

EPA BASINS Technical Note 3

WinHSPF Simulation Module Matrix

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The BASINS' GIS and Windows interface to the Hydrologic Simulation Program Fortran (WinHSPF), is a flexible watershed simulation model that permits users to simulate a large number of pollutants over a range of simplistic to complex formulations. The HSPF program has a modular structure in which pervious and impervious land segments define the first two modules, and free flowing reaches and reservoirs define the third. Each module contains specialized algorithms, or sections, for simulating the environmental fate processes important to a particular pollutant or group of pollutants (e.g. the pesticide section simulates absorption/desorption and volatilization). While all modules and sections can be selected, the typical model simulation requires only a limited selection. Additionally, however, some sections are dependent on output from other modules and WinHSPF will not function with an improper combination of sections selected. Also, by starting simple and gradually building the model's complexity, a user increases their ability to trap errors and will thus reduce the time required to build a functioning, complex HSPF simulation. Finally, some sections need not be simulated as long as the user can supply a time-series of data for the output from that section. This technical note, then, is meant to answer the following two key questions: 1) What is the minimum necessary set of modules and sections for modeling my pollutant of concern; and 2) In what order should I add modules such that I can slowly build the complexity of my model?

The matrix (see Figure 1, below) shows the hydrologic process or pollutant to be simulated along the top, and the HSPF modules and sections along the left. A set of notes, at the end, provides additional details about the conditions under which a section is required, recommended, or optional. To read the matrix, select the process or pollutant you wish to model, and read down that column to determine which HSPF sections you must simulate as well as those which are recommended or optional. For example, to simulate pesticides, reading down the column in the PERLND block, shows ATEMP and SNOW as optional (only necessary if snow is significant in your watershed), PWATER and SEDMNT as required, PSTEMP as only necessary if first-order adsorption-desorption is selected, and MSTLAY (soil moisture storage and fluxes) and PEST (by definition) as required. Reading down the pesticide column in the RCHRES module, HYDR and ADCALC are required, HTRCH is recommended, SEDTRN is recommended to account for reduced photolysis due to sediment shading (and is required if the pesticide is sediment associated) and GQUAL is required. While HSPF does not simulate pesticide application or fate and transport on impervious land segments, you still need to model the simulation elements that will effect quantities in the receiving water body: i.e. ATEMP and SNOW (if simulated in the PERLND module), IWATER (for hydrology), IWTGAS (for temperature if HTRCH selected in RCHRES module) and SOLIDS (if SEDTRN selected in RCHRES).

Note, each module (Pervious Land [PERLND], Impervious Land [IMPLND], and Free Flowing Reach or Reservoir [RCHRES]) is essentially its own separate matrix since they can each be run independently of the others (e.g. running general water quality constituent simulations in a RCHRES segment does not require a constituent load from either a PERLND or IMPLND; similarly, modeling nutrient washoff in a PERLND does not require you to route the runoff to a RCHRES segment).

		HSPF Section		Pervious Land (PERLND)										Impervious Land (IMPLND)										
		Adjusted Air Temp	Snow	Basic Hydrology	Soil Erosion	Soil T temperature	Water T temperature	Dissolved Oxygen	Carbon Dioxide	General WQ	Pesticides	Nitrogen	Phosphorus	Tracers	Adjusted Air Temp	Snow	Basic Hydrology	Solids	Water T temperature	Dissolved Oxygen	Carbon Dioxide	General WQ		
PERLND	ATEMP	●	● ³	○	○	○	○	○	○	○	○	○	○											
	SNOW		●	○	○	○	○	○	○	○	○	○	○											
	PWATER			●	●	●	●	●	●	●	●	●	●											
	SEDMNT			●					● ²	●	●	●												
	PSTEMP				●	●	●	●		○ ⁴	○	○												
	PWTGAS					●	●	●																
	PQUAL								●															
	MSTLAY									●	●	●	●											
	PEST									●														
	NITR										●													
	PHOS											●												
	TRACER												●											
IMPLND	ATEMP													●	● ³	○	○	○	○	○	○	○	○	
	SNOW													●	○	○	○	○	○	○	○	○	○	
	IWATER														●	●	●	●	●	●	●	●	●	
	SOLIDS																●					● ²		
	IWTGAS																●	●	●	●	●	●	●	
	IQUAL																						●	

- 1 - Recommended module sections are required unless a timeseries of observed data or estimated values are available in place of the variables they simulate.
- 2 - Activate only if constituent being modeled is associated with sediment.
- 3 - ATEMP is recommended to adjust for any elevation differences between the observation site and the watershed.
- 4 - PSTEMP is required only if the first-order adsorption-desorption is selected instead of the equilibrium Freundlich approach.

		HSPF Section		Free Flowing Reach or Reservoir (RCHRES)															
		Flow Routing	Conservative	Water T temperature	Sediment	General WQ	Pesticides	Dissolved Oxygen	BOD	Inorganic Phosphorus	Inorganic Nitrogen	Benthic Algae	Phytoplankton	Organic C, N & P	Zooplankton	pH	Carbon Dioxide	Total Inorganic Carbon	
RCHRES	HYDR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	ADCALC		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	CONS		●																
	HTRCH			●	○ ²	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	SEDRN			●	○ ³	○ ³	○ ⁵	○ ⁵	○ ⁴	○ ⁴	○ ⁴	○ ⁴	○ ⁴	○ ⁴	○ ⁴	○ ⁴	○ ⁴	○ ⁴	○ ⁴
	GQUAL					●	●												
	OXRX						●	●	●	●	●	●	●	●	●	●	●	●	●
	NUTRX							○ ⁶	○ ⁶	●	●	●	●	●	●	●	●	●	●
	PLANK							○ ⁶	○ ⁶	○ ⁶	○ ⁶	●	●	●	●	●	●	●	●
	PHCARB												●	●	●	●	●	●	●

- 1 - Recommended module sections are required unless a timeseries of observed data or estimated values are available in place of the variables they simulate.
- 2 - Required only if using Toffaleti or Colby method for sand transport.
- 3 - Required only if constituent being modeled is sediment-associated; recommended if photolysis is considered to account for sediment shading.
- 4 - Required only if NH₄/PO₄ association with sediment is considered - otherwise, highly recommended.
- 5 - Required only if NUTRX is also active and sediment association is considered - otherwise, highly recommended.
- 6 - Consideration of entire nutrient and biological cycle is highly recommended.

Figure 1. Matrix of HSPF Sections Required vs. Pollutants and Processes Modeled

Table Notes:

PERLND

Adjusted Air Temp

ATEMP (required)

by definition; used to adjust for air temperature differences between meteorologic station and site due to elevation differences (HSPF uses lapse rate that varies between 0.0035 and 0.005 degrees-F/ft)

Snow

ATEMP (recommended)

can be bypassed, in HSPF by adjusting gage temperature directly (required in HSPF if SNOW simulated).

SNOW (required)

by definition

Basic Hydrology

ATEMP (optional)

results used only if SNOW is simulated (required in HSPF if SNOW is simulated)

SNOW (optional)

only needed in regions where snow is significant in the hydrologic cycle

PWATER (required)

by definition

Soil Erosion

ATEMP (optional)

results used only if SNOW is simulated (required in HSPF if SNOW simulated)

SNOW (optional)

only needed in regions where snow is significant hydrologic cycle component

PWATER (required)

surface quantities SURO and SURS used in SEDMNT routine

SEDMNT (required)

by definition

Soil Temperature

ATEMP (recommended)

can be bypassed, in HSPF by adjusting gage temperature directly

PSTEMP (required)

by definition

Water Temperature, Dissolved Oxygen, Dissolved CO2

ATEMP (recommended)	results used only if SNOW or PSTEMP simulated
SNOW (optional)	only needed in regions where snow is significant hydrologic cycle component
PWATER (required)	runoff components SURO, IFWO, AGWO are the key simulation elements
PSTEMP (recommended)	observed/estimated soil temps may be input instead
PWTGAS (required)	by definition

General WQ

ATEMP (optional)	results used only if snow is simulated
SNOW (optional)	only needed in regions where snow is significant hydrologic cycle component
PWATER (required)	surface quantities SURO and SURS used in SEDMNT routine
SEDMNT (required)	only needed if water quality constituent is sediment-associated
PQUAL (required)	by definition

Pesticides

ATEMP (recommended)	results used only if SNOW or PSTEMP simulated (required in HSPF if SNOW simulated)
SNOW (optional)	only needed in regions where snow is significant hydrologic cycle component
PWATER (required)	soil moisture fluxes/storages are the key simulation elements
SEDMNT (required)	soil erosion must be simulated
PSTEMP (recommended)	observed/estimated soil temps may be input directly in HSPF
MSTLAY (required)	leaching factors must be simulated
PEST (required)	by definition

Nitrogen

ATEMP (recommended)	results used only if SNOW or PSTEMP simulated (required in HSPF if SNOW simulated)
SNOW (optional)	only needed in regions where snow is significant hydrologic cycle component
PWATER (required)	soil moisture fluxes/storages must be simulated
SEDMNT (required)	soil erosion must be simulated
PSTEMP (recommended)	observed/estimated soil temps may be input directly in HSPF
MSTLAY (required)	leaching factors must be simulated
NITR (required)	by definition

Phosphorus

ATEMP (recommended)	results used only if SNOW or PSTEMP simulated (required in HSPF if SNOW simulated)
SNOW (optional)	only needed in regions where snow is significant hydrologic cycle component
PWATER (required)	soil moisture fluxes/storages must be simulated
SEDMNT (required)	soil erosion must be simulated
PSTEMP (recommended)	observed/estimated soil temps may be input directly in HSPF
MSTLAY (required)	leaching factors must be simulated
PHOS (required)	by definition

Tracer

ATEMP (optional)	results used only if SNOW is simulated
SNOW (optional)	only needed in regions where snow is significant hydrologic cycle component
PWATER (required)	soil moisture fluxes/storages must be simulated
MSTLAY (required)	leaching factors must be simulated
TRACER (required)	by definition

IMPLND

Adjusted Air Temp
ATEMP (required)

by definition; used to adjust for air temperature differences between meteorologic station and site due to elevation differences

Snow

ATEMP (recommended)

can be bypassed, in HSPF by adjusting gage temperature directly (required in HSPF if SNOW is simulated)

SNOW (required)

by definition

Basic Hydrology

ATEMP (optional)

results used only if SNOW is simulated (required in HSPF if SNOW is simulated)

SNOW (optional)

only needed in regions where snow is significant hydrologic cycle component

IWATER (required)

by definition

Solids

ATEMP (optional)

results used only if SNOW is simulated (required in HSPF if SNOW is simulated)

SNOW (optional)

only needed in regions where snow is significant hydrologic cycle component

IWATER (required)

surface runoff must be simulated

SOLIDS (required)

by definition

Water Temperature, Dissolved Oxygen, Dissolved CO2

ATEMP (recommended)

can be bypassed, in HSPF by adjusting gage temperature directly (required in HSPF if SNOW is simulated)

SNOW (optional)

only needed in regions where snow is significant hydrologic cycle component

IWATER (required)

surface runoff must be simulated

IWTGAS (required)

by definition

General WQ

ATEMP (optional)

results used only if SNOW is simulated (required in HSPF if SNOW is simulated)

SNOW (optional)

only needed in regions where snow is significant hydrologic cycle component

IWATER (required)

surface runoff must be simulated

SOLIDS (required)

only needed if water quality constituent is sediment associated

IQUAL (required)

by definition

RCHRES

Flow Routing

HYDR (required) by definition

Conservative Substance

HYDR (required) flow routing must be simulated
ADCALC (required) transport factors must be simulated

Water Temperature

HYDR (required) flow routing must be simulated
ADCALC (required) transport factors must be simulated
HTRCH (recommended) by definition

Sediment Transport

HYDR (required) flow routing must be simulated
ADCALC (required) transport factors must be simulated
HTRCH (recommended) required only if Toffaletti or Colby methods are used for sand, can be bypassed by inputting water temperature directly in HSPF
SEDTRN (required) by definition

General WQ, Pesticides

HYDR (required) flow routing must be simulated
ADCALC (required) transport factors must be simulated
HTRCH (recommended) can be bypassed by inputting water temperature directly in HSPF
SEDTRN (recommended) only required if sediment associated, otherwise is optional; recommended if photolysis is considered (to account for sediment shading); can be bypassed by inputting sediment concentration directly in HSPF
GQUAL (required) by definition

Dissolved Oxygen, BOD

HYDR (required)	flow routing must be simulated
ADCALC (required)	transport factors must be simulated
HTRCH (recommended)	can be bypassed by inputting water temperature directly
SEDTRN (optional)	only if NUTRX used
OXRX (required)	by definition
NUTRX (optional)	nutrients usually important
PLANK (optional)	plankton usually important

Inorganic Phosphorus, Inorganic Nitrogen

HYDR (required)	flow routing must be simulated
ADCALC (required)	transport factors must be simulated
HTRCH (recommended)	can be bypassed by inputting water temperature directly
SEDTRN (required)	phosphate and ammonia absorption usually important
OXRX (required)	DO and BOD must be simulated
NUTRX (required)	by definition
PLANK (optional)	plankton usually important

Benthic Algae, Phytoplankton, Zooplankton, and Organic C, N, and P

HYDR (required)	flow routing must be simulated
ADCALC (required)	transport factors must be simulated
HTRCH (recommended)	can be bypassed by inputting water temperature directly
SEDTRN (recommended)	can be bypassed by inputting sediment concentration directly (unless already needed by NUTRX)
OXRX (required)	DO and BOD must be simulated
NUTRX (required)	nutrients must be simulated
PLANK (optional)	by definition

PH, Carbon Dioxide, Total Inorganic Carbon

HYDR (required)	flow routing must be simulated
ADCALC (required)	transport factors must be simulated
CONS (recommended)	can be bypassed by inputting alkalinity concentrations directly
HTRCH (recommended)	can be bypassed by inputting water temperature directly
SEDTRN (recommended)	only if needed by NUTRX
OXRX (required)	DO and BOD must be simulated
NUTRX (required)	nutrients must be simulated
PLANK (required)	plankton CO2 fluxes must be simulated
PHCARB (required)	by definition