PESTICIDE PARAMETERS

The pesticide component of **GLEAMS** contains the same surface response (runoff and sediment transport of pesticides) as that in **CREAMS**. In addition, **GLEAMS** has the capability of considering movement of pesticides into, within, and through the rootzone. Up to 10 pesticides can be simulated simultaneously, and one or two metabolites of a pesticide can be considered, also.

A parameter editor has been developed for the pesticide component that includes a relatively large data base with pesticide characteristics. Several sources of information went into development of the data base. Some characteristics may be rather site specific, such as half-life and adsorptivity. Model users are urged to use local data where available. There are no changes in the pesticide component from that of the previous version 1.8.55.

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Cards 1 to 3: **TITLE**

TITLE Three 80-character lines of alphanumeric information that identifies the particular computer run. For example, the soil type, the crop rotation, the tillage practices, may be useful in identifying the file. This title will be reproduced on the pesticide output file.

Card 4: **PBDATE, PEDATE, NPEST, IROT, PSTOUT**

PBDATE The Julian date that the model is to begin pesticide simulation, e. g. 73138 **PBDATE** must not be less than **HBDATE** on Card 4 of hydrology parameters. Also, it must be at least one day before the first day pesticides are to be applied.

PEDATE The Julian day that the model is to stop considering pesticides, e.g. 80274

NPEST Number of different pesticides considered in the simulation (maximum of 10), e. g. 7 The number also must include the number of metabolites, if any, to be considered.

IROT Number of years in a rotation cycle, as follows:

0 if pesticide application dates change each year and input is for each year of simulation;

1 if the same crop is grown each year and the same pesticide parameters are to be reused each year of simulation;

2-50 the number of years in the rotation--the pesticide parameters are reused each rotation cycle of the simulation.

PSTOUT Code for level of pesticide output:

0 for annual summary output;
1 for monthly and annual summary output;
2 for abbreviated storm-by-storm output and all summary output (includes runoff, sediment, percolation, and total losses of pesticides for the storm;
3 same as 2 but also includes concentrations in each computational soil layer after redistribution by rainfall evaporation, and crop uptake;
4 same as 3 but also includes concentration in each computational soil layer before and after each storm.

CAUTION: **FLGOUT** = 2, 3, or 4 generates a large amount of printed output.

Card 5: **NOPEST, PSTNAM, METAB**

NOPEST Pesticide identification number, from 1 to 10, e. g. 1

NOTE: Pesticide metabolites must be given identification numbers, also. Metabolite cards must follow that for the parent compound, and are included as part of maximum 10 pesticides that can be considered in a single run.

PSTNAM Pesticide name, up to 16 characters, e. g. ATRAZINE

METAB Number of metabolites of a particular pesticide, e. g. 2

NOTE: As many metabolite Card 6's are required as the number for **METAB**

Card 6: **NOPEST, H2OSOL, HAFLIF, KOC, FOLRES, WSHFRC, COFTRN, COFUP**

NOPEST Pesticide identification number, from 1 to 10, e. g. 1

NOPEST on Card 6 must correspond to **NOPEST** on Card 5. Card 6's for metabolites must follow Card 5 for parent compound.

H2OSOL Water solubility, mg/L, e. g. 33.0

HAFLIF Foliar residue half-life, days, e. g. 2.0

KOC Partitioning coefficient, ratio of the concentration of the pesticide on organic carbon to concentration of the pesticide in water, e. g. 200.0

FOLRES Concentration of pesticide residue on the foliage when simulation begins, Fg/g or ppm, e. g. 0.50

WSHFRC Fraction of pesticide on the foliage available for washoff by rainfall, 0.55

COFTRN Coefficient of transformation from parent compound to metabolite, or metabolite to metabolite, e. g. 1.50

Values range from 0 to approximately 2. If values are not available, use 1.0. Leave blank for pesticides not having metabolites.

COFUP Coefficient of pesticide uptake by plants, e. g. 1.0

Values range from 0.0 for no uptake to 1.0 for uptake by mass flow such as for nitrate.

Card 7: **SOLLIF(I), RESDUE(I)** for I = 1 to **NOSOHZ**

SOLLIF() Soil half-life, days, e. g. 14.0 User can specify a different half-life for each soil horizon, or use the same value for each horizon (**NOSOHZ** on Card 7 of hydrology.)

NOTE: If degradation coefficient is known, **SOLLIF** can be determined as: **SOLLIF** = 0.693 / degradation coefficient

RESDUE() Pesticide residue in the soil horizons when simulation begins, Fg/g, 0.40

NOTE: A maximum of 5 soil horizons can be used. The first 5 fields of Card 7 are for **SOLLIF** and the last 5 fields are for **RESIDUE**. For example, if **NOSOHZ** = 3 on hydrology Card 7, and 3 values are to be input for **SOLLIF** and only two horizons have pesticide residue, Card 7 would contain:

8.0 12.0 20.0 0.0 0.0 0.60 0.40 0.0 0.0 0.0

Updatable pesticide parameters are contained on Cards 8 and 9 which includes specific information on pesticide application.

Card 8: **PDATE, IPST**

PDATE First day on which the pesticide parameters on Card 9 are valid. **PDATE** is the date of application of the pesticide identified by **NOPEST** on Card 9, e.g. 1092

The first digit in **PDATE** is the number of the year in the rotation cycle and the last 3 digits are the Julian day. In the example number (1092), the 1 is the first year of the rotation and 092 is for April 2 (or 3) depending upon whether or not the specific year of simulation is a leap year.

IPST The number of pesticides applied on **PDATE**, e. g. 2

NOTE: Pesticide metabolites are not applied, only the parent compound. **IPST** does not include the 1 or 2 metabolites.

Card 9: **NOPEST,APRATE, DEPINC, FOLFRC, SOLFRC, METH, CHMWAT**

NOPEST Pesticide identification number as on Card 6, e. g. 3

APRATE Rate of application of active ingredient, kg/ha, e. g. 2.24

DEPINC Depth of incorporation, cm, e. g. 7.5

Use 1.0 for surface application. The model assumes that, for a pesticide application within a layer, the application is made over the entire layer. A preplant spray on the surface assumes the pesticide is in the top 1 cm of soil.

FOLFRC Fraction of pesticide applied to the foliage, e. g. 0.30

SOLFRC Fraction of pesticide applied to the soil, e. g. 0.50

NOTE: The sum of **FOLFRC** + **SOLFRC** does not have to equal 1.0 For example, application by airplane, metered at 4 kg/ha, may result in 40% loss to volatization and drift and only 60% reaching the soil and plant canopy. In this case, depending upon canopy, **FOLFRC** may be 0.4 and **SOLFRC** 0.2

METH Code for method of application:

0 for surface application;
1 for incorporation;

2 for injected, or in bottom of furrow;
3 for chemigation.

If **METH** = 2, the value for **DEPINC** is used as the depth of injection.

CHMWAT Depth of chemigation, water applied for pesticide application in irrigation, cm, e. g. 1.50

If **METH** is 0, 1, or 2, user may leave **CHMWAT** blank.

Card 9 is repeated as many times as **IPST** on Card 8 for each application. The end of a pesticide parameter file is signified by a zero for **PDATE** on Card 8. In other words, after the last Card 9 for a rotation cycle, a blank card or a card with 0 in column 8 should be entered. Failure to do this will result in a model execution failure because the end of file is read for a **PDATE** and execution will stop abnormally.

PESTICIDE PARAMETERS DESCRIPTION

The pesticide component of **GLEAMS** is designed to allow simulation of interactions among pesticide properties, soils, climate, and management and the effects on pesticide losses in surface runoff, attached to transported sediments, and in percolate below the root zone. Distribution of pesticide mass in the root zone with time after application is also simulated. **GLEAMS** may be applied for generalized application using parameter values from user help tables, published reference sources, or default values. When using default values or examples provided, the user should consider parameter sensitivity and what possible effects the parameters have on the model outputs. For site-specific application, parameter values should be from site measurements or other local sources. The time spent by users and care for details in acquiring "best" parameter values should be determined by the application and intended analysis of the output. Applications may range from broad screening and grouping of pesticide/soil/ management/climate behavioral scenarios to research where model outputs are compared to actual laboratory or field observations. Parameters and necessary inputs are defined in this manual with a wide range of users in mind with the intent to describe their function and relative sensitivity. The question, what is the most sensitive parameter, has no simple answer. Because of complex interactions, a given parameter may be very sensitive in a given range, appli- cation, or soil/climate setting and much less sensitive in others.

Model inputs are non-updatable parameters that initialize the model, and provide parameter values that do not change once simulation begins or are updated internally in the model, and updatable parameters that may have different values such as application rate and parameters describing when and how the application is made during a cropping cycle.

Initial Parameters

PBDATE, PEDATE, IROT

The time period the model simulates pesticides is established such that pesticide simulation may begin any time after beginning simulation for hydrology and erosion and terminated at any time during the simulation period. When the simulation period contains repeating rotations within a longer time period, for example corn-peanuts-soybeans, for each 3-year period in a 50-year simulation, the pesticide parameter file can be established once and repeated for each rotation period. When this is done, pesticides applied and their rates and application dates remain the same each year a given crop occurs. The simplest situation is a 1-year rotation where the same crop is grown each year and the pesticide parameters are repeated each year. If pesticides, application dates or rates change from year to year, no rotation is assumed and pesticide parameters are entered each year.

NPEST, PSTOUT

A **GLEAMS** simulation can consider up to 10 different pesticides applied or in residue during the simulation period. The number of times each pesticide is applied when multiple applications are necessary, is not limited except that no more than one application of the same pesticide can be made on a single day. For crops such as cotton, peanuts and vegetables where more than 10 different chemicals are applied, multiple simulations may be required. If pesticide metabolites, or daughter products, are to be simulated, each metabolite must be counted in the total of 10.

Five levels of output are available. Annual summaries may suffice for long-term simulations depending upon the desired comparisons, for example comparisons between management alternatives. The detail in output increases to provide flexibility in meeting user requirements in addressing a range of questions relative to system dynamics. Level 4, the most detailed is desirable for research applications and for model validation where simulated soil concentrations are compared with field data.

NOPEST, PSTNAM, METAB

Each pesticide and pesticide metabolite simulated is assigned a number 1 to 10 to be associated with the pesticide name. Internal model identification and output data is by pesticide number. The number of pesticide metabolites to be simulated are identified and their numerical designation must be in the sequence in which they appear in the degradative process. All metabolites are assumed to be formed by sequential first-order reactions:

Pesticide parent v Metabolite (1) v Metabolite (2) v (etc.)

The maximum number of metabolites the model can simulate is 9 since the sum of all pesticides plus metabolites must be 10 or less.

H20SOL, KOC

Pesticide water solubility, H20SOL, sets an upper limit on pesticide concentrations in runoff water and soil pore water. For most pesticides at normal application rates applied to soil, solubility per se seldom limits concentrations in water and transport as simulated by **GLEAMS** (Leonard and Knisel, 1988). This is because K_{oc}, the adsorption or partitioning coefficient, and solubility are interrelated such that K_{oc} usually limits pesticide concentrations in water. Exceptions are pesticides with high crystal energy of the pure solid. In soils, where pesticides are applied at rates in excess of about 5 kg/ha, solubility may become temporarily limiting if solubility is < 10 mg/L. This condition could exist in the vicinity of banded pesticides.

Reported solubility values are determined under laboratory conditions at constant temperature, usually in the range of 20EC to 30EC. In general solubility increases with increasing temperature.

The pesticide K_{oc} partitioning coefficient (KOC) based on percent soil organic carbon (OC) is computed from KD:

$$KOC = \left(\frac{KD}{OC} \right) 100 \qquad [15]$$

The pesticide sorption process is assumed to be linear with concentration and instantaneously reversible such that

$$KD = \frac{Concentration\ \ in\ adsorbed\ phase\ (soil\ \ or\ sediment)}{Concentration\ \ in\ solution\ \ phase\ \ (water)} \qquad [16]$$

or

$$KD = \frac{C_s\ (\mu g/g)}{C_w(\mu g/ml)} \qquad [17]$$

with units of KD being ml/g.

The equation for KD is a simplification of the Freundlich equation:

$$C_s = K_f C_w^N \qquad [18]$$

where N = 1, and K_f is the Freundlich coefficient. Values of N have been found to be approximately 1, actually in the range of 0.75 to 0.95 for many compounds (Green and Karickhoff, 1990). Departures from 1 can introduce significant error at very low and relatively high pesticide concentrations. While assumptions of linearity, equilibrium, and sorption reversibility introduce some error, a further assumption made in converting KD to KOC may introduce additional error. However, use of KOC as an input parameter for modeling rather than KD is advan- tageous because KOC for a given pesticide is assumed independent of the par- ticular soil-pesticide combination. The **GLEAMS** model then computes a specific KD for each soil or soil layer based on organic carbon content. Tabulated values for KOC for the different pesticides range over several orders of magnitude (Wauchope et al., 1992). Therefore, for general screening purposes and comparative model analysis for ranking relative pesticide mobility in soil, potential errors may be inconsequential considering the large differences. For a given pesticide where experimental values are tabulated from different sources, the KOC may vary over a range of 1 to 3 times the mean value. Therefore, when the model is applied for site-specific purposes, particularly when comparing simulated results with field data for validation, site-specific values of KOC and its spatial variability within the site are desirable. KOC may be a sensitive parameter in **GLEAMS**, depending on soil properties, half-life and climatic factors, Leonard and Knisel, 1988.

Potential for leaching losses increases as KOC decreases. Since the fraction of the pesticide in soil pore water is determined by KD and KD = KOC (OC)/100, the sensitivity will also depend on soil organic carbon (OC). For most soils, leaching is most sensitive to KOC in the KOC range of 20 to 500.

Pesticide runoff potential is sensitive to KOC, and for most soils pesticides in surface runoff decreases as KOC decreases in the KOC range less than 500. This decrease occurs because for high mobility compounds the initial infiltrating rainfall reduces the concentration in the 0-1 cm surface soil layer and thereby the runoff source. For KOC ranges greater than 1000, pesticide adsorption to sediments reduces concentrations in the water phase of runoff so that total surface transport is strongly influenced by erosion and sediment transport.

Pesticide characteristics are given in Table P-1 alphabetized by trade name. The same data are given in Table P-2 by common name.

SOLLIF, RESDUE

Pesticide dissipation or degradation rate in the soil is assumed to obey first-order kinetics such that

$$C_d = C_o e^{[-(ks)(d)]} \qquad [19]$$

where C_d = soil pesticide concentration on any day, d, after application, C_o = soil pesticide concentration initially (day = 0), d = number of days after application, k_s = dissipation rate constant, and e = 2.718. The constant k_s used in **GLEAMS** is a "lumped" parameter, that is, the net effect of many individual processes are described by this one parameter. Processes include volatilization, photolysis, hydrolysis, biological degradation and chemical reactions. The dissipation parameter used in **GLEAMS** is SOLLIF = $0.693/k_s$ = half-life in days. The half-life is the number of days required for a given pesticide concentration to be reduced by 1/2.

Although SOLLIF is assumed constant, pesticide half-life for a given compound is different in different soil environments. Soil temperature, water content, and other variables affect dissipation rates. Nash (1988) provides comprehensive discussion of these effects. Values for pesticide half-life provided in **GLEAMS** are to be considered as "average" or representative and are generally consistent with the Wauchope et al. (1992) data base. However, model users should be aware that reported values of pesticide

half-life for the same compound commonly vary by factors of 2 to 3 and sometimes by as much as 10. For atrazine as an example, half-life may vary from 120 days to 12 days comparing cool, dry regions to warm, humid regions. Another important factor for some pesticides is soil treatment history. Repeated soil treatment by the same or chemically similar pesticides may cause what has been called "enhanced degradation", a reduction in pesticide half-life apparently as a result of biological adaptive mechanisms such as buildup of specific populations or enzymatic adaptation. Because of uncertainties in pesticide half-life, site-specific or regionally specific values should be sought by users where the information is available. For general screening purposes the "average" half-life values should be adequate. For model applications comparing different pesticides and management systems, average values can be adequate with the assumption that local environmental variables affect pesticide half-life of the different pesticides relatively the same and half-life is not affected by specific management manipulations.

Different SOLLIF values may be entered for different soil horizons. It is generally believed that for pesticides where biological degradation is the pre- dominant pathway, dissipation rates are greater in horizons of greater biological activity, that is, the Ap horizon or the tilled zone in most soils. Unfortunately, values for pesticide half-life with soil depth are not generally available, and therefore for most applications a single value of SOLLIF will be used for the entire root zone. The flexibility is provided in the model for those cases where data are available, or in situations where the output sensitivity to variable half-life is a question to be addressed.

Dissipation of many pesticides from the surface soil may be more rapid than from the rhizosphere as a result of volatilization and greater environmental extremes. Where these differences are important to represent, the surface 0-1 cm layer can be considered a different soil horizon and different or smaller values for SOLLIF used for this horizon.

SOLLIF is a sensitive parameter in the model. It determines the amount of the pesticide remaining in the soil after application that is subject to runoff, erosion, and percolation.

Usually when a **GLEAMS** run is initiated, it is assumed no residues of the pesticides of interest are present in the soil at the beginning of simulation. However, since simulation can begin at any time during a year, provisions are provided to initialize pesticides residues (RESDUE) by soil horizon. The model distributes RESDUE into each of the computational soil layers. This feature was included in **CREAMS** (Knisel, 1980) because at that time chlorinated insecticides were of interest and many soils had significant residues from past applications. Values for RESDUE must be estimated by the user or determined by site-specific sampling and analysis. RESDUE is in Fg/g or ppm and must be for the day simu- lation begins. Subsequent application of the same pesticides are added to any remaining residue by computational soil layer. Most pesticides in current use are not persistent and initial residues are of little concern, particularly for long-term simulations.

FOLRES, HAFLIF, WSHFRC

These parameters pertain to pesticides applied to or intercepted by plant foliage or crop residue. Detailed discussion of crop canopy interception of pesticide sprays has been provided by Himel et. al., 1990. Since a **GLEAMS** model simulation can begin any day during a year, FOLRES, the initial residue of above-ground pesticide, if any, must be specified. Rarely would a simulation begin under these conditions. However, this option is provided. When a foliar residue is suspected, the user must use intuitive judgment in arriving at the input value. The parameter units are Fg/g, but are not based on pesticide mass per mass of foliage or crop residue. The unit is the pesticide concentration created in the 0-1 cm soil surface should the mass be displaced to the soil. In the updateable parameters, FOLFRC is the fraction of any later pesticide application intercepted by foliage. This fraction of the rate applied is computed internally in the model as

equivalent surface soil concentration and added to FOLRES. The sum is then degraded/dissipated each day after beginning simulation according to the specified HAFLIF. The initial foliar residue, FOLRES, Fg/g, may be estimated by:

$$FOLRES = 6.7\ (APRATE)\ (FOLFRC)\ Exp\left[\frac{-0.693\ DAYS}{HAFLIF}\right] \qquad [20]$$

where:

APRATE = Previous application rate (kg/ha)
FOLFRC = Fraction of application intercepted by foliage
DAYS = Number of days since application
HAFLIF = Half-life of pesticide on foliage

This procedure is applicable only if significant rainfall has not occurred since the initial application. In **GLEAMS**, when rainfall exceeds a threshold value based on canopy water storage (about 0.3 cm for full canopy) all the dislodgeable pesticide is removed to the soil and therefore, no initial foliar residue would be input. Initial pesticide residues would then be a soil residue (RESDUE) as described above.

The foliage half-life, HAFLIF, is a lumped parameter describing the dissi- pation rate of pesticide residing on the crop and weed canopy or crop residue. For most pesticides the mass above ground dissipates significantly faster than that residing in soil because of enhanced volatilization and photodecomposition. Most of the data available is for insecticides applied to living crop leaf surfaces (Willis and McDowell, 1987). Much less information is available for herbicides, particular herbicides intercepted by crop residues in conservation tillage systems. **GLEAMS** does not distinguish between the different above-ground interceptors. Values for HAFLIF in Tables P-1 and P-2 for organochlorine, organophosphorus, carbamate, and pyrethroid insecticides were selected from Willis and McDowell, 1987. Values for a few selected herbicides and fungicides were also available. However, HAFLIF for most of the pesticides were estimated based on the following rules: HAFLIF was assumed less than SOLLIF by a factor of 0.5 to 0.25, depending on vapor pressure and any suspected sensitivity to photodegradation. HAFLIF was adjusted downward for pesticides with vapor pressure less than 10^{-5} mm Hg. (See Wauchope et al., 1992 for vapor pressure values). For those pesticides with relatively long SOLLIF, the maximum HAFLIF assigned was 30 days. Users are encouraged to use other values or estimates of HAFLIF where specific information is available. If a conservative or "worst-case" simulation is desired, HAFLIF could be set equal to SOLLIF.

Above-ground pesticides are partitioned between total and dislodgeable by the parameter, WSHFRC, defined as the fraction of the remaining pesticide potentially removed when rainfall occurs in excess of the volume retained by canopy. This threshold rainfall value is computed internally, based on stage of plant growth as reflected by inputs of leaf-area index (LAI). The washoff fraction, WSHFRC, is related to a number of factors including the nature of the leaf surface, plant morphology, pesticide solubility, and polarity of the pesticide molecule, formulation of the commercial product, and timing and volume of rainfall. All these factors cannot be individually addressed by **GLEAMS**. Values of WSHFRC provided in **GLEAMS** for organochlorine, organophosphous, carbamate, and pyrethroid insecticides are based primarily on the work of Willis et al. (1980), or computed from the algorithms provided by Willis[7] (personal com- munication) relating washoff to rainfall volume and pesticide solubility. For other pesticides, solubility was used as a guide for estimating WSHFRC somewhat analogous to the Willis algorithm.

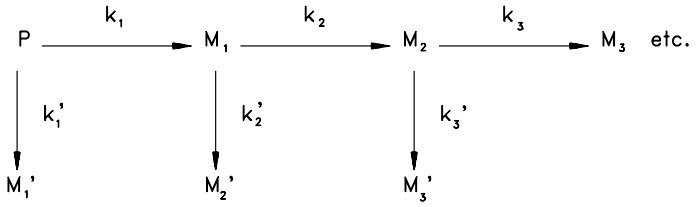
The foliar behavior of a given pesticide can have significant effects on runoff and leaching losses. Foliar applied pesticides are generally not as subject to either leaching or runoff losses as are soil applied

[7]Personal communication, Baton Rouge, Louisiana, April 21, 1992.

pesticides. For most pesticide HAFLIF is not as great as SOLLIF, leading to more rapid dissipation. For most pesticides, not all the pesticides on foliage can be dislodged by rainfall, that is WSHFRC < 1. When rainfall occurs, foliar residues are usually dislodged to the soil surface before runoff occurs, and for the very mobile compounds the pesticides may be moved into the soil below the runoff active zone. Foliar washoff affects runoff concentrations greatest under conditions where the soil is initially wet or for other reasons has little available storage with little initial abstraction of rainfall.

COFTRN, COFUP

When pesticide metabolites are simulated, a coefficient of transformation from parent compound to metabolite, or metabolite to metabolite, (COFTRN) is required. Sequential degradative reactions may be written:



where P = parent pesticide, $M_{1,2,3}$ are metabolites of interest, $M_{1,2,3}N$ are other degradative products resulting from hydrolysis or other side reactions, k_1, k_2, k_3 and k_1N, k_2N, k_3N are the respective rate constants. The coefficient of transformation (COFTRN) describes the proportion of the parent producing M_1 vs M_1' and is

$$COFTRN_{(parent)} = \frac{k_1}{k_1' + k_1} \qquad [21]$$

COFTRN for the other metabolites may be described likewise from the ratios of the appropriate rate constants (Leonard, et al., 1990). Detailed laboratory studies are required to obtain the various rate constants and these may change with soil and environmental conditions. Therefore, it is unlikely that a general model user will have accurate values of COFTRN. For assessments of potential pesticide losses, COFTRN = 1 will represent the likely "worst case". In research applications where comprehensive field data are available to compare with model simulated values, COFTRN may be calibrated or adjusted to values <1 if a better correspondence is obtained. However, COFTRN should not be used as knobs to "tweak" indiscriminately. Pesticide concentrations simulated in **GLEAMS** are mass per volume, or weight per weight (Fg/L or Fg/kg) and not molar concentrations. Therefore, if significant changes in molecular weight occurs from parent to metabolite or from metabolite to metabolite, the ratio of mass change can be reflected in COFTRN, also. For oxidative reactions occurring with pesticides such as aldicarb and fenamiphos, mass changes are inconsequential. For most model applications by the general user COFTRN = 1 will be the preferred input unless specific data are available.

Pesticides may be taken up by plant roots as soil water enters the root through the transpiration process. Briggs et al. (1982) related pesticide concentrations in the transpiration stream to pesticide concentrations in the external solution and the pesticide octanol-water partitioning coefficient, KOW. This coefficient expresses the relative affinity of the pesticide for polar vs non-polar solvents or surfaces and is correlated with the pesticide KOC. In **GLEAMS** the pesticide KOC along with soil organic carbon content and the pesticide mass determines the pesticide concentration in soil solution and thus the concentration

potentially entering the transpiration stream. If the objective is to simulate the actual amount entering and translocated in the plant, then some factor, such as an uptake coefficient, is required that reflects the pesticide adsorption and translocation inside the plant as well. Although COFUP could be used for this purpose provided data are available on the specific plant-pesticide combination, the primary intention is to provide the user with an option to consider uptake, COFUP = 1 or no uptake, COFUP = 0. For soluble, low KOC pesticides, uptake can be significant and will reduce amounts potentially leached below the root zone. For pesticides with large KOC, little uptake in the transpiration stream will be simulated because of the reduced concentrations in solution, even with COFUP = 1.

The COFUP can also be used to reflect how selective chemical placement may affect uptake. For example, a herbicide or soil insecticide/nematicide may be banded over the plant row or a chemical directed in a narrow band at the base of the plants. The application rate (APRATE) as a model input is kg/ha active ingredient applied to the area being simulated. Since transport and degradation rates are assumed independent of concentrations, the areal mass outputs are directly proportional to the application rate and not to areal distribution. That is, the model assumes the application to be uniformly applied over the area. In a situation or time of the year where the plant root distribution is not uniform and is limited to the narrow band of chemical application, potential plant uptake will be greater than if the chemical was broadcast uniformly. For example, a herbicide may be placed over the row in a band covering 1/3 of the soil surface. In this situation using a COFUP of 3 would reflect the increased pesticide concentrations in the band compared to the average concentration based on the total kg/ha rate.

Updatable Parameters

Updatable parameters describe within a rotation cycle what was applied: when, how much, and by what method. Parameters also describe the distribution of the applied pesticide in the soil after application and the distribution between the soil and plant canopy or plant residue.

PDATE IPST

PDATE is the date of application of the specific pesticide(s). PDATE con- sists of two parts: the first digit(s) is the year within the rotation cycle, and the last 3 digits are the Julian day. The year in the rotation cycle allows the model to calculate the calendar year and write an internal file with all applica- tion dates for the period of simulation. Pesticides are not necessarily applied in every year. For example, in a 3-yr rotation of corn-oats-cotton, there may not be a pesticide applied on oats. Pesticide 1 may be a preplant herbicide on corn, and pesticide 2 may be a preplant herbicide for cotton and there may be several insecticides applied on cotton. A PDATE for corn might be 1091 (April 1 of the first year) and the next PDATE might be 3121 (May 1 of the third year). IPST is the number of pesticides applied on PDATE. This simply tells the model how many cards of application data read on a particular date. Pesticide numbers (NOPEST) 1 and 4 may be applied on the same day, thus IPST would be 2. If more than one pesticide is applied on PDATE, the number applied is entered as IPST to alert the program as to the number of cards to be read. Pesticide metabolites are not included in IPST since metabolites are not applied. For multiple applications of a specific pesticide within a rotation cycle, PDATE, IPST, and the information on the Card 9's must be entered for each application. For most herbicide applications, particularly the preplant herbicides, only one application per crop is normally required. However, insecticides and fungicides may be required every 3 to 7 days to control pests during a critical period of crop development and fruiting. The **GLEAMS** program is not limited in the number of applications except up to one application of a specific pesticide on each day for the entire rotation cycle. When multiple applications are made, the program adds pesticides from the new application to residues from previous applications.

APRATE FOLFRC, SOLFRC

Application rate, APRATE, is specified in units of kg/ha active ingredient. While agronomic recommendations and field calibrations are usually given in lbs/ac in the U.S.A., the conversion to metric units within the accuracy of field application is straightforward: 1 lb/Ac = 1.1 kg/ha or 1 kg/ha = 0.9 lb/Ac. Metric units are used throughout the pesticide component of **GLEAMS** since the output relates to water quality where concentrations are Fg/L, mg/L, Fg/kg, etc., and there are no acceptable equivalent English units.

Depending on stage of crop development and the intended target, applied pesticides may be intercepted by the soil, crop foliage, or both. The dis-tribution between soil and crop is described by FOLFRC, the fraction of the application intercepted by the crop canopy and SOLFRC, the fraction of the application intercepted by the soil surface. FOLFRC + SOLFRC may not be equal to 1.0 if significant drift or volatilization losses are incurred. For example, for applications of insecticides by airplane, off target losses may be signif-icant, approaching 50%. Applications of herbicides to soil by ground equipment with spray nozzles close to the surface emitting relatively large droplets will result in most of the pesticide on target. The fractional distribution of the pesticide between soil and crop canopy is a judgment call. For soil applied herbicides and insecticides where little or no crop is present, obviously SOLFRC is very close to 1.0 and FOLFRC near 0, so 1.0 and 0, respectively would be appropriate. However, for herbicides applied to heavy crop residue in no-till systems, FOLFRC should be set near 1.0. For pesticides applied over the top of a closed canopy, most of the application less off-target losses will be intercepted by foliage. Crop growth characteristics, row spacing, and the leaf area index file can be used to judge the percent canopy closure and the appropriate fractional distribution on a given date (APDATE).

The sensitivity of model output to the application distribution is depen-dent on the individual pesticide characteristics. Foliar interception reduces potential pesticide runoff and leaching losses significantly for those compounds with relatively short foliar half-life (HAFLIF = 3 to 5 days) and/or when the washoff fraction (WSHFRC) is less than 0.5.

METH, DEPINC, CHMWAT

The method (METH) by which pesticides are applied determines the initial distribution in the soil. Surface runoff losses are related directly to pes-ticide concentrations in the surface 0-1 cm, and therefore surface applications (METH=0) are significantly more vulnerable to runoff compared to incorporated (METH=1) or injected (METH=2) applications. To compute soil surface pesticide concentrations, some thickness or depth of the surface layer is needed. A thickness of 1 cm (0-1 cm) was somewhat arbitrarily chosen, but is about the minimum thickness for field sampling and was shown to be a good predictor of pesticide concentrations in runoff (Leonard et al., 1977). Therefore, surface applications are assumed to be mixed uniformly with the soil mass to the 1 cm depth. The parameter DEPINC, the depth of incorporation is assigned a value of 1.0 for surface application. For incorporated pesticide DEPINC is assigned a value for the maximum depth of incorporation (cm) and resulting soil pesticide concentrations and distribution are computed in the model assuming uniform mixing to this depth. Different incorporation implements result in differing degrees of mixing efficiency but this is not sufficiently predictable for inclusion in the model. For pesticide injection or placement in the bottom of a furrow (METH=2), DEPINC = injection or placement depth but no mixing with the soil above this depth is allowed.

For pesticide application by chemigation, METH=3, the depth of irrigation water used to apply the chemical (CHMWAT) must be given. The depth CHMWAT will vary depending on the desired depth of chemical penetration into the soil surface and the pest to be controlled. Insecticides applied by chemigation

to control foliar feeders will be applied in low water volumes whereas herbicides or soil insecticides may require 1-3 cm for desired penetration.

Pesticide banding is not specified as a method in the current version of **GLEAMS**. The APRATE is assumed to be uniform over the field (broadcast equiv-alent), and runoff and leaching computed accordingly. While conceptually this will provide correct runoff and leaching estimates in units of mass per unit area, actual soil pesticide concentrations will be different by the ratio of the area actually treated to the total area. When daily outputs of pesticide distri-bution with depth are obtained for comparison with field data under pesticide bands, this factor must be considered when interpreting outputs.

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Table P-1. Characteristics of pesticides sorted by trade name (See footnotes at the end of the table.)

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
2,4,5-TP	Silvex	2.5	20.	5.	0.40	2600
2 Plus 2	Mecoprop Amine	660000.0	21.	10.	0.95	20
Aatrex	Atrazine	33.0	60.	5.	0.45	100
Abate	Temephos	0.001	30.	5.	0.65	100000
Acaraben	Chlorobenzilate	13.0	20.	10.	0.05	2000
Accelerate	Endothall Salt	100000.0	7.	7.	0.90	20
Acclaim	Fenoxaprop-Ethyl	0.8	9.	5.	0.20	9490
Actellic	Pirimiphos-Methyl	9.0	10.	-	-	1000
Alanap	Naptalam Sodium Salt	231000.0	14.	7.	0.95	20
Alar	Daminozide	100000.0	7.	4.	0.95	10
Aldrin	Aldrin	0.1	28.	2.	0.05	300
Aliette	Fosetyl-Aluminum	120000.0	0.1	0.1	0.95	20
Ally	Metsulfuron-Methyl	9500.0	120.0	30.	0.80	35
Amdro	Hydramethylnon	0.006	10.	-	-	730000
Amiben	Chloramben Salts	900000.0	14.	7.	0.95	15
Amid-Thin W	NAA Amide	100.0	10.	5.	0.60	100
Amitrol T	Amitrole	360000.0	14.	5.	0.95	100
Ammo	Cypermethrin	0.004	30.	5.	0.40	100000
Antor	Diethatyl-Ethyl	105.0	21.	10.	0.40	1400
A-Rest	Ancymidol	650.0	120.	30.	0.50	120
Arsenal	Imazapyr Acid	11000.0	90.	30.	0.90	100
Arsonate	MSMA	1000000.0	100.	30.	0.95	10000
Asana	Esfenvalerate	0.002	35.	8.	0.40	5300
Assert	Imazamethabenz-m	1370.0	35.	18.	0.65	66
Assert	Imazamethabenz-p	875.0	35.	18.	0.65	35
Assure	Quizalofop-Ethyl	0.31	60.	15.	0.20	510
Asulox	Asulam Sodium Salt	550000.0	7.	3.	0.95	40
Avenge	Difenzoquat	817000.0	100.	30.	0.95	54500
Azodrin	Monocrotophos	1000000.0	30.	2.	0.95	1
Balan	Benefin	0.1	30.	10.	0.20	9000
Banol	Propamocarb	1000000.0	30.	15.	0.95	1000000
Banvel	Dicamba	400000.0	14.	9.	0.65	2
Basagran	Bentazon	2300000.0	20.	2.	0.60	34
Basta	Glufosinate Ammonia	1370000.0	7.	4.	0.95	100
Baygon	Propoxur	1800.0	30.	-	-	30
Bayleton	Triadimefon	71.5	26.	8.	0.30	300
Baytex	Fenthion	4.2	34.	2.	0.65	1500
Baythroid	Cyfluthrin	0.002	30.	5.	0.40	100000
Benlate	Benomyl	2.0	240.	6.	0.25	1900
Benzex	BHC	0.1	600.	3.	0.05	55000
Betamix	Phenmedipham	4.7	30.	5.	0.70	2400
Betanex	Desmedipham	8.0	30.	5.	0.70	1500
Bidrin	Dicrotophos	1000000.0	28.	20.	0.70	75

Table P-1, Continued. Characteristics of pesticides sorted by trade name (See footnotes at the end of the table.)

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Bladex	Cyanazine	170.0	14.	5.	0.60	190
Bolero	Thiobencarb	28.0	21.	7.	0.70	900

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Bolstar	Sulprofos	0.31	140.	0.5	0.55	12000
Bordermaster	MCPA Ester	5.0	25.	8.	0.50	1000
Botran	DCNA (Dicloran)	7.0	10.	4.	0.50	1000
Bravo	Chlorothalonil	0.6	30.	10.	0.50	1380
Brom-O-Sol	Methyl Bromide	13400.0	55.	-	-	22
Broot	Trimethacarb	58.0	20.	-	-	400
Buctril	Bromoxynil Oct. Ester	0.08	7.	3.	0.20	10000
Butyrac Ester	2,4-DB Ester	8.0	7.	9.	0.45	500
Caparol	Prometryn	33.0	60.	10.	0.50	400
Carbamate	Ferbam	120.0	17.	3.	0.90	300
Carsoron	Dichlobenil	21.2	60.	5.	0.45	400
Carzol	Formetanate Hydro-Cl	500000.0	100.	30.	0.95	1000000
Cerone	Ethephon	1239000.0	10.	5.	0.95	100000
Chem-Hoe	Propham (IPC)	250.0	10.	2.	0.50	200
Chlordane	Chlordane	0.1	100.	2.5	0.05	100000
Chopper	Imazapyr Amine	500000.0	90.	30.	0.80	100
Classic	Chlorimuron-ethyl	1200.0	40.	15.	0.90	110
Cobra	Lactofen	0.1	3.	2.	0.20	100000
Comite	Propargite	0.5	56.	5.	0.20	4000
Command	Clomazone	1000.0	24.	3.	0.80	300
Cotoran	Fluometuron	110.0	85.	30.	0.50	100
Counter	Terbufos	5.0	5.	2.5	0.60	500
Crossbow	Triclopyr Amine	2100000.0	46.	15.	0.95	20
Curacron	Profenofos	28.0	8.	3.	0.90	2000
Cygon	Dimethoate	39800.0	7.	3.	0.95	20
Cyprex	Dodine Acetate	700.0	20.	10.	0.50	100000
Cythion	Malathion	130.0	1.	3.	0.90	1800
Dacamine	2,4-D Acid	890.0	10.	5.	0.45	20
Dacthal	DCPA	0.5	100.	10.	0.30	5000
Dacthal	DCPA	0.5	20.	10.	0.30	5000
D. Monoacid	D. Monoacid	3000.0	10.	-	-	20
D. Diacid	D. Diacid	5780.0	300.	-	-	2
Dalapon	Dalapon Sodium Salt	900000.0	30.	37.	0.95	1
Dasanit	Fensulfothion	0.01	24.	4.	0.90	10000
DDT	DDT	0.1	120.	10.	0.05	240000
Dedweed	MCPA Amine	866000.0	25.	7.	0.95	20
DEF	Tribufos	2.3	30.	7.	0.25	5000
Dessicant L-10	Arsenic Acid	17000.0	10000.	10000.	0.95	100000
Devrinol	Napropamide	74.0	70.	15.	0.60	400
Dibrom	Naled	2000.0	1.	0.5	0.90	180
Dieldrin	Dieldrin	0.1	1400.	5.	0.05	50000
Dimilin	Diflubenzuron	0.08	10.	27.	0.05	10000
Dinitro	Dinoseb Phenol	50.0	20.	3.	0.60	500
Dinitro	Dinoseb Salts	2200.0	20.	10.	0.90	63
Diquat	Diquat Dibromide	718000.0	1000.	30.	0.95	1000000
Di-Syston	Disulfoton	25.0	30.	3.	0.50	600
Dithane	Mancozeb	6.0	70.	10.	0.25	2000
Dowpon	Dalapon	1000.0	30.	37.	0.95	4
Dropp	Thidiazuron	20.0	10.	3.	0.40	110
DSMA	Methanearsonic Acid	1400000.0	1000.	30.	0.95	100000
Dual	Metolachlor	530.0	90.	5.	0.60	200
Du-ter	Triphenyltin Hydroxide	1.0	75.	18.	0.40	23000
Dyfonate	Fonofos	16.9	40.	2.5	0.60	870

Table P-1, Continued. Characteristics of pesticides sorted by trade name (See footnotes at the end of the table.)

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Dylox	Trichlorfon	120000.0	10.	3.	0.95	10
Dymid	Diphenamid	260.0	30.	5.	0.80	210
Dyrene	Anilazine	8.0	1.	0.5	0.50	3000
Elgetol	DNOC Sodium Salt	100000.0	20.	8.	0.95	20
EPN	EPN	0.5	5.	5.	0.60	13000
Eradicane	EPTC	344.0	6.	3.	0.75	200
Ethanox	Ethion	1.1	150.	7.	0.65	10000
Evik	Ametryn	185.0	60.	5.	0.65	300
Evital	Norflurazon	28.0	90.	15.	0.50	600
Far-Go	Triallate	4.0	82.	15.	0.40	2400
Fenatrol	Fenac	500000.0	180.	30.	0.95	20
Fenitox	Fenitrothion	30.0	8.	3.	0.90	2000
Fruitone CPA	3-CPA Sodium Salt	200000.0	10.	3.	0.95	20
Fumazone	DBCP	1000.0	180.	-	-	70
Fundal	Chlordimeform Hydrocl	500000.0	60.	1.	0.90	100000
Funginex	Triforine	30.0	21.	5.	0.80	540
Furadan	Carbofuran	351.0	50.	2.	0.55	22
Fusilade	Fluazifop-P-Butyl	2.0	15.	4.	0.40	5700
Glean	Chlorsulfuron	7000.0	160.	30.	0.75	40
Goal	Oxyfluorfen	0.1	35.	8.	0.40	100000
Guthion	Azinphos-Methyl	29.0	10.	2.	0.65	1000
Harmony	Thifensulfuron-Methyl	2400.0	12.	3.	0.80	45
Harvade	Dimethipin	3000.0	10.	3.	0.80	10
Hoelon	Diclofop-methyl	0.8	37.	8.	0.45	16000
Hyvar	Bromacil	700.0	60.	20.	0.75	32
Imidan	Phosmet	20.0	19.	3.	0.90	820
Isotox	Lindane	7.3	400.	2.5	0.05	1100
Karate	Lambda-Cyhalothrin	0.005	30.	5.	0.40	180000
Karathane	Dinocap	4.0	20.	8.	0.30	550
Karmex	Diuron	42.0	90.	30.	0.45	480
Kelthane	Dicofol	1.0	60.	4.	0.05	180000

Table P-1, Continued. Characteristics of pesticides sorted by trade name (See footnotes at the end of the table.)

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Kerb	Pronamide	15.0	60.	20.	0.30	200
Krenite	Fosamine Ammon. Salt	1790000.0	8.	4.	0.95	150
Lannate	Methomyl	58000.0	30.	0.5	0.55	72
Larvadex	Cyromazine	136000.0	150.	30.	0.95	200
Larvin	Thiodicarb	19.1	7.	4.	0.70	350
Lasso	Alachlor	240.0	15.	3.	0.40	170
Limit	Amidochlor	10.0	20.	8.	0.70	1000
Logic	Fenoxycarb	6.0	1.	-	-	1000
Londax	Bensulfuron methyl	120.0	5.	-	-	310
Lontrel	Clopyralid	300000.0	30.	2.	0.95	6
Lorox	Linuron	75.0	60.	15.	0.60	400
Lorsban	Clorpyrifos	0.4	30.	3.3	0.65	6070
Manzate	Maneb	6.0	12.	3.	0.65	1000
Marlate	Methoxychlor	0.1	120.	6.	0.05	80000
Matacil	Aminocarb	915.0	6.	4.	0.90	100
Mavrik	Fluvalinate	0.005	30.	7.	0.40	1000000
Metasystox	Oxydemeton-Methyl	1000000.0	10.	3.	0.95	10
Metaldehyde	Metaldehyde	230.0	10.	-	-	240
Milogard	Propazine	8.6	135.	5.	0.45	154
Miral	Isazofos	69.0	34.	5.	0.65	100
Mitac	Amitraz	1.0	2.	1.	0.45	1000
Mocap	Ethoprop	750.0	25.	-	-	70

Modown	Bifenox	0.4	7.	3.	0.40	10000
Monitor	Methamidophos	1000000.0	6.	4.	0.95	5
Morestan	Oxythioquinox	1.0	30.	10.	0.50	2300
Nemacur	Fenamiphos	400.0	50.	-	-	100
Nemacur	Fenamiphos	400.0	5.	-	-	240
N. Sulfoxide	F. Sulfoxide	400.0	42.	-	-	40
N. Sulfone	F. Sulfone	400.0	18.	-	-	45
Norton	Ethofumesate	50.0	30.	10.	0.65	340
N-Serve	Nitrapyrin	40.0	10.	-	-	570
Octave	Prochloraz	34.0	120.	30.	0.50	500
Oftanol	Isofenphos	24.0	150.	30.	0.65	600
Ordram	Molinate	970.0	21.	-	-	190
Orthene	Acephate	818000.0	3.	2.5	0.70	2
Orthocide	Captan	5.1	2.5	9.	0.65	200
Oust	Sulfometuron-Methyl	70.0	20.	10.	0.65	78
Paarlan	Isopropalin	0.1	100.	-	-	10000
Pay-Off	Flucythrinate	0.06	21.	5.	0.40	100000
Penncap-M	Methyl Parathion	60.0	5.	3.	0.90	5100
Phenatox	Toxaphene	3.0	9.	2.	0.05	100000
Phosdrin	Mevinphos	600000.0	3.	0.6	0.95	44
Phoskil	Parathion (Ethyl)	24.0	14.	4.	0.70	5000

Table P-1, Continued. Characteristics of pesticides sorted by trade name (See footnotes at the end of the table.)

Trade Name	Common Name	Water Solubility*	Half-Life Soil*	Half-Life Fol.#	Wash-off Frac.#	KOC*
		(ppm)	(---days---)			(ml/g)
Pipron	Piperalin	20.0	30.	10.	0.60	5000
Pix	Mepiquat Chlor. Salt	1000000.0	1000.	30.	0.95	1000000
Plantvax	Oxycarboxin	1000.0	20.	10.	0.70	95
Poast	Sethoxydim	4390.0	5.	3.	0.70	100
Polyram	Metiram	0.1	20.	7.	0.40	500000
Pounce	Permethrin	0.006	30.	8.	0.30	100000
Pramitol	Prometon	720.0	500.	30.	0.75	150
Prefar	Bensulide	5.6	120.	30.	0.40	1000
Prelude	Paraquat	620000.0	1000.	30.	0.60	1000000
Prime	Flumetralin	0.1	20.	7.	0.40	10000
Princep	Simazine	6.2	60.	5.	0.40	130
Probe	Methazole	1.5	14.	5.	0.40	3000
Prowl	Pendimethalin	0.275	90.	30.	0.40	5000
Pursuit	AC 263,499	200000.0	90.	20.	0.90	10
Pydrin	Fenvalerate	0.002	35.	10.	0.25	5300
Pyramin	Pyrazon	400.0	21.	5.	0.85	120
Ramrod	Propaclor	613.0	6.	3.	0.40	80
Reflex	Fomesafen Salt	700000.0	100.	30.	0.95	60
Rescue	2,4-DB Sodium/amine	709000.0	10.	9.	0.45	20
Ridomil	Metalaxyl	8400.0	70.	30.	0.70	50
Ro-Neet	Cycloate	95.0	30.	2.	0.50	430
Ronstar	Oxadiazon	0.7	60.	20.	0.50	3200
Roundup	Glyphosate Amine	900000.0	47.	2.5	0.60	24000
Rovral	Iprodione	13.9	14.	5.	0.40	700
Royal Slo-Gro	Maleic Hydrazide	400000.0	30.	10.	0.95	20
Rubigan	Fenarimol	14.0	360.	30.	0.40	600
Sancap	Dipropetryn	16.0	30.	5.	0.40	900
Savey	Hexythiazox	0.5	30.	5.	0.40	6200
Scepter	Imazaquin Ammonium	160000.0	60.	20.	0.95	20
Sencor	Metribuzin	1220.0	40.	5.	0.80	60
Sevin	Carbaryl	120.0	10.	7.	0.55	300
Sinbar	Terbacil	710.0	120.	30.	0.70	55

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Slug-Geta	Methiocarb	24.0	30.	10.	0.70	300
Sonalan	Ethalfluralin	0.3	60.	4.	0.40	4000
Sonar	Fluridone	10.0	21.	-	-	1000
Spectracide	Diazinon	60.0	40.	4.	0.90	1000
Spike	Tebuthiuron	2500.0	360.	30.	0.90	80
Sprout Nip	Chlorpropham	89.0	30.	8.	0.90	400
Stam	Propanil	200.0	1.	1.	0.70	149
Supracide	Methidathion	220.0	7.	3.	0.90	400
Surflan	Oryzalin	2.5	20.	5.	0.40	600
Sutan	Butylate	44.0	13.	1.	0.30	400
Swat	Phosphamidon	1000000.0	17.	5.	0.95	7

Table P-1, Continued. Characteristics of pesticides sorted by trade name (See footnotes at the end of the table.)

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Tackle	Acifluorfen	250000.0	14.	5.	0.95	113
Talstar	Bifenthrin	0.1	26.	7.	0.40	240000
Tandem	Tridiphane	1.8	28.	8.	0.40	5600
Tanone	Phenthoate	200.0	40.	2.	0.65	250
Tattoo	Bendiocarb	40.0	5.	3.	0.85	570
TBZ	Thiabendazole	50.0	403.	30.	0.60	2500
Telone	Chloropicrin	2270.0	1.	-	-	62
Telone II	Dichloropropene	2250.0	10.	-	-	32
Temik	Aldicarb	6000.0	40.	-	-	40
Temik	Aldicarb	6000.0	7.	-	-	40
T. Sulfoxide	A. Sulfoxide	6000.0	30.	-	-	30
T. Sulfone	A. Sulfone	6000.0	20.	-	-	10
Tenoran	Chloroxuron	2.5	60.	15.	0.40	3000
Terbutrex	Terbutryn	22.0	42.	5.	0.50	2000
Terrachlor	PCNB	0.44	21.	4.	0.40	5000
Terraneb	Chloroneb	8.0	130.	30.	0.50	1650
Terrazole	Etridiazole	50.0	20.	3.	0.60	1000
Thimet	Phorate	22.0	60.	2.	0.60	1000
Thiodan	Endosulfan	0.32	50.	3.	0.05	12400
Thiram	Thiram	30.0	15.	8.	0.50	670
Thistrol	MCPB Sodium Salt	200000.0	14.	7.	0.95	20
Tillam	Pebulate	100.0	14.	4.	0.70	430
Tilt	Propiconazole	110.0	110.	30.	0.70	1000
Tolban	Profluralin	0.1	140.	1.	0.35	2240
Topsin	Thiophanate-Methyl	3.5	10.	5.	0.40	1830
Tordon	Picloram	200000.0	90.	8.	0.60	16
Tralomethrin	Tralomethrin	0.001	27.	1.	0.40	100000
Treflan	Trifluralin	0.3	60.	3.	0.40	8000
Tre-Hold	NAA Ethyl Ester	105.0	10.	5.	0.40	300
Tupersan	Siduron	18.0	90.	30.	0.70	420
Turflon	Triclopyr Ester	23.0	46.	15.	0.70	780
Vapam	Metham Sodium	963000.0	7.	-	-	10
Velpar	Hexazinone	3300.0	90.	30.	0.90	54
Vendex	Fenbutatin Oxide	0.013	90.	30.	0.20	2300
Vernam	Vernolate	108.0	12.	2.	0.80	260
Vitavax	Carboxin	195.0	7.	-	-	260
Volck oils	Petroleum oil	100.0	10.	2.	0.50	1000
Vorlex	Methyl Isothiocyanate	7600.0	10.	-	-	10
Vydate	Oxamyl	282000.0	4.	4.	0.95	25

Table P-1, Continued. Characteristics of pesticides sorted by trade name (See footnotes at the end of the table.)

Trade Name	Common Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Weedar	2,4-D amine	796000.0	10.	9.	0.45	20
Weed-B-Gon	2,4,5-T Amine	500000.0	24.	10.	0.45	80
Wedone	Dichlorprop Ester	50.0	10.	9.	0.45	1000
Zolone	Phosalone	3.0	21.	8.	0.65	1800

* Primarily from Wauchope et al., 1992.

\# Values for organochlorine, organophosphorus, pyrethroid, and carbamate insecticides, and selected herbicides and fungicides adapted from Willis et al., 1980; Willis and McDowell, 1987; and algorithms developed by Willis (personal communication, June 17, 1992). Many of the values for other compounds are subjective estimates based upon chemical properties, formulations, characteristics, and analogy with other compounds.

Table P-2. Characteristics of pesticides sorted by common name (See footnotes at the end of the table.)

Common Name	Trade Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
2,4-D Acid	Dacamine	890.0	10.	5.	0.45	20
2,4-D Amine	Weedar	796000.0	10.	9.	0.45	20
2,4-DB Ester	Butyrac Ester	8.0	7.	7.	0.45	500
2,4-DB Sodium Amine	Rescue	709000.0	10.	9.	0.45	20
2,4,5-T Amine	Weed-B-Gon	500000.0	24.	10.	0.45	80
3-CPA Sodium Salt	Fruitone CPA	200000.0	10.	3.	0.95	20
AC 263,499	Pursuit	200000.0	90.	20.	0.90	10
Acephate	Orthene	818000.0	3.	2.5	0.70	2
Acifluorfen	Tackle	250000.0	14.	5.	0.95	113
Alachlor	Lasso	240.0	15.	3.	0.40	170
Aldicarb	Temik	6000.0	40.	-	-	40
Aldicarb	Temik	6000.0	7.	-	-	40
A. Sulfoxide	T. Sulfoxide	6000.0	30.	-	-	30
A. Sulfone	T. Sulfone	6000.0	20.	-	-	10
Aldrin	Aldrin	0.1	28.	2.	0.05	300
Ametryn	Evik	185.0	60.	5.	0.65	300
Amidochlor	Limit	10.0	20.	8.	0.70	1000
Aminocarb	Matacil	915.0	6.	4.	0.90	100
Amitraz	Mitac	1.0	2.	1.	0.45	1000
Amitrole	Amitrol T	360000.0	14.	5.	0.95	100
Ancymidol	A-Rest	650.0	120.	30.	0.50	120
Anilazine	Dyrene	8.0	1.	5.	0.50	3000
Arsenic Acid	Dessicant L-10	17000.0	10000.	10000.	0.95	100000
Asulam Sodium Salt	Asulox	550000.0	7.	3.	0.95	40
Atrazine	Aatrex	33.0	60.	5.	0.50	100
Azinphos-Methyl	Guthion	29.0	10.	2.	0.65	1000
Bendiocarb	Tattoo	40.0	5.	3.	0.85	570
Benefin	Balan	0.1	30.	10.	0.20	9000
Benomyl	Benlate	2.0	240.	6.	0.25	1900
Bensulfuron Methyl	Londax	120.0	5.	-	-	310
Bensulide	Prefar	5.6	120.	30.	0.40	1000
Bentazon	Basagran	2300000.0	20.	2.	0.60	34
BHC	Benzex	0.1	600.	3.	0.05	55000
Bifenox	Modown	0.4	7.	3.	0.40	10000
Bifenthrin	Talstar	0.1	26.	7.	0.40	240000
Bromacil	Hyvar	700.0	60.	20	0.75	32
Bromoxynil Octan. Ester	Buctril	0.08	7.	3.	0.20	10000
Butylate	Sutan	44.0	13.	1.	0.30	400
Captan	Orthocide	5.1	2.5	2.	0.65	200
Carbaryl	Sevin	120.0	10.	7.	0.55	300
Carbofuran	Furadan	351.0	50.	2.	0.55	22
Carboxin	Vitavax	195.0	7.	-	-	260
Chloramben Salts	Amiben	900000.0	14.	7.	0.95	15

Table P-2, Continued. Characteristics of pesticides sorted by common name (See footnotes at the end of the table.)

Common Name	Trade Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Chlordane	Chlordane	0.1	100.	2.5	0.05	100000
Chlordimeform Hydrochlo.	Fundal	500000.0	60.	1.	0.90	100000
Chlorimuron-ethyl	Classic	1200.0	40.	15.	0.90	110

Common Name	Trade Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Chlorobenzilate	Acaraben	13.0	20.	10.	0.05	2000
Chloroneb	Terraneb	8.0	130.	30.	0.50	1650
Chloropicrin	Telone	2270.0	1.	-	-	62
Chlorothalonil	Bravo	0.6	30.	5.	0.50	1380
Chloroxuron	Tenoran	2.5	60.	15.	0.40	3000
Chlorpropham CIPC	Sprout Nip	89.0	30.	8.	0.90	400
Chlorsulfuron	Glean	7000.0	160.	30.	0.75	40
Clomazone	Command	1000.0	24.	3.	0.80	300
Clopyralid	Lontrel	300000.0	30.	2.	0.95	6
Clorpyrifos	Lorsban	0.4	30.	3.3	0.65	6070
Cyanazine	Bladex	170.0	14.	5.	0.60	190
Cycloate	Ro-Neet	95.0	30.	2.	0.50	430
Cyfluthrin	Baythroid	0.002	30.	5.	0.40	100000
Cypermethrin	Ammo	0.004	30.	5.	0.40	100000
Cyromazine	Larvadex	136000.0	150.	30.	0.95	200
Dalapon	Dowpon	1000.0	30.	37.	0.95	4
Dalapon Sodium Salt	Dalapon	900000.0	30.	37.	0.95	1
Daminozide	Alar	100000.0	7.	4.	0.95	10
DBCP	Fumazone	1000.0	180.	-	-	70
DCNA (Dicloran)	Botran	7.0	10.	4.	0.50	1000
DCPA	Dacthal	0.5	100.	10.	0.30	5000
DCPA	Dacthal	0.5	20.	10.	0.30	5000
D. Monoacid	D. Monoacid	3000.0	10.	-	-	20
D. Diacid	D. Diacid	5780.0	300.	-	-	2
DDT	DDT	0.1	120.	10.	0.05	240000
Desmedipham	Betanex	8.0	30.	5.	0.70	1500
Diazinon	Spectracide	60.0	40.	4.	0.90	1000
Dicamba	Banvel	400000.0	14.	9.	0.65	2
Dichlobenil	Carsoron	21.2	60.	5.	0.45	400
Dichloropropene	Telone II	2250.0	10.	-	-	32
Dichlorprop Ester	Weedone	50.0	10.	9.	0.45	1000
Diclofop-Methyl	Hoelon	0.8	37.	8.	0.45	16000
Dicofol	Kelthane	1.0	60.	4.	0.05	180000
Dicrotophos	Bidrin	1000000.0	28.	20.	0.70	75
Dieldrin	Dieldrin	0.1	1400.	5.	0.05	50000
Diethatyl-Ethyl	Antor	105.0	21.	10.	0.40	1400
Difenzoquat	Avenge	817000.0	100.	30.	0.95	54500
Diflubenzuron	Dimilin	0.08	10.	27.	0.05	10000
Dimethipin	Harvade	3000.0	10.	3.	0.80	10
Dimethoate	Cygon	39800.0	7.	3.	0.95	20

Table P-2, Continued. Characteristics of pesticides sorted by common name (See footnotes at the end of the table.)

Common Name	Trade Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Dinocap	Karathane	4.0	20.	8.	0.30	550
Dinoseb Phenol	Dinitro	50.0	20.	3.	0.60	500
Dinoseb Salts	Dinitro	2200.0	20.	10.	0.90	63
Diphenamid	Dymid	260.0	30.	5.	0.80	210
Dipropetryn	Sancap	16.0	30.	5.	0.40	900
Diquat Dibromide	Diquat	718000.0	1000.	30.	0.95	1000000
Disulfoton	Di-Syston	25.0	30.	3.	0.50	600
Diuron	Karmex	42.0	90.	30.	0.45	480
DNOC Sodium Salt	Elgetol	100000.0	20.	8.	0.95	20
Dodine Acetate	Cyprex	700.0	20.	10.	0.50	100000
Endosulfan	Thiodan	0.32	50.	3.	0.05	12400
Endothall Salt	Accelerate	100000.0	7.	7.	0.90	20
EPN	EPN	0.5	5.	5.	0.60	13000
EPTC	Eradicane	344.0	6.	3.	0.75	200

Ethion	Ethanox	1.1	150.	7.	0.65	10000
Esfenvalerate	Asana	0.002	35.	8.	0.40	5300
Ethalfluralin	Sonalan	0.3	60.	4.	0.40	4000
Ethephon	Cerone	1239000.0	10.	5.	0.95	100000
Ethofumesate	Norton	50.0	30.	10.	0.65	340
Ethoprop	Mocap	750.0	25.	-	-	70
Etridiazole	Terrazole	50.0	20.	3.	0.60	1000
Fenac	Fenatrol	500000.0	180.	30.	0.95	20
Fenamiphos	Nemacur	400.0	50.	-	-	100
Fenamiphos	Nemacur	400.0	5.	-	-	240
F. Sulfoxide	N. Sulfoxide	400.0	42.	-	-	40
F. Sulfone	N. Sulfone	400.0	18.	-	-	45
Fenarimol	Rubigan	14.0	360.	30.	0.40	600
Fenbutatin Oxide	Vendex	0.013	90.	30.	0.20	2300
Fenitrothion	Fenitox	30.0	8.	3.	0.90	2000
Fenoxaprop-Ethyl	Acclaim	0.8	9.	5.	0.20	9490
Fenoxycarb	Logic	6.0	1.	-	-	1000
Fensulfothion	Dasanit	0.01	24.	4.	0.90	10000
Fenthion	Baytex	4.2	34.	2.	0.65	1500
Fenvalerate	Pydrin	0.002	35.	10.	0.25	5300
Ferbam	Carbamate	120.0	17.	3.	0.90	300
Fluazifop-P-Butyl	Fusilade	2.0	15.	4.	0.40	5700
Flucythrinate	Pay-Off	0.06	21.	5.	0.40	100000
Flumetralin	Prime	0.1	20.	7.	0.40	10000
Fluometuron	Cotoran	110.0	85.	30.	0.50	100
Fluridone	Sonar	10.0	21.	-	-	1000
Fluvalinate	Mavrik	0.005	30.	7.	0.40	1000000
Fomesafen Salt	Reflex	700000.0	100.	30.	0.95	60
Fonofos	Dyfonate	16.9	40.	2.5	0.60	870

Table P-2, Continued. Characteristics of pesticides sorted by common name (See footnotes at the end of the table.)

Common Name	Trade Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Fol.#	Wash-off Frac.#	KOC* (ml/g)
Formetanate Hydrochlor.	Carzol	500000.0	100.	30.	0.95	1000000
Fosamine Ammonium Salt	Krenite	1790000.0	8.	4.	0.95	150
Fosetyl-Aluminum	Aliette	120000.0	0.1	0.1	0.95	20
Glufosinate Ammonium	Basta	1370000.0	7.	4.	0.95	100
Glyphosate Amine	Roundup	900000.0	47.	2.5	0.60	24000
Hexazinone	Velpar	3300.0	90.	30.	0.90	54
Hexythiazox	Savey	0.5	30.	5.	0.40	6200
Hydramethylnon	Amdro	0.006	10.	-	-	730000
Imazamethabenz-m	Assert	1370.0	35.	18.	0.65	66
Imazamethabenz-p	Assert	875.0	35.	18.	0.65	35
Imazapyr Acid	Arsenal	11000.0	90.	30.	0.90	100
Imazapyr Amine	Chopper	500000.0	90.	30.	0.80	100
Imazaquin Ammonium	Scepter	160000.0	60.	20.	0.95	20
Iprodione	Rovral	13.9	14.	5.	0.40	700
Isazofos	Miral	69.0	34.	5.	0.65	100
Isofenphos	Oftanol	24.0	150.	30.	0.65	600
Isopropalin	Paarlan	0.1	100.	-	-	10000
Lactofen	Cobra	0.1	3.	2.	0.20	100000
Lambda-Cyhalothrin	Karate	0.005	30.	5.	0.40	180000
Lindane	Isotox	7.3	400.	2.5	0.05	1100
Linuron	Lorox	75.0	60.	15.	0.60	400
Malathion	Cythion	130.0	1.	1.	0.90	1800
Maleic Hydrazide	Royal Slo-Gro	400000.0	30.	10.	0.95	20
Mancozeb	Dithane	6.0	70.	10.	0.25	2000
Maneb	Manzate	6.0	12.	3.	0.65	1000

Common Name	Trade Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
MCPA Amine	Dedweed	866000.0	25.	7.	0.95	20
MCPA Ester	Bordermaster	5.0	25.	8.	0.50	1000
MCPB Sodium Salt	Thistrol	200000.0	14.	7.	0.95	20
Mecoprop Amine	2 Plus 2	660000.0	21.	10.	0.95	20
Mepiquat Chloride Salt	Pix	1000000.0	1000.	30.	0.95	1000000
Metalaxyl	Ridomil	8400.0	70.	30.	0.70	50
Metaldehyde	Metaldehyde	230.0	10.	-	-	240
Methamidophos	Monitor	1000000.0	6.	4.	0.95	5
Metham Sodium	Vapam	963000.0	7.	-	-	10
Methanearsonic Acid Na	DSMA	1400000.0	1000.	30.	0.95	100000
Methazole	Probe	1.5	14.	5.	0.40	3000
Methidathion	Supracide	220.0	7.	3.	0.90	400
Methiocarb	Slug-Geta	24.0	30.	10.	0.70	300
Methomyl	Lannate	8000.0	30.	0.5	0.55	72
Methoxychlor	Marlate	0.1	120.	6.	0.05	80000
Methyl Bromide	Brom-O-Sol	13400.0	55.	-	-	22
Methyl Isothiocyanate	Vorlex	7600.0	10.	-	-	10
Methyl Parathion	Penncap-M	60.0	5.	3.	0.90	5100
Metiram	Polyram	0.1	20.	7.	0.40	500000
Metolachlor	Dual	530.0	90.	5.	0.60	200
Metribuzin	Sencor	1220.0	40.	5.	0.80	60
Metsulfuron-Methyl	Ally	9500.0	120.	30.	0.80	35
Mevinphos	Phosdrin	600000.0	3.	0.6	0.95	44
Molinate	Ordram	970.0	21.	-	-	190
Monocrotophos	Azodrin	1000000.0	30.	2.	0.95	1
MSMA	Arsonate	1000000.0	100.	30.	0.95	10000
NAA Amide	Amid-Thin W	100.0	10.	5.	0.60	100
NAA Ethyl Ester	Tre-Hold	105.0	10.	5.	0.40	300
Naled	Dibrom	2000.0	1.	5.	0.90	180
Napropamide	Devrinol	74.0	70.	15.	0.60	400
Naptalam Sodium Salt	Alanap	231000.0	14.	7.	0.95	20
Nitrapyrin	N-Serve	40.0	10.	-	-	570
Norflurazon	Evital	28.0	90.	15.	0.50	600
Oryzalin	Surflan	2.5	20.	5.	0.40	600
Oxadiazon	Ronstar	0.7	60.	20.	0.50	3200
Oxamyl	Vydate	282000.0	4.	4.	0.95	25
Oxycarboxin	Plantvax	1000.0	20.	10.	0.70	95
Oxydemeton-Methyl	Metasystox	1000000.0	10.	3.	0.95	10
Oxyfluorfen	Goal	0.1	35.	8.	0.40	100000
Oxythioquinox	Morestan	1.0	30.	10.	0.50	2300
Paraquat	Prelude	620000.0	1000.	30.	0.60	1000000
Parathion (Ethyl)	Phoskil	24.0	14.	4.	0.70	5000
PCNB	Terrachlor	0.44	21.	4.	0.40	5000
Pebulate	Tillam	100.0	14.	4.	0.70	430
Pendimethalin	Prowl	0.275	90.	30.	0.40	5000
Permethrin	Pounce	0.006	30.	8.	0.30	100000
Petroleum oil	Volck oils	100.0	10.	2.	0.50	1000
Phenmedipham	Betamix	4.7	30.	5.	0.70	2400
Phenthoate	Tanone	200.0	40.	2.	0.65	250
Phorate	Thimet	22.0	60.	2.	0.60	1000
Phosalone	Zolone	3.0	21.	8.	0.65	1800
Phosmet	Imidan	20.0	19.	3.	0.90	820
Phosphamidon	Swat	1000000.0	17.	5.	0.95	7
Picloram Salt	Tordon	200000.0	90.	8.	0.60	16

Table P-2, Continued. Characteristics of pesticides sorted by common name (See footnotes at the end of the table.)

Common Name	Trade Name	Water Solubility* (ppm)	Half-Life Soil* (---days---)	Half-Life Fol.# (---days---)	Wash-off Frac.#	KOC* (ml/g)
Piperalin	Pipron	20.0	30.	10.	0.60	5000
Pirimiphos-Methyl	Actellic	9.0	10.	-	-	1000
Prochloraz	Octave	34.0	120.	30.	0.50	500
Profenofos	Curacron	28.0	8.	3.	0.90	2000
Profluralin	Tolban	0.1	140.	1.	0.35	2240
Prometon	Pramitol	720.0	500.	30.	0.75	150
Prometryn	Caparol	33.0	60.	10.	0.50	400
Pronamide	Kerb	15.0	60.	20.	0.30	200
Propaclor	Ramrod	613.0	6.	3.	0.40	80
Propamocarb	Banol	1000000.0	30.	15.	0.95	1000000
Propanil	Stam	200.0	1.	1.	0.70	149
Propargite	Comite	0.5	56.	5.	0.20	4000
Propazine	Milogard	8.6	135.	5.	0.45	154
Propham (IPC)	Chem-Hoe	250.0	10.	2.	0.50	200
Propiconazole	Tilt	110.0	110.	30.	0.70	1000
Propoxur	Baygon	1800.0	30.	-	-	30
Pyrazon	Pyramin	400.0	21.	5.	0.85	120
Quizalofop-Ethyl	Assure	0.31	60.	15.	0.20	510
Sethoxydim	Poast	4390.0	5.	3.	0.70	100
Siduron	Tupersan	18.0	90.	30.	0.70	420
Silvex	2,4,5-TP	2.5	20.	5.	0.40	2600
Simazine	Princep	6.2	60.	5.	0.40	130
Sulfometuron-Methyl	Oust	70.0	20.	10.	0.65	78
Sulprofos	Bolstar	0.31	140.	0.5	0.55	12000
Tebuthiuron	Spike	2500.0	360.	30.	0.90	80
Temephos	Abate	0.001	30.	5.	0.65	100000
Terbacil	Sinbar	710.0	120.	30.	0.70	55
Terbufos	Counter	5.0	5.	2.5	0.60	500
Terbutryn	Terbutrex	22.0	42.	5.	0.50	2000
Thiabendazole	TBZ	50.0	403.	30.	0.60	2500
Thidiazuron	Dropp	20.0	10.	3.	0.40	110
Thifensulfuron-Methyl	Harmony	2400.0	12.	3.	0.80	45
Thiobencarb	Bolero	28.0	21.	7.	0.70	900
Thiodicarb	Larvin	19.1	7.	4.	0.70	350
Thiophanate-Methyl	Topsin	3.5	10.	5.	0.40	1830
Thiram	Thiram	30.0	15.	8.	0.50	670
Toxaphene	Phenatox	3.0	9.	2.	0.05	100000
Tralomethrin	Tralomethrin	0.001	27.	1.	0.40	100000
Triadimefon	Bayleton	71.5	26.	8.	0.30	300
Triallate	Far-Go	4.0	82.	15.	0.40	2400
Tribufos	DEF	2.3	30.	7.	0.25	5000
Trichlorfon	Dylox	120000.0	10.	3.	0.95	10
Triclopyr Amine	Crossbow	2100000.0	46.	15.	0.95	20
Triclopyr Ester	Turflon	23.0	46.	15.	0.70	780
Tridiphane	Tandem	1.8	28.	8.	0.40	5600
Trifluralin	Treflan	0.3	60.	3.	0.40	8000
Triforine	Funginex	30.0	21.	5.	0.80	540
Trimethacarb	Broot	58.0	20.	-	-	400
Triphenyltin Hydroxide	Du-ter	1.0	75.	18.	0.40	23000
Vernolate	Vernam	108.0	12.	2.	0.80	260

Table P-2, Continued. Characteristics of pesticides sorted by common name (See footnotes at the end of the table.)

Table P-2, Continued. Characteristics of pesticides sorted by common name, Footnotes.

* Primarily from Wauchope et al., 1992.

Values for organochlorine, organophosphorus, pyrethroid, and carbamate insecticides, and selected herbicides and fungicides adapted from Willis et al., 1980; Willis and McDowell, 1987; and algorithms developed by Willis (personal communication, June 17, 1992). Many of the values for other compounds are subjective estimates based upon chemical properties, formulations, characteristics, and analogy with other compounds.