurements were recorded in low velocity sections of the Cuyahoga River by a benthic respirometer (SOD chamber). The SOD rates measured by this chamber ranged from 0.3 to 1.0 g/ft2/day. In addition, several sites were attempted, but the readings of the D.O. probe went immediately to zero so that no rate could be recorded. The probe was tested for malfunction by measuring the ambient air for oxygen content and typical measurements were recorded. This would indicate that the SOD of these sites was extremely high and beyond the capabilities of the equipment to record. The value of $K_4$ used in the model needed to represent an average value over an entire reach. The $K_4$ values used in this model ranged from 0.1 to 0.3 depending on the reach characteristics. These values were used based on the measured data, the descriptions of the sites where SOD was measured, the reach characteristics and the results of the calibration and validation model runs.

Table 8. Summary of Coefficients for D.O. Modeling in the Middle Cuyahoga River

| Coefficient[1] | Description | Units[2] | Value Used |
|---|---|---|---|
| $\text{á}_5$ | $O_2$ uptake per unit $NH_3$ oxidized | mg O/ mg N | 3.43 |
| $\text{á}_6$ | $O_2$ uptake per unit $NO_2$ oxidized | mg O/ mg N | 1.14 |
| n | Manning's roughness | – | 0.033 |
| $\text{â}_1$ | Rate constant for biological oxidation of $NH_3$ to $NO_2$ | $day^{-1}$ | 1.0 |
| $\text{â}_2$ | Rate constant for biological oxidation of $NO_2$ to $NO_3$ | $day^{-1}$ | 1.5 |
| $\text{â}_3$ | Rate constant for biological oxidation of Org-N to $NH_3$ | $day^{-1}$ | 0.3 |
| $K_1$ | CBOD decay rate | $day^{-1}$ | variable[3] |
| $K_2$ | Reaeration rate | $day^{-1}$ | variable[4] |
| $K_4$ | Sediment oxygen demand | $g/ft^2/day$ | 0.1 - 0.3 |

1 Refer to Figure 5 for pictorial representation of the rates.
2 Presented as the value at 20 degrees C for first-order rate constants $\text{â}_1$, $\text{â}_2$, $\text{â}_3$, $K_1$, $K_2$, and $K_4$.
3 CBOD decay is variable with average reach depth.
4 Reaeration is variable with average reach depth and velocity.

<u>Temperature Effects on Coefficients</u>

First-order kinetic coefficients are temperature dependent and the QUAL2E standard is to input the reaction rate value at 20 degrees C. The program then corrects to the actual reaction rate based on the ambient temperature of the receiving water during simulations. The temperature corrections are calculated using the following formula:

$$X_T = X_{20} \, \text{è}^{(T-20)}$$

Where

$X_T$ = the value of the coefficient at the ambient temperature (in degrees C)
$X_{20}$ = the value of the coefficient at the standard temperature of 20 degrees C
è = an empirical constant derived from literature values
T = the ambient temperature (in degrees C)

The temperature correction values used were:

| Kinetic Coefficient | Correction Factor |
|---|---|
| $K_1$ | 1.047 |
| $K_2$ | 1.024 |
| $K_4$ | 1.065 |
| $\hat{a}_1$ | 1.083 |
| $\hat{a}_2$ | 1.047 |
| $\hat{a}_3$ | 1.047 |

Dam Effects

Dams affect both the upstream and downstream D.O. concentrations. The upstream D.O. concentrations are negatively impacted due to the change in the hydraulics of the stream (decreasing natural stream reaeration, increasing deoxygenation rates of CBOD decay). This impact is captured in the field measurements of the stream hydrology. Oxygen is input to the stream from reaeration over dams so downstream D.O. concentrations are increased. QUAL2E predicts the dam reaeration using the Gameson equation. The inputs required by this equation include:

H = the height through which water falls;
a = an empirical parameter indicating water quality
b = an empirical parameter indicating dam shape

A summary of the dam data is:

| **Dam Location** | **H (ft)** | **a[1]** | **b[2]** |
|---|---|---|---|
| Kent | 12 | 1 | 1 |
| Munroe Falls | 12 | 0.8 | 1 |

[1] The lower the value, the poorer the water quality. A value of 0.8 indicates polluted water.
[2] A value of 1 indicates a weir with free fall.

Relationship between CBOD5 and Ultimate CBOD

QUAL2E uses ultimate CBOD (CBODU) as its default input and output CBOD measure. Waters dominated by domestic waste effluents and waters that are not strongly influenced by industrial wastes typically have 20-day CBOD values that closely approximate the ultimate values (Ohio EPA, 1998). Therefore, CBOD20 and CBODU will be considered equal for the purposes of this study.

The WLAs based on the model output are expressed as CBODU; however, most municipal treatment works' NPDES permits are expressed as CBOD5. The following equation was used to convert from CBODU to CBOD5:

CBOD5 = 0.50 * CBODU . . . . . . . . . . . . for municipal plants with secondary treatment

CBOD5 = 0.43 * CBODU . . . . . . . . . . . . for municipal plants with advanced treatment

## A.5 Breakneck Creek QUAL2E Modeling

Breakneck Creek is the largest tributary to the Cuyahoga River within the bounds of the study area. There are two municipal wastewater treatment plants, Ravenna and Franklin Hills, that discharge to this subwatershed. The upper portion of this stream is influenced by wetland-like swampy conditions. Sedimentation seems to be a problem in the lower section of the stream; the mixing zone of Breakneck Creek as it enters the Cuyahoga can be defined by the changes in turbidity between the two waters. The source of this sedimentation is unknown and further study would be required to address it. The same modeling approach as described for the middle Cuyahoga River was used for the Breakneck Creek modeling. The rates and coefficients used are described in Table 9. Field data is summarized in Table 14, and calibration graphs are shown in graphs B.16 through B.19.

## A.6 Quantified Comparison of Observed and Modeled Dissolved Oxygen

A statistical measure of how well a constructed model compares to observed data is relative error. This technique gives an indication of model adequacy and is the absolute value of the difference between the observed and the predicted values divided by the observed value. The median percent relative error for the calibrated middle Cuyahoga model is 8%. A study of 20 different state-of-the-art models was conducted and the median percent relative error in measured versus simulated D.O. was compared. The results (USEPA, 1997) show that 60 percent of the models studied had relative median errors greater than 8%. The Cuyahoga TMDL model compares well to those models studied and indicates that the Cuyahoga model should give credible results.

**Table 9. Summary of Constants and Coefficients for D.O. Modeling in Breakneck Creek**

| Coefficient[1] | Description | Units[2] | Value Used |
|---|---|---|---|
| $\acute{a}_5$ | $O_2$ uptake per unit $NH_3$ oxidized | mg O/ mg N | 3.43 |
| $\acute{a}_6$ | $O_2$ uptake per unit $NO_2$ oxidized | mg O/ mg N | 1.14 |
| n | Manning's roughness | – | 0.030 |
| $\hat{a}_1$ | Rate constant for biological oxidation of $NH_3$ to $NO_2$ | $day^{-1}$ | 1.0 |
| $\hat{a}_2$ | Rate constant for biological oxidation of $NO_2$ to $NO_3$ | $day^{-1}$ | 2.0 |
| $\hat{a}_3$ | Rate constant for biological oxidation of Org-N to $NH_3$ | $day^{-1}$ | 0.05 |
| $K_1$ | CBOD decay rate | $day^{-1}$ | variable[3] |
| $K_2$ | Reaeration rate | $day^{-1}$ | Bansal[4] |
| $K_3$ | CBOD settling rate | $day^{-1}$ | 0.36 |
| $K_4$ | Sediment oxygen demand | $g/ft^2/day$ | 0.1 - 0.4 |

1 Refer to Figure 5 for pictorial representation of the rates.
2 Presented as the value at 20 degrees C for first-order rate constants $\hat{a}_1$, $\hat{a}_2$, $\hat{a}_3$, $K_1$, $K_2$, and $K_4$.
3 CBOD decay is variable with average reach depth: $K_1 = 0.2*(D/8)^{-0.434}$
4 Reaeration is variable with average reach depth and velocity, and was predicted using the equation developed by M. K. Bansal (1973).

## A.7 Summary

Breakneck Creek and the upper and lower portions of the Middle Cuyahoga River were modeled using QUAL2E and field collected data. The predicted dissolved oxygen concentrations compared reasonably well with the measured values for all areas and the model can be relied on to give credible results. A set of inputs reflective of critical conditions was used to determine the current critical D.O. profile. The conditions that were considered critical (and not subject to change) are a low flow condition (7Q10) and an instream temperature of 74°F which was determined from data collected at the Old Portage USGS gage station since 1939. The effects of various loading and hydromodification changes were then estimated to determine what changes were necessary in the current study area to result in attainment of the dissolved oxygen criteria. Some of these remediation strategies are discussed in section 4. These strategies show that the more the current hydromodifications in the river are altered to reflect more natural river conditions, the less loading controls are necessary.

## Figure 6. Model Representation of the Middle Cuyahoga River

| Rch | Elmnt | Type | RM |
|---|---|---|---|
| 1 | 1 | Headwater | 58 |
| | 2 | Point load | |
| | 3 | Standard | |
| | 4 | Point load | |
| 2 | 5 | Standard | |
| | 6 | Standard | |
| | 7 | Standard | |
| | 8 | Standard | |
| | 9 | Standard | |
| | 10 | Standard | |
| | 11 | Standard | 57 |
| | 12 | Standard | |
| 3 | 13 | Point load | |
| | 14 | Standard | |
| | 15 | Standard | |
| | 16 | Intake | |
| | 17 | Standard | |
| | 18 | Standard | |
| | 19 | Standard | |
| | 20 | Standard | |
| | 21 | Standard | 56 |
| | 22 | Standard | |
| 4 | 23 | Point load | |
| | 24 | Standard | |
| | 25 | Standard | |
| | 26 | Standard | |
| | 27 | Standard | |
| | 28 | Standard | |
| 5 | 29 | Standard | |
| | 30 | Standard | |
| | 31 | Standard | 55 |
| | 32 | Standard | |
| 6 | 33 | Dam | |
| | 34 | Standard | |
| | 35 | Standard | |
| 7 | 36 | Standard | |
| | 37 | Standard | |
| | 38 | Standard | |
| | 39 | Standard | |
| | 40 | Standard | |
| 8 | 41 | Standard | 54 |
| | 42 | Standard | |
| | 43 | Point load | |
| | 44 | Standard | |
| | 45 | Point load | |
| | 46 | Standard | |
| 9 | 47 | Standard | |
| | 48 | Standard | |
| | 49 | Standard | |
| | 50 | Standard | |
| | 51 | Standard | 53 |
| | 52 | Standard | |
| 10 | 53 | Standard | |
| | 54 | Standard | |
| | 55 | Standard | |
| | 56 | Standard | |
| 11 | 57 | Standard | |
| | 58 | Standard | |
| 12 | 59 | Point load | 52 |
| | 60 | Standard | |
| | 61 | Standard | |
| | 62 | Standard | |
| | 63 | Standard | |
| 13 | 64 | Standard | |
| | 65 | Point load | |
| | 66 | Standard | |
| | 67 | Standard | |
| 14 | 68 | Standard | |
| | 69 | Standard | 51 |
| | 70 | Standard | |
| 15 | 71 | Standard | |
| | 72 | Standard | |
| | 73 | Standard | |
| | 74 | Standard | |
| 16 | 75 | Standard | |
| | 76 | Standard | |
| | 77 | Standard | |
| | 78 | Standard | |
| 17 | 79 | Standard | 50 |
| | 80 | Standard | |
| | 81 | Standard | |
| | 82 | Standard | |
| 18 | 83 | Dam | |
| | 84 | Standard | |
| | 85 | Standard | |
| | 86 | Standard | |
| | 87 | Standard | |
| | 88 | Standard | |
| | 89 | Standard | 49 |
| | 90 | Standard | |
| | 91 | Intake | |
| | 92 | Standard | |
| | 93 | Standard | |
| | 94 | Standard | |
| | 95 | Standard | |
| | 96 | Standard | |
| | 97 | Standard | |
| | 98 | Point load | |
| | 99 | Standard | 48 |
| | 100 | Standard | |
| | 101 | Final | |

## Table 10. Middle Cuyahoga River Field Data Summary

| Stream / Site Description | River Mile | Velocity (fps) | Flow* (cfs) | Depth (ft.) | Widt (ft.) | Readings (DO,pH,T) | Date (mo/yr) | Velocity (fps) | Flow* (cfs) | Depth (ft.) | Readings (DO,pH,T) | Date (mo/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lake Rockwell | 57.97 | | | | | | | | | | | |
| Upst Twin Lakes Outlet | 57.85 | | | 1.85 | 71 | Yes | 8/98 | | | | | |
| Twin Lakes Outlet | 57.82 | | *4.1* | | | Yes | 8/98 | | | | | |
| Dst Twin Lakes Outlet | 57.70 | | | 1.34 | 60.9 | Yes | 8/98 | | | | Yes | 9/91 |
| Upstream Breakneck | 56.85 | 0.051 | 5.023 | 1.65 | 79 | Yes | 8/98 | | | | Yes | 9/91 |
| Breakneck Enters | 56.82 | | *97.5* | | | Yes | 8/98 | | | | | |
| Standing Rock | 55.90 | 0.56 | | 1.7 | 91.3 | | 8/98 | | | | Yes | 9/91 |
| Crain Ave | 55.20 | 0.3 | | | | Yes | 8/98 | | | | | |
| Kent Dam | 54.80 | 0.18 | | | | | 8/98 | | | | | |
| Browns Tan Park | 54.60 | 1.1 | 105.9 | 1.29 | 110.2 | Yes | 8/98 | | | | Yes | 9/91 |
| Cuyahoga | 53.90 | 0.55 | | 2.78 | 68 | Yes | 8/98 | | | | Yes | 9/91 |
| | | | | | | | | | | | | |
| Cuyahoga | 54.45 | | 38.6 | | | Yes | 7/96 | | 35 | | Yes | 8/96 |
| Kent Effluent | 53.85 | | *3.84* | | | Yes | 7/96 | | *3.96* | | Yes | 8/96 |
| Plum Creek Enters | 53.67 | | *4.54* | | | | 7/96 | | *3.88* | | | 8/96 |
| Cuyahoga | 53.40 | 0.208 | | 2.76 | 82.7 | Yes | 7/96 | 0.237 | | 2.88 | Yes | 8/96 |
| Cuyahoga | 52.85 | 0.161 | | 3.28 | 108.4 | Yes | 7/96 | 0.126 | | 3.38 | Yes | 8/96 |
| Cuyahoga | 52.55 | 0.116 | | 3.41 | 84.1 | Yes | 7/96 | 0.318 | | 3.54 | Yes | 8/96 |
| Cuyahoga | 52.17 | 0.084 | | 4.17 | 136.8 | Yes | 7/96 | 0.122 | | 4.76 | Yes | 8/96 |
| Fish Creek Enters | 52.12 | | *3.89* | | | Yes | 7/96 | | *2.96* | | Yes | 8/96 |
| Cuyahoga | 51.73 | 0.140 | | 4.17 | 148 | Yes | 7/96 | 0.255 | | 4.26 | Yes | 8/96 |
| Fishcreek Effluent | 51.66 | | *6.69* | | | | 7/96 | | *5.63* | | | 8/96 |
| Cuyahoga | 51.35 | 0.084 | | 4.19 | 174.5 | Yes | 7/96 | 0.072 | | 4.26 | Yes | 8/96 |
| Cuyahoga | 51.00 | 0.144 | | 4.34 | 218.7 | Yes | 7/96 | 0.049 | | 4.44 | Yes | 8/96 |
| Cuyahoga | 50.55 | 0.066 | | 5.14 | 226.5 | Yes | 7/96 | 0.246 | | 5.16 | Yes | 8/96 |
| Cuyahoga | 50.17 | 0.163 | | 6.13 | 214.8 | Yes | 7/96 | 0.128 | | 6.44 | Yes | 8/96 |
| Cuyahoga | 49.80 | | | | | Yes | 7/96 | | | | Yes | |
| Cuyahoga | 48.10 | 0.283 | 57.84 | | | Yes | 7/96 | 0.475 | | | Yes | 8/96 |
| | | | | | | | | | | | | |
| Cuyahoga | 53.90 | | 59.27 | 2.31 | 65.7 | Yes | 9/89 | | | | | |
| Kent Effluent | 53.85 | | *4.64* | | | | 9/89 | | | | | |
| Plum Creek Enters | 53.67 | | *8.9* | | | | 9/89 | | | | | |
| Cuyahoga | 53.44 | 0.245 | 77.37 | 2.68 | 56.2 | | 9/89 | | | | | |
| Cuyahoga | 52.80 | 0.376 | | 5 | | Yes | 9/89 | | | | | |
| Cuyahoga | 52.55 | | | 4.11 | 105 | | 9/89 | | | | | |
| Cuyahoga | 52.20 | 0.203 | | | | Yes | 9/89 | | | | | |
| Fish Creek Enters | 52.12 | | *3.22* | 4.14 | 142.5 | | 9/89 | | | | | |
| Fishcreek Effluent | 51.66 | 0.055 | *3.9* | 4.37 | 149.5 | Yes | 9/89 | | | | | |
| Cuyahoga | 51.28 | 0.036 | | 4.93 | 125 | Yes | 9/89 | | | | | |
| Cuyahoga | 50.70 | 0.131 | | 3.93 | 235 | Yes | 9/89 | | | | | |
| Cuyahoga | 50.00 | 0.160 | | 6.25 | 222 | Yes | 9/89 | | | | | |
| Munroe Falls Dam | 49.80 | | 95.28 | | | Yes | 9/89 | | | | | |

* Numbers in italics indicate the value is for the tributary, not the mainstem.

**Table 11. Middle Cuyahoga Water Chemistry Summary (mg/l)**

| Date | River Mile | CBOD 20-day | TKN | NH3 | Org-N | NO2 | NO2-NO3 | NO3 | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Aug. 98 | 57.95 | 5.2 | 0.8 | 0.26 | 0.54 | 0.09 | 0.1 | 0.01 | Ave of 2 grabs |
| Aug. 98 | 57.6 | 6.7 | 0.8 | 0.38 | 0.42 | 0.1 | 0.33 | 0.23 | Composite 8/12-13 |
| Aug. 98 | 57.85 | 5.2 | 0.8 | 0.39 | 0.41 | 0.08 | 0.21 | 0.13 | Composite 8/12-13 |
| Aug. 98 | 56.6 | 4.5 | 0.7 | 0.07 | 0.63 | 0.03 | 1.02 | 0.99 | Grab 8/12 |
| Aug. 98 | 56.6 | 3.8 | 0.8 | 0.08 | 0.72 | 0.03 | 1.14 | 1.11 | Grab 8/13 |
| Aug. 98 | 56.6 | 4.15 | 0.75 | 0.075 | 0.675 | 0.03 | 1.08 | 1.05 | Average of 2 samples |
| Aug. 98 | 56.2 | 3.8 | 0.7 | 0.07 | 0.63 | 0.03 | 1.14 | 1.11 | Grab 8/13 |
| Aug. 98 | 55.75 | 4.8 | 0.7 | 0.08 | 0.62 | 0.02 | 1.22 | 1.2 | Composite 8/12-13 |
| Aug. 98 | 55.2 | 4.7 | 0.8 | 0.1 | 0.7 | 0.02 | 1.22 | 1.2 | Composite 8/12-13 |
| Aug. 98 | 54.5 | 4.4 | 0.7 | 0.08 | 0.62 | 0.02 | 1.25 | 1.23 | Composite 8/12-13 |
| Aug. 98 | 53.95 | 4.3 | 0.8 | 0.1 | 0.7 | 0.02 | 1.15 | 1.13 | Composite 8/12-13 |
| Aug. 98 | Breakneck | 6.4 | 0.9 | 0.07 | 0.83 | 0.02 | 1.28 | 1.26 | Composite 8/12-13 |
| Aug. 98 | Twin Lake | 6.7 | 1.7 | 0.42 | 1.28 | 0.04 | 0.27 | 0.23 | Composite 8/12-13 |
| 24Jul96 | 53.9 | 6.0 | 0.3 | 0.05 | 0.25 | 0.02 | 1.09 | 1.07 | |
| 24Jul96 | Kent STP | 4.900 | 0.9 | 0.1 | 0.8 | 0.03 | 14.65 | 14.62 | |
| 24Jul96 | Plum Ck | 6.5 | 0.2 | 0.16 | 0.04 | 2.01 | 5.26 | 3.25 | Grab |
| 24Jul96 | 53.4 | 5.0 | 0.3 | 0.05 | 0.25 | 0.06 | 2.29 | 2.23 | |
| 24Jul96 | 52.8 | 7.0 | 0.3 | 0.05 | 0.25 | 0.05 | 2.02 | 1.97 | |
| 24Jul96 | 52.5 | 7.0 | 0.2 | 0.05 | 0.15 | 0.04 | 1.94 | 1.9 | |
| 24Jul96 | 52.2 | 8.5 | 0.3 | 0.05 | 0.25 | 0.03 | 1.42 | 1.39 | |
| 24Jul96 | Fish Ck. | 3.8 | 0.2 | 0.05 | 0.15 | 0.02 | 0.24 | 0.22 | Grab |
| 24Jul96 | 51.7 | 10 | 1.1 | 0.05 | 1.05 | 0.49 | 6.53 | 6.04 | |
| 24Jul96 | FC WWTP | 12.000 | 2.7 | 0.66 | 2.04 | 1.35 | 19.5 | 18.15 | |
| 24Jul96 | 51.28 | 15 | 0.8 | 0.05 | 0.75 | 0.22 | 5.24 | 5.02 | |
| 24Jul96 | 51 | 9.1 | 0.6 | 0.15 | 0.45 | 0.16 | 3.25 | 3.09 | |
| 24Jul96 | 50.7 | 7.9 | 0.4 | 0.05 | 0.35 | 0.14 | 2.42 | 2.28 | |
| 24Jul96 | 50 | 8.1 | 0.6 | 0.16 | 0.44 | 0.09 | 2.26 | 2.17 | |
| 24Jul96 | 49.78 | 8.7 | 0.5 | 0.05 | 0.45 | 0.08 | 2.44 | 2.36 | Grab |
| 24Jul96 | 48.15 | 6.4 | 0.5 | 0.05 | 0.45 | 0.04 | 1.55 | 1.51 | |
| 25Jul96 | 53.9 | 4 | 0.4 | 0.05 | 0.35 | 0.02 | 1.09 | 1.27 | |
| 25Jul96 | Kent STP | 4.9 | 1 | 0.06 | 0.94 | 0.02 | 14.65 | 15.38 | |
| 25Jul96 | Plum Ck | 3.7 | 0.2 | 0.06 | 0.14 | 0.47 | 5.26 | 0.77 | |
| 25Jul96 | 53.4 | 6.3 | 0.2 | 0.05 | 0.15 | 0.02 | 2.29 | 1.85 | |
| 25Jul96 | 52.8 | 17 | 0.6 | 0.05 | 0.55 | 0.02 | 2.02 | 1.59 | |
| 25Jul96 | 52.5 | 7.8 | 0.6 | 0.1 | 0.5 | 0.02 | 1.94 | 1.43 | |
| 25Jul96 | 52.2 | 8.6 | 0.7 | 0.34 | 0.36 | 0.02 | 1.42 | 1.22 | |
| 25Jul96 | Fish Ck. | 4.5 | 0.2 | 0.05 | 0.15 | 0.02 | 0.24 | 0.25 | |
| 25Jul96 | 51.7 | 8.6 | 1.2 | 0.12 | 1.08 | 0.28 | 6.53 | 5.26 | |
| 25Jul96 | FC WWTP | 9.95 | 2.5 | 0.52 | 1.98 | 1.08 | 19.5 | 16.72 | |
| 25Jul96 | 51.28 | 11 | 0.7 | 0.05 | 0.65 | 0.16 | 5.24 | 3.82 | |
| 25Jul96 | 51 | 11 | 1 | 0.13 | 0.87 | 0.14 | 3.25 | 3.18 | |
| 25Jul96 | 50.7 | 6.9 | 0.6 | 0.16 | 0.44 | 0.1 | 2.42 | 2.24 | |
| 25Jul96 | 50 | 10 | 0.5 | 0.06 | 0.44 | 0.05 | 2.26 | 1.32 | |
| 25Jul96 | 49.78 | 6.9 | 0.5 | 0.05 | 0.45 | 0.06 | 2.44 | 1.71 | |
| 25Jul96 | 48.15 | 7.7 | 0.5 | 0.05 | 0.45 | 0.02 | 1.55 | 0.95 | |
| Aug. 96 | 53.9 | 5.8 | 0.7 | 0.05 | 0.65 | 0.02 | 1.16 | 1.14 | |
| Aug. 96 | Kent STP | 3.800 | 0.35 | 0.095 | 0.255 | 0.06 | 18.1 | 18.04 | |
| Aug. 96 | Plum Ck | 5.7 | 0.7 | 0.05 | 0.65 | 0.39 | 1.16 | 0.77 | |
| Aug. 96 | 53.4 | 5.7 | 0.6 | 0.05 | 0.55 | 0.06 | 2.23 | 2.17 | |
| Aug. 96 | 52.8 | 5.4 | 0.2 | 0.05 | 0.15 | 0.04 | 2.23 | 2.19 | |

**Table 11. Middle Cuyahoga Water Chemistry Summary, mg/l (continued)**

| Date | River Mile | CBOD 20-day | TKN | NH3 | Org-N | NO2 | NO2-NO3 | NO3 | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Aug. 96 | 52.5 | 6.3 | 0.4 | 0.05 | 0.35 | 0.04 | 2.25 | 2.21 | |
| Aug. 96 | 52.2 | 6.7 | 0.2 | 0.05 | 0.15 | 0.04 | 2.27 | 2.23 | |
| Aug. 96 | Fish Ck. | 3.2 | 0.2 | 0.05 | 0.15 | 0.02 | 0.21 | 0.19 | |
| Aug. 96 | 51.7 | 5.0 | 0.5 | 0.05 | 0.45 | 0.03 | 2.24 | 2.21 | |
| Aug. 96 | FC WWTP | 8.150 | 0.35 | 0.105 | 0.245 | 1.7 | 20.5 | 18.8 | |
| Aug. 96 | 51.28 | 6.0 | 0.3 | 0.05 | 0.25 | 0.32 | 3.74 | 3.42 | |
| Aug. 96 | 51 | 7.1 | 0.2 | 0.05 | 0.15 | 0.09 | 3.16 | 3.07 | |
| Aug. 96 | 50.7 | 5.7 | 0.4 | 0.05 | 0.35 | 0.09 | 3.2 | 3.11 | |
| Aug. 96 | 50 | 7.2 | 0.4 | 0.05 | 0.35 | 0.06 | 2.79 | 2.73 | |
| Aug. 96 | 49.78 | 4.5 | 0.4 | 0.05 | 0.35 | 0.09 | 3.42 | 3.33 | |
| Aug. 96 | 48.15 | 7.4 | 0.2 | 0.05 | 0.15 | 0.04 | 2.45 | 2.41 | |
| Sept. 89 | 53.9 | 3.8 | 0.7 | | | 0.06 | | | 9/11-9/12 comp |
| Sept. 89 | 53.44 | 4.4 | 0.7 | 0.11 | 0.59 | 0.07 | | 1.85 | 9/11-9/12 comp |
| Sept. 89 | 52.8 | 4.5 | 0.8 | 0.1 | 0.7 | 0.07 | | 1.01 | 9/11-9/12 comp |
| Sept. 89 | 52.2 | 5.1 | 0.8 | 0.1 | 0.7 | 0.06 | | 1.91 | 9/11-9/12 comp |
| Sept. 89 | 51.28 | 4.5 | 0.7 | 0.32 | 0.38 | 0.06 | | 1.3 | 9/11-9/12 comp |
| Sept. 89 | 50.7 | 5.1 | 0.8 | 0.13 | 0.67 | 0.05 | | 0.3 | 9/11-9/12 comp |
| Sept. 89 | 50 | 4.6 | 0.8 | 0.16 | 0.64 | 0.06 | | 1.5 | 9/11-9/12 comp |
| Sept. 89 | Kent STP | 29 | 1.8 | 1.06 | 0.74 | 0.11 | | | 9/11-9/12 comp |
| Sept. 89 | Kent-dup | 19 | 1.9 | 1.06 | 0.84 | 0.1 | | 10.3 | 9/11-9/12 comp |
| Sept. 89 | FC WWTP | 10 | 1.6 | 0.53 | 1.07 | 0.53 | | 13.87 | 9/11-9/12 comp |
| Sept. 89 | FC-dup | 18 | 1.5 | 0.52 | 0.98 | 0.52 | | 15.78 | 9/11-9/12 comp |
| Sept. 89 | Fish Ck. | 4.6 | 0.7 | 0.08 | 0.62 | 0.04 | | 1.38 | 9/11-9/12 comp |
| Sept. 89 | 53.9 | 3.4 | 0.6 | 0.07 | 0.53 | 0.05 | | 1.49 | 9/12-9/13 comp |
| Sept. 89 | 53.44 | 4.2 | 0.7 | 0.15 | 0.55 | 0.08 | | 2.01 | 9/12-9/13 comp |
| Sept. 89 | 52.8 | 5.6 | 0.7 | 0.1 | 0.6 | 0.11 | | 1.6 | 9/12-9/13 comp |
| Sept. 89 | 52.2 | 6.8 | 0.7 | 0.09 | 0.61 | 0.12 | | 1.31 | 9/12-9/13 comp |
| Sept. 89 | 51.5 | 19 | 0.7 | 0.05 | 0.65 | 0.12 | | 1 | 9/12-9/13 comp |
| Sept. 89 | 51.28 | 7.7 | 0.6 | 0.05 | 0.55 | 0.13 | | 2.37 | 9/12-9/13 comp |
| Sept. 89 | 50.7 | 7.1 | 0.7 | 0.05 | 0.65 | 0.17 | | 1.74 | 9/12-9/13 comp |
| Sept. 89 | 50 | 11 | 0.7 | 0.05 | 0.65 | 0.18 | | 1.27 | 9/12-9/13 comp |
| Sept. 89 | Kent STP | 20 | 2.45 | 1.67 | 0.78 | 0.13 | | 12.07 | 9/12-9/13 comp |
| Sept. 89 | Kent-dup | 21 | 2.6 | 1.62 | 0.98 | 0.14 | | 12.56 | 9/12-9/13 comp |
| Sept. 89 | FC WWTP | 28 | 1.8 | 0.63 | 1.17 | 0.3 | | 17.3 | 9/12-9/13 comp |
| Sept. 89 | FC-dup | 23 | 2.3 | 0.76 | 1.54 | 0.4 | | 17.2 | 9/12-9/13 comp |
| Sept. 89 | Fish Ck. | 4.9 | 0.3 | 0.12 | 0.18 | 0.06 | | 0.45 | 9/12-9/13 comp |

**Table 12. Forcing Function Inputs for the Middle Cuyahoga River Calibration Runs**

| Source | Reach | Flow cfs | Temp °F | DO mg/l | CBOD mg/l | Org-N mg/l | $NH_3$-N mg/l | Nitrite mg/l | Nitrate mg/l |
|---|---|---|---|---|---|---|---|---|---|
| Lake Rockwell | 1 | 0.5 | 74.12 | 7 | 5.5 | 0.54 | 0.26 | 0.09 | 0.01 |
| Twin Lakes Outlet | 1 | 4.1 | 74.9 | 7 | 6.7 | 1.28 | 0.42 | 0.04 | 0.23 |
| Akron WTP | 2 | 0.5 | 70 | 5.7 | 8.2 | 0.5 | 0.29 | 0.02 | 1 |
| Breakneck Ck | 3 | 97.5 | 70.3 | 6.36 | 6.4 | 0.83 | 0.07 | 0.02 | 1.26 |
| Oak Knolls | 4 | -0.1 | 70.3 | 6.36 | 4.03 | 0.66 | 0.07 | 0.03 | 1.07 |
| Inc. Inflow | 1 | 0.9 | 73.5 | 6 | 8 | 0.54 | 0.26 | 0.09 | 0.01 |
| Inc. Inflow | 2 | 0.8 | 72.34 | 6 | 8 | 0.54 | 0.26 | 0.09 | 0.01 |
| Inc. Inflow | 3 | 1.1 | 71.17 | 6 | 8 | 0.54 | 0.26 | 0.09 | 0.01 |
| Inc. Inflow | 4 | 0.6 | 70.66 | 6 | 8 | 0.54 | 0.26 | 0.09 | 0.01 |
| Inc. Inflow | 5 | 0.4 | 70.89 | 6 | 8 | 0.54 | 0.26 | 0.09 | 0.01 |
| Inc. Inflow | 6 | 0.3 | 70.95 | 6 | 8 | 0.54 | 0.26 | 0.09 | 0.01 |
| Inc. Inflow | 7 | 0.6 | 70.83 | 6 | 8 | 0.54 | 0.26 | 0.09 | 0.01 |
| Upstream Kent | 1 | 36.8 | 76.8 | 7 | 5.27 | 0.42 | 0.03 | 0.02 | 1.16 |
| Kent WWTP | 1 | 3.9 | 73.4 | 8.4 | 4.9 | 0.67 | 0.08 | 0.04 | 16.03 |
| Plum Ck | 2 | 4.2 | 72.3 | 7.13 | 6.5 | 0.28 | 0.09 | 0.96 | 1.59 |
| Fish Ck | 3 | 3.42 | 72.3 | 7.13 | 4.5 | 0.1 | 0.05 | 0.02 | 0.22 |
| Fishcreek WWTP | 4 | 6.16 | 66.2 | 7.7 | 12 | 1.41 | 0.42 | 1.36 | 17.92 |
| Cuyahoga Falls | 5 | -5 | 72.3 | 7.39 | 5.27 | 0.67 | 0.08 | 0.04 | 1.16 |
| Cuyahoga Falls | 6 | 0.23 | 72.3 | 7.39 | 5.27 | 0.67 | 0.08 | 0.04 | 1.16 |
| Inc. Inflow | 1 | 0.85 | 74.66 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 2 | 0.85 | 74.4 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 3 | 0.57 | 74.12 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 4 | 0.29 | 74.12 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 5 | 0.71 | 73.54 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 6 | 0.57 | 71.6 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 7 | 0.43 | 72.7 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 8 | 0.57 | 70.9 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 9 | 0.57 | 72.3 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 10 | 0.57 | 72.9 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |
| Inc. Inflow | 11 | 2.29 | 76.1 | 6 | 8 | 0.42 | 0.03 | 0.02 | 1.16 |

**Table 13a. Summary of Calibration Reaction Rates for the Upper Middle Cuyahoga River[1]**

| Reach | Element | DO Sat | $K_2$ | $K_1$ | $K_4$ | $\hat{a}_3$ | $\hat{a}_1$ | $\hat{a}_2$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 8.57 | 0.71 | 0.46 | 0.24 | 0.35 | 1.28 | 1.73 |
| 1 | 2 | 8.57 | 0.71 | 0.46 | 0.24 | 0.35 | 1.28 | 1.73 |
| 1 | 3 | 8.57 | 0.71 | 0.46 | 0.24 | 0.35 | 1.28 | 1.73 |
| 1 | 4 | 8.57 | 0.71 | 0.46 | 0.24 | 0.35 | 1.28 | 1.73 |
| 2 | 1 | 8.67 | 0.68 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 2 | 2 | 8.67 | 0.66 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 2 | 3 | 8.67 | 0.66 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 2 | 4 | 8.67 | 0.66 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 2 | 5 | 8.67 | 0.66 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 2 | 6 | 8.67 | 0.66 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 2 | 7 | 8.67 | 0.66 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 2 | 8 | 8.67 | 0.66 | 0.43 | 0.35 | 0.34 | 1.21 | 1.68 |
| 3 | 1 | 8.78 | 1.11 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 2 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 3 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 4 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 5 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 6 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 7 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 8 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 9 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 3 | 10 | 8.78 | 1.56 | 0.42 | 0.34 | 0.33 | 1.15 | 1.63 |
| 4 | 1 | 8.83 | 1.4 | 0.42 | 0.33 | 0.32 | 1.13 | 1.61 |
| 4 | 2 | 8.83 | 1.24 | 0.42 | 0.33 | 0.32 | 1.13 | 1.61 |
| 4 | 3 | 8.83 | 1.24 | 0.42 | 0.33 | 0.32 | 1.13 | 1.61 |
| 4 | 4 | 8.83 | 1.24 | 0.42 | 0.33 | 0.32 | 1.13 | 1.61 |
| 4 | 5 | 8.83 | 1.24 | 0.42 | 0.33 | 0.32 | 1.13 | 1.61 |
| 4 | 6 | 8.83 | 1.24 | 0.42 | 0.33 | 0.32 | 1.13 | 1.61 |
| 5 | 1 | 8.81 | 1.14 | 0.39 | 0.33 | 0.32 | 1.14 | 1.61 |
| 5 | 2 | 8.81 | 1.04 | 0.39 | 0.33 | 0.32 | 1.14 | 1.61 |
| 5 | 3 | 8.81 | 1.04 | 0.39 | 0.33 | 0.32 | 1.14 | 1.61 |
| 5 | 4 | 8.81 | 1.04 | 0.39 | 0.33 | 0.32 | 1.14 | 1.61 |
| 6 | 1 | 8.8 | 4.05 | 0.48 | 0.11 | 0.32 | 1.14 | 1.62 |
| 6 | 2 | 8.8 | 7.07 | 0.48 | 0.11 | 0.32 | 1.14 | 1.62 |
| 6 | 3 | 8.8 | 7.07 | 0.48 | 0.11 | 0.32 | 1.14 | 1.62 |
| 7 | 1 | 8.82 | 4.1 | 0.39 | 0.17 | 0.32 | 1.13 | 1.61 |
| 7 | 2 | 8.82 | 1.14 | 0.39 | 0.17 | 0.32 | 1.13 | 1.61 |
| 7 | 3 | 8.82 | 1.14 | 0.39 | 0.17 | 0.32 | 1.13 | 1.61 |
| 7 | 4 | 8.82 | 1.14 | 0.39 | 0.17 | 0.32 | 1.13 | 1.61 |
| 7 | 5 | 8.82 | 1.14 | 0.39 | 0.17 | 0.32 | 1.13 | 1.61 |
| 7 | 6 | 8.82 | 1.14 | 0.39 | 0.17 | 0.32 | 1.13 | 1.61 |

[1] All coefficients are listed at the standard temperature of 20°C.

**Table 13b. Summary of Calibration Reaction Rates for the Lower Middle Cuyahoga River[1]**

| Reach | Element | DO Sat | $K_2$ | $K_1$ | $K_4$ | $\hat{a}_3$ | $\hat{a}_1$ | $\hat{a}_2$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 8.47 | 1.75 | 0.41 | 0.19 | 0.36 | 1.34 | 1.78 |
| 1 | 2 | 8.47 | 1.75 | 0.41 | 0.19 | 0.36 | 1.34 | 1.78 |
| 1 | 3 | 8.47 | 1.75 | 0.41 | 0.19 | 0.36 | 1.34 | 1.78 |
| 1 | 4 | 8.47 | 1.75 | 0.41 | 0.19 | 0.36 | 1.34 | 1.78 |
| 1 | 5 | 8.47 | 1.75 | 0.41 | 0.19 | 0.36 | 1.34 | 1.78 |
| 1 | 6 | 8.47 | 1.75 | 0.41 | 0.19 | 0.36 | 1.34 | 1.78 |
| 2 | 1 | 8.49 | 1.31 | 0.35 | 0.13 | 0.35 | 1.33 | 1.77 |
| 2 | 2 | 8.49 | 0.87 | 0.35 | 0.13 | 0.35 | 1.33 | 1.77 |
| 2 | 3 | 8.49 | 0.87 | 0.35 | 0.13 | 0.35 | 1.33 | 1.77 |
| 2 | 4 | 8.49 | 0.87 | 0.35 | 0.13 | 0.35 | 1.33 | 1.77 |
| 2 | 5 | 8.49 | 0.87 | 0.35 | 0.13 | 0.35 | 1.33 | 1.77 |
| 2 | 6 | 8.49 | 0.87 | 0.35 | 0.13 | 0.35 | 1.33 | 1.77 |
| 3 | 1 | 8.51 | 1.03 | 0.35 | 0.12 | 0.35 | 1.31 | 1.75 |
| 3 | 2 | 8.51 | 1.19 | 0.35 | 0.12 | 0.35 | 1.31 | 1.75 |
| 3 | 3 | 8.51 | 1.19 | 0.35 | 0.12 | 0.35 | 1.31 | 1.75 |
| 3 | 4 | 8.51 | 1.19 | 0.35 | 0.12 | 0.35 | 1.31 | 1.75 |
| 4 | 1 | 8.51 | 0.92 | 0.34 | 0.12 | 0.35 | 1.31 | 1.75 |
| 4 | 2 | 8.51 | 0.65 | 0.34 | 0.12 | 0.35 | 1.31 | 1.75 |
| 5 | 1 | 8.57 | 0.7 | 0.29 | 0.12 | 0.35 | 1.28 | 1.73 |
| 5 | 2 | 8.57 | 0.75 | 0.29 | 0.12 | 0.35 | 1.28 | 1.73 |
| 5 | 3 | 8.57 | 0.75 | 0.29 | 0.12 | 0.35 | 1.28 | 1.73 |
| 5 | 4 | 8.57 | 0.75 | 0.29 | 0.12 | 0.35 | 1.28 | 1.73 |
| 5 | 5 | 8.57 | 0.75 | 0.29 | 0.12 | 0.35 | 1.28 | 1.73 |
| 6 | 1 | 8.74 | 1.11 | 0.22 | 0.11 | 0.33 | 1.17 | 1.64 |
| 6 | 2 | 8.74 | 1.49 | 0.22 | 0.11 | 0.33 | 1.17 | 1.64 |
| 6 | 3 | 8.74 | 1.49 | 0.22 | 0.11 | 0.33 | 1.17 | 1.64 |
| 6 | 4 | 8.74 | 1.49 | 0.22 | 0.11 | 0.33 | 1.17 | 1.64 |
| 7 | 1 | 8.64 | 1.55 | 0.23 | 0.12 | 0.34 | 1.23 | 1.69 |
| 7 | 2 | 8.64 | 1.6 | 0.23 | 0.12 | 0.34 | 1.23 | 1.69 |
| 7 | 3 | 8.64 | 1.6 | 0.23 | 0.12 | 0.34 | 1.23 | 1.69 |
| 8 | 1 | 8.81 | 1.72 | 0.22 | 0.11 | 0.32 | 1.14 | 1.62 |
| 8 | 2 | 8.81 | 1.89 | 0.22 | 0.11 | 0.32 | 1.14 | 1.62 |
| 8 | 3 | 8.81 | 1.89 | 0.22 | 0.11 | 0.32 | 1.14 | 1.62 |
| 8 | 4 | 8.81 | 1.89 | 0.22 | 0.11 | 0.32 | 1.14 | 1.62 |
| 9 | 1 | 8.68 | 1.76 | 0.22 | 0.12 | 0.33 | 1.21 | 1.67 |
| 9 | 2 | 8.68 | 1.59 | 0.22 | 0.12 | 0.33 | 1.21 | 1.67 |
| 9 | 3 | 8.68 | 1.59 | 0.22 | 0.12 | 0.33 | 1.21 | 1.67 |
| 9 | 4 | 8.68 | 1.59 | 0.22 | 0.12 | 0.33 | 1.21 | 1.67 |
| 10 | 1 | 8.62 | 1.92 | 0.25 | 0.12 | 0.34 | 1.24 | 1.7 |
| 10 | 2 | 8.62 | 2.24 | 0.25 | 0.12 | 0.34 | 1.24 | 1.7 |
| 10 | 3 | 8.62 | 2.24 | 0.25 | 0.12 | 0.34 | 1.24 | 1.7 |
| 10 | 4 | 8.62 | 2.24 | 0.25 | 0.12 | 0.34 | 1.24 | 1.7 |
| 11 | 1 | 8.34 | 2.61 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 2 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 3 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 4 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 5 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 6 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 7 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 8 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 9 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 10 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 11 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 12 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 13 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 14 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 15 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 16 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |
| 11 | 17 | 8.34 | 2.89 | 0.32 | 0.13 | 0.37 | 1.43 | 1.84 |

[1] All coefficients are listed at the standard temperature of 20°C.

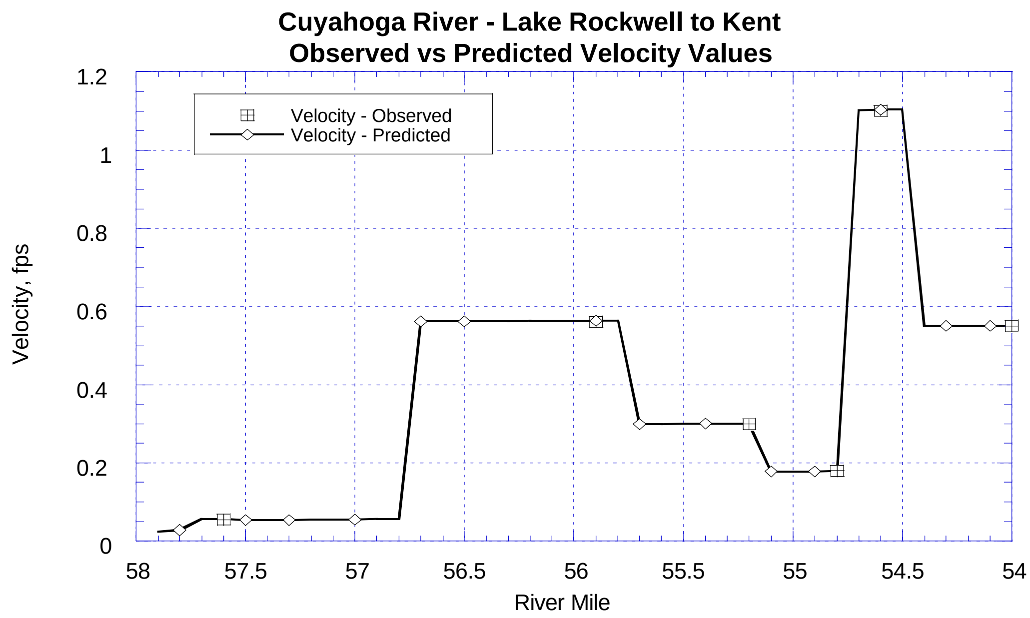
## Table 14.  Summary of Field Data Collected on Breakneck Creek

| Site Description | River Mile | Type of Site | Area ft2 | Width ft | Depth ft | Velocity ft/s | Flow ft3/s | Water Sample | Year | Sedi-ment |
|---|---|---|---|---|---|---|---|---|---|---|
| US Ravenna WWTP | 1.17 | Flow | 0.5375 | 3.1 | 0.17 | 0.617 | 0.332 | Yes | 1989 | Gravel |
| DS Ravenna WWTP | 0.8 | Both | 13.08 | 10.9 | 1.2 | 0.256 | 3.346 | Yes | 1989 | Deep mud |
| Hommon Ave Ditch | 0.4 | XS | 15.16 | 9 | 1.68 | | *3.346* | Yes | 1989 | |
| Hommon Ave Ditch | 0.4 | XS | 5.78 | 8.4 | 0.69 | | *4.13* | | 1984 | |
| Hommon Ave Ditch | 0.01 | XS | 22 | 13.8 | 1.59 | | *3.346* | Yes | 1989 | |
| Hommon Ave Ditch | 0.01 | XS | 10.29 | 10 | 1.03 | | 4.13 | | 1984 | |
| | | | | | | | | | | |
| Wahoo Ditch | 0.51 | Flow | 12.88 | 9.6 | 1.34 | 0.106 | 1.37 | Yes | 1989 | |
| Wahoo Ditch | 0.1 | XS | 29.7 | 18.5 | 1.6 | | *5.135* | Yes | 1989 | |
| Wahoo Ditch | 0.1 | Flow | 6.8 | 16.4 | 0.42 | 0.751 | 5.135 | | 1989 | Rock/Muck |
| Wahoo Ditch | 0.1 | XS | 21.36 | 12.3 | 1.74 | | 4.57 | | 1984 | |
| | | | | | | | | | | |
| Breakneck | 5.15 | Flow | 15.8 | 21.7 | 0.728 | 0.756 | 11.94 | Yes | 1989 | Rock/Gravel |
| Breakneck | 5.13 | XS | 42.6 | 30.2 | 1.41 | | *11.94* | | 1989 | |
| Breakneck | 3.9 | Flow | 14.88 | 24 | 0.62 | 1.174 | 17.47 | Yes | 1989 | Rock/Gravel |
| Breakneck | 3.9 | XS | 41.07 | 26.45 | 1.55 | | *17.47* | | 1989 | |
| Breakneck | 3.08 | Flow | 27.115 | 37.5 | 0.723 | 0.691 | 18.734 | Yes | 1989 | Sand |
| Breakneck | 3.08 | XS | 40.42 | 32 | 1.26 | | 16.41 | | 1984 | |
| Breakneck | 3.08 | XS | 26.36 | 34.2 | 0.77 | | *18.734* | | 1989 | |
| Breakneck | 1.7 | Flow | 47.302 | 32 | 1.478 | 0.3395 | 16.06 | | 1989 | Sand/Clay |
| Breakneck | 1.63 | XS | 49 | 31.9 | 1.54 | | *16.06* | Yes | 1989 | |

# APPENDIX B

## CALIBRATION AND VERIFICATION GRAPHS FOR THE DISSOLVED OXYGEN MODEL OF THE MIDDLE CUYAHOGA RIVER

**Graph B.1** Velocity and Depth Calibrations for the Upper Middle Cuyahoga River



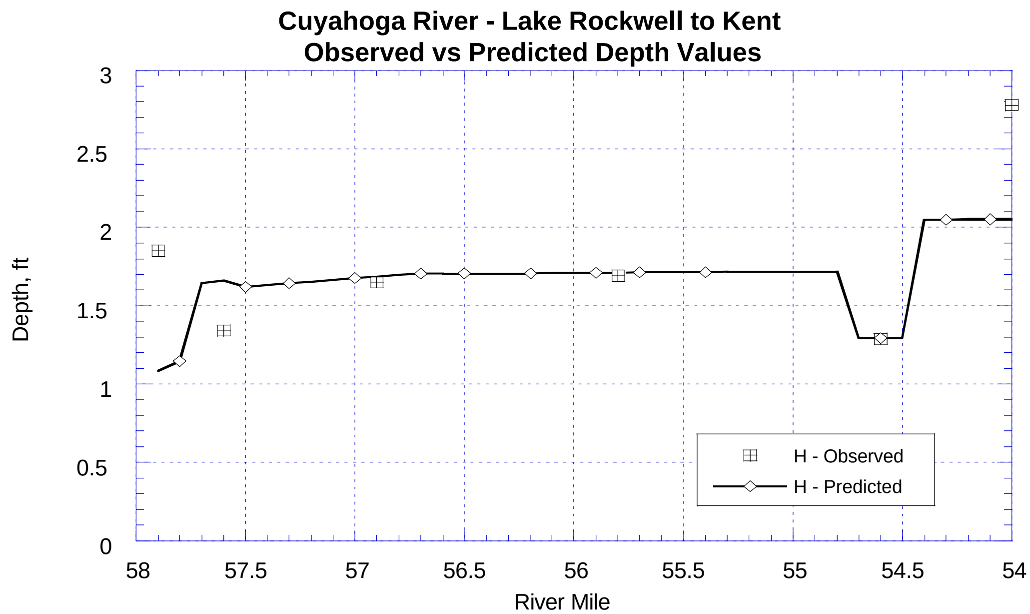
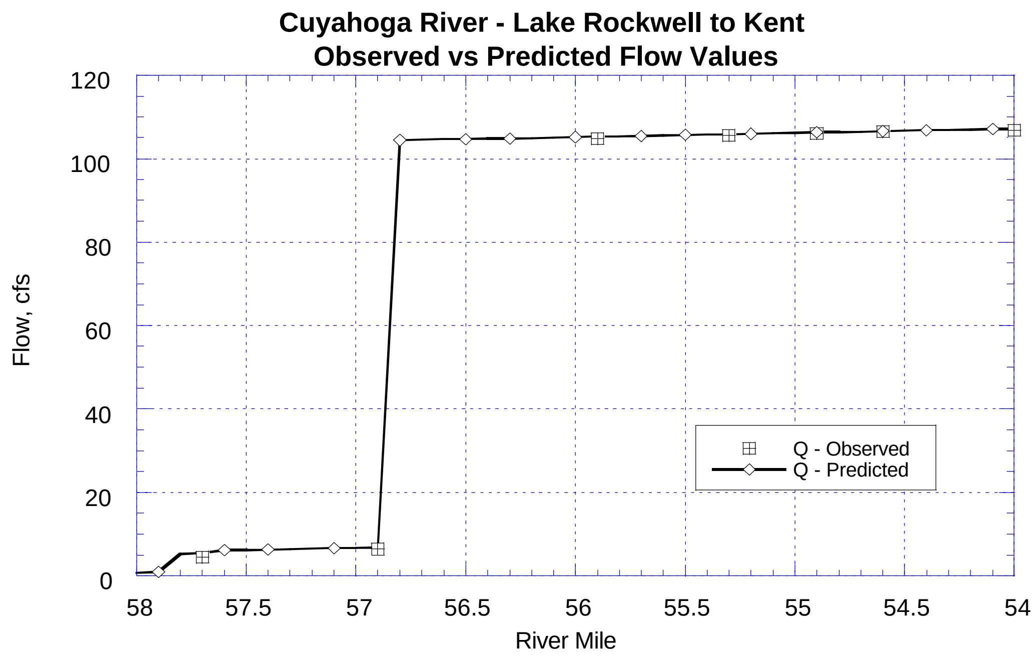



**Figure 3** Flow and Width Calibrations for the Upper Middle Cuyahoga River



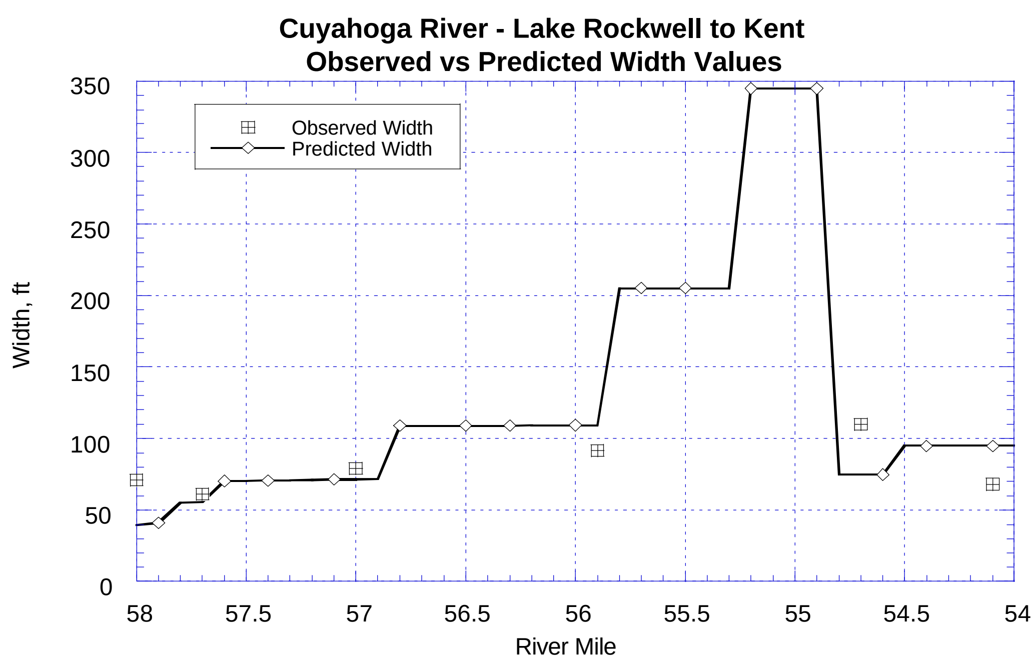
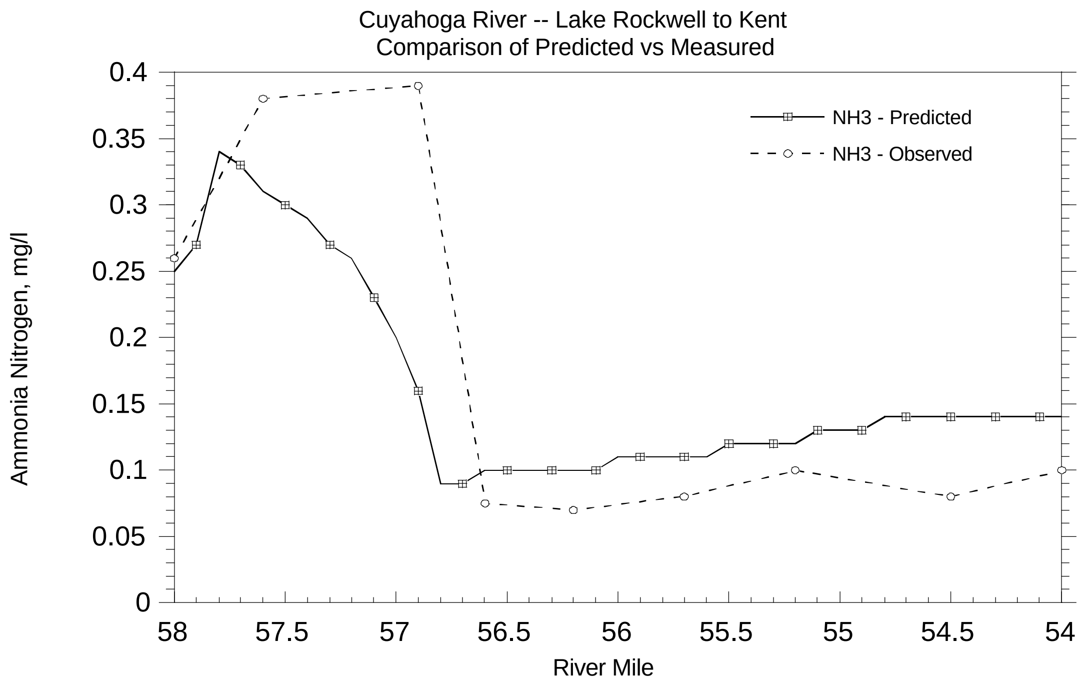



**Figure 4** Ammonia and Organic Nitrogen Calibration for the Upper Middle Cuyahoga



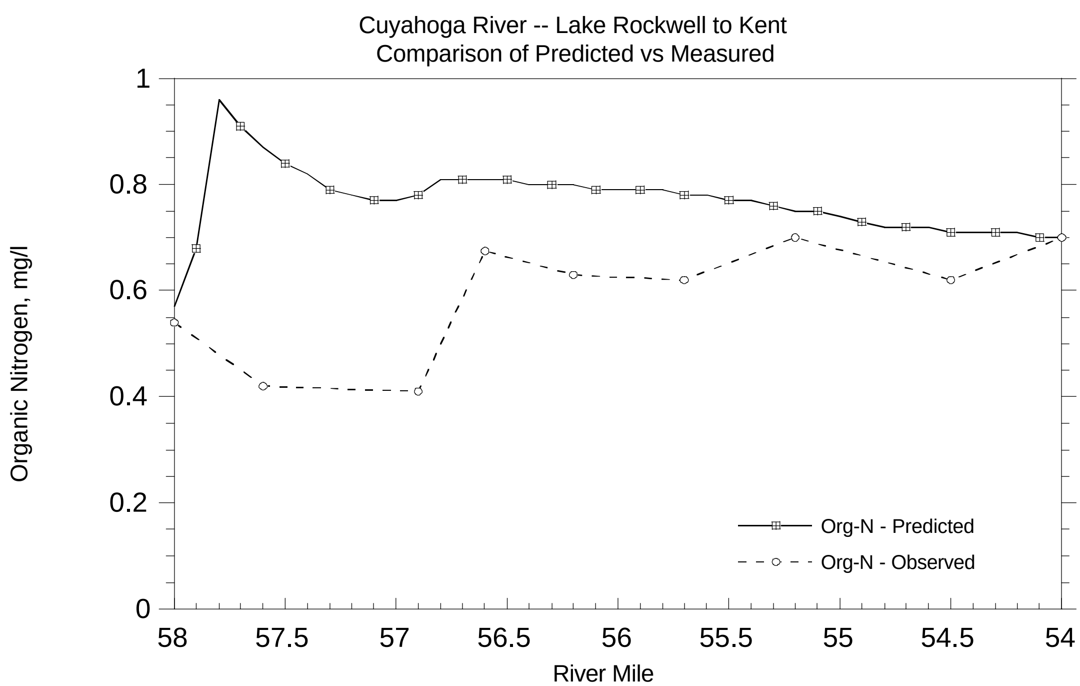
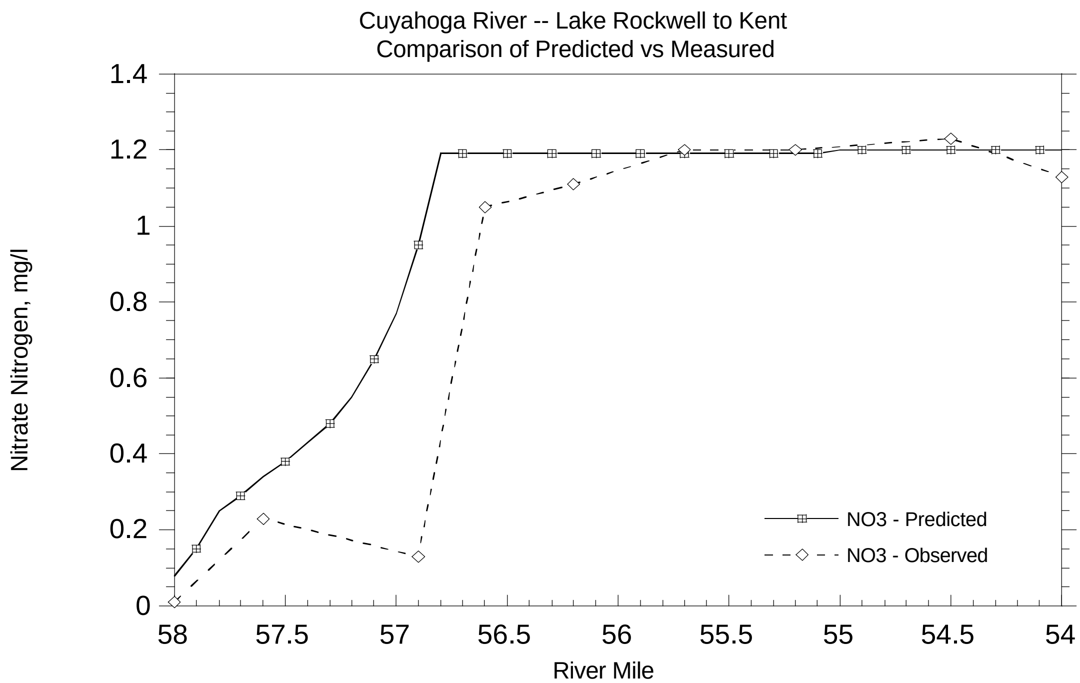



**Figure 5** Nitrate and Nitrite Nitrogen Calibrations for the Upper Middle Cuyahoga



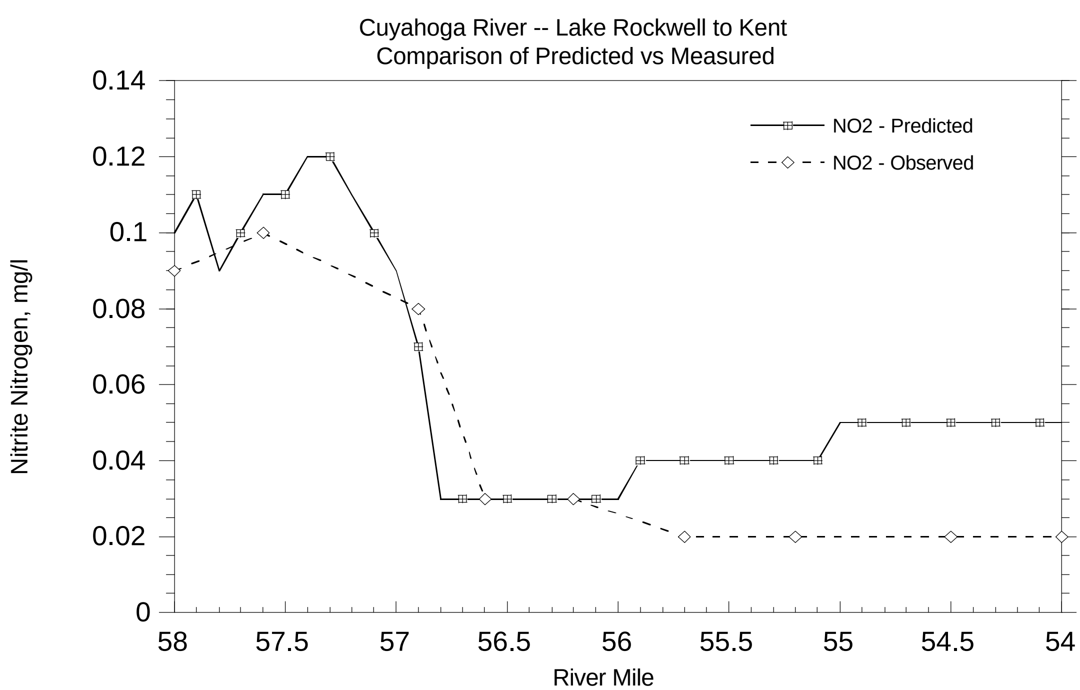



**Figure 6** Carbonaceous BOD Calibration for the Upper Middle Cuyahoga River

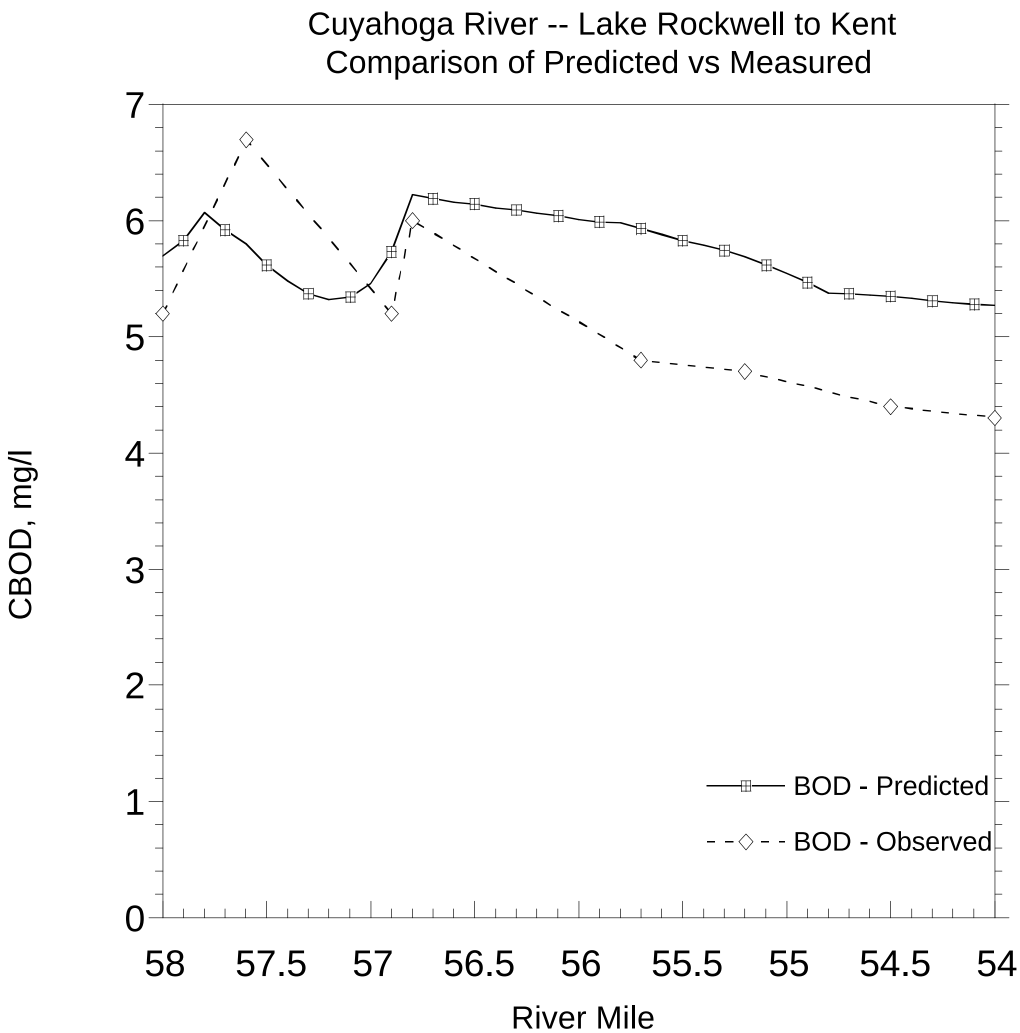


**Figure 7** Dissolved Oxygen Calibration for the Upper Middle Cuyahoga River

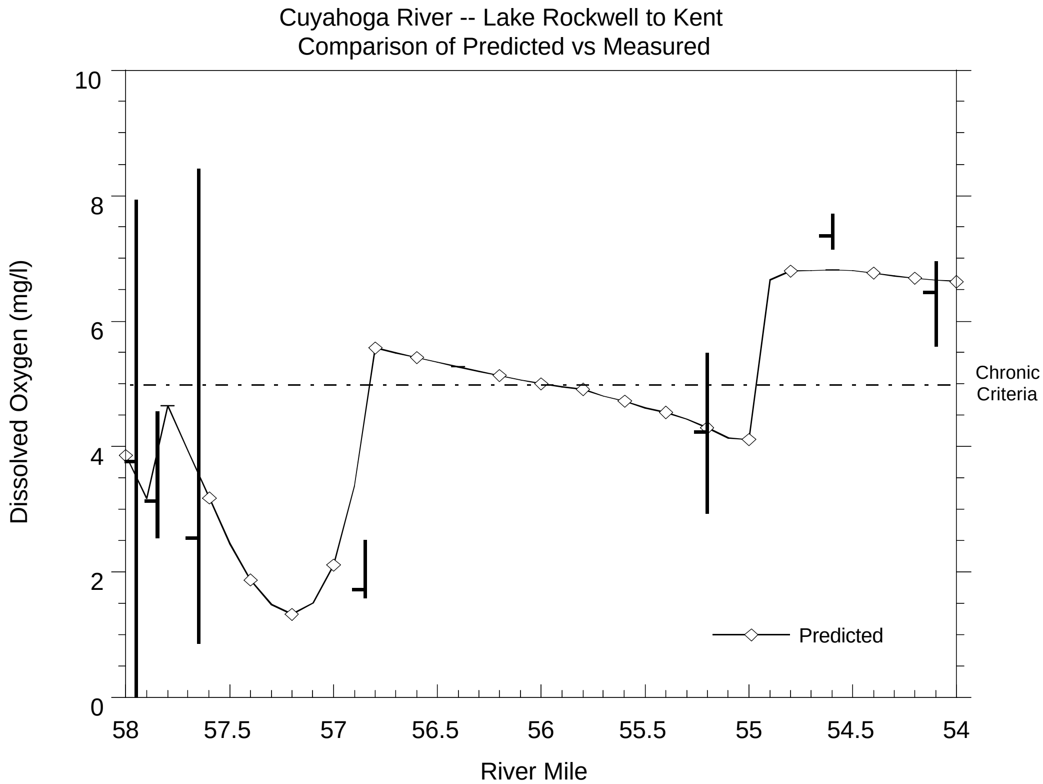
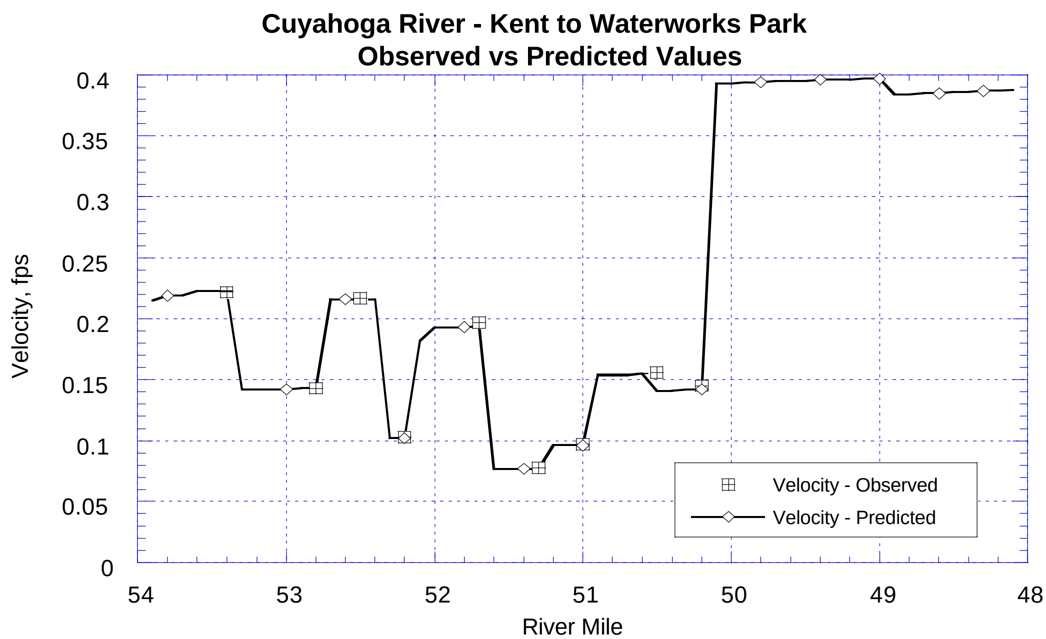


**Figure 8** Velocity and Depth Calibrations for the Lower Middle Cuyahoga River



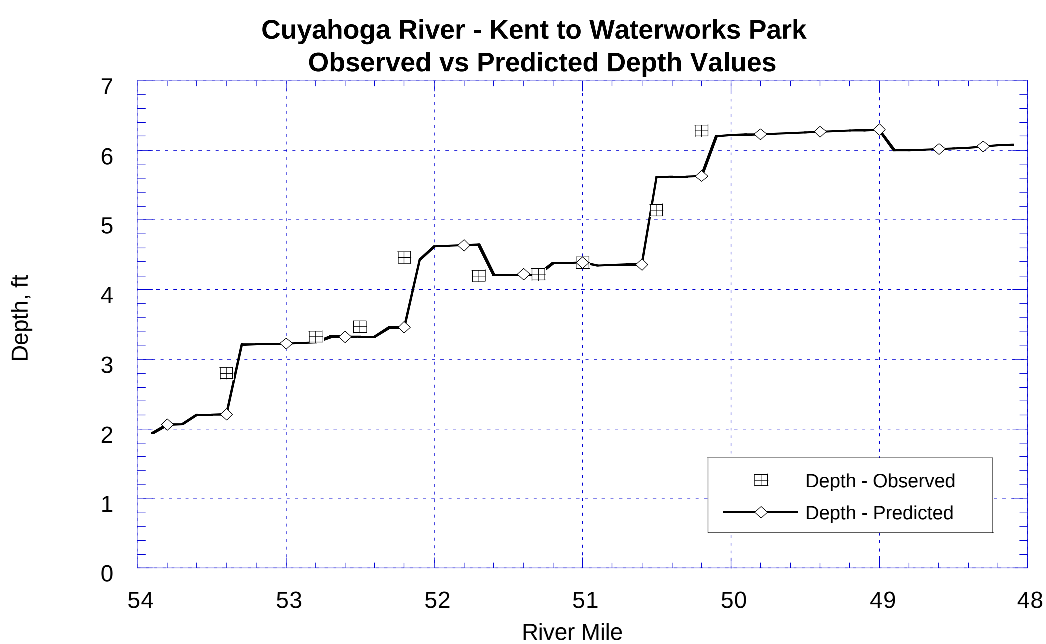
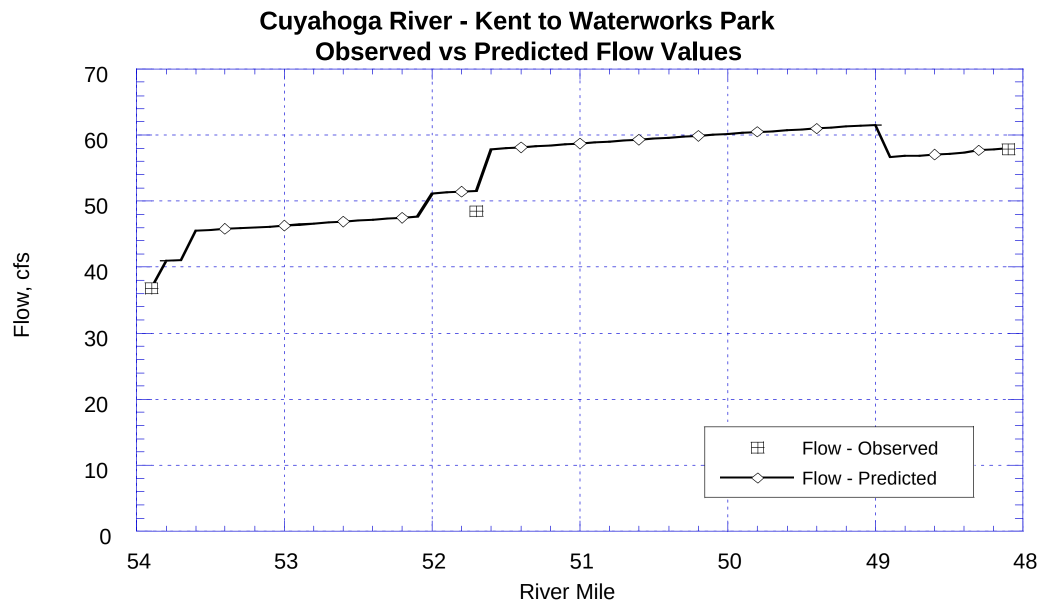



**Figure 9** Flow and Width Calibrations for the Lower Middle Cuyahoga River



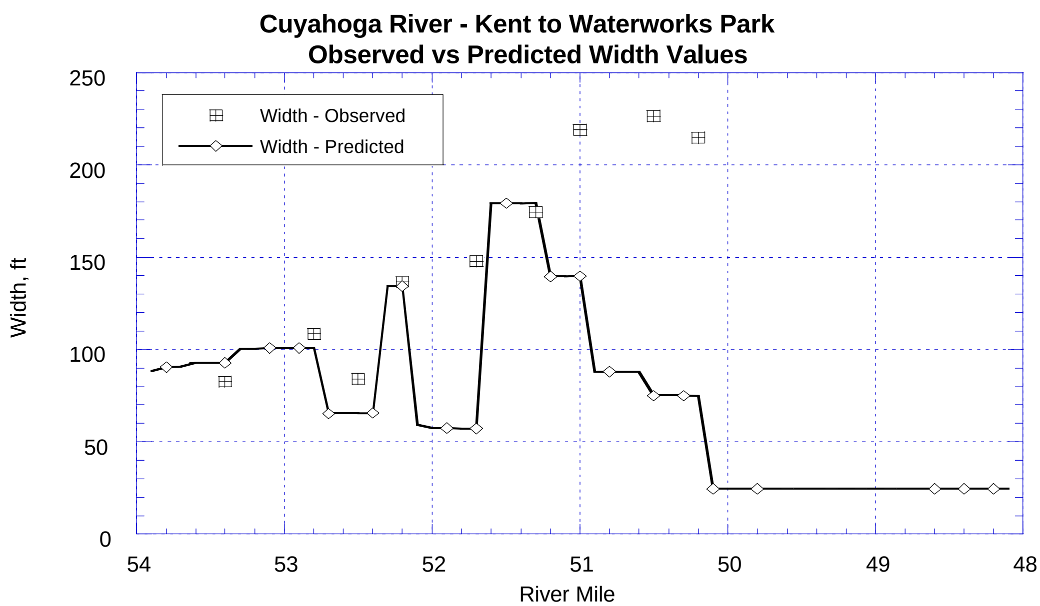



**Figure 10** Ammonia Nitrogen Calibration for the Lower Middle Cuyahoga River

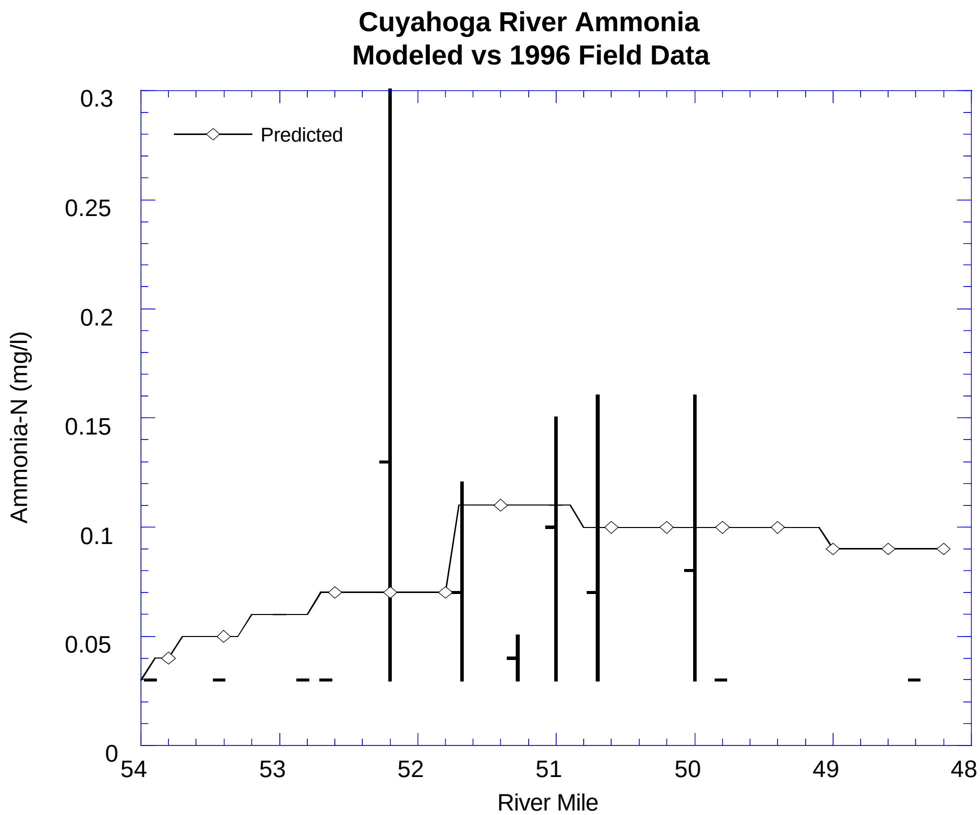


**Figure 11** Nitrite Nitrogen Calibration for the Lower Middle Cuyahoga River

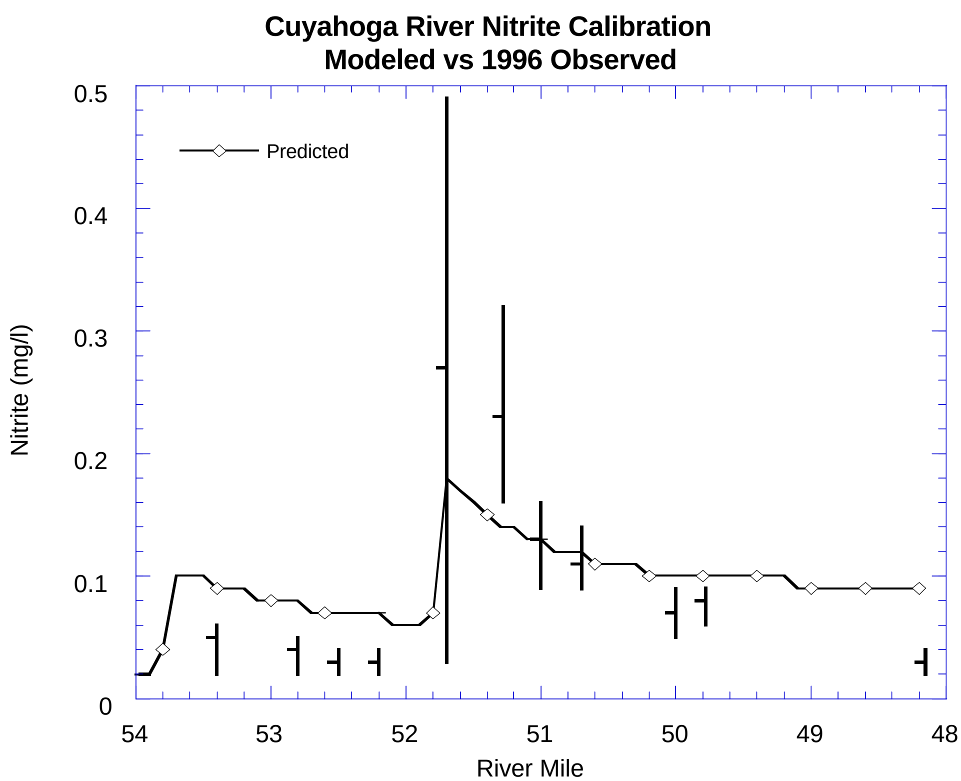


**Figure 12** Nitrate Nitrogen Calibration for the Lower Middle Cuyahoga River

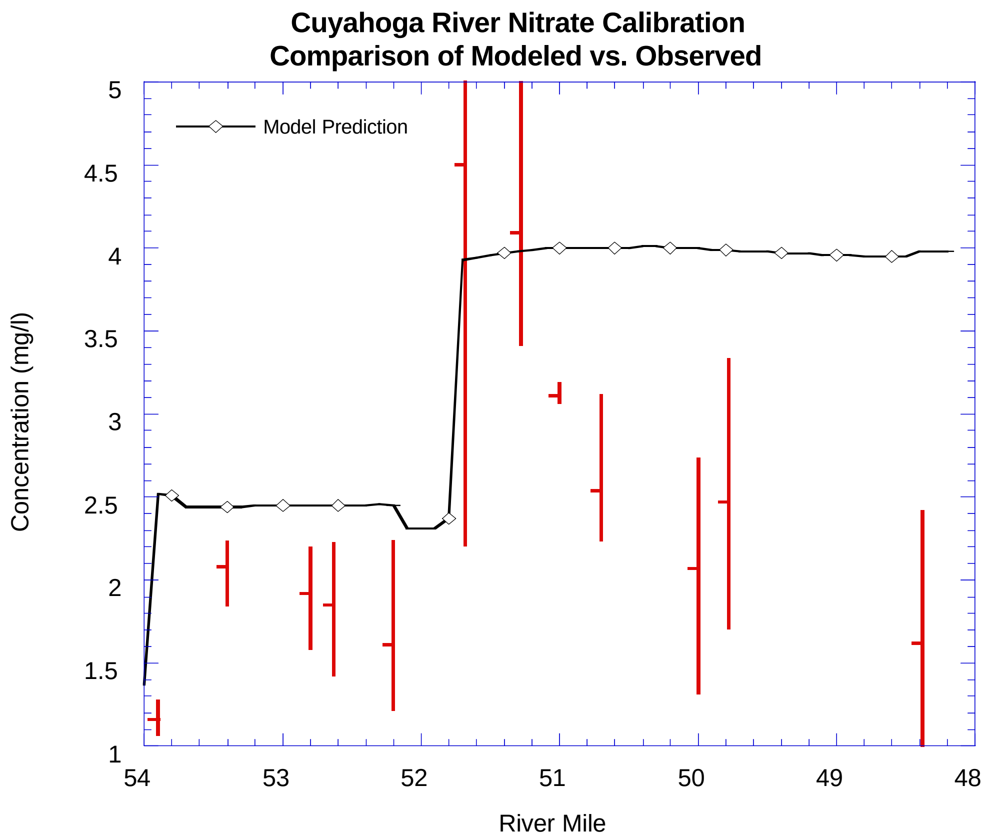


**Figure 13** Carbonaceous BOD Calibration for the Lower Middle Cuyahoga River

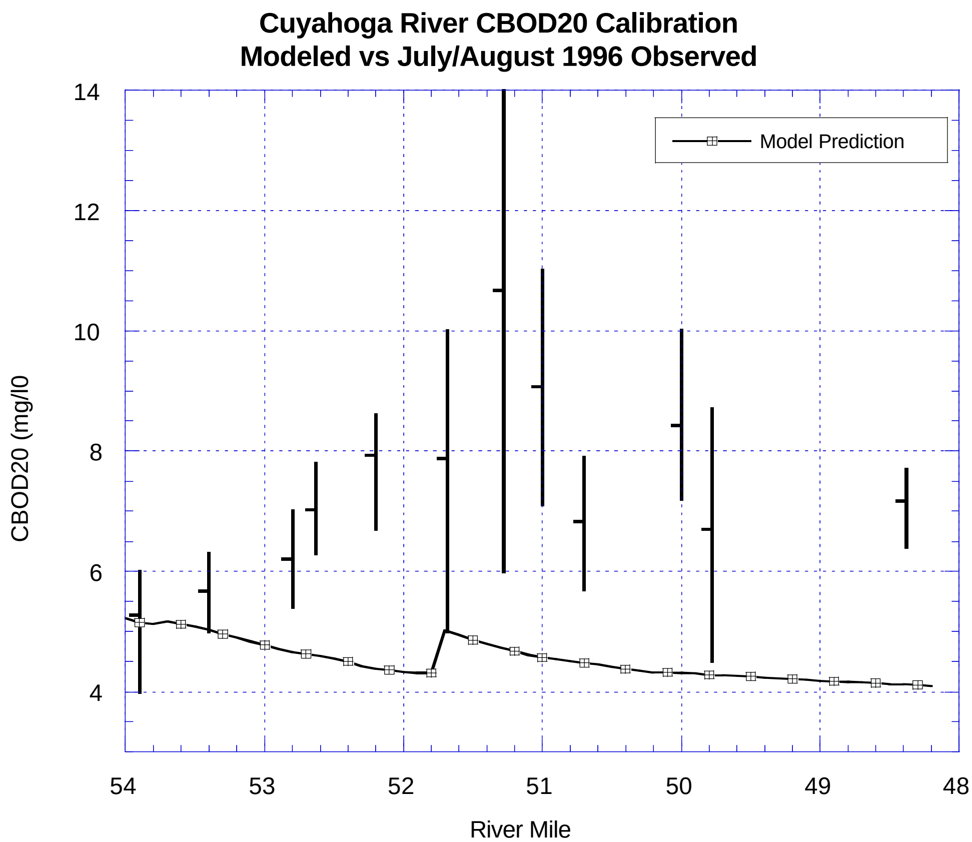


**Figure 14** Dissolved Oxygen Calibration for the Lower Middle Cuyahoga River

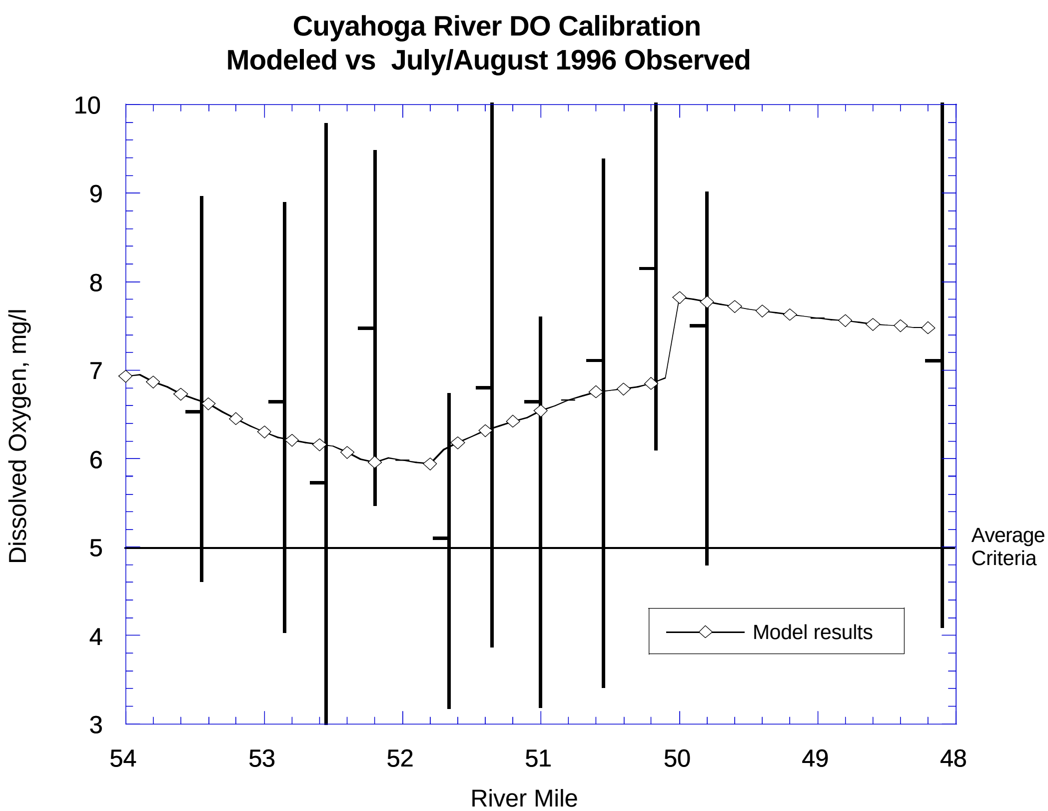


**Figure 15** Dissolved Oxygen Verification of the Lower Middle Cuyahoga River

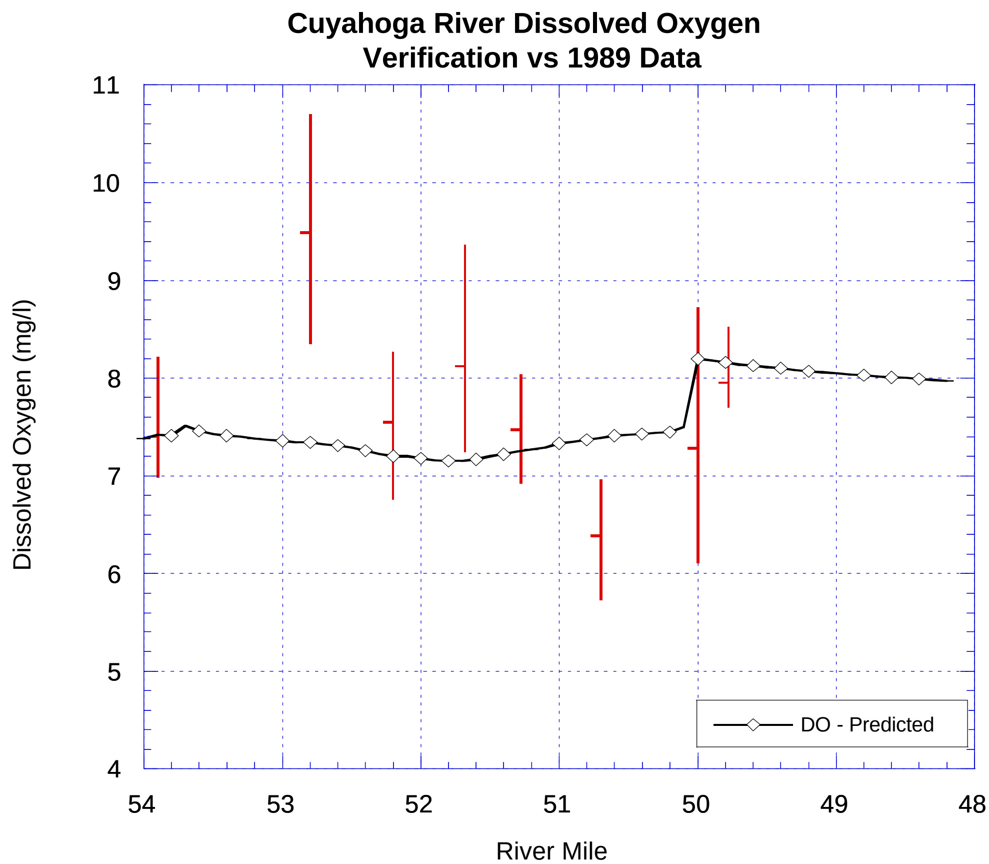


**Figure 16** Nitrification Coefficients Determination for the Lower Middle Cuyahoga River

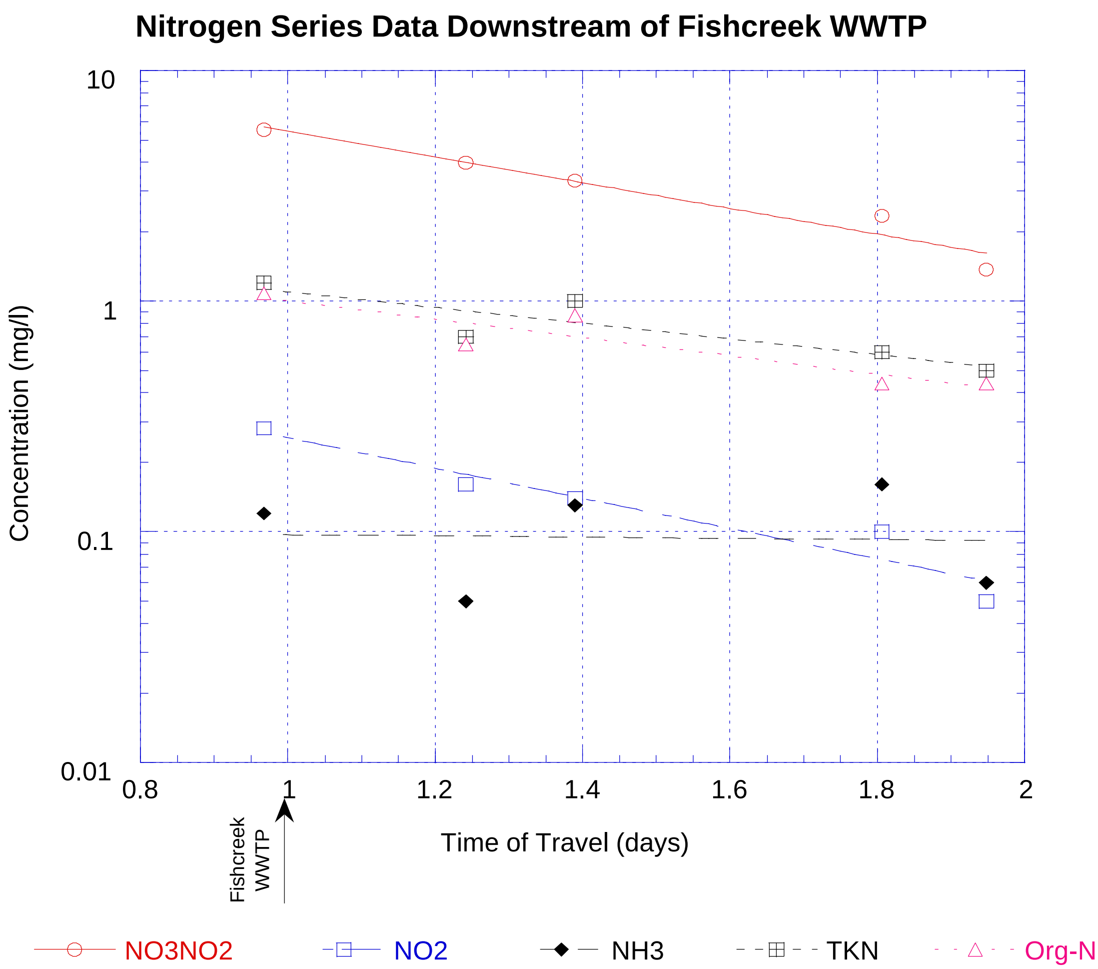
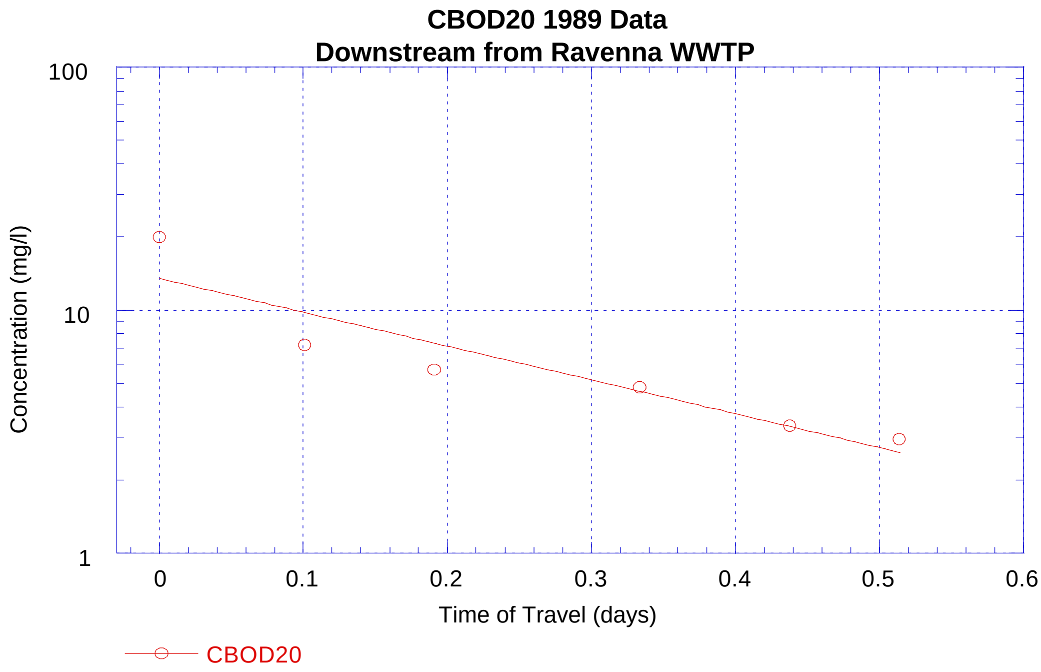


**Figure 17** Nitrification and CBOD Coefficient Determination for Breakneck Creek



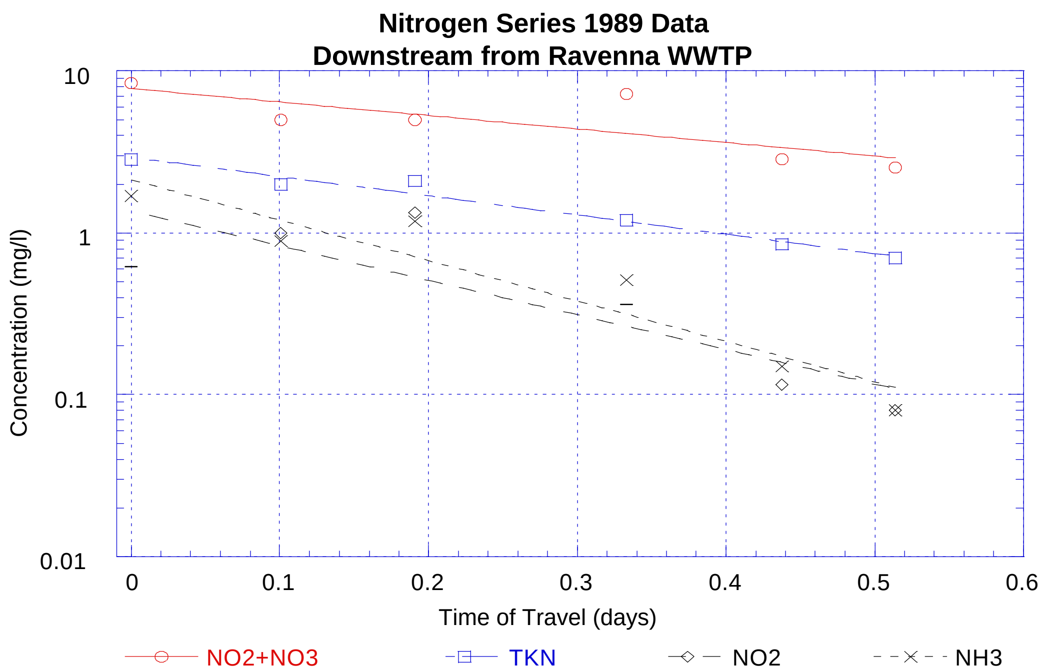
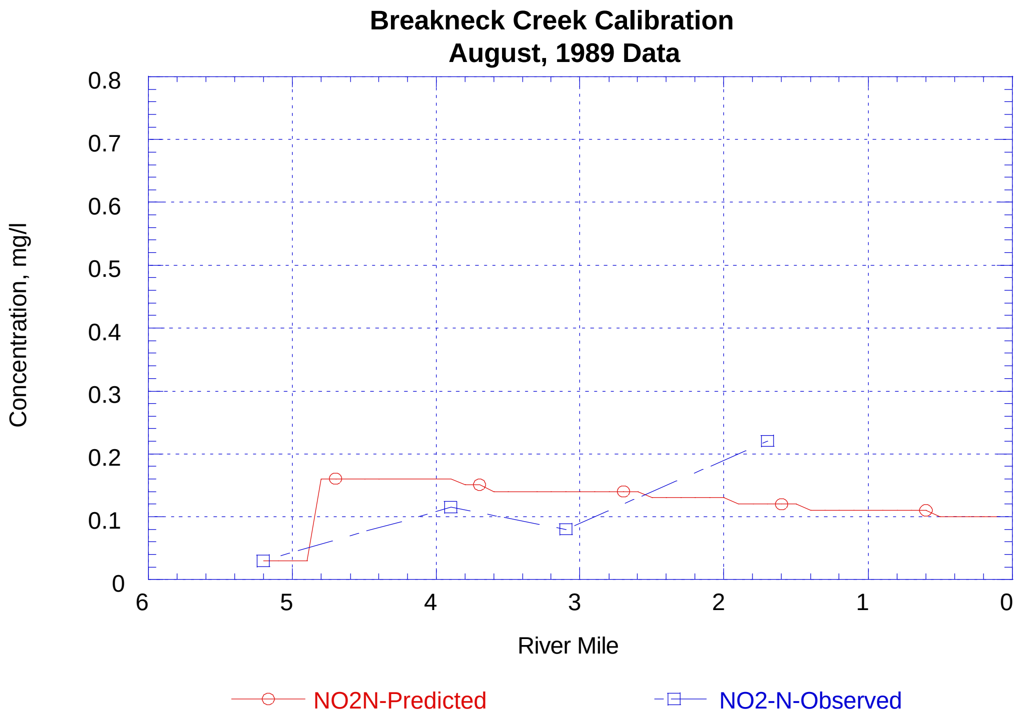



**Figure 18** Nitrite and Ammonia Nitrogen Calibrations for Breakneck Creek



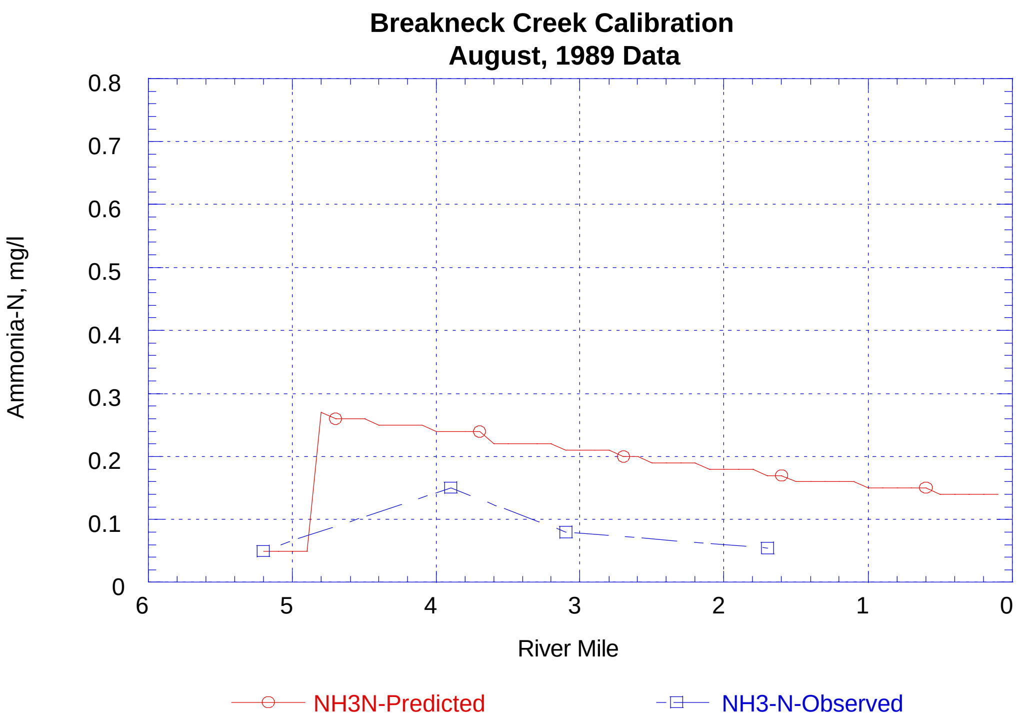



**Figure 19** Carbonaceous BOD Calibration for Breakneck Creek

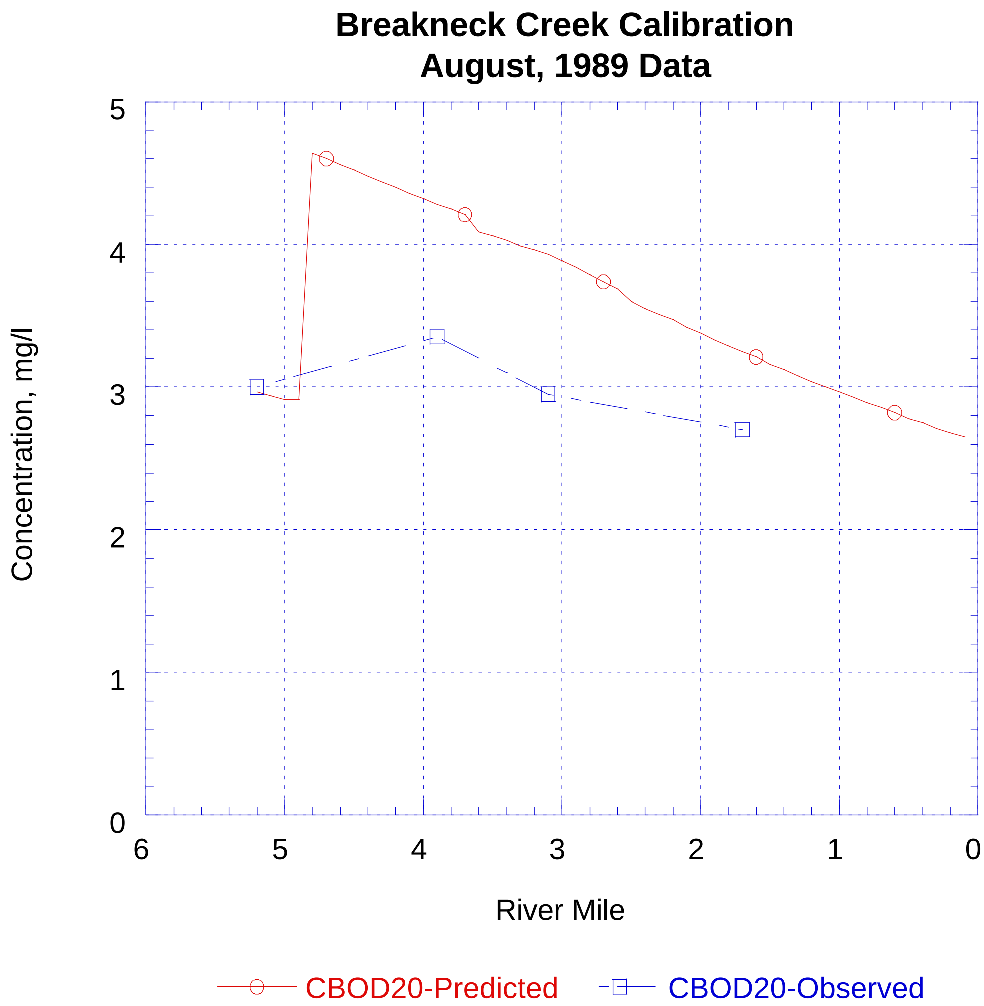
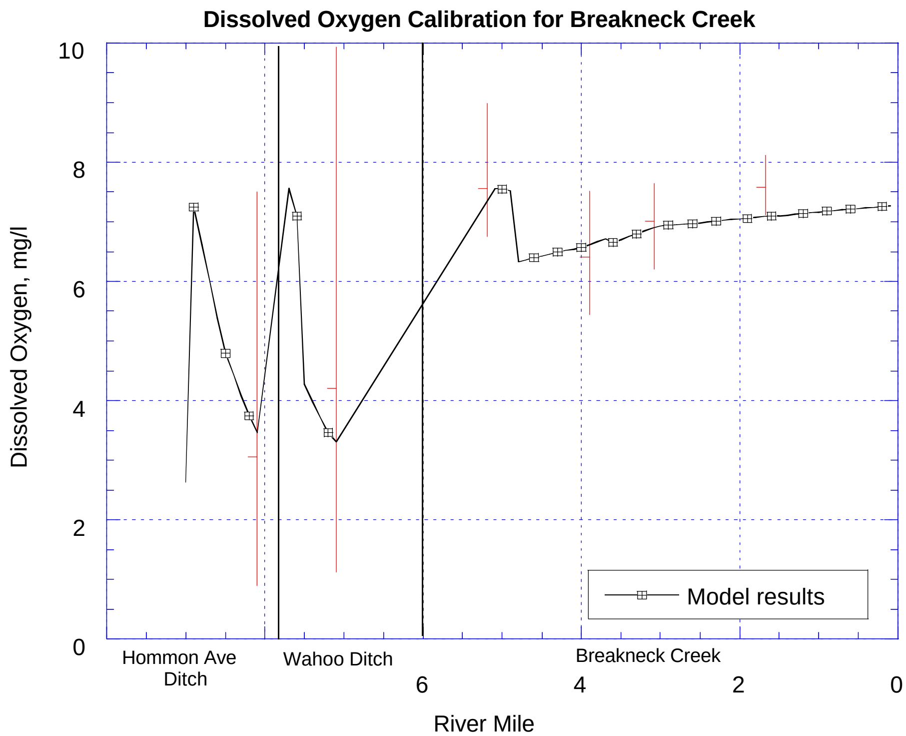


**Figure 20** Dissolved Oxygen Calibration of Wahoo Ditch, Hommon Ave Ditch, and Breakneck Ck



# APPENDIX C

## INPUT DATA SET
## FOR THE
## MIDDLE CUYAHOGA RIVER LEVEL 1 SIMULATION

```
                              * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                         Version 3.21  -  Feb. 1995

          $$$ (PROBLEM TITLES) $$$

         CARD TYPE                                 QUAL-2E PROGRAM TITLES
         TITLE01              Rock. to Wtrwrks @ Q710, 3.5 rel, sed. imp., MFD=5ft; KD=2f
         TITLE02              t
         TITLE03  NO          CONSERVATIVE MINERAL I
         TITLE04  NO          CONSERVATIVE MINERAL II
         TITLE05  NO          CONSERVATIVE MINERAL III
         TITLE06  NO          TEMPERATURE
         TITLE07  YES         BIOCHEMICAL OXYGEN DEMAND
         TITLE08  NO          ALGAE AS CHL-A IN UG/L
         TITLE09  NO          PHOSPHORUS CYCLE AS P IN MG/L
         TITLE10                (ORGANIC-P; DISSOLVED-P)
         TITLE11  YES         NITROGEN CYCLE AS N IN MG/L
         TITLE12                (ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
         TITLE13  YES         DISSOLVED OXYGEN IN MG/L
         TITLE14  NO          FECAL COLIFORM IN NO./100 ML
         TITLE15  NO          ARBITRARY NON-CONSERVATIVE
         ENDTITLE

          $$$ DATA TYPE 1 (CONTROL DATA) $$$

         CARD TYPE                                      CARD TYPE
         LIST DATA INPUT              0.00000                                            0.00000
         NO WRITE OPTIONAL SUMMARY    0.00000                                            0.00000
         NO FLOW AUGMENTATION         0.00000                                            0.00000
         STEADY STATE                 0.00000                                            0.00000
         NO TRAP CHANNELS             0.00000                                            0.00000
         NO PRINT LCD/SOLAR DATA      0.00000                                            0.00000
         NO PLOT DO AND BOD DATA      0.00000                                            0.00000
         FIXED DNSTM CONC (YES=1)=    0.00000           5D-ULT BOD CONV K COEF  =        0.23000
         INPUT METRIC            =    0.00000           OUTPUT METRIC           =        0.00000
         NUMBER OF REACHES       =   18.00000           NUMBER OF JUNCTIONS     =        0.00000
         NUM OF HEADWATERS       =    1.00000           NUMBER OF POINT LOADS   =       10.00000
         TIME STEP (HOURS)       =    1.00000           LNTH. COMP. ELEMENT (DX)=        0.10000
         MAXIMUM ROUTE TIME (HRS)=   30.00000           TIME INC. FOR RPT2 (HRS)=        1.00000
         LATITUDE OF BASIN (DEG) =   34.00000           LONGITUDE OF BASIN (DEG)=       85.00000
         STANDARD MARIDIAN (DEG) =   75.00000           DAY OF YEAR START TIME  =      180.00000
         EVAP. COEF.,(AE)        =    0.00103           EVAP. COEF.,(BE)        =        0.00016
         ELEV. OF BASIN (ELEV)   =1000.00000            DUST ATTENUATION COEF.  =        0.06000
         ENDATA1                      0.00000                                            0.00000

          $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

         CARD TYPE                                             CARD TYPE
         O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300            O UPTAKE BY NO2 OXID(MG O/MG
N)=    1.1400
         O PROD  BY ALGAE (MG O/MG A)   =    1.6000            O UPTAKE BY ALGAE (MG O/MG A)
=    2.0000
         N CONTENT OF ALGAE (MG N/MG A) =    0.0850            P CONTENT OF ALGAE (MG O/MG A)
=    0.0140
         ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000            ALGAE RESPIRATION RATE (1/DAY)
=    0.0500
         N HALF SATURATION CONST (MG/L) =    0.2000            P HALF SATURATION CONST (MG/L)
=    0.0400
         LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0008            NLIN
SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
         LIGHT FUNCTION OPTION (LFNOPT) =    1.0000            LIGHT SAT'N COEF (BTU/FT2-MIN)
=    0.1100
```

```
        DAILY AVERAGING OPTION (LAVOPT)=    2.0000          LIGHT AVERAGING FACTOR (AFACT)
=    0.9200
        NUMBER OF DAYLIGHT HOURS (DLH) =   14.0000          TOTAL DAILY SOLR RAD
(BTU/FT-2)= 1300.0000
        ALGY GROWTH CALC OPTION(LGROPT)=    2.0000          ALGAL PREF FOR NH3-N (PREFN)
=    0.9000
        ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4400          NITRIFICATION INHIBITION COEF
=   10.0000
        ENDATA1A                            0.0000
   0.0000
```

$$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

| CARD TYPE | RATE CODE | THETA VALUE | |
|---|---|---|---|
| THETA( 1) | BOD DECA | 1.047 | USER |
| THETA( 2) | BOD SETT | 1.024 | USER |
| THETA( 3) | OXY TRAN | 1.024 | USER |
| THETA( 4) | SOD RATE | 1.065 | USER |
| THETA( 5) | ORGN DEC | 1.047 | USER |
| THETA( 6) | ORGN SET | 1.024 | USER |
| THETA( 7) | NH3 DECA | 1.083 | USER |
| THETA( 8) | NH3 SRCE | 1.074 | USER |
| THETA( 9) | NO2 DECA | 1.047 | USER |
| THETA(10) | PORG DEC | 1.047 | DFLT |
| THETA(11) | PORG SET | 1.024 | DFLT |
| THETA(12) | DISP SRC | 1.074 | DFLT |
| THETA(13) | ALG GROW | 1.047 | DFLT |
| THETA(14) | ALG RESP | 1.047 | DFLT |
| THETA(15) | ALG SETT | 1.024 | DFLT |
| THETA(16) | COLI DEC | 1.047 | DFLT |
| THETA(17) | ANC DECA | 1.000 | DFLT |
| THETA(18) | ANC SETT | 1.024 | DFLT |
| THETA(19) | ANC SRCE | 1.000 | DFLT |
| ENDATA1B | | | |

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

| CARD TYPE | REACH ORDER AND IDENT | | | | R. MI/KM | | R. MI/KM |
|---|---|---|---|---|---|---|---|
| STREAM REACH | 1.0 | RCH= | Rock to RR | FROM | 58.0 | TO | 57.6 |
| STREAM REACH | 2.0 | RCH= | RR to Break | FROM | 57.6 | TO | 56.8 |
| STREAM REACH | 3.0 | RCH= | Break to Stand | FROM | 56.8 | TO | 55.8 |
| STREAM REACH | 4.0 | RCH= | Stand to Crain | FROM | 55.8 | TO | 55.2 |
| STREAM REACH | 5.0 | RCH= | Crn to Knt Dm | FROM | 55.2 | TO | 54.8 |
| STREAM REACH | 6.0 | RCH= | Knt Dm to Brown | FROM | 54.8 | TO | 54.5 |
| STREAM REACH | 7.0 | RCH= | Brwn to Knt STP | FROM | 54.5 | TO | 54.0 |
| STREAM REACH | 8.0 | RCH= | dst Kent STP | FROM | 54.0 | TO | 53.4 |
| STREAM REACH | 9.0 | RCH= | CR dst Kent | FROM | 53.4 | TO | 52.8 |
| STREAM REACH | 10.0 | RCH= | CR dst Kent | FROM | 52.8 | TO | 52.4 |
| STREAM REACH | 11.0 | RCH= | CR dst Kent | FROM | 52.4 | TO | 52.2 |
| STREAM REACH | 12.0 | RCH= | CR ust Fish | FROM | 52.2 | TO | 51.7 |
| STREAM REACH | 13.0 | RCH= | CR at Fish | FROM | 51.7 | TO | 51.3 |
| STREAM REACH | 14.0 | RCH= | CR dst Fish | FROM | 51.3 | TO | 51.0 |
| STREAM REACH | 15.0 | RCH= | CR dst Fish | FROM | 51.0 | TO | 50.6 |
| STREAM REACH | 16.0 | RCH= | CR dst Fish | FROM | 50.6 | TO | 50.2 |
| STREAM REACH | 17.0 | RCH= | CR at MFDam | FROM | 50.2 | TO | 49.8 |
| STREAM REACH | 18.0 | RCH= | CR dst Dam | FROM | 49.8 | TO | 48.1 |
| ENDATA2 | 0.0 | | | | 0.0 | | 0.0 |

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

| CARD TYPE | REACH | AVAIL HDWS | TARGET | ORDER OF AVAIL SOURCES | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ENDATA3 | 0. | 0. | 0.0 | 0. | 0. | 0. | 0. | 0. | 0. |

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

| CARD TYPE | REACH | ELEMENTS/REACH | COMPUTATIONAL FLAGS |
|---|---|---|---|
| FLAG FIELD | 1. | 4. | 1.2.6.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 2. | 8. | 6.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 3. | 10. | 6.2.2.2.7.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 4. | 6. | 2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 5. | 4. | 2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 6. | 3. | 2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 7. | 5. | 2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 8. | 6. | 2.6.2.6.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 9. | 6. | 2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 10. | 4. | 2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 11. | 2. | 2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 12. | 5. | 2.6.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 13. | 4. | 6.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 14. | 3. | 2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 15. | 4. | 2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 16. | 4. | 2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 17. | 4. | 2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 18. | 17. | 2.2.2.2.2.2.2.2.7.2.2.2.2.2.6.2.5.0.0.0. |
| ENDATA4 | 0. | 0. | 0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

| CARD TYPE | REACH | COEF-DSPN | COEFQV | EXPOQV | COEFQH | EXPOQH | CMANN |
|---|---|---|---|---|---|---|---|
| HYDRAULICS | 1. | 6000.00 | 0.024 | 0.500 | 0.871 | 0.400 | 0.033 |
| HYDRAULICS | 2. | 6000.00 | 0.022 | 0.500 | 0.781 | 0.400 | 0.033 |
| HYDRAULICS | 3. | 3084.00 | 0.055 | 0.500 | 0.460 | 0.400 | 0.033 |
| HYDRAULICS | 4. | 366.00 | 0.060 | 0.400 | 0.251 | 0.400 | 0.033 |
| HYDRAULICS | 5. | 133.00 | 0.060 | 0.400 | 0.452 | 0.400 | 0.033 |
| HYDRAULICS | 6. | 4681.00 | 0.170 | 0.400 | 0.079 | 0.600 | 0.033 |
| HYDRAULICS | 7. | 1626.00 | 0.085 | 0.400 | 0.169 | 0.600 | 0.033 |
| HYDRAULICS | 8. | 531.00 | 0.120 | 0.163 | 0.800 | 0.300 | 0.033 |
| HYDRAULICS | 9. | 232.00 | 0.120 | 0.163 | 0.800 | 0.300 | 0.033 |
| HYDRAULICS | 10. | 250.00 | 0.120 | 0.163 | 0.800 | 0.300 | 0.033 |
| HYDRAULICS | 11. | 250.00 | 0.120 | 0.163 | 0.800 | 0.300 | 0.033 |
| HYDRAULICS | 12. | 49.00 | 0.120 | 0.163 | 0.800 | 0.300 | 0.033 |
| HYDRAULICS | 13. | 179.00 | 0.004 | 0.700 | 3.190 | 0.069 | 0.033 |
| HYDRAULICS | 14. | 26.00 | 0.005 | 0.700 | 1.584 | 0.250 | 0.033 |
| HYDRAULICS | 15. | 59.00 | 0.009 | 0.700 | 1.935 | 0.200 | 0.033 |
| HYDRAULICS | 16. | 64.00 | 0.008 | 0.700 | 1.790 | 0.280 | 0.033 |
| HYDRAULICS | 17. | 52.00 | 0.006 | 0.800 | 5.114 | 0.050 | 0.033 |
| HYDRAULICS | 18. | 265.00 | 0.120 | 0.163 | 0.800 | 0.300 | 0.033 |
| ENDATA5 | 0. | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

| CARD TYPE | REACH | ELEVATION | DUST COEF | CLOUD COVER | DRY BULB TEMP | WET BULB TEMP | ATM PRESSURE | WIND | SOLAR RAD ATTENUATION |
|---|---|---|---|---|---|---|---|---|---|
| TEMP/LCD | 1. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 2. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 3. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TEMP/LCD | 4. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 5. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 6. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 7. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 8. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 9. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 10. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 11. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 12. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 13. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 14. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 15. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 16. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 17. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 18. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| ENDATA5A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

| CARD TYPE | REACH | K1 | K3 | SOD RATE | K2OPT | K2 | COEQK2 OR TSIV COEF FOR OPT 8 | OR EXPQK2 OR SLOPE FOR OPT 8 |
|---|---|---|---|---|---|---|---|---|
| REACT COEF | 1. | 0.37 | 0.00 | 0.150 | 1. | 0.60 | 0.000 | 0.00000 |
| REACT COEF | 2. | 0.38 | 0.00 | 0.100 | 1. | 0.62 | 0.000 | 0.00000 |
| REACT COEF | 3. | 0.41 | 0.00 | 0.100 | 1. | 1.23 | 0.000 | 0.00000 |
| REACT COEF | 4. | 0.53 | 0.00 | 0.100 | 1. | 2.07 | 0.000 | 0.00000 |
| REACT COEF | 5. | 0.41 | 0.00 | 0.150 | 1. | 1.14 | 0.000 | 0.00000 |
| REACT COEF | 6. | 0.67 | 0.00 | 0.100 | 1. | 14.10 | 0.000 | 0.00000 |
| REACT COEF | 7. | 0.48 | 0.00 | 0.100 | 1. | 1.64 | 0.000 | 0.00000 |
| REACT COEF | 8. | 0.35 | 0.00 | 0.100 | 1. | 1.46 | 0.000 | 0.00000 |
| REACT COEF | 9. | 0.35 | 0.00 | 0.100 | 1. | 1.45 | 0.000 | 0.00000 |
| REACT COEF | 10. | 0.35 | 0.00 | 0.100 | 1. | 1.45 | 0.000 | 0.00000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| REACT COEF | 11. | 0.35 | 0.00 | 0.100 | 1. | 1.45 | 0.000 | 0.00000 |
| REACT COEF | 12. | 0.34 | 0.00 | 0.100 | 1. | 1.44 | 0.000 | 0.00000 |
| REACT COEF | 13. | 0.27 | 0.00 | 0.100 | 1. | 1.30 | 0.000 | 0.00000 |
| REACT COEF | 14. | 0.27 | 0.00 | 0.100 | 1. | 1.40 | 0.000 | 0.00000 |
| REACT COEF | 15. | 0.27 | 0.00 | 0.100 | 1. | 1.70 | 0.000 | 0.00000 |
| REACT COEF | 16. | 0.24 | 0.00 | 0.100 | 1. | 1.40 | 0.000 | 0.00000 |
| REACT COEF | 17. | 0.22 | 0.00 | 0.100 | 1. | 1.30 | 0.000 | 0.00000 |
| REACT COEF | 18. | 0.33 | 0.00 | 0.100 | 1. | 1.40 | 0.000 | 0.00000 |
| ENDATA6 | 0. | 0.00 | 0.00 | 0.000 | 0. | 0.00 | 0.000 | 0.00000 |

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

| CARD TYPE | REACH | CKNH2 | SETNH2 | CKNH3 | SNH3 | CKNO2 | CKPORG | SETPORG | SPO4 |
|---|---|---|---|---|---|---|---|---|---|
| N AND P COEF | 1. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 2. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 3. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 4. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 5. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 6. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 7. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 8. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 9. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 10. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 11. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 12. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 13. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 14. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 15. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 16. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 17. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 18. | 0.30 | 0.00 | 1.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 |
| ENDATA6A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

| CARD TYPE | REACH | ALPHAO | ALGSET | EXCOEF | CK5 | CKANC | SETANC | SRCANC |
|---|---|---|---|---|---|---|---|---|
| | | | | | CKCOLI | | | |
| ALG/OTHER COEF | 1. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 2. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 3. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 4. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 5. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 6. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 7. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 8. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 9. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 10. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 11. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 12. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 13. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 14. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 15. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 16. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 17. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 18. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA6B | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

| CARD TYPE | REACH | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 | ANC | COLI |
|---|---|---|---|---|---|---|---|---|---|
| INITIAL COND-1 | 1. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 2. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 3. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 4. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 5. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 6. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 7. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| INITIAL COND-1 | 8. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 9. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 10. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 11. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 12. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 13. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 14. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 15. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 16. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 17. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 18. | 74.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA7 | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

| CARD TYPE | REACH | CHL-A | ORG-N | NH3-N | NO2-N | NO3-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|
| INITIAL COND-2 | 1. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 2. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 3. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 4. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 5. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 6. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 7. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 8. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 9. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 10. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 11. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 12. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 13. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 14. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 15. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 16. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| INITIAL COND-2 | 17. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 18. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA7A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

| CARD TYPE | REACH | FLOW | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 | ANC | COLI |
|---|---|---|---|---|---|---|---|---|---|---|
| INCR INFLOW-1 | 1. | 0.450 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 2. | 0.400 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 3. | 0.550 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 4. | 0.300 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 5. | 0.200 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 6. | 0.150 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 7. | 0.300 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 8. | 0.425 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 9. | 0.425 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 10. | 0.285 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 11. | 0.145 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 12. | 0.355 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 13. | 0.285 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 14. | 0.215 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 15. | 0.285 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 16. | 0.285 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 17. | 0.285 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 18. | 1.145 | 70.00 | 6.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA8 | 0. | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

| CARD TYPE | REACH | CHL-A | ORG-N | NH3-N | NO2-N | NO3-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|
| INCR INFLOW-2 | 1. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 2. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 3. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| INCR INFLOW-2 | 4. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 5. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 6. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 7. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 8. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 9. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 10. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 11. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 12. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 13. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 14. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 15. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 16. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 17. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| INCR INFLOW-2 | 18. | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| ENDATA8A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

| CARD TYPE | JUNCTION ORDER AND IDENT | UPSTRM | JUNCTION | TRIB |
|---|---|---|---|---|
| ENDATA9 | 0. | 0. | 0. | 0. |

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

| CARD TYPE | HDWTR ORDER | NAME | FLOW | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 |
|---|---|---|---|---|---|---|---|---|---|
| HEADWTR-1 | 1. | Rock to RR | 5.50 | 74.12 | 8.00 | 5.50 | 0.00 | 0.00 | 0.00 |
| ENDATA10 | 0. | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

| CARD TYPE | HDWTR ORDER | ANC | COLI | CHL-A | ORG-N | NH3-N | NO2-N | NO3-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|---|---|
| HEADWTR-2 | 1. | 0.00 | 0.00 | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| ENDATA10A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

POINT

| CARD TYPE | LOAD ORDER | NAME | EFF | FLOW | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 |
|---|---|---|---|---|---|---|---|---|---|---|
| POINTLD-1 | 1. | UT/TwinLakeS | 0.00 | 1.00 | 70.00 | 8.00 | 16.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 2. | Akron WTP | 0.00 | 1.00 | 70.00 | 8.00 | 16.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 3. | Breakneck Ck | 0.00 | 12.85 | 70.00 | 6.21 | 5.14 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 4. | Oak Knolls | 0.00 | -1.50 | 70.00 | 7.00 | 5.50 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 5. | Kent WWTP | 0.00 | 7.74 | 72.00 | 8.00 | 23.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 6. | Plum Ck | 0.00 | 1.49 | 72.00 | 7.00 | 5.30 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 7. | Fish Ck | 0.00 | 1.31 | 72.00 | 7.00 | 3.80 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 8. | Fishcreek WW | 0.00 | 12.38 | 70.00 | 8.00 | 23.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 9. | CF WTP Recha | 0.00 | -5.00 | 70.00 | 7.00 | 5.50 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 10. | CF WTP Backw | 0.00 | 0.30 | 70.00 | 7.00 | 5.50 | 0.00 | 0.00 | 0.00 |
| ENDATA11 | 0. | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

| CARD TYPE | POINT LOAD ORDER | ANC | COLI | CHL-A | ORG-N | NH3-N | NO2-N | N03-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|---|---|
| POINTLD-2 | 1. | 0.00 | 0.00 | 0.00 | 0.54 | 1.00 | 0.09 | 0.01 | 0.00 | 0.00 |
| POINTLD-2 | 2. | 0.00 | 0.00 | 0.00 | 0.54 | 1.00 | 0.09 | 0.01 | 0.00 | 0.00 |
| POINTLD-2 | 3. | 0.00 | 0.00 | 0.00 | 0.76 | 0.28 | 0.20 | 6.48 | 0.00 | 0.00 |
| POINTLD-2 | 4. | 0.00 | 0.00 | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| POINTLD-2 | 5. | 0.00 | 0.00 | 0.00 | 1.30 | 1.00 | 1.30 | 18.00 | 0.00 | 0.00 |
| POINTLD-2 | 6. | 0.00 | 0.00 | 0.00 | 0.28 | 0.09 | 0.96 | 1.59 | 0.00 | 0.00 |
| POINTLD-2 | 7. | 0.00 | 0.00 | 0.00 | 0.10 | 0.05 | 0.02 | 0.22 | 0.00 | 0.00 |
| POINTLD-2 | 8. | 0.00 | 0.00 | 0.00 | 1.50 | 1.00 | 1.36 | 18.00 | 0.00 | 0.00 |
| POINTLD-2 | 9. | 0.00 | 0.00 | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |
| POINTLD-2 | 10. | 0.00 | 0.00 | 0.00 | 0.54 | 0.26 | 0.09 | 0.01 | 0.00 | 0.00 |

# APPENDIX D

## INPUT DATA SET
## FOR THE
## BREAKNECK CREEK LEVEL 1 SIMULATION

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                    * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                  Version 3.21  -  Feb. 1995

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                              QUAL-2E PROGRAM TITLES
TITLE01              Breakneck Creek - Option 1 Simulation
TITLE02
TITLE03  NO          CONSERVATIVE MINERAL I
TITLE04  NO          CONSERVATIVE MINERAL II
TITLE05  NO          CONSERVATIVE MINERAL III
TITLE06  NO          TEMPERATURE
TITLE07  YES         BIOCHEMICAL OXYGEN DEMAND
TITLE08  NO          ALGAE AS CHL-A IN UG/L
TITLE09  NO          PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                (ORGANIC-P; DISSOLVED-P)
TITLE11  YES         NITROGEN CYCLE AS N IN MG/L
TITLE12                (ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13  YES         DISSOLVED OXYGEN IN MG/L
TITLE14  NO          FECAL COLIFORM IN NO./100 ML
TITLE15  NO          ARBITRARY NON-CONSERVATIVE
ENDTITLE

 $$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                     CARD TYPE
LIST DATA INPUT              0.00000                                        0.00000
NO WRITE OPTIONAL SUMMARY    0.00000                                        0.00000
NO FLOW AUGMENTATION         0.00000                                        0.00000
STEADY STATE                 0.00000                                        0.00000
NO TRAP CHANNELS             0.00000                                        0.00000
NO PRINT LCD/SOLAR DATA      0.00000                                        0.00000
NO PLOT DO AND BOD DATA      0.00000                                        0.00000
FIXED DNSTM CONC (YES=1)=    0.00000          5D-ULT BOD CONV K COEF  =     0.23000
INPUT METRIC            =    0.00000          OUTPUT METRIC           =     0.00000
NUMBER OF REACHES       =    9.00000          NUMBER OF JUNCTIONS     =     2.00000
NUM OF HEADWATERS       =    3.00000          NUMBER OF POINT LOADS   =     5.00000
TIME STEP (HOURS)       =    1.00000          LNTH. COMP. ELEMENT (DX)=     0.10000
MAXIMUM ROUTE TIME (HRS)=   30.00000          TIME INC. FOR RPT2 (HRS)=     1.00000
LATITUDE OF BASIN (DEG) =   34.00000          LONGITUDE OF BASIN (DEG)=    85.00000
STANDARD MARIDIAN (DEG) =   75.00000          DAY OF YEAR START TIME  =   180.00000
EVAP. COEF.,(AE)        =    0.00103          EVAP. COEF.,(BE)        =     0.00016
ELEV. OF BASIN (ELEV)   =1000.00000           DUST ATTENUATION COEF.  =     0.06000
ENDATA1                      0.00000                                        0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                          CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300         O UPTAKE BY NO2 OXID(MG O/MG N)=
1.1400
O PROD  BY ALGAE (MG O/MG A)   =    1.6000         O UPTAKE BY ALGAE (MG O/MG A)  =
2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850         P CONTENT OF ALGAE (MG O/MG A) =
0.0140
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000         ALGAE RESPIRATION RATE (1/DAY) =
0.0500
N HALF SATURATION CONST (MG/L) =    0.2000         P HALF SATURATION CONST (MG/L) =
0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0008         NLIN SHADE(1/FT-(UGCHA/L)**2/3)=
0.0000
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000         LIGHT SAT'N COEF (BTU/FT2-MIN) =
0.1100
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        DAILY AVERAGING OPTION (LAVOPT)=    2.0000         LIGHT AVERAGING FACTOR (AFACT) =
0.9200
        NUMBER OF DAYLIGHT HOURS (DLH) =   14.0000         TOTAL DAILY SOLR RAD (BTU/FT-2)=
1300.0000
        ALGY GROWTH CALC OPTION(LGROPT)=    2.0000         ALGAL PREF FOR NH3-N (PREFN)   =
0.9000
        ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4400         NITRIFICATION INHIBITION COEF  =
10.0000
        ENDATA1A                            0.0000
0.0000

         $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

        CARD TYPE     RATE CODE     THETA VALUE

        THETA( 1)      BOD DECA        1.047     USER
        THETA( 2)      BOD SETT        1.024     USER
        THETA( 3)      OXY TRAN        1.024     USER
        THETA( 4)      SOD RATE        1.060     USER
        THETA( 5)      ORGN DEC        1.047     USER
        THETA( 6)      ORGN SET        1.024     USER
        THETA( 7)      NH3 DECA        1.083     USER
        THETA( 8)      NH3 SRCE        1.074     USER
        THETA( 9)      NO2 DECA        1.047     USER
        THETA(10)      PORG DEC        1.047     DFLT
        THETA(11)      PORG SET        1.024     DFLT
        THETA(12)      DISP SRC        1.074     DFLT
        THETA(13)      ALG GROW        1.047     DFLT
        THETA(14)      ALG RESP        1.047     DFLT
        THETA(15)      ALG SETT        1.024     DFLT
        THETA(16)      COLI DEC        1.047     DFLT
        THETA(17)      ANC DECA        1.000     DFLT
        THETA(18)      ANC SETT        1.024     DFLT
        THETA(19)      ANC SRCE        1.000     DFLT
        ENDATA1B

         $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

        CARD TYPE           REACH ORDER AND IDENT              R. MI/KM            R. MI/KM
        STREAM REACH     1.0  RCH=         Upst BN   FROM          5.2     TO           4.8
        STREAM REACH     2.0  RCH=         Upst WD   FROM          0.7     TO           0.5
        STREAM REACH     3.0  RCH=  HAD, w/Ravenna   FROM          1.0     TO           0.4
        STREAM REACH     4.0  RCH=        HAD, dst   FROM          0.4     TO           0.0
        STREAM REACH     5.0  RCH=              WD   FROM          0.5     TO           0.0
        STREAM REACH     6.0  RCH=              BN   FROM          4.8     TO           3.9
        STREAM REACH     7.0  RCH=              BN   FROM          3.9     TO           3.0
        STREAM REACH     8.0  RCH=              BN   FROM          3.0     TO           1.7
        STREAM REACH     9.0  RCH=              BN   FROM          1.7     TO           0.0
        ENDATA2          0.0                                       0.0                  0.0

         $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

        CARD TYPE                  REACH  AVAIL HDWS TARGET     ORDER OF AVAIL SOURCES
        ENDATA3                     0.        0.       0.0   0.   0.   0.   0.   0.   0.

         $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

        CARD TYPE        REACH ELEMENTS/REACH            COMPUTATIONAL FLAGS
        FLAG FIELD        1.        4.         1.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD        2.        2.         1.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD        3.        6.         1.6.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD        4.        4.         2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD        5.        5.         4.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD        6.        9.         4.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD        7.        9.         2.2.2.6.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
```

| | | | |
|---|---|---|---|
| FLAG FIELD | 8. | 13. | 2.2.2.2.2.6.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0. |
| FLAG FIELD | 9. | 17. | 2.7.6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0. |
| ENDATA4 | 0. | 0. | 0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. |

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

| CARD TYPE | REACH | COEF-DSPN | COEFQV | EXPOQV | COEFQH | EXPOQH | CMANN |
|---|---|---|---|---|---|---|---|
| HYDRAULICS | 1. | 90.00 | 0.187 | 0.400 | 0.218 | 0.600 | 0.030 |
| HYDRAULICS | 2. | 90.00 | 0.091 | 0.400 | 0.600 | 0.600 | 0.030 |
| HYDRAULICS | 3. | 90.00 | 0.168 | 0.400 | 0.697 | 0.600 | 0.030 |
| HYDRAULICS | 4. | 90.00 | 0.163 | 0.400 | 0.792 | 0.600 | 0.030 |
| HYDRAULICS | 5. | 90.00 | 0.091 | 0.400 | 0.600 | 0.600 | 0.030 |
| HYDRAULICS | 6. | 90.00 | 0.187 | 0.400 | 0.218 | 0.600 | 0.030 |
| HYDRAULICS | 7. | 90.00 | 0.203 | 0.400 | 0.176 | 0.600 | 0.030 |
| HYDRAULICS | 8. | 90.00 | 0.119 | 0.400 | 0.200 | 0.600 | 0.030 |
| HYDRAULICS | 9. | 90.00 | 0.119 | 0.400 | 0.200 | 0.600 | 0.030 |
| ENDATA5 | 0. | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

| CARD TYPE | REACH | ELEVATION | DUST COEF | CLOUD COVER | DRY BULB TEMP | WET BULB TEMP | ATM PRESSURE | WIND | SOLAR RAD ATTENUATION |
|---|---|---|---|---|---|---|---|---|---|
| TEMP/LCD | 1. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 2. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 3. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 4. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 5. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 6. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 7. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 8. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| TEMP/LCD | 9. | 1000.00 | 0.06 | 0.30 | 69.70 | 60.00 | 29.90 | 0.00 | 1.00 |
| ENDATA5A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

| CARD TYPE | REACH | K1 | K3 | SOD RATE | K2OPT | K2 | COEQK2 OR TSIV COEF OR FOR OPT 8 | EXPQK2 SLOPE FOR OPT 8 |
|---|---|---|---|---|---|---|---|---|
| REACT COEF | 1. | 0.54 | 0.36 | 0.100 | 1. | 3.90 | 0.000 | 0.00000 |
| REACT COEF | 2. | 0.37 | 0.36 | 0.100 | 1. | 0.69 | 0.000 | 0.00000 |
| REACT COEF | 3. | 0.35 | 0.36 | 0.400 | 1. | 0.82 | 0.000 | 0.00000 |
| REACT COEF | 4. | 0.33 | 0.36 | 0.200 | 1. | 0.67 | 0.000 | 0.00000 |
| REACT COEF | 5. | 0.37 | 0.36 | 0.100 | 1. | 0.69 | 0.000 | 0.00000 |
| REACT COEF | 6. | 0.54 | 0.36 | 0.100 | 1. | 3.90 | 0.000 | 0.00000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| REACT COEF | 7. | 0.60 | 0.36 | 0.100 | 1. | 5.53 | 0.000 | 0.00000 |
| REACT COEF | 8. | 0.54 | 0.36 | 0.100 | 1. | 3.05 | 0.000 | 0.00000 |
| REACT COEF | 9. | 0.54 | 0.36 | 0.100 | 1. | 3.05 | 0.000 | 0.00000 |
| ENDATA6 | 0. | 0.00 | 0.00 | 0.000 | 0. | 0.00 | 0.000 | 0.00000 |

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

| CARD TYPE | REACH | CKNH2 | SETNH2 | CKNH3 | SNH3 | CKNO2 | CKPORG | SETPORG | SPO4 |
|---|---|---|---|---|---|---|---|---|---|
| N AND P COEF | 1. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 2. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 3. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 4. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 5. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 6. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 7. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 8. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| N AND P COEF | 9. | 0.05 | 0.00 | 1.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| ENDATA6A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

| CARD TYPE | REACH | ALPHAO | ALGSET | EXCOEF | CK5<br>CKCOLI | CKANC | SETANC | SRCANC |
|---|---|---|---|---|---|---|---|---|
| ALG/OTHER COEF | 1. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 2. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 3. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 4. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 5. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 6. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 7. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 8. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALG/OTHER COEF | 9. | 10.00 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA6B | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

| CARD TYPE | REACH | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 | ANC | COLI |
|---|---|---|---|---|---|---|---|---|---|
| INITIAL COND-1 | 1. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 2. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 3. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 4. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 5. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 6. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| INITIAL COND-1 | 7. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 8. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-1 | 9. | 72.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA7 | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

| CARD TYPE | REACH | CHL-A | ORG-N | NH3-N | NO2-N | NO3-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|
| INITIAL COND-2 | 1. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 2. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 3. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 4. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 5. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 6. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 7. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 8. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INITIAL COND-2 | 9. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA7A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

| CARD TYPE | REACH | FLOW | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 | ANC | COLI |
|---|---|---|---|---|---|---|---|---|---|---|
| INCR INFLOW-1 | 1. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 2. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 3. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 4. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 5. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 6. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 7. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 8. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-1 | 9. | 0.000 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA8 | 0. | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

| CARD TYPE | REACH | CHL-A | ORG-N | NH3-N | NO2-N | NO3-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|
| INCR INFLOW-2 | 1. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 2. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 3. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 4. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 5. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 6. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 7. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 8. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INCR INFLOW-2 | 9. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDATA8A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

| CARD TYPE | JUNCTION ORDER AND IDENT | UPSTRM | JUNCTION | TRIB |
|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| STREAM JUNCTION | 1. | JNC= | 1 | 6. | 17. | 16. |
| STREAM JUNCTION | 2. | JNC= | 2 | 4. | 22. | 21. |
| ENDATA9 | 0. | | | 0. | 0. | 0. |

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

| CARD TYPE | HDWTR ORDER | NAME | FLOW | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 |
|---|---|---|---|---|---|---|---|---|---|
| HEADWTR-1 | 1. | Upst BN | 1.44 | 72.00 | 7.56 | 3.00 | 0.00 | 0.00 | 0.00 |
| HEADWTR-1 | 2. | Upst WD | 0.22 | 72.00 | 8.00 | 6.85 | 0.00 | 0.00 | 0.00 |
| HEADWTR-1 | 3. | HAD, w/Ravenna | 0.19 | 72.00 | 8.00 | 8.00 | 0.00 | 0.00 | 0.00 |
| ENDATA10 | 0. | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

| CARD TYPE | HDWTR ORDER | ANC | COLI | CHL-A | ORG-N | NH3-N | NO2-N | NO3-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|---|---|
| HEADWTR-2 | 1. | 0.00 | 0.00 | 0.00 | 0.45 | 0.05 | 0.03 | 0.90 | 0.00 | 0.00 |
| HEADWTR-2 | 2. | 0.00 | 0.00 | 0.00 | 0.54 | 0.06 | 0.06 | 0.08 | 0.00 | 0.00 |
| HEADWTR-2 | 3. | 0.00 | 0.00 | 0.00 | 0.90 | 1.18 | 1.34 | 3.70 | 0.00 | 0.00 |
| ENDATA10A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

| CARD TYPE | POINT LOAD ORDER | NAME | EFF | FLOW | TEMP | D.O. | BOD | CM-1 | CM-2 | CM-3 |
|---|---|---|---|---|---|---|---|---|---|---|
| POINTLD-1 | 1. | Ravenna WWTP | 0.00 | 6.96 | 70.00 | 8.00 | 18.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 2. | Wetlands | 0.00 | 1.26 | 70.00 | 5.00 | 3.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 3. | Franklin Hil | 0.00 | 1.55 | 70.00 | 8.00 | 18.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 4. | Kent WTP | 0.00 | -0.77 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-1 | 5. | Brady Lake O | 0.00 | 2.00 | 70.00 | 6.90 | 3.00 | 0.00 | 0.00 | 0.00 |
| ENDATA11 | 0. | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

| CARD TYPE | POINT LOAD ORDER | ANC | COLI | CHL-A | ORG-N | NH3-N | NO2-N | N03-N | ORG-P | DIS-P |
|---|---|---|---|---|---|---|---|---|---|---|
| POINTLD-2 | 1. | 0.00 | 0.00 | 0.00 | 1.16 | 1.00 | 0.62 | 8.00 | 0.00 | 0.00 |
| POINTLD-2 | 2. | 0.00 | 0.00 | 0.00 | 0.45 | 0.05 | 0.03 | 0.90 | 0.00 | 0.00 |
| POINTLD-2 | 3. | 0.00 | 0.00 | 0.00 | 0.40 | 1.00 | 0.05 | 10.00 | 0.00 | 0.00 |
| POINTLD-2 | 4. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| POINTLD-2 | 5. | 0.00 | 0.00 | 0.00 | 0.38 | 0.06 | 0.02 | 0.58 | 0.00 | 0.00 |
| ENDATA11A | 0. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

| | DAM | RCH | ELE | ADAM | BDAM | FDAM | HDAM |
|---|---|---|---|---|---|---|---|
| ENDATA12 | 0. | 0. | 0. | 0.00 | 0.00 | 0.00 | 0.00 |

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     $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

         CARD TYPE              TEMP      D.O.      BOD      CM-1      CM-2      CM-3      ANC
COLI

    ENDATA13                    DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

     $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

         CARD TYPE              CHL-A     ORG-N     NH3-N     NO2-N     NH3-N     ORG-P     DIS-P

    ENDATA13A                   DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED
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# APPENDIX E

## PUBLIC OUTREACH

**PLEASE NOTE: THE MAJORITY OF THIS APPENDIX CONTAINS HARDCOPY DOCUMENTS NOT AVAILABLE ELECTRONICALLY. PLEASE CONTACT ERIN GASKILL, OHIO EPA AT (614) 644-2890 TO OBTAIN COPIES OF THE DOCUMENTS NOT INCLUDED HERE.**

William J. Anderson, II
426 Spaulding Dr.
Kent, OH 44240-1928

Dear Mr. Anderson,

We received your letter dated August 6, 1999 concerning Ohio EPA's draft Cuyahoga River Total Maximum Daily Load (TMDL) report. We thank you for your interest in the river and for your ideas and suggestions to improve this section of the Cuyahoga River. As you acknowledged, Ohio EPA has invested a lot of resources studying and evaluating the river and in developing this specific draft TMDL report. However, we do not agree with the opinions stated in your letter that the TMDL is short term, expensive and will not result in reasonable success. We believe that if the suggestions in the draft TMDL report are implemented, the result will be a permanent, cost effective solution that will, address the impaired habitat, fish populations and dissolved oxygen concentrations and undoubtably bring this section of the river into compliance with the goals of the Clean Water Act.

Constructing a canal between Mogadore Reservoir and Breakneck Creek and acquiring property or rights of way will be an expensive proposition. Because of the elevations between Breakneck and Mogadore Reservoir, water will have to be pumped into Breakneck Creek creating enormous operation and maintenance costs. Gravity flow could be accomplished through the Plum Creek watershed. This, of course, would reduce the flow of water in the Little Cuyahoga River and may just shift the problem of inadequate flow from one location to another. This proposal also does not address that section of the river between the Lake Rockwell dam and the confluence with Breakneck Creek, which currently has low dissolved oxygen concentrations and impaired fish communities.

The idea of pumping water from Lake Erie to the headwaters of the Cuyahoga River to supplement the supply was recognized, evaluated, and discarded in the 1920's. The cost to pump the water the 14 miles from the Lake to an elevation some 600 feet higher into the headwaters of the East Branch would be very costly. Reduced treatment costs of the higher quality Lake Erie water and the reduced operation and maintenance at the LaDue and East Branch Reservoirs would only slightly offset these pumping costs. We believe the water intakes you refer to are the ones constructed for a possible second power plant at the Perry Nuclear Power Plant. There is no guarantee that either these intakes would be sold, nor whether the water could be used as a drinking water supply.

Also your proposals do not address the remaining two problems associated with the Middle Cuyahoga River which are habitat loss and impaired fish communities. The adverse effects of dams on rivers in general and the Cuyahoga in particular are primarily related to habitat. A river or stream must have a wide range of habitat conditions to support a well balanced stream fishery. This habitat includes different types of substrate (or stream bottom) such as sand, gravel, boulders, vegetation and woody debris, as well as mud and muck. The fish community also needs different types of currents, ranging from slow to fast, and varying depth of water, from shallow to deep. These habitat types allow fish to hunt for food as well as hide from predators, to spawn and to have nursery areas available to protect the fry. A dam drastically reduces the types of habitats available in the stream. Dam pools are often characterized as having only slack current, only mud or muck substrates and little variation in depth. A dam also prevents fish from moving up and down the stream to look for the best available seasonal habitat in which to live or spawn.

These habitat conditions in dam pools usually give rise to depleted oxygen levels in the water. The fish literally suffocate. Although there may be a fish population in a dam pool, it contains fewer species, is usually dominated by tolerant and less desirable fish and the population is not as healthy or robust as in a free flowing river. The modifications to the Kent and Munroe Falls dams will increase available habitat and open up this section of the river to Breakneck Creek and its headwaters for all of the fish in the middle Cuyahoga basin.

Milt Trautman in his book The Fishes of Ohio stated “As is ecologically apparent, the conditions described above (free flowing water with no dams) were highly conducive to the production of a huge population consisting of the larger and better food and game fishes (pikes, walleyes, catfishes, buffalo fishes, suckers, drums and sturgeons), and to a large population of fish species of smaller size which required normally clear waters and bottoms of clean sand (sand darter), gravel (streamline/gravel chubs), boulders (various riffle darters), or aquatic vegetation, down timber and brush (several species of minnows/topminnows).”

He further wrote:
“With few exceptions, the finest of Ohio’s food fishes were migratory to some degree, these going upstream to near the headwaters where they found suitable spawning habitats, and conditions were favorable for the development of their young.” The many dams of the white man were extremely effective in preventing these migratory fishes from reaching their spawning grounds.....”

He summarized:
“*Summary of 1801-1850 period.*—The populations of many species of fishes showed a definite decrease or increase in abundance. There was a decrease in abundance of several of the large and important food fishes. Habitat changes, however, favored some of the smaller-sized species which were less valued or worthless as human food; these were recorded by Kirtland as having increased in abundance. Principal adverse factors were: (1) construction of many dams which prevented the more migratory species from reaching their headwater spawning grounds, (2) polluting of waters with sawdust, and with brewery and slaughterhouse slops, (3) draining of much marsh land which destroyed valuable spawning grounds, (4) increased amount of ditching of streams, (5) drying up of many springs and small streams for part or all of the year, (6) removal of top soil and humus by burning, (7) great increase in amount of commercial seining, especially in inland waters. The silting of stream bottoms with clays and the great turbidity of water which later became so evident had not become apparent at this time.”

Any proposal to bring the Middle Cuyahoga River into attainment must address the impacts that the Munroe Falls and Kent dams have on the chemical, physical and biological integrity of the Middle Cuyahoga River. While it is true that when we deal with natural systems there can be no guarantee of success since biology is not a predictive science. However, we are extremely confident that our proposals will work. We would not have invested so much time and effort into this problem to suggest a solution that did not have the greatest assurance of success. We believe that if the suggestions in the draft TMDL report are implemented, the result will be a permanent, cost effective solution that will bring this section of the river into compliance with the goals of the Clean Water Act. Again, thank you very much for your consideration and support for a better Cuyahoga River.

Sincerely,

cc: Portage Co. Commissioners
Munroe Falls Mayor Rupp
Cuyahoga Falls Mayor Robart
Record Courier
Akron Beacon Journal

# APPENDIX F

## DOCUMENTATION OF REASONABLE ASSURANCES

**PLEASE NOTE: THIS APPENDIX IS COMPOSED OF HARDCOPY DOCUMENTS NOT AVAILABLE ELECTRONICALLY. PLEASE CONTACT ERIN GASKILL, OHIO EPA AT (614) 644-2890 TO OBTAIN COPIES OF THE DOCUMENTS NOT INCLUDED HERE.**

# REFERENCES

Brown, L.C., and T.O. Barnwell. 1987. The enhanced water quality models QUAL2E and QUAL2E-UNCAS: Documentation and users manual. EPA/600/3-87/007. U.S. Environmental Protection Agency.

Division of Surface Water. 1984. Predicting the reaeration coefficient for Ohio streams. Ohio EPA.

Division of Surface Water. 1994. Biological and water quality study of the Cuyahoga River and selected tributaries. Volume 1. OEPA EAS/1992-12-11. Ohio EPA.

Division of Surface Water. 1998. Guidance 6: Ammonia-N toxicity and D.O. modeling. Ohio EPA.

Division of Surface Water. 1998. Water quality permit support documents for the Ravenna, Kent and Fishcreek WWTPs. Monitoring and Assessment Section. Ohio EPA.

NACEPT. 1998. Report of the federal advisory committee on the total maximum daily load (TMDL) program. EPA 100-R-98-006. U.S. Environmental Protection Agency.

Office of Research and Development. 1985. Rates, constants, and kinetics formulations in surface water quality modeling (2nd edition). EPA/600/3-85/040. U.S. Environmental Protection Agency.

Office of Water. 1991. Guidance for water quality-based decisions: The TMDL process. EPA 440/4-91-001. U.S. Environmental Protection Agency.

Office of Water. 1997. Technical guidance manual for developing total maximum daily loads Book 2: Streams and rivers. Part 1: Biochemical oxygen demand/ dissolved oxygen and nutrients/ eutrophication. EPA 823-B-97-002. U.S. Environmental Protection Agency.

Skalsky, D. S. 1984. Inter-office communication on selecting a reaeration rate equation. Ohio EPA.

Thomann, R.V., and J.A. Mueller. 1987. Principles of surface water quality modeling and control. Harper & Row, New York, NY.

USGS. 1981. Low-flow characteristics of Ohio streams. Open-file report 81-1195. U.S. Geological Survey.