**Department of Pesticide Regulation -**
**Environmental Monitoring Branch -**
**1001 I Street**
**Sacramento, California 95812**

# Methodology for Evaluating Pesticides for Surface Water Protection
# I: Initial Screening

Yuzhou Luo, Ph.D., and Xin Deng, Ph.D.

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## Terminology of Chemical Properties

| | |
|---|---|
| AERO | aerobic soil metabolism half-life, day |
| AERO_W | aerobic aquatic metabolism half-life, day |
| ANAER | anaerobic soil metabolism half-life, day |
| ANAER_W | anaerobic aquatic metabolism half-life, day |
| FD | field dissipation half-life, day |
| HLW | dissipation half-life in water, day |
| HLD | dissipation half-life in sediment (or water-sediment system), day |
| HYDROL | hydrolysis half-life, day |
| KOC | organic carbon-normalized soil adsorption coefficient, L/kg[OC] |
| $LC_{50}$ | median lethal concentration, ppb |
| SOL | water solubility, mg/L |

## 1. Introduction

The Surface Water Protection Program (SWPP) is developing a more consistent and transparent method for evaluating registration packages. Historically, these evaluations have been based principally on professional judgment and experience gleaned from past assessment of the conditions and mechanisms responsible for the offsite transport of pesticides to surface water and their associated toxicological impact on aquatic life. A two-stage procedure is proposed here, including stage I evaluation with initial screening, and stage II evaluations with refined modeling (Figure 1). Initial screening is conducted solely on chemical properties (soil adsorption coefficient, water solubility, and reaction half-lives) and aquatic toxicology data of the active ingredient in evaluation. The objective of the stage I evaluation is to classify pesticides as to whether they [1] are unlikely to be a surface water quality problem, and their registrations are supported without conditions, or [2] may potentially cause surface water problems and require additional evaluation. *This document (Part I) outlined the initial screening procedure to evaluate pesticides for the protection of surface water quality.*

For pesticides requiring additional evaluations, stage II evaluation is followed with a more refined modeling approach *as presented in a companion report (Part II)*. Stage II evaluation is

performed based on risk characterization by accounting for the product-specific information (use pattern and application rate). The objective of stage II evaluation is to develop registration recommendations for pesticide products as whether [1] to support registration without conditions, [2] to support conditional registration with requests for analytical methods, or [3] not to support registration.

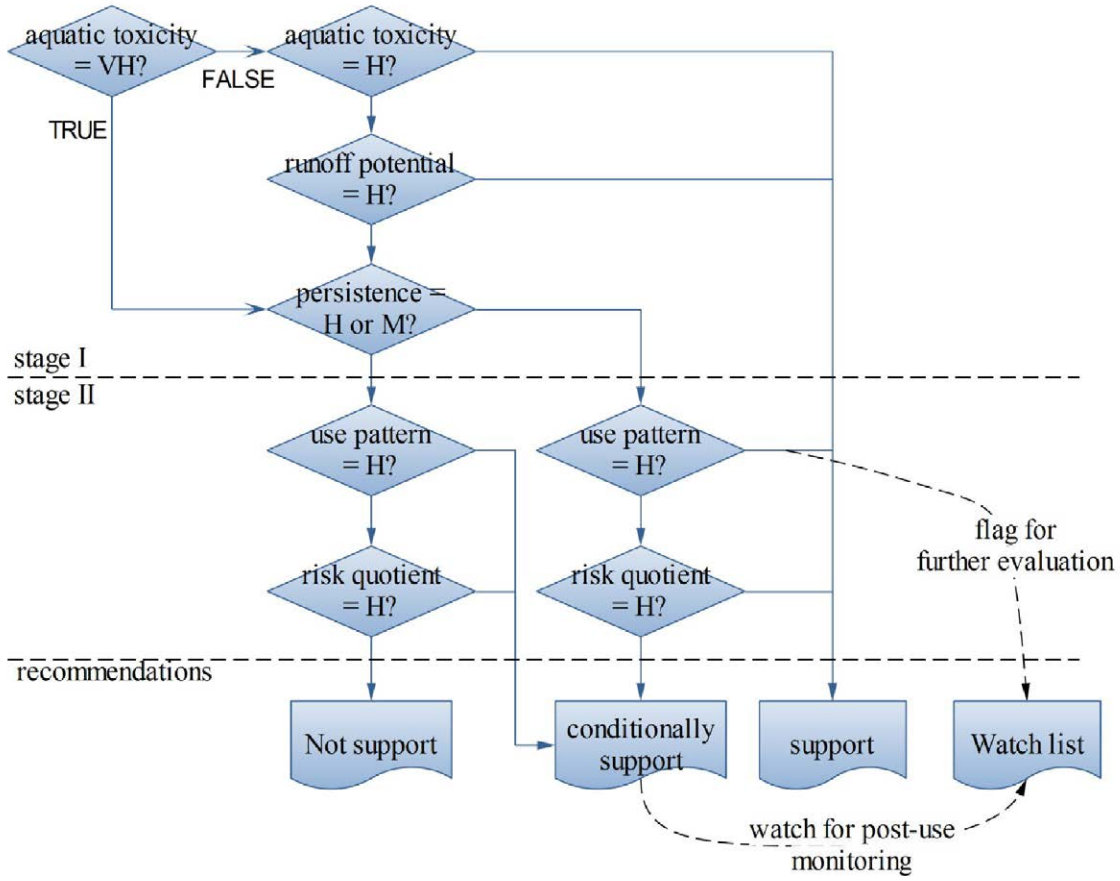


Figure 1. Decision flowchart of the two-stage procedure of pesticide evaluation for surface water protection (indicator classifications: H = "High" and M = "Intermediate"). This only shows a general procedure by highlighting indicators used in this study. Pesticide evaluation should follow the detailed procedures introduced in the reports.

The methodology addresses both water column and sediment-bound phases and considers different use patterns of a pesticide. Except for the use pattern, all other indicators (Figure 1) are defined for pesticides in both water column (aqueous phase) and sediment (adsorbed phase). Evaluation for aqueous phase is conducted for all pesticides, while evaluation for adsorbed phase is only required for pesticides with KOC > 1000. This criterion is set based on the USEPA data requirement for pesticide registration, in which acute sediment toxicity is required for pesticides with KOC > 1000 (USEPA, 2007a). In addition, a pesticide product may be associated with multiple use patterns. Pesticide evaluation could be conducted for each of the use patterns. The final registration recommendation will be based on both the evaluation results and professional judgment with additional information from the chemical properties and product label.

The objective of the methodology development is to provide a more consistent and transparent pesticide evaluation to support the pesticide registration for surface water protection. Therefore, the input data for pesticide evaluation are consistent to those available in a common registration package and used in our previous evaluation. In most cases, the registrant-submitted data has been reviewed and summarized as independent processes before delivering to SWPP. In addition, the methodology is not designed for numerically predict pesticide fate in the real environment since the actual application amount and drainage area characteristics are not available during at the stage of pesticide registration. Therefore it's inappropriate to compare the results from the methodology to the pesticide concentrations, frequency and geographic distribution detected in surface waters. Instead, we compared the derived registration recommendations to our previous evaluation based on best professional judgment for the same chemical and product.

## 2. Methods and Materials

### 2.1. Indicators for Stage I Evaluation

Three indicators are developed for pesticide active ingredient: [1] runoff potential, [2] aquatic persistence, and [3] aquatic toxicity. These indicators were derived from the registrant-submitted data, and assigned as descriptive classifications, i.e., "low", "intermediate", "high", and/or "very high" (for toxicity only) classes. Based on the data availability in a regular registration package and the objectives in this project, we selected dissipation half-lives, water solubility, KOC, and aquatic toxicity value as input parameters for developing the indicators. According to the evaluation matrix presented in Table 1, the resulting indicators provide an initial screening of the environmental distribution and aquatic risks of the pesticide active ingredient. *Detailed information for the development of the three indicators is provided in the following sections.*

Table 1. Evaluation matrix for initial screening

| **Indicators** | | | **Results** | **Recommendations** |
|---|---|---|---|---|
| **Runoff potential** | **Persistence** | **Toxicity** | | |
| H | L | H or VH | The chemical may potentially cause surface water problem | Require addition evaluation |
| Any | Any | VH | | |
| H | M or H | H or VH | The chemical may pose too high of a potential surface water risk | |
| Everything else | | | The chemical is unlikely to cause surface water problems | Support registration |

Notes: indicator ratings: "L" = low, "M" = intermediate, "H" = high, "VH" = very high

The evaluation matrix (Table 1) is applied to both dissolved and adsorbed phases of the pesticide. If the recommendations of supporting registration are made for <u>both</u> phases, the pesticide will be recommended for registrant with no conditions. Otherwise, additional evaluation is required for both chemical phases. Aquatic persistence does not have a direct effect on the result of stage 1 evaluation. It's listed here as an indicator since a chemical with high or intermediate persistence is more likely to case surface water problems compared to one with

lower persistence. In addition, aquatic persistence is considered as one of the physiochemical properties of a pesticide and characterized in the stage 1 evaluation.

## 2.2. Runoff Potential

A screening approach developed by U.S. Department of Agriculture (USDA) (Goss, 1992) was modified for rating pesticide runoff potential. The approach was developed from over 40,000 runs of the Groundwater Loading Effects of Agricultural Management System (GLEAMS) using a wide range of soil and pesticide properties to estimate pesticide loss from soils through runoff processes. Based on a stepwise regression, physiochemical properties of field dissipation half-life (FD), KOC, and water solubility were identified as input parameters that weighted most heavily for estimating each group of pesticide loss potentials from the model runs. The groups for pesticide loss potentials are classified as: "high", "intermediate", and "low". Multiple regression equations were used for each group in order to capture the highly nonlinear relationship between runoff potential and the input parameters. The USDA rating approach is currently used in the WIN-PST (Windows Pesticide Screening Tool) program (USDA, 2010).

Preliminary tests indicated that the USDA rating approach underestimated the runoff potential for pesticides with high KOC or high water solubility. For example, several pyrethroids were classified with only "intermediate" runoff potentials mainly because their field dissipation half-lives were less than 40 days. However, pyrethroids are known to bind strongly to and persist in soils and sediments, and to be toxic to many aquatic invertebrates at very low concentrations. Pyrethroids-associated sediment toxicity have been recognized in California (CEPA, 2010), and they are currently in reevaluation to address these concerns (CDPR, 2006). The other identified issue is that, the USDA rating approach excludes all pesticides with a solubility greater than 100 mg/L, such as organophosphates (dimethoate, malathion, and methidathion), from being classified as having "high" runoff potential. This is not consistent with the fact that organophosphates are frequently detected in surface waters (Pepple, 2009). Therefore, we revised the USDA rating approach for the group of "high" runoff potentials to cover the pesticides with frequent detection in surface water or high toxicity in sediment (Table 2). Testing for the revised model is provided in Section 3.1. If field dissipation half-life is not available in the registrant-submitted data, aerobic soil metabolism half-life will be used for runoff potential rating.

Table 2. Algorithm expressing pesticide runoff potential from soils

(a) Pesticide adsorbed-phase runoff potential

| **Criteria** | **Runoff potential rating** |
|---|---|
| Revised criteria in this project<br>(FD ≥ 15 and KOC ≥ $4\times10^4$) or<br>(FD ≥ 40 and KOC ≥ 1000) or<br>(FD ≥ 40 and KOC ≥ 500 and SOL ≤ 0.5) | High (H) |
| *Original USDA criteria*<br>*(FD ≥ 40 and KOC ≥ 1000) or*<br>*(FD ≥ 40 and KOC ≥ 500 and SOL ≤ 0.5)* | |
| (FD ≤ 1) or<br>(FD ≤ 2 and KOC ≤ 500) or<br>(FD ≤ 4 and KOC ≤ 900 and SOL ≥ 0.5) or<br>(FD ≤ 40 and KOC ≤ 500 and SOL ≥ 0.5) or<br>(FD ≤ 40 and KOC ≤ 900 and SOL ≥ 2) | Low (L) |
| Everything else | Intermediate (M) |

(b) Pesticide solution-phase runoff potential

| **Criteria** | **Runoff potential rating** |
|---|---|
| Revised criteria in this project<br>(SOL ≥ 1 and FD > 20 and KOC < $1\times10^5$) or<br>(SOL ≥ 10 and KOC ≤ 2000) | High (H) |
| *Original USDA criteria*<br>*(SOL ≥ 1 and FD > 35 and KOC < $1\times10^5$) or*<br>*(SOL ≥ 10 and KOC ≤ 700 and SOL < 100)* | |
| (KOC ≥ $1\times10^5$) or<br>(KOC ≥ 1000 and FD ≤ 1) or<br>(SOL < 0.5 and FD < 35) | Low (L) |
| Everything else | Intermediate (M) |

Note: modifications are made only for the criteria of "high" runoff potential, while no changes for other classes.

Pesticides vary in their runoff potential depending on their different use pattern. Some pesticides are directly applied or released into water bodies without experiencing soil runoff processes, such as applications to impervious surfaces, herbicides for rice production, pesticides for the control of mosquito and midge larvae in surface water, or those used in antifouling paint products. In this case, the runoff potential rating was skipped and "high" runoff potential was assumed for both absorbed and dissolved phases as a conservative assumption.

### 2.3. Aquatic Persistence

Aquatic dissipation half-lives in water (HLW) and in sediment (HLD) are used in the classification or aquatic persistence. The overall dissipation half-lives consider pesticide dissipation processes in an aquatic environment, usually including aquatic photolysis, hydrolysis,

metabolism, and volatilization. Pesticides were grouped into three categories based on their half-lives in aquatic systems: "low" persistence with a typical aquatic half-life of less than 30 days, "intermediate" persistence with a half-life of 30 to 100 days, and "high" persistence with a half-life of more than 100 day (Table 3). The breakout points were suggested by Kerle et al. (2007). For pesticide persistence in water phase, aquatic dissipation half-life (HLW) value is determined as the shortest values of hydrolysis half-life, aerobic aquatic metabolism half-life, and dissipation half-life in water phase. For persistence in sediment, USEPA suggested that dissipation half-life in sediment could be taken from the anaerobic soil or aquatic metabolism studies (USEPA, 2007a).

Table 3. Pesticide persistence in water and sediment (half lives in days)

| **Criteria** | **Persistence rating** |
|---|---|
| HLW ≥ 100 | High (H) - |
| 30 ≤ HLW < 100 | Intermediate (M) |
| HLW < 30 | Low (L) - |

## 2.4. Aquatic Toxicity

Toxicity ratings are determined by the acute toxicity value ($LC_{50}$, median lethal concentration) of the most sensitive species for fish and invertebrates in freshwater and saltwater (Table 4). Acute toxicity data requirements for freshwater and saltwater organisms including fish and invertebrates in water and sediment follow the definitions and conditions described in USEPA 40 CFR §158.630 and §158.660 (USEPA, 2007a) for protection of non-target aquatic organisms. Acute toxicity tests should be conducted using acceptable procedures recommended by USEPA. Acceptability of acute toxicity data should be evaluated based on the USEPA guidelines for deriving numerical national water quality criteria for aquatic organisms and their uses (USEPA, 1985). Therefore, the toxicity rating is conducted based on the toxicity values reported in the registration data package.

For sediment toxicity, only a few pesticides were tested and the corresponding toxicity ratings are not readily available. Existing data show that pyrethroids are a group of pesticides considered to be most toxic to the benthic invertebrate *Hyalella azteca* and their $LC_{50}$ values are generally below 10 µg/g[OC]. In this project, pesticides with sediment $LC_{50}$ values below/equal to 10 µg/g[OC] are classified as the highest toxic category. This critical value was scaled up in a 10 fold fashion to determine other toxicity ratings of high, intermediate, slight, and practically nontoxic categories in the sediment, respectively. The 10-fold scale is consistent with that used in rating water column toxicity (Table 4). Toxicity values for aquatic plants are not considered because these toxicity data are not required for pesticide registration by USEPA (2007a) and those are not usually included in the data package for registration evaluation. Current plant toxicity tests usually measure endpoints such as growth and reproduction that are generally associated with chronic toxicity. Moreover, the algal toxicity test guide in Environmental Toxicology Standards (ASTM, 2004) states that an algal toxicity test of short duration (72, 96 or 120 h) should not be viewed as an acute toxicity test because it examines effects upon multiple generations of an algal population.

Table 4. Descriptive acute toxicity ratings for pesticides in water column and sediment

| Toxicity rating | Water column (µg/L) | Sediment (µg/g[OC]) |
|---|---|---|
| Very high (VH) | $LC_{50} \leq 100$ | $LC_{50} \leq 10$ |
| High (H) | $100 < LC_{50} \leq 1000$ | $10 < LC_{50} \leq 100$ |
| Intermediate (M) | $1000 < LC_{50} \leq 10000$ | $100 < LC_{50} \leq 1000$ |
| Slight (L) | $10000 < LC_{50} \leq 100000$ | $1000 < LC_{50} \leq 10000$ |
| Practically nontoxic (L) | $LC_{50} > 100000$ | $LC_{50} > 10000$ |

Note: water column toxicity is rated by following the descriptive classifications by USEPA (Zucker, 1985).

According to USEPA (2007a), for all pesticides with KOC > 1000, acute sediment toxicity test is required for pesticide registration. In the demonstration of the developed approach (Section 3.2), however, sediment toxicity data is not available for some of the previously evaluated pesticides. In this case, we assumed that the sediment toxicity of a pesticide could be estimated as the product of its water toxicity and KOC value. Please note that this assumption was only utilized in the methodology testing, while in the real evaluation processes the actual sediment toxicity for the evaluated active ingredient should be used. Details of the data analysis for comparing pesticide acute toxicity in water and sediment are provided in the Appendix #1.

It's noteworthy that the toxicity values used in this study, based on acute toxicity data for fish and invertebrates, may be significantly different to those for benchmarks, drinking water and recreation water standards, aquatic plants, and chronic toxicity, which are not regularly available for pesticide registration, especially for new active ingredients. For example, diuron has a lowest $LC_{50}$ of 1100 ppb (for mysid shrimp, Table 6), compared to the benchmark of 2.4 for nonvascular plants (USEPA, 2011a) and 2.0 for drinking water (Pepple, 2009).

## 3. Methodology Testing

### 3.1. Test for Runoff-Potential Rating

As part of the methodology testing, the indicator of runoff potential was first rated for 172 pesticides with the E-fate database compiled by Spurlock (2008). Detailed test results are presented in the Appendix #2. Pesticides with high runoff potential identified in the test results were generally consistent with those frequently detected in surface water (Pepple, 2009) or currently in reevaluation for sediment toxicity (CDPR, 2006).

### 3.2. Test for the Initial Screening Procedure

#### 3.2.1. Selection of Pesticides

Two sets of pesticides were selected to test the evaluation approach. The first set of pesticides was selected from the registration evaluations by the Environmental Monitoring Branch. The following filters were used in the selection:

1. evaluations for surface water protection,

2. evaluations supplied with both chemical property data and toxicity data, and
3. evaluations posted during 2008-2010 (as of July 2010 when the study was initialized).

With all of the above filters applied, 21 pesticide active ingredients were selected and denoted with "A" to "U" in the demonstration. The registration packets and evaluation reports were used as the data source for chemical properties and toxicity data.

The second set of pesticides was suggested by scientists from the Environmental Monitoring Branch and the Registration Branch. These pesticides included bifenthrin, chlorpyrifos, diazinon, diuron, fipronil, and simazine, which are known surface water contaminants and/or are currently under re-evaluation. Chemical properties for the six pesticides were obtained from FOOTPRINT database (FOOTPRINT, 2010). Toxicity data was retrieved from multiple sources (NPIC, 2010; UCD, 2010a, 2010b, 2010c, 2010d; USEPA, 2011a). Input data for the two sets of pesticides are listed in Table 5 (chemical property data) and Table 6 (toxicity data).

### 3.2.2. Data Acquisition

The physicochemical properties and degradation half-lives for selected pesticides were retrieved from the registration evaluation reports or from the literature (Table 5). If multiple numerical values are available for a parameter, their geometric mean will be used in the calculation of indicators. If only a range is provided, the mean value of the upper and lower bounds will be applied.

Table 5. Summary of physicochemical property and degradation half-lives for selected pesticides

| Active ingredient | SOL | KOC | HYDROL | AERO | ANERO | FD | AERO_W | ANERO_W | HLW | HLD |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 0.28 | 35838 | 30 | 15.8 | 200 | | | | | |
| B | 2.8 | 459 | 365 | | | 69 | | | 45 | 126.7 |
| C | 2.56 | 1580 | | 101 | 60 | 77 | | | 29 | 163 |
| D | 2100 | 27 | 270 | | | 34 | | | 30 | 60 |
| E | 130 | 252 | 999 | 1358 | | 1358 | | 999 | | 999 |
| F | 0.0225 | 17757 | 999 | 15 | | | 32 | 174 | | |
| G | 0.17 | 11708 | 3 | | | | 31 | 71 | | |
| H | 22 | 1294 | 999 | 618 | 120 | | | 999 | 8 | 485 |
| I | 0.33 | 24300 | 34 | | | 90 | | 105 | 4 | 16 |
| J | 180.6 | 7044 | 999 | 999 | | 1400 | | | | |
| K | 2040 | 23.5 | 16 | | | 23 | | | | 26 |
| L | 200 | 576 | 9.9 | | | 2.2 | | 0.56 | | |
| M | 30 | 225 | | | | 1.13 | 2.48 | 2.48 | | |
| N | 2.8 | 328 | 365 | 365 | | 271 | | | 91.4 | 777 |
| O | 78100 | 68.5 | | | | 7 | | | | |
| P | 15 | 3760 | | 120 | | 85 | | | 3 | 1053 |
| Q | 1 | 339.5 | 30 | | | 222 | 231 | 208 | 0.37 | |
| R | 150 | 1086 | 53.5 | | | 214 | | | 6 | 636 |
| S | 0.44 | 5247 | 97 | | | 0.2 | | | 0.15 | 0.13 |
| T | 0.492 | 2559 | 999 | | | 146 | | | 3.9 | 9.3 |
| U | 429 | 193.8 | 999 | 78 | 48 | 56 | | | 129 | 250 |
| chlorpyrifos | 1.05 | 8151 | 25.5 | | | 21 | | | 5 | 36.5 |
| diazinon | 60 | 643 | 138 | | | 18.4 | | | 4.3 | 10.4 |
| diuron | 35.6 | 1067 | 999 | | | 89 | | | 8.8 | 48 |
| bifenthrin | 0.001 | 236610 | 999 | | | 84.6 | | | 8 | 251 |
| simazine | 5 | 130 | 96 | | | 90 | | | 46 | 33 |
| fipronil | 3.78 | 577 | 999 | | | 65 | | | 54 | 68 |

Notes:

1) - For the first 21 pesticides, data was retrieved from registration packets and evaluation reports. For the last 6 pesticides, data was taken from FOOTPRINT database (FOOTPRINT, 2010)
2) - A value of 999 is set as a numerical value for the "stable" reaction processes. This is used for the convenience of programmatic data processing.

For toxicity data, acute toxicity values for freshwater and saltwater fish and invertebrate species were considered (Table 6). The most sensitive species (i.e., with lowest $LC_{50}$ or $EC_{50}$) was used for toxicity rating. Toxicity values for aquatic plants were not considered in the current evaluation process because data are not required for registration by USEPA and measured toxicity endpoints (i.e., growth and reproduction) for aquatic plants are usually associated with chronic toxicity.

Table 6. Aquatic acute toxicity values (µg/L) for selected pesticides

| **Active ingredient** | **Rainbow trout** | **Bluegill/fathead minnow** | ***Daphnia magna*** | **Mysid shrimp** | **Sheepshead minnow** |
|---|---|---|---|---|---|
| A | 30000 | 5940 | 92670 | N/A | 7870 |
| B | 572 | 320 | 9880 | 1500 | 960 |
| C | 435 | 970 | 940 | 60.4 | N/A |
| D | >120000 | >120000 | 2500-5000 | 8000 | >98000 |
| E | 61000 | 33000 | 67000 | 34000 | 72000 |
| F | 2.7 | 13 | 0.57 | 0.02 | 17 |
| G | 1.3 | 3.2 | 1.5 | 0.98 | 26 |
| H | 2,200 | 6,300 | 4,200 | 750 | 3900 |
| I | 138 | 190 | 280 | N/A | N/A |
| J | 5300 | 3850 | 2630 | N/A | >3400 |
| K | >1000000 | >1000000 | 720000 | N/A | N/A |
| L | 10300 | N/A | 50000 | N/A | N/A |
| M | 2,540 | 2,200 | 4270 | N/A | 1960 |
| N | 6600 | 750 | 1800 | 3200 | 410 |
| O | 3620 | 5800 | 19940 | 15000 | 14000 |
| P | 800 | 1200 | 770 | 150 | N/A |
| Q | 13800 | 15100 | 11.6 | 1150 | 12000 |
| R | 1000 | 1300 | 3200 | 510 | N/A |
| S | 130 (NOEL) | 790 | N/A | N/A | N/A |
| T | >820 | >870 | >920 | 490 | 650 |
| U | >69000 | >74000 | >91000 | 79000 | 94000 |
| chlorpyrifos | 14 | 1.8 | 0.1 | 0.04 | N/A |
| diazinon | 90 | 460 | 0.52 | 4.2 | N/A |
| diuron | 4900 | N/A | 12000 | 1100 | 6700 |
| bifenthrin | 0.15 | 0.35 | 1.6 | 0.003 | 17.5 |
| simazine | >10000 | 6400 | 1000 | N/A | >4300 |
| fipronil | 246 | 83 | 190 | 0.14 | N/A |

Notes: For the first 21 pesticides, data was retrieved from registration packets and evaluation reports. For the last 6 pesticides, data was taken from multiple sources (NPIC, 2010; UCD, 2010a, 2010b, 2010c, 2010d; USEPA, 2000, 2007b, 2007c, 2010a, 2010b).

### 3.2.3. Derived Indicators

The rating criteria (Tables 2-4) are applied to the input data in Tables 5 and 6. Resulting indicators of runoff potential, persistence, and freshwater toxicity are shown in Table 7.

Table 7. Classification of runoff potential, persistence, and freshwater toxicity for the selected pesticides [(1),(2)]

| Active ingredient | Aqueous runoff potential | Persistence in water | Freshwater toxicity | Sediment runoff potential | Persistence in sediment |
|---|---|---|---|---|---|
| A [(3)] | H | M | M | H | H |
| B | H | M | H | M | H |
| C | H | L | VH | H | H |
| D | H | M | M | L | M |
| E | H | H | L | M | H |
| F | L | M | VH | M | H |
| G [(3)] | H | L | VH | H | L |
| H | H | L | H | H | H |
| I [(3)] | H | L | H | H | L |
| J | H | H | M | H | H |
| K | H | L | L | L | L |
| L | H | L | L | L | L |
| M | H | L | M | L | L |
| N | H | M | H | M | H |
| O | H | L | M | L | L |
| P | H | L | H | H | H |
| Q | H | L | VH | M | H |
| R [(3)] | H | L | H | H | H |
| S [(3)] | H | L | H | H | L |
| T | M | L | H | H | L |
| U | H | H | L | M | H |
| chlorpyrifos | H | L | VH | M | M |
| diazinon | H | L | VH | L | L |
| diuron | H | L | M | H | M |
| bifenthrin | L | L | VH | H | H |
| simazine | H | M | H | M | M |
| fipronil | H | M | VH | M | M |

Notes:

1) - "L"=Low, "M"=Intermediate, "H"=High, and "VH"=Very High (for toxicity only, Table 4)
2) - Sediment toxicity values are not available for most of the selected pesticides (except for bifenthrin, chlorpyrifos, and fipronil, as provided in appendix #1), and estimated from the corresponding water toxicity and KOC value. Please refer to Section 2.4 and Appendix #1 for details. The estimated sediment toxicity is only used to demonstrate the proposed procedure of initial screening.
3) - For pesticides released directly into water, the runoff potential is assumed to be "high" for both absorbed and dissolved phases. See Section "2.2 Runoff Potential" for more details on this assumption, and the report part 2 for the pesticide use patterns associated with the evaluated products.

### 3.2.4. Initial Screening Results

Demonstrated in Table 8 are the results of initial screening for the selected pesticides, in comparison with the registration recommendations based on best professional judgment, retrieved from the evaluation reports. Sediment toxicity was not available for most of the selected pesticides, and the toxicity rating was based on the corresponding water toxicity. Therefore, the validation of the proposed method was focused on the dissolved phase. Generally, the procedure of stage I evaluation generates consistent or conservative results compared to the recommendations by best professional judgment (Table 9). Therefore, we concluded that, the proposed initial screening has the capability to identify pesticides which [1] are unlikely to cause surface water problems, or [2] may cause potential problems and require additional evaluation. All chemicals in the second set of pesticides (chlorpyrifos, diazinon, diuron, bifenthrin, simazine, and fipronil) are listed by CDPR as "pesticides with a high potential to contaminate surface water" based on detections in water column or sediment (Pepple, 2009). The results in Table 8 are generally compared to the identification, by requiring chlorpyrifos, diazinon, bifenthrin, simazine, and fipronil for additional evaluation. For diuron, it passes the stage 1 evaluation mainly because the registration evaluation is based on acute toxicity data for fish and invertebrates with a lowest $LC_{50}$ of 1100 ppb (Table 6), which is much lower than the benchmark (2.4) or drinking water standard (2.0) used in identifying pesticides with a high potential to contaminate surface water (Pepple, 2009).

Table 8. Recommendations from model-based evaluation vs. best professional judgment for surface water protection [1]

| Active ingredient | Recommendations by stage I evaluation | | Best professional judgment based recommendations |
|---|---|---|---|
| | Dissolved phase | Adsorbed phase (2) | |
| A | S | S | S |
| B | R | - | S |
| C | R | R | C (sed. toxicity test & runoff test) |
| D | S | - | S |
| E | S | - | S |
| F | R | R | S |
| G | R | R | C (marina test) |
| H | R | S | C (sed. toxicity test) |
| I | R | S | S |
| J | S | S | C (sed. toxicity test) |
| K | S | - | S |
| L | S | - | S |
| M | S | - | S |
| N | R | - | C (runoff test) |
| O | S | - | S |
| P | R | S | S |
| Q | R | - | C (runoff test) |
| R | R | S | N |
| S | R | S | S |
| T | S | S | S |
| U | S | - | S |
| chlorpyrifos | R | R | |
| diazinon | R | - | |
| diuron | S | S | |
| bifenthrin | R | R | |
| simazine | R | - | |
| fipronil | R | - | C (runoff test) |

Notes:

1) - "S" = support registration without conditions; "N" = not support registration; "C" = support conditional registration; and "R" = require additional evaluation. "Best professional judgment based recommendation" was the original recommendations in the evaluation reports.
2) - Evaluations for sediment-bound pesticides were only conducted for those with KOC > 1000, for which USEPA requires sediment toxicity tests (USEPA, 2007a). For pesticides without reported sediment toxicity, we estimated sediment toxicity from the corresponding water toxicity. Therefore, the evaluation results for adsorbed pesticides won't be used in the comparisons best professional judgment based recommendations.

Table 9. Summary of the initial screening results

| Active ingredients | Recommendations by stage I evaluation (dissolved phase) | Best professional judgment based recommendations | Notes |
|---|---|---|---|
| A, D, E, J, K, L, M, O, T, and U | S | S | Consistent results |
| C, G, N, Q, and R | R | C (runoff test) or N | Consistent results |
| B, F, H, I, P, and S | R | S or C (sed. toxicity test) | Conservative results |

## 4. - Discussion and Conclusion

1. - The proposed methodology serves as an initial screening tool for assessing runoff potential, persistence and toxicity of a pesticide active ingredient. Only physicochemical properties and aquatic toxicity are considered in the stage I procedure. The approach allows for an initial estimation of environmental distribution and aquatic risks of pesticides.
2. - For pesticides which require additional evaluation as identified by the initial screening, we proposed a second stage to incorporate additional information such as pesticide use pattern and application rate to refine the evaluation and registration recommendations.
3. - Degradates and formulated products are not included in this demonstration due to limited data availability in the registration package. But the methodology is designed for a general pesticide evaluation, and the same evaluation process can be applied to degradates and formulated products with required chemical and toxicity data, and the final recommendation should be based on combined results for all evaluated chemical species.
4. - The demonstration of the methodology in this report was mainly based on the mean or median values of physiochemical properties. A margin of safety could be introduced for the classifications of runoff potential and persistence if sufficient data is available. For example, the upper or lower 90 confidence limit of KOC, water solubility, and reaction half-lives could be applied to the classifications for more conservative evaluations.

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**Appendix 1 Notes on Comparison of Pesticide Acute Toxicity on *Daphnia*, *Ceriodaphnia*, *Chironomus* and *Hyalella***

The purposes of the comparison are two folds: 1) to find out whether *Daphnia magna* and *Chironomus* or *Hyalella* $LC_{50}$ values are correlated and whether one can be indicative of another in toxicity rating; 2) to justify whether additional data requirement on acute toxicity of benthic invertebrates such as *Chironomus* or *Hyalella* is appropriate for the evaluation process of pesticide registration. Comparable data between species (i.e., *Daphnia* vs. *Chironomus*, *Daphnia* vs. *Hyalella*) were extracted from the OPP ecotox database (USEPA, 2011b). The toxicity values ($LC_{50}$) are chemical concentrations in soluble phase including water or pore-water column. Toxicity data for the comparison between *Hyalella* vs. *Ceriodaphnia* were cited from open literatures (**Table** 12).

*Daphnia* vs. *Chironomus*

Seventeen insecticides and 16 herbicides that have $LC_{50}$ values available for both *Daphnia magna* and *Chironomus* (*C. tentans and C. plumosus*) were sorted out from the OPP database (Table 1). The scattered plots (Figures 1 and 2) show poor correlations on paired $LC_{50}$ values between the two taxa. However, 16 out of 17 insecticides have the same toxicity ratings from both taxa (Table 1). Only 4 out of 16 herbicides are similar in toxicity rating. No correlation trend is observed in other 12 herbicides.

*Daphnia* vs. *Hyalella*

Only 5 pesticides with $LC_{50}$ values of *Daphnia* and *Hyalella* were found in the database (Table 2). There is no correlation between the $LC_{50}$ values of both species.

*Hyalella* vs. *Ceriodaphnia*

Table 3 listed *Hyalella* (water and sediment) and *Ceriodaphina* $LC_{50}$ values for 5 pyrethoids, 2 OPs (chlorpyrifos and diazinon) and fipronil. In general, *Hyalella* are more sensitive to pyrethroids and fipronil but not organophosphates. However, both species are given the same toxicity rating for each chemical.

Conclusion:

1) - There are very limited acute toxicity data available for benthic invertebrates such as *Hyalella* and *Chironomus*.
2) - No correlations are observed in $LC_{50}$ values between *D. manga* and other benthic invertebrates.
3) - For insecticides that are highly toxic to *D. magna* or *C. dubia* ($LC_{50}$ < 1000 ppb), it is highly likely that their toxicity ratings in benthic invertebrates will fall in the same toxicity category.
4) - For herbicides and other pesticides with intermediate or slight toxicity to *Daphnia* or one of the invertebrates, additional toxicity data from benthic species may be helpful to re-categorize their toxicity ratings.

5) - By combining all data pairs in the tables, most of pesticides have sediment toxicity in the same category with their corresponding category for water toxicity.
6) - When data is not available, therefore, the category of sediment toxicity for a pesticide was set the same as the corresponding category for its water toxicity. This assumption was not made for numerically estimating the sediment toxicity, but used only for the descriptive classification of toxicity values for benthic invertebrates when the appropriate data is not available.

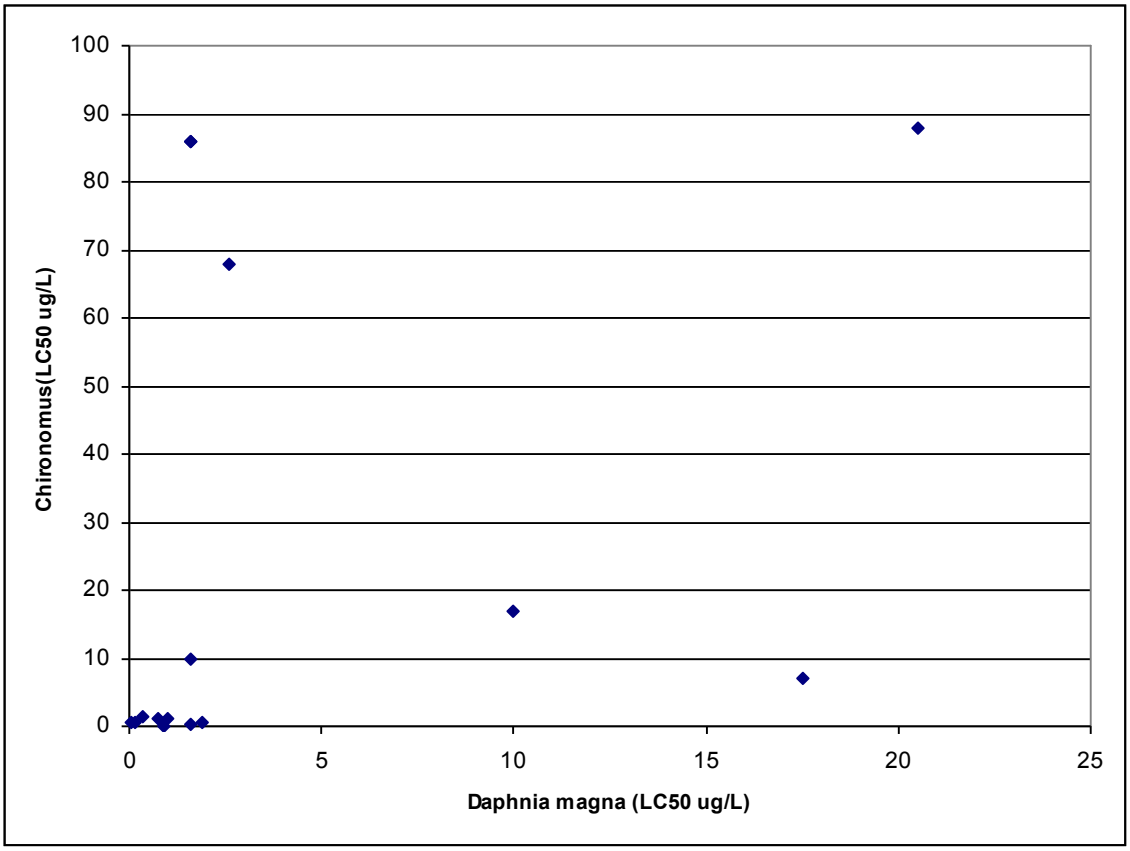


Figure 2. Scattered plot of acute toxicity between *Daphnia magna* and *Chironomus* for 15 insecticides. Note: kepone and oxamyl in Table 10 were not included because their $LC_{50}$ values were out of the scale of the figure scale

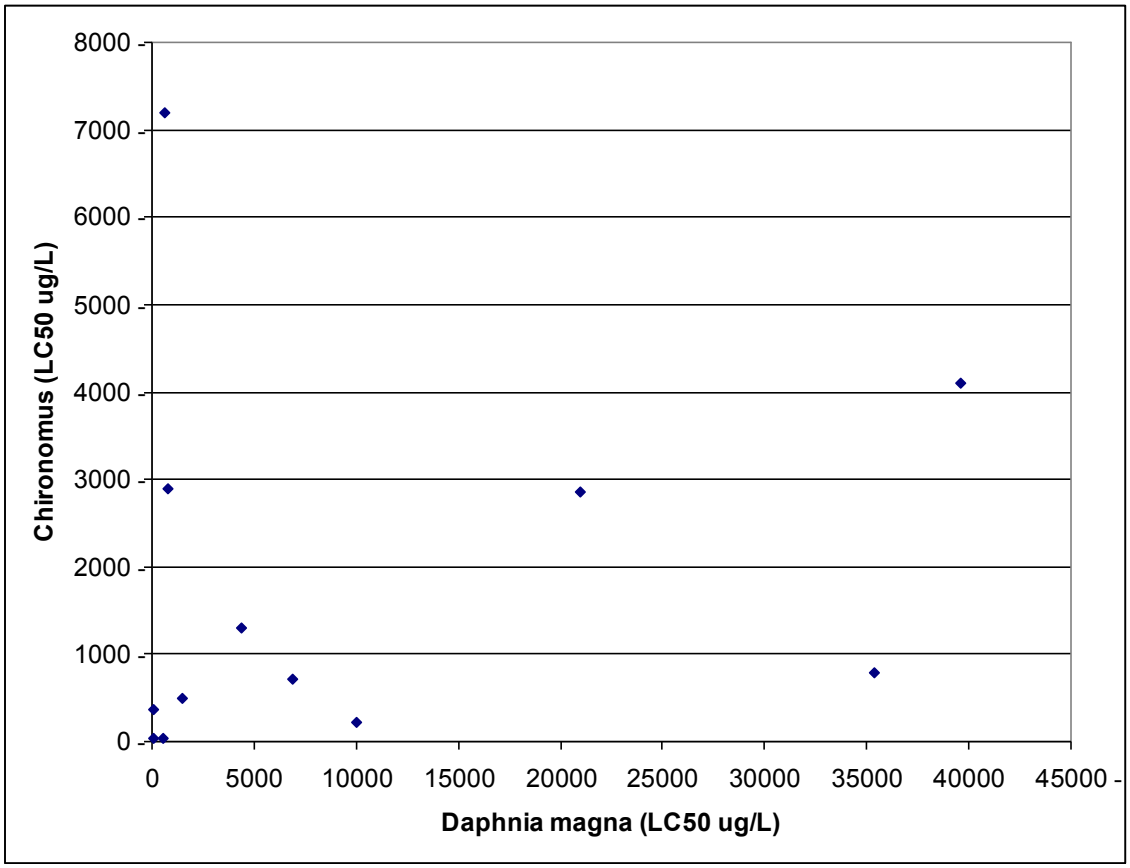


Figure 3. Scattered plot of acute toxicity between *Daphnia magna* and *Chironomus* for 12 herbicides. Note: ethephon, benomyl, chlorthal dimethyl, and glyphosate in Table 10 were not - included because their $LC_{50}$ values were out of the scale of the figure scale -

Table 10. Acute toxicity ratings of insecticides and herbicides on *Daphnia magna* and *Chironomus*. Chemical concentrations were measured from water or pore-water column (USEPA, 2011b)

| Chemical | Use pattern | Acute toxicity ($LC_{50}$ µg/L) | | Toxicity rating |
|---|---|---|---|---|
| | | *D. magna* | *Chironomus* | *D. magna/Chironomus* |
| Bifenthrin | insecticide | 1.6 | 0.33 | VH/VH |
| Chlorpyrifos | insecticide | 0.9 | 0.017 | VH/VH |
| Cyfluthrin | insecticide | 0.141 | 0.44 | VH/VH |
| Cypermethrin | insecticide | 0.75 | 1.2 | VH/VH |
| Diflubenzuron | insecticide | 2.6 | 68 | VH/VH |
| Profenofos | insecticide | 1.6 | 86 | VH/VH |
| Fenitrothion | insecticide | 17.5 | 7 | VH/VH |
| Fenvalerate | insecticide | 0.05 | 0.43 | VH/VH |
| Pydrin | insecticide | 1.6 | 10 | VH/VH |
| Kepone | insecticide | 260 | 320 | H/H |
| Methomyl | insecticide | 20.5 | 88 | VH/VH |
| Mirex | insecticide | 1 | 1 | VH/VH |
| Oxamyl | insecticide | 3050 | 180 | M/H |
| Permethrin | insecticide | 1.88 | 0.56 | VH/VH |
| Profenofos | insecticide | 1.6 | 86 | VH/VH |
| Terbufos | insecticide | 0.35 | 1.4 | VH/VH |
| Toxaphene | insecticide | 10 | 17 | VH/VH |
| Atrazine | herbicide | 6900 | 720 | M/H |
| Ethephon | herbicide | 31700 | 165000 | M/N |
| Oxyfluorfen | herbicide | 1500 | 498.5 | M/H |
| Thiobencarb | herbicide | 101.2 | 364 | H/H |
| 2,4-D | herbicide | 600 | 7200 | H/M |
| Alachlor | herbicide | 21000 | 2850 | L/M |
| Benomyl | herbicide | 317.5 | 100000 | H/N |
| Chlorthal dimethyl | herbicide | 100000 | 100000 | N/N |
| Fluchloralin | herbicide | 560 | 31.1 | H/VH |
| Fluometuron | herbicide | 10000 | 220 | M/H |
| Fluridone | herbicide | 4400 | 1300 | M/M |
| Glyphosate | herbicide | 780000 | 43000 | N/M |
| Linuron | herbicide | 767 | 2900 | H/M |
| Metolachlor | herbicide | 39600 | 4100 | L/M |
| Propachlor | herbicide | 35400 | 790 | L/H |
| Tribufos | herbicide | 58.4 | 40 | VH/VH |

Note: VH=very highly toxic; H=highly toxic; M=intermediately toxic; L=slightly toxic; N=non-toxic.

Table 11. Acute toxicity ratings of pesticides on *Daphnia magna* and *Hyalella azteca*. Chemical concentrations were measured from water or pore-water column (USEPA, 2011b)

| Pesticide | Use pattern | Acute toxicity ($LC_{50}$ µg/L) | | Toxicity rating |
|---|---|---|---|---|
| | | *D. magna* | *H. azteca* | |
| Pentachlorophenol | Preservative | 452 | 230 | H/H |
| Boscalid | Fungicide | 2630 | 97000 | M/L |
| Thiacloprid | Insecticide | 1050 | 37 | M/VH |
| Thiacloprid metabolite | Insecticide | 96100 | 31180 | L/L |
| Chlorantraniliprole | Insecticide | 16.6 | 389 | VH/H |

Note: VH=very highly toxic; H=highly toxic; M=intermediately toxic; L=slightly toxic; N=non-toxic.

Table 12. Acute toxicity ratings of insecticides on *Ceriodaphnia dubia* and *Hyalella azteca* in water and in sediment

| Pesticide | Acute toxicity ($LC_{50}$ µg/L) | | | Toxicity rating | References |
|---|---|---|---|---|---|
| | *H. azteca* | *H. azteca* | *C. dubia* | | |
| | Water (µg/L) | Sediment (µg/g [OC]) | Water (µg/L) | | |
| bifenthrin | 0.0093 | 0.0129 | 0.142 | VH | [1][2][3] |
| cyfluthrin | 0.0023 | 0.0137 | 0.344 | VH | [1][3][4] |
| L-cyhalothrin | N/A | 0.0056 | 0.2 | VH | [1][3] |
| permethrin | 0.021 | 0.2 | 0.25 | VH | [1][2][3] |
| cypermethrin | 0.00125 | 0.015 | 0.683 | VH | [3][5] |
| chlorpyrifos | 0.086 | 0.399 | 0.053 | VH | [1][6][7] |
| diazinon | 6.51 | N/A | 0.32 | VH | [7][8] |
| fipronil | N/A | 0.306 | 17.7 | VH | [9][10] |

Note: VH=very highly toxic; H=highly toxic; M=intermediately toxic; L=slightly toxic; N=non-toxic.
References: [1] (Amweg *et al.*, 2005); [2] (Anderson *et al.*, 2006); [3] (Wheelock *et al.*, 2004); -[4] (Weston and Jackson, 2009); [5] (Maund *et al.*, 2002); [6] (Phipps *et al.*, 1995); [7] (Bailey *et al.*, 1997); [8] (Ankley and Collyard, 1995); [9] (Ma, 2006); [10] (Konwick *et al.*, 2005)

## Appendix 2 Testing Results for Runoff-Potential Rating

Notes:
[1] Runoff potential test results for the 172 pesticides in the Efate database (Spurlock, 2008). Only "High" runoff potentials are identified as "H", while other groups of "Intermediate" and "Low" runoff potentials are indicated by blank cells.
[2] The chemical properties in the Efate database (Spurlock, 2008) may have different values from those registrant-submitted data as shown in Table 5 and Appendix 2, and thus may result in different runoff-potential classifications.

| Chem-code | Chemical name | SOL | KOC | FD | Runoff potential | |
|---|---|---|---|---|---|---|
| | | | | | sediment | aqueous |
| 573 | 1,3-DICHLOROPROPENE | 2250 | 66 | 51.6 | | H |
| 1685 | ACEPHATE | 818000 | 2 | 1.685 | | H |
| 5762 | ACETAMIPRID | 3600 | 244.8929 | 13.55 | | H |
| 5338 | ACIBENZOLAR-S-METHYL | 7.7 | 978.5714 | 4.15 | | |
| 3 | ACROLEIN | 238000 | 89.7619 | 6 | | H |
| 678 | ALACHLOR | 240 | 127.5 | 13.15 | | H |
| 575 | ALDICARB | 5870 | 49.8 | 16.7 | | H |
| 18 | AMETRYNE | 112.2 | 236.25 | 73 | | H |
| 2016 | AMITRAZ | 0.093 | 576.1364 | 0.5 | | |
| 256 | ANILAZINE | 8.02 | 2071.667 | 11 | | |
| 45 | ATRAZINE | 32.5 | 86.45 | 85.9 | | H |
| 5025 | AZAFENIDIN | 16 | 247.9221 | 66.5 | | H |
| 314 | AZINPHOS METHYL | 27.95 | 776.5 | 8.115 | | H |
| 4037 | AZOXYSTROBIN | 6.35 | 527.7778 | 31.9 | | H |
| 53 | BENEFIN | 0.0998 | 9310.417 | 123.8606 | H | |
| 1552 | BENOMYL | 2 | 1212.167 | 82 | H | H |
| 2263 | BENSULFURON METHYL | 216 | 288.1818 | 26.85 | | H |
| 70 | BENSULIDE | 5.6 | 3900 | 15.2 | | |
| 5657 | BIFENAZATE | 3.76 | 1778 | 4 | | |
| 2300 | BIFENTHRIN | 0.000014 | 264276 | 109.5 | H | |
| 83 | BROMACIL | 700 | 14.05882 | 146 | | H |
| 834 | BROMOXYNIL OCTANOATE | 0.08 | 190 | 4.31 | | |
| 3947 | BUPROFEZIN | 0.2635 | 3298.113 | 45.6 | H | |
| 565 | BUTYLATE | 44 | 422.2222 | 12.3 | | H |
| 104 | CAPTAN | 3.3 | 151 | 4.05 | | |
| 105 | CARBARYL | 113 | 138.6667 | 9.485 | | H |
| 106 | CARBOFURAN | 351 | 50.11872 | 30.35 | | H |
| 5130 | CARFENTRAZONE-ETHYL | 22 | 17.58454 | 4.75 | | H |
| 2184 | CHLORAMBEN | 700 | 21 | 14 | | H |
| 677 | CHLOROTHALONIL | 1.2 | 1111.111 | 60 | H | H |
| 253 | CHLORPYRIFOS | 1.39 | 9373.249 | 46 | H | H |
| 2143 | CHLORSULFURON | 31800 | 35.47273 | 22.15 | | H |
| 179 | CHLORTHAL-DIMETHYL | 0.5 | 2565 | 21.4 | | |

| Chem-code | Chemical name | SOL | KOC | FD | Runoff potential | |
|---|---|---|---|---|---|---|
| | | | | | sediment | aqueous |
| 3566 | CLETHODIM | 384 | 60.5 | 3.09 | | H |
| 2249 | CLOFENTEZINE | 0.0025 | 45300 | 25 | H | |
| 3537 | CLOMAZONE | 1100 | 159.8772 | 16.9 | | H |
| 5792 | CLOTHIANIDIN | 259 | 123.3333 | 561.5 | | H |
| 1640 | CYANAZINE | 155 | 236.7547 | 37.5 | | H |
| 516 | CYCLOATE | 95 | 272 | 10.71 | | H |
| 2223 | CYFLUTHRIN | 0.0023 | 124000 | 22 | H | |
| 4002 | CYMOXANIL | 780 | 106.575 | 4.8 | | H |
| 2171 | CYPERMETHRIN | 0.004 | 310000 | 27 | H | |
| 233 | DAZOMET | 3630 | 260 | 0.188 | | H |
| 3010 | DELTAMETHRIN | 0.0002 | 533750 | 54.5 | H | |
| 1748 | DESMEDIPHAM | 0.901 | 691.3684 | 26.65 | | |
| 198 | DIAZINON | 60 | 1856.111 | 9.07 | | H |
| 112 | DICHLOBENIL | 2.1 | 171 | 55 | | H |
| 5060 | DICHLORPROP-P | 108000 | 15.55556 | 4.8 | | H |
| 2034 | DICLOFOP-METHYL | 1.9 | 14025 | 41 | H | H |
| 81 | DICLORAN | 6.4 | 747.5 | 93.8 | | H |
| 346 | DICOFOL | 0.83 | 6994.643 | 65.55 | H | |
| 468 | DIENOCHLOR | 0.025 | 510571.4 | 3.9 | | |
| 1995 | DIETHATYL-ETHYL | 120 | 202.0287 | 20 | | H |
| 1930 | DIFENZOQUAT METHYL SULFATE | 817000 | 64637.36 | 83 | H | H |
| 1992 | DIFLUBENZURON | 0.08 | 7584.615 | 40.7 | H | |
| 216 | DIMETHOATE | 39800 | 10 | 7.8 | | H |
| 231 | DIURON | 36.4 | 540.2321 | 114.5 | H | |
| 259 | ENDOSULFAN | 0.32 | 12000 | 89.75 | H | |
| 264 | EPTC | 345 | 144.5707 | 2.07 | | H |
| 2321 | ESFENVALERATE | 0.00131 | 436515.8 | 31.05 | H | |
| 2166 | ETHALFLURALIN | 0.293 | 5344.444 | 51 | H | |
| 1900 | ETHOFUMESATE | 50 | 145.9821 | 122.25 | | H |
| 404 | ETHOPROP | 843 | 183.4995 | 23.3 | | H |
| 5849 | ETOXAZOLE | 0.0704 | 20550 | 3.5 | | |
| 5878 | FAMOXADONE | 0.0815 | 3636.957 | 12.3 | | |
| 1857 | FENAMIPHOS | 329 | 224.2619 | 9.95 | | H |
| 1980 | FENARIMOL | 13.8 | 723.75 | 280.5 | H | |
| 3905 | FENBUCONAZOLE | 2.15 | 2925.714 | 302 | H | H |
| 4032 | FENHEXAMID | 23.7 | 905.625 | 5.33 | | H |
| 2311 | FENOXAPROP ETHYL | 0.8 | 9490 | 8.1 | | |
| 2283 | FENOXYCARB | 5.66 | 1752.778 | 28.3 | | H |
| 2234 | FENPROPATHRIN | 0.0363 | 42500 | 16.35 | H | |
| 3995 | FIPRONIL | 1.9 | 668.75 | 131 | H | |
| 5886 | FLONICAMID | 5200 | 12.3 | 3.1 | | H |
| 2186 | FLUAZIFOP-BUTYL | 1.1 | 1812.857 | 7.095 | | |
| 5027 | FLUDIOXONIL | 1.83 | 1340.833 | 191 | H | H |
| 5802 | FLUMIOXAZIN | 1.79 | 244.5455 | 15.05 | | |
| 166 | FLUOMETURON | 111 | 87.16667 | 103 | | H |
| 5768 | FLUROXYPYR | 6500 | 291.8016 | 19 | | H |

| Chem-code | Chemical name | SOL | KOC | FD | Runoff potential | |
|---|---|---|---|---|---|---|
| | | | | | sediment | aqueous |
| 254 | FONOFOS | 16.9 | 1051.296 | 22.35 | | H |
| 5851 | FORAMSULFURON | 3290 | 65 | 12.15 | | H |
| 1871 | HEXAZINONE | 33000 | 45.2392 | 138.5 | | H |
| 2303 | HEXYTHIAZOX | 0.12 | 2754.248 | 295.5 | H | |
| 2203 | HYDRAMETHYLNON | 0.2 | 200595.2 | 44 | H | |
| 5911 | IMAZAPIC | 479000 | 55.55556 | 148 | | H |
| 2340 | IMAZETHAPYR | 711 | 58.61538 | 110 | | H |
| 3849 | IMIDACLOPRID | 514 | 288.9835 | 58.9 | | H |
| 5331 | INDOXACARB | 0.2 | 4928.571 | 20.1 | | |
| 2282 | ISAZOPHOS | 168 | 107.2727 | 33.9 | | H |
| 5451 | KRESOXIM-METHYL | 2 | 499.6364 | 6.6 | | |
| 2297 | LAMBDA CYHALOTHRIN | 0.005 | 297500 | 23.35 | H | |
| 359 | LINDANE | 7 | 1636.508 | 172 | H | H |
| 361 | LINURON | 77.2 | 417.165 | 65.9 | | H |
| 367 | MALATHION | 125 | 165 | 9 | | H |
| 211 | MANCOZEB | 13.1 | 6000 | 98.95 | H | H |
| 5898 | MESOSULFURON-METHYL | 483 | 40 | 78 | | H |
| 2132 | METALAXYL | 7100 | 167.381 | 65.25 | | H |
| 379 | METALDEHYDE | 188 | 33.9359 | 180 | | H |
| 1689 | METHIDATHION | 240 | 310 | 5 | | H |
| 375 | METHIOCARB | 27 | 617.4877 | 12 | | H |
| 383 | METHOMYL | 57900 | 40 | 29.785 | | H |
| 5698 | METHOXYFENOZIDE | 3.3 | 394.1667 | 145 | | H |
| 385 | METHYL BROMIDE | 17500 | 126.4996 | 3.8 | | H |
| 394 | METHYL PARATHION | 70.3 | 522.9167 | 2 | | H |
| 1996 | METOLACHLOR | 492.5 | 210.8333 | 113 | | H |
| 1692 | METRIBUZIN | 1031.5 | 50 | 88.75 | | H |
| 2222 | METSULFURON-METHYL | 2790 | 61.09091 | 10 | | H |
| 480 | MEVINPHOS | 600000 | 78.4 | 4.1875 | | H |
| 449 | MOLINATE | 970 | 216.6667 | 14.54 | | H |
| 418 | NALED | 200 | 221.4286 | 1.53 | | H |
| 1728 | NAPROPAMIDE | 74 | 667.8608 | 10 | | H |
| 3829 | NICOSULFURON | 1036.5 | 27.87879 | 34.6 | | H |
| 439 | NITRAPYRIN | 72.1 | 355.3571 | 33.2 | | H |
| 2019 | NORFLURAZON | 33.7 | 460 | 180 | | H |
| 5754 | NOVALURON | 0.053 | 2296.382 | 125 | H | |
| 1868 | ORYZALIN | 2.6 | 886.6667 | 121 | H | |
| 2017 | OXADIAZON | 1 | 2311.667 | 130 | H | H |
| 1910 | OXAMYL | 280000 | 31.57895 | 31.82 | | H |
| 1973 | OXYFLUORFEN | 0.116 | 6601.389 | 175 | H | |
| 410 | OXYTHIOQUINOX | 1 | 22583.33 | 1.55 | | |
| 459 | PARATHION | 12.5 | 1420 | 17.25 | | H |
| 464 | PCNB | 0.1 | 5975 | 224.5 | H | |
| 590 | PEBULATE | 100 | 512.3529 | 6.055 | | H |
| 1929 | PENDIMETHALIN | 0.275 | 15000 | 42 | H | |
| 5889 | PENOXSULAM | 408 | 43.55 | 11.8 | | H |
| 2008 | PERMETHRIN | 0.07 | 277000 | 38.35 | H | |

| Chem-code | Chemical name | SOL | KOC | FD | Runoff potential | |
|---|---|---|---|---|---|---|
| | | | | | sediment | aqueous |
| 675 | PHENMEDIPHAM | 1.8 | 7500 | 63.15 | H | H |
| 478 | PHORATE | 29 | 538.3523 | 1.76 | | H |
| 335 | PHOSMET | 25 | 6288.71 | 8.24 | | |
| 593 | PICLORAM | 430 | 29 | 108 | | H |
| 486 | PIPERONYL BUTOXIDE | 14.3 | 1536.438 | 13.1 | | H |
| 2236 | PRODIAMINE | 0.183 | 8190 | 83.8 | H | |
| 2042 | PROFENOFOS | 28.4 | 2414.286 | 14.295 | | |
| 499 | PROMETON | 393.5 | 100 | 246.5 | | H |
| 502 | PROMETRYN | 32.9 | 240.3333 | 71.1 | | H |
| 503 | PROPANIL | 152 | 468 | 1.38 | | H |
| 445 | PROPARGITE | 1.93 | 7283.333 | 87 | H | H |
| 2276 | PROPICONAZOLE | 100 | 600 | 115 | H | |
| 694 | PROPYZAMIDE | 12.9 | 825 | 53.5 | | H |
| 5232 | PYMETROZINE | 290 | 49.63889 | 169 | | H |
| 5759 | PYRACLOSTROBIN | 19 | 8444.444 | 71 | H | H |
| 3939 | PYRIDATE | 1.49 | 40.96997 | 18.85 | | |
| 4019 | PYRIPROXYFEN | 0.367 | 14436.36 | 26.05 | | |
| 3835 | RIMSULFURON | 5560 | 55 | 7.95 | | H |
| 190 | S,S,S-TRIBUTYL PHOSPHOROTRITHIOATE | 2.3 | 9466.667 | 31.5 | | H |
| 2177 | SETHOXYDIM | 10295 | 50.13095 | 70.4 | | H |
| 603 | SIDURON | 22.3 | 223.9556 | 50.75 | | H |
| 531 | SIMAZINE | 6.15 | 151.7011 | 83.5 | | H |
| 2149 | SULFOMETURON METHYL | 244 | 91.86655 | 15 | | H |
| 2195 | TAU-FLUVALINATE | 0.0122 | 447204.7 | 62 | H | |
| 3850 | TEBUCONAZOLE | 32 | 936.1806 | 224 | H | |
| 3957 | TEBUFENOZIDE | 0.83 | 665.8824 | 36.05 | | |
| 1810 | TEBUTHIURON | 2600 | 79.75 | 690.5 | | H |
| 532 | TERBACIL | 710 | 56.66667 | 208 | | H |
| 1691 | TERBUTRYN | 22 | 2375 | 127 | H | H |
| 580 | TERRAZOLE | 105 | 93.33333 | 8.6 | | H |
| 5598 | THIAMETHOXAM | 4100 | 48.47059 | 92 | | H |
| 3984 | THIAZOPYR | 2.33 | 219.6667 | 69.9 | | H |
| 1933 | THIOBENCARB | 27.5 | 594.7368 | 27.8 | | H |
| 2202 | THIODICARB | 23.5 | 206.1538 | 5 | | H |
| 1696 | THIOPHANATE-METHYL | 24.6 | 300 | 4.2 | | H |
| 2329 | TRALOMETHRIN | 0.08 | 504092.3 | 2.29 | | |
| 2133 | TRIADIMEFON | 64 | 387 | 35.1 | | H |
| 88 | TRICHLORFON | 120000 | 13.91636 | 2.2 | | H |
| 5321 | TRIFLOXYSTROBIN | 0.61 | 3580 | 9.425 | | |
| 2260 | TRIFLUMIZOLE | 18.1 | 710.625 | 6.4 | | H |
| 597 | TRIFLURALIN | 0.3 | 3532.465 | 114.5 | H | |
| 3875 | TRIFLUSULFURON-METHYL | 260 | 55.65217 | 2.895 | | H |
| 2345 | TRINEXAPAC-ETHYL | 15650 | 534.1667 | 1.335 | | H |
| 2129 | VINCLOZOLIN | 3.41 | 292.0741 | 181 | | H |
| 5769 | ZOXAMIDE | 0.681 | 1240 | 12.3 | | |