PREVENTING OFF-SITE MOVEMENT OF PESTICIDES IN ALFALFA AND CORN

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ABSTRACT

A significant number of California surface water bodies suffer water quality degradation as a result of contamination from agricultural chemical residues. Residues reach water bodies through spray drift and through irrigation runoff and stormwater runoff. The California Regional Water Quality Board through the Irrigated Lands Regulatory Program has tasked the Water Quality Coalitions (made up of and funded by grower members) with addressing these issues. The coalitions monitor and analyze the water quality of sub-watersheds and facilitate the implementation of management plans. They provide outreach and support to growers in response to water quality exceedances at sub-watershed monitoring sites, in order to enhance the water quality of those water bodies. Alfalfa and corn are by in large surface irrigated crops which, depending on the site and management practices, significantly contribute via each of these pollution pathways. The person determining the need for or applying the pesticide has the responsibility to ensure pesticide residues do not enter surface waters. Before an agricultural chemical application, the risk that surface water may be impacted must be evaluated. If a risk is determined to exist, management practices should be considered to mitigate the risk. Mitigation practices include using integrated pest management practices, proper mixing and handling practices, and selecting a reduced risk product. If these steps are inadequate, cultural practices including irrigation management, improving water infiltration, or capturing and recycling runoff, or treating the runoff waters should be considered.

Key Words: alfalfa, corn, pesticide residues, water quality, management practices

INTRODUCTION

The Central Valley occupies about 40 percent of the land area in California and provides much of the State's agricultural production. Maintaining this productivity has required the use of about 132 million pounds of pesticides annually. Water quality in the Valley's rivers and streams has suffered as a result of pesticide movement from agricultural lands into these waters. The list of impaired water bodies recently proposed for listing under Clean Water Act Section 303(d) includes nearly a hundred water body segments in which the impairment is due to agriculture. Agriculture is identified more often than any other source in the State as the likely cause of impairment.

Agricultural pesticides reach surface water bodies directly as spray drift or indirectly through stormwater runoff or irrigation runoff from treated fields, vineyards, and orchards. Runoff waters may transport pesticides as dissolved or soil particle-adhering residues. Approximately

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half of the hundred 303(d) listed water body segments impaired due to agriculture in the Central Valley are impaired in whole or in part by highly water soluble organophosphate pesticides. Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. Synthetic pyrethroids are another group of pesticides emerging as a concern. Pyrethroids are a cause for 303(d) listing of about 10 percent of agriculture-impaired water bodies in California.

The continued use of these effective agricultural pesticides is dependent on measures to prevent offsite movement of residues into surface water sources. A listing of the active ingredients and trade names for pesticides commonly used in alfalfa production can be found in Table 1. The table is restricted to those materials with reported use in California during 2008 with use over 500 pounds. Organophosphates represent 78% of this list with chlorpyrifos, an organophosphate, being the highest use product.

Table 1. Alfalfa pesticides used in California, 2008.

Active Ingredient/Common Name	Trade Name(s)	Lbs/Year	Chemical Class
chlorpyrifos	Lorsban/Lock -On	187,460	organophosphate
malathion	Malathion	105,111	organophosphate
dimethoate	Dimethoate	53,167	organophosphate
indoxacarb	Steward	28,951	oxadiazine
naled	Dibrome	17,905	organophosphate
methomyl	Lannate	17,645	carbamate
methamidophos	Monitor	14,436	organophosphate
lambda-cyhalothrin	Warrior	10,957	pyrethroid
methidathion	Supracide	9,699	organophosphate
endosulfan	Thionex	9,017	organochlorine
methoxyfenozide	Intrepid	7,879	diacylhydrazine
carbofuran	Furadan	7,499	carbamate
bacillus thuringiensis	Dipel/Javelin	6,954	biological
formetanate hydrochloride	Carzol	6,489	carbamate
(s)-cypermethrin	Mustang	4,009	pyrethroid
permethrin	Permethrin	3,262	pyrethroid
beta-cyfluthrin	Baythroid	1,621	pyrethroid
bifenthrin	Capture	1,397	pyrethroid
oxydemeton-methyl	Metasystox-R	945	organophosphate
cyfluthrin	Baythroid	906	pyrethroid
carbaryl	Sevin	507	carbamate

Source: California Department of Pesticide Regulation

CURRENT REGULATORY APPROACH TO SURFACE WATER PROTECTION

All growers farm under the requirement not to pollute surface and groundwater. Water leaving agricultural lands as irrigation or stormwater runoff can contain pesticide residues, sediment, or nutrients. These discharges are regulated by the Central Valley Regional Water Quality

Control Board (Water Board) under a program called the Irrigated Lands Regulatory Program. Essentially, the Board is enforcing the California Water Code of 1969 (CWC) and the Federal Clean Water Act of 1972. To this end the Board has:

- Established surface water quality standards in each watershed basin plan
- Enforced waste discharge requirements

THE AG WAIVER

In 1982 the Board adopted a resolution "*Waiving Waste Discharge Requirements for Specific Types of Discharge.*" The resolution contained 23 categories of waste discharges, including *irrigation return flows and stormwater runoff* from agricultural lands. The resolution also listed the conditions required to comply with the waiver, hence the term '**Conditional Ag Waiver.**' However, due to a shortage of resources at the time, the Water Board did not impose measures to verify compliance with these conditions.

The waiver, set to sunset in 2003, was amended by adopting two conditional waivers for discharges from irrigated lands. **One** was for *coalition groups* of individual dischargers that comply with the California Water Code and Water Board. **The other** was for growers to comply as individual entities. To be covered by the waivers, the coalition or individual must have filed with the Water Board by November 1, 2003 a Notice of Intent and General Report that contained specific information about their farm, and then must have adhered to a plan and timeline that includes, among other things, a farm management plan and surface water monitoring plan.

WATER QUALITY COALITIONS

Water quality coalitions are generally formed by growers on a sub-watershed basis, although some are based on a specific commodity. The San Joaquin County and Delta Water Quality Coalition, for example, encompasses all of San Joaquin County and portions of Contra Costa and Calaveras Counties. The coalition includes about 500,000 acres of irrigated lands and 4500 individual members. The coalition monitors and analyzes the water quality of sub-watersheds and facilitates the implementation of management plans. They provide outreach and support to growers in response to water quality exceedances at sub-watershed monitoring sites, in order to enhance the water quality of those water bodies.

Water Quality Monitoring. The coalition currently monitors water quality at numerous sites in both large and small sub-watersheds within the coalition watershed. Water samples are collected monthly, and sediment samples are collected twice per year. During 2008, water quality standards were exceeded many times. At some locations, as many as 40 percent of the samples exceeded water quality standards for pesticide residues (Management Plan, San Joaquin County Delta Water Quality Coalition, Karkoski 2008). When more than one exceedance of water quality limits occurs for any contaminant, a management plan must be developed by the coalition to address it. In addition, any single exceedance of either chlorpyrifos or diazinon triggers the requirement for a management plan.

Management Plans. The overall goal of water quality management plans, whether developed by individuals or coalition groups, is to reduce agricultural impacts on water quality in the plan

area. Management plans evaluate the frequency and magnitude of exceedances and prioritizes locations for outreach.

To achieve the goal of improving water quality, a management plan must include:

- Source identification of constituents causing poor water quality
- Outreach to growers about irrigation and dormant season management practices
- Evaluation of water quality improvements achieved by monitoring and management practices

Under the management plan landowners/growers must:

- Help the coalition succeed by participating in efforts to solve problems identified through water monitoring
- Staying informed – read mailings and updates, respond as necessary
- Attending grower water-quality information meetings
- Implementing management practices that address the identified water quality concerns

HOW CAN WE REDUCE THE RISK TO SURFACE WATERS?

The first step is to make a "risk assessment" of field conditions or operations to identify those that may increase the risk of offsite pesticide movement. Residues can reach water bodies through spray drift and through irrigation runoff and stormwater runoff. Once avenues of possible pesticide movement from a particular field are identified, it is necessary to "zero in" on specific conditions and operations that can be addressed to reduce offsite movement.

The second step is to understand and implement management practices to address the problem areas that were identified.

Use Integrated Pest Management (IPM) Approaches, Handle and Apply Pesticides Correctly. Integrated Pest Management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used **only** after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Coupling use of IPM techniques with proper pesticide selection, handling, and application can go a long way towards preventing offsite movement and protecting water quality.

These practices should be the foundation of any water quality protection program. Implementing at least some of them can reduce risks to human health, beneficial and non-target organisms, and the environment.

Select Pesticides to Reduce Water Quality Risks. Knowledge of how pesticides move and degrade in the environment is useful for product selection. Pesticides and pesticide residues can move along several different pathways, depending on properties of the pesticide, the application method, and conditions at the application site. This movement is a complex process and, combined with several other factors, influences a pesticide's fate and potential water quality

impacts. From a surface water management perspective, keeping the pesticide on or in the soil by preventing runoff is the most desirable option. Alfalfa and corn pesticide active ingredients vary in water solubility, soil adsorption and half-life. Pesticides with high water solubility can move directly in runoff waters while those adsorbed to soil sediments move with the sediment. Half-life of a pesticide is an indication of the persistence in the environment, usually the number of days it takes for the chemical to degrade to one-half strength. USDA-NRCS developed a model that determines a pesticide's tendency to move in dissolved form with water or adsorbed to the soil particles. Aquatic toxicity rankings can be extracted from the US EPA AQUIRE database. The toxicity for the most sensitive indicator species can then be used to rank the overall aquatic toxicity (Long et al. 2005). In ANR publication 8161, Long categorized the potential to move offsite, either in solution or with the soil, as high, intermediate, and low. The overall likelihood to cause negative impact (risk) on surface water quality is a product of the runoff potential and the aquatic toxicity of the pesticide. Table 2 indicates this relationship for commonly used alfalfa insecticides. The table can be used to select pesticides based on the risk of offsite movement.

Table 2. California-registered alfalfa insecticides and their potential to move in solution or as adsorbed particles and overall pesticide runoff risk.

Insecticide Active Ingredient (common name)	**Trade Name**	**Chemical Class**	**Solution Runoff Potential[1]**	**Adsorption Runoff Potential[2]**	**Overall Runoff Risk[3]**
chlorpyrifos	Lorsban/ Lock-On	organophosphate	high	intermediate	very high
endosulfan	Thionex	organochlorine	high	high	very high
bifenthrin	Capture	pyrethroid	low	high	high
cyfluthrin	Baythroid	pyrethroid	low	intermediate	high
cypermethirn	Mustang	pyrethroid	low	high	high
bifenthrin	Capture	pyrethroid	low	high	high
esfenvalerate	Asana	pyrethroid	low	high	high
lambda-cyhalothrin	Warrior	pyrethroid	low	intermediate	high
permethrin	Permethrin	pyrethroid	low	high	high
carbaryl	Sevin	carbamate	intermediate	low	moderate
methidathion	Supricide	organophosphate	intermediate	low	moderate
malathion	Malathion	organophosphate	intermediate	low	moderate
methomyl	Lannate	carbamate	intermediate	low	moderate
carbofuran	Furadan	carbamate	low	intermediate	moderate
dimethoate	Dimethoate	organophosphate	low	low	low
naled	Dibrome	organophosphate	low	low	low
oxydemeton-methyl	Metasystox-R	organophosphate	low	low	low
methamidophos	Monitor	organophosphate	low	low	low
Bacillis thuringiensis	Dipel/Javelin	biological	low	low	low
spinosad	Success	spinosyn	intermediate	intermediate	low
methoxyfenozide	Intrepid	diacylhydrazine	high	intermediate	low
chlorantraniliprole	Coragen	diamide	low	high	
indoxacarb	Steward	oxadiazine	low	intermediate	

[1] Likelihood that the active ingredient will transport from the area of treatment as dissolved chemical in runoff.
[2] Likelihood that the active ingredient will transport from the area of treatment as attachment to soil or sediment particles in runoff.

[3] Overall likelihood to cause negative impact on surface water quality as a product of the runoff potential and the aquatic toxicity of the pesticide
Source**:** Pesticide Choice: Best Management Practice for Protecting Surface Water Quality in Agriculture, Long et al. 2005, UCANR Publication 8161, http://anrcatalog.ucdavis.edu/pdf/8161.pdf

Use Soil and Water Management Practices. Use soil and water management practices that reduce runoff potential. Runoff occurs when using surface irrigation or when rainfall occurs faster than it can enter the soil. Runoff water can carry pesticides in the water itself or adsorbed to eroding soil particles. Proper irrigation method selection, design, and operation, coupled with water treatments that maximize water infiltration, help ensure that the water needs will be met and runoff kept at a minimum.

Capture, Recycle or Treat Runoff Waters. When IPM and soil and water management do not adequately address a water quality problem, techniques for physically intercepting, recycling, or chemically treating runoff water can be used to reduce offsite transport of water-borne pesticides.

Minimizing Spray Drift. Drift is the physical movement of pesticide droplets or particles through the air at the time of pesticide application or soon thereafter, from the target site to any non- or off-target site. Drift can impact surface water quality through direct contact with open ditches or surface water adjacent to the treated field.
Spray drift can be mitigated by management practices to reduce off-target drift. Application practices that take weather and other site conditions into consideration, appropriately equipped delivery systems (low-drift nozzles), appropriate product choice (low vapor pressure, low water solubility), and the use of buffer zones can significantly reduce the risk of offsite movement of pesticides.

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Prichard, T.L., W. M. Canevari, and L. J. Schwankl. 2011. Controlling offsite movement of agricultural chemical residues – alfalfa. ANR publication—submitted.