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**Study 317: Protocol to Use Soil and Water Assessment Tool (SWAT) to Assess Pesticide
Runoff from the Central California Coastal Watershed**

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1. Introduction

The Surface Water Protection Program (SWPP) has been relying on modeling tools for pesticide registration evaluation and post-use risk characterization. Linking pesticide use and associated risks in aquatic ecosystem, or “use-based modeling,” is a critical component of SWPP’s modeling efforts. The Surface Water Monitoring Prioritization Model (Luo, 2015) is an example of such efforts to prioritize pesticides based on use and toxicity data of pesticides at various spatial scales. However, a direct linkage between pesticide uses and in-stream concentrations has not been systematically investigated by SWPP. As such, the goal of this study is to develop a physically-based, spatially-distributed hydrologic/water quality model to establish the use-concentration relationship through field scale to watershed scale for large basins (e.g., 4-digit hydrologic unit code or HUC 4). The model will consist of various components, including pesticide application (urban and agricultural inputs), water management, overland runoff, drift, mitigation measures, and in-stream water quality routing. Features of the modeling system are highlighted below:

- (1) Generate temporal-spatial estimates of pesticide concentration in surface waters
- (2) Estimate efficacy of different mitigation measures
- (3) Identify hotspots of pesticide contamination in water bodies and inform monitoring
- (4) Identify critical sources of pesticide contamination in surface waters and inform regulation and mitigation
- (5) Evaluate the efficiency of regulation over time and space
- (6) Analyze the temporal-spatial distribution of pesticides of interest, such as pyrethroids, fipronil, and neonicotinoids

Monitoring studies of pesticide fate in surface waters offer only a snapshot of what occurs in the environment under a specific set of parameter combinations. The physically-based, spatially-distributed hydrologic/water quality modeling is often used to supplement the limited number of monitoring observations and achieve an overarching picture of variability at the temporal-spatial scale (Gali et al., 2016). The Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) is a prominent watershed-scaled model designated to estimate pesticide loads, transport, and fate in water bodies based on various physical and hydrological environments across large basins. The

SWAT model was originally developed by the US Department of Agriculture, Agricultural Research Service (USDA/ARS) and has been evolved into a continuous-time, process-based, spatially-distributed model that are widely used to evaluate the influence of land management on water, sediment, and agrochemical loads and movements to water bodies for large rural basins (Gassman et al., 2007). The SWAT model has been used as an integrated hydrological and water quality model. It has been tested for the ability to evaluate pesticide loads and fate in water bodies (Holvoet et al., 2005). Case studies based on SWAT model have been performed for several pesticides in certain hydrologic regions of California's Central Valley (Chen et al., 2017; Luo et al., 2008; Zhang and Zhang, 2011).

This study aims to develop a SWAT model for the Central California Coastal Watershed (CCCW, 4-digit HUC 1806). The model will simulate the hydrological processes based on the meteorological and spatial data (for example, hydrography, elevation, soil, and land use/land cover). For land management, the model will be configured to simulate pesticide applications and water management based on information collected in the Pesticide Use Report (PUR) and relevant data sources. Monitoring data for hydrology, sediment, and pesticide concentration will be used for model calibration and validation.

2. Objectives

- 2.1 Develop a physically-based, spatially-distributed model at a large watershed scale. A case study will be conducted for CCCW by using the SWAT model.
- 2.2 Model calibration and validation with monitoring data for hydrology, sediment, and water quality.
- 2.3 Model configuration for various applications, including (a) assessing the temporal-spatial baseline of pesticide contamination in surface waters of CCCW, (b) analyzing the modeling output to inform monitoring and regulation, and (c) evaluating the effectiveness of various mitigation measures.

3. Personnel

This study will be conducted by SWPP staff under the general direction of Nan Singhasemanon, Senior Environmental Scientist (Supervisory). Key personnel are listed below:

- Project Leader: Yina Xie, Ph.D.
- Reviewing Scientists: Yuzhou Luo, Ph.D., Xuyang Zhang, Ph.D.

Questions regarding this protocol should be directed to Yina Xie, Environmental Scientist, at 916-324-4111 or by email at Yina.Xie@cdpr.ca.gov.

4. Study Plan

4.1 Study site

There are a total of ten 4-digit HUC watersheds in California. This study will focus on the Central California Coastal Watershed (i.e., 1806 in Figure 1).

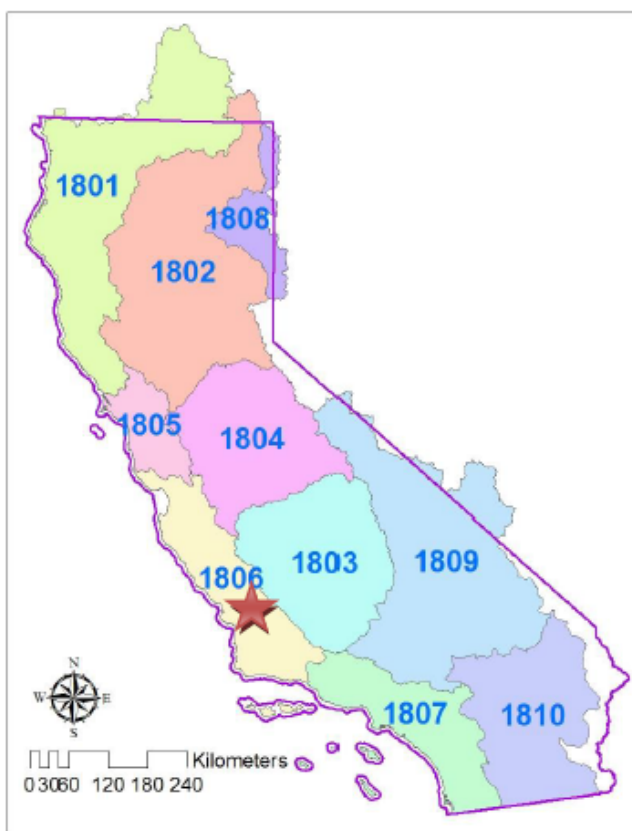


Figure 1: Four-digit HUC watersheds in California

4.2 Model development

The most current version of the SWAT model (ArcSWAT 2012.10.19) will be used for model development. In order to develop SWAT model for the study site, several spatial and tabulated databases will be examined and developed (Table 1). The model will be used to examine specific pesticides based on data availability and regulatory needs. Pesticide candidates could include pyrethroids, fipronil, and neonicotinoids. The watershed will be delineated and divided into sub-watersheds. The delineation is based on the National Hydrography Database (NHD) Watershed Boundary Dataset (WBD) with consideration of local information/survey and data availability (e.g., monitoring data available for model calibration). Both agricultural and urban pesticide uses will be examined. SWAT is a promising tool to simulate pesticide loading from agricultural areas; however, its capability of simulating pesticide loading from urban areas is not well tested yet. A case study will be conducted for model testing.

Table 1: Data examined for model development

Data	Type	Source
Elevation	Spatial	DEM 30m, 10m, 3m; LiDAR bare earth 1m
Land Use/Land Cover	Spatial	NLCD, Cropland Data Layer
Soil	Spatial	SSURGO, STATSGO
Hydrology	Spatial	NHD, WBD
	Tabulated	USGS NWIS
Meteorology	Spatial/Tabulated	CIMIS
Pesticide Application	Tabulated	PUR, Pesticide Sales Data

	Spatial	Field boundaries, Section boundaries
Water Management	Spatial/Tabulated	California Department of Water Resources
Sediment	Tabulated	USGS NWIS
Water Quality	Tabulated	SURF

4.3 Model calibration and validation

The proposed SWAT model will be run for a 15-year period, depending on data availability. The model run will cover dry, average, and wet years. The model will be calibrated and validated with monitoring data for hydrology, total suspended sediment (TSS), and pesticide concentrations. Sensitivity test will be performed to inform calibration. Output variables to be examined will include streamflow, TSS, pesticide loads, and pesticide concentrations. For the modeling of hydrophobic chemicals, such as pyrethroids, it is important to examine pesticide partitioning between water column and benthic region in the water body and output both the aqueous concentration and the concentration in bed sediment. The in-stream routing component of the SWAT model will be evaluated in terms of its capability of simulating pesticide partitioning and in-stream transport. Monitoring data used for model calibration and validation is subject to quality control screening, especially for pesticides with high reporting limits relative to their toxicity thresholds.

4.4 Model applications

The model will be configured for various applications. First, the model will be used to describe the temporal-spatial baseline of pesticide contamination in surface waters of the study watershed. Second, analysis on model outputs will be used to inform monitoring and regulation. For example, identification of hotspots of pesticide contamination in water bodies would inform sampling site selection. Similarly, estimation of the temporal-spatial variation in pesticide concentrations could be used to evaluate the efficacy of regulation and inform regulatory actions. Third, the model will be used to evaluate the effectiveness of different mitigation measures, for example, buffer zone, vegetative filter strip, grassed waterway, cover crops, etc. Specific models such as the Vegetative Filter Strip Modeling System (VFSMOD) (Munoz-Carpena and Parsons, 2004) will be incorporated.

5. Timelines and Expected Deliverables

The proposed study will last for two years (Table 2). The final deliverable will be a physically-based, spatially-distributed hydrologic/water quality model developed for the Central California Coastal Watershed.

Table 2: Study timelines

2017	2018				2019			
Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
I								
II								
	III							
					IV			
								V

Explanations:

- I. Protocol review and discussions
- II. Literature review, data collection and processing
- III. Model development, calibration, and validation; baseline analysis
- IV. Model configuration for evaluating mitigation measures
- V. Report write-up

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