PROPOSED METHODS FOR DETERMINING WATERSHED-DERIVED PERCENT CROP AREAS AND CONSIDERATIONS FOR APPLYING CROP AREA ADJUSTMENTS TO SURFACE WATER SCREENING MODELS

PRESENTATION TO FIFRA SCIENCE ADVISORY PANEL
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Section 1: Overview

Following passage of the Food Quality Protection Act (FQPA) in 1996, the Office of Pesticide Programs (OPP) has developed procedures and science policies for estimating pesticide concentrations in drinking water to support tolerance assessment. At the July 29, 1998 FIFRA Science Advisory Panel (SAP), OPP proposed replacing the existing "edge of field pond" estimation scenario for screening level exposure assessment of drinking water with an "index" reservoir that would also consider the extent of crop coverage on a watershed scale. This SAP session provides a progress report on the development of "Watershed-derived Percent Crop Areas" (previously termed "crop area factors" in Background Document 3), and seeks scientific advice on implementation of the watershed-derived Percent Crop Areas in the FQPA drinking water exposure assessment using the index reservoir modeling scenario.

Science Policy 5: Estimating The Drinking Water Component of a Dietary Exposure Assessment (Background Document 5) describes the Agency's process for including drinking water exposure in its dietary assessments and its current use of screening models to estimate pesticide exposure in drinking water. Briefly, the process for assessing pesticide exposure from surface water sources of drinking water consists of:

- Collecting all available laboratory and field data submitted by the registrant to assess the fate and transport characteristics of the particular pesticide and any toxic degradation or transformation products.

- Entering pesticide-specific data from these studies in mathematical screening models to estimate pesticide concentrations in water in pesticide use areas.

- Comparing the model screening estimates to human health-based "drinking water levels of comparison" (DWLOC), which are derived after first considering all food-related and residential exposures for which EPA has reliable information.

- If the model estimates of pesticide concentration in drinking water exceed the DWLOC, refining its estimate by gathering available water monitoring data for analysis.

OPP generally does not base significant risk management action (e.g., revocation or denial of a tolerance) on screening model estimates. If monitoring data are available and reliable, OPP scientists analyze this data to derive appropriate short- and long-term exposure concentrations. If monitoring data are not available or are not sufficient for refining the screening level estimates, OPP makes a risk management decision as to the need for targeted surface water monitoring and/or risk mitigation.

OPP currently uses a two-tiered mathematical screening model process to rapidly assess whether pesticides are likely or unlikely to occur at substantial levels in drinking water derived from surface water:

- GENEEC (GENeric Estimated Environmental Concentrations) provides an initial screening level assessment of pesticide concentrations in surface water;

- the linked Pesticide Root Zone Model (PRZM) and EXposure Analysis Model System (EXAMS) models provide a more refined screen by considering site-specific environmental and climatic variables.

Background Documents 1 and 3, from the December 1997 and June 1998 FIFRA SAP presentations, provide more detail on the models. GENEEC and PRZM/EXAMS, initially used by OPP for ecological risk assessments, are two mechanistic models available to OPP for rapidly and cost-effectively producing high-end estimates of pesticide levels in surface water. If the surface water estimates using GENEEC do not exceed the DWLOC, then OPP concludes that the pesticide is not expected to pose an unacceptable risk and no further evaluation is necessary. If the GENEEC results indicate a potential concern, then PRZM/EXAMS modeling refines the estimates of potential pesticide levels in surface water by including more pesticide-specific properties, simulating multiple years to reflect climatic variations, and modeling on a crop-specific basis. In comparison to GENEEC, PRZM/EXAMS includes more site-specific information in the scenario details regarding application method and temporal distribution with weather, and better accommodates specific environmental fate properties of chemicals. Both models represent a relatively small body of water (20 million liter, or 5.3 million gallons in capacity) located at the edge of a 10-hectare (approximately 25 acres) treated field. Both models assume that the entire area draining into the water body is planted to the crop being treated and that the entire crop is treated with the pesticide.

The ultimate goal of the Agency is to have a validated basin-scale model to develop a more refined estimate of pesticide levels in surface water sources of drinking water. OPP presented a preliminary assessment of available watershed-scale surface water models at the 1998 FIFRA SAP (Background Document 3) and is continuing with model evaluation efforts. In the interim, the existing field-scale models are being applied at a watershed-scale, with adaptations intended to reflect watershed-scale use.

As indicated in the July 1998 FIFRA SAP presentation, OPP planned to replace the current field pond scenario used in its screening assessments with an index reservoir based on an actual field reservoir (see Background Documents 3, 4, and 5 for a more detailed discussion). Further, the index reservoir model output would be adjusted for the percentage of the reservoir area in agricultural production to more realistically reflect watershed-scale use. OPP proposed that the watershed-based Percent Crop Area (PCA) adjustment would be applied to the model outputs as an additional step in the screening tier process. If pesticide concentrations (peak and/or long-term average) estimated with the first two screening model tiers (GENEEC and PRZM/EXAMS adapted for the index reservoir) still exceeded levels of concern, then the model results from PRZM/EXAMS would be adjusted by a factor that represents the maximum percent crop area found for the crop or crops being evaluated. While several assumptions and limitations, discussed below, are inherent to this process, OPP believed the incorporation of a PCA factor in the screening process would produce more realistic estimates of pesticide concentrations in surface water sources of drinking water while still resulting in an appropriately conservative or protective screening level estimate.

Overview of the Document

The SAP document contains 4 sections with Section 1 describing the introduction, goals, objectives and critical assumptions and limitations. Section 2 presents the basic approach OPP used to estimate watershed-derived percent crop area (PCA) factors using geographic information system (GIS) technology and gives a brief overview of how the PCA would be applied to screening estimates. Section 3 provides a preliminary evaluation of the PCA adjustment using the index reservoir scenario. Model results are compared to midwestern U.S. reservoir and stream monitoring data for selected corn and soybean herbicides, and to USGS National Water Quality Assessment (NAWQA) data from the Central Valley, CA, for selected minor use crop pesticides. These two groups of data are among the best available for model assessments. It is important to know that both the index reservoir scenario and the PCA adjustment are being calibrated against atrazine monitoring data because that is the most extensive and widespread data available. OPP recognizes the need to evaluate these model refinements using a broader spectrum of pesticides and uses. While a preliminary attempt has been started here, further comparisons are needed. Section 4 describes a comparison of screening model results with available surface water monitoring data for various drinking water assessments completed by OPP.

In developing the PCA, OPP encountered some issues that suggest that implementation of the PCA adjustment with the reservoir scenario in screening level assessments may not provide an appropriately conservative estimate of pesticide levels in surface water. Specifically, we are concerned that PRZM/EXAMS may not be realistically capturing basin-scale processes for all pesticides or for all uses. A preliminary survey of water assessments which compared screening model estimates to readily available monitoring data suggest uneven model results (this is discussed in further detail in Section 4). In some instances, the screening model estimates are more than an order of magnitude greater than the highest concentrations reported in available monitoring data; in other instances, the model estimates are less than monitoring concentrations.

OPP believes the following steps need to be taken to evaluate the effectiveness of PRZM/EXAMS as a screening model:

1. Conduct a sensitivity analysis of PRZM, EXAMS, and the linked models to determine what input factors most influence the model results and identify potential conditions (site, chemical, weather) under which the models may not work as expected.

2. Conduct a more thorough survey of modeling and monitoring comparisons for all pesticides in which such data is available. Identify, to the extent possible, the specific conditions of the monitoring data (e.g., water body, date of sampling, characteristics of the drainage area, cropping patterns and likely pesticide use areas, soils present, weather

patterns, and other possible sources of pesticide exposure). Where more than one modeling scenario was run, compare results of each model run to the monitoring data.

3. Through a systematic comparison of modeling and monitoring data and the ancillary data, attempt to identify specific chemical or scenario characteristics that could be leading to inconsistencies in the modeling results. This evaluation could then be used to determine whether, for certain pesticides or uses, corrections are needed or whether another form of screening is necessary.

Goals

OPP plans to develop watershed-scale models to produce refined estimates of drinking water exposure for pesticides in surface waters. Our current approach uses tiered field-scale modeling developed for aquatic exposure assessments to estimate potential exposure from pesticides in surface water used for drinking water. The current approach is intended to serve as a screening method that distinguishes between pesticides with minimal predicted impact to drinking water from those that may pose a greater risk to human health via drinking water exposure.

The application of percent crop area to the currently-used models for producing screening-level estimates of drinking water exposure from pesticides is also an interim approach. Validated basin scale models and adequate and reliable surface water monitoring data are clearly needed to improve the Agency's ability to accurately estimate pesticide exposure from drinking water surface water sources.

Objectives

The objectives of the Percent Crop Area project are to:

1. Develop a method to estimate watershed-derived percent crop areas (PCA) using Geographical Information System (GIS) technology.

2. Evaluate the utility of the PCA adjustment as a modification to the current screening tools by comparing PCA-adjusted PRZM-EXAMS model estimates, using the Index Reservoir, to the best available monitoring data for a comparative evaluation:
   a. Midwestern U.S. reservoir and stream monitoring data for selected corn and soybean herbicides; and
   b. USGS National Water Quality Assessment (NAWQA) program monitoring data in Central Valley, CA, for selected minor crop pesticides.

3. Identify assumptions and limitations that need to be considered in applying the PCA adjustment to existing OPP surface water screening models.

Our objectives in coming before the SAP are to provide an update on the approach we are considering for developing and using PCA factors, present scientific issues and concerns we have encountered in developing this approach, and request scientific input in resolving these issues and proceeding in improving our screening procedures.

Critical Assumptions and Limitations

The PCA is a watershed-based modification. Implicit in its application is the assumption that the currently-used field-scale models to which it is applied reflect basin-scale processes consistently for all pesticides and uses. In other words, we are making the assumption that PRZM/EXAMS is indeed modeling a watershed. This project does not attempt to validate PRZM, EXAMS, or the linkage between PRZM-generated runoff and the fate and transport modeled by EXAMS. These models and model scenarios have not been well validated; however, ongoing and future efforts by the Agency and industry should increase our confidence in the modeled predictions. If the models fail to capture pertinent basin-scale fate and transport processes consistently for all pesticides and all uses, the application of a factor that reduces the estimated concentrations predicted by modeling could, in some instances, result in inadvertently passing a chemical through the screen that may actually pose a risk.

For the GIS analysis, the spatial data was derived from readily-available sources that have inherent limitations due to their scale (1:2,000,000 for the watershed and county coverages). The conversion of the county level data to watershed-based percent crop areas assumes the distribution of the crops within a county is uniform and homogeneous throughout the county area. Other limitations of the spatial analysis include the assumption that the watershed area which contributes surface runoff is spatially uniform and the condition of adjacency between the treated fields and the surface water bodies are not considered. These two limitations should be addressed in future watershed-scale modeling efforts if the goal is to develop realistic predictions of the pesticide concentrations from runoff into surface waters. The crops data were obtained from the 1992 Census of Agriculture which is the most readily available county level data for this project. However, recent changes in the agriculture sector from farm bill legislation may significantly impact the distribution of crops throughout the country. The methods described in this report can rapidly be updated as more current agricultural crops data are obtained. Although yearly changes in cropping patterns may occur, we assume this variation will cause minimal impact to the interim goals described in this report. This project only evaluates pesticides applied to agricultural crops so any contributions to surface waters from non-agricultural uses such as urban environments are not considered. Furthermore, this project does not consider percent crop treated with one or more pesticides because pesticide usage data is extremely limited at this time.

Available monitoring data for pesticides in surface waters are very limited. Sample distribution and frequency typically are not sufficient for accurately predicting peak concentrations and the data examined in this report normally cover a very limited time span (frequently less than 5 years with typical ranges from 1-3 years).

Questions for the SAP Panel

1. Given preliminary comparisons between modeling and monitoring data, and the information presented regarding development of a Percent Crop Area (PCA), does the SAP think the PCA adjustment to PRZM/EXAMS modeling is a reasonable approach to obtain more accurate and appropriately conservative estimates of pesticide concentrations in surface water for screening evaluations of drinking water exposure? If the steps are not considered to be appropriately conservative for screening evaluations, does the SAP have any recommendations for how the EPA should use PCAs in its drinking water assessment process?

2. A GIS data processing method for calculating the PCA was presented. If we are able to resolve concerns regarding current model and monitoring inconsistencies, does the SAP think this GIS procedure is an appropriate method to account for the portion of the watershed planted to the crop or crops of interest?

3. In estimating water concentrations for pesticides applied to multiple crops in a watershed, we modeled each crop separately, applied the maximum PCA to the modeled results, and then summed the outputs. For example, the model results for corn multiplied by the maximum PCA of 0.46 and the results for soybeans, multiplied by 0.41, were then summed to provide an estimate of pesticide concentrations for metolachlor use on corn and soybeans. Limitations to this approach may occur when the pesticide is used on multiple crops (such that the equivalent PCA is greater than 100%) or when the timing and/or rates of application vary for different uses. Can the SAP provide any recommendations for determining a reasonable assessment process that considers multiple uses of one or more pesticides within a watershed?

4. Evaluation of this project required PRZM/EXAMS modeling of selected crops with the preliminary version of the index reservoir scenario. Furthermore, the comparison relied on available reservoir and surface water monitoring data from limited sources (e.g., ARP, USGS NAWQA program). This evaluation produced variable results with some cases in which available monitoring data exceeded modeled results and other cases in which modeled data are conservative (i.e., clearly higher than available monitoring data). In the document overview, we have proposed steps to evaluate PRZM/EXAMS for inconsistencies as a screening model. What suggestions does the SAP have that could help us better understand these inconsistencies?

5. The PRZM developer has indicated the model has scale limitations when changing from field to watershed to basin scales. Possible sources of error when changing scales may be caused by using a single curve number for the entire basin, the hydraulic length, and simplifications for field scale processes that may not apply to the more complex basin scale. In addition, the application of the PCA in this report involves differing scales: PRZM is a field-scale model, the PCAs are generated from basin-scale areas (8-digit

hydrologic units), and the index reservoir represents a watershed scale. Does the SAP have any recommendations for addressing the scale limitations of this model? Can the SAP suggest other watershed-based, mechanistic models that could estimate environmental concentrations of pesticides in drinking water?

6. The proposed application of "percent crop areas" for watershed modeling does not consider "percent crop treated" for one or several pesticides. Because pesticides in drinking water sources is a localized concern, a national percent crop treated estimate is not appropriate. At this time, data on percent crop treated at the farm are extremely limited, available only in New York and California. Does the SAP think it would be reasonable for the Agency to develop a method similar to the PCA approach to incorporate "percent crop treated" into the model refinements?

Section 2: Development of Methodology to Estimate Watershed-derived Percent Crop Areas with Geographical Information Systems (GIS) Technology

The current PRZM-EXAMS modeling for drinking water exposure assessment assumes the watershed is completely planted with the crop of interest (i.e., 100% cropping coverage). The 100% cropped watershed assumption is reasonable for field scale aquatic exposure such as a farm pond adjacent to a corn field in the Midwest states. For modeling of drinking water exposure assessment, the assumption of 100% cropped watersheds may not be reasonable. This section discusses the development of watershed-derived percent crop areas using GIS tools as an interim corrective approach to modeling drinking water exposure assessments in conjunction with the Index Reservoir. The method discussed below is similar to the unpublished procedure developed by the USGS for interpreting the NAWQA study sites (G. P. Thelin, USGS, personal communication, 1999).

Method for Deriving a Watershed-Based Percent Crop Area

Agricultural crop data for the United States are collected at a county level by the U.S. Department of Agriculture. The Census of Agriculture collects county-level crop data every 5 years. For this work, we examined the 1992 Agricultural Census county-level data for five major crops (corn, soybeans, wheat, cotton and potatoes) and five minor crops (apples, citrus, grapes, peanuts, strawberries). Additional minor crops for Central Valley, California discussed in Section 3 of this report included almonds, apricots, alfalfa, and walnuts.

Two principal GIS coverages (County boundaries, 8-digit Hydrologic Unit Codes) were the primary spatial data sources for this analysis. Watershed boundaries (8-digit HUCs) were obtained from 1 to 2,000,000 scale Hydrologic Unit map of the conterminous United States (Allord, 1992; **http://water.usgs.gov/lookup/getcover?huc2m**) and contains Hydrologic Unit Boundaries and Codes for the conterminous United States. This coverage was developed for regional and national data display rather than specific local data analysis due to the small scale of this coverage. County boundaries were obtained from the 1;2,000,000-scale map of county boundaries for the conterminous United States (Lanfear, 1994; **http://water.usgs.gov/lookup/getcover?county2m**). This coverage was derived from the Digital Line Graph (DLG) files representing the 1:2,000,000-scale map in the National Atlas of the United States and used as the base map for the county crops information.

The watershed-derived percent crop areas for each of the 10 crops were calculated by intersecting the HUC coverage and the County Crop coverage in Arc-View 3.1 using the geoprocessing analysis tool. The areas for the resulting polygons within each 8-digit HUC were updated using the Update Area feature to indicate the corrected hectares of the new polygons (Figure 2-1). The percent county area was multiplied by the updated polygons areas to calculate the hectares of crop for each watershed. The calculated crop area was summed for each watershed and then divided by the total watershed area to determine the area-weighted "watershed-based percent crop area" or PCA (expressed as a decimal). These values were ranked from largest to smallest value and the maximum value for each crop is listed in Table 2-1. The ranked values were also checked by comparison to the county maps to verify that data processing errors were not contained within the final output. For example, initial calculations of the soybean PCA revealed a maximum value of 0.92 which resulted from an error during geoprocessing in which the HUC also included some estuarine (non *terra firma*) area. The maximum PCAs for each crop are applied to surface water modeling results for the Index Reservoir scenario in Section 3 of this report. Figures 2-2 through 2-6 illustrate the percent crop area for each major crop (corn, soybeans, wheat, cotton, and potatoes).

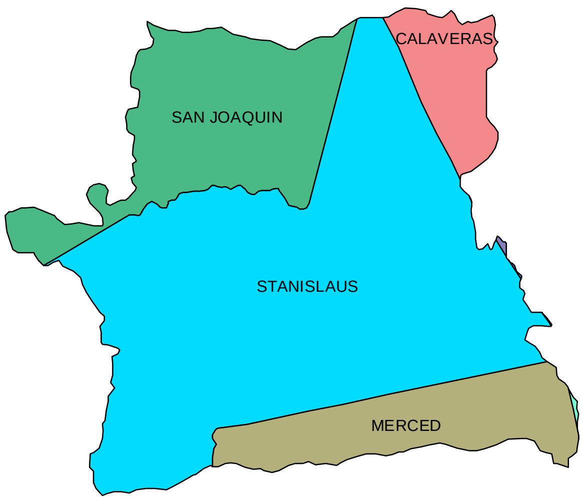


Figure 2-1. Example of Intersected HUC 18040002 with County Boundaries, Central Valley, California.

Table 2-1. Summary of Maximum Percent Crop Areas (without Land Use coverage)			
Crop	Maximum Percent Crop Area (as a decimal)	Hydrologic Unit Code (8-digit)	State
Corn	0.46	07090007 07100003	Illinois Iowa
Soybeans	0.41	08020201	Missouri
Wheat	0.56	09010001	North Dakota
Cotton	0.20	08030207	Mississippi
Potatoes	0.06	02080101	North Dakota
Apples	0.06	18020117 18030008 18030009 18030010	California (all four HUCs)

Grapes	0.03	04140101	New York
Citrus	0.14	03080203	Florida
Peanuts	0.09	03130010 03130004	Georgia, Alabama, and Florida
Strawberries	0.012	18060001	California

Adjustments for Land Use/Land Cover

Most PCAs presented in this report were calculated without considering land use/land cover information. Land use/land cover data can help give a more refined estimate of a PCA because it can help to better define a crops distribution within a county. This can be important in areas where geography limits crops to one area of a county, but is not important in areas such as the midwest where crops are evenly distributed. We used PCAs calculated without land use/land cover data on our corn and soybean modeling, but used land use/land cover adjusted PCAs for modeling done for the minor crops in California. The calculation of land use/land cover adjusted PCAs for the hydrologic unit from California is presented at the end of section 3.

Application of the PCA Adjustment to Screening Models

OPP plans to use the watershed-based PCA adjustment as an additional step in its tiered screening process. The PCA adjustment would be applied only to those pesticides which still exceeded levels of concern after going through the first (GENEEC) and second (PRZM/EXAMS with the index reservoir scenario) screens. For a single crop, the output generated by the PRZM/EXAMS model would be multiplied by the maximum PCA (expressed as a decimal fraction) generated for the crop in question. As an example, for a pesticide used only on corn, the PRZM/EXAMS estimated environmental concentrations would be multiplied by 0.46.

A pesticide with multiple uses raises certain questions in applying the PCA. Should the maximum PCA for each crop be summed together or should individual PCAs for the combined crop uses be generated for each combination? In the section that follows, the PCA for corn and soybeans for metolachlor was generated by adding together the individual PCAs for each crop, even though the PCAs were derived from different areas of the country. For the minor crops evaluated against the Central Valley NAWQA data, a single PCA representing the combined crop acreage was used. In the case of the former approach, a combined PCA of greater than 100% could be generated by summing the maximum PCAs for each crop used. In the latter approach, PCAs would have to be generated for each crop combination being evaluated. Other issues raised by the multiple crop use approach include the application rate to select (whether to use the maximum application rate from the combination of uses or split application rates) and the timing (the modeling assumes the pesticide is applied to all fields at the same time). In each case, more complex adjustment steps require more time and resources and introduce additional levels of uncertainty. Some steps may be feasible in a higher tier screening approach while others may be better left for consideration in a validated basin scale model.

Figure 2-2. Distribution of Watershed-derived Percent Crop Areas for Corn.

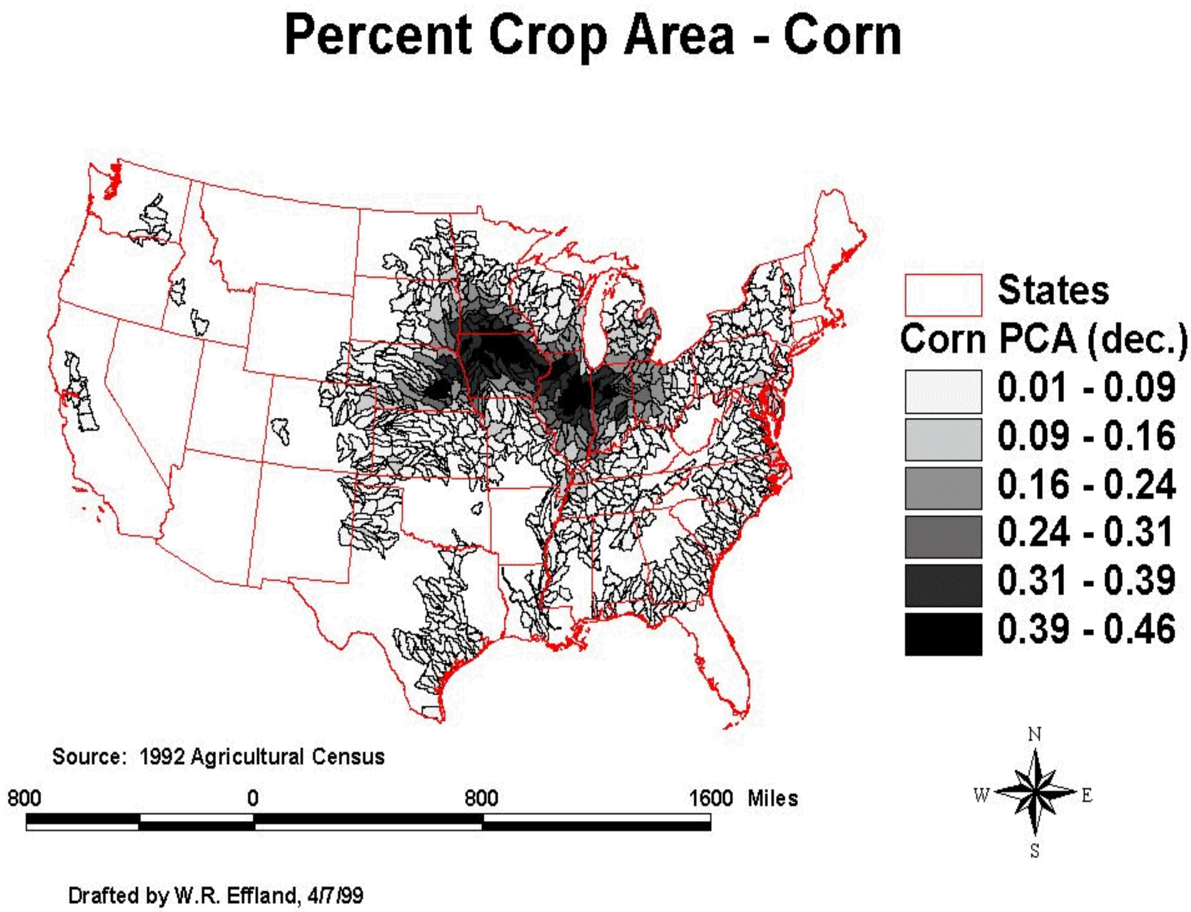


Figure 2-3. Distribution of Watershed-derived Percent Crop Areas for Cotton.

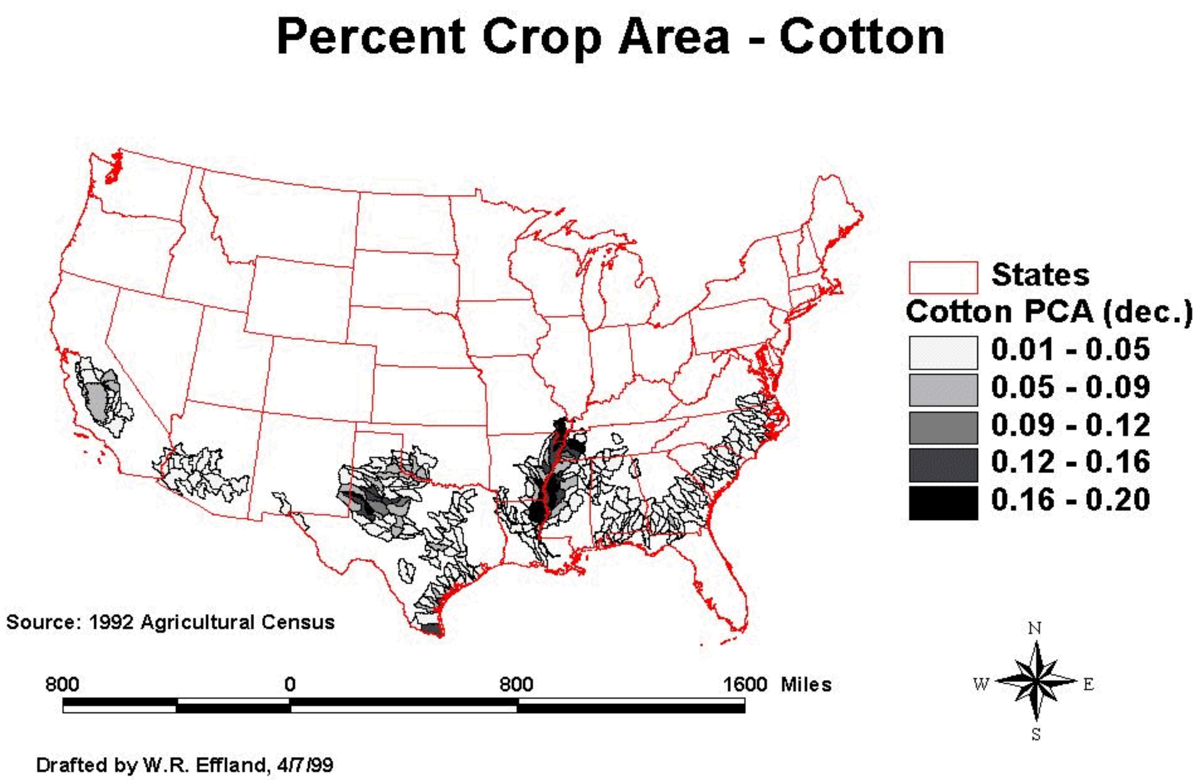


Figure 2-4. Distribution of Watershed-derived Percent Crop Areas for Peanuts.

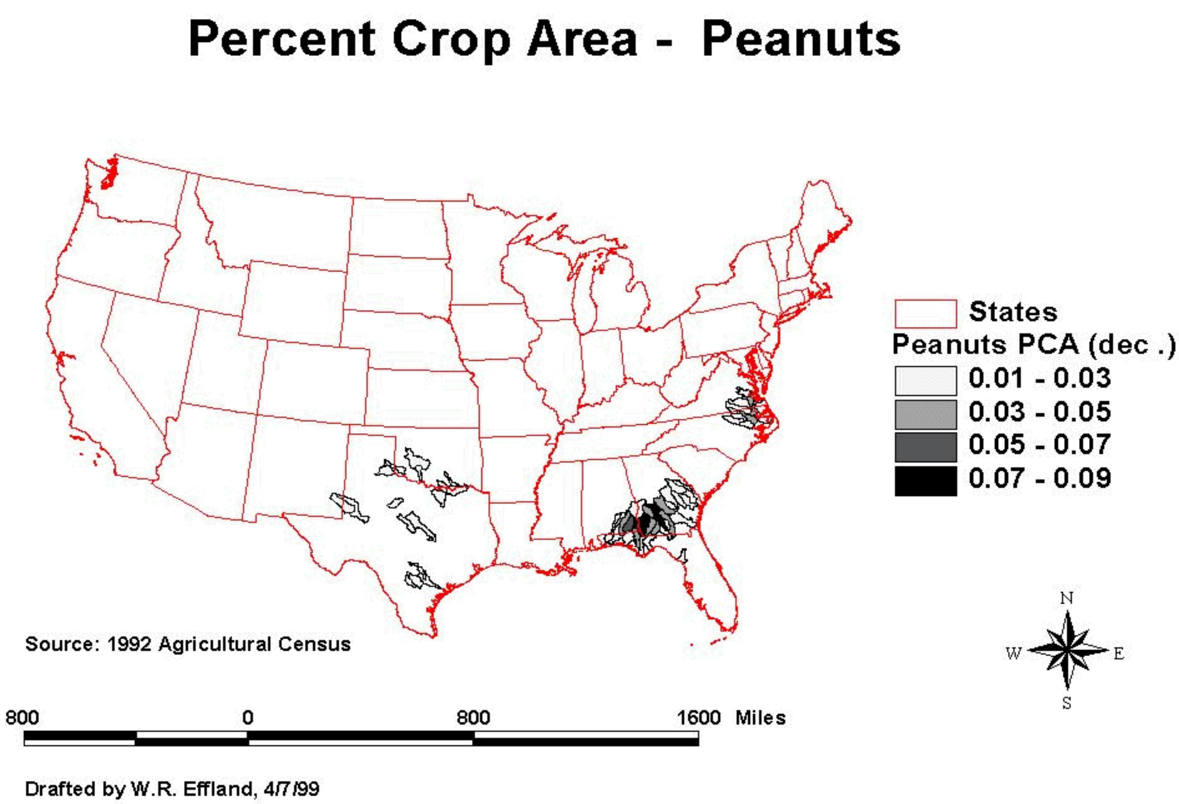


Figure 2-5. Distribution of Watershed-derived Percent Crop Areas for Soybeans.

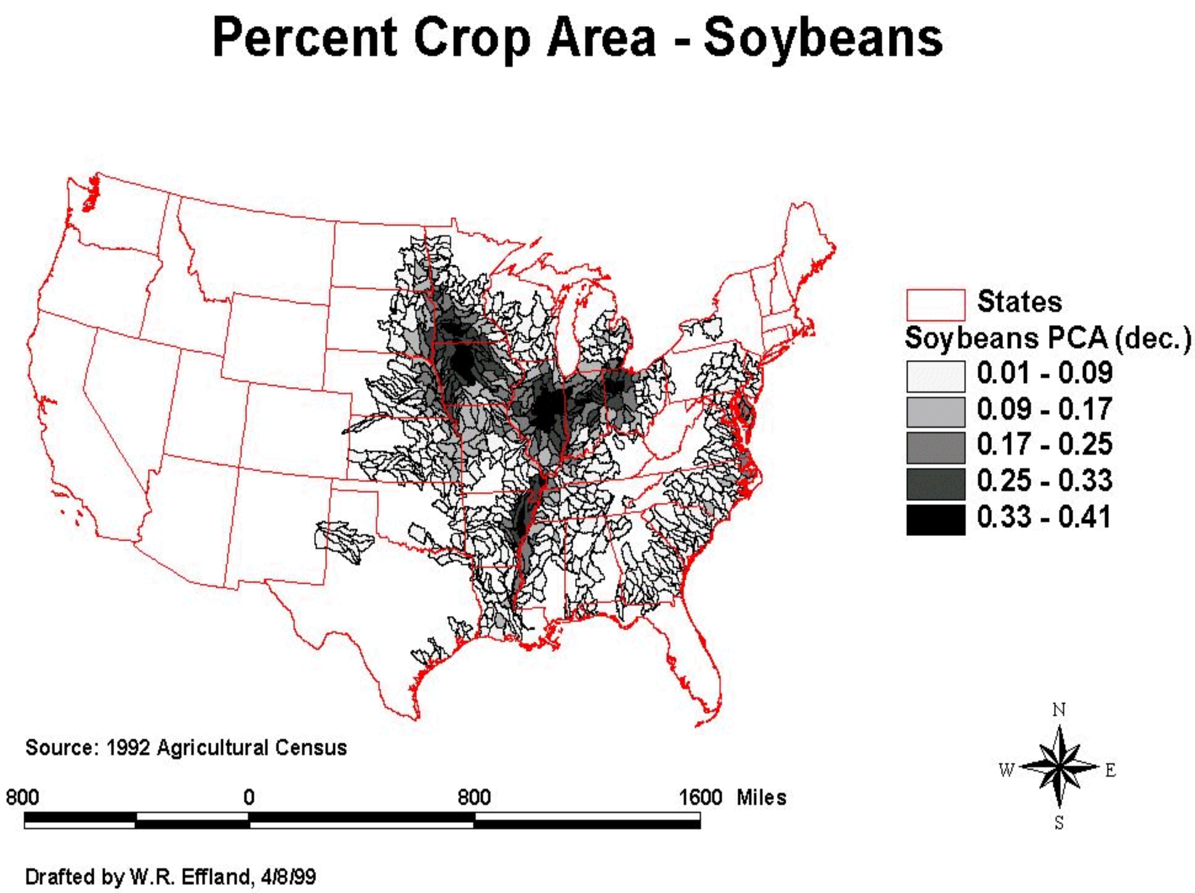
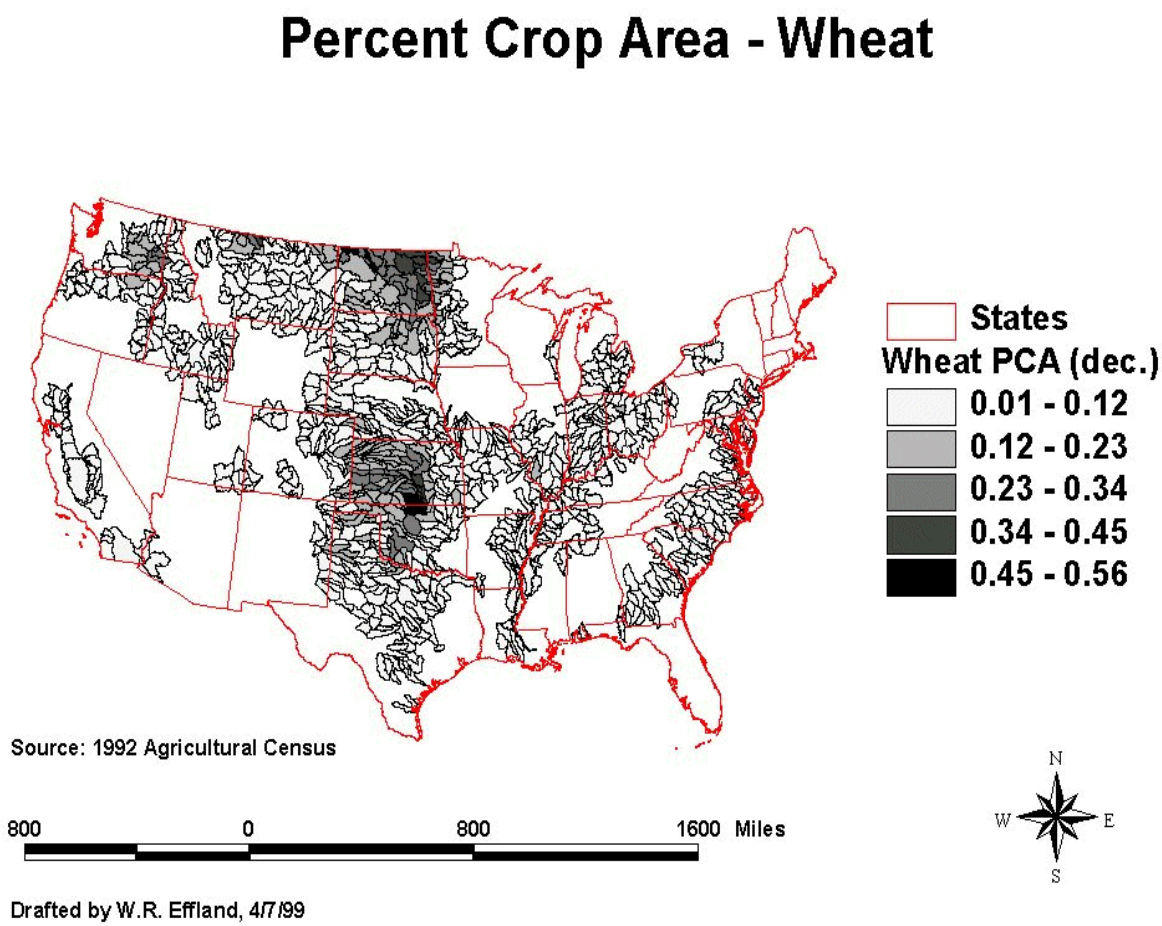


Figure 2-6. Distribution of Watershed-derived Percent Crop Areas for Wheat.



Section 3: Comparison of PCA-Adjusted Modeling Results With Monitoring Data

When OPP initially presented the Crop Area Factor (now Percent Cropped Area, or PCA) approach to the December 1997 FIFRA SAP, the panel recommended that OPP "validate" the approach against monitoring data, particularly the "extensive data available for corn herbicides in the Midwest" (FIFRA SAP, 1997; Background Document 2). The original approach proposed applying the PCA to GENEEC (Tier 1) modeling results. In July 1998, OPP proposed an index reservoir (IR) to replace the existing farm pond scenario used in PRZM/EXAMS (Tier 2) modeling. While OPP is currently in the process of replacing the original index reservoir (Shipman City Lake, IL), the results of the evaluation showed the impact of incorporating the PCA into the modeling approach (FIFRA SAP, 1998; Background Document 3). PRZM/EXAMS modeling with the IR resulted in higher estimated atrazine concentrations than predicted using the standard farm pond; however, when the IR was adjusted for the PCA of 0.25 for corn, concentrations were lower (Table 3-1).

Table 3-1: Comparison of Atrazine Concentrations from Use on Corn Estimated by PRZM/EXAMS with (a) Farm Pond Scenario, (b) IR, and (c) PCA-adjusted IR with Available Monitoring Data for Shipman City Lake (adapted from Background Document 3).

	Peak (μg/L)		**Annual Mean (μg/L)**		**Overall Mean (μg/L)**[1]	
	Median	**90%**[2]	**Median**	**90%**[2]	**Mean**	**UCL_{90}** [3]
Model: Standard Farm Pond	9	56	4	12	6	7
Model: Index Reservoir (IR)	15	132	5	33	11	15
Model: PCA-adjusted IR 4	4	33	1	8	3	4
Monitoring: ARP, 1995 [5]	3		2			
Monitoring: ARP, 1996 [5]	35		12			

[1] Modeling results based on 34 years of simulations, from 1950-1983.
[2] Ninety percent values are greater than ninety percent of peak or annual mean values.
[3] Upper 90% confidence bound on the mean
[4] PCA of 0.25, based on corn acreage in Macoupin County, IL
[5] Concentrations are for treated water samples taken from Shipman City Lake (Hackett, 1996, 1997)

The monitoring data for Shipman City Lake come from an acetochlor registration partnership (ARP) surface water monitoring study (Hackett, 1996, 1997), consisting of 14 finished water samples taken in each of 1995 and 1996. Because this data is for treated water, the concentrations in the untreated water from the reservoir is expected to be higher than those reported. The crop adjustment factor used in the 1998 SAP presentation was based on data from Macoupin County, IL, rather than on the watershed draining into the reservoir. The PCA-adjusted 90% peak concentration was roughly equal to the peak concentration reported for Shipman City Lake in 1996. The upper 90% annual mean concentration (based on 34 years of simulations) estimated using the standard farm pond scenario was nearly identical to the mean concentration found in Shipman City Lake in 1996, while the PCA-adjusted model estimate was lower. Because of the limited size of the monitoring database, both in terms of frequency of sampling per year and number of years of sampling, a more extensive comparison of PCA-adjusted modeling data to available monitoring data is needed.

The application of the PCA to model estimates will result in a reduction in the estimated concentrations by the fractional area of the watershed planted to the crop or crops being evaluated. OPP uses these models to screen out those pesticides which are not likely to be found in surface water sources of drinking water at concentrations sufficient to pose a health concern and to identify those pesticides for which more extensive assessments, including monitoring studies, are needed. To be effective as an adjustment to screening model estimates, the PCA should result in estimated concentrations that are closer to, but not less than, actual pesticide concentrations in vulnerable (prone to pesticide-laden runoff) surface water sources.

Modeling and Monitoring For Corn-Soybean Herbicides in the Midwestern U.S.

The monitoring studies that follow provide an initial assessment of ability of PCA-adjusted model estimates to serve as a screen for selected corn-soybean herbicides. Limitations in available monitoring data make a rigorous assessment of the effect of the PCA-adjustments on the screening capabilities of PRZM-EXAMS difficult. Specifically:

- Few pesticide monitoring studies have been conducted for more than a few years over a geographically broad range. More monitoring data exist for streams and rivers than for reservoirs, which are believed to be more vulnerable to pesticide contamination.

- Most reservoir studies cover a limited scope of pesticides with respect to the extent of use and the physiochemical properties of the compounds studied. More data are available for the corn herbicides than other pesticides. Inferences from monitoring data using these herbicides assume that other pesticides behave similarly in the field and are handled similarly in model simulations.

- The sampling frequency in the monitoring studies is not sufficient to make meaningful comparisons of peak concentrations in the reservoir. The farther apart the sample intervals are spaced, the less is the likelihood that the sampling will capture the true peak concentration of the pesticide in the reservoir. Estimates of medians or mean annual concentrations also depend on the frequency and spacing of the sampling.

- The USGS National Water Quality Assessment (NAWQA) provided non-targeted pesticide data on a number of watersheds throughout the U.S. In some of the sub-basin sampling sites, the sampling frequency (2-3 days during the growing season) provides the best chance of detecting short-term peak concentrations. However, the sampling stations represent flowing water bodies (streams, rivers) with short residence times. Longer-term concentrations would likely be lower than in reservoir with longer residence times.

The reservoirs and watersheds sampled in these studies are concentrated in areas identified as having a high potential for soil, pesticide, and nitrogen runoff (Kellogg et al, 1997). The data sets are limited in time. Rainfall, an important pesticide runoff driver, varies in frequency and timing from year-to-year, and studies of short duration are less likely to capture the range in pesticide concentrations possible in reservoirs. Fallon (1994) observed that timing, as well as frequency and magnitude, of rainfall events are all critical factors controlling pesticide concentrations in reservoirs.

Monitoring Data on Corn-Soybean Herbicides in the Midwest

ARP Reservoir Study, 1995-1997 (Hackett, 1996, 1997, 1998). The ARP Reservoir Study is part of the Acetochlor Registration Partnership agreement in which concentrations of acetochlor, alachlor, and atrazine are being monitored in drinking water sources in 10 states, from Iowa and Minnesota across the upper midwest and east to Delaware. The surface water portion of the study includes sampling of treated water from 175 facilities and of untreated (raw, infiltration gallery, and mixed water) water from 37 of those facilities. Fourteen samples were taken in each of the sample years (1995-1997). Table 3-2 summarizes the concentrations of atrazine in the reservoirs from which untreated water samples were taken.

Table 3-2: Atrazine Concentrations in Raw, Infiltration Gallery, and Mixed Water in Reservoirs Sampled as a Part of the Acetochlor Registration Partnership (ARP) Study, 1995-1997.

Site ID	City	State	Year	No. Samples	Atrazine Concentration, µg/L Maximum	Median	Mean[1]	95%UCL[2]
556-DA-IA	Davenport	IA	1995	14	2.3	0.2	0.4	0.6
			1996	14	1.8	0.2	0.5	0.7
			1997	15	1.2	0.2	0.2	0.4
			All	43	2.3	0.2	0.4	0.5
574-OS-IA	Osceola	IA	1995	14	2.1	1.0	1.2	1.5
			1996	14	7.7	5.5	4.3	5.7
			1997	15	4.3	2.4	2.4	2.7
			All	43	7.7	2.0	2.6	3.2
577-RA-IA	Centerville	IA	1995	14	2.8	2.0	2.1	2.3
			1996	14	5.5	3.3	3.2	3.7
			1997	15	2.5	1.7	1.8	1.9
			All	43	5.5	2.0	2.3	2.6
557-DM-IA	Des Moines	IA	1995	16	1.1	0.4	0.4	0.5
			1996	26	1.4	0.3	0.4	0.5
			1997	28	1.0	0.2	0.2	0.3
			All	70	1.4	0.2	0.3	0.4
582-WI-IA	Winterset	IA	1995	14	5.8	2.6	2.4	3.3
			1996	14	5.7	1.7	2.3	3.3
			1997	15	5.2	2.1	2.2	3.0
			All	43	5.8	2.1	2.3	2.8
569-MI-IA	Milford	IA	1995	--	--	--	--	--
			1996	14	0.3	0.2	0.2	0.3
			1997	15	0.2	0.2	0.2	0.2

Table 3-2: Atrazine Concentrations in Raw, Infiltration Gallery, and Mixed Water in Reservoirs Sampled as a Part of the Acetochlor Registration Partnership (ARP) Study, 1995-1997.

Site ID	City	State	Year	No. Samples	Atrazine Concentration, µg/L Maximum	Median	Mean[1]	95%UCL[2]
			All	29	0.3	0.2	0.2	0.2
222-HI-IL	Highland	IL	1995	14	4.8	4.0	3.0	3.9
			1996	14	13.4	3.7	4.9	7.0
			1997	15	2.9	1.1	1.3	1.9
			All	43	13.4	2.5	3.0	3.8
228-SA-IL	Salem	IL	1995	14	10.9	2.8	3.8	5.3
			1996	14	74.7	2.4	15.6	26.7
			1997	15	1.6	0.6	0.6	0.8
			All	43	74.7	1.2	6.5	10.2
168-PA-IL	Paris	IL	1995	14	5.9	1.8	2.3	3.1
			1996	14	20.8	7.3	7.3	10.3
			1997	15	3.9	1.5	1.5	2.1
			All	43	20.8	1.9	3.7	4.8
170-AL-IL	Altamont	IL	1995	14	1.4	0.8	0.9	1.0
			1996	14	7.0	5.5	4.2	5.5
			1997	15	4.1	1.8	1.9	2.2
			All	43	7.0	1.5	2.3	2.9
197-EL-IL	Elgin	IL	1995	14	0.2	0.1	0.1	0.1
			1996	14	1.2	0.1	0.2	0.4
			1997	15	1.0	0.1	0.2	0.3
			All	43	1.2	0.1	0.2	0.2
244-SP-IL	Sparta	IL	1995	14	4.3	0.9	1.2	1.9
			1996	14	3.4	1.8	1.6	2.1
			1997	15	9.3	1.8	3.4	5.0
			All	43	9.3	1.3	2.1	2.7
245-OL-IL	Olney	IL	1995	14	5.8	3.6	3.3	4.3
			1996	14	3.7	2.9	2.5	3.0
			1997	15	3.0	2.4	2.1	2.4
			All	43	5.8	2.4	2.6	3.0
259-SP-IL	Springfield	IL	1995	14	8.5	4.6	4.3	5.7
			1996	14	14.1	2.8	4.2	6.0
			1997	15	1.6	0.8	0.9	1.0
			All	43	14.1	2.5	3.1	3.9
268-NA-IL	Nashville	IL	1995	14	14.4	7.4	7.4	9.7
			1996	14	23.6	5.8	9.4	13.0
			1997	15	7.7	3.3	3.5	4.7
			All	43	23.6	4.8	6.7	8.1
603-BL-IL	Hudson	IL	1995	14	3.9	1.2	1.5	2.2
			1996	14	3.0	1.8	1.5	1.9
			1997	15	1.8	0.5	0.6	0.8
			All	43	3.9	0.8	1.2	1.5
606-KA-IL	New Athens	IL	1995	14	15.7	3.7	4.1	5.9
			1996	14	17.0	4.9	5.1	7.4
			1997	15	11.6	1.2	2.3	3.6
			All	43	17.0	2.9	3.8	4.8
152-BR-IL	Breese	IL	1995	--	--	--	--	--
			1996	13	10.7	2.1	2.7	4.2

Table 3-2: Atrazine Concentrations in Raw, Infiltration Gallery, and Mixed Water in Reservoirs Sampled as a Part of the Acetochlor Registration Partnership (ARP) Study, 1995-1997.

Site ID	City	State	Year	No. Samples	Atrazine Concentration, µg/L Maximum	Median	Mean[1]	95%UCL[2]
			1997	15	8.1	0.8	1.6	2.7
			All	28	10.7	0.8	2.1	3.0
225-CE-IL	Centralia	IL	1995	--	--	--	--	--
			1996	--	--	--	--	--
			1997	15	3.8	1.7	1.7	2.3
			All	--	--	--	--	--
332-MC-IN	Michigan City	IN	1995	14	0.1	0.1	0.1	0.1
			1996	14	0.1	0.1	0.1	0.1
			1997	15	0.1	0.1	0.1	0.1
			All	43	0.1	0.1	0.1	0.1
344-DU-IN	Dubois	IN	1995	14	1.1	0.3	0.4	0.6
			1996	14	0.9	0.4	0.4	0.5
			1997	15	0.6	0.4	0.3	0.4
			All	43	1.1	0.4	0.4	0.5
346-SA-IN	Salem	IN	1995	14	1.3	0.9	0.7	0.9
			1996	14	1.1	0.6	0.6	0.8
			1997	--	--	--	--	--
			All	28	1.3	0.8	0.7	0.8
328-KO-IN	Kokomo	IN	1995	--	--	--	--	--
			1996	14	2.8	0.7	1.0	1.4
			1997	15	6.3	1.0	1.6	2.5
			All	29	6.3	0.8	1.3	1.8
345-RI-IN	Richmond	IN	1995	--	--	--	--	--
			1996	--	--	--	--	--
			1997	15	15.9	4.1	5.0	7.4
			All	--	--	--	--	--
351-SE-IN	Seymour	IN	1995	--	--	--	--	--
			1996	--	--	--	--	--
			1997	15	10.0	0.7	1.5	2.7
			All	--	--	--	--	--
89-MI-KS	Milford	KS	1995	14	5.4	1.7	2.3	3.0
			1996	14	5.1	1.3	2.1	2.7
			1997	15	2.8	1.0	1.3	1.7
			All	43	5.4	1.3	1.9	2.2
296-SC-MN	St. Cloud	MN	1995	14	0.7	0.1	0.2	0.3
			1996	14	0.5	0.1	0.1	0.2
			1997	15	0.1	0.1	0.0	0.1
			All	43	0.7	0.1	0.1	0.1
1069-VA-MO	Vandalia	MO	1995	--	--	--	--	--
			1996	14	21.5	4.8	7.4	10.9
			1997	15	31.3	4.9	9.0	14.1
			All	29	31.3	4.9	8.2	11.2
1070-WY-MO	Wyaconda	MO	1995	--	--	--	--	--
			1996	14	4.6	0.2	1.1	1.9
			1997	15	7.2	3.6	3.5	4.7
			All	29	7.2	0.9	2.3	3.1
1009-CO-MO	Concordia	MO	1995	--	--	--	--	--

Table 3-2: Atrazine Concentrations in Raw, Infiltration Gallery, and Mixed Water in Reservoirs Sampled as a Part of the Acetochlor Registration Partnership (ARP) Study, 1995-1997.

Site ID	City	State	Year	No. Samples	Atrazine Concentration, µg/L Maximum	Median	Mean[1]	95%UCL[2]
			1996	13	4.4	1.6	2.4	3.0
			1997	15	8.0	3.4	4.3	5.8
			All	28	8.0	3.1	3.4	4.3
1016-HI-MO	Higginsville	MO	1995	--	--	--	--	--
			1996	--	--	--	--	--
			1997	15	5.0	3.6	3.3	4.0
			All	--	--	--	--	--
593-HE-PA	Hummelston	PA	1995	14	0.6	0.1	0.1	0.2
			1996	14	0.7	0.1	0.1	0.2
			1997	15	1.5	0.1	0.2	0.3
			All	43	1.5	0.1	0.1	0.2
737-AW-PA	Norristown	PA	1995	14	0.3	0.1	0.1	0.2
			1996	14	1.7	0.1	0.2	0.4
			1997	15	0.2	0.0	0.0	0.1
			All	43	1.7	0.1	0.1	0.2
997-WE-PA	Mechanicsburg	PA	1995	14	0.7	0.2	0.2	0.3
			1996	14	0.4	0.2	0.2	0.3
			1997	15	1.0	0.1	0.2	0.3
			All	43	1.0	0.2	0.2	0.3
596-DE-PA	Denver	PA	1995	14	0.3	0.0	0.0	0.1
			1996	14	0.2	0.0	0.0	0.1
			1997	14	0.1	0.0	0.0	0.0
			All	42	0.3	0.0	0.0	0.0
13-AP-WI	Appleton	WI	1995	14	0.1	0.1	0.1	0.1
			1996	14	0.4	0.1	0.1	0.2
			1997	15	0.7	0.1	0.2	0.2
			All	43	0.7	0.1	0.1	0.2
18-OK-WI	Oshkosh	WI	1995	14	0.3	0.1	0.1	0.1
			1996	14	0.7	0.1	0.2	0.3
			1997	15	0.3	0.1	0.1	0.2
			All	43	0.7	0.1	0.1	0.2

[1] Arithmetic mean of 14 samples; with concentrations < limit of detection (LOD) set equal to the LOD.
[2] Upper 95% confidence bound on the mean

The highest concentrations of atrazine occurred in reservoirs located in Illinois. The reservoir serving Salem, IL, had the highest peak (74.7 µg/L in 1996) and mean annual (15.6 µg/L with a 95% upper confidence bound of 26.7 µg/L in 1996) concentrations. Over the entire 3-year monitoring period, the reservoir serving Nashville, IL had the highest median (4.8 µg/L) and mean (6.7 µg/L with a 95% upper confidence bound of 8.1 µg/L) concentrations of atrazine. The reservoir serving Vandalia, MO, had a 2-year median of 4.9 µg/L and mean of 8.2 µg/L (95% percent upper confidence bound of 11.2 µg/L). Peak concentrations of greater than 20 µg/L occurred during at least one year in 4 of the 37 reservoirs. Ten reservoirs had peak atrazine concentrations greater than 10 µg/L during at least one year.

USGS Midwestern Reservoir Study, 1992-93 (Scribner et al, 1996). USGS collected water samples from 76 reservoirs in the midwestern United States between April 1992 and September 1993. The reservoirs were sampled 4 times in 1992 (in early spring before herbicide application, during the first major runoff after application, after significant flushing of the reservoir during late summer, and in early fall) and 4 times in 1993 (in early and late winter, during midsummer, and in September). Water samples collected from the reservoir outflow were analyzed for 11 pre-emergent herbicides and 6 metabolites. Tables 3-3 and 3-4 summarize atrazine and metolachlor concentrations for each of the reservoirs. The 6 reservoirs which had no recorded detects of atrazine and 23 reservoirs with no detects of metolachlor were not included in the analysis because no determination could be made as to whether the non-detects were due to pesticide not reaching the reservoir or to an absence of use of the pesticide in the watershed.

Table 3-3: Summary of Atrazine Concentrations in 70 Midwestern Reservoirs Sampled by the USGS in 1992-93 (Scribner et al, 1996).

State	Reservoir	Atrazine Concentration, µg/L			
		Maximum	**Median**	**Mean**[1]	**95% UCL**[2]
IA	Rathbun Lake	3.5	2.2	2.0	2.6
	Lake Panorama	1.0	0.4	0.4	0.7
	Coralville Lake	3.8	0.3	0.7	1.6
	Lake Red Rock	2.8	0.6	0.8	1.4
	Saylorville Lake	2.4	0.3	0.6	1.2
IL	Carlyle Lake	5.8	3.3	3.2	4.5
	Rend Lake	4.3	1.0	1.4	2.3
	Lake Decatur	5.5	0.7	1.4	2.7
	Lake Shelbyville	2.1	1.6	1.4	1.9
	Lake Vermillion	5.3	1.2	2.0	3.4
	Crab Orchard Lake	1.5	0.4	0.5	0.9
	Little Grassy Lake	0.4	0.1	0.2	0.2
	Devils Kitchen Lake	0.4	0.1	0.2	0.3
IN	Patoka Lake	0.3	0.1	0.1	0.2
	Brookville Lake	2.4	1.5	1.4	1.8
	Morse Reservoir	12.1	2.4	3.4	6.2
	Huntington Lake	7.7	1.1	2.3	4.4
	Eagle Creek Reservoir	3.6	2.5	2.1	3.0
	Mississinewa Lake	10.7	4.1	4.0	6.8
	Monroe Lake	0.2	0.1	0.1	0.2
	Mansfield Lake	4.2	1.7	2.0	2.9
	Cataract Lake	11.0	2.2	2.9	5.4
	Salamonie Lake	9.8	3.4	4.2	7.0
	Lake Shafer	1.5	0.3	0.5	0.9
KS	Clinton Lake	1.6	1.2	1.2	1.4
	Kanopolis Lake	1.0	0.7	0.7	0.9
	Milford Lake	4.0	2.0	2.4	3.1
	Perry Lake	2.9	1.9	1.9	2.5
	Hillsdale Lake	3.0	2.5	2.2	2.7
	Waconda Lake	2.8	2.0	2.0	2.3
	Pomona Lake	2.5	2.0	1.9	2.3
	Tuttle Creek Lake	4.2	1.6	1.7	2.5
	Wilson Lake	0.4	0.2	0.2	0.3
MN	Sandy Lake Reservoir	0.1	0.1	0.1	0.1

Table 3-3: Summary of Atrazine Concentrations in 70 Midwestern Reservoirs Sampled by the USGS in 1992-93 (Scribner et al, 1996).

State	Reservoir	Atrazine Concentration, µg/L			
		Maximum	Median	Mean[1]	95% UCL[2]
	Winnibigoshish Reservoir	0.1	0.1	0.1	0.1
	Leech Lake Reservoir	0.1	0.1	0.1	0.1
	Gull Lake Reservoir	0.1	0.1	0.1	0.1
	Lac Qui Parle Reservoir	1.6	0.2	0.4	0.9
	Cross Lake	0.4	0.0	0.1	0.2
MO	Harry S Truman Reservoir	2.7	1.2	1.3	1.8
	Harrisonville Lake	3.8	3.3	2.7	3.6
	Smithville Lake	3.1	2.4	2.4	2.8
	Long Branch Lake	2.5	1.4	1.5	1.9
	Mark Twain Lake	2.5	2.1	1.9	2.3
ND	Pipestem	0.1	0.1	0.1	0.1
NE	Enders Reservoir	0.3	0.1	0.1	0.2
	Cunningham Lake	1.2	0.7	0.7	0.9
	Harry Strunk Lake	1.4	0.3	0.5	0.9
	Hugh Butler Lake	0.7	0.4	0.4	0.5
	Harlan County Lake	1.4	1.3	1.2	1.4
	Swanson Lake	0.3	0.2	0.2	0.3
	Branched Oak Lake	3.0	2.5	2.5	2.8
	Pawnee Lake	3.3	1.8	2.0	2.4
	Willow Creek	2.6	0.4	0.9	1.5
OH	Delaware Lake	5.9	1.8	2.4	3.8
	Harrisonville Lake	3.8	3.3	2.7	1.5
	O'Shaughnessy Reservoir	12.4	1.3	3.0	6.1
	Hoover Reservoir	4.1	1.3	1.7	2.5
	Milton Reservoir	1.9	0.9	0.9	1.4
	Dillon Lake	4.9	0.7	1.2	2.4
	Deer Creek Lake	4.1	2.0	2.0	2.8
SD	Sand Lake	0.1	0.1	0.1	0.1
WI	Lake 7746	0.7	0.2	0.2	0.4
	Lake Mendota 254	0.4	0.3	0.3	0.3
	Lakes Waubesa	0.3	0.2	0.2	0.2
	Lake Monona	0.3	0.3	0.3	0.3
	Lake Menomin 1761	0.4	0.1	0.1	0.3
	Lake Wausau 4016	0.2	0.1	0.1	0.1
	Spring Valley Lake	2.0	0.3	0.7	1.3
	Chippewa Flowage	0.3	0.1	0.1	0.1

[1] Arithmetic mean of 14 samples; with concentrations < limit of detection (LOD) set equal to the LOD.
[2] Upper 95% confidence bound on the mean

Four reservoirs – Morse, Mississinewa, and Cataract in Indiana and O'Shaughnessy in Ohio – had peak atrazine concentrations of greater than 10 µg/L during the sample period. Salmonie Lake, IN, and Mississinewa Lake, IN, had the highest mean and 95% upper confidence bound concentrations (4.2 and 7.0 µg/L and 4.0 and 6.8 µg/L, respectively). Mississinewa Lake had the highest median concentration (4.1 µg/L).

Table 3-4: Summary of Metolachlor Concentrations in 53 Midwestern Reservoirs Sampled by the USGS in 1992-93 (Scribner et al, 1996).

State	Reservoir	Metolachlor Concentration, µg/L			
		Maximum	Median	Mean[1]	95% UCL[2]
IA	Rathbun Lake	0.6	0.2	0.2	0.3
	Lake Panorama	0.5	0.2	0.3	0.4
	Coralville Lake	1.5	0.2	0.4	0.7
	Lake Red Rock	1.6	0.4	0.5	0.9
	Saylorville Lake	1.7	0.3	0.5	1.0
IL	Carlyle Lake	1.4	0.2	0.5	0.8
	Rend Lake	0.1	0.1	0.1	0.1
	Lake Decatur	2.8	0.4	0.8	1.4
	Lake Shelbyville	1.3	0.3	0.4	0.7
	Lake Vermillion	1.3	0.4	0.5	0.8
	Crab Orchard Lake	0.1	0.1	0.1	0.1
IN	Brookville Lake	0.6	0.2	0.3	0.4
	Morse Reservoir	5.3	0.8	1.6	2.9
	Huntington Lake	4.3	0.5	1.3	2.4
	Eagle Creek Res	2.3	1.3	1.3	1.9
	Mississinewa Lake	4.9	1.6	1.9	3.1
	Mansfield Lake	1.9	0.6	0.7	1.1
	Cataract Lake	4.6	0.7	1.1	2.2
	Salamonie Lake	4.3	1.6	1.8	2.8
	Lake Shafer	0.4	0.1	0.2	0.3
KS	Clinton Lake	0.3	0.1	0.2	0.2
	Kanopolis Lake	0.2	0.1	0.1	0.1
	Milford Lake	1.4	0.4	0.5	0.8
	Perry Lake	1.9	0.4	0.7	1.1
	Hillsdale Lake	0.8	0.1	0.2	0.4
	Waconda Lake	0.6	0.2	0.3	0.4
	Pomona Lake	0.7	0.3	0.3	0.5
	Tuttle Creek Lake	2.9	0.8	0.9	1.6
MN	Lac Qui Parle Res	1.2	0.1	0.2	0.5
	Cross Lake	0.1	0.1	0.1	0.1
MN	Harry S Truman Res	0.3	0.1	0.2	0.2
	Harrisonville Lake	1.9	0.4	0.6	1.0
	Smithville Lake	0.5	0.3	0.3	0.4
	Long Branch Lake	0.1	0.1	0.1	0.1
	Mark Twain Lake	0.5	0.2	0.3	0.3
NE	Harry Strunk Lake	0.2	0.1	0.1	0.1
	Hugh Butler Lake	0.1	0.1	0.1	0.1
	Harlan County Lake	0.2	0.1	0.1	0.1
	Branched Oak Lake	0.1	0.1	0.1	0.1
	Pawnee Lake	0.3	0.1	0.1	0.1
	Willow Creek	0.9	0.1	0.3	0.5
OH	Delaware Lake	3.1	0.6	1.1	1.9
	Harrisonville Lake	1.9	0.4	0.6	0.4
	O'Shaughnessy Res	6.1	0.7	1.6	3.2
	Hoover Reservoir	1.1	0.4	0.5	0.7
	Milton Res	0.5	0.2	0.2	0.4
	Dillon Lake	2.7	0.2	0.6	1.2

Table 3-4: Summary of Metolachlor Concentrations in 53 Midwestern Reservoirs Sampled by the USGS in 1992-93 (Scribner et al, 1996).

State	Reservoir	Metolachlor Concentration, µg/L			
		Maximum	Median	Mean[1]	95% UCL[2]
	Deer Creek Lake	2.4	0.4	0.8	1.3
WI	Lake 7746	0.1	0.1	0.1	0.1
	Lake Mendota 254	0.1	0.1	0.1	0.1
	Lake Monona	0.1	0.1	0.1	0.1
	Lake Menomin 1761	0.2	0.1	0.1	0.1
	Chippewa Flowage	0.1	0.0	0.0	0.0

[1] Arithmetic mean of 14 samples; with concentrations < limit of detection (LOD) set equal to the LOD.

[2] Upper 95% confidence bound on the mean

The highest peak concentration of metolachlor detected in the study occurred in O'Shaughnessy Reservoir in Ohio at 6.1 µg/L. Mississinewa Lake in Indiana had the highest median (1.6 µg/L) and mean (1.8 µg/L with a 95% upper confidence bound of 3.1 µg/L) concentrations reported in the studies.

Atrazine concentrations reported in the USGS monitoring study are less than those found in the ARP study. Several factors may explain this difference:

(1) Length of Study: The USGS study covered a 17-month period, while the ARP data covers 3 years. The greater the time span, the more likely the study is to capture the scope of the year-to-year variation in pesticide concentrations.

(2) Frequency of Sampling: The ARP study collected more samples per year (at least 14-15 per year) than did the USGS study and was thus had a greater chance of capturing high and low pesticide concentrations. Even at this frequency, it is unlikely that the ARP study captured the true peak concentration in the sampled reservoirs.

(3) Sample Collection Point Within the Reservoir: The ARP study collected water samples at the water supply intake while the USGS study collected samples downstream of the reservoirs at the outflow. Fallon (1994) observed a pesticide concentration gradient between the reservoir inflow and outflow. The gradient changed over the season, with the highest reservoir concentrations occurring on the upstream end (inflow) after the runoff flush of pesticides and the lowest concentration at that time occurring at the downstream end (outflow). As the pesticide pulse moved down the reservoir, pesticide concentrations were diluted by the reservoir water. Depending in the location of the water supply intake in the reservoir, pesticide concentrations could be greater than that found at the outflow.

USGS NAWQA White River Basin Study (Crawford, 1997). The White River Basin covers 11,350 square miles of central and southern Indiana and includes six hydrogeomorphic regions (Figure 3-1). Agriculture accounts for 70 percent of the watershed, with corn and soybeans accounting for 78 percent of all cropland (40 percent of the basin). Corn and soybean production is most extensive in the northern, southwestern, and southeastern portions of the basin. Approximately 96 percent of all agricultural pesticide use in the basin is on corn and soybeans, with herbicide use on corn accounting for about 70 percent of that use (Crawford, 1995, 1997).

The USGS web site (Crawford, 1997) provides data on 16 pesticides in streams at the 11 sampling stations. Atrazine, metolachlor, and simazine were the three most commonly detected pesticides throughout the entire basin (100, >99, and 92 percent detections, respectively). Table 3-5 summarizes the concentrations of these pesticides found at each sampling station. Unlike the ARP and USGS Midwest Reservoir studies, the data for the NAWQA White River Basin study represent pesticide concentrations from flowing water bodies. With the short residence times, peak pesticide concentrations in streams are likely to be lower than those found in water bodies with longer residence times, such as reservoirs.

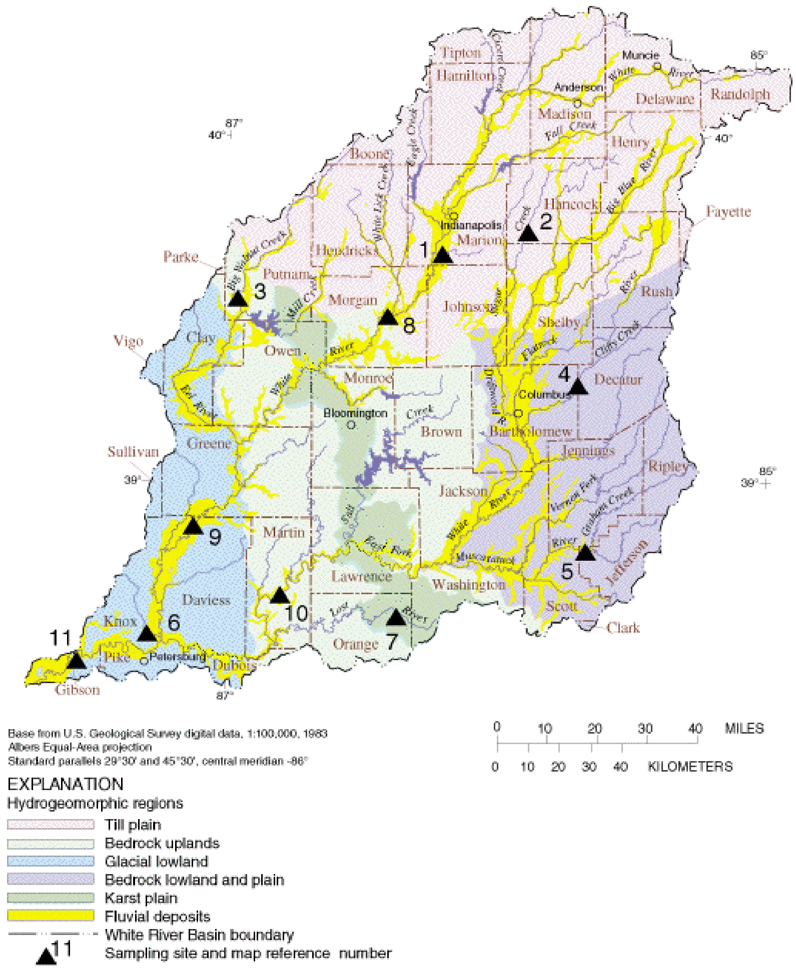


Figure 3-1: White River Basin (IN), showing hydrogeomorphic regions and sampling locations. http://www-dinind.er.usgs.gov/nawqa/wr05001.htm .

Table 3-5: Atrazine, Simazine, and Metolachlor Concentrations at Stream/River Sample Stations in the White River Basin, IN, USGS NAQWA Study (Crawford, 1997).

Map No.	Land Use % ag/forest/urban	Sample Dates	Pesticide	Total No., n > LOD	Concentration, µg/L Max.	Median	Mean[1]	UCL_{95}[2]
INDICATOR SITES IN THE TILL PLAIN								
1	42/<1/ 57	5/92-9/96	Atrazine	120/120	14.0	0.2	0.6	0.9
			Simazine	120/117	0.7	0.0	0.1	0.1
			Metolachlor	120/120	9.1	0.1	0.3	0.4
2	95/1/3	5/92-9/96	Atrazine	112/112	27.0	0.4	0.2	2.6

Table 3-5: Atrazine, Simazine, and Metolachlor Concentrations at Stream/River Sample Stations in the White River Basin, IN, USGS NAQWA Study (Crawford, 1997).

Map No.	Land Use % ag/forest/urban	Sample Dates	Pesticide	Total No., n > LOD	Concentration, µg/L Max.	Median	Mean[1]	UCL_{95}[2]
			Simazine	112/88	1.2	0.0	0.1	0.1
			Metolachlor	112/112	11.6	0.2	0.8	1.1
3	83/15/1	4/94-4/95	Atrazine	16/16	2.3	0.4	0.9	1.3
			Simazine	16/16	1.2	0.1	0.2	0.3
			Metolachlor	16/16	1.0	0.2	0.4	0.5
INDICATOR SITES IN THE BEDROCK LOWLAND AND PLAIN								
4	98/1/<1	4/94-5/95	Atrazine	19/19	16.0	1.2	4.6	6.9
			Simazine	19/19	0.7	0.1	0.2	0.2
			Metolachlor	19/19	2.8	0.3	0.9	1.3
5	71/24/4	4/94-4/95	Atrazine	16/16	6.6	0.6	1.2	2.0
			Simazine	16/16	0.5	0.0	0.1	0.1
			Metolachlor	16/16	3.4	0.1	0.4	0.8
INDICATOR SITE IN THE GLACIAL LOWLAND								
6	94/4/<2	3/93-8/95	Atrazine	55/55	120 (e)[3] 24.0	1.0[3] 1.0	4.8[3] 2.7	8.5[3] 3.7
			Simazine	55/54	2.3	0.1	0.2	0.3
			Metolachlor	55/55	17.0	0.6	1.6	2.3
INDICATOR SITE IN THE KARST PLAIN								
7	94/5/<1	4/94-5/95	Atrazine	18/18	14.5	0.9	2.9	4.7
			Simazine	18/18	7.2	0.1	1.2	2.2
			Metolachlor	18/18	3.7	0.2	0.6	1.0
INTEGRATOR SITES								
8	78/3/18	4/94-3/95	Atrazine	15/15	1.5	0.2	0.4	0.6
			Simazine	15/15	0.3	0.1	0.1	0.1
			Metolachlor	15/15	1.0	0.1	0.2	0.3

Table 3-5: Atrazine, Simazine, and Metolachlor Concentrations at Stream/River Sample Stations in the White River Basin, IN, USGS NAQWA Study (Crawford, 1997).

Map No.	Land Use % ag/forest/urban	Sample Dates	Pesticide	Total No., n > LOD	Concentration, µg/L Max.	Median	Mean[1]	UCL_{95}[2]
9	71/19/8	4/94-5/95	Atrazine	17/17	22.0	0.9	2.9	5.3
			Simazine	17/17	0.9	0.1	0.2	0.3
			Metolachlor	17/17	3.4	0.3	0.9	0.3
10	69/25/5	4/94-5/95	Atrazine	16/16	8.9	0.6	1.7	2.8
			Simazine	16/16	0.4	0.1	0.1	0.2
			Metolachlor	16/16	3.6	0.2	0.6	1.0
11	69/22/7	5/91-9/96	Atrazine	183/183	13.4	0.8	2.0	2.4
			Simazine	183/166	1.2	0.1	0.2	0.2
			Metolachlor	183/180	5.3	0.3	0.8	0.9

[1] Arithmetic mean, with concentrations < limit of detection (LOD) set equal to the LOD.
[2] Upper 95% confidence bound on the mean
[3] Atrazine concentration of 120 µg/L measured at this sampling site is an estimated value, outside the range of the method calibration. Summary statistics are calculated both including this sample (top row of numbers) and excluding the sample (bottom row).

A peak atrazine concentration of 27 µg/L was detected at an indicator site in the till plain. A concentration of 120 µg/L reported at the indicator site in the glacial lowland fell outside the range of the method calibration and was reported as an estimated value. The highest mean concentration for atrazine (excluding the estimated value) occurred in the bedrock lowland and plain region (4.6 µg/L with a 95% upper confidence bound of 6.8 µg/L). The highest detected concentrations for simazine were found in the karst plain (peak of 7.2 µg/L, mean of 1.2 µg/L, upper confidence bound of 2.2 µg/L) while the highest detected concentrations for metolachlor occurred in the glacial lowland (peak of 17.0 µg/L, mean of 1.6 µg/L, upper confidence bound of 2.3 µg/L). Peak concentrations for atrazine in the basin samples were within the range of peak concentrations reported for the Illinois reservoirs sampled in the ARP study.

Perry Lake, KS, 1992-3 (Fallon, 1994). Fallon (1994) conducted five seasonal surveys of the Perry Lake reservoir (1992 pre-application, first runoff event after herbicide application, summer, fall, and 1993 pre-application), along with monthly sampling of the main stream feeding the reservoir, in the reservoir, and downstream below the outfall. The Perry Lake watershed is located in the dissected glacial till plain. Land use is primarily dry-land farming, with 30-60% of the land in crops, principally sorghum, wheat, corn, soybeans, hay. Atrazine is used on corn, sorghum, and winter wheat.

The upstream station showed 3 peaks of atrazine in the April - August period (7 µg/L on

4/24/92; 26 µg/L on 6/12; 18 µg/L on 7/10). Atrazine concentrations dropped to <1 µg/L in the stream between September and the following April. In the reservoir, 1992 pre-application survey concentrations ranged from <1 µg/L at the upstream end to 5 µg/L at the downstream end. After the first flush, the highest concentrations (5-29 µg/L) were found in the headwaters, with mixing occurring downstream in the reservoir. During the summer, the pulse of water with the highest concentrations (4-5 µg/L) moved to the middle of the reservoir. By the fall, atrazine concentrations were consistently between 3-4 µg/L, compared to <1 µg/L in the headwaters. By the time of the 1993 pre-application survey, concentrations were <1 µg/L throughout the reservoir, among the lowest recorded levels for Perry Lake. Below the lake, at the outfall, concentrations varied little (2-4.5 µg/L) between April and November and decreased slowly between November and April.

While precipitation during the study period was 26% greater than average, most of the excess fell during March, July, September, and November 1992. Four soaking rains in late April, at the beginning of the growing season, were followed by little precipitation in May and June. Most of the significant rainfall occurred after July 15th, near the end of the critical period when atrazine is most available for runoff. Rainfall in mid- to late-July accounted for half of the atrazine loading in the reservoir. Later runoff events diluted atrazine concentrations and mass in the reservoir and served to flush the atrazine out of the lake. A comparison of precipitation and runoff data during the study period to historical data suggest that runoff during the critical April-July period was lower than normal while the higher-than-normal rainfall in later months served to dilute the atrazine concentrations in the lake and accelerate flushing of the pesticide from the reservoir. Fallon estimated that the atrazine concentrations measured in Perry Lake were likely lower than average.

Comparison of Monitoring Data to Modeling Results for Corn-Soybean Herbicides in the Midwest U.S.

We used PRZM 3.12 (dated May 7, 1998) and EXAMS 2.97.5 (dated June 11, 1997) to simulate applications of atrazine and simazine on corn and metolachlor simulations on corn and soybeans in the midwest. Runoff from PRZM fed into an index reservoir based on Shipman City Lake, the same reservoir used to test the index reservoir concept in the July 1998 SAP presentation. A description of the site- and reservoir-specific inputs for the Shipman reservoir can be found in the July 1998 FIFRA SAP document (FIFRA SAP, 1998; Background Document 3). Although Shipman City Lake will be replaced by another midwestern reservoir to serve as an index reservoir in modeling for drinking water assessments, it is representative of a number of reservoirs in the central Midwest that are known to be vulnerable to pesticide contamination.

Chemical-specific inputs for atrazine, simazine, and metolachlor can be found in Table 3-6. Model simulations used scenarios for corn and soybeans grown in the Shipman City Lake, IL, watershed, with weather data representing Major Land Resource Area (MLRA) M114. This data is for the period 1948 to 1983 at the Louisville, KY, meteorological station W93821. The soil data represent a Clinton silt loam (classified as a fine smectitic, mesic Chromic Vertic Hapludalf;

SCS Hydrologic Group B). For screening evaluations of pesticides used on corn, OPP currently uses a scenario developed for corn grown on a Hydrologic Group C soil (Cardington silt loam, classified as a fine, illitic mesic Aquic Hapludalf) in Ohio and weather data from MLRA M111. While the overall precipitation was slightly greater with the MLRA M114 data, the Ohio soil is more prone to runoff. As a result, estimated pesticide concentrations in water simulated with the Ohio scenario are expected to be greater than those simulated with the Illinois scenario. For comparison, both scenarios were run for atrazine. The specific inputs for the PRZM-EXAMS modeling are in Appendix A.

Table 3-6. Pesticide and chemical parameters for atrazine, simazine, and metolachlor used in the simulations.

Parameter	Atrazine	Simazine	Metolachlor
Pesticide Application Rate	1 at 2.24 kg/ha	1 at 3.36 kg/ha	1 at 3.87 kg/ha
Application Method	broadcast, unincorporated	broadcast, unincorporated	broadcast, unincorporated
K_d , L/kg	0.7	1.3	4.8
Aerobic soil half-life, days	146	135	67
Molecular Weight, g/mol	216	202	284
Vapor Pressure, torr	3×10^{-7}	6.1×10^{-9}	3×10^{-7}
Henry's Law Constant, atm-m^3/mol	2.6×10^{-9}	3.2×10^{-2}	2.6×10^{-9}
Solubility, mg/L	33	3.5	53.0

Table 3-7 compares 1-in-10 year values (identified as UCL) for the peak and annual mean concentrations simulated from the modeling with monitoring data. These model values are currently used for drinking water assessments, with the peak estimate corresponding to acute values and the annual mean corresponding to chronic values. The table also includes median values for the peak and annual mean. The upper 90% confidence bound based on the standard deviation of the annual means is provided for the overall mean. The PCA adjustment is applied to the model outputs. The model results are compared with the highest peak, median, and 95% upper confidence bound mean concentrations from the monitoring studies. The median value represents the "typical" or "central tendency" exposure level and the upper confidence bound of the mean represents a "high end" exposure level. Because the data are non-normally distributed, the median is more robust than the mean (i.e., less sensitive to extreme values) and better represents the "central tendency."

Table 3-7: Comparison of Selected Corn/Soybean Herbicide Concentrations Estimated by PRZM/EXAMS with and without PCA Adjustments to Available Monitoring from Selected Midwestern Studies.

	Peak (µg/L)		Annual Mean (µg/L)		Overall Mean (µg/L)[1]	
	Median	UCL[2]	Median	UCL[2]	Mean	UCL[2]
Atrazine Use on Corn						

Table 3-7: Comparison of Selected Corn/Soybean Herbicide Concentrations Estimated by PRZM/EXAMS with and without PCA Adjustments to Available Monitoring from Selected Midwestern Studies.

	Peak (µg/L)		**Annual Mean (µg/L)**		**Overall Mean (µg/L)[1]**	
	Median	**UCL[2]**	**Median**	**UCL[2]**	**Mean**	**UCL[2]**
IL Modeling, unadjusted	15	123	6	31	10	14
IL Model, PCA-adjusted[3]	7	57	3	14	5	7
OH Modeling, unadjusted	34	140	11	37	16	20
OH Model, PCA-adj.[3]	16	64	5	17	8	9
ARP: Salem, IL	75		2	27	7	10
USGS: White River, IN	27		1	7	–	–
USGS Midwest Reserv.[4]	12		4	7	–	–
USGS NAQWA[5]	120					
Simazine Use on Corn						
Modeling, unadjusted	36	174	14	70	26	34
Modeling, PCA-adjusted[3]	17	80	6	32	12	16
USGS: White River	7		0	2	–	–
USGS NAQWA[5]	20					
Metolachlor Use on Corn and Soybeans						
Modeling, unadjusted	49	277	20	87	33	39
Modeling, PCA-adjusted[3]						
(a) corn-soybean comb	40	233	17	73	27	33
(b) corn only	22	127	9	40	15	18
USGS Midwest Reserv.[4]	6		2	3	–	–
USGS: White River	17		1	2	–	–
USGS NAQWA[5]	70					

Table 3-7: Comparison of Selected Corn/Soybean Herbicide Concentrations Estimated by PRZM/EXAMS with and without PCA Adjustments to Available Monitoring from Selected Midwestern Studies.

	Peak (µg/L)		Annual Mean (µg/L)		Overall Mean (µg/L)[1]	
	Median	**UCL[2]**	**Median**	**UCL[2]**	**Mean**	**UCL[2]**

[1] Modeling results based on 36 years of simulations, from 1948-1983; the overall mean for the ARP reservoir is based on 3 years of data; all other studies reflect one year of data.
[2] For model data, the UCL for the peak and annual mean concentrations is the 1-in-10 year value which is greater than ninety percent of the annual values; for the overall mean, it is the upper 90% confidence bound on the mean. For the monitoring data, the peak is the highest concentration reported; the UCL for the mean is the upper 95% confidence bound on the mean.
[3] The IL model simulates runoff from a hydrologic group B soil into the index reservoir; the OH model simulates runoff from a hydrologic group C soil into the index reservoir. Corn PCA was 0.46; soybean PCA was 0.41; the combined PCA was 0.87.
[4] Peak concentration occurred in O'Shaughnessy Reservoir, OH; median and UCL concentrations occurred in Mississinewa Lake, IN.
[5] Summary of pesticide occurrence for all 1058 surface water sites sampled as part of the NAQWA studies, 1992-1996.

The unadjusted model estimates bounded the highest reported peak concentrations for atrazine in the ARP data. When the PCA adjustment was applied, the model estimated dropped below the highest reported monitoring concentrations. PCA-adjusted model estimates were still greater than reported monitoring data for metolachlor and simazine on corn.

Another way of evaluating the effectiveness of the modeling and the PCA adjustment of the modeling data as a screening tool is to consider the number of reservoirs for which the pesticide concentrations are less than the predicted model values. Table 3-8 summarizes the number of reservoirs in the ARP and USGS Midwest Reservoir studies for which measured concentrations of atrazine and metolachlor were less than those predicted by modeling. Because of the limited sampling frequency and range of years sampled in both studies, the peak concentrations reported in these studies do not necessarily capture the actual peak concentrations of the pesticides in the reservoirs. The comparisons may be more relevant for longer-term concentrations (median, which represents the central tendency of the data, or upper confidence bound on the mean).

Table 3-8: Number of Reservoirs in the ARP and USGS Midwest Reservoir Studies With Reported Pesticide Concentrations Exceeding the Model Estimates in At Least 1 Year of Monitoring.

	1-in-10 Yr Peak		Median Annual Mean		1-in-10 Yr Ann. Mean	
	Not adjusted	**PCA-adjusted[1]**	**Not adjusted**	**PCA-adjusted[1]**	**Not adjusted**	**PCA-adjusted[1]**
			Atrazine			
Model estimate, µg/L, IL	123	57	6	3	31	14

Model est., µg/L, OH	140	64	11	5	37	17
ARP study vs. IL est.	0/37	1/37	2/37	12/37	0/37	2/37
ARP study vs. OH est.	0/37	1/37	0/37	3/37	0/37	1/37
USGS midwest study	0/70	0/70	0/70	5/70	0/70	0/70
Metolachlor						
Model estimate, µg/L	277	127	20	9	87	40
USGS midwest study	0/53	0/53	0/53	0/53	0/53	0/53

[1] PCA of 0.46 for corn was used for both atrazine and metolachlor.

Currently, OPP uses 1-in-10 year peak and annual mean model estimates as screening values to determine whether the pesticide passes the screen or further evaluation is necessary. Table 3-8 shows that, for the reservoirs where monitoring data are available, PCA adjustment of the means would result in underpredictions of peak atrazine concentrations in 1 of 37 ARP study reservoirs and of mean annual atrazine concentrations in 2 of 37 ARP study reservoirs using the IL scenario. The OH scenario, which used a soil that is more prone to runoff, resulted in slightly higher model estimates and covered all but one of the reservoirs in the ARP study. The PCA adjustment resulted in no underpredictions for either atrazine or metolachlor in the USGS midwest study reservoirs.

Modeling and Monitoring In the Central Valley of California

The Central Valley of California is one of the richest agricultural areas in the United States. Crops grown in the area range from artichokes and alfalfa to watermelons and walnuts. The San Joachin River, which runs north through the valley to its mouth in the San Francisco Bay, is also one of the few areas where minor crops are grown and surface water samples have been taken.

We chose five crops (alfalfa, almonds, grapes, apricots and walnuts) and three pesticides (diazinon, simazine and chlorpyrifos) for our comparison. These were chosen because the crops are relatively major crops in the area (although they still occupy less than 10% of the land area) and relatively major pesticides and because the pesticides were analyzed for in the NAWQA program. Of the three pesticides, chlorpyrifos is used on alfalfa, almonds and walnuts, diazinon is used on almonds and apricots, and simazine is used on almonds, grapes and walnuts. The crops chosen are the highest use crops for each chemicals, representing the majority of the use of the three chemicals in the area.

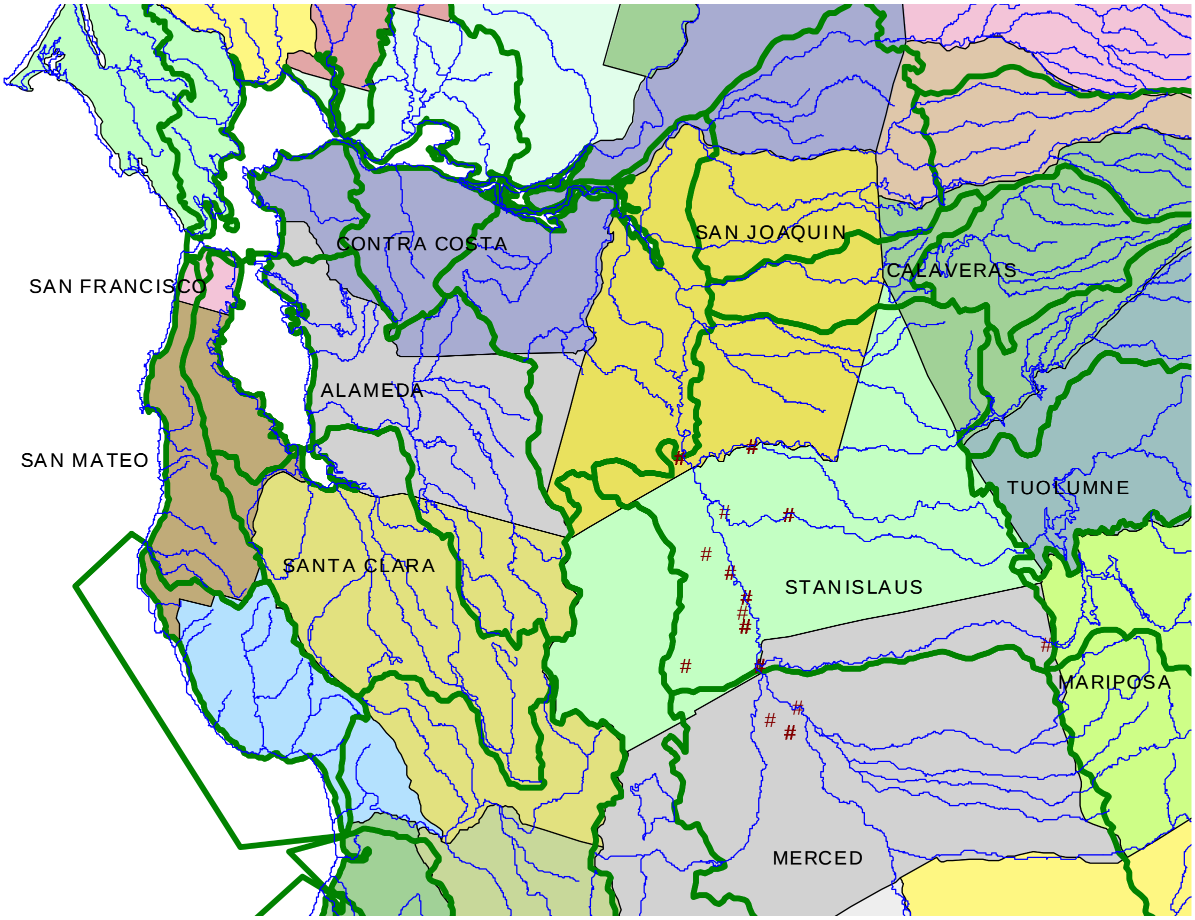


Figure 3-2. NAWQA sampling locations (#) in the San Joachin River valley, California. Hydrologic unit boundaries are shown as thicker lines.

Monitoring Data for the San Joachin River, CA

Samples were taken as part of the USGS's NAWQA program and come from fourteen sites in the San Joachin valley. They were taken mostly in 1993 and 1994, and primarily in the winter months, which are the rainy season in California. The sampling locations are mostly in Stanislaus County, and nearly all fall into a single hydrologic unit (HUC 18040002). A map of the sample locations is shown in Figure 3-2. As a result, we calculated PCAs for HUC 18040002 and used these as multipliers for PRZM/EXAMS modeling results.

The sampling sites themselves are mostly on or near the San Joachin river and the number of samples taken at each site range from 1 to 100, as shown in Figure 3-3.

Modeling of Minor-Use Pesticides in Central Valley, CA

Crop and soil information used in the model runs was based on telephone conversations with extension agents from Stanislaus, Merced, Kern and San Joachin counties. Pesticide application times used in the model runs were based on actual application times but extended to the maximum number of applications permitted by the label. Similarly, application rates were the maximum label rates. The amount of each pesticide used in the models was therefore higher than what farmers in the Central Valley actually use. For the models runs, simazine had one application in January for all three crops for which it is applied, diazinon was applied once (in January) on almonds, and three times (January, May and July) on apricots. Chlorpyrifos was allowed the most applications (according to the label) of the three, being applied three times (march, June and July) on alfalfa, three times (February, July and August) on walnuts and four times (January, February, March and July) on almonds. Spray drift estimates for the models were based on a preliminary spray drift simulation program. These numbers were somewhat lower than in farm pond simulations because not all land in the central valley is adjacent to a water body and in the model all spray drift directly enters the water.

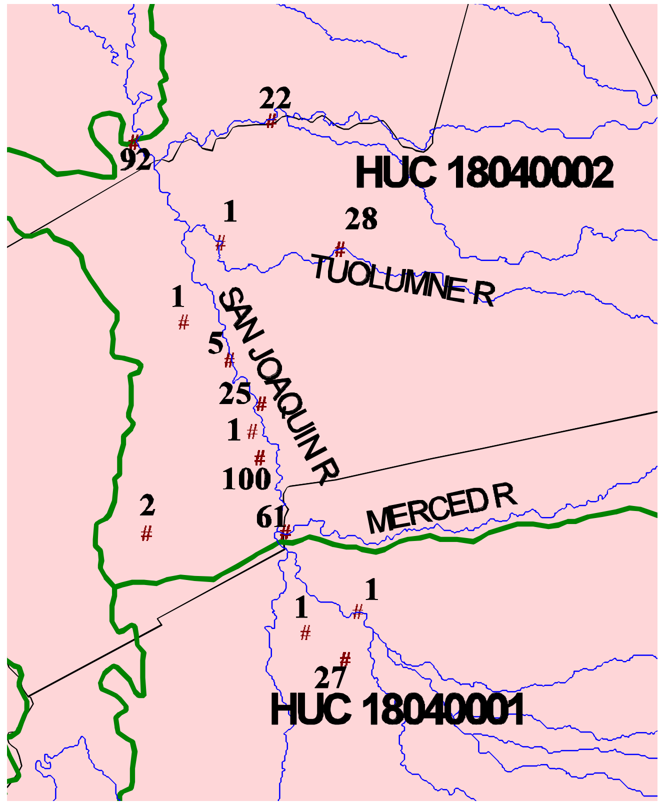


Figure 3-3. Number of samples taken by NAWQA in the San Joachin River valley.

Comparison of Monitoring Data and Modeling Results in the Central Valley, CA

An accurate comparison between these modeling and monitoring data is difficult. The monitoring data was taken over a period of less than four years and had only 368 samples. The modeling, by contrast covered a period of 36 years with over 13,000 simulated days from which to draw the simulated peak concentrations. The comparison here, however is made with the 90th percentile value for the peak concentration, used by EFED for estimated environmental concentrations (EECs).

An overall summary of modeling results with a comparison to peak monitoring values, is given in Table 3-9. For each pesticide, the results of modeling each crop were multiplied by the crop's PCA and then summed to give an overall estimate of pesticide concentration in the hydrologic unit. From this initial look at the data, using a PCA to modify modeling results seems to have a useful moderating effect for Chlorpyrifos and Simazine. For both of these chemicals the PCA reduces EEC's significantly, but to a level above their highest observed concentrations by a factor or two or more. In the case of diazinon, however, multiplying by the PCA decreased the estimated concentrations to the same range as monitoring results, and lower than four monitoring values.

Table 3-9. Overall estimates of the concentration (µg/L) of three pesticides used on minor crops in Central Valley, CA, with and without a PCA adjustment.

	Diazinon	Chlorpyrifos	Simazine
Highest single crop value	53	56	98
All crops modified by PCA	2.7	2.7	10
Highest monitoring value	3.8	0.3	5.3

Time series of modeling for diazinon is shown in Figure 3-4. In order to incorporate irrigation into the PRZM modeling, the irrigation water was added as extra summer precipitation according to a schedule provided by Central Valley Cooperative Extension agents. In the case of

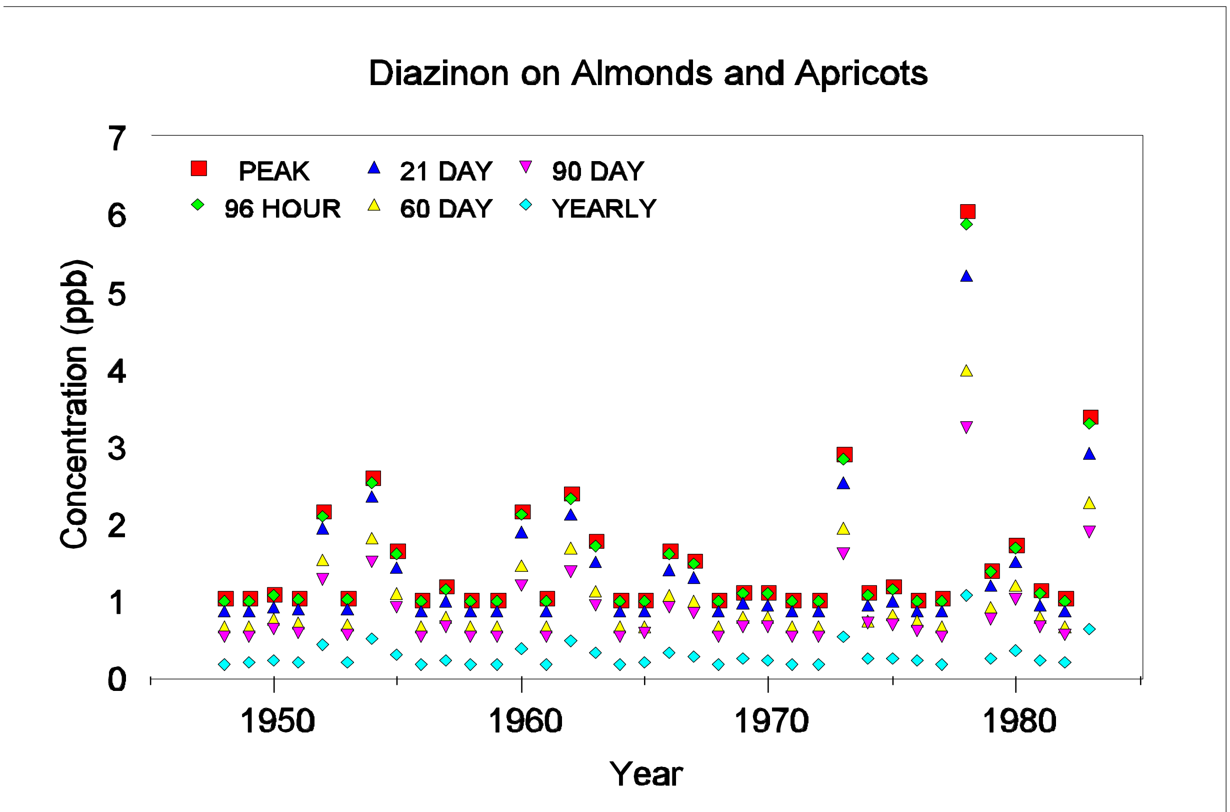


Figure 3-4. Time series plots of PCA-adjusted estimates of diazinon concentrations from use on almonds and apricots.

diazinon and chlorpyrifos, which are applied to the tree foliage, it means the model simulates a much greater amount of pesticide being washed off leaves than would occur under real flood irrigation, where the water is applied at the base of the trees. Winter concentrations predicted by the model are therefore likely to be somewhat lower than shown in Figure 3-4, and it is possible that if the comparison was done without irrigation, modeling values would be lower in comparison. Simazine is applied once per year, in the winter, on the crops considered here, so it shows none of the problems associated with modeling irrigation.

Calculation of PCAs in California

As an example, we calculated PCA values for HUC 18040002 both using and not using land cover data. For calculations without land cover data, a map of the hydrologic unit looks like Figure 2-1. The calculation proceeds as follows. For each county in the hydrologic unit, we calculate the fraction of the county's area in the unit. This fraction is then multiplied by the acreage of the crop in the county, to get an estimate of the total area of the county's crop inside the hydrologic unit. These areas, calculated for each county, are then summed and divided by the total area of the hydrologic unit to get an estimate of the fraction of cropped area in the unit. A summary of these calculations is shown in Table 3-10. To refine the calculation using land cover data, we look only at the cropped area of each county when dividing the county's crops between the portion inside and outside of the hydrologic unit. For the particular hydrologic unit considered here, the western portion of each county is neither cropped nor inside the unit, making the calculated crop percentages higher inside. A summary of the calculations using land cover data is shown in Table 3-11.

The PCAs were used to modify modeling results by multiplying the final PRZM/EXAMS results for each crop by the PCA for that crop and then summing over all the crops.

Table 3-10. Calculation of PCA in the San Joaquin River Hydrologic Unit (HU) without land cover modifications.

County	Fraction of County in HU	Estimated acreage of crop in hydrologic unit			
		Almonds	Apricots	Grapes	Walnuts
Stanislaus	0.73	61,019	4,675	9,791	17,866
San Joachin	0.26	10,203	1,179	14,187	8,871
Merced	0.12	8,599	178	1,500	950
Calaveras	0.11	5	0	31	78
PCA:		0.067	0.005	0.021	0.023

Table 3-11. Calculation of PCA in the San Joaquin River Hydrologic Unit (HU) with land cover modifications.

County	Fraction of County's orchards in HU	Estimated acreage of crop in hydrologic unit			
		Almonds	Apricots	Grapes	Walnuts
Stanislaus	1.00	83,011	8,692	39,206	24,306
San Joachin	0.39	15,004	1,733	20,848	13,044
Merced	0.39	28,884	599	5,037	3,192
Calaveras	0.00	0	0	0	0
PCA:		0.107	0.007	0.033	0.034

Section 4: Preliminary Comparison of Screening Model Results With Available Surface Water Monitoring Data

In order to evaluate the effectiveness of the PCA as a screening model adjustment beyond the preliminary comparisons in Section 3, we must first evaluate the assumption that the existing screening models work equally for these other pesticides. In other words, the PRZM-EXAMS model overpredicts in the same manner and fashion for other pesticides as it does for the pesticides evaluated here. While OPP has not yet undertaken a full, rigorous comparison of modeled estimates with available monitoring concentrations for all of the pesticides we have evaluated, a preliminary survey suggests that the models do not consistently overpredict pesticide concentrations found in monitoring studies.

Neither PRZM nor the linkage that empties runoff from PRZM into the water body modeled in EXAMS have been fully validated. Our attempt here is not to validate the models per se but to evaluate their effectiveness as a screening tool. To be effective screening tools, the models should generate appropriately conservative estimates of pesticide concentrations in water that do not underestimate pesticide concentrations that could actually be found in reservoirs vulnerable to high pesticide runoff while not generating unrealistic estimates that are so high that pesticides that do not pose an actual concern or true risk pass the screening evaluation.

For screening purposes, the model scenarios and inputs were selected to represent what OPP believes to be high-end exposure conditions. The models use maximum pesticide application rates, pesticide environmental fate properties that reflect highest mobility and longest persistence, and site characteristics that are conducive to runoff. In the comparisons made below, the model estimates reflect runoff from a 100% crop area, all treated at the same time, into the smaller (20 million liter) edge-of-field water body. The monitoring data reflect pesticide applications that range from the minimum amount required for efficacy to maximum label rates, treatment on less than 100% of the drainage area at varying times, with runoff into water bodies located at varying distances from the treated fields.

The summaries below are brief capsules taken from more detailed water assessments which go into more depth on modeling parameters, monitoring study conditions, and uncertainties in the data. This is not a complete listing of water assessments, but only those for which Tier 2 (PRZM-EXAMS) or, in a couple of instances, Tier 1 (GENEEC) modeling estimates have been compared with available monitoring data. The intent is to get a picture as to how often our modeling, using the current small edge-of-field pond, overestimates pesticide concentrations found in monitoring data and how often the modeling estimates are similar to monitoring concentrations. In all of the water assessments listed below, the conclusion of the OPP scientist evaluating the data was that the available monitoring data was not sufficient to base a drinking water assessment.

Pesticides For Which Model and Monitoring Concentrations are Within the Same Order of Magnitude:

Aldicarb: In an initial screening assessment for Aldicarb (S. Dutta, 3/31/99), Tier 1 GENEEC model results for aldicarb were compared to STORET data. Tier 2 (PRZM/EXAMS) modeling had not been conducted and a more extensive review of monitoring data was not available for this project. The maximum peak modeled concentration of aldicarb estimated by GENEEC was 88 µg/L for aldicarb use on citrus, pecans, and sugar beets. Modeled peak concentrations for other uses ranged from 13 to 54 µg/L. Longer-term average model estimates (56 days) ranged from 3 to 19 µg/L. Detections of aldicarb and its degradates were reported in 27 surface water samples in 9 states. Monitoring concentrations ranged from 0.5 to 29 µg/L. The Tier 1 peak model concentrations are only 3 times greater than the limited monitoring data used in this assessment, while the longer-term average model concentrations were less than the highest reported monitoring level.

EPTC: The range of peak EPTC EECs generated by PRZM/EXAMS (6 to 57 µg/L) corresponds reasonably well with the range of highest surface water concentrations of EPTC observed (without considering data limitations or modeling short comings) in the monitoring studies (10 to 40 µg/L) (J. Wolf, 3/25/99) The estimated 90th percentile upper-bound value for the annual mean ranged from 0.2 to 3.8 µg/L. The mean of the annual means ranged from 0.16 to 3.40 µg/L. Available monitoring from at least thirty states indicates that EPTC concentrations in surface water are generally very low (generally less than 0.05 µg/L, but rarely greater than 1 µg/L). However, EPTC concentrations in surface water monitoring have occasionally been detected at levels up to approximately 40 µg/L.

Methidathion: Tier 2 PRZM/EXAMS modeling for California, where 90-95% of methidathion is used, estimated peak concentrations of 3 to 6 µg/L and annual average concentrations of 0.2 to 0.6 µg/L (J. Lin, 12/30/98). Methidathion was detected in 11 of 25 samples from the San Joaquin River, at concentrations ranging from less than 1 µg/L to 15 µg/L, with an average of less than 3 µg/L. The model estimates were similar to slightly lower than the limited monitoring results. Although STORET showed no detects (limits of detection ranging from 0.5 to 10 µg/L) in 264 drinking water samples from California, only 5 samples represented surface water sources.

Methomyl: Peak methomyl concentrations estimated from Tier 2 PRZM/EXAMS screening models, which ranged from 30 µg/L (use on lettuce) to 99 µg/L (peaches), were comparable to peak concentrations found in environmental monitoring studies conducted by the registrant, which ranged from 2 µg/L in a pond near a corn field in Illinois to 175 µg/L in a stream adjacent to a corn field in Georgia (N. Thurman, 8/7/97). Differences between modeled estimates and monitoring results increased to roughly an order of magnitude or greater when 21-day average concentrations were compared. While the water bodies sampled did not represent drinking water sources, comparisons of the monitoring data with PRZM/EXAMS runs made by the registrant simulating actual site and weather conditions found that the model predictions were similar in magnitude and pattern of dissipation to the observed values.

Triallate: Tier 2 PRZM/EXAMS modeling estimated peak concentrations of 2 µg/L for triallate and 2.4 µg triallate equivalents/L for the cumulative triallate residues (triallate + TCPSA) from fall application on winter wheat and 2.5 µg/L and 3.5 µg/L, respectively, from spring application on spring wheat (A. Al-Mudallal and J. A. Hetrick, 3/17/99). The annual average concentrations for triallate and cumulative residues, respectively, were 0.1 and 0.2 µg/L for winter wheat and 0.3 and 0.8 µg triallate equivalents/L for spring wheat. The highest concentrations of triallate detected in the USGS NAWQA monitoring program were 0.65 µg/L in the Central Columbia Plateau and 0.28 µg/L in the Red River Basin. The median concentration from 209 detects in the NAQWA program was 0.01 µg/L. The NAWQA study units with the highest frequency of triallate detections and highest concentrations of triallate, Red River of the North Basin and Central Columbia Plateau, correspond to high triallate use areas (> 11 lbs ai per square mile). The reported maximum concentrations from the NAWQA are within a factor of 3 to 4 of the peak triallate concentrations estimated with PRZM/EXAMS modeling. While OPP had sufficient monitoring data to assess the parent triallate, it did not have monitoring information on the toxic degradate of concern, trichloropropene sulfonic acid (TCPSA). The PRZM/EXAMS model estimates for TCPSA exceed the drinking water level of concern.

Pesticides For Which Model Estimates Are More Than An Order of Magnitude Greater than Monitoring Concentrations:

Butylate: Tier 1 modeling with GENEEC estimated a peak concentration for butylate of 33 µg/L and a 56-day average concentration of 30 µg/L (J. Breithaupt, 8/18/98). These values were compared to USGS NAQWA data, which reported 295 detections in 5,193 surface water samples. Most detections (61 %) were in the White River in Indiana, which includes significant corn production. The detections ranged from 0.002 to 1.4 µg/L, with 3 detections of >1 µg/L, 17 detections of 0.1-1 µg/L, and 275 detections of 0.002-0.1 µg/L. The Tier 1 modeled concentrations were approximately 30 times greater than the maximum concentration found in the NAQWA study. Laboratory data suggest that butylate dissipates primarily by volatility from soil and water. The difference between model estimates and monitoring data is at least in part due to the fact that the GENEEC model does not account for volatility of the pesticide. Also, it is unclear if the monitoring data represent time periods with maximum usage and highest runoff.

Chlorpyrifos: Tier 2 PRZM/EXAMS model estimates for chlorpyrifos generated peak concentrations of 41 µg/L for chlorpyrifos use on tobacco (range of peak values from 11 to 41 µg/L) and 90-day average concentrations of 2 to 7 µg/L (M. Barrett, 11/20/98). The highest concentration of chlorpyrifos detected in several stream monitoring studies was 0.4 µg/L, an order of magnitude lower than the longer-term model estimates and two orders lower than peak estimates. No monitoring data were available for small reservoirs. All of the monitoring data represent dissolved chlorpyrifos, while significant additional residues of this lipophilic pesticide are likely to occur in sediment and suspended solids. Therefore, these estimates apply only to drinking water exposure potential.

Halosulfuron: Tier 2 PRZM/EXAMS modeling of the application of this pesticide on sugarcane, cotton, and fallow land generated estimated peak concentrations of 2 to 4 µg/L and average annual concentrations of 0.3 to 1 µg/L (J. Carleton, 3/30/99). Although little monitoring data is available, a preliminary study of surface waters of in the midwest detected halosulfuron in 7 of 130 river water samples (LOD = 10 ppt, or 0.01 µg/L) at concentrations up to 67 ppt (0.067 µg/L) (communication with W. Battaglin, USGS, Denver, CO).

Methyl Parathion: Methyl parathion concentrations estimated from Tier 2 PRZM/EXAMS modeling was considerably greater for cotton use (peak of 214 µg/L and long-term mean of 7 µg/L) than for any of the other agricultural uses modeled (peaks ranged from 4 µg/L for alfalfa to 39 µg/L for corn, with long-term means of <2 µg/L) (K. Costello, 3/11/99). The maximum concentration of methyl parathion found in agricultural streams in the USGS NAWQA study was 0.3 µg/L. However, the analytical recovery for methyl parathion in the NAWQA study is 46% (SD=13%), which limits extensive quantitative interpretation of the monitoring data. A search of other monitoring data found methyl parathion concentrations of up to 6 µg/L in a California DPR study of rice herbicides. These concentrations dropped in later studies after CDPR took steps to reduce the concentration of rice pesticides in surface water. Although the monitoring data reported for methyl parathion are lower than modeling results, they don't necessarily reflect the use scenarios most vulnerable to contamination. For instance, the CDPR monitoring of the Colusa Basin Drain is targeted to methyl parathion use on rice. It includes sampling which coincides with times of application, but the maximum rate at which methyl parathion is applied to rice is one quarter of the maximum rate applied to cotton, with fewer applications annually. In addition, retention of water on treated fields is a mitigation measure relevant only to rice, and not other crops to which methyl parathion is applied.

Phorate: Maximum estimated concentrations of phorate from Tier 2 PRZM/EXAMS modeling ranged from 2 µg/L for wheat in North Dakota to 23 µg/L for cotton in Mississippi (Breithaupt, 10/3/97). Parent phorate is not persistent in water and the estimated chronic concentrations for all modeled crops was $\leq$1.0 µg/L, except for cotton at 1.2-2.1 µg/L. Parent phorate was not found above 0.6 µg/L in surface monitoring data from Colorado. However, the amount of monitoring data is very limited. Also, the monitoring data do not assess the more persistent and mobile sulfone and sulfoxide degradates.

Terbufos: Maximum concentrations of parent terbufos from PRZM/EXAMS modeling were 4 µg/L for sugar beets, 5 µg/L for corn, and 22 µg/L for grain sorghum (D. Farrar and J. Breithaupt, 2/6/98). Terbufos is moderately persistent in water, and the estimated chronic concentration for corn was 1 µg/L. Terbufos was not found above 2.25 µg/L in monitoring data from the Midwest. However, the monitoring data are limited, and the data quality is unknown for some of the information. Also, the available monitoring data do not determine the more persistent and mobile sulfone and sulfoxide degradates of parent terbufos.

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Laurence, KS.

Listing of Background Documents

1. *Use of a CAF in Estimating Surface-Water-Source Drinking Water Exposure*, presented to the Dec. 10, 1997 FIFRA SAP Meeting, Arlington, VA.

2. Response from the FIFRA SAP on the Dec. 10, 1997 document *A Set of Science Issues Being Considered in Connection with Estimating Drinking Water Exp. as a Component of the Dietary Risk Assessment*.

3. *Proposed Methods for Basin-Scale Estimates of Pesticide Concentrations in Flowing Water and Reservoirs for Tolerance Reassessment*, presented at the July 29, 1998 FIFRA SAP Meeting, Arlington, VA.

4. Response from the FIFRA SAP on July 29, 1998 document *Proposed Methods for Basin-Scale Estimates of Pesticide Concentrations in Flowing Water and Reservoirs for Tolerance Reassessment*.

5. *Science Policy 5: Estimating The Drinking Water Component of a Dietary Exposure Assessment*.

Appendix A: PRZM Model Inputs

Inputs for Corn-Soybean Herbicide Simulations in the Midwest U.S.

Table A-1. Selected PRZM 3.12 input parameters for the Midwestern U.S. corn/soybean scenarios

Parameter	*IL Corn*	*IL Soybeans*	*OH Corn*
Weather Factors			
Pan Evaporation Factor (PFAC)	0.74	0.74	0.72
Erosion and Landscape Factors			
USLE K Factor (USLEK), tons EI^{-1*} * EI = 100 ft-tons * in/ acre*hr	0.42	0.42	0.37
USLE LS Factor (USLELS)	1.0	1.0	0.43
USLE P Factor (USLEP)	1.0	1.0	0.50
Field Area (AFIELD), ha	172	172	172
Land Slope (SLP)	6.0	6.0	6.0
Hydraulic Length (HLP)	464	464	354
Crop Parameters			
Initial Surface Condition (ISCOND)	1 (fallow)	1 (fallow)	1 (fallow)
Maximum rainfall interception storage of crop (CINTCP), cm	0.25	0.25	0.25
Maximum Active Root Depth (AMAXDR), cm	90	90	90
Maximum Canopy Coverage (COVMAX), %	100	100	100
Soil Surface Condition After Harvest (ICNAH)	3 (residue)	3 (residue)	3 (residue)
Date of Crop Emergence (EMD, EMM, IRYEM)	May 16	May 16	May 16
Date of Crop Maturity (MAD, MAM, IYRMAT)	Sept. 16	Sept. 16	Sept. 26
Date of Crop Harvest (HAD, HAM,IYRHAR)	Oct. 1	Oct. 1	Oct. 11
Maximum canopy height (HTMAX), cm	300	300	100

CN, C Factor and Manning's N sychronized with crop dates for fallow/cropped/residue covers

Table A-1. Selected PRZM 3.12 input parameters for the Midwestern U.S. corn/soybean scenarios

Parameter	***IL Corn***	***IL Soybeans***	***OH Corn***
SCS Curve Number (CN)	86 / 78 / 82	86 / 78 / 82	91 / 85 / 88
USLE C Factor (USLEC)	0.50 / 0.50 / 0.50	0.50 / 0.50 / 0.50	0.50 / 0.25 / 0.30
Mannings N (MNGN)	.04 / .04 / .04	04 / .04 / .04	0.02 / 0.02 / 0.02
Soil Parameters			
Soil Series	Clinton	Clinton	Cardington
Soil Classification	fine, smectitic, mesic Chromic Vertic Hapludalf	fine, smectitic, mesic Chromic Vertic Hapludalf	fine, illitic, mesic Aquic Hapludalf
Total Soil Depth (CORED), cm	178	178	100
Number of Horizons (NHORIZ)	4	4	2
First Soil Horizon (HORIZN = 1)			
Horizon Thickness (THKNS), cm	13	13	22
Bulk Density (BD), g $\cdot$cm^{-3}	1.3	1.3	1.6
Initial Water Content (THETO), cm^3-H_2O $\cdot$cm^3-soil	0.421	0.421	0.294
Compartment Thickness (DPN), cm	0.1	0.1	0.2
Field Capacity (THEFC), cm^3-H_2O $\cdot$cm^3-soil	0.421	0.421	0.294
Wilting Point, cm^3-H_2O $\cdot$cm^3-soil	0.201	0.201	0.086
Organic Carbon Content, % (w/w)	2.80	2.80	1.16
Second Soil Horizon (HORIZN = 2)			
Horizon Thickness (THKNS), cm	27	27	78
Bulk Density (BD), g $\cdot$cm^{-3}	1.30	1.30	1.65
Initial Water Content (THETO), cm^3-H_2O $\cdot$cm^3-soil	0.421	0.421	0.147
Compartment Thickness (DPN), cm	5	5	1
Field Capacity (THEFC), cm^3-H_2O $\cdot$cm^3-soil	0.421	0.421	0.147
Wilting Point, cm^3-H_2O $\cdot$cm^3-soil	0.201	0.201	0.087
Organic Carbon Content, %	1.067	1.067	0.174
Third Soil Horizon (HORIZN = 3)			

Table A-1. Selected PRZM 3.12 input parameters for the Midwestern U.S. corn/soybean scenarios

Parameter	*IL Corn*	*IL Soybeans*	*OH Corn*
Horizon Thickness (THKNS), cm	60	60	
Bulk Density (BD), g ·cm^{-3}	1.35	1.35	
Initial Water Content (THETO), cm^3-H_2O ·cm^3-soil	0.451	0.451	
Compartment Thickness (DPN), cm	5	5	
Field Capacity (THEFC), cm^3-H_2O ·cm^3-soil	0.451	0.451	
Wilting Point, cm^3-H_2O ·cm^3-soil	0.251	0.251	
Organic Carbon Content, %	0.40	0.40	
Fourth Soil Horizon (HORIZN = 4)			
Horizon Thickness (THKNS), cm	78	78	
Bulk Density (BD), g ·cm^{-3}	1.40	1.40	
Initial Water Content (THETO), cm^3-H_2O ·cm^3-soil	0.416	0.416	
Compartment Thickness (DPN), cm	5	5	
Field Capacity (THEFC), cm^3-H_2O ·cm^3-soil	0.416	0.416	
Wilting Point, cm^3-H_2O ·cm^3-soil	0.216	0.216	
Organic Carbon Content, %	0.167	0.167	

Table A-2. Selected PRZM 3.12 input parameters for the California scenarios

Parameter	*Almonds*	*Walnuts*	*Alfalfa*	*Apricots*	*Grapes*
Weather Factors					
Pan Evaporation Factor (PFAC)	0.85	0.85	0.85	0.85	0.85
Erosion and Landscape Factors					
USLE K Factor (USLEK), tons EI^{-1*} * EI = 100 ft-tons * in/ acre*hr	0.05	0.05	0.05	0.05	0.05
USLE LS Factor (USLELS)	0.01	0.01	0.01	0.01	0.01
USLE P Factor (USLEP)	0.1	0.1	0.1	0.1	0.1
Field Area (AFIELD), ha	172	172	172	172	172
Land Slope (SLP)	0.5	0.5	0.5	0.5	0.5

Table A-2. Selected PRZM 3.12 input parameters for the California scenarios

Parameter	*Almonds*	*Walnuts*	*Alfalfa*	*Apricots*	*Grapes*
Hydraulic Length (HLP)	464	464	464	464	464
Crop Parameters					
Initial Surface Condition (ISCOND)	3 (residue)	3 (residue)	3 (residue)	3 (residue)	3 (residue)
Maximum rainfall interception storage of crop (CINTCP), cm	0.3	0.3	0.25	0.3	0.25
Maximum Active Root Depth (AMAXDR), cm	60	60	180	60	90
Maximum Canopy Coverage (COVMAX), %	90	90	100	90	100
Soil Surface Condition After Harvest (ICNAH)	1 (fallow)	1 (fallow)	1 (fallow)	1 (fallow)	3 (residue)
Date of Crop Emergence (EMD, EMM, IRYEM)	March 15	March 15	Sept. 15	March 15	April 7
Date of Crop Maturity (MAD, MAM, IYRMAT)	May 15	May 15	April 15	May 15	June 30
Date of Crop Harvest (HAD, HAM,IYRHAR)	Nov. 1	Nov. 1	Sept. 1	Nov. 1	Oct. 31
Maximum canopy height (HTMAX), cm	1500	1500	82	1500	150
CN, C Factor and Manning's N sychronized with crop dates for fallow/cropped/residue covers					
SCS Curve Number (CN)	86 / 59 / 82	86 / 59 / 82	86 / 59 / 82	86 / 59 / 82	85 / 88
USLE C Factor (USLEC)	.05/ .05/ .05	.05/ .05/ .05	.02/.02/.40	.05/ .05/ .05	0.25 / 0.30
Mannings N (MNGN)	.02/.02/.02	.02/.02/.02	.15/.15/.15	.02/.02/.02	.02/.02/.02
Soil Parameters					
Soil Series	Kimberlina	Kimberlina	Kimberlina	Kimberlina	Hanford
Soil Classification	Coarse-loamy, mixed, superactive, calcareous, thermic Typic Torriorthents	Coarse-loamy, mixed, superactive, calcareous, thermic Typic Torriorthents	Coarse-loamy, mixed, superactive, calcareous, thermic Typic Torriorthents	Coarse-loamy, mixed, superactive, calcareous, thermic Typic Torriorthents	Coarse-loamy, mixed, nonacid, thermic Typic Xerorthents

Table A-2. Selected PRZM 3.12 input parameters for the California scenarios

Parameter	*Almonds*	*Walnuts*	*Alfalfa*	*Apricots*	*Grapes*
Total Soil Depth (CORED), cm	125	125	185	125	150
Number of Horizons (NHORIZ)	3	3	3	3	3
First Soil Horizon (HORIZN = 1)					
Horizon Thickness (THKNS), cm	5	5	5	5	30
Bulk Density (BD), $g \cdot cm^{-3}$	1.45	1.45	1.45	1.45	1.5
Initial Water Content (THETO), cm^3-H_2O $\cdot cm^3$-soil	0.212	0.212	0.212	0.212	.222
Compartment Thickness (DPN), cm	0.1	0.1	0.1	0.1	0.1
Field Capacity (THEFC), cm^3-H_2O $\cdot cm^3$-soil	0.212	0.212	0.212	0.212	0.125
Wilting Point, cm^3-H_2O $\cdot cm^3$-soil	0.097	0.097	0.097	0.097	0.075
Organic Carbon Content, % (w/w)	0.80	0.80	0.80	0.80	0.75
Second Soil Horizon (HORIZN = 2)					
Horizon Thickness (THKNS), cm	20	20	20	20	60
Bulk Density (BD), $g \cdot cm^{-3}$	1.45	1.45	1.45	1.45	1.5
Initial Water Content (THETO), cm^3-H_2O $\cdot cm^3$-soil	0.212	0.212	0.212	0.212	0.210
Compartment Thickness (DPN), cm	5.0	5.0	5.0	5.0	1.0
Field Capacity (THEFC), cm^3-H_2O $\cdot cm^3$-soil	0.212	0.212	0.212	0.212	0.12
Wilting Point, cm^3-H_2O $\cdot cm^3$-soil	0.097	0.097	0.097	0.097	0.075
Organic Carbon Content, %	0.80	0.80	0.80	0.80	0.2
Third Soil Horizon (HORIZN = 3)					
Horizon Thickness (THKNS), cm	100	100	160	100	60
Bulk Density (BD), $g \cdot cm^{-3}$	1.45	1.45	1.45	1.45	1.5
Initial Water Content (THETO), cm^3-H_2O $\cdot cm^3$-soil	0.212	0.212	0.212	0.212	0.200
Compartment Thickness (DPN), cm	0.1	0.1	0.1	0.1	5.0
Field Capacity (THEFC), cm^3-H_2O $\cdot cm^3$-soil	0.212	0.212	0.212	0.212	0.10
Wilting Point, cm^3-H_2O $\cdot cm^3$-soil	0.097	0.097	0.097	0.097	0.075
Organic Carbon Content, %	0.80	0.80	0.80	0.80	0.125

PRZM Input File for Atrazine on Corn, IL Scenario

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*** PRZM 3.1 Input Data File, ILCORNB1.INP; Created June 14, 1998 ***
*** Modified PRZM program; Multiple Scenario/Stream-Reservoir Model ***
*** Location: South Western Illinois, Macoupin Cty. 150,000 acres corn ***
*** Modeled basin 427 ac.; Corn intensity: 115 ac. (27% 1997 county data) ***
*** Manning's N values for cornstalk residue fallow surface 2 ton/acre ***
*** Soil series: Clinton silt loam; Hydrologic group B soil ***
*** Typical pedon slope: 3%; range 0-25%. Assume 6% ***
Chemical Name:Atrazine
Location: IL Crop: corn;  MLRA 114
    0.74    0.30       0   16.00       1       1
       4
    0.42    1.00    1.00  172.00    6.60       3    6.00   464.0
       1
       1    0.25   90.00  100.00       3  86   78  82                0.00  300.00
       1       3
1605 1609 0110
0.50 0.50 0.50
0.04 0.04 0.04
      36
  100548  210948  211048       1
  100549  210949  211049       1
     ⋮                         ⋮
  100583  210983  211083       1
Application: 1 apps of 3.87 kg a.i./ha, BROADCAST meth.of app., @ 99 eff, 1% drift
      36       1       0       0
ATRAZINE; KD: 0.73 (LOAM); ASM T1/2 = 146 dayS; AnSM T1/2 = 159 days
*** Record 16: Application information; set specific to chemical ***
  050548  0 4 0.10 2.240 0.99 0.01
  050549  0 4 0.10 2.240 0.99 0.01
     ⋮                          ⋮
  050583  0 4 0.10 2.240 0.99 0.01
*** Record 17: Filtra., disposit. foliar pest. after harvest, and plant uptake ***
     0.0       0    0.00
Soil Series: Clinton silt loam; 6% slope; Hydrologic Group B
  178.00          0   0   0   0   0   0   0   0   0
*** Record 26: Soil volatilization constants ***
    0.00    0.00   00.00
       4
       1  13.000   1.300   0.421   0.000   0.000   0.000
          1.6E-3  1.6E-3   0.000
           0.100   0.421   0.201   2.800   00.73
       2  27.000   1.300   0.421   0.000   0.000   0.000
          1.6E-3  1.6E-3   0.000
           5.000   0.421   0.201   1.067   00.73
       3  60.000   1.350   0.451   0.000   0.000   0.000
          1.6E-3  1.6E-3   0.000
           5.000   0.451   0.251   0.400   00.73
       4  78.000   1.400   0.416   0.000   0.000   0.000
          1.6E-3  1.6E-3   0.000
           5.000   0.416   0.216   0.167   00.73
       0
    WATR    YEAR      10    PEST    YEAR      10    CONC    YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TSER   0   0
    RUNF    TCUM   0   0 1.7E10
    INFL    TSER   1   1
    ESLS    TSER   0   0   1.E3
    RFLX    TSER   0   0   1.E5
    EFLX    TSER   0   0   1.E5
    RZFX    TSER   0   0   1.E5
```

PRZM Input File for Atrazine on Corn, OH Scenario

```
*** PRZM3 Input File, OHCORN1.inp converted 1/16/98 SWA***
*** OHCORN1.inp created 2/13/98***
*** Modeler: S. Abel ***
*** Manning's N values for cornstalk residue, fallow surface, 1 ton/acre***
*** Application method by broadcast incorporated 3 days before planting***
*** Cardington silt loam is not one of the benchmark soils ***
*** Benchmark soils include: blount; crosby; pewamo; miami; brookston; glynwood ***
*** miamian; morley; bennington; and fincastle ***
ATRAZINE
Location: OH Crop: corn    MLRA 111
    0.72    0.30       0   15.00       1       3
       4
    0.37    0.43    0.50   172.00    5.80      3    6.00   464.0
       1
       1    0.25   90.00  100.00       3  91   85   88                0.00  100.00
       1       3
1605 1609 1110
0.50 0.25 0.30
0.02 0.02 0.02
      36
  160548  260948  111048       1
  160549  260949  111049       1
     ⋮                         ⋮
  160583  260983  111083       1
Application: 1 apps of 2.24 kg a.i./ha, BROADCAST meth.of app., @ 100 eff, 0% drift
      36       1       0       0
ATRAZINE; KD: 0.73 (LOAM); ASM T1/2 = 146 days; AnSM T1/2 = 159 days
*** Record 16: Application information; set specific to chemical ***
  100548  0 4 0.01 2.240 0.99 0.01
  100549  0 4 0.01 2.240 0.99 0.01
     ⋮                         ⋮
  100583  0 4 0.01 2.240 0.99 0.01
      0.       0    0.00
Soil Series: Cardington silt loam; Hydrogic Group C
  100.00           0   0   0   0   0   0   0   0   0
    0.00    0.00   00.00
       2
       1  22.000   1.600   0.294   0.000   0.000   0.000
          1.6E-3  1.6E-3   0.000
           0.200   0.294   0.086   1.160    0.73
       2  78.000   1.650   0.147   0.000   0.000   0.000
          1.6E-3  1.6E-3   0.000
           1.000   0.147   0.087   0.174    0.73
       0
          YEAR      10            YEAR      10            YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TCUM   0   0
    RUNF    TCUM   0   0
    INFL    TCUM   1   1
    ESLS    TCUM   0   0   1.E3
    RFLX    TCUM   0   0   1.E5
    EFLX    TCUM   0   0   1.E5
    RZFX    TCUM   0   0   1.E5
```

PRZM Input File for Simazine on Corn

```
*** PRZM 3.1 Input Data File, ILCRNSMZ.INP; Created June 14, 1998 ***
*** Modified 3/29/99 for use with shipman reservior and simazine ***
```

```
*** Modified PRZM program; Multiple Scenario/Stream-Reservoir Model ***
*** Location: South Western Illinois, Macoupin Cty. 150,000 acres corn ***
*** Modeled basin 427 ac.; Corn intensity: 115 ac. (27% 1997 county data) ***
*** Manning's N values for soybean residues small grain moderate stand ***
*** Soil series: Clinton silt loam; Hydrologic group B soil ***
*** Typical pedon slope: 3%; range 0-25%. Assume 6% ***
*** this assumes continuous corn cropping ***
Chemical Name:Simazine
Location: IL Crop: corn;  MLRA 114
    0.74    0.30       0   16.00       1       1
       4
    0.42    1.00    1.00   172.0    6.60       3    6.00   464.0
       1
       1    0.25   90.00  100.00       3  86  78  82                0.00  300.00
       1       3
1605 1609 0110
0.50 0.50 0.50
0.04 0.04 0.04
      36
  100548  210948  211048       1
  100549  210949  211049       1
  100550  210950  211050       1
  100551  210951  211051       1
  100552  210952  211052       1
  100553  210953  211053       1
  100554  210954  211054       1
     ⋮                         ⋮
  100583  210983  211083       1
Application Schedule: 1 apps. @ 3.0 lb/acre, GROUND SPRAY @ 100% eff. w/0% drift
      36       1       0       0
SIMAZINE Kd:1.27  (sandy loam); ASM: T1/2 = 135 days; AnSM: T1/2 = 270 days
*** Record 16: Application information; set specific to chemical ***
  050548  0 4 0.10 3.360 0.99 0.01
  050549  0 4 0.10 3.360 0.99 0.01
     ⋮                        ⋮
  050583  0 4 0.10 3.360 0.99 0.01
*** Record 17: Filtra., disposit. foliar pest. after harvest, and plant uptake ***
     0.0       0    0.00
Soil Series: Clinton silt loam; 6% slope; Hydrologic Group B
  178.00    0.00   0   0   0   0   0   0   0   0   0
*** Record 26: Soil volatilization constants ***
    0.00    0.00   00.00
       4
       1  13.000   1.300   0.421   0.000   0.000   0.000
         5.13E-3 2.57E-3   0.000
           0.100   0.421   0.201   2.800    1.27
       2  27.000   1.300   0.421   0.000   0.000   0.000
         5.13E-3 2.57E-3   0.000
           5.000   0.421   0.201   1.067    1.27
       3  60.000   1.350   0.451   0.000   0.000   0.000
         5.13E-3 2.57E-3   0.000
           5.000   0.451   0.251   0.400    1.27
       4  78.000   1.400   0.416   0.000   0.000   0.000
         5.13E-3 2.57E-3   0.000
           5.000   0.416   0.216   0.167    1.27
       0
    WATR    YEAR      10    PEST    YEAR      10    CONC    YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TSER   0   0
    RUNF    TCUM   0   0 1.7E10
    INFL    TSER   1   1
    ESLS    TSER   0   0   1.E3
```

```
    RFLX     TSER    0    0    1.E5
    EFLX     TSER    0    0    1.E5
    RZFX     TSER    0    0    1.E5
```

PRZM Input File for Metolachlor on Corn

```
*** PRZM 3.1 Input Data File, ILCORNB1.INP; Created June 14, 1998 ***
*** Modified PRZM program; Multiple Scenario/Stream-Reservoir Model ***
*** Location: South Western Illinois, Macoupin Cty. 150,000 acres corn ***
*** Modeled basin 427 ac.; Corn intensity: 115 ac. (27% 1997 county data) ***
*** Manning's N values for cornstalk residue fallow surface 2 ton/acre ***
*** Manning's N values for soybean residues small grain moderate stand ***
*** Soil series: Clinton silt loam; Hydrologic group B soil ***
*** Typical pedon slope: 3%; range 0-25%. Assume 6% ***
Chemical Name:METOLACHLOR
Location: IL Crop: corn;  MLRA 114
    0.74     0.30        0   16.00        1        1
       4
    0.42     1.00     1.00  172.00     6.60        3     6.00    464.0
       1
       1     0.25    90.00  100.00        3   86   78   82                0.00   300.00
       1        3
1605 1609 0110
0.50 0.50 0.50
0.04 0.04 0.04
      36
  100548  210948  211048       1
  100549  210949  211049       1
     ⋮                         ⋮
  100583  210983  211083       1
Application: 1 apps of 3.87 kg a.i./ha, BROADCAST meth.of app., @ 100 eff, 0% drift
      36        1       0       0
METOLACHLOR; KD: 4.81 (SANDY LOAM); ASM T1/2 = 67 days; AnSM = 81 days
*** Record 16: Application information; set specific to chemical ***
  050548  0 4 0.10 3.870 0.99 0.01
  050549  0 4 0.10 3.870 0.99 0.01
     ⋮                         ⋮
  050583  0 4 0.10 3.870 0.99 0.01
     0.0        0     0.00
Soil Series: Clinton silt loam; 6% slope; Hydrologic Group B
  178.00             0    0    0    0    0    0    0    0    0
*** Record 26: Soil volatilization constants ***
    0.00     0.00    00.00
       4
       1  13.000    1.300    0.421    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           0.100    0.421    0.201    2.800    04.81
       2  27.000    1.300    0.421    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           5.000    0.421    0.201    1.067    04.81
       3  60.000    1.350    0.451    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           5.000    0.451    0.251    0.400    04.81
       4  78.000    1.400    0.416    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           5.000    0.416    0.216    0.167    04.81
       0
    WATR     YEAR       10     PEST     YEAR       10     CONC     YEAR       10    1
       1
       1  -----
       7     YEAR
    PRCP     TSER    0    0
    RUNF     TCUM    0    0 1.7E10
```

```
    INFL     TSER    1    1
    ESLS     TSER    0    0    1.E3
    RFLX     TSER    0    0    1.E5
    EFLX     TSER    0    0    1.E5
    RZFX     TSER    0    0    1.E5
```

PRZM Input File for Metolachlor on Soybeans

```
*** PRZM 3.1 Input Data File, ILSOYBB1.INP; Created June 15, 1998 ***
*** modified 23 Apr 1999 with new planting/harvesting/spraying dates ***
*** to be more representative of Illinois conditions reported by USDA***
*** Modified PRZM program; Multiple Scenario/Stream-Reservoir Model ***
*** Location: South Western Illinois, Macoupin Cty. 148,000 acres soybean ***
*** Modeled basin 427 ac.; Soybean intensity: 111 ac. (26% 1997 county data) ***
*** Manning's N values for soybean residues small grain moderate stand ***
*** Manning's N value for wheat is small grain moderate stand ***
*** Soil series: Clinton silt loam; Hydrologic group B soil ***
*** Typical pedon slope: 3%; range 0-25%. Assume 6% ***
*** Assume a three year rotation of soybean-soybean-wheat ***
*** See ILSOYBB1.wpd for scenario details (pending) ***
Chemical Name:METOLACHLOR
Location: IL Crop: soybeans  MLRA 114
    0.74     0.30        0   16.00        1        1
       4
    0.33     1.00     1.00  172.00     6.60        3     6.00    464.0
       1
       1     0.20    22.00  100.00        3   86   78   82                0.00    90.00
       1        3
1605 1609 0110
0.50 0.50 0.50
.023 .023 .023
      36
  250548  101048  250948        1
  250549  101049  250949        1
     ⋮                          ⋮
  250583  101083  250983        1
Application: 1 apps of 3.46 lbs a.i./a, BROADCAST meth.of app., @ 99 eff, 1% drift
      36        1        0        0
Metolachlor; KD: 4.81 (SANDY LOAM); ASM T1/2 = 67 days; AnSM T1/2 = 81 days
  190548  0 4 0.10 3.870 0.99 0.01
  190549  0 4 0.10 3.870 0.99 0.01
     ⋮                          ⋮
  190583  0 4 0.10 3.870 0.99 0.01
     0.0        0     0.00
Soil Series: Clinton silt loam; 6% slope; Hydrologic Group B
  178.00             0    0    0    0    0    0    0    0    0
    0.00     0.00    00.00
       4
       1   13.000    1.300    0.421    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           0.100    0.421    0.201    2.800    04.81
       2   27.000    1.300    0.421    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           5.000    0.421    0.201    1.067    04.81
       3   60.000    1.350    0.451    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           5.000    0.451    0.251    0.400    04.81
       4   78.000    1.400    0.416    0.000    0.000    0.000
         1.03e-2 8.6e-03    0.000
           5.000    0.416    0.216    0.167    04.81
       0
    WATR     YEAR       10     PEST     YEAR       10     CONC     YEAR       10    1
       1
```

```
   1  -----
   7    YEAR
PRCP    TSER   0   0
RUNF    TSER   0   0
INFL    TSER   1   1
ESLS    TSER   0   0   1.E3
RFLX    TSER   0   0   1.E5
EFLX    TSER   0   0   1.E5
RZFX    TSER   0   0   1.E5
```

Inputs for Simulations in the San Joachin River, CA

PRZM Input File for Chlorpyrifos on Walnuts

```
***PRZM 3.1 Input File Modified from  PRZM 2 File***
***CAAL.INP created 12/23/98***
***Crop: Walnuts, also applies to Pistachios and other nuts grown in region***
***Kern Co, CA; Sacramento and San Joaquin Valleys, MLRA 17***
***Based on mature trees approximately 50 feet tall with sparse grass understory***
***Chemical is SIMAZINE applied AERIAL. IRRIGATION APPLIED. MET FILE MODIFIED***
*** TALKED TO EXTENSION AGENT IN KERN CO. ***
*** cropping curve number reduced from 78 to fit the 15% of flood irrigation ***
*** water which runs off. The 15% number comes from Terry Pritchard, ***
*** San Joachin county cooperative extension, (209) 468-2085 ***
CHLORPYRIFOS
Kimberlina Sandy Loam; Hyrologic Group B
   0.852   0.450       0  20.000       1       3
       4
     0.05    0.01     0.1   172.0     3.8       3     0.5   464.0
       1
       1    0.30    60.0  90.000       1  86   59  82                 0.0  1500.0
       1       3
0101 0104 0112
0.05 0.05 0.05
.023 .023 .023
      36
  150348  150548  011148       1
  150349  150549  011149       1
     ⋮                         ⋮
  150383  150583  011183       1
Application Schedule: 3 APPS. AERIAL at 4.0 lbs a.i./acre, 95% eff. w/ 5% drift
     108       1       0       0
CHLORPYRIFOS: Kd: 68.7; AeSM: T1/2 = 77 days; AnSM: T1/2 = 154 days
  030148  0 2  0.0 4.480 0.95 0.05
  170748  0 2  0.0 4.480 0.95 0.05
  170848  0 2  0.0 4.480 0.95 0.05
     ⋮                          ⋮
  030183  0 2  0.0 4.480 0.95 0.05
  180783  0 2  0.0 4.480 0.95 0.05
  180883  0 2  0.0 4.480 0.95 0.05
    0.00       1     0.0
    0.00  0.0000    0.50
Kimberlina Sandy Loam; Hydrologic Group B;
   125.0          0   0   0   0   0   0   0   0   0
    0.00    0.00    0.00
       3
       1     5.0    1.45   0.212     0.0     0.0   0.000
          0.009 4.5E-03   0.00
            0.1   0.212   .0973    0.80    68.7
       2    20.0    1.45   0.212     0.0     0.0   0.000
          0.009 4.5E-03   0.00
            5.0   .2240   .0973    0.80    68.7
       3   100.0    1.65   0.211     0.0     0.0   0.000
          0.009 4.5E-03   0.00
            5.0  0.2020  0.0962    0.80    68.7
       0
         YEAR      10             YEAR      10             YEAR      10   1
       1
       1   -----
       7    YEAR
    PRCP    TCUM   0   0
    RUNF    TCUM   0   0
```

```
    INFL     TCUM    1   1
    ESLS     TCUM    0   0  1.0E3
    RFLX     TCUM    0   0  1.0E5
    EFLX     TCUM    0   0  1.0E5
    RZFX     TCUM    0   0  1.0E5
```

PRZM Input File for Diazinon Use on Almonds

```
***PRZM 3.1 Input File Modified from  PRZM 2 File***
***CAAL.INP created 12/23/98***
***Crop: Almonds, also applies to Pistachios and other nuts grown in region***
***Kern Co, CA; Sacramento and San Joaquin Valleys, MLRA 17***
***Based on mature trees approximately 50 feet tall with sparse grass understory***
***Chemical is SIMAZINE applied AERIAL. IRRIGATION APPLIED. MET FILE MODIFIED***
*** TALKED TO EXTENSION AGENT IN KERN CO. ***
*** cropping curve number reduced from 78 to fit the 15% of flood irrigation ***
*** water which runs off. The 15% number comes from Terry Pritchard, ***
*** San Joachin county cooperative extension, (209) 468-2085 ***
DIAZINON
Kimberlina Sandy Loam; Hyrologic Group B
   0.852   0.450       0  20.000       1       3
       4
    0.05    0.01     0.1   172.0     3.8       3     0.5   464.0
       1
       1    0.30    60.0  90.000       1  86  59  82                 0.0  1500.0
       1       3
0101 0104 0112
0.05 0.05 0.05
.023 .023 .023
      36
  150348  150548  011148       1
  150349  150549  011149       1
     ⋮                         ⋮
  150383  150583  011183       1
Application Schedule: 1 app. @ 3.0 lb/acre, Aerial, 95%,5%
     36       1       0       0
DIAZINON Kd: 4.0 (loamY SAND); ASM: T1/2 = 38 DAYS; AnSM: T1/2 = 34 days
  100148  0 2 0.00 3.360 0.95 0.05
  100149  0 2 0.00 3.360 0.95 0.05
     ⋮                         ⋮
  100182  0 2 0.00 3.360 0.95 0.05
  100183  0 2 0.00 3.360 0.95 0.05
    0.00       1     0.0
    0.00  0.0000    0.50
Kimberlina Sandy Loam; Hydrologic Group B;
   125.0           0   0   0   0   0   0   0   0   0
    0.00    0.00    0.00
       3
       1     5.0    1.45   0.212     0.0     0.0   0.000
         1.80E-2 1.80E-2   0.00
             0.1   0.212   .0973    0.80    4.00
       2    20.0    1.45   0.212     0.0     0.0   0.000
         1.80E-2 1.80E-2   0.00
             5.0   .2240   .0973    0.80    4.00
       3   100.0    1.65   0.211     0.0     0.0   0.000
         1.80E-2 1.80E-2   0.00
             5.0  0.2020  0.0962    0.80    4.00
       0
            YEAR      10            YEAR      10            YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TCUM    0   0
```

```
RUNF    TCUM   0   0
INFL    TCUM   1   1
ESLS    TCUM   0   0  1.0E3
RFLX    TCUM   0   0  1.0E5
EFLX    TCUM   0   0  1.0E5
RZFX    TCUM   0   0  1.0E5
```

PRZM Input File for Chlorpyrifos Use on Alfalfa

```
*** PRZM 3.1 Input Data File ***
*** CAALF.INP; created March 18, 1999 ***
*** Emergence, and maturity dates from Stanislaus country extension. ***
*** Harvest date from Extension Office Homepage for Stanislaus County ***
*** Central Valley, Stanislaus County, California ***
*** weather Met17.met ***
*** Mannings N values for small grain, across slope, moderate stand ***
*** Modified 26 March 1999 by Ian Kennedy. Changed to 12 3-year ***
*** cropping periods. R9 changed to correct format. INCLUDES IRRIGATION ***
*** cropping curve number reduced from 72 to fit the 15% of flood irrigation ***
*** water which runs off. The 15% number comes from Terry Pritchard, ***
*** San Joachin county cooperative extension, (209) 468-2085 ***
CHLORPYRIFOS
Location: Kimberlina samdy loam, MLRA 17; Stanislaus County, CA, alfalfa
   0.852   0.450       0   20.00       1       3
       4
     0.05    0.01    0.10  172.00    3.80       1    0.50   464.0
       1
       1    0.25   180.0  100.00       1  86  59  82               0.00    82.0
       1       3
0101 1009 1509
0.02 0.02 0.40
0.15 0.15 .015
      12
  150947  150448  010950       1
  150950  150451  010953       1
     ⋮                         ⋮
  150980  150481  010983       1
Application Schedule: 4 APPS. ground spray at 1.0 lbs a.i./acre, 99% eff. w/ 1%
drift
     144       1       0       0
CHLORPYRIFOS: Kd: 68.7; AeSM: T1/2 = 77 days; AnSM: T1/2 = 154 days
  170348  0 2  0.0 1.120 0.99 0.01
  020648  0 2  0.0 1.120 0.99 0.01
  020748  0 2  0.0 1.120 0.99 0.01
  020848  0 2  0.0 1.120 0.99 0.01
     ⋮                          ⋮
  170383  0 2  0.0 1.120 0.99 0.01
  020683  0 2  0.0 1.120 0.99 0.01
  020783  0 2  0.0 1.120 0.99 0.01
  020883  0 2  0.0 1.120 0.99 0.01
     0.0       3     0.0
    0.00   0.000     0.5
KIMBERLINA SANDY loam; Hydrologic Group B
   185.0           0   0   0   0   0   0   0   0   0
    0.00    0.00    0.00
       3
       1     5.0    1.45   0.212     0.0     0.0   0.000
          0.009 4.5E-03   0.00
             0.1   0.212   .0973    0.80    68.7
       2    20.0    1.45   0.212     0.0     0.0   0.000
          0.009 4.5E-03   0.00
             5.0   .2240   .0973    0.80    68.7
       3   160.0    1.65   0.211     0.0     0.0   0.000
```

```
          0.009 4.5E-03   0.00
            5.0  0.2020  0.0962    0.80    68.7
      0
           YEAR      10            YEAR      10            YEAR      10   1
      1
      1  -----
      7    YEAR
   PRCP    TCUM   0   0
   RUNF    TCUM   0   0
   INFL    TCUM   1   1
   ESLS    TCUM   0   0  1.0E3
   RFLX    TCUM   0   0  1.0E5
   EFLX    TCUM   0   0  1.0E5
   RZFX    TCUM   0   0  1.0E5
```

PRZM Input File for Diazinon Use on Apricots

```
***PRZM 3.1 Input File ***
***CAAPRICO.INP created 03/18/99***
***Crop: Apricots - information on maturity incomplete ***
***Stanislaus County, Central Valley, CA, MLRA 17, IRRIGATION INCLUDED***
***Based on mature trees approximately 15 feet tall with sparse grass understory***
DIAZINON
Kimberlina Sandy Loam; Hyrologic Group B
   0.852   0.450       0  20.000       1       3
      4
    0.05    0.01     0.1   172.0     8.8       1   25.25   464.0
      1
      1    0.30    60.0  90.000       1  86   59  82                0.0  450.0
      1       3
0101 0104 0112
0.05 0.05 0.05
.023 .023 .023
     36
  150348  150548  011148       1
  150349  150549  011149       1
     ⋮                         ⋮
  150382  150582  011182       1
  150383  150583  011183       1
Application Schedule: 3 apps. @ 2.0 lb/acre, AERIAL, 95%,5%
     108       1       0       0
DIAZINON Kd: 4.0 (loamY SAND); ASM: T1/2 = 38 DAYS; AnSM: T1/2 = 34 days
  100148  0 2  0.0 2.240 0.95 0.05
  100548  0 2  0.0 2.240 0.95 0.05
  100748  0 2  0.0 2.240 0.95 0.05
     ⋮                          ⋮
  100183  0 2  0.0 2.240 0.95 0.05
  110583  0 2  0.0 2.240 0.95 0.05
  110783  0 2  0.0 2.240 0.95 0.05
    0.00       1     0.0
    0.00  0.0000    0.50
Kimberlina Sandy Loam; Hydrologic Group B;
   125.0          0   0   0   0   0   0   0   0   0
    0.00    0.00    0.00
      3
      1     5.0    1.45   0.212     0.0     0.0   0.000
        1.80E-2 1.80E-2   0.00
            0.1   0.212   .0973    0.80     4.0
      2    20.0    1.45   0.212     0.0     0.0   0.000
        1.80E-2 1.80E-2   0.00
            5.0   .2240   .0973    0.80     4.0
      3   100.0    1.65   0.211     0.0     0.0   0.000
```

```
       1.80E-2 1.80E-2   0.00
           5.0  0.2020  0.0962    0.80     4.0
   0
          YEAR      10            YEAR      10             YEAR      10   1
   1
   1  -----
   7      YEAR
PRCP      TCUM   0   0
RUNF      TCUM   0   0
INFL      TCUM   1   1
ESLS      TCUM   0   0  1.0E3
RFLX      TCUM   0   0  1.0E5
EFLX      TCUM   0   0  1.0E5
RZFX      TCUM   0   0  1.0E5
```

Appendix B: Output Data From PRZM/EXAMS Simulations

Table B-1: Results of 36 years of PRZM/EXAMS modeling for atrazine use on corn in the midwest, IL scenario.

	Estimated Atrazine Concentrations, µg/L						
Peak/Yearly Probability	Peak	PCA-Adj Peak	Yearly	PCA-Adj Yearly	3-Yr Avg	PCA-Adj 3-Yr Avg	3-Yr Avg Probability
0.03	309	142	82	38			
0.05	133	61	38	17	47	22	0.03
0.08	123	57	31	14	40	18	0.06
0.11	123	57	30	14	38	17	0.09
0.14	98	45	30	14	17	8	0.11
0.16	69	32	25	12	17	8	0.14
0.19	46	21	11	5	16	7	0.17
0.22	44	20	11	5	16	7	0.20
0.24	30	14	10	5	15	7	0.23
0.27	30	14	8	4	13	6	0.26
0.30	27	12	8	4	13	6	0.29
0.32	25	11	8	3	13	6	0.31
0.35	24	11	7	3	12	6	0.34
0.38	22	10	7	3	12	6	0.37
0.41	21	10	7	3	7	3	0.40
0.43	19	9	6	3	6	3	0.43
0.46	19	9	6	3	6	3	0.46
0.49	17	8	6	3	6	3	0.49
0.51	13	6	6	3	6	3	0.51
0.54	12	5	6	3	6	3	0.54
0.57	12	5	4	2	5	2	0.57
0.60	11	5	4	2	4	2	0.60
0.62	10	5	4	2	4	2	0.63
0.65	9	4	3	1	4	2	0.66
0.68	8	4	2	1	4	2	0.69
0.70	8	4	2	1	4	2	0.71
0.73	7	3	2	1	4	2	0.74
0.76	6	3	2	1	3	2	0.77
0.78	3	2	2	1	3	2	0.80
0.81	3	1	1	1	3	1	0.83
0.84	3	1	1	1	3	1	0.86
0.87	3	1	1	1	2	1	0.89
0.89	2	1	1	0	1	1	0.91
0.92	1	1	0	0	1	1	0.94
0.95	1	0	0	0	1	0	0.97
0.97	0	0	0	0			
1 in 10 Year Probability [1]	123	57	30	14	25	13	
Median	15	7	6	3			
Overall Mean			10	5			
(36 yr)[2]			14	7			

[1] 1-in-10 year probability values are used in screening assessments.
[2] Mean of the annual values and 90% upper bound on the mean, respectively.

Table B-2: Results of 36 years of PRZM/EXAMS modeling for atrazine use on corn in the midwest, OH scenario.

Peak/Yearly Probability	Estimated Atrazine Concentrations, µg/L Peak	PCA-adj Peak	Yearly	PCA-adj Yearly
0.03	231	67	106	31
0.05	175	44	80	20
0.08	162	41	75	19
0.11	129	35	59	16
0.14	121	35	56	16
0.16	110	32	51	15
0.19	106	28	49	13
0.22	103	27	47	12
0.24	102	27	47	12
0.27	82	23	38	11
0.30	69	20	32	9
0.32	63	18	29	9
0.35	50	15	23	7
0.38	45	13	21	6
0.40	43	13	20	6
0.43	41	12	19	5
0.46	39	11	18	5
0.49	38	11	17	5
0.51	30	10	14	5
0.54	29	10	13	5
0.57	25	10	11	5
0.60	23	10	10	4
0.62	22	9	10	4
0.65	22	9	10	4
0.68	21	9	10	4
0.70	17	6	8	3
0.73	17	6	8	3
0.76	16	5	8	2
0.78	14	5	6	2
0.81	14	5	6	2
0.84	14	5	6	2
0.86	14	4	6	2
0.89	12	4	6	2
0.92	10	4	5	2
0.95	7	4	3	2
0.97	6	3	3	1
1 in 10 Year Probability [1]	139	64	37	17
Median	34	16	11	5
Overall Mean			17	8
(36 yr)[2]			20	9

[1] 1-in-10 year probability values are used in screening assessments.
[2] Mean of the annual values and 90% upper bound on the mean, respectively.

Table B-3: Results of 36 years of PRZM/EXAMS modeling for Simazine use on corn in the midwest, IL scenario.

	Estimated Simazine Concentrations, µg/L						
Peak/Yearly Probability	Peak	PCA-Adj Peak	Yearly	PCA-Adj Yearly	3-Yr Avg	PCA-Adj 3-Yr Avg	3-Yr Avg Probability
0.03	460	212	173	80			
0.05	208	96	82	38	105	49	0.03
0.08	184	85	80	37	92	42	0.06
0.11	170	78	66	30	78	36	0.09
0.14	147	68	61	28	41	19	0.11
0.16	136	63	55	25	40	19	0.14
0.19	103	47	35	16	39	18	0.17
0.22	75	34	31	14	39	18	0.20
0.24	64	30	28	13	36	17	0.23
0.27	58	27	25	12	34	16	0.26
0.30	57	26	23	11	33	15	0.29
0.32	51	23	22	10	32	15	0.31
0.35	47	22	21	10	30	14	0.34
0.38	46	21	20	9	30	14	0.37
0.41	43	20	19	9	20	9	0.40
0.43	39	18	19	9	20	9	0.43
0.46	38	17	18	8	18	8	0.46
0.49	37	17	14	6	18	8	0.49
0.51	35	16	13	6	17	8	0.51
0.54	33	15	13	6	16	7	0.54
0.57	31	14	13	6	16	7	0.57
0.60	31	14	12	6	14	7	0.60
0.62	26	12	12	5	14	6	0.63
0.65	23	11	11	5	12	5	0.66
0.68	23	10	11	5	12	5	0.69
0.70	22	10	9	4	12	5	0.71
0.73	20	9	9	4	11	5	0.74
0.76	19	9	8	4	10	5	0.77
0.78	12	6	6	3	9	4	0.80
0.81	12	6	6	3	9	4	0.83
0.84	12	5	6	3	9	4	0.86
0.87	8	4	4	2	8	4	0.89
0.89	7	3	4	2	6	3	0.91
0.92	6	3	3	1	6	3	0.94
0.95	6	3	3	1	4	2	0.97
0.97	1	0	0	0			
1 in 10 Year Probability [1]	174	80	70	32			
Median	36	17	14	6			
Overall Mean			26	12			
(36 yr)[2]			34	16			

[1] 1-in-10 year probability values are used in screening assessments.

[2] Mean of the annual values and 90% upper bound on the mean, respectively.

Table B-4: Results of 36 years of PRZM/EXAMS modeling for metolachlor use on corn and soybeans in the midwest, IL scenario.

Peak/Yearly Probability	Estimated Simazine Concentrations, µg/L					
	Corn Peak	Soybean Peak	PCA-Adj Peak	Corn Yearly	Soybean Yearly	PCA-Adj Yearly
0.03	318	313	275	99	97	85
0.05	309	284	248	91	85	76
0.08	285	270	237	90	83	73
0.11	274	251	234	85	80	70
0.14	260	224	223	81	66	69
0.16	221	219	191	66	65	57
0.19	180	120	132	55	47	42
0.22	131	114	100	52	47	42
0.24	115	105	99	48	41	41
0.27	107	94	92	48	38	41
0.30	96	93	82	34	33	29
0.32	84	83	73	33	32	28
0.35	70	67	60	27	26	23
0.38	68	67	59	25	25	22
0.41	68	67	59	24	24	21
0.43	64	63	55	24	24	21
0.46	51	47	42	21	21	18
0.49	49	47	42	21	20	18
0.51	49	44	38	20	17	15
0.54	44	43	38	20	17	15
0.57	43	42	38	18	16	15
0.60	43	42	37	18	15	15
0.62	43	41	37	18	14	14
0.65	42	41	36	16	14	13
0.68	42	36	36	15	13	12
0.70	41	34	32	14	13	12
0.73	41	30	31	14	13	12
0.76	38	26	29	14	12	12
0.78	36	26	26	14	11	11
0.81	31	26	25	12	11	10
0.84	30	24	25	11	11	10
0.87	26	23	22	11	10	10
0.89	23	22	20	10	10	8
0.92	22	21	19	8	9	7
0.95	21	21	19	8	8	7
0.97	8	10	8	5	5	4
1 in 10 Year Probability [1]	277	257	233	87	81	73
Median	49	45	40	20	19	17
Overall Mean				32	30	27
(36 yr)[2]				39	36	33

[1] 1-in-10 year probability values are used in screening assessments.

[2] Mean of the annual values and 90% upper bound on the mean, respectively.