

Ammonia Toxicity Model (AMMTOX, Version 2a)

A Tool for Determining Effluent Ammonia Limits

Operating Instructions

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Operating Instructions for AMMTOX Version 2a

AMMTOX consists of two independent models, one that performs recurrence analysis on grab sample data for pH and temperature, and one that predicts concentrations of ammonia in a reach model framework. This configuration offers great flexibility for modeling complex scenarios, especially those that may require a TMDL framework. Instructions for model operation begin with the recurrence analysis model. Both models were developed in Excel 2000™, and it is assumed that users will be familiar with that software. These instructions also assume that users are already modestly familiar with concepts embodied in AMMTOX.

Recurrence Analysis Model

The recurrence model contains macros, which must be enabled in order to run the model on your machine. If the security level for macros (Tools – Macro – Security) is set to “High”, macros will be disabled automatically; make sure the security level is set to “Medium” or “Low.”

The recurrence analysis model (**AMMTOX Recur Model.xls**) is comprised of numerous pages, each with a specific function. The operator must make some decisions about the applicability of default conditions, load a data set, and activate macros that perform the analyses. A yellow background has been applied to all cells where the user can enter data or make changes to existing values. After macros have been run, model output is a set of monthly pH and temperature values characterizing acute and chronic setpoint conditions as described in the background manual.

Operation begins with the first page, for which the tab is labeled **controls**. In most instances, the required information is easy to identify (Figure 1). The site name can be any number of characters (the width of the column can be increased, or “wrap text” selected from cell alignment options, if the selected name exceeds the initial width of the column). At a minimum, the operator must supply a few basic characteristics for the stream reach that is the subject of analysis: 1) Are salmonids present?, 2) In what months are early life stages (ELS) of fish present?, and 3) Is the amplitude of daily pH variation best characterized as low, medium, or high? Some entries are case-sensitive. Many other characteristics can be changed, but would require site-specific data to justify the action. In particular, the various constants affecting the calculation of stream standards, which appear as linked values on the **controls** page, have been grouped on the **constants** page under the heading “Things you can change, but probably shouldn’t” (Figure 2).

If the operator has site-specific data defining amplitudes and times of maximum pH and temperature, that information should be entered on the page with the tab **pHT** (Figure 3). When the operator chooses to enter values that are not in the default set, all 12 monthly values must be entered. The cells in which user-defined values are entered will display “Not entered” initially. This is simply a precaution to avoid omission of values when the operator has indicated intent to supply them. Type the site-specific values for each month. If site-specific values are not available for every month, default values can be

assigned to those months. Entering site-specific data in the spreadsheet makes the information available for use, but another step is required before those values will affect model output. User-defined values are not activated until the appropriate selection is made on the **controls** page (i.e., enter “User” to activate any of the four data sets defining temporal patterns of variation). When this step has been completed successfully, the block of information (“pH and temperature characteristics in use”) at the right of the **controls** page will show the user-defined values.

Ammonia Toxicity Model (AMMTOX)		
Control Panel		
User-supplied Information		
Site Name:	Your Site	
Salmonids present?	Y	Enter Y or N
Amplitudes and Times of Maxima		
pH amplitude	M	Enter H, M, L, or User
Time of pH max	Default	Enter Default or User
Temperature amplitude	Default	Enter Default or User
Time of temperature max	Default	Enter Default or User
Constants (edit numerical values on "Constants" page)		
FAV	11.23	depends on "Salmonids present?"
R (acute)	0.00704	
R (chronic)	0.0232	
pH _T (acute)	7.204	
pH _T (chronic)	7.688	
Early Life Stages Present?		
Month	Present? (Y/N)	
January		N
February		N
March		N
April		N
May		N
June		N
July		N
August		N
September		N
October		N
November		N
December		N

Figure 1. A portion of the control page of AMMTOX showing information that must be supplied by the user.

Things you can change, but probably shouldn't

R, acute	0.275	Default
R, chronic	0.0577	Default
pHT, acute	7.204	Default
pHT, chronic	7.688	Default
B, acute	39.0	Default
B, chronic	2.487	Default
Fish GMCV (ELS)	2.85	Default
Fish GMCV (no ELS)	8.78	Default
Fish GMCV in use	2.85	
invertebrate GMCV	1.45	Default
invertebrate slope	0.028	Default
invertebrate reference Temp	25	Default
invertebrate low temp cutoff	7	Default

Figure 2. Contents of the constants page of AMMTOX showing values that can be changed if appropriate site-specific information is available.

Month	Default pH Selections				User Supplied Values	
	Time of maximum	Daily Amplitude (s.u.)			Time of maximum	Daily amplitude
		High	Medium	Low		
Jan	14:00	0.3	0.2	0.2	Not entered	Not entered
Feb	14:00	0.3	0.2	0.2	Not entered	Not entered
Mar	15:00	0.3	0.2	0.2	Not entered	Not entered
Apr	15:00	0.3	0.2	0.2	Not entered	Not entered
May	16:00	0.5	0.3	0.2	Not entered	Not entered
Jun	16:00	0.5	0.3	0.2	Not entered	Not entered
Jul	16:00	0.5	0.3	0.2	Not entered	Not entered
Aug	16:00	0.5	0.3	0.2	Not entered	Not entered
Sep	16:00	0.5	0.3	0.2	Not entered	Not entered
Oct	15:00	0.5	0.3	0.2	Not entered	Not entered
Nov	15:00	0.3	0.2	0.2	Not entered	Not entered
Dec	14:00	0.3	0.2	0.2	Not entered	Not entered

Figure 3. Contents of part of the pHT page of AMMTOX showing the default configuration defining the temporal patterns of diel variation in pH. User-supplied values are typed in the cells now displaying "Not entered." The layout for temperature is the same.

The next step in preparing for a model run is to organize the grab sample data and format entries properly. There are significant advantages to making these preparations in a separate file. Values can be graphed for preliminary screening, and missing data can be

located or estimated. The grab sample data set should have four columns of information in the following sequence: date, time, pH, and temperature. Standard EXCEL formats must be used for dates and times. The actual appearance of dates and times on the spreadsheet will depend on the format selected for display. PH and temperature values do not require formatting, but must be numeric (sometimes data derived from ASCII files or relational databases will be in text format, which cannot be processed by the model). After the preliminary formatting has been completed, copy the entire set of values, not including field names, and paste into row 7 of the page labeled **raw data** (Figure 4).

Earliest Date	Min Time	Min pH	Min Temp	Min Interval	# Intervals > 30 d
1-Jan-97	7:27	6.73	0	5	2
Latest Date	Max Time	Max pH	Max Temp	Avg Interval	
26-Jun-02	14:46	9.02	23.7	7.9	
Date	Time	pH	Temp	Interval	
1-Jan-97	8:37	8.03	11.8	7	
8-Jan-97	11:03	8.12	1.5	6	
14-Jan-97	13:53	7.77	0.0	8	
22-Jan-97	13:32	8.34	3.0	7	
29-Jan-97	11:17	8.35	3.5	7	
5-Feb-97	11:05	8.19	2.0	7	
12-Feb-97	11:04	8.07	3.0	7	

Figure 4. A portion of the **raw data** page of AMMTOX showing the characteristics of a trial data set and displaying the first sampling date.

The next step involves initiating a macro, called “Raw Data Preparation” that is the first of three macros represented by buttons in the box labeled “Model Initiation Controls” on the **controls** page. This macro will sort the grab sample data, compute the time interval between each sampling date, and screen for missing data. If the data set is missing pH, temperature, or time of day for any sampling date, an error message box will appear on the screen. There is an option to enter the missing data or to delete the record. Time of day must be entered in a standard EXCEL format (e.g., 13:30).

At the conclusion of the macro, the operator should examine values displayed in the cells at the top of the **raw data** page (Figure 4). These cells show the first and last sampling date, minimum and maximum sampling time, minimum and maximum pH, minimum and maximum temperature, as well as the minimum and average sampling interval, and the number of sampling intervals exceeding 30 days in length. All of these values provide the user with a simple mechanism for additional screening of the data set. If the minimum or maximum values are outside of the expected range, the operator should peruse the data set and check the validity of selected values. If the minimum sampling interval is zero, it indicates that there are two or more grab samples from one date. These values will be highlighted in green, and all but one of the dates must be changed or deleted before the model can proceed. The model will not function properly when more than one entry appears on a given date. Replicates or extra samples on a given date must be discarded.

The pH data are subject to additional scrutiny to locate possible or probable outliers because pH is such an influential determinant of toxicity. Outliers are defined by their distance from the central 50% of all pH measurements in the data set. The central 50% of the data is determined as the distance between the first and third quartiles (box dimension). The quartiles are selected with an Excel function. If the distance from a high pH value to the third quartile is more than 1.5 times the box dimension, that pH value is a possible outlier. Similarly, if a low pH is less than the first quartile by more than 1.5 times the box dimensions, it also is a possible outlier. Probable outliers, which are even more extreme than possible outliers, are outside of the central box by a factor of 3, rather than 1.5. Records containing possible outliers values are marked in blue background, and probable outliers are marked with orange. Each value should be examined for possible deletion.

After all appropriate changes have been made and the data set is in final form, return to the **controls** page and select the button labeled “Accept data set” within the box labeled “Model Initiation Controls.” The model will not continue to process data until this step has been completed.

The analysis is continued by initiating another macro, “Acute/Chronic Calculations,” which is the third button within the box labeled “Model Initiation Controls” on the **controls** page. It computes daily conditions for pH and temperature based on grab sample values and the suite of characteristics defining temporal variation in pH and temperature. The mean pH is computed from the observed pH and the sampling time recorded on each sampling date, and values on dates not sampled are set by linear interpolation. The same is done for temperature (not required for the acute analysis). For every day in the interpolated record, the maximum daily pH is calculated from the daily means and the month-specific amplitudes. The maximum pH is used in the acute analysis.

The analysis for chronic conditions is more complex primarily because it is not sufficient to track patterns of the underlying variables. The setpoint analysis is designed to produce the values of pH and temperature that correspond to the limiting condition for the standard; this does not necessarily correspond to extremes of either pH or temperature alone. The analysis becomes a mechanism for integrating the nonlinear effects of pH and temperature. After the macro has concluded, the user must go to the page labeled **chronic** and adjust threshold value manually for the CCC. The objective is to set the threshold such that the number of exceedences is 1 per three years, or 0.33/y. Once the threshold has been set, click on the “Accept Threshold” button to confirm selection and proceed with the analysis.

Several columns of calculations on the **chronic** page have been hidden to make it easier to view relevant features of the analysis. Those columns can be displayed by clicking on the button “More Detail.” Six columns of additional calculations will be displayed. They can be hidden again by clicking on the same button, which will read “Less Detail.”

Occasionally, it may be useful to repeat the analysis after changing or deleting elements in the data set. Because all calculations will be erased in this process, it may be prudent to save the file under a different name before proceeding. After data elements have been changed, return to the **controls** page and select the button “Reset Calculations” which appears in the box labeled “Model Reset Controls.” Then it is possible to accept the revised data set and repeat the calculations. It is also possible to clear the raw data set (another button in the box labeled “Model Reset Controls”) and start over with a new data set. In general, however, it is preferable to begin with a fresh copy of the model for each data set to avoid carrying forward site-specific selections of characteristics.

Results of the setpoint analysis, which are summarized on the **setpoint** page, are used in the reach model, as discussed below. The setpoint analysis can be performed on as many data sets as are available. The reach model is designed to accept up to 6 sets, but can be expanded (by extending the boundaries associated with the relevant range names) to any number.

Longitudinal Water Quality Model

The longitudinal water quality model (**AMMTOX Reach Model.xls**) uses mass balance principles to predict changes in water quality through a series of discrete stream reaches. The format is intended for application in a TMDL-style situation. There can be as many as 200 reaches, which will extend predictions over 20 miles of river (if a reach length of 0.1 miles is used), and up to 30 source flows, including as many as 6 wastewater treatment facilities. Graphs are used for immediate feedback on the downstream effects of a particular effluent limitation for each discharger.

Initial conditions for each run are specified in the first page (**control**) of the worksheet (Figure 5). These conditions must match those used in the recurrence analysis, but they are not linked. A yellow background appears in cells where the user can enter new data or make changes to existing values. There are also a few instances, described later, where numeric values may be typed over an existing formula in cells that do not have a yellow background.

Reach length is set to a nominal value of 0.1 miles, but this may be changed by typing a different value, for example 0.2 miles, that would affect all reaches in the model. Alternatively, lengths of some or all reaches maybe changed individually in column C of the **chronicmod** page. Changes in reach lengths that are made on the **chronicmod** page automatically affect reach lengths on the **acutemod** page through linked cells.

Rebound rates for temperature and pH have default values of 0.7 degrees C/mi and 0.2 s.u./mi respectively. If the default values are changed on the **control** page, a note will appear in column C indicating that values are “not default.” The terms of the velocity equation can also be adjusted on the control panel, but that requires supporting information on channel geometry. It is also possible to override the equation by supplying velocities for individual reaches. This is done in column AR on the **chronicmod** page. When a value is typed in that column, it supersedes the value produced by the power function (see column AQ). The same feature is available on the

acutemod page. For obvious reasons, velocities on the two pages are not linked. The seepage accrual rate and ammonia concentration have default values of 0, but these can be changed if supporting data are available. Finally, the ammonia removal rate can be changed to reflect results of site-specific studies (this rate is defined in base e, not base 10). The temperature adjustment factor could also be changed, but there is little reason to do so. There is a long list of constants related to the calculation of CMC and CCC that should match the values used in the recurrence analysis. If the reach model includes stream segments that differ with respect to the presence of salmonids or ELS, more substantial changes, beyond the scope of this manual, will be required.

The last item shown in Figure 5 is labeled “Minimum Flow,” which sets a floor for flow in all mass balance calculations. It prevents division by zero and calculation with negative flows, which would otherwise be a possibility if seepage is negative, headwater low flows are zero, or a diversion can equal or exceed flow in the stream. The default floor is set at 0.1 cfs, but any positive value could be used depending on what is reasonable in a given situation.

**AMMTOX
Control Panel**

Scenario Definition

	Entered	In Use
Month	7	July ELS Absent

User-supplied Information

Site Name:	u-name-it	
Nominal Reach Length, mi	0.1	
Salmonids present? (Y or N)	Y	Salmonids Present
ELS present? (Y or N)		
Jan	N	ELS Absent
Feb	N	ELS Absent
Mar	N	ELS Absent
Apr	N	ELS Absent
May	N	ELS Absent
Jun	N	ELS Absent
Jul	N	ELS Absent
Aug	N	ELS Absent
Sep	N	ELS Absent
Oct	N	ELS Absent
Nov	N	ELS Absent
Dec	N	ELS Absent

Rebound Rates

Temperature, °C/mi	0.70	Default
pH, s.u./mi	0.20	Default

Velocity Equation

coefficient a, $V=aQ^b$	0.30	Default
exponent b, $V=aQ^b$	0.40	Default

Seepage Conditions

Accrual Rate, cfs/mi	0.0	Default
Ammonia conc, mg/L	0.0	Default

Ammonia Removal Rate

K3 at 20 °C	6.0	Default
Temperature Adj Factor	1.080	

Minimum Flow, cfs	0.1	
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Figure 5. Operating conditions for the reach model of AMMTOX. Some information must be supplied by the user to characterize a particular site, and some information reflects default conditions that may be changed by the user when proper justification exists.

The **control** page also contains a list of constants controlling the calculation of standards. The values must match those used in the recurrence model (see Figure 2).

It is worth emphasizing that there are two ways to change most constants in the model. General conditions can be changed on the **control** page, and reach-specific values can be changed by typing over formulas on the **chronicmod** or **acutemod** pages. The flexibility is desirable, but it requires more attention to detail for proper setup of each run. In particular, it is a good idea always to start with a blank file (i.e., one that has not been altered for any previous run). If a previous run is used, there will always be a risk that a flow value will be left in row 108, for example, or a modified reach length will not reset when the nominal value is changed. In addition, careful documentation of changes, especially those that are reach-specific, is an essential part of the modeling process. Changes to general conditions can be recorded easily by printing the contents of the control page, but documenting reach-specific changes by printing a sheet with 200 rows would be very cumbersome.

Flows should be loaded on page labeled **flow** and there must be entries for each of the twelve months, although they could be identical (Figure 6). Note that headwater flows are separate from the other sources. Headwaters must be defined as minimum flow conditions (e.g., biologically-based, $7Q_{10}$, etc.). There are separate values for chronic and acute low flows. All flows entered as cfs. Flows should be loaded for each source, and although it is not essential that they be loaded in longitudinal sequence, it is a good idea to do so. In particular, it is imperative that flows be loaded in the same sequence that chemistry data will be loaded. For convenience, the name of each source can be typed over "source 1", "source 2", etc., on the **chem**. Page, but the offset number should not be changed. If effluent design flows are involved, these must be converted to cfs.

Effluents must use Design Flows		See Graphs Below											
Offset	SITE	CHRONIC FLOWS, cfs											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Headwater	25	25	25	25	25	25	25	25	25	25	25	25
1	WWTP A	23.205	23.205	23.205	23.205	23.205	23.205	23.205	23.205	23.205	23.205	23.205	23.205
2	WWTP B	7.735	7.735	7.735	7.735	7.735	7.735	7.735	7.735	7.735	7.735	7.735	7.735

Figure 6. A portion of the flow page of AMMTOX showing entries for chronic flow conditions for the headwaters and two WWTPs. A comparable block (not shown) is used for acute flows.

With the present version of AMMTOX, it is also possible to include the effects of diversions. Characteristic withdrawals must be entered for each month, and all non-zero flows should be shown as negative values (to reduce the flow in the main channel). If the diversion exceeds the flow in the river for a particular scenario, river flow will be set arbitrarily to 0.1 cfs (the default value for minimum flow, specified on the **control** page). Withdrawals have no direct effect on stream chemistry (i.e., the mixed values for temperature, pH, and total ammonia will be equal to the upstream values).

Although it is possible to have different acute and chronic flows for each tributary, it may not be practical to do so. Users should be cautious about applying DFLOW values to some or all of the sources unless there is evidence to suggest that co-occurrence of low flows is a high probability event. Even if it is decided to use the same flows for chronic and acute conditions, flows must be entered separately in both tables.

On the chemistry page (**chem**), enter temperature, pH, and total ammonia for headwaters and for each source (Figure 7). Total ammonia concentrations are not required for sources that are wastewater treatment facilities for which limits will be set in the analysis. Sources must appear in the same order and in the same row number as those on the flow page. Nothing should be typed in the gray-shaded areas to the right of the total ammonia field; these incorporate values for effluents. Up to 6 of the sources can be wastewater treatment facilities. They can be in any one of the 30 slots, but each one must also be assigned a number in the WWTP number column. Most of the entries in this column will be zero indicating that the source is not a wastewater treatment facility. Only numbers 1 through 6 may be used for this assignment, and it is a good idea to assign numbers in longitudinal sequence.

CHEMISTRY INPUT DATA SETS														
SITE	WWTP Number	Source Offset	Temperature, °C											
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Headwater Conditions			5	8	11	14	17	20	20	20	17	14	11	8
WWTP A	1	1	20	20	20	20	20	20	20	20	20	20	20	20
WWTP B	2	2	20	20	20	20	20	20	20	20	20	20	20	20

Figure 7. A portion of the chem page of AMMTOX showing entries for temperature for the headwaters and two WWTPs. Comparable blocks (not shown) are used for pH and ammonia.

The next step involves installation of setpoint values on the page labeled **setpoint**. Acute and chronic values for pH and chronic values for temperature must be entered for each month of the year (Figure 8). The chronic setpoint temperatures also are applied to the acute analysis. Setpoint values are derived from the recurrence model. Up to 6 sets of setpoint values may be installed, but typically only the one set is used. The name of the location from which setpoint data were taken can be type in place of “setpoint 1”, “setpoint 2”, etc.

In column D of the **chronicmod** page, the source offset for all reaches except the headwater has a default value of zero, which indicates that no flow is added to or withdrawn from that reach. If a tributary, WWTP, or diversion will affect the flow in a reach, and therefore the mass balance, a positive integer must be entered for the source offset. The number correspond must match the offset of the source for which data were entered on the **chem** and **flow** pages. Repeat as needed until all sources have been labeled. Make sure that the offset number assigned to the last source is same as a total number of sources that will be included in the analysis.

Setpoint Conditions													
		Chronic Setpoint Temperature, °C											
SITE	Setpoint Offset	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Setpoint 1	1	2.4	4.2	8.8	11.6	14.5	16.2	19.8	18.3	17.7	12.8	8.1	5.1
Setpoint 2	2												
Setpoint 3	3												
Setpoint 4	4												
Setpoint 5	5												
Setpoint 6	6												
		Acute Setpoint Temperature, °C											
SITE	Setpoint Offset	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Setpoint 1	1	2.4	4.2	8.8	11.6	14.5	16.2	19.8	18.3	17.7	12.8	8.1	5.1
Setpoint 2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Setpoint 3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Setpoint 4	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Setpoint 5	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Setpoint 6	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Chronic Setpoint pH											
SITE	Setpoint Offset	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Setpoint 1	1	8.4	8.5	8.5	8.3	8.2	8.0	8.0	8.1	8.1	8.3	8.4	8.4
Setpoint 2	2												
Setpoint 3	3												
Setpoint 4	4												
Setpoint 5	5												
Setpoint 6	6												
		Acute Setpoint pH											
SITE	Setpoint Offset	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Setpoint 1	1	8.8	8.9	8.8	8.7	8.9	8.7	8.8	8.7	8.6	8.9	8.9	8.6
Setpoint 2	2												
Setpoint 3	3												
Setpoint 4	4												
Setpoint 5	5												
Setpoint 6	6												

Figure 8. Appearance of the setpoint page of AMMTOX showing locations for data entry. Setpoint values are derived from the recurrence analysis. Acute setpoint temperatures (gray background) are set equal to the chronic values for reasons explained in the text.

In column E of the **chronicmod** page, setpoint offset numbers are entered for the purpose of creating a link to the setpoint conditions that will guide rebound. All values are zero in the unedited spreadsheet. If zero is retained, all changes in pH and temperature will be driven solely by mass balance calculations, and rebound will not function. Determine which reaches will be affected by rebound. Typically this will extend from the outfall to a point several miles downstream. Enter 1 in the setpoint offset column for each and every reach in this section of model. If an additional setpoint exists, enter 2 in each row for this part of the model. Whenever a number appears in this column, it determines the target value toward which rebound will move pH and temperature in the stream. Up to six sets of rebound conditions can be entered in the model. If no setpoint offset is supplied, rebound will not function in that reach. No further alterations should be required on the **acutemod** page.

On the **control** page, enter the number corresponding to the month for which limits will be set. Move to the block for chronic ammonia values (below the upper graph) and enter the source offsets that will apply to each wastewater treatment facility of interest (typically, there will only be one facility). Verify on the **chem** page that the corresponding wastewater treatment number has been entered next to the source offset number. Enter a trial value for total ammonia under conditions for the month of interest. Adjust the value until the predicted concentration of total ammonia (blue line) touches the chronic limit (red line). If more than one discharger is present, the selection of total ammonia values will depend on the TMDL strategy being employed. For example, if all wastewater treatment facilities will be governed by the same concentration, then all must be set simultaneously. More likely, however, there will be considerations involving technological limits or issues of fairness, etc. that are best determined by negotiation.

Follow the same procedure for acute ammonia in the corresponding table below the acute graph. If the acute value is less than the chronic value, a warning symbol (<) will appear in the blue-shaded block of cells below the block used to enter acute values. This is simply an advisory notice that does not compel any action on the part of the operator and has no effect on model operation.

Appendix A – Test run of recurrence model

The file for the test run is **TEST Recur Model.xls** which comes loaded with a suitable data set. A test data set, complete with site-specific characteristics of variation for pH and temperature, already has been entered to facilitate the training process. The exercise takes a realistic data set, complete with blemishes, as a way of demonstrating how to correct data, change some constants and obtain setpoint values. The exercise will be run with default characteristics of pH (M for amplitude) and temperature variation, and then run again after choosing user-defined values for those characteristics. For this example, it is assumed that salmonids are present, but that ELS are not present in any month.

When the data set is screened, 10 errors will be encountered (Table A-1). Changes should be made according to the entries shown in the table. When screening is complete, the maxima and minima should appear as in Table A-2, and there will be 3 possible outliers, but no probable outliers. The data set should be “accepted” at this time (button on **controls** page).

Select the button that activates calculations for acute and chronic conditions. When the macro has stopped, adjust the threshold value on the **chronic** page until the exceedences do not exceed 0.33/y (Hint: the answer is 1.082, and it yields a slightly lower threshold). Output on the setpoint page should match the values listed in Table A-3.

The exercise will be repeated using a different set of conditions for variation in pH and temperature. To make the second run, calculations must be reset by selecting the red button “Reset calculations” on the **controls** page. Next, type “User” in each of the four boxes for characterizing pH and temperature variation. Finally, run the acute and chronic calculations again. The chronic threshold is slightly different (1.562). Accept the threshold value and view the setpoint values, which have changed (Table A-3).

Sample Date	Problem	Resolution
9-Sep-1997	Missing temperature	21
28-Apr-1998	Missing time and pH	Delete entry
29-Apr-1998	Missing time and temperature	Delete entry
12-Nov-1998	Missing time	Delete entry
7-Apr-1999	Missing time	Set time to 9:15
7-Jul-1999	Missing time	Delete entry
26-Oct-1999	Missing temperature	8.9
5-Jan-2000	Missing time	Delete entry
3-Nov-2000	Missing time and pH	Delete entry
6-Dec-2000	Missing time	Delete entry

Table 1. Actions required to correct test data set prior to model run.

Earliest Date	Min Time	Min pH	Min Temp	Min Interval#	Intervals > 30 d
1-Jan-97	7:27	6.73	0	4	1
Latest Date	Max Time	Max pH	Max Temp	Avg Interval	
26-Jun-02	14:46	9.02	23.7	7.8	

Table 2. Characteristics of screened data set.

Default Setpoint Values

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chronic Median Temp	3.3	5.4	10.5	12.3	15.4	18.4	22.0	20.1	17.7	12.6	9.0	5.8
Chronic pH	8.39	8.51	8.51	8.40	8.22	8.14	8.22	8.28	8.28	8.31	8.42	8.36
Acute pH	8.72	8.83	8.64	8.67	9.01	8.83	8.86	8.73	8.63	8.94	8.93	8.60

User Setpoint Values

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chronic Median Temp	2.4	4.2	8.8	11.3	14.5	16.2	19.8	18.3	17.7	12.8	8.1	5.1
Chronic pH	8.42	8.52	8.51	8.38	8.19	8.05	8.02	8.12	8.15	8.31	8.46	8.38
Acute pH	8.76	8.90	8.84	8.68	8.93	8.67	8.80	8.68	8.57	8.93	8.92	8.61

Table 3. Setpoint conditions derived from test data set with default characteristics of variation and with user-defined characteristics of variation.

Appendix B – Test run of reach model

A very simple test case has been assembled for the reach model in which there are two WWTPs and no tributaries, diversions, or seepage. Flow at the start of the reach is 25 cfs in all months for chronic conditions, and 20 cfs for acute. The first WWTP is located 1.90 mi from the start of the reach and has a design capacity of 15 mgd. The second WWTP is 15 mi from the start of the reach and has a design capacity of 5 mgd.

There is no ammonia upstream of the first WWTP. Temperature in the stream varies seasonally from 5 to 20 °C. Effluent temperature is constant at 20°C in all months. The pH in the stream is 8 in all months. Effluent pH is 7 for WWTP A and 8 for WWTP B. Setpoint conditions have been loaded, and they define trend for pH and temperature for all reaches downstream of the first outfall.

Locate the appropriate reaches on the **chronic** page (1.90 and 15.00 miles) and enter source offsets 1 and 2, respectively, in column D. Until the source flows are identified in this manner, their additions to mass balance will not be represented in the model. The setpoint offset (1) must be entered in every reach for which those conditions will apply. In this case, start with the reach receiving effluent from the first WWTP (row 28) and make sure that a “1” is entered in column E for all subsequent reaches to the end of the model (row 209).

On the **control** page, enter source offset numbers in column F under the “chronic total ammonia” section. The names of the WWTPs will appear in the adjacent cells of column E. Select September (enter 9 in cell B5) and begin adjusting the chronic permit limits. Limits will be about 8.5 for WWTP A and about 10 for WWTP B. Acute limits for the same month will be about 15 and 12 for the two facilities. The following figure shows the concentration profiles for chronic conditions in September.

