Causal Assessment Evaluation and Guidance for California Appendix B - Salinas River Causal Assessment Case Study

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EXECUTIVE SUMMARY

This study provides an example of a causal assessment to determine the likely cause of biological impairment for a perennial stream in an agricultural dominated watershed. The Salinas River is located in the central coast region of California, USA. Benthic macroinvertebrate communities in the lower Salinas River were impacted, defined here as a southern California benthic macroinvertebrate index of biological integrity (SoCal B-IBI) score greater than or equal to 39 (Ode et al. 2005). This study utilized the USEPA causal assessment framework, based on the EPA Stressor Identification guidance (USEPA, 2000), to identify the probable cause(s) of biological impairment. The framework encourages the early engagement of stakeholders. For this case study, the participants included:

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Through three workshops and regular communications, the workgroup followed the five step stressor identification process to identify potential candidate causes.

First, the *Case Definition* was established. The Salinas Valley is one of the most productive agricultural regions in California. The Salinas River watershed encompasses 10,774 km^2 and flows 280 km from central San Luis Obispo County through Monterey County before discharging to Monterey Bay, a National Marine Sanctuary. The river has 12 designated beneficial uses that can be broadly categorized as 1) municipal and domestic water supply, 2) ground water recharge, 3) agricultural supply, and 4) aquatic habitat.

For this case study, the impairment was defined as follows: In 2006, benthic samples from lower river sites 309DAV and 309SSP had SC-IBI scores of 14 and 19, respectively, and were categorized as "very poor". In contrast, upstream at Chualar (309SAC) scores were greater than 24. The lower SC-IBI scores for the lower Salinas River sites indicated a greater degree of impairment relative to upstream samples. The biological assessments were conducted by two organizations. The Central Coast Regional Water Quality Control Board (CCRWQB) assessed biological integrity on 9 June 2006 at Davis Road (309DAV) and near the city of Chualar (309SAC). The Central Coast Water Quality Preservation, Inc. (CCWQP) assessed biological integrity on 26 May 2006 near the city of Spreckels (309SSP) and near Chualar (309SAC). Specific effects for the two lower Salinas River sites relative to upstream samples included an increase in the percent noninsect taxa, an increase in the percent tolerant taxa, a decrease in

percent intolerant individuals, and a decrease in ephemeroptera + plecoptera + trichoptera (EPT) taxa. Oligochaeta accounted for the greatest taxonomic difference, with more individuals and greater relative abundances associated with the impacted sites.

Second, *Candidate Causes* were listed. Eight candidate causes were proposed for the Salinas River 2006 benthic macroinvertebrate biological impairment. Potential candidate causes were identified and discussed by participants at a workshop held in Costa Mesa, CA in February 2012. For causal hypotheses advocated by any participant, conceptual diagrams that link the candidate cause with potential sources and effects were developed and data sources identified. The eight potential candidate causes, in no particular order, were: decreased dissolved oxygen, increased nutrients, increased pesticides, increased metals, increased ionic strength, increased sediments, altered flow regime, and altered physical habitat.

Third, *Data from the Case* was evaluated. For each candidate cause, available data from the case were analyzed to produce evidence to support or weaken the cause. Chemical, physical, and biological data were obtained from two primary sources; the CCRWQB's Central Coast Ambient Monitoring Program (CCAMP) and CCWQP's Cooperative Monitoring Program (CMP). Additional significant data sources included U.S. Geological Survey daily streamflow data and the City of Salinas stormwater discharge data. For each candidate cause, data for the case study were assembled into different evidence types and analyzed and evaluated using a systematic scoring framework applied to each type of evidence. For this case study, the evidence types were: spatial-temporal co-occurrence, causal pathway, stressor-response from the field, laboratory test of site media, and temporal sequence.

Fourth, *Data from Outside the Case* were evaluated. For each candidate cause, available data independent of that observed at the case sites were analyzed to produce evidence to support or weaken the cause. For each candidate cause, data from outside the case study were assembled into different evidence types and analyzed and evaluated using a systematic scoring framework applied to each type of evidence. For this case study, the evidence types were: stressor-response relationships from the field and stressor-response from laboratory studies.

Fifth, a *Probable Cause* was identified. Based on the available evidence, the following candidate cause determinations were made. Increased suspended sediments were identified as the likely cause of the biological impairment at both the Davis Rd (309DAV) and Spreckels (309SSP) sites. This diagnosis was based on greater suspended sediment concentrations at the impacted sites relative to comparator sites at the time of impact, supporting evidence of spatial temporal co-occurrence. Benthic macroinvertebrate responses to increased concentrations were strongly correlated and in the expected direction, supporting evidence of stressor-response from the field. Concentrations were in the range reported to cause an ecological effect, supporting evidence of stressor-response relationship from other studies. Finally, data were available to link sources to the candidate cause, supporting evidence for causal pathway. Physical habitat was also diagnosed, mostly because sediments are a component of this candidate cause. Increased pesticides and metals were unresolved stressors due to a lack of data. Decreased dissolved oxygen, increased nutrients, increased ionic strength, and altered flow regime were unlikely stressors because there was no consistent evidence either in spatial-temporal co-occurrence or stressor response relationships.

INTRODUCTION

The Salinas River is a biologically impacted river located in the central coast region of California, USA. The main purpose for conducting the case study was to assess the utility and capabilities of the USEPA causal assessment framework, based on the EPA Stressor Identification guidance (USEPA 2000), to identify the probable cause(s) of biological impairment. This case study provides an example of a causal assessment in an agriculturally dominated watershed. Agricultural land use impacts the biological integrity of aquatic resources via nonpoint source stressors that include nutrients, pesticides, sediments, flow alterations, and habitat/channel modifications (Allan 2004; Riseng et al. 2011). Although representative of an agricultural dominated land use, biological impacts may be caused by stressors and sources not associated with the dominant land use. For example, impacts may be coupled to other land uses (urbanization) or point source discharges (stormwater drains or POTW). A major tenant of the causal assessment framework is to remain objective and avoid theory tenacity (i.e., the tendency to favor a theory in advance of evidence). The framework focuses on identifying candidate causes and evaluating causal relationships between proximate stressors and the biological response variable (invertebrates). Thus, although agriculture is the dominant land use within the Salinas Valley, care was taken to consider all the potential stressors and sources that could cause biological impacts.

Study Area Description

The Salinas Valley is one of the most productive agricultural regions in California. Commonly referred to as the "salad bowl of the world", the region provides the majority of salad greens consumed within the United States. In 2011, Monterey County reported 708 km^2 of crop production with earnings exceeding $3.8 billion dollars (Monterey County Agricultural Commission 2011a) and directly employed 45,140 people (Monterey County Agricultural Commission 2011b). A diverse array of crops is produced with lettuce, strawberries, broccoli, cauliflower, grapes, and other vegetables typically accounting for the highest yields. In addition to vegetables and fruits, the region also supports approximately 160km^2 of vineyards.

From its headwaters in central San Luis Obispo County, the Salinas River flows approximately 280 km through Monterey County before discharging to Monterey Bay, a National Marine Sanctuary. The Salinas River has 12 designated beneficial uses that can be broadly categorized as 1) municipal and domestic water supply, 2) ground water recharge, 3) agricultural supply, and 4) aquatic habitat. The watershed encompasses 10,774 km^2 and, although a single hydrologic unit, is divided into an upper, middle, and lower watershed (segment) based on geographic, political, land use, and groundwater divisions for developing 303(d) listings of impaired waterbodies. In 2006, all three segments were listed as impaired waterbodies (http://www.swrcb.ca.gov/water_issues/programs/tmdl/303d_lists2006_epa.shtml). The upper segment, extending from the headwaters to the city of Bradley, was listed for chloride and sodium. The middle segment, from Bradley to the city of Gonzales, was listed for pesticides and salinity/total dissolved solids/chlorides/sulfates. The lower segment, from Gonzales to Monterey Bay, was listed for fecal coliform, nitrogen as nitrate, nutrients, pesticides, and salinity/total dissolved solids/chlorides/sulfates.

This study focuses on just the lower segment, from Gonzales to Monterey Bay, of the Salinas River (Figure 1). The lower Salinas River watershed encompasses an area of 574 km^2 and is composed of six subwatersheds (Salinas River, Chualar Creek, Quail Creek, Esperanza Creek, El Toro Creek, and Blanco Drain). Land use within the lower watershed is dominated by agricultural (191 km^2; 33%) and grazing (191 km^2; 33%). Agricultural lands are mostly concomitant with the river channel whereas grazing tends to occur in higher elevations. Approximately 167 km^2 (29%) of the lower watershed is classified as undeveloped, forest, or restricted. Urban land use occupies 25 km^2 (4%) of the watershed. Total maximum daily loads (TMDLs) have been developed for fecal coliform (CRWQCBCCR 2009) and for the pesticides chlorphyrifos and diazon (CRWQCBCCR 2011). A TMDL for nitrogen compounds and orthophosphate is currently in draft form (CRWQCBCCR 2012). Numerous toxicity, pesticide, nutrient, and sediment reports and publications specific to the Salinas River are available from the California Regional Water Quality Control Board Central Coast Region (http://www.ccamp.org/ccamp/Reports.html).

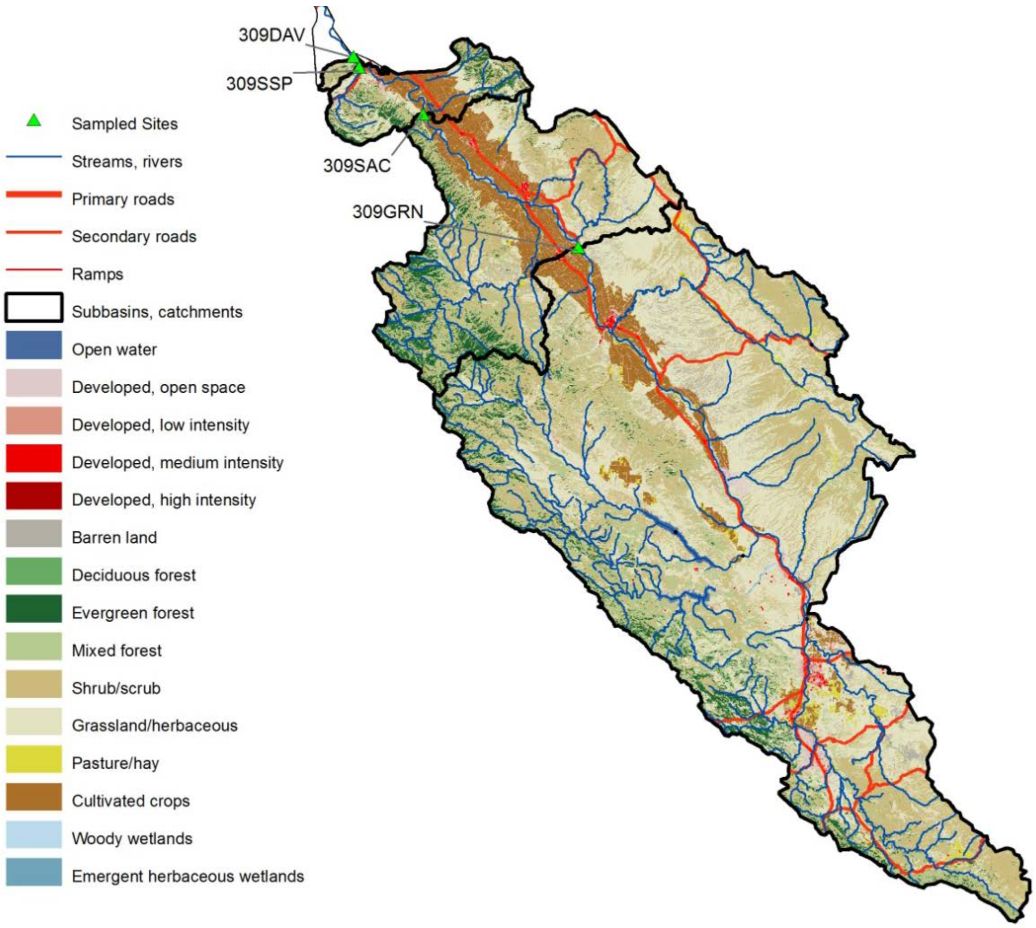


Figure 1. Land use map of the Salinas River watershed, San Luis Obispo and Monterey County, California. The entire river length (280 km) and associated watershed (10,774 km2) are depicted. Also shown are the locations of the two impacted (309DAV and 309SSP) and primary and secondary comparator sites (309SAC and 309GRN) used for the case study. Site subwatersheds are delineated by the thick black line. Data source- USDA National Agricultural Statistics Service, 2007 California Cropland Data Layer.

The mainstem of the lower Salinas River is a naturally sediment-dominated system comprised mostly of unconsolidated alluvial well-drained sand (Watson et al. 2003). The Salinas is one of just a few watersheds in California with no interbasin transfers of water. The annual flow pattern is coupled to the regional climatic conditions characterized by a wet season (Nov-May) and a dry season (Jun-Oct). Between 1999 and 2011, annual precipitation ranged between 28 and 84 cm/yr. The average discharge near the city of Spreckels (USGS Gage 111525000) was 6.18 m^3/sec (range 0-2690 m^3/sec), equivalent to an annual discharge of 268,699 acre-feet. Wet and dry season peak discharges averaged 10.38 m^3/sec and 0.35 m^3/sec, respectively. Further upstream near the city of Chualar (USGS Gage 111523000), wet season (11.47 m^3/sec) and annual (7.27 m^3/sec) discharges were similar to that at Spreckels but dry-season discharges were greater (1.45 m^3/sec). Dry season flows are managed through reservoir releases for the purpose of aquifer recharge. Salinas River bed infiltration accounts for 30% of the more than 500,000 acre-feet per year total lower basin aquifer recharge (Monterey County Water Resources Agency, 2006). Groundwater is the primary source of irrigation water, with withdraws equal to, or greater than, the annual total lower basin aquifer recharge (Monterey County Water Resources Agency, 2006). The mean total suspended sediment load has been estimated to be 1.54 million tonnes per year whereas bedload is estimated to be less than 0.5 million tonnes (Watson et al. 2003). The major component of the sediment budget is sediment storage with aggregation occurring during periods of low flow and degradation during high flows. Although a sediment dominated system, runoff from agricultural fields can be a significant sediment source but varies greatly depending on precipitation, irrigation methods, field status, best management practices, and crop type (Watson et al. 2003).

METHODS AND APPROACH

This causal analysis followed the USEPA Stressor Identification guidance (USEPA 2000). Further and more updated guidance is available through the USEPA Causal Analysis/Diagnosis Decision Information System (CADDIS: http://www.epa.gov/caddis). The remainder of this report is comprised of the following sections.

- **Case Definition: Salinas River**- Describes the basis for the causal analysis, the specific biological effects that triggered the assessment and defines the assessment framework (reason and rational for comparator site selection).
- **Candidate Cause Definitions**- Describes the potential candidate causes.
- **Identification of Probable Causes**- Describes the overall conclusions and supporting evidence for each potential candidate cause.
- **Lessons Learned**- Describes lessons learned about the application of the causal assessment framework to assess California's biological objectives in agricultural dominated perennial streams.

The intended audience is for managers, policy makers, and stakeholders with minimal causal assessment technical training and scientific technical personnel likely responsible for conducting causal assessments. This report does not include a detailed discussion of methods and results specific to the case. Examples of detailed causal assessments reports are available on the

CADDIS web site in Volume 3: Examples and Applications (http://www.epa.gov/caddis/examples_tropo.html).

CASE DEFINITION

In this case, biological impact was defined the southern California IBI (SoCal B-IBI;Ode et al. 2005). Sites with values less than or equal to 39 were categorized as “poor”. Values less than or equal to 19 were categorized as “very poor”.

In 2006, benthic samples from three sites on the lower Salinas River (Figures 1 and 2) had scores near or well below the SoCal B-IBI value of 39 (Table 1). The biological assessments were conducted by two organizations. The Central Coast Regional Water Quality Control Board (CCRWQB) assessed biological integrity on 9 June 2006 at Davis Road (309DAV) and near the city of Chualar (309SAC). The Central Coast Water Quality Preservation, Inc. (CCWQP) assessed biological integrity on 26 May 2006 near the city of Spreckels (309SSP) and near Chualar (309SAC). The lower river sites 309DAV and 309SSP had scores of 14 and 19, respectively, and were categorized as “very poor”. In contrast, upstream at Chualar (309SAC) scores were 24 and 29 in May and June 2006, respectively. The lower scores for the lower Salinas River sites indicated a greater degree of impact relative to upstream samples.

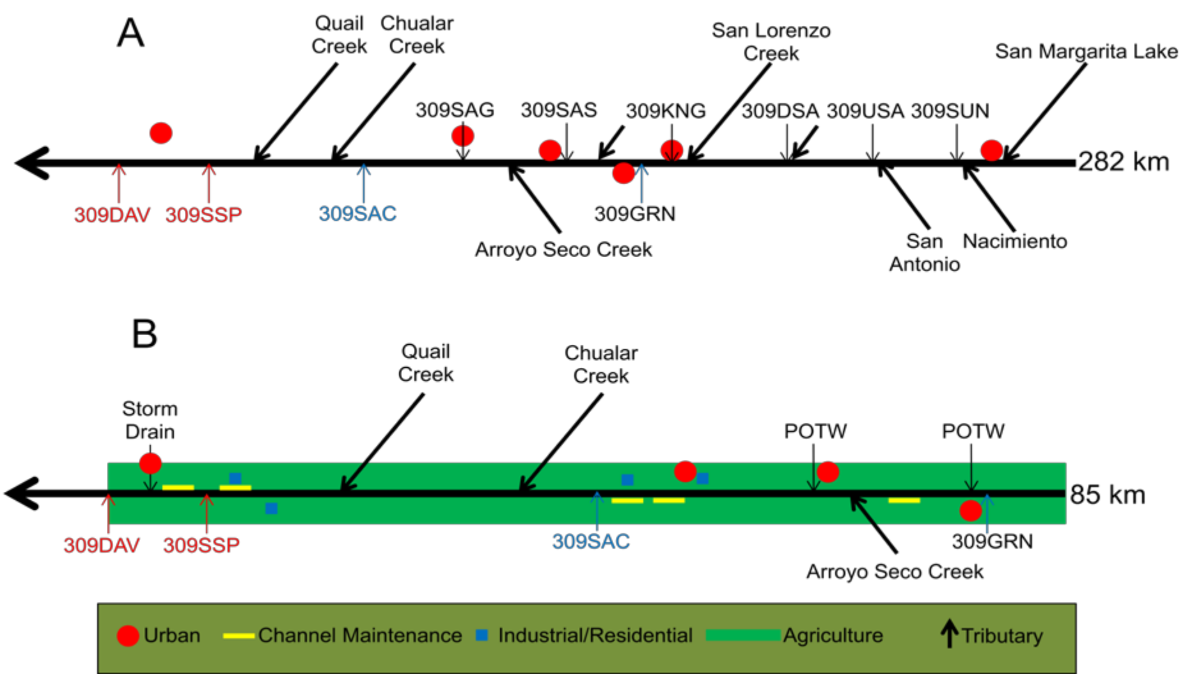


Figure 2. Features of the Salinas River, California. A) Identification of sampling locations (designated as 309XXX), major tributaries, and cities along the Salinas River. B) Location of potential sources to the lower Salinas River. Point sources included stormwater drains, POTWs, industrial/residential facilities, and recently devegetated regions within the river floodplain. The non-point source consisted of agricultural fields. Red and blue text indicates the biological impacted and comparator sites used for the case study.

Table 1. Biological characterization of the Salinas River, California, biological impacted and comparator sites.

Site	Davis Rd 309DAV	Spreckels 309SSP	Chualar Bridge 309SAC	Chualar Bridge 309SAC	Greenfield 309GRN
Type	Impacted	Impacted	Comparator	Comparator	Comparator
Organization	CCAMP	CMP	CCAMP	CMP	CMP
Sampling Date	6 Jun 2006	26 May 2006	6 Jun 2006	25 May 2006	26 May 2006
SoCal Benthic Invertebrate Index of Biological Integrity					
SoCal IBI Score	14	19	29	24	30
Coleoptera Taxa	0	0	1	0	1
EPT Taxa	3	2	4	5	7
Predator Taxa	2	2	3	3	2
% Collectors	95	100	98	92	97
% Intolerant Taxa	6	1	26	19	9
% Non-insect Taxa	25	14	31	38	21
% Tolerant Taxa	38	29	31	31	21
Species Composition- count (relative abundance)					
Richness	7	6	13	13	24
Chironomidae	178 (36%)	312 (63%)	22 (37%)	262 (52%)	134 (38%)
Oligochaeta	246 (49%)	168 (34%)	3 (5%)	21 (4%)	12 (3%)
Tricorythodes	2 (<1%)	3 (1%)	7 (12%)	61 (12%)	68 (19%)
Centroptilum	29 (6%)	7 (1%)	11 (19%)	136 (27%)	32 (9%)
Acentrella	0 (0%)	0 (0%)	1 (2%)	0 (0%)	63 (18%)
Hydropsyche	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (1%)
Total Count	497	498	59	500	356

The SoCal B-IBI was disaggregated into its seven component metrics to identify the specific effects that contributed to differences among sites (Table 1). Specific effects for the two lower Salinas River sites relative to upstream samples included an increase in the percent noninsect taxa, an increase in the percent tolerant taxa, a decrease in percent intolerant individuals, and a decrease in ephemeroptera + plecoptera + trichoptera (EPT) taxa. Oligochaeta accounted for the greatest taxonomic difference, with more individuals and greater relative abundances associated with the impacted sites (Table 1).

This case was limited to identifying the cause of the “very poor” SoCal B-IBI scores for the Davis Road (309DAV) and Spreckels Gage (309SSP) in 2006 (Figure 2). The comparator site consisted of two samples collected the Chualar Bridge at River Road site (309SAC). The Chualar Bridge site was selected because of the better SoCal-IBI scores, close proximity to the impacted sites, similar geomorphic features (i.e., sandy-bottom, low gradient), and the availability of flow data. A second location near Greenfield (309GRN) was analyzed but not considered as a primary comparator site since, although having some geomorphic similarities, contained more gravel, lacked an “on-site” stream gauge, was located some distance from the impacted sites. In addition, the Arroyo Seco, a major tributary, was located between the Chualar Bridge (309SAC) and Greenfield (309GRN) comparator sites (Figure 2A). Nonetheless, the site provided information useful for understand the dynamics of the river. Additional information was obtained from water quality monitoring conducted at Gonzales River Road Bridge (309SAG), Highway 101 in Soledad (309SAS), Highway 101 in King City (309KNG) and the upper river sites at San Ardo at Cattleman Road (309DSA), San Ardo at Bradley Bridge (309USA), and Nacimiento at Bradley Road (309SUN) (Figure 2A). These additional sites had SoCal B-IBI scores in the "poor" to "fair" categories.

CANDIDATE CAUSE DEFINITIONS

Eight candidate causes were proposed for the Salinas River 2006 benthic macroinvertebrate biological impairment. Potential candidate causes were identified and discussed by participants in a workshop held in Costa Mesa, CA in February 2012. The participants included scientists representing a stakeholder group, a state agency, and a federal agency; specifically, the Central Coast Water Quality Preservation, Inc (CCWQP), Central Coast Regional Water Quality Control Board (CCRWQB), and US Environmental Protection Agency (EPA). For causal hypotheses advocated by any participant, conceptual diagrams that link the candidate cause with potential sources and effects were developed and data sources identified (Figures 3 through 10). The general format of the conceptual diagrams depict sources and contributing landscape changes near the top of the figure, leading down the diagram to steps in the causal pathway, proximate stressors, modes of action, and concluding with observed biological responses at the bottom. The detailed diagrams and narratives for the Salinas River were modified and adapted from the general diagrams and narratives available through CADDIS (http://www.epa.gov/caddis/ssr_home.html). Biological responses are limited to plants and macroinvertebrates.

The eight potential candidate causes, in no particular order, were:

- Decreased dissolved oxygen- human related activities (e.g., fertilizer applications, wastewater treatment plant effluent, stormwater drainage, septic tank leakage, and animal waste) that increase chemical or biological oxygen demand resulting in reduce dissolved oxygen concentrations that affect aquatic biota (e.g., cause respiratory stress).
- Increased nutrients- human related activities (e.g., fertilizer applications, wastewater treatment plant effluent, stormwater drainage, septic tank leakage, and animal waste) that result in excessive amounts of nitrogen and phosphorus that negatively affect aquatic communities (e.g., indirect food web affects and nitrogen toxicity).
- Increased pesticides- applications of insecticides and herbicides (e.g., agriculture, landscaping, and golf courses), collectively referred to as pesticides, and their metabolites that have lethal and sub-lethal effects of aquatic biota, potentially changing community structure and ecosystem function.
- Increased metals- human related activities or natural land disturbances that concentrate or redistribute metals that affect aquatic communities if biologically available at toxic concentrations.
- Increased ionic strength- human activities or natural processes that changes ionic strength and/or composition which can benefit some aquatic organisms while harming others, ultimately changing organism composition.

- Increased sediments (bedded & suspended)- adverse effects to aquatic biota caused by human activities (agriculture, devegetation, and instream gravel mining) that greatly alter sediment budgets (i.e., the supply, movement, and retention of mineral and organic particles of all sizes).
- Altered flow regime- adverse effects to aquatic biota caused by human activities (e.g., agriculture related extraction & discharge, point source discharges, industrial or mining extraction, water management) that greatly alter discharge patterns, water velocity, and water depth.
- Altered physical habitat- adverse effects to aquatic biota associated with human activities that greatly alter the structural geomorphic or vegetative features of stream channels.

Several potential sources and landscape changes were identified (Figure 2B). The primary non-point source was agriculture. Point source discharges included the City of Salinas stormwater drain located between the Davis Rd (309DAV) and Spreckels (309SSP) sites and two tributaries, Quail Creek and Chualar Creek. There were several residential and industrial facilities; however, there were no documented point sources associated with them. Besides agriculture and urban development, the other obvious landscape change was the removal of channel vegetation associated with a flood improvement project. There was no evidence of instream gravel mining within the case study footprint.

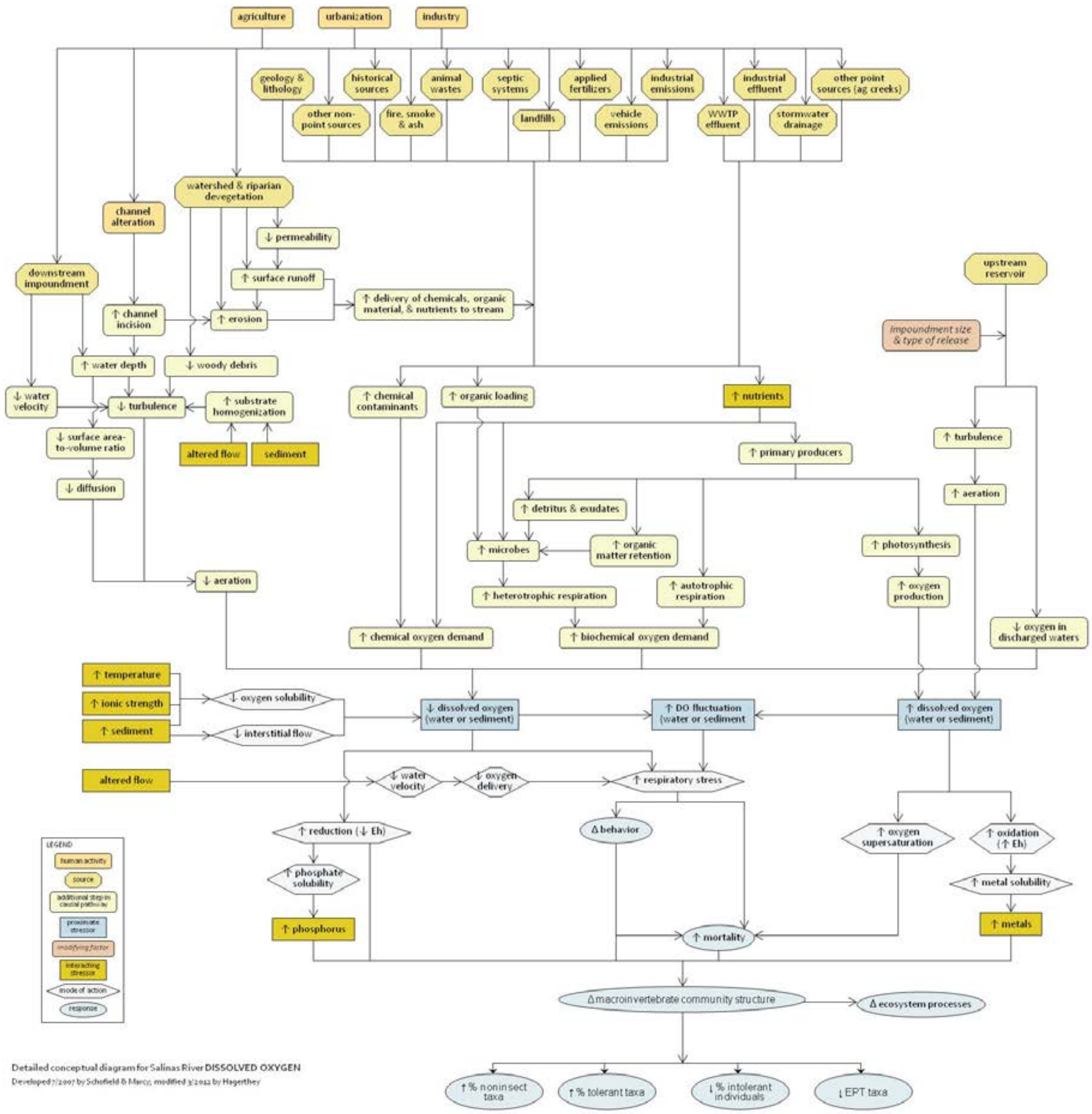


Figure 3. Decreased dissolved oxygen conceptual diagram.

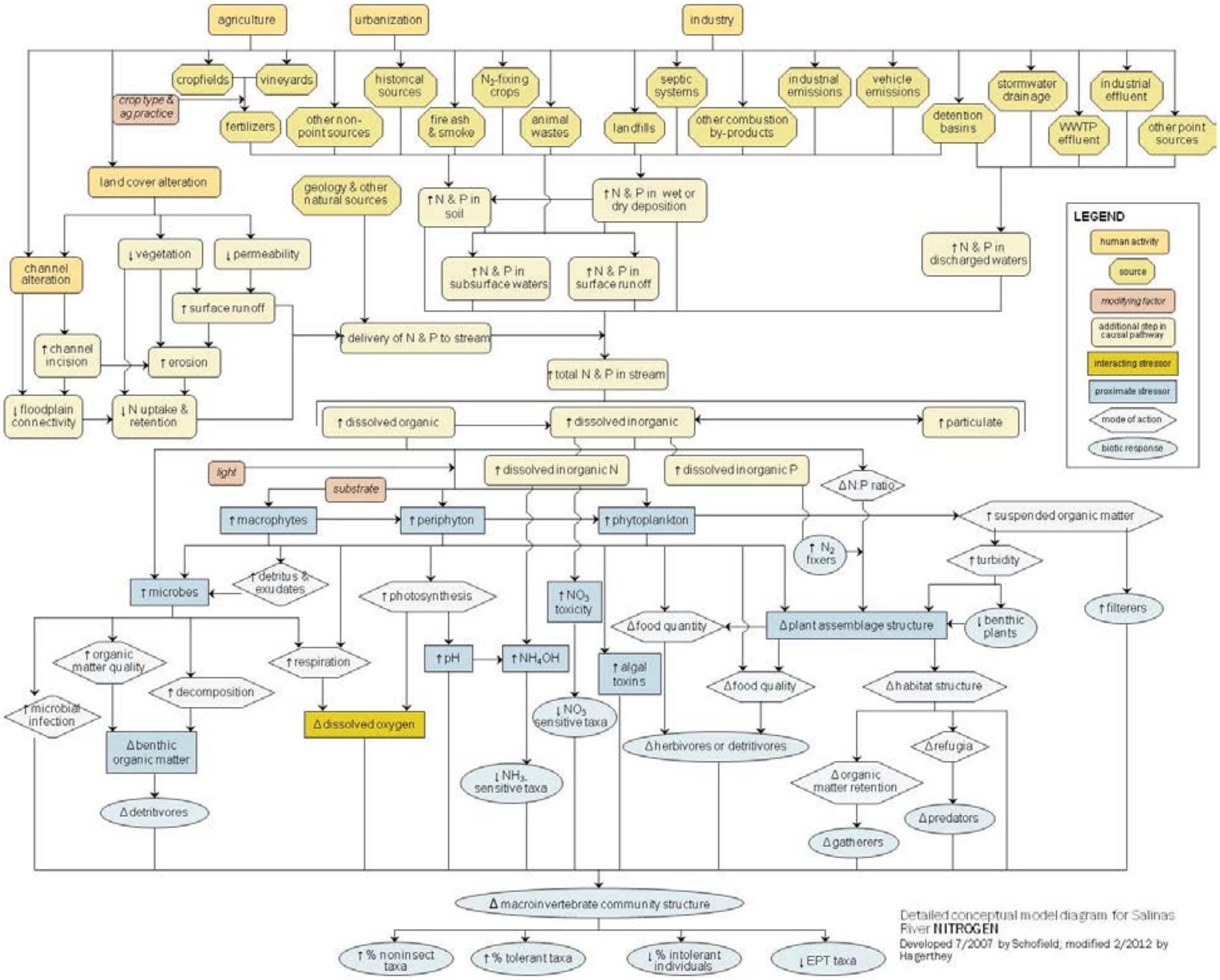


Figure 4. Increased nutrients conceptual diagram.

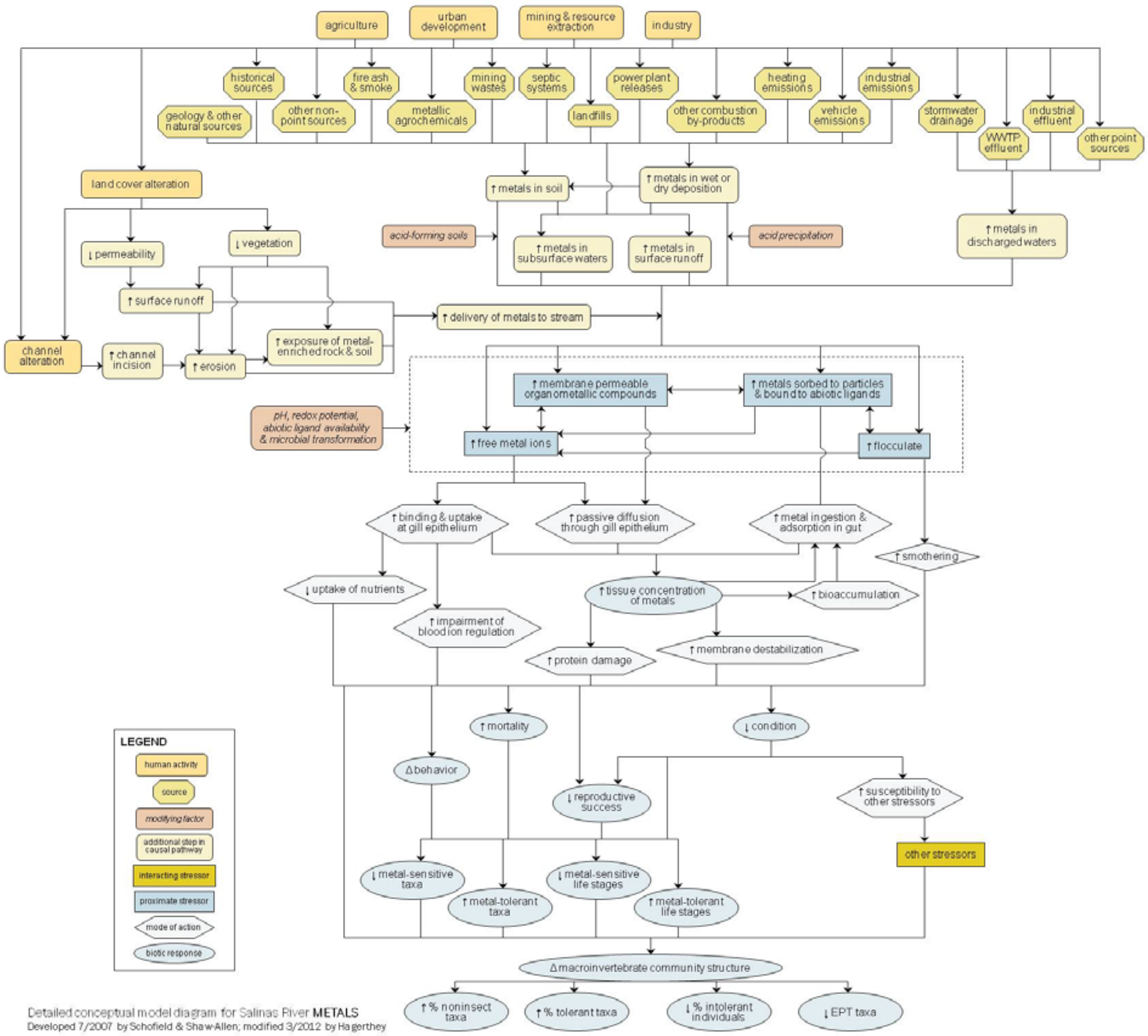


Figure 5. Increased metals conceptual diagram.

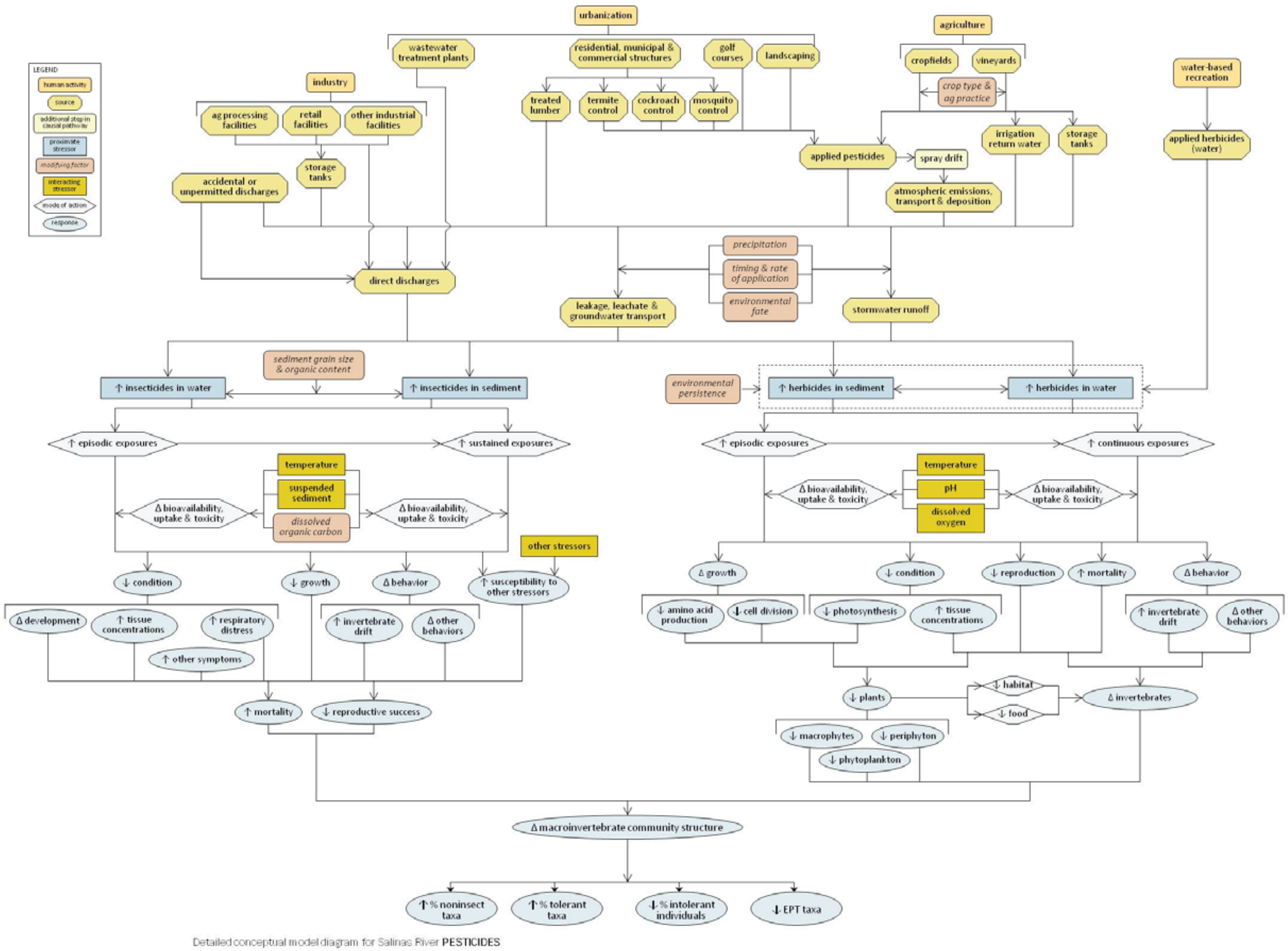


Figure 6. Increased pesticides conceptual diagram.

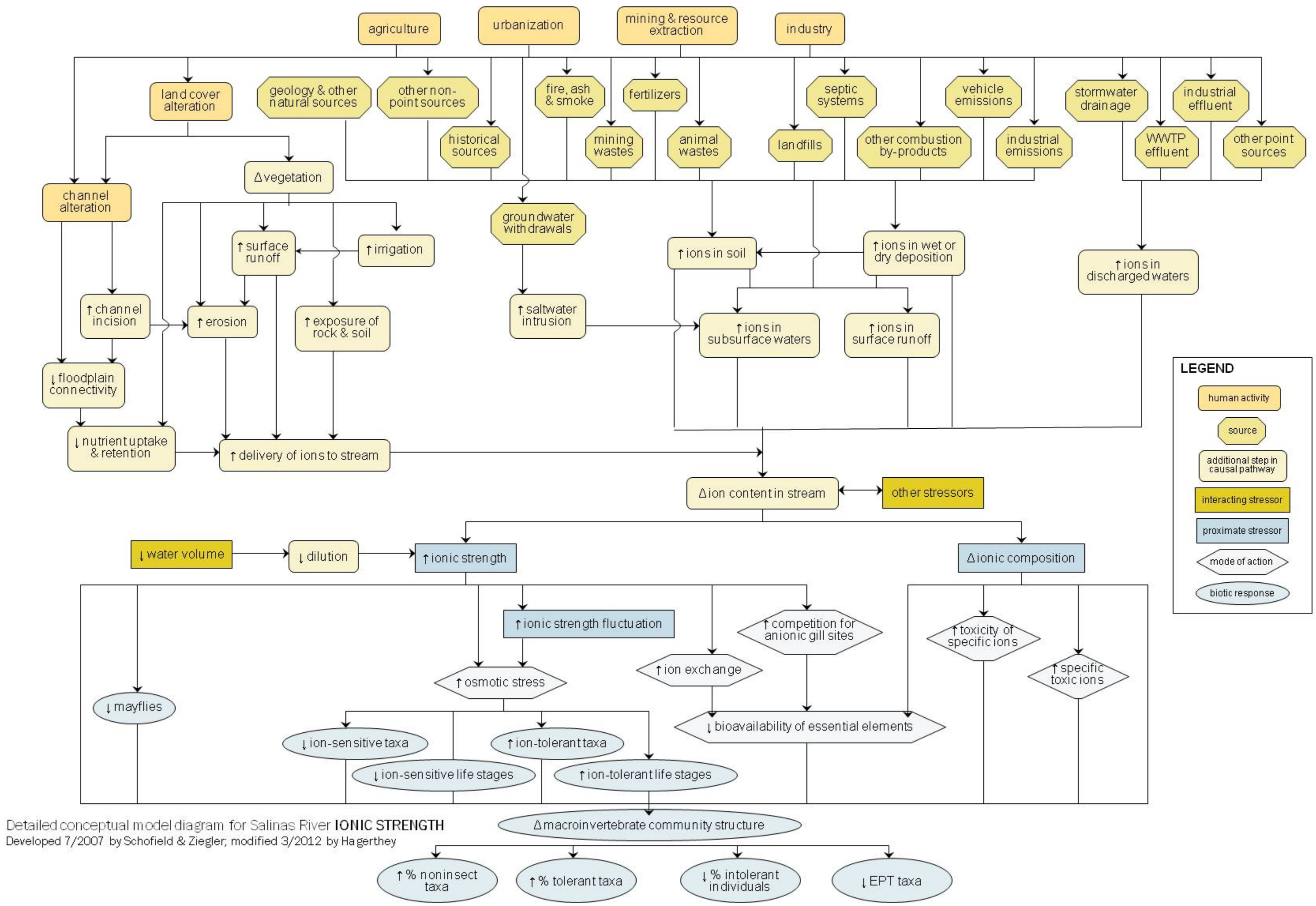


Figure 7. Increased ionic strength conceptual diagram.

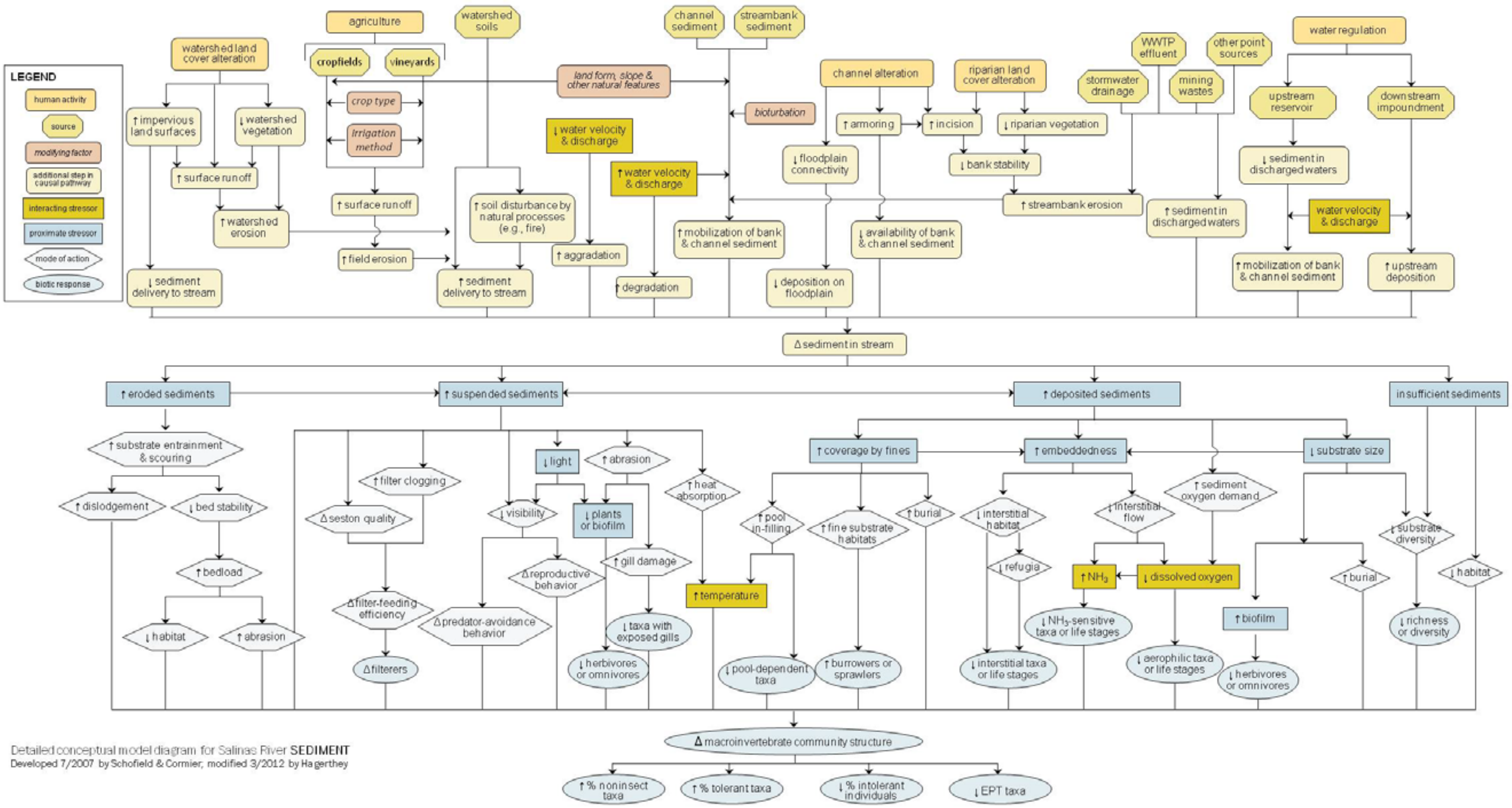


Figure 8. Increased sediments conceptual diagram.

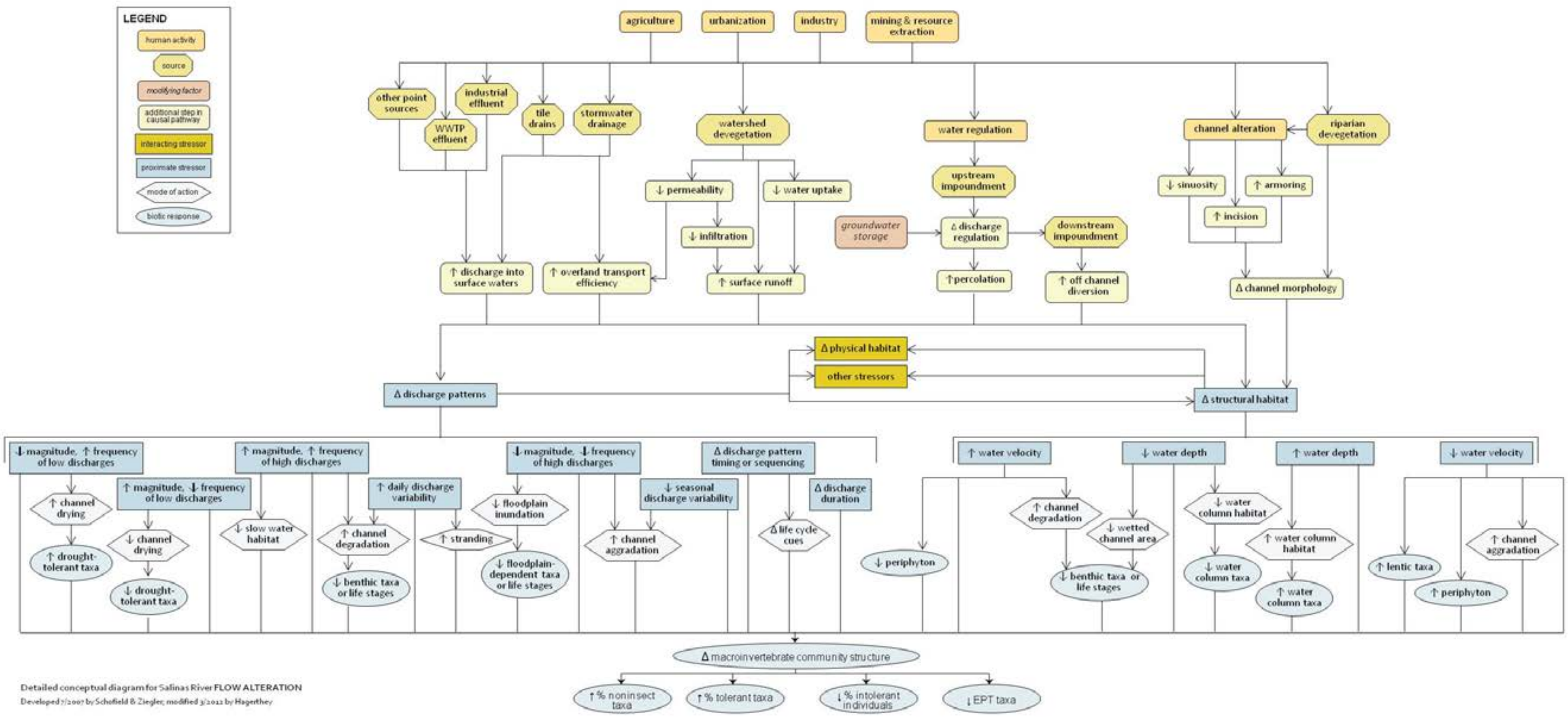
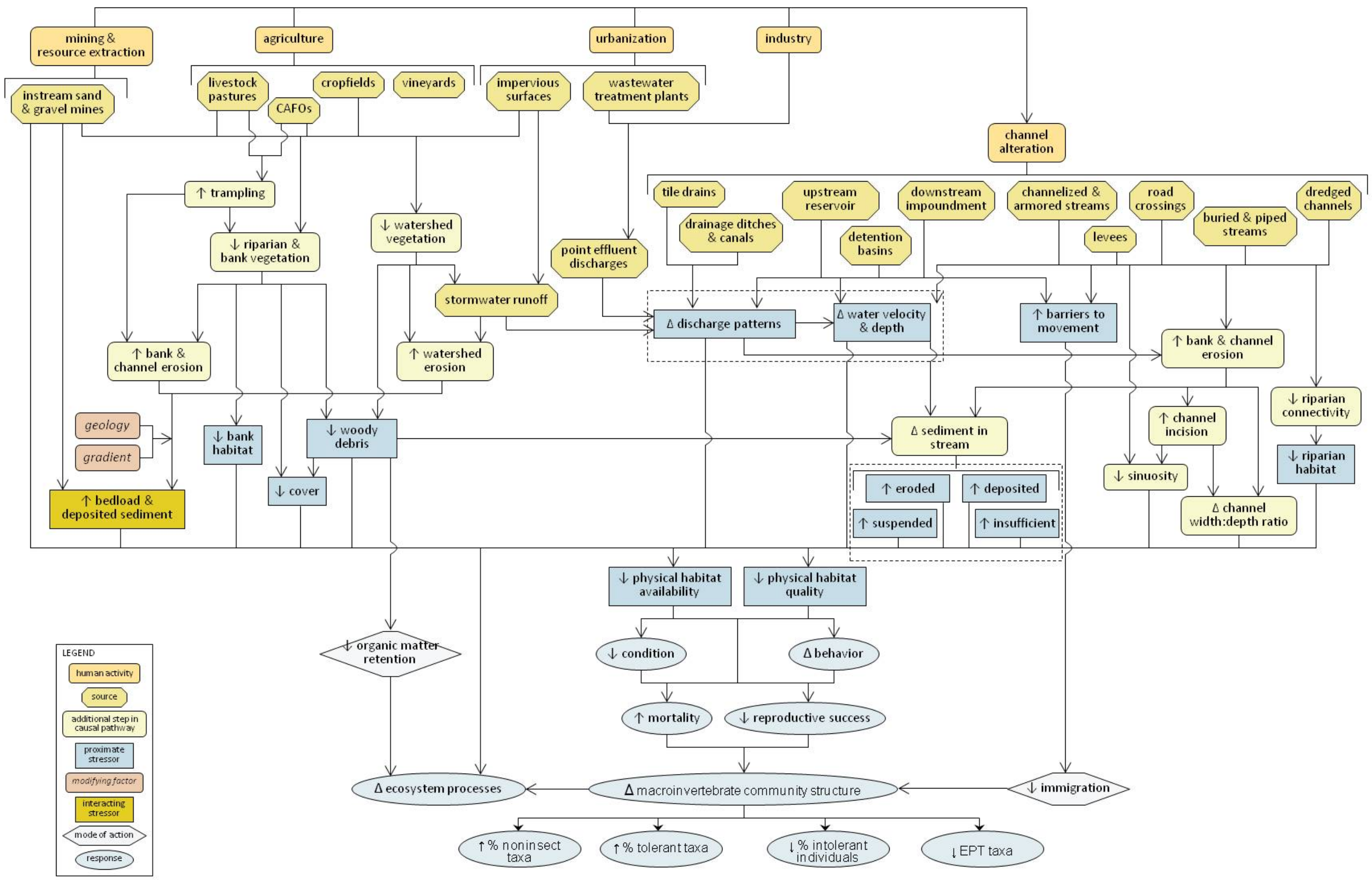


Figure 9. Flow alterations conceptual diagram.



Detailedconceptual model diagram for Salinas River **PHYSICAL HABITAT**
Modified by Hagerthey 3/2012

Figure 10. Altered physical habitat conceptual diagram.

Data Inventory

An initial set of data sources were identified by the Salinas workgroup at the February 2012 workshop. The two primary sources were chemical, physical, and biological data obtained from the CCRWQB's Central Coast Ambient Monitoring Program (CCAMP) and CCWQP's Cooperative Monitoring Program (CMP). Additional significant data sources included U.S. Geological Survey daily streamflow data and the City of Salinas stormwater discharge data.

Identification of Probable Cause(s)

For each candidate cause, available data were analyzed to produce evidence to support or weaken the cause. For each candidate cause, data for the case study were assembled into different evidence types (Table 2) and analyzed and evaluated using a systematic scoring framework applied to each type of evidence (Table 3).

Table 2. The different evidence types utilized in the Salinas River case study. Refer to the CADDIS website for further information on evaluating data from the case (http://www.epa.gov/caddis/si_step3_overview.html) and from elsewhere (http://www.epa.gov/caddis/si_step4_overview.html).

Evidence Type	Definition
Using Data from the Case	
Spatial-Temporal Co-Occurrence	The biological effect must be observed where and when the cause is observed or not observed when absent.
Causal Pathway	Steps in the causal pathway (conceptual diagram) linking sources to the cause are present; thus, increase the likelihood that the agent is present.
Stressor-Response from the Field	As exposure to the cause increases or decreases, intensity or frequency of the biological effect responds accordingly.
Laboratory Test of Site Media	Controlled exposure in laboratory tests to stressors present in site media induce biological effects consistent with observations from the field.
Temporal Sequence	The cause must precede the biological effect.
Using Data from Elsewhere	
Stressor-Response from Field Studies	At the impacted site, the cause must be at levels sufficient to cause similar biological effects in other field studies.
Stressor-Response from Lab Studies	Within the case, the cause must be at levels associated with related biological effects in laboratory studies.
Evaluation of Multiple Types of Evidence	
Consistency of Evidence	Evaluation of the consistency and credibility of evidence types within and across candidate causes.

Table 3. Scores and interpretation applied to the analysis of evidence for the causes of 2006 biological impairment at the Davis Rd (309DAV) and Spreckels (309SSP) sites in the Salinas River, CA.

Score	Interpretation
+++	Convincingly supports
++	Strongly supports
+	Somewhat supports
0	Ambiguous
-	Somewhat weakens
--	Strongly weakens
---	Convincingly weakens
0	Ambiguous
NE	No evidence
R	Refutes

Table 4 summarizes the scores for the available evidence for each candidate cause as well as presents a measure of the consistency of evidence. Analyses and scoring tables for evidence from the case are presented in Appendices 1 through 9 and from elsewhere in Appendices 10 through 17.

Based on the available evidence, the following candidate cause determinations were made (Table 5). Increased suspended sediment was identified as the likely cause of the biological impairment at both the Davis Rd (309DAV) and Spreckels (309SSP) sites. Increased pesticides and metals could not be evaluated due to a lack of data. The remaining candidate causes were determined to be unlikely.

- *Increased sediments*- Although the Salinas River is a sediment dominated system, comprised of unconsolidated sands (Watson et al. 2003), excess suspended sediments was identified as a likely cause of the biological impairment because there were multiple lines of supporting evidence. Suspended sediments were greater for the impacted sites than comparator sites and coincided with the impairment, supporting evidence of spatial temporal co-occurrence (Figure 11). Benthic macroinvertebrate responses to increased concentrations were strongly related and in the expected direction, supporting evidence of stressor-response from the field (Figure 12). Concentrations were in the range reported to cause an ecological effect, evidence of stressor-response relationship from other studies (Figure 13). Data were available to link sources to the candidate cause, supporting evidence for causal pathway (Figure 14). For example, precipitation and irrigation tended to be greater in the impacted site subwatersheds indicating a greater likelihood of watershed erosion. Increased sediment delivery to the river was supported by tributaries and the City of Salinas storm drain having suspended sediment concentrations greater than the river. Alternatively, bedded (deposited) sediments were likely not a cause because there were multiple lines of weakening evidence.

Table 4. Summary of evidence for the 2006 biological impairments for the Salinas River sites Davis Rd (309DAV) and Spreckels (309SSP). The Chualar site (309SAC) was used as the comparator site in both cases; however, the analysis relied on different data sets. NA is not applicable.

	Candidate Causes								
	Decreased DO	**Increased Pesticides**	**Increased Metals**	**Increased Nutrients**	**Increased Ionic Strength**	**Increased Sediments (Bedded)**	**Increased Sediments (Suspended)**	**Altered Flow Regime**	**Altered Physical Habitat**
Impacted (309DAV) vs Comparator (309SAC)									
Types of Evidence that Uses Data from the Case									
Spatial-Temporal Co-Occurrence[†]	-	NE	NE	+	---	---	+	+	-
Causal Pathway[§]	NA	+	0	0	NA	-	+	0	+
Stressor-Response from the Field[¥]	-			-	-	-	++	+	
Laboratory Test of Site Media[£]									
Temporal Sequence[ø]				-	---	---		+	
Types of Evidence that Uses Data from Elsewhere									
Stressor Response from Other Studies[α]							+		
Stressor Response from Laboratory[è]		+	+						
Evaluation of Multiple Types of Evidence									
Consistency of Evidence	-			-	---	-	+	-	-
Impacted (309SSP) vs Comparator (309SAC)									
Types of Evidence that Uses Data from the Case									
Spatial-Temporal Co-Occurrence[†]	-	NE	NE	---	---	+	+	+	-
Causal Pathway[§]	NA	+	0	0	NA	-	+	0	+
Stressor-Response from the Field[¥]	-			-	-	-	++	+	0
Laboratory Test of Site Media[£]		-	-						
Temporal Sequence[ø]	0			-	-	-	+	-	-
Types of Evidence that Uses Data from Elsewhere									
Stressor Response from Other Studies[α]							+		
Stressor Response from Laboratory[è]		+	+						
Evaluation of Multiple Types of Evidence									
Consistency of Evidence	-			-	---	-	+	-	-

[†] spatial- temporal co-occurrence data and strength of evidence tables are presented in Appendix 1.
[§] causal pathway data and strength of evidence tables are presented in Appendix 2 & 3.
[¥] stressor-response relationships from the field data and strength of evidence tables are presented in Appendix 4 & 5.
[£] laboratory test of site media data and strength of evidence tables are presented in Appendix 6 & 7.
[ø] temporal sequence figures are presented in Appendix 8 & 9.
[α] stressor-response relationships from other studies data and strength of evidence tables are presented in Appendix 10 and 11.
[è] stressore-response relationships from laboratory studies data and strength of evidence tables are presented in Appendix 12-17.

Table 5. Identification, based on results of a causal assessment, of the candidate causes responsible for the benthic macroinvertebrate biological impairment observed at the Davis Rd (309DAV) and Spreckels (309SSP) sites in the Salinas River, 2006.

Conclusion	Candidate Cause	Evidence and Comments
Likely	Suspended sediments	Concentrations consistently higher at subject sites relative to comparator; Concentrations at levels associated with effects in other studies
Likely	Physical habitat	Especially as influenced by suspended sediments
Uncertain	Pesticides	Very limited data available for assessment.
Uncertain	Metals	Very limited data available for assessment.
Unlikely	Dissolved oxygen	Concentrations similar between subject and comparator sites; however, data was limited.
Unlikely	Nutrients	Concentrations peak and differences occur well after invertebrate samples are collected.
Unlikely	Ionic Strength	Concentrations peak and differences occur well after invertebrate samples are collected.
Unlikely	Flow Regime	Flow regimes are similar among the subject and comparator sites.

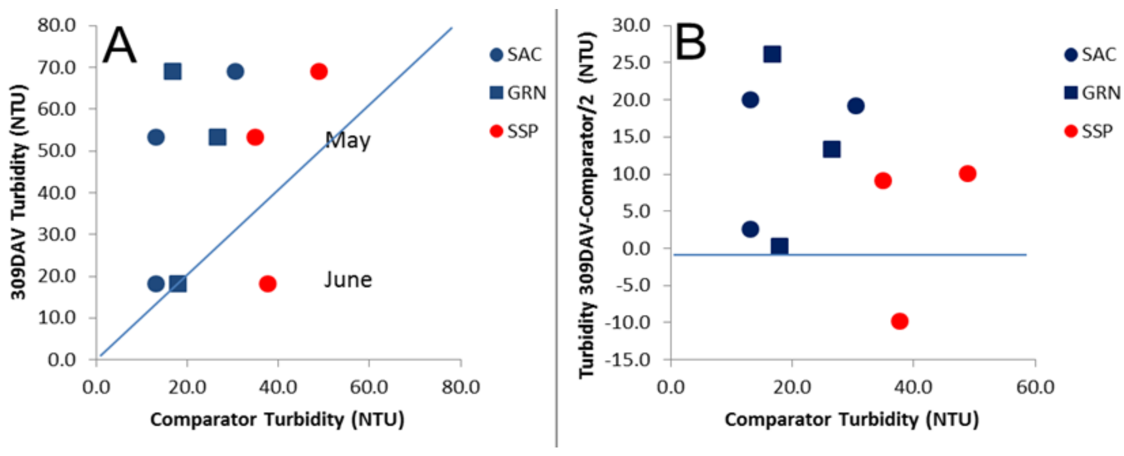


Figure 11. Example of supporting evidence for spatial/temporal co-occurrence. Suspended sediment concentrations at the impacted sites (309DAV) were greater in the months preceding biological assessment than at the upstream, impacted site (309SSP) comparator sites (309SAC and 309GRN) but were similar in the months following the impairment, indicated here using June. Also note that turbidity was greater for the other impacted sites (309SSP) than the comparator sites.

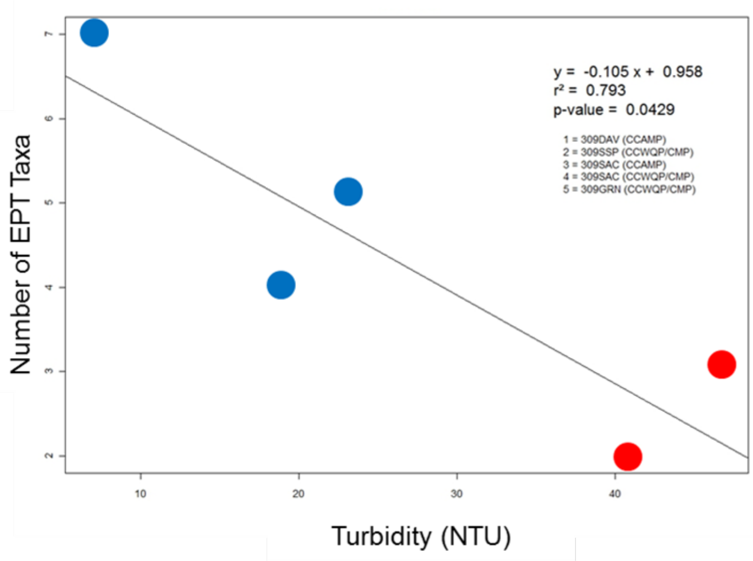


Figure 12. Example of supporting evidence for stressor-response from the field. The negative relationship was expected and effects were greater for the impacted sites (red circles) than comparator sites (blue circles).

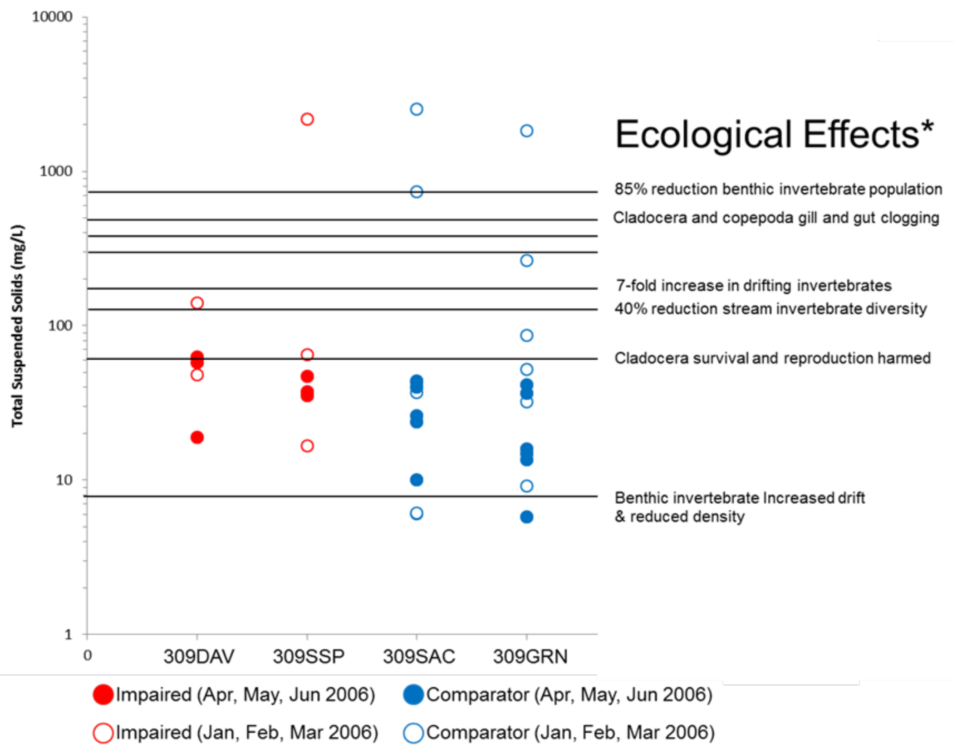


Figure 13. Stressor-response relationships from field studies using data from elsewhere for total suspended solids, Salinas River, California. Salinas River total suspended solid concentrations for the biologically impacted (red) and comparator sites (blue) for the months preceding assessment are plotted in relation to known adverse ecological effects as synthesized in Bilotta and Brazier (2008). Total suspended solids were collected by CCAMP.

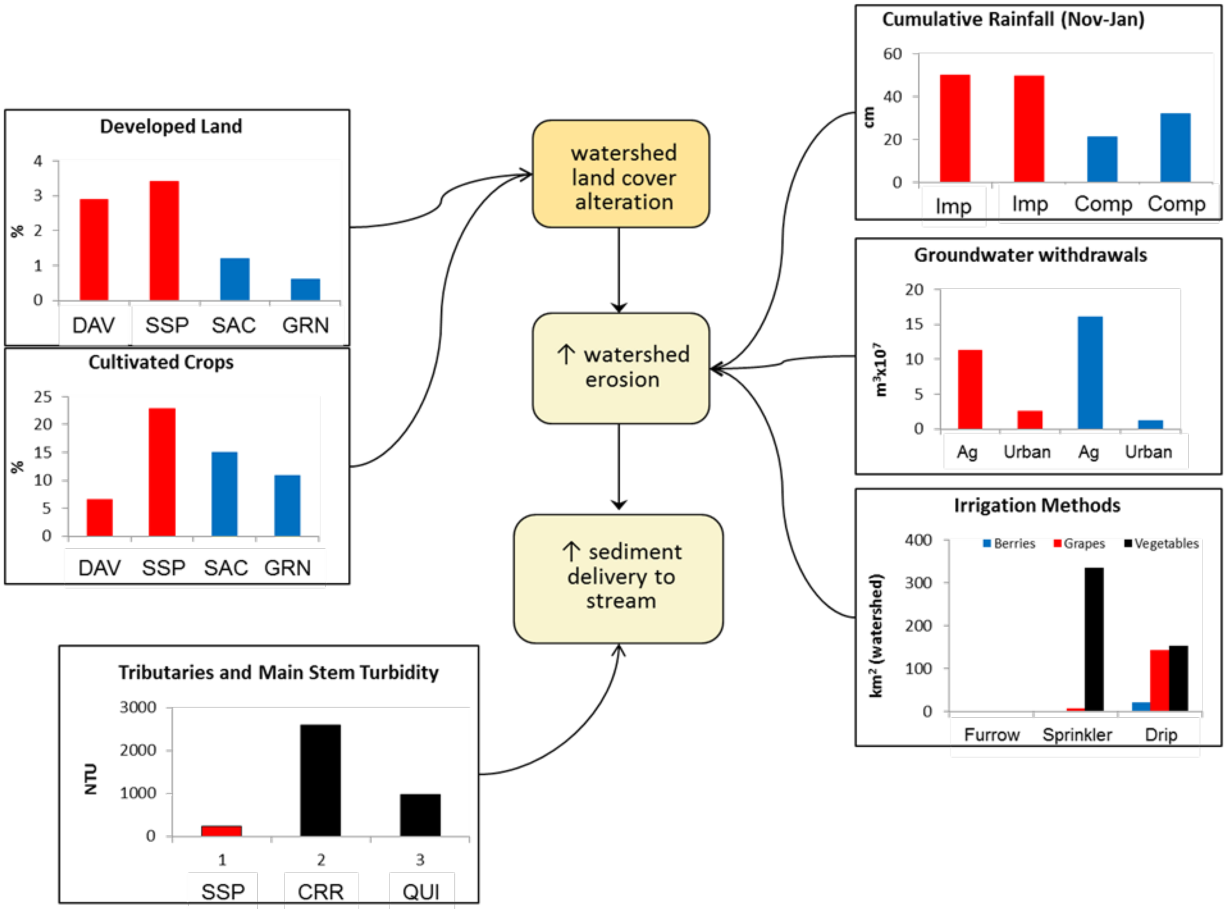


Figure 14. Example of causal pathway supporting evidence. For the potential candidate cause increased sediment (see sediment conceptual diagram; Figure 8), data for multiple steps (i.e., watershed land cover alteration, watershed erosion, and sediment delivery to stream) linked sources to the candidate cause. The percentage of developed and cultivated land was greater for the impacted sites, indicating greater land cover alteration. Greater precipitation and use of sprinklers within the lower watershed suggest a greater likelihood of watershed erosion. Greater turbidity in Chualar Creek (CRR) and Quail Creek (QUI), tributaries to the Salinas River, suggest a greater likelihood of sediment delivery to the river.

- *Altered physical habitat*- Altered physical habitat was identified as a likely cause of the biological impairment mainly because increased sediment was included as a proximate stressor in the conceptual diagram (Figure 10). Other physical habitat stressors, for example, bank erosion and woody debris, were determined to have unlikely caused the impairment.
- *Increased pesticides*- There was not enough evidence to determine if pesticides were a potential cause of the biological impairment. The available surface water and sediment pesticide data did not coincide with the impairment (spatial/temporal co-occurrence); thus, it could not be determined if the stressor coincided with the response.

- *Increased metals*- There was not enough evidence to determine if metals were a potential cause of the biological impairment. The available surface water and sediment metal data did not spatially nor temporally co-occur with the impairment; thus, it could not be determined if the stressor coincided with the response.
- *Decreased dissolved oxygen*- Dissolved oxygen was determined to be an unlikely cause of the biological impairment as there was somewhat weakening evidence. Grab samples of dissolved oxygen, measurements representing a single point in time, for the impacted sites at the time preceding and including the biological impairment did not differ from upstream comparator sites. In addition, concentrations were sufficient to not adversely affect invertebrates (spatial-temporal co-occurrence). However, the interpretability of daytime grab samples of dissolved oxygen was recognized. The working group was uneasy about concluding that DO was the cause without the availability of spatially and temporally co-occurring high resolution diel data that would capture night-time minima. Other lines of evidence further weaken the case for dissolved oxygen. These include the lack of organic matter, algal production, and low flow (stressor-response from the field and causal pathway).
- *Increased nutrients*- Increased nutrients was determined to be an unlikely cause of the biological impairment as there were multiple lines of weakening evidence. Although nutrient concentrations with the river can be considered elevated, nutrient concentrations (nitrogen and phosphorus) did not differ between impacted and comparator sites at the time of the impairments (spatial-temporal co-occurrence). Differences between impacted and comparator sites were observed but occurred in the late summer, several months preceding the benthic invertebrate assessment; thus the effect preceded the cause (temporal sequence). Similarly, responses for steps within the causal pathway (e.g., increased algal growth) were temporally disconnected from the benthic invertebrate assessment.
- *Increased ionic strength*- Increased ionic strength was determined to be an unlikely cause of the biological impairment as there were multiple lines of weakening evidence. Ionic strength or composition did not differ between impacted and comparator sites at the time of the impairments (spatial-temporal co-occurrence). Differences between comparator sites and one impacted site (309DAV) and the City of Salinas storm drain were observed but occurred in the late summer, several months preceding the benthic invertebrate assessment; thus, the effect preceded the cause (temporal sequence).
- *Altered flow regime*- Altered flow regime was determined to be an unlikely cause of the biological impairment as there were multiple lines of weakening evidence. Although flows in 2006 were greater than average due to above normal precipitation, the timing and magnitude of flows did differ markedly between impacted (downstream) and comparator (upstream) sites (spatial-temporal co-occurrence). Long-term hydrographs comparison between Spreckels (impacted) and Chualar (comparator) stream gages were very similar in flow volumes, peak discharges, and flood durations.

LIMITATIONS

There were several factors that limited the strength of candidate cause determinations.

- *Coordinated and integrated sampling designs*- Within the Salinas River case study, two potential candidate causes (increased pesticides & increased metals) could not be adequately evaluated because insufficient data were available to establish spatial-temporal co-occurrence. Although surface water and sediment pesticide data were collected, the data were temporally disconnected making it difficult to establish causation (e.g., did the effect precede the cause). In most cases, surface water pesticide and toxicity testing occurred several months after invertebrate collection when flow was minimal. Sediment pesticide sampling did not occur in the same year as the bioassessment. Condition assessment of metals in the Salinas River was minimal. Coupling of stressor sampling within the water and sediment with bioassessments would strengthen the ability to establish causation.
- *Comparator site selection*- A suitable reference condition (i.e., a site with a So-Cal IBI score greater than or equal to 39) was not found that represented similar conditions for a low gradient, sandy-bottom California stream. However, within the Salinas River there was enough of a biological contrast between downstream (309SSP & 309DAV) and upstream (309SAC) sites to perform a casual assessment even though So-Cal IBI scores were less than 39.
- *Biological assessment boundaries*- It is important to establish upfront the boundaries, or expectations, of the biological metric (e.g., macroinvertebrates, algae, or fish). For example, increased nutrients were identified as a potential candidate cause for the observed benthic macroinvertebrate impairment. However, nutrient enrichment does not directly affect benthic macroinvertebrates (i.e., nutrients are not the proximate stressor); thus, making it difficult to establish causation. Rather, effects emanate through the causal pathway, where, for example, nutrients affect macroinvertebrate resources by altering primary production (biomass or composition). Since nutrients are not a proximate stressor for invertebrates more evidence is required to strengthen the case then would be required if algae (the proximate stressor) were used as the biological objective.
- *Benthic macroinvertebrate integration time*- Opinions differ over the integration period that the benthic invertebrate assemblage being assessed represents. In this, the Salinas River case study, it was assumed that the natural seasonal hydrologic pattern imparted a strong regulatory effect on the invertebrate assemblage across all sites within the mainstem of the Salinas River; thus, near-term (i.e., beginning with the start of the wet season) response to stressors were assumed more likely than far-term stressors (i.e., the previous season). This limited the scope of the analysis to a narrow window of time (November 2005-June 2006). The alternative view contends that invertebrates integrate over a much longer timeframe and, thus, stressor events in the previous year should have been analyzed for causality. There is no clear scientific consensus for what an appropriate integration window for invertebrates is; however, life history knowledge of the taxa present can reduce uncertainty.
- *Assessment scale*- The Salinas River case study addressed biological impairments observed at specific sites and at a discrete time; thus, this casual assessment was narrowly focused. It was not established to address all impairments within the watershed (multiple

sites) or across multiple years (same site, different years). The benefits of identifying and documenting the scope of the causal assessment when the case study was defined allowed for more focused stakeholder discussions and effective communication.

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APPENDIX 1

Strength of evidence scoring of spatial/temporal co-occurrence for the Salinas River impacted Davis Rd site (309DAV) versus the comparator Chualar Bridge site (309SAC) and for the impacted Spreckels site (309SSP) versus the comparator Chualar Bridge site (309SAC).

Strength of evidence (SOE) scoring system for spatial/temporal co-occurrence.

- \+ The evidence occurs where or when the candidate cause occurs OR the effect does not occur where or when the candidate cause occurs
- 0 It is uncertain whether the candidate cause and the effect co-occur
- --- The effect does not occur where and when the candidate cause occurs OR the effect occurs where and when the candidate cause does not occur
- R The effect does not occur where and when the candidate cause occurs OR the effect occurs where and when the candidate cause does not occur and the evidence is indisputable
- NE No evidence

The workgroup developed the following rules to aid in scoring the stressors.

- if the difference in stressor values was in the wrong direction, then the evidence was scored ---
- if the stressors values were the same, the evidence was scored ---
- if the difference was leaning in the weakening direction but within measurement error, the evidence was scored ---
- if the difference was leaning in the supporting direction but within measurement error, the evidence was scored 0
- if the difference was leaning in the supporting direction and outside measurement error, the evidence was scored +.

Candidate Cause	Variable, units	309DAV	309SAC	Difference	SOE Score	Overall SOE Score	Comments
Decreased Dissolved Oxygen	Dissolved oxygen (mg/L)	9.2[2] 9.1-10.4	7.4[2] 6.1-8.9	25%	---	-	The - score is based on a lack of diel and nighttime oxygen minima data. While the increase in DO at the impacted site is compelling evidence for DO to not be a stressor, the values are based on grab samples collected at different times of day.
	Percent saturation (%)	97[2] 93-111	102[2] 54-102	-5%	0		
Increased Pesticides						NE	No pesticide data, surface water or sediment was collected in 2006.
Increased Metals						NE	No metals data, surface water or sediment was collected in 2006.
Increased Nutrients	Chlorophyll *a* (ug/L)	9[2] 4.4-16.3	4[2] 2.8-25.0	125%	+	+	Variables are proximate stressors to invertebrates. Scored overall as a + because of the + associated with the qualitative measures.
	Volatile Total Suspended Solids (mg/L)	4.7[2] 1.7-23	3.5[2] 1.8-90	34%	+		
	†Filamentous algae	0	5	<	-		
	†Aquatic macrophytes	0	0	=	-		

Candidate Cause	Variable, units	309DAV	309SAC	Difference	SOE Score	Overall SOE Score	Comments
Increased Ionic Strength	Specific Conductivity (µS/cm)	711 343-874	722 121-824	-2%	---	---	
	Total Dissolved Solids (mg/L)	510 290-610	525 140-600	-3%	---		
	Fixed Total Dissolved Solids (mg/)	405 210-500	415 97-470	-2%	---		
	Salinity (ppt)	0.37 0.17-0.45	0.38 0.05-0.43	-2%	---		
	Hardness (mg/L as $CaCO_3$)	295 150-360	295 68-340	0%	---		
	Chloride (mg/L)	42 19-57	42 2.5-52	0%	---		
	Calcium (mg/L)	71 35-85	71 18-81	0%	---		
	Sodium (mg/L)	50 25-64	50 8.2-61	0%	---		
	Magnesium (mg/L)	29 15-35	29 5.7-33	0%	---		
Altered Physical Habitat†						-	
↓*Woody Debris*	Woody debris >0.3m	3.2	0	>	---	-	
	Woody debris <0.3m	10	3.2	>	---		
	Artificial structures	0	0	=	---		
↓*Riparian Habitat*	Riparian trees and saplings >5m high	30	40	<	---		
	Riparian shrubs and saplings 0.5m to 5m high	20	46	<	+		
	Riparian shrubs and saplings, herbs/grasses	4	20	<	+		
	Barren, bare soil/duff	57	51	>	---		
	Arrundo donax coverage within 400 m of site (m^2)	11079	18253	-39%	---		
↓*Cover*	Plant cover (%)	1	1	=	---		

Candidate Cause	Variable, units	309DAV	309SAC	Difference	SOE Score	Overall SOE Score	Comments
↓*Bank Habitat*	Undercut banks	0	0	=	---		
	Overhang vegetation	7.3	17.7	<	0		
	Live tree roots	7.3	25	<	0		
	Bank stability (stable)	0%	50%	<	0		
	Bank stability (vulnerable)	0%	50%	<	0		
	Bank stability (eroded)	100%	0%	>			
↑ Sediment (suspended)						+	
	Total Suspended Solids (mg/L)	39[2] 19-140	25[2] 10-740	54%	+		
	Fixed Total Suspended Solids (mg/L)	34[2] 15-120	22[2] 8.4-650	55%	+		
	Turbidity (NTU)	36[2] 18-148	13[2] 13-900	177%	+		
	Non-flood Sediment Load (kg/d)*	3326[2]	2160[2]	54%	+		
↑ Sediment (bed)						---	
	Coarse Gravel (16-64mm)	0%	0%	0%	---		
	Fine Gravel (2-16mm)	0%	0%	0%	---		
	Sand (0.06-2mm)	100%	100%	0%	---		
	Fines (<0.06mm)	0%	0%	0%	---		
	Other	0%	0%	0%	---		
	†Sediment deposition	0 (Poor)	1 (Poor)	=	---		
	†Epifaunal substrate available cover	1 (Poor)	3 (Poor)	=	---		
	†Flow Habitat	100% Run	100% Glide		---		
Altered Flow Regime*						+	
	Annual discharge (m^3x10^8)	4.4	4.5	-2%	+		
	Discharge Nov-Jun (m^3x10^8)	4.4	4.5	-2%			
	Baseflow (m^3/s)	7.0	9.0	-22%	+		

Candidate Cause	Variable, units	309DAV	309SAC	Difference	SOE Score	Overall SOE Score	Comments
	Baseflow discharge per watershed area ($m^3/s/km^2$)	0.0008	0.0011	-27%	+		
	Water velocity (m/s)	1.01	0.70	44%			
	Water depth (m)	0.35	0.45	-22%			
	All storms event peak discharge (m^3/s)	320	309	4%	0		
	All storms event peak discharge per watershed area ($m^3/s/km^2$)	0.037	0.036	3%	0		
	All storms volume ($m^3 x10^8$)	3.4	3.0	13%	+		
	All storms volume per watershed area ($m^3 x10^4/km^2$)	3.8	3.5	9%	+		
	April storm volume ($m^3 x10^8$)	2.8	2.6	8%			
	April storm volume per watershed area ($m^3 x10^4/km^2$)	3.2	3.0	7%			
	April storm flow duration (d)	34	33	3%			
	Channel alteration	15	14	>			

Values are mean [n] (range), where more than one value available.
Difference calculations: the majority of differences are expressed as a percent =[(impacted value-reference value]/reference value]*100%; differences between ABL Stream Habitat Characterizations are shown as greater or less than the reference value due, in part, to the qualitative nature of the values.
† indicates qualitative metrics obtained from the ABL Stream Habitat Characterization full version form. Values for parameters listed under Altered Physical Habitat are averages for the sampled reach calculated following EPA (2003) per SWAMP protocols.
*Annual sediment load and discharge for 309DAV were calculated assuming flow at 309SSP USGS gauge (11152500) is equal to flow at 309DAV. The discharge of the Salinas City MS4 storm drain is not quantified; thus, its contribution to the discharge at 309DAV is unknown.
Sediment Deposition- poor qualitatively defined as heavy deposits of ine material, increased bar development; more than 50% of the bottom changing frequently.
Epifaunal Substrate Available Cover- less than 20% stable habitat; lack of habitat is obvious.

Candidate Cause	Variable Units	309SSP	309SAC	Difference	SOE Score	Overall SOE Score	Comments
Decreased Dissolved Oxygen	Dissolved oxygen (mg/L)	7.7 7.7-11.3	7.6 7.6-11.4	1.3%	---	-	The - score is based on a lack of diel and nighttime oxygen minima data. While the increase in DO at the impacted site is compelling evidence for DO to not be a stressor, the values are based on grab samples collected at different times of day.
	Percent saturation (%)	83 77-106	80 54-104	3.8%	---		
Increased Pesticides						NE	No pesticide data, surface water or sediment was collected in 2006.
Increased Metals						NE	No metals data, surface water or sediment was collected in 2006.
Increased Nutrients	Chlorophyll *a* (ug/L)	1.5 1.0-3.9	2.0 0.7-2.6	-25%	---	---	
Increased Ionic Strength	Specific Conductivity (µS/cm)	718 406-1063	744 413-1058	-3%	---	---	
	Total Dissolved Solids (mg/L)	480 300-610	490 300-580	-2%	---		
	Salinity (ppt)	0.37 0.20-0.56	0.38 0.21-0.55	-3%	---		
Altered Physical Habitat†						-	
↓*Woody Debris*	Woody Debris	5	0	>	---		
↓*Riparian Habitat*	Riparian vegetation zone width (Left Bank/Right Bank)	8/8 (Suboptimal)	8/8 (Suboptimal)		---		
	Arrundo donax coverage within 400 m of site (m^2)	3130	18253	-83%	---		
↓*Cover*	Vegetation Protection (Left Bank/Right Bank)	4/7 (Marginal)	10/8 (Optimal)		0		
	Submersed Vegetation	25	5	>	---		
↓*Bank Habitat*	Bank stability (Left Bank/Right Bank)	1/2 (Poor)	8/6 (Suboptimal)		+	+	

Candidate Cause	Variable Units	309SSP	309SAC	Difference	SOE Score	Overall SOE Score	Comments
↑ Sediment (suspended)						+	
	Turbidity (NTU)	35 13-2584	22 0.5-3000	59%	+		
↑ Sediment (bed)							
	Coarse Gravel (16-64mm)	0%	0%	0%	---	-	
	Fine Gravel (2-16mm)	0%	0%	0%	---		
	Sand (0.06-2mm)	75%	100%	-25%	+		
	Fines (<0.06mm)	25%	0%	100%	+		
	Other	0%	0%	0%	---		
	Sediment Deposition	2 (Poor)	2 (Poor)		---		
	Embeddedness	2 (Poor)	0 (Poor)		---		
	Epifaunal substrate available cover	4 (Poor)	2 (Poor)		---		
Altered Flow Regime	Annual discharge (m^3x10^8)	4.4	4.5	-2%	+	+	
	Discharge Nov-Jun (m^3x10^8)	4.4	4.5	-2%			
	Baseflow discharge (m^3/s)	7.0	9.0	-22%	+		
	Baseflow discharge per watershed area ($m^3/s/km^2$)	0.0008	0.0011	-27%	+		
	Water velocity (m/s)	1.01	0.70	44%	+		
	Water depth (m)	0.35	0.45	-22%	+		
	All storms event peak discharge (m^3/s)	320	309	4%	0		
	All storms event peak discharge per watershed area ($m^3/s/km^2$)	0.037	0.036	3%	0		
	All storms volume (m^3x10^8)	3.4	3.0	13%	+		
	All storms volume per watershed area (m^3 $x10^4/km^2$)	3.8	3.5	9%	+		

April storm volume ($m^3 x10^8$)	2.8	2.6	8%	+
April storm volume per watershed area ($m^3 x10^4/km^2$)	3.2	3.0	7%	+
April storm flow duration (d)	34	33	3%	+
Channel alteration	10 (Marginal)	15 (Suboptimal)		---
Velocity/Depth regimes	6 (Marginal)	3 (Poor)		---
Frequency of riffles	3 (Poor)	2 (Poor)		---
Channel flow status	13 (Suboptimal)	14 (Suboptimal)		---

Values are mean [n] (range), where more than one value available.
Difference calculations: the majority of differences are expressed as a percent =[(impacted value-reference value]/reference value]*100%; differences between California Bioassessment Worksheet: 2003 Multi-habitat Method form are shown as greater or less than the reference value due, in part, to the qualitative nature of the values.
† indicates qualitative metrics obtained from the California Bioassessment Worksheet: 2003 Multi-habitat Method form.
Sediment Deposition- poor, heavy deposits of ine material, increased bar development; more than 50% of the bottom changing frequently.
Epifaunal Substrate Available Cover- poor, less than 20% stable habitat; lack of habitat is obvious.
Embeddedness- poor, gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
Velocity/Depth Regimes- marginal, only 2 of the 4 habitat regimes present; poor- dominated by 1 velocity/depth regime (usually slow-deep)
Channel Flow Status- suboptimal, water fills >75% of the available channel; or <25% of channel substrate is exposed.
Channel Alteration- suboptimal, some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging,, (greater than past 20yrs) may be present, but recent channelization is not; marginal, channelization may be extensive; embankments or shoring structures present to both banks; and 40-80% of stream reach channelized and disrupted.
Frequency of Riffles- poor, generally all flat water or shallow riffles; poor habitat, distances between riffles divided by the width of the stream is a ratio >25.
Bank Stability- optimal, banks stable; evidence of erosion or bank failures absent or minimal; little potential for future problems. <5% of bank affected; suboptimal, moderately stable; infrequent, small areas of erosion mostly healed over, 5-30% of bank reach has areas of erosion.
Vegetation Protection-optimal, more than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation; marginal, 50-70% of the streambank surfaces covered by vegetation; disruptions obvious, patches of bare soil or closely cropped vegetation common.
Riparian Vegetative Zone Width- suboptimal, width of riparian zone 12-18 meters; human activities have impacted zone only minimally.

APPENDIX 2

Data tables used to evaluate evidence from the case associated with Causal Pathways for the Salinas River, California. Presented are data for steps in the causal pathway, identified in conceptual diagrams, for six candidate causes. Increased dissolved oxygen and increased ionic strength were not evaluated because of the spatial/temporal - scores for both impacted sites suggest the cause is unlikely. Strength of evidence (SOE) scores for this evidence type are presented in Appendix 3.

Candidate Cause- Increased Pesticides (refer to Pesticide Conceptual Diagram; Figure 6)						
Steps In the Causal Pathway						
Increased Pesticide Use	Variable Units			Sites		Comments
	Cumulative†	309DAV	309SSP	309SAC	309GRN	Values are based on 2010 pesticide application rates.
	Cypermethrin (kg)	62707	62706	62701	95	
	Permethrin (kg)	6692	6428	4766	2668	
	(S)-Cypermethrin (kg)	1789	1752	1324	652	
	Fenpropathrin (kg)	497	483	325	237	
	Lamda-Cyhalothrin (kg)	673	644	523	203	
	Esfenvalerate (kg)	264	261	202	112	
	Bifenthrin (kg)	11	8	0	0	
	Pyrethrins (kg)	143	129	113	69	
	Cyfluthrin (kg)	147	147	141	127	
	Gamma-Cyhalothrin (kg)	94	93	73	20	
	Tau-Fluvalinate (kg)	28	28	0	0	
	Diazinon (kg)	33022	31326	22309	8504	
	Malathion (kg)	11598	11381	7395	3327	
	Chlorpyrifos (kg)	16975	16686	12186	5677	
	Dimethoate (kg)	9092	8846	6613	2498	
	Naled (kg)	4693	4684	2586	1247	
	Disulfoton (kg)	2189	2189	1799	531	
	Ethoprop (kg)	625	625	625	544	
	Phosmet (kg)	9	9	9	9	
	Dicofol (kg)	365	365	365	280	
	Phorate (kg)	479	479	479	323	
	Total By Subwatershed†	309DAV	309SSP	309SAC	309GRN	Values are based on 2010 pesticide application rates.
	Cypermethrin (kg)	1	5	62637	95	

Permethrin (kg)	263	1662	2098	2668	
(S)-Cypermethrin (kg)	37	428	672	652	
Fenpropathrin (kg)	14	158	88	237	
Lamda-Cyhalothrin (kg)	29	122	319	203	
Esfenvalerate (kg)	3	59	90	112	
Bifenthrin (kg)	3	8	0	0	
Pyrethrins (kg)	14	16	44	69	
Cyfluthrin (kg)	0	6	14	127	
Gamma-Cyhalothrin (kg)	1	19	53	20	
Tau-Fluvalinate (kg)	0	28	0	0	
Diazinon (kg)	1697	9016	13806	8504	
Malathion (kg)	217	3986	4068	3327	
Chlorpyrifos (kg)	289	4500	6509	5677	
Dimethoate (kg)	245	2233	4115	2498	
Naled (kg)	9	2098	1340	1247	
Disulfoton (kg)	0	391	1267	531	
Ethoprop (kg)	0	0	82	544	
Phosmet (kg)	0	0	0	9	
Dicofol (kg)	0	0	85	280	
Phorate (kg)	0	0	156	323	

Mass Per Unit Area†	309DAV	309SSP	309SAC	309GRN	Values are based on 2010 pesticide application rates.
Cypermethrin (kg/km^2)	0.06	0.02	41.48	0.04	
Permethrin (kg/km^2)	20.25	7.92	1.39	1.77	
(S)-Cypermethrin (kg/km^2)	2.82	2.04	0.44	0.43	
Fenpropathrin (kg/km^2)	1.09	0.75	0.06	0.16	
Lamda-Cyhalothrin (kg/km^2)	2.19	0.58	0.21	0.13	
Esfenvalerate (kg/km^2)	0.23	0.28	0.06	0.07	
Bifenthrin (kg/km^2)	0.24	0.04	0.00	0.00	
Pyrethrins (kg/km^2)	1.04	0.08	0.03	0.05	
Cyfluthrin (kg/km^2)	0.00	0.03	0.01	0.08	
Gamma-Cyhalothrin (kg/km^2)	0.10	0.09	0.04	0.01	
Tau-Fluvalinate (kg/km^2)	0.00	0.13	0.00	0.00	
Diazinon (kg/km^2)	130.53	42.93	9.14	5.63	
Malathion (kg/km^2)	16.67	18.98	2.69	2.20	
Chlorpyrifos (kg/km^2)	22.23	21.43	4.31	3.76	
Dimethoate (kg/km^2)	18.88	10.64	2.72	1.65	
Naled (kg/km^2)	0.70	9.99	0.89	0.83	
Disulfoton (kg/km^2)	0.00	1.86	0.84	0.35	

Ethoprop (kg/km^2)	0.00	0	0.05	0.36
Phosmet (kg/km^2)	0.00	0	0.00	0.01
Dicofol (kg/km^2)	0.00	0	0.06	0.19
Phorate (kg/km^2)	0.00	0	0.10	0.21

Active Ingredient Applied Per Month in Monterey County (2006)[§]	All Pesticides (kg)	Diazinon (kg)	Chlorpyrifos (kg)	Precipitation (mm)[¥]
Jan	33961	1825	1513	78
Feb	71130	2662	5282	51
Mar	86817	4159	2728	188
Apr	242576	6651	1261	15
May	393104	9799	1904	0
Jun	393538	9808	2668	0
Jul	333766	9714	2889	0
Aug	442028	10180	2503	0
Sep	759390	7133	2019	0
Oct	692221	2753	709	0
Nov	130624	506	2508	0
Dec	48006	681	2372	62

Active Ingredient Applied Per Commodity in Monterey County (2006)[§]	All Pesticides (kg)	Diazinon (kg)	Chlorpyrifos (kg)
All Commodities	3267159	65872	28357
Broccoli	86810	5542	14043
Brussel Sprouts	12353	86	477
Cauliflower	20840	2608	3583
Lettuce, Leaf	299748	27705	20
Lettuce, Head	309471	22258	
Spinach	64625	4329	
Strawberry	1500886	424	
Wine Grapes	865088	69	7443
All others	376832	2842	2768
Landscape Maintenance	11564	6	1.9
Rights of Way	20992		
Structural Pest Control	15340	0.4	<1

	Active Ingredient Applied Per Application Method in Monterey County (2006)[§]	All Pesticides (kg)	Diazinon (kg)	Chlorpyrifos (kg)
	Ground	3221645	61983	28350
	Air	293070	3106	15
	Other	588		

Point Source	Variable, Units	Mainstem	Tributary
Chualar Creek (309CCR)[£]	Diazion applied in 2002 (kg)	10896	3119
	Diazon estimate reaching waterbodies in 2002 (kg)	0.1090	0.3119
	Chlorpyrifos applied in 2002 (kg)	5567	2418
	Chlorpyrifos estimate reaching waterbodies in 2002 (kg)	0.5567	0.2148
Quail Creek (309QUI)[£]	Diazion applied in 2002 (kg)	10896	896
	Diazon estimate reaching waterbodies in 2002 (kg)	0.1090	0.896
	Chlorpyrifos applied (kg)	5567	1006
	Chlorpyrifos estimate reaching waterbodies in 2002 (kg)	0.5567	0.1006

[†]Source: Central Coast Ambient Monitoring Program (CCAMP), Central Coast Regional Water Quality Control Board. Values are based on 2010 pesticide application rates.
[§]Source: California Department of Pesticide Regulation, 2006 Pesticide Use for Monterey County, California (www.cdpr.ca.gov)
[¥]Source: California Irrigation Management Information System (wwwcimis.water.gov), Gage 89.
[£]Source: California Regional Water Quality Control Board Central Coast Region. 2011. Total Maximum Daily Loads for Chlorpyrifos and Diazinon in the Lower Salinas River Watershed in Monterey County, California. Final Report.

Candidate Cause- Increased Metals (refer to Metals Conceptual Diagram; Figure 5)						
Steps In the Causal Pathway						
Metals in Discharged Waters						
	Point Source	Variable, Units	Concentration			Comments
	Discharges between 309GRN and 309SAC					
	Arroyo Seco	No data				
	Soledad MS4 Storm Water§	Copper (µg/L)	not detected			
		Lead (µg/L)	not detected			
		Zinc (µg/L)	63			
	Gonzales POTW	No data				
	Chualar POTW	No Data				
	Discharges between 309SAC and 309SSP					
	Chualar Creek (309CCR)£	No data				
	Quail Creek (309QUI)£	No data				
	Discharges between 309SSP and 309DAV					
	MS4 Salinas Storm Waterø	Copper (µg/L)	20			
		Zinc (µg/L)	90			
Metals in Soil						
		No Data				
Metals in wet or Dry Deposition						
		No Data				
Metals in Surface Runoff						
		No Data				
Metals in Subsurface Waters£		Variable, Units	309DAV/309SSP	309SAC	309GRN	
		Arsenic (µg/L)	1.8	1.4	2.6	
		Barium (µg/L)	57.7	62.5	36.3	
		Cadmium (µg/L)	0.2	0.1	0.1	
		Chromium (µg/L)	3.5	4.1	0.4	
		Cobalt (µg/L)	0.2	0.1	0.2	
		Copper (µg/L)	2.0	0.8	1.1	
		Iron (µg/L)	7.0	11.7	182.3	
		Lead (µg/L)	2.1	0.3	2.8	
		Lithium (µg/L)	17.2	25.4	36.6	
		Manganese	1.4	5.7	144.0	

(µg/L)			
Molybdenum (µg/L)	15.7	8.9	8.3
Nickel (µg/L)	2.6	1.5	2.5
Selenium (µg/L)	3.9	2.7	0.6
Strontium (µg/L)	502	574	722
Uranium (µg/L)	8.3	7.4	1.5
Vanadium (µg/L)	12.3	8.4	2.0
Zinc (µg/L)	6.2	3.2	369.3

[§]Source: City of Soledad Annual Report, General Permit for the Discharge of Storm Water form Municipal Separate Storm Sewer Systems (General Permit) Second Permit Year report- (2005-2006), December 2006.

[£]Source: Kulongoski, JT & Belitz, K. 2007, Ground-Water Quality Data in the Monterey Bay and Salinas Valley Basins, California, 2005-Results from the California GAMA Program: U.S. Geological Survey Data Series 258, 84p.

[ø]Values obtained from the City of Salinas storm drain monitoring program. Monitoring reporting began in August of 2006.

Candidate Cause- Increased Nutrients (refer to Nutrients Conceptual Diagram; Figure 4)					
Steps In the Causal Pathway					
Evidence of Elevated Nutrients in the Salinas River					
Variable, units	309DAV*	309SSP	309SAC	309GRN	Comments
Ammonia (mg/L) (Apr-Jun 2006)	0.014 [3] 0.010-0.016	0.042 [3] 0.042-0.042	0.033 [6] 0.010-0.075	0.035 [6] 0.010-0.082	
Ammonia (mg/L) (Nov-Oct 2006)	0.032 [12] 0.010-0.066	0.053 [12] 0.010-0.093	0.040 [18] 0.010-0.078	0.045 [16] 0.010-0.085	309SAC and 309GRN lack data for Sept and Oct 2006
Ammonia Load (kg/d) (Nov-Oct 2006)	39	64	50	53	
Nitrate-Nitrite (mg/L) (Apr-Jun 2006)	3.7 [3] 1.51-7.2	2.31 [3] 1.30-2.92	3.67 [6] 1.40-6.69	1.89 [6] 1.30-3.12	
Nitrate-Nitrite (mg/L) (Nov-Oct 2006)	11.50 [12] 0.35-36.51	1.40 [12] 0.014-7.50	2.10 [12] 0.14-7.50	1.36 [16] 0.27-4.2	309SAC and 309GRN lack data for Sept and Oct 2006
Nitrate-Nitrite Load (kg/d) (Nov-Oct 2006)	13900	1692	2619	1612	
Dry Season Nitrate (mg/L)†	17.24		1.59		
Dry Season Nitrate Load (kg/d)†	126		110		
Orthophosphate (mg/L) (Apr-Jun 2006)	0.077 [3] 0.067-0.085	0.058 [3] 0.008-0.102	0.059 [6] 0.013-0.083	0.070 [6] 0.012-0.109	309SAC and 309GRN lack data for Sept and Oct 2006
Orthophosphate (mg/L) (Nov-Oct 2006)	0.067 [12] 0.010-0.150	0.188 [12] 0.008-1.35	0.074 [18] 0.008-0.210	0.069 [16] 0.008-0.158	
Orthophosphate Load (kg/d) (Nov-Oct 2006)	81	227	92	82	
Flow (m^3/s) (Nov-Oct 2006)		13.99	14.44	10.07	
Total Nitrogen (mg/L) (Apr-Jun 2006)	4.07 [3] 1.80-7.60		3.97 [3] 1.80-6.70	2.18 [3] 1.45-3.40	
Total Nitrogen (mg/L) (Nov-Oct 2006)	12.40 [12] 1.30-38.00		2.51 [8] 1.20-6.70	1.60 [8] 0.49-3.4	309SAC and 309GRN lack data for Sept and Oct 2006
Total Nitrogen Load (kg/d) (Nov-Oct 2006)	14988		3131	1896	
Total Phosphorus (mg/L) (Apr-Jun 2006)	0.21 [3] 0.16-0.26		0.19 [3] 0.18-0.20	0.24 [3] 0.19-0.32	
Total Phosphorus (mg/L) (Nov-Oct 2006)	0.21 [12] 0.07-0.75		0.26 [8] 0.11-1.00	0.22 [8] 0.08-0.46	309SAC and 309GRN lack data for Sept and Oct 2006
Total Phosphorus Load (mg/d) (Nov-Oct 2006)	254		324	261	
Groundwater Nitrate (mg/L)¥	11[40] 1.3-49		24[44] 2.0-55		
Minimum Diel Dissolved Oxygen (mg/L)	3.7		7.8		Diel oxygen was measured in August 2006 when flows were 0.0 and 1.8 m^3/s at 309DAV and 309SAC, respectively.

Maximum Diel Dissolved Oxygen (mg/L)	20.3		9.8		
Average Diel Dissolved Oxygen (mg/L)	9.8		8.6		
Minimum Oxygen Saturation (%)	36.5		85.6		
Maximum Oxygen Saturation (%)	260		117		
Average Oxygen Saturation (%)	118		96.6		
Maximum Nitrate (mg/L) Jan-Jun 2006; evaluation of nitrate toxicity	7.1	2.92	6.4	3.10	LC_{10} values are within reported short (48hr) and long (120hr) term nitrate concentrations that negatively affect freshwater invertebrates. (48 hr LC_{10}=16.2-62.7 mg/L; 120 hr LC_{10}=8.5-27.8 mg/L) but below LC_{50} values (48 hr LC_{50}=107-592 mg/L; 120 hr LC_{50}=56-230 mg/L)[æ]
Maximum Nitrate (mg/L) Nov-Oct 2006; evaluation of nitrate toxicity	36	7.5	6.4	3.10	LC_{10} values are within reported short (48hr) and long (120hr) term nitrate concentrations that negatively affect freshwater invertebrates. (48 hr LC_{10}=16.2-62.7 mg/L; 120 hr LC_{10}=8.5-27.8 mg/L) but below LC_{50} values (48 hr LC_{50}=107-592 mg/L; 120 hr LC_{50}=56-230 mg/L)[æ]
Nitrogen Atmospheric Deposition (N kg/ha/yr)[†]	1.61-1.62		1.59-1.60		

Point Source Discharges

Point sources between 309GRN and 309SAC

	Variable, Units	Mainstem Salinas at 309SAC	Point Source
Arroyo Seco			
	Ammonia (mg/L)	0.052	Nd
	Ammonia Load (kg/d)	65	Nd
	Nitrate-Nitrite (mg/L)	2.17	Nd
	Nitrate-Nitrite Load (kg/d)	2707	Nd
	Orthophosphate (mg/L)	0.082	Nd
	Orthophosphate Load (kg/d)	102	Nd
Soledad MS4 Storm Water[§]			
	Ammonia (mg/L)	0.052	0.22
	Ammonia Load (kg/d)	65	Nd
	Nitrate-Nitrite (mg/L)	2.17	1.6
	Nitrate-Nitrite Load (kg/d)	2707	Nd

	Orthophosphate (mg/L)	0.082	0.31
	Orthophosphate Load (kg/d)	102	Nd
Gonzales POTW			
	Ammonia (mg/L)	0.052	Nd
	Ammonia Load (kg/d)	65	Nd
	Nitrate-Nitrite (mg/L)	2.17	Nd
	Nitrate-Nitrite Load (kg/d)	2707	Nd
	Orthophosphate (mg/L)	0.082	Nd
	Orthophosphate Load (kg/d)	102	Nd
Chualar POTW			
	Ammonia (mg/L)	0.052	Nd
	Ammonia Load (kg/d)	65	Nd
	Nitrate-Nitrite (mg/L)	2.17	Nd
	Nitrate-Nitrite Load (kg/d)	2707	Nd
	Orthophosphate (mg/L)	0.082	Nd
	Orthophosphate Load (kg/d)	102	Nd

Point Source Discharges between 309SAC and 309SSP

	Variable, Units	Mainstem Salinas at 309SSP	Point Source
Chualar Creek (309CCR)[£]			
	2006 Ammonia (mg/L)	0.053	7.75
	2006 Ammonia Load (kg/d)	64	20
	2006 Nitrate-Nitrite (mg/L)	1.4	38
	2006 Nitrate-Nitrite Load (kg/d)	1692	98.5
	Long-term Nitrate-Nitrite (mg/L)	1.4	91
	Long-term Nitrate Loads (kg/d)	1902	397
	Dry Season Nitrate (mg/L)	17.24	106.42
	Dry Season Nitrate Load (kg/d)	126	123
	2006 Orthophosphate (mg/L)	0.188	1.37
	2006 Orthophosphate Load (kg/d)	227	3.55
Quail Creek (309QUI)[£]			
	2006 Ammonia (mg/L)	0.053	4.45
	2006 Ammonia Load (kg/d)	64	23.07
	2006 Nitrate-Nitrite (mg/L)	1.4	26
	2006 Nitrate-Nitrite Load (kg/d)	1692	134.8
	Long-term Nitrate Loads (kg/d)	1902	52
	Dry Season Nitrate (mg/L)	17.24	28.32
	Dry Season Nitrate Load (kg/d)	126	69
	2006 Orthophosphate (mg/L)	0.188	0.97

	2006 Orthophosphate Load (kg/d)	227	5.02
Point Source Discharges between 309SSP and 309DAV			
	Variable, Units	Mainstem Salinas at 309DAV	Point Source
MS4 Salinas Storm Water[ø]			
	Ammonia (mg/L)	0.032	Nd
	Ammonia Load (kg/d)	Nd	Nd
	Nitrate-Nitrite (mg/L)	11.47	2.9
	Nitrate-Nitrite Load (kg/d)	Nd	Nd
	Orthophosphate (mg/L)	0.067	0.73
	Orthophosphate Load (kg/d)	Nd	Nd

Annual Loads by Land Use†

	N Load (kg)	P Load (kg)
Urban	62773	9887
Cropland	1002998	285533
Grazing Lands	95037	55979
Forest	12541	5138
Septic	11	4.5
Groundwater	146945	3168
Atmospheric Deposition	408	96

Values are mean [n] (range), where more than one value available. Nd is no data.

*Annual nutrient loads for 309DAV were calculated assuming flow at 309SSP USGS gauge (11152500) is equal to flow at 309DAV. The discharge of the City of Salinas MS4 storm drain is not quantified; thus, its contribution to the discharge at 309DAV is unknown.

[†]Summary values obtained from the draft 2012 TMDL report for the lower Salinas River.

[æ]Camargo, J.A., A. Alonso, and A. Salamanca. 2005. Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. Chemosphere 58:1255-1267.

[¥] Source: Kulongoski, JT & Belitz, K. 2007, Ground-Water Quality Data in the Monterey Bay and Salinas Valley Basins, California, 2005-Results from the California GAMA Program: U.S. Geological Survey Data Series 258, 84p.[§]Source: City of Soledad Annual Report, General Permit for the Discharge of Storm Water form Municipal Separate Storm Sewer Systems (General Permit) Second Permit Year report- (2005-2006), December 2006.

[£]Source: Central Coast Water Quality Preservation, Inc.'s Cooperative Monitoring Program.

[ø]Values obtained from the City of Salinas storm drain monitoring program. Monitoring reporting began in August of 2006.

Candidate Cause- Increased Sediments (refer to Sediments Conceptual Diagram; Figure 8)

Steps In the Causal Pathway

Increased Sediment (suspended)

Variable Units	309DAV*	309SSP	309SAC	309GRN	Comments
Total Suspended Solids (mg/L) (Apr-Jun 2006)	47 [3] 19-63		31 [3] 8.4-39	31 [3] 16-42	
Non-flood Sediment Load (kg/d) (Apr-Jun 2006)	3326 [2]		2160 [2]	3326 [2]	Calculated assuming flow at 309SSP USGS gage is equal to flow at 309DAV.
Total Suspended Solids (mg/L) (Nov-Oct 2006)	51 [12] 4-140		128 [8] 10-740	65 [8] 16-256	
Total Suspended Solids Load (kg/d) (Nov-Oct 2006)	61646		159695	48602	
Fixed Total Suspended Solids (mg/L) (Apr-Jun 2006)	41 [3] 15-54		27 [3] 8.4-39	22 [3] 15-34	
Fixed Total Suspended Solids (mg/L) (Nov-Oct 2006)	43 [12] 1.2-120		111 [8] 8.4-650	55 [8] 15-235	
Turbidity (NTU) (Apr-Jun 2006)	47 [3] 18-69	41 [3] 35-49	21 [5] 13-30	14 [6] 0.2-27	
Turbidity (NTU) (Nov-Oct 2006)	53 [12] 1.7-148	238 [12] 1.9-2584	265 [16] 0.6-3000	190 [15] 0.2-2166	
Water Temperature (Apr-Jun 2006)	17.3 [3] 17.3-18.6	16.5 [3] 16.1-22.1	18.1 [6] 15.0-24.6	20.1 [6] 15.4-23.7	
Water Temperature (NTU) (Nov-Oct 2006)	14.3 [12] 10.7-20.9	16.5 [12] 10.0-22.1	16.7 [17] 10.4-28.7	18.9 [15] 10.1-25.4	

Altered Land use†

Variable Units	309DAV*	309SSP	309SAC	309GRN	Comments
Developed Land (km^2)	0.8	13	20	14	Sum of high, medium, and low intensity
Developed Land (%)	2.9	3.4	1.2	0.6	
Cultivated Crops (km^2)	1.7	89	261	255	
Cultivated Crops (%)	6.6	22.8	15.0	10.9	
Watershed Vegetation (km^2)	21	262	1346	1835	Sum of deciduous forest, evergreen forest, grassland/herbaceous, mixed forest, pasture/hay, and shrub/scrub
Watershed Vegetation (%)	79.8	67.2	77.4	78.3	
Wetlands (km^2)	0.3	4.7	24	30	Sum of emergent herbaceous wetlands, open water, and woody wetlands.
Wetlands (%)	1.0	1.2	1.4	1.3	

Increased Sediment (bedded)

Variable Units	309DAV*	309SSP	309SAC	309GRN	Comments
Coarse Gravel (16-64mm)	0%		0%		
Fine Gravel (2-16mm)	0%		0%		
Sand (0.06-2mm)	100%		100%		
Fines (<0.06mm)	0%		0%		
Other	0%		0%		
SHC Sediment deposition	0 (Poor)		0 (Poor)		
SHC Epifaunal substrate available cover	1 (Poor)		2 (Poor)		
SHC Flow Habitat	100% Run		100% Glide		
SHC Bank stability (stable)	0%		50%		
SHC Bank stability (vulnerable)	0%		50%		
SHC Bank stability (eroded)	100%		0%		
MHM Sediment deposition		2 (Poor)	2 (Poor)	2 (Poor)	
MHM Epifaunal substrate available cover		4 (Poor)	2 (Poor)	1 (Poor)	
MHM Embeddedness		2 (Poor)	0 (Poor)	3 (Poor)	
MHM Left Bank stability		1 (Poor)	8 (Suboptimal)	2 (Poor)	
MHM Right Bank Stability		2 (Poor)	6 (Suboptimal)	2 (Poor)	

Point Source Discharges

Point Source Discharges between 309GRN and 309SAC

	Variable, Units	Mainstem Salinas at 309SAC	Point Source
Arroyo Seco			
	TSS (mg/L)	128	Nd
	Turbidity (NTU)	265	Nd
Soledad MS4 Storm Water§			
	TSS (mg/L)	128	58
	Turbidity (NTU)	265	85
Gonzales POTW			
	TSS (mg/L)	128	Nd
	Turbidity (NTU)	265	Nd
Chualar POTW			
	TSS (mg/L)	128	Nd

	Variable, Units					
	Turbidity (NTU)	265	Nd			
Point Source Discharges between 309SAC and 309SSP						
	Variable, Units	Mainstem Salinas at 309SSP	Point Source			
Chualar Creek (309CCR)[£]						
	TSS (mg/L)	Nd	Nd			
	Turbidity (NTU)	238	2606			
Quail Creek (309QUI)[£]						
	TSS (mg/L)	Nd	Nd			
	Turbidity (NTU)	238	992			
Point Source Discharges between 309SSP and 309DAV						
	Variable, Units	Mainstem Salinas at 309DAV	Point Source			
MS4 Salinas Storm Water[ø]						
	TSS (mg/L)	51	Nd			
	Turbidity (NTU)	53	39			
Precipitation[¥]						
	Variable, Units	Below 309SAC	Below 309SAC	Above 309SAC	Above 309SAC	Below and above refer to the location of rain gages in relation to the 309SAC comparator site.
	CMS Gage ID	116	89	114	113	
	Cumulative Rainfall (cm) Nov-Jun 2006	50.1	49.4	21.1	32.0	
Irrigation[£]						
	Variable, Units	Pressure Formation	Forebay Formation			The Pressure Formation includes 309DAV, 309SSP, and 309SAC and the Forebay Formation includes 309GRN
	Agricultural withdrawal (m^3x10^7)	11.3	16.0			
	Urban withdrawal (m^3x10^7)	2.6	1.2			
	Berries (m^3x10^5)	40	-			
	Field (m^3x10^5)	-	10			
	Forage (m^3x10^5)	0.8	-			
	Grapes (m^3x10^5)	12	209			

Nursery (m^3x10^5)	0.2		
Tress (m^3x10^5)	3.6	22	
Vegetables (m^3x10^5)	1053	1208	
Other (m^3x10^5)	-	31	
Net km^2 of irrigation methods[£]			
Variable	Furrow	Sprinkler	Drip
Berries	0	0	22
Field	0.6	3.3	0.8
Forage	0	1.6	0
Grapes	0	8.0	144
Tress	0	11	12
Vegetables	2.4	335	153

Values are mean [n] (range), where more than one value available. Nd is no data.
*Annual nutrient loads for 309DAV were calculated assuming flow at 309SSP USGS gauge (11152500) is equal to flow at 309DAV. The discharge of the City of Salinas MS4 storm drain is not quantified; thus, its contribution to the discharge at 309DAV is unknown.
SHC refers to the ABL Stream Habitat Characterization Form used by CCAMP in 2006. Sediment Deposition- poor qualitatively defined as heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently. Epifaunal Substrate Available Cover- poor qualitatively defined as less than 20% stable habitat; lack of habitat is obvious. Bank stability assessed 5 m up and 5 m downstream of transect and from Bankfull to wetted width.
MHM refers to the 2003 Multi-habitat method used by CMP to characterize stream habitat in 2006. Sediment Deposition- poor qualitatively defined as heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently. Epifaunal Substrate Available Cover- poor qualitatively defined as less than 20% stable habitat; lack of habitat is obvious. Embeddedness- poor qualitatively defined as gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. Bank stability- suboptimal qualitatively defined as moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank reach has areas of erosion. Bank stability- poor qualitatively defined as unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
[†]Source: USDA, National Agricultural Statistics Service, 2007 California Cropland Data Layer. Values represent the watershed area between monitoring sites (i.e., they are not cumulative).
[§]Source: City of Soledad Annual Report, General Permit for the Discharge of Storm Water form Municipal Separate Storm Sewer Systems (General Permit) Second Permit Year report- (2005-2006), December 2006.
[¥]Source: California Irrigation Management Information System (wwwcimis.water.gov)
[£]Source: Monterey County Water Resources Agency. 2008. 2006 Ground Water Summary Report. Net km2 of sprinklers was obtained by summing sprinkler & furrow, hand moved, solid set, and linear move methods.

Candidate Cause- Altered Flow Regime (refer to Altered Flow Regime Conceptual Diagram; Figure 9)

Steps In the Causal Pathway

Land Use[†]

Variable Units	309DAV[*]	309SSP	309SAC	309GRN	Comments
Developed Land (km^2)	0.8	13	20	14	Sum of high, medium, and low intensity
Developed Land (%)	2.9	3.4	1.2	0.6	
Cultivated Crops (km^2)	1.7	89	261	255	
Cultivated Crops (%)	6.6	22.8	15.0	10.9	
Watershed Vegetation (km^2)	21	262	1346	1835	Sum of deciduous forest, evergreen forest, grassland/herbaceous, mixed forest, pasture/hay, and shrub/scrub
Watershed Vegetation (%)	79.8	67.2	77.4	78.3	
Wetlands (km^2)	0.3	4.7	24	30	Sum of emergent herbaceous wetlands, open water, and woody wetlands.
Wetlands (%)	1.0	1.2	1.4	1.3	

In Channel Human Influence[€] (within channel or bank)

Variable Units	309DAV[*]	309SSP	309SAC	309GRN	Comments
Walls/Rip-Rap/Dams	1/22		0/4	0/22	
Buildings	0/22		0/4	0/22	Within 10 to 50 m of channel
Pavement/Cleared Lots	0/22		0/4	0/22	
Road/Railroad	0/22		0/4	0/22	
Pipes (inlet/outlet)	0/22		0/4	0/22	
Landfill/Trash	4/22		1/4	3/22	
Park/Lawn	0/22		0/4	0/22	
Row Crops	0/22		0/4	0/22	
Pasture/Range	0/22		0/4	0/22	
Logging Operations	0/22		0/4	0/22	
Mining Activity	0/22		0/4	0/22	

Out of Channel Human Influence[€] (within 10 to 50 m of channel)

Variable Units	309DAV[*]	309SSP	309SAC	309GRN	Comments
Walls/Rip-Rap/Dams	18/22		4/4	0/22	
Buildings	0/22		0/4	0/22	
Pavement/Cleared Lots	0/22		0/4	0/22	
Road/Railroad	11/22		4/4	1/22	
Pipes (inlet/outlet)	0/22		0/4	0/22	
Landfill/Trash	0/22		1/4	0/22	

Park/Lawn	0/22		0/4	0/22	
Row Crops	22/22		4/4	0/22	
Pasture/Range	0/22		0/4	0/22	
Logging Operations	0/22		0/4	0/22	
Mining Activity	0/22		0/4	0/22	

Channel Alteration

Variable Units	309DAV*	309SSP	309SAC	309GRN	Comments
Channel Alteration	15	10	15	17	
MHM Vegetation Protection (Left Bank/Right Bank)		4/7	10/8	5/4	
MHM Riparian Vegetation Zone Width		8	8	10	
SHC Flow Habitat	100% Run		100% Glide		
SHC Bank stability (stable)	0%		50%		
SHC Bank stability (vulnerable)	0%		50%		
SHC Bank stability (eroded)	100%		0%		
MHM Left Bank stability		1 (Poor)	8 (Suboptimal)	2 (Poor)	
MHM Right Bank Stability		2 (Poor)	6 (Suboptimal)	2 (Poor)	

Point Source Discharges

Point Source Discharges between 309GRN and 309SAC

Variable, Units	Mainstem Salinas at 309SAC	Point Source
Arroyo Seco		
Annual Discharge (m^3x10^8)	4.5	1.7
Soledad MS4 Storm Water§		
Annual Discharge (m^3x10^8)		Nd
Gonzales POTW		
Annual Discharge (m^3x10^8)		Nd
Chualar POTW		
Annual Discharge (m^3x10^8)		Nd

Point Source Discharges between 309SAC and 309SSP

Variable, Units	Mainstem Salinas at	Point Source

		309SSP				
Chualar Creek (309CCR)[£]						
	Annual Discharge (m^3x10^8)	4.4	Nd			
Quail Creek (309QUI)[£]						
	Annual Discharge (m^3x10^8)		Nd			
Point Source Discharges between 309SSP and 309DAV						
	Variable, Units	Mainstem Salinas at 309DAV	Point Source			
MS4 Salinas Storm Water[ø]						
	Annual Discharge (m^3x10^8)	Nd	Nd			
Precipitation[¥]						
	Variable, Units	Below 309SAC	Below 309SAC	Above 309SAC	Above 309SAC	Below and above refer to the location of rain gages in relation to the 309SAC comparator site.
	CMS Gage ID	116	89	114	113	
	Cumulative Rainfall (cm) Nov-Jun 2006	50.1	49.4	21.1	32.0	
Irrigation[£]						
	Variable, Units	Pressure Formation	Forebay Formation			The Pressure Formation includes 309DAV, 309SSP, and 309SAC and the Forebay Formation includes 309GRN
	Agricultural withdrawal (m^3x10^7)	11.3	16.0			
	Urban withdrawal (m^3x10^7)	2.6	1.2			
	Berries (m^3x10^5)	40	-			
	Field (m^3x10^5)	-	10			
	Forage (m^3x10^5)	0.8	-			
	Grapes (m^3x10^5)	12	209			
	Nursery (m^3x10^5)	0.2				
	Tress (m^3x10^5)	3.6	22			
	Vegetables (m^3x10^5)	1053	1208			
	Other (m^3x10^5)	-	31			

Net km² of irrigation methods[£]				
	Variable	Furrow	Sprinkler	Drip
	Berries	0	0	22
	Field	0.6	3.3	0.8
	Forage	0	1.6	0
	Grapes	0	8.0	144
	Tress	0	11	12
	Vegetables	2.4	335	153

Values are mean [n] (range), where more than one value available. Nd is no data.
*Annual nutrient loads for 309DAV were calculated assuming flow at 309SSP USGS gauge (11152500) is equal to flow at 309DAV. The discharge of the City of Salinas MS4 storm drain is not quantified; thus, its contribution to the discharge at 309DAV is unknown.
[€]In-Channel and Out of Channel Human Influences was assessed by the number of observed disturbances over the number of possible disturbances recorded on the ABL Stream Habitat Characterization Form used by CCAMP in 2006.
SHC refers to the ABL Stream Habitat Characterization Form used by CCAMP in 2006. Sediment Deposition- poor qualitatively defined as heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently. Epifaunal Substrate Available Cover- poor qualitatively defined as less than 20% stable habitat; lack of habitat is obvious. Bank stability assessed 5 m up and 5 m downstream of transect and from Bankfull to wetted width.
MHM refers to the 2003 Multi-habitat method used by CMP to characterize stream habitat in 2006. Sediment Deposition- poor qualitatively defined as heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently. Epifaunal Substrate Available Cover- poor qualitatively defined as less than 20% stable habitat; lack of habitat is obvious. Embeddedness- poor qualitatively defined as gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. Bank stability- suboptimal qualitatively defined as moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank reach has areas of erosion. Bank stability- poor qualitatively defined as unstable; many eroded areas; “raw” areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. *Vegetation Protection*- Optimal (9-10) qualitatively defined as more than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetation disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. Suboptimal (6-8) qualitatively defined as 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evidentbut not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. Marginal (3-5)- 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. *Riparian Vegetation Zone Width*- Optimal (9-10) qualitatively defined as width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear cuts, lawns, or crops) have not impacted zone. Suboptimal (6-8) qualitatively defined as width of riparian zone 12-18 meters; human activities have impacted zone only minimally. *Channel Alteration* was quantitatively defined by both monitoring programs using the same scale. Optimal (16-20)- channelization or dredging absent or minimal; streams with normal pattern. Suboptimal (11-15)- some channelization present (e.g., bridge abutments; recent channelization not present. Marginal (6-10)- channelization or shoring structures present on both banks; 40 to 80% of stream reach disrupted.
[†]Source: USDA, National Agricultural Statistics Service, 2007 California Cropland Data Layer. Values represent the watershed area between monitoring sites (i.e., they are not cumulative).
[§]Source: City of Soledad Annual Report, General Permit for the Discharge of Storm Water form Municipal Separate Storm Sewer Systems (General Permit) Second Permit Year report- (2005-2006), December 2006.
[¥]Source: California Irrigation Management Information System (wwwcimis.water.gov)

[£]Source: Monterey County Water Resources Agency. 2008. 2006 Ground Water Summary Report. Net km2 of sprinklers was obtained by summing sprinkler & furrow, hand moved, solid set, and linear move methods.

Candidate Cause- Altered physical habitat (refer to Altered Physical Habitat Conceptual Diagram; Figure 10)

Steps In the Causal Pathway

Altered Flow Regime

Variable Units	309DAV*	309SSP	309SAC	309GRN	Comments
Channel Alteration					Scored 0, see Causal Pathway Altered Flow Regime
Changes in Discharge Pattens					Scored 0, see Causal Pathway Altered Flow Regime
Changes in Sediments in Stream					Scored +, see Causal Pathway Increased Sediments
Changes in Sediments bedload and deposited sediments					Scored 0, see Causal Pathway Increased Sediments
MHM Woody Debris		5%	0%	0%	
SHC Woody Debris (<0.3 m diameter)	0-40%		0-<10%	0%	
SHC Woody Debris (>0.3 m diameter)	<10%		0%	0%	

Land Use[†]

Variable Units	309DAV*	309SSP	309SAC	309GRN	Comments
Developed Land (km^2)	0.8	13	20	14	Sum of high, medium, and low intensity
Developed Land (%)	2.9	3.4	1.2	0.6	
Cultivated Crops (km^2)	1.7	89	261	255	
Cultivated Crops (%)	6.6	22.8	15.0	10.9	
Watershed Vegetation (km^2)	21	262	1346	1835	Sum of deciduous forest, evergreen forest, grassland/herbaceous, mixed forest, pasture/hay, and shrub/scrub
Watershed Vegetation (%)	79.8	67.2	77.4	78.3	
Wetlands (km^2)	0.3	4.7	24	30	Sum of emergent herbaceous wetlands, open water, and woody wetlands.
Wetlands (%)	1.0	1.2	1.4	1.3	

Values are mean [n] (range), where more than one value available. Nd is no data.

*Annual nutrient loads for 309DAV were calculated assuming flow at 309SSP USGS gauge (11152500) is equal to flow at 309DAV. The discharge of the City of Salinas MS4 storm drain is not quantified; thus, its contribution to the discharge at 309DAV is unknown.

[€]In-Channel and Out of Channel Human Influences was assessed by the number of observed disturbances over the number of possible disturbances recorded on the ABL Stream Habitat Characterization Form used by CCAMP in 2006.

SHC refers to the ABL Stream Habitat Characterization Form used by CCAMP in 2006

MHM refers to the 2003 Multi-habitat method used by CMP to characterize stream habitat in 2006

[†]Source: USDA, National Agricultural Statistics Service, 2007 California Cropland Data Layer. Values represent the watershed area between monitoring sites (i.e., they are not cumulative).

APPENDIX 3

Strength of evidence for scoring summary causal pathway (evidence from the case) for the Salinas River, California

Strength of Evidence scoring for plausible effect given stressor-response relationships ++ Data show that all steps in at least one causal pathway are present. + Data show that some steps in at least one causal pathway are present. 0 Data show that the presence of all steps in the causal pathway is uncertain. - Data show that there is at least one missing step in each causal pathway. --- Data show, with a high degree of certainty, that there is at least one missing step in each causal pathway.	
Reasoning and Comments	**SOE Score**
Increased Pesticides- Evidence for some causal steps- Primary evidence consists of 2006 Monterey County pesticide use data and 2010 pesticide application data for the four individual site subwatersheds. The amount of pesticide applied in 2006 was high in the months preceding the biological assessment and coincided with periods of peak precipitation increasing the likelihood of transport to the Salinas River via runoff. Although not available for 2006, per km^2 diazinon and chlorpyrifos application rates in 2010 were greater in the impacted subwatersheds compared to the comparator basins. For 2006, agriculture was the primary user of pesticides in Monterey County.	+
Increased Metals- Ambiguous Evidence- There is simply not enough data available to assess the causal pathway of metals as a candidate cause of biological impairment. Evidence for missing steps- Metals in groundwater tended to be similar among sites with the exception of iron, manganese, strontium, and zinc which are greater in the upper watershed rather than lower watershed.	0
Increased Nutrients- Evidence for some causal steps- for the period immediately preceding the invertebrate bioassessment, there was little difference in nutrient concentrations and loadings between impacted and comparator sites. Nutrient concentrations, especially nitrate and total nitrogen, are greatest in the dry season months (July, August, and September) following invertebrate collection when flows are low and algal biomass and plant cover tends to be greater. Significant sources of nutrients to the mainstem of the Salinas likely include Chualar Creek, Quail Creek, and MS4 discharges; however, limited data on nutrient concentrations and flow limit the degree of certainty. Loadings from the numerous POTWs could not be accurately assessed. Nitrate toxicity remains uncertain as the maximum observed concentrations did not exceed reported LC_{50}s but were greater than LC_{10}s. While elevated nutrients are a concern for the lower Salinas River, there is a temporal disconnect between the invertebrate bioassessment (spring) and peak nutrient effects (late summer); thus, increased nutrients have been scored 0.	0
Increased Sediments- Evidence for some causal steps- The greater proportion of developed lands and cultivated crops in the subwatersheds of the impacted 309DAV and 309SSP sites could increase sediment discharges to the Salinas River. Increased sediment discharges may be attributable to the greater amount of precipitation and sprinkler irrigation methods for vegetable production in the lower basin of the Salinas River and high turbidity values in two tributaries (309CRR and 309QCR), although quantification is difficult due to many factors (e.g., precipitation patterns, slope, soil saturation, irrigation method, crop type and maturity, and use of sediment retention and detention basins). Although turbidity and TSS remain elevated throughout the water year, estimating sediment loads was difficult given the rapid increases in discharge and turbidity that can occur over short time periods (e.g., hours) and the lack of turbidity measures associated with peak discharges or storm events. The natural sandy bottom of the river is highly dynamic and all case study sites exhibited poor conditions for invertebrates. Impacted and comparator sites had increased erosion as evident by low bank stability and sediment deposition scores. Ambiguous evidence- Although the bottom sediments are mostly sand and highly mobile, there is limited information available to assess aggradation and degradation. Other activities that could not be assessed because of limited data included in-stream gravel mining and channel maintenance activities. Evidence for a pathway not existing- there is a high degree of certainty that water regulation, either in the form of upstream reservoirs or downstream impoundments, did not cause the	+

impairment. The upstream reservoirs (Nacimiento and San Antonio) are located approximately 70km from 309GRN and the downstream impoundment (rubber dam) had yet to be constructed. Increased sediments is scored a + as there is evidence for some steps increasing suspended sediments. Although there is evidence for some steps contributing to altering the river bed, the similarity between impacted and comparator sites weakens differences in bed sediments as a causal factor.	
Altered Flow Regime- Ambiguous evidence- Among sites there is little evidence to suggest that the channels have been greatly altered, either through modification or devegetation; however, this information is based mostly on qualitative data. The contributions of individual point sources are not quantified well enough to determine if a step in the discharge to surface waters causal pathway is missing. Evidence for a pathway not existing- there is a high degree of certainty that water regulation, either in the form of upstream reservoirs or downstream impoundments, did not cause the impairment. The upstream reservoirs (Nacimiento and San Antonio) are located approximately 70km from 309GRN and the downstream impoundment (rubber dam) had yet to be constructed. Note that regulatory releases for groundwater recharge typically occur during the dry season and ceases in October or November to allow for channel maintenance. Altered flow regime is scored “0” as there is a chance some steps may be present. However, serious consideration was given for a “-“ score given the strong possibility that the poorly characterized causal pathways were likely not to differ among sites (e.g., the greater number of point sources between the comparator sites).	0
Altered Physical Habitat- Evidence for some causal steps- The greater proportion of developed lands and cultivated crops in the subwatersheds of the impacted 309DAV and 309SSP sites could increase sediment discharges to the Salinas River. Increased sediment discharges may be attributable to the greater amount of precipitation and sprinkler irrigation methods for vegetable production in the lower basin of the Salinas River and high turbidity values in two tributaries (309CRR and 309QCR), although quantification is difficult due to many factors (e.g., precipitation patterns, slope, soil saturation, irrigation method, crop type and maturity, and use of sediment retention and detention basins). Although turbidity and TSS remain elevated throughout the water year, estimating sediment loads was difficult given the rapid increases in discharge and turbidity that can occur over short time periods (e.g., hours) and the lack of turbidity measures associated with peak discharges or storm events. Ambiguous evidence- Among sites there is little evidence to suggest that the channels have been greatly altered, either through modification or devegetation; however, this information is based mostly on qualitative data. The contributions of individual point sources are not quantified well enough to determine if a step in the discharge to surface waters causal pathway is missing. Evidence for a pathway not existing- there is a high degree of certainty that water regulation, either in the form of upstream reservoirs or downstream impoundments, did not cause the impairment. The upstream reservoirs (Nacimiento and San Antonio) are located approximately 70km from 309GRN and the downstream impoundment (rubber dam) had yet to be constructed. Note that regulatory releases for groundwater recharge typically occur during the dry season and ceases in October or November to allow for channel maintenance. The natural sandy bottom of the river is highly dynamic and all case study sites exhibited poor conditions for invertebrates. Impacted and comparator sites had increased erosion as evident by low bank stability and sediment deposition scores. The low gradient, sandy bottom coastal rivers and streams of California are naturally paupered in woody debris. Physical Habitat is scored “+” as there is evidence to indicate suspended sediments my affect physical habitat.	+

APPENDIX 4

Strength of evidence scoring table for stressor-responses relationships from the field. Relationships were derived for the 2006 Salinas River B-IBI score, the seven SoCal B-IBI metrics, and taxa richness. Stressor values reflect the average for samples collected between April and June 2006. CCAMP and CMP samples were not combined as methodologies may exist between programs; thus, five samples were used to construct the relationships (309DAV, 309SSP, 309SAC from CCAMP, 309SAC from CMP, and 309GRN). Individual taxa were not used because of the low numbers (total number of individuals=59) associated with sample 309SAC CCAMP, it was felt that this would bias the relationships. Scoring was based on the strength of the relationship, with strong associations having r>0.80 and weak associations having r>0.50 in the expected direction and without sample inconsistencies (shaded gray). Inconsistency among impacted and comparator sites indicates that both of the impacted sites were neither greater nor lesser than the comparator sites. See figure 12 for a graphical example of stressor-response relationship ++.

Strength of evidence (SOE) scoring for stressor-response relationship in the field
++ A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is in the expected direction.
+ A weak effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is in the expected direction.
0 An uncertain effect gradient is observed relative to exposure to the candidate cause.
- An inconsistent effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is NOT in the expected direction.
-- A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is NOT in the expected direction.
NE No evidence.

Candidate Cause	Variable, Units	Specific Effect	Result	SOE Score
Decreased Dissolved Oxygen	Dissolved oxygen (mg/L)	IBI Score	No apparent gradient (r=-0.307)	-
		Coleoptera Taxa	No apparent gradient (r=0.000)	-
		EPT Taxa	No apparent gradient (r=-0.551)	-
		Predatory Taxa	No apparent gradient (r=0.324)	-
		% Collector Individuals	No apparent gradient (r=0.055)	-
		% Intolerant Individuals	No apparent gradient (r=0.404)	-
		% Non-insect Taxa	No apparent gradient (r=0.270)	-
		% Tolerant Taxa	No apparent gradient (r=0.783); not in expected direction	-
		Taxa Richness	No apparent gradient (r=0.071)	-
	Oxygen Saturation (%)	IBI Score	No apparent gradient (r=-0.297)	-
		Coleoptera Taxa	No apparent gradient (r=0.000)	-
		EPT Taxa	No apparent gradient (r=-0.550)	-
		Predatory Taxa	No apparent gradient (r=0.329)	-
		% Collector Individuals	No apparent gradient (r=0.063)	-
		% Intolerant Individuals	No apparent gradient (r=0.409)	-
		% Non-insect Taxa	No apparent gradient (r=0.268)	-
		% Tolerant Taxa	No apparent gradient (r=0.775); not in expected direction	-
		Taxa Richness	No apparent gradient (r=-0.071)	-

Candidate Cause	Variable, Units	Specific Effect	Result	SOE Score
Increased Pesticides			No data available	NE
Increased Metals			No data available	NE
Increased Nutrients	Chl *a* (µg/L)	IBI Score	No apparent gradient (r=-0.579)	-
		Coleoptera Taxa	No apparent gradient (r=-0.164)	-
		EPT Taxa	No apparent gradient (r=-0.369)	-
		Predatory Taxa	No apparent gradient (r=-0.167)	-
		% Collector Individuals	No apparent gradient (r=-0.152)	-
		% Intolerant Individuals	No apparent gradient (r=-0.032)	-
		% Non-insect Taxa	No apparent gradient (r=0.084)	-
		% Tolerant Taxa	No apparent gradient (r=0.784); inconsistency among impacted and comparator sites.	0
		Taxa Richness	No apparent gradient (r=-0.158)	-
	NH_3-N (µg/L)	IBI Score	No apparent gradient (r=0.321)	-
		Coleoptera Taxa	No apparent gradient (r=-0.089)	-
		EPT Taxa	No apparent gradient (r=0.495)	-
		Predatory Taxa	No apparent gradient (r=-0.089)	-
		% Collector Individuals	No apparent gradient (r=-0.176)	-
		% Intolerant Individuals	No apparent gradient (r=-0.249)	-
		% Non-insect Taxa	No apparent gradient (r=-0.077)	-
		% Tolerant Taxa	No apparent gradient (r=-0.702); not in expected direction	-
		Taxa Richness	No apparent gradient (r=0.122)	-
	NO_2-NO_3-N (µg/L)	IBI Score	No apparent gradient (r=-0.290)	-
		Coleoptera Taxa	No apparent gradient (r=-0.272)	-
		EPT Taxa	No apparent gradient (r=-0.322)	-
		Predatory Taxa	No apparent gradient (r=0.635); inconsistent	-
		% Collector Individuals	No apparent gradient (r=-0.532); inconsistent	-
		% Intolerant Individuals	No apparent gradient (r=0.574); inconsistent	-
		% Non-insect Taxa	No apparent gradient (r=0.740); inconsistent	-
		% Tolerant Taxa	No apparent gradient (r=0.835); inconsistent	-
		Taxa Richness	No apparent gradient (r=0.210)	-
	OPO_4-P (µg/L)	IBI Score	No apparent gradient (r=-0.214)	-
		Coleoptera Taxa	No apparent gradient (r=0.321)	-
		EPT Taxa	No apparent gradient (r=-0.071)	-
		Predatory Taxa	No apparent gradient (r=-0.481)	-
		% Collector Individuals	No apparent gradient (r=0.274)	-

Candidate Cause	Variable, Units	Specific Effect	Result	SOE Score
		% Intolerant Individuals	No apparent gradient (r=-0.170)	-
		% Non-insect Taxa	No apparent gradient (r=-0.319)	-
		% Tolerant Taxa	No apparent gradient (r=0.253)	-
		Taxa Richness	No apparent gradient (r=-0.095)	-
Increased Ionic Strength		IBI Score	No apparent gradient (r=-0.170)	-
		Coleoptera Taxa	No apparent gradient (r=-0.648); inconsistent	-
		EPT Taxa	No apparent gradient (r=-0.212)	-
		Predatory Taxa	No apparent gradient (r=0.470)	-
		% Collector Individuals	No apparent gradient (r=-0.452)	-
		% Intolerant Individuals	No apparent gradient (r=0.100)	-
		% Non-insect Taxa	No apparent gradient (r=0.416)	-
		% Tolerant Taxa	No apparent gradient (r=0.173)	-
		Taxa Richness	No apparent gradient (r=-0.077)	-
Altered Physical Habitat†	Channel Alteration	IBI Score	No apparent gradient (r=0.346)	-
		Coleoptera Taxa	No apparent gradient (r=0.390)	-
		EPT Taxa	Weak effect in expected direction with slight inconsistency (r=0.776)	0
		Predatory Taxa	No apparent gradient (r=0.195)	-
		% Collector Individuals	Weak effect in expected direction with slight inconsistency (r=-0.664)	0
		% Intolerant Individuals	No apparent gradient (r=0.396)	-
		% Non-insect Taxa	No apparent gradient (r=0.567)	-
		% Tolerant Taxa	No apparent gradient (r=-0.089)	-
		Taxa Richness	Weak effect in expected direction with slight inconsistency (r=0.801)	0
Altered Sediment (suspended)	Turbidity (NTU)	IBI Score	Strong effect in expected direction (r=-0.966; p=0.007)	++
		Coleoptera Taxa	Weak effect in expected direction (r=-0.801)	+
		EPT Taxa	Strong effect in expected direction (r=-0.891)	++
		Predatory Taxa	Uncertain effect (r=-0.354)	0
		% Collector Individuals	No apparent gradient (r=0.071)	-
		% Intolerant Individuals	Weak effect in expected direction (r=-0.523)	+
		% Non-insect Taxa	Uncertain effect (r=-0.286)	0
		% Tolerant Taxa	Weak effect in expected direction (r=0.792)	+
		Taxa Richness	Weak effect in expected direction (r=-0.825)	+

Candidate Cause	Variable, Units	Specific Effect	Result	SOE Score
Altered Sediment (bed)	Epifaunal Substrate (range all poor 1-4)	IBI Score	No apparent gradient (r=0.000)	-
		Coleoptera Taxa	No apparent gradient (r=-0.141)	-
		EPT Taxa	No apparent gradient (r=-0.618)	-
		Predatory Taxa	No apparent gradient (r=0.210)	-
		% Collector Individuals	No apparent gradient (r=0.603)	-
		% Intolerant Individuals	No apparent gradient (r=0.032)	-
		% Non-insect Taxa	No apparent gradient (r=-0.266)	-
		% Tolerant Taxa	No apparent gradient (r=0.000)	-
		Taxa Richness	No apparent gradient (r=-0.468)	-
	Sediment Deposition (range all poor 1-2)	IBI Score	No apparent gradient (r=0.521)	-
		Coleoptera Taxa	No apparent gradient (r=0.100)	-
		EPT Taxa	No apparent gradient (r=0.378)	-
		Predatory Taxa	No apparent gradient (r=0.010)	-
		% Collector Individuals	No apparent gradient (r=0.110)	-
		% Intolerant Individuals	No apparent gradient (r=-0.045)	-
		% Non-insect Taxa	No apparent gradient (r=-0.110)	-
		% Tolerant Taxa	No apparent gradient (r=-0.781); inconsistent	-
		Taxa Richness	No apparent gradient (r=0.122)	-
Altered Flow Regime	Baseflow Discharge (m^3/sec)	IBI Score	Weak effect in expected direction (r=0.844)	+
		Coleoptera Taxa	Weak effect in expected direction (r=0.579)	+
		EPT Taxa	Weak effect in expected direction (r=0.685)	+
		Predatory Taxa	Weak effect in expected direction (r=0.802)	+
		% Collector Individuals	No apparent gradient (r=-0.375)	-
		% Intolerant Individuals	Weak effect in expected direction (r=0.868)	+
		% Non-insect Taxa	Weak effect in expected direction (r=0.731)	+
		% Tolerant Taxa	No apparent gradient (r=-0.381)	+
		Taxa Richness	Strong effect in expected direction (r=0.924)	++
	Baseflow Discharge per watershed area ($m^3/sec/km^2$)	IBI Score	Strong effect in expected direction (r=-0.902)	++
		Coleoptera Taxa	Weak effect in expected direction (r=-0.663)	+
		EPT Taxa	Weak effect in expected direction (r=-0.801)	+
		Predatory Taxa	Weak effect in expected direction (r=-0.675)	+
		% Collector Individuals	No apparent gradient (r=0.332)	-
		% Intolerant Individuals	Weak effect in expected direction (r=-0.781)	+

Candidate Cause	Variable, Units	Specific Effect	Result	SOE Score
		% Non-insect Taxa	Weak effect in expected direction (r=-0.632)	+
		% Tolerant Taxa	No apparent gradient (r=0.518)	-
		Taxa Richness	Strong effect in expected direction (r=-0.943)	++
	April storm flow duration (days)	IBI Score	Weak effect in expected direction (r=-0.645)	+
		Coleoptera Taxa	Weak effect in expected direction (r=-0.662)	+
		EPT Taxa	Weak effect in expected direction (r=-0.869)	+
		Predatory Taxa	No apparent gradient (r=0.298)	-
		% Collector Individuals	No apparent gradient (r=-0.063)	-
		% Intolerant Individuals	No apparent gradient (r=0.071)	-
		% Non-insect Taxa	No apparent gradient (r=0.195)	-
		% Tolerant Taxa	Weak effect in expected direction (r=0.846)	+
		Taxa Richness	No apparent gradient (r=0.483)	-
	April storm volume (m^3x10^8)	IBI Score	Weak effect in expected direction (r=-0.851)	+
		Coleoptera Taxa	Weak effect in expected direction (r=-0.757)	+
		EPT Taxa	Strong effect in expected direction (r=-0.964)	++
		Predatory Taxa	No apparent gradient (r=-0.089)	-
		% Collector Individuals	No apparent gradient (r=0.105)	-
		% Intolerant Individuals	No apparent gradient (r=0.295)	-
		% Non-insect Taxa	No apparent gradient (r=0.141)	-
		% Tolerant Taxa	Weak effect in expected direction (r=0.822)	+
		Taxa Richness	Weak effect in expected direction (r=-0.756)	+
	April storm volume per area (m^3x10^4/km^2)	IBI Score	No apparent gradient (r=-0.446)	-
		Coleoptera Taxa	No apparent gradient (r=-0.167)	-
		EPT Taxa	No apparent gradient (r=-0.141)	-
		Predatory Taxa		
		% Collector Individuals	No apparent gradient (r=0.420)	-
		% Intolerant Individuals	No apparent gradient (r=-0.924); inconsistent	-
		% Non-insect Taxa	No apparent gradient (r=-0.863); inconsistent	-
		% Tolerant Taxa	No apparent gradient (r=-0.152)	-
		Taxa Richness	No apparent gradient (r=-0.6286)	-
	Depth (m)	IBI Score	Weak effect in expected direction (r=0.868)	+
		Coleoptera Taxa	Weak effect in expected direction (r=0.761)	+
		EPT Taxa	Strong effect in expected direction (r=0.965)	++
		Predatory Taxa	No apparent gradient (r=0.134)	-
		% Collector Individuals	No apparent gradient (r=-0.122)	-

Candidate Cause	Variable, Units	Specific Effect	Result	SOE Score
		% Intolerant Individuals	No apparent gradient (r=0.336)	-
		% Non-insect Taxa	No apparent gradient (r=0.182)	-
		% Tolerant Taxa	Weak effect in expected direction (r=-0.811)	+
		Taxa Richness	Weak effect in expected direction (r=0.782)	+
	Storm peak discharge (m^3/sec)	IBI Score	No apparent gradient (r=0.443)	-
		Coleoptera Taxa	No apparent gradient (r=0.536)	-
		EPT Taxa	No apparent gradient (r=0.725); inconsistent	-
		Predatory Taxa	No apparent gradient (r=-0.543)	-
		% Collector Individuals	No apparent gradient (r=0.170)	-
		% Intolerant Individuals	No apparent gradient (r=-0.321)	-
		% Non-insect Taxa	No apparent gradient (r=-0.412)	-
		% Tolerant Taxa	No apparent gradient (r=-0.786); inconsistent	-
		Taxa Richness	No apparent gradient (r=0.249)	-
	Velocity (m/sec)	IBI Score	Strong effect in expected direction (r=-0.909)	++
		Coleoptera Taxa	Weak effect in expected direction (r=-0.675)	+
		EPT Taxa	Weak effect in expected direction (r=-0.819)	+
		Predatory Taxa	No apparent gradient (r=0.481)	-
		% Collector Individuals	No apparent gradient (r=0.322)	-
		% Intolerant Individuals	Weak effect in expected direction (r=-0.762)	+
		% Non-insect Taxa	Weak effect in expected direction (r=-0.611)	+
		% Tolerant Taxa	No apparent gradient (r=0.541)	-
		Taxa Richness	Weak effect in expected direction (r=-0.649)	+
	Cumulative Precipitation (Nov-Jun) (m)	IBI Score	Weak effect in expected direction (r=-0.637)	+
		Coleoptera Taxa	Weak effect in expected direction (r=-0.683)	+
		EPT Taxa	Strong effect in expected direction (r=-0.846)	++
		Predatory Taxa	No apparent gradient (r=0.483)	-
		% Collector Individuals	No apparent gradient (r=-0.138)	-
		% Intolerant Individuals	No apparent gradient (r=0.224)	-
		% Non-insect Taxa	No apparent gradient (r=0.319)	-
		% Tolerant Taxa	Strong effect in expected direction (r=0.855)	++
		Taxa Richness	No apparent gradient (r=-0.458)	-
	Cumulative Precipitation (Apr-Jun) (m)	IBI Score	Strong effect in expected direction (r=-0.901)	++
		Coleoptera Taxa		
		EPT Taxa	Strong effect in expected direction (r=-0.820)	++
		Predatory Taxa	No apparent gradient (r=-0.443)	-

Candidate Cause	Variable, Units	Specific Effect	Result	SOE Score
		% Collector Individuals	No apparent gradient (r=0.259)	-
		% Intolerant Individuals	Weak effect in expected direction (r=-0.630)	+
		% Non-insect Taxa		
		% Tolerant Taxa	Weak effect in expected direction (r=-0.610)	+
		Taxa Richness	Strong effect in expected direction (r=-0.925)	++

APPENDIX 5

Strength of evidence for scoring summary for stressor-response relationships from the field.

Strength of evidence (SOE) scoring for stressor-response relationship in the field
++ A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is in the expected direction.
+ A weak effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is in the expected direction.
0 An uncertain effect gradient is observed relative to exposure to the candidate cause.
- An inconsistent effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is NOT in the expected direction.
-- A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is NOT in the expected direction.
NE No evidence.

Reasoning and Comments	SOE Score Endpoint	Score
Decreased dissolved oxygen	IBI Score	-
Scatter plots for dissolved oxygen (concentration and percent saturation) show inconsistent relationships, often in not in the expected direction for all the endpoints; therefore, - scores were given.	Coleoptera Taxa	-
	EPT Taxa	-
	Predatory Taxa	-
	% Collector Individuals	-
	% Intolerant Individuals	-
	% Non-insect Taxa	-
	% Tolerant Taxa	-
	Taxa Richness	-
Increased Pesticides	IBI Score	NE
Appropriate stressor-response data from the project site are not available for direct analysis of this cause; therefore NE scores were given.	Coleoptera Taxa	NE
	EPT Taxa	NE
	Predatory Taxa	NE
	% Collector Individuals	NE
	% Intolerant Individuals	NE
	% Non-insect Taxa	NE
	% Tolerant Taxa	NE
	Taxa Richness	NE
Increased Metals	IBI Score	NE
Appropriate stressor-response data from the project site are not available for direct analysis of this cause; therefore NE scores were given.	Coleoptera Taxa	NE
	EPT Taxa	NE
	Predatory Taxa	NE
	% Collector Individuals	NE
	% Intolerant Individuals	NE
	% Non-insect Taxa	NE
	% Tolerant Taxa	NE
	Taxa Richness	NE
Increased Nutrients	IBI Score	-
Scatter plots for nutrients and aquatic vegetation were used to determine stressor-response relationships for increased nutrients. Scatter plots for show inconsistent relationships, often in the opposite expected direction; thus, - scores were given.	Coleoptera Taxa	-
	EPT Taxa	-
	Predatory Taxa	-
	% Collector Individuals	-
	% Intolerant Individuals	-
	% Non-insect Taxa	-
	% Tolerant Taxa	-
	Taxa Richness	-

Increased Ionic Strength Scatter plots for specific conductivity used to determine stressor-response relationships for increased nutrients. Scatter plots for show inconsistent relationships, often in the opposite expected direction; thus, - scores were given.	IBI Score	-
	Coleoptera Taxa	-
	EPT Taxa	-
	Predatory Taxa	-
	% Collector Individuals	-
	% Intolerant Individuals	-
	% Non-insect Taxa	-
	% Tolerant Taxa	-
	Taxa Richness	-
Physical Habitat Alteration Scatter plots for the qualitative habitat characterization variable, channel alteration, was used to determine stressor-response relationships for physical habitat alteration. EPT Taxa, % collector individuals, and taxa richness were weak correlated, high "r" but not significant, with channel alteration; however, sites scores were similar, within the same category, and were, therefore, scored 0. The other response variables had low correlation coefficients and were scored -.	IBI Score	-
	Coleoptera Taxa	-
	EPT Taxa	0
	Predatory Taxa	-
	% Collector Individuals	0
	% Intolerant Individuals	-
	% Non-insect Taxa	-
	% Tolerant Taxa	-
	Taxa Richness	0
Physical Habitat Alteration (suspended sediments) Scatter plots for turbidity were used to determine stressor-response relationships for increased suspended sediments. IBI scores and EPT taxa were strongly and negatively correlated with turbidity and, therefore, scored ++. Coleoptera taxa, percent collector individuals, percent intolerant individuals, and taxa richness were weakly and negatively correlated with turbidity and, therefore, scored +. Turbidity and percent tolerant taxa were weakly, but positively, correlated and also scored a +. Noticeable relationships between predatory taxa and turbidity and percent non-insect taxa were unclear and scored a 0.	IBI Score	++
	Coleoptera Taxa	+
	EPT Taxa	++
	Predatory Taxa	0
	% Collector Individuals	+
	% Intolerant Individuals	+
	% Non-insect Taxa	0
	% Tolerant Taxa	+
	Taxa Richness	+
Physical Habitat Alteration (bedded sediments) Scatter plots for the qualitative habitat characterization variables, epifaunal substrate cover and sediment deposition, were used to determine stressor-response relationships for increased bed sediments. Scatter plots for show inconsistent relationships, often in the opposite expected direction; thus, - scores were given. In addition, all sites scored in the "poor" category.	IBI Score	-
	Coleoptera Taxa	-
	EPT Taxa	-
	Predatory Taxa	-
	% Collector Individuals	-
	% Intolerant Individuals	-
	% Non-insect Taxa	-
	% Tolerant Taxa	-
	Taxa Richness	-
Physical Habitat Alteration (altered flow regime) Scatter plots for baseflow discharge (volume and per watershed area), stormflow (duration, volume, per watershed area, and peak discharge), river depth, river velocity, and cumulative precipitation (spring and water year) were used to determine stressor-response relationships for altered flow regime. IBI scores coleoptera taxa, EPT taxa and taxa richness were correlated (strong and weak) within the expected direction with many of the variables and were, therefore, score collectively as +. Consistent relationships were not observed for predatory taxa, percent intolerant individuals, percent non-insect taxa, and percent tolerant taxa; thus, scored 0. Percent collector individuals was negatively related to all the flow regime variables and, thus, scored -.	IBI Score	+
	Coleoptera Taxa	+
	EPT Taxa	+
	Predatory Taxa	0
	% Collector Individuals	-
	% Intolerant Individuals	0
	% Non-insect Taxa	0
	% Tolerant Taxa	0
	Taxa Richness	+

APPENDIX 6

Sediment toxicity results of laboratory tests of site media, evidence from the case. Sediment samples collected on 26 May 2006 from the CMP sites 309SSP (impacted), 309SAC (comparator), and 309GRN (comparator) and assessed for *Hyalella azteca* percent growth and survival following 10 days exposure to sediment.

Laboratory Test and Media	309SSP	309SAC	309GRN
Sediment Toxicity (26 May 2006)			
Hyalella azteca growth (%) 10 days	163	164	118
Hyalella azteca survival (%) 10 days	107	117	199

Strength of evidence (SOE) scoring system for laboratory tests of site media		
+++ Laboratory tests with site media show clear biological effects that are closely related to the observed impairment. + Laboratory tests with site media show ambiguous effects OR clear effects that are not closely related to the observed impairment. 0 Laboratory tests with site media show uncertain effects. - Laboratory tests with site media show no toxic effects that can be related to the observed impairment. NE no evidence.		
	SOE score	
Reasoning and Comments	**Endpoint**	**Score**
309SSP relative to 309SAC		
The amphipod (*Hyalella azteca*) laboratory specimen is a surrogate for non-insects. Amphipod relative growth and survival for both sites were greater than the laboratory control indicating no sediment toxicity.	% non-insects	-
309SSP relative to 309GRN		
The amphipod (*Hyalella azteca*) laboratory specimen is a surrogate for non-insects. Amphipod relative growth and survival for both sites were greater than the laboratory control indicating no sediment toxicity.	% non-insects	-

10-day laboratory exposure does not accurately represent site condition, where longer term exposures to sediment are likely.

APPENDIX 7

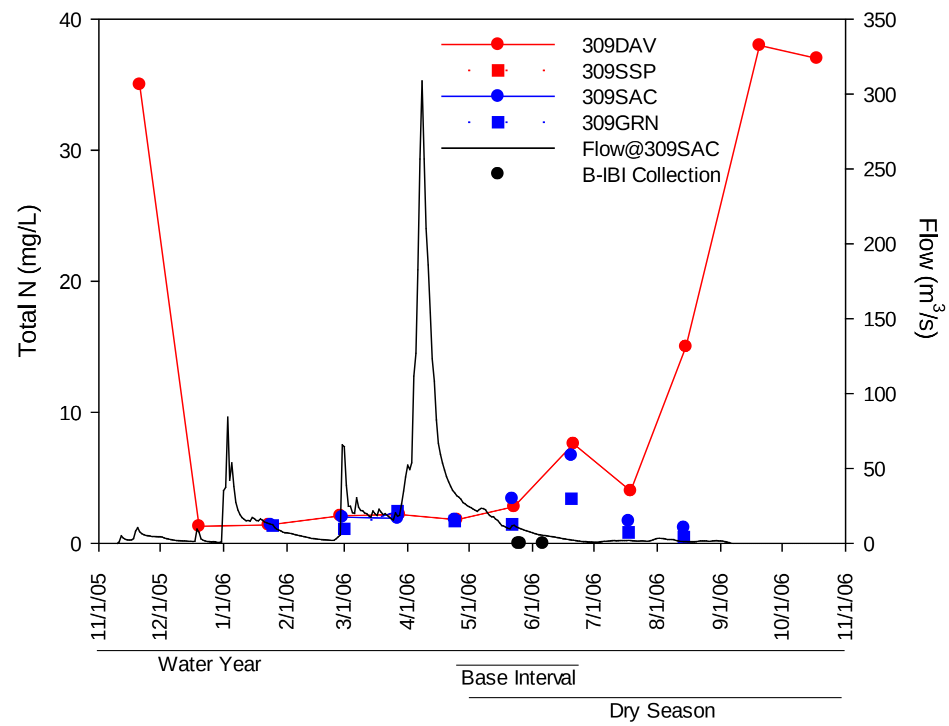
Surface water toxicity results of laboratory tests of site media, evidence from the case. Surface water samples collected on 23 Feb 2006 and 24 Aug 2006 from the CMP sites 309SSP (impacted), 309SAC (comparator), and 309GRN (comparator) and assessed for *Ceriodaphnia dubia* reproduction and percent survival, *Pimephales promelas* percent growth and survival, and *Selenastrum capricornutum* growth following 7days exposure to surface water.

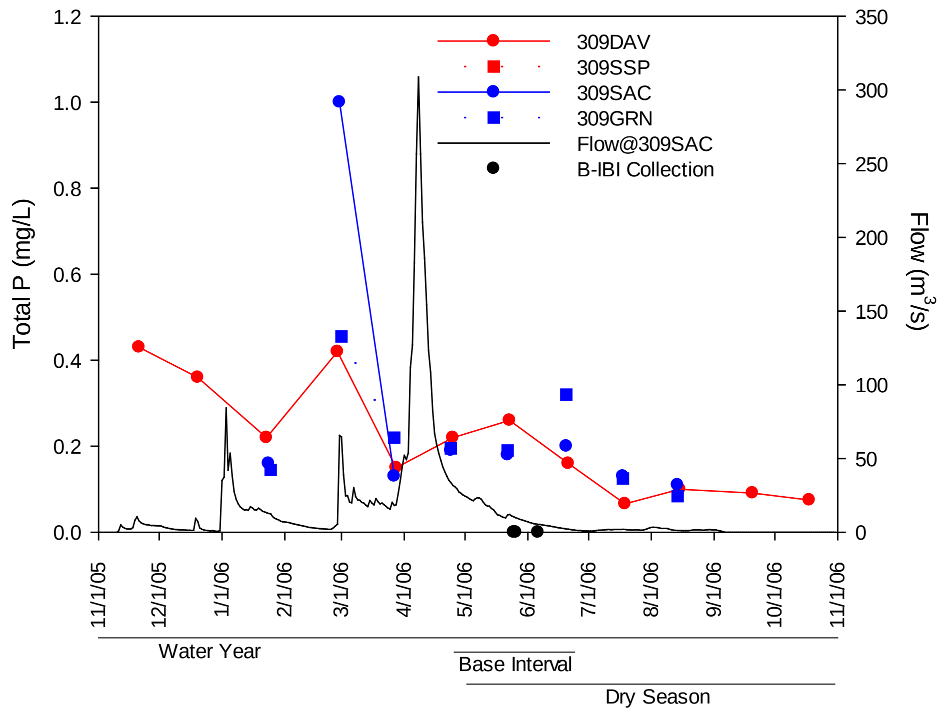
Laboratory Test and Media	309SSP	309SAC	309GRN
Surface Water Toxicity (23 Feb 2006)			
Ceriodaphnia dubia reproduction (%)7 days	***80***	***51***	***58***
Ceriodaphnia dubia survival (%) 7 days	100	100	100
Pimephales promelas growth (mg/ind) 7 days	128	117	130
Pimephales promelas survival (%) 7 days	111	111	100
Selenastrum capricornutum growth (%) 7 days	100	100	100
Surface Water Toxicity (24 August 2006)			
Ceriodaphnia dubia reproduction 7 days	***28***	***0***	***0***
Ceriodaphnia dubia survival (%) 7 days	***20***	***0***	***0***
Pimephales promelas growth (%) 7 days	142	137	154
Pimephales promelas survival (%) 7 days	137	125	125
Selenastrum capricornutum growth (%) 7 days	100	100	100

Reasoning and Comments	Endpoint	Score
309SSP relative to 309SAC		
The alga (*Selenastrum capricornutum*) laboratory specimen is a surrogate for primary producers. Algal relative growth for both sites showed no decline and were equal to laboratory controls indicating no chronic surface water toxicity.	Primary Producers	-
The cladoceran (*Ceriodaphnia dubia*) laboratory specimen is a surrogate for lower trophic levels. Cladoceran reproduction and survival for both sites were lower than the laboratory control indicating surface water chronic toxicity; however, effects were greater for the comparator site (309SAC) than the impacted site (309SSP). The effect was greater in the summer, little to no survivorship, than winter, 100% survivorship.	Lower trophic level	-
The minnow (*Pimephales promelas*) laboratory specimen is a surrogate for higher trophic levels. Minnow relative growth and survival for both sites were greater than the laboratory control indicating no chronic surface water toxicity.	Higher trophic level	-
309SSP relative to 309GRN		
The alga (*Selenastrum capricornutum*) laboratory specimen is a surrogate for primary producers. Algal relative growth for both sites showed no decline and were equal to laboratory controls indicating no chronic surface water toxicity.	Primary Producers	-
The cladoceran (*Ceriodaphnia dubia*) laboratory specimen is a surrogate for lower trophic levels. Cladoceran reproduction and survival for both sites were lower than the laboratory control indicating surface water chronic toxicity; however, effects were greater for the comparator site (309SAC) than the impacted site (309SSP). The effect was greater in the summer, little to no survivorship, than winter, 100% survivorship.	Lower trophic level	-
The minnow (*Pimephales promelas*) laboratory specimen is a surrogate for higher trophic levels. Minnow relative growth and survival for both sites were greater than the laboratory control indicating no chronic surface water toxicity.	Higher trophic level	-

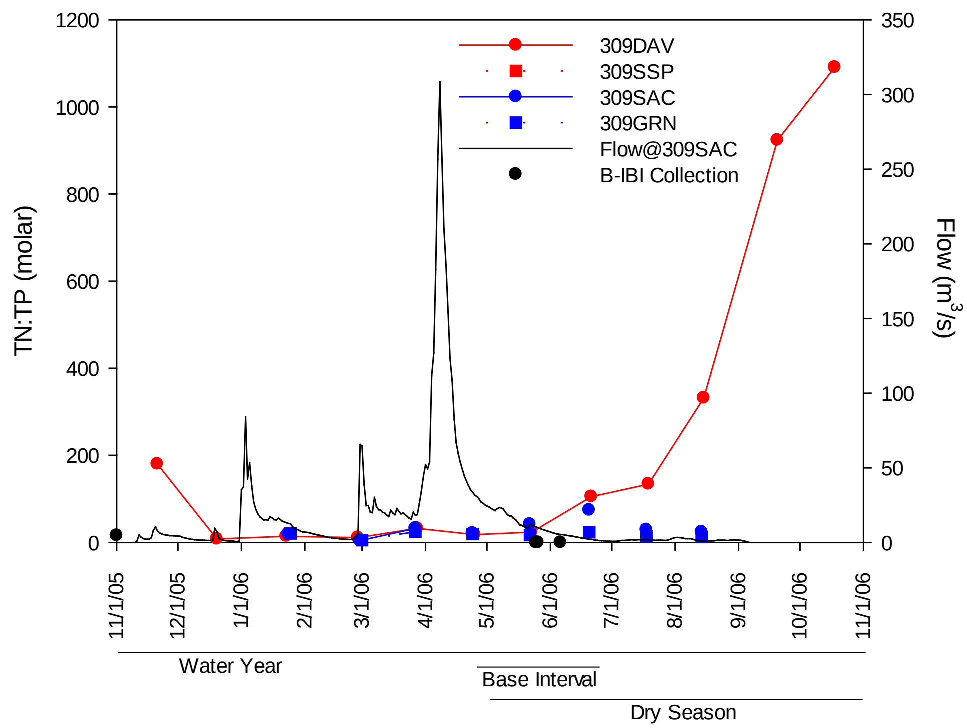
APPENDIX 8

Analyses of temporal sequence, evidence from the case, that illustrate the cause did not precede the effect (biological impairment) for the Salinas River, California. Two candidate causes were evaluated; increased nutrients, represented by time-series of impacted and comparator site plots of total N, total P, and molar N:P, and increased ionic strength, represented by a time-series plot of specific conductivity. Also indicated are the times of B-IBI collection.

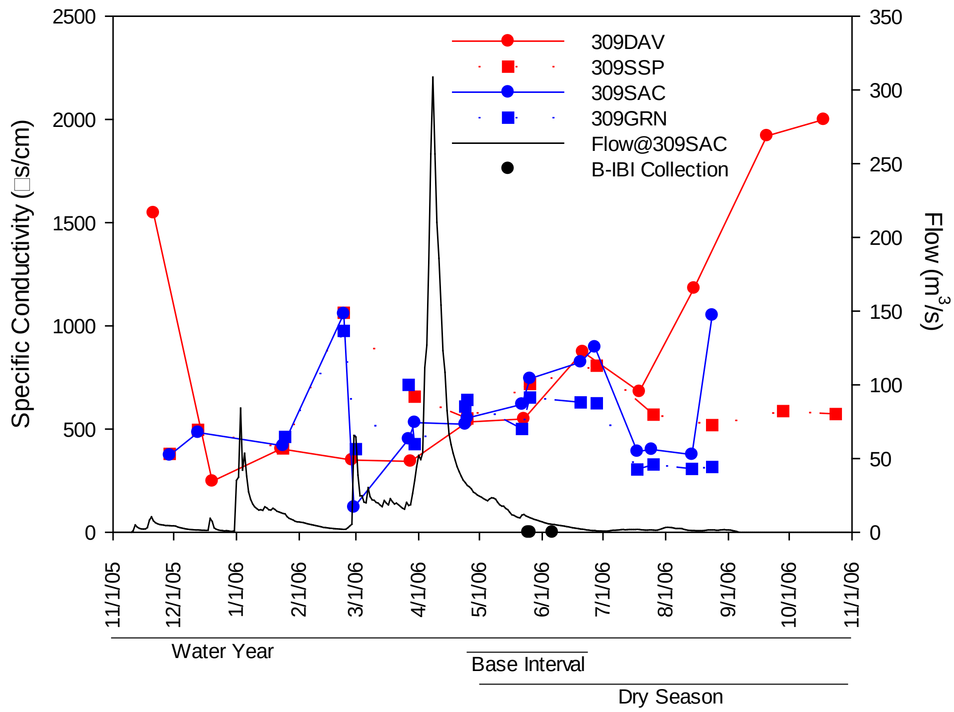




Total P (mg/L)
Flow (m3/s)
309DAV
309SSP
309SAC
309GRN
Flow@309SAC
B-IBI Collection
1.2
1.0
0.8
0.6
0.4
0.2
0.0
350
300
250
200
150
100
50
0
11/1/05
12/1/05
1/1/06
2/1/06
3/1/06
4/1/06
5/1/06
6/1/06
7/1/06
8/1/06
9/1/06
10/1/06
11/1/06
Water Year
Base Interval
Dry Season



TN:TP (molar)
Flow (m3/s)
309DAV
309SSP
309SAC
309GRN
Flow@309SAC
B-IBI Collection
1200
1000
800
600
400
200
0
350
300
250
200
150
100
50
0
11/1/05
12/1/05
1/1/06
2/1/06
3/1/06
4/1/06
5/1/06
6/1/06
7/1/06
8/1/06
9/1/06
10/1/06
11/1/06
Water Year
Base Interval
Dry Season



2500
2000
1500
1000
500
0
350
300
250
200
150
100
50
0
Specific Conductivity (□s/cm)
Flow (m3/s)
309DAV
309SSP
309SAC
309GRN
Flow@309SAC
B-IBI Collection
11/1/05
12/1/05
1/1/06
2/1/06
3/1/06
4/1/06
5/1/06
6/1/06
7/1/06
8/1/06
9/1/06
10/1/06
11/1/06
Water Year
Base Interval
Dry Season

APPENDIX 9

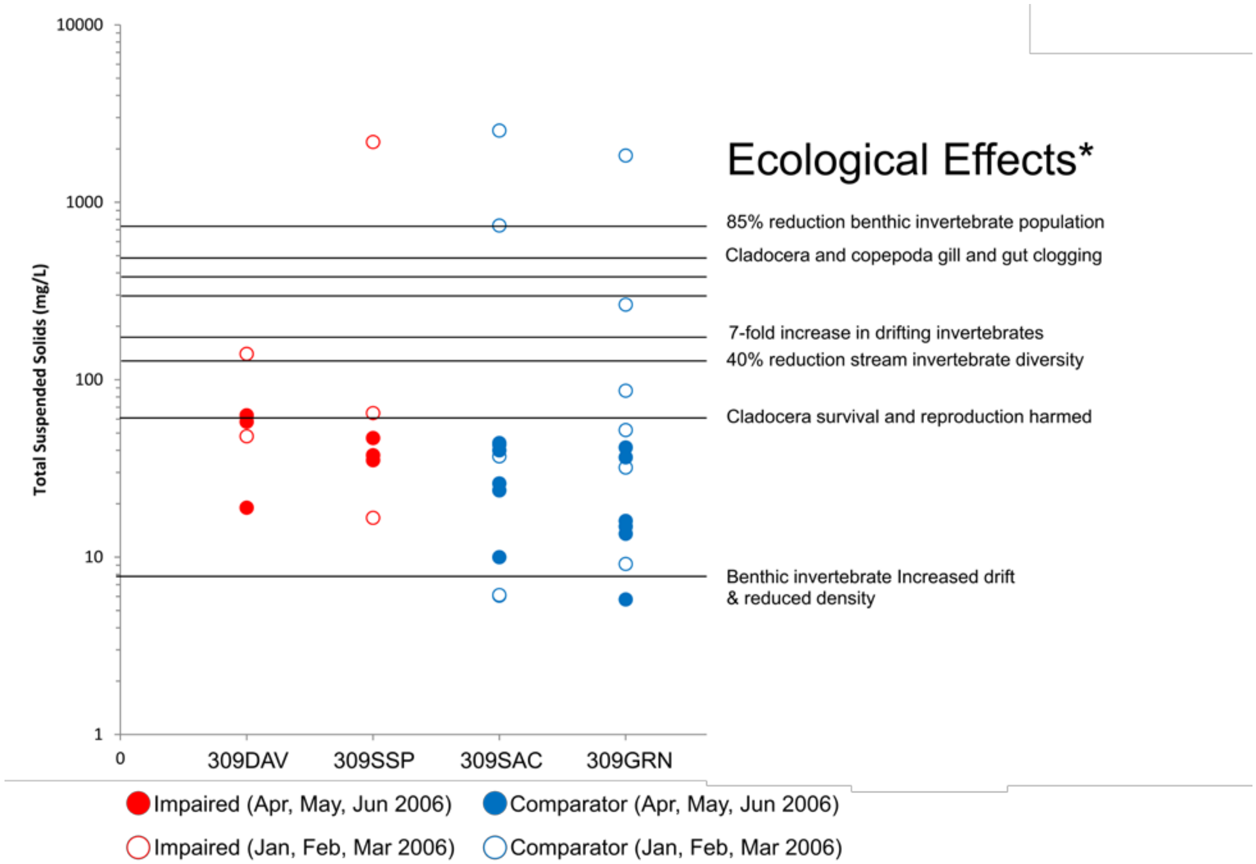
Strength of evidence scoring of temporal sequence, evidence from the case, for the Salinas River impacted Davis Rd site (309DAV) and Spreckels site (309SSP) versus the comparator Chualar Bridge site (309SAC) and Greenfield site (309GRN).

Strength of evidence (SOE) scoring for temporal sequence
+ The candidate cause occurred prior to the effect.
0 The temporal relationship between the candidate cause and the effect is somewhat uncertain.
--- The candidate cause occurs after the effect.
R The candidate cause occurs after the effect, and the evidence is indisputable.

Reasoning and Comments	SOE Score
Increased Nutrients Time-series plots of total N, total P, and N:P molar ratios show consistent relationships, with greater values preceding the period of biological impairment; thus, the cause does not precede the effect. Elevated concentrations were coincident with periods of low flow (summer & fall). There was disagreement among workshop members, however, if the observed invertebrate community would be impacted by elevated concentrations from the previous year (i.e., integrated the effects). With this uncertainty in mind, a score of ---, rather than R, was given.	---
Increased Ionic Strength Time-series plots of specific conductivity shows consistent relationships, with greater values preceding the period of biological impairment; thus, the cause does not precede the effect. Elevated concentrations were coincident with periods of low flow (summer & fall). There was disagreement among workshop members, however, if the observed invertebrate community would be impacted by elevated concentrations from the previous year (i.e., integrated the effects). With this uncertainty in mind, a score of ---, rather than R, was given.	---

APPENDIX 10

Stressor-response relationships from field studies using data from elsewhere for total suspended solids, Salinas River, California. Salinas River total suspended solid concentrations for the biologically impacted (red) and comparator sites (blue) for the months preceding assessment are plotted in relation to known adverse ecological effects as synthesized in Bilotta and Brazier (2008). Total suspended solids were collected by CCAMP.



*Bilotta, G.S., and R.E. Brazier. 2008. Understanding the influence of suspended solids on water quality and aquatic biota. Water Research 42: 2849-2861.

APPENDIX 11

Strength of evidence scoring for stressor-response relationships from the field, evidence from elsewhere, of total suspended solids for the Salinas River case study.

Strength of Evidence scoring for plausible effect given stressor-response relationships

++ The observed relationship between exposure and effects in the case agrees quantitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

+ The observed relationship between exposure and effects in the case agrees qualitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

0 The agreement between the observed relationship between exposure and effects in the case and stressor-response relationships in controlled laboratory experiments or from other field studies is ambiguous.

- The observed relationship between exposure and effects in the case does not agree with stressor-response relationships in controlled laboratory experiments or from other field studies.

-- The observed relationship between exposure and effects in the case does not quantitatively agree with stressor-response relationships in controlled laboratory experiments or from other field studies or the quantitative differences are very large.

	SOE Score	
Reasoning and Comments	**Endpoint**	**Score**
Total suspended solids		
For the available data, total suspended solids concentrations for impacted and comparator sites in 2006 were within the range of published studies reporting adverse ecological effects. Although values are consistently within the adverse range and the slight tendency for greater concentrations for impacted, there is relatively little data. Thus, there is weak supporting evidence, suggesting the S-R data support the case for suspended sediments.	IBI score	+

APPENDIX 12

Stressor-response relationships from laboratory studies using data from elsewhere for sediment and water column organochlorine pesticide contents Salinas River, California. When it was not readily apparent if the benchmark value was derived from laboratory or field studies, it was assumed to be derived from laboratory studies. Sediment contents reported for 309DAV were collected by CCAMP in March 2004, June 2008 and June 2009. Contents reported for 309SSP, 309SAG, 309SAC, and 309GRN were collected by CMP in May of 2010. CCAMP surface water pesticide data was available for 309DAV (Feb 2010 and Jul 2010). CMP surface water pesticide data was available for 309SSP (Aug 2006, Sep 2006, Feb 2007, and Mar 2007), 309SAG (Aug 2009), 309SAC (Aug 2006, Feb 2007, and Mar 2007), and 309GRN (Aug 2009). Values were contrasted against consensus based threshold effect concentrations (TEC) and probable effect concentrations (PEC) (MacDonald et al. 2000). Additional contrasts were made against CCRWQCB action and attention levels, set using NOAA effects low range (ERL) and effects range median (ERM), respectively (CCAMP 2000). Contents exceeding probable effect concentrations and CCRWQCB attention levels benchmarks are indicated with bold and italics.

Sediment organochlorine pesticide content (ng/g dw)									
			309DAV			309SSP	309SAG	309SAC	309GRN
	Stressor-response Benchmark	Value	2004	2008	2009	2010	2010	2010	2010
chlordane	Consensus Based Threshold Effect Concentration	3.24	1.47	2.27	*13.6*	<2.0	<2.0	<2.0	<2.0
	Consensus Based Probable Effect Concentration	17.6							
	CCRWQCB Action Level	0.5							
	CCRWQCB Attention Level	6.0							
dieldrin	Consensus Based Threshold Effect Concentration	1.9	0.676	2.62	18.7	<1.0	<1.0	<1.0	<1.0
	Consensus Based Probable Effect Concentration	61.8							
sum DDD	Consensus Based Threshold Effect Concentration	4.88	3.11	8.18	*65.8*	4.6	<2.0	3.3	<2.0
	Consensus Based Probable Effect Concentration	28							
sum DDE	Consensus Based Threshold Effect Concentration	3.16	11.6	25.6	*159*	23.5	4.7	11.9	4.3
	Consensus Based Probable Effect Concentration	31.3							
	CCRWQCB Action Level	2.2							
	CCRWQCB Attention Level	27							

Sediment organochlorine pesticide content (ng/g dw)										
			309DAV			309SSP	309SAG	309SAC	309GRN
sum DDT	Consensus Based Threshold Effect Concentration	4.16	7.23	6.96	29.9	8.4	<2.0	<2.0	<2.0
	Consensus Based Probable Effect Concentration	62.9							
	CCRWQCB Action Level	1.58							
	CCRWQCB Attention Level	46.1							
endrin	Consensus Based Threshold Effect Concentration	2.22	1.23	0.466	1.53	<1.0	<1.0	<1.0	<1.0
	Consensus Based Probable Effect Concentration	207							
	CCRWQCB Action Level	0.02							
	CCRWQCB Attention Level	45							
Heptachlor epoxide	Consensus Based Threshold Effect Concentration	2.47	0.662	0.498	0.765	<1.0	<1.0	<1.0	<1.0
	Consensus Based Probable Effect Concentration	16							
Lindane (gamma-BHC)	Consensus Based Threshold Effect Concentration	2.37				<1.0	<1.0	<1.0	<1.0

Water column pesticide toxicity (µg/L)							
	Stressor-response Benchmark	Value	309DAV	309SSP	309SAG	309SAC	309GRN
chlorpyrifos	EPA Criterion Maximum Concentration	0.083	0.005-0.020	*<0.001-0.029*	<0.001	<0.001	<0.001
	EPA Criterion Continuous Concentration	0.041	[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	0.050					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.040					

Water column pesticide toxicity (µg/L)							
	Stressor-response Benchmark	Value	309DAV	309SSP	309SAG	309SAC	309GRN
	Salinas River Criterion Max. Conc. Water Column Numeric Target	0.025					
	Salinas River Criterion Continuous Concentration Water Column Numeric Target	0.015					
	LC50 *Ceriodaphnia dubia*	0.08	0.005-0.020	<0.001-0.029	<0.001	<0.001	<0.001
	LC50 *Hyalella azteca*	0.09	[2]	[4]	[1]	[3]	[1]
	Acute toxicity thresholds (media 96-hr LC50) for *Ceriodaphnia dubia*	0.053					
	Chronic toxicity thresholds (10-day LC50) for *Hyalella azteca*	0.086					
diazinon	EPA Criterion Maximum Concentration	0.170	0.005	*<0.002-0.221*	<0.002	<0.002-0.085	<0.002
	EPA Criterion Continuous Concentration	0.170	[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	0.110					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.170					
	Salinas River Criterion Maximum Concentration Water Column Numeric Target	0.16					
	Salinas River Criterion Continuous Concentration Water Column Numeric Target	0.10					
	LC50 *Ceriodaphnia dubia*	0.45	0.005	<0.002-0.221	<0.002	<0.002-0.085	<0.002
	LC50 *Hyalella azteca*	16.1	[2]	[4]	[1]	[3]	[1]
	Acute toxicity thresholds (media 96-hr LC50) for *Ceriodaphnia dubia*	0.32					

Water column pesticide toxicity (µg/L)							
	Stressor-response Benchmark	Value	309DAV	309SSP	309SAG	309SAC	309GRN
	Chronic toxicity thresholds (10-day LC50) for *Hyalella azteca*	6.51					
chlorpyrifos+diazinon	Salinas River Additive Criterion Maximum Concentration Water Column Numeric Target	>1	0.23-0.83 [2]	*0.05-2.55* [4]	0.05 [1]	0.05-0.09 [3]	0.05 [1]
	Salinas River Additive Criterion Continuous Concentration Water Column Numeric Target	>1	*0.38-1.38 [2]*	*0.09-4.16 [2]*	0.09 [1]	0.09-0.15 [3]	0.09 [1]
azinphos methyl	EPA Criterion Maximum Concentration		<0.030		<0.010		<0.010
	EPA Criterion Continuous Concentration		[2]		[1]		[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	0.080					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.036					
coumaphos	EPA Criterion Maximum Concentration		<0.040				
	EPA Criterion Continuous Concentration		[2]				
	EPA Invertebrate Acute Aquatic Life Benchmark	0.037					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.037					
dicrotophos	EPA Criterion Maximum Concentration		<0.030				
	EPA Criterion Continuous Concentration		[2]				
	EPA Invertebrate Acute Aquatic Life Benchmark	6.35					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.99					

Water column pesticide toxicity (µg/L)							
	Stressor-response Benchmark	Value	309DAV	309SSP	309SAG	309SAC	309GRN
dimethoate	EPA Criterion Maximum Concentration		<0.030-0.150	<0.030	<0.030	<0.030	<0.030
	EPA Criterion Continuous Concentration		[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	21.5					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.500					
fenitrothion	EPA Criterion Maximum Concentration		<0.030		<0.010		<0.010
	EPA Criterion Continuous Concentration		[2]		[1]		[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	1.15					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.087					
methamidophos	EPA Criterion Maximum Concentration				<0.050		<0.050
	EPA Criterion Continuous Concentration				[1]		[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	13.0					
	EPA Invertebrate Chronic Aquatic Life Benchmark	4.5					
naled	EPA Criterion Maximum Concentration		<0.030				
	EPA Criterion Continuous Concentration		[1]				
	EPA Invertebrate Acute Aquatic Life Benchmark	0.045					
	EPA Invertebrate Chronic Aquatic Life Benchmark						

Water column pesticide toxicity (µg/L)							
	Stressor-response Benchmark	Value	309DAV	309SSP	309SAG	309SAC	309GRN
phosmet	EPA Criterion Maximum Concentration		<0.050		<0.050		<0.050
	EPA Criterion Continuous Concentration		[2]		[1]		[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	1.0					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.8					
trichlorfon	EPA Criterion Maximum Concentration		<0.030				
	EPA Criterion Continuous Concentration		[2]				
	EPA Invertebrate Acute Aquatic Life Benchmark	2.65					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.0057					
chlorpyrifos methyl	EPA Criterion Maximum Concentration		<0.020				
	EPA Criterion Continuous Concentration		[2]				
	EPA Invertebrate Acute Aquatic Life Benchmark	0.085					
	EPA Invertebrate Chronic Aquatic Life Benchmark						
dichlorvos (DDVP)	EPA Criterion Maximum Concentration		<0.030	<0.030	<0.030	<0.030	<0.030
	EPA Criterion Continuous Concentration		[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	0.035					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.0058					

Water column pesticide toxicity (µg/L)							
	Stressor-response Benchmark	Value	309DAV	309SSP	309SAG	309SAC	309GRN
disulfoton	EPA Criterion Maximum Concentration		<0.010	<0.010	<0.010	<0.010	<0.010
	EPA Criterion Continuous Concentration		[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	1.95					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.01					
ethoprop	EPA Criterion Maximum Concentration		<0.030	<0.010	<0.010	<0.010	<0.010
	EPA Criterion Continuous Concentration		[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	22					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.80					
fenthion	EPA Criterion Maximum Concentration		<0.030	<0.020	<0.020	<0.020	<0.020
	EPA Criterion Continuous Concentration		[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	2.6					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.013					
malathion	EPA Criterion Maximum Concentration		<0.030	<0.030	<0.030	<0.030	<0.030
	EPA Criterion Continuous Concentration	0.10	[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	0.30					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.035					

Water column pesticide toxicity (µg/L)							
	Stressor-response Benchmark	Value	309DAV	309SSP	309SAG	309SAC	309GRN
phorate	EPA Criterion Maximum Concentration		<0.050	<0.060	<0.060	<0.060	<0.060
	EPA Criterion Continuous Concentration		[2]	[4]	[1]	[3]	[1]
	EPA Invertebrate Acute Aquatic Life Benchmark	0.3					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.21					
tetrachlorvinphos	EPA Criterion Maximum Concentration		<0.030				
	EPA Criterion Continuous Concentration		[2]				
	EPA Invertebrate Acute Aquatic Life Benchmark						
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.95					
terbufos	EPA Criterion Maximum Concentration		<0.030				
	EPA Criterion Continuous Concentration		[2]				
	EPA Invertebrate Acute Aquatic Life Benchmark	0.01					
	EPA Invertebrate Chronic Aquatic Life Benchmark	0.03					
chlordane (aspon)	EPA Criterion Maximum Concentration	0.0043	<0.030				
	EPA Criterion Continuous Concentration	2.4	[2]				
	EPA Invertebrate Acute Aquatic Life Benchmark						
	EPA Invertebrate Chronic Aquatic Life Benchmark						

Contents and concentrations reflect ranges. Samples size are reported in [].

CCAMP (2000). Salinas River Watershed Characterization Report 1999. Central Coast Regional Water Quality Control Board, July 31, 2000. 96pg.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger (2000). Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Archives of Environmental Contamination and Toxicology 39:20-31.

The additive toxicity affect associated with chlorpyrifos and diazinon was calculated using: $S=([C_{diazinon}/NT_{diazinon}]+[C_{chlorpyrifos}/NT_{chlorpyrifos]})$

where S=sum, C is the pesticide concentration in the surface water, and NT is the numeric target for each pesticide (for diazinon, CMC=0.16 µg/L, CCC=0.10 µg/L; for chlorpyrifos, CMC=0.025 µg/L, CCC=0.015 µg/L). If S exceeds 1, then a beneficial use may be adversely affected (Total Maximum Daily Loads for Chlorpyrifos and Diazinon in Lower Salinas River Watershed in Monterey County, California; California Regional Water Quality Control Board, Central Coast Region, 2011).

APPENDIX 13

Strength of evidence scoring for stressor-response relationships from the laboratory, evidence from elsewhere, of sediment and water column organochlorine pesticides for the Salinas River case study.

Strength of Evidence scoring for plausible effect given stressor-response relationships

++ The observed relationship between exposure and effects in the case agrees quantitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

+ The observed relationship between exposure and effects in the case agrees qualitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

0 The agreement between the observed relationship between exposure and effects in the case and stressor-response relationships in controlled laboratory experiments or from other field studies is ambiguous.

- The observed relationship between exposure and effects in the case does not agree with stressor-response relationships in controlled laboratory experiments or from other field studies.

-- The observed relationship between exposure and effects in the case does not quantitatively agree with stressor-response relationships in controlled laboratory experiments or from other field studies or the quantitative differences are very large.

	SOE Score	
Reasoning and Comments	**Endpoint**	**Score**
Sediment chlordane, dieldrin, sum DDT, and endrin Elevated chlordane, dieldrin, sum DDT, and endrin sediment contents were observed at 309DAV for which data was available. Despite the paucity of data, contents exceeded, at least once, the consensus based threshold effect concentration and/or the Central Coast Regional Water Quality Board's action level. Thus, this is supporting evidence that chlordane or dieldrin may have an effect; however, a zero (0) is given because data is limited to a single site (309DAV) and the lack of a robust dataset.	IBI score	0
Sediment sum DDD and sum DDE Elevated sum DDD, sum DDE, and sum DDT sediment contents were detected at 309DAV, 309SSP, and 309SAC for which data was available. Despite the paucity of data, contents exceeded the consensus based probable effect concentration and the Central Coast Regional Water Quality Board's attention level. Thus, this is supporting evidence that these organochlorine pesticides may have an effect. A single plus is given because data is limiting.	IBI score	+
Sediment heptachlor epoxide and lindane (gamma BHC) For the available data, sediment contents for endrin, heptachlor epoxide, and lindane (gamma BHC) were low or not detected and were below the consensus based threshold effect concentration, the consensus based probable effect concentration and the Central Coast Regional Water Quality Board's action and attention levels. Although there is no supporting evidence, suggesting the S-R data weaken the case for, these organochlorine pesticides cannot be ruled out due to the paucity of data,	IBI score	0
Water column chlorpyrifos and diazinon For the available data, surface water chlorpyrifos and diazinon concentrations exceeded LC50 and acute toxicity thresholds during the period of record. Thus, this is supporting evidence that chlorpyrifos and diazinon, alone or in tandem, may have an effect. A single plus is given because of the lack of a robust dataset.	IBI score	+
Water column all other pesticidewss There was limited surface water concentration data for many of the other pesticides to determine if toxicity thresholds were exceeded; thus, the relationships are ambiguous. A zero is given because of the lack of a robust dataset.	IBI score	0

APPENDIX 14

Stressor-response relationships from laboratory studies using data from elsewhere for surface water metal concentrations Salinas River, California. When it was not readily apparent if the benchmark value was derived from laboratory or field studies, it was assumed to be derived from laboratory studies. Values reflect the maximum concentration observed during the appropriate period of record except for EPA Criterion Continuous Concentrations which are arithmetic means. Stressor-response benchmarks in the EPA criterion maximum concentration (CMC), EPA criterion continuous concentration (CCC), California Water Quality Objectives, and invertebrate sensitive species distributions (SSD). Maximum concentrations exceeding a benchmark are denoted in bold and italic. The period of record for 309SSP was 1968-1977 and for 309SAC was 1977-1994. Values are also reported for the City of Salinas storm drain (SDIS), upstream of the storm drain (SUD), and downstream of the storm drain (SDD). The period of record for the storm drain was from 2006-2011.

Variable mg/L	**Stressor-response Benchmark Description**	**Value**	**309SSP**	**309SAC**	**SUD**	**SDIS**	**SDD**
arsenic	EPA Criterion Maximum Concentration	0.340	0.006	0.005			
	EPA Criterion Continuous Concentration	0.150	0.004	0.002			
	Invertebrate SSD, LC50 for 10% of species (T<=15C; moderate exposure)	0.510	0.006	0.003			
	Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure)	4.81	0.005	0.005			
	Invertebrate SSD, LC50 for 10% of species (T<=15C; long exposure)	0.360	0.005	0.005			
cadmium	EPA Criterion Maximum Concentration	0.002	<0.002	0.002			
	EPA Criterion Continuous Concentration	0.0003	<0.002	0.001			
	California Water Quality Objective	0.030	<0.002	0.002			
	Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure, hard water)	0.010	0.002	0.001			
	Invertebrate SSD, LC50 for 10% of species (T>15C; short exposure, very hard water)	0.258	0.002	0.002			
	Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure, very hard water)	0.107	0.002	0.002			
	Invertebrate SSD, LC50 for 10% of species (T>15C; long exposure, very hard water)	0.006	0.002	0.002			
chromium	California Water Quality Objective	0.050	<0.020	0.020			
	Invertebrate SSD, LC50 for 10% of species (T>15C; short exposure, hard water)	1.46	-	0.020			
	Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure, very hard water)	0.075	0.010	0.010			
	Invertebrate SSD, LC50 for 10% of species (T>15C; long exposure, very hard water)	0.011	0.010	0.010			
copper	California Water Quality Objective	0.030	***0.080***	***0.080***	***0.140***	***0.290***	***0.230***
	Invertebrate SSD, LC50 for 10% of species (T>15C; short exposure, moderately hard water)	0.015	**-**	***0.080***	***0.140***	***0.290***	***0.035***
	Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure, moderately hard water)	0.012	**-**	***0.080***	***0.140***	***0.290***	***0.035***
	Invertebrate SSD, LC50 for 10% of species (T>15C; long exposure, moderately hard water)	0.011	**-**	***0.080***	***0.140***	***0.290***	***0.035***
	Invertebrate SSD, LC50 for 10% of species (T>15C; short exposure, very hard water)	0.047	***0.030***	0.002	0.002	***0.230***	***0.060***
	Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure, very hard water)	0.013	***0.030***	0.002	0.002	***0.230***	***0.060***
	Invertebrate SSD, LC50 for 10% of species (T>15C; long exposure, very hard water)	0.017	***0.030***	0.002	0.002	***0.230***	***0.060***
zinc	EPA Criterion Maximum Concentration	0.120	0.070	0.020	***0.220***	***1.10***	***0.440***
	EPA Criterion Continuous Concentration	0.120	0.037	0.011	0.110	***0.252***	***0.196***

California Water Quality Objective	0.200	0.070	0.020	0.220	***1.10***	***0.440***
Invertebrate SSD, LC50 for 10% of species (T>15C; short exposure, moderately hard water)	0.462	-	0.020	0.220	0.350	0.015
Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure, moderately hard water)	0.354	-	0.020	0.220	0.350	0.015
Invertebrate SSD, LC50 for 10% of species (T>15C; long exposure, moderately hard water)	0.140	-	0.020	***0.220***	***0.350***	0.015
Invertebrate SSD, LC50 for 10% of species (T>15C; short exposure, very hard water)	6.44	0.070	0.020	0.011	0.330	-
Invertebrate SSD, LC50 for 10% of species (T>15C; moderate exposure, very hard water)	0.212	0.070	0.020	0.011	***0.330***	-
Invertebrate SSD, LC50 for 10% of species (T>15C; long exposure, very hard water)	0.087	0.070	0.020	0.011	***0.330***	-

Data for 309SSP and 309SAC were obtained from the USGS National Water Information System, at the Spreckels Gauge 11152500 (1968-1977) and Chualar Gauge 11152300 (1977-1994); SUD (Salinas River upstream, near 309SSP, of the City of Salinas Storm Drain), SDIS (the City of Salinas Storm Drain), and SDD (Salinas River downstream, near 309DAV, of the City of Salinas Storm Drain) from the City of Salinas 2006-2011.
Values reflect the maximum concentration observed during the appropriate period of record except for EPA Criterion Continuous Concentrations which are arithmetic means.

APPENDIX 15

Strength of evidence scoring for Stressor-response relationships from laboratory studies using data from elsewhere of surface water metal concentrations for the Salinas River case study.

Strength of Evidence scoring for plausible effect given stressor-response relationships

++ The observed relationship between exposure and effects in the case agrees quantitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

+ The observed relationship between exposure and effects in the case agrees qualitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

0 The agreement between the observed relationship between exposure and effects in the case and stressor-response relationships in controlled laboratory experiments or from other field studies is ambiguous.

- The observed relationship between exposure and effects in the case does not agree with stressor-response relationships in controlled laboratory experiments or from other field studies.

-- The observed relationship between exposure and effects in the case does not quantitatively agree with stressor-response relationships in controlled laboratory experiments or from other field studies or the quantitative differences are very large.

	SOE Score	
Reasoning and Comments	**Endpoint**	**Score**
arsenic, cadmium, and chromium For the available data, surface water arsenic, cadmium, and chromium concentrations were below EPA criterion maximum concentrations (CMC), EPA criterion continuous concentrations (CCC), California Water Quality Objectives, and invertebrate LC50 species sensitive distributions less than 10%. Although there is no supporting evidence, suggesting the S-R data weaken the case for, these metals cannot be ruled out due to the paucity of data,	IBI score	0
copper and zinc For the available data, surface water copper and zinc concentrations were above at least one of the following benchmarks: EPA criterion maximum concentrations (CMC), EPA criterion continuous concentrations (CCC), California Water Quality Objectives, and invertebrate LC50 species sensitive distributions greater than 10%. Thus, this is supporting evidence chromium, copper, nickel, and zinc may have an effect. A single plus is given because of the lack of a robust dataset.	IBI score	+

APPENDIX 16

Stressor-response relationships from laboratory studies using data from elsewhere for sediment metal content, Salinas River, California. When it was not readily apparent if the benchmark value was derived from laboratory or field studies, it was assumed to be derived from laboratory studies. Contents were obtained by the Cooperative Monitoring program (CMP) and the maximum value for the years 2004, 2008, 2009, and 2010 is reported. Consensus based threshold effect concentrations (TEC) and probable effect concentrations (PEC) were obtained from MacDonald et al. (2000). CCRWQCB action and attention levels were set using NOAA effects range median (ERM) and effects low range (ERL) and the probable effects level (PEL) and threshold effects level (CCAMP 2000). Contents exceeding the stressor-response benchmark are indicated with bold and italics.

Variable mg/kg	**Stressor-response Benchmark Description**	**Value**	**309DAV 2004**	**309DAV 2008**	**309DAV 2009**	**309DAV 2010**
arsenic	Consensus Based Threshold Effect Concentration	9.79				
	Consensus Based Probable Effect Concentration	33	3.08	9.79	7.37	5.90
	CCRWQCB Action or Attention Level					
cadmium	Consensus Based Threshold Effect Concentration	0.99				
	Consensus Based Probable Effect Concentration	4.98	0.30	***1.46***	***1.32***	***1.28***
	CCRWQCB Action or Attention Level	1.2				
chromium	Consensus Based Threshold Effect Concentration	43.4				
	Consensus Based Probable Effect Concentration	111	42.9	***112***	***72.6***	***68.8***
	CCRWQCB Action or Attention Level	81				
copper	Consensus Based Threshold Effect Concentration	31.6				
	Consensus Based Probable Effect Concentration	149	7.36	***32.5***	***69.5***	30.9
	CCRWQCB Action or Attention Level	34				
lead	Consensus Based Threshold Effect Concentration	35.8				
	Consensus Based Probable Effect Concentration	128	10.6	14.7	20.8	14.2
	CCRWQCB Action or Attention Level	46.7				
mercury	Consensus Based Threshold Effect Concentration	0.18				
	Consensus Based Probable Effect Concentration	1.06	0.006	0.030	0.085	0.114
	CCRWQCB Action or Attention Level	0.15				
nickel	Consensus Based Threshold Effect Concentration	22.7				
	Consensus Based Probable Effect Concentration	48.6	***23.2***	***102***	***61.6***	***64.8***
	CCRWQCB Action or Attention Level	20.9				
zinc	Consensus Based Threshold Effect Concentration	121				
	Consensus Based Probable Effect Concentration	459		96	***167***	85
	CCRWQCB Action or Attention Level	410				

APPENDIX 17

Strength of evidence scoring for stressor-response relationships from the laboratory, evidence from elsewhere, of sediment metal content for the Salinas River case study.

Strength of Evidence scoring for plausible effect given stressor-response relationships

++ The observed relationship between exposure and effects in the case agrees quantitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

+ The observed relationship between exposure and effects in the case agrees qualitatively with stressor-response relationships in controlled laboratory experiments or from other field studies.

0 The agreement between the observed relationship between exposure and effects in the case and stressor-response relationships in controlled laboratory experiments or from other field studies is ambiguous.

- The observed relationship between exposure and effects in the case does not agree with stressor-response relationships in controlled laboratory experiments or from other field studies.

-- The observed relationship between exposure and effects in the case does not quantitatively agree with stressor-response relationships in controlled laboratory experiments or from other field studies or the quantitative differences are very large.

	SOE Score	
Reasoning and Comments	**Endpoint**	**Score**
arsenic, lead, and mercury For the available data, sediment contents for arsenic, cadmium, lead, and mercury were low or not detected and were below consensus based threshold effect concentrations, consensus based probable effects concentrations, and the Central Coast Regional Water Quality Control Board's action or attention levels. Although there is no supporting evidence, suggesting the S-R data weaken the case for, these metals cannot be ruled out due to the paucity of data,	IBI score	0
cadmium, chromium, copper, nickle, and zinc Elevated sediment chromium, copper, nickle, and zinc contents were detected at 309DAV across multiple years. Despite the paucity of data, concentrations exceeded, at least once, consensus based threshold effect concentrations, consensus based probable effects concentrations, and the Central Coast Regional Water Quality Control Board's action or attention levels. Thus, this is supporting evidence that these sediment metals may have an effect. A single plus is given because data is limited to a single site (309DAV) and the lack of a robust dataset.	IBI score	+