CHAPTER 30

SWAT INPUT DATA: .LWQ

While water quality is a broad subject, the primary areas of concern are nutrients, organic chemicals—both agricultural (pesticide) and industrial, heavy metals, bacteria and sediment levels in streams and large water bodies. SWAT is able to model processes affecting nutrient, pesticide and sediment levels in the main channels and reservoirs. The data used by SWAT for water quality in impoundments located on the main channel network is contained in the lake water quality input file (.lwq).

Following is a brief description of the variables in the lake water quality input file. They are listed in the order they appear within the file.

Variable name	**Definition**
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank.
NUTRIENT TITLE	The second line is reserved for the nutrient section title. This line is not processed by the model and may be left blank.
IRES1	Beginning month of mid-year nutrient settling period. The model allows the user to define two settling rates for each nutrient and the time of the year during which each settling rate is used. A variation in settling rates is allowed so that impact of temperature and other seasonal factors may be accounted for in the modeling of nutrient settling. To use only one settling rate for the entire year, both variables for the nutrient may be set to the same value. Setting all variables to zero will cause the model to ignore settling of nutrients in the water body. Required.
IRES2	Ending month of mid-year nutrient settling period. See comment for IRES1. Required.
PSETLR1	Phosphorus settling rate in reservoir for months IRES1 through IRES2 (m/year). The apparent settling velocity is most commonly reported in units of m/year and this is how the values are input to the model. For natural lakes, measured phosphorus settling velocities most frequently fall in the range of 5 to 20 m/year although values less than 1 m/year to over 200 m/year have been reported (Chapra, 1997). Panuska and Robertson (1999) noted that the range in apparent settling velocity values for man-made reservoirs tends to be significantly greater than for natural lakes. Higgins and Kim (1981) reported phosphorus apparent settling velocity values from –90 to 269 m/year for 18 reservoirs in Tennessee with a median value of 42.2 m/year. For 27 Midwestern reservoirs, Walker and Kiihner (1978) reported phosphorus apparent settling velocities ranging

Variable name	Definition
PSETLR1, cont.	from –1 to 125 m/year with an average value of 12.7 m/year. A negative settling rate indicates that the reservoir sediments are a source of N or P; a positive settling rate indicates that the reservoir sediments are a sink for N or P. Table 30-1 summarizes typical ranges in phosphorus settling velocity for different systems. Required if nutrient cycling is being modeled.

Table 30-1: Recommended apparent settling velocity values for phosphorus (Panuska and Robertson, 1999)

Nutrient Dynamics	Range in settling velocity values (m/year)
Shallow water bodies with high net internal phosphorus flux	$\nu \leq 0$
Water bodies with moderate net internal phosphorus flux	$1 < \nu < 5$
Water bodies with minimal net internal phosphorus flux	$5 < \nu < 16$
Water bodies with high net internal phosphorus removal	$\nu > 16$

PSETLR2	Phosphorus settling rate in reservoir for months other than IRES1-IRES2 (m/year). See explanation for PSETLR1 for more information about this parameter. Required if nutrient cycling is being modeled.
NSETLR1	Nitrogen settling rate in reservoir for months IRES1 through IRES2 (m/year). See explanation for PSETLR1 for more information about this parameter. Required if nutrient cycling is being modeled.
NSETLR2	Nitrogen settling rate in reservoir for months other than IRES1-IRES2 (m/year). See explanation for PSETLR1 for more information about this parameter. Required if nutrient cycling is being modeled.

Variable name	**Definition**
CHLAR	Chlorophyll *a* production coefficient for reservoir. Chlorophyll *a* concentration in the reservoir is calculated from the total phosphorus concentration. The equation assumes the system is phosphorus limited. The chlorophyll *a* coefficient was added to the equation to allow the user to adjust results to account for other factors not taken into account by the basic equation such as nitrogen limitations. The default value for CHLAR is 1.00, which uses the original equation. Required if nutrient cycling is being modeled.
SECCIR	Water clarity coefficient for the reservoir. The clarity of the reservoir is expressed by the secci-disk depth (m) which is calculated as a function of chlorophyll *a*. Because suspended sediment also can affect water clarity, the water clarity coefficient has been added to the equation to allow users to adjust for the impact of factors other than chlorophyll *a* on water clarity. The default value for SECCIR is 1.00, which uses the original equation. Required if nutrient cycling is being modeled.
RES_ORGP	Initial concentration of organic P in reservoir (mg P/L). 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 RES_ORGP is not going to be important if the reservoir is in operation at the beginning of the simulation. However, if the reservoir starts operation in the middle of a simulation, this value needs to be reasonably accurate. Required if nutrient cycling is being modeled.
RES_SOLP	Initial concentration of soluble P in reservoir (mg P/L). See comment for RES_ORGP. Required if nutrient cycling is being modeled.

Variable name	Definition
RES_ORGN	Initial concentration of organic N in reservoir (mg N/L). See comment for RES_ORGP. Required if nutrient cycling is being modeled.
RES_NO3	Initial concentration of NO_3-N in reservoir (mg N/L). See comment for RES_ORGP. Required if nutrient cycling is being modeled.
RES_NH3	Initial concentration of NH_3-N in reservoir (mg N/L). See comment for RES_ORGP. Required if nutrient cycling is being modeled.
RES_NO2	Initial concentration of NO_2-N in reservoir (mg N/L). See comment for RES_ORGP. Required if nutrient cycling is being modeled.
PESTICIDE TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
LKPST_CONC	Initial pesticide concentration in the reservoir water for the pesticide defined by IRTPEST (mg/m^3). See comment for RES_ORGP. Required if pesticide cycling is being modeled.
LKPST_REA	Reaction coefficient of the pesticide in reservoir water (day^{-1}) The rate constant is related to the aqueous half-life: $k_{p,aq} = \frac{0.693}{t_{1/2,aq}}$ where $k_{p,aq}$ is the rate constant for degradation or removal of pesticide in the water (1/day), and $t_{1/2,aq}$ is the aqueous half-life for the pesticide (days). Required if pesticide cycling is being modeled.

Variable name	**Definition**
LKPST_VOL	Volatilization coefficient of the pesticide from the reservoir (m/day). The volatilization mass-transfer coefficient can be calculated based on Whitman's two-film or two-resistance theory (Whitman, 1923; Lewis and Whitman, 1924 as described in Chapra, 1997). While the main body of the gas and liquid phases are assumed to be well-mixed and homogenous, the two-film theory assumes that a substance moving between the two phases encounters maximum resistance in two laminar boundary layers where transfer is a function of molecular diffusion. In this type of system the transfer coefficient or velocity is: $$v_v = K_l \cdot \frac{H_e}{H_e + R \cdot T_K \cdot \left(K_l / K_g\right)}$$ where v_v is the volatilization mass-transfer coefficient (m/day), K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), H_e is Henry's constant (atm m^3 mole^{-1}), R is the universal gas constant (8.206×10^{-5} atm m^3 (K mole)$^{-1}$), and T_K is the temperature (K). For lakes, the transfer coefficients are estimated using a stagnant film approach: $$K_l = \frac{D_l}{z_l} \qquad K_g = \frac{D_g}{z_g}$$ where K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), D_l is the liquid molecular diffusion coefficient (m^2/day), D_g is the gas molecular diffusion coefficient (m^2/day), z_l is the thickness of the liquid film (m), and z_g is the thickness of the gas film (m). Alternatively, the transfer coefficients can be estimated with the equations: $$K_l = K_{l,\mathrm{O}_2} \cdot \left(\frac{32}{MW}\right)^{0.25} \qquad K_g = 168 \cdot \mu_w \cdot \left(\frac{18}{MW}\right)^{0.25}$$

Variable name	Definition
LKPST_VOL, cont.	where K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), K_{l,O_2} is the oxygen transfer coefficient (m/day), MW is the molecular weight of the compound, and μ_w is the wind speed (m/s). Chapra (1997) lists several different equations that can be used to calculate K_{l,O_2}. Required if pesticide cycling is being modeled.
LKPST_KOC	Pesticide partition coefficient between water and sediment (m^3/g). The pesticide partition coefficient can be estimated from the octanol-water partition coefficient (Chapra, 1997): $K_d = 3.085 \times 10^{-8} \cdot K_{ow}$ where K_d is the pesticide partition coefficient (m^3/g) and K_{ow} is the pesticide's octanol-water partition coefficient ($\text{mg m}_{\text{octanol}}^{-3}\left(\text{mg m}_{\text{water}}^{-3}\right)^{-1}$). Values for the octanol-water partition coefficient have been published for many chemicals. If a published value cannot be found, it can be estimated from solubility (Chapra, 1997): $\log\left(K_{ow}\right) = 5.00 - 0.670 \cdot \log\left(pst'_{sol}\right)$ where pst'_{sol} is the pesticide solubility (µmoles/L). The solubility in these units is calculated: $pst'_{sol} = \dfrac{pst_{sol}}{MW} \cdot 10^3$ where pst'_{sol} is the pesticide solubility (µmoles/L), pst_{sol} is the pesticide solubility (mg/L) and MW is the molecular weight (g/mole). LKPST_KOC ranges between 10^{-4} to 10 m^3/g. Required if pesticide cycling is being modeled.

Variable name	**Definition**
LKPST_STL	Settling velocity of pesticide sorbed to sediment (m/day). Pesticide in the particulate phase may be removed from the water layer by settling. Settling transfers pesticide from the water to the sediment layer. Required if pesticide cycling is being modeled.
LKPST_RSP	Resuspension velocity of pesticide sorbed to sediment (m/day). Pesticide in the sediment layer is available for resuspension which transfers it back into the water. Required if pesticide cycling is being modeled.
LKPST_MIX	Pesticide diffusion or mixing velocity (m/day) The diffusive mixing velocity, v_d, can be estimated from the empirically derived formula (Chapra, 1997): $v_d = \frac{69.35}{365} \cdot \phi \cdot MW^{-2/3}$ where v_d is the rate of diffusion or mixing velocity (m/day), ϕ is the sediment porosity, and MW is the molecular weight of the pesticide compound. Required if pesticide cycling is being modeled.
LKSPST_CONC	Initial pesticide concentration in the reservoir bottom sediments. (mg/m^3). 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 LKSPST_CONC is not going to be important if a pesticide with a short half-life is being modeled. For pesticides with a long half-life, this variable is important. Required if pesticide cycling is being modeled.

Variable name	Definition
LKSPST_REA	Reaction coefficient of pesticide in reservoir bottom sediment (day^{-1}) The rate constant is related to the sediment half-life: $k_{p,sed} = \frac{0.693}{t_{1/2,sed}}$ where $k_{p,sed}$ is the rate constant for degradation or removal of pesticide in the sediment (1/day), and $t_{1/2,sed}$ is the sediment half-life for the pesticide (days). Required if pesticide cycling is being modeled.
LKSPST_BRY	Burial velocity of pesticide in reservoir bottom sediment (m/day). Pesticide in the sediment layer may be lost by burial. Required if pesticide cycling is being modeled.
LKSPST_ACT	Depth of active sediment layer in reservoir (m). Required if pesticide cycling is being modeled.

The lake water quality 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. The format of the lake water quality input file is:

Variable name	**Line #**	**Format**	**F90 Format**
TITLE	1	character	a80
NUTRIENT TITLE	2	character	a80
IRES1	3	integer	free
IRES2	4	integer	free
PSETLR1	5	real	free
PSETLR2	6	real	free
NSETLR1	7	real	free
NSETLR2	8	real	free
CHLAR	9	real	free
SECCIR	10	real	free
RES_ORGP	11	real	free
RES_SOLP	12	real	free
RES_ORGN	13	real	free
RES_NO3	14	real	free
RES_NH3	15	real	free
RES_NO2	16	real	free
PESTICIDE TITLE	17	character	a80
LKPST_CONC	18	real	free
LKPST_REA	19	real	free
LKPST_VOL	20	real	free
LKPST_KOC	21	real	free
LKPST_STL	22	real	free
LKPST_RSP	23	real	free
LKPST_MIX	24	real	free
LKSPST_CONC	25	real	free
LKSPST_REA	26	real	free
LKSPST_BRY	27	real	free
LKSPST_ACT	28	real	free

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