# CHAPTER 4

# SWAT INPUT DATA: .BSN

General watershed attributes are defined in the basin input file. These attributes control a diversity of physical processes at the watershed level. The interfaces will automatically set these parameters to the "default" or recommended values listed in the variable documentation. Users can use the default values or change them to better reflect what is happening in a given watershed. Variables governing bacteria or pesticide transport need to be initialized only if these

processes are being modeled in the watershed. Even if nutrients are not being studied in a watershed, some attention must be paid to these variables because nutrient cycling impacts plant growth which in turn affects the hydrologic cycle.

Following is a brief description of the variables in the basin input file. They are listed by topic.

# 4.1 TITLE

| Variable name | Definition |
|---|---|
| TITLE | The first line is reserved for a description. The description may take up to 80 spaces. The title line is not processed by the model and may be left blank. |
| | Optional. |

# 4.2 MODELING OPTIONS: LAND AREA

## WATER BALANCE

| Variable name | Definition |
|---|---|
| SFTMP | Snowfall temperature (ºC). |
| | Mean air temperature at which precipitation is equally likely to be rain as snow/freezing rain. The snowfall temperature should be between –5 ºC and 5 ºC. |
| | A default recommended for this variable is SFTMP = 1.0. |
| | Required in watersheds where snowfall is significant. |
| SMTMP | Snow melt base temperature (ºC). |
| | The snow pack will not melt until the snow pack temperature exceeds a threshold value, $T_{mlt}$. The snow melt base temperature should be between –5 ºC and 5 ºC. |
| | A default recommended for this variable is SMTMP = 0.50. |
| | Required in watersheds where snowfall is significant. |

| Variable name | Definition |
|---|---|
| SMFMX | Melt factor for snow on June 21 (mm H$_2$O/°C-day). |

If the watershed is in the Northern Hemisphere, SMFMX will be the maximum melt factor. If the watershed is in the Southern Hemisphere, SMFMX will be the minimum melt factor. SMFMX and SMFMN allow the rate of snow melt to vary through the year. The variables account for the impact of snow pack density on snow melt.

In rural areas, the melt factor will vary from 1.4 to 6.9 mm H$_2$O/day-°C (Huber and Dickinson, 1988). In urban areas, values will fall in the higher end of the range due to compression of the snow pack by vehicles, pedestrians, etc. Urban snow melt studies in Sweden (Bengston, 1981; Westerstrom, 1981) reported melt factors ranging from 3.0 to 8.0 mm H$_2$O/day-°C. Studies of snow melt on asphalt (Westerstrom, 1984) gave melt factors of 1.7 to 6.5 mm H$_2$O/day-°C.

If no value for SMFMX is entered, the model will set SMFMX = 4.5.

Required in watersheds where snowfall is significant.

| | |
|---|---|
| SMFMN | Melt factor for snow on December 21 (mm H$_2$O/°C-day). |

If the watershed is in the Northern Hemisphere, SMFMN will be the minimum melt factor. If the watershed is in the Southern Hemisphere, SMFMN will be the maximum melt factor. SMFMX and SMFMN allow the rate of snow melt to vary through the year. The variables account for the impact of snow pack density on snow melt.

In rural areas, the melt factor will vary from 1.4 to 6.9 mm H$_2$O/day-°C (Huber and Dickinson, 1988). In urban areas, values will fall in the higher end of the range due to compression of the snow pack by vehicles, pedestrians, etc. Urban snow melt studies in Sweden (Bengston, 1981; Westerstrom, 1981) reported melt factors ranging from 3.0 to 8.0 mm H$_2$O/day-°C. Studies of snow melt on asphalt (Westerstrom, 1984) gave melt factors of 1.7 to 6.5 mm H$_2$O/day-°C.

If no value for SMFMN is entered, the model will set SMFMN = 4.5.

Required in watersheds where snowfall is significant.

| Variable name | Definition |
| --- | --- |
| TIMP | Snow pack temperature lag factor. |
| | The influence of the previous day's snow pack temperature on the current day's snow pack temperature is controlled by a lagging factor, $\ell_{sno}$. The lagging factor inherently accounts for snow pack density, snow pack depth, exposure and other factors affecting snow pack temperature. TIMP can vary between 0.01 and 1.0. As $\ell_{sno}$ approaches 1.0, the mean air temperature on the current day exerts an increasingly greater influence on the snow pack temperature and the snow pack temperature from the previous day exerts less and less influence. As TIMP goes to zero, the snow pack's temperature will be less influenced by the current day's air temperature. |
| | If no value for TIMP is entered, the model will set TIMP = 1.0. |
| | Required in watersheds where snowfall is significant. |
| SNOCOVMX | Minimum snow water content that corresponds to 100% snow cover, $SNO_{100}$, (mm $H_2O$). |
| | Due to variables such as drifting, shading and topography, the snow pack in a subbasin will rarely be uniformly distributed over the total area. This results in a fraction of the subbasin area that is bare of snow. This fraction must be quantified to accurately compute snow melt in the subbasin. |
| | The factors that contribute to variable snow coverage are usually similar from year to year, making it possible to correlate the areal coverage of snow with the amount of snow present in the subbasin at a given time. This correlation is expressed as an areal depletion curve, which is used to describe the seasonal growth and recession of the snow pack as a function of the amount of snow present in the subbasin (Anderson, 1976). |
| | The areal depletion curve requires a threshold depth of snow, $SNO_{100}$, to be defined above which there will always be 100% cover. The threshold depth will depend on factors such as vegetation distribution, wind loading of snow, wind scouring of snow, interception and aspect, and will be unique to the watershed of interest. |

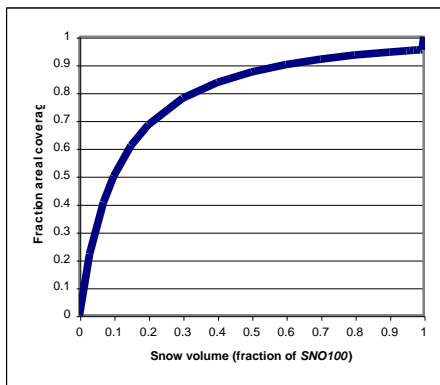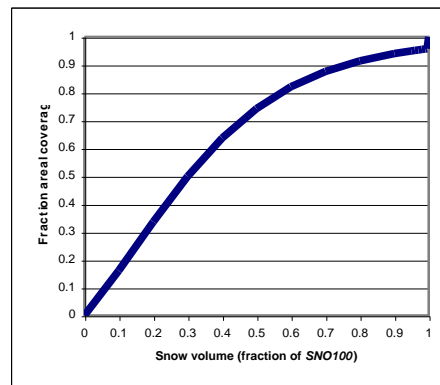| Variable name | Definition |
|---|---|
| SNOCOVMX, cont. | If the snow water content is less than SNOCOVMX, then a certain percentage of ground cover will be bare. |
| | It is important to remember that once the volume of water held in the snow pack exceeds $SNO_{100}$ the depth of snow over the HRU is assumed to be uniform, i.e. $sno_{cov} = 1.0$. The areal depletion curve affects snow melt only when the snow pack water content is between 0.0 and $SNO_{100}$. Consequently if $SNO_{100}$ is set to a very small value, the impact of the areal depletion curve on snow melt will be minimal. As the value for $SNO_{100}$ increases, the influence of the areal depletion curve will assume more importance in snow melt processes. |
| | If no value for SNOCOVMX is entered, the model will set SNOCOVMX = 1.00. |
| | Required in watersheds where snowfall is significant. |
| SNO50COV | Fraction of snow volume represented by SNOCOVMX that corresponds to 50% snow cover. SWAT assumes a nonlinear relationship between snow water and snow cover. SNO50COV can vary between 0.01 and 0.99. |
| | Example areal depletion curves for various fractions of $SNO_{100}$ at 50% coverage are shown in the following figures. |
| | If no value for SNO50COV is entered, the model will set SNO50COV = 0.50, i.e. 50% of SNOCOVMX. |
| | Required in watersheds where snowfall is significant. |



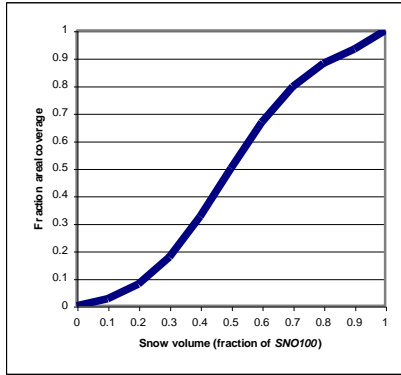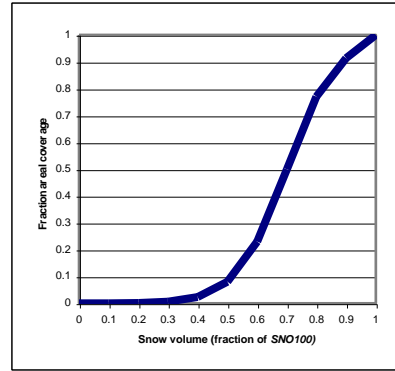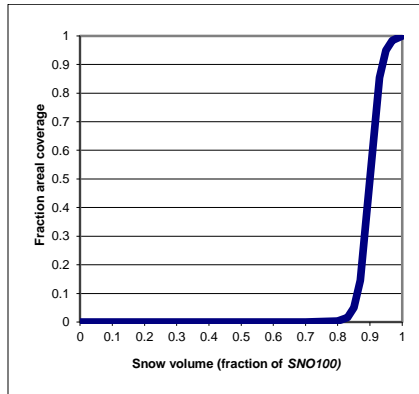Figure 4-1: 10% $SNO_{100}$ = 50% coverage



Figure 4-2: 30% $SNO_{100}$ = 50% coverage

Figure 4-3: 50% $SNO_{100}$ = 50% coverage



Figure 4-4: 70% $SNO_{100}$ = 50% coverage



Figure 4-5: 90% $SNO_{100}$ = 50% coverage

| Variable name | Definition |
|---|---|
| IPET | Potential evapotranspiration (PET) method. |

There are four options for potential ET calculations:
- 0   Priestley-Taylor method
- 1   Penman/Monteith method
- 2   Hargreaves method
- 3   read in potential ET values

Numerous methods exist to calculate potential evapotranspiration. Three of the most popular or widely-used are included in SWAT. However, if a method other than Priestley-Taylor, Penman/Monteith, or Hargreaves is recommended for the area in which the watershed is located, the user can calculate daily PET values with the recommended method and import them into SWAT. A discussion of Priestley-Taylor, Penman-Monteith and Hargreaves PET methods is found in Chapter 2:2 of the theoretical documentation.

Required.

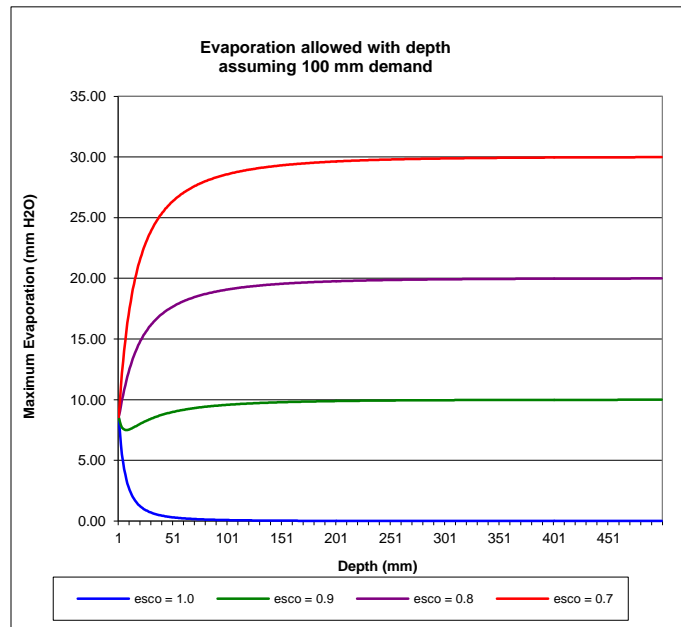| Variable name | Definition |
| --- | --- |
| PETFILE | Name of potential evapotranspiration input file (**.pet**). This file is described in Chapter 11.<br><br>Required only if IPET = 3. |
| ESCO | Soil evaporation compensation factor.<br><br>This coefficient has been incorporated to allow the user to modify the depth distribution used to meet the soil evaporative demand to account for the effect of capillary action, crusting and cracks. ESCO must be between 0.01 and 1.0. As the value for ESCO is reduced, the model is able to extract more of the evaporative demand from lower levels.<br><br>The change in depth distribution resulting from different values of *esco* are graphed in Figure 4-6. |



Figure 4-6: Soil evaporative demand distribution with depth

If no value for ESCO is entered, the model will set ESCO = 0.95. The value for ESCO may be set at the watershed or HRU level (ESCO in .hru file, see Chapter 19).

Required.

| Variable name | Definition |
| --- | --- |
| EPCO | Plant uptake compensation factor. |
|  | The amount of water uptake that occurs on a given day is a function of the amount of water required by the plant for transpiration, $E_t$, and the amount of water available in the soil, *SW*. If upper layers in the soil profile do not contain enough water to meet the potential water uptake, users may allow lower layers to compensate. The plant uptake compensation factor can range from 0.01 to 1.00. As *epco* approaches 1.0, the model allows more of the water uptake demand to be met by lower layers in the soil. As *epco* approaches 0.0, the model allows less variation from the original depth distribution to take place. |
|  | If no value for EPCO is entered, the model will set EPCO = 1.0. The value for EPCO may be set at the watershed or HRU level (EPCO in .hru file, see Chapter 19). |
|  | Required. |
| EVLAI | Leaf area index at which no evaporation occurs from water surface. |
|  | EVLAI is used in HRUs where a plant is growing in a ponded environment (e.g. rice). Currently, this is simulated only in HRUs defined as depressional areas/potholes. |
|  | Evaporation from the water surface is allowed until the leaf area of the plant reaches the value specified for EVLAI. Chapter 8:1 in the Theoretical Documentation provides more detail on the use of this parameter. |
|  | EVLAI should be set between 0.0 and 10.0. If no value for EVLAI is entered, the model will set EVLAI = 3.0. |
|  | Required if depressional areas/potholes are modeled in the watershed. |

| Variable name | Definition |
|---|---|
| FFCB | Initial soil water storage expressed as a fraction of field capacity water content. |
| | All soils in the watershed will be initialized to the same fraction. |
| | FFCB should be between 0.0 and 1.0. If FFCB is not set to a value, the model will calculate it as a function of average annual precipitation. The default method is to allow the model to calculate FFCB (set FFCB = 0.0). |
| | We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for FFCB is not going to impact model results. |
| | Required. |

# SURFACE RUNOFF

| Variable name | Definition |
|---|---|
| IEVENT | Rainfall/runoff/routing option: |
| | 0   daily rainfall/curve number runoff/daily routing |
| | 1   daily rainfall/Green & Ampt infiltration/daily routing (sub-hourly rainfall required for Green & Ampt is generated from daily) |
| | 2   sub-hourly rainfall/Green & Ampt infiltration/daily routing |
| | 3   sub-hourly rainfall/Green & Ampt infiltration/hourly routing |
| | Option 0 is the default option. |
| | Required. |

| Variable name | Definition |
|---|---|
| ICN | Daily curve number calculation method: |

> 0   calculate daily CN value as a function of soil moisture
> 1   calculate daily CN value as a function of plant evapotranspiration
> 2   use traditional SWAT method which bases CN on soil moisture but retention is adjusted for mildly-sloped tiled-drained watersheds

Option 0 was the only method used to calculate the daily CN value in versions of SWAT prior to SWAT2012. Calculation of the daily CN value as a function of plant evapotranspiration was added because the soil moisture method was predicting too much runoff in shallow soils. By calculating daily CN as a function of plant evapotranspiration, the value is less dependent on soil storage and more dependent on antecedent climate.

Required.

| CNCOEF | Plant ET curve number coefficient. |

ET weighting coefficient used to calculate the retention coefficient for daily curve number calculations dependent on plant evapotranspiration.

This value can vary between 0.5 and 2.0. If no value is entered for CNCOEF, the model will set CNCOEF = 1.0.

Required if ICN = 1.

| ICRK | Crack flow code. |

There are two options:
0   do not model crack flow in soil
1   model crack flow in soil

Crack, or bypass, flow is a newer feature in SWAT and has been tested on a limited basis in simulations of some areas in Texas. This type of flow should be modeled only on soils classified as Vertisols.

The default option is to model the watershed without crack flow.
Required.

| Variable name | Definition |
| --- | --- |
| SURLAG | Surface runoff lag coefficient. |

In large subbasins with a time of concentration greater than 1 day, only a portion of the surface runoff will reach the main channel on the day it is generated. SWAT incorporates a surface runoff storage feature to lag a portion of the surface runoff release to the main channel.

SURLAG controls the fraction of the total available water that will be allowed to enter the reach on any one day. Figure 4-7 plots the fraction of total available water entering the reach at different values for *surlag* and $t_{conc}$.

Note that for a given time of concentration, as *surlag* decreases in value more water is held in storage. The delay in release of surface runoff will smooth the streamflow hydrograph simulated in the reach.

If no value for SURLAG is entered, the model will set SURLAG = 4.0.
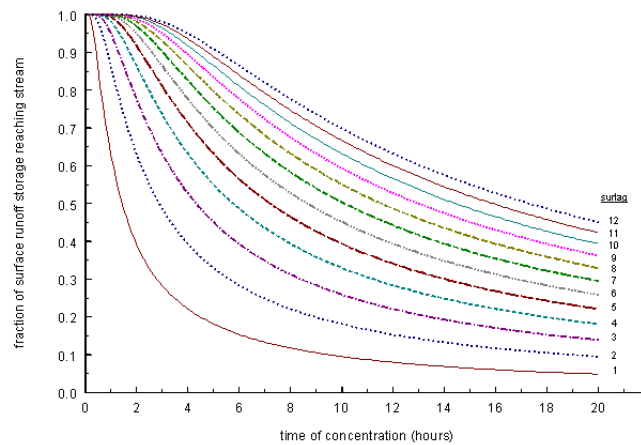
Required.



Figure 4-7: Influence of *surlag* and $t_{conc}$ on fraction of surface runoff released.

| Variable name | Definition |
|---|---|
| ISED_DET | Code governing calculation of daily maximum half-hour rainfall value: |

> 0   generate daily value using triangular distribution
> 1   use monthly maximum half-hour rainfall value for all days in month

The user has the option of using the monthly maximum half-hour rainfall for all days in the month. The randomness of the triangular distribution used to generated daily values causes the maximum half-hour rainfall value to jump around. For small plots or microwatersheds in particular, the variability of the triangular distribution is unrealistic.

Required.

| ADJ_PKR | Peak rate adjustment factor for sediment routing in the *subbasin (tributary channels)*. |

Sediment routing is a function of peak flow rate and mean daily flow. Because SWAT originally could not directly calculate the sub-daily hydrograph due to the use of precipitation summarized on a daily basis, this variable was incorporated to allow adjustment for the effect of the peak flow rate on sediment routing. This factor is used in the MUSLE equation and impacts the amount of erosion generated in the HRUs.

If no value for ADJ_PKR is entered, the model will set ADJ_PKR=1.0.

Required.

| TB_ADJ | *New variable in testing.* |

*Adjustment factor for subdaily unit hydrograph basetime.*

# NUTRIENT CYCLING

| Variable name | Definition |
|---|---|
| RCN | Concentration of nitrogen in rainfall (mg N/L). |

If no value for RCN is entered, the model will set RCN = 1.0.

Required.

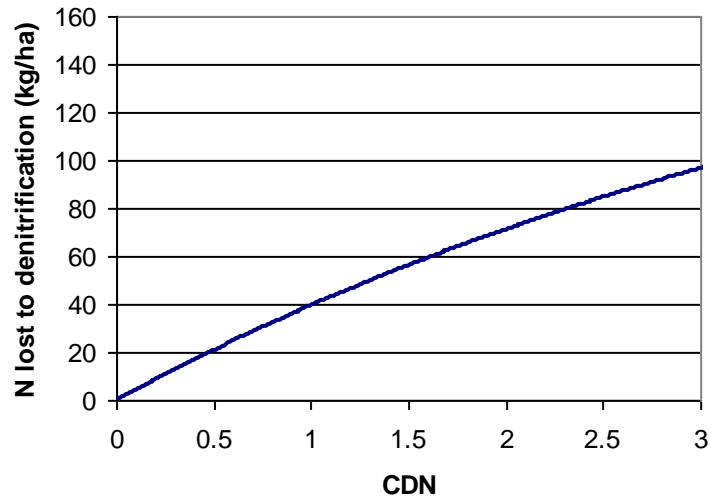| Variable name | Definition |
|---|---|
| CMN | Rate factor for humus mineralization of active organic nutrients (N and P). |
| | Chapters 3:1 and 3:2 of the Theoretical Documentation describe the use of this parameter in the mineralization calculations. |
| | If no value for CMN is specified, the model will set CMN = 0.0003. |
| | Required. |
| CDN | Denitrification exponential rate coefficient. |
| | This coefficient allows the user to control the rate of denitrification. |
| | Acceptable values for CDN range from 0.0 to 3.0. If no value for CDN is specified, the model will set CDN = 1.4. |
| | Required. |



Fig 4-8: Impact of CDN value on amount of nitrogen lost to denitrification assuming initial nitrate content in layer is 200 kg/ha, temperature of layer is 10 °C, and organic carbon content of layer is 2%.

| Variable name | Definition |
|---|---|
| SDNCO | Denitrification threshold water content. |
| | Fraction of field capacity water content above which denitrification takes place. |
| | Denitrification is the bacterial reduction of nitrate, $NO_3^-$, to $N_2$ or $N_2O$ gases under anaerobic (reduced) conditions. Because SWAT does not track the redox status of the soil layers, the presence of anaerobic conditions in a soil layer is defined by this variable. If the soil water content calculated as fraction of field capacity is $\geq$ SDNCO, then anaerobic conditions are assumed to be present and denitrification is modeled. If the soil water content calculated as a fraction of field capacity is $<$ SDNCO, then aerobic conditions are assumed to be present and denitrification is not modeled. |
| | If no value for SDNCO is specified, the model will set SDNCO = 1.10. |
| | Required. |
| N_UPDIS | Nitrogen uptake distribution parameter. |
| | Root density is greatest near the surface, and plant nitrogen uptake in the upper portion of the soil will be greater than in the lower portion. The depth distribution of nitrogen uptake is controlled by $\beta_n$, the nitrogen uptake distribution parameter. |
| | The importance of the nitrogen uptake distribution parameter lies in its control over the maximum amount of nitrate removed from the upper layers. Because the top 10 mm of the soil profile interacts with surface runoff, the nitrogen uptake distribution parameter will influence the amount of nitrate available for transport in surface runoff. The model allows lower layers in the root zone to fully compensate for lack of nitrate in the upper layers, so there should not be significant changes in nitrogen stress with variation in the value used for $\beta_n$. |
| | If no value for N_UPDIS is entered, the model will set N_UPDIS = 20.0. |
| | Figure 4-9 illustrates nitrogen uptake as a function of depth for four different uptake distribution parameter values. |
| | Required. |

| **Variable name** | **Definition** |
|---|---|

N_UPDIS, cont.
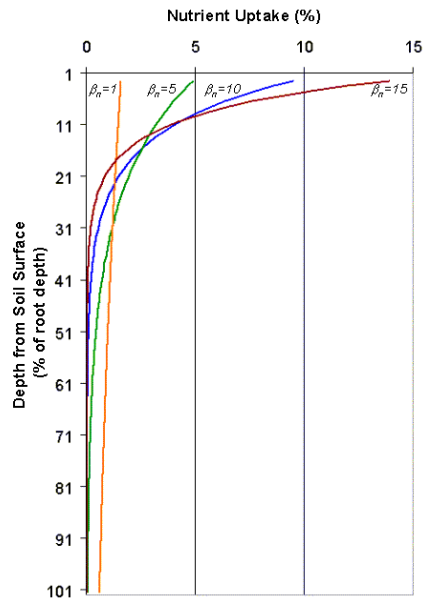


Figure 4-9: Depth distribution of nitrogen uptake

P_UPDIS

Phosphorus uptake distribution parameter.

This parameter controls plant uptake of phosphorus from the different soil horizons in the same way that UBN controls nitrogen uptake. The illustration of nitrogen uptake as a function of depth for four different uptake distribution parameter values in Figure 4-9 is valid for phosphorus uptake as well.

Phosphorus removed from the soil by plants is taken from the solution phosphorus pool. The importance of the phosphorus uptake distribution parameter lies in its control over the maximum amount of solution P removed from the upper layers. Because the top 10 mm of the soil profile interacts with surface runoff, the phosphorus uptake distribution parameter will influence the amount of labile phosphorus available for transport in surface runoff. The model allows lower layers in the root zone to fully compensate for lack of solution P in the upper layers, so there should not be significant changes in phosphorus stress with variation in the value used for $\beta_p$.

| Variable name | Definition |
| --- | --- |
| P_UPDIS, cont. | If no value for P_UPDIS is entered, the model will set P_UPDIS = 20.0. |
| | Required. |
| NPERCO | Nitrate percolation coefficient. |
| | NPERCO controls the amount of nitrate removed from the surface layer in runoff relative to the amount removed via percolation. |
| | The value of NPERCO can range from 0.01 to 1.0. As NPERCO $\rightarrow$ 0.0, the concentration of nitrate in the runoff approaches 0. As NPERCO $\rightarrow$ 1.0, surface runoff has the same concentration of nitrate as the percolate. |
| | If no value for NPERCO is entered, the model will set NPERCO = 0.20. |
| | Required. |
| PPERCO | Phosphorus percolation coefficient (10 m$^3$/Mg). |
| | The phosphorus percolation coefficient is the ratio of the solution phosphorus concentration in the surface 10 mm of soil to the concentration of phosphorus in percolate. |
| | The value of PPERCO can range from 10.0 to 17.5 If no value for PPERCO is entered, the model will set PPERCO = 10.0. |
| | Required. |
| PHOSKD | Phosphorus soil partitioning coefficient (m3/Mg). |
| | The phosphorus soil partitioning coefficient is the ratio of the soluble phosphorus concentration in the surface 10 mm of soil to the concentration of soluble phosphorus in surface runoff. |
| | The primary mechanism of phosphorus movement in the soil is by diffusion. Diffusion is the migration of ions over small distances (1-2 mm) in the soil solution in response to a concentration gradient. Due to the low mobility of solution phosphorus, surface runoff will only partially interact with the solution P stored in the top 10 mm of soil. |
| | If no value for PHOSKD is entered, the model will set PHOSKD = 175.0. |
| | Required. |

| **Variable name** | **Definition** |
| --- | --- |

PSP             Phosphorus availability index.

Many studies have shown that after an application of soluble P fertilizer, solution P concentration decreases rapidly with time due to reaction with the soil. This initial "fast" reaction is followed by a much slower decrease in solution P that may continue for several years (Barrow and Shaw, 1975; Munns and Fox, 1976; Rajan and Fox, 1972; Sharpley, 1982). In order to account for the initial rapid decrease in solution P, SWAT assumes a rapid equilibrium exists between solution P and an "active" mineral pool. The subsequent slow reaction is simulated by the slow equilibrium assumed to exist between the "active" and "stable" mineral pools. The algorithms governing movement of inorganic phosphorus between these three pools are taken from Jones et al. (1984).

Equilibration between the solution and active mineral pool is governed by the phosphorus availability index. This index specifies the fraction of fertilizer P which is in solution after an incubation period, i.e. after the rapid reaction period.

A number of methods have been developed to measure the phosphorus availability index. Jones et al. (1984) recommends a method outlined by Sharpley et al. (1984) in which various amounts of phosphorus are added in solution to the soil as $K_2HPO_4$. The soil is wetted to field capacity and then dried slowly at 25°C. When dry, the soil is rewetted with deionized water. The soil is exposed to several wetting and drying cycles over a 6-month incubation period. At the end of the incubation period, solution phosphorus is determined by extraction with anion exchange resin.

The P availability index is then calculated:

$$pai = \frac{P_{solution,f} - P_{solution,i}}{fert_{minP}}$$

where *pai* is the phosphorus availability index, $P_{solution,f}$ is the amount of phosphorus in solution after fertilization and incubation, $P_{solution,i}$ is the amount of phosphorus in solution before fertilization, and $fert_{minP}$ is the amount of soluble P fertilizer added to the sample.

If no value for PSP is entered, the model will set PSP = 0.40.

Required.

| Variable name | Definition |
| --- | --- |
| RSDCO | Residue decomposition coefficient. |
| | The fraction of residue which will decompose in a day assuming optimal moisture, temperature, C:N ratio and C:P ratio. |
| | If no value for RSDCO is entered, the model will set RSDCO = 0.05. |
| | Required. |

# PESTICIDE CYCLING

| Variable name | Definition |
| --- | --- |
| PERCOP | Pesticide percolation coefficient. |
| | PERCOP controls the amount of pesticide removed from the surface layer in runoff and lateral flow relative to the amount removed via percolation. The value of PERCOP can range from 0.01 to 1.0. As PERCOP → 0.0, the concentration of pesticide in the runoff and lateral flow approaches 0. As PERCOP → 1.0, surface runoff and lateral flow has the same concentration of pesticide as the percolate. |
| | If no value for PERCOP is entered, the model will set PERCOP = 0.50. |
| | Required if pesticide transport is of interest. |

# ALGAE/CBOD/DISSOLVED OXYGEN

| Variable name | Definition |
| --- | --- |
| ISUBWQ | Subbasin water quality code. |
| | The algorithms used to calculate loadings of algae, organic carbonaceous biological oxygen demand and dissolved oxygen to the stream network (see Chapter 4:4 in Theoretical Documentation) were derived from results of limited studies and are still in the testing phase. ISUBWQ allows the user to choose to apply or not apply the algorithms. |
| | 0    do not calculate algae/CBOD loadings and set dissolved oxygen to saturated oxygen concentration |
| | 1    calculate algae/CBOD/dissolved oxygen loadings using algorithms documented in Theoretical Documentation |
| | The default option is ISUBWQ=0. |
| | Required. |

# BACTERIA

| Variable name | Definition |
| --- | --- |
| WDPQ | Die-off factor for persistent bacteria in soil solution at 20°C. (1/day) |
| | SWAT allows two different bacteria types to be modeled in a given simulation. In the input/output files these two types are referred to as 'persistent' and 'less persistent'. These terms are purely descriptive and are used solely to differentiate between the two types. The bacteria input variables in the .bsn file govern the actual persistence of the two bacteria types. The user may choose to model no, one, or two types of bacteria. |
| | Required if bacteria processes are of interest. |
| WGPQ | Growth factor for persistent bacteria in soil solution at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WDLPQ | Die-off factor for less persistent bacteria in soil solution at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WGLPQ | Growth factor for less persistent bacteria in soil solution at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WDPS | Die-off factor for persistent bacteria adsorbed to soil particles at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WGPS | Growth factor for persistent bacteria adsorbed to soil particles at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WDLPS | Die-off factor for less persistent bacteria adsorbed to soil particles at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WGLPS | Growth factor for less persistent bacteria adsorbed to soil particles at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |

| Variable name | Definition |
| --- | --- |
| WDPF | Die-off factor for persistent bacteria on foliage at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WGPF | Growth factor for persistent bacteria on foliage at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WDLPF | Die-off factor for less persistent bacteria on foliage at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WGLPF | Growth factor for less persistent bacteria on foliage at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| BACT_SWF | Fraction of manure applied to land areas that has active colony forming units. |
| | If no value for BACT_SWF is specified, the model will set BACT_SWF = 0.15. |
| | Required if bacteria processes are of interest. |
| WOF_P | Wash-off fraction for persistent bacteria. |
| | Fraction of persistent bacteria on foliage that washes off during a rainfall event. |
| | Required if bacteria processes are of interest. |
| WOF_LP | Wash-off fraction for less persistent bacteria. |
| | Fraction of less persistent bacteria on foliage that washes off during a rainfall event. |
| | Required if bacteria processes are of interest. |

| Variable name | Definition |
|---|---|
| BACTKDQ | Bacteria soil partitioning coefficient ($m^3$/Mg). |
| | The bacteria soil partitioning coefficient is the ratio of the solution bacteria concentration in the surface 10 mm of soil to the concentration of solution bacteria in surface runoff. |
| | Due to the low mobility of bacteria, surface runoff will only partially interact with the solution bacteria stored in the top 10 mm of soil. |
| | If no value for BACTKDQ is entered, the model will set BACTKDQ = 175.0. |
| | Required if bacteria processes are of interest. |
| BACTMIX | Bacteria percolation coefficient (10 $m^3$/Mg). |
| | The bacteria percolation coefficient is the ratio of the solution bacteria concentration in the surface 10 mm of soil to the concentration of bacteria in percolate. |
| | The value of BACTMIX can range from 7.0 to 20.0. If no value for BACTMIX is entered, the model will set BACTMIX = 10.0. |
| | Required if bacteria processes are of interest. |
| THBACT | Temperature adjustment factor for bacteria die-off/growth. |
| | If no value for THBACT is entered, the model will set THBACT = 1.07. |
| | Required if bacteria processes are of interest. |
| BACTMINLP | Minimum daily bacteria loss for less persistent bacteria (# cfu/$m^2$). |
| | This is the minimum daily bacteria loss from each of the different bacteria pools. Also, when bacteria levels fall below BACTMIN the model considers the remaining bacteria in the soil to be insignificant and zeros out, i.e. kills, the remaining bacteria. |
| | If no value for BACTMIN is entered, the model will set BACTMIN = 0.0. |

| | |
|---|---|
| BACTMINP | Minimum daily bacteria loss for persistent bacteria (# cfu/m$^2$). |
| | This is the minimum daily bacteria loss from each of the different bacteria pools. Also, when bacteria levels fall below BACTMIN the model considers the remaining bacteria in the soil to be insignificant and zeros out, i.e. kills, the remaining bacteria. |
| | If no value for BACTMIN is entered, the model will set BACTMIN = 0.0. |
| WDLPRCH | Die-off factor for less persistent bacteria in streams (moving water) at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WDPRCH | Die-off factor for persistent bacteria in streams (moving water) at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WDLPRES | Die-off factor for less persistent bacteria in water bodies (still water) at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |
| WDPRES | Die-off factor for persistent bacteria in water bodies (still water) at 20°C. (1/day) |
| | Required if bacteria processes are of interest. |

# 4.3 MODELING OPTIONS: REACHES

| Variable name | Definition |
|---|---|
| IRTE | Channel water routing method: |
| | 0    variable storage method |
| | 1    Muskingum method |
| | The user must be careful to define MSK_CO1, MSK_CO2 and MSK_X when the Muskingum method is chosen. |
| | The default option is IRTE=0. |
| | Required. |

| Variable name | Definition |
|---|---|
| MSK_CO1 | Calibration coefficient used to control impact of the storage time constant ($K_m$) for normal flow (where normal flow is when river is at bankfull depth) upon the $K_m$ value calculated for the reach. |
| | Required only if IRTE = 1. |
| MSK_CO2 | Calibration coefficient used to control impact of the storage time constant ($K_m$) for low flow (where low flow is when river is at 0.1 bankfull depth) upon the $K_m$ value calculated for the reach. |
| | Required only if IRTE = 1. |
| MSK_X | MSK_X is a weighting factor that controls the relative importance of inflow and outflow in determining the storage in a reach. |
| | The weighting factor has a lower limit of 0.0 and an upper limit of 0.5. This factor is a function of the wedge storage. For reservoir-type storage, there is no wedge and $X = 0.0$. For a full-wedge, $X = 0.5$. For rivers, $X$ will fall between 0.0 and 0.3 with a mean value near 0.2. |
| | If no value for MSK_X is entered, the model will set MSK_X $= 0.2$. |
| | Required only if IRTE = 1. |
| TRNSRCH | Fraction of transmission losses from main channel that enter deep aquifer. The remainder if the transmission losses enter bank storage. |
| | In arid watersheds, transmission losses from the main channel network may be permanently lost due to transmission to aquifers that do not contribute flow back to the stream network. This variable allows the user to specify the fraction of transmission losses from the channel network that is permanently lost. |
| | TRNSRCH varies between 0.00 and 1.00. The default value for TRNSRCH is 0.00. |
| | Required. |

| Variable name | Definition |
| --- | --- |
| EVRCH | Reach evaporation adjustment factor. |
| | The evaporation coefficient is a calibration parameter for the user and is allowed to vary between 0.0 and 1.0. This coefficient was created to allow reach evaporation to be dampened in arid regions. The original equation tends to overestimate evaporation in these areas. |
| | If no value for EVRCH is entered, the model will set EVRCH = 1.00. |
| | Required. |
| IDEG | Channel degradation code. |
| | There are two options: 0   channel dimensions are not updated as a result of degradation (the dimensions remain constant for the entire simulation) 1   channel dimensions are updated as a result of degradation |
| | Traditionally, channel dimensions remain fixed, or constant, throughout the simulation. The change in channel dimensions with time is a new feature in SWAT that is still in the testing phase. The recommended option is to keep the channel dimensions constant. |
| | Required. |
| PRF | Peak rate adjustment factor for sediment routing in the main channel. |
| | Sediment routing is a function of peak flow rate and mean daily flow. Because SWAT originally could not directly calculate the sub-daily hydrograph, this variable was incorporated to allow adjustment for the effect of the peak flow rate on sediment routing. This variable impacts channel degradation. |
| | If no value for PRF is entered, the model will set PRF = 1.0. |
| | Required. |

| Variable name | Definition |
|---|---|
| SPCON | Linear parameter for calculating the maximum amount of sediment that can be reentrained during channel sediment routing. |
| | The maximum amount of sediment that can be transported from a reach segment is calculated $conc_{sed,ch,mx} = c_{sp} \cdot v_{ch,pk}{}^{spexp}$ where concsed,ch,mx is the maximum concentration of sediment that can be transported by the water (ton/m3 or kg/L), csp is a coefficient defined by the user, vch,pk is the peak channel velocity (m/s), and spexp is an exponent defined by the user. |
| | SPCON should be between 0.0001 and 0.01. If no value for SPCON is entered, the model will set SPCON = 0.0001. |
| | Required. |
| SPEXP | Exponent parameter for calculating sediment reentrained in channel sediment routing |
| | The maximum amount of sediment that can be transported from a reach segment is calculated $conc_{sed,ch,mx} = c_{sp} \cdot v_{ch,pk}{}^{spexp}$ where concsed,ch,mx is the maximum concentration of sediment that can be transported by the water (ton/m3 or kg/L), csp is a coefficient defined by the user, vch,pk is the peak channel velocity (m/s), and spexp is an exponent defined by the user. |
| | The exponent, spexp, normally varies between 1.0 and 2.0 and was set at 1.5 in the original Bagnold stream power equation (Arnold et al., 1995). If no value for SPEXP is entered, the model will set SPEXP = 1.0. |
| | Required. |

| Variable name | Definition |
|---|---|
| IWQ | In-stream water quality code. |
| | The variable identifies whether in-stream transformation of nutrients using the QUAL2E algorithms and in-stream transformation of pesticides is allowed to occur. |
| | 0   do not model in-stream nutrient and pesticide transformations<br>1   model in-stream nutrient and pesticide transformations |
| | The default option is IWQ=0. |
| | Required. |
| WWQFILE | Name of watershed water quality input file (**.wwq**). |
| | This file is described in Chapter 26. |
| | Required. |
| IRTPEST | Identification number of pesticide to be routed through the watershed channel network. |
| | This is the pesticide ID number from the pesticide database. While more than one type of pesticide may be applied to the HRUs, the model will monitor the movement of only one pesticide through the channel network. |
| | Required only if pesticide transport processes are of interest. |

DEPIMP_BSN          Depth to impervious layer for modeling perched water tables (mm).

This variable is included for convenience. A value for DEPIMP_BSN can be defined that will be used to set the value of DEP_IMP (.hru) for every HRU in the watershed. If the user sets a value for DEPIMP_BSN and also sets values for DEP_IMP in some HRUs, the customized values for DEP_IMP will not be overwritten by the basin level value (DEPIMP_BSN).

For watersheds where there are no perched water tables, DEPIMP_BSN should be set to 0. For watersheds where perched water tables occur in only a portion of the watershed, DEPIM_BSN should be set to 0 and the DEP_IMP variable (.hru) should be used to set the depth to the impervious layer for those areas that have perched water tables.

See DEP_IMP (.hru) for more information.

Optional.

DDRAIN_BSN          Depth to the sub-surface drain (mm)

Optional.

TDRAIN_BSN          Time to drain soil to field capacity (hours).

Optional.

GDRAIN_BSN          Drain tile lag time (hours).

Optional.

CNFROZ_BSN          Parameter for frozen soil adjustment on infiltration/runoff.

If no value for CNFROZ_BSN is entered, the model will set CNFROZ_BSN = 0.000862.

Optional.

DORM_HR             Time threshold used to define dormancy (hours). The maximum day length minus DORM_HR  is equal to when dormancy occurs.

Optional.

SMXCO               Adjustment factor for maximum curve number S factor. Coefficient curve number method that uses antecedent climate.

Optional.

FIXCO               Nitrogen fixation coefficient. (0.0 – 1.0)

1.0 = fixes 100% of nitrogen demand.  0.0 = fixes none of nitrogen demand.

| | |
|---|---|
| NFIXMX | Maximum daily-n fixation (kg/ha). (1.0 – 20.0) |
| ANION_EXCL_BSN | Fraction of porosity from which anions are excluded. (.01 – 1.00) |
| CH_ONCO_BSN | Channel organic nitrogen concentration in basin (ppm). (0.0 – 100.0) |
| CH_OPCO_BSN | Channel organic phosphorus concentration in basin (ppm).  (0.0 – 100) |
| HLIFE_NGW_BSN | Half-life of nitrogen in groundwater (days) (0.0 – 500.0) |
| RCN_SUB_BSN | Concentration of nitrate in precipitation (ppm). (0.0 – 2.0) |
| BC1_BSN | Rate constant for biological oxidation of NH3 (1/day). (0.10 – 1.0) |
| BC2_BSN | Rate constant for biological oxidation NO2 to NO3 (1/day) (0.2 – 2.0) |
| BC3_BSN | Rate constant for hydrolosis of organic nitrogen to ammonia (1/day). (0.02 – 0.40) |
| BC4_BSN | Rate constant for decay of organic phosphorus to dissolved phosphorus (1/day) (0.01 – 0.70) |
| DECR_MIN | Minimum daily residue decay (fraction 0.0 – 0.05) |
| ICFAC | ICFAC = 0 for C-factor calculation using Cmin. ICFAC = 1 for new C-factor calculation.  (0-1) |
| RSD_COVCO | Residue cover factor for computing fraction of cover. (0.1 – 0.5) |
| VCRIT | Critical velocity |
| CSWAT | Code for new carbon routines:<br>　0 = original routines<br>　1 = new carbon routines |
| RES_STLR_CO | Reservoir sediment settling coefficient (0.09 – 0.27) |
| SOL_P_MODEL | Code<br>　0 = use new soil phosphorus routines<br>　1 = use original soil phosphorus subroutines |
| IABSTR | Initial abstraction on impervious cover (mm) |
| BFLO_DIST | Baseflow distribution factor during the day for subdaily runs.<br>　0 = baseflow evenly distributed to each time step during the day<br>　0.5 = even weights between even distribution and rainfall pattern<br>　1= profile of baseflow in a day follows rainfall pattern |
| IUH | Unit hydrograph method:<br>　1 = triangular UH<br>　2 = gamma function UH |

| | |
|---|---|
| UHALPHA | Alpha coefficient for gamma function unit hydrograph. Required if iuh = 2 is selected |
| TLU | A temporary string variable )no default or min/max values) |
| LU_NODRAIN | Land use typed in urban.dat that do not make runoff to urban BMPs |

# 4.4 SUBDAILY EROSION

| Variable name | Definition |
|---|---|
| EROS_SPL | Splash erosion coefficient (0.9 – 3.1) |
| RILL_MULT | Rill erosion coefficient – multiplier to USLE_K for soil susceptible to rill erosion (0.5-2.0) |
| EROS_EXPO | Exponential coefficient for overland flow – (1.5-3.0) |
| SUBD_CHSED | Instream sediment model, 0=Bagnold model, 1=Brownlie model, 2=Yang model |
| C_FACTOR | Scaling parameter for cover and management factor for overland flow erosion (0.03/0.001/0.45) |
| CH_D50 | Median particle diameter of main channel (mm)  (50/10/100) |
| SIG_G | Geometric standard deviation of particle size (1.57/1.0/5.0) |

# 4.5 SUBBASIN DRAINAGE

| Variable name | Definition |
| --- | --- |
| DRAIN_CO_BSN | Daily drainage coefficient (mm day$^{-1}$). |
| | Range (10-51 mm day$^{-1}$) |
| LATKSATF_BSN | Multiplication factor to determine lateral ksat (conk(j1,j)) from SWAT ksat input value (sol_k(j1,j)) for HRU |
| | Range (0.01 - 4.00) |
| PC_BSN | Pump capacity  (mm h$^{-1}$) |
| | Default value = 1.042 mm h$^{-1}$ or 22 mm day$^{-1}$ |
| RE_BSN | Effective radius of drains (mm) |
| | Range (3.0 – 40.0 mm) |
| SDRAIN_BSN | Distance between two drain tubes or tiles (mm) |
| | Range (7600 – 30000 mm) |
| ITDRN | Tile drainage equations flag/code |
| | Tile drainage routines flag/code: 1 = DRAINMOD tile equations (Subroutine DRAINS)<br>　　1 simulate tile flow using subroutine drains(wt_shall)<br>　　0 simulate tile flow using subroutine origtile(wt_shall,d) |
| IWTDN | water table depth algorithms flag/code |
| | 1 simulate wt_shall using subroutine new water table depth routine |
| | 0 simulate wt_shall using subroutine original water table depth routine |
| SOL_P_MODEL | Soil phosphorus model<br>0 = original soil phosphorus model<br>1 = new soil phosphorus model |
| IABSTR | Initial abstraction on impervious cover (mm) |
| IATMODEP | Atmospheric deposition values<br>0=read in average annual values<br>1=read in monthly values |
| R2ADJ | Curve number retention parameter adjustment for low gradient, non-draining soils (dimensionless) (0-3) |

The basin input file is a free format file. The variables may be placed in any position the user wishes on the line. Values for variables classified as integers *should not* include a decimal while values for variables classified as reals *must* contain a decimal. A blank space denotes the end of an input value and the beginning of the next value if there is another on the line.

| Variable name | Line # | Format | F90 Format |
|---|---|---|---|
| TITLE | 1 | character | a80 |
| *Comment line* | 2 | character | a80 |
| *Comment line* | 3 | character | a80 |
| SFTMP | 4 | real | free |
| SMTMP | 5 | real | free |
| SMFMX | 6 | real | free |
| SMFMN | 7 | real | free |
| TIMP | 8 | real | free |
| SNOCOVMX | 9 | real | free |
| SNO50COV | 10 | real | free |
| IPET | 11 | integer | free |
| PETFILE | 12 | character | a13 (space 1-13) |
| ESCO | 13 | real | free |
| EPCO | 14 | real | free |
| EVLAI | 15 | real | free |
| FFCB | 16 | real | free |
| *Comment line* | 17 | character | a80 |
| IEVENT | 18 | integer | free |
| ICRK | 19 | integer | free |
| SURLAG | 20 | real | free |
| ADJ_PKR | 21 | real | free |
| PRF | 22 | real | free |

| Variable name | Line # | Format | F90 Format |
|---|---|---|---|
| SPCON | 23 | real | free |
| SPEXP | 24 | real | free |
| *Comment line* | 25 | character | a80 |
| RCN | 26 | real | free |
| CMN | 27 | real | free |
| N_UPDIS | 28 | real | free |
| P_UPDIS | 29 | real | free |
| NPERCO | 30 | real | free |
| PPERCO | 31 | real | free |
| PHOSKD | 32 | real | free |
| PSP | 33 | real | free |
| RSDCO | 34 | real | free |
| *Comment line* | 35 | character | a80 |
| PERCOP | 36 | real | free |
| *Comment line* | 37 | character | a80 |
| ISUBWQ | 38 | integer | free |
| *Comment line* | 39 | character | a80 |
| WDPQ | 40 | real | free |
| WGPQ | 41 | real | free |
| WDLPQ | 42 | real | free |
| WGLPQ | 43 | real | free |
| WDPS | 44 | real | free |
| WGPS | 45 | real | free |
| WDLPS | 46 | real | free |
| WGLPS | 47 | real | free |
| BACTKDQ | 48 | real | free |
| THBACT | 49 | real | free |
| WOF_P | 50 | real | free |
| WOF_LP | 51 | real | free |
| WDPF | 52 | real | free |
| WGPF | 53 | real | free |
| WDLPF | 54 | real | free |
| WGLPF | 55 | real | free |

| Variable name | Line # | Format | F90 Format |
|---|---|---|---|
| ISED_DET | 56 | integer | free |
| *Comment line* | 57 | character | a80 |
| IRTE | 58 | integer | free |
| MSK_CO1 | 59 | real | free |
| MSK_CO2 | 60 | real | free |
| MSK_X | 61 | real | free |
| IDEG | 62 | integer | free |
| IWQ | 63 | integer | free |
| WWQFILE | 64 | character | a13 (space 1-13) |
| TRNSRCH | 65 | real | free |
| EVRCH | 66 | real | free |
| IRTPEST | 67 | integer | free |
| ICN | 68 | real | free |
| CNCOEF | 69 | real | free |
| CDN | 70 | real | free |
| SDNCO | 71 | real | free |
| BACT_SWF | 72 | real | free |
| BACTMX | 73 | real | free |
| BACTMINLP | 74 | real | free |
| BACTMINP | 75 | real | free |
| WDLPRCH | 76 | real | free |
| QWDPRCH | 77 | real | free |
| WDLPRES | 78 | real | free |
| WDPRES | 79 | real | free |
| TB_ADJ | 80 | real | free |
| DEPIMP_BSN | 81 | real | free |
| DDRAIN_BSN | 82 | real | free |
| TDRAIN_BSN | 83 | real | free |
| GDRAIN_BSN | 84 | real | free |
| CN_FROZ | 85 | real | free |
| DORM_HR | 86 | real | free |
| SMXCO | 87 | real | free |
| FIXCO | 88 | real | free |
| NFIXMX | 89 | real | free |
| ANION_EXCL_BSN | 90 | real | free |
| **Variable name** | **Line #** | **Format** | **F90 Format** |

| Variable name | Line # | Format | F90 Format |
|---|---|---|---|
| CH_OPCO_BSN | 92 | real | free |
| CH_ONCO_BSN | 91 | real | free |
| HLIFE_NGW_BSN | 93 | real | free |
| RCN_SUB_BSN | 94 | real | free |
| BC1_BSN | 95 | real | free |
| BC2_BSN | 96 | real | free |
| BC3_BSN | 97 | real | free |
| BC4_BSN | 98 | real | free |
| DECR_MIN | 99 | real | free |
| ICFAC | 100 | real | free |
| RSD_COVCO | 101 | real | free |
| VCRIT | 102 | real | free |
| CSWAT | 103 | integer | free |
| RES_STLR_CO | 104 | real | free |
| SOL_P_MODEL | 105 | integer | free |
| IABSTR | 106 | real | free |
| BFLO_DIST | 107 | real | free |
| IUH | 108 | integer | free |
| UHALPHA | 109 | real | free |
| title | 110 | character | free |
| TLU/ LU_NODRAIN | 111 | real | free |
| title | 112 | character | free |
| EROS_SPL | 113 | real | free |
| RILL_MULT | 114 | real | free |
| EROS_EXPO | 115 | real | free |
| SUB_CHSED | 116 | integer | free |
| C_FACTOR | 117 | real | free |
| CH_D50 | 118 | real | free |
| SIG_G | 119 | real | free |
| RE_BSN | 120 | real | free |
| SDRAIN_BSN | 121 | real | free |
| DRAIN_CO_BSN | 122 | real | free |
| PC_BSN | 123 | real | free |
| LATKSATF_BSN | 124 | real | free |
| ITDRN | 125 | integer | free |
| **Variable name** | **Line #** | **Format** | **F90 Format** |

| IWTDN | 126 | integer | free |
| SOL_P_MODEL | 127 | integer | free |
| IABSTR | 128 | real | free |
| IATMODEP | 129 | integer | free |
| R2ADJ | 130 | real | free |

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