3.0 Approach and Scope of Work

Methods and materials. Spatial and temporal patterns of pesticide loadings in both the Sacramento and San Joaquin watersheds will be predicted using field-scale simulation models (pollutant source models) including the Pesticide Root Zone Model (PRZM), the rice water quality model (RICEWQ), and the spray drift model, AgDRIFT . The models have been accepted for regulatory use in the U.S. and Europe and have the ability to address chemical mass balance on a spatial and temporal scale. Processes represented include: the distribution of pesticide residues during application on foliage, soil, and spray drift; adsorption to soil; uptake by plants; leaching through soil; and degradation in foliage, soil, and by different breakdown mechanisms (microbial degradation, photolysis, hydrolysis, and volatilization). Degradation processes include transformation of parent' compound to degradation products. A short synopsis of the recommended models follows:

- PRZM (Suarez, 2005) is the standard model used for ecological and drinking-water risk assessments for pesticides by the U.S. Environmental Protection Agency's Office of Pesticide Programs (USEPA, 2004). The model has undergone an extensive validation effort against numerous field-scale runoff and leaching studies conducted for pesticides in the United States (Jones and Russell 2001). The model has been integrated into watershed assessments in the U.S. (Parker et al., in press) and pesticide risk assessment procedures in Europe (FOCUS, 2005; FOCUS, 2004). Pesticide loading assessments in the Sacramento River watershed have also been conducted (SRWP, 2006; SRWP, 2004).

- RICEWQ (Williams et al., 1999) simulates pesticide mass balance and watermanagement practices in rice paddy environments. The model has been endorsed by the European community (Delmas et al., 2001) and has been validated with a number of field and watershed applications (Capri and Miao, 2002; Cheplick et al., 2002; Miao et al., 2003a; Miao et al., 2003b; Warren et al., 2004).

- AgDRIFTOO is a predictive tool for calculating off-site deposition of pesticides applied by aerial, ground, and orchard airblast spraying means, and for evaluating the potential of buffer zones to protect sensitive aquatic and terrestrial habitats from undesired exposures (Teske et al. 2001). The model was developed and tested by a number of regulatory stakeholders that include the U.S. Department of Agriculture, USEPA, and a coalition of pesticide registrants.

The Pesticide Use Reporting (PUR) database (CDPR, 2006) will be used to identify when and where pesticide applications have occurred, at what rate, and to what crop. PUR records are related to specific square-mile sections, based on the Public Land Survey System (PLSS). A Geographical Information System (GIS) will be used to identify other relevant factors that determine the magnitude and timing of pesticide transport to adjacent

water bodies for each PLSS section, including spatially related soils, generalized proximity to water, and weather patterns. Data that feed into the GIS will be combined with other informational databases on crop factors, soil properties, land use, meteorological data, and geomorphology to determine detailed input files. Model output will consist of a daily time-series prediction of pesticide loadings from runoff, erosion, irrigation return flow, and drift sources for each PUR record. Loadings from urban and residential uses will also be addressed, but at a lower level of accuracy because these pesticide use records are not available at the same level of resolution. Loadings will expressed seasonally and cumulatively along the major tributaries and main stems of the Sacramento and San Joaquin rivers. Results will be analyzed relative to spatial and temporal cooccurrence of critical species and sensitive life cycles. Figure 2 shows a schematic of the models and data linkage to be used for the project.

Four sets of model simulations will be conducted.

- The first set combines the specific year of weather data with PUR application to compare spatial and temporal patterns of pesticide loadings to concentrations observed in monitoring data. These simulations will be used to validate the ability of the model to simulate the relative magnitude and timing of exposure from monitoring data.

- The second set simulates two or three recent years of PUR applications with 20-30 years of weather data to predict pesticide loadings in a probabilistic context under a range of low, moderate, and high runoff events.

- The third set simulates anticipated changes in pesticide use for the same 20-30 years of weather data to predict the future trends in pesticide loadings on aquatic ecosystems.

- The fourth set will be used to evaluate the feasibility of alternate management practices in minimizing impacts to those same aquatic ecosystems.

This study builds on previous research efforts conducted in the Sacramento River basin (SRWP, 2004; SWRP 2006). The 2006 study provides the "proof-of-concept" for this project. The objective of that study was to estimate pesticide loadings to the Sacramento River and its tributaries in terms of spatial and temporal probability of occurrence. The study was performed for the Sacramento River Watershed Program funded by USEPA Region 9. Five chemicals (chlorpyrifos, diazinon, dim-on, paraquat dichloride, and pennethrin) were selected for analysis from a list of 22 chemicals identified by the Central Valley Regional Water Quality Control Board (CVRWQCB, 2006b). The five chemicals were selected based on volume of use, toxicity, persistence in the enviromnent, and the amount of chemical applied during the wet season. A Geographical Information System (GIS) was used to construct approximately 43,000 model simulations representing unique combinations of soil, land use, and chemical use within the study" area. Simulations were conducted using the USEPA's Pesticide Root Zone Model

(PRZM) (Suarez, 2005). Information about chemical use was obtained from the Pesticide Use Reporting (PUR) database (CDPR, 2006). Environmental fate properties of the five chemicals were obtained from the USDA-ARS Pesticide Property database (USDA, 2003). Detailed land use data for the pesticide application sites in the 23 counties were also obtained from the PUR database. The land uses were associated with seven major categories for modeling: corn, fruit, grain, grape, grass, nut, and vegetable. Soil parameters were identified from the State Soil Geographic (STATS GO) database (USDA, 2004). Cropping dates (emergence, maturation, and harvest) and other crop parameters (interception storage, maximum coverage, active root depth, aerial coverage, maximum canopy height) were derived from USEPA's Office of Pesticide Program's standard modeling scenarios (USEPA, 2004). Simulations were conducted for 30-years of historical weather to evaluate runoff loadings under a range of potential low, moderate, and high rainfall events. The weather data were obtained from USEPA's Center for Exposure Assessment Modeling (CEAM) for five meteorological stations within and around the watershed.

Simulations were conducted at the township-range-section level, which is the reporting level of the PUR database and has a resolution of 1 square mile. Edge-of-field predictions of pesticide runoff were aggregated (scaled-up) to the township scale (36 square miles) for visual presentation and to the county scale for tabular presentation. Model predictions were represented in terms of temporal probability of occurrence by calculating 50th and 90th percentile annual mass loadings.

This proposal builds on that work for this current study by including additional pesticides (including uses on rice), refining areas of uncertainty from the previous analysis, and expanding the scope to include the San Joaquin River and Bay-Delta estuary. CVRWQCB is currently preparing a parallel relative pesticide risk report for the San Joaquin and Delta waterways. Coordination between projects will occur through the involvement of CVRWQCB on the TAP. Areas of refinement from the previous study will include: incorporation of predictions of irrigation return flow into the simulations; increase of the density of weather stations for greater spatial resolution; utilization of the SSURGO database (USDA, 2006) to obtain a more accurate estimate of soil properties for applications in each PLSS section; additional years of PUR records to address year-to-year variability in pesticide application (e.g., crop rotation), incorporation of urban and residential uses; and incorporation of an assessment of potential spray drift.

A geostatistical approach will be used to estimate pesticide loadings from urban and residential uses. Detailed land use records from DWR (CDWR, 2006) will be used to improve estimates of where urban and residential applications have occurred. It will be assumed that applications will occur at typical rates and dates in urban and residential settings for model simulations.

Spray drift loadings will be estimated based on field proximity to water. Fields having the potential to have received the pesticide application in the township-range-section documented by the PUR database will be identified from the DWR detailed land use

database and the high resolution version of the National Hydrography Dataset (http://nhd.usgs.gov/index.html) using GIS analysis. Spray drift loads will be assessed based on generalized distances of those fields to water (e.g., 0-25' zone, 25-50' zone, etc). Figure 3 provides an example of DWR detailed land use data for walnuts at the township-rangesection level and its proximity to high resolution NHD data. Buffers of 25, 50, and 75 feet are also shown for each water body.

For this study, we will also present cumulative loadings along river reaches and into the Bay-Delta estuary using the NHDplus hydrography data set that has recently been released for California (http://www.horizon-systeins.coin/NHDPIus/). The data set includes significant quality control and improvements in database and network navigation.

Temporal patterns of loading within accumulation reaches will be evaluated in context of temporal cooccurrence of critical life stages for sensitive species. Pesticide loads will be summed seasonally for each chemical and expressed in terms of frequency of occurrence (90" percentile and 50th percentile corresponding to 10-year and 2-year return periods) or other endpoints as dictated by the TAP. Daily predictions for each PUR section (1 mi) will be retained so that the output is available for future studies and applications (e.g., to provide loadings into receiving water models, ecosystem population models, and other program-specific assessments).

Project tasks. Eleven tasks have been identified as described below. Costs are provided in the Task and Budget Summary and the accompanying Detailed Budget.

1. Project Administration. Activities relate to day-to-day management and coordination between technical teams.
2. Chemical Selection. Priority chemicals for simulation will be selected based on use volume, chemical properties indicating persistence and mobility, toxicity, and historical detections near or exceeding the State's water quality objectives or TMDL target levels. The TAP will provide input into this process. Once selected, the Pesticide Use Report (PUR) database will be used to guide model applications and crops.
3. Data Collection/Reduction. This task involves the collection and pre-processing of relevant spatial and temporal data on soil properties, pesticide use, weather, land use, and ecology into formats that can be used for other tasks. Five parallel activities are included in this effort:

a) Critical Habitat - development of GIS data layers for critical species habitats that will later be used in evaluating model results and their potential impacts. Data from the federal and state agencies, including the U.S. Fish and Wildlife Services (USFWS) and National Oceanic and Atmospheric Administration (NOAA) fisheries, (http://www.dfg.ca.gov/whdab/html/cnddb_info.html), and/or other appropriate data sources as determined through contacts with local experts and agencies, will be acquired to define the locations of critical habitats

as well as the times of year that species are estimated to be present in those water bodies, especially during sensitive life cycles.

b) Water Quality Monitoring - development of a geocoded database that summarizes the location, sampling periods, and results of pesticide monitoring efforts in both watersheds. The data will be used to validate the relative magnitude and duration of model predictions during Task 5 and to assess the adequacy of existing monitoring programs in characterizing exposure concentration from pesticide sources in the Sacramento and San Joaquin watersheds during Task 7. Agencies involved in assessing monitoring efforts, including CDPR, USGS, CVRWQCB, State Water Resources Control Board, and SFEI will be contacted to minimize redundancy and duplication of efforts for this task.

c) Soil Data - USDA's soil survey geographical database (SSURGO), currently available for the majority of California, will be processed on a county-by-county basis to obtain relevant soil properties (Curve Number, organic matter, texture, slope, etc.) for model simulations. The STATSGO database will be used for remaining areas. This is a significant data processing activity because of the large geographical area of study. SSURGO is preferred for this study because it identifies the location of soils on a soil series level. STATSGO is at a coarser detail and introduces uncertainty in the assessment.

d) Weather Data - Daily weather data (precipitation, temperature, solar radiation, and pan evaporation) will be obtained from the National Weather Service for use in model simulations. Data will be collected for a dozens of meteorological stations to address weather variability in the study area. Missing weather data will be filled in from appropriate adjacent stations to provide for a complete network. The weather data are used to set boundary conditions in PRZM and RICEWQ for calculating runoff, soil moisture, evapotranspiration, and the need for irrigation.

e) Proximity to Water - The proximity of pesticide application sites to water will be assessed using GIS processing to provide load estimates due to spray drift. DWR's high-resolution land use database will be used to identify locations within each township-range-section where each PUR application may have occurred. The shortest distance to water for each of these locations will be calculated and the average distance from all locations in the section will be used for drift calculations. Drift will be based on the method of application identified in the PUR (aerial vs. ground). Calculations will be performed for every PLSS section in a 3-year recent history.

4. Database Linkage/Model Processor Development. This task includes the modification of existing processors that have been developed to automate the production of thousands of model simulations with PRZM and RICEWQ. The processors link the geocoded databases prepared in Task 3 with other input parameter databases to define specific model input parameter values to each

unique combination of soil, weather, crop, and pesticide application.

5. Validation / Sensitivity Analysis. a) Simulations and development of a sensitivity matrix of parameters for the Pollutant Source Assessment Model that may include crop, enviromnental fate, and soil parameters, including parameters of greatest uncertainty. Sensitivity will be reviewed at the point of loading and key location(s) along the river network. b) Validation will be performed through comparison of model results to the relative magnitude and duration of observed in-stream water quality data. Validation will be conducted primarily through visual techniques. Travel time analysis of USGS stream flow stations may be used to refined temporal predictions. c) Evaluate predictions in context with SWAT modeling being conducted by University of California - Davis.

6. Baseline, Future Trends, and Mitigation Scenarios. Model scenarios will address 20-30 years of historical meteorology to assess chemical loadings and concentrations in a probabilistic framework (i.e., high, moderate, and low rainfall conditions), under existing pesticide use and agronomic practices, and under other alternate "what-if" scenarios. Scenarios can be designed to represent projected changes in climate, land use, and agronomic practices in the watershed and updated as needed in the future to address evolving pesticide uses and additional management scenarios. Mitigation scenarios can be designed to predict pesticide reductions likely to occur under the implementation of BMPs and other mitigation measures. Specific scenarios will be identified by the TAP.

7. Result Integration. Temporal patterns of loading within accumulation reaches will be evaluated in context of temporal co-occurrence of critical life stages for sensitive species. Results will be used to prioritize areas of risk, identify source loadings for potential mitigation, and to assess the adequacy of existing monitoring programs in characterizing exposure concentration from pesticide. sources in the Sacramento and San Joaquin watersheds. Recommendations will be provided on strategic placement of BMPs, monitoring locations, and sampling frequency.

8. Reports and Publications. To include technical progress reports, draft fu^{g}al report, response to peer review comments, final report, and publication in scientific journal(s) (e.g., SETAC).

9. Technical Meetings. Under this task it is assumed that two meetings will occur between subcontractors and the TAP at key stages of the project: 1) project initiation and 2) review of baseline results. The second meeting will also be used to define the future condition and mitigation scenarios.

10. Quality Assurance Project Plan (QAPP). Although this study does not involve sample collection or analysis, a QAPP will be developed for quality control, documentation, and to ensure results are reproducible. The plan will justify and summarize the quality of databases and models used for the project. A description of the

quality control procedures to be implemented will also be provided. In addition, a budget item has been included for developing study-specific QAPP procedures.

11. Training. A training workshop will be provided to interested parties and stakeholder agency staff. The workshop will contain a technical overview of the models, associated databases and GIS.layers, and model linkage.

Project deliverables. Work products include: one-page project summary for public audience at the beginning of the project; one-page project summary for public audience upon project completion; progress reports at key stages of completion; semi-annual and final reports (including peer review of final report); project closure summary report; presentation at CALFED science conferences; presentation at other events at the request of the CALFED Science Program staff; and a copy of all published material resulting from the grant. A time-series database of model predictions will be provided that can be used for future studies, including other water quality models, ecosystem population models, or other analyses by as the Central Valley Regional Water Quality Control Board staff, State Water Resources Control Board, Resource Conservation Districts, CDPR, USDA, and other entities.

The final report will document methods, materials, and results including: input parameter values, sources and rationale; sensitivity analysis, calibration, and validation; maps and tables illustrating the relative mass loadings of priority pesticides at key locations in the watershed system relative to critical habitats; and identification of areas of model uncertainty.

4.0 Feasibility

The potential for project success is high given that a pilot study has already been conducted as proof-ofconcept (SWRP, 2004; SWRP, 2006). The 2006 study was conducted in a 5-month period. The current work, allowing for contingencies, can be completed in an 18-month period. This study does not require the development or completion of external models or databases. The study is not contingent on permits, weather, or the establishment of biological communities.

The scope has been limited to produce a well defined deliverable. We have not added additional phases or stages that require additional investigation and controversial negotiation between stakeholders (e.g., linkage to receiving water models or population models). Rather the deliverables would provide an immediate utility in the understanding of the spatial and temporal variability in pesticide loadings as well as the building blocks to a variety of future programs.

EXHIBIT A: ATTACHMENT 4
Task Table

Spatial and Temporal Quantification of Pesticide Loadings to the Sacramento River, San Joaquin River, and Bay-Delta to Guide Risk Assessment for Sensitive Species

Task #	Start Month	End Month	Description
1	1	30	Activities related to contracts, day-to-day management, and coordination between technical teams.
2	1	2	Justify pesticides to be included in the analysis based on persistence, mobility, and vlume of use.
3	1	4	Data layer acquisition and pre-processing for model simulations and result analysis
4	2	24	Link geocoded databases with other informational databases to develop model input parameter values and automate many thousand model runs.
5	24	30	Compare relative magnitude and temporal predictions of pesticed loadings to in-stream monitoring data. Evaluate sensitifity of key input parameters on predicted loadings. Compare model predictions to University of California SWAT project.
6	24	30	Configure scenarios, conduct model runs, and perform quality control on model output
7	24	30	Evaluate temporal patterns of loadings within accumulation reaches to co-occurance with sensitive species. Provide recommendations on strategic placement of BMPs, monitoring locations, and sampling frequency
8	24	30	Produce technical progress reports, draft final report, response to peer review comments, final report, and publication in scientific journal(s).
9	24	30	Technical meetings between subcontractors and Technical Advisory Panel at Key junctures to convey results and review options. Present study at CALFED or other conferences.
10	1	30	Justify and summarize quality of databases and modesl that will be used. Describe quality control procedures that will be implemented.
11	24	30	Conduct training workshops to government agencies and other stakeholders. The workshop will contain a technical overview of the modesl, associated databases and GIS layers, and model linkage.