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SUBJECT: SPECIFICATION OF TOTAL SOIL DEPTH AND SEGMENT THICKNESS ON EVAPORATION AND DRAINAGE ESTIMATES AND ON PREDICTED BROMIDE MOVEMENT FOR LEACHP MODEL WITH COMPARISON TO THE PRZM MODEL

BACKGROUND

In the late 1980's, the Environmental Monitoring Branch of the Department of Pesticide Regulation (DPR), California Environmental Protection Agency (EPA), contracted with the authors of the Leaching Estimation And Chemistry Model (LEACHM) to determine the application of the model to field data sets generated during Branch investigations (Hutson and Wagenet, 1993). LEACHM contains a few submodels of which LEACHP is used to model pesticide movement. One of the data sets used in the evaluation was a study of the effect of method and amount of irrigation water application on movement of atrazine in a sandy soil (Troiano, et al. 1993). The comparisons of modeled to field data lead to revisions of the model that provided better description of solute movement through soil. During calibration of version 3 of the model to the irrigation field data, Spurlock (2000), noted a better fit of model prediction to field bromide soil distribution when the number of soil layers specified in the model was increased. The normal modeling scenario was to mimic the field sampling protocol where soil was cored to 3,000 mm in twenty soil layers, each 150-mm thick. Model results were in better agreement with field data when each 150-mm soil layer was divided into 5 thinner 30-mm soil layers, resulting in a model structured into 100 instead of 20 soil layers.

Differences in the estimate of evaporation or evapotranspiration between models have previously been recognized as an important factor driving differences in estimation of water movement. Models of solute movement employ different methodology to estimate evaporation or evapotranspiration, which under similar climatic inputs could produce different estimates of partitioning of water between evaporation and drainage. Clemente et al. (1994) concluded that the difference in the estimation of evaporation or evapotranspiration and its effects on soil water movement was the main cause of differences observed in predicted soil water content among SWATRE, SWASIM, and LEACHW models. LEACHW is a LEACHM submodel to predict water movement. Similarly, Smith et al. (1991), noted that the GLEAMS model provided greater estimation of evaporation or evapotranspiration than the PRZM model, resulting in less drainage volume with GLEAMS. Effects noted on partitioning of water between evaporation and drainage is subsequently reflected in prediction of solute movement. In a comparison of bromide movement between sprinkler and flood irrigation, the location of center mass in the soil profile indicated upward movement of water under deficit conditions when the volume of flood irrigation applied was less than daily measured evaporation (Nachabe et al., 1999).

This current investigation sought to provide a physical explanation for the effects of soil layer thickness on water and solute movement. Effects on partitioning of water between evaporation and drainage, and on bromide distribution in the soil were compared between LEACHP model simulations where soil layer thickness and the total soil depth modeled were varied. Additional comparisons were made to another commonly used model of pesticide transport named Pesticide Root Zone Model (PRZM) (Carsel et al., 2003). PRZM, which was developed by the U.S. EPA, incorporates different physical processes to model water movement and different methodology to estimate evaporation.

MATERIALS AND METHODS

Data for soil, climatic, and sprinkler irrigation applications from an irrigation study conducted in 1987 were used to establish a standard modeling scenario (Troiano et al., 1993; Spurlock, 2000). The study was conducted on the California State University, Fresno campus. The soil was a Delhi Loamy Sand and climatic data were obtained from a local weather station operated by the California Irrigation Management Information System (CIMIS), Department of Water Resources Station number 80 at Fresno State: <http://www.cimis.water.ca.gov/cimis/frontStationDetailInfo.do?stationId=80&src=info>. Examples of LEACHP input files in Appendix I contain the specific soil and climatic parameters. Macro-sprinkler irrigation treatments were simulated where water was emitted at a rate of 10.9 mm/hr. Irrigations were made one day a week at three different run times of approximately 4, 6, or 8 hours per day, producing 3 graded levels of percolating water, denoted as low, medium, and high, respectively. The simulated study period was for 48 days from June 11, 1987 to July 29, 1987. Following the field study protocol, atrazine at 3.8 kg/ha and bromide at 72 kg/ha were broadcast onto the soil after which an irrigation of 12 mm was applied to move residues from the surface into the soil matrix. The plots were scheduled to receive five weekly sprinkler irrigation treatments. In 1987, problems were encountered with the sand filter on the well supplying irrigation water so the first irrigation event was split into three smaller applications occurring on consecutive days. Subsequent repairs forced the next irrigation to occur a few days later than scheduled. Figure 1 indicates the relationship between cumulative reported daily reference evapotranspiration (ETo) obtained from the local CIMIS station and cumulative water application for each irrigation percolation treatment. After the fifth week of irrigation treatments, four replicate soil cores were sampled from the plots to the 3,000 mm depth in 150-mm increments. Water content and bromide and atrazine concentration were measured at each depth.

LEACHP and PRZM models differ in their approaches to modeling water movement. PRZM is a capacity based water-flow model, also denoted as a tipping bucket method, where water flows downward when soil water content reaches field capacity in a compartment (Boesten, 2004; Carsel, et al., 2003). Since the model simulates only advective, downward movement of water and does not account for diffusive movement due to soil water gradients, upward movement of water in response to evaporation or evapotranspiration losses is not possible. The model runs on a daily time step where drainage to field capacity for each soil layer occurs within one day. The version of PRZM used was 3.12.1, August 2003. Available at: <http://www.epa.gov/ceampubl/gwater/przm3/przm3121.htm>.

LEACHP provides for a choice between a similar tipping bucket approach and a more dynamic method that uses the Richard's equation for describing transient vertical flow. In this method, water flow is assumed as the product of a hydraulic gradient and a water content-dependent hydraulic conductivity (Hutson, 2003). In contrast to PRZM, water flow can move upward in response to established soil water gradients. Drainage is not limited to one day and proceeds in a dynamic fashion according to temporal establishment of soil water gradients. The time step for LEACHP is set to 0.1 fractions of a day or less. In these simulations a time step of 0.05 fractions of a day was specified.

Both models share some similarities in their approach to estimating evaporation when reference or pan evaportranspiration values are supplied. Evaporation will only be discussed because the irrigation study was conducted under a bare soil condition. The amount of water available for evaporation is based on the volumetric soil water content (Theta) value of the defined first soil layer. Evaporation occurs in two phases. In phase one, evaporation is limited by energy inputs determined by meteorological conditions and not soil water content (Allen et al, 1998). Phase two is described as a falling rate where soil is drying so evaporation is decreased as Theta values decrease below a specific threshold. The exact algorithms to determine the beginning of phase two, the slope of the falling rate, and the duration differ between the models. Other major differences between the models that affect the estimate of evaporation are:

- <u>Definition of first soil layer</u>: For LEACHP soil layer thickness is the same throughout the soil column, so the first soil layer depth is fixed and it is determined as the total soil depth simulated divided by the number of layers specified. For PRZM, the extraction depth for evaporation is a separate variable so the specified extraction depth can be different than the first soil horizon layer thickness.
- <u>Dynamic nature of Theta in the first soil layer</u>: Owing to the methods used to simulate water flow, LEACHP provides upward movement so Theta of the surface layer can increase over time. As indicated, the methodology in PRZM does not allow for upward redistribution of water.

- Daily time step to estimate evaporative losses: For LEACHP weekly cumulative evapotranspiration values are input that first are reduced to daily values and then are further distributed within a day according to a sinusoidal curve. The curve starts at 0.3 fraction of a day and end at 0.8 fraction of a day with the maximum evaporation value assumed at occur at 0.55 fraction of the daily time step. For PRZM, all calculations are conducted on a daily time step.

During this investigation, estimates for total evaporation over the 48-day simulated period were observed to differ between LEACHP model specifications and between models. This presented a quandary as to which of the estimates most accurately represented evaporation from the bare soil condition at the experimental site. The Food and Agriculture Organization of the United Nations published a method to estimate evaporation from bare soil using local climatic data and estimated water-holding capacities of various soil types (Allen et al., 1998). The method is known by the moniker FAO-56, which is the title of the published report. Burt et al. (2002) recently reviewed estimates for evaporation and concluded that the FAO-56 methodology produced reasonable estimates for evaporation from bare soil when compared to available studies. The FAO-56 approach is similar to LEACHP and PRZM in that evaporation is modeled in two phases where, at the first phase, evaporation is limited by energy inputs and in the second falling phase, evaporation is limited by soil moisture content. Evaporation ceases at the mid-point of oven dry and wilting point Theta values. The total evaporable water (TEW) is determined for both phases as:

$$\text{Eq. 1.} \quad TEW = 1000(FC - 0.5WP)*Z$$

where FC is Theta at field capacity, WP is Theta at the wilting point, and Z is the depth of the surface soil layer that is subject to drying. The end of phase one is determined as a cumulative depth of evaporation and noted as readily evaporable water (REW). Estimated REW values for various soil textures are available in Table 19 in FAO-56 (Allen et al, 1998). Based on procedures suggested in the document, a spreadsheet was developed to calculate FAO-56 daily estimates of evaporation for a bare soil using local measures of ETo, irrigation or rainfall inputs, and TEW and REW.

Similar to the PRZM model’s depth of extraction, the Z value in Eq. 1 sets the depth to which water can be extracted. For PRZM, suggested extraction depths for regions in the U.S. are obtained from Figure 5.2 in the PRZM manual (Carsel et al, 2003). For the Central Valley of California, the suggested range was 150 to 200 mm. For FAO-56, depths between 100 and 150 mm are suggested. A depth of 150 mm was used in the FAO-56 model and also for the initial PRZM simulations. For PRZM, separate soil layer data are entered as horizons that can be set to different thicknesses if needed. For PRZM, soil compartments in each soil horizon was set at 10 mm for horizons 1 through 4, at 30 mm for horizons 5 through 9 and at 50 mm for horizons 10 through 20. A further specification can be made for the number of compartments within each soil horizon to provide greater spatial resolution. Dispersion values were set at 0 in an attempt to produce the least amount of smearing of the solute throughout the profile.

In order to provide consistency in the modeling of soil water movement between models, values for Theta at FC and WP were obtained from estimates produced by the LEACHP model. In LEACHP, the Rawls and Brankensiek (1985) pedotransfer functions option was used to calculate water retention from particle size distribution, bulk density, and organic mater content for each soil layer. Values for FC and WP were obtained for estimated Theta values at –30 and –1,500 kPa, respectively, for each of the 20 field-sampled soil layers. PRZM allows substitution of these estimates into each of the 20 soil horizons. Estimated Theta values for the first soil layer were 0.115 m3/m3 and 0.05 m3/m3 for FC and WP, respectively and these were also used in the FAO-56 estimation of TEW.

The amount of water evaporated and drained was compared among LEACHP model simulations where soil layer thickness was varied from the original 150-mm soil sampling thickness to 75, 50, 37.5, 30, and 25 mm. Thinner segments were developed by repeating data from the original 150-mm soil sampling thickness into 2, 3, 4, 5, and 6 additional segments, respectively. Effect of total soil core depth on estimates of evaporation and drainage was also investigated by essentially halving the original soil core taken down to the 3,000 mm depth into 1,500 mm then into 750 mm and finally 300 mm soil core depths. Input data for soil texture, initial water content, and organic carbon content were derived from the corresponding soil segments in the original 3,000 mm soil core depth. For example, the first 10 soil layers from the original 150-mm soil layer thickness were used to simulate the 1,500 mm total soil core depth. Investigation of soil layer thickness at each total soil core depth was conducted as previously described by replicating soil layer data as required.

PRZM model estimates of water partitioning and bromide soil movement were compared at evaporation extraction soil depths of 150 and 300 mm and for compartment sizes in the first soil horizon at 10 and 1 mm. Examples of LEACHP files in Appendix I are given for the 150-mm and 25-mm soil layer thicknesses. Example of a PRZM input file is given in Appendix II.

Results from these specific comparisons are discussed:

1. Comparison of results between versions of the LEACHM model. Spurlock’s (2000), calibration used version 3, which was dated March 3, 1999 and which was modified to allow specification of a greater number of soil layers. The LEACHM author updated the model to version 4 dated January 9, 2003, which was further revised and dated November 25, 2005. The latest version corrected a problem noted with the volatilization component. The first version 4 will be referred to as version 4A, dated January 9, 2003, and the revised version as 4B, dated November 25, 2005.

2. Comparison among LEACHM model simulations for the effect of soil layer thickness and total soil core depth on estimates of evaporation and drainage.
3. Comparison between LEACHM and PRZM model predictions for evaporation and drainage. For PRZM, additional modifications to the model were investigated to determine the effect of doubling the soil extraction depth from 150 mm to 300 mm, and to determine the effect of decreasing the compartment size in the first 150-mm soil horizon from 10 mm to 1 mm.
4. Comparison of LEACHM and PRZM model predictions for soil distribution to the observed field data from the three percolation treatments.

RESULTS AND DISCUSSION

Comparison Among Versions of the LEACHP Model

The results for the estimate of total amount of water evaporated or drained over the simulated 48-day period were virtually identical between the two most recent versions, 4A and 4B (Table 1). These simulations were conducted mimicking the field soil sampling protocol where soil was sampled in150-mm thick segments down to 3,000 mm depth. For the older version 3, estimates for total amount of water evaporated were very similar to versions 4A and 4B, but some slight disparities were evident in the amount of water drained and it differed between percolation treatments. At the lowest percolation treatment, the amount of water drained in version 3 was 1 mm less than in versions 4A and 4B. In the medium percolation treatment 3 mm less water drained in version 3, and, at the high percolation treatment approximately 4 mm less water drained in version 3.

A contrary response was observed for bromide movement where greater amounts were drained in version 3 than in version 4A or 4B, which was especially noticeable at the high percolation treatment (Table 2). The modeled volumetric soil water contents (Theta) in the soil profiles at the high percolation treatment were essentially identical throughout the simulated period for all versions, indicating consistency in modeling of water flow. The method used to model nonequilibrium chemical transport was changed in version 4 (Hutson, 2003). In version 3, an upstream weighting method was used throughout the soil profile, whereas in version 4, a central differencing method denoting the Crank-Nicolson approach was used for all other soil layer nodes located between the boundary nodes. Upstream weighting was maintained at the boundary nodes, which were at the highest and lowest soil layers. The change was made because the Crank-Nicolson method was free of problems caused by numerical dispersion. Since differences in estimates of water movement were unaffected between versions, the change in approach to modeling chemical transport apparently caused the differences in solute movement with a tendency for slightly less downward movement in version 4.

For atrazine, the modeled time period produced only a small amount of mass leached past 3,000 mm at the high percolation treatment, but consistent with the bromide result slightly more atrazine was drained in version 3 (Table 2). The estimated mass of atrazine remaining in the soil at the end of 48 days was very similar for all versions indicating consistency in the methodology used to estimate disappearance within the soil core.

LEACHP: Segment Thickness and Total Soil Core Depth

The most recent version of LEACHP, version 4B, was used in subsequent investigations of soil layer thickness and total soil core depth on evaporation and drainage and on predicted soil bromide movement.

Evaporation and Drainage at 3,000 mm and Total Soil Core Depth: Investigation of the effect of soil layer thickness on estimates of evaporation and drainage were first conducted with the total soil core depth set at 3,000 mm, which reflected the depth to which field data were collected in the irrigation study (Troiano and Garretson, 1993). The amount of evaporated water increased as soil layer thickness increased from 25 to 150 mm (Table 3, see 3,000 mm total soil core depth). The relationship between evaporated water and soil layer thickness was nearly linear, but residuals of a linear fit were not random and indicated a curvilinear response. The TableCurve ® 2D program (SYSTAT Software Inc., Richmond California) was used to explore potential equations that fit the data. An excellent fit was observed at all percolation treatments when the amount of evaporated water was expressed as a function of the square root of segment thickness (Eq. 2 and Figure 2):

Eq. 2. $$Y = A + B * \sqrt{X}$$

The SAS NLIN procedure for fitting nonlinear functions to data was used to produce parameter estimates, standard deviations, and respective upper and lower 95% confidence limits for all LEACHP model runs (Table 4) (SAS INC, 1988). Confidence limits for all parameters were very narrow and observed values were nearly identical to predicted values (Figure 2).

Daily estimates of evaporated water for the low percolation treatment were compared between model simulations conducted at either 30- or 150-mm soil layer thicknesses (Figure 3). These two thicknesses were used because the center of the soil depth for the 150-mm thickness corresponded to the center of the third soil layer for the 5 corresponding 30-mm thick layers. The surface soil was initially dry, so significant evaporation was not measured until the first incorporation irrigation was applied on day seven. The magnitude of evaporation was greater directly after irrigation on day 7 for the thicker 150-mm soil layers. This effect was caused by differences in the complexity of the modeled soil water gradient where differences in redistribution of water among the soil layers from day 0 to day 1 were observed (Table 5). Data in Table 5 are the modeled Theta values for selected days for the first 750-mm soil depth of the total 3,000-mm soil depth that was modeled. For simulations with the thinner 30-mm soil layers, Theta of the first soil layer was unchanged between day 0 and 1, whereas, the first soil layer for the thicker 150-mm layers simulations indicated a small increase from 0.045 to 0.047 m^3/m^3. On the day before the first irrigation, day 6, Theta of the first soil layer remained at 0.045 m^3/m^3 for the thinner, 30-mm soil layer simulation but increased to 0.069 m3/m3 for the thicker 150-mm soil layers. LEACHP simulates upward movement of water so water content in upper layers of soil can become wetter in response to local water gradients. The soil water gradient for thicker 150-mm layers was less refined than for the thinner segments so movement in response to gradient differences was integrated over a larger distance thereby causing an increase in Theta in the first soil layer. For the thinner 30-mm soil layers, water was redistributed in response to local gradients but the absolute distance traveled was less with respect to total soil depth. These differences were maintained throughout the first 6 days; The Theta value on day 6 for the first 150-mm thick soil layer eventually increased to 0.069 m^3/m^3 whereas the Theta valve was unchanged for the 30-mm thickness at 0.045 m^3/m^3 (Table 5).

Another effect caused by increased complexity in the specification of the soil water gradient for thinner 30-mm layers was enhanced drainage of water. The estimated amount of evaporated water on day 26, the day of an irrigation, was the same for both soil layer thicknesses at 7 mm of water (Table 5). Total amount of added water was 42 mm so 35 mm could have potentially been retained within the 750-mm soil segment. For thicker 150-mm soil layers, 34.5 mm of water were retained in the core, whereas, less water at 31.5 mm was retained in the 30-mm thick layers. On the day of irrigation alone, approximately 7% more water drained past the 750-mm soil depth at the thinner, 30-mm soil layer specification. The results were similar for the remaining irrigations where 14% more water drained on days 28 and 35, and 9% more water drained at the last irrigation on day 43.

The combined effect of these processes was evident in a comparison of the magnitude of evaporation projected for day 27 which was the day after irrigation. For thinner 30-mm soil layers, the volume of evaporated water decreased from 7 mm on day 26 to 5.9 mm (Figure 3). Faster drainage of water on the previous day amplified the effect on drying of the first soil layer by reducing the potential for upward movement. In contrast, the amount of evaporated water for the thicker 150-mm layers increased from 7 mm to 9.2 mm. Interestingly, the peaks for the thicker segments occurred the day after higher volume irrigations and not on the day of irrigation. Water content of the first soil layer was theoretically not limiting so the amount of water evaporated for the thicker 150-mm soil layers should have been the same between days 26 and 27. On the day of irrigation, however, the timing of the irrigation event overlapped with the model process for estimating daily evaporation resulting in loss of potential evaporation on the day of irrigation. A similar effect was noted for a subtle difference in the amount of water evaporated between percolation treatments where high<low<medium percolation (Table 3, see 3,000-mm total soil depth). Total times for application of irrigations were approximately 4, 6, and 8 hours for the low, medium, and high percolation treatments, corresponding to 0.17, 0.25, and 0.33 fractions of a day, respectively. Irrigations were initiated at 0.3 fraction of a day, so sprinkler irrigations at the highest

percolation treatment lasted from 0.3 to 0.63 fractions of a day, excluding this portion of the sinusoidal curve from the estimate of potential daily evaporation. The effect was more complicated at medium percolation because even though some potential evaporation was lost on the day of irrigation from 0.33 to 0.55 fractions of a day, soil water content was high enough in the first soil layer to offset the loss of potential evaporation. These effects though subtle are cumulative and over a long period of time could produce significant differences in estimates of water partitioning or solute movement.

Total Soil Depth: Censoring the original soil core depth of 3,000 mm to 1,500 mm did not affect the estimate for evaporated water (Table 3). The estimates for both parameters in Eq.2 were virtually identical producing identical predicted curves (Table 4). Differences in the estimate of evaporation were observed at the next censoring of total soil core depth to 750 mm but the differences appeared dependent on soil layer thickness: Predicted evaporation at the lowest percolation treatment was 1.7 mm less at the thinnest, 25-mm soil layer, progressing to 3.6 mm less water at the 150-mm thick soil layer (Fig. 2). This effect was reflected in Eq. 2 where estimates for the intercept were the same but the value for the slope was less at 750-mm soil depth simulations, as indicated by the slightly shallower curve in Figure 2. These effects were pronounced when total core depth was censored to only 300-mm total length. Evaporation was clearly decreased at each soil layer thickness with progressively greater differences as soil layer thickness increased (Table 1). Both intercept and slope values for Eq. 2 were less (Table 4). The LEACHP observed effects and estimated curves were virtually the same at the medium and high percolation treatments. In general, the amount of water available for evaporation at the shorter soil core lengths was limited by loss of water to drainage, effectively removing it from further modeling. In order to maintain balance in water movement over a range of water applications, the total soil core depth should be at least 1,000 mm.

PRZM: Extraction Depth and Compartment Thickness

As expected, increasing the size of the soil extraction layer increased the amount of water evaporated by approximately 67% from 78 to 121 mm of water, for 150-mm and 300-mm soil extraction depths respectively (Table 6). Decreasing the compartment thickness of the first soil horizon from 10 mm to 1 mm had a small effect where at the 150-mm soil extraction depth the amount evaporated was only a fraction of a millimeter less than for the larger compartment. A larger difference was noted at the 300-mm soil extraction thickness where approximately 4 mm less water evaporated for the thinner compartments. Within each set of model specifications, the estimate of evaporation was the same for all irrigation percolation treatments.

For drainage, an anomalously large amount of water was estimated to drain on the first day of simulation. The value was consistent at 36 mm for all percolation treatments and for all specifications of evaporation extraction soil depth and soil compartment thickness. Since soil water content was initially relatively low, this value was not included in cumulative values. In direct response to the effect on evaporation, drainage was increased at the larger evaporation extraction soil depth of 300 mm (Table 6). Similarly, only fractional differences in amount of water drained were noted between compartment thicknesses of 10 and 1 mm for the 150-mm extraction depth. For the 300-mm extraction depth, the 4 mm less evaporated water measured for the thinner 1-mm soil compartment was made up in the drainage estimate for each percolation treatment.

Comparison of Evaporation Among LEACHP and PRZM, and FAO-56 Methods

The methodology for PRZM and FAO-56 share a commonality in that the depth for soil extraction of evaporation is fixed. When the evaporation soil extraction depth in PRZM was set at 150 mm, which was the same as specified for the FAO-56 method, less cumulative evaporation was modeled for PRZM at 73 mm evaporated water compared to 98 mm water for the FAO-56 method (Figure 4). When the soil extraction layer was doubled to 300 mm in PRZM, the estimate increased to 121 mm of water, which was 23% greater than the FAO-56 value. The estimate from LEACHP at the thickest soil layer at 150 mm greatly overestimated the FAO-56 value by 58%. The estimate for the thinnest soil layer investigated at 25 mm was the closest approximation to the FAO-56 value and it was greater by 19%.

Comparison of Soil Bromide Movement between LEACHP and PRZM

Figure 5 contains modeled bromide soil distributions from LEACHP simulations at either 25-mm or 150-mm thick soil layers for low (A), medium (B), and high (C) percolation treatments compared to the averaged distribution measured from the field soil cores. For each percolation treatment, the agreement was very good between LEACHP modeled soil distribution and observed field data at all percolation treatments when the soil layers were thinnest at 25 mm. Deeper movement of bromide in thinner soil layers was due to less loss of water to evaporation which resulted in an increase in drainage (Table 1).

Figure 6 contains similar comparisons for PRZM where the distributions from modeled simulations were compared between evaporation extraction soil depths at 150 mm or 300 mm. As previously observed, setting the extraction depth in PRZM to a thicker depth of 300 mm resulted in more evaporated water causing shallower movement of bromide at the low percolation treatment as compared to the 150-mm extraction depth. The difference between the distributions, however, became less distinct with increases in the amount of percolated water with the shapes of the distribution nearly coinciding at the highest percolation treatment. Even though the dispersion value was set at 0 to produce the least smearing, the shape for PRZM distributions was less defined than observed for the field data. The modeled leading edge was also located deeper in the soil profile, a result that in this unstructured coarse soil was due to the methodology used in PRZM to simulate water movement (Carsel et al., 2003).

Combining the observations from Figures 5 and 6, PRZM and LEACHP predicted very similar bromide distributions for the low percolation treatment when PRZM soil extraction depth was 300 mm and LEACHP soil layer thickness was 25 mm. The distributions diverged as the amount of percolating water increased where the LEACHP predications more closely matched and maintained the shape observed for the field data. The importance of this observation is that comparison of model results to field data and/or to each other would be maximal when water input is low in relation to evaporative demand. Application of greater amounts of water within the same timeframe provided testing of model processes under a broader range of hydrolytic conditions and produced model outcomes that were much less in concurrence.

Lastly, the daily pattern of evaporation and drainage at the lowest percolation treatment was compared between the LEACHP model where soil layer thickness was set to the thinnest value at 25 mm and the PRZM model where the soil extraction depth was 150 mm and the soil compartments in the first soil layer was 10 mm (Figure 7). Except for the first irrigation, the amount of evaporated water on subsequent days of irrigation was similar between the two models. For the first small irrigation event PRZM allowed for greater loss of water to evaporation, which is likely due to the larger extraction depth for the first soil layer. A major difference between the patterns was extension of the period of evaporation after irrigation with LEACHP. This effect is a direct result of the inherent differences in how water movement is modeled where the dynamic nature of the LEACHP model allowed for more complex description of water movement. An interesting yet more drastic difference was observed in the pattern of drainage. At the initial small additions of water in the first four irrigation events, LEACHP predicted drainage of water, whereas, PRZM modeled only a very small amount. In contrast, the larger last four irrigations produce a rather large daily estimate for PRZM. LEACHP produced smaller peaked flows on the day of irrigation but drainage continued on subsequent days.

SUMMARY

Registrants of pesticide products have increased the use of pesticide fate models to supplement data in support of registration requests, thus knowledge of the factors affecting predictions could be important in reconciling differences between models as well as between modelers. This investigation indicated that physical specification of soil layer thickness and total depth of the soil core affects the estimation of evaporation in the LEACHP model. Effects on evaporation had a direct affect on water balance where drainage and ultimately solute movement was affected. For the LEACHP model, soil layer thickness from 50 to 100 mm is suggested in the manual due to computation considerations. In this investigation, there was no noticeable effect on computational time between the largest or thinnest soil layer specifications using technology currently available on desktop computers. Rather, specifying layers in thinner slices produced better estimation of soil water movement as measured by agreement of estimated evaporation to a standard measure supplied by the FAO-56 model, and agreement in soil distribution of bromide between model results and field observations at three levels of percolating water. Thus, there appears to be no disadvantage to specifying thin soil layers. With respect to total soil depth modeled, water that would otherwise be available for redistribution was lost to drainage past the lowest depth when total soil core length was too short.

RECOMMENDATIONS

1. Use 25 mm for soil layer thickness in LEACHM. Based on the amount of evaporation modeled and the very close agreement between modeled and observed bromide distribution in soil, the thinnest soil layer specification should be used in LEACHP. Real-world conditions are apparently more closely described by the more refined and discrete soil water gradient that is inherently produced by the thinner soil layer specification.
2. Total soil core depth should not be less than 1,000 mm. Estimates of evaporation were affected by total soil core depth because water drained by the smaller total depth modeled was unavailable for redistribution within the soil profile.
3. Use of LEACHP versus PRZM recommendation. If the goal of an exercise is to accurately predict movement of solutes under varied climatic conditions, then the dynamic nature of LEACHP provides a greater probability for comparable results. But if only relative ranking of leaching potential under a single set of specific climatic conditions is of interest, then either model should provide acceptable results.
4. Applications to conditions outside the scope of this study require further testing. These results apply to the conditions of this study typified by an unstructured, coarse-textured soil condition where runoff did not occur, and climatic conditions where evaporative demand was high.

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Table 1. Estimate of the amount of water that was evaporated or drained compared between LEACHP model versions after 48 days of simulated sprinkler irrigation water treatments.

Sprinkler Percolation Treatment	Water Applied	LEACHP Estimates for Water Evaporated Ver 3	Water Evaporated Ver 4A	Water Evaporated Ver 4B	Water Drained Ver 3	Water Drained Ver 4A	Water Drained Ver 4B
	mm	mm	mm	mm	mm	mm	mm
Low Percolation	215.8	155.2	155.1	155.0	41.6	42.3	42.1
Medium Percolation	354.9	160.0	159.8	159.7	158.5	161.1	161.2
High Percolation	485.2	151.4	151.8	151.6	294.9	298.3	298.7

Table 2. Estimates of amount of bromide remaining in the soil or drained, and the amount of atrazine remaining in soil or drained compared between LEACHP model versions after 48 days of simulated sprinkler irrigation water treatments. A 20-day half-life for atrazine was determined from the recovery of the low percolation treatment and used for all simulations.

Chemical Modeled and Sprinkler Percolation Treatment	Water Applied	LEACHP Estimates for					
		Amount Remaining in Soil			Amount Drained		
		Ver 3	Ver 4A	Ver 4B	Ver 3	Ver 4A	Ver 4B
	---mm---	---------------mg/m sq---------------					
Bromide							
Low Percolation	215.8	7200.0	7200.0	7206.1	0.0	0.0	0.0
Medium Percolation	354.9	7134.2	7177.6	7177.4	65.8	28.6	28.7
High Percolation	485.2	5302.3	5599.8	5589.4	1897.7	1609.2	1619.5
Atrazine							
Low	215.8	89.0	89.2	89.0	0.0	0.0	0.0
Medium	354.9	89.0	89.2	89.1	0.0	0.0	0.0
High	485.2	87.7	88.5	88.4	1.6	0.8	0.8

Table 3. Effect of soil layer thickness at four simulated total soil core depths in LEACHP model simulations on the amount of water evaporated or drained after 48 days of simulated sprinkler irrigation treatments.

Sprinkler Irrigation Treatment	Depth of Soil Core	Water Applied	LEACHP Estimates for											
			Water Evaporated						Water Drained					
			Soil Layer Thickness (mm)						Soil Layer Thickness (mm)					
			25.0	30.0	37.5	50.0	75.0	150.0	25.0	30.0	37.5	50.0	75.0	150.0
	mm													
Low Percolation	3000	215.8	117.2	119.9	123.1	127.8	136.9	155.0	64.8	63.1	60.9	57.9	52.3	42.1
	1500	215.8	117.4	119.8	122.9	128.0	136.7	154.8	87.1	85.1	82.7	78.7	71.8	58.3
	750	215.8	115.5	117.8	120.9	125.7	134.1	151.4	85.6	83.6	81.0	76.9	70.0	56.0
	300	215.8	106.0	107.8	110.4	113.9	119.7	130.7	95.1	93.6	91.5	88.6	83.5	74.4
Medium Percolation	3000	354.9	118.9	121.4	124.9	130.2	139.6	159.7	194.1	192.1	189.2	185.0	177.5	161.2
	1500	354.9	119.0	121.4	124.9	130.1	139.7	159.8	223.2	221.2	218.3	213.9	206.0	189.5
	750	354.9	118.0	120.5	123.8	129.0	137.9	156.5	221.7	219.6	216.8	212.3	204.9	189.4
	300	354.9	106.3	108.2	110.8	115.0	121.1	131.7	233.7	232.2	230.0	226.4	221.2	212.4
High Percolation	3000	485.2	110.6	112.9	116.4	121.6	130.7	151.6	331.6	329.8	327.0	322.8	315.6	298.7
	1500	485.2	110.7	113.1	116.6	122.0	130.7	151.4	361.2	359.3	356.4	351.8	344.6	327.8
	750	485.2	109.6	112.0	115.2	119.9	128.8	148.0	360.0	358.0	355.3	351.4	344.0	327.7
	300	485.2	98.6	100.4	102.9	106.7	112.3	122.4	371.6	370.1	368.0	364.8	360.2	351.8

Table 4. Statistics for fit of Eq. 2 for expressing amount of water evaporated as a function of soil layer thickness.

Sprinkler		Statistics for Fit of Eq. 2							
Irrigation	Soil Core	Intercept (A)		95% Confidence Limits		Coefficient (B)		95% Confidence Limits	
Treatment	Depth	Value	STDERR	Lower	Upper	Value	STDERR	Lower	Upper
	---mm---								
Low Percolation	3000	91.2	0.4	90.0	92.3	5.23	0.05	5.08	5.37
	1500	91.4	0.3	90.5	92.3	5.19	0.04	5.08	5.30
	750	90.6	0.3	89.7	91.4	4.98	0.04	4.87	5.09
	300	89.4	0.7	87.4	91.4	3.41	0.09	3.15	3.67
Medium Percolation	3000	90.4	0.3	89.7	91.1	5.66	0.03	5.57	5.75
	1500	90.4	0.4	89.4	91.3	5.67	0.05	5.54	5.79
	750	91.3	0.3	90.5	92.1	5.34	0.04	5.23	5.44
	300	89.3	1.2	86.0	92.6	3.52	0.15	3.10	3.95
High Percolation	3000	81.7	0.4	80.5	82.9	5.69	0.06	5.53	5.84
	1500	82.3	0.3	81.4	83.1	5.63	0.04	5.52	5.74
	750	82.7	0.4	81.7	83.7	5.32	0.05	5.19	5.45
	300	82.7	1.0	79.9	85.6	3.29	0.13	2.93	3.66

Table 5. Temporal changes in modeled soil volumetric water content (Theta) throughout the first 750-mm soil depth of a 3,000 mm total soil depth simulation. Theta values are compared between soil layer thicknesses of 30 mm or 150 mm. Irrigations were 13 mm of water on day 7, 42 mm of water on days 26, 28, and 35, and 39 mm of water on day 43. Total amount of water in the core and daily evaporation is given at the bottom of the table.

Center of Soil Depth	Theta Values at Elasped Time and Segment Thickness																							
	Day 0		Day 1		Day 6		Day 7		Day 25		Day 26		Day 27		Day 28		Day 34		Day 35		Day42		Day 43	
	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm	30mm	150mm
---mm---	m^3/m^3																							
-15	0.045		0.045		0.045		0.083		0.073		0.151		0.102		0.152		0.079		0.151		0.077		0.148	
-45	0.045		0.045		0.045		0.098		0.088		0.153		0.116		0.154		0.095		0.153		0.094		0.150	
-75	0.045	0.045	0.045	0.047	0.045	0.069	0.106	0.093	0.098	0.081	0.155	0.156	0.126	0.113	0.156	0.158	0.106	0.088	0.155	0.158	0.104	0.088	0.152	0.155
-105	0.045		0.045		0.048		0.108		0.104		0.157		0.134		0.158		0.113		0.157		0.111		0.155	
-135	0.045		0.048		0.067		0.107		0.108		0.159		0.139		0.160		0.118		0.160		0.116		0.158	
-165	0.060		0.057		0.074		0.093		0.099		0.142		0.126		0.143		0.108		0.143		0.106		0.141	
-195	0.060		0.060		0.083		0.091		0.101		0.144		0.129		0.145		0.110		0.144		0.108		0.143	
-225	0.060	0.060	0.061	0.077	0.090	0.087	0.093	0.097	0.103	0.092	0.145	0.144	0.131	0.122	0.146	0.146	0.112	0.101	0.146	0.146	0.110	0.100	0.144	0.143
-255	0.060		0.069		0.095		0.096		0.104		0.146		0.132		0.148		0.114		0.147		0.112		0.146	
-285	0.060		0.084		0.098		0.099		0.105		0.148		0.134		0.149		0.115		0.149		0.114		0.147	
-315	0.090		0.097		0.103		0.103		0.108		0.149		0.136		0.151		0.118		0.150		0.116		0.149	
-345	0.090		0.105		0.106		0.105		0.109		0.150		0.137		0.152		0.119		0.151		0.118		0.150	
-375	0.090	0.090	0.110	0.106	0.108	0.104	0.107	0.105	0.110	0.103	0.151	0.147	0.138	0.133	0.153	0.152	0.120	0.114	0.152	0.151	0.119	0.113	0.151	0.148
-405	0.090		0.115		0.109		0.109		0.111		0.151		0.139		0.154		0.121		0.153		0.120		0.152	
-435	0.090		0.119		0.111		0.110		0.112		0.152		0.140		0.155		0.122		0.154		0.121		0.152	
-465	0.135		0.115		0.107		0.106		0.107		0.143		0.132		0.146		0.117		0.145		0.115		0.144	
-495	0.135		0.117		0.108		0.107		0.107		0.143		0.133		0.147		0.117		0.146		0.116		0.144	
-525	0.135	0.135	0.119	0.116	0.109	0.106	0.108	0.106	0.108	0.102	0.143	0.136	0.133	0.128	0.148	0.147	0.118	0.114	0.147	0.144	0.116	0.112	0.145	0.140
-555	0.135		0.121		0.110		0.109		0.108		0.143		0.133		0.148		0.119		0.147		0.117		0.145	
-585	0.135		0.122		0.111		0.110		0.108		0.143		0.133		0.149		0.119		0.147		0.117		0.145	
-615	0.150		0.128		0.116		0.115		0.113		0.146		0.137		0.153		0.124		0.151		0.122		0.149	
-645	0.150		0.129		0.117		0.116		0.113		0.145		0.138		0.154		0.124		0.151		0.123		0.149	
-675	0.150	0.150	0.130	0.128	0.118	0.116	0.116	0.115	0.114	0.109	0.144	0.131	0.138	0.132	0.154	0.153	0.125	0.122	0.152	0.146	0.123	0.120	0.149	0.140
-705	0.150		0.131		0.118		0.117		0.114		0.143		0.138		0.155		0.125		0.152		0.124		0.148	
-735	0.150		0.132		0.119		0.118		0.114		0.142		0.138		0.155		0.126		0.152		0.124		0.148	
	mm																							
Total Amount of Water	72	72	70.47	71.1	70.8	72.3	78.9	77.4	79.17	73.05	110.6	107.1	99.36	94.2	113.6	113.4	86.52	80.85	112.7	111.8	85.29	79.95	111.1	108.9
Daily Evaporation	0	0	0	0	0	0	4.7	7.9	0.5	0.5	7.0	6.9	5.9	9.2	2.7	7.0	1.1	1.2	7.0	7.0	0.9	0.9	7.6	7.6

Table 6. Estimates of evaporated and drained water from PRZM model where the evaporation extraction depth was either 150 mm or 300 mm and where the compartment in the first soil horizon was specified at 10 mm or 1 mm thick. The total amount drained does not include an estimated output of 36 mm for the first day of the study.

Extraction Depth and Sprinkler Irrigation Treatment	Water Applied	PRZM Estimates for:			
		Evaporated Water		Drained Water	
		Compartment Thickness			
		10 mm	1 mm	10 mm	1 mm
	mm				
150 mm Extraction Depth					
Low Percolation	215.8	73	72	134	134
Medium Percolation	354.9	73	72	269	269
High Percolation	485.2	73	72	403	403
300 mm Extraction Depth					
Low Percolation	215.8	121	117	94	98
Medium Percolation	354.9	121	117	229	233
High Percolation	485.2	121	117	363	367

Figure 1. Comparison of cumulative daily reference evapotranspiration (Eto) (filled circles) to cumulative amount of water added by sprinkler irrigation treatments producing low (open triangles), medium (filled diamonds), and high (open squares) amounts of percolating water. The study duration was 48 days from June 11, 1987 to July 29, 1987 in Fresno, California with climatic data obtained from a local weather station.

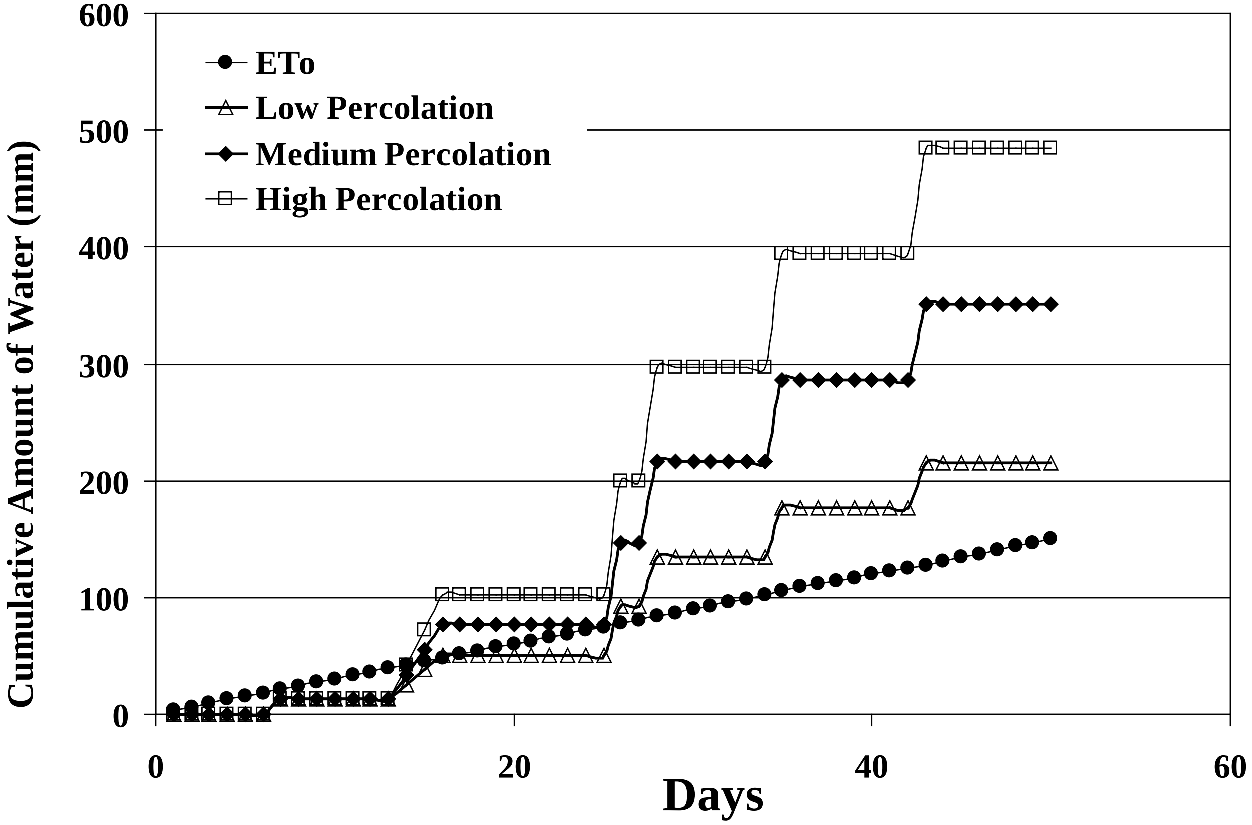


Figure 2. LEACHP model estimated values for evaporated water at each total soil core depth of 3,000 mm (open circles), 750 mm (filled diamonds), and 300 mm (X) compared to each predicted line from Eq. 2 describing the amount of evaporated water as a function of soil layer thickness. Soil layer thickness was set at 25, 30, 37.5, 50, 75, or 150 mm at each percolation treatment of low (A), medium (B), or high (C).

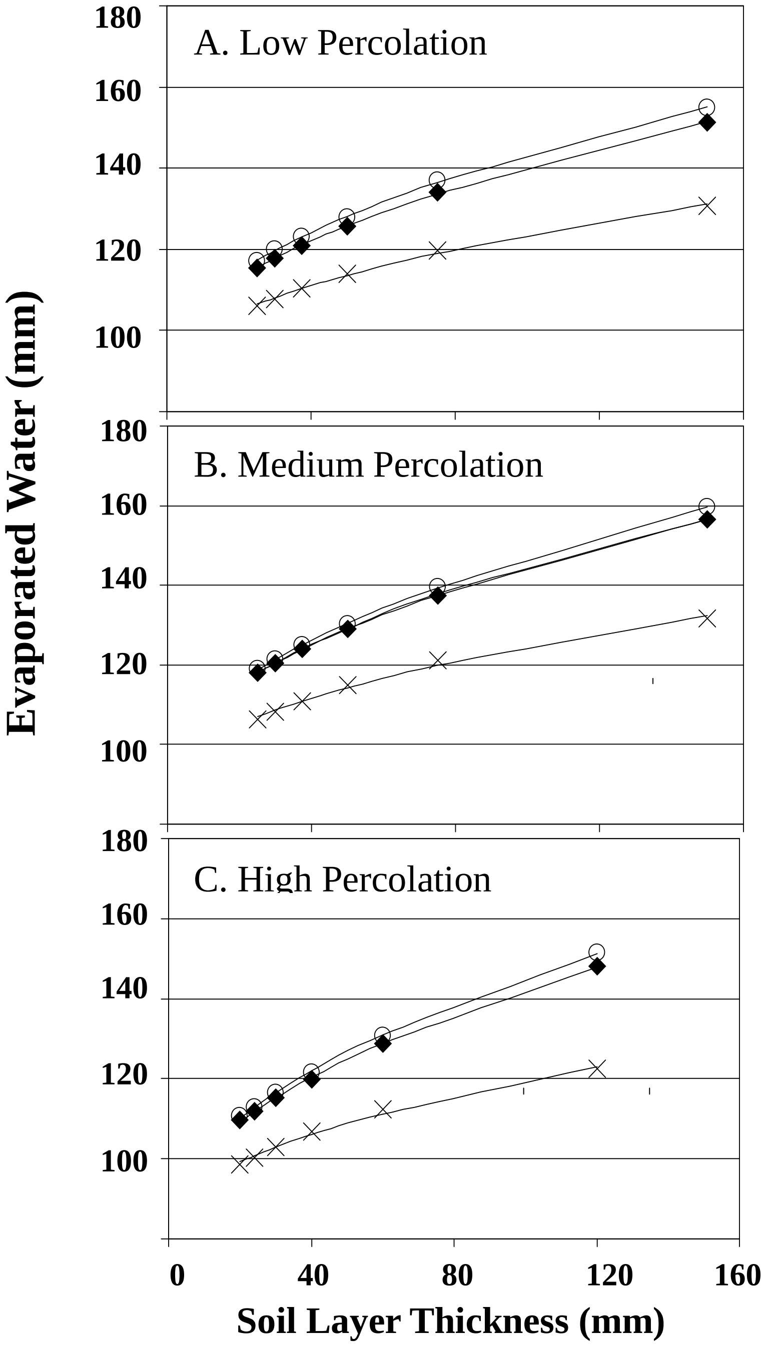


Figure 3. Daily estimates for evaporation From LEACHP version 4B for low percolation sprinkler irrigation treatments using 30-mm (filled triangles) or 150-mm (open circles) thick soil layers and for a total soil core depth of 3,000 mm.

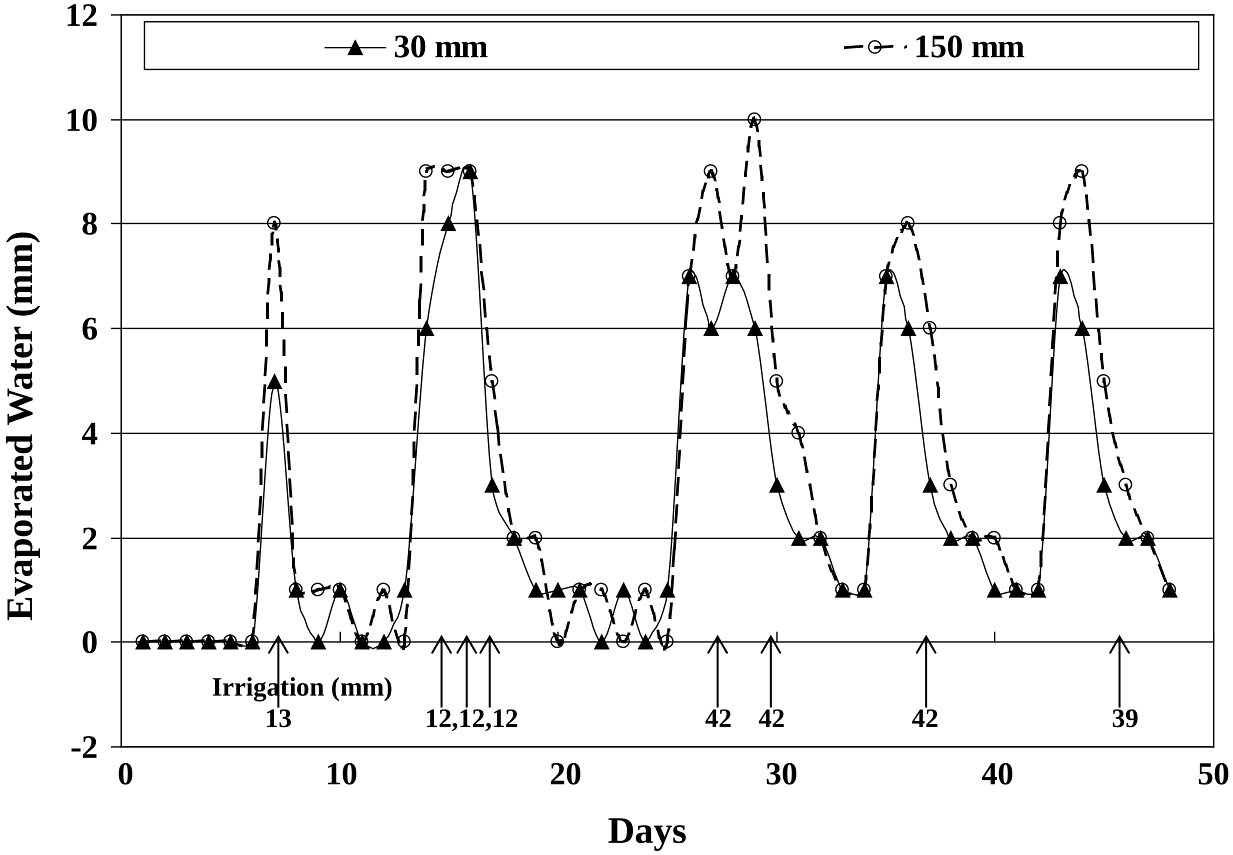


Figure 4. Cumulative estimated evaporation for low percolation treatments for the FAO-56 method (filled circles) and for LEACHP model simulations using 25-mm (open triangles) or 150-mm (filled triangles) soil layer thickness and for PRZM model simulations with the thickness of the evaporation extraction depth specified at either 150 mm (filled squares) or 300 mm (open squares). The text boxes contain the total cumulative evaporated water in mm from the 48-day study period.

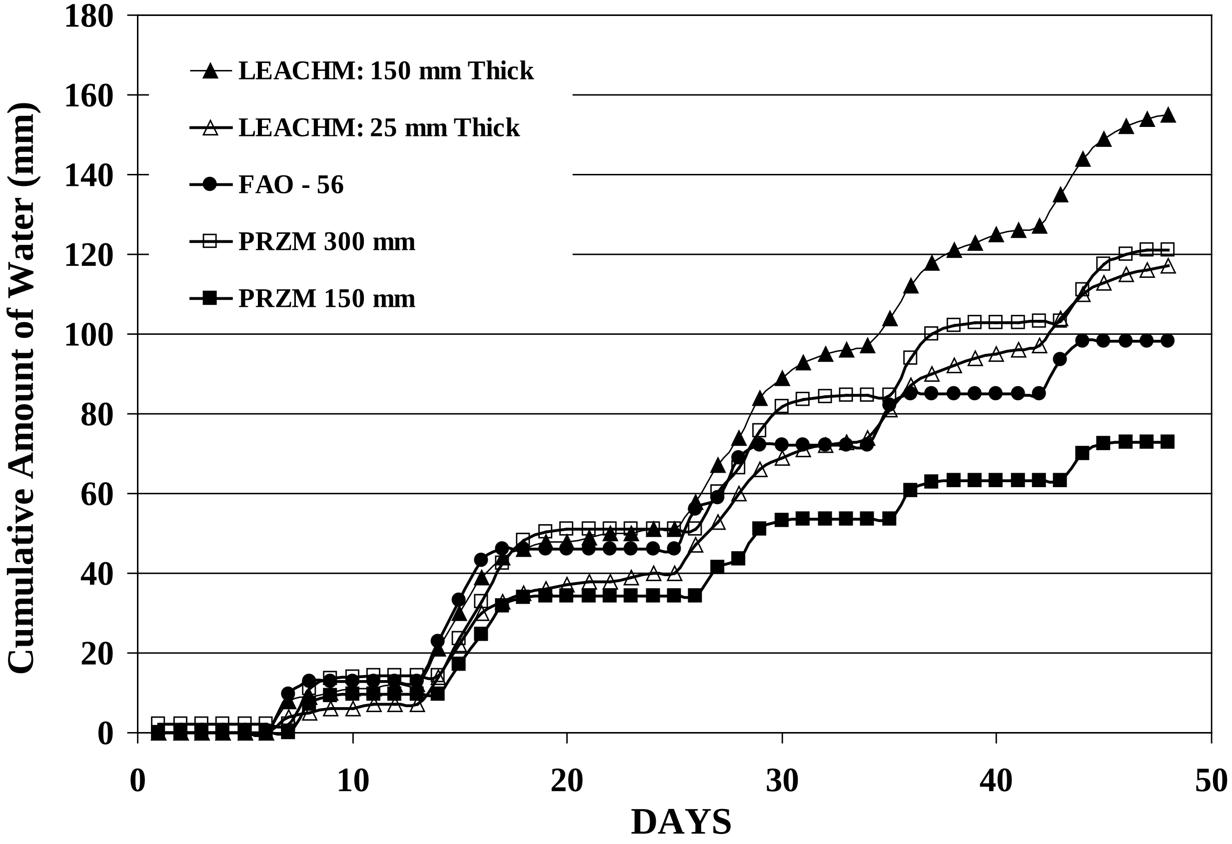


Figure 5. Soil bromide distribution for observed field data (open circles) compared to LEACHP modeled distribution where soil layer thickness was set at 25 mm (filled circles) or 150 mm (triangles).

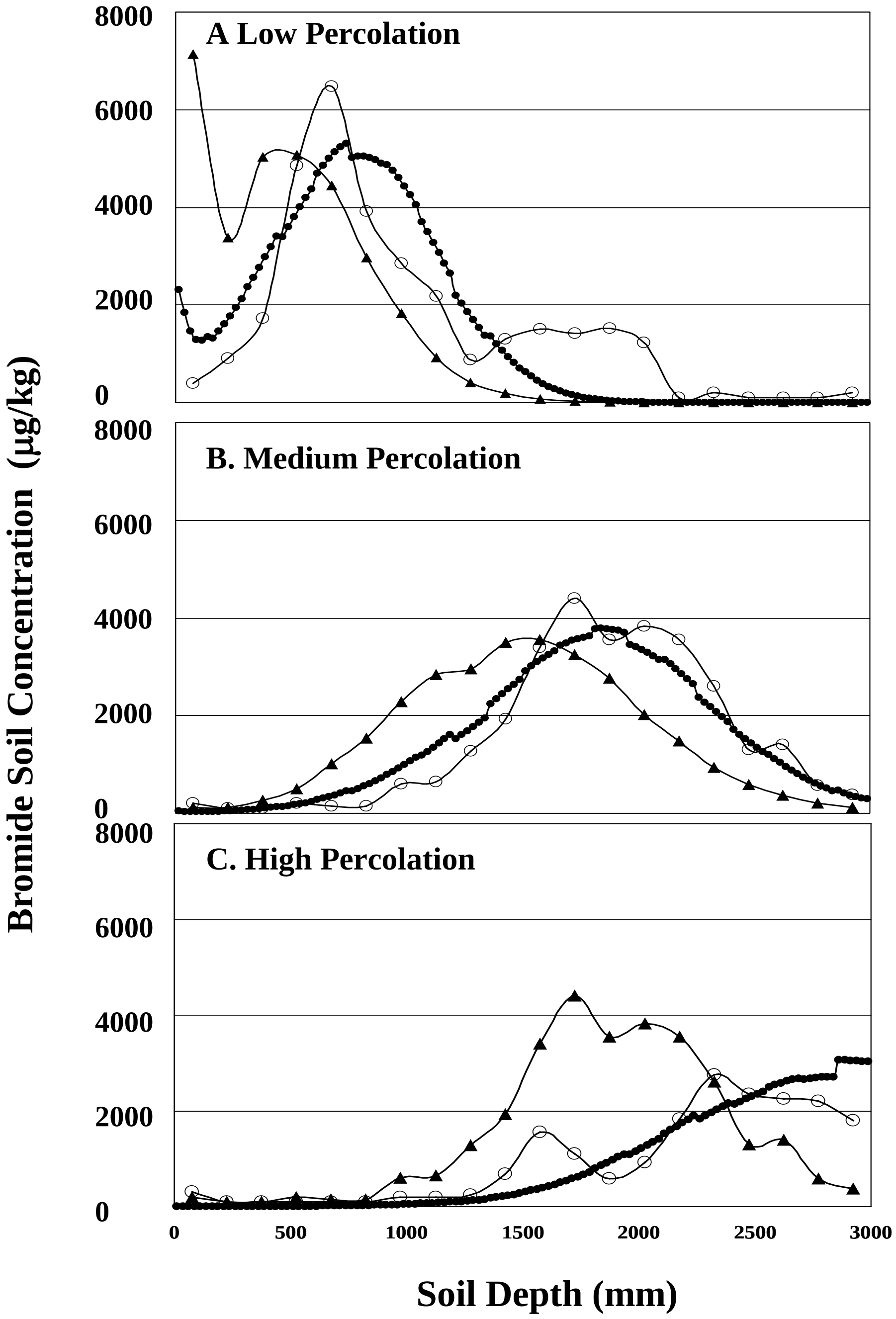


Figure 6. Soil bromide distribution for observed field data (open circles) compared to PRZM modeled distribution where evaporation extraction depth was 150 mm (triangles) or 300 mm (filled circles).

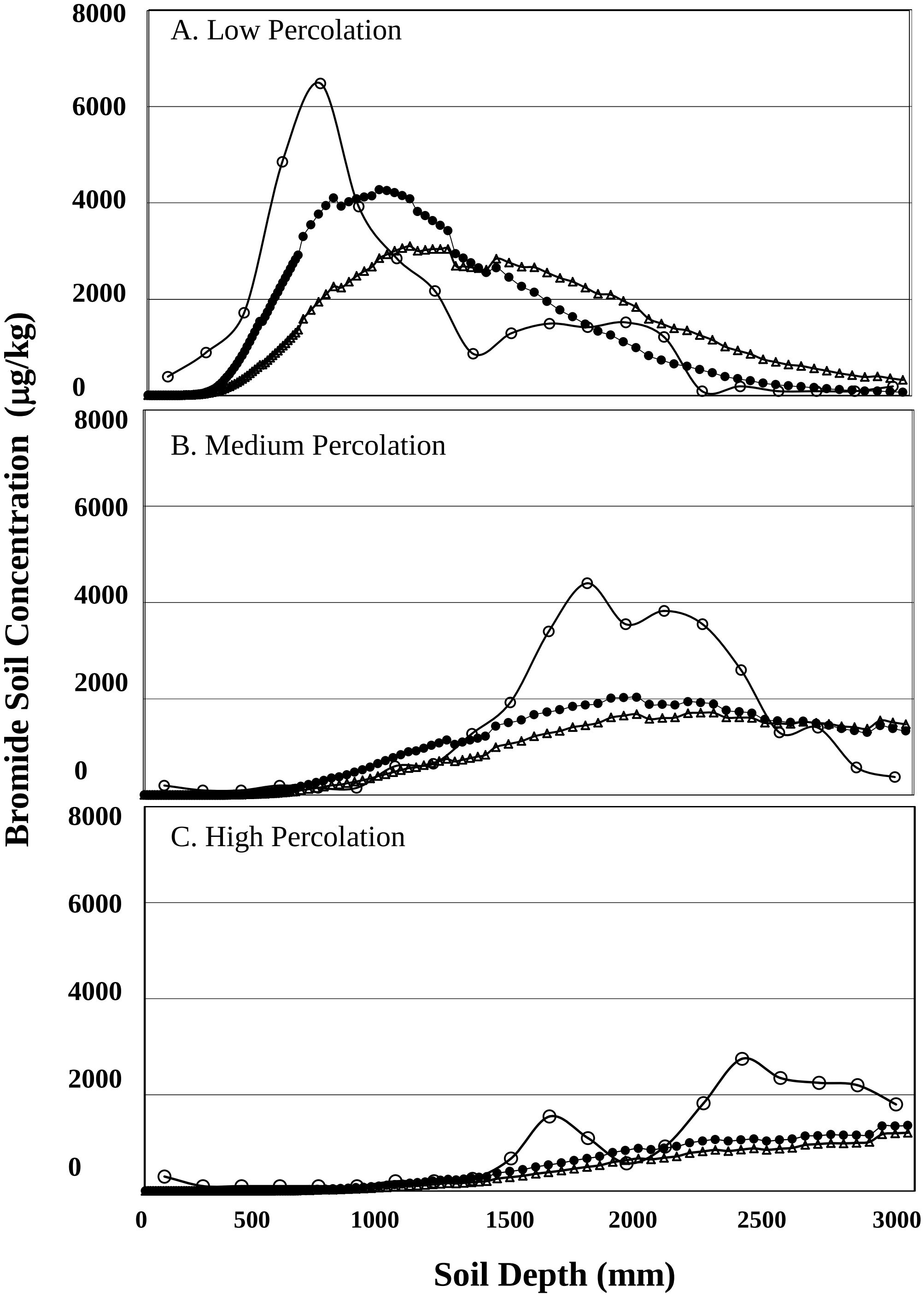
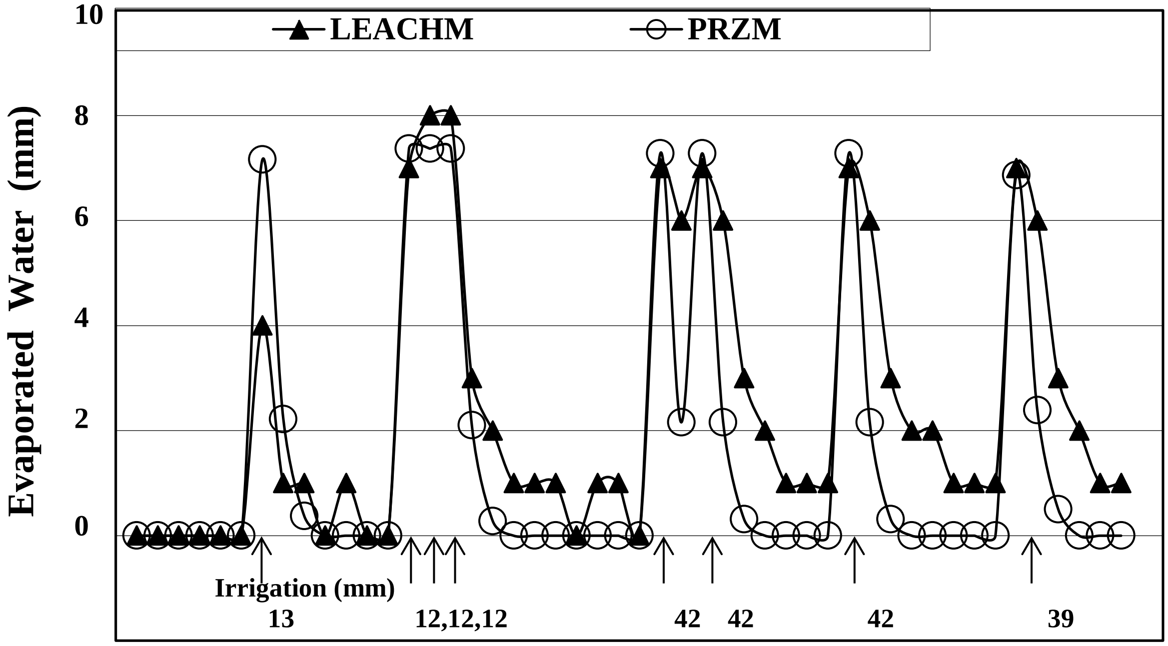
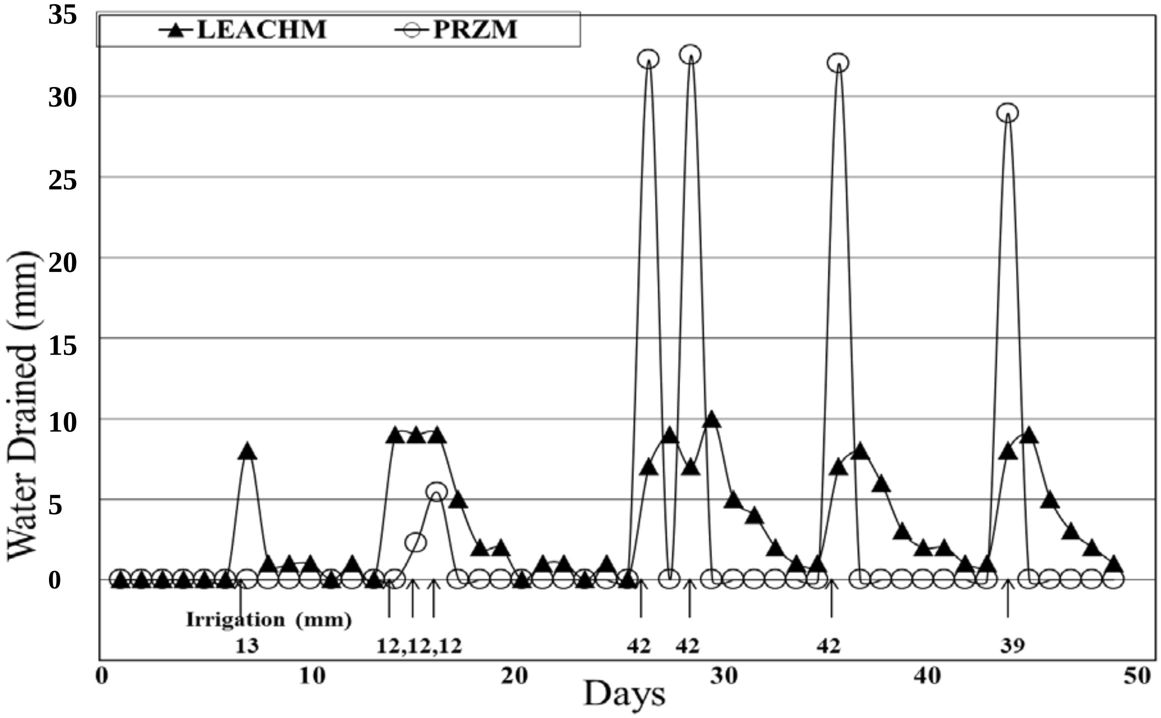


Figure 7. Daily pattern of evaporated (A) and drained (B) water for sprinkler low percolation treatment compared between LEACHP (filled triangles) and PRZM (open circles) models. For LEACHP soil layer thickness was 25 mm and for PRZM soil extraction depth was 150 mm and compartments set at 10 mm for the first 150 mm soil horizon.

A. Evaporated Water



B. Drained Water



Appendix I

Specimen LEACHM Input File
Low Percolation, 3000 Total Soil Core Depth and 150 mm Soil Layers

```
Sm3th150 < DOS Filename, 8 characters with no extension. Used in batch runs
(started as LEACHP<filename).
--------------------------------------------------------------------------
                      LEACHP PESTICIDE DATA FILE.
Numeric data and comments may extend to position 120. Unless defined as
'not read' a value must be present for each item, although it may not be used.
Free format with blank delimiters. Preserve division and heading records.
Number of depth segments may be changed.
******************************************************************************
********************************
 1      <Date format (1: month/day/year;  2: day/month/year).  Dates must be 6
digits, 2 each for day, mo, yr.
 061187 <Starting date.  No date in the input data should precede this date.
 000050 <Ending date or day number.  The starting date is day 1. (A value
<010101 is treated as a day number).
 0.05    <Largest time interval within a day (0.1 day or less).
 1      <Number of repetitions of rainfall, crop and chemical application
data.
 3000   <Profile depth (mm), preferably a multiple of the segment thickness.
 150    <Segment thickness (mm).  (The number of segments should be between
about 8 and 30.
 2      <Lower boundary condition: 1:fixed depth water table; 2:free drainage,
3:zero flux 4:lysimeter.
 0000   <Water table depth (mm), if the lower boundary is 1 (water table).
---------------------------------------------------------------------------
The steady-state flow option uses constant water fluxes during the application
periods specified in the rainfall data table, and a uniform water content
specified here.  Steady-state flow implies a lab column, and crop and
evaporation data are ignored.
---------------------------------------------------------------------------
  1     < Water flow: 1: Richards; 2: Addiscott tipping bucket; 3: steady-
state.
  0.4   < Steady-state flow water content (theta); 999: saturated column.
******************************************************************************
********************************
******************************************************************************
********************************
 1      <Number of output files: 1: OUT only; 2: OUT + SUM; 3: OUT + SUM + BTC
--------------------------------------
--- For the *.OUT file :
 1      <Units for depth data: 1: ug/kg, 2: mg/m2 per segment depth, 3: mg/kg,
4: g/m2, 5: kg/ha.
```

```
 1      <Node print frequency (print data for every node (1), alternate nodes
(2).
 1      <Print options: 1 or 2.  Use to specify one of the following options.
 1      <Option 1: Print at fixed time intervals (days between prints).
 1      <Option 2: No. of prints (the times for which are specified below)
 2      <Tables printed: 1: mass balance; 2: + depth data; 3: + crop data
 0      <Reset *.OUT file cumulative values every 12 months after start date?
0: No, 1: Yes
---------------------------------------(if yes: .sum printouts must be monthly
(code 999) and .out prints should be at the end of each year)
--- For the * .SUM file :
 50     <Summary print interval (d)  (999 for calendar month printouts)
 000    <Surface to [depth 1?] mm     ( Three depth segments for the
                                               file. Zero defaults to nodes
                                               to thirds of the profile)
  3     <4th segment: Root zone (1); profile (2); Depth 3 to lower boundary
(3); Surface to shallowest of lower boundary or water table (4)
---------------------------------------
--- For the *.BTC (breakthrough) file :
 1.0    <Incremental depth of drainage water per output (mm)
---------------------------------------------------------------------------
-- List here the times at which the *.OUT file is desired for print option 2.
-- The number of records must match the 'No. of prints' under option 2 above.
        Date or    Time of day          (At least one must be specified
        Day no.  (to nearest tenth)      even if print option is not 2)
        --------  ----------------
        000050         .5       (These dates can be past the last day)
*************************************************************************
*************************************************************************
                  SOIL PHYSICAL PROPERTIES
-------------------------------------------------------------------------
-- Retentivity model 0 uses listed Campbell's retention parameters, otherwise
-- the desired particle size-based regression model is used.
-------------------------------------------------------------------------
 Soil |                     |Retention|   Starting   |   Roots   | Starting
layer | Clay  Silt  Organic |  model  |theta or pot'l|  (for no  | temp (C)
 no.  |             carbon  |         |(one is used) |  growth)  | (not read
in
      |  %     %     %      |         |          kPa | (relative)|  LEACHC)
 ---    ----  ----   ----     ------   -----   -----    ------    -----------
       1       3       8    0.71       5   0.045     -10     0.2       20
       2       4       6    0.25       5    0.06     -10     0.2       20
       3       5       6     0.1       5    0.09     -10    0.15       20
       4       5       4     0.1       5   0.135     -10    0.13       20
       5       6       4   0.067       5    0.15     -10     0.1       20
       6       5       4   0.009       5   0.144     -10    0.08       20
       7       6       4   0.058       5   0.135     -10    0.05       20
       8       6       5    0.05       5    0.12     -10    0.04       20
       9       5       4   0.025       5   0.128     -10    0.02       20
      10       6       5   0.017       5   0.114     -32    0.02       20
```

```
      11       6       5   0.025       5   0.144    -100    0.02      20
      12       6       5   0.025       5    0.15    -316    0.02      20
      13       7       5   0.017       5    0.12   -1000    0.02      20
      14       6       5   0.008       5   0.105   -3000    0.02      20
      15       7       6       0       5    0.09   -3000    0.02      20
      16       7       5       0       5   0.105   -3000    0.02      20
      17       6       6       0       5    0.09   -3000    0.02      20
      18       7       6       0       5   0.105   -3000    0.02      20
      19       7       7   0.008       5    0.12   -3000    0.01      20
      20       9       7       0       5   0.135   -3000    0.01      20
---------------------------------------------------------------------------
   1    < Use listed water contents (1) or potentials (2) as starting values.
Particle density:  Clay    Silt and sand    Organic matter  (kg/dm3) (to
calculate porosity)
                   2.65         2.65               1.10
***************************************************************************
For a uniform profile: Any non-zero value here will override those in
the table below (only if retentivity model is 0).
----------------------------------------------------------------------
  0     0   <Soil bulk density and particle density (kg/dm3) .
 -0.0         <'Air-entry value' (AEV) (kPa) (a in eq 2.1 to 2.4).
  0         <Exponent (BCAM) in Campbell's water retention equation (b in eq.
2.1 to 2.4).
  2019.0000  -0.5 <Conductivity (mm/day) and corresponding matric potential
(kPa) (for potential-based version of eq. 2.5).
  1         <Pore interaction parameter (P) in Campbell's conductivity
equation (eq.2.5 in manual).
  48.8075123 <Dispersivity (mm) (eq. 3.12).
                                 Matric potential (kPa) at field capacity
                                 Division between mobile and immobile water
(kPa)
******************************************************************************
***************************
 Soil  |  Soil retentivity |   Bulk  |  Match K(h) curve at: | Dispersivity |
For Addiscott flow option:
 segment      parameters   | density |   K    Matric  using  |              |
Field     Mobile/immobile
 no.   |    AEV     BCAM   |         |         potl      P   |              |
capacity      threshold
       |    kPa            |  kg/dm3 |  mm/d    kPa          |     mm       |
kPa            kPa
 -----    ------   -----     ------    ----  -----   -----       -----
------         ---------
1     -.01644000000 5.1910000E+00   1.53     1   -15     3    30   0.3   -200
2     -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
3     -.01644000000 5.1910000E+00    1.5     1   -15     3    30   0.3   -200
4     -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
5     -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
6     -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
7     -.01644000000 5.1910000E+00   1.55     1   -15     3    30   0.3   -200
```

```
8     -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
9     -.01644000000 5.1910000E+00   1.61     1   -15     3    30   0.3   -200
10    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
11    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
12    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
13    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
14    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
15    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
16    -.01644000000 5.1910000E+00   1.62     1   -15     3    30   0.3   -200
17    -.01644000000 5.1910000E+00   1.63     1   -15     3    30   0.3   -200
18    -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
19    -.01644000000 5.1910000E+00   1.67     1   -15     3    30   0.3   -200
20    -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
******************************************************************************
**************************
******************************************************************************
**************************
Runoff according to the SCS curve number approach.  Curve number listed here
will be
adjusted by slope. During periods of crop growth, CN2 replaced by value for
crop.
(Procedure according to J.R. Williams (1991). Runoff and Water Erosion.
Chap 18, Modeling Plant and Soil Systems, Agronomy 31.)
----------------
 75   <Curve number (CN2).  In LEACHM, water content use to adjust CN2 based
on top 20 cm.
 0    <Slope, %. Used to adjust CN2 according to equation of Williams (1991).
** (Set slope to 0 to bypass the runoff routine.  Runoff owing to profile
saturation will still be accumulated)
*************************************************************************
*************************************************************************
                          CROP DATA
-------------------------------------------------------------------------
  Data for at least one crop must be specified, even if no crop desired.
  For fallow soil, set flag below to 0, or germination past the simulation end
date.
-------------------------------------------------------------------------
0      <Plants present: 1 yes, 0 no.  This flag overrides all other crop data.
1     <No. of crops (>0), even if bypassed.  Dates can be past last day of
simulation. my comment: # of years (for 9, 9 yrs) of simulation.
-1500  <Wilting point (soil) kPa.
-3000  <Min.root water pot'l(kpa).
1.1    <Maximum ratio of actual to potential transpiration (dry surface).
1.05   <Root resistance (weights water uptake by depth). (>1, No weighting:
1.0).
-------------------------------------------------------------------------
Growth  Perennial  N_uptake              Date or day of          Rel.  Max
crop   Crop    Mulch     ETp  |  Crop    Min   Harvested
1: No   1: Yes   1:to maturity                  Maturity         root   cover
cover at  effect  scaling| uptake    N    fraction
```

```
2: Yes  2: No    2:to harvest  Germ. Emerg.   Root  Cover  Harv. depth
fraction  harvest    %      factor|  N   P   fixed
------  -------  ------------  -------------------------------- -----  ------
----    -----kg/ha---- ----------
   1      1           1     051488  051588 051688 032487 041287  1.00   0.8
.8        0       1.0    102  20   0     .88
**********************************************************************
**********************************************************************
             INITIAL PROFILE CHEMICAL DATA
----------------------------------------------------------------------
   2     < Number of chemical species.  At least one must be specified.
----------------------------------------------------------------------
 Soil     Chem1     Chem2     Chem3     Chem4
layer         ----mg/kg dry soil----
----------------------------------------------------------------------
           1          0           0           0           0
           2          0           0           0           0
           3          0           0           0           0
           4          0           0           0           0
           5          0           0           0           0
           6          0           0           0           0
           7          0           0           0           0
           8          0           0           0           0
           9          0           0           0           0
          10          0           0           0           0
          11          0           0           0           0
          12          0           0           0           0
          13          0           0           0           0
          14          0           0           0           0
          15          0           0           0           0
          16          0           0           0           0
          17          0           0           0           0
          18          0           0           0           0
          19          0           0           0           0
          20          0           0           0           0
----------------------------------------------------------------------
Concentration (mg/l) below profile, used with lower boundaries 1 or 5
                  0.0       0.0       0.0       0.0      0.0
0       < Depth (mm) of water in mixing cell (boundaries 1 and 5 only). Enter
0 for no mixing cell.
**********************************************************************
**********************************************************************
                   CHEMICAL PROPERTIES
                   -------------------
Chem                  Solubility  Vapour Density    Link        Plant
 No.        Name        mg/l          mg/l                      Uptake
-------     ----        ------        --------     -------    1(yes),0(no)
  1  '    Atrazine'     .33E+02        .800E-05       0              0
  2  '     Bromide'     .5000E+06      .0000E-00      0              0
----------------------------------------------------------------------
```

```
       Linear(1)     |      Linear isotherm     | Freundlich isotherm
Chem     or          |   Koc    2-site model    |   Kfoc  Exponent
 No.  Freundlich(2)  |  l/kg    f      alpha    | (unit dependent!)
----   -----          -----   ---    ------      ------     ---
  1        1           100.0  1.0      .693        100      1.0
  2        1             0.0  1.0      .693        100      0.9
--------------------------------------------------------------------------
Diffusion coefficients:
--------------------
 120       <Molecular diffusion coefficient in water (mm2/day)
 .4300E+06 <Molecular diffusion coefficient in air (mm2/day)
 .1400E+06 <Air diff. coeff. enhancement to account for atmospheric pressure
fluctuations.
***********************************************************************
*  The values of L1,L2--->Ln ('Link' in the Chemical Properties above)
*   determine which species form a transformation chain.
*   Setting Ln = 0 breaks the pathway, Ln = 1 restores it.
*
*                     Transformation pathways------------------->
*     |    RATE 1         RATE 2         RATE 3        RATE 4
*    SE1----/L1/--->SE2----/L2/--->SE3----/L3/--->SE4---/L4/--->...
*     |               |              |             |
*     | RATE 5        | RATE 6       | RATE 7      | RATE 8     Degradation
*     |               |              |             |              pathways
*     v               v              v             v                 |
*  PRODUCT         PRODUCT        PRODUCT       PRODUCT              |
*                                                                    v
****************************************************************************


            TRANSFORMATION AND DEGRADATION RATE CONSTANTS
----------------------------------------------------------------------------
     1   <Rate constants apply to bulk soil (1), or solution phase only (0)
 Temperature and water content effects (transformation rate constants only):
     0   <Include temperature subroutine and adjustments? yes(1), no(0)
     3   <Q10: factor by which rate constant changes per 10 C increase
    20   <Base temperature: at which rate constants below apply
    35   <Optimum temperature: Q10 relationship applies from 0 C to here
    50   <Maximum temperature: Rate constants decrease from optimum to here
   .08   <High end of optimum water content range: air-filled porosity
  -300   <Lower end of optimum water content: matric potential kPa
 -1500   <Minimum matric potential for transformations kPa
   0.6   <Relative transformation rate at saturation
**************************************************************************
     TRANSFORMATION RATE CONSTANTS (may be adjusted as specified above)
--------------------------------------------------------------------------
Layer          Chemical 1     Chemical 2     Chemical 3    Chemical 4
 no            ----------     ----------     ----------    ----------
---------      <--------------------- day^(-1) --------------------->
    1          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
```

```
    2          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    3          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    4          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    5          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    6          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    7          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    8          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    9          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   10          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   11          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   12          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   13          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   14          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   15          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   16          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   17          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   18          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   19          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   20          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
**************************************************************************
    DEGRADATION RATE CONSTANTS (not influenced by water or temperature)
--------------------------------------------------------------------------
Layer          Chemical 1     Chemical 2     Chemical 3    Chemical 4
 no            ----------     ----------     ----------    ----------
---------      <--------------------- day^(-1) --------------------->
    1          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    2          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    3          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    4          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    5          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    6          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    7          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    8          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    9          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   10          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   11          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   12          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   13          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   14          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   15          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   16          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   17          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   18          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   19          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   20          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
**************************************************************************
**************************************************************************
                   CHEMICAL   APPLICATIONS
                   -----------------------
 1   <  Number of broadcast applications. (At least 1.  Can be past last date.
```

10

```
----------------------------------------------------------------------
                              Chem1      Chem2      Chem3     Chem4
                                     mg/sq.m (1mg/sq.m = .01kg/ha)
    -----       is surface)   --------     -----      -----      -----
    061687         0           380        7200        0          0
**************************************************************************
**************************************************************************
                    CULTIVATIONS
                    ------------
 1  < Number of cultivations.  At least one must be specified.  Can be past
last day (ie. if do not want cultivations).
 ------------------------------------------------------
 Date or   Depth of cultivation
 day no.        mm
 -------      -----
 000060         200
**************************************************************************
**************************************************************************
               RAIN/IRRIGATION AND WATER COMPOSITION
               -------------------------------------
8   < Number of water applications.  Some or all can be past last day.
--------------------------------------------------------------------------
  Start time     Amount  Surface flux      Dissolved in water (can be 0)
Date or  Time of    mm     density      Chem1     Chem2    Chem3    Chem4.....
Day no.    day              mm/d                        mg/l
-------  ------  ------  ------------  -----     -----    -----    -----
061787     0.3    012.7  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
062487     0.3    021.3  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
062587     0.3    023.3  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
062687     0.3    023.3  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
070687     0.3    069.9  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
070887     0.3    069.9  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
071587     0.3    069.5  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
072387     0.3    065.0  260.0    0.000E+00  .000E+00  .000E+00  .000E+00
**************************************************************************
**************************************************************************
        POTENTIAL ET (evap. trans.WEEKLY TOTALS, mm), DEPTH TO WATER TABLE
(mm)
        MEAN WEEKLY TEMPERATURES AND MEAN WEEKLY AMPLITUDE (degrees C)
--------------------------------------------------------------------------
      Week no.    ET   Water table  Mean temp  Amplitude
      ------------------------------------------------
       1   61.0    0000   22.4   2.0
       2   66.0    0000   23.5   3.0
       3   64.0    0000   24.4   4.0
       4   64.0    0000   25.0   4.0
       5   64.0    0000   25.6   6.0
       6   55.0    0000   22.9   2.0
       7   67.0    0000   20.1   3.0
       8   60.0    0000   20.0   4.0
```

```
       9   60.0    0000   20.0   4.0
```

Specimen LEACHM Input File
Low Percolation, 3000 Total Soil Core Depth and
25 mm Soil Layers

```
Sl3th025< DOS Filename, 8 characters with no extension. Used in batch runs
(started as LEACHP<filename).
--------------------------------------------------------------------------
                      LEACHP PESTICIDE DATA FILE.
Numeric data and comments may extend to position 120. Unless defined as
'not read' a value must be present for each item, although it may not be used.
Free format with blank delimiters. Preserve division and heading records.
Number of depth segments may be changed.
******************************************************************************
********************************
 1      <Date format (1: month/day/year;  2: day/month/year).  Dates must be 6
digits, 2 each for day, mo, yr.
 061187 <Starting date.  No date in the input data should precede this date.
 000050 <Ending date or day number.  The starting date is day 1. (A value
<010101 is treated as a day number).
 0.05    <Largest time interval within a day (0.1 day or less).
 1      <Number of repetitions of rainfall, crop and chemical application
data.
 3000   <Profile depth (mm), preferably a multiple of the segment thickness.
 25     <Segment thickness (mm).  (The number of segments should be between
about 8 and 30.
 2      <Lower boundary condition: 1:fixed depth water table; 2:free drainage,
3:zero flux 4:lysimeter.
 0000   <Water table depth (mm), if the lower boundary is 1 (water table).
---------------------------------------------------------------------------
The steady-state flow option uses constant water fluxes during the application
periods specified in the rainfall data table, and a uniform water content
specified here.  Steady-state flow implies a lab column, and crop and
evaporation data are ignored.
---------------------------------------------------------------------------
  1     < Water flow: 1: Richards; 2: Addiscott tipping bucket; 3: steady-
state.
  0.4   < Steady-state flow water content (theta); 999: saturated column.
******************************************************************************
********************************
******************************************************************************
********************************
 1      <Number of output files: 1: OUT only; 2: OUT + SUM; 3: OUT + SUM + BTC
--------------------------------------
--- For the *.OUT file :
 1      <Units for depth data: 1: ug/kg, 2: mg/m2 per segment depth, 3: mg/kg,
4: g/m2, 5: kg/ha.
 1      <Node print frequency (print data for every node (1), alternate nodes
(2).
 1      <Print options: 1 or 2.  Use to specify one of the following options.
```

```
 1      <Option 1: Print at fixed time intervals (days between prints).
 1      <Option 2: No. of prints (the times for which are specified below)
 2      <Tables printed: 1: mass balance; 2: + depth data; 3: + crop data
 0      <Reset *.OUT file cumulative values every 12 months after start date?
0: No, 1: Yes
---------------------------------------(if yes: .sum printouts must be monthly
(code 999) and .out prints should be at the end of each year)
--- For the * .SUM file :
 50     <Summary print interval (d)  (999 for calendar month printouts)
 000    <Surface to [depth 1?] mm     ( Three depth segments for the
 Days                                          file. Zero defaults to nodes
                                               to thirds of the profile)
  3     <4th segment: Root zone (1); profile (2); Depth 3 to lower boundary
(3); Surface to shallowest of lower boundary or water table (4)
---------------------------------------
--- For the *.BTC (breakthrough) file :
 1.0    <Incremental depth of drainage water per output (mm)
--------------------------------------------------------------------------
-- List here the times at which the *.OUT file is desired for print option 2.
-- The number of records must match the 'No. of prints' under option 2 above.
        Date or    Time of day          (At least one must be specified
        Day no.  (to nearest tenth)      even if print option is not 2)
        --------  ----------------
        000050         .5        (These dates can be past the last day)
*************************************************************************
*************************************************************************
                  SOIL PHYSICAL PROPERTIES
-------------------------------------------------------------------------
-- Retentivity model 0 uses listed Campbell's retention parameters, otherwise
-- the desired particle size-based regression model is used.
-------------------------------------------------------------------------
 Soil |                   |Retention|   Starting    |   Roots    | Starting
layer | Clay  Silt  Organic |  model  |theta or pot'l|  (for no   | temp (C)
 no.  |             carbon  |         |(one is used) |  growth)   | (not read
in
      |   %     %     %     |         |          kPa | (relative)|  LEACHC)
 ---    ----  ----   ----     ------   -----  -----    ------    -----------
      1       3       8    0.71       5   0.045     -10     0.2       20
      2       3       8    0.71       5   0.045     -10     0.2       20
      3       3       8    0.71       5   0.045     -10     0.2       20
      4       3       8    0.71       5   0.045     -10     0.2       20
      5       3       8    0.71       5   0.045     -10     0.2       20
      6       3       8    0.71       5   0.045     -10     0.2       20
      7       4       6    0.25       5    0.06     -10     0.2       20
      8       4       6    0.25       5    0.06     -10     0.2       20
      9       4       6    0.25       5    0.06     -10     0.2       20
     10       4       6    0.25       5    0.06     -10     0.2       20
     11       4       6    0.25       5    0.06     -10     0.2       20
     12       4       6    0.25       5    0.06     -10     0.2       20
     13       5       6     0.1       5    0.09     -10    0.15       20
```

14	5	6	0.1	5	0.09	-10	0.15	20
15	5	6	0.1	5	0.09	-10	0.15	20
16	5	6	0.1	5	0.09	-10	0.15	20
17	5	6	0.1	5	0.09	-10	0.15	20
18	5	6	0.1	5	0.09	-10	0.15	20
19	5	4	0.1	5	0.135	-10	0.13	20
20	5	4	0.1	5	0.135	-10	0.13	20
21	5	4	0.1	5	0.135	-10	0.13	20
22	5	4	0.1	5	0.135	-10	0.13	20
23	5	4	0.1	5	0.135	-10	0.13	20
24	5	4	0.1	5	0.135	-10	0.13	20
25	6	4	0.067	5	0.15	-10	0.1	20
26	6	4	0.067	5	0.15	-10	0.1	20
27	6	4	0.067	5	0.15	-10	0.1	20
28	6	4	0.067	5	0.15	-10	0.1	20
29	6	4	0.067	5	0.15	-10	0.1	20
30	6	4	0.067	5	0.15	-10	0.1	20
31	5	4	0.009	5	0.144	-10	0.08	20
32	5	4	0.009	5	0.144	-10	0.08	20
33	5	4	0.009	5	0.144	-10	0.08	20
34	5	4	0.009	5	0.144	-10	0.08	20
35	5	4	0.009	5	0.144	-10	0.08	20
36	5	4	0.009	5	0.144	-10	0.08	20
37	6	4	0.058	5	0.135	-10	0.05	20
38	6	4	0.058	5	0.135	-10	0.05	20
39	6	4	0.058	5	0.135	-10	0.05	20
40	6	4	0.058	5	0.135	-10	0.05	20
41	6	4	0.058	5	0.135	-10	0.05	20
42	6	4	0.058	5	0.135	-10	0.05	20
43	6	5	0.05	5	0.12	-10	0.04	20
44	6	5	0.05	5	0.12	-10	0.04	20
45	6	5	0.05	5	0.12	-10	0.04	20
46	6	5	0.05	5	0.12	-10	0.04	20
47	6	5	0.05	5	0.12	-10	0.04	20
48	6	5	0.05	5	0.12	-10	0.04	20
49	5	4	0.025	5	0.128	-10	0.02	20
50	5	4	0.025	5	0.128	-10	0.02	20
51	5	4	0.025	5	0.128	-10	0.02	20
52	5	4	0.025	5	0.128	-10	0.02	20
53	5	4	0.025	5	0.128	-10	0.02	20
54	5	4	0.025	5	0.128	-10	0.02	20
55	6	5	0.017	5	0.114	-32	0.02	20
56	6	5	0.017	5	0.114	-32	0.02	20
57	6	5	0.017	5	0.114	-32	0.02	20
58	6	5	0.017	5	0.114	-32	0.02	20
59	6	5	0.017	5	0.114	-32	0.02	20
60	6	5	0.017	5	0.114	-32	0.02	20
61	6	5	0.025	5	0.144	-100	0.02	20
62	6	5	0.025	5	0.144	-100	0.02	20
63	6	5	0.025	5	0.144	-100	0.02	20

64	6	5	0.025	5	0.144	-100	0.02	20
65	6	5	0.025	5	0.144	-100	0.02	20
66	6	5	0.025	5	0.144	-100	0.02	20
67	6	5	0.025	5	0.15	-316	0.02	20
68	6	5	0.025	5	0.15	-316	0.02	20
69	6	5	0.025	5	0.15	-316	0.02	20
70	6	5	0.025	5	0.15	-316	0.02	20
71	6	5	0.025	5	0.15	-316	0.02	20
72	6	5	0.025	5	0.15	-316	0.02	20
73	7	5	0.017	5	0.12	-1000	0.02	20
74	7	5	0.017	5	0.12	-1000	0.02	20
75	7	5	0.017	5	0.12	-1000	0.02	20
76	7	5	0.017	5	0.12	-1000	0.02	20
77	7	5	0.017	5	0.12	-1000	0.02	20
78	7	5	0.017	5	0.12	-1000	0.02	20
79	6	5	0.008	5	0.105	-3000	0.02	20
80	6	5	0.008	5	0.105	-3000	0.02	20
81	6	5	0.008	5	0.105	-3000	0.02	20
82	6	5	0.008	5	0.105	-3000	0.02	20
83	6	5	0.008	5	0.105	-3000	0.02	20
84	6	5	0.008	5	0.105	-3000	0.02	20
85	7	6	0	5	0.09	-3000	0.02	20
86	7	6	0	5	0.09	-3000	0.02	20
87	7	6	0	5	0.09	-3000	0.02	20
88	7	6	0	5	0.09	-3000	0.02	20
89	7	6	0	5	0.09	-3000	0.02	20
90	7	6	0	5	0.09	-3000	0.02	20
91	7	5	0	5	0.105	-3000	0.02	20
92	7	5	0	5	0.105	-3000	0.02	20
93	7	5	0	5	0.105	-3000	0.02	20
94	7	5	0	5	0.105	-3000	0.02	20
95	7	5	0	5	0.105	-3000	0.02	20
96	7	5	0	5	0.105	-3000	0.02	20
97	6	6	0	5	0.09	-3000	0.02	20
98	6	6	0	5	0.09	-3000	0.02	20
99	6	6	0	5	0.09	-3000	0.02	20
100	6	6	0	5	0.09	-3000	0.02	20
101	6	6	0	5	0.09	-3000	0.02	20
102	6	6	0	5	0.09	-3000	0.02	20
103	7	6	0	5	0.105	-3000	0.02	20
104	7	6	0	5	0.105	-3000	0.02	20
105	7	6	0	5	0.105	-3000	0.02	20
106	7	6	0	5	0.105	-3000	0.02	20
107	7	6	0	5	0.105	-3000	0.02	20
108	7	6	0	5	0.105	-3000	0.02	20
109	7	7	0.008	5	0.12	-3000	0.01	20
110	7	7	0.008	5	0.12	-3000	0.01	20
111	7	7	0.008	5	0.12	-3000	0.01	20
112	7	7	0.008	5	0.12	-3000	0.01	20
113	7	7	0.008	5	0.12	-3000	0.01	20

```
     114       7       7   0.008       5    0.12   -3000    0.01      20
     115       9       7       0       5   0.135   -3000    0.01      20
     116       9       7       0       5   0.135   -3000    0.01      20
     117       9       7       0       5   0.135   -3000    0.01      20
     118       9       7       0       5   0.135   -3000    0.01      20
     119       9       7       0       5   0.135   -3000    0.01      20
     120       9       7       0       5   0.135   -3000    0.01      20
---------------------------------------------------------------------------
   1    < Use listed water contents (1) or potentials (2) as starting values.
Particle density:  Clay    Silt and sand    Organic matter  (kg/dm3) (to
calculate porosity)
                   2.65        2.65              1.10
***************************************************************************
For a uniform profile: Any non-zero value here will override those in
the table below (only if retentivity model is 0).
----------------------------------------------------------------------
  0     0   <Soil bulk density and particle density (kg/dm3) .
 -0.0         <'Air-entry value' (AEV) (kPa) (a in eq 2.1 to 2.4).
  0         <Exponent (BCAM) in Campbell's water retention equation (b in eq.
2.1 to 2.4).
  2019.0000  -0.5 <Conductivity (mm/day) and corresponding matric potential
(kPa) (for potential-based version of eq. 2.5).
   1         <Pore interaction parameter (P) in Campbell's conductivity
 equation (eq.2.5 in manual).
  48.8075123 <Dispersivity (mm) (eq. 3.12).
```

Water Evaporated (mm)

```
                                Matric potential (kPa) at field capacity
                                Division between mobile and immobile water
(kPa)
******************************************************************************
**************************
 Soil  |  Soil retentivity |   Bulk  |  Match K(h) curve at: | Dispersivity |
For Addiscott flow option:
 segment      parameters   | density |   K    Matric  using  |              |
Field    Mobile/immobile
 no.   |    AEV     BCAM   |         |         potl      P   |              |
capacity      threshold
       |    kPa            |  kg/dm3 |  mm/d    kPa          |     mm       |
kPa            kPa
 -----    ------   -----     ------    ----  -----   -----       -----
------         ---------
1     -.01644000000 5.1910000E+00   1.53     1   -15     3    30   0.3   -200
2     -.01644000000 5.1910000E+00   1.53     1   -15     3    30   0.3   -200
3     -.01644000000 5.1910000E+00   1.53     1   -15     3    30   0.3   -200
4     -.01644000000 5.1910000E+00   1.53     1   -15     3    30   0.3   -200
5     -.01644000000 5.1910000E+00   1.53     1   -15     3    30   0.3   -200
6     -.01644000000 5.1910000E+00   1.53     1   -15     3    30   0.3   -200
7     -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
8     -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
9     -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
10    -.01644000000 5.1910000E+00   1.52     1   -15     3    30   0.3   -200
```

```
11    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
12    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
13    -.01644000000 5.1910000E+00    1.5     1   -15      3    30   0.3   -200
14    -.01644000000 5.1910000E+00    1.5     1   -15      3    30   0.3   -200
15    -.01644000000 5.1910000E+00    1.5     1   -15      3    30   0.3   -200
16    -.01644000000 5.1910000E+00    1.5     1   -15      3    30   0.3   -200
17    -.01644000000 5.1910000E+00    1.5     1   -15      3    30   0.3   -200
18    -.01644000000 5.1910000E+00    1.5     1   -15      3    30   0.3   -200
19    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
20    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
21    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
22    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
23    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
24    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
25    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
26    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
27    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
28    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
29    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
30    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
31    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
32    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
33    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
34    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
35    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
36    -.01644000000 5.1910000E+00   1.52     1   -15      3    30   0.3   -200
37    -.01644000000 5.1910000E+00   1.55     1   -15      3    30   0.3   -200
38    -.01644000000 5.1910000E+00   1.55     1   -15      3    30   0.3   -200
39    -.01644000000 5.1910000E+00   1.55     1   -15      3    30   0.3   -200
40    -.01644000000 5.1910000E+00   1.55     1   -15      3    30   0.3   -200
41    -.01644000000 5.1910000E+00   1.55     1   -15      3    30   0.3   -200
42    -.01644000000 5.1910000E+00   1.55     1   -15      3    30   0.3   -200
43    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
44    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
45    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
46    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
47    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
48    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
49    -.01644000000 5.1910000E+00   1.61     1   -15      3    30   0.3   -200
50    -.01644000000 5.1910000E+00   1.61     1   -15      3    30   0.3   -200
51    -.01644000000 5.1910000E+00   1.61     1   -15      3    30   0.3   -200
52    -.01644000000 5.1910000E+00   1.61     1   -15      3    30   0.3   -200
53    -.01644000000 5.1910000E+00   1.61     1   -15      3    30   0.3   -200
54    -.01644000000 5.1910000E+00   1.61     1   -15      3    30   0.3   -200
55    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
56    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
57    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
58    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
59    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
60    -.01644000000 5.1910000E+00   1.59     1   -15      3    30   0.3   -200
```

```
61    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
62    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
63    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
64    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
65    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
66    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
67    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
68    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
69    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
70    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
71    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
72    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
73    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
74    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
75    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
76    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
77    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
78    -.01644000000 5.1910000E+00   1.56     1   -15     3    30   0.3   -200
79    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
80    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
81    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
82    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
83    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
84    -.01644000000 5.1910000E+00   1.57     1   -15     3    30   0.3   -200
85    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
86    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
87    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
88    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
89    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
90    -.01644000000 5.1910000E+00   1.59     1   -15     3    30   0.3   -200
91    -.01644000000 5.1910000E+00   1.62     1   -15     3    30   0.3   -200
92    -.01644000000 5.1910000E+00   1.62     1   -15     3    30   0.3   -200
93    -.01644000000 5.1910000E+00   1.62     1   -15     3    30   0.3   -200
94    -.01644000000 5.1910000E+00   1.62     1   -15     3    30   0.3   -200
95    -.01644000000 5.1910000E+00   1.62     1   -15     3    30   0.3   -200
96    -.01644000000 5.1910000E+00   1.62     1   -15     3    30   0.3   -200
97    -.01644000000 5.1910000E+00   1.63     1   -15     3    30   0.3   -200
98    -.01644000000 5.1910000E+00   1.63     1   -15     3    30   0.3   -200
99    -.01644000000 5.1910000E+00   1.63     1   -15     3    30   0.3   -200
100   -.01644000000 5.1910000E+00   1.63     1   -15     3    30   0.3   -200
101   -.01644000000 5.1910000E+00   1.63     1   -15     3    30   0.3   -200
102   -.01644000000 5.1910000E+00   1.63     1   -15     3    30   0.3   -200
103   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
104   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
105   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
106   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
107   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
108   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
109   -.01644000000 5.1910000E+00   1.67     1   -15     3    30   0.3   -200
110   -.01644000000 5.1910000E+00   1.67     1   -15     3    30   0.3   -200
```

```
111   -.01644000000 5.1910000E+00   1.67     1   -15     3    30   0.3   -200
112   -.01644000000 5.1910000E+00   1.67     1   -15     3    30   0.3   -200
113   -.01644000000 5.1910000E+00   1.67     1   -15     3    30   0.3   -200
114   -.01644000000 5.1910000E+00   1.67     1   -15     3    30   0.3   -200
115   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
116   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
117   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
118   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
119   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
120   -.01644000000 5.1910000E+00   1.64     1   -15     3    30   0.3   -200
******************************************************************************
**************************
******************************************************************************
**************************
Runoff according to the SCS curve number approach.  Curve number listed here
will be
adjusted by slope. During periods of crop growth, CN2 replaced by value for
crop.
(Procedure according to J.R. Williams (1991). Runoff and Water Erosion.
Chap 18, Modeling Plant and Soil Systems, Agronomy 31.)
----------------
 75   <Curve number (CN2).  In LEACHM, water content use to adjust CN2 based
on top 20 cm.
 0    <Slope, %. Used to adjust CN2 according to equation of Williams (1991).
** (Set slope to 0 to bypass the runoff routine.  Runoff owing to profile
saturation will still be accumulated)
*************************************************************************
*************************************************************************
                          CROP DATA
-------------------------------------------------------------------------
  Data for at least one crop must be specified, even if no crop desired.
  For fallow soil, set flag below to 0, or germination past the simulation end
date.
-------------------------------------------------------------------------
0      <Plants present: 1 yes, 0 no.  This flag overrides all other crop data.
1     <No. of crops (>0), even if bypassed.  Dates can be past last day of
simulation. my comment: # of years (for 9, 9 yrs) of simulation.
-1500  <Wilting point (soil) kPa.
-3000  <Min.root water pot'l(kpa).
1.1    <Maximum ratio of actual to potential transpiration (dry surface).
1.05   <Root resistance (weights water uptake by depth). (>1, No weighting:
1.0).
-------------------------------------------------------------------------
Growth  Perennial  N_uptake              Date or day of          Rel.  Max
crop   Crop    Mulch     ETp  |  Crop    Min   Harvested
1: No   1: Yes   1:to maturity                  Maturity         root   cover
cover at  effect  scaling| uptake    N    fraction
2: Yes  2: No    2:to harvest  Germ. Emerg.   Root  Cover  Harv. depth
fraction  harvest    %      factor|  N   P   fixed
```

```
------  -------  -----------  -------------------------------- -----  ------
----    -----kg/ha---- ----------
   1       1           1     051488  051588 051688 032487 041287  1.00   0.8
.8        0       1.0    102  20   0     .88
**********************************************************************
**********************************************************************
             INITIAL PROFILE CHEMICAL DATA
----------------------------------------------------------------------
   2    < Number of chemical species.  At least one must be specified.
----------------------------------------------------------------------
 Soil     Chem1     Chem2     Chem3     Chem4
layer         ----mg/kg dry soil----
----------------------------------------------------------------------
           1           0           0           0           0
           2           0           0           0           0
           3           0           0           0           0
           4           0           0           0           0
           5           0           0           0           0
           6           0           0           0           0
           7           0           0           0           0
           8           0           0           0           0
           9           0           0           0           0
          10           0           0           0           0
          11           0           0           0           0
          12           0           0           0           0
          13           0           0           0           0
          14           0           0           0           0
          15           0           0           0           0
          16           0           0           0           0
          17           0           0           0           0
          18           0           0           0           0
          19           0           0           0           0
          20           0           0           0           0
          21           0           0           0           0
          22           0           0           0           0
          23           0           0           0           0
          24           0           0           0           0
          25           0           0           0           0
          26           0           0           0           0
          27           0           0           0           0
          28           0           0           0           0
          29           0           0           0           0
          30           0           0           0           0
          31           0           0           0           0
          32           0           0           0           0
          33           0           0           0           0
          34           0           0           0           0
          35           0           0           0           0
          36           0           0           0           0
          37           0           0           0           0
```

38	0	0	0	0
39	0	0	0	0
40	0	0	0	0
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50	0	0	0	0
51	0	0	0	0
52	0	0	0	0
53	0	0	0	0
54	0	0	0	0
55	0	0	0	0
56	0	0	0	0
57	0	0	0	0
58	0	0	0	0
59	0	0	0	0
60	0	0	0	0
61	0	0	0	0
62	0	0	0	0
63	0	0	0	0
64	0	0	0	0
65	0	0	0	0
66	0	0	0	0
67	0	0	0	0
68	0	0	0	0
69	0	0	0	0
70	0	0	0	0
71	0	0	0	0
72	0	0	0	0
73	0	0	0	0
74	0	0	0	0
75	0	0	0	0
76	0	0	0	0
77	0	0	0	0
78	0	0	0	0
79	0	0	0	0
80	0	0	0	0
81	0	0	0	0
82	0	0	0	0
83	0	0	0	0
84	0	0	0	0
85	0	0	0	0
86	0	0	0	0
87	0	0	0	0

```
          88           0           0           0           0
          89           0           0           0           0
          90           0           0           0           0
          91           0           0           0           0
          92           0           0           0           0
          93           0           0           0           0
          94           0           0           0           0
          95           0           0           0           0
          96           0           0           0           0
          97           0           0           0           0
          98           0           0           0           0
          99           0           0           0           0
         100           0           0           0           0
         101           0           0           0           0
         102           0           0           0           0
         103           0           0           0           0
         104           0           0           0           0
         105           0           0           0           0
         106           0           0           0           0
         107           0           0           0           0
         108           0           0           0           0
         109           0           0           0           0
         110           0           0           0           0
         111           0           0           0           0
         112           0           0           0           0
         113           0           0           0           0
         114           0           0           0           0
         115           0           0           0           0
         116           0           0           0           0
         117           0           0           0           0
         118           0           0           0           0
         119           0           0           0           0
         120           0           0           0           0
-----------------------------------------------------------------------
Concentration (mg/l) below profile, used with lower boundaries 1 or 5
                  0.0       0.0       0.0       0.0      0.0
0        < Depth (mm) of water in mixing cell (boundaries 1 and 5 only). Enter
0 for no mixing cell.
***********************************************************************
***********************************************************************
                   CHEMICAL PROPERTIES
                   -------------------
Chem                  Solubility  Vapour Density    Link        Plant
 No.        Name        mg/l          mg/l                      Uptake
-------     ----        ------        --------     -------    1(yes),0(no)
  1  '    Atrazine'     .33E+02        .800E-05        0             0
  2  '     Bromide'     .5000E+06      .0000E-00       0             0
-----------------------------------------------------------------------
       Linear(1)     |      Linear isotherm     | Freundlich isotherm
Chem     or          |   Koc    2-site model    |   Kfoc  Exponent
```

```
 No.  Freundlich(2)  |  l/kg    f      alpha    | (unit dependent!)
----   -----          -----   ---    ------      ------     ---
  1        1           100.0  1.0      .693        100      1.0
  2        1             0.0  1.0      .693        100      0.9
--------------------------------------------------------------------------
Diffusion coefficients:
--------------------
 120       <Molecular diffusion coefficient in water (mm2/day)
 .4300E+06 <Molecular diffusion coefficient in air (mm2/day)
 .1400E+06 <Air diff. coeff. enhancement to account for atmospheric pressure
fluctuations.
***********************************************************************
*  The values of L1,L2--->Ln ('Link' in the Chemical Properties above)
*   determine which species form a transformation chain.
*   Setting Ln = 0 breaks the pathway, Ln = 1 restores it.

*                    Transformation pathways------------------->
*     |    RATE 1         RATE 2         RATE 3        RATE 4
*    SE1----/L1/--->SE2----/L2/--->SE3----/L3/--->SE4---/L4/--->...
*     |               |              |             |
*     | RATE 5        | RATE 6       | RATE 7      | RATE 8     Degradation
*     |               |              |             |              pathways
*     v               v              v             v                 |
*  PRODUCT         PRODUCT        PRODUCT       PRODUCT              |
*                                                                    v
****************************************************************************
            TRANSFORMATION AND DEGRADATION RATE CONSTANTS
----------------------------------------------------------------------------
     1   <Rate constants apply to bulk soil (1), or solution phase only (0)
 Temperature and water content effects (transformation rate constants only):
     0   <Include temperature subroutine and adjustments? yes(1), no(0)
     3   <Q10: factor by which rate constant changes per 10 C increase
    20   <Base temperature: at which rate constants below apply
    35   <Optimum temperature: Q10 relationship applies from 0 C to here
    50   <Maximum temperature: Rate constants decrease from optimum to here
   .08   <High end of optimum water content range: air-filled porosity
  -300   <Lower end of optimum water content: matric potential kPa
 -1500   <Minimum matric potential for transformations kPa
   0.6   <Relative transformation rate at saturation
**************************************************************************
     TRANSFORMATION RATE CONSTANTS (may be adjusted as specified above)
--------------------------------------------------------------------------
Layer          Chemical 1     Chemical 2     Chemical 3    Chemical 4
 no            ----------     ----------     ----------    ----------
---------      <--------------------- day^(-1) --------------------->
    1          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    2          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    3          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    4          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
    5          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
```

```
   6          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   7          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   8          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   9          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  10          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  11          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  12          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  13          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  14          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  15          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  16          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  17          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  18          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  19          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  20          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  21          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  22          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  23          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  24          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  25          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  26          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  27          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  28          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  29          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  30          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  31          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  32          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  33          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  34          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  35          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  36          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  37          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  38          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  39          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  40          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  41          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  42          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  43          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  44          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  45          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  46          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  47          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  48          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  49          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  50          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  51          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  52          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  53          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  54          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  55          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
```

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   56          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   57          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   58          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   59          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   60          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   61          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   62          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   63          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   64          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   65          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   66          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   67          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   68          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   69          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   70          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   71          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   72          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   73          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   74          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   75          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   76          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   77          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   78          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   79          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   80          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   81          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   82          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   83          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   84          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   85          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   86          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   87          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   88          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   89          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   90          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   91          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   92          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   93          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   94          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   95          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   96          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   97          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   98          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
   99          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  100          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  101          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  102          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  103          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  104          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  105          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
```

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  106          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  107          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  108          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  109          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  110          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  111          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  112          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  113          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  114          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  115          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  116          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  117          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  118          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  119          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
  120          0.0347E+00     0.0000E+00     0.0000E+00     0.0000E+00
**************************************************************************
    DEGRADATION RATE CONSTANTS (not influenced by water or temperature)
--------------------------------------------------------------------------
Layer          Chemical 1     Chemical 2     Chemical 3    Chemical 4
 no            ----------     ----------     ----------    ----------
---------      <--------------------- day^(-1) --------------------->
    1          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    2          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    3          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    4          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    5          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    6          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    7          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    8          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
    9          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   10          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   11          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   12          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   13          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   14          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   15          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   16          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   17          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   18          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   19          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   20          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   21          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   22          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   23          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   24          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   25          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   26          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   27          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   28          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   29          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
```

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   30          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   31          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   32          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   33          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   34          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   35          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   36          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   37          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   38          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   39          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   40          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   41          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   42          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   43          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   44          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   45          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   46          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   47          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   48          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   49          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   50          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   51          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   52          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   53          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   54          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   55          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   56          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   57          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   58          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   59          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   60          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   61          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   62          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   63          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   64          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   65          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   66          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   67          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   68          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   69          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   70          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   71          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   72          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   73          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   74          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   75          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   76          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   77          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   78          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   79          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
```

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   80          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   81          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   82          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   83          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   84          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   85          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   86          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   87          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   88          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   89          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   90          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   91          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   92          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   93          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   94          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   95          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   96          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   97          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   98          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
   99          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  100          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  101          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  102          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  103          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  104          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  105          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  106          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  107          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  108          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  109          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  110          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  111          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  112          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  113          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  114          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  115          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  116          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  117          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  118          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  119          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
  120          0.0000E+00     0.0000E+00     0.0000E+00     0.0000E+00
**************************************************************************
**************************************************************************
                   CHEMICAL   APPLICATIONS
                   -----------------------
 1   <  Number of broadcast applications. (At least 1.  Can be past last date.
----------------------------------------------------------------------
0          10              20     Chem1      Chem2      Chem3     Chem4
30          40             50           mg/sq.m (1mg/sq.m = .01kg/ha)
    -----       is surface)   --------     -----      -----      -----
```

```
    061687          0           380        7200        0         0
**************************************************************************
**************************************************************************
                    CULTIVATIONS
                    ------------
 1  < Number of cultivations.  At least one must be specified.  Can be past
last day (ie. if do not want cultivations).
 -----------------------------------------------------
 Date or   Depth of cultivation
 day no.        mm
 -------      -----
 000060         200
**************************************************************************
**************************************************************************
               RAIN/IRRIGATION AND WATER COMPOSITION
               -------------------------------------
8   < Number of water applications.  Some or all can be past last day.
--------------------------------------------------------------------------
  Start time     Amount  Surface flux      Dissolved in water (can be 0)
Date or  Time of    mm     density      Chem1     Chem2    Chem3    Chem4.....
Day no.    day              mm/d                    mg/l
-------  ------  ------  ------------  -----     -----    -----    -----
061787     0.3    012.7    260.0       0       0       0       0
062487     0.3    012.8    260.0       0       0       0       0
062587     0.3    012.8    260.0       0       0       0       0
062687     0.3    012.8    260.0       0       0       0       0
070687     0.3    042.0    260.0       0       0       0       0
070887     0.3    042.0    260.0       0       0       0       0
071587     0.3    041.8    260.0       0       0       0       0
072387     0.3    038.9    260.0       0       0       0       0
**************************************************************************
**************************************************************************
        POTENTIAL ET (evap. trans.WEEKLY TOTALS, mm), DEPTH TO WATER TABLE
(mm)
        MEAN WEEKLY TEMPERATURES AND MEAN WEEKLY AMPLITUDE (degrees C)
--------------------------------------------------------------------------
      Week no.    ET   Water table  Mean temp  Amplitude
      ----------------------------------------------
       1   61.0    0000   22.4   2.0
       2   66.0    0000   23.5   3.0
       3   64.0    0000   24.4   4.0
       4   64.0    0000   25.0   4.0
       5   64.0    0000   25.6   6.0
       6   55.0    0000   22.9   2.0
       7   67.0    0000   20.1   3.0
       8   60.0    0000   20.0   4.0
       9   60.0    0000   20.0   4.0
```

Appendix II

Specimen PRZM Input File
Twenty 150 mm Thick Soil Horizons with 10 mm Thick Compartments in Horizons 1 through 4, and with Extraction Depth for Evaporation at 150 mm

```
EXAMS - PRZM Exposure Simulation Shell v1.2.22, Apr 2003
*** Example file used to fill-in with CA data
1987 Sprinkler - Bromide simulated, 0.045mm theta extd 15 cm RD 150 cm
     1.0    0.0        0   15.00       1       1
       0
       1
       1    0.20  150.00   98.00       3     0  0  0    0.00  120.00
       1
  101087  101187  101287       1
PESTICIDE TRANSPORT AND TRANSFORMATION AND APPLICATION PARAMETERS
       1       1       0       0
Bromide
  160687  0 1  4.0  72.0  1.0  0.0
     0.0    1     0.0
Delhi Sandy Loam
   300.0          0   0   0   0   0   0   0   0   0
     0.0     0.0     0.0
      20
       1    15.0    1.53    .045     0.0     0.0     0.0
             0.0     0.0     0.0
             1.0    .115    .050    0.71     0.0
       2    15.0    1.52    .060     0.0     0.0     0.0
             0.0     0.0     0.0
             1.0    .102    .045    0.25     0.0
       3    15.0    1.50    .090     0.0     0.0     0.0
             0.0     0.0     0.0
             1.0    .104    .047     0.1     0.0
       4    15.0    1.52    .135     0.0     0.0     0.0
             0.0     0.0     0.0
             1.0    .099    .046     0.1     0.0
       5    15.0    1.52    .150     0.0     0.0     0.0
             0.0     0.0     0.0
             3.0    .103    .050     .07     0.0
       6    15.0    1.52    .144     0.0     0.0     0.0
             0.0     0.0     0.0
             3.0    .096    .044    0.01     0.0
       7    15.0    1.55    .135     0.0     0.0     0.0
             0.0     0.0     0.0
             3.0    .101    .049    0.06     0.0
       8    15.0    1.59    .120     0.0     0.0     0.0
             0.0     0.0     0.0
             3.0    .099    .049    0.05     0.0
```

```
       9    15.0    1.61    .128     0.0     0.0     0.0
             0.0     0.0     0.0
             3.0    .089    .043    0.03     0.0
      10    15.0    1.59    .114     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .098    .048    0.02     0.0
      11    15.0    1.57    .144     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .100    .049    0.03     0.0
      12    15.0    1.56    .150     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .101    .049    0.03     0.0
      13    15.0    1.56    .120     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .106    .053    0.02     0.0
      14    15.0    1.57    .105     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .099    .048    0.01     0.0
      15    15.0    1.59    .090     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .105    .053    0.00     0.0
      16    15.0    1.62    .105     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .101    .052    0.00     0.0
      17    15.0    1.63    .090     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .096    .047    0.00     0.0
      18    15.0    1.64    .105     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .101    .052    0.00     0.0
      19    15.0    1.67    .120     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .101    .052    0.01     0.0
      20    15.0    1.64    .135     0.0     0.0     0.0
             0.0     0.0     0.0
             5.0    .114    .095    0.00     0.0
       0
    WATR     DAY       1    PEST     DAY       1    CONC     DAY       1   0
       4    YEAR
    PRCP    TSER
    TETD    TSER
    COFX    TSER   0   0    1.E5
    INFL    TSER 253 253
```