UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

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MEMORANDUM

DATE: June 1, 2016

SUBJECT: Diazinon Registration Review Drinking Water Assessment

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1 EXECUTIVE SUMMARY

This memo summarizes the estimated drinking water concentrations (EDWCs) of diazinon (PC Code 057801; phosphorothioic acid, O,O-diethyl O-[6-methyl-2-(1-methylethyl)-4-pyrimidinyl]

ester) and degradate residues of concern (diazoxon) in surface water and in groundwater in support of the Registration Review of diazinon.

The Surface Water Concentration Calculator (SWCC), the Tier I Rice Model, and the Pesticides in Flooded Agriculture Model (PFAM) were used to generate surface water Estimated Drinking Water Concentrations (EDWCs) for use in the human health dietary risk assessment. The Pesticide Root Zone Model for Groundwater (PRZM-GW) was used to generate groundwater EDWCs.

Residues of concern for human health in drinking water have been identified as diazinon and diazoxon (USEPA, 2000, D270838)[1]. Models were not used to simulate EDWCs for diazoxon because not enough data are available for a full model simulation. Data on drinking water treatment suggests that in many water treatment facilities diazinon will degrade rapidly to its more toxic degradate diazoxon, where diazoxon may be stable (see Drinking Water Treatment Section). In other treatment facilities, diazinon may be degraded to other degradates or will have a low level of removal. To provide an estimate of potential diazoxon concentrations in drinking water, diazinon concentrations were converted to diazoxon concentrations in **Table 1** using a molecular weight conversion factor (0.947) and assuming that 100% of diazinon was converted to diazoxon.

The EDWCs for both surface water and groundwater recommended for use in HED's human health dietary risk assessment are summarized in **Table 1**. The EDWCs for cranberries are the highest, but reflect a use that is limited to a small geographic area, with potential drinking water concerns mainly in the New England area such as Massachusetts. The EDWCs for apples and pears and melons are the next highest EDWCs and represent uses that could occur over larger geographic areas than cranberries. Still these EDWC are only expected to occur in vulnerable areas such as those with high usage of diazinon over the watershed and/or high runoff. EDWCs reflecting multiple crop cycles per year are presented, in accordance with EFED's understanding of potential agricultural practices based on the Diazinon Use Summary Table. Uncertainty about the extent to which multiple crop cycles per year are actually employed translates to uncertainty regarding the representativeness of model outputs for these simulated scenarios. Complete modeling results are presented in Section 10 **Modeling Results**. Also attached is an electronic file which contains, for dietary risk calculation purposes, daily concentration time series for use with the Health Effects Division's CALENDEX and DEEM models.

For surface water sources of drinking water, the PFAM modeled maximum (1-in-10 year return frequency) acute EDWCs associated with diazinon use on cranberries was 141 µg/L. This EDWC may overestimate actual concentrations in drinking water. Cranberry bogs are flooded to protect plants from the cold, to harvest, and to remove fallen leaves and control pests (Cape Cod Cranberry Growers Association, 2001). The most common flooding times when the crop is active is when cranberry bogs are flooded a few days prior to harvest followed with the release of water a few days later. The released water may be recycled or may be released to canals or other waterways. The simulation that produced the peak EDWC of 141 µg/L employed the assumption that diazinon was applied to cranberry plants in dry bog soil, and then flood water was introduced to the bog. The estimated concentration represents residues in the bog, post-

[1] Dannette Drew confirmed the residues of concern in an email dated 7/23/2014.

flood. This concentration is not expected to correspond with concentrations occurring outside of cranberry bogs where drinking water intakes are located. At the very least, water released from cranberry bog will undergo some degree of dilution before residues reach a drinking water treatment facility intake. The Surface Water Concentration Calculator (SWCC) for simulation for cranberries estimated peak and annual average concentrations that were lower than those estimated for other use patterns. Analysis of the locations of drinking water intakes in areas where cranberries are grown indicates that the area where drinking water is most likely to be influenced by pesticides used on cranberries is in Massachusetts (Lafleur, 2002). While these model results are generally expected to overestimate human exposure, monitoring data suggest that residues of diazinon may occur within an order of magnitude of the modeled PFAM peak EDWC, monitoring data do not confirm that diazinon residues will remain high near drinking water intakes outside of cranberry bogs over time. The annual average EDWC from PFAM is higher than what is expected to occur and was therefore not recommended for use in the drinking water assessment. Diazinon has also been detected in water draining from cranberry bogs into the Grays Harbor County Drainage Ditch and Pacific County Ditch in Washington State over the previous 17 years (Baker, 2014) at a maximum concentration of 7.7 µg/L. While there are no drinking water intakes influenced by cranberries in Washington State, this also supports the potential for diazinon use on cranberries to result in movement of residues off of cranberry bogs, to adjacent waters.

The next highest 21-day average EDWC was generated by the simulation of use on apples and/or pears. It reflects two foliar applications of diazinon (to apple or pear tree orchards) at 2 lbs active ingredient per acre (lbs a.i./A) with a 14-day retreatment interval. The associated 1-in-10 year peak and annual average EDWCs were 110 and 8.85 µg/L, respectively. A simulation of the use of diazinon on melons at 4 lbs a.i./A with soil incorporation, followed by a foliar application at 0.75 lbs a.i./A, resulted in a peak and annual average EDWC of 119 and 7.09 µg/L, respectively. These simulations of EDWCs using the SWCC reflect potential surface water concentrations in runoff-vulnerable locations where apples, pears, or melons are grown and diazinon is applied over a large portion of the watershed. It is not expected that these high EDWCs represent concentrations in all waters in apple, pear, or melon growing areas nationally. It is estimated by the Biological and Economic Analysis Division (BEAD) that approximately 30,000 lbs of diazinon per year was applied to apples and pears between 2004 and 2012 (**Table 2**), indicating that this is an important use pattern for diazinon. These peak EDWCs are similar to diazinon concentrations measured in a pond adjacent to an application area in an aquatic field dissipation study (peak=113 µg/L), and are within an order of magnitude of maximum concentrations detected in ambient surface water monitoring for parent diazinon.

Modeling was used to explore how some of the uncertainties in model inputs and labels could influence the EDWC. These uncertainties include the sorption coefficient, the number of seasons per year, and the aerobic soil metabolism half-life. See the section on modeling results for a discussion of details.

Table 1. EDWCs for Residues of Diazinon and Diazoxon[a]

Drinking Water Source (Model)	Use and Rate Modeled	Diazinon Concentration in Drinking Water (µg/L)[b] (Diazoxon concentration)[f]			
		1-in-10 Year Peak	1-in-10-year 21-day Ave	1-in-10 Year Annual Ave (SWCC) or Post Breakthrough Ave (PRZM-GW)	30 Year Mean
Surface Water[e] (PFAM and SWCC)	Cranberries 3 lbs a.i./A, 3x, 14d MRI, foliar ground	21.7[c]– 141[d] (20.5 - 134)	16.2[c]– 131[d] (15.3-124)	3.82[c] (3.62)	3.82[c] (2.54)
Surface water (SWCC)	Apples or Pears 2 lbs a.i./A, 2x, 14d MRI, foliar ground	110 (104)	65.8 (62.3)	8.85 (8.38)	4.25 (4.02)
Surface Water (SWCC)	Melons 4 lbs a.i./A, 1x with 2 inch soil incorporation, 0.75 lbs a.i./A 1x, foliar ground	119 (113)	62.9 (59.6)	7.09 (6.71	3.56 (3.37)
Groundwater (PRZM-GW)	CA Nursery 5 lbs a.i./A, 12x, 14d MRI, foliar, ground	2.37 (2.24)	--	1.72 (1.63)	--

MRI=minimum retreatment interval; Ave=Average

* The molecular weight conversion to diazoxon is 0.947. EDWCs for diazoxon would be approximately 0.947 of those reported here if chlorination and/or other processes converted all diazinon to diazoxon.

[b] Drinking water concentrations were modeled for residues of diazinon plus lost radioactivity and residues of diazinon alone based on some uncertainty about aerobic soil metabolism study results with substantial lost radioactivity. Most lines of evidence suggest that diazinon is not persistent; therefore, the EDWCs reflecting residues of diazinon alone are recommended for use in the exposure assessment and shown in this table for surface water. However, it should be noted that there is some uncertainty as to whether there may be some vulnerable areas where the aerobic soil metabolism DT_{50} would be higher than the DT_{50} of 34-days used to determine these EDWC. There is one measured DT_{50} for aerobic soil metabolism of 56 days. The PRZM-GW results reflect residues of diazinon and lost radioactivity and the aerobic soil metabolism input value was 155-days.

[c] Calculated using the SWCC

[d] Calculated using PFAM, reflects concentrations in water that could be released from the cranberry bog.

[e] The primary area of concern for cranberries and drinking water is in Massachusetts as this is an area with a high mass of diazinon applied per year and drinking water intakes located near cranberry growing areas.

[f] Reflects residues of diazoxon. Calculated by multiplying the diazinon EDWC by 0.947.

Diazinon is one of the most frequently detected pesticides in surface water and has been detected in 46 states (**Figure 7**), in every major river basin (including the Mississippi, Columbia, Rio Grande, and Colorado), and in large rivers and major aquifers. The highest known diazinon concentration detected in surface water was 61.9 µg/L in a creek in California in 2009 (**Table 21**). Eleven states[2] had surface water detections at 0.9 µg/L or greater and 34 states had detections above 0.1 µg/L. Detections greater than 1 µg/L are still occurring after 2007, when several mitigations on diazinon use[3] were implemented, with concentrations above 0.1 µg/L being common, especially in high use areas (**Figure 5**). Additionally, analysis of the locations of drinking water intakes in relation to the locations where surface water monitoring occurred, shows that detections have occurred in and near waters with drinking water intakes. Diazinon

[2] California, Georgia, Virginia, Oregon, Utah, Texas, Indiana, Tennessee, Alabama, Wisconsin, and Louisiana

[3] RED mitigations include cancellation of residential uses, seed treatments, and use of granules. Additionally, most aerial applications were cancelled. While these mitigations were implemented in prior to 2008, it may have taken some time for all products to be removed from the market.

has been detected in raw drinking water samples. Diazoxon was also detected in surface water at a maximum concentration of 0.43 µg/L.

Diazinon has also been detected in groundwater, sediment, air, precipitation, and tissue (fish, clam, and mussel) but at lower concentrations and/or detection frequencies. The highest concentration reported in fish fillet was 140 ng/g wet-weight. The highest diazinon concentration detected in groundwater was 19 µg/L; however, the detection frequency in groundwater is much lower than that in surface water. Much of the monitoring data available are non-targeted (not specific to a particular diazinon application), and sampling did not occur with sufficient frequency to capture peak concentrations, except perhaps by accident. Therefore, monitoring data should not be assumed to define the upper bound of potential real world exposures. While it may be helpful to compare monitoring results with modeled values, the two are not expected to be similar. Modeled EDWCs represent concentrations in a runoff-vulnerable reservoir, while monitoring reflects a range of waterbodies and use areas. Monitoring results provide one line of evidence about whether concentrations in the environment are at or near levels where risk may occur.

2 CHEMICAL CLASS AND MODE OF ACTION

Diazinon, O, O-Diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl)phosphorothioate is an insecticide/acaricide belonging to the organophosphate class of pesticides. The pesticide acts through inhibition of acetylcholinesterase and is used to kill a broad range of insects and mites. Organophosphate toxicity is based on the inhibition of the enzyme acetylcholinesterase which cleaves the neurotransmitter acetylcholine. Inhibition of acetylcholinesterase by organophosphate insecticides, such as diazinon, interferes with proper neurotransmission in cholinergic synapses and neuromuscular junctions (USEPA, 2000, D154949, D159643, D183157).

3 USE AND USAGE

The EPA worked with registrants (ADAMA, Drexel, and the CA Department of Agriculture) to summarize all currently registered Section 3, 24C, and 18 uses for diazinon, clarify missing or unclear information on labels, and define uses that registrants intend to continue to support after completion of the Registration Review process. From this effort, a summary of uses that will be supported and that will be assessed in Registration Review was developed in a Diazinon Use Summary Table (**Appendix A**). Exposure was estimated for the use patterns described in the table.

Diazinon was originally registered for use in the United States in 1962. Currently, diazinon is registered for use on almonds, filberts, stone fruit (apricot, cherries, peaches, nectarines, plums), berries (blueberries, caneberries, cranberries, strawberries), figs, vegetables (including beans, parsley, Swiss chard, cucumbers, squash, sweet potato, cole crops, endive, lettuce, melons, onions and bulb vegetables, peas, peppers, spinach, red beet, radishes, carrots, rutabaga, turnips, tomatoes, and parsnips), pome fruit (apples and pears), ginseng, pineapple, outdoor ornamentals grown in nurseries, and cattle ear tags. While most of the uses are allowed across the United States, many of the labeled uses are on Special Local Needs (SLN) labels and are only allowed in

one state. There are three technical labels, six Section 3 labels for agricultural products applied to crops, ten 24C or SLN Labels that are supplements to the six Section 3 labels, and six cattle ear tag labels. The cattle ear tag uses are assumed to result in minimal drinking water exposure. Formulations include wettable powder, emulsifiable concentrate, and ear tags. All products (except the cattle ear tags) are applied in liquid form. Aerial applications are allowed on lettuce only. Foliar ground, airblast, soil drench under plant, and soil incorporation applications are also common application methods allowed on diazinon labels.

The current maximum annual application rates on the labels are 5 pounds active ingredient per acre (lbs a.i./A) per application, with a maximum number of applications per year of 12, and a maximum of 60 pounds a.i./acre per year applied as a soil drench to containerized nursery stock in California[4]. This maximum use pattern is on a special local needs (SLN label) with EPA registration number CA-050002. It is registered to the California Department of Food and Agriculture, to be used for fruit fly pests subject to State quarantine action. Treatments are for quarantine and eradication purposes, and are limited to applications under direct supervision by federal, state or county authorized persons. This SLN is generally used at large nurseries in southern California to treat fruit fly (in the *Tephritidae* family) infestations. There is a Section 18 label in Florida with a similar use pattern where diazinon is used under host trees.

The next highest annual or seasonal application rate is for a foliar ground application at 9 lbs a.i./A/year (3 lbs a.i./A/application with 3 possible application per year at a minimum 14 day retreatment interval) registered for use on cranberries.

Based on the *Screening Level Estimates of Agricultural Uses of Diazinon* (USEPA, 2014c) provided by the Biological and Economic Analysis Division (BEAD), on average 559,000 pounds of diazinon were used per year between 2004 and 2012 for agricultural purposes in the United States. Approximately 18% (100,000 lbs) of the total pounds of diazinon used in agriculture in the United States each year is applied to lettuce. Approximately 4 to 7% of diazinon (20,000 to 40,000 lbs to each crop) is applied to onions, almonds, apples, spinach, tomatoes, walnuts, cantaloupes, carrots, peaches, and plums. The remaining 32% of agriculturally applied diazinon is applied to over 40 different crops, with 10,000 lbs or less applied to each crop. The crops with the highest percent crop treated (PCT) include lettuce and spinach with 60% PCT, caneberries with 50% PCT, carrot and apricots with 40% PCT, and cantaloupes with 35% PCT. Onions, plums, cabbage, blueberries, broccoli, and cauliflower have 20 to 25% PCT. The SLUA results are provided in **Table 2**. This analysis does not include information on use of diazinon in nurseries or use on cranberries.

[4] Email from PRD (Khue Nguyen on 8/28/2014 forwarding an email from the California Department of Food and Agriculture (Laura O Petro).

Table 2. Screening Level Estimates of Agricultural Uses of Diazinon (2004 to 2012)

Crop	Average Lbs a.i.	Percent Crop Treated		Percent of Total lbs
		Average	Max	
Lettuce	100,000	35	60	18%
Onions	40,000	15	25	7%
Spinach	30,000	25	60	5%
Almonds	30,000	<2.5	10	5%
Apples	30,000	5	10	5%
Tomatoes	30,000	5	10	5%
Walnuts	30,000	5	10	5%
Carrots	20,000	15	40	4%
Cantaloupes	20,000	15	35	4%
Plums/Prunes	20,000	10	25	4%
Peaches	20,000	5	15	4%
Grapes	10,000	<2.5	<2.5	2%
Potatoes	10,000	<1	<2.5	2%
Sugar Beets	10,000	<1	<2.5	2%
Caneberries	10,000	30	50	2%
Cabbage	10,000	15	25	2%
Broccoli	10,000	5	20	2%
Cherries	10,000	5	15	2%
Watermelons	10,000	5	10	2%
Corn (seed treatment)++	10,000	<2.5	5	2%
Blueberries	9,000	20	25	2%
Sugarcane++	8,000	<2.5	5	1%
Sweet Corn	8,000	<2.5	5	1%
Alfalfa++	6,000	<1	<2.5	1%
Corn	6,000	<1	<2.5	1%
Apricots	6,000	20	40	1%
Cucumbers	6,000	5	10	1%
Beans, Green	6,000	<2.5	5	1%
Cauliflower	5,000	10	20	1%
Garlic	5,000	10	15	1%
Dry Beans/Peas	4,000	<1	<2.5	1%
Pears	4,000	5	10	1%
Peppers	4,000	<2.5	10	1%
Cotton	3,000	<1	<2.5	1%
Pecans	3,000	<1	<2.5	1%
Strawberries	3,000	5	15	1%
Oranges++	2,000	<1	<2.5	0.4%
Squash	2,000	5	10	0.4%
Brussels Sprouts	1,000	NC	NC	0.2%
Grapefruit++	1,000	<1	<2.5	0.2%
Nectarines	1,000	<2.5	<2.5	0.2%
Peanuts++	1,000	<1	<2.5	0.2%

Peas, Green	1,000	<1	<2.5	0.2%
Pumpkins	1,000	<1	<2.5	0.2%
Sorghum++	1,000	<1	<2.5	0.2%
Tobacco ++	1,000	<1	<2.5	0.2%
Honeydews	1,000	5	10	0.18%
Figs	<500	NC	NC	NC
Pluots	<500	NC	NC	NC
Celery	<500	5	10	NC

NC=not calculated
+Crops not know to be listed on active end use product registrations or as Section 18 emergency exemptions when this report was run.
++ There is no current active registration for this use. Usage in this report may reflect usage occurring before cancellation or as a result of using existing stocks after cancellation.

Cranberries are a specialty crop, and information about diazinon usage on them is not available in the SLUA. The Cranberry Institute provided the following information for diazinon usage on cranberries in 2009[5]. The average percent crop treated was 54.8% and the total pounds of diazinon applied to cranberries in 2009 was 79,097. This suggests that application to cranberries is another important use pattern for diazinon.

Table 3. Summary of Usage of Diazinon on Cranberries Provided by the Cranberry Institute

Parameter	Massachusetts	New Jersey	Oregon	Washington	Wisconsin	
Percent of crop treated	72.1	9.9	71.7	64.1	56.1	Average 54.8
Total lbs used	26,025	240	7,847	3,152	41,833	Total 79,097
Median lbs of AI applied per acre	2.24	3.12	2.08	2.08	2.3	--
% applied Aerial	0	95.3	0	.5	5.5	
% applied Ground (spray)	51	4.7	100	83.9	94.4	
% applied through Sprinkler	49	0	0	15.6	.1	
Median early application date	5/23/09	7/14/09	5/5/09	5/12/08	6/4/09	
Median late application date	7/25/09	8/8/09	8/1/09	8/9/09	8/14/09	

The geographic extent of diazinon use is widespread. The annual average use intensity of diazinon between 2008 and 2012 is displayed in **Figure 1**.[6] This map reveals intensive

[5] Data provided in an email from Claire Paisley-Jones on 2/62015.

[6] The map was created and provided by BEAD via email from Claire Paisley-Jones on 8/20/2014. The map provides a very broad geographical view of the average annual amount (in pounds) of active ingredient applied per 1,000 acres of crop acres grown. These data are included in the maps because risk assessors are interested in the

agricultural use of diazinon across the United States, especially in parts of California, Oregon, Washington, Idaho, Arizona, Colorado, South Dakota, Oklahoma, Texas, Iowa, Missouri, Michigan, Ohio, Pennsylvania, New York, Rhode Island, Florida, Alabama, and Georgia.

No data are available on use of diazinon in nurseries nationally. The nursery uses include a national use at a rate of 1 lbs a.i./A with one application per crop cycle. The number of crop cycles per year is reported by Registrants in the Diazinon Use Summary Table to be one to several. There are also two unique use patterns at a rate of 5 lbs a.i./A with up to three applications a year in California and Florida to control fruit flies in the *Tephritidae* family. Fruit fly outbreaks in Florida are rare, but when they occur, diazinon is applied in residential areas on a per-tree basis, under Federal/State supervision, whereby infested trees are cordoned off and the fruit is removed. Nursery stock is only treated if the nursery stock are located outside and under a host tree[7] (*e.g.*, mango trees). According to the Animal and Plant Health Inspection Service (APHIS), the total amount of diazinon used in Florida amounts to less than one quart over a 4-year period.[8] The total amount of diazinon applied to nursery stock in California in 2011 was 422 lbs.[9]

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amount of a pesticide used across agricultural land. The calculated values presented in the map are broadly area based and are not equivalent to on-field application rates (lb a.i./A).

The data used to make these maps have several limitations. Any interpretation of the maps should consider the underlying data and the associated limitations carefully.

The numerator (annual average pounds applied) is based on private market surveys of pesticide use in agriculture averaged over the last five years (Proprietary Data, 2008-2012). These surveys cover about 60 crops and are targeted in states that produce the majority of the crop. Although the surveys capture most of the use of a particular active ingredient in agriculture, there are several limitations to these surveys.

- States with minor production of a surveyed crop are not sampled
- Not all types of pesticides are surveyed in every crop in every year
- Many specialty crops with very small acreages are not included in the survey

The result of these limitations is that states that show no usage may actually have some usage of the active ingredient. In some cases the displayed use intensity may be distorted because the surveyed crops and the reported pesticide usage may not accurately represent the actual pesticide usage on the crops produced in the state.

The denominator (1,000 crop acres grown) was also obtained from the same private market survey database. The "Crop Acres Grown" variable represents the total acres in a given state, of all of the surveyed crops grown there. This value is independent of pesticide usage and pesticide registration. It is important to note that the surveyed crops (of which there are about 60) are sampled from states that are major producers of each crop. Therefore, there are cases where the actual crop acreage in a state is higher than that reported by crop acres grown in the survey because either that state and/or crop was not included in the survey.

The reader should pay particular attention to the figure legends and realize that a map prepared for a particular chemical is not directly comparable to a map prepared for a different chemical, as the legend bins will likely be different.

[7] A host tree is a tree that may be infested with fruit fly.

[8] Email from Susan O'Toole (APHIS) to Khue Nguyen on 8/18/2014.

[9] The California Pesticide Use Reporting Database reported that 422 lbs of diazinon were applied in nurseries (CADPR, 2012a).

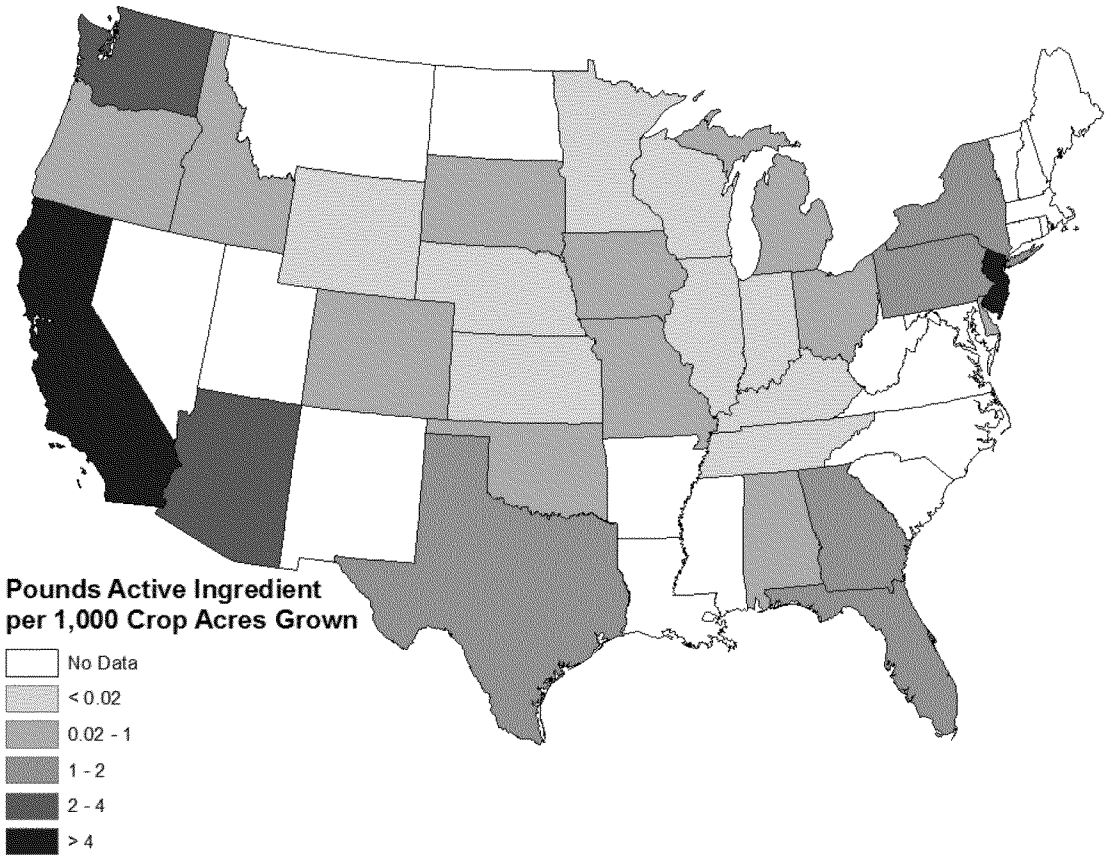

Figure 1. Pounds Diazinon Applied per 1000 Crop Acres Grown in the United States between 2008 and 2012

4 PREVIOUS DRINKING WATER ASSESSMENTS

Several drinking water assessments (DWAs) have been completed for diazinon. Previous assessments relied upon Tier I groundwater modeling, Tier II surface water modeling, and monitoring data. As part of the 2002 *Final Revised Environmental Fate and Ecological Risk Assessment Chapter for the Reregistration Eligibility Decision on Diazinon* (USEPA, 2002, D183157), a drinking water exposure assessment was completed. This exposure assessment included a review of surface and groundwater monitoring data as well as model estimations for diazinon. Concentrations of diazoxon, an environmental transformation product, were not modeled because the available fate information on diazoxon was insufficient to permit quantitative exposure analysis.

In previous DWAs, EDWCs for surface water have provided the highest exposure values. EDWCs for surface water reported in the RED (USEPA, 2002, D183157) are summarized in **Table 4**. A range of values is presented with the lower end of the range derived from monitoring and the upper end derived from modeling.

For surface water, the monitoring values were calculated as the 95th percentile value. There were 98 agricultural and 26 non-agricultural sites where samples were collected from surface waters that were potential drinking water sources (rivers, streams, *etc.*). The maximum reported diazinon concentration at each monitored site was tabulated (separating agricultural from non-agricultural studies). The lower bound on acute exposure was then estimated as the resulting 95th percentile value.

The 95th percentile of the arithmetic means of all samples at each site (detects and non-detects) from monitoring studies whose samples were from potential drinking water sources was assumed to constitute an estimated chronic concentration. Samples with values below the limit of detection (LOD) were given a value of one-half the LOD in these calculations.

For groundwater monitoring, values were reported as the detection limit of 0.002 µg/L [10]. There were only three studies other than those conducted by the United States Geological Survey (USGS) as part of their National Water-Quality Assessment (NAWQA) program. The NAWQA groundwater data had 0.7% detects in the field blanks spiked with diazinon and the total percent of detects for the environmental samples was 1.8 (51 detects in 3,023 samples). Samples were not necessarily collected in diazinon use areas.

Table 4. Previously Reported Estimated Drinking Water Concentration of Diazinon in 2002 RED (USEPA, 2004)[2]

Type	Diazinon Concentration in Drinking Water in µg/L	
	Acute (monitor-model[1])	Chronic (monitor-model[1])
Surface Water – Agricultural Use (peaches in Georgia)	2.3 – 70.1	0.19 – 9.4
Surface Water – Non-Agricultural Use	3.0 – 70.1	0.46 – 9.4
Groundwater	<0.002 – 0.8	<0.002 – 0.8

[1] A range of values is presented with the lower end of the range derived from monitoring and the upper derived from modeling. See text for an explanation of how the monitoring values were estimated.
[2] Surface water concentrations were modeled using PRZM/EXAMs and the Index Reservoir where peaches were simulated in Georgia. Groundwater modeling was completed using SCI-GROW. A use rate of 3 lbs a.i./A as an aerial spray with two applications was simulated. A default percent cropped area of 0.87 was applied to the surface water modeling result.

The previous drinking water assessment (USEPA, 2004) noted that surface water monitoring data underestimates the peak exposure because of the following sources of uncertainty:

- The portion of each county treated with diazinon (Merced, Sacramento, San Joaquin, and Stanislaus) in the sampled watersheds during the majority of the sampling periods (dormant spray period: December thru March) was estimated to be less than one percent.
- There is a lack of monitoring data in the majority of diazinon use areas (both agricultural and non-agricultural).

[10] The NAWQA method detection limit reported for the groundwater monitoring data was 0.002 µg/L.

- The concentrations of diazinon (or any pesticide) detected in surface water are functions of the frequency and timing of monitoring in relation to the temporal dynamics of pesticide application and runoff events.

5 ENVIRONMENTAL FATE AND TRANSPORT

Physical-chemical properties and dissipation-related parameters for diazinon and its major degradates of concern are provided in **Table 5**. A more complete discussion of the fate information is available in **Appendix B**.

Diazinon enters the environment via direct spray and spray drift onto soil, foliage, and/or water. The environmental fate properties of diazinon along with monitoring data identifying its presence in surface waters, air, and in precipitation indicate that important transport pathways include runoff and spray drift. Volatilization, atmospheric transport, and subsequent deposition of diazinon to aquatic and terrestrial habitats also occur.

Based on diazinon's aerobic soil metabolism and aerobic and anaerobic aquatic metabolism data, diazinon is not considered persistent[11] in the environment, with half-lives on the order of days to weeks (representative[12] half-life values range from 9 to 57 days). Diazinon also degrades via hydrolysis with time to 50% decline (DT_{50}) values of 2 days at pH 4, 12 days at pH 5, and ranging from 62 to 139 days at pH 7 and 9. The dominant degradation process is expected to depend on environmental conditions. At low pH (pH 4 to 5), hydrolysis may be the primary degradation process, while at higher pH (above pH 5), aerobic metabolism will be more important. Terrestrial field dissipation DT_{50}s ranged from five to 20 days in 18 field studies, and did not exhibit any obvious relationship with formulation. There was no obvious relationship with DT_{50} values and whether the field was cropped or bare. Residues of diazinon were still present in soils after a year with repeated application at some sites, but not at others. Results from the terrestrial field dissipation studies are consistent with those observed in the lab. Dissipation DT_{50} values ranged from 5 to 20 days and aerobic soil metabolism DT_{50} values ranged from 9 to 57 days. The presence of residues in terrestrial field dissipation studies is consistent with laboratory studies when DT90 values and the shape of the decline curves are considered. Aerobic soil DT_{90} values ranged from 28 to 188 days for diazinon and 28 to 1285 days for diazinon plus lost radioactivity and some degradation curves showed an initial rapid rate of decline followed by more gradual decline. Diazinon does undergo atmospheric degradation,

[11] Based on the Toxic Release Inventory classification system where half-lives greater than 60 days in water, soil, and sediment are considered persistent and half-life greater than 6 months are considered very persistent (USEPA, 2012a).

[12] Representative half-life values are generated for use as model inputs using the North American Free Trade Agreement (NAFTA) guidance for calculating degradation kinetics (NAFTA, 2012; USEPA, 2012c). The representative half-life may reflect both initial and later (potentially slower) portions of the decline curve and is not necessarily numerically similar to the value of the DT_{50}, rather it provides a half-life input value for use in modeling that is generated using a standardized procedure from decay data that do not necessarily exhibit first-order behavior. The actual DT_{50} and DT_{90} from the representative degradation kinetic equations for the curve are used for descriptive purposes and for understanding the decline curve and the nature of the representative half-life used in modeling, see **Appendix B** for these values.

the half-life estimated for the average 12-hour day time concentration of hydroxyl radicals (1.5×10^6 molecules (radicals/cm^3) in the troposphere[13] at 40°C (104°F) was 1.3 hours.

Diazinon is classified as moderately mobile to slightly mobile (K_{OC}s range from 138-3779 L/kg)[14] and has the potential to reach surface water through runoff and soil erosion. Overall, soil/sediment-water distribution coefficients increase with increasing percent organic-carbon. Diazinon has the potential to reach groundwater especially in high-permeability soils with low organic-carbon content and/or the presence of shallow groundwater. The maximum depth of leaching in the terrestrial field dissipation studies was 48 inches. In water and sediment, diazinon will be present both in the water column and bound to sediments. Based on measured octanol-water partition coefficients (K_{ow}s) and K_{OC}s exposure to sediment-dwelling organisms is likely to occur. Diazinon is semivolatile and may also be transported in air in both the vapor form and associated with particles. Diazinon is oxidized to diazoxon by hydroxyl radicals and ozone. Based on the drinking water treatment data (Acero *et al.*, 2008; Beduk *et al.*, 2011; Chamberlain *et al.*, 2012; Duirk *et al.*, 2009; Magara *et al.*, 1994; Ohashi *et al.*, 1994; Wu *et al.*, 2009; Zhang and Pehkonen, 1999), it is possible that diazoxon could form in air in the presence of ozone.

Empirical bioconcentration factors (BCF) for diazinon range from 3 to 82 µg/kg-wet weight per µg/L in aquatic invertebrates and 18 to 213 µg/kg-wet weight per µg/L in fish, and the estimated time to steady state for diazinon is ≥4 days (estimated using KABAM). Based on diazinon's log octanol-water partition coefficient (k_{ow}), it is possible that mammals and birds could be exposed to diazinon via consumption of aquatic animals exposed to diazinon in water. Based on diazinon's log K_{ow} and its log octanol-air partition coefficient (log K_{OA}) of 8.4, diazinon is likely to bioconcentrate in terrestrial organisms, if it does not degrade and is not metabolized (Armitage and Gobas, 2007; Gobas *et al.*, 2003; USEPA, 2008, 2009c). However, the short atmospheric half-life of diazinon will limit the amount of diazinon in air over time and metabolism of diazinon is known to occur in vertebrates.

The only identified degradate of concern[15] for diazinon is diazoxon. Diazoxon has been identified as a residue of concern for both human health and ecological risk assessments. Diazoxon was only observed in one submitted aerobic soil metabolism study at a maximum of 0.6% applied radioactivity and in an air photolysis study where it formed before the photolysis portion of the study began. Limits of quantitation for diazoxon were high (0.01 to 0.02 mg/kg-soil) in the studies where it was examined and there was a portion of unidentified residues in submitted laboratory studies. Although formation and degradation of diazoxon cannot be quantified from available laboratory fate studies involving diazinon, diazoxon has been detected in air, rain, fog (Majewski and Capel, 1995) and surface waters in the United States (USGS, 2011). Organophosphates that contain a phosphothionate group (P=S), such as diazinon are known to transform to the corresponding oxon analogue containing a phosphorus-oxygen double bond (P=O) instead. This transformation occurs via oxidative desulfonation and can occur through photolysis and aerobic metabolism, as well as other oxidative processes. Disinfection

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[14] Mobility was classified using the Food and Agriculture Organization (FAO) classification system (FAO, 2000) and supplemental sorption coefficients.
[15] Diazoxon is a residue of concern for humans and other terrestrial and aquatic animals.

with chlorine or ozone converts diazinon to diazoxon (Acero *et al.*, 2008; Beduk *et al.*, 2011; Chamberlain *et al.*, 2012; Duirk *et al.*, 2009; Magara *et al.*, 1994; Ohashi *et al.*, 1994; Wu *et al.*, 2009; Zhang and Pehkonen, 1999) and similar reactions with ozone could occur in the natural environment[l]. In surface water monitoring data wherein residues of both diazinon and diazoxon were detected, the ratios of the concentrations of diazoxon to diazinon ranged from 0 to 0.5. The atmospheric degradation half-life estimated for the average 12-hour day time concentration of hydroxyl radicals at 30°C (104°F) was 4.1 hours (MRID 49049902).

Table 5. Physical/Chemical and Environmental Fate Properties of Diazinon and Diazoxon[a]

Chemical Fate/Parameter	Range of Values (Number of Values)		
Common name	Diazinon		Diazoxon
IUPAC Name	*O,O*-diethyl *O*-2-isopropyl-6-methylpyrimidin-4-yl phosphorothioate		Phosphoric acid, diethyl 6-methyl-2-(1-methylethyl)-4-pyrimidinyl ester
Chemical Formula	$C_{12}H_{21}N_2O_3PS$		$C_{12}H_{21}N_2O_4P$
Molecular Mass (g/mole)	304.35		288.28
Vapor Pressure (Torr, 25°C)	7.22×10^{-5} 6.6×10^{-5}		1.1×10^{-5}estimated
Solubility (25°C) (mg/L)	59.5 pH 6.07 65.5 pH not reported		245 estimated pH NR
Octanol-water partition coefficient (K_{ow})	4898 (log K_{OW}=3.69) at 24°C 6393 (log K_{OW}=3.8) at 25°C		117 (log K_{OW} 2.07) estimated
Atmospheric Degradation half-life (hours, 39.5°N)	1.3 at 40°C In presence of OH radicals		4.1 30°C In presence of OH radicals
Hydrolysis half-life (days)	pH 4, 25°C	1.93	No data
	pH 5, 23-25°C	12.4	
	pH 7, 25°C	82.3	
	pH 7, 23-25°C	139	
	pH 9, 23-25°C	77.1	
	pH 9, 25°C	61.9	
Aqueous photolysis half-life (days)	Stable at pH 7, 25°C 0.3-1 in presence of NO_3^-, CO_3^{2-}, and DOC at summertime ambient light 53°N, pH 7, 20°C[e]		No data
Soil photolysis half-life (days)	No acceptable data		No data
Aerobic soil metabolism representative half-life[a] range (days)	9 – 57 (5) Not Persistent[b]		No data
Anaerobic soil metabolism representative half-life[a] range (days)	No data		No data
Aerobic aquatic metabolism representative half-life[a] range (days)	10 – 16 (2) in water-soil 6.3 – 41.0 (4) in surface water[f]		No data
Anaerobic aquatic metabolism representative half-life[a] range (days)	24.5 (1)		No data
Organic-carbon normalized soil –water distribution coefficients (Koc) L/kg-OC	138-3779 (32)[d] Moderately to Slightly Mobile[c]		174.7 (estimated using EPIWeb 4.1) Moderately Mobile[c]
Terrestrial field dissipation DT_{50}s	5 – 20 (18)		NR
Aquatic field dissipation DT_{50}s	Not available		No data
Bioconcentration factor (L/kg-wet weight)	3 – 82 (8) in aquatic invertebrates 18 – 213 (15) in fish		No data

NR=not reported; DT_{50}=time to 50% decline of residues

[a] Representative half-life values are generated using the North American Free Trade Agreement (NAFTA) guidance for calculating degradation kinetics (NAFTA, 2012; USEPA, 2012c). The representative half-life considers both initial and later (potentially slower) portions of the decline curve and is not necessarily numerically similar to the value of the DT_{50}, rather it provides an input value for modeling that is generally expected to be conservative. The actual DT_{50} and DT_{90} from the representative degradation kinetic equations for the curve are used for descriptive purposes and for understanding the decline curve and the nature of the representative half-life used in modeling, see **Appendix B** for these values.
[b] Based on the Toxic Release Inventory classification system where half-lives greater than 60 days in water, soil, and sediment are considered persistent and half-life greater than six months are considered very persistent (USEPA, 2012a).
[c] Mobility was classified using the Food and Agriculture Organization (FAO) classification system (FAO, 2000).
[d] Sorption coefficients for diazinon did not have reliable mass balances, did not confirm equilibrium was achieved, did not account for sorption to test systems, did not confirm the identity of the compound associated with radioactivity, or had added solvents in the test systems and are considered supplemental. The EPIWeb estimated sorption coefficient is within the range of measured values.
[e] (Ukpebor and Halsall, 2012)
[f] (Bondarenko *et al.*, 2004)

6 DRINKING WATER TREATMENT

The Office of Pesticide Programs has completed a review of the effects of drinking water treatment on pesticides in water (Hetrick *et al.*, 2000; USEPA, 2002). This review indicates that standard drinking water treatment, consisting of flocculation/sedimentation and filtration does not substantially affect concentrations of pesticides in drinking water. For surface water treatment plants, 84% of plants disinfect using chlorine and 3.8% disinfect using ozone (USEPA, 2009a). The removal of diazinon exposed to free chlorine (the most commonly used disinfection method) is greater than 50%, and is 20 to >50% for ozone (**Table 6**). Other disinfection methods (chloramines, chlorine dioxide, and ultraviolet light) result in less removal (<20% to 50%) of diazinon (Chamberlain *et al.*, 2012). While some processes degrade diazinon, some processes convert diazinon to diazoxon, a residue of concern. Disinfection with chlorine or ozone converts diazinon to diazoxon (Acero *et al.*, 2008; Beduk *et al.*, 2011; Chamberlain *et al.*, 2012; Duirk *et al.*, 2009; Magara *et al.*, 1994; Ohashi *et al.*, 1994; Wu *et al.*, 2009; Zhang and Pehkonen, 1999). Diazoxon is stable in the presence of chlorine (Acero *et al.*, 2008). Ozone treatment showed a pH-dependent degradation of diazinon and 100% removal of diazinon after 30 minutes; however, diazoxon accumulation was noted (Beduk *et al.*, 2011). Shemer and Linden (2006) found that diazinon degraded during ultraviolet (UV) and UV/H_2O_2 treatment with formation of only trace amounts (0.1% of the original diazinon concentration) of diazoxon. Overall, evidence suggests that in many water treatment facilities diazinon will degrade rapidly to its more toxic degradate diazoxon. Less frequently, diazinon will degrade rapidly to degradates not identified as residues

of concern or will remain in drinking water unchanged. Available evidence indicates that it is reasonable to assume that 100% of diazinon may be converted to diazoxon in drinking water[16].

Table 6. Summary of Diazinon Removal with Different Types of Water Treatment along with the Prevalence of Treatment Methodologies

Treatment Methodology	Prevalence of Treatment Use		Diazinon % Removal[2]	Evidence for Diazoxon Formation?
	Surface Water Source[1]	Groundwater source[1]		
Chlorine	84.4	91.7	>50%	Yes
Chlorine Dioxide	6.6	0.4	<20 – 50%	--
Chloramines only	11.9	0.9	<20%	--
Ozone	3.8	0.1	20 – >50%	Yes
Ultraviolet Light	2.1	0.5	<20%	A small amount
Mixed oxidant	4.1	0.6	--	--

[1] Based on the 2006 Community Water System Survey (USEPA, 2009a)
[2] (Chamberlain *et al.*, 2012)

7 RESIDUES OF CONCERN

Residues of concern for human health in drinking water have been identified as diazinon and diazoxon (USEPA, 2000, D270838). Previous drinking water assessments have been completed on diazinon alone because the fate information on diazoxon was insufficient for exposure analysis. Fate information for diazoxon is still not adequate to estimate diazoxon concentrations using modeling; however, diazoxon EDWCs can be derived from diazinon EDWCs by multiplying diazinon EDWCs by 0.947 (molecular weight correction factor) and assuming that 100% of diazinon is converted to diazoxon. In this drinking water assessment, concentrations of diazoxon were also estimated using a molecular weight conversion factor of 0.947 for the highest EDWC. Rounding to two significant figures, the EDWC for diazoxon will be 95% of the value estimated for diazinon.

8 MODELING APPROACH AND INPUT PARAMETERS

8.1 PRZM-GW (Groundwater)

Tier 1 groundwater EDWCs for diazinon were derived with PRZM-GW (Pesticide Root Zone Model for Groundwater, version 1.07), using the GW-GUI (Graphical User Interface, version 1.07) (Baris *et al.*, 2013). PRZM-GW is a one-dimensional leaching model used to estimate potential concentrations of pesticides in groundwater. The model accounts for pesticide fate in the crop root zone by simulating transport and degradation occurring throughout the soil profile after a pesticide is applied to an agricultural field. PRZM-GW permits the simulation of multiple years of pesticide application (up to 100 years) on a single site. Six standard scenarios, each representing a different region known to be vulnerable to groundwater contamination, are currently available for use with PRZM-GW for risk assessment purposes. In the PRZM-GW simulations for this assessment, all of these standard scenarios were used. PRZM-GW outputs

[16] This is assuming 100% conversion of diazinon to diazoxon and that the molecular weight conversion factor (0.947) is so close to 1, that the diazinon concentration may be assumed to reflect residues of diazoxon.

represent pesticide concentrations in a vulnerable groundwater supply located directly beneath an agricultural field. Percent Cropped Area adjustment factors (PCAs) are not applied to the results of groundwater modeling, such as those generated by the PRZM-GW model.

8.2 SWCC (Surface Water)

The Surface Water Concentration Calculator (SWCC, version 1.106) is used to calculate surface water EDWCs. The SWCC is a graphical user interface that runs the Pesticide Root Zone Model (PRZM, version 5, November 15, 2006) and the Variable Volume Water Body Model (VVWM, 3/6/2014) (USEPA, 2006). PRZM simulates pesticide fate and transport as a result of leaching, direct spray drift, runoff and erosion from an agricultural field, and VVWM estimates resulting concentrations of pesticides in an adjacent surface water body over a 30-year period. The combined models are expected to provide high-end estimates of pesticide concentrations that might be found in vulnerable aquatic environments following pesticide application. The location of the field is specific to the crop being simulated using site-specific information on the soils, weather, cropping, and management factors associated with the scenario. The crop/location scenario is intended to represent a high-end exposure site on which the crop is normally grown. Based on historical rainfall data, the receiving water body receives multiple runoff (and possibly spray drift) event loadings over the course of the simulated time span. Weather and agricultural practices are simulated for 30 year periods (1961 through 1990) so that the 1-in-10-year exceedance probability concentration at the site can be estimated. Additional information on PRZM and EXAMS can be found at: http://www.epa.gov/oppefed1/models/water/. For drinking water exposure assessments, the Index Reservoir (IR) receiving water body is used in lieu of the standard pond. The IR is used in a manner similar to that in which the standard pond is used in ecological exposure assessments, except that the IR is simulated as a flow-through system, with a scenario-specific steady flow rate based upon the daily-mean runoff over the duration of a simulation (a function of local weather conditions). The IR is approximately 82-m wide and 640-m long, with an area of 5.3 hectare (USEPA, 1998, 2010c). The area of the entire watershed draining to the IR is 172.8 ha. Guidance for using the IR is located at: http://www.epa.gov/oppefed1/models/water/index_reservoir_dwa.html.

8.3 Cranberry Modeling for Surface Water

To determine EDWCs for cranberry use, EFED used the SWCC along with the ORberries scenario, the EFED Tier 1 Rice Model (v1.0, May 8, 2007), and the Pesticides in Flooded Applications Model (PFAM, version 1.09). Some cranberries are grown in bogs, where the field is temporarily flooded to control pests, prevent freezing, and to facilitate harvest. After flooding, water may be held in a holding system, recirculated to other cranberry growing areas, or released to adjacent waterbodies (rivers, streams, lakes, or bays). Exposure due to movement of residues in water released from bogs is evaluated using the Tier I Rice Model Modified for Cranberries and PFAM[17]. The SWCC is used to estimate exposure to diazinon residues from runoff and spray drift from dry harvested cranberries. Together the results from the Tier I Rice Model Modified for Cranberries, PFAM, and the SWCC will be used to represent the various agronomic

[17] PFAM and the Tier I Rice Model do not simulate the movement of water, but the models are used to estimate an exposure due to this pathway.

practices utilized for growing cranberry in a weight of evidence approach for evaluating the potential risk associated with the use of diazinon on cranberries.

SWCC

The SWCC was used to model applications to the terrestrial environment, including to cranberries. Some cranberries are grown in bogs, where the bog may be actively flooded and those flood waters actively managed, and the direct surface water runoff calculations in the SWCC were not designed to represent this sort of circumstance. Outside of the managed flooding of release of waters in cranberry bogs, an analysis of runoff related to cranberry bogs in the New England area described some unique hydrology considerations related to cranberry bogs,

> "*Glaciation and the distribution of glacial deposits greatly influence the hydrologic characteristics of southern New England streams and rivers. Bog sites in low-lying southeastern coastal areas of Massachusetts and Rhode Island have significant areas (greater than 50%) of stratified sand and gravel glacial deposits and floodplain alluvium deposits. These stratified deposits are conducive to high infiltration rates, large storage capacities, and significant baseflow contributions to the surface water channels. The combination of stratified, highly conductive deposits and the low topographic relief allows water to move through the subsurface between surface water basins. Hence, peak discharges cannot be accurately computed by procedures based on direct surface runoff alone*." (USDA, 2012)

While the typical surface runoff simulated in the SWCC does not apply to cranberries grown in bogs, residues related to runoff from cranberries will occur and the SWCC is the tool available to capture exposure due to transport in runoff and spray drift. Additionally, some cranberries are dry harvested and are be grown in a depressed area. Therefore, the SWCC was also used to calculate EDWC for cranberries and both runoff and spray drift were simulated.

Tier I Rice Model Modified for Cranberries

The Tier 1 Rice Model is used to estimate aquatic exposures for direct application to water. The Tier 1 Rice Model estimates one concentration that represents both acute and chronic exposures, it was modified to evaluate degradation in water after the time of application, multiple applications, and to account for the depth of water in a cranberry bog.

The Tier 1 Rice model estimates concentrations in a water body holding a 10 cm water depth. When a pesticide is applied to the water, the model employs the assumption that the pesticide instantaneously partitions between water and sediment, as determined by the chemical's sorption coefficient, according to:

$$C_{w0} = \frac{10^2 m_{ai}'}{d_w + d_{sed}\left(\theta_{sed} + 10^{-3}\rho_b K_d\right)}$$

Where,

C_{w0} = initial water concentration [µg/L]
m_{ai}' = mass applied per unit area [kg/ha]
K_d = water-sediment partitioning coefficient [L/kg]
K_{OC} = organic carbon partitioning coefficient [L/kg]
d_w = water column depth = 0.10 m
d_{sed} = sediment depth = 0.01 m
θ_{sed} = porosity of sediment = 0.509
ρ_b = bulk density of sediment = 1300 kg/m^3

This simplifies to:

$$C_w = \frac{m_{ai}'}{0.00105 + 0.00013K_d}$$

And, if appropriate:

$$K_d = 0.01K_{oc}$$

Where:

C_w=water concentration in µg/L
m_{ai}'=mass applied per unit area in kg/ha
K_d=soil-water distribution coefficient (L/kg-soil)
K_{oc}=organic-carbon normalized soil-water distribution coefficient (L/kg-oc)

This model was used for this assessment with a modification to the depth of the water body, to reflect concentrations in the water of a cranberry bog rather than that of a rice paddy (Cape Cod Cranberry Growers Association, 2001). Specifically, in the first equation above, the value of d_w (water column depth) was changed to 0.305 m (1 foot), from the usual 0.10 m depth that is assumed for rice paddies. This modification has been used in a previous assessment, to estimate aquatic exposure concentrations for the chemical fenpyroximate (USEPA, 2012, D391431, 2012, D405064).

The concentration in water over time for the modified Tier I Rice Model was based on the following equation:

$$C_{w,t} = C_{w,0}\, e^{(-kt)}$$

Where

Cw, t = the concentration in water at time, t
Cw, 0 = the concentration in water at application or time of zero
e = base of natural logarithm
k = first-order rate constant of degradation or dissipation (1/days)
t = time after application (days)

When three applications were modeled, the initial concentration in the water after each application was estimated using the Tier I Rice model, degradation/dissipation was modeled from the date of application for every day after for a specified time. Concentrations in water from the first, second, and third applications were added to determine the total concentration in water over time for each day. Acute concentrations were reported at the maximum concentration for the given scenario. Chronic concentrations were taken as the average daily concentration over 365 days.

PFAM

PFAM was developed specifically for regulatory applications to estimate exposure for pesticides used in flooded agriculture such as rice paddies and cranberry bogs. The model considers the environmental fate properties of pesticides and allows for the specifications of common management practices that are associated with flooded agriculture such as scheduled water releases and refills. It estimates both acute and chronic concentrations over different durations, allows for defining different receiving water bodies, and allows for more flexibility in refinement of assessments when needed.

PFAM was used to estimate the concentration of diazinon in the flood water released from a bog. The reported concentrations represent water introduced to the field and not mixed with any additional water (*i.e.*, receiving water body). The concentration of diazinon is expected to be more than what would be expected in adjacent water bodies due to additional degradation and dilution. The difference in the concentration of diazinon in the flood water to that in an adjacent waterbody depends on 1) the length of time diazinon is in the flooded bog, 2) the distance the water travels between the bog and the adjacent waterbody, 3) the amount of dilution and 4) whether the flood water is mixed with additional water that also contains diazinon. PFAM can simulate application of pesticide to a dry field and degradation in soil before water is introduced to the bog, which is what is expected to occur for diazinon. While PFAM does have the capability of simulating release of cranberry bog water into a mixing cell or waterbody, this was not simulated because a conceptual model is not currently available.

8.4 Percent Cropped Area Adjustment Factor

Percent Cropped Areas (PCA) that account for the maximum area within a watershed that may be planted with a modeled crop are applied to concentrations predicted by the SWCC according to *Development of Community Water System Drinking Water Intake Percent Cropped Area Adjustment Factors for use in Drinking Water Exposure Assessments* (USEPA, 2014a). Diazinon has proposed uses on a variety of agricultural crops and on nurseries, which may be found in agricultural or developed areas. Therefore, the EDWC were not multiplied by a PCA.

9 INPUT PARAMETERS

Summaries of the model input parameter values used in PRZM-GW, SWCC, the Tier I Rice Model modified for cranberries, and PFAM are presented in Error! Reference source not found. to **12**. Input parameters were selected in accordance with EFED's guidance documents:

- *Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides*, Version 2.1[18] (USEPA, 2009),
- *Guidance for Selecting Input Parameters for Modeling Pesticide Concentrations in Groundwater Using the Pesticide Root Zone Model*, Version 1 (USEPA and Health Canada, 2013),
- *Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media*[19] (NAFTA, 2012; USEPA, 2012c), and
- *Guidance on Modeling Offsite Deposition of Pesticides Via Spray Drift for Ecological and Drinking Water Assessment*[20] (USEPA, 2013)

Application Date, and Use Patterns Modeled

In general, for foliar and soil applications to agricultural crops, the date of application was chosen as the day when the crop was present on the field, and during a period of generally high rainfall as it is expected that diazinon may be used when the crop is on the field and during periods of high rainfall. For at-plant applications, the application date was chosen as 14 days before crop emergence in the scenario. Crop-specific management practices were used for modeling, including maximum proposed application rates, maximum proposed numbers of applications per year, minimum proposed re-application intervals, and the first application date for each crop. The incorporation depths were chosen to be the minimum depth required on the label.

PRZM Scenarios

PRZM scenarios are used to specify soil, climatic, and agronomic inputs in PRZM (a component of the SWCC), and are intended to represent runoff-vulnerable soil conditions that result in high-end water concentrations associated with a particular crop and pesticide within a geographic region. Each PRZM scenario is specific to a location. Soil and agronomic data specific to the location are built into the scenario, and a specific meteorological station providing 30 years of daily weather values is associated with the location. **Table 18** identifies the use sites associated with each PRZM scenario.

Currently approved standard PRZM crop scenarios were used in modeling when available. Additionally, the OP-cumulative scenarios were also used when applicable. Unlike EFED's standard crop scenarios, the OP-cumulative scenarios were not developed specifically to represent high-end exposure (*i.e.*, vulnerable) sites. Instead, these scenarios were developed by first identifying areas of high combined use of the entire OP class of chemicals that coincided with drinking water intakes that draw from surface water sources. Within these high OP-use

[18] http://www.epa.gov/oppefed1/models/water/input_parameter_guidance.htm (accessed April 11, 2014)
[19] http://www.epa.gov/oppfead1/international/naftatwg/guidance/degradation-kin.pdf (accessed April 11, 2014)
[20] http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OPP-2013-0676 (accessed April 11, 2014)

areas, major crop uses were identified and scenarios were developed to represent high runoff-prone soils known to support the crops in these areas. In some instances, these scenarios may represent the major growing area for a particular crop. In other instances, the major crop area may be elsewhere, and the scenario in the high OP-use area may represent a "fringe" area of the crop in question. It has not been determined how the vulnerability of a crop scenario developed for the OP cumulative assessment compares to a standard scenario developed for the same crop; therefore, the OP scenarios may represent either greater or lesser vulnerability than standard scenarios. Because the OP scenarios focused on areas that coincided with drinking water intakes, their suitability as high-end vulnerable scenarios for ecological exposure assessments is less certain.

The South Texas NMC scenarios were used to simulate applications to some vegetables for applications that may only occur in Texas because the scenario was the only scenario available in Texas that could be applicable to the use pattern. The scenarios ending in NMC were developed to support the N-methyl carbamate risk assessments.

PFAM Scenario

A 12-inch flood was modeled on October 1, followed by draining the bog on October 4th. A winter flood was also simulated. The modeled flood date was selected as a plausible date of harvest. Crop stages were estimated. The maximum aerial coverage for berry crops used in the OR berries scenario for PE was used in PFAM as well. **Table 7** summarizes the PFAM inputs assumed for setting up the scenario and **Table 10** summarizes the PFAM inputs specific to diazinon.

Table 7. Summary of Model Inputs for the Crop and Physical Tab Input Sheets in PFAM

PFAM Parameter	Input Value	Comments/Reference
Crop Tab		
Zero Height Reference	05/01	Information from Maine Cooperative Extension (Armstrong, 2015)
Days from Zero Height to Full Height	120 (08/29)	Assumed
Days from Zero Height to Removal	153 (10/1)	Assumed
Maximum Fractional Areal Coverage	0.2	Value from OR berries PE scenario
Physical Tab		
Meteorological files	CT W14740 NJ W14734 WI W14839 WI W14920 OR W24221	Weather stations from cranberry growing areas. The New Jersey weather station was simulated because drinking water intakes are located in cranberry growing areas in the New England area.
Latitude	42.3	Latitudes are CT 41.6, 40.0 NJ, 44.5 in WI, and 44.0 in Oregon. These are close enough that a default latitude was chosen.
Area of Application (m^2)	526,090	Represents 10x the area of the Index Reservoir
Weir Leakage (m/d)	0	PFAM default
Benthic Leakage (m/d)	0	PFAM default

PFAM Parameter	Input Value	Comments/Reference
Mass transfer coefficient (m/s)	$1x10^{-8}$	PFAM default
Reference depth (m)	0.458	Set to same depth as weir height.
Benthic depth (m)	0.05	PFAM default
Benthic porosity	0.50	PFAM default
Dry bulk density (g/cm^3)	1.35	PFAM default
F_{OC} Water Column on SS	0.04	PFAM default
F_{OC} benthic	0.01	PFAM default
SS (mg/L)	30	PFAM default
Water column DOC (mg/L)	5.0	PFAM default
Chlorophyll CHL (mg/L)	0.005	PFAM default
Dfac	1.19	PFAM default
Q10	2	PFAM default

Multiple Crop Cycles Per Year

The Diazinon Use Summary Table indicated that many of the vegetable crops may have more than one crop planted on the same area of land in a year. For example, the Diazinon Use Summary Table indicated that succulent beans may have one spring and one fall crop. When maximum annual application rates were specified for a vegetable crop in the Diazinon Use Summary Table, it was assumed that only one crop was planted per area of land per year for that crop, even when the registrant indicated more than one crop season per year could occur. This is because the maximum annual application rate would apply per area of land regardless of whether multiple crops cycles per year were planted in the same area.

When maximum application rates were specified on labels on a crop cycle basis and the Diazinon Use Summary Table indicated that multiple crop cycles per year would be allowed on the label, it was assumed that multiple crops per year could be planted on the same plot of land for crops where greater than 30,000 lbs of diazinon are applied per year based on the SLUA. Multiple crop cycles per year were simulated for lettuce and for ornamentals grown in nurseries by simply assuming that the number of applications per year could be doubled or tripled.

Modeling of multiple crop cycles per year was not conducted for groundwater modeling as the groundwater EDWCs for one season per year were so much smaller than the surface water EDWCs.

Additionally, BEAD summarized some common crop combination scenarios for vegetable crops grown in four regions where PRZM scenarios are readily available for vegetables (California, Florida, Texas, and Michigan). These scenarios were used to further characterize potential exposure from planting more than one vegetable crop in the same year.

Table 8. Uses with Possible Multiple Crop Cycles per Year and Max Rates Provided on a Crop Cycle Basis[1]

Crop Group	Crop cycles per year
Swiss Chard	2
Squash	2
Lettuce	2
Turnip	3
Nursery Ornamentals	3

[1] Based on the Diazinon Use Summary Table

Tables Summarizing Input Parameters

Table 9. Tier I PRZM-GW Input Parameters

Parameter (units)	Residues	Input Value	Data Source	Comments
Application Rate (kg residue/ha)	Diazinon	See results table.	Diazinon Use Summary Table	Simulations were run for select use patterns that will result in high EDWCs.
Number of Applications				
Application Date(s)				
Applications Occur Every		1/year and from year 1 to the last year		--
Application Method		Above canopy (2) Soil incorporation(4)		PRZM-GW input parameter guidance (USEPA and Health Canada, 2013).
Hydrolysis Half-life (days)	Diazinon	82.3	MRID 48417201	Hydrolysis half-life at pH 7 and 25°C.
Soil Metabolism Half-life at 25°C (days)	Diazinon	34 at 25°C	MRIDs 46867004, 44746001, 46386605	The 90 percent upper confidence bound on the mean of four half-life values. Values were adjusted to 25°C using equation 1 in the PRZM-GW input parameter guidance (USEPA and Health Canada, 2013).
	Diazinon + unrecovered residues	155 at 25°C		
K_{oc} (L/kg-OC)	Diazinon	824 138, 3779, and 2184 for characterization	EPIWEB v4.1 (Arienzo *et al.*, 1994; IglesiasJimenez *et al.*, 1996; Nemeth-Konda *et al.*, 2002)	Available measured K_{OC} values were considered supplemental and range from 138 to 3779 L/kg-OC. Across sorption studies, K_d values correlated with the percent organic carbon. The average value (824 L/kg) was used to determine EECs used in the main risk characterization. The minimum (138) and maximum (3779) measured values were also used to characterize uncertainty. As the measured values are all supplemental with varying degrees of reliability, the KOCWIN value (2184) was also used in exploring the uncertainty in this model input.

Table 10. Input Values used for Tier II Surface Water Modeling with SWCC and PFAM (Chemical Tab Sheet)

Parameter (units)	Residue	Value (s)	Source	Comments
Organic-carbon Normalized Soil-water Distribution Coefficient (K_{OC} (L/kg-$_{OC}$))	Diazinon	824 138, 3779, and 2184 for characterization	EPIWEB v4.1 (Arienzo *et al.*, 1994; IglesiasJimenez *et al.*, 1996; Nemeth-Konda *et al.*, 2002)	Available measured K_{OC} values were considered supplemental and range from 138 to 3779 L/kg-OC. Across sorption studies, Kd values correlated with the percent organic carbon. The average value (824 L/kg) was used to determine EECs used in the main risk characterization. The minimum (138) and maximum (3779) measured values were also used to characterize uncertainty. As the measured values are all supplemental with varying degrees of reliability, the KOCWIN value (2184) was also used in exploring the uncertainty in this model input.
Water Column Metabolism Half-life or Aerobic Aquatic Metabolism Half-life (days) and Reference Temperature	Diazinon	13.2 at 25°C	MRID 46386604	Represents the 90 percent upper confidence bound on the mean of two representative half-life values. Values were adjusted to 25°C because the studies were conducted at two different temperatures.
Benthic Metabolism Half-life or Anaerobic Aquatic Metabolism Half-life (days) and Reference Temperature	Diazinon	73.5 at 20°C	MRID 46386602	Representative half-life value from one study times three.
Aqueous Photolysis Half-life @ pH 7 (days) and Reference Latitude, 25°C	Diazinon	Stable (0) at 40°N (SWCC) 1e8 (PFAM)	MRID 48417202	The aqueous photolysis half-life input value was adjusted for continuous illumination as well as for latitude/season to reflect photolysis in summer sunlight at 40° N latitude.
Hydrolysis Half-life (days)	Diazinon	Stable (0) (SWCC) 1e8 (PFAM)	MRID: 46235726	Diazinon does undergo hydrolysis. The aquatic metabolism rates were not corrected for hydrolysis because the metabolism studies were conducted at different pH and temperatures than the hydrolysis studies. Therefore, diazinon was assumed to be stable to hydrolysis in modeling. Hydrolysis should be captured by the aerobic aquatic metabolism values because they were not corrected for hydrolysis.
Soil Half-life or Aerobic Soil Metabolism Half-life	Diazinon	34 at 25°C	MRIDs 46867004,	The 90 percent upper confidence bound on the mean of four half-life

Parameter (units)	Residue	Value (s)	Source	Comments
(days) and Reference Temperature	Diazinon plus lost residues	155 at 25°C	44746001, 46386605	values. Values were adjusted to a temperature of 25°C using equation 1 in the PRZM-GW input parameter guidance (USEPA and Health Canada, 2013).
Molecular Weight (g/mol)	Diazinon	304.35	--	--
Vapor Pressure (Torr) at 25°C	Diazinon	7.22×10^{-5}	MRID 42970809, 40226101.	--
Solubility in Water @ 25 °C, pH not reported (mg/L)	Diazinon	65.5	MRID 42970808	--
Foliar Half-life (days)	All	Stable (0)	Default	--
Heat of Henry	Diazinon	98,000 at 20°C	(Feigenbrugel *et al.*, 2004)	--
Number of Applications	All	See Results Table	Diazinon Use Summary table	--
Dates	All	See results table.	Assumed based on type of application	Absolute and relative dates were used in modeling.
Amount			Diazinon Use Summary table	Maximum single application rate for the crop or use pattern
Application method		Foliar for foliar application, incorporate for soil incorporation, ground for broadcast to soil	Diazinon Use Summary table	Incorporation depth was assumed to be the minimum incorporation depth for the use pattern. Runoff only occurs from the top 2 cm of soil (Carsel *et al.*, 1997).
Application Efficiency	All	Aerial: 0.95 Ground: 0.99	Input parameter guidance (USEPA, 2009)	--
Drift	All	Aerial: 0.135 Ground: 0.066	Offsite transport guidance (USEPA, 2013)	
PRZM Scenario	All	See Results Table	--	Screening scenario that is expected to result in a high end EEC.

Table 11. Modified Tier I Rice Model Input Parameters (for Estimating Exposure from Use on Cranberries)

Input Parameter	Value	Comments	Source
Application Rate (lbs a.i./A)	3	Maximum proposed annual application rate	Use summary table
Soil-water Distribution Coefficient (K_d) (L/kg)	824 138, 3779, and 2184 for characterization	Available measured K_{OC} values were considered supplemental and range from 138 to 3779 L/kg-OC. Across sorption studies, K_d values correlated with the percent organic carbon. The average value (824 L/kg) was used to determine EECs used in the main risk characterization. The minimum (138) and maximum (3779) measured values were also used to characterize uncertainty. As the measured values are all supplemental with varying degrees of reliability, the KOCWIN value (2184) was also used in exploring the uncertainty in this model input.	EPIWEB v4.1 (Arienzo *et al.*, 1994; IglesiasJimenez *et al.*, 1996; Nemeth-Konda *et al.*, 2002)
Water Column Metabolism Half-life or Aerobic Aquatic Metabolism Half-life (days) and Reference Temperature	13.2 at 25°C	Represents the 90 percent upper confidence bound on the mean of two representative half-life values. Values were adjusted to 25°C because the studies were conducted at two different temperatures.	MRID 46386604

Table 12. PFAM Inputs Specific to Diazinon

Input Parameter	Value	Source	Comment
Chemical Tab, see Table 10			
Applications Tab			
Application rate	3.0 lbs a.i./A 3.4 kg a.i./ha	Diazinon Use Summary Table	
Number of Applications	3	---	---
Application dates	07/18 8/1 8/15	---	Registrant (email to Khue Nguyen on 9/26/2014) and BEAD indicated in an email that the last day of application of diazinon to cranberry bogs would be in mid-August. Agricultural extension information is consistent with this timing. The minimum retreatment interval is 14 days.
Slow Release 1/day	0	--	Not applicable
Drift Application	0	--	Drift to an adjacent water body or mixing cell was not modeled.
Flood Tab			
Number of Flood Events	4	--	Harvest occurs between September and November. Field is flooded just prior to harvest. Field may also be flooded over the winter from December through March 15 (Cape
Date of Event 1 (Month-Day)	10-01	--	
Turn Over (1/day)	0	Assumed	

Input Parameter	Value	Source	Comment
Days After (Month-day)	**Fill Level, Min Level (m)**	**Weir (m)**	Cod Cranberry Growers Association, 2001). The winter flood height was assumed to be similar to the harvest flood height. In some areas, there is also a late water flood to control spring frost where the bog is flooded in late April for one month. This was not simulated.
0 (Oct-1)	0.305	0.458	
3 (Oct-4)	0	0	
61 (Dec-1)	0.305	0.458	
105 (March-15)	0	0	

10 MODELING RESULTS

EDWCs were calculated for aerial, ground, and soil incorporation applications. Modeling was conducted to explore some of the uncertainties in model inputs and labels. These uncertainties include the sorption coefficient, number of seasons per year, and the aerobic soil metabolism rate. For the multiple season per year simulations, the crop in the PRZM scenario was only present for one season a year; however, applications were assumed to occur over multiple seasons. The modeling results recommended for use by HED in the exposure assessment are summarized in **Table 13** and in **Figure 2**. The uncertainties and additional modeling results are discussed in more detail in sections below.

Table 13. Summary of Most Reliable Diazinon EDWC[1]

Use Site	EDWC			
	Peak	21-day Average	Annual Average	Entire Mean
Cranberries, PFAM[2]	141	131	--[4]	--
Melons	119	62.9	7.09	3.56
Apples/pears	110	65.8	8.85	4.25
Texas vegetables[3]	90.2	44.2	5.4	2.91
CA vegetables[3]	80	45.7	7.55	5.26
Spinach	77	58.4	9.36	4.81
FL vegetables[3]	69.5	45.6	7.18	4.84
Tomato	54.9	30.6	3.2	1.54
Nursery	53.6	27.8	3.41	1.95
Bulb Vegetables	46.5	28.6	2.96	1.43
Almonds, CA	46.4	35.1	5.24	3.07
Michigan vegetables[3]	42	30.8	6.31	3.99
Lettuce, 2 crop cycles	41.5	31.7	7.44	4.59
Lettuce, 1 crop cycles	39.1	29.0	5.59	3.35
Cranberries, SWCC	21.7	16.2	3.82	2.68

[1] Simulations using the aerobic soil metabolism input of 34 days and the mean K_{OC} value of 824 L/kg. Excludes EDWC for the use to control fruit flies and the Tier I Rice Modeling results.
[2] Reflects diazinon concentrations in cranberry bogs and adjacent waters. Drinking water intakes are known to be located near cranberry bogs in the New England area. They are not in drainage areas for cranberries grown in Oregon and Washington.
[3] Simulation for multiple crops of vegetables on the same plot of land.
[4] The annual average concentration estimated in a cranberry bog using PFAM was 76.6 µg/L. However, this value is not recommended for use in the drinking water assessment because the value is likely to overestimate residues near drinking water intakes and cranberry bogs are not flooded for an entire year.

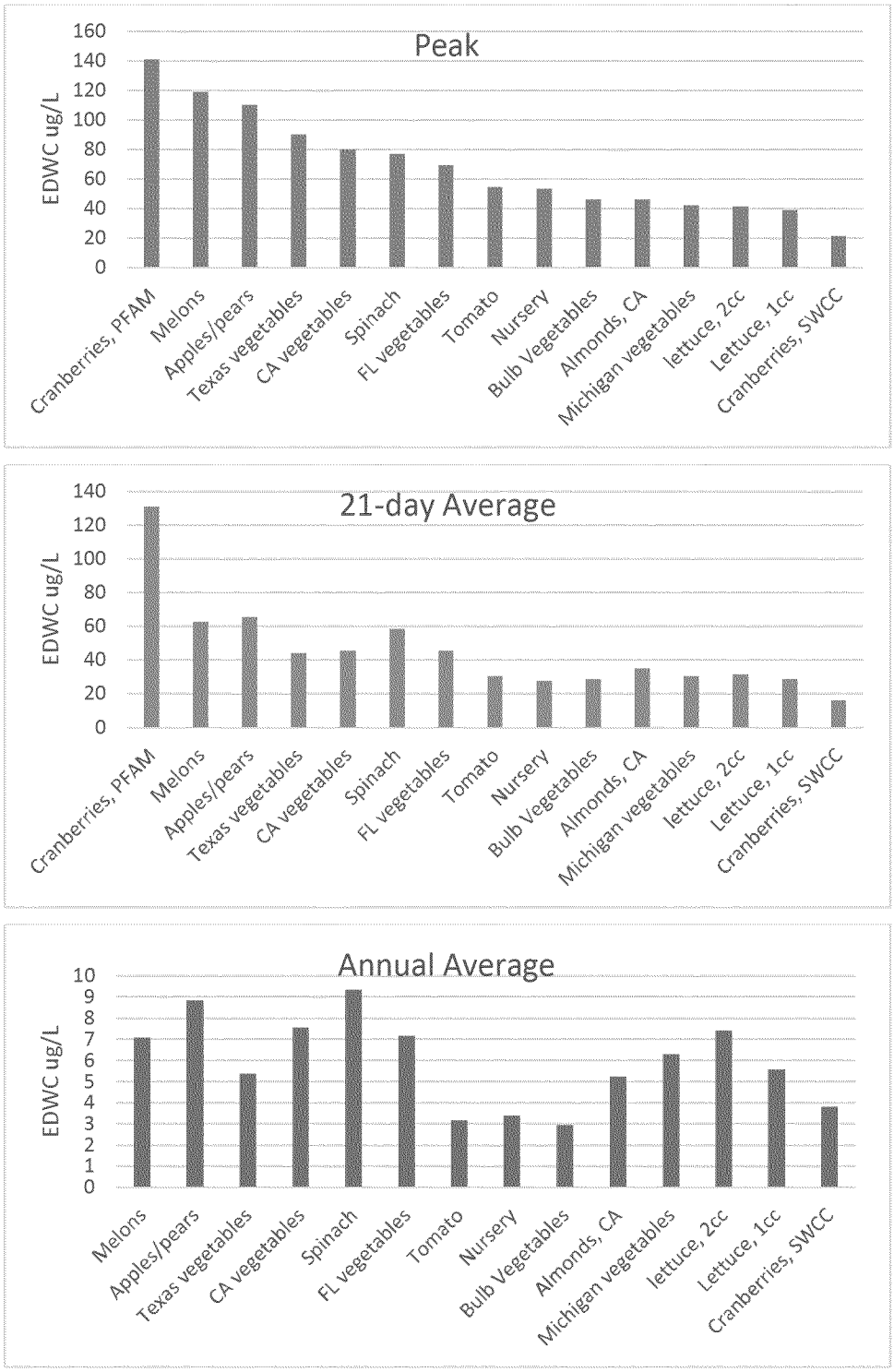


Figure 2. Peak and Annual Average EDWC for Surface Water for Diazinon Used on Various Crops (Excluding the Use to Control Fruit Flies and PFAM Annual Average Output)

Sorption Coefficients

Modeling was originally completed assuming a mean K_{OC} of 618 L/kg based on the batch equilibrium study submitted by the registrant. These values are summarized in **Appendix C** and provide an understanding of the vulnerable use scenarios and spread of EDWC for different use patterns. After completing the simulations for all use patterns using the 618 L/kg K_{OC} value, it was determined that the solvent concentrations in the study supporting that input value may have been higher than the recommended 0.1% concentration which would result in an underestimation of the sorption coefficient and possibly overestimation of EDWCs. Therefore, modeling was completed assuming a mean K_{OC} of 824 L/kg based on the batch equilibrium study submitted by the registrant and K_{OC} values from open literature studies. All of these values are classified as supplemental due to various deficiencies in the studies such as solvent concentrations greater than 0.1%, no confirmation that equilibration was achieved, or the identity of radioactivity was not determined; however, it was assumed that measured values with deficiencies would be more reliable than an estimated value[21]. To explore the range of potential EDWC from the uncertainty in the K_{OC} values, modeling was also conducted using the highest and lowest K_{OC} value of 138 and 3779, respectively. Finally, an estimated K_{OC} value of 2184 L/kg was also simulated.

Modeling was simulated for the use scenarios that resulted in the highest EDWC for surface water using the SWCC and PFAM, and for groundwater using PRZM-GW. The results are summarized in Error! Reference source not found.. EDWC were sensitive to the K_{OC} input value, especially when estimating concentrations of diazinon in groundwater. The EDWC based on the highest K_{OC} of 3779 were 34 to 61% of the EDWC based on the mean K_{OC} of 824 L/kg in surface water. The EDWC based on the lowest K_{OC} of 138 L/kg were 140 to 201% of the EDWC based on the mean K_{OC} in surface water. The groundwater source EDWC based on the lowest K_{OC} of 138 L/kg resulted in higher annual average EDWC than those estimated in surface water. The EDWC based on the estimated K_{OC} of 2184 L/kg resulted in EDWC that were 52 to 58% of the EDWC based on the mean K_{OC} in surface water. The lack of confidence in the K_{OC} values results in uncertainty in the EDWC. As there are deficiencies in the submitted studies and open literature studies on the measurement of sorption coefficients, it is uncertain what the actual mean sorption coefficient is; however, based on the available evidence it is reasonable to assume that the range of K_{OC} values used in modeling will capture the range of K_{OC} values that will occur in the environment. This sensitivity analysis illustrates the importance of having reliable sorption coefficients to estimate exposure. **Figure 3** illustrates that depending on the sorption coefficient, the model estimating the highest EDWC changes. This has the greatest impact on uncertainty in annual average concentrations estimated for groundwater source drinking water.

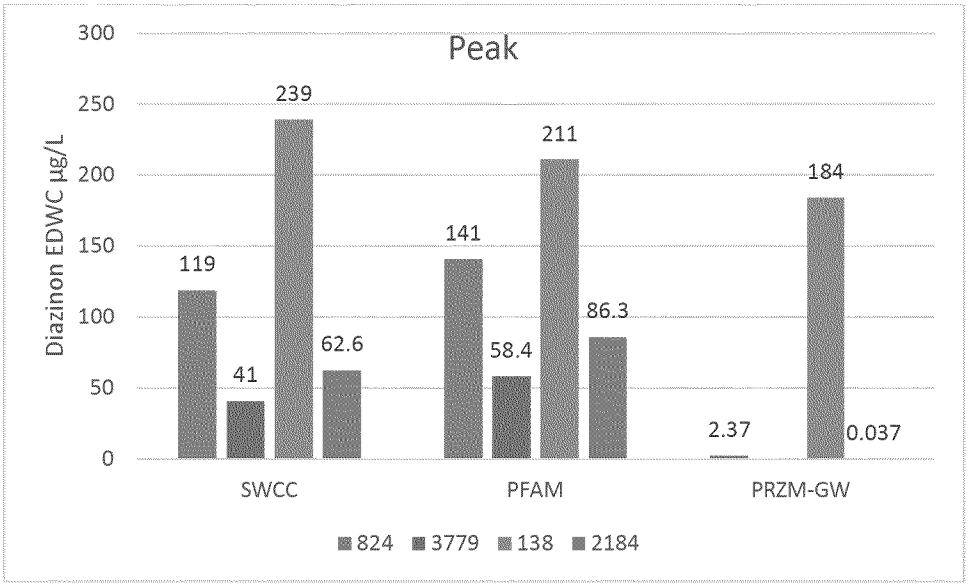
[21] See **Appendix B** for a more detailed discussion of the sorption studies available for diazinon.

Table 14. EDWC Based on Different K_{OC} Inputs[2]

Simulation Description	K_{OC} L/kg	EDWC (µg/L)				Ratio of EDWC for Simulation/EDWC with Mean KOC		
		Peak	21-day Average	365-day Average	Simulation Average[1]	Peak	Annual Average	Simulation Average
Surface Water, SWCC, Melons								
Mean	824	119	62.8	6.93	3.46	1.0	1.0	1.0
Highest	3779	41.0	17.5	2.35	1.33	0.34	0.34	0.38
Lowest	138	239	133	10.6	4.93	2.0	1.5	1.4
EPIWEB Estimated	2184	62.6	30.0	3.86	2.00	0.53	0.56	0.58
Surface Water, PFAM, Cranberries								
Mean	824	141	--	76.6	--	1.00	1.00	--
Highest	3779	58.4		47.1		0.41	0.61	
Lowest	138	211		118		1.50	1.54	
EPIWEB Estimated	2184	86.3		65.3		0.61	0.85	
GroundWater, PRZM-GW, Ornamentals								
Mean	824	2.37	--		1.72	1.00	--	1.00
Lowest	138	184			53.7	77.6		31.2
EPIWEB Estimated	2184	0.037			0.030	0.02		0.02

[1] Post-breakthrough average value is shown for PRZM-GW output.

[2] The aerobic soil metabolism half-life input value was 34-days.



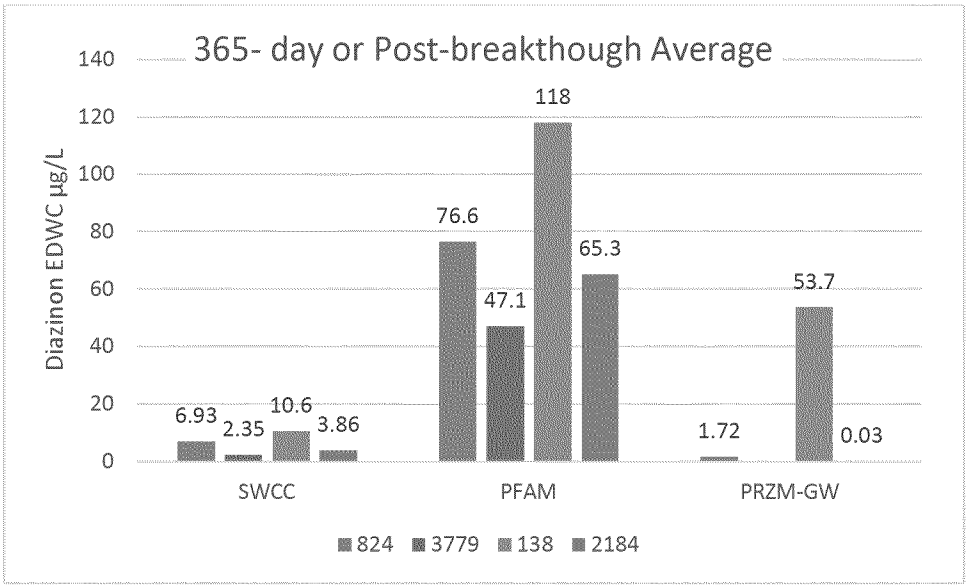


Figure 3. EDWC Using Different Models and the Range of Measured K_{OC} Values. The aerobic soil metabolism half-life input value was 34-days.

Aerobic Soil Metabolism Input

There is variability in the aerobic soil metabolism rate of diazinon, and uncertainty about the rate that may occur at any given site. Data that may be used in modeling are available from four soils. In three of those soils, mass balances were incomplete with up to 30% loss of radioactivity in one of the soils. Degradation kinetics were therefore calculated for diazinon alone and diazinon plus lost radioactivity. The range of DT_{50}s for diazinon alone was 8.86 to 56.6 days (90 percent upper bound on the mean representative half-life values=34-days). The range for parent plus lost radioactivity (some or all of which could constitute diazinon and/or diazoxon) was 9.74

to 56.6 days (90 percent upper bound on the mean representative half-life values=155-days). The range for parent plus lost residues DT_{50} values overlap with the range DT_{50} values for parent alone. Most modeling was completed using the aerobic soil metabolism half-life input based on known diazinon residues (half-life =34-days) as we are confident that the value reflect residues of diazinon. Modeling was also completed using the aerobic soil metabolism half-life input based on diazinon plus lost radioactivity (half-life=155 days) to explore the potential range of EDWC with the uncertainty in the aerobic soil metabolism. EDWCs for diazinon alone were 5% of EDWC of diazinon plus lost radioactivity in groundwater and 80% of those calculated for diazinon plus lost radioactivity in surface water (**Table 15**).

Table 15. EDWC Based on Simulations with 34-day and 155-day Aerobic Soil Metabolism Half-life Inputs

Model	Aerobic Soil Half-life (day)*	EDWC (µg/L)		Ratio of EDWC for 34-day input /EDWC with 155-day input	
		Peak	Simulation Average[1]	Peak	Simulation Average[1]
SWCC	34	119	3.46	0.79	0.72
	155	155	4.83		
PRZM-GW	34	2.37	40.0	0.04	0.04
	155	55.6	1.72		

[1] Post-breakthrough average value is shown for PRZM-GW output.
* The aerobic soil metabolism half-life input value is the 90 percent upper confidence bound on the mean representative half-life value. The value was calculated using four data from four soils for residues of diazinon (34 day) and diazinon plus lost radioactivity (155 day).

Nursery, Control of Fruit Fly

When using the 34-day aerobic soil metabolism half-life input value and the mean K_{OC} value, surface water modeling produced higher diazinon EDWCs than groundwater modeling. There were two use patterns that generated EDWCs substantially greater than all others: the Florida and California use pattern for control of fruit flies in containerized ornamentals grown in nurseries, and the cranberry use pattern. The Florida fruit fly use pattern resulted in peak and annual average EDWCs of 351 and 17.9 µg/L, respectively. This is due in part to the relatively high application rate for this use (5.6 lbs a.i./A/application, with up to three applications per year), and in part to the relatively runoff-vulnerable Florida scenario. According to the Animal and Plant Health Inspection Service (APHIS), the total amount of diazinon in products used in Florida is less than one quart of product containing diazinon in Florida over a 4-year period.[22] Therefore, this use pattern is not likely to result in significant residues in drinking water in Florida. Likewise, the analogous use pattern in California is unlikely to contribute to residues of diazinon in drinking water. The California Department of Pesticide Regulation (CA Dept. of Food and Agriculture, 2014), stated "Although the treatments which may be conducted under the Proposed Program may contribute to surface water concentrations of these ingredients, treatments are limited to areas where potentially impacted surface waters are not used as drinking water resources." This use pattern is a unique one that is highly regulated by the state of California. The average total amount of diazinon applied to outdoor nursery stock, melons, and lettuce in

[22] Email from Susan O'Toole (APHIS) to Khue Nguyen on 8/18/2014.

California between 2008 and 2010 was 738, 1710, and 64,677 lbs, respectively.[23] Therefore, this risk assessment will focus on the EDWC simulated for other use patterns.

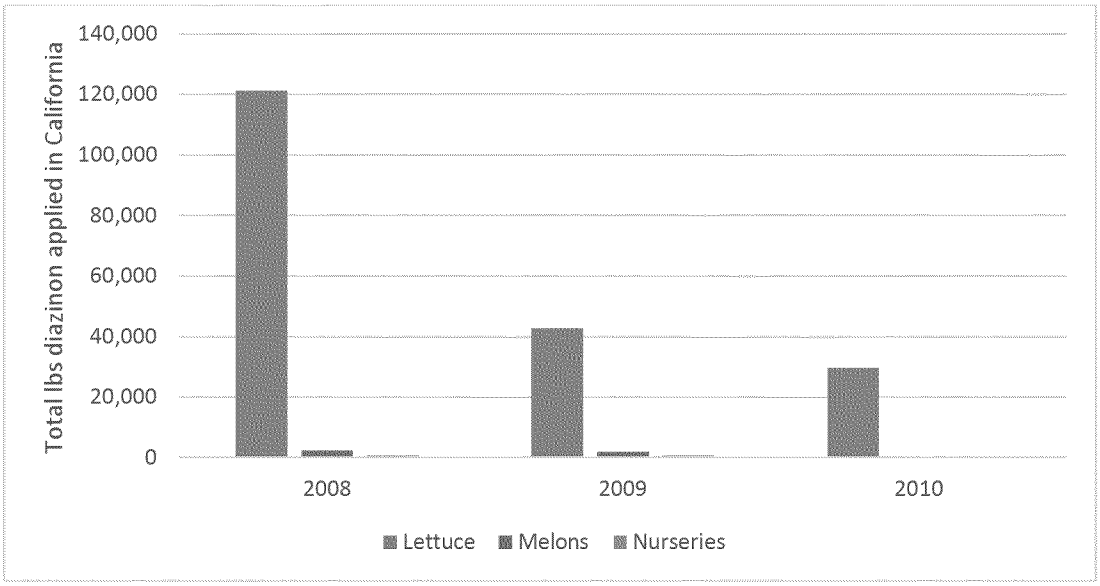


Figure 4. Total Pounds Diazinon Applied to Lettuce, Melons, and Nurseries in California, based on the California Pesticide Use Reporting Database[24]

Cranberries

Another high EDWC resulted for the use on cranberries, and is high presumably due to the unusual models used to determine EDWCs for cranberries, and to the crop's application rates. Of all diazinon's uses, cranberries have some of the highest single and annual application rates (3 lbs a.i./A/application, with 3 applications per year). Cranberry bogs are flooded at the end of the season before harvest. If diazinon were applied to flooded bogs and the water released suddenly, concentrations before dilution occurs could be, at least locally, fairly high (for residues of diazinon plus lost radioactivity peak EDWC = 566 µg/L and annual average EDWC = 355 µg/L, estimated using the Modified Tier 1 Rice Model). Using PFAM to simulate degradation happening between application and flooding results in a lower, though still high, EDWC (for residues of diazinon alone (peak EDWC =141µg/L and annual average EDWC = 76.6 µg/L). These numbers represent diazinon concentrations in undiluted bog water or in waters adjacent to bogs. When the same use pattern is modeled with the SWCC, EDWC are similar to those produced for other use patterns (for residues of diazinon alone peak=21.7µg/L, annual average=3.82 µg/L). While none of the models used to determine EDWCs for cranberries simulates all of the factors that perhaps should be considered in determining plausible drinking water concentrations, these models' EDWCs are believed to provide conservative (high end) representations for the use on cranberries, especially the annual average EDWCs since dilution is not accounted for. Cranberries are only grown in a few areas of the country, and drinking water intakes are understood to be located near cranberry growing areas in Massachusetts. A better

[23] Numbers based on the the California Pesticide Use Reporting Database (CADPR, 2012a).
[24] http://calpip.cdpr.ca.gov/year.cfm

understanding of risks due to this use pattern could be obtained with a focused analysis of drinking water in relation to cranberries in Massachusetts.

PFAM does simulate concentrations in bog water and does not consider dilution. However, PFAM modeling is still relevant to EDWC, as the SWCC may underestimate residues in adjacent waters. As PFAM does estimate residues in the bog, the peak and 21-day average EDWC from PFAM are more relevant than the annual average value. These monitoring results suggest that the annual average value of 76.6 µg/L value from PFAM is not likely to occur.

Table 16. Concentrations of Diazinon in Water and Sediment of Cranberry Bogs and Adjacent Waterways

Site	Max diazinon concentration in water (days after first app) in µg/L			Max diazinon concentration in sediment (days after first app)		
	After 1st App	After 2nd App	Final Detection	After 1st App	After 2nd App	Final Detection
Irrigation ditch	338 (1d)	456 (14d)	0.2 (35 d)	21200 (4d)	8920 (21d)	20 (137d)
Reservoir	78.5 (2d)	58.1 (17d)	0.3 (51d)	2380 (1d)	110 (17d)	10 (51d)
Waterways outside dyke	29.1 (2d)	2.6 (15d)	0.1 (42d)	80 (1d)	20 (14d)	10 (35d)
Tributaries 100 m downstream	2.8 (4d)	1.1 (15d)	0.1 (35d)	10 (4d)	Not detected	Not detected

App= application

High EDWC and Use Patterns

Excluding the cranberry and fruit fly uses, high peak and annual average EDWCs for residues of diazinon alone occurred for apples and pears (peak = 110 µg/L, annual average = 8.85 µg/L) and melons (peak = 119 µg/L, annual average = 7.09 µg/L). These EDWC are similar to those estimated in the previous drinking water assessment (peak = 70.1 µg/L, annual average = 9.4 µg/L).

Overall, the number of crop cycles per year had a small impact on peak and 21-day average EDWCs, but did influence annual average EDWCs (**Table 17**). For lettuce and nurseries, peak and 21-day average EDWCs for a single crop cycle were 92 to 96% of EDWCs for multiple crop cycles per year. For lettuce and nurseries, annual average EDWCs for a single crop cycle were 39 to 67% of EDWCs for multiple crop cycles per year; however, the actual values have a small range (0.76 to 4.59 µg/L). Finally, modeling results for combinations of vegetable crops rotated on the same field were simulated in California, Florida, Michigan, and Texas. The range of these EDWCs falls within the EDWC range calculated for other crops, however these EDWCs were generally higher than those calculated assuming only a single vegetable crop cycle per year. These results provide support for considering the impacts of the possibility that diazinon may be applied to multiple vegetable crops on the same plot of land in the same year.

Table 17. EDWC Simulated for Single and Multiple Crop Cycles per Year

EDWC were estimated assuming a K_{OC} value of 824 L/kg and aerobic soil metabolism DT_{50} of 34-days reflecting residues of diazinon only.

Use Pattern Simulated[5]	1-in 10 Year Peak	1-in 10 Year 21-day average	1-in 10 Year Annual Average	30-year average
	Lettuce simulation			
Lettuce 1 crop cycle	38.4	29.1	5.64	3.09
Lettuce 2 crop cycles	41.5	31.7	7.44	4.59
	Nursery simulation			
Nursery 1 crop cycles	51.2	26.7	2.35	0.761
Nursery 2 crop cycles	52.8	27.7	2.71	1.33
Nursery 3 crop cycles	53.6	27.8	3.41	1.95
	Multiple Crop Rotation			
California (Spinach, Cauliflower, Lettuce)[1]	80.0	45.7	7.55	5.26
Florida (Radish, Cabbage, Lettuce)[2]	69.5	45.6	7.18	4.84
Michigan (Cabbage, Melon)[3]	42.0	30.8	6.31	3.99
Texas (Carrot, Onion)	90.2	44.2	5.40	2.91

[1] Applications modeled were at plant application to spinach on January 1, at plant application to cauliflower on March 20, at plant application to lettuce on July 31 followed by an aerial foliar application on August 30. The rate details for each application may be found in **Table 18**. The PRZM scenario used in modeling was the CAlettuceSTD.

[2] Applications modeled were at plant application to radish on October 1, ground application to cabbage on November 18, at plant application to lettuce on April 10 followed by an aerial foliar application on May 10. The rate details for each application may be found in **Table 18**. The PRZM scenario used in modeling was FLcabbageSTD.

[3] Applications modeled were a ground application to cabbage on April 8 followed by an at plant application to melons on July 21. The original BEAD scenario called for the second crop to be squash but use of diazinon on squash is only approved in Texas. The rate details for each application may be found in **Table 18** The PRZM scenario used in modeling was MImelonSTD.

[4] Applications modeled were a ground application to carrot on July 1 followed by an at plant application to onion on October 15. The rate details for each application may be found in **Table 18**. The PRZM scenario used in modeling was MImelonSTD.

[5] The application dates and crop combinations were based on information provided by BEAD.

Table 18. Estimated Concentrations of Diazinon in Surface Water Source Drinking Water+

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App method for modeling (spray drift assumptions)	App Date (Day-Month / Relative Days)	EDWC for Diazinon, unless otherwise specified (µg/L)				Comments
					Peak	21-day Ave.	Annual Ave.	Entire Ave.	
Almonds	3 (3.4), 1x dormant	Caalmond _WirrigSTD	Foliar (ground)	15-12	46.4	35.1	5.24	3.07	California Only
Cranberries	3 (3.4), 3x, 14d, 7d PHI	ORberries OP	Foliar (ground)	15-06, 22-06, 29-06	21.7	16.2	3.82	2.68	May not be conservative for cranberries grown in bogs.
		Tier I Rice Model	Foliar (NA)	NA	814γ	--	483γ	--	Not likely to occur in drinking water.
		PFAM CT	Foliar (NA)	18-7	141 211β	131	76.6γ 118βγ	--	Reflects concentrations in cranberry bog and are assumed to be conservative for adjacent waters.
Melons	4 (4.5), 1x at plant at 2 inch, and 0.75 (0.84),1x, 30d foliar	FLcucumberSTD	Incorp. to 2 inch (ground), foliar (ground)	-14, 15	**119 150* 41.0# 239β 62.6∞**	**62.9**	**7.09 9.32* 2.37# 10.7β 3.93∞**	**3.56 4.83* 1.36# 5.07β 2.05∞**	1 soil and 1 foliar for honeydew melon only.
Lettuce	2 (2.24), 1x at plant incorp 2 inch, 0.5 (0.6), 1x foliar, 30d, 1cc	CAlettuce STD	Incorp to 2 inch (ground), 1 foliar (aerial)	-14, 15	39.1	29.0	5.59	3.35	--
	2 (2.24), 1x at plant incorp 2 inch, 0.5 (0.6), 1x foliar, 30d, 2cc			-14, 15, 180, 210	41.5	31.7	7.44	4.59	
Spinach	4 (4.5), 1x, before planting	CAlettuce STD	Incorp of 2 inch (ground)	-14	77.0	58.4	9.36	4.81	--
Onions and Bulb Vegetables	4 (4.5), 1x, before plant incorp 3 inches	GAonion_WirrigSTD	Incorp of 3 inch. (ground)	-14	46.5	28.6	2.96	1.43	--
Tomato	4 (4.5), 1x, at plant with 2 inch.	FLtomato STD_V2	Incorp of 2 inch (ground)	-14	54.9	30.6	3.20	1.54	Registrant allows for 2 cc but rates are given on annual basis.
Apples and pears	2 (2.24), 2 foliar apps, 14d	PAappleSTD_V2	Foliar (ground)	15-8, 29-8	110	65.8	8.85	4.25	1 dormant and 1 foliar application with 60 day MRI may also occur.
Ornamentals in nurseries	1 (1.12). 1x, 3 cc	FLnurserySTD_V2	Ground (ground)	15-4, 15-7, 15-10	43.8	22.8	2.90	1.71	National label, 1 to several crop cycles per year.

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App method for modeling (spray drift assumptions)	App Date (Day-Month / Relative Days)	EDWC for Diazinon, unless otherwise specified (µg/L)				Comments
					Peak	21-day Ave.	Annual Ave.	Entire Ave.	
			Foliar (ground)		53.6	27.8	3.41	1.95	
Ornamentals grown in nurseries in containers in California and Florida	5 (5.6), 3x, 14d	CAnursery STD_V2	Ground (ground)	16-3, 30-3, 13-4	129γ	88.6γ	13.4γ	6.58γ	The total pounds of diazinon used to control fruit flies is small. The current label will be updated to reflect use on containerized nursery stock for a maximum of 3 applications (email to Khue Nguyen on 11/25/2014 from .CA Dept. of Food and Agriculture).
		FLnursery STD_V2		16-3, 30-3, 13-4	351γ	185γ	17.9γ	8.43γ	

NA=not applicable; incorp=incorporate into soil
*Reflects residues of diazinon plus lost radioactivity (*e.g.*, aerobic soil metabolism half-life input was 155 days).
Simulation completed with a sorption coefficient of 3779 L/kg-organic carbon
β Simulation completed with a sorption coefficient of 138 L/kg-organic carbon
∞Simulation completed with a sorption coefficient of 2184 L/kg-organic carbon
+EDWCs were calculated assuming a K_{OC} value of 824 L/kg and aerobic soil metabolism half-life input of 34 days reflecting residues of diazinon only. EDWCs were also calculated assuming an aerobic soil metabolism half-life input of 155-days, reflecting residues of diazinon plus lost radioactivity (designated with an asterisk) and for other sorption coefficients to explore uncertainty in EDWC.
γ EDWC in purple are considered less likely to occur due to the amount of diazinon used for the use pattern, the unique use pattern, or the model used to simulate EDWC.

When using the mean K_{OC} of 824 and the aerobic soil metabolism half-life input value of 34-days, groundwater EDWCs were lower than surface water EDWCs. Therefore, the maximum use pattern (use of diazinon in California nurseries to control fruit flies) was the only use pattern simulated in PRZM-GW. The maximum single-day and post breakthrough average concentration of diazinon generated using PRZM-GW with the FL citrus scenario was 2.37 and 1.72 µg/L, respectively. As discussed previously, groundwater source EDWC are similar to EDWC from surface water sources when the lowest K_{OC} value (138 days) is used as an input and the aerobic soil metabolism input value for residues of diazinon plus lost radioactivity (155 days) are used as model inputs.

Table 19. Estimated Concentrations of Diazinon in Groundwater Source Drinking Water
EDWCs were estimated assuming a K_{OC} value of 824 L/kg and aerobic soil metabolism half-life of 155 days reflecting residues of diazinon plus lost radioactivity, unless otherwise specified.

Use Site (Timing of App)	Single App. Rate lbs. a.i./A[a] (kg a.i./ha)	# of App	Ret. Int. Days	App. Type[6]	EDWC in µg/L for Diazinon+lost radioactivity			
					Scenario	Daily Peak	Post Breakthrough Average	Ave Breakthrough Time (Days)
CA-SLN	5 (5.6) 11.2+	12 6+	14	F, G	NJ/DE	19.1	18.8	10772
					FL Citrus	54.9 7.99α **2.37***	39.5 5.95α **1.72***	9009
					FL Potato	0.02	0.01	18575
					NC	0.95	0.509	9577
					WI	9.14+	6.66+	13399+
					GA	0.318	0.249	14834

Abbreviations: App=Application; G=ground, F=foliar; NJ/DE=Delmarva Sweet Corn; NC=NC cotton; WI=Wisconsin Corn; GA=Georgia Peanuts; Ave.=average
+ Results were estimated for six applications with double the recommended application rate for 100 year simulations in PRZM-GW because PRZM-GW did not have the capability of running 12 applications for 100 years.
*Diazinon residues only. Results are shown for met station in Wisconsin.
α Results assuming the highest measured aerobic soil metabolism input value of 56-days.

11 MONITORING DATA

There are several monitoring studies, and data from several sources, available on diazinon residues in drinking water (raw and finished), surface water, groundwater, sediment, tissue (fish and mussels), air, rain, and snow. Most studies were not specifically targeted at diazinon, or were collected in agricultural areas during the season of pesticide use, but the frequency of sample collection was not adequate to ensure the capture of peak concentrations. The data are useful in that they provide some information on the occurrence of diazinon in the environment under existing usage conditions. However, the measured concentrations should not be interpreted as reflecting the upper end of potential exposures. Targeted monitoring, wherein application dates and amounts of applied materials are known, and concentrations are followed in relation to the application(s) are discussed in the summarized field dissipation data. Changes

in diazinon use patterns were implemented between 2004 and 2008, after the Reregistration Eligibility Decision was completed. Updates included cancellation of non-agricultural uses (except nurseries), seed treatment uses, cancellation of granular formulations, and only allowing aerial applications of diazinon to lettuce.[25] Thus, monitoring conducted prior to this period may not reflect current use patterns of diazinon. In order to evaluate whether changes in the observed monitoring results reflect changes in use patterns, the frequency and location of monitoring and how it relates to usage information in the area monitored must be considered.

1.1 Clean Water Act Programs

Diazinon is identified as a cause of impairment for 59 water bodies listed as impaired under section 303(d) of the Clean Water Act in California, Kansas, Oklahoma, and Washington.[26] Impaired waters include rivers, creeks, drains, sloughs, channels, lakes, harbors, and drainage ditches. There are 107 Total Maximum Daily Loads (TMDL) listed for diazinon in California. Section 304(a) ambient water quality criteria[27], Aquatic life benchmarks, and Health Advisory levels[28] (**Table 20**), have been established for diazinon. Monitoring data, impaired waters, and TMDLs for diazinon, demonstrate that the use of diazinon may result in transport of diazinon to surface water at levels that may cause risk to human health and/or ecological receptors.

Table 20. Office of Water Health Advisories for Diazinon[1]

Health Advisories[2]					
10-kg Child		70-kg Adult			
1-day (µg/L)	10-day (µg/L)	RfD (mg/kg/day)	DWEL (µg/L)	Life-time (µg/L)	mg/L at 10^{-4} Cancer Risk
20	20	0.0002	7	1	NA

DWEL=Drinking Water Equivalent Level
RfD=Reference Dose
[1] The 2012 Edition of the Drinking Water Standards and Health Advisories is available at: http://water.epa.gov/action/advisories/drinking/upload/dwstandards2012.pdf (accessed 2/28/2015)
[2] Health advisories, sponsored by the EPA's Office of Water (OW), are concentrations of drinking water contaminants at which adverse health effects are not anticipated to occur over specified exposure durations.

1.2 Surface Water

Diazinon is one of the most frequently detected pesticides in surface water, and has been detected in 46 states (**Figure 7**), in every major U.S. river basin (including the Mississippi, Columbia, Rio Grande, and Colorado rivers), and in miscellaneous waters including various large rivers and major aquifers. The highest diazinon concentration reported was 61.9 µg/L, detected in a creek in California in 2009 (**Table 21**). Concentrations detected in tributaries to

[25] http://www.epa.gov/pesticides/reregistration/diazinon/
[26] Specific state causes of impairment that make up the national pesticides cause of impairment group are listed at http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.cause_detail_303d?p_cause_group_id=885.
[27] Specific state pollutants that make up the National Pesticides Pollutant Group and have TMDLs are listed at http://iaspub.epa.gov/tmdl_waters10/attains_nation.tmdl_pollutant_detail?p_pollutant_group_id=885&p_pollutant_group_name=PESTICIDES.
[28] http://water.epa.gov/action/advisories/drinking/upload/dwstandards2012.pdf

rivers are generally higher than those in rivers (Munoz *et al.*, 2011; Starner, 2009). Eleven states[29] had surface water detections at 0.9 µg/L or greater, and 34 states had detections above 0.1 µg/L. Generally, the greater the number of samples collected, the higher the concentrations detected within a given state. Detections above 1 µg/L have continued to occur since 2007, when several mitigations on diazinon use[30] were implemented; concentrations above 0.1 µg/L are common, especially in high use areas (**Figure 5**). Higher diazinon concentrations and higher frequencies of detection are generally observed in high use areas following precipitation events. For example, in California higher concentrations and detection frequencies (up to 90% detection frequency) were found in the Salinas and Imperial Valleys where lettuce, which receives the highest pounds of diazinon annually (in the U.S. between 2004 and 2012), is grown (Starner, 2009). In California, diazinon has been detected in areas with high and moderate irrigation season agricultural use, and in areas where orchards are grown and diazinon is commonly applied in the dormant season (November through February). Crops commonly grown in these areas include lettuce, spinach, broccoli, and other cool season crops (Starner, 2009), as well as almonds and stone fruit. There are two datasets that were specific to drinking water, and these are discussed in more detail below. Geospatial analysis suggests that some detections may also have occurred near the locations of drinking water treatment plant intakes. The number of samples collected per year across the United States has also varied over time, with a reduction in the number of samples collected in recent years, especially in the NAWQA data set (**Figure 6**).

Diazoxon was also detected in surface water, at a maximum concentration of 0.43 µg/L. The detection frequency of diazoxon in surface water is lower (<0.1 to 6%) than that for parent diazinon. In surface water monitoring data wherein residues of both diazinon and diazoxon were detected, the ratios of the concentrations of diazoxon to diazinon ranged from 0 to 0.5. Diazinon and diazoxon were sometimes detected in the same samples and sometimes did not co-occur in samples.

[29] California, Georgia, Virginia, Oregon, Utah, Texas, Indiana, Tennessee, Alabama, Wisconsin, and Louisiana

[30] RED mitigations include cancellation of residential uses, seed treatments, and use of granules. Additionally, most aerial applications were cancelled. While these mitigations were implemented in prior to 2008, it may have taken some time for all products to be removed from the market.

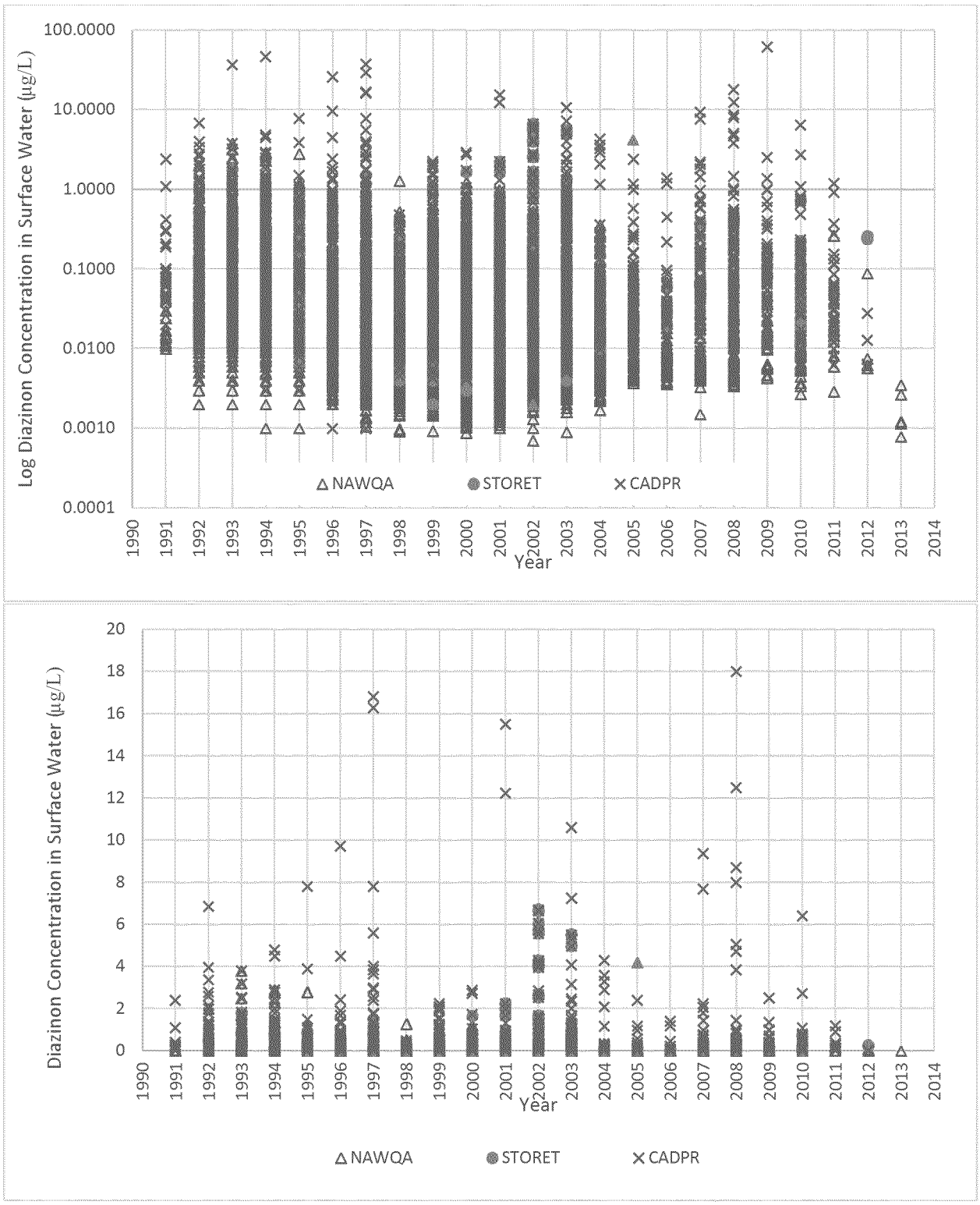


Figure 5. Diazinon Concentrations in Surface Water between 1991 and 2013 Based on NAWQA, STORET, and CADPR Data.

The figure is shown with a log scale and without a log scale. In the graph without the log scale, six data points above 10 µg/L are not displayed.

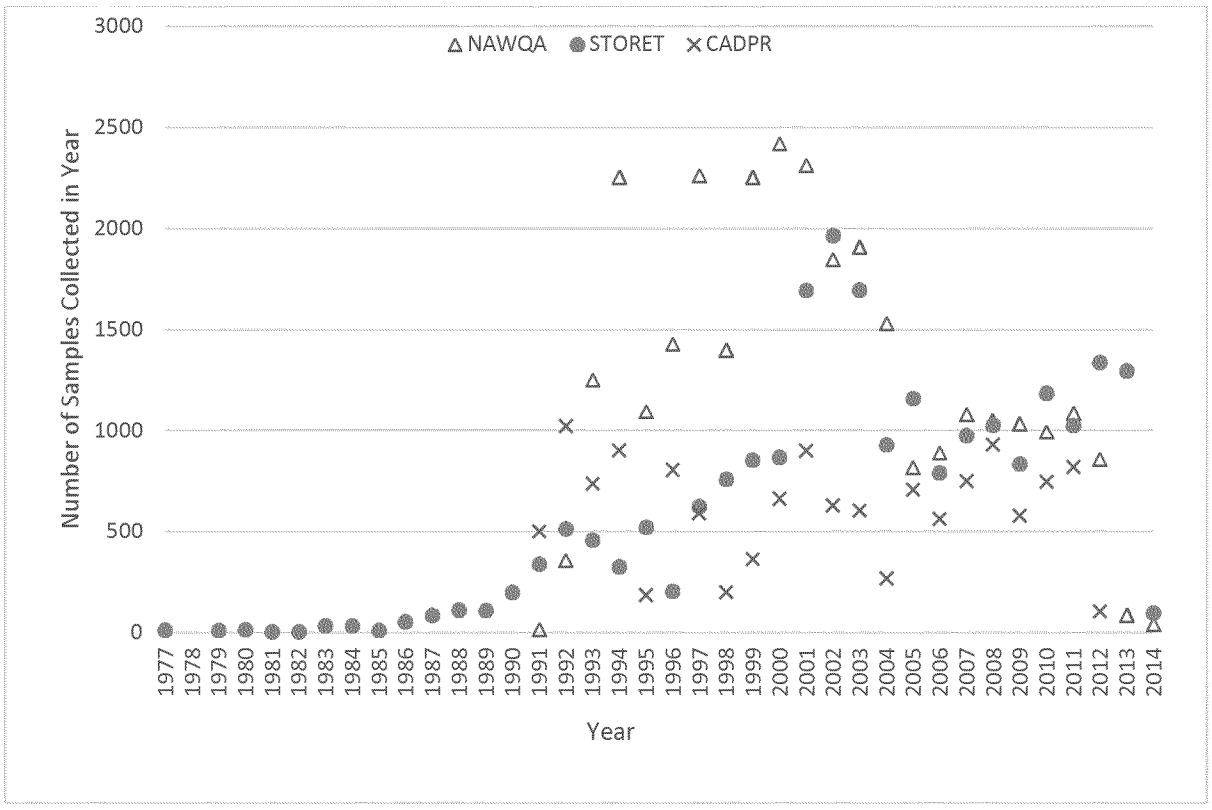


Figure 6. Number of Surface Water Samples Collected and Analyzed for Diazinon

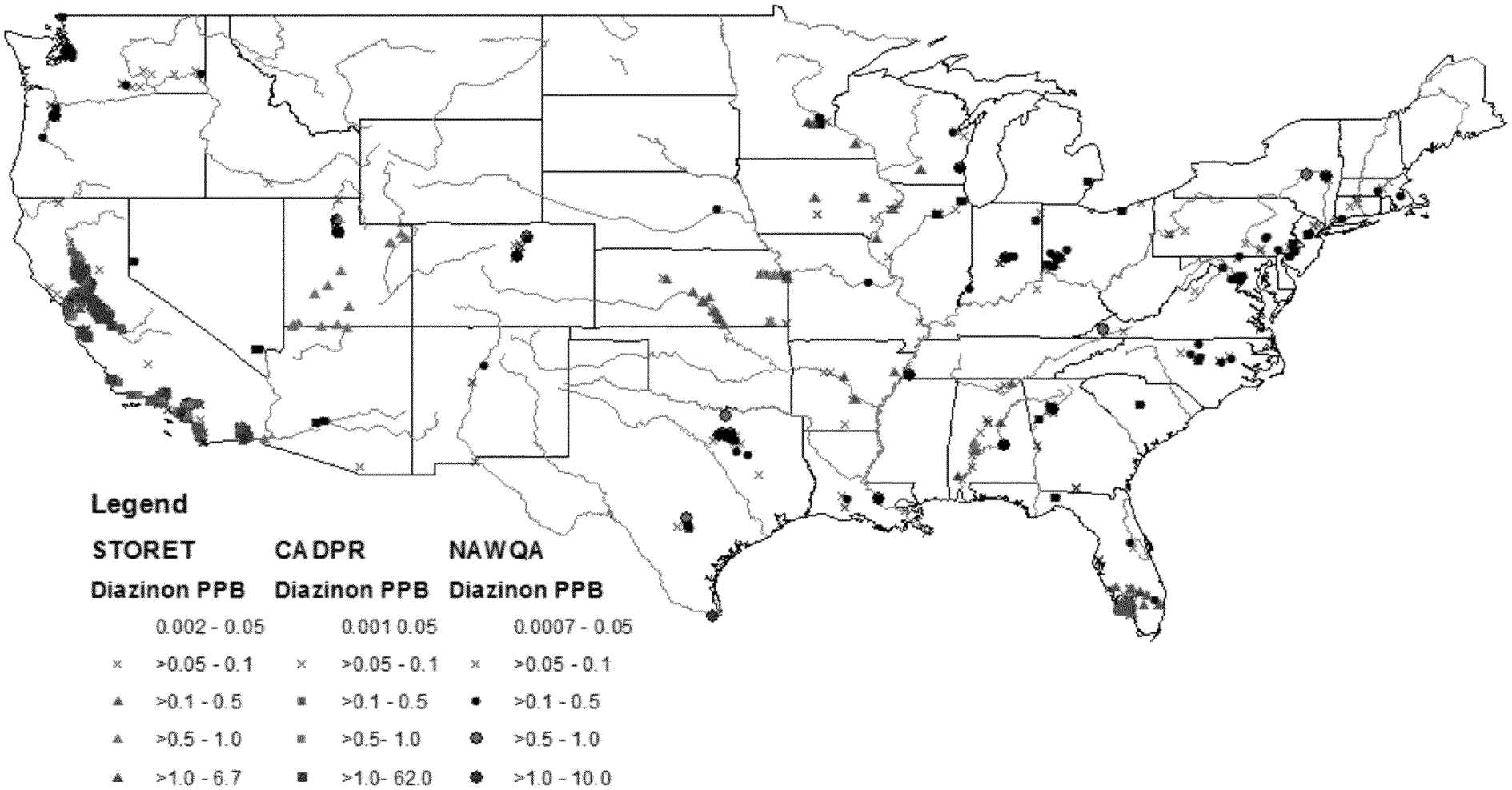


Figure 7. Diazinon Concentrations in Surface Water in µg/L (ppb) Across the United States Based on Data Obtained from STORET, NAWQA, and CADPR

Table 21. Summary of Surface Water Monitoring Data

Sites (Dataset Source)	Year	Study Type	Sampling Frequency	Maximum Diazinon Conc. µg/L	Detection frequency (Detects/samples)	Source
Diazinon						
National (NAWQA)	1993 - 2014	Non-targeted	Irregular	3.8 (0.359 after 2003)	27% (8313/30,297)	NAWQA (USGS, 2015b)
12 Drinking Water Reservoirs (USGS/USEPA)	1999-2000	Collected in areas of high pesticide use	Quarterly and weekly to biweekly during pesticide use season	0.11	35% (114/323)	USEPA and USGS (Blomquist *et al.*, 2001)
Raw and finished drinking water across the U.S. (USDA)	2001-2013	Non-targeted	Irregular	0.133	0.10% (6/5,921)	PDP (USDA, 2013)
National (STORET)	1986-2012	Non-targeted	Irregular	6.7	8% (1784/22,616)	STORET (USEPA, 2015b)
South Florida	1992-2007	Non-targeted	Quarterly	1.9	21% (15/71)	(Pfeuffer, 2011)
Washington Cranberry Growing Area	1994 – 2012	Collected in cranberry drainage ditch pre and post pesticide application	Every 2 days with a total of 5 samples from 2 ditches	7.0	56 to 100% of samples, depending on the site	(Anderson and Davis, 2000)
Washington State	1992 – Present	Non-targeted	Irregular	5.7	5% (233/4,667)	(Washington State Department of Ecology, 2015)
Oregon	1998	Non-targeted	Irregular	--	0% (0/190)	(Oregon Department of Environmental Quality, 2015)
44 Community Water Systems: Drinking Water	1999-2001	Collected in watersheds with high sales	Irregular	--	0% (0/1103)	MRID 45513501, 45526200, 45526201
California Data Analysis						
California (CADPR)	1990-2012	Non-targeted	Irregular	61.9 (in 2009)	33% (4495/13,620)	(CADPR, 2012b)
California (CEDEN)	1993-2014	Non-targeted	Irregular	6.7 1.15 (after 2007)	47% (1,680/3,563)	(State Water Resources Control Board, 2015)
Regions of California with High Detection Frequency (CADPR)	2005-2010	Non-targeted	Irregular	24	10 – 91%	(Zhang *et al.*, 2012)
California, irrigation season use (CADPR)	2003-2008	Filtered data for areas not influenced by dormant and	Irregular	9% exceeded 0.16 (Max not reported)	24% (637/2,635)	USGS and CADPR (Starner, 2009)

Sites (Dataset Source)	Year	Study Type	Sampling Frequency	Maximum Diazinon Conc. µg/L	Detection frequency (Detects/samples)	Source
		urban use and analyzed diazinon use data				
San Joaquin River (USGS) and Tributaries	January-February 2000	Collected during dormant season for orchards in known diazinon use area	Weekly during dry periods and more than weekly during wet periods	1.06	82-100% of samples depending on the site	(Kratzer *et al.*, 2002)
	January-February 2000			0.435	95-100% of samples depending on the site	(Zamora *et al.*, 2003)
	April – August 2001	12 sites sampled in areas receiving drainage from orchards and field crops	Weekly between April and August	0.325	10-100% of samples depending on the site	(Domagalski and Munday, 2003)
Sacramento River and Tributaries (USGS)	January – February 2000	Collected during dormant season for orchards	5 consecutive days after 3 storm events	2.89	77% (106/138)	(Dileanis *et al.*, 2002)
	January – February 2001		5 consecutive days after two storm events	1.38	0-100%, depending on site	(Dileanis *et al.*, 2003)
Santa Clara River and Callequas Creek Watersheds	Wet and dry season 2009	Collected during wet season after rain events and during dry season	One sample collected at 14 sites after two rain events and 2 samples collected during dry season	0.172	82% during wet season 4% during dry season	(Delgado-Moreno *et al.*, 2011)
Salinas River, where agricultural drains enter river	2000-2001	Non-targeted	4x in 2 years	3.340	44% (17/39)	(Anderson *et al.*, 2003)
Central Coast California Monitoring Data	2006 to 2013	Non-targeted	Irregular	24.46	37% (80/216)	Central Valley Water Quality Control Board (email dated 2/26/2015)
Central Coast California Monitoring Data	2000-2011	Non-targeted	Irregular	40.8	34% (3024/8963)	Central Valley Water Quality Control Board (email dated 1/29/2015)
Central Valley of California TMDL (UCDavis)	Winter 2006	Counties with known diazinon use	Daily for 2 to 8 days following storm event	0.778	50-100%	(Regional Water Quality Control Board, 2006)
Diazoxon						
NAWQA National	2002 – 2014	Non-targeted	Irregular	0.06	2% (30/1499)	NAWQA (USGS, 2015b)

Sites (Dataset Source)	Year	Study Type	Sampling Frequency	Maximum Diazinon Conc. µg/L	Detection frequency (Detects/samples)	Source
National (STORET)	2009, 2012-2013	Non-targeted	Irregular	Below LOQ (0.075 to 0.15 µg/L)	8% (10/2900)	STORET (USEPA, 2015b)
California (CADPR)	1991-1995	Non-targeted	Irregular	0.43	0.6% (5/773)	CADPR Surface Water Protection Program Database (CADPR, 2012b)
44 Community Water Systems: Drinking Water	1999-2001	Collected in watersheds with high sales	Irregular	0.15	<0.1 (3/1103)	MRID 45513501, 45526200, 45526201

LOQ=Limit of Quantitation

[a] Targeted refers to sampling occurring after a known pesticide application at a known location, with a well-described relationship to the sampling event. Non-targeted refers to studies in which, when samples were collected, no consideration was given to pesticide use patterns.

1.2.1 Pesticide Concentrations in Drinking Water USGS and USEPA in (1999-2000)

In 1999 and 2000, the United States Geological Survey (USGS) and USEPA collaborated in examining concentrations of pesticides in twelve small drinking-water supply reservoirs in areas of high pesticide use. The reservoirs range in size from 120 to 92,600 acre-feet with contributing watersheds ranging in size from 3.3 to 784 square miles (Blomquist *et al.*, 2001). Water samples were collected from raw-water intakes, finished drinking water, and some reservoir outflows. Samples were collected quarterly throughout the year and at weekly or biweekly intervals following the primary pesticide application periods. Diazinon was detected in 35% (114 of 323) of raw water samples and was one of the most frequently detected insecticides, with a maximum concentration of 0.11 µg/L detected in Lake Arcadia, Oklahoma. This was the reservoir with the smallest capacity among those sampled (120 acre-feet) and a high sampling frequency. Its watershed includes both urban and agricultural land uses. Diazinon was not detected in any of the finished water samples. Diazoxon was not included as an analyte in this study. Other studies have shown that organophosphorus insecticides are readily oxidized in the presence of chlorine, suggesting that diazoxon could form (see Drinking Water Treatment Section). Although diazinon was not observed in finished water samples, it is possible that diazoxon was present.

1.2.2 Pesticide Data Program (PDP) Surface Water (2001-2013)

The Pesticide Data Program (PDP) is a national pesticide residue database program that examines pesticide residues in agricultural commodities and drinking water in the United States' food supply, to support pesticide dietary exposure assessments (USDA, 2013). Finished drinking water monitoring in California and New York began in 2001. In 2002, the program was expanded to Colorado, Kansas, and Texas. In 2004, the program began examining paired raw and finished drinking water samples sourced from surface water. The survey ended in 2013. The limit of detection ranged from 3.3 to 30 ng/L.

Diazinon was detected in 0.10% of surface water source water samples (six of 5,921 samples) at a maximum concentration of 0.133 µg/L (**Table 22**). Detections occurred in 2001, 2002, 2003,

2007, and 2010. Most detections were in raw water; however, there were some detections in finished water.

Table 22. Summary of Surface Water Sourced Drinking Water Monitoring Data from the PDP

Year	Detects	Number of Samples	Frequency of Detects	Diazinon Max Concentration (µg/L)	Detect(s) in
2001	1	283	0.35%	0.010	Finished Water
2002	1	657	0.15%	0.010	Finished Water
2003	1	794	0.13%	0.133	Finished Water
2004	0	239	0.00%	NA	Paired raw and finished water
2005	0	232	0.00%	NA	Paired raw and finished water
2006	0	368	0.00%	NA	Paired raw and finished water
2007	1	733	0.14%	0.0164	Paired raw and finished water
2008	1	619	0.16%	0.1	Paired raw and finished water
2009	0	612	0.00%	NA	Paired raw and finished water
2010	1	559	0.18%	0.059	Paired raw and finished water
2011	0	240	0.00%	NA	Paired raw and finished water
2012	0	485	0.00%	NA	Paired raw and finished water
2013	0	100	0.00%	NA	Paired raw and finished water
Total	6	5921	0.10%	0.133	Raw and finished water

NA=not applicable

1.3 Groundwater

Diazinon has also been detected in groundwater, though at a lower frequency (0 to 3%) than in surface water, and typically at lower concentrations. Although the maximum groundwater detection was 19 µg/L, the majority of detections were at lower concentration. Detections occurred in Colorado, Idaho, Iowa, California, Connecticut, Florida, Illinois, Indiana, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nevada, New Hampshire, New Mexico, New York, North Carolina, Pennsylvania, South Carolina, and Virginia.

Table 23. Summary of Groundwater Monitoring Data

Sites (Dataset Source)	Year	Study Type	Sampling Frequency	Maximum Diazinon Conc. µg/L	Detection frequency (Detects/samples)	Source
Diazinon						
National (NAWQA)	1992-2014	Non-targeted	Varies	19 (0.098 after 2002)	0.8% (105/12,640)	(USGS, 2015a)
Private Drinking Water Wells on farms, schools, daycares across the nation and municipal drinking	2007-2013	Non-targeted	Varies	0.081 (in 2013)	0.16% (3/1,915)	PDP (USDA, 2013)

Sites (Dataset Source)	Year	Study Type	Sampling Frequency	Maximum Diazinon Conc. µg/L	Detection frequency (Detects/samples)	Source
water (USDA)						
Private wells in vulnerable counties in New York	2007-2009	Vulnerable private wells in rural areas	Single Sample collected	0.1	3% (2/80)	(Richards *et al.*, 2012)
Oregon	1998	Non-targeted	Varies	--	0% (0/71)	(Oregon Department of Environmental Quality, 2015)

1.4 Sediment and Tissue

Diazinon has also been detected in sediment, at a maximum concentration of 0.46 µg/L in pore water and 4.72 µg/kg-dry weight sediment. The frequency of detection in sediment is much lower than that in water, ranging from 1 to 60 percent of samples among data sources.

Table 24. Summary of Sediment and Tissue Monitoring Data

Sites (Dataset Source)	Year	Study Type	Sampling Frequency	Maximum Diazinon Concentration			Source
				Pore water µg/L	Sediment µg/kg-dw	Detection frequency (Detects/samples)	
National (NAWQA)	1992-2007	Non-targeted	Varies	--	3.5	1% (3/242)	(USGS, 2015a)
Oregon	1998	Non-targeted	Varies	--	8	20% (1/5)	(Oregon Department of Environmental Quality, 2015)
Salinas River, where agricultural drains enter river	2000-2001	Non-targeted	4x in 2 years	0.46	--	44% (3/9)	(Anderson *et al.*, 2003)
Central Coast California Monitoring Data	2006 to 2009	Non-targeted	Varies	0.03	4.72	9% (11 of 122)	Central Valley Water Quality Control Board (email dated
Santa Clara River and Callequas Creek Watersheds	Wet and dry season 2009	Collected during wet season after rain events and during dry season	One sample collected at 14 sites after two rain events and 2 samples collected during dry season		Median=1 ng/g	60%	(Delgado-Moreno *et al.*, 2011)

Tissue data were obtained from the California Environmental Data Exchange Network (CEDEN) on January 10, 2015. Data on tissue containing residues of diazinon were reported by the Surface Water Ambient Monitoring Program, the Regional Monitoring Program for Water Quality, and the Newport Bay Watershed Biotrend Monitoring Program.

Twenty detections were reported between 1984 and 1989 on residues in freshwater clams (*Corbicula fluminea*) and in California Mussels (*Mytilus californianus*). Diazinon was present at concentrations ranging from 1,060 ng/g-lipid to 13,853.4 ng/g-lipid. Samples were collected from rivers, creeks, harbors, canals, and sloughs.

There were 166 detections in freshwater clam, California Mussel, Sailfin Molly (*Poecilia latipinna*), Asiatic clam (*Corbicula manilensis*), Channel catfish *(Ictalurus punctatus*), Common carp (*Cyprinus carpio*), Fathead minnow (*Pimephales promelas*), goldfish (*Carassius auratus*), red shiner (*Cyprinella lutrensis*), Treespine stickleback (*Gasterosteus aculeatus*), longjaw mudsucker (*Gillichthys mirabilis*), Tilapia spp., mosquitofish (*Gambusia affinis*), white croaker (*Genyonemus lineatus*), red rock crab (*Cancer productus*), and Jacksmelt (*Atherinopsis californiensis*). Detected concentrations were a maximum of 1100 ng/g dry-weight (usually whole organisms without gut but some soft tissue) and 1050 ng/g wet-weight whole organism. The highest concentration reported in fillet was 140 ng/g wet-weight.

1.5 Atmospheric Monitoring

Diazinon is one of the most frequently detected pesticides in air and in precipitation. The majority of monitoring studies involving diazinon have been conducted in California; however, diazinon has been detected throughout the United States in air and precipitation. Available air and precipitation monitoring data for diazinon in California are reported in **Zabik and** Seiber (1993) collected air samples in 1990 and 1991 from a national park in the Sierra Nevada Mountains and analyzed for both diazinon and diazoxon. The authors reported that 26% of the parent was converted to the oxon in air. In paired air samples, the ratio of the oxon to the parent ranged 0.068-3.9 (N = 34). Zabik and Seiber (1993) also collected rain samples deposited in the Sierra Nevada Mountains. In their limited samples, they detected diazoxon at lower levels compared to the parent.

Diazinon and diazoxon have been quantified fog in two different studies conducted in California. In 1986, diazinon concentrations ranged 0.31-18 µg/L and diazoxon concentrations ranged 0.42-28 µg/L (n = 6). The ratios of the oxon to the parent ranged 0.056-7.1, where the majority of the samples had concentrations of the two that were on the same order of magnitude (Glotfelty *et al.* 1990). In 1987, diazinon concentrations ranged 0.15-4.8 µg/L and diazoxon concentrations ranged 1.9-11 µg/L (n = 5). The ratios of the oxon to the parent ranged 0.067-13, where the majority of the samples had concentrations of the two that were on the same order of magnitude (Schomburg *et al.* 1991).
Table 25.

The magnitude of detected concentrations of diazinon in air and in precipitation could vary based on several factors, including proximity to use areas and timing of applications. In air, diazinon has been detected at concentrations up to 0.306 µg/m^3. Measured concentrations of diazinon in rain in California have been detected at concentrations up to 2.22 µg/L. In fog, diazinon has been detected at up to 76.3 µg/L (Majewski and Capel, 1995). Deposition studies in California in diazinon use areas show that diazinon was detected in rain after applications to orchards. Wet deposition generally had higher concentrations of diazinon than dry deposition. Diazinon was detected in 93% of rain samples (n=137), with mean and maximum concentrations of 0.149 and

2.220 µg/L, respectively (Majewski *et al.*, 2006). Diazinon has been detected in California lakes (maximum concentration of 0.0741 µg/L) that do not receive runoff or spray drift from agricultural areas and are presumed to receive inputs of diazinon from atmospheric deposition only (Fellers *et al.*, 2004; LeNoir *et al.*, 1999).

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Table 25. Diazinon Detections in Air and Precipitation Samples Taken in California.

Location	Year	Sample type	Maximum Conc.*	Detection frequency	Source
CA, MD	1970s-1990s	Air	0.306	NA	(Majewski and Capel, 1995)
Sequoia National Park, CA	1996	Air	0.00024	41.7%	(LeNoir *et al.*, 1999)
Sacramento, CA (Franklin Field Airport)	1996-1997	Air	0.0191	37.1 %	(Majewski and Baston, 2002)
Sacramento, CA (Sacramento Metropolitan Area)	1996-1997	Air	0.0122	46.5 %	(Majewski and Baston, 2002)
Sacramento, CA (Sacramento International Airport)	1996-1997	Air	0.112	38.5 %	(Majewski and Baston, 2002)
Fresno County, CA	1997	Air	0.290	NA	(State of California, 1998a)
Fresno County, CA	1998	Air	0.160	NA	(State of California, 1998b)
Mississippi River from New Orleans, LA to St. Paul MN	1994	Air	0.00036	100%	(Majewski *et al.*, 1998)
Central Valley, CA	1990-1991	Air	0.01 (parent) 0.003 (diazoxon)	100%	(Zabik and Seiber, 1993)
Orchard Application in Glenn county California	01/2010	Air	4.261 (parent) 0.124 (diazoxon)	85%	(Rider, 2010)
Sequoia national Park, CA	1995-1996	Rain	0.019	57 %	(McConnell *et al.*, 1998b)
San Joaquin River Basin, CA	2001	Rain	0.908	100%	(Zamora *et al.*, 2003)
San Joaquin Valley, CA	2002-2004	Rain	2.22	93%	(Majewski *et al.*, 2006)
Central Valley, CA	1990-	Rain	6.1 (parent)	100%	(Zabik and Seiber,

Location	Year	Sample type	Maximum Conc.*	Detection frequency	Source
	1991		2.3 (diazoxon)		1993)
CA, MD	1970s-1990s	Fog	76.3	NA	(Zhang *et al.*, 2012)
Parlier, CA	1986	Fog	18.0	NA	(Glotfelty *et al.*, 1990)
Monterey, CA	1987	Fog	4.80	NA	(Schomburg *et al.*, 1991)
Sequoia national Park, CA	1995-1996	Snow	0.014	62.5 %	(McConnell *et al.*, 1998a)

*For Air, µg/m^3; for rain, snow and fog, µg/L

12 UNCERTAINTIES

There are a number of uncertainties associated with this drinking water exposure assessment and most of these are discussed in the drinking water treatment section and the modeling results section. These include uncertainty about the soil sorption coefficient of diazinon, aerobic soil metabolism rates, number of crop cycles per year for some crops, and effect of drinking water treatment processes. Additional uncertainties include the percentage of diazinon converted to diazoxon in the environment, the percentage of a watershed that will receive treatment with diazinon, and the representativeness of results of screening level models.

One major uncertainty is the amount of diazoxon that may form in the environment and during drinking water treatment. In this assessment, a maximum 100% conversion was assumed. While this is a conservative assumption it is not an unreasonable one, because data indicate (Acero *et al.*, 2008; Beduk *et al.*, 2011; Chamberlain *et al.*, 2012; Duirk *et al.*, 2009; Magara *et al.*, 1994; Ohashi *et al.*, 1994; Wu *et al.*, 2009; Zhang and Pehkonen, 1999) that the prevalent method of drinking water disinfection does convert diazinon to diazoxon rapidly and that diazoxon can persist in treated water. Nevertheless, additional data on the percent of diazoxon formed by different treatment processes could be used to refine this assumption.

The drinking water assessment is a screening-level assessment based upon standard models and assumptions. The EDWCs in this document are believed to represent high-end estimates of concentrations that may occur vulnerable areas. Such concentrations are not expected to occur in drinking water broadly across the United States. The modeling assessment relies on a maximum use pattern (*i.e.*, maximum label application rates) to estimate surface water and groundwater concentrations, and assumes a national PCA of 1. This PCA represents the highest available value for any Community Water Supply – Drinking Water Intake watershed (plus HUC-12 surrogates) nationally and represents an entire watershed being treated with diazinon at the same time. To the extent that actual use patterns involve application of less a.i. than the permitted maximum on the label, and that watersheds are not comprised entirely of treated crop acreage, aquatic concentrations could be lower than EDWCs reported herein.

As a groundwater screening tool, PRZM-GW in general works to simulate concentrations greater than those that are likely to be present in the vast majority of ground water supplies.

While there are many uncertainties associated with the EDWCs, and some conservative assumptions were employed in modeling, it is noteworthy that monitoring results that almost

certainly do not reflect true maximum diazinon concentrations, are often within an order of magnitude of modeled EDWCs. If diazinon EDWCs result in risk concerns, more refined analysis on drinking water exposure may be conducted such as estimating drinking water concentrations for different regions.

13 LITERATURE CITED

Acero, J. L., Benitez, F. J., Real, F. J., & Gonzalez, M. 2008. Chlorination of organophosphorus pesticides in natural waters. *Journal of Hazardous Materials, 153*, 320-328.

Anderson, B. S., Hunt, J. W., Phillips, B. M., Nicely, P. A., Vlaming, V., Connor, V., et al. 2003. Integrated assessment of the impacts of agricultural drainwater in the Salinas River (California, USA). *Environmental Pollution, 124*, 523-532.

Anderson, P., & Davis, D. 2000. *Evaluation of Efforts to Reduce Pesticide Contamination in Cranberry Bog Drainage*. Publication No. 00-03-041. September 2000. Washington State Department of Ecology. Available at http://longbeach.wsu.edu/cranberries/documents/evaluationofeffortstoreducepesticidesinbogdrainage.pdf (Accessed February 21, 2015).

Arienzo, M., Crisanto, T., Sanchezmartin, M. J., & Sanchezcamazano, M. 1994. EFFECT OF SOIL CHARACTERISTICS ON ADSORPTION AND MOBILITY OF (C-14)DIAZINON. *Journal of Agricultural and Food Chemistry, 42*(8), 1803-1808.

Armitage, J. M., & Gobas, F. A. P. C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025.

Armstrong, C. 2015. *How to Grow Cranberries - Cranberry Production Timetable*. University of Maine Cooperative Extension. Available at http://umaine.edu/cranberries/growing-cranberries/cranberry-production-timetable/ (Accessed February 1, 2015).

Association, N. G. 2014. *Annual Monitoring Report- Year Three Under Order # R4-2010-0186*. December 23, 2014. Nursery Growers Association. Los Angeles County. Irrigated Lands Group.

Baker, R. 2014. *The Grayland Ditch*. AGR Pub 102-401. March 31, 2014. Washington State Department of Agriculture. Natural Resource Assessment Section. Available at http://agr.wa.gov/FP/Pubs/docs/401-2013CranberryReportFinal.pdf (Accessed February 23, 2015).

Baris, R., Barrett, M., Bohaty, R. F. H., Echeverria, M., Villaneuva, P., Wolf, J., et al. 2013. *Guidance for Using PRZM-GW in Drinking Water Exposure Assessments*. December 11, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. United States Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/przm_gw/wqtt_przm_gw_guidance.htm (Accessed April 11, 2014).

Bartlet-Hunt, S. L., Knappe, D. R. U., & Barlaz, M. A. 2014. A review of chemical warfare agent simulants for the study of environmental behavior. *Critical Reviews in Environmental Science and Technology, 2008*, 112-136.

Beduk, F., Aydin, M. E., & Ozcan, S. 2011. Chemical oxidation of diazinon in aqueous solution by ozonation. *Fresnius Environmental Bulletin, 20*(7a), 1785-1972.

Blomquist, J. D., Denis, J. M., Cowles, J. L., Hetrick, J. A., Jones, R. D., & Birchfield, N. 2001. *Pesticides in Selected Water-Supply Reservoirs and Finished Drinking Water, 1999-2000: Summary of Results from a Pilot Monitoring Program*. Open-File Report 01-456.

United States Geological Survey. Available at http://md.water.usgs.gov/nawqa/ (Accessed January 2, 2015).

CA Dept. of Food and Agriculture. 2014. *Statewide Plant Pest Prevention and Management Program*. S. 2011062057. August 2014. Available at http://www.cdfa.ca.gov/plant/peir/ (Accessed September 9, 2014).

CADPR. 2012a. Pesticide Use Reporting. California Department of Pesticide Regulation. Available at http://www.cdpr.ca.gov/docs/pur/purmain.htm (Accessed February 13, 2012).

CADPR. 2012b. Surface Water Protection Program Database. Available at http://www.cdpr.ca.gov/docs/emon/surfwtr/surfdata.htm (Accessed February 16, 2012).

California Department of Pesticide Regulation. 2015. Surface Water Protection Program Database. Available at http://www.cdpr.ca.gov/docs/emon/surfwtr/surfdata.htm (Accessed February 15, 2015).

Cape Cod Cranberry Growers Association. 2001. *Conservation District Grant Program of the Commonwealth of Massachusetts Executive Office of Environmental Affairs. Cranberry Water Use. An Information Fact Sheet*. June 2001. Available at http://www.cranberries.org/pdf/wateruse.pdf (Accessed October 25, 2012).

Carsel, R. F., Imhoff, J. C., Hummel, P. R., Cheplick, J. M., & Donigian Jr., J. S. 1997. *PRZM-3, A Model for Predicting Pesticide and Nitrogen Fate in Crop Root and Unsaturated Soil Zones: Users Manual for Release 3.0*. Memorandum From to Environmental Research Laboratory. Office of Research and Development. United States Environmental Protection Agency.

Chamberlain, E., Shi, H., Wang, T., Ma, Y., Fulmer, A., & Adams, C. 2012. Comprehensive screening study of pesticide degradation vai oxidation and hydrolysis. *Journal of Agricultural and Food Chemistry, 60*, 354-363.

Delgado-Moreno, L., Lin, K., Veiga-Nascimento, R., & Gan, J. 2011. Ocurrence and toxicity of three classes of insecticides in water and sediment in two southern California coastal watersheds. *Journal of Agricultural and Food Chemistry, 59*, 9448-9456.

Dileanis, P. D., Bennett, K. P., & Domagalski, J. L. 2002. *Occurence and Transport of Diazinon in the Sacramento River, California, and Selected Tributaries During Three Winter Storms, January - February 2000*. W.-R. I. R. 02-4101. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri02-4101/wri02-4101.pdf (Accessed February 17, 2015).

Dileanis, P. D., Brown, D. L., Knifong, D. L., & Saleh, D. 2003. *Occurence and Transport of Diazinon in the Sacramento River and Selected Tributaries, California, During Two Winter Storms, January - February 2001*. Water-Resources Investigations Report 03-4111. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri034111/wrir_034111.pdf (Accessed February 17, 2015).

Domagalski, J. L., & Munday, C. 2003. *Evaluation of Diazinon and Chlorpyrifos Concentrations and Loads, and Other Pesticide Concentrations, at Selected Sites in te San Joaquin Valley, California, April to August 2001*. W.-R. I. R. 03-4088. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri034088/pdf/wri03_4088.pdf (Accessed February 17, 2015).

Duirk, S. E., Desetto, L. M., & Davis, G. M. 2009. Transformation of organophosphorus pesticides in the presence of aqueous chlorine: kinetics, pathways, and structure-activity relationships. *Environ Sci Technol, 43*, 2335-2340.

FAO. 2000. Appendix 2. Parameters of pesticides that influence processes in the soil. In FAO Information Division Editorial Group (Ed.), *Pesticide Disposal Series 8. Assessing Soil Contamination. A Reference Manual*. Rome: Food & Agriculture Organization of the United Nations (FAO). Available at http://www.fao.org/DOCREP/003/X2570E/X2570E06.htm (Accessed July 10, 2009).

Feigenbrugel, V., LeCalve, S., & Mirabel, P. 2004. Temperature dependence of Henry's law constants of metolachlor and diazinon. *Chemosphere, 57*, 319-327.

Fellers, G. M., McConnell, L. L., Pratt, D., & Datta, S. 2004. Pesticides in Mountain Yellow-Legged Frogs (*Rana Mucosa*) from the Sierra Nevada Mountains of California. *Environmental Toxicology and Chemistry, 23*(9), 2170-2177.

Fendinger, N. J., Glotfelty, D. E., & Freeman, H. P. 1989. Comparison of two experimental techniques for determining air/water Henry's law constants. *Environmental Science & Technology, 23*(12), 1528-1531.

Gilliom, R. J., Barbash, J. E., Crawford, C. G., Hamilton, P. A., Martin, J. D., Nakagaki, N., et al. 2007. *The quality of Our Nation's Waters. Pesticides in the Nation's Streams and Ground Water, 1992-2001.* C. 1291. February 15, 2007. United States Department of Interior. United States Giological Survey. National Water-Quality Assessment Program. Available at http://pubs.usgs.gov/circ/2005/1291/pdf/circ1291.pdf (Accessed September 21, 2009).

Glotfelty, D. E., Majewski, M. S., & Seiber, J. N. 1990. Distribution of several organophosphorus insecticides and their oxygen analogues in a foggy atmosphere. *Environemntal Science and Technology, 24*(3), 353-357.

Gobas, F. A. P. C., Kelly, B. C., & Arnot, J. A. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food-webs. *QSAR Comb. Sci, 22*, 329-336.

Hall Jr, L., & Anderson, R. D. 2014. Historical trends analysis of 2004 to 2009 toxicity and pesticide data for California's central valley. *Journal of Environmental Science and Health Part A: Toxic/Hazardous Substances and Environmental Engineering, 47*, 801-811.

Hetrick, J., Parker, R., Pisigan, R., & Thurman, N. 2000. *Progress Report on Estimating Concentrations in Drinking Water and Assessing Water Treatment Effects on Pesticide Removal and Transformation: A Consultation. Briefing Document for a Presentation to the FIFRA Scientific Advisory Panel on September 29, 2000.* September 29, 2000. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/scipoly/sap/meetings/2000/september/sept00_sap_dw_0907.pdf (Accessed September 9, 2014).

IglesiasJimenez, E., SanchezMartin, M. J., & SanchezCamazano, M. 1996. Pesticide adsorption in a soil-water system in the presence of surfactants. *Chemosphere, 32*(9), 1771-1782.

Kratzer, C. R., Zamora, C., & Knifong, D. L. 2002. *Diazinon and Chlorpyrifos Loads in the San Joaquin River Basin, California, January and February 2000.* Water Resources Investigations Report 02-4103. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri02-4103/wri024103.pdf (Accessed February 15, 2015).

Lafleur, J. 2002. *Resource Planning for Cranberry Bogs within Drinking Water Supply Areas*. Project Number 99-14SWT. June 14, 2002. Cape Cod Cranberry Growers' Association. Available at http://www.cranberries.org/pdf/resource_planning_2002.pdf (Accessed February 23, 2015).

LeNoir, J. S., McConnell, L. L., Fellers, G. M., Cahill, T. M., & Seiber, J. N. 1999. Summertime Transport of Current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry, 18*(12), 2715-2722.

Magara, Y., Aizawa, T., Matumoto, N., & Souna, F. 1994. Degradation of pesticides by chlorination during water purificcation, ground water contamination, environmental restoration, and diffuse sourcce pollution. *Water Science and Technology, 30*(7), 119-128.

Majewski, M. S., & Baston, D. S. 2002. *Atmospheric transport of pesticides in the Sacramento, California, Metropolitan Area, 1996-1997.* W. R. I. R. 02-4100. National Water-Quality Assessment Program. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri024100/wri02-4100.pdf (Accessed February 28, 2015).

Majewski, M. S., & Capel, P. D. 1995. *Pesticides in the Atmosphere: Distribution, Trends, and Governing Factors*. Chelsea, MI: Ann Arbor Press.

Majewski, M. S., Foreman, W. T., Goolsbey, D. A., & Nakagaki, N. 1998. Airborne pesticide residues along the Mississippi River. *Environmental Science & Technology, 32*, 3689-3698.

Majewski, M. S., Zamora, C., Foreman, W. T., & Kratzer, C. R. 2006. *Contribution of atmospheric deposition to pesticide loads in surface water runoff.* O.-f. R. 2005-1307. United States Geological Survey. Available at http://pubs.usgs.gov/of/2005/1307/ (Accessed January 20, 2011).

McConnell, L. L., LeNoir, J. S., Datta, S., & Seiber, J. N. 1998a. Wet deposition of current-use pesticides in the Sierra Nevada mountain range, California, USA. *Environmental Toxicology and Chemistry, 17*(10), 1908-1916.

McConnell, L. L., LeNoir, J. S., Datta, S., & Seiber, J. N. 1998b. Wet deposition of current-use pesticides in the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry, 17*(10), 1908-1916.

Munoz, A., Le Person, A., Le Calve, S., Mellouki, A., Borras, E., Daele, V., et al. 2011. Studies on atmospheric degradation of diazinon in the EUPHORE simulation chamber. *Chemosphere, 85*, 724-730.

NAFTA. 2012. *Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media*. December 2012. NAFTA Technical Working Group on Pesticides. Available at http://www.epa.gov/oppfead1/international/naftatwg/guidance/degradation-kin.pdf (Accessed April 11, 2014).

Nemeth-Konda, L., Fuleky, G., Morovjan, G., & Csokan, P. 2002. Sorption behavior of acetochlor, atrazine, carbendazim, diazinon, imidacloprid, and isoproturon on Hungarian agricultural soil. *Chemosphere, 48*, 545-552.

NMFS. 2008. *National Marine Fisheries Service Endangered Species Action 7 Consultation. Biological Opinion. Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, and Malathion*. November 2008. National Marine Fisheries Service. National Oceanic and Atmospheric Administration. U.S. Department of Commerce. Available at http://www.epa.gov/espp/litstatus/1st-biop.pdf (Accessed March 2, 2012).

Ohashi, N., Tsuchida, Y., Sasano, H., & Hamada, A. 1994. Ozonation products of organophosphorus pesticides in water. *Japanese Journal of Toxicology and Health, 40*(2), 185-192.

Oregon Department of Environmental Quality. 2015. *Laboratory Analytical Storage and Retrieval Database (LASAR)*. Available at http://www.deq.state.or.us/lab/lasar.htm (Accessed February 23, 2015).

Pfeuffer, R. J. 2011. South Florida Water Management District ambient pesticide monitoring network: 1992-2007. *Environ Monit Assess, 182*, 485-508.

Regional Water Quality Control Board. 2006. *Results of the 2006 TMDL Monitoring of Pesticides in California's Central Valley Waterways January - March 2006*. October 2006. John Muir Institute of the Environment. Aquatic Ecosystems Analysis Laboratory. University of California, Davis. California Regional Water Quality Control Board. Central Valley Region. Available at http://www.swrcb.ca.gov/centralvalley/water_issues/water_quality_studies/2006-tmdl-winter-storm-report-dfg.pdf (Accessed January 20, 2015).

Richards, B. K., Pacenka, S., Salvucci, A. E., Saia, S. M., Whitbeck, L. F., Furdyna, P. M., et al. 2012. Surveying Upstate NY Well Water for Pesticide Contamination: Cayuga and Orange Counties. *Ground Water Monitoring and Remediation, 32*(1), 73-82.

Schomburg, C. J., Glotfelty, D. E., & Seiber, J. N. 1991. Pesticide occurence and distribution in fog collected near Monterrey California. *Environmental Science & Technology, 25*, 155-160.

Shemer, H., & Linden, K. G. 2006. Degradation and by-product formation of diazinon in water during UV and UV/H20 treatment. *Journal of Hazardous Materials B136*, 553-559.

Smolen, J. M., & Stone, A. T. 1997. Divalent metal ion-catalyzed hydrolysis of phosphorothionate ester pesticides and their corresponding oxonates. *Environmental Science & Technology, 31*, 1664-1673.

Starner, K. 2009. *Spatial and temperal analysis of diazinon irrigation-season use and monitoring data*. October 8, 2009. California Environmental Protection Agency. California Department of Pesticide Regulation. Environmental Monitoring Branch. Available at http://www.cdpr.ca.gov/docs/emon/surfwtr/policies/starner_sw08.pdf (Accessed January 17, 2015).

State of California. 1998a. *Report for the Ambient Air Monitoring of Diazinon in Fresno County During Winter, 1997*. P. N. C96-036. April 6, 1998. California Environmental Protection Agency. . Available at http://www.cdpr.ca.gov/docs/emon/pubs/tac/tacpdfs/diaamb.pdf (Accessed February 28, 2015).

State of California. 1998b. *Report for the Application (Kings County) and Ambient (Fresno County) Air Monitoring of Diazinon During Winter, 1998*. Available at http://www.cdpr.ca.gov/docs/emon/pubs/tac/tacpdfs/diamapl.pdf (Accessed February 28, 2015).

State Water Resources Control Board. 2015. California Environmental Data Exchange Network. California State Water Resources Control Board. Available at http://www.ceden.org/ (Accessed January 17, 2015).

Szeto, S. Y., Wan, M. T., Price, P., & Roland, J. 1990. Distribution and persistence of diazinon in a cranberry bog. *Journal of Agricultural and Food Chemistry, 38*, 281-285.

Ukpebor, J. E., & Halsall, C. J. 2012. Effects of dissolved water constituents on the photodegradation of fenitrothion and diazinon. *Water Air Soil Pollut, 223*, 655-666.

USDA. 2012. *Runoff-Frequency: Peaks, Volumes, Timing for Low-Relief, Sandy "Cranberry Bog" Drainage Areas of Southeastern Massachusetts and Rhode Island"*. Technical Note No. 301. September 2012. National Resources Conservation Service. United States

Department of Agriculture. Available at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1101082.pdf (Accessed February 13, 2015).

USDA. 2013. Pesticide Data Program. U.S. Department of Agriculture. Agricultural Marketing Service. Available at http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateC&navID=&rightNav1=&topNav=&leftNav=ScienceandLaboratories&page=PesticideDataProgram&resultType=&acct=pestcddataprg (Accessed January 15, 2015).

USEPA. 1998. *An Index Reservoir for Use in Assessing Drinking Water Exposure. Proposed Methods for Basin-scale Estimation of Pesticide Concentrations in Flowing Water and Reservoirs for Tolerance Reassessment.* J.-. Presentation to FIFRA Science Advisory Panel, 1998., .

USEPA. 2000.D270838. *Diazinon: Revised HED Human Health Risk Assessment for the Reregistration Eligibility Decision (RED) D270838.* D270838. Memorandum From D. Drew, J. Doherty & D. Smegal to B. Chambliss. December 5, 2000. Health Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2000.D154949, D159643, D183157. *Environmental Fate and Effects Division Revised Science Chapter for the Diazinon Reregistration Eligibility Decision Document*. November 16, 2000. Environmental Fate and Effect Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2002.D183157. *Final Revised Environmental Fate and Ecological Risk Assessment Chapter for the Reregistration Eligibility Decision on Diazinon*. February 20, 2002. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2002. *Organophosphate Pesticides: Revised Cumulative Risk Assessment*. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/pesticides/cumulative/rra-op/ (Accessed February 28, 2015).

USEPA. 2004. *Interim Reregistration Eligibility Decision for Diazinon. Case No. 0238*. E. 738-R-04-006. May 2004. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/pesticides/reregistration/REDs/diazinon_red.pdf (Accessed June 13, 2014).

USEPA. 2006. *(P)RZM (E)XAMs Model Shell, Version 5.0*. November 15, 2006. Environmental Fate and Effects Division. Office of Pesticide Programs. Office of Chemical Safety and Pollution Prevention. United States Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/pe5_user_manual.htm (Accessed April 18, 2013).

USEPA. 2009a. *2006 Community Water System Survey Volume II: Detailed Tables and Survey Methodology*. E. 815-R-09-002. May 2009. Office of Water. U.S. Environmental Protection Agency.

USEPA. 2009b. *SAP Minutes No. 2009-01. A set of Scientific Issues Being Considered by the Environmental Protection Agency Regarding: Selected Issues Associated with the Risk Assessment Process for Pesticides with Persistent, Bioaccumulative, and Toxic Characteristics. October 28-31, 2008., January 29, 2009*. Available at http://www.epa.gov/scipoly/sap/meetings/2008/102808_mtg.htm (Accessed July 9, 2009).

USEPA. 2009c. *User's Guide and Technical Documentation KABAM version 1.0 (KOW (based) Aquatic BioAccumulation Model)*. April 7, 2009. Environmental Fate and Effects Division. Office of Pesticide Programs. Available at http://www.epa.gov/oppefed1/models/water/kabam/kabam_v1_0_users_guide.pdf (Accessed January 27, 2010).

USEPA. 2010a. *Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in the Problem Formulation for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments*. January 25, 2010. Environmental Fate and Effects Division. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency. Available at http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm (Accessed July 5, 2012).

USEPA. 2010b. *Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in the Problem Formulation for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments, January 25, 2010.*

USEPA. 2010c. *Guidance on Development and Use of the Index Reservoir in Drinking Water Exposure Assessments*. September 14, 2010. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/index_reservoir_dwa.pdf (Accessed December 9, 2010).

USEPA. 2012a. *Criteria Used by the PBT Profiler*. September 4, 2012. Office of Chemical Safety and Pollution Prevention. United States Environmental Protection Agency. Available at http://www.pbtprofiler.net/criteria.asp (Accessed September 7, 2012).

USEPA. 2012.D391431. *Fenpyroximate: Drinking Water Exposure Assessment for Proposed New Uses on Snap Beans and Tropical Fruits including Avocado and a Proposed Outdoor Use on Cucumbers*. D391431. Memorandum From G. Orrick to G. Kramer & S. Jackson. Environmental Fate and Effects Division. Office of Pesticide Programs. United States Environmental Protection Agency.

USEPA. 2012b. *Risks of Diazinon Use to Federally Threatened Delta Smelt (Hypomesus transpacificus) and the Federally Endangered Tidewater Goby (Eucyclogobius newberryi)*. March 28, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/espp/litstatus/effects/redleg-frog/#diazinon (Accessed June 16, 2014).

USEPA. 2012c. *Standard Operating Procedure for Using the NAFTA Guidance to Calculate Representative Half-life Values and Characterizing Pesticide Degradation*. November 30, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/ecorisk_ders/degradation_kinetics/NAFTA_Degradation_Kinetics.htm (Accessed December 16, 2013).

USEPA. 2012.D405064. *Tier I Drinking Water Exposure Assessment for the Section 3 New Use of Boscalid on Various Agricultural Crops Including Cranberries*. D405064. Memorandum From K. White to S. Funk, B. O'Keefe, A. Ertman & B. Madden. November 27, 2012. Environmental Fate and Effects Division. Office of Pesticide

Programs. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency.

USEPA. 2013. *Guidance on Modeling Offsite Deposition of Pesticides Via Spray Drift for Ecological and Drinking Water Assessment*. Environmental Fate and Effects Division. Office of Pesticide Programs. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency. Available at http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OPP-2013-0676 (Accessed April 11, 2014).

USEPA. 2014a. *Development of Community Water System Drinking Water Intake Percent Cropped Area Adjustment Factors for use in Drinking Water Exposure Assessments: 2014 Update*. 9/9/14. Environmental Fate and Effects Division. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/Development_and_Use_of_Community_Water_System.pdf (Accessed February 9, 2014).

USEPA. 2014b. Estimation Program Interface (EPI) Suite: United States Environmental Protection Agency. Available at http://www.epa.gov/oppt/exposure/pubs/episuite.htm (Accessed August 5, 2014).

USEPA. 2014c. *Screening Level Estimates of Agricultural Uses of Diazinon (Reporting Years 2004-2012)*. Memorandum From C. Paisley-Jones to K. Nguyen. April 18, 2014. Bioloigical and Economic Analysis Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2015a. Storet Data Warehouse. U.S. Environmental Protection Agency. Available at http://www.epa.gov/storet/dw_home.html (Accessed January 15, 2015).

USEPA. 2015b. *Storet/WQX Data Warehouse*. United States Environmental Protectin Agency. Available at http://www.epa.gov/storet/dw_home.html (Accessed January 15, 2015).

USEPA, & Health Canada. 2013. *Guidance for Selecting Input Parameters for Modeling Pesticide Concentrations in Groundwater Using the Pesticide Root Zone Model*. Version 1. October 15, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/przm_gw/wqtt_przm_gw_input_guidance.htm (Accessed February 28, 2013).

USGS. 2011. *Trends in Pesticide Concentrations in Urban Streams in the United States, 1992-2008*. Scientific Investigation Report 2010-5139. National Water Quality Assessment Program. United States Geological Survey. United States Department of the Interior. Available at http://pubs.usgs.gov/sir/2010/5139/pdf/sir2010-5139.pdf (Accessed February 2, 2012).

USGS. 2015a. National Water-Quality Assessment Program. U.S. Geological Survey. Available at http://water.usgs.gov/nawqa/ (Accessed February 15, 2015).

USGS. 2015b. National Water-Quality Assessment Program (NAWQA). U.S. Geological Survey. Available at http://water.usgs.gov/nawqa/ (Accessed January 15, 2015).

USNLM. 2014. TOXNET Toxicology Data Network. United States National Library of Medicine (USNLM). Available at http://toxnet.nlm.nih.gov/ (Accessed August 5, 2014).

Washington State Department of Ecology. 2015. *http://www.ecy.wa.gov/eim/index.htm*. Washington State Department of Ecology. Available at http://www.ecy.wa.gov/eim/index.htm (Accessed February 23, 2015).

Wu, J., Lan, C., & Chan, G. Y. S. 2009. Organophosphorus pesticide ozonation and formation of oxon intermediates. *Chemosphere, 76*, 1308-1314.

Zabik, J. M., & Seiber, J. N. 1993. Atmospheric transport of organophosphate pesticides from California's Central Valley to the Sierra Nevada Mountains. *Journal of Environmental Quality, 22*, 80-90.

Zamora, C., Kratzer, C. R., Majewski, M. S., & Knifong, D. L. 2003. *Diazinon and chlropyrifos loads precipitation and urban and agricultural runoff during January and February 2001 in the San Joaquin River Basin, California.* W. R. I. R. 03-4091. United States Geological Survey. Available at http://pubs.usgs.gov/wri/wri034091/wrir034091.pdf (Accessed February 17, 2015).

Zhang, Q., & Pehkonen, S. O. 1999. Oxidation of diazinon by aqueous chlorine: kinetics, mechanisms, and product studies. *J. Agric. Food Chem., 47*, 1760-1766.

Zhang, X., Starner, K., & Goh, K. S. 2012. Analysis of diazinon agricultural use in regions of frequent surface water detections in California, USA. *Bulletin of Environmental Contamination and Toxicology, 88*, 333-337.

Zhao, X., Hickey, R. F., & Voice, T. C. 1999. Long-term evaluation of adsorption capacity in a biological activated carbon fluidized bed reactor system. *Water Research, 33*(13).

Appendix A. Abbreviated Diazinon Use Summary Table (The full table is in an attached excel file, Attachment 1)

Possible aggregate use patterns, not disallowed by the labels, highlighted in Red (currently do not include crop cycles per year)
TX SLN stuff is in peach
crop categories in blue
ADAMA comments shown in red and orange highlighting.

Diazinon Use Summary - revisions 9.24.14 by K. Nguyen, Katrina White updated CA-050002 SLN summary based on email received from K. Nguyen on 11/26/2014.

Uses	App Timing	App type**	Formulation	Max App rate / App (ai/A)	# of applications/year unless otherwise specified	Max app rate/year (lbs a.i./A/yr)	CC per yr[e]	MRI (days)	Comments	Labels
Tree Nuts										
Almonds	Dormant	Ground, airblast	WP	3	1	3	1	--	CA only.	66222-10*
			WP, EC	2.99 - 3	1	3		--	CA only. Some labels do not specify a maximum number of applications per year.	5905-248, 66222-9, 19713-492, 19713-91, 66222-103
Filberts	With infestation	Ground, airblast	WP, EC	0.5	1	0.5		--	WA only. Filbert leafroller, aphids	5905-248,66222-9, 66222-10
Stone Fruit										

Apricot	Dormant, Foliar	Ground, airblast	WP, EC	2	2 (1 foliar, 1 dormant)	4*	1	60 Days between Dormant App & In-Season Application; 120 Days between Dormant App & Post Harvest Application		5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
Cherries	Dormant, Preharvest, Post-harvest	Ground, airblast	WP, EC	2	2 (1 foliar, 1 dormant)	4	1	30 Days between Dormant App & In-Season Application;90 Days between Dormant App & Post Harvest Application		5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
Peaches, Nectarines	Dormant, foliar, post-harvest	Ground, airblast	WP, EC	2	2 (1 foliar, 1 dormant)	4*	1	60 Days between Dormant App & In-Season Application; 120 Days between Dormant App & Post Harvest Application (Postharvest application not labeled for nectarines)		5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
Plums, prunes	Dormant and Foliar	Ground, airblast	WP, EC	2	2 (1 foliar, 1 dormant)	4*	1	60 Days between Dormant App & In-Season Application; 120 Days between Dormant App & Post Harvest Application		5905-248, 66222-9 66222-10, 19713-492, 19713-91, 66222-103
Berries										
Blueberries	Foliar and ant control	Ground, Airblast	WP, EC	0.5 - 1	2 (1 foliar, 1 ant control) Yr	2	1	30	0.5 lbs a.i. per ant mound but also has limitation for lbs per acre	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
		Ant mounds		0.5 - 1						
Caneberries[g]	Foliar spray or drench to crown and lower canes before bud break	Ground, Airblast	WP, EC	1.99-2	1	2*	1	Single application allowed per year	CA, OH, OR, and WA only	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
Cranberries	Foliar	Ground, Airblast	WP, EC	3	3	9*	1	14	Larval stage for blackheaded fireworm, berry inspection for eggs or larval for cranberry fruitworm, and cranberry tipworm.	5905-248,66222-9, 66222-10, 19713-492, 19713-91, 6222-103

Strawberries	Foliar, before plant	Ground, Soil inc.	WP, EC	1	2 (1 foliar, 1 soil)	2	1	30	For soil application, broadcast before transplant and then incorporate 1-2 inches	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
Figs	With infestation	Ground, Airblast	WP, EC	0.5	1	0.5*	1 (USDA, 1999b)	--	CA only. Vinegar flies-drosphilia spp., dried fruit beetle	5905-248, 66222-9, 66222-10
Vegetable Crops										
Beans, succulent	Before planting	Soil[f] inc.	WP, EC	4	1	4*	1 Spring and 1 Fall Crop	--	Incorporation depth 1-8 inches	5905-248, 66222-9, 66222-10
Parsley	Before planting	Soil[f] inc.	EC	4	1	4	2	NA	TX only. Incorporation depth 2-8 inches depending on pest	TX-040026
Swiss Chard	Before planting	Soil[f] inc.	EC	4	1/cc	4/cc	2	NA	TX only. Incorporation depth 2-8 inches depending on pest	TX-040026
	With infestation	Foliar		0.5	5/cc	2.5*		7	TX only.	
	Aggregate TX	Combined soil inc. and foliar applications allowed in TX.			6/cc	6.5/cc	2	--	Aggregate applies to TX only.	--
Cucumbers,	Before planting	Soil[f] inc.	EC	4	1/	4*	1	NA	TX only. Incorporation depth 2-8 inches.	TX-040026
	With infestation	Foliar		0.5	5/	2.5*		7		
	Aggregate TX	Combined soil inc. and foliar applications allowed in TX.			6/cc	6.5*/cc	1	--	Aggregate applies to TX only.	
Summer and winter squash	Before planting	Soil[f] inc.	EC	4	1/cc	4*	2	7	PHI (Summer squash 3) (winter squash and cucumbers 7)	TX-040026
	With infestation	Foliar		0.75	5/cc	3.75*				
	Aggregate TX	Combined soil inc. and foliar applications allowed in TX.			6/cc	7.75/cc	2	--	Aggregate applies to TX only.	
Sweet potato	Before planting	Soil[f] inc.	EC	4	1	NS	1		Sweet potato incorporation depth is 4-8 inches.	TX-040026
Cole crops[a], Endive	Before planting	Soil[f] inc.	WP, EC	4	1	4*	2	--	Incorporation depth 2-8 inches	5905-248,66222-9, 66222-10, 19713-492, 19713-91, 66222-103

				1		1*			Incorporation depth 1-2 inches	
Cole Crops[b]	At transplant	Spray to base of plant with tractor mounted drop nozzle	WP, EC	0.25, 1, 3.75, 4.00	1	4	2	--		5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
Ginseng	At infestation	Ground	WP, EC	0.5	1	0.5*	less than 1 (multi year crop)	--	Leafhoppers, aphids, lygus bugs, flea beetles, jumping plant lice	5905-248, 19713-91, 66222-103, 66222-9
Lettuce	Before planting	Aerial or ground to Soil[f] inc.	WP, EC	2	2 (1 foliar, 1 soil)	4	2	30	Incorporate 2-8 inches	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
				1					Incorporate 1 to 2 inches	
	Foliar, with infestation	Aerial or Ground		0.5					Aphids, Dipterous, leafminer	
Melons	Before planting	Soil[f] inc.	WP, EC	4	1 soil only; 2 (1 soil, 1 foliar honeydew only)	4			Incorporate 2-8 inches	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
	Foliar (honeydew only)	Ground		0.74-0.8		0.8		30		
Onions and other bulb vegetables[d]	Before planting	Soil[f] inc.	WP, EC	4	1	4*	2	--	Incorporate 3-8 inches	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
peas	Before planting	Soil[f] inc.	EC	4	1	4*/cc	1	--	TX only.	TX-040026
	With infestation	Foliar		0.5	3	1.5/cc		--	TX only.	
	Aggregate TX	Combined soil inc. and foliar applications allowed in TX.			4	5.5*/cc		--	Aggregate only applies to TX.	--

Peppers	Before planting	Soil[f] inc.	EC	4	1/cc	4*/cc	1	NS	May only be used in TX, GA, and CA only. Incorporate 2-8 inches. In CA, do not apply within a distance of 100 feet of lakes, ponds, streams and estuaries unless a suitable method is used to contain or divert runoff waters. In CA, must incorporate 4-8 inches.	TX-040026, GA-020003, CA030014
	Before planting	Soil[f] inc.		1	1/cc	1*/CC		NS	May only be used in TX and GA only. Incorporate 1-2 inches	
	With infestation	Foliar		0.5	5/cc			7	May only be used in TX.	
	Aggregate TX	Combined soil inc. and foliar applications allowed in TX.			6/cc	5*/cc		--	Aggregate only applies to TX.	--
Spinach	Before planting	Soil[f] inc.	WP, EC	4	1	4	2	1	Incorporate 1-2 inches for 1 lb a.i./A and 2-8 inches for 4 lbs a.i./A.	5905-248, 66222-9, 66222-10, 19713-91, 66222-103
Red beet, radishes, carrots, rutabagas	Before planting	Soil[f] inc.	WP, EC	4 (rutabegas 3-4)	1/yr	4*	red beets - 2 radishes 2- 3 carrots and rutabagas - 1 (in California)		Incorporate 2-8 inches for 4 lbs a.i./A.	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103,
				1		1*			Incorporate 1-2 inches for 1 lb a.i./A	
Turnips	Before planting	Soil[f] inc.	EC	4	1/cc	4*/cc	2-3	3	May only be used in TX and GA. Incorporate 2-8 inches.	TX-040026, GA020002
				1	1/cc	1*/cc		3	May only be used in TX and GA. Incorporate 1-2 inches.	
	As insects occur	Foliar		0.5	5/cc	2.5*/cc		3	May only be used in TX. Treat aphids, flea beetles, leafminers	

	Aggregate TX	Combined soil inc. and foliar applications allowed in TX.			6	6.5*/cc	--		Aggregate only applies to TX.	--
Potatoes	Before planting	Soil[f] inc.	WP, EC	4	1/	4	1	--	. WA040034 has a 25 foot buffer (for ground applications) between application and fish bearing water to protect endangered species.DE, ID, OH, OR, TX and WA only. Incorporate 4-8 inches (DE, WA, OR). Incorporate 2-8 inches (ID, OH, TX)	WA040034, ID030018, ID020003, OH070003, DE060001, TX-040026, (supplement to 66222-9 and 5905-248)
Tomatoes	Before planting	Soil[f] inc.	WP, EC	3.75-4	1	3.75-4*	1-2 (not back to back)	--	Incorporate 2-8 inches	5905-248, 66222-9, 66222-10, 19713-91, 19713-492, 66222-103
			WP, EC	1		1*		--	Incorporate 1-2 inches	5905-248, 66222-9, 66222-10, 19713-492, 19713-91
	~~With infestation~~	~~Foliar~~	~~EC~~	~~0.8~~	~~5~~	-	-	~~7~~	~~Vinegar flies~~	~~19713-91~~
	Aggregate US	Combined soil inc. and foliar applications.			6	8		--	--	--
Parsnips	As insects occur	Foliar	EC	0.996	5	5*	1	7		TX-040026
Pome Fruit										
apples	Dormant and Foliar	Ground, airblast	WP	2	2 (1 dormant/ 1 foliar)	4*		14		19713-492
	Dormant, Delayed dormant, Foliar	Ground, airblast	WP, EC	2	2 (1 dormant/1foliar)	4*		60 Days between Dormant App & In-Season Application; 120 Days between Dormant App & Post Harvest Application		66222-10, 66222-103
pears	Dormant, Delayed Dormant and foliar	Ground, airblast	WP, EC	2	2 (1 foliar, 1 dormant)	4*		70 Days between Dormant App & In-Season Application		66222-10, 19413-492, 66222-103

Other										
Pineapple	foliar	Ground, airblast	WP	1	2	2*	less than 1 (multi year crop)	28	NS MRID is on 19713-492.	66222-10, 19713-492
Ornamentals grown outdoor in nurseries (trees, bushes, herbs, nonflowering plants, flowers, shrubs, vines)	Nursery stock	Ground, Airblast	WP, EC	1	1/cc	1*/cc	Varies 1 to several	--	Commercial grown ornamentals in outdoor nurseries	5905-248, 66222-9, 66222-10, 19713-492, 19713-91, 66222-103
	Application made when infestation occurs	soil drench of compromised containerized nursery stock in quarantine	EC	5	3	15		14		CA-050002[h]

NS=not specified; inc.=incorporated; WP=wettable powder; EC=emulsifiable concentrate

*Maximum yearly application rate was calculated as the maximum single application rate times the maximum number of applications.

[b] Includes broccoli, broccolini, Brussels sprouts, cabbage, cauliflower, and broccoflower

[c] Melons include cantaloupes, casabas, crenshaws, honeydews, muskmelons, Persians and hybrids, and watermelons.

[d] Includes bulb and green onion, garlic, leeks, spring onions or scallions, Japanese bunching onions, green shallots, and green escholats.

[f] Broadcast then immediately incorporate into soil.

[g] Caneberries include blackberries, boysenberries, loganberries, raspberries, dewberries.

[h] Apply only with County Ag Commissioner permission to control fruit fly. Fruit must be removed before application.

Appendix B. Detailed Information on the Environmental Fate of Diazinon

Appendix B summarizes environmental fate data for diazinon and diazoxon. Data summarized here include data submitted to the U.S. EPA and open literature data. Open literature data were included in this summary when it was determine the information would add to the overall understanding of the environmental fate of diazinon and diazoxon. ECOTOX studies classified as ECOTOX plus were examined as to whether they would be relevant and important in understanding the environmental fate of diazinon. If the study involved environmental fate properties or dissipation studies, the data are discussed in this appendix. If the study involved monitoring, it is discussed in Appendix D.

Table B 1 summarizes the identity information and physical-chemical properties of diazinon and diazoxon. Diazinon has an acid dissociation constant (pK_a) of 2.6, indicating that its form will not change significantly at environmentally relevant pH and exists as a cation below this pH. Diazinon is uncharged between pH 4 and 7.[31] The vapor pressure, air-water partition coefficient (K_{AW}), and $C_{water+soil}/C_{air}$ indicate that diazinon should be considered semi-volatile from dry non-sorbing surfaces, slightly volatile from water, and slightly volatile to non-volatile from moist soil (OPPTS[32] Guideline 835.6100 classifications). The log octanol-water partition coefficient (log K_{ow}) is 3.8 at 25°C and the log octanol-air partition coefficient (log K_{OA}) is 8.4 suggesting that diazinon is likely to bioconcentrate in terrestrial organisms, if it does not degrade and is not metabolized (Armitage and Gobas, 2007; Gobas *et al.*, 2003; USEPA, 2009b). The atmospheric half-life suggests that diazinon will not be long-lived in the atmosphere; although it was frequently observed in atmospheric monitoring and does volatilize, especially from wet surfaces. Because diazinon's log K_{OW} is greater than three, risk to terrestrial organisms due to consumption of residues in aquatic organisms due to bioconcentration may occur.[33] Typically, risk to sediment-dwelling organisms is evaluated when the log K_{OW} is greater than three as compounds with higher K_{OW}s have greater propensity to concentrate in sediment (40 CFR Part 158.630 Terrestrial and Aquatic Nontarget Organism Data Requirements); additionally, diazinon is very toxic to aquatic invertebrates that may be found in sediment; consequently, a risk assessment on sediment-dwelling organisms is relevant to diazinon.

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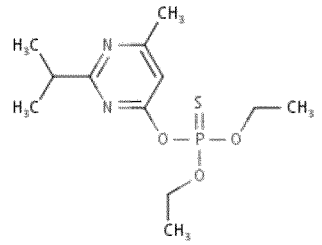
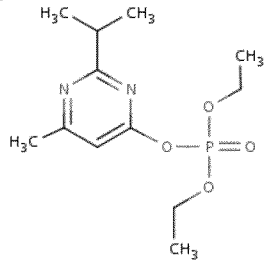
[31] Estimated pKa values are reported in the open literature at 3.52 and 3.81 for the tertiary amine; however, submitted data did not support these pKa values. Diazinon reportedly can sorb via cation exchange and can form a six membered ring with metal cations (with the nitrogen, metal, and sulfur) (Bartlet-Hunt *et al.*, 2014; Smolen and Stone, 1997; Zhao *et al.*, 1999).

[32] Office of Prevention, Pesticides, and Toxic Substances (OPPTS) is now the Office of Chemical Safety and Pollution Prevention (OCSPP); however, the guidelines still reference OPPTS and so the guidelines are referenced with OPPTS in this document.

[33] The Kow (based) Aquatic BioAccumulation Model (KABAM) is the model used in EFED to assess potential risk to terrestrial organisms due to consumption or residues of pesticides in aquatic organisms. The user guide recommends that KABAM be used in the assessment when the log K_{OW} value is between four and eight (USEPA, 2009c). A model is not currently available to assess risk to aquatic organisms due to bioconcentration and toxicity data because tissue residue analysis paired with toxicity are not available for aquatic organisms; however, bioconcentration factor data are typically requested for chemicals with a log K_{OW} of at least three.

Table B 1. Summary of Physical-Chemical Properties of Diazinon and Diazoxon[1]

Parameter	Value and Units		Source and/or Comment for Diazinon[2]
	Diazinon	Diazoxon	
PC Code	057801	657802	--
CAS Number	333-41-5	962-58-3	--
Structure			--
SMILES Code	C1=C(C)N=C(N=C1O[P](OCC)(OCC)=S)C(C)C	C1=C(N=C(N=C1O[P](OCC)(=O)OCC)C(C)C)C	--
Chemical Name	*O,O*-diethyl *O*-2-isopropyl-6-methylpyrimidin-4-yl phosphorothioate	Phosphoric acid, diethyl 6-methyl-2-(1-methylethyl)-4-pyrimidinyl ester	--
Empirical Formula	$C_{12}H_{21}N_2O_3PS$	$C_{12}H_{21}N_2O_4P$	--
Molecular Weight	304.35 g/mole	288.28 g/mole	--
Water Solubility at 25°C (mg/L)	pH: NR; Solubility: 65.5 pH: 6.07; Solubility: 59.5	245 (estimated), pH NR	MRID 42970808, 40226101. Solubility not pH dependent at pH 5, 7, and 9
Vapor Pressure at 25°C	7.22×10^{-5} torr 6.6×10^{-5} torr	1.1×10^{-5} torr (estimated)	MRID 42970809, 40226101. Semivolatile from dry nonadsorbing surfaces.
Henry's Law constant	1.1×10^{-7} atm-m^3/mol at 23°C 4.4×10^{-7} atm-m^3/mol at 25°C (estimated)	1.89×10^{-10} (estimated)	Calculated from measured value reported as a unitless value of 4.6×10^{-6} (Fendinger *et al.*, 1989) Calculated with 6.6×10^{-5} torr vapor pressure and 59.5 mg/L water solubility.
Log Dissociation Constant (pK_a)	2.6 Temperature NR	--	MRID 46523401. Neutral at environmental pH.
Octanol-water partition coefficient (K_{ow}) at 25°C	4898 (log K_{OW}=3.69) at 24°C	117 (log K_{OW} 2.07)	MRID 42970810
	6393 (log K_{OW}=3.8) at 25°C		MRID 40226101
Air-water partition coefficient (K_{AW})	1.8×10^{-5} (log K_{AW} = -4.7)	ND	Slightly volatile from a water surface.[3] Estimated from vapor pressure and water solubility at 25°C and pH 6.07.

Parameter	Value and Units		Source and/or Comment for Diazinon[2]
	Diazinon	Diazoxon	
Octanol-air partition coefficient (K_{OA})	3.5×10^8 (log K_{OA} = 8.5)	ND	Estimated from K_{AW} and K_{OW}. May bioconcentrate in terrestrial food chains if degradation is low [2] (Gobas et al. 2003; USEPA,, 2009a)
Cwater+soil/Cair	2.31×10^5	ND	Estimated using and average Kd value of 4.02 L/kg soil. Rapidly lost from moist soil.[3]

NR=Not reported; Not determined

[1] Estimated values were calculated according to "*Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in Problem Formulations for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments*" (USEPA, 2010a) or using similar calculations and provided by TOXNET (USNLM, 2014) or EPISuite (USEPA, 2014b).

[2] Data for diazoxon were obtained from TOXNET (USNLM, 2014).

3 Classifications for volatility were taken for Guideline 835.6100 (USEPA, 2010b).

14 TRANSFORMATION RATES IN LABORATORY STUDIES

Table B 2 summarizes abiotic and biotic transformation data. Study results indicate that diazinon is not persistent[34] in soil, sediment, or water. The dominant degradation process depends on environmental conditions. For example, at low pH, hydrolysis may be the primary degradation process, while at higher pH, aerobic metabolism will be more important.

Hydrolysis of diazinon is pH dependent, with the most rapid hydrolysis at pH 4 and 5 where time to 50% decline (DT_{50}) values were 1.93 and 12.4 days, respectively. The slowest hydrolysis rates occurred at pH 7 where DT_{50}s ranged from 82.3 to 139 days. Hydrolysis DT_{50}s at pH 9 ranged from 61.9 to 77.1 days. Diazinon was stable to aqueous photolysis and acceptable soil photolysis data are not available. Ukepor and Halsall (2012) analyzed aqueous photolysis of diazinon in MilliQ water buffered to pH 7 and 9, and with added nitrate (0.3 and 3.0 mM), carbonate (0.3 and 3.0 mM), and dissolved organic carbon (DOC, 0.7 and 7 mg/L) at concentrations expected to occur in the natural environment. They observed no significant photolysis in the MilliQ water without added constituents. Diazinon did undergo aqueous photolysis (half-life ranged from 7-25 hours) in the presence of nitrate, carbonate, and DOC. Ukepor and Halsall (2012) indicated that degradation is most likely attributable to light-induced release of aqueous hydroxyl radicals ($^{\bullet}OH$) through photo dissociation of NO_3^-. Ukepor and Halsall (2012) stated that solar UV radiation could result in "excited" DOC which releases reactive oxygen species such as $^{\bullet}OH$ which then react with diazinon. Finally, carbonate radicals ($CO_3^{\bullet-}$) may also result from reaction between carbonate and $^{\bullet}OH$, and these radicals could react with diazinon.

Measured aerobic soil DT_{50} values ranged from 4.36 to 56.6 days in five soils. There was some uncertainty in the measured DT_{50} in three of the soils where up to 30% of applied radioactivity

[34] According to the Toxic Release Inventory Classification System, chemicals with half-lives greater than 60 days are classified as persistent and chemicals with half-lives greater than 180 days are classified as very persistent (USEPA, 2012a).

was unaccounted for in the study. DT_{50} values measured assuming that the lost radioactivity was diazinon are 1.1 to 2 times the DT_{50} for diazinon alone. All of the DT_{50} for diazinon plus lost radioactivity are within the range of DT_{50} observed in other soils for diazinon alone where there was not a high portion of unidentified radioactivity. Therefore, the data from these three soils may be used to better understand the degradation of diazinon in soil and to calculate a model input. Aerobic aquatic metabolism DT_{50} ranged from 9.94 to 10.2 days in two sediment systems. Anaerobic aquatic metabolism was measured in one soil and the DT_{50} was 24.5 days. Bondarenko *et al.* (2004) measured half-lives in water collected from four locations in the Upper Newport Bay-San Diego Creek watershed. The measured half-lives range from 6.3 to 41 days and are within the range of those observed studies submitted to the U.S. EPA[35].

EFED exposure models employ first-order decay coefficients corresponding to half-life inputs for representing pesticide transformation processes, even though pesticide transformations in laboratory soil and aquatic systems often do not follow first-order decline. For this reason, the North American Free Trade Agreement (NAFTA) guidance was developed to generate a "representative half-life (t_R)", for use as an exposure model input.[36] These t_R values for diazinon are shown in **Table B 2**. The representative half-life considers both initial and later (potentially slower) portions of the decline curve and is not necessarily numerically similar to the value of the DT_{50}, rather it provides an input value for modeling that is generally expected to be conservative and is generated using a standardized procedure. The actual DT_{50} and DT_{90} from the representative degradation kinetic equations for the curve are used for descriptive purposes and for understanding the decline curve and the nature of the representative half-life used in modeling. Three out of eight of the decline curves characterizing parent alone were not the SFO (first-order) model. These decline curves had an initial rapid rate of decline followed by more gradual decline. The curves for which this occurred were described using the indeterminate-order rate equation (IORE). Actual DT_{50} and DT_{90} values for IORE are available in **Table B2**. **Figure B 1** gives an example of a decline curve where the rate of decline changes over time. Half or the initial concentration declined over seven days and the next 50% decline occurred over 14 days (MRID 46867004, aerobic soil degradation in a Swiss soil). While degradation slowed during these studies, it did not apparently cease. For some curves in which the residues included both parent diazinon and an unidentified residue, the observed decline did stop (see example in **Figure B 1**).

[35] Mass balance data are not available for the Bondarenko *et al.* (2004) data these results are not used to develop a model input.

[36] http://www.epa.gov/oppefed1/ecorisk_ders/degradation_kinetics/NAFTA_Degradation_Kinetics.htm

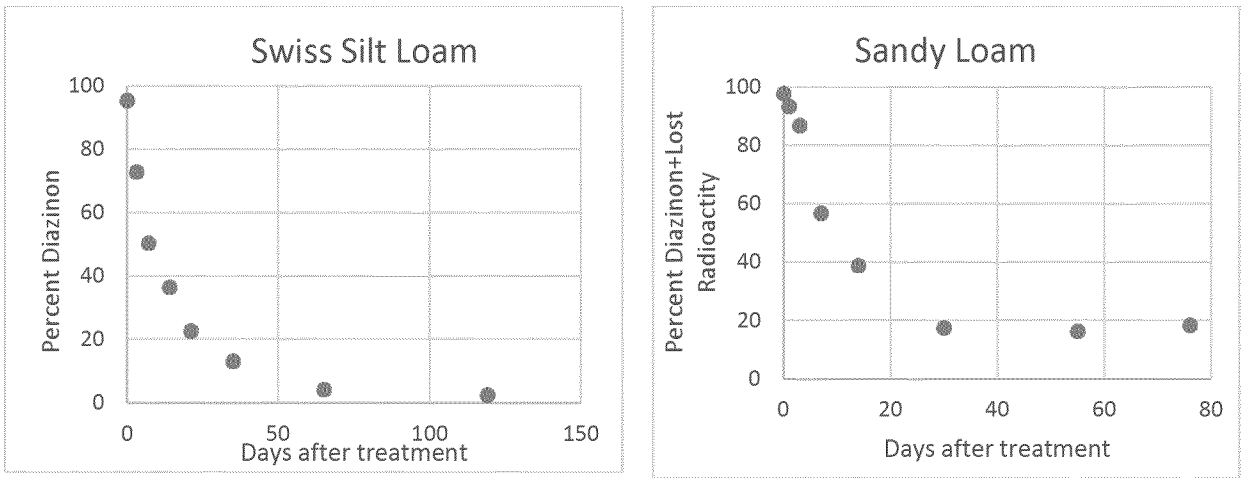


Figure B 1. Example of Decline Curves for Aerobic Soil Metabolism (MRID 46867004 and 46386605) for Diazinon Alone and Diazinon Plus Lost Radioactivity.

Table B 2. Abiotic and Biotic Transformation Kinetics of Diazinon and Diazinon plus Unidentified Residue

Study	System Details (Kinetic Equation)	Kinetic Equation Fitted[1] Value[1]		Representative Half-life to Derive Model Input (days)[2]	Reference Or (MRID), Study Classification And Comments
		DT_{50} (days)	DT_{90} (days)		
Hydrolysis	pH 4, 25°C, SFO	1.93	6.42	NA	MRID 48417201, acceptable.
	pH 7, 25°C, SFO	82.3	273		
	pH 9, 25°C, SFO	61.9	206		
	pH 5, 23-25°C, SFO	12.4	41.3	139 317*	MRID 40931101, Acceptable. DT_{50} were calculated for parent only and parent plus an unidentified residue (shown with an asterisk) that increased throughout the study.
	pH 7, 23-25°C, SFO	139 317*	461 1053*		
	pH 9, 23-25°C, SFO	77.1 115*	256 384*		
Atmospheric Degradation	Hydroxyl Radical	0.111 (est)	--	NA	Estimated using EPIWEB v.4.1 for 12-hour day, 1.5×10^6 OH- molecules/cm^3. Diazinon is not expected to undergo long range transport in the vapor phase.[2]
Air Photolysis	Photolysis at 40±5°C	>4.0	Not reported	NA	MRID 49049901, supplemental due to no mass balance, large temperature range, and insufficient sampling. Diazoxon formed during heating of sample but not with exposure to light.
	Hydroxyl Radical 30±5°C	1.3 hours	Not reported	NA	
Laboratory Volatilization	Dry soil, <5% MHWC Wet soil, 60% WHD and 95% humidity	Dry: Flux 34.7 ng/cm^2/hour Wet: 347.7 ng/cm^2/hour		NA	MRID 48515501, supplemental. Applied in AG500 liquid formulation. 74% of diazinon as volatilized from a wet soil and 2.6% from a dry soil.

Study	System Details (Kinetic Equation)	Kinetic Equation Fitted[1] Value[1]		Representative Half-life to Derive Model Input (days)[2]	Reference Or (MRID), Study Classification And Comments
		DT_{50} (days)	DT_{90} (days)		
Aqueous Photolysis	pH 7, 25°C Sterile 40°N sunlight NO_3^-, CO_3^{2-}, and DOC at 53°N, pH 7, 20°C[3]	Stable 0.3-1[3]		0	MRID 48417202, Acceptable. (Ukpebor and Halsall, 2012)
Soil Photolysis	25±5°C	No acceptable data		NA	MRID 153229 and 153230, supplemental. Intensity of sunlight not reported. In one study, temperature was not reported.
Aerobic Soil Metabolism (20°C)	Swiss Silt Loam, 20°C pH 7.7, 1.4% OC (IORE)	4.36	28	8.43	MRID 46867004, supplemental. One replicate.
	Sandy loam, 25°C pH 7.8, 1.3%OC (SFO)	56.6	188	56.6	MRID 44746001, supplemental. Unexplained loss of 25% of AR at all sampling intervals after 181 days. Value calculated for days 0-90 which had acceptable mass balance.
	Sandy loam, 20°C pH 6.4, 1.6%OC (SFO, IORE*)	8.86 9.74*	29.4 80.8*	8.86 24.3*	MRID 46386605, supplemental. Mass balances were incomplete with up to 30% loss of radioactivity in one soil. Degradation kinetics calculated for diazinon alone and diazinon plus lost radioactivity (designated with an *).
	Loamy sand, 20°C pH 6.2, 0.8%OC (IORE, IORE*)	18.2 37.7*	79.3 1285*	23.9 387*	
	Clay loam, 20°C pH 6.5, 2.8%OC (SFO, IORE*)	9.7 10.8*	32.2 184*	9.7 55.5*	
Aerobic Aquatic	UK Pond, 25°C pH 8.0, 4.0 %OC (SFO)	9.94	33.0	9.94	MRID 46386604, acceptable. 23-49% unextracted residues which did not begin to increase until most diazinon degraded. Unextracted residues are unlikely to be parent.
	UK lake, 20°C pH 7.4, 1.20 %OC (IORE)	10.2	54.2	16.3	
	San Diego Creek,21°C PH 7.98	6.3	Not Availabl e	Not applicable	Bondarenko *et al.* (2004), qualitative. No mass balance conducted in water only. Provide a line of evidence in understanding persistence.
	Peter's Canyon Wash pH 8.07	14.0			
	San Joaquin Marsh pH 8.86	6.4			
	Upper Newport Bay pH 8.02	41.0			
Anaerobic Aquatic	UK sandy loam soil, 20°C pH 8.3, 2.6% OC (SFO)	24.5	81.3	24.5	MRID 46386602, acceptable. Single samples

OC=organic carbon; DT_X=time for concentration/mass to decline by X percentage; SFO=single first order; DFOP=double first order in parallel; IORE=indeterminate order (IORE); SFO DT_{50}=single first order half-life; T_{IORE}=the half-life of a SFO model that passes through a hypothetical DT_{90} of the IORE fit; DFOP slow DT_{50}=slow rate half-life of the DFOP fit, NA=not available, AR=applied radioactivity; est=estimated

[*] Value calculated for parent and unidentified or lost radioactivity. These values are relevant in understanding the uncertainty in data.

[1] DT_{50} and DT_{90} values were calculated using nonlinear regression and SFO, DFOP, or IORE equations. The equations can be found in the document, *Standard Operating Procedure for Using the NAFTA Guidance to Calculate Representative Half-life Values and Characterizing Pesticide Degradation* (USEPA, 2012c).

[2] The value used to estimate a model input value is the calculated SFO DT_{50}, T_{IORE}, or the DFOP slow DT_{50} from the DFOP equation. The model chosen is consistent with that recommended using the, *Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media (NAFTA, 2012)*. The same kinetic equation used to determine the representative model input value was used to describe the DT_{50} and DT_{90} results based on standard kinetic equations.

Transformation products resulting from environmental degradation of diazinon include:

- oxypyrimidine (2-isopropyl-4-methyl-6-hydroxypyrimidine, G-27550)
- diazoxon (diethyl 2-isopropyl-6-methyl-4-pyrimidinyl phosphate)
- GS-31144 (2-(2-Hydroxy-2-propanyl)-6-methyl-4(1H)-pyrimidinone)
- demethyl oxypyramidine (2-Ethyl-6-methyl-4(1H)-pyrimidinone), and
- desethyl diazinon.

Structures of the parent and degradates are shown in **Figure B 2**. Diazinon, diazoxon, and desethyl diazinon are organophosphates, with the sulfur atom replaced by oxygen in the case of the oxon. Oxypyrimidine and GS-31144 are not organophosphates, and are structurally similar to each other. The maximum amounts of degradates observed in fate studies are summarized in **Table B 3**. Oxypyrimidine, GS-31144, and desethyl diazinon were each found to be major degradates (*i.e.*, present at greater than or equal to 10% of applied radioactivity) in at least one environmental fate study. All other degradates were minor. While desethyl diazinon was a major degradate in one hydrolysis study at one time point, it was not detected in any other study.

Table B 3. Summary of Maximum Amount of Transformation Products Observed in Fate Studies

Compound	Maximum % of Applied Radioactivity Associated with Degradate (Time of Peak) Amount Detected at Final Sampling Interval in Corresponding Study						
	Hydrolysis	Aqueous Photolysis	Soil Photolysis	Aerobic Soil	Aerobic Aquatic	Anaerobic Aquatic	Observed in Field Dissipation
Oxypyrimidine, G-27550	98 (20d)a	39 (360h)a	24 (32.6h)a	82 (21d) 1 (119d)	70 (30d) 56 (100d)	66 (87d) 56 (366d)	Yes
GS-31144	NA	NA	4 (32.6 h)a	13 (195d) 6 (371d)	NA	2 (59d)a	Yes
Diazoxon	ND	ND	ND	0.6 (76d)a	NA	NA	ECM not reliable

Compound	Maximum % of Applied Radioactivity Associated with Degradate (Time of Peak) Amount Detected at Final Sampling Interval in Corresponding Study						
	Hydrolysis	Aqueous Photolysis	Soil Photolysis	Aerobic Soil	Aerobic Aquatic	Anaerobic Aquatic	Observed in Field Dissipation
Desethyl diazinon	11 (30d)a	4.3 (14d)a	NA	ND	NA	NA	NA
Demethyl diazinon	NA	NA	NA	NA	NA	NA	Yes
Demethyl oxypyrimidine	NA	NA	NA	NA	NA	NA	Yes
Unidentified	7.2 (10d)	0.9 (14d)a	10 (32.6h)a	6.2 (65d) 1.4 (119d)	13 (30d) 10 (100d)	4 (59d)a	NA
Unextracted	NA	NA	34 (32.6h)a	19.0 (65d) 15.9 (119d)	49 (100d)a	25 (59d)a	NA
CO_2	NA	NA	2.3 (8d)	85.6 (119d)ab	5.3 (100d)[a]	0.2 (59d)[a]	NA

NA=not analyzed; ND=not detected; d=day; h=hour; ECM=Environmental Chemistry Method
[a] Peak at final sampling interval in some studies.
[b] In some aerobic soil metabolism studies, significant CO_2 formation occurred while in others minimal mineralization occurred (max CO_2 in one soil was 6% of AR).

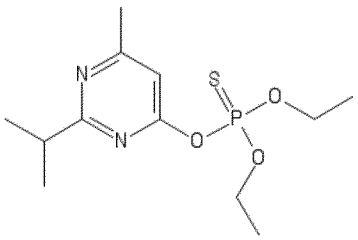
Oxypyrimidine was detected in every fate study submitted, and the maximum radioactivity observed associated with oxypyrimidine was frequently greater than 50% (maximum 82%). In the hydrolysis and photolysis studies, the maximum amount detected was observed at the final sampling interval indicating that oxypyrimidine's abiotic degradation rates are slower than its rate of formation, and thus the maximum amount that may ultimately be formed was probably not observed. While residues declined with time in some of the aerobic metabolism studies, they often remained at very high percentages for significant periods of time. For example, in an aerobic aquatic metabolism study, 70% of applied radioactivity was associated with oxypyrimidine at 30 days, and 56% was still associated with oxypyrimidine at 100 days (MRID 46386604). The same trend was observed in the anaerobic aquatic study. This indicates that oxypyrimidine is relatively stable in both aerobic and anaerobic environments. GS-31144 was observed at a maximum of 13% of applied radioactivity at 195 days in one aerobic soil metabolism study, but was a minor degradate in all other studies. Demethyl oxypyrimidine was not monitored in laboratory studies but was observed at low concentrations (ranging from not detected to 0.17 mg/kg soil) near the level of detection in terrestrial field dissipation studies. Desethyl diazinon was only observed in hydrolysis studies, at a maximum of 11% of applied radioactivity[37]. In most samples, it was a minor residue.

Diazoxon is considered a residue of concern for both human health and ecological risk as it retains the organophosphorus functional group and has been shown to be more toxic to some organisms than the parent (USEPA, 2000, D270838, 2012b). Diazoxon was not monitored in many environmental fate studies, and was not detected in others in which it was monitored for, except for one aerobic soil metabolism study, in which it was observed at a maximum amount of 0.6% AR. Limits of quantitation for diazoxon were 0.01 to 0.02 mg/kg-soil in the studies in

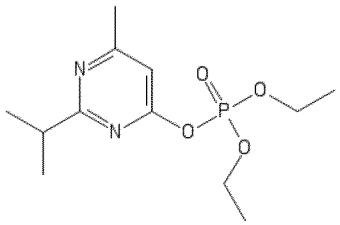
[37] Desethyl diazinon was observed at pH 7 and 9 in MRID 48417201 and not analyzed at pH 4.

which it was looked for. Diazoxon was present in air before exposure to light in an air photolysis study (MRID 49049901) at 9.60 parts per billion. Diazinon was heated to cause volatilization and it was hypothesized by the study report author that diazoxon formed with the heating of diazinon and was not due to photolysis. Although formation and degradation of diazoxon cannot be quantified from available laboratory fate studies involving diazinon, diazoxon has been detected in air, rain, fog (Majewski and Capel, 1995) and surface waters in the United States (USGS, 2011). The predominant circumstances involving formation of diazoxon in the environment as well as its persistence are uncertain. This represents a major uncertainty in the Agency's understanding of the fate and persistence of diazinon and its residues of concern.

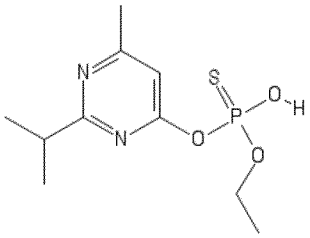
Diazinon



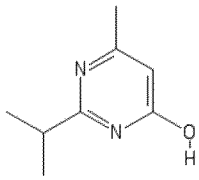
Diazoxon



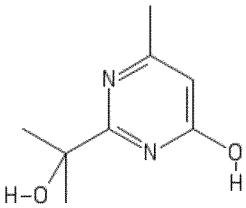
Desethyl Diazinon



Oxypyrimidine



GS3114



Demethyl Oxypyrimidine

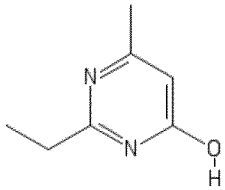


Figure B 2. Chemical Structures of Diazinon and its Identified Degradates

15 SORPTION AND MOBILITY

Using supplemental[38] sorption coefficient estimates, diazinon is classified as moderately mobile to slightly mobile using the Food and Agriculture Organization (FAO) classification system, which means diazinon may be transported into surface and groundwater (FAO, 2000). Across studies, sorption coefficients correlated with the percent organic-carbon, and soil-water distribution coefficients normalized to organic-carbon ranged from 138 to 3,779 L/kg-organic carbon with an average value of 824 L/kg-organic carbon. The slope of a graph of the percent organic carbon by the K_d results in a slope of 3.64 and a K_{OC} of 364 (R^2=0.56). Results of several column leaching studies also demonstrate mobility of diazinon and oxypyrimidine, with both compounds found in column leachate (MRID 40512601, 132734, 118034). The majority of the radioactivity that leached through columns in these studies was associated with oxypyrimidine, however, a small percentage (approximately 0-3%) was also associated with diazinon. Available studies are discussed below and data are summarized in **Table B 4**. As these results are all considered supplemental with various deficiencies, they will be used as a line of evidence in exploring the range of potential sorption coefficients for diazinon. KOCWIN version 2.0 estimates a K_{OC} value of 3034 using the Molecular Connectivity Index (MCI) method and 2184 L/kg using the log K_{OW} method.[39] The KOCWIN program has been updated since it was reviewed by OPP for use with pesticides; however, the previous review (Eckel *et al.*, 2006) found that for chemical classes that were not an outlier, 89% of predicted K_{OC}s were within a factor of ten of the experimental value.

Table B 4. Summary of Supplemental Sorption Coefficients Reported in Submitted and Open Literature Studies[1]

Soil Texture	pH	%OC	Kd L/kg-soil	K_{OC} L/kg-OC	K_F (L/kg-soil)$^{-1/n}$	K_{FOC} (L/kg-OC)$^{-1/n}$	Freundlich Exponent	Source and Comment
sand	6.2	0.2	1.0	651	1.50	752	0.82	MRID 49019101, supplemental. Solvent concentration exceeded 0.1% and sorption coefficients likely underestimate sorption. Measured at 25°C.
loam	6.4	0.6	3.94	657	4.13	688	0.77	
sandy loam	7.9	0.8	3.13	391	3.29	411	0.85	
silty clay	7.1	1.0	7.72	772	7.37	737	0.85	
San Diego Creek	7.1	1.05	3.5	334	Not reported			(Bondarenko and Gan, 2004) Equilibration time was 4-hours and values may be underestimated.
Bonita Creek	7.8	0.72	1.0	138				
silty clay	7.7	0.48	18.14	3779	20.04	4204	1.05	(Arienzo *et al.*, 1994). Mass balance not completed. Shook intermittently for 24-hours. Degradation
clayed	7.8	0.64	4.64	725	4.83	755	1.02	
clayed	7.6	0.90	5.56	618	7.15	793	1.13	
clayed	7.7	0.33	4.45	1348	5.35	1614	1.06	

[38] One submitted sorption study and several open literature studies report supplemental sorption coefficients. These sorption coefficients are uncertain due to different deficiencies in the study such as a solvent concentration that exceeded 0.1% by volume in some test systems, no mass balance, and not identifying radioactivity, to not determining whether equilibration occurred.

Soil Texture	pH	%OC	Kd L/kg-soil	K_{OC} L/kg-OC	K_F (L/kg-soil)$^{-1/n}$	K_{FOC} (L/kg-OC)$^{-1/n}$	Freundlich Exponent	Source and Comment
sandy clay loam	7.8	1.26	4.90	389	6.25	498	1.13	(especially at low pH) and loss to vessel walls may have occurred. Identity of radioactivity not confirmed and diazinon may have degraded in some systems. Data to confirm equilibrium was achieved was not available for review.
sandy clay loam	7.9	0.32	1.66	519	1.58	494	0.97	
sandy clay loam	7.9	0.27	0.84	311	0.7	256	0.92	
sandy clay loam	7.7	0.54	2.57	476	2.74	507	1.03	
sandy clay	7.4	0.33	1.75	530	1.46	441	0.92	
sandy clay loam	4.6	0.09	2.57	2856	1.58	1812	0.8	
sandy loam	5.8	0.76	3.41	449	4.14	548	1.1	
sandy loam	4.6	0.13	3.16	2431	2.58	2017	0.91	
sandy loam	7.9	0.42	1.54	367	1.79	428	1.07	
clayed	7.4	1.17	3.58	306	4.2	359	1.08	
clayed	7.4	1.51	4.49	297	5.11	338	1.06	
sandy clay loam	7.9	1.10	4.25	386	6.57	598	1.26	
sandy clay loam	7.2	0.88	4.19	476	5.15	583	1.11	
sandy clay loam	7.9	0.30	2.52	840	2.45	810	0.99	
sandy	5.2	0.40	2.00	500	1.75	436	0.94	
sandy loam	7.5	0.45	1.36	302	0.93	208	0.85	
sandy loam	4.7	5.93	19.72	333	22.73	383	1.07	
sandy loam	5	5.17	18.48	357	25.73	497	1.18	
loamy sand	5.3	3.46	12.64	365	19.76	571	1.27	
loamy sand	5.1	2.71	6.88	254	9.42	348	1.17	
sandy loam	5.6	2.00	8.90	445	9.83	492	1.05	
sandy loam (Spain)	7.5	0.01	NR	3779	9.95	1292	0.91	(IglesiasJimenez *et al.*, 1996). Identity of radioactivity not determined. Equilibrium may not have occurred. Control sample not utilized.
Clay (Hungary)	6.1	0.68	NR	NR	10.19	1493	0.97	(Nemeth-Konda *et al.*, 2002). No mass balance or control test system.
Average			5.3	824	6.8	818	1.0	--
Standard Deviation			5.1	966	6.6	777	0.13	--
Coefficient of Variation			0.97	1.2	0.98	0.95	0.13	--

[1] Measured at 20°C, unless otherwise stated.

One supplemental batch equilibrium study is available for diazinon (MRID 49091901). In this study, the maximum amount of solvent in test systems was not clear in the study report and it is likely that at least some test systems had a higher-than-recommended solvent concentration. This would result in an underestimation of sorption coefficients. However, measured sorption coefficients are within the range available in other studies for diazinon. Measured Freundlich organic-carbon normalized solid-water distribution coefficients (K_{OC}) range from 411 to 752 L/kg-organic-carbon$^{-1/n}$ and Freundlich exponents range from 0.77 to 0.85, indicating that

sorption coefficients were not independent of the diazinon equilibrium concentrations in water and sorption isotherms were nonlinear.

Open literature studies suggest that K_{FOC} values range from 208 to 4,204 L/kg-organic carbon measured in 27 soils (Arienzo *et al.*, 1994; IglesiasJimenez *et al.*, 1996; Nemeth-Konda *et al.*, 2002). These values are uncertain as the studies either did not identify radiolabeled compounds or did not include a material balance. EPIWEB version 4.1 (USEPA, 2014b) predicts a K_{oc} of 2,184 L/kg-organic carbon, which is within the range of the values reported in the open literature. These studies are discussed further below.

Nemeth-Konda *et al.* (2002) conducted batch equilibrium experiments where the sorption coefficient was based on the difference between the total diazinon applied and the total diazinon measured in solution after shaking for 24 hours at 20°C. The soil was a brown Hungarian forest soil with clay alluviation which contained 0.68% organic carbon and pH of 6.1. The soil was sieved (<2mm) and the solution was a 0.01 M calcium chloride solution. A control polypropylene tube showed loss of diazinon to walls and the diazinon experiment was conducted in glass tubes with Teflon lined lids. The measured organic carbon normalized Freundlich sorption coefficient was 1493 L/kg-organic carbon and the corresponding Freundlich exponent was 0.98. The main deficiency in this experiment is that there was no mass balance for the total system and loss of diazinon was observed in the polypropylene tubes. It was not clear from the study description whether there was a control tube for the experiment conducted with glass tubes. Additionally, the location that the soil was collected from was not described and it was not determined whether the collected soil already contained some background diazinon.

Iglesias-Jimenez *et al.* (1996) measured sorption coefficients of diazinon with and without the presence of surfactants on a soil collected in Salamanca, Spain. Batch equilibrium experiments were conducted with radiolabeled diazinon and the amount of radioactivity in the solution was measured. Sorption coefficients were calculated based on the difference between the total radioactivity added to the system and the amount measured in a 1 mL aliquot of solution. The batch equilibrium systems were shaken for 16 hours at 20°C and soils were sieved (<2mm). The experiments were conducted in duplicate. Typically, batch equilibrium experiments require that the identity of the radioactivity be confirmed to determine whether degradation occurred. Additionally, if a sorption coefficient is going to be determined based on the difference in the amount added and the amount added to solution, usually a control is completed to determine whether loss of the chemical occurred through either degradation or sorption to the vessel walls. Sorption of diazinon to vessel walls was observed by Nemeth-Konda *et al.* (2002) with polypropylene tubes and Iglesias-Jimenez et al. (1996) did not report the type of centrifuge tube used. The control sample serves to determine the total amount in the system. These two deficiencies indicate that these measured sorption coefficients may not be accurate. The measured Freundlich distribution coefficient in a Eutric Cambisol collected in Spain was 9.95 L/kg and the Freundlich coefficient was 0.91. The soil contained 0.01% organic carbon and the pH was 7.5. A K_{OC} value was not reported but was estimated to be 1292 L/kg-organic carbon. This study did not determine whether diazinon was present in the soil before it was used in the sorption experiment.

Arienzo *et al.* (1994) measured sorption of diazinon in 25 soils at 20°C. Twenty soils were from Marismas del Guadalquivir and five soils were from the province of Salamanca. Soils were air dried and sieved (<2-mm). Batch equilibrium experiments were conducted with radiolabeled diazinon with initial concentrations ranging from 5-25 mg/L. The samples were shaken intermittently for 24 hours at 20°C. Preliminary experiments indicated that equilibration was achieved; however, data were not available to confirm this. After 24-hours the samples were centrifuged and a 1-mL aliquot was removed and the radioactivity measured in the aliquot. Sorption coefficients were calculated based on the difference between the diazinon added and the amount of radioactivity measured in the aliquot. The type of container that the samples were shaken in was not specified. It is possible that some sorption of diazinon to vessel walls occurred or degradation of diazinon occurred. Additionally, the identity of the compound that radioactivity was associated with was not determined. It is likely that some diazinon degraded during the study (especially at low pH), and the sorption coefficients may not be specific to diazinon. Organic-carbon Normalized Freundlich Sorption coefficients for the 25 soils ranged from 208 to 4204 L/kg-organic carbon (L/kg_{oc}).

Bondarenko and Gan (2004) measured sorption coefficients after aging diazinon in sediment over 56 days. Diazinon was added at a rate of 10 mg/kg sediment (dry weight equivalent) to San Diego Creek or Bonita Creek sediment collected in Orange County California. The samples were covered with aluminum foil and maintained at a temperature of 21 ± 2°C. Triplicate samples were removed at 0, 1, 2, 6, 28 and 56 days post treatment. The samples were mixed with 20 mL of 0.01M $CaCl_2$ and placed on a mechanical shaker for four hours. After centrifugation, diazinon was extracted and measured in the aqueous phase and sediment phase and sorption coefficients were calculated. The results of this study are uncertain because equilibrium may not have been achieved in four hours. Measured K_d values increased in residence time in both sediments. K_d values ranged from 3.5 L/kg with no aging to 24.6 L/kg after 28 days of aging in the San Diego creek sediment. K_d values ranged from 1.0 L/kg with no aging to 10.7 L/kg after 28 days of aging in the Bonita creek sediment.

One batch equilibrium study (MRID 46579601) was submitted examining sorption of diazoxon. Diazoxon degraded rapidly in the study, soils were subjected to gamma-irradiation to reduce abiotic degradation rates, and the equilibration time was only 2 hours. Measured sorption coefficients are not reliable. EPIweb version 4.1 estimated a K_{OC} of 175 L/kg organic-carbon and is classified as moderately mobile[40].

Field Dissipation

Terrestrial Field Dissipation

The terrestrial field dissipation of diazinon was studied at sixteen United States sites on various crops, and on bare ground plots and with granular, wettable powder, and emulsifiable concentrate formulations. These studies are summarized in **Table B 5**. Application rates in the studies ranged from 2.2 lbs a.i./A to 10 lbs a.i./A with single and multiple applications depending on the site. These application rates are on the high end of current labeled uses of diazinon. The

[40] Using the Food and Agriculture Organization (FAO) classification system (FAO, 2000)

dissipation half-lives for diazinon ranged from five to 20 days and did not show a trend with cropped versus bare plots or formulations. Diazinon accumulated in soils with repeated application at some sites, but not at others. The highest measured concentration of diazinon in soil was 6.36 mg/kg-soil, and the maximum depth to which the compound leached was 48 inches. In one study in which diazinon was detected at 48 inches, that was the deepest depth sampled. In another, there were deeper sampling depths. Oxypyrimidine was detected at the maximum depth sampled (48 inches) at one site, and was detected at a maximum concentration of 3.26 mg/kg-soil at another site. GS-31144 was detected at a maximum depth of 0.45 meters (18 inches) and a maximum concentration of 0.178 mg/kg-soil at the same site. Diazoxon was detected near the level of quantitation (0.014 to 0.02 mg/kg-soil), and at a maximum depth of 12 inches. It is likely that these concentrations underestimate the true concentration of diazoxon, as this degradate was shown to be unstable when storing samples for 30 days, and samples were stored for lengths of time that were unspecified in some cases, and greater than 190 days in others. Given that diazoxon is a residue of concern, this produces significant uncertainty in the understanding of the environmental fate of diazinon and its degradates. It is possible that diazoxon could move into surface water through runoff.

Table B 5. Summary of Supplemental Terrestrial Field Dissipation Studies Submitted for Diazinon[g]

MRID	Study Location, Crop, Form	Half-life (days) [b]	Max depth of leaching (inches unless otherwise listed)/ Max Concentration mg/kg-soil unless otherwise listed[c]					Application Rate in lbs a.i./A, number of apps, application interval
			Diazinon	Oxypyr.	GS-31144	Diazoxon[e]	demethyl G27550	
46867006	CA, turf, EC	d	44.74 mg/kg dislodgeable diazinon[f] 138.34 mg/kg ww thatch[f]	NR	NR	0.24 mg/kg ww dislodgeable residues[f] 0.64 mg/kg ww thatch[f]	NR	5.0, 3x, 14 day
46867006	CA, bare, EC	d	0-1 cm[a]/29.23[f]	NR	NR	ND/ <0.01[f]	NR	5.0, 3x, 14 day
41320101	CA, corn, G	9	6/3.4	12/0.72	6/0.04	ND	ND	2.2, 4x, 7 day
41320102	CA, bare, G	7	6/5.6	24/0.28	6/0.027	ND	ND	8, 1x
41320103	FL, citrus, WP	5.51	24/1.022	48a/0.502	6/0.048	**12/0.015**	6/0.01	3.3-5.5, 5x, 7 day
41320104	CA, bare, EC	20	48[a]/3.89	36/1.47	ND	ND	ND	8, 1x
41320105	CA, orange, EC	7	36/2.82	48/1.45	12/0.04	ND	6/0.04	3.3-5.5, 5x, 7 day
41432701	IL, corn, G	5	12/2.2	72/0.32	6/0.021	ND	ND	2.2, 7x, 7 day
41432702	IL, bare, G	6	12/2.6	72/0.26	<0.012	ND	6/0.012	8, 1x
41432703	CA, apples, WP	10	18/1.538	48/1.267	**18/0.178**	6/0.02	6/0.011	3.3, 7x, 14 day
41432704	CA, bare, WP	6	**48**/2.313	48/2.029	6/0.128	6/0.012	ND	10, 1x
41432705	FL, bare, WP	8.23	18/1.334	**48**[a]/0.210	ND	12/0.014	6/0.015	10, 1x
41432706	NY, bare, EC	5.3	12/**6.36**	24/**3.26**	12/0.13	ND	**6/0.17**	10, 1x
41432707	NY, apples, EC	17	12/1.93	12/ 0.79	12/ 0.09	ND	ND	3.3, 7x, 14-21 day
118024	CA, turf, EC	<7	15/4.7	NR	NR	NR	NR	6, 1x
118024	WA, turf, EC	<7	15/3.4	NR	NR	NR	NR	5.5, 1x
118024	PA, turf, EC	<7	15/0.75	NR	NR	NR	NR	6, 1x
118024	TX, turf, EC	<7	15/0.30	NR	NR	NR	NR	4 1, 1x

Form=formulation; G=granular; WP=wettable powder; EC=emulsifiable concentration; NR=not reported; app=application; Oyxpyr.=oxypyramidine; ww =wet weight

a Detected at the highest depth sampled.

b Half-life calculated using ln/linear regression and the single first order equation. The value reflects residues in the top six inches of soil only.

c Bold values indicate the greatest depth sampled or concentration detected in soil.

d Values could not be calculated due to insufficient analytical methods.

e Storage stability studies indicate that diazoxon was not stable in samples and these concentrations likely lower than actual concentrations that occurred in the field.

f Residues may be lower than actual values due to little information on analytical method. Dislodgeable diazinon residues were removed from turf with a mixture of water and an unspecified surfactant.

g All studies were classified as supplemental due to insufficient storage stability and analytical method data discussed in previous footnotes.

Cranberry Bogs and Adjacent Reservoir

Szeto *et al.* (1990) evaluated concentrations of diazinon and diazoxon in cranberry bogs and adjacent waters after application of Diazinon 5G (a granular formulation)[41]. Diazinon was applied at a rate of 6 kg a.i./ha (5.35 lbs a.i./A)[42] by aircraft to 19 hectares of cranberries in nine beds on July 26 and August 8. Cranberries bogs were surrounded by irrigation ditches, reservoirs, and waterways linking to two small tributaries to the Fraser River (near Forth Langley, British Columbia). Cranberry bogs were irrigated in April and water held with gates until after harvest. Sediment and water was collected at six stations within plots and outside of plots. Stations were as follows:

- one in an irrigation ditch in treatment plot,
- one in the reservoir adjacent to treatment plot,
- two in waterways outside of the dyke, and
- one at each of the two tributaries approximately 100 m downstream from the edge of the treatment plot.

Samples were collected at 10 days before the first application, pre-spray, post-spray, and at intervals up to 137 days after application. Recoveries of diazinon and diazoxon from water were near 100% but recoveries from sediment (69 to 76%) were low, likely due to hydrolysis (sediment pH ranged from 4.4 to 6.0). The limit of detection was 0.1 µg/L for sediment and 10 µg/kg for sediment. Results for the waterways and tributaries were similar and the results were averaged in the report (Table B 6). Diazoxon was not detected in any of the samples of water or sediment. The maximum diazinon concentration in water detected was 456 µg/L in irrigation ditches which decreased to below 100 µg/L within three to four days after treatment. Concentrations in the adjacent reservoir were lower with a maximum of 78.5 µg/L. Szeto *et al.* (1990) indicated residues observed in tributaries were much lower and were likely caused by leakage from the irrigation water through the gate between the reservoir and the waterways. Increased concentrations were also observed with a high rainfall event. Diazinon was also detected in sediment. Hydrolysis was likely a major loss mechanism. The pH of water ranged from 5.1 to 6.6 and diazinon is known to undergo hydrolysis in acidic environments and pH of sediment ranged from 4.4 to 6.0. This study was obtained from the open literature and the results are considered supplemental. **Table B 6** summarizes the concentrations of diazinon in water and sediment of cranberry bogs and adjacent waterways.

Table B 6. Concentrations of Diazinon in Water and Sediment of Cranberry Bogs and Adjacent Waterways

Site	Max diazinon concentration in water (days after first app) in µg/L			Max diazinon concentration in sediment (days after first app)		
	After 1st App	After 2nd App	Final Detection	After 1st App	After 2nd App	Final Detection
Irrigation ditch	338 (1d)	456 (14d)	0.2 (35 d)	21200 (4d)	8920 (21d)	20 (137d)

[41] There are currently no registered granular formulations in the United States.

[42] The current registered application rate for use on cranberries is 3 lbs a.i/A with up to three applications.

Site	Max diazinon concentration in water (days after first app) in µg/L			Max diazinon concentration in sediment (days after first app)		
	After 1st App	After 2nd App	Final Detection	After 1st App	After 2nd App	Final Detection
Reservoir	78.5 (2d)	58.1 (17d)	0.3 (51d)	2380 (1d)	110 (17d)	10 (51d)
Waterways outside dyke	29.1 (2d)	2.6 (15d)	0.1 (42d)	80 (1d)	20 (14d)	10 (35d)
Tributaries 100 m downstream	2.8 (4d)	1.1 (15d)	0.1 (35d)	10 (4d)	Not detected	Not detected

App= application

Orchard Treatments and Pond Concentrations

Three field dissipation studies (MRID 41490401, 41490402, and 41490403) were conducted in which diazinon was applied to apple orchards six times at 3 lbs a.i./A and concentrations of diazinon were measured in an adjacent pond[43]. The final applications took place in July. The maximum and range of concentrations are summarized in **Table B 7**. Diazinon was detected shortly after the applications and rainfall events with concentrations decreasing through October, when the final samples were collected. The final mean measured concentrations[44] ranged from 0.2 to 0.5 µg/L. The Jack Ely and Ronald Rice sites are similar to the aquatic bin 7. The R.R. Showers site is between Aquatic bin 6 and 7.

Table B 7. Summary of Diazinon Concentrations in Ponds near Apple Orchards after Applications of Diazinon.*

Site/MRID	Maximum Diazinon Concentration (µg/L)	Range of Average Concentrations+	Area of Watershed Pond Volume, Surface area	Comments
Jack Ely/ MRID 41490402	82.1	0.5 to 44.1	10.2 acres watershed 10.2 acres treated 1.7 acre pond, 8.3 acre-feet	Detectable residues in pond sediment
R.R.Showers/ MRID 41490403	12.8	0.5 to 9.2	69.4 acre watershed 24.2 acres treated 4.9 acre pond, 21.5 acre-feet	
Ronald Rice /MRID 41490401	113.0	0.6 to 53.4	33.7 acres watershed 14.1 acres treated 0.7 acre pond, 3.2 acre-feet	Stream in same watershed as the pond. Residues not quantifiable in pond sediment due to unacceptable recoveries in fortified samples.

*These studies were classified as supplemental.
+ Average of individual samples collected from three different zones of the pond on the same day.

[43] The ponds were immediately adjacent to the orchards but were not surrounded by orchard.
[44] Average of individual samples collected from three different zones of the pond on the same day

16 BIOCONCENTRATION FACTOR

Available octanol-water partition coefficients for diazinon (Log Kow 3.69-3.81; USNLM 2009, MRID 42970810 and MRID 40226101) suggest that diazinon may bioaccumulate in aquatic organisms. Empirical bioconcentration factors (BCF) for diazinon range from 3-82 µg/kg-ww per µg/L in aquatic invertebrates (**Table B 8**) and 18-213 µg/kg-ww per µg/L in fish (**Table B 9**). These tables present whole-organism BCFs based on exposures that were ≥4 days in duration, which is representative of the time to steady-state in fish exposed to constant diazinon concentrations in water (estimated by KABAM).

Table B 8. Diazinon BCFs for Invertebrates

Test species (Scientific name)	BCF (µg/kg-ww per µg/L; whole organism; steady state)	Source
Shrimp (*Panaeopsis joyneri*)	3	(Seguchi and Asaka, 1981)
Crayfish (*Procambarus clarkii*)	5	(Kanazawa, 1978)
Pond snail (*Cipangopoludina malleata*)	6	(Kanazawa, 1978)
Red snail (*Indoplanorbis exustus*)	17	(Kanazawa, 1978)
Amphipod (*Gammarus pulex)*	13	(Ashauer, Caravatti, *et al.*, 2010)
Daphnid (*Daphnia magna*)	18	(Kretschmann *et al.*, 2011)
American oyster (*Crassostrea virginica*)	56	(Williams, 1989)
Amphipod (*Gammarus pulex)*	82	(Ashauer, Hintermeister, *et al.*, 2010)

Table B 9. Diazinon BCFs for Fish

Test species (Scientific name)	BCF (µg/kg-ww per µg/L; whole organism; steady state)	Source
Guppy (*Labistes reticulatus*)	18	(Kanazawa, 1978)
Loach (*Misgurnus anguillicaudatus*)	26	(Seguchi and Asaka, 1981)
Killifish (*Oryzias latipes*)	28	(Tsuda *et al.*, 1995)
Silver crucian carp (*Cyprinus auratus*)	37	(Kanazawa, 1978)
Goldfish (*Cassius aurapus*)	49	(Tsuda *et al.*, 1997)
Rainbow trout (*Salmo gairdneri*)	63	(Seguchi and Asaka, 1981)
Motsugo (*Pseudorasbora parva*)	64	(Kanazawa, 1975)
Carp (*Cyprinus carpio*)	65	(Kanazawa, 1978)
Killifish (*Oryzias latipes*)	94	(Tsuda *et al.*, 1997)
Guppy (female) (*Lebistes reticulatus*)	98	(Tsuda *et al.*, 1997)
Carp (*Cyprinus carpio*)	120	(Seguchi and Asaka, 1981)
Guppy (male) (*Lebistes reticulatus*)	142	(Tsuda *et al.*, 1997)
Sheepshead minnow (*Cyprinodon variegatus*)	147	(Goodman *et al.*, 1979)
Topmouth gudgeon (*Pseudorasbora parva*)	152	(Kanazawa, 1978)
Sheepshead minnow (*Cyprinodon variegatus*)	213	(Goodman *et al.*, 1979)

Available studies indicate that oxypyrimidine can make up a substantial portion of residues in tissue. Data from a registrant-submitted bioconcentration study in bluegill (MRIDs 40660808

and 41194401) indicate that diazinon is almost completely metabolized to oxypyrimidine, which is not of toxicological concern (available studies with fish indicate that it is practically non-toxic). In this study, oxypyrimidine accounted for 67-95% of total residues in fish, while diazinon only represented 2.3-10% of residues. Seguchi and Asaka 1981 exposed three different species of fish (carp, rainbow trout and loach) as well as shrimp to diazinon for 14 days. Quantification of residues in tissues indicated that the majority of residues (51-90%) were diazinon. Oxypyrimidine also made up a substantial proportion of the residues in the fish (9-28%) and shrimp (18-28%). Although both studies analyzed samples for diazoxon, no residues of this degradate of concern were detected.

The KABAM-estimated BCFs for invertebrates range 300-440 and for fish range 580-590. These estimates are based on mean Log Kow of 3.77 and the assumption that diazinon is not metabolized by fish. The estimated factors are expected to overstate the bioconcentration of diazinon because the chemical metabolizes substantially in aquatic organisms. Because a reliable metabolism rate constant cannot be generated for KABAM, the empirical BCF values for aquatic invertebrates and fish will be used to estimate diazinon concentrations in aquatic organisms.

Studies that reported BCFs in tissues or organs were not included in **Tables B8 and B9**. In addition, studies that were based on total radioactive residues, and did not distinguish between diazinon and oxypyrimidine, were not included because they do not represent bioconcentration of residues of concern.

Appendix C. Estimated Drinking Water Concentrations for All Use Patterns Simulated Using a K_{OC} value of 618 L/kg and an Aerobic Soil Metabolism Rate of 155 days

Table C1. Estimated Concentrations of Diazinon in Surface Water Source Drinking Water For Residues of Diazinon and Lost Residues.

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App type for modeling	App Date Day-Month	EDWC for Diazinon (µg/L)			Comments
					Peak	Annual Average	Entire Mean	
Tree nuts								
Almonds	3 (3.4), 1x dormant	Caalmond_WirrigSTD	Foliar, ground	**22-12**	**76.7**	**9.38**	**4.53**	California Only. One label is not clear on the max number of apps, so 2 apps were also assumed for one simulation.
	3 (3.4), 2x dormant, 7d	Caalmond_WirrigSTD	Foliar, ground	22-12	90	10.8	5.22	
Filbert	0.5 (0.6), 1x	ORfilbertSTD	Foliar, ground	23-07	4.27	0.632	0.417	Washington only.
Stone Fruit								
Apricot	2 (2.2), 2x (1 foliar+1 dormant), 60d	MIcherriesSTD	Foliar, ground	29-5 and 01-01	26	5.58	4.05	The apricot and peaches simulations may be considered representative for plum, apricot, and peaches as they all have a 60-d MRI. The cherry simulation had a 30-d MRI.
Cherries	2 (2.2), 2x (1 foliar 1 dormant or postharvest), 30d	Cafruit_wirrigSTD	Foliar, ground	16-01, 15-12	**41.7**	**5.59**	**3.02**	
Peaches and plums	2 (2.2), 2x (1 foliar 1 dormant or postharvest), 60d	GApeachesSTD	Foliar, ground	01-07, 01-09	30.7	2.32	1.24	
Berries								
Blueberries	1 (1.1), 2x (1 foliar and 1 ant mound), 30d	ORberriesOP	Foliar-ground + Ground without drift	23-07, 23-06	12.1	1.98	1.38	
		NYgrapesSTD		14-08, 15-09	**30.6**	**4.97**	**2.96**	
Caneberries[g]	2 (2.2), 1x, Foliar	NYgrapesSTD	Foliar, ground	14-08, 15-09	**61.2**	**10.5**	**6.73**	
Cranberries	3 (3.4), 3x, 14d, 7d PHI	ORberriesOP	Foliar, ground	24-06, 08-07, 23-07	**59.9**	**10.5**	**7.44**	
		Modified Tier I Rice Model	Foliar	NA	861	510	--	
Strawberries	1 (1.1), 2x (1 foliar and	CAStrawberry-noplasticRLF	Soil incorp. To 1 inch	24-12, 23-01	**77.2**	**10.3**	**6.2**	

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App type for modeling	App Date Day-Month	EDWC for Diazinon (µg/L)			Comments
					Peak	Annual Average	Entire Mean	
	1 soil before plant), 30d	Flstrawberry_WirrigSTD	then foliar, ground		67.5	3.28	1.88	
Figs	0.5 (0.6), 1x	Cafruit_wirrigSTD	Foliar		1.44	0.105	0.0959	
Legumes								
Succulent Beans	4 (4.5), 1x	CArowcropRLF_V2	Broadcast followed by soil incorp. to 1 inch, before planting	15-12	87.9	11.8	6.1	
		STXvegetableNMC		15-09	288	12.6	8.29	
		MIbeansSTD		15-05	49.5	8.75	5.57	
Peas	4 (4.5), 1x at plant, and 0.5 (0.6), 3x, 3d foliar	CArowcropRLF_V2	Broadcast followed by soil incorp. to 1 inch, then foliar	15-12, 10-01, 14-01, 18-01	**88.8**	**13.6**	**8.06**	3d MRI assumed for the foliar application. TX only.
		STXvegetableNMC		15-09, 10-10, 14-10, 18-10	**288**	**20**	**10.6**	
Herbs								
Parsley	4 (4.5), 1x	ORmintSTD	Broadcast followed by soil incorp. to 1inch	4-Jan	29	3.49	1.91	TX only
		STXvegetableNMC		15-9	288	12.6	8.29	
Cucurbits								
Cucumbers	4 (4.5), 1x at plant, and 0.5 (0.6), 5x, 7d foliar, 7d PHI	STXmelonNMC	Broadcast followed by soil incorp. to 1 inch, then foliar	15-01, 6-4, 13-4, 20-4, 27-4, 5-4	216	16.4	10.5	TX only
Squash	4 (4.5), 1x at plant, and 0.75 (0.84), 5x, 7d foliar	STXmelonNMC	Broadcast followed by soil incorp. to 1 inch, then foliar	15-01, 6-4, 13-4, 20-4, 27-4, 5-4	266	20	12.5	TX only. May have 2 crop cycles per year and the max rates are on a crop cycle basis.
Melons	4 (4.5), 1x at plant, and 0.75	STXmelonNMC	Broadcast followed	15-01, 14-02	136	11.4	6.5	1 soil and 1 foliar for honeydew melon only.

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App type for modeling	App Date Day-Month	EDWC for Diazinon (µg/L)			Comments
					Peak	Annual Average	Entire Mean	
	(0.84),1x, 30d foliar	NJmelonSTD	by soil incorp. to 1 inch, then foliar	15-04, 15-05	57.5	6.77	3.48	
		MOmelonSTD		27-3, 2-5	108	9.05	5.88	
		FLcucumberSTD		1-10, 31-10	**295**	**16.4**	**8.28**	
		MImelonSTD		15-04, 15-05	48.3	5.53	2.99	
Potato								
Sweet Potato	4 (4.5), 1x, 90d PHI	STXvegetableNMC	Broadcast followed by soil incorp. to 4 inch	15-9	80	3.46	2.38	TX only.
		NCsweetpotatoSTD		1-5	25.1	2.13	1.5	
Potato	4 (4.5), 1x, NS PHI	CApotatoRLF_V2	Broadcast followed by soil incorp. to 2 inch	1-2	29.2	3.41	1.65	DE, ID, OH, OR, TX, and WA only. Not clear on whether this is a current label and whether there is a tolerance.
		IDNpotato_wirrigSTD		16-5	25.6	2.42	1.48	
		MEpotatoSTD		16-5	31.8	5.45	3.57	
		WApotatoNMC		16-4	14.9	2.53	1.64	
		NCsweetpotatoSTD		1-5	40.2	3.62	2.32	
		STXvegetableNMC		15-9	149	6.49	4.35	
Cole and Leafy Greens								
Lettuce	2 (2.24), 1x at plant incorp 2 inch, 0.5 (0.6), 1x foliar, 30d, 1cc	CAlettuceSTD	Soil incorporation (2 inches for 2 lbs ai/A and 1 inch for 1 lbs a.i./A), 1 foliar aerial.	1-2, 3-3	53.1	7.82	4.7	Not clear on whether this is allowed on the label. The max rates are on an annual basis but the registrant indicated that they could have 2 cc per year.
		FLcabbageSTD		1-10, 31-10	33.1	2.73	1.85	
	1 (1.12), 1x at plant incorp 1 inch, 0.5 (0.6), 1x foliar, 30d, 1cc	CAlettuceSTD		1-2, 3-3	51.5	7.57	4.29	

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App type for modeling	App Date Day-Month	EDWC for Diazinon (µg/L)			Comments
					Peak	Annual Average	Entire Mean	
	2 (2.24), 1x at plant incorp 2 inch, 0.5 (0.6), 1x foliar, 30d, 1cc		Soil incorporation (2 inches for 2 lbs ai/A and 1 inch for 1 lbs a.i./A), 1 foliar ground.	1-2, 3-3	51.4	7.42	4.14	
Swiss Chard	4 (4.5), 1x at plant, and 0.5 (0.6), 5x, 7d foliar, 7d PHI, 1cc	CAlettuceSTD	Soil incorporation (2 inches), followed by 5 foliar ground, repeated for 2cc	1-2, 3-3, 10-3, 17-3, 24-3, 31-3	109	18.9	10.8	
	4 (4.5), 1x at plant, and 0.5 (0.6), 5x, 7d foliar, 7d PHI, 2cc			1-2, 3-3, 10-3, 17-3, 24-3, 31-3, 1-6, 1-7, 8-7, 15-7, 22-7, 29-7	151	30.8	20	
Cole crops, endive	4 (4.5), 1x before planting	CAcolecropRLF_V2	Soil incorporation of 2 inches	15-12	70.3	9.63	6.2	It is not clear whether cole crops may have 2 crop cycles per year. The registrant indicated the crop could have 2 seasons; however, the maximum label rates are on an annual basis. Assumed 1 crop cycle per year for modeling.
		CArowcropRLF_V2		15-12	48.2	6.65	3.71	
		CAlettuceSTD		1-2	102	11.8	6.39	
		FLcabbageSTD		1-10	54.2	3.74	2.08	
	1 (1.12), 1x before planting	CAlettuceSTD	Soil incorp of 1 inches	1-2	26.6	3.52	2.51	
Cole Crops	4 (4.5), 1x, at transplant	CAlettuceSTD	Spray to base of plant with tractor mounted drop nozzle.	1-2	102	11.8	6.39	
Spinach	4 (4.5), 1x, before planting	CAlettuceSTD	Soil incorporation of 1 inch.	1-2	102	11.8	6.39	Not clear on whether this is allowed on the label. The max rates are on an annual basis

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App type for modeling	App Date Day-Month	EDWC for Diazinon (µg/L)			Comments
					Peak	Annual Average	Entire Mean	
								but the registrant indicated that they could have 2 cc per year. Assumed 1 crop cycle per year for modeling.
Root Vegetables								
Ginseng	0.5 (0.6), 1x, 30d PHI	MNsugarbeet STD	Broadcast	1-6	7.16	0.998	0.595	
		CAsugarbeet OP		15-2	3.32	0.409	0.255	
		MIasparagus STDv2		1-9	3.52	0.668	0.324	
Onions and Bulb Vegetables	4 (4.5), 1x, before plant incorp 3 inches	CAonion_WirrigSTD	Broadcast followed by soil incorporation of 3 inch.	1-1	14.1	2.08	1.55	
		GAonion_WirrigSTD		1-9	58.5	3.63	1.95	
Turnips	4 (4.5), 1x at plant, and 0.5(0.6), 1x foliar, 14d PHI, 2-3cc	STXvegetableNMC	Soil incorporation of 2 inch.	15-9, 15-10	149	8.85	5.16	At plant may occur in GA and TX, Foliar application may occur in TX only. Aggregate applies to TX only. App rates given on a cc basis and registrant indicated may have up to 3 cc per year. MRI not specified.
Red Beet, radishes, carrots, rutabegas	4 (4.5), 1x, before plant incorp 2 inches	STXvegetableNMC	Soil incorporation	15-9	149	6.49	4.35	Possibly 2 to 3 cc per year specified by registrant but application rate is provided on yearly basis.
	1 (1.12), 1x, before plant incorporate 1 inch	STXvegetableNMC		15-9	37.2	1.62	1.08	
	4 (4.5), 1x, before plant incorp 2 inches	FlcarrotSTD		1-10	150	7.2	3.61	
Parsnip	1 (1.12). 5x, 7d,	STXvegetableNMC	Broadcast		40.4	2.8	1.47	TX only.
Fruiting Vegetables								

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App type for modeling	App Date Day-Month	EDWC for Diazinon (µg/L)			Comments
					Peak	Annual Average	Entire Mean	
Peppers	4 (4.5), 1x, at plant with 2 inch.	STXvegetableNMC	Soil incorporation	15-9	149	6.49	4.35	In CA, must incorporate 4 inches and have a 100 foot buffer from aquatic areas. A TX scenario was modeled instead.
	1 (1.12), 1x, before plant incorporate 1 inch	STXvegetableNMC	Soil incorporation	15-9	71.6	3.12	2.06	TX and GA only.
	4 (4.5), 1x, at plant with 2 inch followed by foliar application 0.5 (0.6), 5x, 7d, 5d PHI	STXvegetableNMC	Soil incorporation, then foliar app.	15-9, 15-10, 22-10, 29-10, 5-11, 12-11	169	14.8	7.95	TX only.
	4 (4.5), 1x, at plant with 2 inch.	FLpeppersSTD	Soil incorporation	15-8	105	4.81	2.55	
Tomato	4 (4.5), 1x, at plant with 2 inch.	CAtomato_WirrigSTD	Soil incorporation	15-2	29.8	3.34	1.96	Registrant allows for 2 cc but rates are given on annual basis.
		FLtomatoSTD_V2		15-1	74.8	4.87	2.54	
		PAtomatoSTD		1-4	29.4	3.63	2.45	
	1 (1.12), 1x, before plant incorporate 1 inch	FLtomatoSTD_V2		15-1	35.8	2.29	1.14	
Pome Fruit								
Apples and pears	2 (2.24), 2 foliar apps, 14d	NCappleSTD	Broadcast	1-6, 15-6	101	7.53	4.02	1 dormant and 1 foliar application with 60d MRI may also occur.
		ORappleSTD		1-10, 15-10	58.3	10.1	8	
		PAappleSTD_V2		24-8, 7-9	148	12.8	6.61	
		CAfruit_WirrigSTD		16-1	35.6	4.98	2.55	
Other								
Pineapple	1 (1.12), 2x, 14d	PRcoffeeSTD	foliar	16-1, 19-1	86.2	4.36	2.19	The MRI is NS on some labels. Registrant did not indicate they would change this. May

Use Site	Single app rate in lbs a.i./A (kg a.i./ha), # of apps, MRI days	PRZM Scenario	App type for modeling	App Date Day-Month	EDWC for Diazinon (µg/L)			Comments
					Peak	Annual Average	Entire Mean	
								run this with different metstation.
Ornamentals in nurseries	1 (1.12). 1x, 1 cc	FLnurserySTD_V2	Ground, broadcast	23-4	76.4	3.6	1.09	National label, 1 to several crop cycles per year.
	1 (1.12). 1x, 2 cc			23+4, 30-7	78.1	4.07	1.89	
	1 (1.12). 1x, 3 cc			23+4, 23-7, 23-10	78.5	5.05	2.58	
Ornamentals grown in nurseries in containers	5 (5.6), 3x, 14d	CAnurserySTD_V2	Ground, broadcast	16-3, 30-3, 13-4	48	5.46	4.33	The current label will be updated to reflect us on containerized nursery stock. Applications may be repeated if needed. While containers may be shipped after applications, this is not required on the label. Additionally, if it rains on a pot before shipping, diazinon residues could move to groundwater and surface water. Therefore, repeated applications are relevant. State may only allow use of diazinon in areas where surface water may not be impacted.
		FLnurserySTD_V2		16-3, 30-3, 13-4	522	26.1	11.7	
		MInurserySTD_V2		16-3, 30-3, 13-4	122	22.3	17.2	
		NJnurserySTD_V2		16-3, 30-3, 13-4	218	27.3	17	
		ORnurserySTD_V2		16-3, 30-3, 13-4	62.7	11.3	8.54	
		TNnurserySTD_V2		16-3, 30-3, 13-4	343	34.2	16.9	
	5 (5.6), 6x, 14d	FLnurserySTD_V2		16-3, 30-3, 13-4	560	29	13.5	

Appendix D. Summary of Diazinon Monitoring Data

There are a large number of studies and data available on diazinon residues in air, surface water, drinking water, ground water, tissue (fish, mussel, clam, and crab), rain, and snow. Most of the available monitoring studies include samples collected at sites that were not chosen based on proximity (spatial or temporal) to pesticide usage and are thus referred to in this document as 'non-targeted' monitoring studies. Generally, 'targeted' monitoring would refer to data collected in a sampling program designed to correspond, both spatially and temporally, with a high likelihood of detection of a particular pesticide. Typically, sampling frequencies employed in monitoring studies are insufficient to ensure high probability that peak concentrations are captured. The limited amount of targeted data (which is discussed in the Environmental Fate Characterization in the section on dissipation studies), coupled with the fact that available data are not temporally or spatially correlated with known pesticide application times and/or areas, limit the utility of these data as indications of reasonably upper end exposure concentrations for risk assessment purposes. Therefore, in this assessment model-generated values are used for estimating acute and chronic exposure concentrations and monitoring data are used for characterization purposes. A lack of detections or low detected concentrations should not be interpreted as a reason to dismiss potential risk.

1. CLEAN WATER ACT PROGRAMS

Diazinon is identified as a cause of impairment for 59 water bodies listed as impaired under section 303(d) of the Clean Water Act in California, Kansas, Oklahoma, and Washington (Error! Reference source not found.).[45] Impaired waters include rivers, creeks, drains, sloughs, channels, lakes, harbors, and drainage ditches. There are 107 Total Maximum Daily Loads (TMDL) listed for diazinon, and all of them are in California[46]. Section 304(a) ambient water quality criteria[47], Aquatic life benchmarks, and Health Advisory levels[48], have been established for diazinon (**Table D 1**). Monitoring data, impaired waters, and TMDLs for diazinon, demonstrate that the use of diazinon may result in transport of diazinon to surface water at levels that may cause risk to human health or the environment.

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[45] Specific state causes of impairment that make up the national pesticides cause of impairment group are listed at http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.cause_detail_303d?p_cause_group_id=885.

[46] Documents describing the TMDLs are available at: http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.tmdls?p_pollutant_id=400. The TMDLs are listed for Callequas creek, Chicken Ranch slough, Chollas creek, Elder creek, Elk Grove creek, Feather river, Lower Salinas River Watershed, Morrison creek, Pajaro river, Sacramento river, Sacramento urban creeks, Sacramento and San Juaquin Delta Waterways and tributaries, San Diego creek, San Francisco Bay Area and Urban creeks, San Juaquin River Strong Ranch Slough, Arroyo Paredon Watershed, Upper Newport Bay, and San Diego creek.

[47] Specific state pollutants that make up the National Pesticides Pollutant Group and have TMDLs are listed at http://iaspub.epa.gov/tmdl_waters10/attains_nation.tmdl_pollutant_detail?p_pollutant_group_id=885&p_pollutant_group_name=PESTICIDES.

[48] http://water.epa.gov/action/advisories/drinking/upload/dwstandards2012.pdf

Table D 1. Office of Water Health Advisories for Diazinon[1]

Health Advisories					
10-kg Child		70-kg Adult			
1-day (µg/L)	10-day (µg/L)	RfD (mg/kg/day)	DWEL[1] (µg/L)	Life-time (µg/L)	mg/L at 10^{-4} Cancer Risk
20	20	0.0002	7	1	NA

DWEL=Drinking Water Equivalent Level
RfD=Reference Dose
[1] The 2012 Edition of the Drinking Water Standards and Health Advisories are available at http://water.epa.gov/action/advisories/drinking/upload/dwstandards2012.pdf (accessed 2/28/2015)

Table D 2. OPP Aquatic Life Benchmarks and Office of Water Aquatic Life Criteria for Diazinon

OPP Aquatic Life Benchmarks						Office of Water Aquatic Life Criteria	
Fish		Invertebrates		Nonvascular Plants	Vascular Plants		
Acute[1]	Chronic[2]	Acute[3]	Chronic[4]	Acute[5]	Acute[6]	Maximum Concentration	Continuous Concentration
45	<0.55	0.105	0.17	3700	Not available	0.17	0.17

1. Benchmark = Toxicity value x LOC. For acute fish, toxicity value is generally the lowest 96-hour LC50 in a standardized test (usually with rainbow trout, fathead minnow, or bluegill), and the LOC is 0.5.
2. Benchmark = Toxicity value x LOC. For chronic fish, toxicity value is usually the lowest NOEAC from a life-cycle or early life stage test (usually with rainbow trout or fathead minnow), and the LOC is 1.
3. Benchmark = Toxicity value x LOC. For acute invertebrate, toxicity value is usually the lowest 48- or 96-hour EC_{50} or LC_{50} in a standardized test (usually with midge, scud, or daphnid), and the LOC is 0.5.
4. Benchmark = Toxicity value x LOC. For chronic invertebrates, toxicity value is usually the lowest NOAEC from a life-cycle test with invertebrates (usually with midge, scud, or daphnids), and the LOC is 1.
5. Benchmark = Toxicity value x LOC. For acute nonvascular plants, toxicity value is usually a short-term (less than 10 days) EC_{50} (usually with green algae or diatoms), and the LOC is 1.
6. Benchmark = Toxicity value x LOC. For acute vascular plants, toxicity value is usually a short-term (less than 10 days) EC50 (usually with duckweed) and the LOC is 1.

Table D 3. Summary of Waters Listed as Impaired Due to Diazinon

State	Waterbody	River basin
CA	ALAMO RIVER	COLORADO RIVER BASIN
	ARROYO PAREDON	CENTRAL COAST
	ARROYO TRABUCO CREEK	NR
	BEAR CREEK (SAN JOAQUIN AND CALAVERAS COUNTIES; PARTLY IN DELTA WATERWAYS, EASTERN PORTION)	NR
	BEAR RIVER, LOWER (BELOW CAMP FAR WEST RESERVOIR)	CENTRAL VALLEY
	BLANCO DRAIN	CENTRAL COAST
	BUTTE SLOUGH	CENTRAL VALLEY
	CHUALAR CREEK	CENTRAL COAST
	COLUSA BASIN DRAIN	CENTRAL VALLEY
	COYOTE CREEK	LOS ANGELES
	DEL PUERTO CREEK	CENTRAL VALLEY

State	Waterbody	River basin
	DOMINGUEZ CHANNEL (LINED PORTION ABOVE VERMONT AVE)	LOS ANGELES
	DRY CREEK (TRIBUTARY TO TUOLUMNE RIVER AT MODESTO, E STANISLAUS COUNTY)	NR
	ESPINOSA LAKE	CENTRAL COAST
	ESPINOSA SLOUGH	CENTRAL COAST
	FRENCH CAMP SLOUGH (CONFLUENCE OF LITTLEJOHNS AND LONE TREE CREEKS TO SAN JOAQUIN RIVER, SAN JOAQUIN CO; PARTLY IN DELTA WATERWAYS, EASTERN PORTION)	NR
	GILSIZER SLOUGH (FROM YUBA CITY TO DOWNSTREAM OF TOWNSHIP ROAD, SUTTER COUNTY)	NR
	INGRAM CREEK (FROM CONFLUENCE WITH SAN JOAQUIN RIVER TO CONFLUENCE WITH HOSPITAL CREEK)	CENTRAL VALLEY
	JACK SLOUGH	CENTRAL VALLEY
	LIVE OAK SLOUGH	NR
	LOS ANGELES RIVER REACH 1 (ESTUARY TO CARSON STREET)	LOS ANGELES
	MAIN DRAINAGE CANAL	CENTRAL VALLEY
	MAIN STREET CANAL	CENTRAL COAST
	MERCED RIVER, LOWER (MCSWAIN RESERVOIR TO SAN JOAQUIN RIVER)	CENTRAL VALLEY
	MORRISON SLOUGH	NR
	MOSS LANDING HARBOR	CENTRAL COAST
	MUSTANG CREEK (MERCED COUNTY)	NR
	NATOMAS EAST MAIN DRAINAGE CANAL (AKA STEELHEAD CREEK, DOWNSTREAM OF CONFLUENCE WITH ARCADE CREEK)	CENTRAL VALLEY
	NEW RIVER (IMPERIAL COUNTY)	COLORADO RIVER BASIN
	OLD SALINAS RIVER	CENTRAL COAST
	ORCUTT CREEK	CENTRAL COAST
	ORESTIMBA CREEK (ABOVE KILBURN ROAD)	CENTRAL VALLEY
	ORESTIMBA CREEK (BELOW KILBURN ROAD)	CENTRAL VALLEY
	PETALUMA RIVER	SAN FRANCISCO BAY
	PETALUMA RIVER (TIDAL PORTION)	SAN FRANCISCO BAY
	PIXLEY SLOUGH (SAN JOAQUIN COUNTY; PARTLY IN DELTA WATERWAYS, EASTERN PORTION)	NR
	QUAIL CREEK	CENTRAL COAST
	REDHAWK CHANNEL	NR
	SALINAS RECLAMATION CANAL	CENTRAL COAST
	SALINAS RIVER (LOWER, ESTUARY TO NEAR GONZALES RD CROSSING, WATERSHEDS 30910 AND 30920)	CENTRAL COAST
	SANTA CLARA RIVER REACH 6 (W PIER HWY 99 TO BOUQUET CYN RD) (WAS NAMED SANTA CLARA RIVER REACH 8 ON 2002 303(D) LIST)	LOS ANGELES
	SPRING CREEK (COLUSA COUNTY)	NR
	STANISLAUS RIVER, LOWER	CENTRAL VALLEY
	TEMBLADERO SLOUGH	CENTRAL COAST
	TUOLUMNE RIVER, LOWER (DON PEDRO RESERVOIR TO SAN JOAQUIN RIVER)	CENTRAL VALLEY
	ULATIS CREEK (SOLANO COUNTY)	NR

State	Waterbody	River basin
	WADSWORTH CANAL	CENTRAL VALLEY
	WINTERS CANAL (YOLO COUNTY)	NR
KS	LABETTE CR	NEOSHO RIVER BASIN
	LABETTE CR	NEOSHO RIVER BASIN
	LITTLE LABETTE CR	NEOSHO RIVER BASIN
	TOLEN CR	NEOSHO RIVER BASIN
	UNNAMED STREAM	NEOSHO RIVER BASIN
	UNNAMED STREAM	NEOSHO RIVER BASIN
	UNNAMED STREAM	NEOSHO RIVER BASIN
	UNNAMED STREAM	NEOSHO RIVER BASIN
OK	Haikey Creek	NR
WA	GRAYS HARBOR COUNTY DRAINAGE DITCH NO. 1 (GHCDD-1)	NR
	PACIFIC COUNTY DRAINAGE DITCH NO. 1 (PCDD-1)	NR

NR=not reported.

2. SURFACE WATER

2.1. USGS NAWQA Surface Water Data (1992 – 2014)

Surface water data from the USGS NAWQA program were obtained on December 30, 2014 (USGS, 2015a). A total of 30,297 water samples across 2,206 sites throughout the United States were analyzed for diazinon between 1993 and 2014. There were 8,313 detections (27% of samples) of diazinon in the United States and concentrations ranged from not detectable to 3.8 µg/L. Forty-six states had detections of diazinon in surface water. After 2004, the highest detected concentration was 0.359 µg/L. The long term method detection level is 0.003 µg/L (Gilliom *et al.*, 2007). As expected, higher numbers of samples collected within a given state tended to correspond with higher maximum concentrations detected (**Figure 8**). Eleven states[49] had detections at 0.9 µg/L or greater and 34 states had detections above 0.1 µg/L (**Table D 4**). Detections above 0.1 µg/L occurred in creeks and storm drains, as well as in major rivers.

[49] California, Georgia, Virginia, Oregon, Utah, Texas, Indiana, Tennessee, Alabama, Wisconsin, and Louisiana.

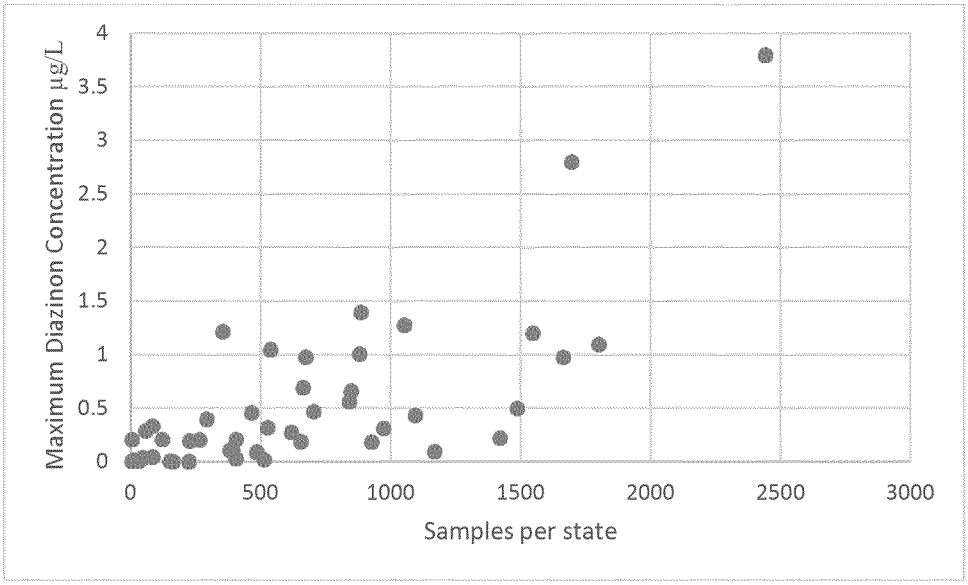


Figure 8. Number of surface water samples analyzed for diazinon in each state and the maximum diazinon concentration in surface water detected in that state

Table D 4. Summary of NAWQA monitoring results for diazinon by state

State/Tribal Area	Detections	Samples	Frequency	Maximum Diazinon Concentration Detected (µg/L)	Sample Years
Alabama	197	881	22%	1.01	1998-2008
Alaska	5	47	11%	0.0427	1999
Arizona	95	265	36%	0.207	1996-2010
Arkansas	55	404	14%	0.0328	1994-2010
California	1602	2442	66%	3.8	1992-2012
Colorado	298	848	35%	0.66	1993-2010
Connecticut	116	406	29%	0.21	1993-2010
Delaware	1	5	20%	0.007	1999
District of Columbia	6	6	100%	0.21	1994 & 2000
Florida	116	618	19%	0.276	1993-2005
Georgia	441	1696	26%	2.8	1993-2010
Hawaii	23	57	40%	0.293	1999-2001
Idaho	17	485	4%	0.093	1994-2004
Illinois	434	1421	31%	0.224	1996-2009
Indiana	669	1801	37%	1.1	1991-2010
Iowa	28	1169	2%	0.095	1996-2011
Kentucky	11	151	7%	0.0067	1997-2008
Louisiana	347	1664	21%	0.978	1995-2009
Maine	0	4	0%	Not detected	2000

State/Tribal Area	Detections	Samples	Frequency	Maximum Diazinon Concentration Detected (µg/L)	Sample Years
Maryland	50	393	13%	0.1	1994-2004
Massachusetts	117	293	40%	0.4	1994-2011
Michigan	68	227	30%	0.197	1996-2006
Minnesota	121	655	18%	0.19	1996-2010
Mississippi	29	513	6%	0.025	1996-2007
Missouri	49	383	13%	0.114	1994-2005
Montana	1	224	0%	0.003	2000
Nebraska	123	927	13%	0.184	1992-2009
Nevada	190	465	41%	0.46	1993-2008
New Hampshire	5	32	16%	0.006	1994 & 2000
New Jersey	216	704	31%	0.47	1996-2009
New Mexico	28	122	23%	0.21	1993-1996
New York	135	663	20%	0.697	1994-2007
North Carolina	246	973	25%	0.315	1992-2009
North Dakota	1	162	1%	0.004	1995
Ohio	336	842	40%	0.564	1996-2008
Oklahoma	2	13	15%	0.017	1994-1995
Oregon	320	1053	30%	1.28	1992-2011
Pennsylvania	235	1095	21%	0.436	1993-2010
Rhode Island	0	1	0%	Not Detected	1999
South Carolina	94	526	18%	0.323	1996-2005
Tennessee	97	537	18%	1.05	1996-2004
Texas	661	1547	43%	1.2	1993-2013
Utah	166	354	47%	1.22	1999-2010
Vermont	0	9	0%	Not detected	1994-1995
Virginia	213	886	24%	1.4	1993-2010
Washington	210	1487	14%	0.501	1993-2012
West Virginia	4	84	5%	0.338	1994 & 1996
Wisconsin	148	673	22%	0.98	1993-2011
Wyoming	2	84	2%	0.0474	2003
United States	8328	30297	27%	3.80	1993-2014

A total of 1,499 surface water samples across sites throughout the United States were analyzed for diazoxon between 2002 and 2014. Detections occurred in 2004 in California and Texas. Concentrations ranged from not detected to 0.06 µg/L with the highest detection occurring in 2004. The limit of quantitation ranged from 0.006 to 0.045 µg/L based on the range of less than values reported in the dataset. Diazinon and diazoxon were analyzed in these samples and the ratio of the concentration of the oxon to the diazinon concentration ranged from 0.11 to 0.25.

2.2. Pesticide Concentrations in Drinking Water USGS and USEPA in (1999-2000)

In 1999 and 2000, the United States Geological Survey (USGS) and USEPA collaborated in examining concentrations of pesticides in twelve small drinking-water supply reservoirs in areas of high pesticide use. The reservoirs range in size from 120 to 92,600 acre-feet with contributing watersheds ranging in size from 3.3 to 784 square miles and (Blomquist *et al.*, 2001). Water samples were collected from raw-water intake, finished drinking water, and some reservoir outflows. Samples were collected quarterly throughout the year and at weekly or biweekly intervals following the primary pesticide application periods. Diazinon was detected in 35% (114 of 323) of raw water samples and was one of the most frequently detected insecticides at a maximum concentration of 0.11 µg/L detected in Lake Arcadia, Oklahoma. This was the reservoir with the smallest capacity of 120 acre-feet and a high sampling frequency and had both urban and agriculture areas in the counties intersecting the watershed. Diazinon was not detected in finished water samples. Diazoxon was not included as an analyte in the study. Studies have shown that organophosphorus compounds are readily oxidized in the presence of chlorine and ozone, and could form diazoxon. While diazinon was not observed in finished water samples, it is possible that diazoxon was present in the samples.

2.3. Pesticide Data Program (PDP) Surface Water (2001-2013)

The Pesticide Data Program (PDP) is a national pesticide residue database program that examines pesticide residues in agricultural commodities and drinking water in the United States food supply to support pesticide dietary exposure assessments (USDA, 2013). Finished drinking water monitoring in California and New York began in 2001. In 2002, the program was expanded to Colorado, Kansas, and Texas. In 2004, the program began examining paired raw and finished drinking water samples sourced from surface water. The survey ended in 2013. The limit of detection ranged from 3.3 to 30 ng/L.

Diazinon was detected in 0.10% of surface water source water samples (six of 5,921 samples) at a maximum diazinon concentration of 0.133 µg/L (**Table 22**). Detections occurred in 2001, 2002, 2003, 2007, and 2010. Most detections occurred in raw water; however, there were also detections in finished water.

Table D 5. Summary of Surface Water Sourced Drinking Water Monitoring Data from the PDP

Year	Detects	Number of Samples	Frequency of Detects	Diazinon Max Concentration (µg/L)	Detect(s) in
2001	1	283	0.35%	0.010	Finished Water
2002	1	657	0.15%	0.010	Finished Water
2003	1	794	0.13%	0.133	Finished Water
2004	0	239	0.00%	NA	Paired raw and finished water
2005	0	232	0.00%	NA	Paired raw and finished water
2006	0	368	0.00%	NA	Paired raw and finished water
2007	1	733	0.14%	0.0164	Paired raw and finished water
2008	1	619	0.16%	0.1	Paired raw and finished water

Year	Detects	Number of Samples	Frequency of Detects	Diazinon Max Concentration (µg/L)	Detect(s) in
2009	0	612	0.00%	NA	Paired raw and finished water
2010	1	559	0.18%	0.059	Paired raw and finished water
2011	0	240	0.00%	NA	Paired raw and finished water
2012	0	485	0.00%	NA	Paired raw and finished water
2013	0	100	0.00%	NA	Paired raw and finished water
Total	6	5921	0.10%	0.133	Raw and finished water

NA=not applicable

2.4. STORET/WQX Data Warehouse (1986-2012)

STORET/Water Quality Exchange (WQX) is a repository for water quality, biological, and physical data maintained by the USEPA. Data are submitted by states, tribes, and others. Data were downloaded on February 15, 2015 (USEPA, 2015a). Data were available from several states and are summarized in **Table D** 6. This summary includes data that are reported elsewhere for California but were also submitted to STORET. There were 29 samples with diazinon concentrations above 1 µg/L. Most of these higher detections occurred in California and Alabama but some also occurred in Minnesota, Missouri, and Florida in samples collected between 1993 and 2003.

Surface water samples were collected and analyzed for diazoxon. In 2009 in Washington State, 10 samples were collected in Callam County and diazoxon was present in all samples above the method detection limit, but below an unreported quantitation limit. Diazoxon was not detected in 2,890 samples collected in Minnesota between 2012 and 2013 with a method detection limit ranging from 0.075 to 0.15 µg/L.

Table D 6. Summary of STORET Surface Water Monitoring Data by State

State	Detections	Total Samples	Frequency of Detections	Max Diazinon Concentration µg/L
Alabama	24	474	5.06%	4.2
Arizona	47	846	5.56%	0.697
Arkansas	40	545	7.34%	0.38732
California[a]	415	683	60.76%	6.7
Colorado	0	127	0.00%	--
Florida	374	4864	7.69%	1.8
Idaho	0	19	0.00%	--
Illinois	161	1318	12.22%	0.48
Iowa	28	3970	0.71%	0.46
Kansas	50	262	19.08%	0.85
Kentucky	6	277	2.17%	0.0501
Louisiana	1	18	5.56%	0.0569
Minnesota	134	6628	2.02%	1.66
Missouri	20	110	18.18%	1.5

State	Detections	Total Samples	Frequency of Detections	Max Diazinon Concentration µg/L
Montana	0	2	0.00%	--
New Mexico	0	91	0.00%	--
North Carolina	0	1135	0.00%	--
North Dakota	20	247	8.10%	Detections below quantitation Level of (MDL=0.1 µg/L)
Oklahoma	32	39	82.05%	0.03035
South Dakota	251	251	100.00%	Detections below quantitation Level (MDL=0.25 µg/L)
Tennessee	0	5	0.00%	--
Texas	0	1	0.00%	--
Spirit Lake (Tribal Data)	1	1	100.00%	Detections below quantitation Level of (MDL=0.1 µg/L)
Utah	32	513	6.24%	0.6
Washington	79	116	68.10%	0
Wisconsin	69	69	100.00%	0.5
Wyoming	0	5	0.00%	--
All States	1784	22616	7.89%	6.7

MDL=method detection limit

[a] Some values reported in California were duplicates. These duplicates were not removed for this analysis.

2.5. South Florida Water Management District (1992 – 2007)

The south Florida Water Management District is responsible for management of water quality in 16 counties from Orlando to the Florida Keys. The area includes management of canals, levees, water control structures, and pump stations. Monitoring for 80 pesticides and degradation products was conducted at 34 aquatic sampling sites in South Florida. Sampling sites covered the area from Lake Okeechobee south into the Everglades National Park. Water samples are collected four times a year and sediment samples are collected twice a year from each designated site. Diazinon was one of the most frequently detected insecticides and was observed in 21% of surface water samples (15 out of 71). The maximum concentration detected was 1.9 µg/L. Diazinon was not observed in sediment samples. Sediment samples were collected from the same sites as water samples, but not as many samples were collected.

2.6. Oregon Laboratory Analytical Storage and Retrieval Database (LASAR)

The Oregon Laboratory Analytical Storage and Retrieval Database (LASAR) was searched on February 23, 2015 (Oregon Department of Environmental Quality, 2015). Diazinon was not detected in 190 surface water samples collected between 1999 and 2002 or in 71 groundwater samples collected in 1993, 1994, and 1999. The limit of detection for surface water ranged from 0.01 to 0.2 µg/L based on less-than values reported in the dataset. Diazinon was detected in 20% (1 of 5) of sediment samples collected in 1998 at a maximum concentration of 8 µg/kg-dry weight. The limit of detection in sediment was 5 µg/kg-dry weight.

2.7. Washington Monitoring Data

2.7.a. State of Washington Environmental Information Management System

The Washington Environmental Information Management System (Washington State Department of Ecology, 2015) is a repository of data for air, water, soil, sediment, aquatic animals, and plants for the state of Washington. Data were downloaded from the site on February 23, 2015. Data from this database were submitted to the Water Quality Exchange System (STORET) and in the cranberry monitoring summary. The limit of detection for different methods ranged from 0.024 to 0.3 µg/L. Diazinon was detected in 233 of 4667 surface water samples (5.0%). There were 11 surface water samples with diazinon concentrations above 1 µg/L (maximum of 5.7 µg/L) that were collected in the Grayland Ditch System in 1996 and 2002. There were 161 surface water samples with diazinon concentrations ranging from 0.1 to 0.9 µg/L and 183 surface water samples between 0.05 and 0.099 µg/L.

2.7.b. Washington State Cranberry Bog

Diazinon has been detected above state water quality criteria over the previous 17 years in water draining from cranberry bogs into the Grays Harbor County Drainage Ditch and Pacific County Drainage Ditch (Baker, 2014). Exceedances of water quality criteria requires the Washington State Department of Agriculture to follow guidance in pesticide management. Under this plan, sampling in the ditches draining from cranberry bogs is monitored.

In June and July of 1998, the Washington State Department of Ecology collected water samples at three sites in surface drainage ditches from cranberry-growing areas near Grayland, Washington (Anderson and Davis, 2000). Two sites were test sites, and a third location was a control site. Samples were collected to evaluate whether implemented best management practices resulted in lower pesticide concentrations in the ditches. Water draining from cranberry bogs and residential property in the Grayland/North Cove area south of Westport is collected in a ditch system that discharges into Willapa Bay to the north and in the south bay of Grays Harbor. Both ditches receive water from small streams that run down the hills east of the cranberry bogs and directly from shallow groundwater within bogs. Water samples were collected pre and post-spray and analyzed for diazinon, chlorpyrifos, and azinphos-methyl. Diazinon was detected in all but two samples (8 of 10 samples) and concentrations ranged from 0.033 µg/L to 7.0 µg/L. Anderson and Davis (2000) summarized results from previous years (**Table D** 7), and results indicated that the best management practices that were implemented did not result in decreased diazinon concentrations in the ditches. The limit of quantitation for diazinon was 0.06 µg/L.

A report in 2014 (Baker, 2014) updated the analysis with monitoring data collected in 2002 and 2012. Additional sites were added in each drainage ditch. Samples were collected one week prior to pesticide application, during the week of peak application, and two weeks following application. These results are also summarized in **Table D** 7. Diazinon was detected in up to 100% of samples in at least one site every year. The maximum detected concentration in 2002 was 5.7 µg/L and 2.2 µg/L in 2009.

Table D 7. Summary of diazinon concentrations in water

Parameter	Diazinon Concentration in Water µg/L					
	1994	1995	1996	1998	2002	2009
Grays Harbor County Drainage Ditch No. 1						
Frequency	NR	NR	100% (26/26)	100% (5/5)	100% (9/9)	56% (5/9)
Mean	0.20	0.24	0.86	1.13	0.96	0.281
Max	0.029	0.68	5.4	4.4	5.7	2.2
Pacific County Drainage Ditch No. 1						
Frequency	NR	NR	96% (25/26)	100% (5/5)	100% (12/12)	100% (9/9)
Mean	No data	No data	0.3	2.4	0.31	0.180
Range	No data	No data	1.7	7.0	0.71	0.42

NR=Not reported

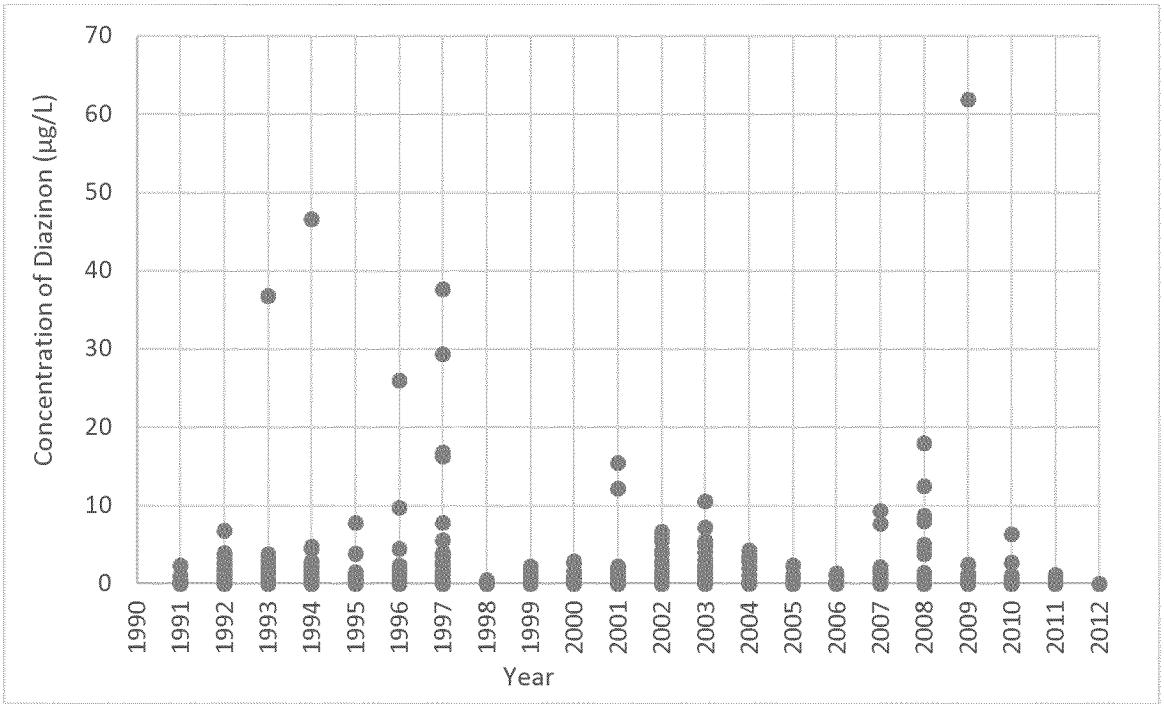
2.8. California Monitoring Data

Since 2000, USGS, in cooperation with the CADPR, has published several reports involving monitoring of California water bodies for diazinon. These studies are briefly described below. Several mitigations resulting from the registration review of diazinon were implemented between 2004 and 2008. These include cancellation of all granular formulations, residential uses (excluding use in nurseries), and aerial applications to all crops except lettuce. Hall and Anderson (2014) evaluated toxicity and pesticide monitoring data in the California central valley in 2004 to 2009 and noted that "regression analysis of the annual percent of diazinon samples exceeding the water quality objective of 100 ng/L showed a significant decline in exceedances from 2004 to 2009." Several of California waters on are on the 303(d) list of impaired waters due to contamination with diazinon. These include waters in the San Francisco Bay region, Central Coast region, Los Angeles region, Central Valley region, Colorado River Basin, and San Diego region.

2.8.a. California Department of Pesticide Regulation (CADPR) Data (1990-2012)

CADPR maintains a database of monitoring data on pesticides in CA surface waters (California Department of Pesticide Regulation, 2015). The sampled water bodies include rivers, creeks, urban streams, agricultural drains, the San Francisco Bay delta region, and storm water runoff from urban areas. The database contains data from 51 different studies by federal (including the USGS NAWQA program), state and local agencies as well as groups from private industry and environmental interests. Data are available from 1990-2012 for several pesticides and degradates. Data on diazinon and diazoxon are included in this database. For the purpose of this assessment, diazinon and diazoxon monitoring data from 1991-2012 were accessed from the CADPR database and are discussed below. Data on diazinon are also available after 2012; however, they are not included in the numbers here because these data are not in the database.[50] Additionally, the detections are within the range of detections reported in earlier years. Concentrations of diazinon in surface waters measured in California are shown in **Figure 9**. From 2004 to 2012, 13,620 samples from CA surface waters were analyzed for diazinon. Of these, diazinon was detected in 33% of samples, at a maximum concentration of 61.9 µg/L in a creek in an agricultural area[51] in 2009. Detections greater than 10 µg/L occurred when more than 500 samples were collected in a year in creeks, large rivers, and artificial drains. The month in which peak concentrations occurred varied by site with peaks occurring somewhere in almost every month of the year. Several mitigations were implemented on use of diazinon between 2004 and 2008 including cancelling residential uses (except nurseries), granular formulations, and seed treatment uses.[52,53] Additionally, aerial applications were only allowed for use on lettuce. It is not possible to draw conclusions on the impact of these mitigations on monitoring results as the frequency of sampling and locations of sampling have changed over time; however, there have been only two detections above 15 µg/L since 2007. Detections between 1 and 10 µg/L (15 detections between 2008 and 2012) occur up to the last year sampled, and detections below 1 µg/L are common (307 detections between 2008 and 2012).

[50] http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps.htm?filter=surfwater
[51] The detection occurred in Alisal creek at Hartnel Road.
[52] http://www.epa.gov/pesticides/reregistration/diazinon/
[53] While the cancellations were implemented between 2004 and 2008, it would take some time between the implementation and when all products were finally off of the market.



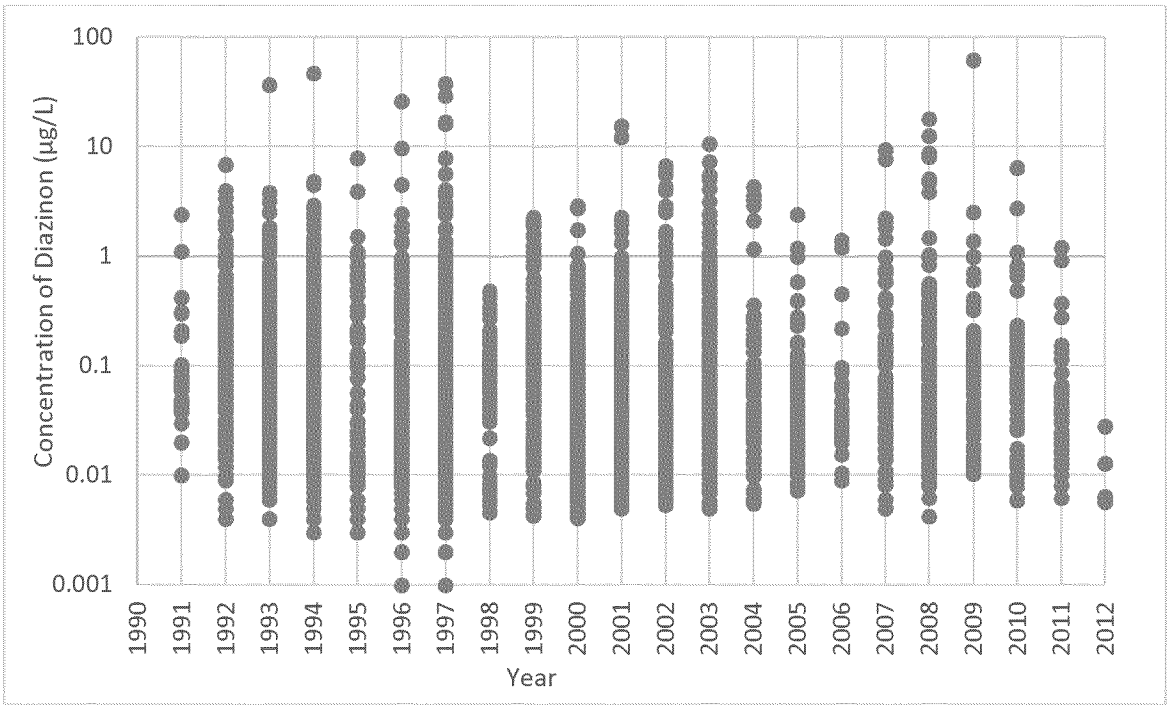


Figure 9. CADPR reported concentrations of diazinon in surface waters in CA (includes detections only) between 1991 and 2012. The same data are shown in two figures, with and without log transformation of the y-axis.

In California, 773 samples were analyzed to determine whether they contained diazoxon between 1991 and 1995. Diazoxon was detected in five samples at 0.06, 0.08, 0.21, 0.39, and 0.43 µg/L.

The limit of quantitation ranged from 0.05 to 0.1 µg/L. Detections occurred in Merced and San Joaquin counties in Spillways, wasteways[54], and a slough.

Data were also collected for both diazinon and diazoxon at a number of sites in California on the same date. For four of the diazoxon detections, the ratio of the concentration of diazoxon to the concentration of diazinon was below 8%. For one diazoxon detection, the ratio was 51%.

2.8.b. CEDEN

Surface water and sediment monitoring data from the California Environmental Data Exchange Network (CEDEN) were obtained on January 19, 2015 (State Water Resources Control Board, 2015). These data are also included in the STORET summary. A total of 3,563 water samples across 8,165 sites throughout the California were analyzed for diazinon between 1993 and 2014. There were 1,680 detections (47% of samples) of diazinon in the California and concentrations ranged from not detected to 6.7 µg/L. After 2007, the highest detection was 1.15 µg/L. The method detection limit ranged from 0.0001 to 0.05 µg/L. There were 23 detects at 1 µg/L and above and they occurred in the Alamo River, New River, Bouquet Canyon creek, river outlets, and Strong Ranch slough between 2001 and 2012.

2.8.c. Regions of California with Frequent Detections (2005 – 2010)

Zhang *et al.* (2012) analyzed monitoring results and diazinon usage data collected between 2005 and 2010 in five agricultural regions in California with the objective of identifying diazinon use scenarios that contribute to frequent detections in surface water in California. Diazinon usage decreased 75% between 2005 and 2010 in California. The Salinas Valley had the highest amount of diazinon used and the greatest area treated. The Sacramento valley ranked second. The San Joaquin, Imperial, and Santa Maria Valleys had lower amounts of diazinon applied. Use on lettuce accounted for 77% of the diazinon used in California. The Salinas Valley had detections in 91% of samples collected and the maximum diazinon concentration detected was 24.47 µg/L. Zhang *et al.* (2012) noted that the high frequency of detection and high maximum concentration detected were likely due to the large amount of diazinon used in a relatively small watershed.

Table D 8. Summary of Monitoring Results for Regions with High Detection Frequency of Diazinon

Region	Sites	# of Samples	Frequency of Detections	Max Diazinon Concentration µg/L	Lbs Diazinon Applied	Major Crops
Sacramento	73	850	30.2%	2.5	152,557	Prune, tomatoes, peach, walnut
San Joaquin	121	2465	10.0%	1.2	46,272	Cherry, peach, almond, corn
Salinas	33	244	91.0%	24.465	380,508	Lettuce, Broccoli, Cauliflower and Spinach
Santa Maria	12	21	90.5%	0.977	27,700	Lettuce, broccoli, cauliflower

[54] A wasteway is a channel for carrying off superfluous water.

Region	Sites	# of Samples	Frequency of Detections	Max Diazinon Concentration µg/L	Lbs Diazinon Applied	Major Crops
Imperial	12	58	51.7%	3.240	105,761	Sugar beet, lettuce, broccoli

2.8.d. Irrigation-Season Use in California (2003-2008)

California monitoring data collected between 2003 to 2008 were evaluated to better understand the extent to which diazinon moves offsite into surface water after irrigation season use (Starner, 2009). Monitoring data from samples sites that could potentially receive runoff from dormant spray applications of diazinon, or from urban sources, were identified and eliminated from the analysis to focus the analysis on irrigation seasons uses and sources. Samples that were included in the analysis were collected in the Central Valley (Sacramento Valley, San Joaquin Valley, and Tulare), areas along the Central Coast (including Salinas Valley, Pajaro, and Santa Maria) and southeastern California (Imperial Valley). Overall, diazinon was detected in 637 of 2,635 samples (24 percent) and concentrations exceeded 0.16 µg/L in nine percent of all samples. Frequencies of detections exceeding 0.16 µg/L were up to 65% in some areas. Crops grown in high frequency/high detection areas included cool weather crops such as lettuce, spinach and broccoli.

2.8.e. San Joaquin River Basin

The San Joaquin River Basin drains an area in Sierra Nevada Mountains and the San Joaquin Valley, and the Pacific Coast. Relevant diazinon usage for this basin included dormant season applications (December – February) to stone fruits and almonds (Kratzer *et al.*, 2002; Zamora *et al.*, 2003) and field crops and orchards during the April to August 2001 time frame (Domagalski and Munday, 2003).

In January-February 2000, USGS sampled 13 sites within the San Joaquin River Basin, on a weekly basis during non-storm periods, and more frequently during storm events (Kratzer *et al.*, 2002). These sampling periods coincided with dormant season applications of diazinon to orchards (mainly stone fruit and nuts). Applications may have also occurred in urban areas. In 2000, five major river (Tuolumne River and San Joaquin River) and eight minor tributary sites were sampled. In January-February 2001, 16 sites (7 rivers, 8 precipitation, and one urban storm drain) were sampled, with some overlap between the sites from one year to the next. During both time periods and for the majority of the sample sites, the highest concentrations of diazinon were observed during storm runoff events. Samples were collected weekly during non-storm periods and several times during storm runoff from one or two storms in 2000, and during four storm events in 2001. In the 2000 study, diazinon was detected in 82-100% of samples per site with a maximum observed concentration of 1.06 µg/L at Del Puerto Creek at Vineyard Road, near Patterson (Kratzer *et al.*, 2002)[55]. In the 2001 study, diazinon was detected in 95-100% of samples per site with a maximum observed concentration of 0.435 µg/L in the Merced River (Zamora *et al.*, 2003).

[55] The method detection limit for diazinon was 0.002 µg/L for samples collected in 2000 and 0.005 µg/L for samples collected in 2001.

During April to August 2001, 12 sites within the San Joaquin Valley were sampled weekly for diazinon (Domagalski and Munday, 2003). Some of the sites sampled during this study overlapped with those studied in previous USGS studies. During April-August, diazinon was detected in 10% of samples at some sites and 100% of samples at other sites. Median concentrations at the sample sites ranged from <0.005 to 0.011 µg/L, with 90 percent of all measured concentrations <0.06 µg/L. The maximum measured concentration for all sites was 0.325 µg/L. **Figure 10** provides an example of measured diazinon concentrations at the San Joaquin River near Vernalis with frequent diazinon detections. This is provided to give an example of what chemographs in the San Juaquin Valley look like, and times of year when diazinon residues are found.

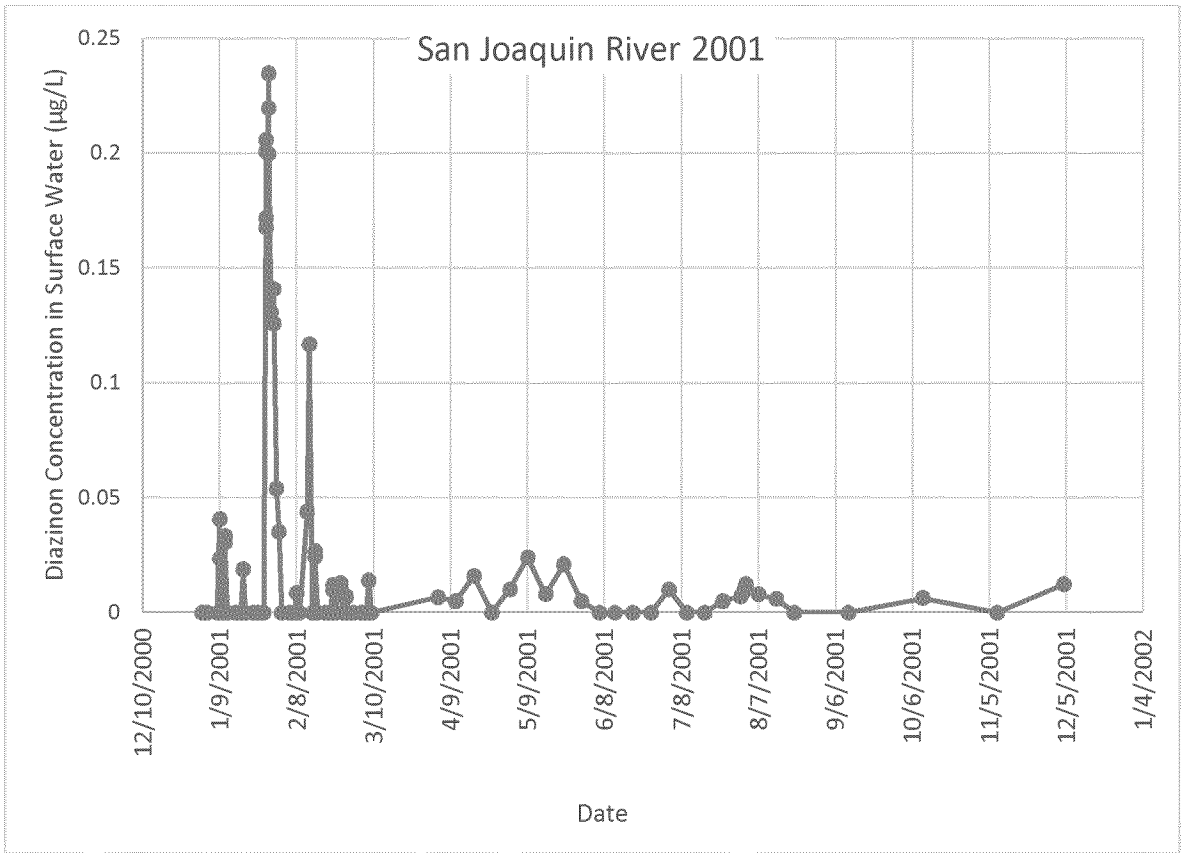


Figure 10. Diazinon concentration in the San Joaquin River near Vernalis in 2001 (Data from CADPR database)

2.8.f.Sacramento River and Tributaries

Dormant Season (2000-2001)

The Sacramento River and its tributaries drain land in northern California. Two studies were completed by the USGS to monitor water concentrations of diazinon resulting from dormant season applications of diazinon to orchards. The first study was targeted to monitor diazinon concentrations in runoff resulting from three winter storms which occurred during January 30-

February 25, 2000 (Dileanis *et al.*, 2002). Sites (n=17) on the Sacramento River and its tributaries that were located upstream of orchards, were sampled for five consecutive days for each of the three storms and after diazinon had been applied to orchards in the basin. The peak measured concentration of diazinon was 2.89 µg/L, while the median (n=138) was 0.044 µg/L. The method detection limit was 0.02 µg/L and there were 106 detections. Thirty percent of samples had concentrations greater than 0.08 µg/L. Observed diazinon concentrations were greatest in samples collected from small streams draining areas with agricultural or urban landcovers.

The second study was targeted to monitor diazinon concentrations in runoff resulting from two winter storms during January 24-February 14, 2001 (Dileanis *et al.*, 2003). These storms occurred after dormant spray applications of diazinon to orchards located within the Sacramento Valley. Different sized tributaries as well as portions of the Sacramento River (21 sites total) were sampled. The sites received runoff from areas with both agricultural and urban land uses. The maximum observed concentration of diazinon was 1.38 µg/L, with median concentrations for the first and second storms of 0.055 and 0.026 µg/L, respectively. Observed diazinon concentrations were greatest in samples collected from small streams draining areas with agricultural landcovers.

2.8.g. Santa Clara River Watershed and Callequas Creek watershed

Paired surface water and sediment samples were collected from 14 sites in the Santa Clara River and Callequas creek watersheds in California in 2009 (Delgado-Moreno *et al.*, 2011). Sites received runoff from agricultural and urban areas. Wet season samples were collected after major rain events in December and February and dry season samples were collected in May and September during periods with no measureable precipitation. Limits of detection ranged from 0.5 ng/L in water and 0.1 to 0.5 ng/g sediment. In general, pesticide concentrations in surface water were higher during the wet season. Diazinon was one of the most frequently detected pesticides[56] and was observed in 82% of samples collected during the wet season and 44% during the dry season. Diazinon was detected at a maximum concentration of 0.172 µg/L in water. Diazinon was detected in 60% of sediment samples during the wet and dry seasons and the median concentration was 1 ng/g sediment during the wet season and <0.5 ng/g during the dry season.

2.8.h. Salinas River

Anderson *et al.* (2003) measured pesticide (diazinon and chlorpyrifos) concentrations in the Salinas River at four sites. The sites were located upstream from where two agricultural drains join the river, between the two drains, where the section drain enters the river, and about 50 m downstream from both drainage inputs. The drains are approximately 60 km upstream of the point where the river enters Monterrey Bay. Water and sediment samples were collected on April 12, May 15, September 5, 2000, and May 14, 2001. Diazinon was detected in 44% (17 of 39) samples at a maximum concentration of 3.340 µg/L. The limit of detections was 0.03 to 0.04 µg/L (depending on the method used). Diazinon was also detected in pore-water in 3 of 9 sites (33%) at a maximum concentration of 0.46 µg/L. The Salinas River is one of the largest rivers

[56] Diazinon, chlorpyrifos, fipronil, and pyrethroids were monitored in the study.

of the central coast of California. Toxicity testing and macro invertebrate community structure were also examined.

2.8.i. TMDL monitoring in California's Central Valley

Additional water monitoring data are available in a study entitled "*Results of the TMDL Monitoring of Pesticides in California's Central Valley Waterways*" (Regional Water Quality Control Board, 2006). This study was conducted by the Aquatic Ecosystems Laboratory of the John Muir Institute at UC-Davis under a contract from the Regional Water Quality Control Board, Central Valley Region (NMFS, 2008; Regional Water Quality Control Board, 2006). The purpose of the study was "to monitor selected sites in the Sacramento River Basin, the eastern Sacramento-San Joaquin Delta tributary area, and the San Joaquin River Basin over two storm events during the winter of 2005-06 to further characterize and define sources of diazinon, chlorpyrifos, and other pesticides that may cause surface water contamination and toxic conditions to aquatic life." In part, the results of the study would be used by the study sponsor to support development of Total Maximum Daily Loads (TMDLs) for pesticides in Central Valley watersheds.

Locations for sample collection were taken from three general regions in the Sacramento-San Joaquin Watershed, the Sacramento River and its tributaries, the San Joaquin and its tributaries, and the Sacramento-San Joaquin Delta. The sites in the Sacramento River Watershed were located in Sutter, Butte, and Sacramento Counties, those for the Delta in San Joaquin and those in the San Joaquin River Watershed are in Stanislaus and Merced Counties. Some sites were chosen based on documented pesticide use in the watershed, pesticide-caused toxicity observed in the stream or river, and the inclusion of targeted pesticide on a 303(d) impaired water body lists. Data were reported for concentrations of diazinon in surface water at 12 sites. The detection frequency ranged 50-100% and 6 of the 12 sites had detections over 0.1 µg/L (NMFS, 2008). Sites were sampled daily for a 2 to 8 days following two storm events. The method detection limit was 0.003 µg/L.

Table D 9. Results from monitoring for diazinon in the Central Valley of California in the winter of 2006 (NMFS, 2008)

Site	Number of Samples	Percent Detections	Maximum Concentration (µg/L)
Sacramento River Watershed Sites			
Angel Canal/Commanche Creek	4	100	0.360
Gilsizer Slough	4	100	0.778
Live Oak Slough	4	100	0.738
Morrison Slough	4	100	0.294
Sacramento River (Alamar)	9	56	0.009
Sacramento River (Freeport)	9	56	0.003
Delta Sites			
Littlejohn Creek	4	100	0.044
Lone Tree Creek	4	100	0.246
Mormon Sough	4	50	0.014
Pixley Slough	4	100	0.116
San Joaquin River Watershed Sites			
Del Puerto Creek	4	50	0.015
Orestimba Creek	2	50	0.009

Available county level pesticide use data for California were employed to infer the predominant uses of diazinon in the counties sampled. Data for 2005 provide information on the extent of use in the counties where monitoring data were collected in this study. All six counties in the study showed considerable amounts of diazinon applied during January and February, which is considered the dormant spray season as the trees are leafless at this time of year. In addition to the crops identified in **Table D** 10, there were small amounts of diazinon applied in these six counties to apricots, pears, and walnuts (total <350 lbs). Other diazinon uses in these six counties include: 3 lbs used for 'landscape maintenance', 24 lbs used in green houses, 33 lbs for outdoor nursery plants, and 91 lbs used around structures. Consequently, the CDPR usage data suggest that the occurrence of diazinon in this monitoring study is associated with the dormant spray application to deciduous orchard crops.

Table D 10. Pounds Diazinon Applied in January and February in Six Counties in California in 2005 Using CDPR pesticide use reporting data

County	Pounds Diazinon Applied				
	Almonds	Apples	Cherries	Peaches and nectarines	Prunes and plums
Butte	2409	4510	961	1822	2177
Merced	1218	0	16	16	83
Sacramento	0	4566	116	20	16
San Joaquin	12022	8	1408	0	4
Sutter	14080	0	102	1666	184
Stanislaus	12	0	0	10687	14396

2.8.j.Central Coast Monitoring Data

Monitoring data were sent from the Central Valley Regional Water Quality Control Board.[57] Data reported in one file cover 2006 through 2013 and include data from the Irrigated Lands Program[58] and the California Surface Water Ambient Monitoring Program[59] (SWAMP). These data may already be summarized in the CEDEN summary; however, the sender indicated that not all of the data were included in the CEDEN database. The method detection limit ranged from 0.0005 to 0.03 µg/L. Diazinon was detected in 37% of samples (80 of 216 samples) at a maximum concentration of 24.46 µg/L in Quail creek in 2007. There were seven detections at 1 µg/L and above in creeks, sloughs, and canals. Diazinon was detected in 2.5% (3 of 119) of sediment samples at a maximum concentration of 4.72 µg/kg-dry weight sediment in Monterey Drainage ditch. The limit of detection ranged from 2 to 14.3 µg/kg-dry weight. Sediment detections also occurred in Salinas River and Orcutt Creek.

[57] Received data in an email from Karen Worcester to Charles Peck dated 2/25/2015, filename rb3_selected_Ops_2015_02_26_v01.xlsand Sites_list_region_3.xls(replaces filename CentralCoastOPdata.xlsx). The senders indicated that these data may not be in CEDEN.
[58] The irrigated lands regulatory program works to prevent agricultural discharges from impairing waters receiving discharges from irrigated lands. Water discharge requirements are issues that may require water quality monitoring of discharges and corrective action if impairment is found.
[59] Information on the SWAMP program is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/about.shtml

Another monitoring data file was received from the Central Valley Regional Water Quality Control.[60] These data summarize data from a number of different agencies. The water bodies sampled include 7728 receiving waters, 840 agricultural drains, 127 urban storm drain, and 268 waste water treatment plant effluent. Diazinon was detected in 34% (3024 out of 8963) samples collected between 2000 and 2011 at a maximum concentration of 40.8 µg/L in 2006 in Strong Ranch slough in an urban area. The next highest detected concentrations were also detected in Strong Ranch slough at 24.40 and 18.60 µg/L in 2006. The highest detected concentration after 2007 was 4.29 µg/L in 2008. There were 18 detections between 1 and 4.4 µg/L collected between 2000 and 2008. These detections occurred in creeks, the Calusa Basin Drain, canals, drains, and a slough. There were 43 detections between 0.5 and 1.0 µg/L between 2000 and 2009. These detections occurred in creeks, canals, storm drains, sloughs, canals, and Calaveras River. There were 438 detections between 0.1 and 0.50 µg/L at the same type of sites previously mentioned but also large rivers such as the San Joaquin River and Stanislaus River. The detection limits reported ranged from 0.002 to 0.032 µg/L.

2.8.k. Nursery Growers Association, Los Angeles County Irrigated Lands Group

The LA Water Quality Control Board is a State of California Agency that regulates water quality within the coastal watershed of Ventura and Los Angeles Counties (Nursery Growers Association, 2014). Irrigated crops are the dominant agricultural land use. When water quality benchmarks[61] were established several waterbodies in the area were found to exceed them. Water quality monitoring was implemented in the Los Angeles region to help to mitigate these exceedances. When exceedances occur a Water Quality Management plan is implemented. Data are available from 2007 to 2013. These sampling sites were mostly collected from runoff from nurseries that runoff into storm drains. Diazinon is detected in runoff from nurseries. The maximum concentration detected was 6.06 µg/L in August 2008. This demonstrates that use of diazinon on nurseries may result in residues of diazinon being transported to surface water.

2.8.l. Drinking Water Monitoring in 44 Community Water Systems (MRID 45513501, 45526200, 46626201)

This monitoring study was conducted on behalf of five companies for supporting the registration of organophosphates. This study was initiated voluntarily by a consortium of registrants, not in response to an EPA Data-Call-In. Residues of six organophosphate insecticides were monitored at finished drinking water collected from 44 community water systems near areas where a high percentage of the sales of the pesticide were made.

The study collected and analyzed 1103 samples from 44 surface-water-sourced CWS's, 73 1 of these were from 27 agriculturally influenced CWS's and 372 were from 17 urban influenced

[60] Received data in an email from Daniel McClure to Rochelle Bohaty on 1/27/2015. Filename CV_DNC_BPA_Conc_Data_2012_03_02.xlsx The senders indicated that these data may not be in CEDEN.
[61] The water quality benchmarks were derived, "of the Waiver, along with the Water Quality Control Plan Los Angeles Region (Basin Plan) objectives, California Toxics Rule benchmarks, USEAP ALB guidelines, and CCR Title 22 maximum contamination levels for municipal water (organic chemicals)." The Diazinon water quality benchmark was 0.10 µg/L based on the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Order # R4-2010-0186).

CWS's. All of these samples were taken from finished water. In addition 12 samples were taken from raw water, 6 from each of two sites. (The collection of these samples was not indicated in the protocol, and the purpose of collecting them is not clear.) There were a total of 77 detections during the study. However, 64 of the detections were attributed to laboratory cross-contamination and 6 were due to matrix interference. The remaining 7 detects represent actual occurrence of the analyte in the samples. Each of the 7 detections represents the occurrence of one pesticide in a sample.

Diazinon was not found in any sample collected during the study; however, diazoxon was found in three samples, each from a different water supply. The detections are summarized in **Table D 11**.

Table D 11. Detections of diazoxon in drinking water

Location	Water Body	Date	Concentration (µg/L)
York, PA	Codorus Creek	June 21, 1999	0.15
Atlanta, GA	Cattahoochie River	April 4, 2000	0.131
Philadelphia Suburban Water Co., PA	Nashaminy Creek	August 16, 1999	0.055

3. GROUNDWATER

3.1. USGS NAWQA Ground Water Data

Diazinon was detected in 0.86% (105/12,640) of ground water samples between 1992 and 2014 in the NAWQA program. Diazinon was detected at a maximum concentration of 19 µg/L occurring in 1996 in Minnesota. Three samples ranged from 0.16 to 0.38 µg/L collected in 1994, 1996, and 2002 in Minnesota, Florida, and North Carolina. All other detections were 0.098 µg/L and below. Detections occurred in Colorado, Idaho, Iowa, California, Connecticut, Florida, Illinois, Indiana, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nevada, New Hampshire, New Mexico, New York, North Carolina, Pennsylvania, South Carolina, and Virginia.

3.2. PDP Groundwater Data

In 2007, a groundwater survey was started to test drinking water wells at farms and private residences in agricultural areas (**Table D 12**). In 2009, the program began including wells at schools and daycare centers across the nation. Samples were collected from 1,495 wells in 45 states plus the District of Columbia. This program ended in 2013. From 2010 to 2012, water samples were also collected from municipal water facilities that draw from groundwater sources. Water was collected from 16 facilities in 13 states. Diazinon was detected in 0.16% (three of 1,915 samples) at a maximum concentration of 0.081 µg/L.

Table D 12. Summary of Ground Water Sourced Drinking Water Monitoring Data from the PDP

Year	Detects	Number of Samples	Frequency of Detects	Max Concentration (µg/L)
2007	0	272	0	NA
2008	2	250	0.80%	0.05
2009	0	278	0	NA
2010	0	248	0	NA
2011	0	603	0	NA
2012	0	164	0	NA
2013	1	100		0.081
All Years	3	1915	0.16%	0.081

NA=not applicable

3.3. New York Ground Water Monitoring

A study was conducted on behalf of the New York Department of Environmental Conservation to survey representative areas in Upstate New York to determine the occurrence and extent of pesticide contamination in groundwater by sampling rural water systems (domestic and farm) (Richards *et al.*, 2012). Single groundwater samples were collected in 2007 to 2009 from 80 vulnerable private wells (40 in each county) in Cayuga and Orange counties in New York. Water was collected from the tap closest to the well and preceding (where possible) water treatment. Water was run for several minutes to purge the lines prior to collection of the samples. Samples were analyzed for 93 different compounds, including diazinon. Vulnerability was evaluated based on information on local groundwater knowledge, risk modeling, aerial photo assessments, and pesticide use mapping[62]. Diazinon was detected in two wells at a maximum concentration of 0.1 µg/L in Orange County (detection frequency = 3%). The method detection limit ranged from 0.03 (Orange County) to 0.7 µg/L (Cayuga County).

1.1. Oregon Laboratory Analytical Storage and Retrieval Database (LASAR)

The Oregon Laboratory Analytical Storage and Retrieval Database (LASAR) was searched on February 23, 2015 (Oregon Department of Environmental Quality, 2015). Diazinon was not detected in 71 groundwater samples collected in 1993, 1994, and 1999. The limit of detection ranged from 0.01 to 0.2 µg/L based on less than values reported in the dataset.

4. SEDIMENT DATA

4.1. USGS NAWQA Sediment

A total of 242 bottom sediment samples across sites throughout the United States were analyzed for diazinon, and it was detected in three samples at a maximum concentration of 3.5 µg/kg-

[62] Based on data from the Pesticide Sales and Use Reporting (PSUR) database (http://www.dec.ny.gov/chemical/27506.html).

sediment dry weight. Detections occurred in samples collected in 1992 and 1995 in creeks in Indiana and Texas. The limit of quantitation ranged from 0.1 to 80 µg/kg-sediment dry-weight based on the range of less than values reported in the dataset.

A total of four sediment samples collected in Georgia were analyzed for diazoxon in 2010. Diazoxon was not detected. The limit of quantitation was 3 µg/kg sediment dry weight based on the less-than values reported in the dataset.

1.2. Oregon Laboratory Analytical Storage and Retrieval Database (LASAR)

The Oregon Laboratory Analytical Storage and Retrieval Database (LASAR) was searched on February 23, 2015 (Oregon Department of Environmental Quality, 2015). Diazinon was detected in 20% (1 of 5) of sediment samples collected in 1998 at a maximum concentration of 8 µg/kg-dry weight. The limit of detection in sediment was 5 µg/kg-dry weight.

5. TISSUE DATA

Tissue data were obtained from CEDEN on January 10, 2015. Data on tissue containing residues of diazinon were reported by the Surface Water Ambient Monitoring Program, the Regional Monitoring Program for Water Quality, and the Newport Bay Watershed Biotrend Monitoring Program.

Twenty detections were reported between 1984 and 1989 on residues in freshwater clam (*Corbicula fluminea*) and the California Mussel (*Mytilus californianus*). Diazinon was present at concentrations ranging from 1,060 ng/g-lipid to 13,853.4 ng/g-lipid. Samples were collected from rivers, creeks, harbors, canals, and sloughs.

There were 166 detections reported on a wet weight and dry weight for freshwater clam, California Mussel, Sailfin Molly (*Poecilia latipinna*), Asiatic clam (*Corbicula manilensis*), Channel catfish *(Ictalurus punctatus*), Common carp (*Cyprinus carpio*), Fathead minnow (*Pimephales promelas*), goldfish (*Carassius auratus*), red shiner (*Cyprinella lutrensis*), Treespine stickleback (*Gasterosteus aculeatus*), longjaw mudsucker (*Gillichthys mirabilis*), Tilapia spp., mosquitofish (*Gambusia affinis*), white croaker (*Genyonemus lineatus*), red rock crab (*Cancer productus*), and Jacksmelt (*Atherinopsis californiensis*). Detected concentrations were a maximum of 1100 ng/g dry-weight (usually whole organisms without gut but some soft tissue) and 1050 ng/g wet-weight whole organism. The highest concentration reported in fillet was 140 ng/g wet-weight.

6. ATMOSPHERIC MONITORING

6.1. Atmospheric Monitoring Data

Diazinon is one of the most frequently detected organophosphate pesticides in air and in precipitation. The majority of monitoring studies involving diazinon have been in California;

however, diazinon has been detected throughout the United States. Available air and precipitation monitoring data for diazinon are reported in **Table D 13**.

Table D 13. Diazinon detections in air and precipitation

Location	Year	Sample type	Maximum Conc.*	Detection frequency	Source
CA, MD	1970s-1990s	Air	0.306	NA	(Majewski and Capel, 1995)
Sequoia National Park, CA	1996	Air	0.00024	41.7%	(LeNoir *et al.*, 1999)
Sacramento, CA (Franklin Field Airport)	1996-1997	Air	0.0191	37.1 %	(Majewski and Baston, 2002)
Sacramento, CA (Sacramento Metropolitan Area)	1996-1997	Air	0.0122	46.5 %	(Majewski and Baston, 2002)
Sacramento, CA (Sacramento International Airport)	1996-1997	Air	0.112	38.5 %	(Majewski and Baston, 2002)
Fresno County, CA	1997	Air	0.290	NA	(State of California, 1998a)
Fresno County, CA	1998	Air	0.160	NA	(State of California, 1998b)
Mississippi River from New Orleans, LA to St. Paul MN	1994	Air	0.00036	100%	(Majewski *et al.*, 1998)
Central Valley, CA	1990-1991	Air	0.01 (parent) 0.003 (diazoxon)	100%	(Zabik and Seiber, 1993)
Sequoia national Park, CA	1995-1996	Rain	0.019	57 %	(McConnell *et al.*, 1998b)
San Joaquin River Basin, CA	2001	Rain	0.908	100%	(Zamora *et al.*, 2003)
San Joaquin Valley, CA	2002-2004	Rain	2.22	93%	(Majewski *et al.*, 2006)
Central Valley, CA	1990-1991	Rain	6.1 (parent) 2.3 (diazoxon)	100%	(Zabik and Seiber, 1993)
CA, MD	1970s-1990s	Fog	76.3	NA	(Zhang *et al.*, 2012)
Parlier, CA	1986	Fog	18.0	NA	(Glotfelty *et al.*, 1990)
Monterey, CA	1987	Fog	4.80	NA	(Schomburg *et al.*, 1991)
Sequoia national Park, CA	1995-1996	Snow	0.014	62.5 %	(McConnell *et al.*, 1998a)

*For Air, $\mu g/m^3$; for rain, snow and fog, $\mu g/L$

The magnitude of detected concentrations of diazinon in air and in precipitation can vary based on several factors, including proximity to use areas and timing of applications. In air, diazinon has been detected at concentrations up to 0.306 $\mu g/m^3$. Measured concentrations of diazinon in rain in California have been detected at concentrations up to 2.22 $\mu g/L$. In fog, diazinon has been detected up to 76.3 $\mu g/L$ (Majewski and Capel, 1995). Diazoxon has also been detected in air but is generally present at lower concentrations than parent diazinon (Zabik and Seiber, 1993).

6.2. Deposition Data

In a study of diazinon loads in winter precipitation and runoff to the San Joaquin River Basin, precipitation samples were collected from a January 2001 storm event. In order to observe the influences of dormant season applications of diazinon, four sampling sites were placed near areas dominated by orchards. Concentrations of diazinon measured in rainfall ranged from 0.175 to 0.870 µg/L. The authors concluded that diazinon in precipitation could contribute significantly to the overall diazinon load entrained in runoff (Zamora *et al.*, 2003).

In a 3.5 year study (from 2001-2004) in the central San Joaquin Valley, wet and dry deposition of pesticides, including diazinon, were monitored at six sites, including some with agricultural and urban land uses. When comparing wet and dry deposition, wet deposition represented a larger source of diazinon. Diazinon was detected in 93% of rain samples (n=137), with mean and maximum concentrations of 0.149 and 2.220 µg/L, respectively (Majewski *et al.*, 2006).

6.3. Monitoring data from lakes assumed to only receive atmospheric deposition

Studies are available involving monitoring of diazinon concentrations in California lakes which are removed from agricultural areas and are presumed to receive inputs of diazinon from atmospheric deposition only. Two 1997 studies (Fellers *et al.*, 2004; LeNoir *et al.*, 1999) measured diazinon concentrations in lake water in Kings Canyon and Sequoia National Parks (located in the Sierra Nevada Mountains in California). Fellers *et al.* (2004) reported a maximum concentration of 0.0034 µg/L, and LeNoir *et al.* (1999) reported a maximum concentration of 0.0741 µg/L in lake water. The authors attributed these detections to dry deposition and/or gas exchange from air samples of diazinon originating from agricultural sites located in California's Central Valley, which is upwind of the lakes.

Literature Cited

Acero, J. L., Benitez, F. J., Real, F. J., & Gonzalez, M. 2008. Chlorination of organophosphorus pesticides in natural waters. *Journal of Hazardous Materials, 153*, 320-328.

Anderson, B. S., Hunt, J. W., Phillips, B. M., Nicely, P. A., Vlaming, V., Connor, V., et al. 2003. Integrated assessment of the impacts of agricultural drainwater in the Salinas River (California, USA). *Environmental Pollution, 124*, 523-532.

Anderson, P., & Davis, D. 2000. *Evaluation of Efforts to Reduce Pesticide Contamination in Cranberry Bog Drainage*. Publication No. 00-03-041. September 2000. Washington State Department of Ecology. Available at http://longbeach.wsu.edu/cranberries/documents/evaluationofeffortstoreducepesticidesinbogdrainage.pdf (Accessed February 21, 2015).

Arienzo, M., Crisanto, T., Sanchezmartin, M. J., & Sanchezcamazano, M. 1994. EFFECT OF SOIL CHARACTERISTICS ON ADSORPTION AND MOBILITY OF (C-14)DIAZINON. *Journal of Agricultural and Food Chemistry, 42*(8), 1803-1808.

Armitage, J. M., & Gobas, F. A. P. C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025.

Armstrong, C. 2015. *How to Grow Cranberries - Cranberry Production Timetable.* University of Maine Cooperative Extension. Available at http://umaine.edu/cranberries/growing-cranberries/cranberry-production-timetable/ (Accessed February 1, 2015).

Ashauer, R., Caravatti, I., Hintermeister, A., & Escher, B. I. 2010. Bioaccumulation kinetics of organic xenobiotic pollutants in the freshwater invertebrate Gammarus pulex modeled with prediction intervals. *Environmental Toxicology and Chemistry, 29*(7), 1625-1636.

Ashauer, R., Hintermeister, A., Caravatti, I., Kretschmann, A., & Escher, B. I. 2010. Toxicokinetic and toxicodynamic modeling explains carry-over toxicity from exposure to diazinon by slow organism recovery. *Environmental Science & Technology, 44*, 3963-3971.

Baker, R. 2014. *The Grayland Ditch*. AGR Pub 102-401. March 31, 2014. Washington State Department of Agriculture. Natural Resource Assessment Section. Available at http://agr.wa.gov/FP/Pubs/docs/401-2013CranberryReportFinal.pdf (Accessed February 23, 2015).

Baris, R., Barrett, M., Bohaty, R. F. H., Echeverria, M., Villaneuva, P., Wolf, J., et al. 2013. *Guidance for Using PRZM-GW in Drinking Water Exposure Assessments*. December 11, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. United States Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/przm_gw/wqtt_przm_gw_guidance.htm (Accessed April 11, 2014).

Bartlet-Hunt, S. L., Knappe, D. R. U., & Barlaz, M. A. 2014. A review of chemical warfare agent simulants for the study of environmental behavior. *Critical Reviews in Environmental Science and Technology, 2008*, 112-136.

Beduk, F., Aydin, M. E., & Ozcan, S. 2011. Chemical oxidation of diazinon in aqueous solution by ozonation. *Fresnius Environmental Bulletin, 20*(7a), 1785-1972.

Blomquist, J. D., Denis, J. M., Cowles, J. L., Hetrick, J. A., Jones, R. D., & Birchfield, N. 2001. *Pesticides in Selected Water-Supply Reservoirs and Finished Drinking Water, 1999-2000: Summary of Results from a Pilot Monitoring Program*. Open-File Report 01-456. United States Geological Survey. Available at http://md.water.usgs.gov/nawqa/ (Accessed January 2, 2015).

Bondarenko, S., & Gan, J. 2004. Degradation and sorption of selected organophosphate and carbamate insecticides in urban stream sediments. *Environmental Toxicology and Chemistry, 23*(8), 1809-1814.

Bondarenko, S., Gan, J., Haver, D. L., & Kabashima, J. N. 2004. Persistence of selected organophosphate and carbamate insecticides in waters from a coastal watershed. *Environmental Toxicology and Chemistry, 23*(11), 2649-2654.

CA Dept. of Food and Agriculture. 2014. *Statewide Plant Pest Prevention and Management Program*. S. 2011062057. August 2014. Available at http://www.cdfa.ca.gov/plant/peir/ (Accessed September 9, 2014).

CADPR. 2012a. Pesticide Use Reporting. California Department of Pesticide Regulation. Available at http://www.cdpr.ca.gov/docs/pur/purmain.htm (Accessed February 13, 2012).

CADPR. 2012b. Surface Water Protection Program Database. Available at http://www.cdpr.ca.gov/docs/emon/surfwtr/surfdata.htm (Accessed February 16, 2012).

California Department of Pesticide Regulation. 2015. Surface Water Protection Program Database. Available at http://www.cdpr.ca.gov/docs/emon/surfwtr/surfdata.htm (Accessed February 15, 2015).

Cape Cod Cranberry Growers Association. 2001. *Conservation District Grant Program of the Commonwealth of Massachusetts Executive Office of Environmental Affairs. Cranberry Water Use. An Information Fact Sheet.* June 2001. Available at http://www.cranberries.org/pdf/wateruse.pdf (Accessed October 25, 2012).

Carsel, R. F., Imhoff, J. C., Hummel, P. R., Cheplick, J. M., & Donigian Jr., J. S. 1997. *PRZM-3, A Model for Predicting Pesticide and Nitrogen Fate in Crop Root and Unsaturated Soil Zones: Users Manual for Release 3.0.* Memorandum From to Environmental Research Laboratory. Office of Research and Development. United States Environmental Protection Agency.

Chamberlain, E., Shi, H., Wang, T., Ma, Y., Fulmer, A., & Adams, C. 2012. Comprehensive screening study of pesticide degradation vai oxidation and hydrolysis. *Journal of Agricultural and Food Chemistry, 60*, 354-363.

Delgado-Moreno, L., Lin, K., Veiga-Nascimento, R., & Gan, J. 2011. Ocurrence and toxicity of three classes of insecticides in water and sediment in two southern California coastal watersheds. *Journal of Agricultural and Food Chemistry, 59*, 9448-9456.

Dileanis, P. D., Bennett, K. P., & Domagalski, J. L. 2002. *Occurence and Transport of Diazinon in the Sacramento River, California, and Selected Tributaries During Three Winter Storms, January - February 2000.* W.-R. I. R. 02-4101. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri02-4101/wri02-4101.pdf (Accessed February 17, 2015).

Dileanis, P. D., Brown, D. L., Knifong, D. L., & Saleh, D. 2003. *Occurence and Transport of Diazinon in the Sacramento River and Selected Tributaries, California, During Two Winter Storms, January - February 2001.* Water-Resources Investigations Report 03-4111. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri034111/wrir_034111.pdf (Accessed February 17, 2015).

Domagalski, J. L., & Munday, C. 2003. *Evaluation of Diazinon and Chlorpyrifos Concentrations and Loads, and Other Pesticide Concentrations, at Selected Sites in te San Joaquin Valley, California, April to August 2001.* W.-R. I. R. 03-4088. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri034088/pdf/wri03_4088.pdf (Accessed February 17, 2015).

Duirk, S. E., Desetto, L. M., & Davis, G. M. 2009. Transformation of organophosphorus pesticides in the presence of aqueous chlorine: kinetics, pathways, and structure-activity relationships. *Environ Sci Technol, 43*, 2335-2340.

Eckel, W., Tunkel, J., Meylan, W. M., & Aronson, D. 2006. *Evaluation of EPI Suite for Use in Filing Data Gaps for Pesticide Degradates* Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Syracuse Research Corporation.

FAO. 2000. Appendix 2. Parameters of pesticides that influence processes in the soil. In FAO Information Division Editorial Group (Ed.), *Pesticide Disposal Series 8. Assessing Soil Contamination. A Reference Manual.* Rome: Food & Agriculture Organization of the United Nations (FAO). Available at http://www.fao.org/DOCREP/003/X2570E/X2570E06.htm (Accessed July 10, 2009).

Feigenbrugel, V., LeCalve, S., & Mirabel, P. 2004. Temperature dependence of Henry's law constants of metolachlor and diazinon. *Chemosphere, 57*, 319-327.

Fellers, G. M., McConnell, L. L., Pratt, D., & Datta, S. 2004. Pesticides in Mountain Yellow-Legged Frogs (*Rana Mucosa*) from the Sierra Nevada Mountains of California. *Environmental Toxicology and Chemistry, 23*(9), 2170-2177.

Fendinger, N. J., Glotfelty, D. E., & Freeman, H. P. 1989. Comparison of two experimental techniques for determining air/water Henry's law constants. *Environmental Science & Technology, 23*(12), 1528-1531.

Gilliom, R. J., Barbash, J. E., Crawford, C. G., Hamilton, P. A., Martin, J. D., Nakagaki, N., et al. 2007. *The quality of Our Nation's Waters. Pesticides in the Nation's Streams and Ground Water, 1992-2001.* C. 1291. February 15, 2007. United States Department of Interior. United States Giological Survey. National Water-Quality Assessment Program. Available at http://pubs.usgs.gov/circ/2005/1291/pdf/circ1291.pdf (Accessed September 21, 2009).

Glotfelty, D. E., Majewski, M. S., & Seiber, J. N. 1990. Distribution of several organophosphorus insecticides and their oxygen analogues in a foggy atmosphere. *Environemntal Science and Technology, 24*(3), 353-357.

Gobas, F. A. P. C., Kelly, B. C., & Arnot, J. A. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food-webs. *QSAR Comb. Sci, 22*, 329-336.

Goodman, L. R., Hansen, D. J., Coppage, D. L., Moore, J. C., & Matthews, E. 1979. Diazinon: Chronic toxicity to, and brain acetylcholinesterase inhibition in, the sheepshead minnow, *Cyprinodon variegatus*. *Trans. Am. Fish. Soc, 108*, 479-488.

Hall Jr, L., & Anderson, R. D. 2014. Historical trends analysis of 2004 to 2009 toxicity and pesticide data for California's central valley. *Journal of Environmental Science and Health Part A: Toxic/Hazardous Substances and Environmental Engineering, 47*, 801-811.

Hetrick, J., Parker, R., Pisigan, R., & Thurman, N. 2000. *Progress Report on Estimating Concentrations in Drinking Water and Assessing Water Treatment Effects on Pesticide Removal and Transformation: A Consultation. Briefing Document for a Presentation to the FIFRA Scientific Advisory Panel on September 29, 2000.* September 29, 2000. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/scipoly/sap/meetings/2000/september/sept00_sap_dw_0907.pdf (Accessed September 9, 2014).

IglesiasJimenez, E., SanchezMartin, M. J., & SanchezCamazano, M. 1996. Pesticide adsorption in a soil-water system in the presence of surfactants. *Chemosphere, 32*(9), 1771-1782.

Kanazawa, J. 1975. Uptake and excretion of organophosphorus and carbamate insecticides by fresh water fish, Motsugo, Pseudorasbora parva. *Bull. Environ. Contam. Toxicol., 14*(3), 346-352.

Kanazawa, J. 1978. Bioconcentration ratio of diazinon by freshwater fish and snail. *Bull. Environ. Contam. Toxicol, 20*, 613-617.

Kratzer, C. R., Zamora, C., & Knifong, D. L. 2002. *Diazinon and Chlorpyrifos Loads in the San Joaquin River Basin, California, January and February 2000.* Water Resources Investigations Report 02-4103. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri02-4103/wri024103.pdf (Accessed February 15, 2015).

Kretschmann, A., Ashauer, R., Hitzfeld, K., Spaak, P., Hollender, J., & Escher, B. I. 2011. Mechanistic toxicodynamic model for receptor-mediated toxicity of diazoxon, the active metabolite of diazinon, in *Daphnia magna*. *Environemntal Science and Technology, 45*(11), 4980-4987.

Lafleur, J. 2002. *Resource Planning for Cranberry Bogs within Drinking Water Supply Areas*. Project Number 99-14SWT. June 14, 2002. Cape Cod Cranberry Growers' Association. Available at http://www.cranberries.org/pdf/resource_planning_2002.pdf (Accessed February 23, 2015).

LeNoir, J. S., McConnell, L. L., Fellers, G. M., Cahill, T. M., & Seiber, J. N. 1999. Summertime Transport of Current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry, 18*(12), 2715-2722.

Magara, Y., Aizawa, T., Matumoto, N., & Souna, F. 1994. Degradation of pesticides by chlorination during water purificcation, ground water contamination, environmental restoration, and diffuse sourcce pollution. *Water Science and Technology, 30*(7), 119-128.

Majewski, M. S., & Baston, D. S. 2002. *Atmospheric transport of pesticides in the Sacramento, California, Metropolitan Area, 1996-1997*. W. R. I. R. 02-4100. National Water-Quality Assessment Program. U.S. Geological Survey. Available at http://pubs.usgs.gov/wri/wri024100/wri02-4100.pdf (Accessed February 28, 2015).

Majewski, M. S., & Capel, P. D. 1995. *Pesticides in the Atmosphere: Distribution, Trends, and Governing Factors*. Chelsea, MI: Ann Arbor Press.

Majewski, M. S., Foreman, W. T., Goolsbey, D. A., & Nakagaki, N. 1998. Airborne pesticide residues along the Mississippi River. *Environmental Science & Technology, 32*, 3689-3698.

Majewski, M. S., Zamora, C., Foreman, W. T., & Kratzer, C. R. 2006. *Contribution of atmospheric deposition to pesticide loads in surface water runoff*. O.-f. R. 2005-1307. United States Geological Survey. Available at http://pubs.usgs.gov/of/2005/1307/ (Accessed January 20, 2011).

McConnell, L. L., LeNoir, J. S., Datta, S., & Seiber, J. N. 1998a. Wet deposition of current-use pesticides in the Sierra Nevada mountain range, California, USA. *Environmental Toxicology and Chemistry, 17*(10), 1908-1916.

McConnell, L. L., LeNoir, J. S., Datta, S., & Seiber, J. N. 1998b. Wet deposition of current-use pesticides in the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry, 17*(10), 1908-1916.

Munoz, A., Le Person, A., Le Calve, S., Mellouki, A., Borras, E., Daele, V., et al. 2011. Studies on atmospheric degradation of diazinon in the EUPHORE simulation chamber. *Chemosphere, 85*, 724-730.

NAFTA. 2012. *Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media*. December 2012. NAFTA Technical Working Group on Pesticides. Available at http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-calculate-representative-half-life-values (Accessed November 13, 2015).

Nemeth-Konda, L., Fuleky, G., Morovjan, G., & Csokan, P. 2002. Sorption behavior of acetochlor, atrazine, carbendazim, diazinon, imidacloprid, and isoproturon on Hungarian agricultural soil. *Chemosphere, 48*, 545-552.

NMFS. 2008. *National Marine Fisheries Service Endangered Species Action 7 Consultation. Biological Opinion. Environmental Protection Agency Registration of Pesticides*

Containing Chlorpyrifos, Diazinon, and Malathion. November 2008. National Marine Fisheries Service. National Oceanic and Atmospheric Administration. U.S. Department of Commerce. Available at http://www.nmfs.noaa.gov/pr/pdfs/pesticide_biop.pdf (Accessed November 13, 2015).

Nursery Growers Association. 2014. *Annual Monitoring Report- Year Three Under Order # R4-2010-0186*. December 23, 2014. Nursery Growers Association. Los Angeles County. Irrigated Lands Group.

Ohashi, N., Tsuchida, Y., Sasano, H., & Hamada, A. 1994. Ozonation products of organophosphorus pesticides in water. *Japanese Journal of Toxicology and Health, 40*(2), 185-192.

Oregon Department of Environmental Quality. 2015. *Laboratory Analytical Storage and Retrieval Database (LASAR)*. Available at http://www.deq.state.or.us/lab/lasar.htm (Accessed February 23, 2015).

Pfeuffer, R. J. 2011. South Florida Water Management District ambient pesticide monitoring network: 1992-2007. *Environ Monit Assess, 182*, 485-508.

Regional Water Quality Control Board. 2006. *Results of the 2006 TMDL Monitoring of Pesticides in California's Central Valley Waterways January - March 2006*. October 2006. John Muir Institute of the Environment. Aquatic Ecosystems Analysis Laboratory. University of California, Davis. California Regional Water Quality Control Board. Central Valley Region. Available at http://www.swrcb.ca.gov/centralvalley/water_issues/water_quality_studies/2006-tmdl-winter-storm-report-dfg.pdf (Accessed January 20, 2015).

Richards, B. K., Pacenka, S., Salvucci, A. E., Saia, S. M., Whitbeck, L. F., Furdyna, P. M., et al. 2012. Surveying Upstate NY Well Water for Pesticide Contamination: Cayuga and Orange Counties. *Ground Water Monitoring and Remediation, 32*(1), 73-82.

Rider, S. 2010. *Report on Air Monitoring of an Orchard Application of Diazinon in Glenn County During January 2010*. December 13, 2010. Air Resources Board. California Environmental Protection Agency. . Available at http://www.cdpr.ca.gov/docs/emon/pubs/tac/diazinon.htm (Accessed May 29, 2015).

Schomburg, C. J., Glotfelty, D. E., & Seiber, J. N. 1991. Pesticide occurence and distribution in fog collected near Monterrey California. *Environmental Science & Technology, 25*, 155-160.

Seguchi, K., & Asaka, S. 1981. Intake and excretion of diazinon in freshwater fishes. *Bull. Environ. Contam.Toxicol., 27*, 244-249.

Shemer, H., & Linden, K. G. 2006. Degradation and by-product formation of diazinon in water during UV and UV/H20 treatment. *Journal of Hazardous Materials B136*, 553-559.

Smolen, J. M., & Stone, A. T. 1997. Divalent metal ion-catalyzed hydrolysis of phosphorothionate ester pesticides and their corresponding oxonates. *Environmental Science & Technology, 31*, 1664-1673.

Starner, K. 2009. *Spatial and temperal analysis of diazinon irrigation-season use and monitoring data*. October 8, 2009. California Environmental Protection Agency. California Department of Pesticide Regulation. Environmental Monitoring Branch. Available at http://www.cdpr.ca.gov/docs/emon/surfwtr/policies/starner_sw08.pdf (Accessed January 17, 2015).

State of California. 1998a. *Report for the Ambient Air Monitoring of Diazinon in Fresno County During Winter, 1997*. P. N. C96-036. April 6, 1998. California Environmental Protection

Agency. . Available at http://www.cdpr.ca.gov/docs/emon/pubs/tac/tacpdfs/diaamb.pdf (Accessed February 28, 2015).

State of California. 1998b. *Report for the Application (Kings County) and Ambient (Fresno County) Air Monitoring of Diazinon During Winter, 1998*. Available at http://www.cdpr.ca.gov/docs/emon/pubs/tac/tacpdfs/diamapl.pdf (Accessed February 28, 2015).

State Water Resources Control Board. 2015. California Environmental Data Exchange Network. California State Water Resources Control Board. Available at http://www.ceden.org/ (Accessed January 17, 2015).

Szeto, S. Y., Wan, M. T., Price, P., & Roland, J. 1990. Distribution and persistence of diazinon in a cranberry bog. *Journal of Agricultural and Food Chemistry, 38*, 281-285.

Tsuda, T., Aoki, S., Inoue, T., & Kojima, M. 1995. Accumulation of diazinon, fenthion and fenitrothion by killfish from mixtures of the three pesticides. *Toxicological and Environmental Chemistry 37*(3-4), 251-255.

Tsuda, T., Kojima, M., Harada, H., Nakajima, A., & Aoki, S. 1997. Relationships of bioconcentration factors of organophosphate pesticides among species of fish. *Comparative Biochemistry and Physiology C: Pharmacology, Toxicology, & Endocrinology, 116*, 213-218.

Ukpebor, J. E., & Halsall, C. J. 2012. Effects of dissolved water constituents on the photodegradation of fenitrothion and diazinon. *Water Air Soil Pollut, 223*, 655-666.

USDA. 2012. *Runoff-Frequency: Peaks, Volumes, Timing for Low-Relief, Sandy "Cranberry Bog" Drainage Areas of Southeastern Massachusetts and Rhode Island"*. Technical Note No. 301. September 2012. National Resources Conservation Service. United States Department of Agriculture. Available at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1101082.pdf (Accessed February 13, 2015).

USDA. 2013. Pesticide Data Program. U.S. Department of Agriculture. Agricultural Marketing Service. Available at http://www.ams.usda.gov/datasets/pdp (Accessed November 13, 2015).

USEPA. 1998. *An Index Reservoir for Use in Assessing Drinking Water Exposure. Proposed Methods for Basin-scale Estimation of Pesticide Concentrations in Flowing Water and Reservoirs for Tolerance Reassessment.* J.-. Presentation to FIFRA Science Advisory Panel, 1998., .

USEPA. 2000.D270838. *Diazinon: Revised HED Human Health Risk Assessment for the Reregistration Eligibility Decision (RED) D270838.* D270838. Memorandum From D. Drew, J. Doherty & D. Smegal to B. Chambliss. December 5, 2000. Health Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2000.D154949, D159643, D183157. *Environmental Fate and Effects Division Revised Science Chapter for the Diazinon Reregistration Eligibility Decision Document*. November 16, 2000. Environmental Fate and Effect Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2002.D183157. *Final Revised Environmental Fate and Ecological Risk Assessment Chapter for the Reregistration Eligibility Decision on Diazinon*. February 20, 2002. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2002. *Organophosphate Pesticides: Revised Cumulative Risk Assessment*. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/pesticides/cumulative/rra-op/ (Accessed February 28, 2015).

USEPA. 2004. *Interim Reregistration Eligibility Decision for Diazinon. Case No. 0238*. E. 738-R-04-006. May 2004. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://archive.epa.gov/pesticides/reregistration/web/pdf/diazinon_ired.pdf (Accessed November 13, 2015).

USEPA. 2006. *(P)RZM (E)XAMs Model Shell, Version 5.0*. November 15, 2006. Environmental Fate and Effects Division. Office of Pesticide Programs. Office of Chemical Safety and Pollution Prevention. United States Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/pe5_user_manual.htm (Accessed April 18, 2013).

USEPA. 2008. *White paper on Methods for Assessing Ecological Risks of Pesticides with Persistent, Bioaccumulative, and Toxic Characteristics*. In Submitted to the FIFRA Scientific Advisory Panel for Review and Comment (Ed.), *October 7, 2008*. Washington, D.C. Available at http://www.epa.gov/scipoly/SAP/meetings/2008/october/sap_pbt_whitepaper_final_Oct_7_08d.pdf (Accessed January 27, 2010).

USEPA. 2009a. *2006 Community Water System Survey Volume II: Detailed Tables and Survey Methodology*. E. 815-R-09-002. May 2009. Office of Water. U.S. Environmental Protection Agency.

USEPA. 2009b. *SAP Minutes No. 2009-01. A set of Scientific Issues Being Considered by the Environmental Protection Agency Regarding: Selected Issues Associated with the Risk Assessment Process for Pesticides with Persistent, Bioaccumulative, and Toxic Characteristics. October 28-31, 2008., January 29, 2009*. Available at http://www.epa.gov/scipoly/sap/meetings/2008/102808_mtg.htm (Accessed July 9, 2009).

USEPA. 2009c. *User's Guide and Technical Documentation KABAM version 1.0 (KOW (based) Aquatic BioAccumulation Model)*. April 7, 2009. Environmental Fate and Effects Division. Office of Pesticide Programs. Available at http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/kabam-version-10-users-guide-and-technical (Accessed November 13, 2015).

USEPA. 2010a. *Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in the Problem Formulation for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments*. January 25, 2010. Environmental Fate and Effects Division. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency. Available at http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm (Accessed July 5, 2012).

USEPA. 2010b. *Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in the Problem Formulation for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments, January 25, 2010.*

USEPA. 2010c. *Guidance on Development and Use of the Index Reservoir in Drinking Water Exposure Assessments*. September 14, 2010. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/index_reservoir_dwa.pdf (Accessed December 9, 2010).

USEPA. 2012a. *Criteria Used by the PBT Profiler*. September 4, 2012. Office of Chemical Safety and Pollution Prevention. United States Environmental Protection Agency. Available at http://www.pbtprofiler.net/criteria.asp (Accessed September 7, 2012).

USEPA. 2012.D391431. *Fenpyroximate: Drinking Water Exposure Assessment for Proposed New Uses on Snap Beans and Tropical Fruits including Avocado and a Proposed Outdoor Use on Cucumbers*. D391431. Memorandum From G. Orrick to G. Kramer & S. Jackson. Environmental Fate and Effects Division. Office of Pesticide Programs. United States Environmental Protection Agency.

USEPA. 2012b. *Risks of Diazinon Use to Federally Threatened Delta Smelt (Hypomesus transpacificus) and the Federally Endangered Tidewater Goby (Eucyclogobius newberryi)*. March 28, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www3.epa.gov/pesticides/endanger/litstatus/effects/bss-diazinon-assessment.pdf (Accessed November 6, 2015).

USEPA. 2012c. *Standard Operating Procedure for Using the NAFTA Guidance to Calculate Representative Half-life Values and Characterizing Pesticide Degradation*. November 30, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-calculate-representative-half-life-values (Accessed November 13, 2015).

USEPA. 2012.D405064. *Tier I Drinking Water Exposure Assessment for the Section 3 New Use of Boscalid on Various Agricultural Crops Including Cranberries*. D405064. Memorandum From K. White to S. Funk, B. O'Keefe, A. Ertman & B. Madden. November 27, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency.

USEPA. 2013. *Guidance on Modeling Offsite Deposition of Pesticides Via Spray Drift for Ecological and Drinking Water Assessment*. Environmental Fate and Effects Division. Office of Pesticide Programs. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency. Available at http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OPP-2013-0676 (Accessed April 11, 2014).

USEPA. 2014a. *Development of Community Water System Drinking Water Intake Percent Cropped Area Adjustment Factors for use in Drinking Water Exposure Assessments: 2014 Update*. 9/9/14. Environmental Fate and Effects Division. Office of Chemical Safety and Pollution Prevention. U.S. Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/Development_and_Use_of_Community_Water_System.pdf (Accessed February 9, 2014).

USEPA. 2014b. Estimation Program Interface (EPI) Suite: United States Environmental Protection Agency. Available at https://www.epa.gov/tsca-screening-tools/download-epi-suitetm-estimation-program-interface-v411 (Accessed May 15, 2016).

USEPA. 2014c. *Screening Level Estimates of Agricultural Uses of Diazinon (Reporting Years 2004-2012)*. Memorandum From C. Paisley-Jones to K. Nguyen. April 18, 2014. Bioloigical and Economic Analysis Division. Office of Pesticide Programs. U.S. Environmental Protection Agency.

USEPA. 2015a. Storet Data Warehouse. U.S. Environmental Protection Agency. Available at http://www.epa.gov/storet/dw_home.html (Accessed January 15, 2015).

USEPA. 2015b. *Storet/WQX Data Warehouse*. United States Environmental Protectin Agency. Available at http://www.epa.gov/storet/dw_home.html (Accessed January 15, 2015).

USEPA, & Health Canada. 2013. *Guidance for Selecting Input Parameters for Modeling Pesticide Concentrations in Groundwater Using the Pesticide Root Zone Model*. Version 1. October 15, 2012. Environmental Fate and Effects Division. Office of Pesticide Programs. U.S. Environmental Protection Agency. Available at http://www.epa.gov/oppefed1/models/water/przm_gw/wqtt_przm_gw_input_guidance.htm (Accessed February 28, 2013).

USGS. 2011. *Trends in Pesticide Concentrations in Urban Streams in the United States, 1992-2008*. Scientific Investigation Report 2010-5139. National Water Quality Assessment Program. United States Geological Survey. United States Department of the Interior. Available at http://pubs.usgs.gov/sir/2010/5139/pdf/sir2010-5139.pdf (Accessed February 2, 2012).

USGS. 2015a. National Water-Quality Assessment Program. U.S. Geological Survey. Available at http://water.usgs.gov/nawqa/ (Accessed February 15, 2015).

USGS. 2015b. National Water-Quality Assessment Program (NAWQA). U.S. Geological Survey. Available at http://water.usgs.gov/nawqa/ (Accessed January 15, 2015).

USNLM. 2014. TOXNET Toxicology Data Network. United States National Library of Medicine (USNLM). Available at http://toxnet.nlm.nih.gov/ (Accessed August 5, 2014).

Washington State Department of Ecology. 2015. *http://www.ecy.wa.gov/eim/index.htm*. Washington State Department of Ecology. Available at http://www.ecy.wa.gov/eim/index.htm (Accessed February 23, 2015).

Williams, R. L. 1989. Thesis: *Uptake kinetics and toxicity of diazinon in the American oyster, Crassostrea virginica Gmelin. Ph.D. Thesis.* College of William and Mary.

Wu, J., Lan, C., & Chan, G. Y. S. 2009. Organophosphorus pesticide ozonation and formation of oxon intermediates. *Chemosphere, 76*, 1308-1314.

Zabik, J. M., & Seiber, J. N. 1993. Atmospheric transport of organophosphate pesticides from California's Central Valley to the Sierra Nevada Mountains. *Journal of Environmental Quality, 22*, 80-90.

Zamora, C., Kratzer, C. R., Majewski, M. S., & Knifong, D. L. 2003. *Diazinon and chlropyrifos loads precipitation and urban and agricultural runoff during January and February 2001 in the San Joaquin River Basin, California.* W. R. I. R. 03-4091. United States Geological Survey. Available at http://pubs.usgs.gov/wri/wri034091/wrir034091.pdf (Accessed February 17, 2015).

Zhang, Q., & Pehkonen, S. O. 1999. Oxidation of diazinon by aqueous chlorine: kinetics, mechanisms, and product studies. *J. Agric. Food Chem., 47*, 1760-1766.

Zhang, X., Starner, K., & Goh, K. S. 2012. Analysis of diazinon agricultural use in regions of frequent surface water detections in California, USA. *Bulletin of Environmental Contamination and Toxicology, 88*, 333-337.

Zhao, X., Hickey, R. F., & Voice, T. C. 1999. Long-term evaluation of adsorption capacity in a biological activated carbon fluidized bed reactor system. *Water Research, 33*(13).

Appendix E. Selected Modeling Output

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                SCIGROW
               VERSION 2.3
     ENVIRONMENTAL FATE AND EFFECTS DIVISION
        OFFICE OF PESTICIDE PROGRAMS
      U.S. ENVIRONMENTAL PROTECTION AGENCY
            SCREENING MODEL
        FOR AQUATIC PESTICIDE EXPOSURE

SciGrow version 2.3
chemical:DiazinoN
time is  9/ 8/2014  16:22:12
-----------------------------------------------------------------------
 Application     Number of      Total Use    Koc      Soil Aerobic
 rate (lb/acre)  applications   (lb/acre/yr)  (ml/g)   metabolism (days)
-----------------------------------------------------------------------
    3.000          3.0          9.000     2.18E+03      56.0
-----------------------------------------------------------------------
groundwater screening cond (ppb) =   2.51E-01
***********************************************************************

SciGrow version 2.3
chemical:DiazinoN
time is  9/ 8/2014  16:24:16
-----------------------------------------------------------------------
 Application     Number of      Total Use    Koc      Soil Aerobic
 rate (lb/acre)  applications   (lb/acre/yr)  (ml/g)   metabolism (days)
-----------------------------------------------------------------------
    5.000         12.0         60.000     2.18E+03      56.0
-----------------------------------------------------------------------
groundwater screening cond (ppb) =   1.68E+00
***********************************************************************
```

Groundwater Analysis for Diazinon and the Wisconsin Corn - WI Central Sands Scenario

Estimated groundwater concentrations and breakthrough times for Enter chemical name or descriptive information. are presented in Table 1 for the Wisconsin Corn - WI Central Sands groundwater scenario. A graphical presentation of the daily concentrations in the aquifer is presented in Figure 1. These values were generated with the PRZM-GW (Version 1.07). Critical input values for the model are summarized in Tables 2 and 3.

Table 1. Groundwater Results for Enter chemical name or descriptive information. and the Wisconsin Corn - WI Central Sands Scenario.

Peak Concentration (ppb)	9.14
Post-Breakthrough Mean Concentration (ppb)	6.66
Entire Simulation Mean Concentration (ppb)	5.01

Average Breakthrough Time (days)	13399.95
Throughputs	2.698666

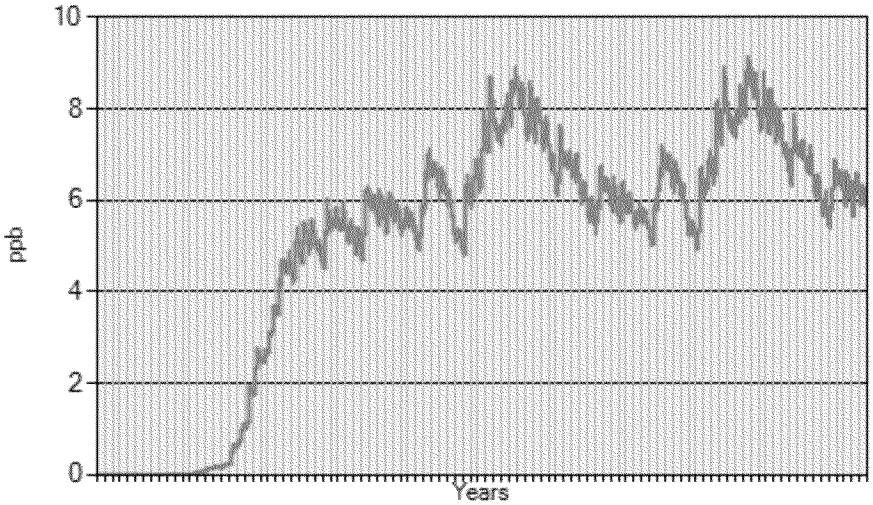
Table 2. Chemical Properties for Groundwater Modeling of Enter chemical name or descriptive information..

Koc (ml/g)	824
Surface Soil Half Life (days)	155
Hydrolysis Half Life (days)	82.3
Diffusion Coefficint Air (cm2/day)	0.0
Henry's Constant	0.0
Enthalpy (kcal/mol)	0.0

Table 3. Pesticide application scheme used for Enter chemical name or descriptive information.. This application scheme was applied every year of the simulation.

Application Days Relative to Emergence Date (05/01)	Application Method	Application Rate (kg/ha)
30	Above canopy application	11.2
44	Above canopy application	11.2
58	Above canopy application	11.2
72	Above canopy application	11.2
86	Above canopy application	11.2
100	Above canopy application	11.2

Figure 1. Aquifer Breakthrough Curve for Enter chemical name or descriptive information. and the Wisconsin Corn - WI Central Sands Scenario



Groundwater Analysis for Diazinon and the Florida Citrus - FL Central Ridge, Polk County - (Tampa) Met File (12842.Dvf) - Astatula Sand, Hrgb A Scenario

Estimated groundwater concentrations and breakthrough times for Diazinon are presented in Table 1 for the Florida Citrus - FL Central Ridge, Polk County - (Tampa) Met File (12842.dvf) - Astatula sand, hrgb A groundwater scenario. A graphical presentation of the daily concentrations in the aquifer is presented in Figure 1. These values were generated with the PRZM-GW (Version 1.07). Critical input values for the model are summarized in Tables 2 and 3.

Table 1. Groundwater Results for Enter diazinon the Florida Citrus - FL Central Ridge, Polk County - (Tampa) Met File (12842.dvf) - Astatula sand, hrgb A Scenario.

Peak Concentration (ppb)	54.9
Post-Breakthrough Mean Concentration (ppb)	39.5
Entire Simulation Mean Concentration (ppb)	24.4
Average Breakthrough Time (days)	9009.154
Throughputs	1.21654

Table 2. Chemical Properties for Groundwater Modeling of Enter diazinon.

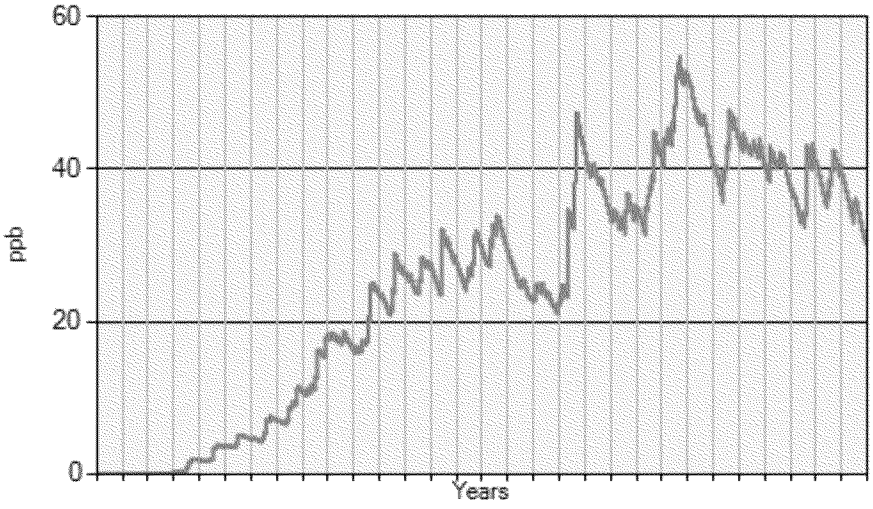
Koc (ml/g)	824
Surface Soil Half Life (days)	155
Hydrolysis Half Life (days)	82.3
Diffusion Coefficint Air (cm2/day)	0.0

Henry's Constant	0.0
Enthalpy (kcal/mol)	0.0

Table 3. Pesticide application scheme used for diazinon. This application scheme was applied every year of the simulation.

Application Days Relative to Emergence Date (01/01)	Application Method	Application Rate (kg/ha)
30	Above canopy application	5.6
44	Above canopy application	5.6
58	Above canopy application	5.6
72	Above canopy application	5.6
86	Above canopy application	5.6
100	Above canopy application	5.6
114	Above canopy application	5.6
128	Above canopy application	5.6
142	Above canopy application	5.6
156	Above canopy application	5.6
170	Above canopy application	5.6
184	Above canopy application	5.6

Figure 1. Aquifer Breakthrough Curve for Enter chemical name or descriptive information. and the Florida Citrus - FL Central Ridge, Polk County - (Tampa) Met File (12842.Dvf) - Astatula Sand, Hrgb A Scenario



Summary of Water Modeling of Diazinon and the USEPA Standard Reservoir

Apple

Estimated Environmental Concentrations for Diazinon are presented in Table 1 for the USEPA standard reservoir with the PAappleSTD_V2 field scenario. A graphical presentation of the year-to-year peaks is presented in Figure 1. These values were generated with the Surface Water Concentration Calculator (SWCC Version 1.106). Critical input values for the model are summarized in Tables 2 and 3.

This model estimates that about 1% of Diazinon applied to the field eventually reaches the water body. The main mechanism of transport from the field to the water body is by runoff (72.3% of the total transport), followed by spray drift (20.1%) and erosion (7.6%).

In the water body, pesticide dissipates with an effective water column half-life of 23.4 days. (This value does not include dissipation by transport to the benthic region; it includes only processes that result in removal of pesticide from the complete system.) The main source of dissipation in the water column is metabolism (effective average half-life = 27.8 days) followed by washout (178.9 days) and volatilization (933 days).

In the benthic region, pesticide dissipates slowly (109.3 days). The main source of dissipation in the benthic region is metabolism (effective average half-life = 109.3 days). The vast majority of the pesticide in the benthic region (98.89%) is sorbed to sediment rather than in the pore water.

Table 1. Estimated Environmental Concentrations (ppb) for Diazinon.

Peak (1-in-10 yr)	110.
4-day Avg (1-in-10 yr)	97.9
21-day Avg (1-in-10 yr)	65.8
60-day Avg (1-in-10 yr)	36.6
365-day Avg (1-in-10 yr)	8.85
Entire Simulation Mean	4.25

Table 2. Summary of Model Inputs for Diazinon.

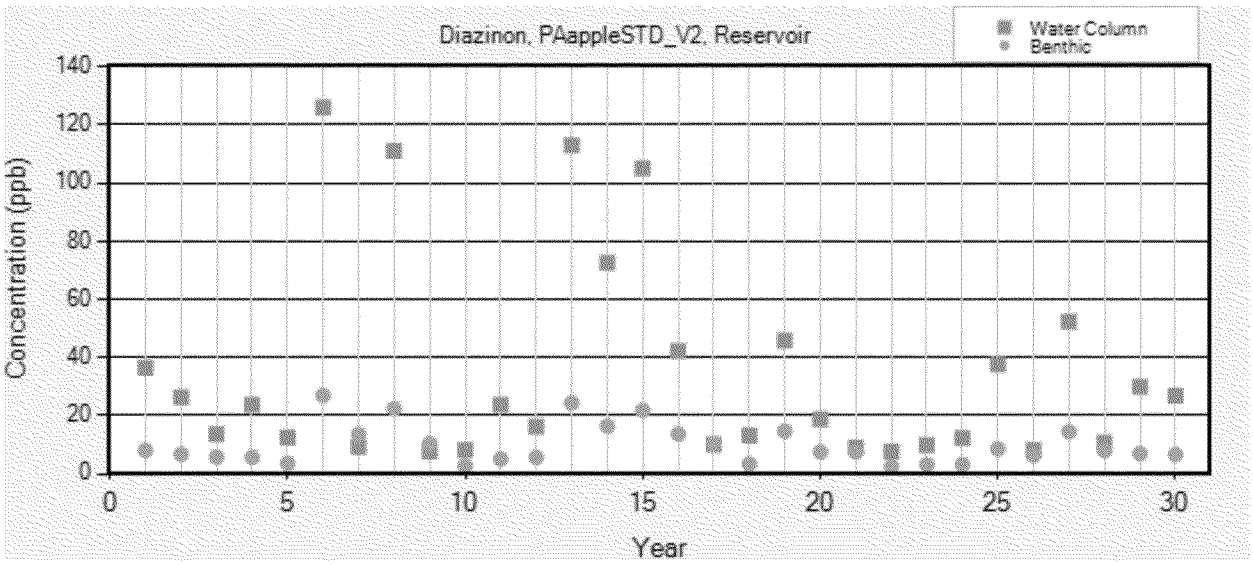
Scenario	PAappleSTD_V2
Cropped Area Fraction	1.0
Koc (ml/g)	824
Water Half-Life (days) @ 25 °C	13.2
Benthic Half-Life (days) @ 20 °C	73.5
Photolysis Half-Life (days) @ 40 °Lat	0
Hydrolysis Half-Life (days)	0

Soil Half-Life (days) @ 20 °C	34
Foliar Half-Life (days)	0
Molecular Wt	304.35
Vapor Pressure (torr)	7.22e-5
Solubility (mg/l)	65.5

Table 3. Application Schedule for Diazinon.

Date (Mon/Day)	Type	Amount (kg/ha)	Eff.	Drift
8/15	Foliar	2.24	0.99	0.066
8/29	Foliar	2.24	0.99	0.066

Figure 1. Yearly Peak Concentrations



Summary of Water Modeling of Diazinon and the USEPA Standard Reservoir

Melon

Estimated Environmental Concentrations for Diazinon are presented in Table 1 for the USEPA standard reservoir with the FLcucumberSTD field scenario. A graphical presentation of the year-to-year peaks is presented in Figure 1. These values were generated with the Surface Water Concentration Calculator (SWCC Version 1.106). Critical input values for the model are summarized in Tables 2 and 3.

This model estimates that about 1.6% of Diazinon applied to the field eventually reaches the water body. The main mechanism of transport from the field to the water body is by runoff (86.3% of the total transport), followed by spray drift (12.9%) and erosion (0.74%).

In the water body, pesticide dissipates with an effective water column half-life of 10.0 days. (This value does not include dissipation by transport to the benthic region; it includes only processes that result in removal of pesticide from the complete system.) The main source of dissipation in the water column is metabolism (effective average half-life = 14.2 days) followed by washout (36.1 days) and volatilization (642.2 days).
In the benthic region, pesticide dissipates (55.9 days). The main source of dissipation in the benthic region is metabolism (effective average half-life = 55.9 days). The vast majority of the pesticide in the benthic region (98.89%) is sorbed to sediment rather than in the pore water.

Table 1. Estimated Environmental Concentrations (ppb) for Diazinon.

Peak (1-in-10 yr)	119.
4-day Avg (1-in-10 yr)	104.
21-day Avg (1-in-10 yr)	62.9
60-day Avg (1-in-10 yr)	35.8
365-day Avg (1-in-10 yr)	7.09
Entire Simulation Mean	3.56

Table 2. Summary of Model Inputs for Diazinon.

Scenario	FLcucumberSTD
Cropped Area Fraction	1.0
Koc (ml/g)	824
Water Half-Life (days) @ 25 °C	13.2
Benthic Half-Life (days) @ 20 °C	73.5
Photolysis Half-Life (days) @ 40 °Lat	0
Hydrolysis Half-Life (days)	0
Soil Half-Life (days) @ 20 °C	34
Foliar Half-Life (days)	0
Molecular Wt	304.35
Vapor Pressure (torr)	7.22e-5
Solubility (mg/l)	65.5

Table 3. Application Schedule for Diazinon.

Date (Days Since Emergence)	Type	Amount (kg/ha)	Eff.	Drift
-14	Incorporated to 5.08 cm	4.5	0.99	0.066
15	Foliar	0.84	0.99	0.066

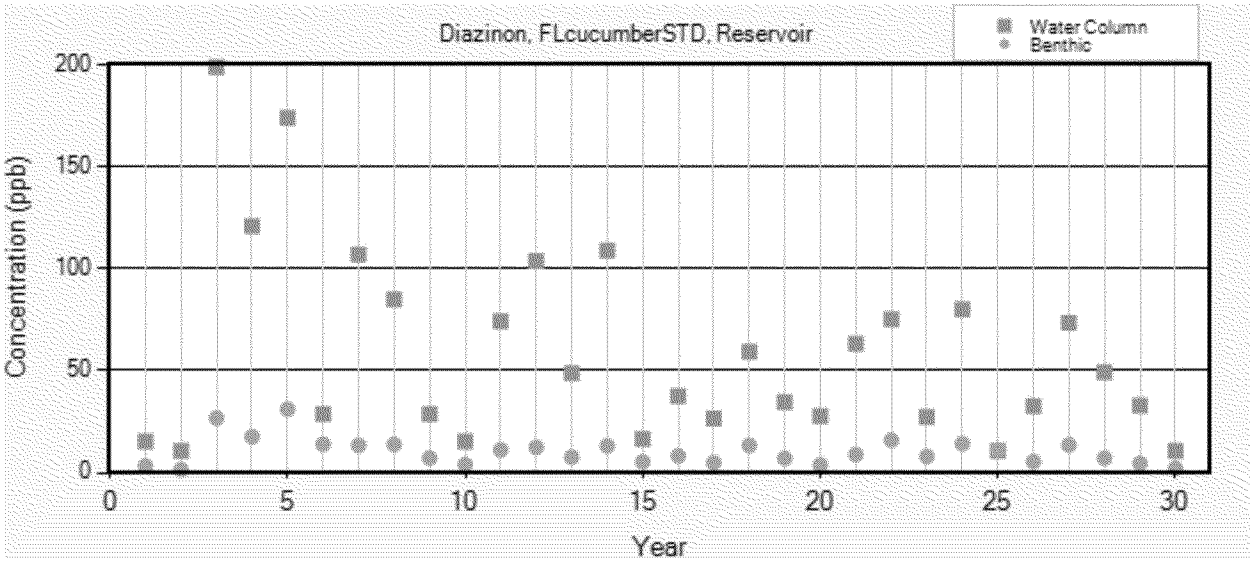



Figure 1. Yearly Peak Concentrations