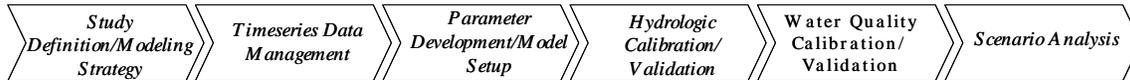




Exercise 12 – Nutrient, Dissolved Oxygen, and Algae Modeling

BASINS/HSPF Application Steps



In this exercise, we will add nutrients, BOD, dissolved oxygen, and algae to a Western Patuxent model that has been previously calibrated for hydrology, sediment, and water temperature. We will discuss modeling a watershed's nutrient and BOD/organic matter loads using PQUAL and IQUAL, as well as instream modeling of nutrients, dissolved oxygen, and algae. To assess parameter sensitivity, we will adjust key calibration parameters and examine the results.

We will model the following non-point source constituents:

- Water Temperature (added in Exercise 9)
- Dissolved Oxygen
- Total Ammonia as Nitrogen
- Nitrate as Nitrogen
- Orthophosphate as Phosphorus
- BOD/Organics

In WinHSPF, after the resultant non-point source loadings are calculated individually for each land use, they and identified point sources are added to their corresponding channel reaches. For each channel reach, WinHSPF will simulate the fate, transport, and delivery of the nutrient loads using the reach quality module (RQUAL).

Questions addressed in this exercise:

- 1) How do I add nutrients, BOD/organics, dissolved oxygen, and algae to my model?
- 2) What are the required inputs for estimating nutrient and BOD/organic matter loading from the watershed?
- 3) What tables and inputs are required for modeling nutrients, BOD, dissolved oxygen, and algae for the instream portion of my model?
- 4) How do I plot the output for dissolved nutrients, dissolved oxygen, BOD, and phytoplankton as chlorophyll *a* concentrations?
- 5) Which parameters affect nutrients, dissolved oxygen, and algae?

A. Adding Nutrients, BOD, Dissolved Oxygen and Algae in WinHSPF

QUESTION ANSWERED:

1) How do I add nutrients, BOD, dissolved oxygen, and algae to my model?

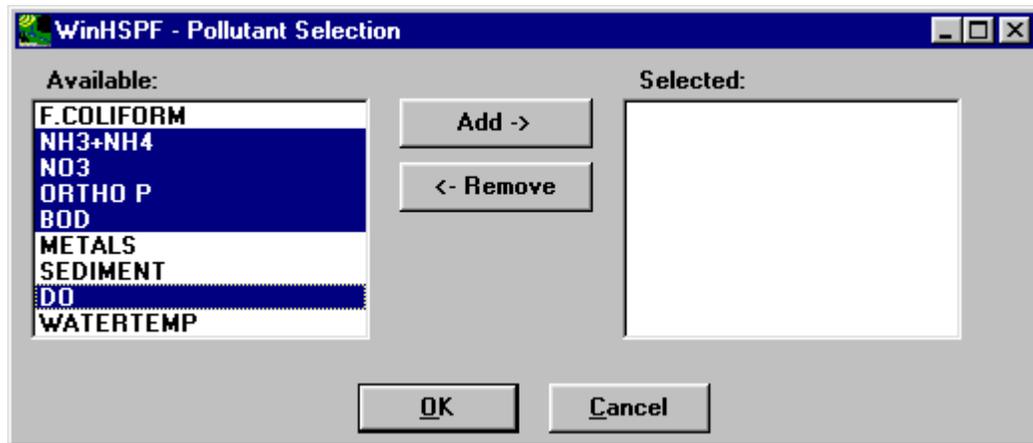
In this section, we will add nutrients, dissolved oxygen, BOD, and algae to our WinHSPF model.

1. If WinHSPF isn't already open, from the **Start** menu under **Programs**, select **BASINS** and then **WinHSPF**.
2. From the **File** menu, select **Open**.
3. Navigate to `c:\basins\modelout\nutrient` and select "nutrient.uci." Click OPEN.



4. Click the "Pollutant Selection" button.
5. Click "NH3+NH4," "NO3," "ORTHO P," "BOD," and "DO" in the "Available" window while holding the "Ctrl" key down.

Note: We don't need to select SEDIMENT nor WATERTEMP because this *.uci file already has sediment and water temperature implemented and calibrated (see Exercise 9). The "Pollutant Selection" tool does not indicate that sediment and water temperature are selected, but the "Control Cards" show that these modules have been selected.



6. Click ADD. The selected items will be transferred from the "Available" frame to the "Selected" frame.
7. Click OK.

Note: Appendix G explains the modules, tables, and MASS-LINKS that are added when a pollutant is chosen in the "Pollutant Selection" tool. Appendix F shows more detail about what happens behind the scenes when a pollutant is chosen in the "Pollutant Selection" tool. Appendix F is specific to fecal coliform and temperature, but the process or steps taken are similar for each

constituent with only the modules, tables, and MASS-LINKS varying according to Appendix G. As stated in a previous exercise, when a pollutant is selected using the “Pollutant Selection” tool, the required “Control Cards” are selected, the corresponding tables are added for each constituent selected, and the appropriate MASS-LINKS are added. Additionally, some of the fields within the tables are updated.

8. Click the “Edit Control Cards” button, .
9. Click DESCRIPTIONS.
10. Make sure the “Pervious Land” tab is active. Notice the following modules are selected.

***ATEMP** - Module that estimates the surface air temperature over the land segment by correcting for elevation differences between the gage and the land segments.*

***PWATER** – Module used to calculate the components of the water budget, primarily to predict the total runoff from a pervious area.*

***SEDMNT** - Module that simulates the production and removal of sediment from a pervious land segment.*

***PSTEMP** - Module that simulates soil temperatures for the surface, upper, and lower/groundwater layers of a land segment for use in module section PWTGAS and the agri-chemical sections.*

***PWTGAS** – PWTGAS estimates water temperature and concentrations of dissolved oxygen and carbon dioxide in surface, interflow, and groundwater outflows from a land segment.*

***PQUAL** - Module that simulates water quality constituents or pollutants in the outflows from a pervious land segment using simple relationships with water and/or sediment yield. Any constituent can be simulated with this module section.*

Pervious Land	Impervious Land	Reaches/Reservoirs
<input checked="" type="checkbox"/> ATEMP - Air Temperature Elevation Difference		
<input type="checkbox"/> SNOW - Accumulation and Melting of Snow and Ice		
<input checked="" type="checkbox"/> PWATER - Water Budget Pervious		
<input checked="" type="checkbox"/> SEDMNT - Production and Removal of Sediment		
<input checked="" type="checkbox"/> PSTEMP - Soil Temperatures		
<input checked="" type="checkbox"/> PWTGAS - Water Temperature and Dissolved Gas Concentrations		
<input checked="" type="checkbox"/> PQUAL - Quality Constituents Using Simple Relationships		
<input type="checkbox"/> MSTLAY - Moisture Content of Soil Layers		
<input type="checkbox"/> PEST - Pesticide Behavior		
<input type="checkbox"/> NITR - Nitrogen Behavior		
<input type="checkbox"/> PHOS - Phosphorous Behavior		
<input type="checkbox"/> TRACER - Movement of a Tracer		

Note: Appendix F explains which modules and tables were automatically selected in the “Pervious Land” tab when each constituent was added using the “Pollutant Selection” tool.

11. Click the “Impervious Land” tab. Notice that the following modules are now selected.

- ATEMP** - Module that estimates the surface air temperature over the land segment by correcting for elevation differences between the gage and the land segments.
- IWATER** - This module simulates the retention, routing, and evaporation of water from an impervious land segment.
- SOLIDS** - This module simulates the accumulation and removal of solids by runoff and other means from the impervious land segment.
- IWTGAS** - IWGAS estimates the water temperature and concentrations of dissolved oxygen and carbon dioxide in the outflow from the impervious land segment.
- IQUAL** - The IQUAL module section simulates water quality constituents or pollutants in the outflows from an impervious land segment using simple relationships with water yield and/or solids. Any constituent can be simulated with this module section.

Pervious Land	Impervious Land	Reaches/Reservoirs
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Note: Appendix F explains which modules and tables were automatically selected in the “Impervious Land” tab when each constituent was added using the “Pollutant Selection” tool.

12. Click the “Reaches/Reservoirs” tab. Notice the modules are now selected.

- HYDR** - Module that simulates the hydraulic processes occurring in a reach or a mixed reservoir (RCHRES).
- ADCALC** - Module that calculates values for the variables necessary to simulate longitudinal advection of dissolved or entrained constituents. These variables are dependent upon the volume and outflow values calculated in the hydraulics section (HYDR).
- HTRCH** - Module that simulates the processes that determines the water temperature in a reach or mixed reservoir.
- SEDTRN** - Module that simulates the transport, deposition, and scour of inorganic sediment in free-flowing reaches and mixed reservoirs.
- RQUAL** - Parent routine to the four subroutine groups which simulate constituents involved in biochemical transformations.
- OXR** - Module that simulates the primary processes that determine the dissolved oxygen concentration in a reach or mixed reservoir.
- NUTR** - Module that simulates the primary processes that determine the balance of inorganic nitrogen and phosphorus in natural waters.
- PLANK** - Module that simulates phytoplankton, zooplankton, and/or benthic algae.

Pervious Land	Impervious Land	Reaches/Reservoirs
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> HYDR - Hydraulic Behavior
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> ADCALC - Advection of Fully Entrained Constituents
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> CONS - Conservative Constituents
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> HTRCH - Heat Exchange and Water Temperature
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> SEDTRN - Behavior of Inorganic Sediment
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> GQUAL - Generalized Quality Constituents
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> OXRX - Primary DO and BOD Balances
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> NUTRX - Primary Inorganic Nitrogen and Phosphorus Balances
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> PLANK - Plankton Populations and Associated Reactions
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> PHCARB - pH, Carbon Dioxide, Total Inorganic Carbon, and Alkalinity

Note: Appendix F explains which modules and tables were automatically selected in the “Reaches/Reservoirs” tab when each constituent was added using the “Pollutant Selection” tool.

13. Click OK.

14. Click the “Input Data Editor” button, . Look through the tables that are associated (and automatically added (in bold)) with each newly selected module. An outline of the tables and parameters associated with these modules is included at the end of the exercise. It is critical to understand how the tables within each module relate to each other. Additionally, it is important to understand how flags set in one table determine the required inputs in others.

In the following sections, we will discuss a few of the key inputs that were automatically populated when using the “Pollutant Selection” tool.

B. Watershed Loading of Nutrients and BOD/Organics

QUESTION ANSWERED:

2) *What are the required inputs for estimating nutrient and BOD/organics loading from the watershed?*

This section will explain the inputs required to model nutrient and BOD/organic loads to the stream and will help us understand the resulting instream dissolved oxygen, nutrient, and algae dynamics (discussed in the next section). There are two available methods for modeling nutrient and BOD/organic loads in HSPF using PQUAL and IQUAL: 1) accumulation and depletion/removal with a first-order washoff rate for all constituents and 2) a potency factor approach that indicates constituent strength relative to the sediment removal. Recall that we applied the first-order washoff rate in the fecal coliform exercise. We will use a similar approach for NO_3 , NH_3+NH_4 , and BOD/organics since these constituents are generally not adsorbed to sediment. However, because orthophosphate tends to adsorb to sediment and the phosphorus load is highly correlated to the sediment load, we will use a potency factor approach to model this constituent.

PERVIOUS LAND

PWTGAS

PWTGAS estimates water temperature and concentrations of dissolved oxygen and carbon dioxide in surface, interflow, and groundwater outflows from a land segment. The inputs for this module were discussed in Exercise 9 and Appendix F when we were populating inputs for water temperature modeling. We will not change the inputs in this section.

PQUAL

1. **Double click** PERLND →PQUAL → NQUALS. Click OK if asked whether to add the table. Notice that the value for NQUAL is “4” for each pervious land segment. This specifies that we will model four general quality constituents (those chosen in the “Pollutant Selection” tool): total ammonia (Occurrence 1), nitrate (Occurrence 2), orthophosphate (Occurrence 3), and biochemical oxygen demand (Occurrence 4).

OpNum	Description	NQUAL
101	Forest Land	4
102	Urban or Built-up La	4
103	Agricultural Land	4
104	Barren Land	4
105	Wetlands	4

2. Click OK or CANCEL.
3. **Double click** QUAL-PROPS.

<input checked="" type="checkbox"/> Show Description Occurrence <input type="text" value="1"/>		QUALID	QTYID	QSDFG	VPFWFG	VPFSG	QSOFG	VQOFG	QIFWFG	VIQCFG	QAGWFG	VAQCFG
101	Forest Land	NH3+NH4	LBS	0	0	0	1	1	1	3	1	3
102	Urban or Built-u	NH3+NH4	LBS	0	0	0	1	1	1	3	1	3
103	Agricultural Lar	NH3+NH4	LBS	0	0	0	1	1	1	3	1	3
104	Barren Land	NH3+NH4	LBS	0	0	0	1	1	1	3	1	3
105	Wetlands	NH3+NH4	LBS	0	0	0	1	1	1	3	1	3

Note: Notice that the QUALID (constituent name) and QTYID (units of constituent) columns were automatically populated for NH3+NH4. Change the “Occurrence” to 2 and you will see NO3. “Occurrence” 3 and 4 represent Ortho P and BOD/organics, respectively. Also notice that the each of these constituents is assumed to be associated with overland flow (QSOFG), interflow (QIFWFG), and groundwater (QAGWFG) by these flags being turned on (set to 1) automatically. We will need to change the inputs for Ortho P (Occurrence 3) because we have chosen to model it using the potency factor approach. This is done by changing the flag for Occurrence 3

(orthophosphate) so that it is sediment-associated (QSDFG set to 1) rather than overland-flow associated (QSOFG set to 1).

4. In the “Occurrence” menu, select “3.”
5. Click in the “QSDFG” column and enter “1” in the first cell. **Double click** the column heading to copy the values to the other cells.

Note: Setting “QSDFG” to “1” depicts that this constituent is associated with sediment loads.

6. Click in the “VPFWFG” column and enter “2” in the first cell. **Double click** the column heading to copy the values to the other cells.
7. Click in the “QSOFG” column and enter “0” in the first cell. **Double click** the column heading to copy the values to the other cells.

Note: Setting “QSOFG” to “0” specifies that this constituent is not associated with overland flow.

8. Click in the “VQOFG” column and enter “0” in the first cell. **Double click** the column heading to copy the values to the other cells.
9. Click APPLY.
10. Click OK.
11. **Double click** QUAL-INPUT. Read the following parameter explanations:

***SQO:** The initial storage of QUALOF on the surface of the PLS.*

***POTFW:** The washoff potency factor for a QUALSD. A potency factor is the ratio of constituent yield to sediment (washoff or scour) outflow.*

***POTFS:** The scour potency factor for a QUALSD. A potency factor is the ratio of constituent yield to sediment (washoff or scour) outflow.*

***ACQOP:** The rate of accumulation of QUALOF if QSOFG is positive. If QSOFG is negative, then ACQOP is the concentration of QUALOF in the surface outflow in mg/l.*

***SQOLIM:** The maximum storage of QUALOF if QSOFG is positive.*

***WSQOP:** The rate of surface runoff that will remove 90 percent of stored QUALOF per hour.*

***IOQC:** The concentration of the constituent in interflow outflow (meaningful only if this is a QUALIF).*

***AOQC:** The concentration of the constituent in active groundwater outflow (meaningful only if this is a QUALGW).*

Recall that QUALOF stands for the “Quality associated with Overland Flow,” QUALSD stands for the “Quality associated with Sediment,” QUALIF stands for the “Quality associated with Interflow,” and so forth. Also remember that we are modeling orthophosphate as sediment associated, so we are interested in POTFW. We have set the VPFWFG to “2,” specifying that we will provide monthly values for POTFW for orthophosphate. This means that it isn’t necessary to provide any POTFW values in this table for Occurrence 3.

Note: The default values for SQO and WSQOP can be ignored or changed to zero for Occurrence 3. WinHSPF will not use these values because we are using the potency factor approach instead of the build up washoff approach.

12. Click OK.

Note: Notice that the MON-ACCUM, MON-SQOLIM, MON-IFLW-CONC, and MON-GRND-CONC tables are already added (bold). Because we changed the flags in the QUAL-PROPS table for Occurrence 3, we can disregard the MON-ACCUM and MON-SQOLIM tables for this constituent (because these tables are associated with the accumulation and depletion/removal with a first-order washoff rate approach). We will need to populate the following tables: the MON-POTFW table for orthophosphate; the MON-ACCUM and MON-SQOLIM tables for NO₃, NH₃+NH₄, and BOD; and the MON-INFLW-CONC and MON-GRND-CONC tables for all constituents. To save time, we will continue on to the impervious land portion of the exercise. We will then open a new *.uci file later in the exercise that has all the correct information required in the specified monthly tables.

13. Click CANCEL.

IMPERVIOUS LAND

IQUAL

1. **Double click** IMPLND → IQUAL → NQUALS. Notice that the value in the “NQUAL” column is “4.” This specifies that we will model four quality constituents.
2. Click CANCEL.
3. **Double click** QUAL-PROPS. Notice that the QUALID and QTYID values are already populated for each of the four occurrences.

Note: This table is similar to the PERLND → QUAL-PROPS table. We will not need to make changes because we will not associate orthophosphate with sediment for impervious land. We will use the build up/washoff approach.

4. Click OK or CANCEL.
5. **Double click** QUAL-INPUT. The parameters in this table are similar to those in the PQUAL → QUAL-INPUT table. The difference is that the quality constituent(s) cannot be associated with interflow and groundwater since impervious land does not include these hydrologic components.
6. Click OK and then CLOSE.

7. From the **File** menu, select **Exit**.

C. Instream Modeling of Nutrients, DO, and Algae

In this section, we will briefly discuss the required inputs for nutrient, dissolved oxygen and algae modeling in the stream given the loads from the watershed. We will open a new *.uci file (*nutrien2.uci*) that has all the monthly tables for the PQUAL sections, the required inputs for IQUAL, and all the required instream parameters.

QUESTION ANSWERED:

3) *What tables and inputs are required for modeling nutrients, BOD, dissolved oxygen, and algae for the instream portion of my model?*

1. From the **File** menu, select **Open**.
2. Navigate to *c:\basins\modelout\nutrient* and select “*nutrien2.uci*.” Click OPEN.
3. Click  (Input Data Editor).

REACHES AND RESERVOIRS

4. **Double click** RCHRES → RQUAL. Look through the tables that are added (in bold) and the required inputs. For parameter explanations, refer to the outline at the end of the exercise.
5. **Double click** RCHRES → OXRX. Look through the tables that are added (in bold) and the required inputs. For parameter explanations, refer to the outline at the end of the exercise.
6. **Double click** RCHRES → NUTRX. Look through the tables that are added (in bold) and the required inputs. For parameter explanations, refer to the outline at the end of the exercise.
7. **Double click** RCHRES → PLANK. Look through the tables that are added (in bold) and the required inputs. For parameter explanations, refer to the outline at the end of the exercise.

Note: Bowie et al. (1985) summarizes typical ranges of values for many of the kinetic coefficients required by the RCHRES portion of WinHSPF.

8. Click CLOSE.

D. Selecting Output Time series for Nutrient Modeling

QUESTION ANSWERED:

4) *How do I plot the output for the various dissolved nutrient, dissolved oxygen, BOD, and phytoplankton as chlorophyll a concentrations?*

In this section, we will specify which output we would like the model to produce.

1. Click the “Output Manager” button, .
2. Click the button beside “Other.”
3. Click ADD.
4. In the “Operation” frame, select “RCHRES 5 (Western Branch Patuxent).”
5. In the “Group/Member” frame, select “OXRX:DOX.” This specifies that output will be produced for the dissolved oxygen concentrations in Reach 5 (mg/l).
6. Click OK.
7. Click ADD.
8. In the “Operation” frame, select “RCHRES 5 (Western Branch Patuxent).”
9. In the “Group/Member” frame, select “OXRX:BOD.” This specifies that output will be produced for the BOD concentrations in Reach 5 (mg/l).
10. Click OK.
11. Click ADD.
12. In the “Operation” frame, select “RCHRES 5 (Western Branch Patuxent).”
13. In the “Group/Member” frame, select “NUTRX:DNUST(1,1).” This specifies that output will be produced for the dissolved concentrations of nitrate (NO₃⁻) in Reach 5.

Note: The subscripts for the NUTRX:DNUST parameters represent various dissolved nutrients.

Subscript	Constituent	Requirement
1	NO ₃	-
2	TAM (Total Ammonia)	Must be modeling ammonia (TAMFG = 1)
3	NO ₂	Must be explicitly modeling NO ₂ (NO2FG = 1)

4	PO ₄ (Orthophosphate)	Must be modeling PO4 (PO4FG = 1)
5	NH ₄ ⁺	To determine valid NH ₃ /NH ₄ ⁺ fractions from TAM, the user must model pH, enter a timeseries of pH; otherwise pH = 7. See information on PHFLAG in table NUT-FLAGS
6	NH ₃	(same as NH ₄ ⁺)

14. Repeat the steps taken previously, except select the following constituents in the “Group/Member”:

 - “NUTRX:DNUST(2,1)” (total ammonia concentrations in Reach 5 (mg/l))
 - “NUTRX:DNUST(4,1)” (orthophosphate concentrations in Reach 5 (mg/l))
 - “PLANK:PHYCLA” (phytoplankton concentrations as chlorophyll in Reach 5 (ug/l))
 - “HTRCH:TW” (water temperature in Reach 5 (degree F))

15. Click CLOSE.
16. Click  (Run HSPF).
17. Click SAVE/RUN.
18. Click  (View Output through GENSCN).
19. Click the “HSPF Output” tab.
20. Check the box beside “c:\basins\modelout\nutrient.wdm.”
21. Click OK.
22. In the “Scenarios” frame, select “OBSERVED” and “NUTRIEN2.”
23. Click the “Add to time series list” button, .

Note: This will add all the time series available for “OBSERVED” and “NUTRIEN2.”

Note: The records for the DNUST time series indicate the subscript number, but not the nutrient type (nitrate, ammonia, nitrite, or orthophosphate). In the following steps, we will change the constituent names within GenScn so that we don’t have to keep track of the constituents according to the subscript numbers.

- 24. **Double click** the “DNUST1” timeseries in the “Time Series” frame. The “Edit Time Series Attributes” window should appear.
- 25. Click in the cell next to “Constituent” and enter “NO3.” Your screen should look similar to the following:

Attribute	DSN 1001
ID/DSN	1001
Scenario	NUTRIEN2
Location	RCH5
Constituent	NO3
Description	
Time Units	Day (4)
Time Step	1
DATCRE	20030127110940
DATMOD	20030127111028
TSTYPE	DNUS
TGROUP	6

- 26. Click OK.
- 27. **Double click** the “DNUST2” timeseries with the next DSN in the “Time Series” frame. The “Edit Time Series Attributes” window should appear.
- 28. Click in the cell next to “Constituent” and enter “TAM.”
- 29. Click OK.
- 30. **Double click** the “DNUST4” timeseries in the “Time Series” frame. The “Edit Time Series Attributes” window should appear.
- 31. Click in the cell next to “Constituent” and enter “PO4.”
- 32. Click OK. The three DNUST timeseries should now show up in the “Time Series” frame *similar* to the following:

WDM	nutrient	1001	NUTRIEN2	RCH5	NO3
WDM	nutrient	1002	NUTRIEN2	RCH5	TAM
WDM	nutrient	1003	NUTRIEN2	RCH5	PO4

- 33. Plot various constituents with the related observed data to see how well we are predicting each of the following constituents. The following table will help in understanding the difference between the observed and simulated data.

<i>Definition</i>	<i>Simulated Name (nutrien2)</i>	<i>Observed Name (Observed)</i>
Water Temperature	TW	TW
Nitrate (NO ₃ ⁻)	NO3	NO3
Total Ammonia (TAM)	TAM	-
Orthophosphate (PO ₄)	PO4	PO4

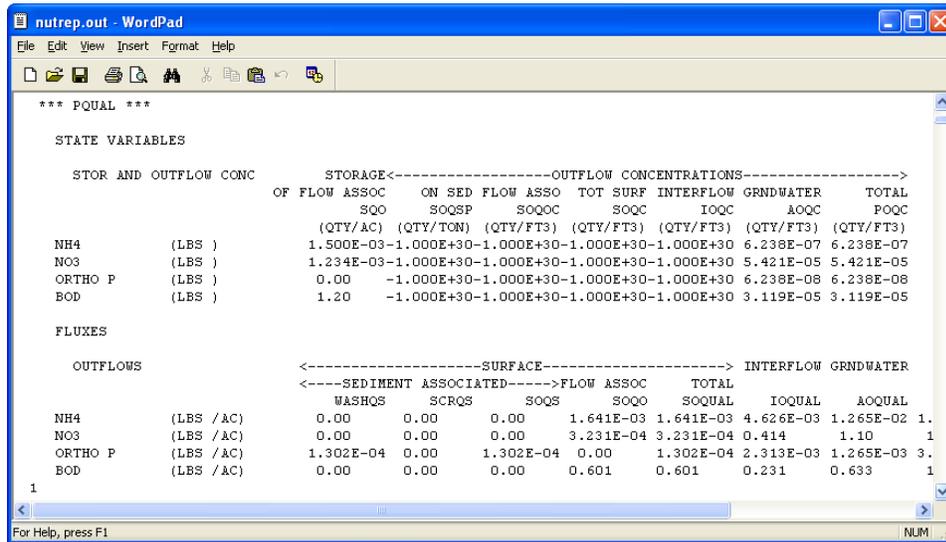
BOD	BOD	BOD
Dissolved Oxygen (DO)	DOX	DO
Phytoplankton Concentrations	PHYCLA	CHL-a

34. Close the plots and “Graph” window.

When modeling nutrients, the overland flow loads are as important to understand as instream concentrations. Some general information about loads from each land use is automatically written to the “.out” file associated with the “.ucf” file. We will first look at the information contained in the “.out” file and then we will use another reporting tool that can give us some additional information.

35. Using Windows Explorer or My Computer, navigate to *c:\basins\modelout\nutrient*.

36. Open *nutrep.out*. If prompted to select a program to open the file, select WordPad.



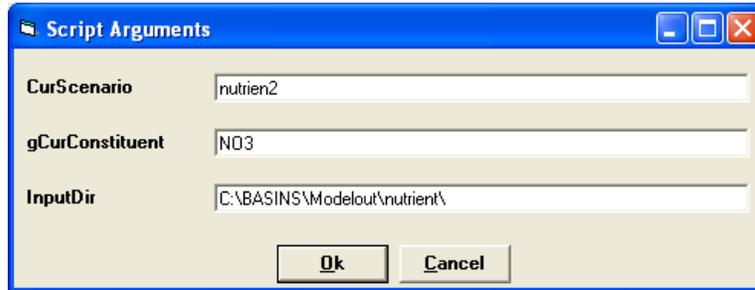
Note: In the PQUAL section of this output file, there is a list of the quality constituents simulated and their associated storage and outflow concentrations. In the next section, the total outflow of each of these constituents is provided in lbs/acre for each land use.

To provide a more comprehensive understanding of the overland flow loads, a set of scripts have been provided that produce another type of loading report summarizing some of the same information available in the “.out” file. It additionally provides other relative information such as the number of acres per landuse and the total loads from each landuse. In the following steps, we will produce an example report for NO3 using the scripts.

37. In GenScn, from the **Analysis** menu, select **Run Script**.

38. Navigate to *c:/basins/models/hspf/bin* and select “*GenScnWatershedSummary.spt*.”

- 39. Click OPEN.
- 40. In the “Script Arguments” window enter “nutrien2” in the “CurScenario” box, “NO3” in the “gCurConstituent” box, and “c:\BASINS\Modelout\nutrient\” in the “InputDir” box. Your screen should look like the following.

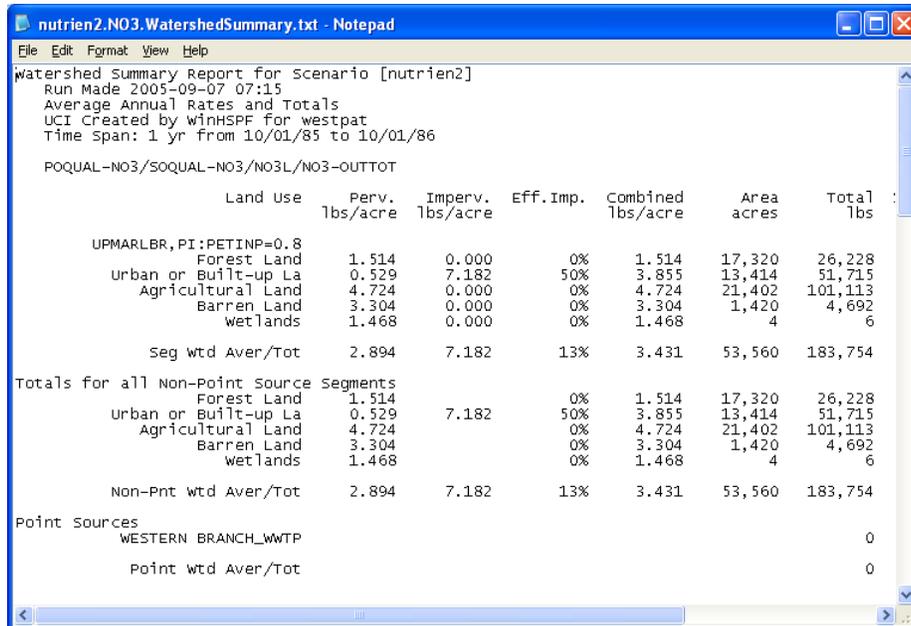


Notes: Be sure to use the same capitalization for the constituent name and include the backslash at the end of the input directory path.

Also note that these reports may be generated only for constituents for which a script has been prepared. GenScn includes scripts for the set of constituents listed below; or in other words, the valid values for “gCurConstituent” are as follows:

BOD, DO, FColi, Flow, Lead, NH3, NH4, NO3, OrganicN, OrganicP, PO4, Sed, TotalN, TotalP, WTEMP, and Zinc

- 41. Click OK and the script will run. When it has completed, the watershed summary report will open in a text editor. Your screen should look like the following.



Note: This report shows the per acre loading of NO₃ from each land use for each model segment. It also includes the total number of acres of each land use and the total number of lbs of NO₃ from each land use. We will talk more about these loads and calibration of them in the next exercise. We will also discuss some additional reports available in the next exercise.

You may repeat the process of producing the reports for other constituents, including BOD, DO, Flow, NH₄, OrganicN, OrganicP, PO₄, Sed (sediment), TotalN and TotalP.

42. Close “*nutrien2.no3.WatershedSummary.txt*” and any other reports you may have opened.

Note: These reports will be not be created each time you run the model. You will have to explicitly enter GenScn and run the report each time you run the model.

Note: When the reporting scripts are run, the file is saved in the “Output” folder located in the same folder as your “.uci” file.

43. Close GenScn and return to WinHSPF.

E. Calibration of Nutrients, DO, and Algae

In this section, we will discuss key calibration parameters for nutrients, dissolved oxygen and algae modeling. In order to assess the sensitivity and impact of these parameters on the nutrient simulation, we will adjust some of the parameter values and then examine the reports and graphs.

QUESTION ANSWERED:

5) *Which parameters should I adjust to calibrate nutrients, dissolved oxygen, and algae?*

There are several parameters you can adjust in WinHSPF to calibrate nutrients, dissolved oxygen, and algae. Below is an outline of some basic guidelines. **Read through these guidelines, but don’t make any changes to your model yet!!!**

Key Calibration Categories:

- ***Nutrient Loading***
 - potency factors (POTFW) for PO₄
 - rate of accumulation (ACQOP, MON-ACCUM) and storage (SQOLIM, MON-SQOLIM) for NO₃, TAM, BOD
 - sub-surface concentrations (IOQC, AOQC) for NO₃, TAM, PO₄, BOD
- ***Instream Nitrification and/or Denitrification***
 - reaction rates (KTAM20, KNO320)

- **Dissolved Oxygen**
 - reaeration rate (REAK, TCGINV, EXPRED, EXPREV)
 - BOD decay rate (KBOD20)
 - BOD settling rate (KODSET)
 - benthic oxygen demand (BENOD, EXPOD)
 - DO supersaturation factor (SUPSAT)

- **Phytoplankton and Benthic Algae Parameters**
 - algal growth rate (MALGR)
 - algal respiration rate (ALR20)
 - phytoplankton settling rate (PHYSET)
 - maximum benthic algae density (MBAL)
 - ratio of benthic algae to phytoplankton growth rate (CFBALG)
 - ratio of benthic algae to phytoplankton respiration rate (CFBALR)
 - fraction of N-requirements satisfied by NO₃ (ALNPR)

Now that you have a general idea of the calibration categories, we will adjust some parameters to ascertain their affects on the simulated nutrient, dissolved oxygen, and phytoplankton concentrations as chlorophyll *a*.



1. In WinHSPF, click the “Input Data Editor” button,
2. The table below gives some suggestions for adjusting parameters. Adjust the parameters, run the model, plot the corresponding constituents, and examine the resultant reports to determine the model’s sensitivity to each parameter.

Parameter	Location	Typical Range	Constituents to Plot
KNO320	RCHRES → NUTRX → NUT-NITDENIT	0.001-0.4 hr ⁻¹	NH ₃ , NO ₃ , DO
REAK	RCHRES → OXRX → OX-REAPARM	0.2-2.0 hr ⁻¹	DO and BOD
KBOD20	RCHRES → OXRX → OX-GENPARM	0.00004-0.04 hr ⁻¹	DO and BOD
KODSET	RCHRES → OXRX → OX-GENPARM*	0.0004-0.06 ft/hr	DO and BOD
MALGR	RCHRES → PLANK → PLNK-PARM1	0.008-0.3 hr ⁻¹	PO ₄ , TAM, NO ₃ , DO, Chl <i>a</i>
PHYSET	RCHRES → PLANK → PHYTO-PARM	0.001-0.55 ft/hr	PO ₄ , TAM, NO ₃ , DO, Chl <i>a</i>

*This parameter range is site specific.

If time allows, continue to vary these parameters and observe the effects of parameter changes on output concentrations.

References:

Bicknell, B.R., Imhoff, J.C., Kittle, J.L., Jr., Donigian, A.S., Jr. and Johanson, R.C., 2001. Hydrological Simulation Program -- FORTRAN, User's manual for Release 12. U.S. Environmental Protection Agency, EPA/600/R-97/080, Environmental Research

Laboratory, Athens, GA.

Bowie, G.L., Mills, W.B., Porcella, D.B., Campbell, C.L., Pagenkopf, J.R., Rupp, G.L., Johnson, K.M., Chan, P.W.H., Gherini, S.A., 1985. *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition)*. U.S. Environmental Protection Agency, EPA/600/3-85/040, Environmental Research Laboratory. Athens, GA.

NUTRIENT, BOD, DO, and ALGAE INPUTS

MODULE

TABLE

PARAMETER

PERVIOUS LAND

ATEMP *Module that estimates the surface air temperature over the land segment by correcting for elevation differences between the gage and the land segments.*

ATEMP-DAT (ATEMP Data)

ELDAT: *The difference in elevation between the temperature gage and the previous land segment; it is used to estimate the temperature over the pervious land segment by application of a lapse rate. It is positive if the pervious land segment is higher than the gage, and negative if the land segment is lower than the gage.*

AIRTMP: *The initial (i.e., at the starting time of the RUN) air temperature over the land segment.*

PSTEMP *Module that simulates soil temperatures for the surface, upper, and lower/groundwater layers of a land segment for use in module section PWTGAS and the agri-chemical sections.*

PSTEMP-PARM1 (Soil Temperature Simulation Flags)

SLTVFG: *If this is 1, parameters for estimating surface layer temperature can vary monthly.*

ULTVFG: *If this is 1, parameters for estimating upper layer temperature can vary monthly.*

LGTVFG: *If this is 1, parameters for estimating lower layer and active groundwater layer temperature calculations can vary monthly.*

TSOPFG: *Governs the methods used to estimate subsurface soil temperatures. If TSOPFG is 0, they are computed using a mean departure from air temperature, together with smoothing factors. If TSOPFG is 1, upper layer soil temperature is estimated by regression on air temperature (like surface temperature). The lower layer/groundwater layer temperature is supplied directly by the user (a different value may be specified for each month). If it is 2, the same method is used as for a value of 0, except that the upper layer temperature is used instead of the air temperature to compute the lower layer/groundwater layer temperature.*

PSTEMP-PARM2 (Soil Temperature Estimation Inputs)

ASLT: *The surface layer temperature when the air temperature is 32 degrees F (0 degrees C). It is the intercept of the surface layer temperature regression equation.*

BSLT: *The slope of the surface layer temperature regression equation.*

ULTP1: *The smoothing factor in upper layer temperature calculation, if TSOPFG = 0 or 2. ULP1 is the intercept in the upper layer soil temperature regression equation (like ASLT and BSLT for the surface layer), if TSOPFG = 1.*

ULTP2: *The mean difference between upper layer soil temperature and air temperature, if TSOPFG = 0 or 2. ULP2 is the slope in the upper layer soil temperature regression equation (similar to ASLT and BSLT for the surface layer), if TSOPFG = 1.*

LGTP1: *The smoothing factor for calculating lower layer/groundwater soil temperature, if TSOPFG = 0 or 2. LGTP1 is the lower layer/groundwater layer soil temperature, if TSOPFG = 1.*

LGTP2: *The mean departure from air temperature for calculating lower layer/groundwater soil temperature, if TSOPFG = 0 or 2. LGTP2 is not used if TSOPFG is 1.*

PSTEMP-TEMPS (Soil Temperature Initial Conditions)

AIRTC: *The initial air temperature.*

SLTMP: *The initial surface layer soil temperature.*

ULTMP: *The initial upper layer soil temperature.*

LGTMP: The initial lower layer/groundwater layer soil temperature.

PWTGAS Module that estimates water temperature and concentrations of dissolved oxygen and carbon dioxide in surface, interflow, and groundwater outflows from a land segment.

PWT-PARM1 (Dissolved Oxygen and Carbon Dioxide Flags)

IDVFG: If IDVFG is 1, interflow DO concentration may vary monthly.

ICVFG: If ICVFG is 1, interflow CO2 concentration may vary monthly.

GDVFG: If GDVFG is 1, groundwater DO concentration may vary monthly.

GCVFG: If GCVFG is 1, groundwater CO2 concentration may vary monthly.

PWT-PARM2 (Water Temperature and Gas Input Estimations)

ELEV: The elevation of the PLS above sea level (used to adjust saturation concentrations of dissolved gasses in surface outflow).

IDOXP: The concentration of dissolved oxygen in interflow outflow.

ICO2P: The concentration of dissolved CO2 in interflow outflow.

ADOXP: The concentration of dissolved oxygen in active groundwater outflow.

ACO2P: The concentration of dissolved CO2 in active groundwater outflow.

PWT-GASES (Initial Conditions for DO and CO2 concentrations)

SODOX: The initial DO concentration in surface outflow.

SOCO2: The initial CO2 concentration in surface outflow.

IDOXP: The initial DO concentration in interflow outflow.

ICO2P: The initial CO2 concentration in interflow outflow.

AODOX: The initial DO concentration in active groundwater outflow.

AOCO2: The initial CO2 concentration in active groundwater outflow.

PQUAL Module that simulates water quality constituents or pollutants in the outflows from a pervious land segment using simple relationships with water and/or sediment yield.

NQUALS (Contains the number of quality constituents to be modeled)

NQUAL: The total number of quality constituents to be modeled.

QUAL-PROPS (Identifiers and Flags for Quality Constituents)

QUALID: A string of up to 10 characters that identifies the quality constituent.

QTYID: A string of up to 4 characters that identifies the units associated with this constituent (e.g., kg, (for coliforms)). These are the units referred to as "qty" subsequent tables (eg. Table-type QUAL-INPUT).

QSDFG: If 1, this constituent is a QUALSD (sediment associated).

VPFWFG: If 1, the washoff potency factor may vary monthly. If VPWFG is 2, the daily factors are not interpolated between monthly values.

VPFSFG: If 1, the scour potency factor may vary monthly.

QSOFG: If 1 or 2, this constituent is a QUALOF (directly associated with overland flow). If 1, then accumulation and removal are performed daily, and the removal rate is dependent only on the accumulation and storage limit parameters (ACQ and SQOLIM). If 2, accumulation and removal are performed every interval, and the removal rate also takes into account atmospheric deposition plus lateral inflows.

VQOFG: If 1 then the rate of accumulation and the limiting storage of QUALOF may vary monthly.

QIFWFG: If 1 this constituent is a QUALIF (interflow associated).

VIQCFG: If 1 or greater, then the concentration of this constituent in interflow outflow may vary monthly. If 2 or 4, no interpolation is used. If 3 or 4, units are mg/L. This requires QTYID to be LB (English or KG (Metric)).

QAGWFG: If 1, this constituent is a QUALGW (groundwater associated).

VAQCFG: If 1, the concentration of this constituent in groundwater outflow may vary monthly. If VAQCFG is 2 or 4, the daily values are obtained directly from the monthly values; no interpolation between monthly values is performed. If VAQCFG is 3 or 4, the units of the input concentrations are mg/l; note: this option requires that the "qty" units be pounds (English system) or kilograms (Metric system).

QUAL-INPUT (Quality Storage Parameters)

SQO: The initial storage of QUALOF on the surface of the PLS.

POTFW: The washoff potency factor for a QUALSD. A potency factor is the ratio of constituent yield to sediment (washoff or scour) outflow.

POTFS: The scour potency factor for a QUALSD. A potency factor is the ratio of constituent yield to sediment (washoff or scour) outflow.

ACQOP: The rate of accumulation of QUALOF if QSOFG is positive. If QSOFG is negative, then ACQOP is the concentration of QUALOF in the surface outflow in mg/l.

SQOLIM: The maximum storage of QUALOF if QSOFG is positive.

WSQOP: The rate of surface runoff that will remove 90 percent of stored QUALOF per hour.

IOQC: The concentration of the constituent in interflow outflow (meaningful only if this is a QUALIF).

AQOC: The concentration of the constituent in active groundwater outflow (meaningful only if this is a QUALGW).

IMPERVIOUS LAND

ATEMP Module that estimates the surface air temperature over the land segment by correcting for elevation differences between the gage and the land segments.

ATEMP-DAT (ATEMP data)

ELDAT - The difference in elevation between the temperature gage and the impervious land segment; it is used to estimate the temperature over the impervious land segment by application of a lapse rate. It is positive if the impervious land segment is higher than the gage, and negative if the land segment is lower than the gage.

AIRTMP – The initial (i.e., at the starting time of the RUN) air temperature over the land segment.

IWTGAS– IWTGAS estimates the water temperature and concentrations of dissolved oxygen and carbon dioxide in the outflow from the impervious land segment.

IWT-PARM1 (IWTGAS Flags)

WTFVFG: A value of 1 means to vary the water temperature regression parameters (AWTF and BWTF) monthly; 0 means use annual values.

CSNOFG: A value of 1 means the effects of snow accumulation and melt are being considered; if it is zero, they are not. If section IWATER is active the value of CSNOFG supplied here is ignored because it was first supplied in the input for that section.

IWT-PARM2 (Temperature Estimation Parameters)

ELEV: The elevation of the ILS above sea level (used to adjust saturation concentrations of dissolved gasses in surface outflow).

AWTF: The surface water temperature, when the air temperature is 32 degrees F (0 degrees C). It is the intercept of the surface water temperature regression equation.

BWTF: The slope of the surface water temperature regression equation.

IQUAL Module that simulates water quality constituents or pollutants in the outflows from an impervious land segment using simple relationships with water yield and/or solids.

NQUALS (Contains the number of quality constituents to be modeled)

NQUAL: The total number of quality constituents to be modeled.

QUAL-PROPS (Identifiers and Flags for Quality Constituents)

QUALID: A string of up to 10 characters that identifies the quality constituent.

QTYID: A string of up to 4 characters that identifies the units associated with this constituent (e.g., kg, (for coliforms)). These are the units referred to as "qty" subsequent tables (eg. Table-type QUAL-INPUT).

QSDFG: If 1, this constituent is a QUALSD (sediment associated).

VPWFG: If 1, the washoff potency factor may vary monthly. If VPWFG is 2, the daily factors are not interpolated between monthly values.

QSOFG: If 1 or 2, this constituent is a QUALOF (directly associated with overland flow). If 1, then accumulation and removal are performed daily, and the removal rate is dependent only on the accumulation and storage limit parameters (ACQ and SQOLIM). If 2, accumulation and removal are performed every interval, and the removal rate also takes into account atmospheric deposition plus lateral inflows.

VQOFG: If 1 then the rate of accumulation and the limiting storage of QUALOF may vary monthly.

QUAL-INPUT (Quality Storage Parameters)

SQO: The initial storage of QUALOF on the surface of the impervious land segment.

POTFW: The wash off potency factor for a QUALSD. A potency factor is the ratio of constituent yield to sediment outflow.

ACQOP: The rate of accumulation of QUALOF if QSOFG is positive. If QSOFG is negative, then ACQOP is the concentration of QUALOF in the surface outflow in mg/l.

SQOLIM: The maximum storage of QUALOF if QSOFG is positive.

WSQOP: The rate of surface runoff that will remove 90 percent of stored QUALOF per hour.

REACHES AND RESERVOIRS

ADCALC Module that calculates values for the variables necessary to simulate longitudinal advection of dissolved or entrained constituents.

HTRCH Module that simulates the processes that determines the water temperature in a reach or mixed reservoir.

HEAT-PARM (Correction Factors and Energy Balance Coefficients)

ELEV: The mean RCHRES elevation.

ELDAT: The difference in elevation between the RCHRES and the air temperature gage (positive if RCHRES is higher than the gage).

CFSSEX: The correction factor for solar radiation (it includes fraction of RCHRES surface exposed to radiation).

KATRAD: The long-wave radiation coefficient.

KCOND: The conduction-convection heat transport coefficient.

KEVAP: The evaporation coefficient.

HEAT-INIT (Initial Temperature Conditions)

TW: The initial water temperature in the RCHRES.

AIRTMP: The initial air temperature at the RCHRES

SEDTRN Module that simulates the transport, deposition, and scour of inorganic sediment in free-flowing reaches and mixed reservoirs.

SANDFG (Sandload Method Flag)

SANDFG: This indicates the method that will be used for sandload simulation; 1 means Toffaletti method, 2 means Colby method, and 3 means the "old" HSPF input power function method.

SED-GENPARM (General Sediment Inputs)

BEDWID: This is the width of the cross-section over which HSPF will assume bed sediment is deposited regardless of stage, top-width, etc. It is used to estimate the depth of bed sediment.

BEDWRN: This is the bed depth which, if exceeded (eg, through deposition) will cause a warning message to be printed.

POR: This is the porosity of the bed (volume voids/total volume). It is used to estimate bed depth.

SAND-PM (Sand parameters)

D: This is the effective diameter of the transported sand particles. Note that the transport formulae do not actually use D (they use DB50, supplied in Table-type HYDR-PARM2). D is included here for consistency with the input data supplied for cohesive sediment.

W: This is the fall velocity of transported sand particles in still water.

RHO: This is the density of the sand particles.

KSAND: This is the coefficient in the "old" HSPF sandload input power function formula.

EXPSND: This is the exponent in the "old" HSPF sandload input power function formula.

SILT-CLAY-PM (Silt and clay inputs)

D: This is the effective diameter of the particles.

W: This is the fall velocity of the particles in still water.

RHO: This is the density of the particles.

TRUCD: This is the critical bed shear stress for deposition. Above this stress, there will be no deposition, as the stress drops below this value to zero, deposition will gradually increase to the value implied by the fall velocity in still water.

TAUCS: This is the critical bed shear stress for scour. Below this value, there will be no scour; above it, scour will steadily increase. In general TAUCD should be less than or equal to TAUCS.

M: This is the erodibility coefficient of the sediment.

SSED-INIT (Initial suspended sediment concentrations)

SSED1: The initial concentration (in suspension) of sand.

SSED2: The initial concentration (in suspension) of silt.

SSED3: The initial concentration (in suspension) of clay.

BED-INIT (Initial fractions of bed sediment)

BEDDEP: This is the initial total depth (thickness) of the bed.

SANDFR: The initial fraction (by weight) of sand in the bed material. The sum of the three fractions must be 1.00.

SILTFR: The initial fraction (by weight) of silt in the bed material. The sum of the three fractions must be 1.00.

CLAYFR: The initial fraction (by weight) of clay in the bed material. The sum of the three fractions must be 1.00.

RQUAL Parent routine to the four subroutine groups which simulate constituents involved in biochemical transformations.

BENTH-FLAG (Benthic release flag)

BENRFG: value of 1 means benthic influences are considered.

OXRX This module simulates the primary processes which determine the dissolved oxygen concentration in a reach or mixed reservoir.

OX-FLAGS (Oxygen flags)

REAMFG: indicates the method used to calculate reaeration coefficient for free-flowing streams; 1 means Tsivoglou method is used, 2 means Owens, Churchill, or O'Connor-Dobbins method is used depending on velocity and depth of water, and 3 means coefficient is calculated as a power function of velocity and/or depth; user inputs exponents for velocity and depth and an empirical constant (REAK)

OX-GENPARM (General oxygen parameters)

KBOD20: The unit BOD decay rate at 20 degrees C.

TCBOD: The temperature correction coefficient for BOD decay.

KODSET: The rate of BOD settling.

SUPSAT: The allowable dissolved oxygen supersaturation (expressed as a multiple of DO saturation concentration).

OX-BENPARM (Oxygen benthic parameters - this table is used only if BENRFG = 1 in BENTH-FLAG table)

BENOD: The benthic oxygen demand at 20 degrees C (with unlimited DO concentration).

TCBEN: The temperature correction coefficient for benthic oxygen demand.

EXPOD: The exponential factor in the dissolved oxygen term of the benthic oxygen demand equation.

BRBOD(1): The benthic release rate of BOD under aerobic conditions, and BRBOD(2) is the increment to benthic release of BOD under anaerobic conditions.

EXPREL: The exponent in the DO term of the benthic BOD release equation.

OX-REAPARM (Parameters for user-supplied reaeration formula)

TCGINV: The temperature correction coefficient for surface gas invasion.

REAK: The empirical constant for equation used to calculate the reaeration coefficient.

EXPRED: The exponent to depth used in calculation of the reaeration coefficient.

EXPREV: The exponent to velocity used in calculation of the reaeration coefficient.

OX-INIT (Initial concentrations for section OXRX)

DOX: The initial dissolved oxygen concentration.

BOD: The initial biochemical oxygen demand.

SATDO: The initial dissolved oxygen saturation concentration.

NUTRX Module that simulates the primary processes which determine the balance of inorganic nitrogen and phosphorus in natural waters.

NUT-FLAGS (Nutrient flags)

NH3FG: A value of 1 means ammonia is simulated.

NO2FG: A value of 1 means nitrite is simulated.

PO4FG: A value of 1 means ortho-phosphorus is simulated.

AMVFG: A value of 1 means ammonia vaporization is simulated.

DENFG: A value of 1 means denitrification is simulated.

ADNHFG: A value of 1 means NH₄ adsorption is simulated

ADPOFG: A value of 1 means PO₄ adsorption is simulated

PHFLAG: A value of 1=time series, 2=annual, 3=monthly values

CONV-VAL1 (Conversion factors)

CVBO: The conversion from milligrams biomass to milligrams oxygen.

CVBPC: The conversion from biomass expressed as phosphorus to carbon equivalency.

CVBPN: The conversion from biomass expressed as phosphorus to nitrogen equivalency.

BPCNT: *The percentage, by weight, of biomass that is carbon.*

NUT-BENPARM (Nutrient benthic parameters)

BRNIT(1): *The benthic release rate of inorganic nitrogen under aerobic conditions.*
BRNIT(2): *The benthic release rate of inorganic nitrogen under anaerobic conditions.*
BRPO4(1): *The benthic release rate of ortho-phosphate under aerobic conditions.*
BRPO4(2): *The benthic release rate of ortho-phosphate under anaerobic conditions.*
NAER: *The concentration of dissolved oxygen below which anaerobic conditions exist.*

NUT-NITDENIT (Nitrification/denitrification parameters)

KTAM20: *The unit oxidation rate of total ammonia at 20 C.*
KNO20: *The unit oxidation rate of nitrite at 20°C.*
TCNIT: *The temperature correction coefficient for the nitrogen oxidation rates.*
KNO320: *The unit denitrification rate of nitrate at 20 C.*
TCDEN: *The temperature correction coefficient for the denitrification rate.*
DENOXT: *The dissolved oxygen concentration threshold above which denitrification ceases.*

NUT-BEDCONC (Bed concentrations of adsorbed NH₃ and PO₄)

BNH4(1-3) *are the constant bed concentrations of ammonia-N adsorbed to sand, silt, and clay.*
BPO4(1-3) *are the constant bed concentrations of ortho-phosphorus-P adsorbed to sand, silt, and clay.*

NUT-ADSPARM (Adsorption coefficients for ammonia and ortho-phosphorus)

ADNHPM(1-3) *are the adsorption coefficients (Kd) for ammonia-N adsorbed to sand, silt, and clay.*
ADPOPM(1-3) *are the adsorption coefficients for ortho-phosphorus-P adsorbed to sand, silt, and clay.*

NUT-DINIT (Initial dissolved concentrations)

NO3: *The initial concentration of nitrate (as nitrogen).*
TAM: *The initial concentration of total ammonia (as N)*
NO2: *The initial concentration of nitrite (as nitrogen).*
PO4: *The initial concentration of ortho-phosphorus (as phosphorus).*
PHVAL: *The constant (annual) or initial value of pH.*

NUT-ADSINIT (Initial concentrations of NH₃ and PO₄ adsorbed to suspended sediment)

SNH4(1-3) *are the initial concentrations of ammonia-N adsorbed to sand, silt, and clay.*
SPO4(1-3) *are the initial concentrations of ortho-phosphorus-P adsorbed to sand, silt, and clay.*

PLANK *Module that simulates phytoplankton, zooplankton, and/or benthic algae.*

PLNK-FLAGS (Plankton flags)

PHYFG: *Value of 1 means phytoplankton are simulated.*
ZOOFG: *Value of 1 means zooplankton are simulated.*
BALFG: *Value of 1 means benthic algae are simulated.*
SDLTFG: *Value of 1 means influence of sediment washload on light extinction is simulated.*
AMRFG: *Value of 1 means ammonia retardation of nitrogen limited growth is enabled.*
DECFG: *Value of 1 means linkage between carbon dioxide and phytoplankton growth is decoupled.*
NSFG: *Value of 1 means ammonia is included as part of available nitrogen supply in nitrogen limited growth calculations.*
ZFOOD: *The quality of zooplankton food.*

PLNK-PARM1 (General plankton parameters, group 1)

RATCLP: The ratio of chlorophyll "A" content of biomass to phosphorus content.

NONREF: The nonrefractory fraction of algae and zooplankton biomass.

LITSED: The multiplication factor to total sediment concentration to determine sediment contribution to light extinction.

ALNPR: The fraction of nitrogen requirements for phytoplankton growth satisfied by nitrate.

EXTB: The base extinction coefficient for light.

MALGR: The maximal unit algal growth rate for phytoplankton.

PLNK-PARM2 (General plankton parameters, group 2)

CMLLT: The Michaelis-Menten constant for light limited growth.

CMMN: The nitrate Michaelis-Menten constant for nitrogen limited growth.

CMMNP: The nitrate Michaelis-Menten constant for phosphorus limited growth.

CMMP: The phosphate Michaelis-Menten constant for phosphorus limited growth.

TALGRH: The temperature above which algal growth ceases.

TALGRL: The temperature below which algal growth ceases.

TALGRM: The temperature below which algal growth is retarded.

PLNK-PARM3 (General plankton parameters, group 3)

ALR20: The algal unit respiration rate at 20 degrees C.

ALDH: The high algal unit death rate.

ALDL: The low algal unit death rate.

OXALD: The increment to phytoplankton unit death rate due to anaerobic conditions.

NALDH: The inorganic nitrogen concentration below which high algal death rate occurs (as nitrogen).

PALDH: The inorganic phosphorus concentration below which high algal death rate occurs (as phosphorus).

PHYTO-PARM (Phytoplankton parameters)

SEED: The minimum concentration of plankton not subject to advection (i.e. at high flow).

MXSTAY: The concentration of plankton not subject to advection at very low flow.

OREF: The outflow at which concentration of plankton not subject to advection is midway between SEED and MXSTAY.

CLALDH: The chlorophyll "A" concentration above which high algal death rate occurs.

PHYSET: The rate of phytoplankton settling.

REFSET: The rate of settling for dead refractory organics.

BENAL-PARM (General benthic algae parameters)

MBAL: The maximum benthic algae density (as biomass).

CFBALR: The ratio of benthic algal to phytoplankton respiration rate

CFBALG: The ratios of benthic algal to growth rate

PLNK-INIT (Initial plankton conditions)

PHYTO: The initial value of phytoplankton, as biomass.

ZOO: The initial value of zooplankton.

BENAL: The initial value of benthic algae, as biomass.

ORN: The initial value of dead refractory organic nitrogen.

ORP: The initial value of dead refractory organic phosphorus.

ORC: The initial value of dead refractory organic carbon.