A Work Plan for Assessing Watershed Processes of Pesticide Movement into Surface Water Using Modeling

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Introduction

The widespread contamination of pesticides in the State's surface water bodies, as evidenced by the surface water-monitoring database compiled by the Department of Pesticide Regulation (DPR), has prompted an urgent need for DPR to understand and assess watershed processes that lead to pesticide transport into surface water. This need is further heightened by the recent requirement of US Environmental Protection Agency (EPA) for California, as well as other states, to establish "total maximum daily loads" or TMDLs for impaired, polluted surface water bodies so that they can get cleaned up and comply with applicable water quality objectives. As the state lead agency for pesticide regulation, DPR is expected to initiate surface water protection programs to prevent and mitigate degradation of surface water quality by pesticides, and provide expert advice to other agencies on the development of TMDLs for pesticides. These responsibilities require DPR to possess a fundamental knowledge of pesticide processes at the field and watershed scales, and the capability of predicting pesticide fate and transport and assessing pesticide impacts on surface water quality under a wide range of probable environmental conditions.

The primary approach that DPR uses to assess surface water conditions of pesticide contamination is by field investigation. This approach relies directly on environmental

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Abbreviation: PRZM - Pesticide Root Zone Model; EXAMS - Exposure Analysis Modeling System; GLEAMS - Groundwater Loading Effects of Agricultural Management Systems; AGNPS - Agricultural Nonpoint Source Pollution Model; SWAT - Soil and Water Assessment Tool; BASINS- Better Assessment Science Integrating Point and Nonpoint Sources; SPARROW – Spatially Referenced Regressions On Watershed Attributes.

sampling, and thus is typically resource intensive and time consuming. In addition, field monitoring results are specific to the environmental conditions occurring during monitoring. It is, therefore, difficult or may be improper to extrapolate such results to other relevant conditions. Due to these limitations of the field approach, in recent years, the use of computer modeling to assess pesticide fate and transport has become increasingly popular in the scientific community, industry, and government agencies. Computer modeling involves abstract calculations built upon governing scientific principles and/or established empirical relationships, and is capable of predicting pesticide transport under a host of prescribed conditions. Although model predictions do not always conform to field observations due to reasons related to limitations of model representation and/or field variability, modeling presents a concise and straightforward framework that integrates the current scientific understanding and hypotheses regarding transport processes, and thus offers an alternative approach useful to the study of complex pesticide transport problems when the field method is prohibitive or insufficient.

At present DPR has only limited capability in computer modeling for surface water assessment with respect to pesticide transport. In this work plan, we propose to expand DPR's expertise in surface water assessment. Such an effort would enhance DPR's capability of making regulatory decisions in surface water protection on a sound scientific basis, and enable DPR to participate effectively dialogues with other agencies on issues of TMDLs, toxicity control, remediation strategies, etc. This document describes, as a first step, activities to be taken towards this effort, the product to be delivered, and a timetable. It is expected that this research will allow us to build upon our current inventory of field investigations to explore watershed processes controlling pesticide movement, and to derive additional information and understanding that may lead to practical solutions to problems of surface water contamination by pesticides.

Objectives

Our ultimate goal is to build environmental modeling capacities to facilitate the evaluation and understanding of pesticide contamination of surface water and the linkage to watershed characteristics. Specific objectives of this project are 1) to assess major environmental models that have potential utility in surface water quality studies; and 2) to evaluate and compare the feasibility and limitations of these models in simulating runoff potential into surface water. In addition, a technical document presenting our understanding and viewpoints regarding these models will be prepared that will serve as a quick reference for staff with interest in modeling. In addition, future modeling studies using the real world data collected under varying hydrological, crop, and climatic conditions will also be proposed. These studies will provide important information on the temporal and spatial distribution of pesticides in the environment, a vital input needed for DPR to make its regulatory decisions.

Personnel

This study will be conducted by Environment Monitoring and Pest Management branch under the direction of Marshall Lee, Senior Environmental Research Scientist (Supervisor). Other key personnel will include:

Project Leader: Lei Guo
Senior Scientist: Frank Spurlock

Questions concerning this study should be directed to Marshall Lee at (916)-324-4269 or mlee@cdpr.ca.gov.

Study Plan

The study will consist of three integrated tasks as described below:

Task 1. Identification of Candidate Models

The major activities under this task will be a literature search and document review to identify potential candidate models for further evaluation under Task 2. The U.S. Environmental Protection Agency has no restrictions on the type of simulation models that may be used for studies in support of regulatory decisions. However there are certain models which have been more widely used than others, and consequently their advantages and disadvantages are better understood. These would be the models of our choice. Potential candidate models may include PRZM (Pesticide Root Zone Model), GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), EXAMS (Exposure Analysis Modeling System), SWAT (Soil and Water Assessment Tool), and BASINS (Better Assessment Science Integrating Point and Nonpoint Sources). These models are process-based, formulated to simulate pesticide processes at field and watershed scales. Besides the process-based models, models based on statistical regression such as SPARROW (Spatially Referenced Regressions on Watershed Attributes), will also be reviewed. Regression models, in contrast to process models, predict pesticide concentration based on historical monitoring data and known predictor variables.

Task 2. Model Performance Evaluation

The feasibility and reliability of the models selected in Task 1 will be evaluated by simulation experiments under a variety of simulation scenarios, which will include different combinations of soil/cover/weather/hydrology/landscape options. The purpose of Task 2 is to develop a full understanding of each model in terms of its intended use, assumptions, input requirements, limitations, as well as uncertainties, so that the most appropriate model can be selected for future modeling studies. Specific activities of this

task will include: 1) model installation and testing, 2) input data preparation, 3) model calibration (if applicable), and 4) sensitivity analysis.

Task 3. Report preparation

A technical report will be prepared from this study, summarizing the results of the model evaluation conducted in Task 2. The following aspects will be discussed for each model:

1. The scope of modeling and mechanisms,
2. Assumptions,
3. Ease of use and input data requirements,
4. The feasibility and limitations,
5. Uncertainties, and
6. Case studies.

The report is intended to provide a technical reference for DPR's scientists who have a modeling need. Models that are believed to be particularly applicable and relevant will be recommended for further study. Upon the Branch Chief's approval, a study protocol for modeling studies will be developed according to the guiding principles of good modeling practice.

Timetable

November 2000 – December 2000: Task 1
January 2001 – June 2001: Task 2
July 2001 – August 2001: Task 3