1. SUMMARY OF STUDIES AND REPORTS

Total Maximum Daily Loads for Chlorpyrifos and Diazinon in Lower Salinas River Watershed in Monterey County, CA, Final Project Report (CRWQCB, 2011)

The total maximum daily loads developed in this project address water column toxicity and chlorpyrifos and diazinon impairments in the lower Salinas River watershed. The 16 waterbodies listed below were identified as impaired:

- Moss Landing Harbor
- Old Salinas River Estuary
- Old Salinas River, Salinas River Lagoon (North)
- Tembladero Slough
- Alisal Slough
- Blanco Drain
- Salinas Reclamation Canal
- Lower Salinas River
- Espinosa Slough
- Espinosa Lake
- Natividad Creek
- Quail Creek
- Chualar Creek
- Merritt Ditch
- Gabilan Creek

This project identified agricultural uses of chlorpyrifos and diazinon as the sources of impairments; urban/non-agricultural uses were previously banned by USEPA. Targets and load allocations were based on water-column concentrations of chlorpyrifos and diazinon, along with an additive toxicity formula for combinations of the pesticides in water. For TMDL implementation and monitoring, the TMDL relies upon the Agricultural Order.

2010 Follow-up Monitoring Report: Pesticides and Toxicity to Hyalella azteca in Sediments (CCWQP, 2010)

This monitoring study was conducted by Central Coast Water Quality Preservation, Inc. (CCWQP) on behalf of irrigated agriculture on the central coast enrolled in the Agricultural Order. CCWQP conducted conventional as well as toxicity monitoring in irrigated agricultural drainages on a regular basis for compliance with the Agricultural Order monitoring and reporting programs. The study was a follow-up to the regular sediment toxicity monitoring and includes analysis of organochlorine, organophosphate, and pyrethroid pesticide concentrations in sediment. The special pesticide sediment monitoring was conducted along with regularly scheduled monitoring of sediment toxicity to *Hyalella azteca* in May 2010 at 46 cooperative monitoring program sites on the central coast, of which 12 were located in the lower Salinas River and Reclamation Canal watershed (HU 309). The samples were also analyzed for total organic carbon (TOC), which was used along with published toxicity values to assess toxicity of the detected pesticide concentrations in a toxicity unit (TU) evaluation. The report concluded that the majority of sediment toxicity observed in the study could be linked to concentrations of either pyrethroids or chlorpyrifos in sediment.

Patterns of Pyrethroid Contamination and Toxicity in Agricultural and Urban Stream Segments (Ng et al., 2008)

In this study, the researchers evaluated the sources of sediment toxicity and pyrethroid pesticides in agricultural and urban drainages in proximity to the City of Salinas in the lower Salinas River watershed in 2005. They detected sediment toxicity to *Hyalella azteca* and concentrations of pyrethroids in the sediment above levels known to cause toxicity. The researchers also monitored sediment samples for other pesticides and in one sample chlorpyrifos was detected at a concentration likely to be toxic. The results strongly linked concentrations of pyrethroid pesticides to sediment toxicity to *Hyalella azteca* based on analysis of toxicity units (Figure 1). Waterbodies identified as impaired for toxicity and pyrethroids include Gabilan Creek, Natividad Creek, and Alisal Creek/Reclamation Canal.

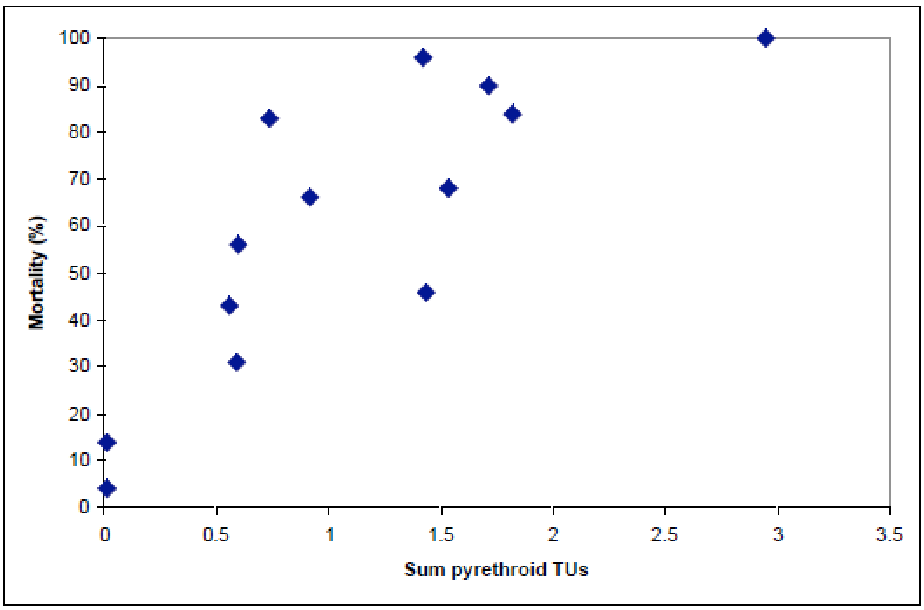

Figure 1. Graph of the percent mortality of Hyalella azteca in sediment samples at each site in relation to the sum of pyrethroid toxicity units (TU).

The study notes that pyrethroid pesticides are used commonly in both urban and agricultural areas for invertebrate pest control, and the study evaluated land uses in relation to toxicity and pyrethroid concentrations. The study compared the composition of pyrethroid pesticides in sediment from the two land uses and found that cyfluthrin and cypermethrin were detected in urban areas, while lambda-cyhalothrin was found in agricultural areas, and bifenthrin and permethrin were found in both urban and agricultural areas.

The study analyzed state and Monterey County agricultural and non-agricultural commercial pesticide use patterns with data from the DPR pesticide use reporting (PUR) database (refer to Table 1). The primary agricultural use of bifenthrin was applications to strawberry crops.

Pyrethroids were also found to be used on crops such as: lettuce, artichokes, celery, broccoli, and spinach.

Table 1. Relative agricultural and non-agricultural commercial use of pyrethroids in California as a whole and in Monterey County (2005 data). Non-agricultural use consists largely of applications by professional pest control firms, and figures do not include retail sales to homeowners for which comparable data are not available. The table also shows whether the compound was characteristic of urban or agricultural stream segments in the study.

Pyrethroid	Statewide agricultural use (kg)	Statewide non-agricultural use (kg)	Monterey County agricultural use (kg) and primary crop	Monterey County non-agricultural use (kg)	Finding in current Salinas study
Bifenthrin	9,439	18,748	297 Strawberries	175	Largely urban but some agricultural
Cyfluthrin	7,810	14,526	11 Lettuce	63	Urban
Cypermethrin (including S-cypermethrin	14,070	92,068	3138 Lettuce	140	Urban
Deltamethrin	38	6,238	0	19	Not detected
Esfenvalerate	14,780	118	1555 Artichokes, lettuce, broccoli	0	Undetermin ed
Fenpropathrin	17,940	3	2295 Grapes, strawberries	0	Not measured
Lambda-cyhalothrin	10,296	6,298	1390 Lettuce	2	Agricultural
Permethrin	67,796	183,110	9900 Lettuce, spinach, celery	519	Both urban and agric.

Use of Toxicity Identification Evaluations to Determine the Pesticide Mitigation Effectiveness of On-Farm Vegetated Treatment Systems (Hunt et al., 2008)

In this study, the researchers evaluated the effectiveness of on-farm vegetative treatment systems (VTS) in treating pesticide contamination in agricultural drainage water on two farms in the Salinas watershed. The toxicity of inflow and outflow drainage water and sediment was tested along with nutrient and sediment concentrations. In addition, toxicity identification evaluations (TIEs) were used to determine the pesticide sources of toxicity. Water inflow samples were toxic to *Ceriodaphnia dubia* and TIEs indicated that toxicity was due to either chlorpyrifos or diazinon. All inflow and outflow sediment samples of the VTS were toxic to *Hyalella azteca* and TIEs indicated that the toxicity was caused by pyrethroid pesticides, specifically cypermerthrin, lambda-cyhalothrin, and permerthin. Chlorpyrifos was also a source of some sediment toxicity in one of the VTS. The VTS were found to greatly reduce the concentrations of pyrethroids in the outlet sediments. The study also monitored the VTS inlet and outlet turbidity and the results indicate substantial reductions in turbidity.

Pyrethroid Insecticides in California Surface Waters and Bed Sediments: Concentrations and Estimated Toxicities (Starner et al., 2006)

In this study, scientists from the California Department of Pesticide Regulation (DPR) monitored pyrethroid concentrations in bed sediments and whole water from four agricultural regions of California. The study did not directly measure sediment toxicity but estimated toxicity using toxicity unit (TU) analysis based on expected toxicity to *Hyalella azteca*. The four regions sampled were the Salinas River/Monterey, Sacramento Valley/Feather River, Northern San Joaquin Valley, and Imperial Valley. Each region was sampled 3 times over a 24-month period. Of the four regions, the highest frequency of detection was in the Salinas River region. In the Salinas River watershed, 76 samples were evaluated and 42 percent of the sediment samples exceeded 1 TU. Mostly trace detections of pyrethroids were found in the water samples. The primary source of the estimated sediment toxicity was esfenvalerate and bifenthrin and the primary crops were lettuce and spinach.

Watershed-scale Evaluation of Agricultural BMP Effectiveness in Protecting Critical Coastal Habitats: Final Report on the Status of Three Central California Estuaries (Anderson et al., 2010)

This study monitored water quality in three central coast estuaries, the Pajaro, Salinas, and the Santa Maria, in 2008 and 2009. These estuaries are located in watersheds with extensive agricultural land use and were selected to study the impacts of agricultural pesticide run-off on the estuarine habitats.

For the study, eight stations were monitored in the Salinas estuary and two stations in adjacent subwatersheds (Blanco Drain and Salinas River at Davis Road) with agricultural land use (refer to Figure 2 and Figure 3). The stations were monitored for sediment toxicity and pesticides in sediment. Each of the sites was monitored three times (refer to Table 2). In the estuary, 3 of the 24 sediment samples were toxic to *Hyalella azteca.* The sediment was monitored for pesticides; however, none were detected at sufficient concentrations to be toxic. Sediments samples at the Blanco Drain and Davis Road sites were toxic and a mix of pyrethroids was also detected in the sediment. Pyrethroids detected include bifenthrin, cyhalothrin, and cypermethrin.

Table 2. Sediment monitoring in the Salinas River Estuary, Blanco Drain, and Salinas River at Davis Road. Shading indicates significant toxicity or sum TU values > 0.5

Station	Jun - 08		Oct - 08		Oct - 09	
	Survival Mean	**OC-Corrected Sum TU**	**Survival Mean**	**OC-Corrected Sum TU**	**Survival Mean**	**OC-Corrected Sum TU**
Salinas 1	95 (11)		89 (10)		79 (33)	
Salinas 2	88 (10)	0.002	98 (5)		98 (5)	0.078
Salinas 3	91 (4)		95 (5)	0.001	89(14)	
Salinas 4	79 (11)	0.010	96 (5)		81 (16)	
Salinas 5	91 (11)	0.038	98 (5)		86 (15)	
Salinas 6	73 (20)	0.001	95 (5)		90 (8)	0.003
Salinas 7	63 (19)	0.001	83 (16)		85 (23)	
Salinas 8	94 (7)	0.002	91 (6)		76 (23)	
Blanco	89 (6)	0.001	29 (36)	0.724	35 (34)	0.210
Davis	96 (7)	0.028	94 (5)		34 (18)	0.630

Notes: Mean percent survival (standard deviation) and organic carbon-corrected toxic unit (TU) sums for Salinas River sediment tests. The chemicals driving the sum TU are listed for sum TU > 0.1

Figure 2. Map of the Salinas River estuary showing the eight sediment sampling stations (diamonds 1-8) and the five benthic community sampling stations (diamonds 1-5). The upper and lower estuary water toxicity and chemistry stations are depicted with triangles.

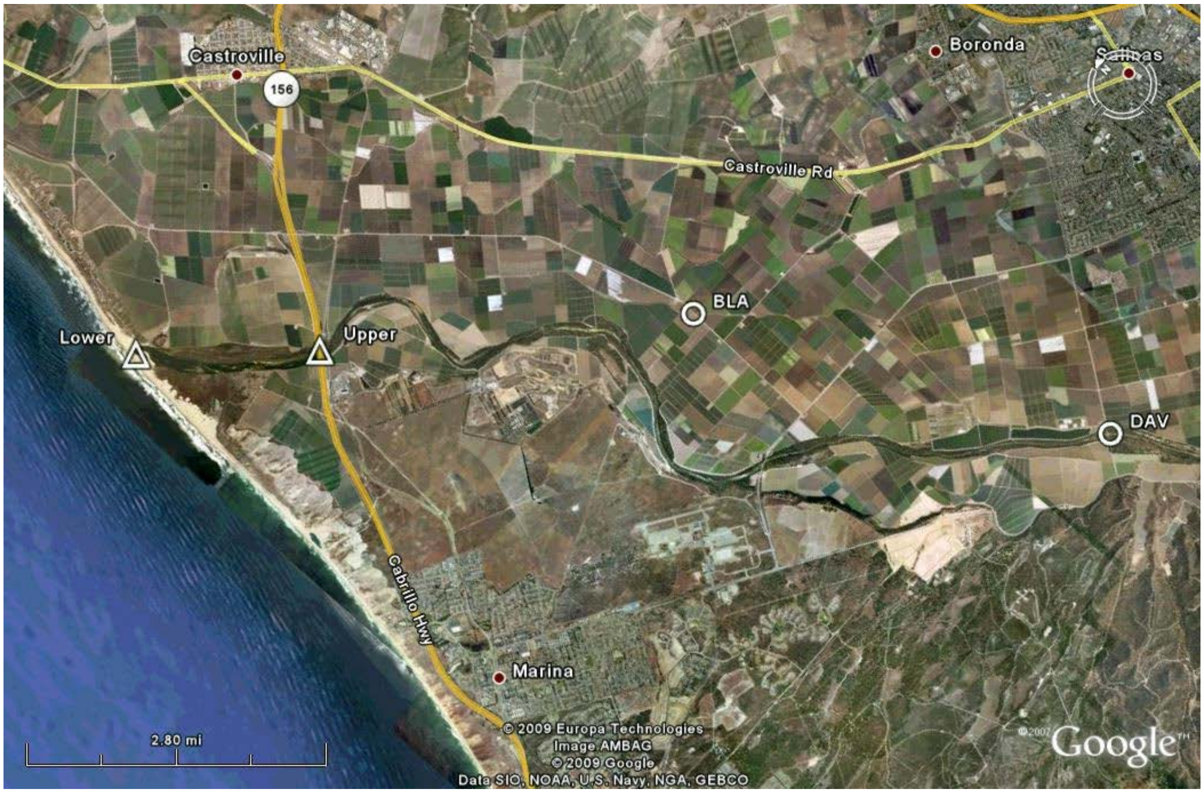

Figure 3. Map of the two Salinas River tributary stations (circles), Blanco Drain at Cooper Road (BLA) and the Salinas River at Davis Road (DAV).

Trends in Chemical Contamination, Toxicity and Land Use in California Watersheds: Stream Pollution Trends (SPoT) Monitoring Program Third Report - Five-Year Trends 2008-2012 (Phillips et al., 2014)

This report summarizes five years of annual sediment monitoring by the Stream Pollution Trends (SPoT) Monitoring Program of streams in the lower Salinas River watershed and throughout California. SPoT is part of the State Water Board's Surface Water Ambient Monitoring Program. In this project, sediments were monitored once a year for toxicity to *Hyalella azteca* and for toxic compounds such as pesticides, industrial contaminants, and metals. The SPoT program provides a regional and statewide view of water quality trends and uses GIS analysis to distinguish sites by land use characteristics (urban, agricultural, and open).

At the statewide level, the study found increasing levels of pyrethroid pesticides in sediment, in particular the pyrethroid pesticide bifenthrin. The increase in pyrethroid pesticides and sediment toxicity was most significant in urban watersheds, and there were no reported trends in pyrethroid concentrations at sites in agricultural or open watersheds. The study reported that statewide use of bifenthrin had more than doubled from 2008 to 2012 with the pounds of active ingredient applied going from 120,089 in 2008 to 285,941 in 2012. Bifenthrin is also very stable in sediment, which increases its persistence in the environment.

The SPoT program monitored two sites in the lower Salinas River watershed, Salinas River at Davis Road (309DAV) and Tembladero Slough at Monterey Dunes (309TDW). The sediment sampled from the Tembladero Slough site was classified in the SPoT report as moderately toxic but with significant improvements from 2008 to 2012. One sample from 2009 at the Salinas River site was toxic but others were not toxic. Based on GIS analysis of watershed land use, the land use draining to the Salinas River site was open space and the land use draining to the Tembladero Slough site was agricultural.

2. REFERENCES

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