# Causal Assessment Evaluation and Guidance for California Appendix D - Santa Clara River Causal Assessment Case Study

## CONTENTS

## TABLES

## FIGURES

## PREFACE

This assessment was conducted as part of a series of case studies testing the utility of the US EPA Causal Analysis Diagnosis Decision Information System (CADDIS) causal assessment framework for application in California's perennial wadeable streams.  As part of this test, an assessment was conducted using biotic data collected from the Santa Clara River in October 2006.  This time period was selected, in part, because it coincided with a special study conducted by the LA County Sanitation District that sampled water quality, stream macrobenthos, and benthic algae at a number of sites beyond their normal suite of NPDES monitoring stations. However, these data were not ideally suited for the diagnosis of the marginal quality macrobenthic communities historically observed in the Santa Clara River.  The macrobenthic samples collected at the test site in October 2006 had a higher (i.e., better) Southern California IBI score than typically observed.  In fact, the score at the test site was greater than at the comparator sites and was right at the IBI's degradation threshold (i.e., it would probably not have normally necessitated a causal assessment).  It was decided by everyone involved with the case study that the extra sites and types of data provided by the 2006 dataset were valuable enough for testing the CADDIS framework to conduct the analysis in lieu of switching to a different year that had lower scoring biology at the test site, but fewer amounts and types of data. Consequently, the conclusions from this assessment may not provide a definitive diagnosis of biological condition in the Santa Clara River, but the conclusions reached herein – especially the multi-year analysis – do provide a good starting point for understanding the causes behind the macrobenthic communities observed in other years.

## EXECUTIVE SUMMARY

A causal assessment was conducted in the upper reaches of the Santa Clara River in Santa Clarita, California. This assessment was conducted to determine the causes behind the reduced biological condition of the stream. The condition of the stream's biological condition was quantified as a low (38.6 out of 100) Southern California Index of Biotic Integrity (IBI) (Ode et al. 2005) score observed in 2006 at the long-term monitoring site (designated RD) immediately downstream of the Los Angeles County Sanitation District's (LACSD) Valencia Water Reclamation Plant outfall. Seven monitoring sites along the Santa Clara River and its tributaries (RB, RC, RE, RF, SAP8, SAP11, and SAP14) were selected as the comparator sites. All of the sites had poor to fair IBI scores (4.3 – 34.3) like the test site. To better differentiate among the sites, three metrics of the Southern California IBI were used as biological endpoints in a number of the analyses: 1) % of non-insect taxa (e.g., oligochaetes); 2) % of tolerant taxa (e.g., *Physa* spp); and 3) the number of predator taxa.

This causal assessment was performed following the USEPA's CADDIS causal assessment framework (USEPA 2000). In brief, this approach consists of: 1) Identifying a site with biological impairment and characterizing the nature of that impairment (defining the case); 2) Selecting similar sites within the same stream network for comparison (comparator sites); 3) Identifying the potential stressors to the stream (candidate causes); 4) Analyzing differences in stressors, biology, and their interaction at the test and comparator sites (within the case); 5) Comparing stressors, biology, and their interaction at the test site to similar data from elsewhere (outside the case); and 6) Summarizing these results into a narrative classifying the potential stressors as likely, unlikely, or uncertain causes to the biological impairment.

This assessment was conducted as a partnership between the Southern California Coastal Water Research Project (SCCWRP), the Sanitation Districts of Los Angeles County (LACSD), and the Los Angeles Regional Water Quality Control Board. The assessment partners decided to focus on seven candidate cause stressors potentially responsible for the biological conditions observed at the RD site in the Santa Clara River: 1) Habitat simplification; 2) Metals; 3) Elevated conductivity; 4) Increased nutrients; 5) Pesticides; 6) Temperature; and 7) River discontinuity. These stressors were chosen by the project partners based upon input from the local stakeholders familiar with the stream, the larger watershed, and the potential anthropogenic disturbances within the system. Each one of these candidate cause stressors was comprised of a number of proximate stressors (e.g., dissolved metals, sediment-bound metals, periphyton-bound metals), upon which the actual analyses were conducted to assess the impact of the candidate cause. Data were not available for every proximate stressor within each candidate cause at every site (e.g., pyrethroid pesticides or sediment-bound metals), but enough data were available for some degree of evaluation for all seven of the candidate causes.

The causal assessment was conducted with pre-existing data provided by LACSD. The RD, RB, RC, and RE sites are part of LACSD's National Pollutant Discharge Elimination System (NPDES) monitoring network associated with their Valencia and Saugus outfalls. The remaining comparator sites were part of special study related to nitrogen loads in the Santa Clara River conducted concurrently with the routine monitoring in October 2006. The chemical, biological (benthic macroinvertebrates), and physical habitat data from the NPDES monitoring program provided the bulk of the information needed for the within the case portion of the causal assessment. These data were also supplemented with algal community structure, algal biomass, and temporally intensive water quality data from the test and all comparator sites as part of the special nitrogen study. Data used for the outside the case portion of the causal assessment were assembled from a variety of sources, including: the State of California's State of California's Reference Condition Monitoring Program (RCMP), the Surface Water Ambient Monitoring Program (SWAMP), various probabilistic stream biomonitoring programs (e.g., Perennial Stream Assessment [PSA] and Stormwater Monitoring Coalition [SMC]), and appropriate examples from the scientific literature.

Within the CADDIS causal assessment framework, there are a number of potential types of evidence (i.e., analyses) that can be brought to bear in the within the case and the outside of the case portions of the assessment. The spatial temporal co-occurrence and stressor-response types of evidence were used in the within the case step. The field stressor-response, laboratory stressor-response, and reference condition comparison evidence types were used for the outside the case step.

The overall results from the causal assessment are summarized in Table ES-1. Of the seven candidate causes, there was supporting evidence that elevated conductivity may be partially responsible for the observed biological condition at the test site. Conversely, the evidence indicated that heavy metals (dissolved metals), pesticides (non-pyrethroid pesticides), and increased nutrients were likely not a cause. There was inconsistent or contradicting evidence for habitat simplification, river discontinuity, and temperature in the within the case portion of the analyses. Furthermore, there was limited or no data available for these candidate causes for the outside the case analyses. Consequently, habitat simplification, temperature, and river discontinuity were ruled as indeterminate; not excluded, but not confirmed as causes for the observed biological impairment.

**Table ES-1. Overall results from the causal assessment.**

| Outcome | Candidate Cause | Evidence & Comments |
|---|---|---|
| Likely Stressors | Conductivity | Elevated conductivity and TDS at RD compared to some of the comparator sites, though biology was better at RD. Elevated conductivity at RD compared to outside of the case reference expectations. Apparent stressor response relationships with outside the case for tolerant taxa. |
| Unlikely Stressors | Heavy Metals | Levels of some metals in the water column at RD similar to or below comparator sites, but there was supporting stressor response evidence inside the case. However, all concentrations were well below toxic effect levels. No data were available for sediment or periphyton-bound metals. |
| | Pesticides | All measured pesticides and herbicides in the water column were below detection limit. Pyrethroids were not measured in the water column and no sediment pesticide measurements of any kind were available. |
| | Nutrients | Consistent inverse stressor respsonses and lower nutrient responses at RD compared to inside the case sites. No data from outside the case were available for evaluation. |
| Indeterminate Stressors | Habitat Simplification | Lower or indeterminate levels at RD compared to in- and outside the case. Inconsistent stressor response relationship in- and outside the case. There was relatively little outside the case data available for evaluation. |
| | River Discontinuity | Lower or indeterminate levels at RD compared to inside the case. Inconsistent stressor response relationship in- and outside the case. There was relatively little outside the case data available for evaluation. |
| | Temperature | Elevated mean temperature and reduced range compared to inside the case comparator sites, but RD had better or equivlent biology to compartor sites. Stressor response relationship w/non-insect and predator taxa inside the case. No outside the case data were availabe for evaluation. |

The most confident conclusions that could be made about candidate causes were those examples where both within the case and outside the case data were available. For the stressor-response and reference condition comparison outside of the case evidence types, data were selected from sites with similar geographic/environmental characteristics to the RD site. Sites were selected to reduce the variability in the observed biological communities due to non-anthropogenic forcing factors (e.g., elevation, slope, or underlying geology) known to have an influence on benthic macroinvertebrate community structure. These outside of the case evidence types were extremely valuable in the causal assessment process, as there was degraded biology, not only at the test site, but at nearly all of the within case comparator sites. This pattern weakened our confidence in the diagnostic power of the within the case analyses used by themselves. Contextualizing the stressors and observed biotic response(s) with data from outside the case allowed us to come to more definitive conclusions about the role of conductivity, pesticides, and metals in the observed impairments. Conversely, the lack of these types of evidence was one of the contributing factors to our uncertainty about the roles of river discontinuity and habitat simplification.

In an effort to increase the confidence in assessment conclusions and to try and extend the CADDIS approach to multiple years, a multi-year evaluation of evidence was used. Traditionally, the CADDIS framework focuses on a spatially and temporally constrained case definition (i.e., one test site and a single sampling event). However, the upper Santa Clara River is part of a routine monitoring program and this abundance of data provided a good opportunity to test the concept of a causal assessment conducted across multiple years. Temperature, conductivity, and bioassessment data from 2006 – 2010 at the RB, RC, RD, and RE sites were used in five separate annual causal assessments. The scoring patterns for the individual years were then synthesized by either: selecting the most frequently observed score, the average condition across all years, or based on varying distributions of the data for each line of evidence. Regardless of approach, multi-year data assessments still indicated that conductivity was a likely cause and temperature was an indeterminate cause. This initial foray into conducting causal assessments with expanded case definitions provides a potential template for refining the CADDIS framework to incorporate additional time or space.

All causal assessments are subject to uncertainty and this case study was no exception. To reduce this uncertainty, additional effort should focus in at least two areas. First, additional within the case data should be collected within the upper Santa Clara River to fill data gaps and produce information on appropriate time scales. For instance, diel dissolved oxygen and temperature data were only collected over one 24-hr period. Given the potentially significant night/day and seasonal differences in these measures, a single day’s worth of data was of limited use. Collecting more diagnostically useful data (e.g., quarterly week-long hourly measurements) could confirm or deny these candidate causes. In other instances, data to evaluate certain proximate stressors (e.g., pyrethroid pesticides or sediment bound metals) were not available for consideration. Despite their potential impact on stream biota, many types of stressor data are not part of typical regular monitoring efforts and consequently hamper the ability to properly evaluate their effects. Second, additional outside the case assessment tools should be created to provide the context necessary for limited comparator sites. A good example would be the temperature range found at environmentally-similar reference sites. A similar tool for conductivity was developed in this case study, and its utility was important for diagnosing this candidate cause. However, no such assessment tool exists for temperature, but would help immensely in this and other causal assessments.

## CASE DEFINITION

This causal assessment was conducted as a response to low Southern California Index of Biotic Integrity (IBI) (Ode et al. 2005) scores observed in the upper Santa Clara River in October 2006. The assessment was conducted as a partnership between the Southern California Coastal Water Research Project, the Sanitation Districts of Los Angeles (LACSD), and the Los Angeles Regional Water Quality Control Board. The actual test site for the assessment was the long-term monitoring site RD located immediately downstream of the Los Angeles County Sanitation District (LACSD) Valencia Water Reclamation Plant outfall in Santa Clarita, CA. The Southern California IBI is a multi-metric index that uses community structure of benthic macroinvertebrates to evaluate the condition of a stream. During the 2006 Autumn sampling (Table 1), the RD site had a score of 38.6 out of 100 (mean of reference sites ~66).

**Table 1. Top 90+ % most abundant taxa at each of RD and the comparator sites in Autumn 2006.**

| Site | Taxon | Relative Abundance |
|---|---|---|
| RB | Chironomidae | 65.3 |
| | Oligochaeta | 15.1 |
| | *Argia* sp | 5.8 |
| | *Physa /Physella* sp | 5.6 |
| RC | *Fallceon quilleri* | 44.1 |
| | *Baetis* sp | 25.7 |
| | Chironomidae | 5.7 |
| | *Tricorythodes* sp | 5.5 |
| | Ostracoda | 4.3 |
| | Oligochaeta | 3.1 |
| | *Hydroptila* sp | 2.7 |
| RD | Chironomidae | 28.0 |
| | *Physa /Physella* sp | 14.3 |
| | *Fallceon quilleri* | 10.5 |
| | *Tricorythodes* sp | 9.9 |
| | Ostracoda | 9.1 |
| | Planariidae | 6.2 |
| | *Hydroptila* sp | 5.0 |
| | *Caloparyphus /Euparyphus* sp | 3.0 |
| | Oligochaeta | 3.0 |
| | *Baetis* sp | 2.4 |
| RE | *Fallceon quilleri* | 31.3 |
| | Chironomidae | 30.0 |
| | Oligochaeta | 9.7 |
| | *Tricorythodes* sp | 9.3 |
| | *Baetis* sp | 5.5 |
| | Ostracoda | 3.7 |
| | *Hydrellia* sp | 2.6 |
| RF | *Tricorythodes* sp | 25.2 |
| | Chironomidae | 17.6 |
| | *Fallceon quilleri* | 16.4 |
| | *Physa /Physella* sp | 7.3 |
| | *Hydroptila* sp | 5.7 |
| | *Dasyhelea* sp | 4.5 |
| | Oligochaeta | 4.1 |
| | *Prostoma* sp | 3.2 |
| | Planariidae | 3.2 |
| | *Callibaetis* sp | 2.4 |
| | *Simulium* sp | 2.2 |
| SAP 8 | Chironomidae | 43.2 |
| | *Fallceon quilleri* | 17.1 |
| | *Hydroptila* sp | 9.0 |
| | Oligochaeta | 5.9 |
| | *Simulium* sp | 5.0 |
| | Ostracoda | 4.5 |
| | *Tricorythodes* sp | 4.1 |
| | *Hydrellia* sp | 4.1 |
| SAP 11 | Chironomidae | 58.5 |
| | *Fallceon quilleri* | 15.0 |
| | *Tricorythodes* sp | 13.0 |
| | *Physa /Physella* sp | 4.8 |
| SAP 14 | Chironomidae | 87.3 |
| | Oligochaeta | 6.2 |

Comparator sites were located in the Santa Clara River above (RB and RC) or below (RE, SAP8 and RF) the test site, as well as on nearby tributaries (SAP11 and SAP14; Figure 1). The test and comparator sites comprised the within the case portion of the assessment. The test and mainstem comparator sites were part of the LACSD Valencia and Saugus water reclamation plant outfall National Pollutant Discharge Elimination System (NPDES) Permit monitoring network. As part of the NPDES monitoring network, synoptic measures of biological, chemical, and physical habitat data from the 2006 period of interest were collected at the same time as the RD test site. Additionally, there was monthly chemistry/water quality data collected from most of the sites prior to the collection of the biological data. Data from the RF, SAP8, SAP11, and SAP14 comparator sites were part of a special study where macrobenthic community structure, physical habitat, algal community structure, nutrients, and temporally intensive water quality were collected. Tributaries sites were free from the influence of the LACSD wastewater outfalls. These data formed the core of the comparative analyses that made up the causal assessment and were used in the within the case spatial co-occurrence and stressor-response lines of evidence.

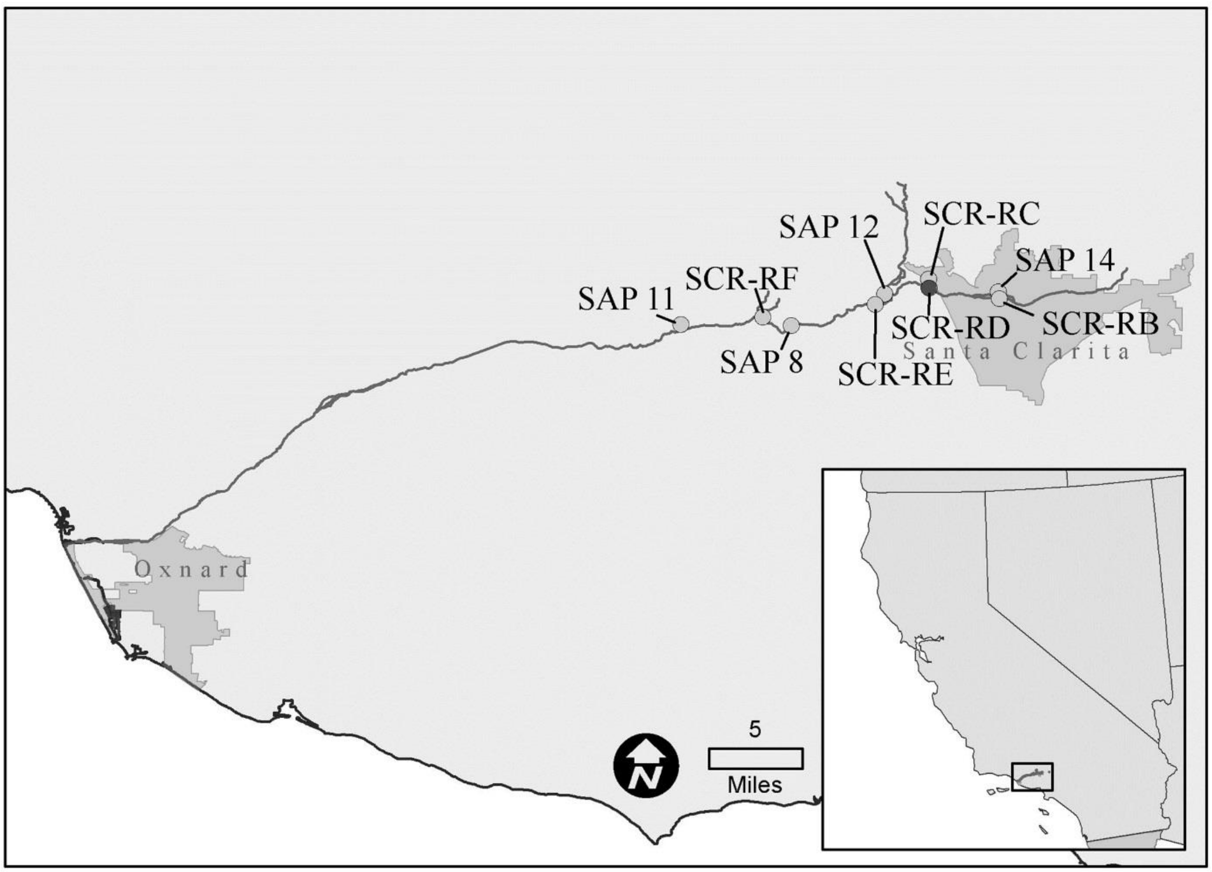



**Figure 1. A map of the Santa Clara River showing the location of the RD test site and the comparator sites RB, RC, RE, RF, SAP8, SAP11, and SAP12. Inset with a map of the west coast of US for reference.**

The upper Santa Clara River and its tributaries that comprise the test and comparator sites are part of a low gradient (<1% slope) system with a relatively mobile, sandy bottom. The constrained flood plain is consolidated sand with some riparian vegetation (e.g., grasses and small woody growth). The surface water of the river is intermittently discontinuous during dry weather flows. The test site was wetted year round due to the LACSD discharge and surface water flow at RD was contiguous with RC and RE, but was disconnected from the RB site. There is shallow-groundwater /hyporheic connection between all of the NPDES sites (Markle pers. comm). The upper reach of the Santa Clara River runs through urban and suburban development and this portion of the river (State Water Resources Control Board [SWRCB] Reach 5 and Reach 6) is on the US Environmental Protection Agency (USEPA) 303(d) list for chlorpyrifos, fecal coliform bacteria, diazinon, and toxicity impairments (CA EPA 2012).

The actual biological endpoints chosen as response variables in the assessment, in addition to the total IBI score, consisted of three metrics of the Southern California IBI: 1) % of non-insect taxa (e.g., oligochaetes); 2) % of tolerant taxa (e.g., *Physa* spp); and 3) number of predator taxa (e.g., *Dicranota* spp). The three metrics were chosen because they were of specific interest to the stakeholders and they allowed for greater differentiation among the test and comparator sites (Figure 2). Additionally, as components of the IBI, insights into the poor scoring of these metrics should provide direct insights to the causes behind the low overall IBI scores.

All of the comparator sites had relatively similar macrobenthic community structure (Table 2) and IBI scores (Figure 2a) to RD. The macrobenthic communities of the RD and comparator sites were dominated by chironomids, *Fallceon quilleri*, *Tricorythodes* sp., and *Physa* sp. These taxa are indicative of lower quality macrobenthic conditions and observed across the entirety of the upper portions of the Santa Clara River. Similar taxa were observed at the comparator sites, hindering the contrasts that lead to causal inference.

Macrobenthic community and stream physical habitat data were collected in October of 2006. Macrobenthic community sampling was conducted using a kick-net, and individual samples from multiple transects were composited along a 150-m reach, encompassing approximately 1.0 $m^2$ of streambed. Macrobenthic and physical habitat were collected, processed, and analyzed using California Bioassessment Procedures (Harrington 2002). Water chemistry and water quality data were collected as monthly grab or point samples. The NPDES data were supplemented with algal community data, monthly water grabs for nutrients, and quarterly diurnal water quality (pH, dissolved oxygen, temperature, and conductivity) measurements collected as part of the nitrogen TMDL special study (see Santa Clarita Valley Sanitation District of Los Angeles County [2007] for methodology details).

The statewide perennial wadeable stream assessment data (Ode et al. in press) was also used for casual assessment. These data from elsewhere were comprised of >600 reference sites and >1500 sites with varying level of stress. There is a great deal of heterogeneity among this population of streams and it was thought that only streams with a similar ecosystem setting should be used in the analysis. There are a number of different approaches to characterizing and selecting streams and a simple approach based upon elevation and slope was chosen for this assessment. Streams selected for comparison to the RD site were filtered for similar natural gradients: slope <1.5%;

elevation <333m.  There were 32 samples from 22 reference sites and there were 540 samples from 515 stressed sites.

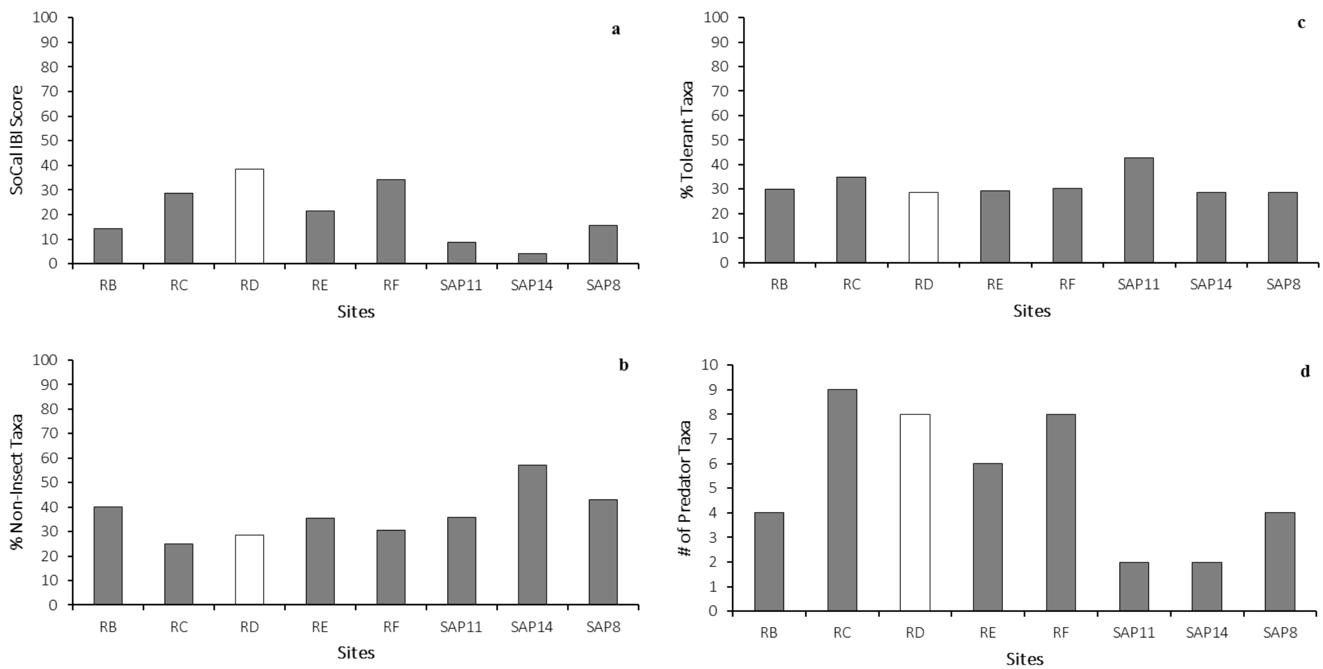



**Figure 2.  Southern California Index of Biotic Integrity (IBI) scores measured at the test and comparator sites in Fall 2006 (a), as well as the biological endpoints used in the stressor-response portions of the assessment (b – d).**

**Table 2. Inventory of the type of data and its original source used in the analyses of each candidate cause and their component proximate stressors for each line of evidence used in the causal assessment.**

| Candidate Cause /Conceptual Diagram | Proximate Stressor | Data Available | Data Source | Data Within the Case Lines of Evidence | | Data From Outside the Case Lines of Evidence | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Spatial Co-Occurrence | Stressor Response From the Field | Reference Condition | Stressor Response From the Field | S-R from lab |
| Elevated Conductivity | Increased Conductivity | Mean of monthly point measures made during quarter previous to biotic sampling (July-September). | NPDES Monitoring | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | Comparison of RD to environmentally similar reference sites | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | No Data Available |
| | Increased TDS | Mean of monthly point measures of TDS, chloride, and hardness made during quarter previous to biotic sampling (July-September). | NPDES Monitoring | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |
| Increased Nutrients | Change in Algal Community | Bray-Curtis similarity to RD site based upon algal community structure. | Nitrogen Loading Special Study | Comparison of RD to comparator sites in multivariate space | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites. | No Data Available | No Data Available | No Data Available |
| | Increase in Toxic Algal Compounds | | | No Data Available | No Data Available | No Data Available | No Data Available | No Data Available |
| | Increased Frequency of Hypoxia | Frequency of mild hypoxia (2-5 mg $O_2$ $L^{-1}$) observed in in monthly daytime point measurements during quarter prior to biological sampling. Frequency of hypoxia (<2 mg $O_2$ $L^{-1}$) observed in daytime point measures during quarter prior to biological sampling. Frequency of mild hypoxia (2-5 mg O2 L-1) observed in diel data collected over 24 hr period during month of biological sampling. Frequency of hypoxia (<2 mg O2 L-1) observed in diel data collected over 24 hr period during month of biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |

| Candidate Cause /Conceptual Diagram | Proximate Stressor | Data Available | Data Source | Data Within the Case Lines of Evidence | | Data From Outside the Case Lines of Evidence | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Spatial Co-Occurrence | Stressor Response From the Field | Reference Condition | Stressor Response From the Field | S-R from lab |
| Increased Nutrients (cont.) | Increased pH | Mean of monthly point measures made during quarter previous to biotic sampling (July - September). Mean of diel data collected over 24 hr period during the month of biotic sampling | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |
| | Increased Ammonia Concentration | Mean of monthly point measures made during quarter previous to biotic sampling (July-September). | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |
| Pesticides | Increased Other Sediment Pesticides | | | No Data Available | No Data Available | No Data Available | No Data Available | No Data Available |
| | Increased Other Water Column Pesticides | Maximum observed values of 4,4'-DDD, 4,4'-DDE, Acrolein, Acrylonitrile, Aldrin, alpha-BHC, cis-1,3-Dichloropropene, delta-BHC, Diazinon, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin aldehyde, Endrin, Heptachlor Epoxide (Isomer B), Heptachlor, Methoxychlor, o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDT, Technical Chlordane, and Toxaphene in 12 months prior to biological sampling<br>Frequency of dectection of any compound above detection limit | NPDES Monitoring | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | Comparison of Diazinon concentrations observed at RD to species sensitivity distribution (SSD) curves developed by US EPA. |
| | Increased Water Column Pyrethroids | | | No Data Available | No Data Available | No Data Available | No Data Available | No Data Available |
| | Increased Sediment Pyrethroids | | | No Data Available | No Data Available | No Data Available | No Data Available | No Data Available |
| | Increased Water Column Herbicides | Maximum observed value of 2,3,7,8-TCDD, 2,4,5-TP (Silvex), and 2,4'-D in 12 months prior to biological sampling. | NPDES Monitoring | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |

| Candidate Cause /Conceptual Diagram | Proximate Stressor | Data Available | Data Source | Data Within the Case Lines of Evidence | | Data From Outside the Case Lines of Evidence | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Spatial Co-Occurrence | Stressor Response From the Field | Reference Condition | Stressor Response From the Field | S-R from lab |
| Heavy Metals | Increase in Dissolved Metals | Mean of point measures of Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Hexavalent Chromium, Iron, Lead, Mercury, Nickel, Selenium, Silver, Thallium, and Zinc collected in quarter previous to biotic sampling (July-September). | NPDES Monitoring | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | Comparison of Arsenic, Cadmium, Chromium, Copper, Nickel, Selenium, and Zinc values observed at RD to species sensitivity distribution (SSD) curves developed by US EPA. |
| | Increase in Particulate Bound Metals | | | No Data Available | No Data Available | No Data Available | No Data Available | No Data Available |
| | Increased Concentration of Metals in Periphyton | | | No Data Available | No Data Available | No Data Available | No Data Available | No Data Available |
| Temperature | Increased Water Temperature | Mean of monthly point measures made during quarter previous to biotic sampling (July-September). Mean of diel data collected over 24 hr period during the month of biotic sampling | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |
| | Decreased Variability in Water Temperature | Max - Min value of monthly point measures made during quarter previous to biotic sampling (July-September). Max - Min value of diel data collected over 24 hr period during the month of biotic sampling | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |

| Candidate Cause /Conceptual Diagram | Proximate Stressor | Data Available | Data Source | Data Within the Case Lines of Evidence | | Data From Outside the Case Lines of Evidence | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Spatial Co-Occurrence | Stressor Response From the Field | Reference Condition | Stressor Response From the Field | S-R from lab |
| River Discontinuity | Decreased Recruitment of Fauna | | | No Data Available | No Data Available | No Data Available | No Data Available | No Data Available |
| | Decrease in Woody Debris | Length of reach (m) with woody debris during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | No Data Available |
| | Increase in Sands and Fines | Percent of reach with sand or fine sediment substrate during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | Comparison of RD to environmentally similar reference sites | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | No Data Available |
| | Decrease in Cobbles | Percent of reach with cobble substrate during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | No Data Available |
| | Burial of Cobbles | Mean percent embeddedness of cobbles observed during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | No Data Available |

| Candidate Cause /Conceptual Diagram | Proximate Stressor | Data Available | Data Source | Data Within the Case Lines of Evidence | | Data From Outside the Case Lines of Evidence | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Spatial Co-Occurrence | Stressor Response From the Field | Reference Condition | Stressor Response From the Field | S-R from lab |
| River Discontinuity (Cont.) | Increased Simplification of Habitat | Euclidean distance from RD location in nMDS comparison of sites based upon the presence of different substrates (artificial, boulders, roots, woody debris, sands+fines, gravel, cobbles, or bedrock), filamentous algae, overhanging vegetation, undercut banks, large woody debris, and mean thalweg depth. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to comparator sites in multivariate space | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites. | No Data Available | No Data Available | No Data Available |
| Habitat Simplification | Change in Food Source | Euclidean distance from RD location in nMDS comparison of sites based upon the occurrence of course particulate organic matter, macrophyte, filamentous algae, woody debris, and fine sediments. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to comparator sites in multivariate space | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites. | No Data Available | No Data Available | |
| | Increase in Channel Depth | Mean of thalweg depth (cm) measured at the transects and inter-transects of the reach during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | |
| | Decrease in the extent of Riffle Habitat | | | | | No Data Available | No Data Available | |
| | Decrease in Woody Debris | Length of reach (m) with woody debris during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | |

| Candidate Cause /Conceptual Diagram | Proximate Stressor | Data Available | Data Source | Data Within the Case Lines of Evidence | | Data From Outside the Case Lines of Evidence | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Spatial Co-Occurrence | Stressor Response From the Field | Reference Condition | Stressor Response From the Field | S-R from lab |
| Habitat Simplification (cont.) | Increase in Sands and Fines | Percent of reach with sand or fine sediment substrate during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | Comparison of RD to environmentally similar reference sites | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | |
| | Increase in Simplified Habitat | Euclidean distance from RD location in nMDS comparison of sites based upon the presence of different substrates (artificial, boulders, roots, woody debris, sands+fines, | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to comparator sites in multivariate space | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites. | No Data Available | No Data Available | |
| | Decrease in Cobbles | Percent of reach with cobble substrate during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | No Data Available | |
| | Decrease in Extent of Undercut Banks | Percent of reach with undercut banks during biological sampling. | NPDES Monitoring and Nitrogen Loading Special Study | Comparison of RD to individual comparator sites | Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites. | No Data Available | Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation. | |

## CANDIDATE CAUSES

The following list of candidate causes was developed as the outcome of discussions held among the data analyst and the local stakeholders at a workshop held February 2012. Stressors were proposed and eventually included/excluded for consideration based upon the local stakeholders' knowledge of the Santa Clara River watershed, the human activities therein, as well as its environmental, geological, and hydrological characteristics. Each candidate cause consists of a series of proximate stressors, the stressors that directly touch the in-stream biota.

*Candidate Cause*: Elevated Conductivity – Most freshwater streams have some degree of natural conductivity imparted by the underlying geology of the stream's watershed (i.e. CaO, MgO content). Alterations to that "natural" conductivity level can have adverse effects on macrobenthic community structure reducing the numbers of stenohaline taxa through outright toxicity or increased physiological/osmotic stress that consumes energy normally dedicated to growth and reproduction (Kinne 1971, Hassell et al. 2006). As noted in the conceptual diagram (Figure 3), there were two proximate stressors within the elevated conductivity candidate cause: 1) Increased total dissolved solids (TDS); and 2) Increased conductivity

*Candidate Cause*: Habitat Alteration – Most wadeable streams have a high degree of physical habitat heterogeneity (e.g., riffles vs. pools, woody debris, undercut banks) at small spatial scales (10's of meters) that produce a multitude of different niches, which are in turn occupied by different macroinvertebrate species. This habitat heterogeneity increases the overall diversity of the macrobenthic community because individual taxa are often dependent on specific habitat characteristics (e.g. complex structure, fast moving water, or deep pools). Habitat alteration can have negative effects on the macrobenthic community. Habitat alteration ranges from direct modification of the stream bed and channel walls for flood or erosion control (concrete or rip rap walls), to modification of the riparian corridor, or development within the stream's upland watershed. Habitat alteration reduces habitat complexity and heterogeneity, acting as a barrier for certain taxa to recruit or survive in-stream. In the conceptual diagram (Figure 4), habitat alteration has 10 potential proximate stressors: 1) Change in available food; 2) Increase in channel deepening, 3) A decrease in the amount of riffle habitat, 4) A decrease in the amount of instream wood debris; 5) An increase in sands and fines; 6) An increase in the extent of undercut banks; 7) A decrease in the number of cobbles; and 8) A decrease in overall substrate complexity.

*Candidate Cause*: Metals – While there are some natural sources of metals to streams due to the erosion of metal bearing soils in the underlying geology of a watershed (e.g., Aluminum or Iron), most metals observed in streams are related to anthropogenic activities. Most metals impact stream macroinvertebrates by causing cell wall failure, interference with ion transfer, and interference with respiratory function. Metals can be transferred to stream biota either through direct ingestion or absorption from the water column. Consequently, the conceptual model for increased metals (Figure 5) has three proximate stressors: 1) increase in dissolved water column metals; 2) increase in metal concentration of periphyton; and 3) increase in particulate bound metals.

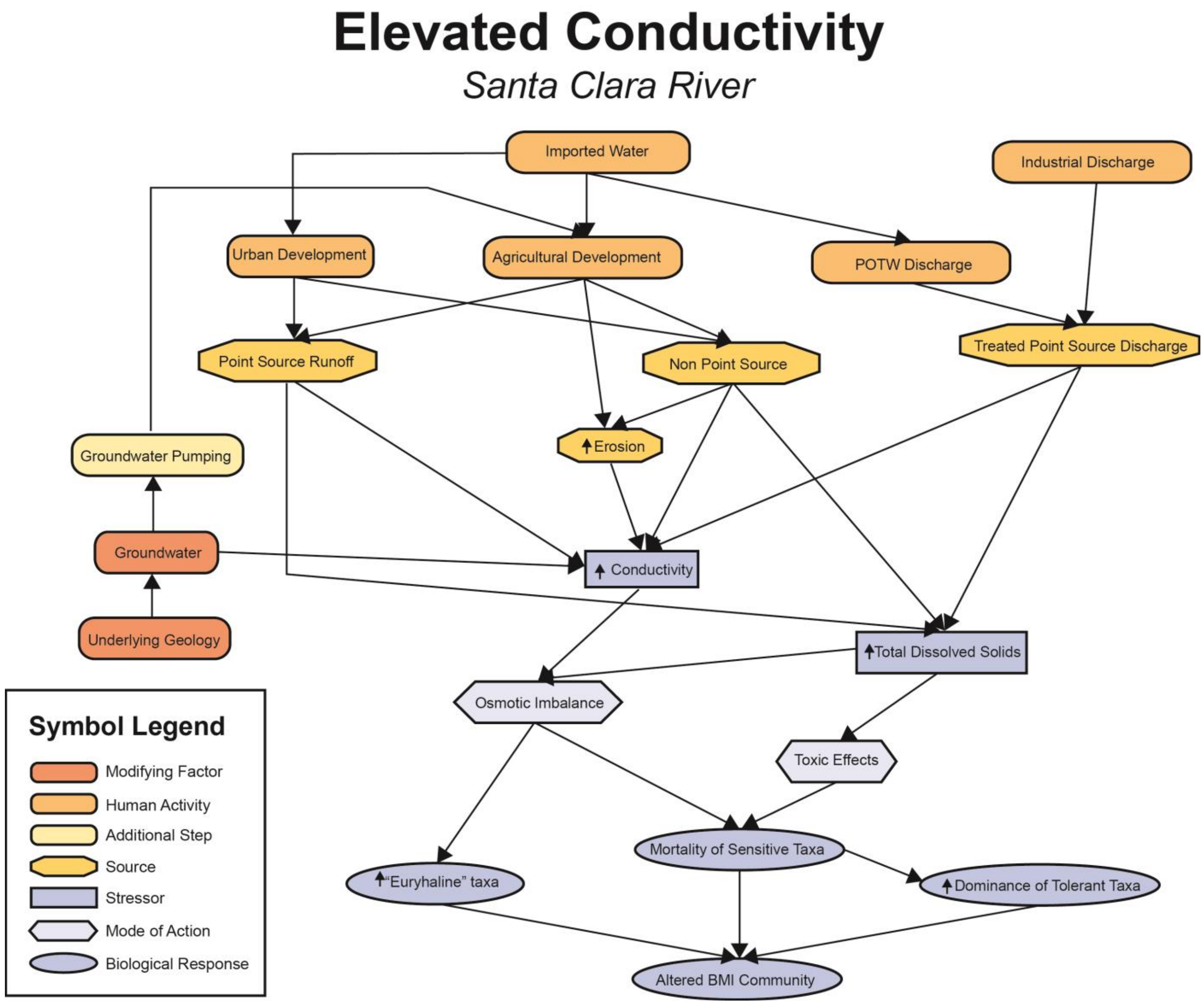



**Figure 3. Elevated conductivity conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.**

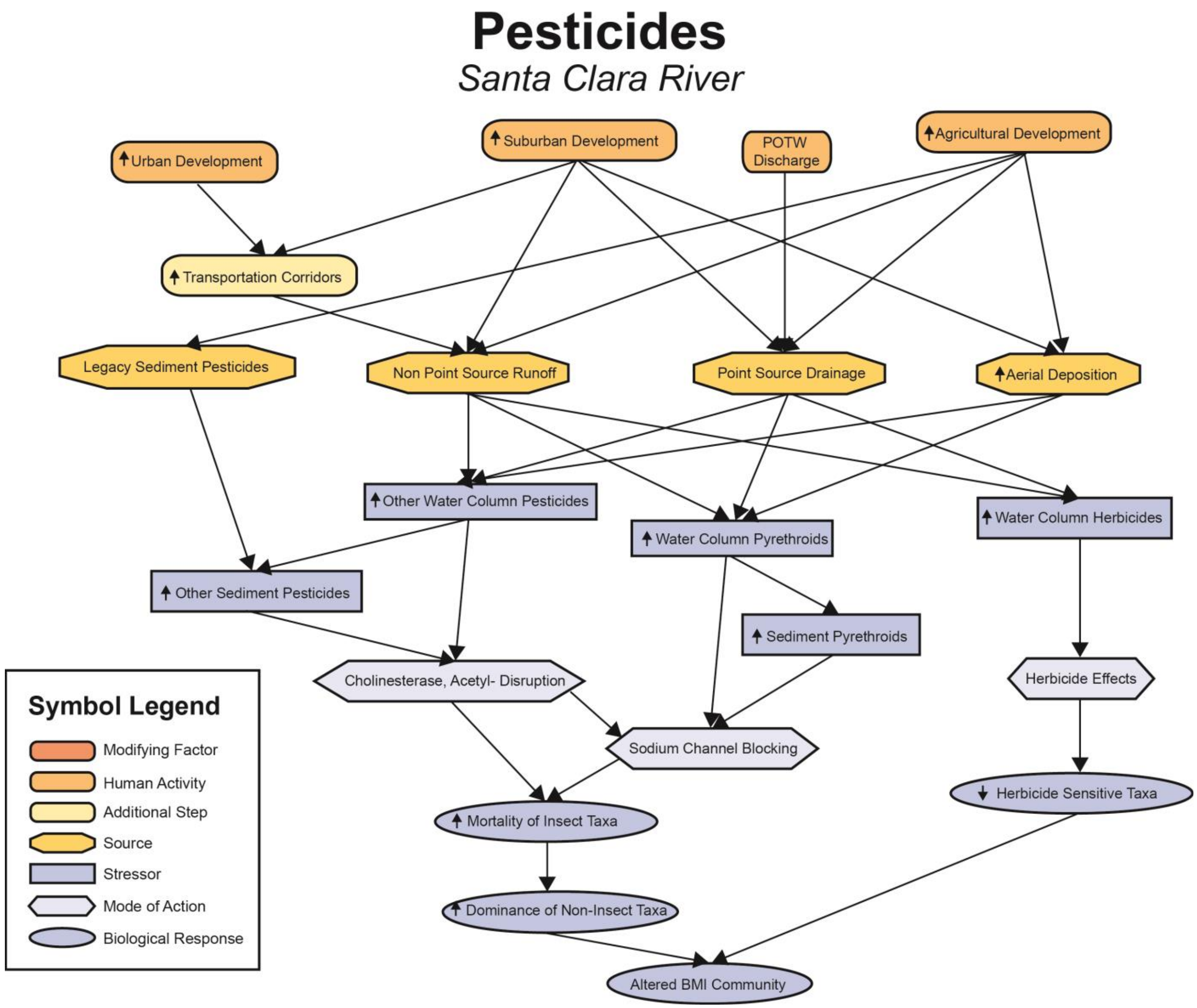



**Figure 4. Pesticides conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.**

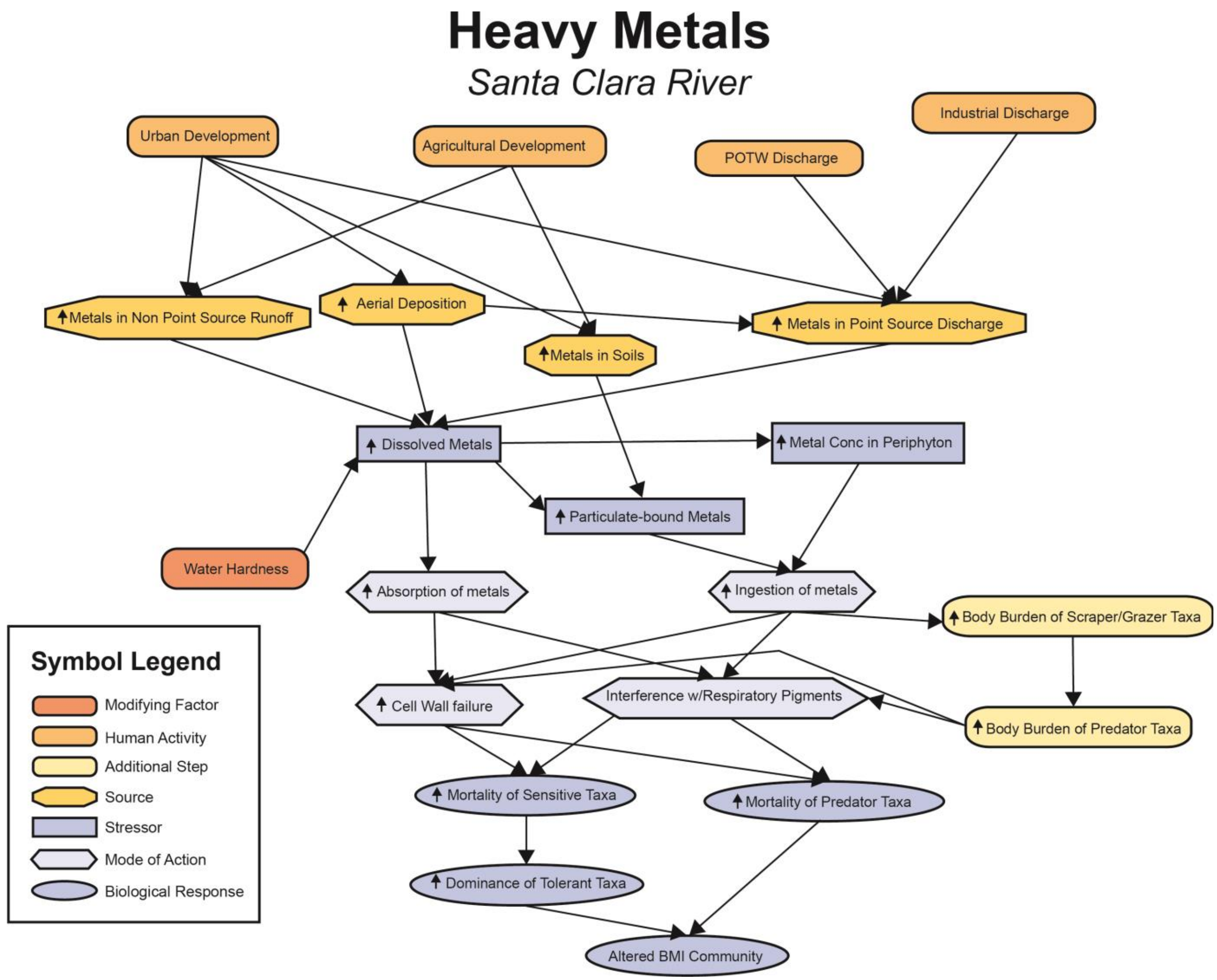



**Figure 5. Heavy metals conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.**

*Candidate Cause*: Increased Nutrients – Stream macroinvertebrates typically experience problems from increasing concentrations of the different species of nitrogen and phosphorus as indirect effects, where the increased nutrients influence autotrophic community structure and primary production rates. These effects can include clogging of micro-habitats by algal mats, changes in algal taxa and their palatability to grazers, increased dominance of cyanobactieria and other toxic algae, or night time hypoxia. Ammonia toxicity is the primary direct effect that increased nutrients can have on stream macrobenthic community structure, with certain taxa being more sensitive than others (Arthur et al. 1987, Hickey and Vickers 1994). In the conceptual diagram (Figure 6), increased nutrients is comprised of five proximate stressors: 1) A change in algal community structure; 2) An increase in toxic compounds; 3) An increase in water column pH; 4) An increase in the frequency of hypoxia; and 5) An increase in ammonia concentration.

*Candidate Cause*: Pesticides – Much like metals, there is a large amount of evidence about the negative effects of pesticides on stream macroinvertebrates (e.g. Hickey and Clements 1998, Pollard and Yuan 2006). Pesticides, especially insecticides, have acute and chronic toxic effects on stream macroinvertebrates. This candidate cause includes current-use pesticides (synthetic pyrethroids) and legacy pesticides (diazinon, DDT), which can be dissolved in the water column or adsorbed to sediments. There were five proximate stressors in the conceptual model (Figure 7): 1) Increased water column synthetic pyrethroids; 2) Increased sediment synthetic pyrethroids; 3) Increased “other” water column pesticides; 4) Increased “other” sediment pesticides; and 5) Increased water column herbicides.

*Candidate Cause*: Temperature – Water temperature can be one of the key environmental variables setting community structure among stream macroinvertebrates, with certain taxa flourishing best in cold water conditions and others in warm water. In temperate climates like southern California, seasonal temperature fluctuations are an important reproductive or metamorphic cue for stream fauna (e.g., Harper and Peckarsky 2006). Point source discharges and non-point source runoff can increase mean stream temperatures and decrease the range in temperature flux over short and long timescales. To capture both of these aspects, the temperature conceptual diagram (Figure 8) had two proximate stressors: 1) Elevated water temperature; and 2) Decreased variability in water temperature.

*Candidate Cause*: River Discontinuity – Though likely connected by hyporheic flows, the surface waters of the Santa Clara River are disconnected by stretches of dry streambed between the RB and RC monitoring sites for most of the year due to the natural climate, permeability of the riverbed, groundwater pumping, and surface water diversions. This discontinuity could potentially impact community structure by, among other things, limiting downstream recruitment of juvenile invertebrates, a loss of large woody debris from the upper watershed, limiting the export of sand and other fine grain sediments. The conceptual diagram (Figure 9) contains six proximate stressors: 1) Decreased recruitment; 2) A decrease in woody debris; 3) A decrease in cobbles; 4) An increase in sands & fines; 5) Burial of cobbles; and 6) An increase in simplified habitat.

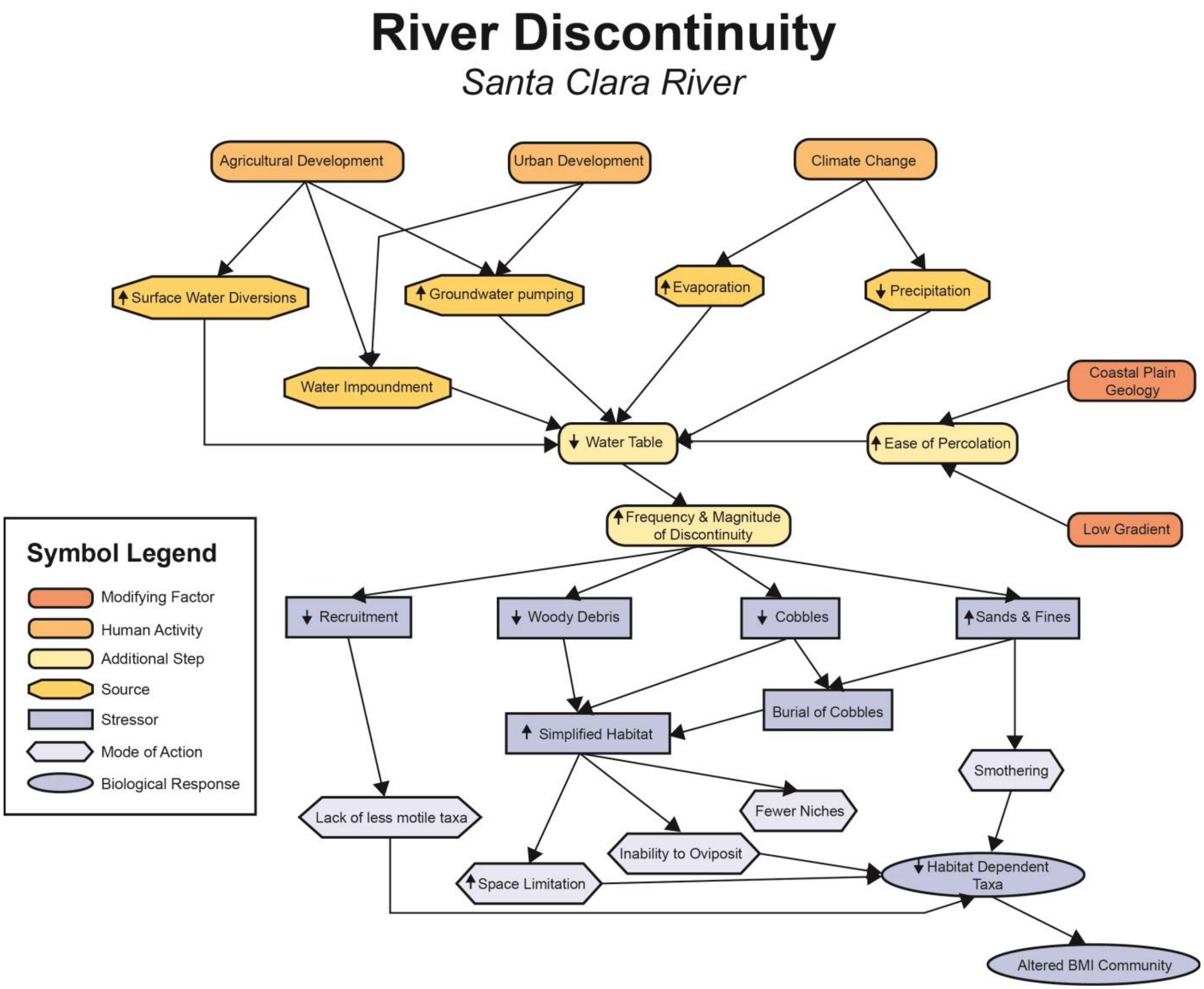



**Figure 6. River discontinuity conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.**

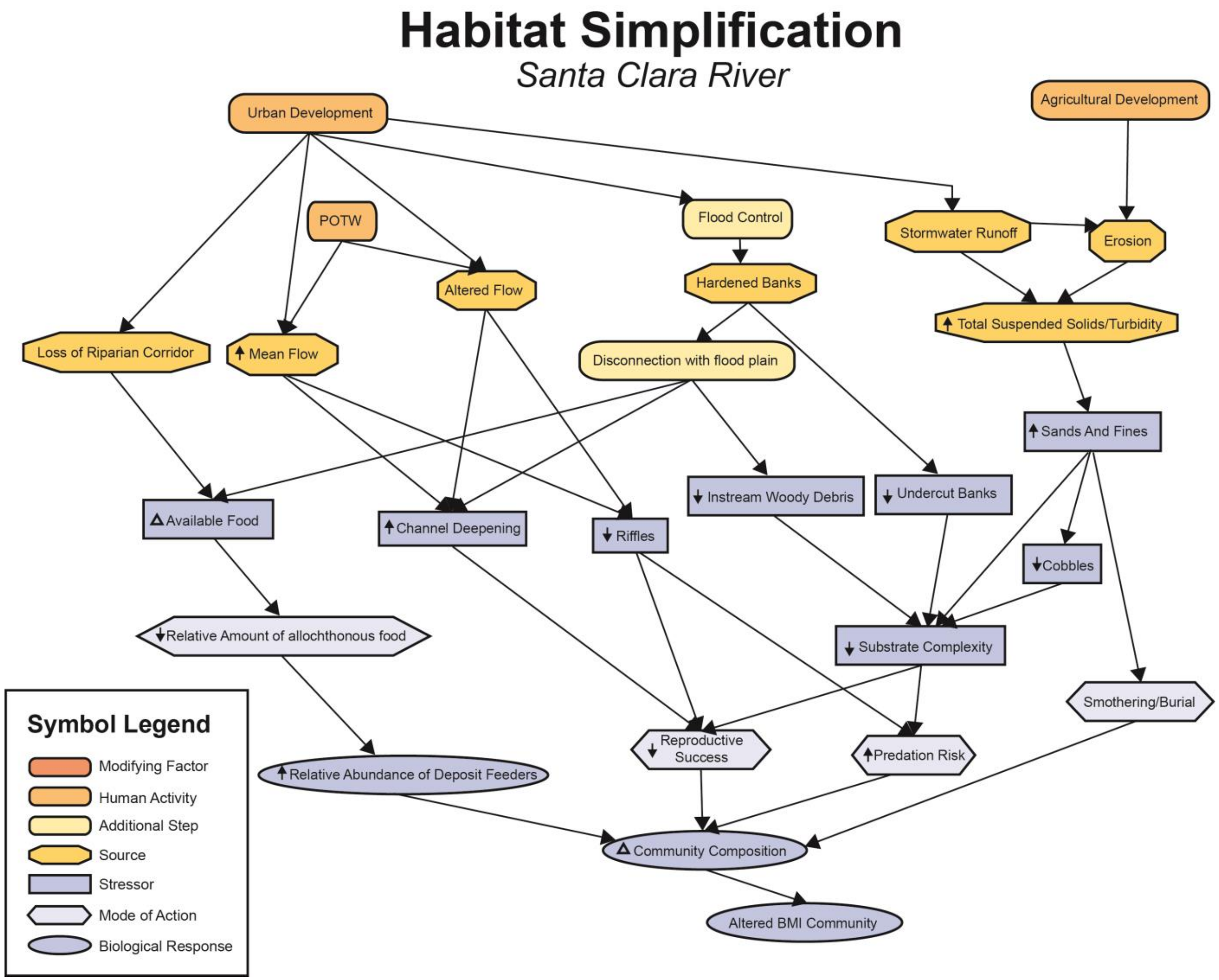



**Figure 7. Habitat simplification conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.**

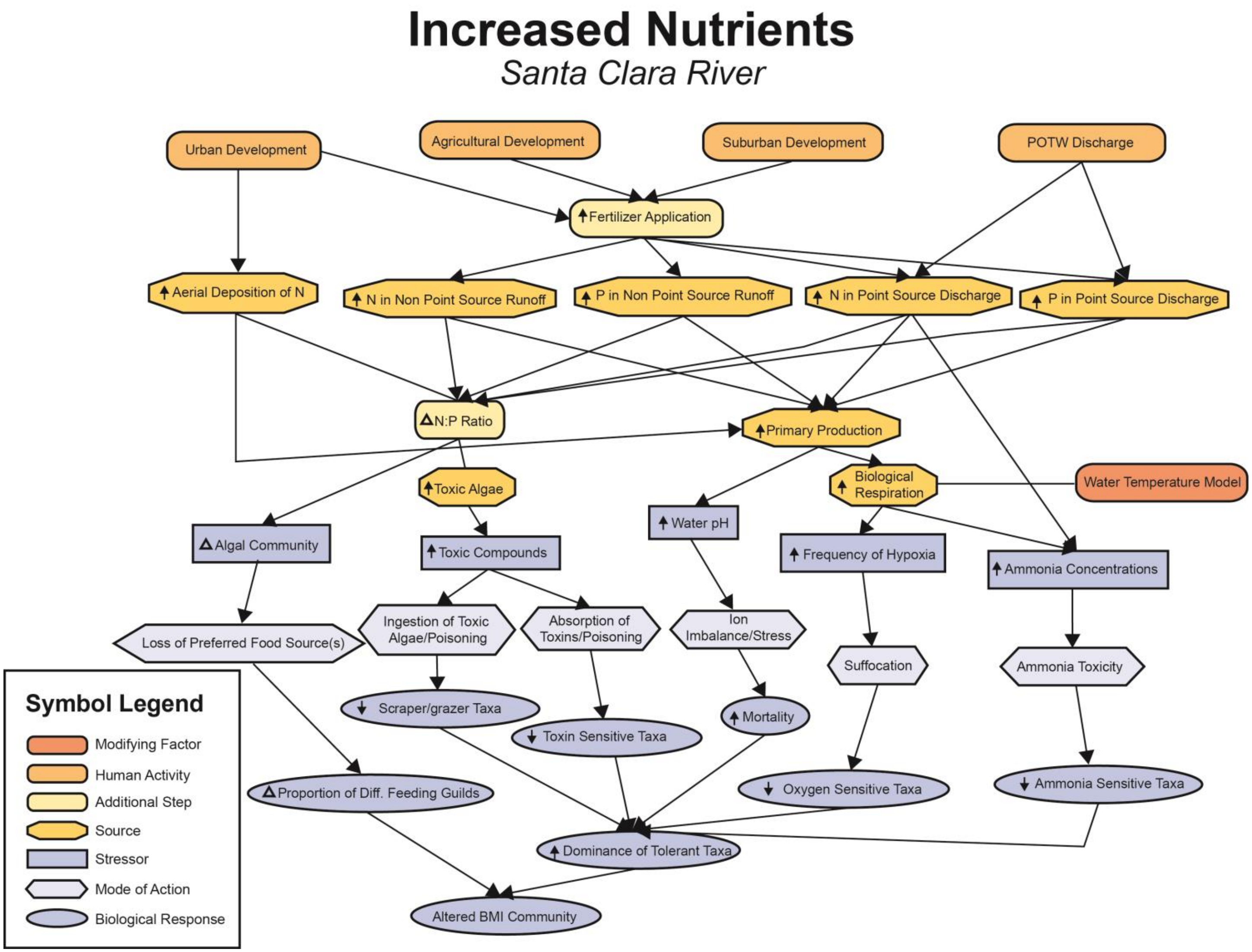



**Figure 8. Increased nutrients conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.**

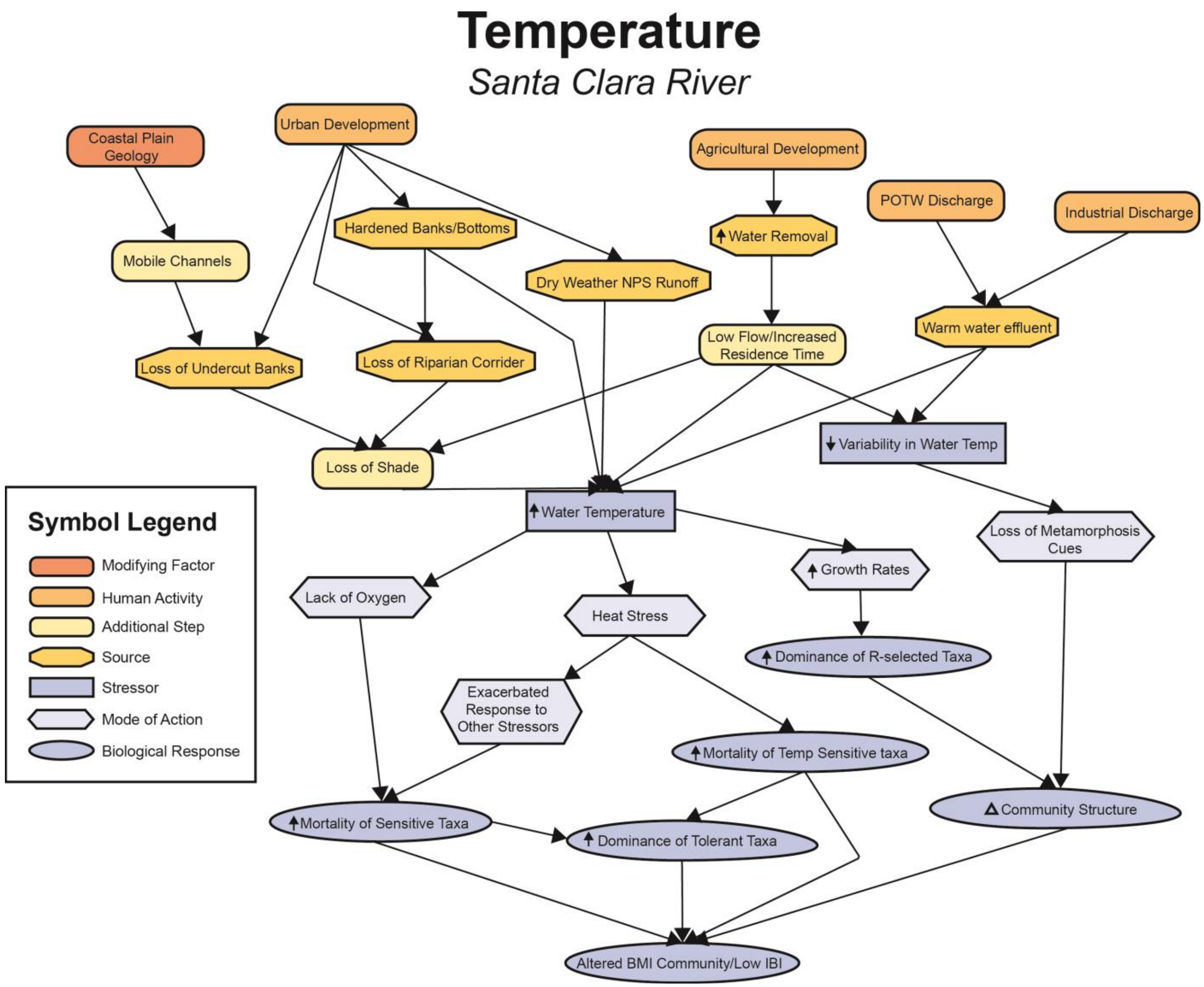



**Figure 9. Temperature conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.**

## IDENTIFYING THE CAUSE

In this causal assessment of degraded biological condition observed at the RD site in the Santa Clara River, seven candidate causes were evaluated including conductivity, habitat simplification, river discontinuity, metals, increased nutrients, temperature, and pesticides. Based upon our review of the available data across seven comparator sites elevated conductivity was the most likely cause behind the low IBI scores observed at RD in 2006. Metals, pesticides, and nutrients were likely not causes. Habitat simplification, river discontinuity, and temperature could not be diagnosed or refuted due to conflicting evidence and lack of appropriate data. The summary of all scores for all evidence types are presented in Table 3.

Elevated conductivity was indicated as a likely stressor based on three lines of evidence. First, the quarterly mean observation of conductivity at the test site was outside the distribution of conductivity values measured at ecologically similar sites in the statewide reference network. Relative risk patterns of conductivity and macrobenthic invertebrates used in outside of the case stressor response line of evidence indicated that the levels of conductivity observed at RD were high enough to potentially produce the degraded levels of the % of tolerant taxa observed at the test site. Lastly, spatial co-occurrence indicated that mean quarterly conductivity, TDS, and hardness were elevated at RD relative to the RB site. It should be noted that given the difficulties in case definition wherein the test site had equivalent or better quality biological measures than the comparator sites this line of evidence has limited interpretability. Furthermore, no proximate stressor data were available for many of the comparator sites (RF, SAP8, SAP11, or SAP14 sites). Consequently, between the poor case construction and data gaps, the power of the within the case analyses were somewhat diminished. However, the availability of more robust outside of case data provided enough information to make a diagnosis with some degree of confidence.

Metals, specifically dissolved metals in the water column, were not diagnosed as a potential cause for the observed biological degradation at RD. There were a few dissolved metals that were higher at RD than the comparator sites (e.g., copper or zinc) and there were strong correlations with increasing non-insect taxa and decreasing predator taxa with zinc (stressor response from the field). However, none of the concentrations observed at the RD site were high enough to cause the biological degradation observed at the site (stressor response from laboratory studies). All of the evidence was based upon water column dissolved metals. No data were available to evaluate sediment-bound or periphyton-accumulated metals and therefore no conclusions can be drawn about the influence of these fractions of metals that may have an impact on the biota of the Santa Clara River. The water column measurements were made in the three months (July-September) prior to biotic sampling. These dry season concentrations and loadings of metals are likely lower than during wet weather. However, the fauna observed at the test and comparator sites (Table 1) are primarily ephemeral, multivoltine taxa and the previous quarter’s water measurements are probably a more accurate representation of their exposure than winter/wet season measurements.

**Table 3. Summary score sheets for RD and each of the comparator sites in the Santa Clara River assessment. Each candidate cause score is the integration of the component proximate stressor scores, which are detailed in the supplemental material. The consistency line of evidence evaluates the continuity of each line of evidence for each of the three biological endpoints: % non-insect taxa/% tolerant taxa/# of predator taxa.**

**RD vs. RB**

| Candidate Cause | | Heavy Metals | Elevated Conductivity | River Discontinuity | Habitat Simplification | Increased Nutrients | Pesticides | Temperature |
|---|---|---|---|---|---|---|---|---|
| Spatial Co-Occurrence | | + | + | --- | --- | --- | --- | 0 |
| Stressor Response | Non-Insect Taxa | - | - | 0 | 0 | 0 | -- | + |
| | Tolerant Taxa | - | 0 | 0 | 0 | 0 | -- | 0 |
| | Predator Taxa | - | - | 0 | 0 | 0 | -- | + |
| Reference Condition Comparison | | NE | + | - | - | NE | NE | NE |
| Stressor Response From Outside the Case | Non-Insect Taxa § | -- | -- | -- | -- | NE | NE | NE |
| | Tolerant Taxa | 0 | + | + | + | NE | NE | NE |
| | Predator Taxa§ | -- | -- | -- | -- | NE | NE | NE |
| Stressor Response From the Laboratory | | -- | NE | NE | NE | NE | - | NE |
| Consistency of Evidence | | -/-/- | -/+/- | +/-/+ | +/-/+ | 0/0/0 | +/+/+ | 0/0/0 |

**RD vs RC**

| Candidate Cause | | Heavy Metals | Elevated Conductivity | River Discontinuity | Habitat Simplification | Increased Nutrients | Pesticides | Temperature |
|---|---|---|---|---|---|---|---|---|
| Spatial Co-Occurrence | | + | --- | 0 | 0 | --- | --- | + |
| Stressor Response | Non-Insect Taxa | - | - | 0 | 0 | 0 | -- | + |
| | Tolerant Taxa | - | 0 | 0 | 0 | 0 | -- | 0 |
| | Predator Taxa | - | - | 0 | 0 | 0 | -- | + |
| Reference Condition Comparison | | NE | + | - | - | NE | NE | NE |
| Stressor Response From Outside the Case | Non-Insect Taxa § | -- | -- | -- | -- | NE | NE | NE |
| | Tolerant Taxa | 0 | + | + | + | NE | NE | NE |
| | Predator Taxa§ | -- | -- | -- | -- | NE | NE | NE |
| Stressor Response From the Laboratory | | -- | NE | NE | NE | NE | - | NE |
| Consistency of Evidence | | -/-/- | -/-/- | +/-/+ | -/-/0 | 0/0/0 | +/+/+ | +/0/+ |

**§** % non -insect taxa and # of predator taxa values were below the relative risk biotic threshold (i.e. good condition) and were scored "--" for stressor response from outside the case

**Table 3. cont.**

| Candidate Cause | | Heavy Metals | Elevated Conductivity | River Discontinuity | Habitat Simplification | Increased Nutrients | Pesticides | Temperature |
|---|---|---|---|---|---|---|---|---|
| **RD vs RE** | | | | | | | | |
| Spatial Co-Occurrence | | --- | --- | 0 | --- | --- | --- | + |
| Stressor Response | Non-Insect Taxa | - | - | 0 | 0 | 0 | -- | + |
| | Tolerant Taxa | - | 0 | 0 | 0 | 0 | -- | 0 |
| | Predator Taxa | - | - | 0 | 0 | 0 | -- | + |
| Reference Condition Comparison | | NE | + | - | - | NE | NE | NE |
| Stressor Response From Outside the Case | Non-Insect Taxa § | -- | -- | -- | -- | NE | NE | NE |
| | Tolerant Taxa | 0 | + | + | + | NE | NE | NE |
| | Predator Taxa§ | -- | -- | -- | -- | NE | NE | NE |
| Stressor Response From the Laboratory | | -- | NE | NE | NE | NE | - | NE |
| Consistency of Evidence | | -/-/- | -/-/- | +/-/+ | -/-/0 | 0/0/0 | +/+/+ | +/0/+ |

| Candidate Cause | | Heavy Metals | Elevated Conductivity | River Discontinuity | Habitat Simplification | Increased Nutrients | Pesticides | Temperature |
|---|---|---|---|---|---|---|---|---|
| **RD vs RF** | | | | | | | | |
| Spatial Co-Occurrence | | NE | NE | 0 | 0 | 0 | NE | + |
| Stressor Response | Non-Insect Taxa | - | - | 0 | 0 | 0 | -- | + |
| | Tolerant Taxa | - | 0 | 0 | 0 | 0 | -- | 0 |
| | Predator Taxa | - | - | 0 | 0 | 0 | -- | + |
| Reference Condition Comparison | | NE | + | - | - | NE | NE | NE |
| Stressor Response From Outside the Case | Non-Insect Taxa § | -- | -- | -- | -- | NE | NE | NE |
| | Tolerant Taxa | 0 | + | + | + | NE | NE | NE |
| | Predator Taxa§ | -- | -- | -- | -- | NE | NE | NE |
| Stressor Response From the Laboratory | | -- | NE | NE | NE | NE | - | NE |
| Consistency of Evidence | | +/+/+ | -/+/- | +/-/+ | -/-/0 | 0/0/0 | +/+/+ | +/0/+ |

§ % non -insect taxa and # of predator taxa values were below the relative risk biotic threshold (i.e. good condition) and were scored "--" for stressor response from outside the case

**Table 3. cont.**

| Candidate Cause | | RD vs. SAP8 Heavy Metals | Elevated Conductivity | River Discontinuity | Habitat Simplification | Increased Nutrients | Pesticides | Temperature |
|---|---|---|---|---|---|---|---|---|
| Spatial Co-Occurrence | | NE | NE | 0 | 0 | 0 | NE | + |
| Stressor Response | Non-Insect Taxa | - | - | 0 | 0 | 0 | -- | + |
| | Tolerant Taxa | - | 0 | 0 | 0 | 0 | -- | 0 |
| | Predator Taxa | - | - | 0 | 0 | 0 | -- | + |
| Reference Condition Comparison | | NE | + | - | - | NE | NE | NE |
| Stressor Response From Outside the Case | Non-Insect Taxa § | -- | -- | -- | -- | NE | NE | NE |
| | Tolerant Taxa | 0 | + | + | + | NE | NE | NE |
| | Predator Taxa§ | -- | -- | -- | -- | NE | NE | NE |
| Stressor Response From the Laboratory | | -- | NE | NE | NE | NE | - | NE |
| Consistency of Evidence | | 0/0/0 | -/+/- | +/-/+ | +/-/+ | 0/0/0 | +/+/+ | +/0/+ |

| Candidate Cause | | RD vs SAP11 Heavy Metals | Elevated Conductivity | River Discontinuity | Habitat Simplification | Increased Nutrients | Pesticides | Temperature |
|---|---|---|---|---|---|---|---|---|
| Spatial Co-Occurrence | | NE | NE | 0 | + | 0 | NE | + |
| Stressor Response | Non-Insect Taxa | - | - | 0 | 0 | 0 | -- | + |
| | Tolerant Taxa | - | 0 | 0 | 0 | 0 | -- | 0 |
| | Predator Taxa | - | - | 0 | 0 | 0 | -- | + |
| Reference Condition Comparison | | NE | + | - | - | NE | NE | NE |
| Stressor Response From Outside the Case | Non-Insect Taxa § | -- | -- | -- | -- | NE | NE | NE |
| | Tolerant Taxa | 0 | + | + | + | NE | NE | NE |
| | Predator Taxa§ | -- | -- | -- | -- | NE | NE | NE |
| Stressor Response From the Laboratory | | -- | NE | NE | NE | NE | - | NE |
| Consistency of Evidence | | +/+/+ | -/+/- | +/-/+ | -/-/- | 0/0/0 | +/+/+ | +/0/+ |

**§** % non -insect taxa and # of predator taxa values were below the relative risk biotic threshold (i.e. good condition) and were scored "--" for stressor response from outside the case

**Table 3. cont.**

| Candidate Cause | | Heavy Metals | Elevated Conductivity | River Discontinuity | Habitat Simplification | Increased Nutrients | Pesticides | Temperature |
|---|---|---|---|---|---|---|---|---|
| Spatial Co-Occurrence | | NE | NE | --- | 0 | --- | NE | + |
| Stressor Response | Non-Insect Taxa | - | - | 0 | 0 | 0 | -- | + |
| | Tolerant Taxa | - | 0 | 0 | 0 | 0 | -- | 0 |
| | Predator Taxa | - | - | 0 | 0 | 0 | -- | + |
| Reference Condition Comparison | | NE | + | - | - | NE | NE | NE |
| Stressor Response From Outside the Case | Non-Insect Taxa § | -- | -- | -- | -- | NE | NE | NE |
| | Tolerant Taxa | 0 | + | + | + | NE | NE | NE |
| | Predator Taxa§ | -- | -- | -- | -- | NE | NE | NE |
| Stressor Response From the Laboratory | | -- | NE | NE | NE | NE | - | NE |
| Consistency of Evidence | | -/-/- | -/+/+ | -/-/+ | -/-/0 | +/+/0 | +/+/+ | +/0/0 |

§ % non -insect taxa and # of predator taxa values were below the relative risk biotic threshold (i.e. good condition) and were scored "--" for stressor response from outside the case

Pesticides, specifically non-pyrethroid compounds in the water column, were likely not the cause of biological impacts because no detectable amounts of 24 different non-pyrethroid pesticides and 3 herbicides were observed at RD or the comparator sites where samples were collected (RB, RC, and RE) in the 12 months prior to collection of the macroinvertebrates. Synthetic pyrethroids were not measured at any of the sites, so that evidence could not be evaluated. Similarly, no measurements of any pesticide were made in sediments of the Santa Clara River. These absences serve to reduce the certainty in the conclusion of unlikely stressor for pesticides in the Santa Clara River. Consequently, investigation of sediment-bound pesticide compounds and pyrethroids in general would be recommended in future analyses in order to more definitively rule out the influence of pesticides in the degraded benthic communities observed at RD.

Increased nutrients were not likely stressors at the RD site because none of the proximate stressors within the conceptual diagram were elevated at RD compared to the comparator sites and there were inverse relationships between all of the biological endpoints and the measures of nutrient impact. Nutrient-related stressors were difficult to tie into macroinvertebrate community structure as most of the effects of increased nutrients are indirect; translated through algal growth, primary production, and oxygen consumption. However, reasonable quality data were available for evaluating the presence and effects of potential low dissolved oxygen or altered pH, with the diel data that covered daytime periods of net productivity and night time periods of net respiration. Although these temporally detailed measurements were only available for a 24-hr period, they provide better insight than many daytime point measures made once a month. Overall though, the indirect nature of much of the evidence for nutrient impacts to benthic macrofauna creates a reduced degree of confidence in the nutrient candidate cause conclusion. Better conceptual models, as well as additional types of data, would likely help to increase the confidence in the final conclusion about nutrients. More frequent diel monitoring of dissolved oxygen with a longer than 24-hr duration would improve the data quality of the assessment and provide a more accurate picture of the effects of low dissolved oxygen. Additional research into the relationships between algae and benthic macroinvertebrates would and help to elucidate some of the indirect effects of elevated nutrients on stream macroinvertebrates and could be used to create better informed conceptual models.

River discontinuity and habitat simplification were unresolved candidate causes. These two candidate causes shared a number of component proximate stressors (e.g., loss of woody debris, loss of cobbles, etc) that capture different aspects of stream physical habitat. The differences in the proximate stressors were small between test and comparator sites (often within the perceived error of the method). Similarly, there was no consistent stressor response relationship with any of the biological endpoints. However, none of the comparator sites had particularly good biological condition. Hence, all of the sites in the upper Santa Clara River may be impacted by sands and fine sediments. This ambiguity was further compounded by a lack of data, or inconsistent data, from elsewhere for many of the component proximate stressors to provide context to the conditions at RD. For example, the increase in sands and fine sediments observed at RD were within the range observed at similar low elevation, low gradient reference sites, but those same values of sands and fine sediments were also linked to degraded community structure in biogeographically similar non-reference sites. These kinds of ambiguities illustrate a need to better understand the influence physical habitat on community structure, a better characterization of expectation in low gradient/elevation streams, and the development of more precise measures of stream habitat. Additional research in these areas will be needed to better evaluate physical habitat-related candidate causes in future causal assessments.

Temperature was indicated as an indeterminate cause due to inconsistency in some of the evidence (i.e., quarterly vs. diel patterns) and lack of outside of the case data. As the measures of the macrobenthic community at RD were comparable to the comparator sites, the spatial temporal co-occurrence line of evidence could not be clearly evaluated. The RD had elevated mean temperature and reduced temperature range compared to all of the comparator sites, with the exception of RB (RB is also located near a water reclamation plant outfall like RD). There was an apparent stressor-response pattern across the test and the comparator sites between increasing mean temperature and decreasing temperature range from the previous quarter with increasing % of non-insect taxa and decreasing number of predator taxa (quarterly measurements were only associated with the RB, RC, RD, and RE sites [table 2]). These patterns would suggest that water temperature has some potential to influence components of the macrobenthic community at the RD site. However, the biological community condition scores were comparable among the RD and comparator sites. Therefore, temperature range was either insufficient to have uniquely impacted the RD site relative to its comparators, or there was an alternate stressor that impacted at all of the sites (RD + comparator sites) along the upper Santa Clara River. Furthermore, there was no outside of the case data to evaluate the potential magnitude of impact from temperature changes in the upper Santa Clara River. Without data from elsewhere to contextualize the magnitude of temperature range or mean temperature against environmentally similar streams, a more conclusive diagnosis for temperature cannot be made. The apparent disconnect in the patterns of temperature and macrobenthic infauna from the diel versus the quarterly data within the case further reduces the certainty that can be placed in the temperature conclusion. Given these uncertainties in the available data and the important nature of water temperature to both regulated and regulatory stakeholders in the system, a directed study of water temperatures and biota observed in the Santa Clara River should be considered. Part of this additional effort should include comparing the local patterns to those from environmentally similar streams could improve confidence and a more conclusive diagnosis.

## Lessons Learned

There were several things to be learned from this causal assessment. First, diagnosing candidate cause in this assessment was difficult because much of the upper Santa Clara River was of similar biological condition. There were marginal differences among the biological endpoints at RD and comparator sites making traditional causal assessment approaches such as spatial temporal co-occurrence difficult. Second, since the use of within case evidence was hampered by potentially similar stressor exposure and biotic condition at comparator sites and the test site. In cases like this, valuable evidence was gained by examining evidence from elsewhere. Additional data assessment tools need to be developed utilizing the statewide data set for future causal assessments plagued with this same problem. Third, candidate causes comprised of complex interactions of proximate stressors such as nutrients or habitat alteration might be better served by being separated into their respective stressors. For many of these stressors, additional research into the complex interactions with biological response should be explored. This research can then be used for future causal assessments as part of the stressor response from elsewhere line of evidence.

### Developing a Solid Case

The Santa Clara River case study provides an instructive point about the construction of the case, specifically the careful and purposeful selection of comparator sites and the biological endpoints to characterize those sites. During the initial construction of the Santa Clara River case, comparator sites were selected more for their proximity to the test site and data availability rather than their relative differences in biotic condition and potential stressor exposure. As an example, four biological endpoints were originally selected for evaluation, but one of them – % abundance of collector-gatherer individuals – was actually not observed at a level indicative of degraded conditions (within the context of the Southern California IBI) at the test site. Similarly, % non-insect taxa and the number of predator taxa metrics at the test site were measured at levels similar to that at the comparator sites. Certain lines of evidence (i.e., stressor response from the field or spatial-temporal co-occurrence) implicitly work upon the notion that the condition of the biological endpoints at the test site are worse than the within case comparator sites. For the % collector-gatherer endpoint, this was certainly not the case. This oversight speaks to the need to carefully consider which sites are selected as comparators and what biological endpoints are to be evaluated in future causal analyses. Emphasis should be placed upon those endpoints which capture the biological degradation at the site and whose remediation may improve condition at the site.

### Certainty in Assessment

The CADDIS framework traditionally categorizes each of the evaluated candidate causes into one of three categories: likely cause, indeterminate cause, or unlikely cause. In practice, however, within each of those categories there is going to be gradient of certainty in the assignment that has been made. This certainty is important, as it should be used in combination with the likely/unlikely/indeterminate classification of a candidate cause to inform the next steps stakeholders and regulators are likely to take after the causal assessment in order to ameliorate the observed biological impairments in the stream. As an example, a candidate cause assigned with high certainty into the unlikely category could be disregarded from follow up action with some confidence. Conversely, a candidate cause assigned to the likely category with moderate or low certainty should probably require additional confirmatory data collection or analysis (in lieu of corrective actions) as a post-causal assessment action.

At present, the CADDIS framework does not have a formal process for categorizing or denoting the certainty in the different lines of evidence or in the interpretation of those results. The consistency line of evidence speaks to these issues somewhat by looking at the agreement/disagreement in scores across evidence types, but does not do a comprehensive job. We captured the certainty of each candidate cause assignment from our assessment in a narrative fashion. There was enough evidence to suggest that conductivity was a likely candidate cause at the test site on the upper Santa Clara River, but due to data limitations (e.g., limited within the case data and tentative linkages to biological response) the certainty in that assessment was moderately low and probably requires additional investigation for final confirmation. Similarly, the data suggested two candidate causes (pesticides and nutrients) were unlikely stressors at the test site, but the certainty in this evaluation was reduced due to lack of proximate stressor measurements and the indirect nature of the evidence. Consequently, additional confirmation before ultimately dismissing both unlikely candidate causes is recommended.

## Data Analysis from within the Case

### Spatial Co-Occurrence

Spatial co-occurrence was one of the analyses with the most coverage of sites and proximate stressors for all of the different candidate causes in the Santa Clara River assessment. The analysis was set up as a comparison of the value of a potential stressor at the RD site versus each of the comparator sites (RB, RC, RE, RF, SAP8, SAP11, and SAP14). In scoring these comparisons, a series of guidelines were created to assist in making consistent evaluations across the large dataset. Summarized in Figure 10 and assuming the presence of a variable was considered as having a negative impact on a macrobenthic community structure: if the test site had a higher value than the comparator and that difference was greater than the detection limit of that variable, the data were scored "+"; if the test site had a higher value than the comparator site and the difference was less than the detection limit, the data were scored "0"; if the test and comparator sites had equal values, the data were scored "---"; if the test site had a lower value than the comparator site and the difference was less than the detection limit, the data were scored "---"; and if the test site had a lower value than the comparator site and that difference was greater than the detection limit, the data were scored as "---". If the variable was a positive variable, i.e., reducing its value would negatively affect macrobenthic community structure, the guidelines were reversed. The spatial co-occurrence comparisons (observed values, differences, and individual scores) between RD and the comparator sites for all of the individual analyses are presented in Table 4 and the scores for each candidate cause and their proximate stressors are summarized in Table 5.

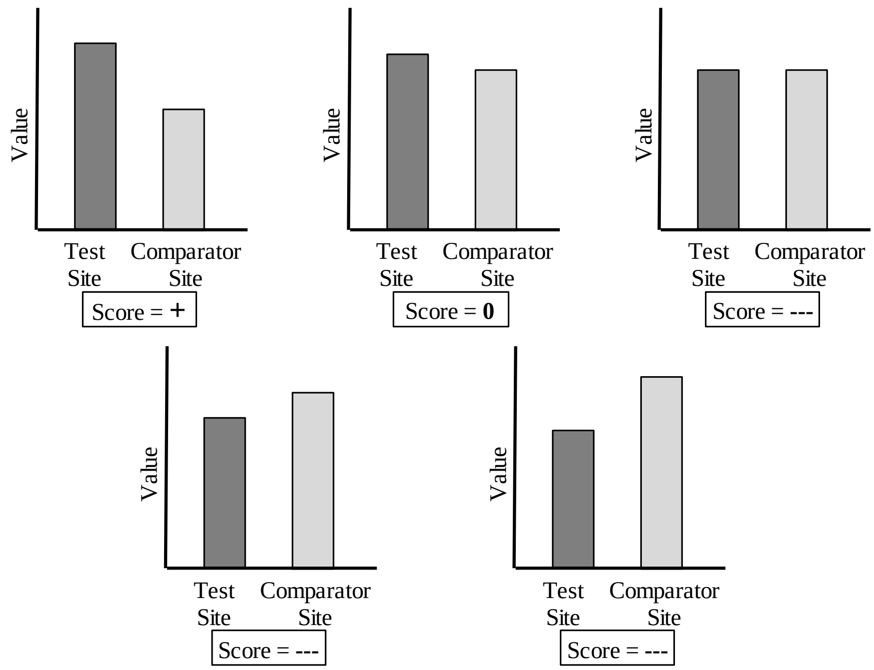



**Figure 10. Illustration of scoring rules established during this case study for assessing spatial co-occurrence data assuming a negative variable. A + indicates supporting evidence, 0 indicates indeterminate evidence, and --- indicates strong contrary or weakening evidence.**

**Table 4. Detailed spatial co-occurrence score sheet for calculating and scoring the differences of each proximate stressor and the components therein between RD and each comparator site. Data are scored + for supporting evidence, --- for strongly weakening evidence, 0 for indeterminate evidence, or NE for no evidence. bdl = below detection limit nd = no data n/a = not applicable.**

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RE Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | --- | |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | |
| | | | Antimony (μg $L^{-1}$) | 0.63 | 0.53 | 0.10 | 0 | | |
| | | | Arsenic (μg $L^{-1}$) | 0.82 | 1.36 | -0.54 | --- | | |
| | | | Barium (μg $L^{-1}$) | 41.70 | 47.50 | -5.80 | --- | | |
| | | | Beryllium (μg $L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Cadmium (μg $L^{-1}$) | 0.09 | 0.13 | -0.04 | --- | | |
| | | | Chromium (μg $L^{-1}$) | 0.23 | 0.70 | -0.47 | --- | | |
| | | | Copper (μg $L^{-1}$) | 3.42 | 3.72 | -0.30 | --- | | |
| | | | Hexavalent Chromium (mg $L^{-1}$) | 0.01 | 0.00 | 0.00 | --- | | |
| | | | Iron (mg $L^{-1}$) | 0.10 | 0.53 | -0.43 | --- | | |
| | | | Lead (μg $L^{-1}$) | 0.10 | 0.31 | -0.21 | --- | | |
| | | | Mercury (μg $L^{-1}$) | 0.02 | 0.02 | 0.00 | --- | | |
| | | | Nickel (μg $L^{-1}$) | 6.86 | 5.92 | 0.95 | 0 | | |
| | | | Selenium (μg $L^{-1}$) | 1.33 | 1.90 | -0.57 | --- | | |
| | | | Silver (μg $L^{-1}$) | 0.13 | 0.01 | 0.12 | --- | | |
| | | | Thallium (μg $L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Zinc (μg $L^{-1}$) | 27.97 | 29.53 | -1.57 | --- | | |
| | Increase in Particulate Bound Metals | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increase in Metals in Periphyton | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| **Elevated Conductivity** | | | | | | | | | |
| | Increase in Conductivity | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Conductivity mmhos $cm^{-1}$ | 1207.3 | 1232.3 | -25.00 | --- | | |
| | Increase in Total Dissolved Solids | | | | | | | --- | Lower TDS and Hardness, but elevated Chloride |
| | | Mean of Previous Quarter | | | | | | | |
| | | | TDS (mg $L^{-1}$) | 788.00 | 815.00 | -27.00 | --- | | |
| | | | Chloride (mg $L^{-1}$) | 128.50 | 116.50 | 12.00 | + | | |
| | | | Hardness (mg $L^{-1}$) | 350.00 | 380.67 | -30.67 | --- | | |
| **River Discontinuity** | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5 | 5 | 0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 4.0 | -4.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 23.3 | -4.3 | --- | | |
| | Burial of Cobbles | | | | | | | NE | Few if any cobbles observed, so measurements unreliable |
| | | Mean % of Cobbles Embeddedness | | | | | | | |
| | | | Cobble Embeddedness (%) | | | No Data Available | | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RE Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Habitat Simplification** | | | | | | | | | |
| | Change in Available Food | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |
| | Increase in Channel Deepening | | | | | | | --- | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 28.3 | -1.7 | --- | | |
| | Decrease in Riffles | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 4.0 | -4.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 23.3 | -4.3 | --- | | |
| | Decrease in Undercut Banks | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Undercut banks (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |
| **Increased Nutrients** | | | | | | | | | |
| | Change in Algal Community | | | | | | | --- | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | --- | | |
| | Increase in Algal Toxins | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in pH | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | pH | 7.76 | 8.10 | -0.34 | --- | | Only based upon quarterly data |
| | | Mean of 24 Hours | | | | | | | |
| | | | pH | 7.77 | n/d | n/a | NE | | |
| | Increased Frequency of Hypoxia | | | | | | | --- | |
| | | Percent of Observations in Daytime Point Measures | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | Increased Ammonia Concentrations | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.34 | 0.05 | 0.29 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RE Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | --- | All measurements below detection limit at both sites |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 4,4'-DDD ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 4,4'-DDE ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrolein ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrylonitrile ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Aldrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | alpha-BHC ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | cis-1,3-Dichloropropene ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | delta-BHC ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Diazinon ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Dieldrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan I ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan II ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan sulfate ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin aldehyde ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor Epoxide (Isomer B) ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Methoxychlor ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDD ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDE ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDT ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | p,p'-DDT ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Technical Chlordane ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Toxaphene ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | 0 | 0 | --- | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Water Column Herbicides | | | | | | | --- | All measurements below detection limit at both sites |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 2,3,7,8-TCDD ($pg\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 2,4,5-TP (Silvex) ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 2,4'-D ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RE Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | |
| | Increased Water Temperature | | | | | | | 0 | Ambivilent in quarterly data, but higher in 24 hour diel data |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 26.4 | 25.7 | 0.7 | 0 | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 24.6 | 23.2 | 1.4 | + | | |
| | Decreased Variability in Water Temperature | | | | | | | + | |
| | | Range of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 3.8 | 6.9 | -3.1 | + | | |
| | | Range of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 3.3 | 6.4 | -3.1 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RB Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | + | Supporting evidence for As, Ba, Ni, and Se. Weakening evidence for Be, Cr, Cr VI, Fe, Hg, Ag, Tl, and Zn |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | |
| | | | Antimony ($\mu g\ L^{-1}$) | 0.63 | 0.30 | 0.33 | 0 | | |
| | | | Arsenic ($\mu g\ L^{-1}$) | 0.82 | 0.30 | 0.52 | + | | |
| | | | Barium ($\mu g\ L^{-1}$) | 41.70 | 16.00 | 25.70 | + | | |
| | | | Beryllium ($\mu g\ L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Cadmium ($\mu g\ L^{-1}$) | 0.09 | 0.02 | 0.07 | 0 | | |
| | | | Chromium ($\mu g\ L^{-1}$) | 0.23 | 0.23 | 0.00 | --- | | |
| | | | Copper ($\mu g\ L^{-1}$) | 3.42 | 3.11 | 0.31 | 0 | | |
| | | | Hexavalent Chromium ($mg\ L^{-1}$) | 0.01 | 0.01 | 0.00 | --- | | |
| | | | Iron ($mg\ L^{-1}$) | 0.10 | 0.10 | 0.00 | --- | | |
| | | | Lead ($\mu g\ L^{-1}$) | 0.10 | 0.08 | 0.02 | 0 | | |
| | | | Mercury ($\mu g\ L^{-1}$) | 0.02 | 0.02 | 0.00 | --- | | |
| | | | Nickel ($\mu g\ L^{-1}$) | 6.86 | 5.11 | 1.75 | + | | |
| | | | Selenium ($\mu g\ L^{-1}$) | 1.33 | 0.50 | 0.83 | + | | |
| | | | Silver ($\mu g\ L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Thallium ($\mu g\ L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Zinc ($\mu g\ L^{-1}$) | 27.97 | 40.40 | -12.43 | --- | | |
| | Increase in Particulate Bound Metals | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in Metals in Periphyton | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| **Elevated Conductivity** | | | | | | | | | |
| | Increase in Conductivity | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Conductivity mmhos $cm^{-1}$ | 1207.33 | 1031.67 | 175.67 | + | | |
| | Increase in Total Dissolved Solids | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | TDS ($mg\ L^{-1}$) | 788.00 | 631.33 | 156.67 | + | | |
| | | | Chloride ($mg\ L^{-1}$) | 128.50 | 126.00 | 2.50 | + | | |
| | | | Hardness ($mg\ L^{-1}$) | 350.00 | 195.00 | 155.00 | + | | |
| **River Discontinuity** | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 4.1 | 0.9 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 0.0 | 0 | --- | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 39.5 | -20.4 | --- | | |
| | Burial of Cobbles | | | | | | | NE | Few if any cobbles observed, so measurements unreliable |
| | | Mean % of Cobbles Embeddedness | | | | | | | |
| | | | Cobble Embeddedness (%) | | No Data Available | | | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |

| Table 4. Cont. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RB Value | Difference | Component Score | Proximate Stressor Score | Comment |
| **Habitat Simplification** | | | | | | | | | |
| | Change in Available Food | | | | | | | --- | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | |
| | | | Euclidean Distance from RD | | | | --- | | |
| | Increase in Channel Deepening | | | | | | | --- | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 28.5 | -2 | --- | | |
| | Decrease in Riffles | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 4.1 | 0.9 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 0.0 | 0.0 | --- | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 39.5 | -20.4 | --- | | |
| | Decrease in Undercut Banks | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Undercut banks (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |
| **Increased Nutrients** | | | | | | | | | |
| | Change in Algal Community | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | 0 | | |
| | Increase in Algal Toxins | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in pH | | | | | | | --- | Only 24hr measurements available |
| | | Mean of Previous Quarter | | | | | | | |
| | | | pH | 7.76 | 7.42 | 0.34 | --- | | |
| | | Mean of 24 Hours | | | | | | | |
| | | | pH | 7.77 | 7.24 | 0.53 | --- | | |
| | Increased Frequency of Hypoxia | | | | | | | --- | |
| | | Percent of Observations in Daytime Point Measures | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 7.4 | -7.4 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | Increased Ammonia Concentrations | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.337 | 1.030 | -0.693 | --- | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RB Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | --- | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 4,4'-DDD (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 4,4'-DDE (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrolein (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrylonitrile (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Aldrin (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | alpha-BHC (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | cis-1,3-Dichloropropene (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | delta-BHC (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Diazinon (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Dieldrin (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan I (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan II (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan sulfate (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin aldehyde (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor Epoxide (Isomer B) (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Methoxychlor (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDD (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDE (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDT (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | p,p'-DDT (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Technical Chlordane (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Toxaphene (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | 0 | 0 | --- | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Water Column Herbicides | | | | | | | --- | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 2,3,7,8-TCDD (pg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 2,4,5-TP (Silvex) (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 2,4'-D (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RB Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | |
| | Increased Water Temperature | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 26.4 | 27.4 | -1.0 | --- | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 24.6 | 26.4 | -1.8 | --- | | |
| | Decreased Variability in Water Temperature | | | | | | | --- | |
| | | Range of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 3.8 | 1.7 | 2.1 | --- | | |
| | | Range of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 3.3 | 1.6 | 1.7 | --- | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RC Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | + | Supporting evidence for Cu and Zn. Ambivilent evidence for Sn and weakening evidence for the rest |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | |
| | | | Antimony (µg $L^{-1}$) | 0.63 | 0.27 | 0.36 | 0 | | |
| | | | Arsenic (µg $L^{-1}$) | 0.82 | 1.51 | -0.69 | --- | | |
| | | | Barium (µg $L^{-1}$) | 41.70 | 79.00 | -37.30 | --- | | |
| | | | Beryllium (µg $L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Cadmium (µg $L^{-1}$) | 0.09 | 0.13 | -0.04 | --- | | |
| | | | Chromium (µg $L^{-1}$) | 0.23 | 0.25 | -0.02 | --- | | |
| | | | Copper (µg $L^{-1}$) | 3.42 | 2.48 | 0.94 | + | | |
| | | | Hexavalent Chromium (mg $L^{-1}$) | 0.01 | 0.01 | 0.00 | --- | | |
| | | | Iron (mg $L^{-1}$) | 0.10 | 0.10 | 0.00 | --- | | |
| | | | Lead (µg $L^{-1}$) | 0.10 | 0.07 | 0.03 | --- | | |
| | | | Mercury (µg $L^{-1}$) | 0.02 | 0.02 | 0.00 | --- | | |
| | | | Nickel (µg $L^{-1}$) | 6.86 | 11.40 | -4.54 | --- | | |
| | | | Selenium (µg $L^{-1}$) | 1.33 | 2.87 | -1.54 | --- | | |
| | | | Silver (µg $L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Thallium (µg $L^{-1}$) | 0.13 | 0.13 | 0.00 | --- | | |
| | | | Zinc (µg $L^{-1}$) | 27.97 | 7.40 | 20.57 | + | | |
| | Increase in Particulate Bound Metals | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in Metals in Periphyton | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| **Elevated Conductivity** | | | | | | | | | |
| | Increase in Conductivity | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Conductivity mmhos $cm^{-1}$ | 1207.33 | 1295.67 | -88.33 | --- | | |
| | Increase in Total Dissolved Solids | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | TDS (mg $L^{-1}$) | 788.00 | 866.67 | -78.67 | --- | | Lower TDS and hardness, but higher chloride |
| | | | Chloride (mg $L^{-1}$) | 128.50 | 118.33 | 10.17 | + | | |
| | | | Hardness (mg $L^{-1}$) | 350.00 | 472.67 | -122.67 | --- | | |
| **River Discontinuity** | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 2.0 | -2.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 45.1 | -26.0 | --- | | |
| | Burial of Cobbles | | | | | | | NE | Few if any cobbles observed, so measurements unreliable |
| | | Mean % of Cobbles Embeddedness | | | | | | | |
| | | | Cobble Embeddedness (%) | | No Data Available | | | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RC Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Habitat Simplification** | | | | | | | | | |
| | Change in Available Food | | | | | | | --- | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | |
| | | | Euclidean Distance from RD | | | | --- | | |
| | Increase in Channel Deepening | | | | | | | + | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 16.7 | 9.8 | + | | |
| | Decrease in Riffles | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 2.0 | -2.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 45.1 | -26.0 | --- | | |
| | Decrease in Undercut Banks | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Undercut banks (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |
| **Increased Nutrients** | | | | | | | | | |
| | Change in Algal Community | | | | | | | --- | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | --- | | |
| | Increase in Algal Toxins | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in pH | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | pH | 7.76 | 7.91 | -0.15 | --- | | |
| | | Mean of 24 Hours | | | | | | | |
| | | | pH | 7.77 | 7.72 | 0.05 | --- | | |
| | Increased Frequency of Hypoxia | | | | | | | --- | |
| | | Percent of Observations in Daytime Point Measures | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | Increased Ammonia Concentrations | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.337 | 0.050 | 0.287 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RC Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | --- | All measurements below detection limit at both sites |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 4,4'-DDD (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 4,4'-DDE (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrolein (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrylonitrile (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Aldrin (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | alpha-BHC (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | cis-1,3-Dichloropropene (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | delta-BHC (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Diazinon (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Dieldrin (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan I (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan II (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan sulfate (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin aldehyde (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor Epoxide (Isomer B) (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Methoxychlor (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDD (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDE (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDT (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | p,p'-DDT (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Technical Chlordane (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Toxaphene (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | 0 | 0 | --- | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Water Column Herbicides | | | | | | | --- | |
| | | Maximum Value of Previous Year | | | | | | | All measurements below detection limit at both sites |
| | | | 2,3,7,8-TCDD (pg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 2,4,5-TP (Silvex) (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 2,4'-D (μg L$^{-1}$) | bdl | bdl | n/a | --- | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RC Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | |
| | Increased Water Temperature | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 26.4 | 25.0 | 1.4 | + | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 24.6 | 18.4 | 6.2 | + | | |
| | Decreased Variability in Water Temperature | | | | | | | + | |
| | | Range of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 3.8 | 8.7 | -4.9 | + | | |
| | | Range of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 3.3 | 4.7 | -1.5 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RF Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | NE | |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | |
| | | | Antimony ($\mu g\ L^{-1}$) | 0.63 | nd | n/a | | | |
| | | | Arsenic ($\mu g\ L^{-1}$) | 0.82 | nd | n/a | | | |
| | | | Barium ($\mu g\ L^{-1}$) | 41.70 | nd | n/a | | | |
| | | | Beryllium ($\mu g\ L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Cadmium ($\mu g\ L^{-1}$) | 0.09 | nd | n/a | | | |
| | | | Chromium ($\mu g\ L^{-1}$) | 0.23 | nd | n/a | | | |
| | | | Copper ($\mu g\ L^{-1}$) | 3.42 | nd | n/a | | | |
| | | | Hexavalent Chromium ($mg\ L^{-1}$) | 0.01 | nd | n/a | | | |
| | | | Iron ($mg\ L^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Lead ($\mu g\ L^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Mercury ($\mu g\ L^{-1}$) | 0.02 | nd | n/a | | | |
| | | | Nickel ($\mu g\ L^{-1}$) | 6.86 | nd | n/a | | | |
| | | | Selenium ($\mu g\ L^{-1}$) | 1.33 | nd | n/a | | | |
| | | | Silver ($\mu g\ L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Thallium ($\mu g\ L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Zinc ($\mu g\ L^{-1}$) | 27.97 | nd | n/a | | | |
| | Increase in Particulate Bound Metals | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in Metals in Periphyton | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| **Elevated Conductivity** | | | | | | | | | |
| | Increase in Conductivity | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Conductivity mmhos $cm^{-1}$ | 1207.33 | nd | n/a | | | |
| | Increase in Total Dissolved Solids | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | TDS ($mg\ L^{-1}$) | 788.00 | nd | n/a | | | |
| | | | Chloride ($mg\ L^{-1}$) | 128.50 | nd | n/a | | | |
| | | | Hardness ($mg\ L^{-1}$) | 350.00 | nd | n/a | | | |
| **River Discontinuity** | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.5 | 0.0 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 2.0 | -2.0 | + | | |
| | Increase in Sands and Fines | | | | | | | | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 37.6 | -18.6 | --- | | |
| | Burial of Cobbles | | | | | | | NE | Few if any cobbles observed, so measurements unreliable |
| | | Mean % of Cobbles Embeddedness | | | | | | | |
| | | | Cobble Embeddedness (%) | | No Data Available | | | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RF Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Habitat Simplification** | | | | | | | | | |
| | Change in Available Food | | | | | | | --- | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | |
| | | | Euclidean Distance from RD | | | | --- | | |
| | Increase in Channel Deepening | | | | | | | + | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 20.5 | 6.0 | + | | |
| | Decrease in Riffles | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.5 | 0.0 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 2.0 | -2.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 37.6 | -18.6 | --- | | |
| | Decrease in Undercut Banks | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Undercut banks (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |
| **Increased Nutrients** | | | | | | | | | |
| | Change in Algal Community | | | | | | | + | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | + | | |
| | Increase in Algal Toxins | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in pH | | | | | | | --- | Only 24 hour diel data |
| | | Mean of Previous Quarter | | | | | | | |
| | | | pH | 7.76 | nd | n/a | | | |
| | | Mean of 24 Hours | | | | | | | |
| | | | pH | 7.77 | 8.02 | -0.25 | --- | | |
| | Increased Frequency of Hypoxia | | | | | | | --- | Only 24 hour diel data |
| | | Percent of Observations in Daytime Point Measures | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | Increased Ammonia Concentrations | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.337 | 0.050 | 0.287 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RF Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 4,4'-DDD ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 4,4'-DDE ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrolein ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrylonitrile ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Aldrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | alpha-BHC ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | cis-1,3-Dichloropropene ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | delta-BHC ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Diazinon ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Dieldrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan I ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan II ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan sulfate ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin aldehyde ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor Epoxide (Isomer B) ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Methoxychlor ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDD ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDE ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDT ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | p,p'-DDT ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Technical Chlordane ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Toxaphene ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | nd | n/a | | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Water Column Herbicides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 2,3,7,8-TCDD ($pg\ L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4,5-TP (Silvex) ($\mu g\ L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4'-D ($\mu g\ L^{-1}$) | bdl | nd | n/a | | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | RF Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | |
| | Increased Water Temperature | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | Only 24 hour diel data |
| | | | Water Temperature (C) | 26.4 | nd | n/a | | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 24.6 | 20.2 | 4.4 | + | | |
| | Decreased Variability in Water Temperature | | | | | | | + | |
| | | Range of Previous Quarter | | | | | | | Only 24 hour diel data |
| | | | Water Temperature (C) | 3.8 | nd | n/a | | | |
| | | Range of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 3.3 | 9.7 | -6.4 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP8 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | NE | |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | |
| | | | Antimony ($\mu$g L$^{-1}$) | 0.63 | nd | n/a | | | |
| | | | Arsenic ($\mu$g L$^{-1}$) | 0.82 | nd | n/a | | | |
| | | | Barium ($\mu$g L$^{-1}$) | 41.70 | nd | n/a | | | |
| | | | Beryllium ($\mu$g L$^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Cadmium ($\mu$g L$^{-1}$) | 0.09 | nd | n/a | | | |
| | | | Chromium ($\mu$g L$^{-1}$) | 0.23 | nd | n/a | | | |
| | | | Copper ($\mu$g L$^{-1}$) | 3.42 | nd | n/a | | | |
| | | | Hexavalent Chromium (mg L$^{-1}$) | 0.01 | nd | n/a | | | |
| | | | Iron (mg L$^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Lead ($\mu$g L$^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Mercury ($\mu$g L$^{-1}$) | 0.02 | nd | n/a | | | |
| | | | Nickel ($\mu$g L$^{-1}$) | 6.86 | nd | n/a | | | |
| | | | Selenium ($\mu$g L$^{-1}$) | 1.33 | nd | n/a | | | |
| | | | Silver ($\mu$g L$^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Thallium ($\mu$g L$^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Zinc ($\mu$g L$^{-1}$) | 27.97 | nd | n/a | | | |
| | Increase in Particulate Bound Metals | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in Metals in Periphyton | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| **Elevated Conductivity** | | | | | | | | | |
| | Increase in Conductivity | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Conductivity mmhos cm$^{-1}$ | 1207.33 | nd | n/a | | | |
| | Increase in Total Dissolved Solids | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | TDS (mg L$^{-1}$) | 788.00 | nd | n/a | | | |
| | | | Chloride (mg L$^{-1}$) | 128.50 | nd | n/a | | | |
| | | | Hardness (mg L$^{-1}$) | 350.00 | nd | n/a | | | |
| **River Discontinuity** | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 1.8 | 3.2 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 2.0 | -2.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 31.0 | -11.9 | --- | | |
| | Burial of Cobbles | | | | | | | NE | Few if any cobbles observed, so measurements unreliable |
| | | Mean % of Cobbles Embeddedness | | | | | | | |
| | | | Cobble Embeddedness (%) | | No Data Available | | | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP8 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Habitat Simplification** | | | | | | | | | |
| | Change in Available Food | | | | | | | --- | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | |
| | | | Euclidean Distance from RD | | | | --- | | |
| | Increase in Channel Deepening | | | | | | | 0 | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 24.4 | 2.2 | 0 | | |
| | Decrease in Riffles | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 1.8 | 3.2 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.0 | 0.5 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 2.0 | -2.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 31.0 | -11.9 | --- | | |
| | Decrease in Undercut Banks | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Undercut banks (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | Increase in Simplified Habitat | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | 0 | | |
| **Increased Nutrients** | | | | | | | | | |
| | Change in Algal Community | | | | | | | 0 | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | 0 | | |
| | Increase in Algal Toxins | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in pH | | | | | | | --- | Only 24 hour diel data |
| | | Mean of Previous Quarter | | | | | | | |
| | | | pH | 7.76 | nd | n/a | | | |
| | | Mean of 24 Hours | | | | | | | |
| | | | pH | 7.77 | 8.61 | -0.84 | --- | | |
| | Increased Frequency of Hypoxia | | | | | | | --- | Only 24 hour diel data |
| | | Percent of Observations in Daytime Point Measures | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | Increased Ammonia Concentrations | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.337 | 0.050 | 0.287 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP8 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 4,4'-DDD ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 4,4'-DDE ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrolein ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrylonitrile ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Aldrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | alpha-BHC ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | cis-1,3-Dichloropropene ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | delta-BHC ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Diazinon ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Dieldrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan I ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan II ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan sulfate ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin aldehyde ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor Epoxide (Isomer B) ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Methoxychlor ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDD ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDE ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDT ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | p,p'-DDT ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Technical Chlordane ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Toxaphene ($\mu g\ L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | nd | n/a | | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Water Column Herbicides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 2,3,7,8-TCDD ($pg\ L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4,5-TP (Silvex) ($\mu g\ L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4'-D ($\mu g\ L^{-1}$) | bdl | nd | n/a | | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP8 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | |
| | Increased Water Temperature | | | | | | | + | Only 24 hour diel data |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 26.4 | nd | n/a | | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 24.6 | 21.6 | 3.0 | + | | |
| | Decreased Variability in Water Temperature | | | | | | | + | Only 24 hour diel data |
| | | Range of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 3.8 | nd | n/a | | | |
| | | Range of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 3.3 | 8.5 | -5.2 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP11 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | NE | |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | |
| | | | Antimony ($\mu g\ L^{-1}$) | 0.63 | nd | n/a | | | |
| | | | Arsenic ($\mu g\ L^{-1}$) | 0.82 | nd | n/a | | | |
| | | | Barium ($\mu g\ L^{-1}$) | 41.70 | nd | n/a | | | |
| | | | Beryllium ($\mu g\ L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Cadmium ($\mu g\ L^{-1}$) | 0.09 | nd | n/a | | | |
| | | | Chromium ($\mu g\ L^{-1}$) | 0.23 | nd | n/a | | | |
| | | | Copper ($\mu g\ L^{-1}$) | 3.42 | nd | n/a | | | |
| | | | Hexavalent Chromium ($mg\ L^{-1}$) | 0.01 | nd | n/a | | | |
| | | | Iron ($mg\ L^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Lead ($\mu g\ L^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Mercury ($\mu g\ L^{-1}$) | 0.02 | nd | n/a | | | |
| | | | Nickel ($\mu g\ L^{-1}$) | 6.86 | nd | n/a | | | |
| | | | Selenium ($\mu g\ L^{-1}$) | 1.33 | nd | n/a | | | |
| | | | Silver ($\mu g\ L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Thallium ($\mu g\ L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Zinc ($\mu g\ L^{-1}$) | 27.97 | nd | n/a | | | |
| | Increase in Particulate Bound Metals | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in Metals in Periphyton | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| **Elevated Conductivity** | | | | | | | | | |
| | Increase in Conductivity | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Conductivity mmhos $cm^{-1}$ | ####### | nd | n/a | | | |
| | Increase in Total Dissolved Solids | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | TDS ($mg\ L^{-1}$) | 788.00 | nd | n/a | | | |
| | | | Chloride ($mg\ L^{-1}$) | 128.50 | nd | n/a | | | |
| | | | Hardness ($mg\ L^{-1}$) | 350.00 | nd | n/a | | | |
| **River Discontinuity** | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.5 | 0.0 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 16.0 | -16.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 36.5 | -17.4 | --- | | |
| | Burial of Cobbles | | | | | | | NE | Few if any cobbles observed, so measurements unreliable |
| | | Mean % of Cobbles Embeddedness | | | | | | | |
| | | | Cobble Embeddedness (%) | | No Data Available | | | | |
| | Increase in Simplified Habitat | | | | | | | + | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | + | | |

| Table 4. Cont. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP11 Value | Difference | Component Score | Proximate Stressor Score | Comment |
| **Habitat Simplification** | | | | | | | | | |
| | Change in Available Food | | | | | | | + | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | |
| | | | Euclidean Distance from RD | | | | + | | |
| | Increase in Channel Deepening | | | | | | | + | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 18.8 | 7.7 | + | | |
| | Decrease in Riffles | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.5 | 0.0 | --- | | |
| | Decrease in Cobbles | | | | | | | + | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 16.0 | -16.0 | + | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 36.5 | -17.4 | --- | | |
| | Decrease in Undercut Banks | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Undercut banks (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | Increase in Simplified Habitat | | | | | | | + | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | + | | |
| **Increased Nutrients** | | | | | | | | | |
| | Change in Algal Community | | | | | | | + | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | + | | |
| | Increase in Algal Toxins | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increase in pH | | | | | | | --- | Only 24 hour diel data |
| | | Mean of Previous Quarter | | | | | | | |
| | | | pH | 7.76 | nd | n/a | | | |
| | | Mean of 24 Hours | | | | | | | |
| | | | pH | 7.77 | 8.31 | -0.54 | --- | | |
| | Increased Frequency of Hypoxia | | | | | | | --- | Only 24 hour diel data |
| | | Percent of Observations in Daytime Point Measures | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0 | 0 | --- | | |
| | Increased Ammonia Concentrations | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.337 | 0.050 | 0.287 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP11 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 4,4'-DDD (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 4,4'-DDE (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrolein (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrylonitrile (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Aldrin (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | alpha-BHC (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | cis-1,3-Dichloropropene (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | delta-BHC (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Diazinon (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Dieldrin (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan I (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan II (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan sulfate (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin aldehyde (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor Epoxide (Isomer B) (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Methoxychlor (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDD (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDE (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDT (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | p,p'-DDT (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Technical Chlordane (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Toxaphene (μg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | n/a | nd | | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | | No Data Available | | | |
| | Increased Water Column Herbicides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 2,3,7,8-TCDD (pg $L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4,5-TP (Silvex) (μg $L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4'-D (μg $L^{-1}$) | bdl | nd | n/a | | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP11 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | |
| | Increased Water Temperature | | | | | | | + | |
| | | Mean of Previous Quarter | | | | | | | Only 24 hour diel data |
| | | | Water Temperature (C) | 26.4 | nd | n/a | | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 24.6 | 14.7 | 9.9 | + | | |
| | Decreased Variability in Water Temperature | | | | | | | + | Only 24 hour diel data |
| | | Range of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 3.8 | nd | n/a | | | |
| | | Range of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 3.3 | 5.4 | -2.1 | + | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP14 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | NE | |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | |
| | | | Antimony (μg $L^{-1}$) | 0.63 | nd | n/a | | | |
| | | | Arsenic (μg $L^{-1}$) | 0.82 | nd | n/a | | | |
| | | | Barium (μg $L^{-1}$) | 41.70 | nd | n/a | | | |
| | | | Beryllium (μg $L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Cadmium (μg $L^{-1}$) | 0.09 | nd | n/a | | | |
| | | | Chromium (μg $L^{-1}$) | 0.23 | nd | n/a | | | |
| | | | Copper (μg $L^{-1}$) | 3.42 | nd | n/a | | | |
| | | | Hexavalent Chromium (mg $L^{-1}$) | 0.01 | nd | n/a | | | |
| | | | Iron (mg $L^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Lead (μg $L^{-1}$) | 0.10 | nd | n/a | | | |
| | | | Mercury (μg $L^{-1}$) | 0.02 | nd | n/a | | | |
| | | | Nickel (μg $L^{-1}$) | 6.86 | nd | n/a | | | |
| | | | Selenium (μg $L^{-1}$) | 1.33 | nd | n/a | | | |
| | | | Silver (μg $L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Thallium (μg $L^{-1}$) | 0.13 | nd | n/a | | | |
| | | | Zinc (μg $L^{-1}$) | 27.97 | nd | n/a | | | |
| | Increase in Particulate Bound Metals | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in Metals in Periphyton | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| **Elevated Conductivity** | | | | | | | | | |
| | Increase in Conductivity | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Conductivity mmhos $cm^{-1}$ | 1207.33 | nd | n/a | | | |
| | Increase in Total Dissolved Solids | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | TDS (mg $L^{-1}$) | 788.00 | nd | n/a | | | |
| | | | Chloride (mg $L^{-1}$) | 128.50 | nd | n/a | | | |
| | | | Hardness (mg $L^{-1}$) | 350.00 | nd | n/a | | | |
| **River Discontinuity** | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.5 | 0.0 | --- | | |
| | Decrease in Cobbles | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 0.0 | 0.0 | --- | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 45.7 | -26.7 | --- | | |
| | Burial of Cobbles | | | | | | | NE | Few if any cobbles observed, so measurements unreliable |
| | | Mean % of Cobbles Embeddedness | | | | | | | |
| | | | Cobble Embeddedness (%) | | No Data Available | | | | |
| | Increase in Simplified Habitat | | | | | | | + | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | + | | |

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP14 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Table 4.** Cont. | | | | | | | | | |
| **Habitat Simplification** | | | | | | | | | |
| | Change in Available Food | | | | | | | + | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | |
| | | | Euclidean Distance from RD | | | | + | | |
| | Increase in Channel Deepening | | | | | | | + | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 6.2 | 20.4 | + | | |
| | Decrease in Riffles | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Decrease in Woody Debris | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.5 | 0.5 | 0.0 | --- | | |
| | Decrease in Cobbles | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Cobbles (%) | 0.0 | 0.0 | 0.0 | --- | | |
| | Increase in Sands and Fines | | | | | | | --- | |
| | | % of Reach Area Where Present | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 45.7 | -26.7 | --- | | |
| | Decrease in Undercut Banks | | | | | | | --- | |
| | | Length of Reach Where Present | | | | | | | |
| | | | Undercut banks (m) | 5.0 | 5.0 | 0.0 | --- | | |
| | Increase in Simplified Habitat | | | | | | | + | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | |
| | | | Euclidean Distance from RD | | | | + | | |
| **Increased Nutrients** | | | | | | | | | |
| | Change in Algal Community | | | | | | | + | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | + | | |
| | Increase in Algal Toxins | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increase in pH | | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | pH | 7.76 | nd | n/a | | | |
| | | Mean of 24 Hours | | | | | | | |
| | | | pH | 7.77 | nd | n/a | | | |
| | Increased Frequency of Hypoxia | | | | | | | --- | Only 24 hour diel data and data are questionable |
| | | Percent of Observations in Daytime Point Measures | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | nd | n/a | | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | 50.4 | -50.4 | --- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | 0.1 | -0.1 | --- | | |
| | Increased Ammonia Concentrations | | | | | | | --- | |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.337 | 0.547 | -0.210 | --- | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP14 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | NE | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 4,4'-DDD (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | 4,4'-DDE (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrolein (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Acrylonitrile (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Aldrin (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | alpha-BHC (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | cis-1,3-Dichloropropene (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | delta-BHC (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Diazinon (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Dieldrin (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan I (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan II (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endosulfan sulfate (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin aldehyde (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Endrin (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor Epoxide (Isomer B) (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Heptachlor (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Methoxychlor (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDD (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDE (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | o,p'-DDT (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | p,p'-DDT (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Technical Chlordane (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | | Toxaphene (µg $L^{-1}$) | bdl | bdl | n/a | --- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | nd | n/a | | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | NE | |
| | | | | | No Data Available | | | | |
| | Increased Water Column Herbicides | | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | |
| | | | 2,3,7,8-TCDD (pg $L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4,5-TP (Silvex) (µg $L^{-1}$) | bdl | nd | n/a | | | |
| | | | 2,4'-D (µg $L^{-1}$) | bdl | nd | n/a | | | |

**Table 4.** Cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | SAP14 Value | Difference | Component Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | |
| | Increased Water Temperature | | | | | | | + | Only 24 hour diel data |
| | | Mean of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 26.4 | nd | n/a | | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 24.6 | 17.8 | 6.8 | + | | |
| | Decreased Variability in Water Temperature | | | | | | | + | Only 24 hour diel data |
| | | Range of Previous Quarter | | | | | | | |
| | | | Water Temperature (C) | 3.8 | nd | n/a | | | |
| | | Range of Diel Measurements (24hr) | | | | | | | |
| | | | Water Temperature (C) | 3.3 | 16.0 | -12.8 | + | | |

**Table 5. Summary of spatial co-occurrence comparisons between RD and each comparator site for the candidate causes and their component proximate stressors. Data are scored + for supporting evidence, --- for strongly weakening evidence, 0 for indeterminate evidence, or NE for no evidence.**

| Candidate Cause | Proximate Stressor | RD vs RE | Comment | RD vs RB | Comment |
|---|---|---|---|---|---|
| **Heavy Metals** | | | | | |
| | Increase in Dissolved Metals | --- | | + | Supporting evidence for |
| | Increase in Particulate Bound Metals | NE | | NE | |
| | Increase in Metals in Periphyton | NE | | NE | |
| **Elevated Conductivity** | | | | | |
| | Increase in Conductivity | --- | | + | |
| | Increase in Total Dissolved Solids | --- | Lower TDS and Hardness, but elevated Chloride | + | |
| **River Discontinuity** | | | | | |
| | Decrease in Recruitment | NE | | NE | |
| | Decrease in Woody Debris | --- | | --- | |
| | Decrease in Cobbles | + | | --- | |
| | Increase in Sands and Fines | --- | | --- | |
| | Burial of Cobbles | NE | Few if any cobbles observed, so measurements unreliable | NE | |
| | Increase in Simplified Habitat | 0 | | 0 | |
| **Habitat Simplification** | | | | | |
| | Change in Available Food | 0 | | --- | |
| | Increase in Channel Deepening | --- | | --- | |
| | Decrease in Riffles | NE | | NE | |
| | Decrease in Woody Debris | --- | | --- | |
| | Decrease in Cobbles | + | | --- | |
| | Increase in Sands and Fines | --- | | --- | |
| | Decrease in Undercut Banks | --- | | --- | |
| | Increase in Simplified Habitat | 0 | | 0 | |
| **Increased Nutrients** | | | | | |
| | Change in Algal Community | --- | | 0 | |
| | Increase in Algal Toxins | NE | | NE | |
| | Increase in pH | --- | | --- | Only 24hr measurements |
| | Increased Frequency of Hypoxia | --- | | --- | |
| | Increased Ammonia Concentrations | + | | --- | |
| **Pesticides** | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | NE | | NE | |
| | Increased Water Column Non-pyrethroid Pesticides | --- | All measurements below detection limit at both | --- | |
| | Increased Water Column Pyrethroid Pesticides | NE | | NE | |
| | Increased Sediment Pyrethroid Pesticides | NE | | NE | |
| | Increased Water Column Herbicides | --- | All measurements below | --- | |
| **Temperature** | | | | | |
| | Increased Water Temperature | 0 | Ambivilent in quarterly data, but higher in 24 hour diel data | --- | |
| | Decreased Variability in Water Temperature | + | | + | |

**Table 5.** Cont.

| Candidate Cause | Proximate Stressor | RD vs RC | Comment | RD vs RF | Comment |
|---|---|---|---|---|---|
| **Heavy Metals** | | | | | |
| | Increase in Dissolved Metals | + | Supporting evidence for Cu and Zn. Ambivilent evidence for Sn | NE | |
| | Increase in Particulate Bound Metals | NE | | NE | |
| | Increase in Metals in Periphyton | NE | | NE | |
| **Elevated Conductivity** | | | | | |
| | Increase in Conductivity | --- | | NE | |
| | Increase in Total Dissolved Solids | --- | | NE | |
| **River Discontinuity** | | | | | |
| | Decrease in Recruitment | NE | | NE | |
| | Decrease in Woody Debris | --- | | --- | |
| | Decrease in Cobbles | + | | + | |
| | Increase in Sands and Fines | --- | | | |
| | Burial of Cobbles | NE | Few if any cobbles observed, so measurements unreliable | NE | Few if any cobbles observed, so measurements unreliable |
| | Increase in Simplified Habitat | 0 | | 0 | |
| **Habitat Simplification** | | | | | |
| | Change in Available Food | --- | | --- | |
| | Increase in Channel Deepening | + | | + | |
| | Decrease in Riffles | NE | | NE | |
| | Decrease in Woody Debris | --- | | --- | |
| | Decrease in Cobbles | + | | + | |
| | Increase in Sands and Fines | --- | | --- | |
| | Decrease in Undercut Banks | --- | | --- | |
| | Increase in Simplified Habitat | 0 | | 0 | |
| **Increased Nutrients** | | | | | |
| | Change in Algal Community | --- | | + | |
| | Increase in Algal Toxins | NE | | NE | |
| | Increase in pH | --- | | --- | Only 24 hour diel data |
| | Increased Frequency of Hypoxia | --- | | --- | Only 24 hour diel data |
| | Increased Ammonia Concentrations | + | | + | |
| **Pesticides** | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | NE | | NE | |
| | Increased Water Column Non-pyrethroid Pesticides | --- | All measurements below detection limit at both sites | NE | |
| | Increased Water Column Pyrethroid Pesticides | NE | | NE | |
| | Increased Sediment Pyrethroid Pesticides | NE | | NE | |
| | Increased Water Column Herbicides | --- | | NE | |
| **Temperature** | | | | | |
| | Increased Water Temperature | + | | + | Only 24 hour diel data |
| | Decreased Variability in Water Temperature | + | | + | Only 24 hour diel data |

**Table 5.** Cont.

| Candidate Cause | Proximate Stressor | RD vs SAP8 | Comment | RD vs. SAP11 | Comment |
|---|---|---|---|---|---|
| **Heavy Metals** | | | | | |
| | Increase in Dissolved Metals | NE | | NE | |
| | Increase in Particulate Bound Metals | NE | | NE | |
| | Increase in Metals in Periphyton | NE | | NE | |
| **Elevated Conductivity** | | | | | |
| | Increase in Conductivity | NE | | NE | |
| | Increase in Total Dissolved Solids | NE | | NE | |
| **River Discontinuity** | | | | | |
| | Decrease in Recruitment | NE | | NE | |
| | Decrease in Woody Debris | --- | | --- | |
| | Decrease in Cobbles | + | | + | |
| | Increase in Sands and Fines | --- | | --- | |
| | Burial of Cobbles | NE | Few if any cobbles observed, so measurements unreliable | NE | Few if any cobbles observed, so measurements unreliable |
| | Increase in Simplified Habitat | 0 | | + | |
| **Habitat Simplification** | | | | | |
| | Change in Available Food | --- | | + | |
| | Increase in Channel Deepening | 0 | | + | |
| | Decrease in Riffles | NE | | NE | |
| | Decrease in Woody Debris | --- | | --- | |
| | Decrease in Cobbles | + | | + | |
| | Increase in Sands and Fines | --- | | --- | |
| | Decrease in Undercut Banks | --- | | --- | |
| | Increase in Simplified Habitat | 0 | | + | |
| **Increased Nutrients** | | | | | |
| | Change in Algal Community | 0 | | + | |
| | Increase in Algal Toxins | NE | | NE | |
| | Increase in pH | --- | Only 24 hour diel data | --- | Only 24 hour diel data |
| | Increased Frequency of Hypoxia | --- | Only 24 hour diel data | --- | Only 24 hour diel data |
| | Increased Ammonia Concentrations | + | | + | |
| **Pesticides** | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | NE | | NE | |
| | Increased Water Column Non-pyrethroid Pesticides | NE | | NE | |
| | Increased Water Column Pyrethroid Pesticides | NE | | NE | |
| | Increased Sediment Pyrethroid Pesticides | NE | | NE | |
| | Increased Water Column Herbicides | NE | | NE | |
| **Temperature** | | | | | |
| | Increased Water Temperature | + | Only 24 hour diel data | + | Only 24 hour diel data |
| | Decreased Variability in Water Temperature | + | Only 24 hour diel data | + | Only 24 hour diel data |

**Table 5.** Cont.

| Candidate Cause | Proximate Stressor | RD vs SAP14 | Comment |
|---|---|---|---|
| **Heavy Metals** | | | |
| | Increase in Dissolved Metals | NE | |
| | Increase in Particulate Bound Metals | NE | |
| | Increase in Metals in Periphyton | NE | |
| **Elevated Conductivity** | | | |
| | Increase in Conductivity | NE | |
| | Increase in Total Dissolved Solids | NE | |
| **River Discontinuity** | | | |
| | Decrease in Recruitment | NE | |
| | Decrease in Woody Debris | --- | |
| | Decrease in Cobbles | --- | |
| | Increase in Sands and Fines | --- | |
| | Burial of Cobbles | NE | Few if any cobbles observed, so measurements unreliable |
| | Increase in Simplified Habitat | + | |
| **Habitat Simplification** | | | |
| | Change in Available Food | + | |
| | Increase in Channel Deepening | + | |
| | Decrease in Riffles | NE | |
| | Decrease in Woody Debris | --- | |
| | Decrease in Cobbles | --- | |
| | Increase in Sands and Fines | --- | |
| | Decrease in Undercut Banks | --- | |
| | Increase in Simplified Habitat | + | |
| **Increased Nutrients** | | | |
| | Change in Algal Community | + | |
| | Increase in Algal Toxins | NE | |
| | Increase in pH | NE | |
| | Increased Frequency of Hypoxia | --- | Only 24 hour diel data and |
| | Increased Ammonia Concentrations | --- | |
| **Pesticides** | | | |
| | Increased Sediment Non-pyrethroid Pesticides | NE | |
| | Increased Water Column Non-pyrethroid Pesticides | NE | |
| | Increased Water Column Pyrethroid Pesticides | NE | |
| | Increased Sediment Pyrethroid Pesticides | NE | |
| | Increased Water Column Herbicides | NE | |
| **Temperature** | | | |
| | Increased Water Temperature | + | Only 24 hour diel data |
| | Decreased Variability in Water Temperature | + | Only 24 hour diel data |

## Stressor-Response from the Field

The stressor-response line of evidence also had relatively good coverage across all of the candidate causes and nearly all of the proximate stressors could be evaluated. Stressor response relationships were evaluated by calculating Spearman's rank correlations between the different proximate stressors and the three biological response variables: % non-insect taxa, % tolerant taxa, and the number of predator taxa observed at RD and the seven comparator sites. The % non-insect taxa and % tolerant taxa are negative measures of community structure and habitat quality, which would be expected to increase as habitat is degraded. Conversely, the number of predator taxa is a positive measure of community structure and habitat quality, which would be expected to decrease as habitat is degraded.

Data were scored based upon the rho (ρ) value of the correlation and the direction of the expected relationship between the biological endpoints and the different proximate stressors – a negative variable (e.g., % sands and fines) with negative biology would be a direct relationship, while a positive variable (% woody debris) with a negative biology would be an inverse relationship. As an example of an expected direct relationship: ρ= -1 – -0.9 would be scored --, ρ <-0.9 – -0.75 would be scored -, ρ <-0.75 – <0.75 would be scored 0, ρ= 0.75 - <0.9 would be scored +, and ρ = 0.9 – 1.0 would be scored ++. This pattern would be reversed for any expected inverse relationship. Any relationship scored ++ or -- was investigated visually by plotting the proximate stressor and the biological endpoint and looking for spurious or less compelling relationships. If there was a question about the pattern of the correlation versus the ρ-value, the ++ or -- was changed to + or -. Additionally, if a chemical compound (i.e., metals or pesticides) was below detection limit at RD, it was scored --. Note that data evaluation in the CADDIS framework is not built around hypothesis testing, so the statistical significance of any one correlation was not considered in scoring. The rho values were used to quantify the nature of any relationship between stressor and biotic measurements. The correlation coefficients for the three biological endpoints (% tolerant taxa, % of non-insect taxa, and # of predator taxa) and the different components of each candidate cause are presented in Table 6. The scores from these evaluations are presented in Table 7.

**Table 6. Detailed correlation and scoring of within the case stressor-response data across the three biological endpoints for each proximate stressors and their candidate causes. Data are scored ++ for a strongly supporting response, + for a supporting response, 0 for ambivalent response, - for a weakening response, -- for a strongly weakening response, and NE for no evidence. bdl = below detection limit.**

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | % Non-Insect Taxa Rho | % Non-Insect Taxa Score | % Non-Insect Taxa Proximate Stressor Score | % Non-Insect Taxa comment | Predator Taxa Rho | Predator Taxa Score | Predator Taxa Proximate Stressor Score | Predator Taxa comment | % Tolerant Taxa Rho | % Tolerant Taxa Score | % Tolerant Taxa Proximate Stressor Score | % Tolerant Taxa comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | - | Supporting evidence for Zn, but weakening evidence for As, Ba, Be, Hg, Ni, Se, and Tl | | | - | Supporting evidence for Zn, but weakening evidence for As, Ba, Be, Hg, Ni, Se, and Tl | | | - | |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | | | | | | | |
| | | | Antimony (µg L$^{-1}$) | 0.200 | 0 | | | -0.200 | 0 | | | -1.000 | -- | | |
| | | | Arsenic (µg L$^{-1}$) | -0.800 | - | | | 0.800 | - | | | 0.400 | 0 | | |
| | | | Barium (µg L$^{-1}$) | -0.800 | - | | | 0.800 | - | | | 0.400 | 0 | | |
| | | | Beryllium (µg L$^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Cadmium (µg L$^{-1}$) | -0.632 | 0 | | | 0.632 | 0 | | | 0.211 | 0 | | |
| | | | Chromium (µg L$^{-1}$) | -0.211 | 0 | | | 0.211 | 0 | | | 0.211 | 0 | | |
| | | | Copper (µg L$^{-1}$) | 0.400 | 0 | | | -0.400 | 0 | | | -0.800 | - | | |
| | | | Hexavalent Chromium (mg L$^{-1}$) | -0.258 | 0 | | | 0.258 | 0 | | | 0.258 | 0 | | |
| | | | Iron (mg L$^{-1}$) | 0.258 | 0 | | | -0.258 | 0 | | | -0.258 | 0 | | |
| | | | Lead (µg L$^{-1}$) | 0.400 | 0 | | | -0.400 | 0 | | | -0.800 | - | | |
| | | | Mercury (µg L$^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Nickel (µg L$^{-1}$) | -1.000 | -- | | | 1.000 | -- | | | 0.200 | 0 | | |
| | | | Selenium (µg L$^{-1}$) | -0.800 | - | | | 0.800 | - | | | 0.400 | 0 | | |
| | | | Silver (µg L$^{-1}$) | -0.258 | 0 | | | 0.258 | 0 | | | 0.258 | 0 | | |
| | | | Thallium (µg L$^{-1}$) | n/a | -- | | | n/a | -- | | | n/a | -- | | |
| | | | Zinc (µg L$^{-1}$) | 1.000 | ++ | | | -1.000 | ++ | | | -0.200 | 0 | | |
| | Increase in Particulate Bound Metals | | | | | NE | | | | NE | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| | Increase in Metals in Periphyton | | | | | NE | | | | NE | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| **Elevated Conductivity** | | | | | | | | | | | | | | | |
| | Increase in Conductivity | | | | | - | | | | - | | | | 0 | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | |
| | | | Conductivity mmhos cm$^{-1}$ | -0.800 | - | | | 0.800 | - | | | 0.400 | 0 | | |
| | Increase in Total Dissolved Solids | | | | | - | | | | - | | | | 0 | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | |
| | | | TDS (mg L$^{-1}$) | -0.800 | - | | | 0.800 | - | | | 0.400 | 0 | | |
| | | | Chloride (mg L$^{-1}$) | 0.000 | 0 | | | 0.000 | 0 | | | -0.400 | 0 | | |
| | | | Hardness (mg L$^{-1}$) | -0.800 | - | | | 0.800 | - | | | 0.400 | 0 | | |

**Table 6** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | % Non-Insect Taxa Rho | % Non-Insect Taxa Score | % Non-Insect Taxa Proximate Stressor Score | % Non-Insect Taxa comment | Predator Taxa Rho | Predator Taxa Score | Predator Taxa Proximate Stressor Score | Predator Taxa comment | % Tolerant Taxa Rho | % Tolerant Taxa Score | % Tolerant Taxa Proximate Stressor Score | % Tolerant Taxa comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **River Discontinuity** | | | | | | | | | | | | | | | |
| | Decrease in Recruitment | | | | | NE | | | | NE | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| | Decrease in Woody Debris | | | | | 0 | | | | 0 | | | | 0 | |
| | | Length of Reach Where Present | | | | | | | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | -0.514 | 0 | | | 0.254 | 0 | | | 0.303 | 0 | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.000 | 0 | | | -0.222 | 0 | | | 0.000 | 0 | | |
| | Decrease in Cobbles | | | | | 0 | | | | 0 | | | | 0 | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | |
| | | | Cobbles (%) | -0.175 | 0 | | | -0.051 | 0 | | | 0.590 | 0 | | |
| | Increase in Sands and Fines | | | | | 0 | | | | 0 | | | | 0 | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | |
| | | | Sands and Fines (%) | 0.262 | 0 | | | -0.182 | 0 | | | 0.268 | 0 | | |
| | Burial of Cobbles | | | | | NE | | | | 0 | | | | 0 | |
| | | Mean % of Cobbles Embeddedness | | | | | | | | | | | | | |
| | | | Cobble Embeddedness (%) | 0.144 | 0 | | | -0.275 | 0 | | | 0.300 | 0 | | |
| | Increase in Simplified Habitat | | | | | 0 | | | | 0 | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | | | | | | | |
| | | | Euclidean Distance from RD | 0.214 | 0 | | | -0.600 | 0 | | | 0.378 | 0 | | |
| **Habitat Simplification** | | | | | | | | | | | | | | | |
| | Change in Available Food | | | | | 0 | | | | 0 | | | | 0 | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | | | | | | | |
| | | | Euclidean Distance from RD | 0.107 | 0 | | | -0.400 | 0 | | | 0.090 | 0 | | |
| | Increase in Channel Deepening | | | | | 0 | | | | 0 | | | | 0 | |
| | | | Mean Thalweg Depth (cm) | -0.048 | 0 | | | 0.133 | 0 | | | -0.195 | 0 | | |
| | Decrease in Riffles | | | | | NE | | | | NE | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| | Decrease in Woody Debris | | | | | 0 | | | | 0 | | | | 0 | |
| | | Length of Reach Where Present | | | | | | | | | | | | | |
| | | | Small (<0.3m length) Woody Debris (m) | -0.514 | 0 | | | 0.254 | 0 | | | 0.303 | 0 | | |
| | | | Large (>0.3m length) Woody Debris (m) | 0.000 | 0 | | | -0.222 | 0 | | | 0.000 | 0 | | |
| | Decrease in Cobbles | | | | | 0 | | | | 0 | | | | 0 | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | |
| | | | Cobbles (%) | -0.175 | 0 | | | -0.051 | 0 | | | 0.590 | 0 | | |
| | Increase in Sands and Fines | | | | | 0 | | | | 0 | | | | 0 | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | |
| | | | Sands and Fines (%) | 0.262 | 0 | | | -0.182 | 0 | | | 0.268 | 0 | | |
| | Decrease in Undercut Banks | | | | | -- | | | | -- | | | | 0 | |
| | | Length of Reach Where Present | | | | | | | | | | | | | |
| | | | Undercut banks (m) | n/a | -- | | | n/a | -- | | | n/a | | | |
| | Increase in Simplified Habitat | | | | | 0 | | | | 0 | | | | 0 | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | | | | | | | |
| | | | Euclidean Distance from RD | 0.214 | 0 | | | -0.600 | 0 | | | 0.378 | 0 | | |

**Table 6** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | % Non-Insect Taxa: Rho | % Non-Insect Taxa: Score | % Non-Insect Taxa: Proximate Stressor Score | % Non-Insect Taxa: comment | Predator Taxa: Rho | Predator Taxa: Score | Predator Taxa: Proximate Stressor Score | Predator Taxa: comment | % Tolerant Taxa: Rho | % Tolerant Taxa: Score | % Tolerant Taxa: Proximate Stressor Score | % Tolerant Taxa: comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Increased Nutrients** | | | | | | | | | | | | | | | |
| | Change in Algal Community | | | | | 0 | | | | 0 | | | | 0 | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | | | | | | | |
| | | | Bray-Curtis Similarity to RD | -0.321 | 0 | | | 0.436 | 0 | | | 0.018 | 0 | | |
| | Increase in Algal Toxins | | | | | NE | | | | | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| | Increase in pH | | | | | 0 | | | | 0 | | | | 0 | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | |
| | | | pH | -0.400 | 0 | | | 0.400 | 0 | | | 0.000 | 0 | | |
| | | Mean of 24 Hours | | | | | | | | | | | | | |
| | | | pH | 0.429 | 0 | | | -0.441 | 0 | | | -0.058 | 0 | | |
| | Increased Frequency of Hypoxia | | | | | 0 | based primarily on 24 hour data | | | 0 | based primarily on 24 hour data | | | 0 | based primarily on 24 hour data |
| | | Percent of Observations in Daytime Point Measures | | | | | | | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | n/a | -- | | | n/a | -- | | | n/a | -- | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | n/a | -- | | | n/a | -- | | | n/a | -- | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0.655 | 0 | | | -0.540 | 0 | | | -0.303 | 0 | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0.577 | 0 | | | -0.504 | 0 | | | -0.423 | 0 | | |
| | Increased Ammonia Concentrations | | | | | 0 | | | | 0 | | | | 0 | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.382 | 0 | | | -0.306 | 0 | | | -0.419 | 0 | | |

**Table 6** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | % Non-Insect Taxa Rho | Score | Proximate Stressor Score | comment | Predator Taxa Rho | Score | Proximate Stressor Score | comment | % Tolerant Taxa Rho | Score | Proximate Stressor Score | comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides** | | | | | | | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | NE | | | | NE | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | -- | | | | -- | | | | -- | |
| | | Maximum Value of Previous Year | | | | | | | | | | | | | |
| | | | 4,4'-DDD (mg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | 4,4'-DDE (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Acrolein (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Acrylonitrile (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Aldrin (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | alpha-BHC (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | cis-1,3-Dichloropropene (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | delta-BHC (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Diazinon (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Dieldrin (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Endosulfan I (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Endosulfan II (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Endosulfan sulfate (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Endrin aldehyde (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Endrin (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Heptachlor Epoxide (Isomer B) (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Heptachlor (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Methoxychlor (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | o,p'-DDD (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | o,p'-DDE (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | o,p'-DDT (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | p,p'-DDT (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Technical Chlordane (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | Toxaphene (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | nd | 0 | | | nd | 0 | | | nd | 0 | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | NE | | | | NE | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | NE | | | | NE | | | | NE | |
| | | | | No Data Available | | | | No Data Available | | | | No Data Available | | | |
| | Increased Water Column Herbicides | | | | | -- | | | | -- | | | | -- | |
| | | Maximum Value of Previous Year | | | | | | | | | | | | | |
| | | | 2,3,7,8-TCDD (pg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | 2,4,5-TP (Silvex) (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |
| | | | 2,4'-D (µg $L^{-1}$) | bdl | -- | | | bdl | -- | | | bdl | -- | | |

**Table 6** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | % Non-Insect Taxa: Rho | Score | Proximate Stressor Score | comment | Predator Taxa: Rho | Score | Proximate Stressor Score | comment | % Tolerant Taxa: Rho | Score | Proximate Stressor Score | comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | | | | | | | |
| | Increased Water Temperature | | | | | + | | | | + | | | | 0 | |
| | | Mean of Previous Quarter | | | | | Only from RB, RC, RD & RE sites | | | | Only from RB, RC, RD & RE sites | | | | Only RB, RC, RD, RE sites |
| | | | Water Temperature (C) | 0.800 | + | | | -0.800 | + | | | -0.400 | 0 | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | | | | | | | |
| | | | Water Temperature (C) | -0.119 | 0 | | | 0.327 | 0 | | | -0.415 | 0 | | |
| | Decreased Variability in Water Temperature | | | | | + | | | | + | | | | 0 | |
| | | Range of Previous Quarter | | | | | Only from RB, RC, RD & RE sites | | | | Only from RB, RC, RD & RE sites | | | | Only from RB, RC, RD & RE sites |
| | | | Water Temperature (C) | 0.800 | + | | | -0.800 | + | | | 0.400 | 0 | | |
| | | Range of Diel Measurements (24hr) | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 0.429 | 0 | | | -0.291 | 0 | | | -0.244 | 0 | | |

**Table 7. Summary within the case stressor-response scores across the three biological endpoints for each proximate stressor in the candidate causes.**

| Candidate Cause | Proximate Stressor | % Non-Insect Taxa: Proximate Stressor Score | % Non-Insect Taxa: comment | Predator Taxa: Proximate Stressor Score | Predator Taxa: comment | % Tolerant Taxa: Proximate Stressor Score | % Tolerant Taxa: comment |
|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | |
| | Increase in Dissolved Metals | - | Supporting evidence for Zn, but weakening evidence for As, Ba, Be, Hg, Ni, Se, and Tl | - | Supporting evidence for Zn, but weakening evidence for As, Ba, Be, Hg, Ni, Se, and Tl | - | |
| | Increase in Particulate Bound Metals | NE | | NE | | NE | |
| | Increase in Metals in Periphyton | NE | | NE | | NE | |
| **Elevated Conductivity** | | | | | | | |
| | Increase in Conductivity | - | | - | | 0 | |
| | Increase in Total Dissolved Solids | - | | - | | 0 | |
| **River Discontinuity** | | | | | | | |
| | Decrease in Recruitment | NE | | NE | | NE | |
| | Decrease in Woody Debris | 0 | | 0 | | 0 | |
| | Decrease in Cobbles | 0 | | 0 | | 0 | |
| | Increase in Sands and Fines | 0 | | 0 | | 0 | |
| | Burial of Cobbles | NE | | 0 | | 0 | |
| | Increase in Simplified Habitat | 0 | | 0 | | 0 | |
| **Habitat Simplification** | | | | | | | |
| | Change in Available Food | 0 | | 0 | | 0 | |
| | Increase in Channel Deepening | 0 | | 0 | | | |
| | Decrease in Riffles | NE | | NE | | NE | |
| | Decrease in Woody Debris | 0 | | 0 | | 0 | |
| | Decrease in Cobbles | 0 | | 0 | | 0 | |
| | Increase in Sands and Fines | 0 | | 0 | | 0 | |
| | Decrease in Undercut Banks | -- | | -- | | 0 | |
| | Increase in Simplified Habitat | 0 | | 0 | | 0 | |
| **Increased Nutrients** | | | | | | | |
| | Change in Algal Community | 0 | | 0 | | 0 | |
| | Increase in Algal Toxins | NE | | NE | | NE | |
| | Increase in pH | 0 | | 0 | | 0 | |
| | Increased Frequency of Hypoxia | 0 | based primarily on 24 hour data | 0 | based primarily on 24 hour data | 0 | based primarily on 24 hour data |
| | Increased Ammonia Concentrations | | | 0 | | 0 | |
| **Pesticides** | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | NE | | NE | | NE | |
| | Increased Water Column Non-pyrethroid Pesticides | -- | | -- | | -- | |
| | Increased Water Column Pyrethroid Pesticides | NE | | NE | | NE | |
| | Increased Sediment Pyrethroid Pesticides | NE | | NE | | NE | |
| | Increased Water Column Herbicides | -- | | -- | | -- | |
| **Temperature** | | | | | | | |
| | Increased Water Temperature | + | | + | | 0 | |
| | Decreased Variability in Water Temperature | + | | + | | 0 | |

## Data Analysis from Outside the Case

### Reference Condition Comparison

The idea of this line of evidence was to provide context for the level of a given proximate stressor at the test site and to determine how different the observed value was from that seen in geographically similar reference sites. This comparison was made by characterizing the distribution of the proximate stressor values in the pool of reference sites, calculating the median, upper quartile, lower quartile, upper fence values (the upper quartile + 1.75X the interquartile range), and lower fence values. These types of data can be plotted in a schematic box and whisker plot (Tukey 1977) overlaid with the RD value for ease of display and interpretation (Figure 11). Reference sites from the large bioassessment database available in California. (see Ode et al in press for reference definition) were selected as similar based upon slope (<1.5%) and elevation (<333 m). Data from the RD site were scored as follows (assuming a negative stressor): if the RD value was less than the upper quartile, then score = -; if the RD value was between the upper quartile and the upper fence, then score = 0; and if the RD value was greater than the upper fence, then score = +. If the proximate stressor was the loss of a positive variable, then the same rules would apply, but with reference to the lower quartile and fence values.

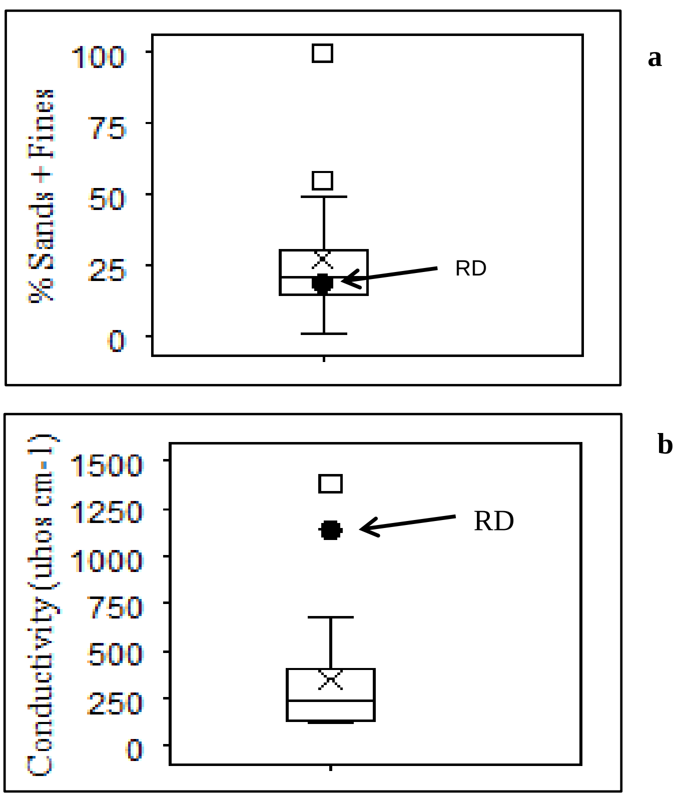



**Figure 11. Examples of reference condition comparisons for outside of the case portions of the assessment. The box plot describes the reference site distribution of conductivity (a), and % Sands + Fines (b). The components of the plot are the solid line representing the median, the span of the box illustrating the upper and lower quartile, the whiskers are 1.75X the interquartile range, the cross representing the mean, and the hollow squares show outlier values. The dark circle overlaid represents the observed value at the test site.**

It should be noted though, that not every bioassessment program has collected the same types of data. As such, after the reference sites for evaluation of the of the RD site were selected from the larger pool of California sites, the only variables where there was enough data coverage were conductivity and % sands&fines, Within the elevated conductivity candidate cause, the monthly mean conductivity value at RD from the previous quarter (1207 μmhos $cm^{-1}$) was well above the upper fence value (683 μmhos $cm^{-1}$), scoring the proximate stressor +. Consequently, the overall candidate cause score for elevated conductivity was also scored +. Data were available to evaluate % sands&fines, which was part of both the river discontinuity and habitat simplification candidate causes. The observed % sands&fines (19.1) at RD was between the 1st and 3rd quartile value of the reference sites (15.2 – 30.5), was scored -. As % sands&fines were the only proximate stressor that could be evaluated in either candidate cause, both river discontinuity and habitat simplification were scored - as well.

## Stressor-Response from Other Field Studies

A relative risk approach (Van Sickle et al. 2006, Agresti 2007) was used to characterize and provide context to the observed relationships between the different biological endpoints and different proximate stressors at RD. These analyses were designed to assess whether the degraded biological condition captured in each biological endpoint could be the result of the observed level of the proximate stressor based upon patterns seen in other, environmentally similar sites within the State of California. Like the reference condition comparisons, sites were selected based upon slope (<1.5%) and elevation (<333 m) from the large bioassessment database available in California. An important difference however, was that both reference and non-reference sites (540 samples from 515 sites) were selected to span the range of potential biological and stressor conditions.

For these analyses, semi-continuous relative risk values were calculated for all proximate stressors where enough data were available. Relative risk is part of the larger topic of contingency table analysis (Van Sickle et al. 2006, Agresti 2007) and as such, thresholds that classify both stressor and biological data into degraded/non-degraded categories must be created. Thresholds for the Southern California IBI metrics used as biological endpoints were set at metric values that would produce a metric score of 4 (see Ode et al. 2005 for metric values), below which they would be considered impaired for this analysis. The relative risk of observing degraded biology with 95% confidence intervals were then calculated at 50+ increments (i.e., thresholds) of the proximate stressors observed across the environmentally similar sites from the state's biomonitoring database.

Proximate stressor data from the RD site were scored based upon the risk (+/- the 95% confidence interval) of the observed level of the stressor causing the degraded biological conditions (Figure 12). If the observed biological endpoint was not at impaired levels (a SoCal IBI metric score of 4 in this case), the line of evidence was scored "--" regardless of the level of stressor observed. If impaired biology was observed and the relative risk plus the confidence interval was less than 1, then the data would be scored as -. If impaired biology was observed and relative risk minus the confidence interval was greater than 1.2, then the data would be scored as +. If impaired biology was observed and the relative risk +/- the confidence interval was between 1 and 1.2 then the data would be scored 0.

Data for calculation of relative risks were not available for any of the proximate stressors associated with the increased nutrients, pesticides, or temperature candidate causes (consequently scored NE). Values of the different proximate stressors observed at RD and the relative risk associated with that value to each of the four biological endpoints are presented in Table 8. A summary of all the scores for each proximate stressor are presented in Table 9.

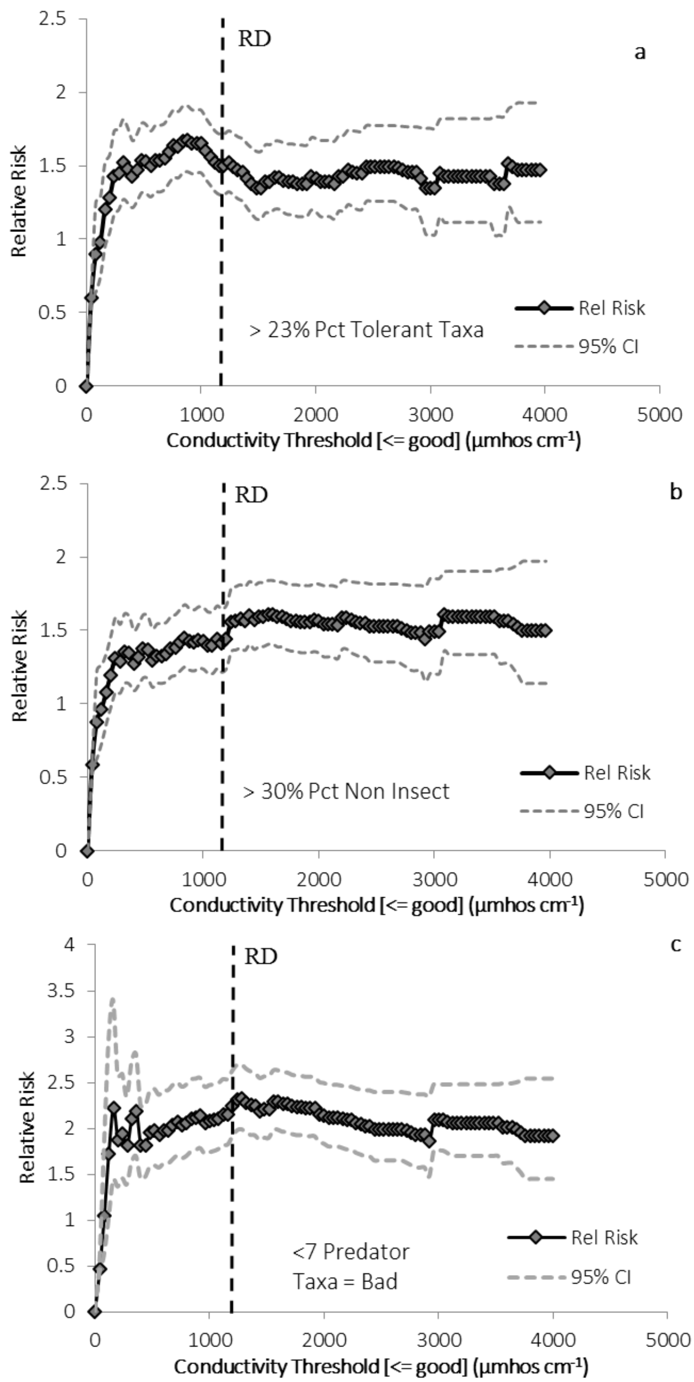



**Figure 12. Examples of continuous relative risk plots using conductivity as the stressor and % tolerant taxa (a), % non-insect taxa (b), and number of predator taxa (c) as biological endpoints. The solid dark line with grey diamonds represent the relative risk of observing biological impact at each respective value of the stressor, the dashed line represents the 95% confidence interval in that relative risk estimate, and the vertical dashed line represents the observed level of the stressor at the test site. Each panel describes the level of each biological endpoint above which was considered indicative of impaired conditions.**

**Table 8. Detailed scoring sheet for the outside of the case stressor-response from other field studies across each of the four biological endpoints for each proximate stressors and the components therein. For those components where they could be calculated, relative risk (Rel Risk) and 95% confidence intervals (UCI and LCI) are provided. Collector-gather abundance, % non-insect taxa, and number of predator taxa at RD were below the relative risk biotic threshold, so they were scored "--" by default.**

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | % Non Insect Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | % Tolerant Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | # of Predator Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | | | | | | | | | | | | | | | | |
| | Increase in Dissolved Metals | | | | | | | | -- | Only evaluated Copper, Lead, and Zinc | | | | | 0 | | | | | | -- | Only evaluated Copper and Zinc |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | | | | | | | | | | | | | | | | | |
| | | | Antimony ($\mu g\ L^{-1}$) | 0.63 | | | | | | | | | | | | | | | | | | |
| | | | Arsenic ($\mu g\ L^{-1}$) | 0.82 | | | | | | | | | | | | | | | | | | |
| | | | Barium ($\mu g\ L^{-1}$) | 41.70 | | | | | | | | | | | | | | | | | | |
| | | | Beryllium ($\mu g\ L^{-1}$) | 0.13 | | | | | | | | | | | | | | | | | | |
| | | | Cadmium ($\mu g\ L^{-1}$) | 0.09 | | | | | | | | | | | | | | | | | | |
| | | | Chromium ($\mu g\ L^{-1}$) | 0.23 | | | | | | | | | | | | | | | | | | |
| | | | Copper ($\mu g\ L^{-1}$) | 3.42 | 1.00 | 0.73 | 1.38 | -- | | | 0.94 | 0.75 | 1.19 | 0 | | | 1.09 | 0.97 | 1.22 | -- | | |
| | | | Hexavalent Chromium (mg $L^{-1}$) | 0.01 | | | | | | | | | | | | | | | | | | |
| | | | Iron (mg $L^{-1}$) | 0.10 | | | | | | | | | | | | | | | | | | |
| | | | Lead ($\mu g\ L^{-1}$) | 0.10 | 1.40 | 0.48 | 4.04 | -- | | | 1.07 | 0.56 | 2.03 | 0 | | | | | | | | |
| | | | Mercury ($\mu g\ L^{-1}$) | 0.02 | | | | | | | | | | | | | | | | | | |
| | | | Nickel ($\mu g\ L^{-1}$) | 6.86 | | | | | | | | | | | | | | | | | | |
| | | | Selenium ($\mu g\ L^{-1}$) | 1.33 | | | | | | | | | | | | | | | | | | |
| | | | Silver ($\mu g\ L^{-1}$) | 0.13 | | | | | | | | | | | | | | | | | | |
| | | | Thallium ($\mu g\ L^{-1}$) | 0.13 | | | | | | | | | | | | | | | | | | |
| | | | Zinc ($\mu g\ L^{-1}$) | 27.97 | 1.08 | 0.72 | 1.61 | -- | | | 0.94 | 0.65 | 1.37 | 0 | | | 1.09 | 0.99 | 1.21 | -- | | |
| | Increase in Particulate Bound Metals | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| | Increase in Metals in Periphyton | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| **Elevated Conductivity** | | | | | | | | | | | | | | | | | | | | | | |
| | Increase in Conductivity | | | | | | | | -- | | | | | | + | | | | | | -- | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | | | | | | | | |
| | | | Conductivity mmhos $cm^{-1}$ | 1233.9 | 1.44 | 1.24 | 1.67 | -- | | | 1.50 | 1.31 | 1.72 | + | | | 2.24 | 1.91 | 2.63 | + | | |
| | Increase in Total Dissolved Solids | | | | | | | | NE | | | | | | NE | | | | | | | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | | | | | | | | |
| | | | TDS (mg $L^{-1}$) | 788 | | | | | | | | | | | | | | | | | | |
| | | | Chloride (mg $L^{-1}$) | 128.5 | | | | | | | | | | | | | | | | | | |
| | | | Hardness (mg $L^{-1}$) | 350 | | | | | | | | | | | | | | | | | | |

**Table 8** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | % Non Insect Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | % Tolerant Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | # of Predator Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **River Discontinuity** | | | | | | | | | | | | | | | | | | | | | | |
| | Decrease in Recruitment | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| | Decrease in Woody Debris | | | | | | | | -- | | | | | | 0 | | | | | | -- | |
| | | Length of Reach Where Present | | | | | | | | | | | | | | | | | | | | |
| | | | Length w/ Small + Large Woody Debris | 5.45 | 0.71 | 0.48 | 1.05 | -- | | | 0.86 | 0.62 | 1.19 | 0 | | | 1.23 | 0.78 | 1.93 | -- | | |
| | Decrease in Cobbles | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | | | | | | | | |
| | | | Cobbles (%) | 0.0 | | | | | | | | | | | | | | | | | | |
| | Increase in Sands and Fines | | | | | | | | -- | | | | | | + | | | | | | -- | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 1.86 | 1.39 | 2.50 | -- | | | 1.68 | 1.28 | 2.20 | + | | | 1.00 | 0.77 | 1.28 | -- | | |
| | Burial of Cobbles | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Mean % of Cobbles Embeddedness | | | | | | | | | | | | | | | | | | | | |
| | | | Cobble Embeddedness (%) | 0 | | | | | | | | | | | | | | | | | | |
| | Increase in Simplified Habitat | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | | | | | | | | | | | | | | |
| | | | Euclidean Distance from RD | | | | | | | | | | | | | | | | | | | |
| **Habitat Simplification** | | | | | | | | | | | | | | | | | | | | | | |
| | Change in Available Food | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | nMDS Comparison of Sites Based Upon Food Type Availability | | | | | | | | | | | | | | | | | | | | |
| | | | Euclidean Distance from RD | | | | | | | | | | | | | | | | | | | |
| | Increase in Channel Deepening | | | | | | | | -- | | | | | | 0 | | | | | | -- | |
| | | | Mean Thalweg Depth (cm) | 26.5 | 1.35 | 0.98 | 1.86 | -- | | | 1.03 | 0.77 | 1.37 | 0 | | | 0.90 | 0.61 | 1.32 | -- | | |
| | Decrease in Riffles | | | | | | | | NE | | | | | | | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| | Decrease in Woody Debris | | | | | | | | -- | | | | | | 0 | | | | | | -- | |
| | | Length of Reach Where Present | | | | | | | | | | | | | | | | | | | | |
| | | | Length w/ Small + Large Woody Debris | 5.5 | 0.71 | 0.48 | 1.05 | -- | | | 0.86 | 0.62 | 1.19 | 0 | | | 1.23 | 0.78 | 1.93 | -- | | |
| | Decrease in Cobbles | | | | | | | | -- | | | | | | | | | | | | NE | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | | | | | | | | |
| | | | Cobbles (%) | 0.0 | | | | | | | | | | | | | | | | | | |
| | Increase in Sands and Fines | | | | | | | | -- | | | | | | + | | | | | | -- | |
| | | % of Reach Area Where Present | | | | | | | | | | | | | | | | | | | | |
| | | | Sands and Fines (%) | 19.1 | 1.86 | 1.39 | 2.50 | -- | | | 1.68 | 1.28 | 2.20 | + | | | 1.00 | 0.77 | 1.28 | -- | | |
| | Decrease in Undercut Banks | | | | | | | | -- | | | | | | 0 | | | | | | -- | |
| | | Length of Reach Where Present | | | | | | | | | | | | | | | | | | | | |
| | | | Undercut banks (m) | 5 | 0.65 | 0.49 | 0.87 | -- | | | 0.82 | 0.59 | 1.13 | 0 | | | 0.56 | 0.38 | 0.81 | -- | | |
| | Increase in Simplified Habitat | | | | | | | | NE | | | | | | NE | | | | | | | |
| | | nMDS Comparison of Sites Based on Habitat Types Present | | | | | | | | | | | | | | | | | | | | |
| | | | Euclidean Distance from RD | | | | | | | | | | | | | | | | | | | |

**Table 8** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | % Non Insect Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | % Tolerant Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | # of Predator Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Increased Nutrients** | | | | | | | | | | | | | | | | | | | | | | |
| | Change in Algal Community | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | nMDS Comparison of Sites Based on Diatom Communty Structure | | | | | | | | | | | | | | | | | | | | |
| | | | Bray-Curtis Similarity to RD | | | | | | | | | | | | | | | | | | | |
| | Increase in Algal Toxins | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| | Increase in pH | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | | | | | | | | |
| | | | pH | 7.76 | | | | | | | | | | | | | | | | | | |
| | | Mean of 24 Hours | | | | | | | | | | | | | | | | | | | | |
| | | | pH | 7.77 | | | | | | | | | | | | | | | | | | |
| | Increased Frequency of Hypoxia | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Percent of Observations in Daytime Point Measures | | | | | | | | | | | | | | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | | | | | | | | | | | | | | | | | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | | | | | | | | | | | | | | | | | | |
| | | Percent of Observations in Diel Measures (24hrs) | | | | | | | | | | | | | | | | | | | | |
| | | | Mild Hypoxia (2-5 mg $L^{-1}$ Dissolved Oxygen) | 0 | | | | | | | | | | | | | | | | | | |
| | | | Hypoxia (<2.0 mg $L^{-1}$ Dissolved Oxygen) | 0 | | | | | | | | | | | | | | | | | | |
| | Increased Ammonia Concentrations | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | | | | | | | | |
| | | | Ammonia (mg $L^{-1}$) | 0.34 | | | | | | | | | | | | | | | | | | |

**Table 8** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | % Non Insect Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | % Tolerant Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | | | | | | | |
| | Increased Water Temperature | | | | | | | | NE | | | | | | NE |
| | | Mean of Previous Quarter | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 26.4 | | | | | | | | | | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 24.6 | | | | | | | | | | | |
| | Decreased Variability in Water Temperature | | | | | | | | NE | | | | | | NE |
| | | Range of Previous Quarter | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 3.8 | | | | | | | | | | | |
| | | Range of Diel Measurements (24hr) | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 3.3 | | | | | | | | | | | |

**Table 8** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | % Non Insect Taxa | | | | Proximate Stressor Score | Comment | % Tolerant Taxa | | | | Proximate Stressor Score | Comment | # of Predator Taxa | | | | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Rel Risk | LCI | UCI | Score | | | Rel Risk | LCI | UCI | Score | | | Rel Risk | LCI | UCI | Score | | |
| **Pesticides** | | | | | | | | | | | | | | | | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | | | | | | | | | | | | | | |
| | | | 4,4'-DDD (mg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | 4,4'-DDE (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Acrolein (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Acrylonitrile (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Aldrin (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | alpha-BHC (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | cis-1,3-Dichloropropene (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | delta-BHC (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Diazinon (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Dieldrin (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Endosulfan I (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Endosulfan II (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Endosulfan sulfate (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Endrin aldehyde (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Endrin (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Heptachlor Epoxide (Isomer B) (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Heptachlor (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Methoxychlor (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | o,p'-DDD (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | o,p'-DDE (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | o,p'-DDT (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | p,p'-DDT (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Technical Chlordane (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | Toxaphene (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | Detection of Any Compound Above Detection Limit | | | | | | | | | | | | | | | | | | | | |
| | | | Frequency of Detection (# observed/# measured) | 0 | | | | | | | | | | | | | | | | | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | | | No Data Available | | | | | | | | | | | | | | | | | | |
| | Increased Water Column Herbicides | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Maximum Value of Previous Year | | | | | | | | | | | | | | | | | | | | |
| | | | 2,3,7,8-TCDD (pg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | 2,4,5-TP (Silvex) (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |
| | | | 2,4'-D (μg $L^{-1}$) | bdl | | | | | | | | | | | | | | | | | | |

**Table 8** cont.

| Candidate Cause | Proximate Stressor | Measurement | Components (units) | RD Value | % Non Insect Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | % Tolerant Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment | # of Predator Taxa Rel Risk | LCI | UCI | Score | Proximate Stressor Score | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | | | | | | | | | | | | | | |
| | Increased Water Temperature | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Mean of Previous Quarter | | | | | | | | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 26.4 | | | | | | | | | | | | | | | | | | |
| | | Mean of Diel Measurements (24hr) | | | | | | | | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 24.6 | | | | | | | | | | | | | | | | | | |
| | Decreased Variability in Water Temperature | | | | | | | | NE | | | | | | NE | | | | | | NE | |
| | | Range of Previous Quarter | | | | | | | | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 3.8 | | | | | | | | | | | | | | | | | | |
| | | Range of Diel Measurements (24hr) | | | | | | | | | | | | | | | | | | | | |
| | | | Water Temperature (C) | 3.3 | | | | | | | | | | | | | | | | | | |

**Table 9. Summary of scores for outside the case stressor-response from other field studies across the four biological endpoints for each proximate stressor in the candidate causes. Data are scored + for supporting evidence, - for weakening evidence, 0 for indeterminate evidence, -- if the biological endpoint is not below the degradation threshold, or NE for no evidence.**

| Candidate Cause | Proximate Stressor | % Non Insect Taxa: Proximate Stressor Score | % Non Insect Taxa: Comment | % Tolerant Taxa: Proximate Stressor Score | % Tolerant Taxa: Comment | Number of Predator Taxa: Proximate Stressor Score | Number of Predator Taxa: Comment |
|---|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | | |
| | Increase in Dissolved Metals | -- | Only evaluated Copper, Lead, and Zinc | 0 | Only evaluated Copper, Lead, and Zinc | -- | Only evaluated Copper and Zinc |
| | Increase in Particulate Bound Metals | NE | | NE | | NE | |
| | Increase in Metals in Periphyton | NE | | NE | | NE | |
| **Elevated Conductivity** | | | | | | | |
| | Increase in Conductivity | -- | | + | | -- | |
| | Increase in Total Dissolved Solids | NE | | NE | | NE | |
| **River Discontinuity** | | | | | | | |
| | Decrease in Recruitment | NE | | NE | | NE | |
| | Decrease in Woody Debris | -- | | 0 | | -- | |
| | Decrease in Cobbles | NE | | NE | | NE | |
| | Increase in Sands and Fines | -- | | + | | -- | |
| | Burial of Cobbles | NE | | NE | | NE | |
| | Increase in Simplified Habitat | NE | | NE | | NE | |
| **Habitat Simplification** | | | | | | | |
| | Change in Available Food | NE | | NE | | NE | |
| | Increase in Channel Deepening | -- | | 0 | | -- | |
| | Decrease in Riffles | NE | | NE | | NE | |
| | Decrease in Woody Debris | -- | | 0 | | -- | |
| | Decrease in Cobbles | NE | | NE | | NE | |
| | Increase in Sands and Fines | -- | | + | | -- | |
| | Decrease in Undercut Banks | -- | | 0 | | -- | |
| | Increase in Simplified Habitat | NE | | NE | | NE | |
| **Increased Nutrients** | | | | | | | |
| | Change in Algal Community | NE | | NE | | NE | |
| | Increase in Algal Toxins | NE | | NE | | NE | |
| | Increase in pH | NE | | NE | | NE | |
| | Increased Frequency of Hypoxia | NE | | NE | | NE | |
| | Increased Ammonia Concentrations | NE | | NE | | NE | |
| **Pesticides** | | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | NE | | NE | | NE | |
| | Increased Water Column Non-pyrethroid Pesticides | NE | | NE | | NE | |
| | Increased Water Column Pyrethroid Pesticides | NE | | NE | | NE | |
| | Increased Sediment Pyrethroid Pesticides | NE | | NE | | NE | |
| | Increased Water Column Herbicides | NE | | NE | | NE | |
| **Temperature** | | | | | | | |
| | Increased Water Temperature | NE | | NE | | NE | |
| | Decreased Variability in Water Temperature | NE | | NE | | NE | |

## Laboratory Data from Outside the Case

The laboratory data from outside the case line of evidence was evaluated by using species sensitivity distribution (SSD) curves to assess the relative toxicity of the observed heavy metal and pesticide compounds measured at the RD site. Species sensitivity distribution curves synthesize compound-specific laboratory toxicity tests, expressing the number of different taxa that show a toxic effect at different concentrations of that compound (e.g., Figure 13). Curves were available for Arsenic, Cadmium, Chromium, Copper, Nickel, Selenium, Zinc, and diazinon. Data were scored -- if the observed RD concentration was below any observed toxic level, - if the concentration produced less than a 10% species loss, 0 if the concentration was equivalent to between 10 – 30% species loss, + if the concentration was between 30 – 60% species loss, and ++ if the concentration produced greater than 60% species loss. All of the elements observed at RD that had applicable SSD curves were scored --, so dissolved metals were scored -- and consequently, so was the heavy metal candidate cause. The pesticides candidate cause was scored -- based upon the scores of water column non-pyrethroid pesticides. Increased water column non-pyrethroid pesticides was scored --, with diazinon scoring -- (Table 10). It should be noted that all of the SSD curves constructed for pesticides were still in draft form and have yet to undergo formal peer review (S. Hagerthey, *pers comm*).

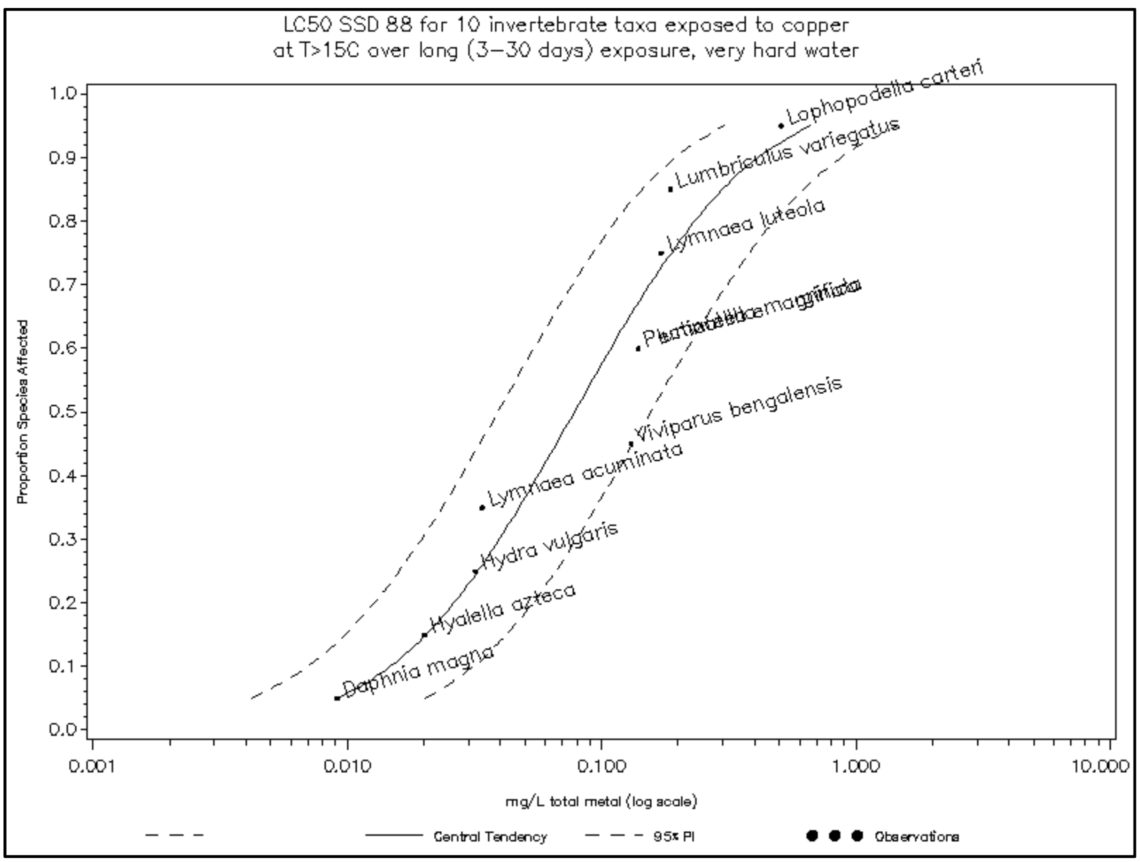



**Figure 13. An example of a species sensitivity distribution curve (USEPA 2013) illustrating the different taxa where potential mortality would be expected from different concentrations of copper in water >15°C and >180 mg L$^{-1}$ $CaCO_3$ (i.e., warm, very hard water). The dashed line represents the mean monthly observed concentration of copper at the RD site (3.42 µg L$^{-1}$).**

**Table 10 Scoring of the laboratory data from outside the case line of evidence. Data from the test site were compared to published (metals) or draft (pesticides) species sensitivity distribution curves. Data are scored ++ for moderately strong supporting evidence, + for strongly supporting evidence, -- for moderately weakening evidence, - for weakening evidence, 0 for indeterminate evidence, or NE for no evidence. bdl = below detection limit.**

| Candidate Cause | Proximate Stressor | Components (units) | RD Value | Component Score | Comment | Proximate Stressor Score |
|---|---|---|---|---|---|---|
| **Heavy Metals** | | | | | | |
| | Increase in Dissolved Metals | | | | | -- |
| | | Mean of Previous Quarter (BDL = 1/2 MDL) | | | | |
| | | Antimony (μg $L^{-1}$) | 0.63 | NE | | |
| | | Arsenic (μg $L^{-1}$) | 0.82 | -- | Not Hardness corrected | |
| | | Barium (μg $L^{-1}$) | 41.70 | NE | | |
| | | Beryllium (μg $L^{-1}$) | 0.13 | NE | | |
| | | Cadmium (μg $L^{-1}$) | 0.09 | -- | | |
| | | Chromium (μg $L^{-1}$) | 0.23 | - | | |
| | | Copper (μg $L^{-1}$) | 3.42 | -- | | |
| | | Hexavalent Chromium (mg $L^{-1}$) | 0.01 | NE | | |
| | | Iron (mg $L^{-1}$) | 0.10 | NE | | |
| | | Lead (μg $L^{-1}$) | 0.10 | NE | | |
| | | Mercury (μg $L^{-1}$) | 0.02 | -- | | |
| | | Nickel (μg $L^{-1}$) | 6.86 | - | | |
| | | Selenium (μg $L^{-1}$) | 1.33 | - | Not Hardness corrected | |
| | | Silver (μg $L^{-1}$) | 0.13 | NE | | |
| | | Thallium (μg $L^{-1}$) | 0.13 | NE | | |
| | | Zinc (μg $L^{-1}$) | 27.97 | - | | |
| | Increase in Particulate Bound Metals | | | | | NE |
| | | | No Data Available | | | |
| | Increase in Metals in Periphyton | | | | | NE |
| | | | No Data Available | | | |
| **Pesticides** | | | | | | |
| | Increased Sediment Non-pyrethroid Pesticides | | | | | NE |
| | | | No Data Available | | | |
| | Increased Water Column Non-pyrethroid Pesticides | | | | | -- |
| | | Maximum Value of Previous Year | | | | |
| | | 4,4'-DDD (μg $L^{-1}$) | bdl | NE | | |
| | | 4,4'-DDE (μg $L^{-1}$) | bdl | NE | | |
| | | Acrolein (μg $L^{-1}$) | bdl | NE | | |
| | | Acrylonitrile (μg $L^{-1}$) | bdl | NE | | |
| | | Aldrin (μg $L^{-1}$) | bdl | NE | | |
| | | alpha-BHC (μg $L^{-1}$) | bdl | NE | | |
| | | cis-1,3-Dichloropropene (μg $L^{-1}$) | bdl | NE | | |
| | | delta-BHC (μg $L^{-1}$) | bdl | NE | | |
| | | Diazinon (μg $L^{-1}$) | bdl | -- | | |
| | | Dieldrin (μg $L^{-1}$) | bdl | NE | | |
| | | Endosulfan I (μg $L^{-1}$) | bdl | NE | | |
| | | Endosulfan II (μg $L^{-1}$) | bdl | NE | | |
| | | Endosulfan sulfate (μg $L^{-1}$) | bdl | NE | | |
| | | Endrin aldehyde (μg $L^{-1}$) | bdl | NE | | |
| | | Endrin (μg $L^{-1}$) | bdl | NE | | |
| | | Heptachlor Epoxide (Isomer B) (μg $L^{-1}$) | bdl | NE | | |
| | | Heptachlor (μg $L^{-1}$) | bdl | NE | | |
| | | Methoxychlor (μg $L^{-1}$) | bdl | NE | | |
| | | o,p'-DDD (μg $L^{-1}$) | bdl | NE | | |
| | | o,p'-DDE (μg $L^{-1}$) | bdl | NE | | |
| | | o,p'-DDT (μg $L^{-1}$) | bdl | NE | | |
| | | p,p'-DDT (μg $L^{-1}$) | bdl | NE | | |
| | | Technical Chlordane (μg $L^{-1}$) | bdl | NE | | |
| | | Toxaphene (μg $L^{-1}$) | bdl | NE | | |
| | Increased Water Column Pyrethroid Pesticides | | | | | NE |
| | | | No Data Available | | | |
| | Increased Sediment Pyrethroid Pesticides | | | | | NE |
| | | | No Data Available | | | |
| | Increased Water Column Herbicides | | | | | NE |
| | | Maximum Value of Previous Year | | | | |
| | | 2,3,7,8-TCDD (pg $L^{-1}$) | bdl | NE | | |
| | | 2,4,5-TP (Silvex) (μg $L^{-1}$) | bdl | NE | | |
| | | 2,4'-D (μg $L^{-1}$) | bdl | NE | | |

## MULTI-YEAR ASSESSMENTS

Traditionally, causal assessments using the CADDIS framework have focused on a spatially and temporally constrained case definition (i.e., one test site and a single sampling event). These constraints have been both practical and philosophical. Practically, many sites that may need a causal assessment often have a limited amount of data at the test and comparator sites; especially data that are collected uniformly and concurrently at all of the sites. Philosophically, the constrained case definition can reduce complexity in the assessment as well as limit the number of candidate causes and their potential interaction. It can also make data management easier.

For all of the benefits, constraining the case definition in an assessment to a single point in time can also be problematic. Any biotic measurement used as the endpoint to an assessment is going to be prone to year-to-year variation independent of anthropogenic disturbance (e.g., variable recruitment, predation, or productivity rates). This natural biotic variability can be further exacerbated in environmentally variable systems like small streams in Mediterranean climates found through much of coastal southern California. The natural biotic variability may potentially obscure or distort the perceived impacts of stressors on stream biota, especially if the stressor-response dynamics are subtle and non-acute. Given the chronic, non-point source nature of the impacts experienced by many of the streams throughout California, as well as the inherent year-to-year variability in stream macrobenthos, defining the case for a causal assessment so as to incorporate multiple years of data could potentially improve the accuracy of an assessment and improve the confidence in the results of the causal assessment.

Following convention, a spatially-temporally constrained framework was used for the assessment of the Santa Clara River (RD site in 2006). However, as noted in the main body of this report, the biomonitoring efforts along the upper Santa Clara River were part of their NPDES monitoring efforts. Consequently there was biological, chemical, water quality, and physical habitat data collected at multiples sites regularly for almost a decade. As such, the stakeholders and analysts felt that the Santa Clara River causal assessment provided a great opportunity for preliminary investigation into the utility of using a multi-year case definition in diagnosing the biotic conditions in a stream, as well as an opportunity to experiment with how to best evaluate multi-year data.

Conducting a meaningful causal assessment over multiple years will be dependent upon at least two assumptions. First is that all of the years under consideration are similar and free of natural stochastic events (i.e., anomalously wet or dry years or fires) that may also impact the biology observed at a site. If those events can be detected, the data from those years should not be included in a multi-year assessment. There are number of potential approaches for the detection of these kinds of anomalies including plotting of fire occurrence, rainfall, or flow data through time to look for outliers (e.g., Fig 14). From the biological perspective, plots of multivariate (e.g., non-metric Multi-Dimensional Scaling [nMDS]) or univariate (e.g., species richness, diversity, dominance) community characterizations from the test and comparator sites over the multiple years can be used to highlight any potentially anomalous years and to ensure relative comparability (e.g., Figures 15 and 16). Anomalous data that cannot be accounted for should be noted and potentially analyzed separately. A second assumption is that there is relatively consistent pressure from the same stressor(s) and a relatively similar biological response over the time period of interest. This assumption is probably best tested after the data analysis of the assessment has been conducted.  If there is a lack of consistency in the stressor-biology patterns through the years or a large amount of variance in year-to-year data, then the assessment should not be done in the multi-year framework.

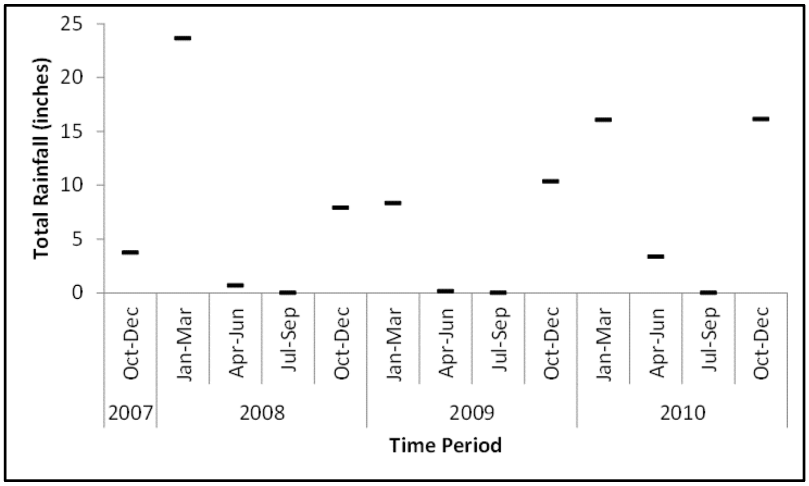
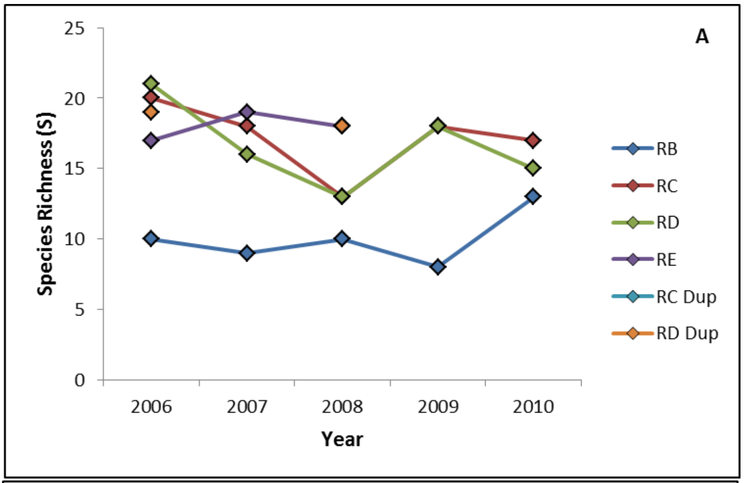



**Figure 14  Total rainfall at US Geological Survey rain gauge located near the upper Santa Clara River (Fillmore, CA; Station ID 343120118533301) from October 2007-Decmeber 2010.  No value was deemed anomalous and consequently no associated data were excluded from the assessment.**

Once appropriate data are gathered and organized, there are a number of potential approaches to utilizing the stressor and biological data from multiple years.  The goal of any of these approaches would be to incorporate the year-to-year variability in all of the data and the relationships between the biology and the stressors.  These data can be synthesized across multiple years using the most frequently observed relationships from the individual years across the period of interest, estimates of the distribution (e.g., 25th, 50th, and 75th percentiles or absolute range across years), or an estimate of central tendency (e.g., means or median values across years).  The choice of which approach to use could vary from assessment to assessment, but should be a decision made by the data analyst in conjunction with the stakeholders involved in the assessment during the case definition process.

When assembling data for a multi-year assessment, it is possible that the basic unit of data (e.g., monthly, bi-weekly, or quarterly frequency) will vary from year to year.  However, a uniform unit should be used across all of the different years being incorporated into the assessment.  As an example, for the single year Santa Clara River assessment it was decided among the stakeholders and analysts to use the biological and physical habitat data collected at the time of bioassessment but that the mean or maximum observed values - dependent upon the measure - over the three months prior to bioassessment for water quality and chemistry data (where available) were to be used.  As such, these values had to be calculated for each year’s data in the multi-year study.  These calculated values were then, in turn, synthesized and scored in the multi-year assessment using one of the four approaches detailed below.



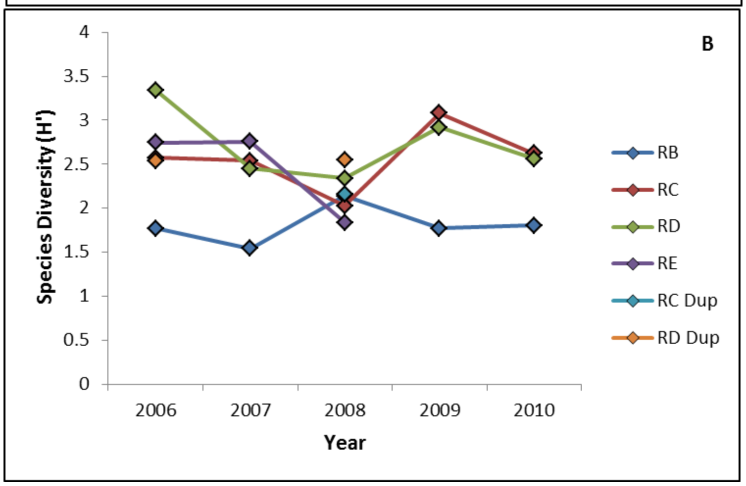




**Figure 15 Species richness (A) and Shannon Weiner Diversity (B) of the macrobenthic community collected at the test site RD and comparator sites RB, RC, and RE in 2006 -2010. No particular year appears to be an outlier, so no data were excluded from the assessment. Note that a duplicate sample was collected at RC in 2008 and RD in 2006 and 2008**

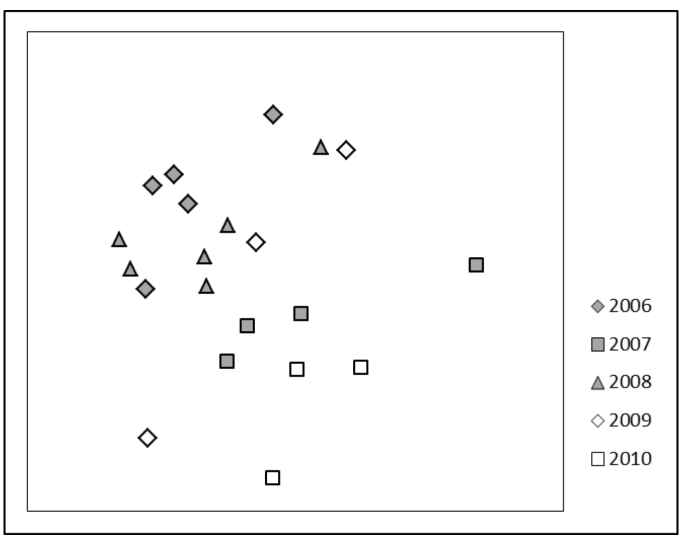



**Figure 16 Non-metric multidimensional scaling (n-MDS) plot based upon Bray-Curtis similarity of macrobenthic community structure at the test site RD and the comparator sites RB, RC, and RE from 2006-2010. No single year appears to be an outlier, so no data were excluded from the assessment.**

Synthesizing and scoring data using measures of central tendency is relatively straight forward and most similar to the traditional evidence evaluation/scoring process. The arithmetic mean or median value for the time period of interest should be calculated from all of the data observations in their appropriate unit of analysis (e.g., single measurement at time of bioassessment or maximum value from preceding three months) for each proximate stressor and biological endpoint used in the assessment. These mean or median values can then be evaluated using the different lines of evidence in the assessment and scored like any other data. It may be useful to look at the variance and heteroscedasticity of each proximate stressor/biotic endpoint to ensure that the data are indeed relatively comparable and therefore appropriate to be combined.

There are several estimates of data distributions that can be used in synthesizing the multiple years of data. The calculation of the distribution values is relatively simple, but the lines of evidence using these data will have to be scored in a modified process. Example data distribution metrics can include the maximum and minimum observation or the quartiles of all observations in their appropriate unit of analysis across the time period of interest. Once these values are calculated for each proximate stressor and biotic endpoint, they are scored individually for each line of evidence in the assessment (e.g., a separate score for each quartile or the min/max value). These individual scores will then be synthesized into a single score for each candidate cause.

Using the most frequently observed pattern across years will also require an additional scoring of evidence step. In this approach, stressor and biology data in their appropriate unit of analysis from each year are evaluated and scored independently for each time period of record. The scores are then synthesized by evaluating the most frequently observed score across all time periods for that line of evidence. Additionally, consistency across multiple years could be used as support towards indicating or refuting the candidate cause, whereas inconsistency would lead to an indeterminate score for the cause.

The Santa Clara River causal assessment provided a good opportunity to test these approaches for using multiple years of data in an assessment and to evaluate if they produced a different result than the single-year approach. We used data on biological condition, conductivity, and temperature that were collected over a five year period (2006-2010) to evaluate what a multi-year causal assessment might look like and how the data can be summarized. As this was only an experiment, the analyses were limited to the temperature (an indeterminate cause) and elevated conductivity (a likely cause) candidate causes at the original test (RD) and comparator sites (RB, RC, and RE) [Note: biological data from the RE comparator site were not available for 2009-10].

We believed that the frequency approach was the best way to summarize the multi-year data since this approach does not obscure potentially meaningful year-to-year variability that may get lost using other approaches, while at the same time ensuring data from the same year are consistently evaluated against each other. However, the frequency method also involves the most work. As alternatives for comparison, we also conducted the multi-year assessment using the 25th, 50th, and 75th percentile measurements observed across years (percentiles method), the median of measures observed across years (median method), and the mean of measures across years (mean method). We have provided detailed results for the different lines of evidence using the frequency method (Tables 12-15) to compare against the single year assessment, and a summary of the four multi-year methods (Table 16) to compare different multi-year approaches.

The 2006-2010 data synthesized with the frequency method were used for within case lines of evidence (spatial co-occurrence and stressor response) and outside the case lines of evidence (reference comparison and stressor-response) in an evaluation of the biological condition observed at the RD site in the upper Santa Clara River (Table 11). Elevated conductivity and temperature were evaluated as likely and indeterminate causes, respectively, for the biological conditions observed at the RD site from 2006-2010. These were the same evaluation results that were arrived at using the single-year approach, with much of the same reasoning behind those conclusions.

Elevated conductivity was a likely cause based upon multiple lines of evidence from both within and outside of the case. Levels of conductivity observed at the RD site in each year were higher than measures observed at environmentally similar reference sites. Furthermore, these levels were high enough to potentially cause degraded levels of three of the three biological endpoints based upon a relative risk approach to outside of the case stressor response. There was mixed evidence supporting elevated conductivity as a cause at some comparator sites and for some biological endpoints but weakening for others (Table 11).

Temperature was evaluated as an indeterminate cause due to the lack of outside of the case data to provide context to the within the case lines of evidence. The spatial co-occurrence data at two sites and the stressor response relationships with non-insect taxa indicated that temperature was a likely candidate cause. However, as was the problem with the single year assessment, the biological condition at the RD site was comparable to all of the comparators in 2006 and 2007. This poor case construction hampers the utility of the within the case lines of evidence by itself to come to a more definitive diagnosis (i.e. unlikely/likely). It should be noted that both aspects of the temperature candidate cause, elevated mean temperature and decreased temperature range, tended to score in the same fashion across the different lines of evidence.

One of the primary differences between this multi-year assessment and the single year assessment is the use of comparator sites. Beyond the “baseline” comparator sites (RB, RC, and RE) used in the multi-year assessment, the single year assessment took advantage of a special study that occurred only in 2006 that provided an additional four comparator sites. In fact, that is why 2006 was originally chosen; data were not available for these additional sites for the 2007-2010 time period. As a result the additional comparator sites were not utilized for the multi-year assessment. Data completeness is another variable to consider when deciding if multi-year assessment is warranted.

Table 12 provides an example scoresheet for conductivity when applying spatial co-occurrence lines of evidence using the frequency-based approach to multi-year assessments. For the spatial co-occurrence line of evidence, elevated conductivity was scored “+” for RD vs. RB, “---“ for RD vs. RC, and “0” for RD vs. RE. Conductivity and RD was always higher than at RB (scored “+”) and lower or equivalent to measurements at RC and RE (scored “---“ or “0”). Total dissolved solids (TDS) at RD – measured as TDS, hardness, and chloride – were most frequently higher than at RB and RE, while most frequently lower than measures from RC.

Table 13 provides an example scoresheet for conductivity when applying stressor-response lines of evidence using the frequency-based approach to multi-year assessments. Within the case stressor response was scored "-" for number of predator taxa, and "0" for % tolerant taxa and % non-insect taxa. The individual proximate stressor of conductivity was most frequently scored "+" for collector-gatherer abundance, "-" for predator taxa, and "0" for tolerant and non-insect taxa. The proximate stressor of TDS was most frequently scored 0 for all four of the biological endpoints.

For the reference comparison and outside the case stressor response lines of evidence, data were only available for the proximate stressor of conductivity, so all elevated conductivity scores were the same as those for the proximate stressor. Conductivity at RD was greater in all years than the outer fence value of similar reference sites (683 μmhos $cm^{-1}$) and were consequently scored "+" (Table 14). Stressor response from outside the case was most frequently scored "+" for non-insect taxa, tolerant taxa, and predator taxa (Table 15).

The temperature candidate cause was scored "---" for spatial co-occurrence for RD vs. RB and "+" for RD vs. RC and RD vs. RE. The temperature candidate cause was comprised of two proximate stressors: elevated mean temperature across the 3 months prior to bioassessment and decreased range across the 3 months prior to bioassessment. Both temperature proximate stressors were most frequently scored "---" comparing RD to RB and both were most frequently scored "+" comparing RD to RC and RE (Table 12).

The within the case stressor response line of evidence for temperature was scored "+" for % non-insect taxa and # of predator taxa, with both increased mean temperature and decreased temperature range most frequently scored "+". The % tolerant taxa was scored "0", as were both of the respective proximate stressors (Table 13).

No data were available for evaluation of either of the temperature proximate stressors using reference site comparison or stressor response from outside the case lines of evidence. Consequently, they were scored "NE" for all of the biological endpoints.

Though we recommend the frequency method for assessing multiple years of data, comparisons between the different multi-year methods were made. Table 16 provides an example, comparing the within the case stressor-response scoring for each of the different multi-year methods by synthesizing stressor and biological data described above (frequency, percentiles, median, and mean). In this particular case study, the different approaches produced relatively comparable patterns in the proximate stressor scores (and their constituent components), as well as the candidate causes. However, this is only one case study and further investigation of the mathematical tendencies of each method, and how they influence a given assessment's outcome, need to be done in subsequent causal assessments from other sites with multiple years of useable data.

**Table 11 Comparison of summary score sheets for RD and each of the comparator sites in the Santa Clara River assessment using a single year and multiple years of data (summarized with frequency method). Each candidate cause score is the integration of the component proximate stressor scores. The continuity line of evidence evaluates the continuity of each line of evidence for each of the four biological endpoints: % collector-gatherer abundance/% non-insect taxa/% tolerant taxa/# of predator taxa.**

| | Candidate Cause | | RD vs RB Elevated Conductivity | RD vs RB Temperature | RD vs RC Elevated Conductivity | RD vs RC Temperature | RD vs RE Elevated Conductivity | RD vs RE Temperature |
|---|---|---|---|---|---|---|---|---|
| Single Year (2006) | Spatial Co-Occurrence | | + | 0 | --- | + | --- | + |
| | Stressor Response | Non-Insect Taxa | - | + | - | + | - | + |
| | | Tolerant Taxa | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Predator Taxa | 0 | 0 | 0 | 0 | 0 | 0 |
| | Reference Condition Comparison | | + | NE | + | NE | + | NE |
| | Stressor Response From Outside the Case | Non-Insect Taxa § | -- | NE | -- | NE | -- | NE |
| | | Tolerant Taxa | + | NE | + | NE | + | NE |
| | | Predator Taxa§ | -- | NE | -- | NE | -- | NE |
| | Continuity | | -/+/- | 0/0/0 | -/-/- | +/0/0 | -/-/- | +/0/0 |
| Multi-Year (2006-2010) | Spatial Co-Occurrence | | + | --- | --- | + | 0 | + |
| | Stressor Response | Non-Insect Taxa§ | 0 | + | 0 | + | 0 | + |
| | | Tolerant Taxa | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Predator Taxa§ | - | + | - | + | - | + |
| | Reference Condition Comparison | | + | NE | + | NE | + | NE |
| | Stressor Response From Outside the Case | Non-Insect Taxa§ | + | NE | + | NE | + | NE |
| | | Tolerant Taxa | + | NE | + | NE | + | NE |
| | | Predator Taxa§ | + | NE | + | NE | + | NE |
| | Continuity | | +/+/- | -/0/- | -/-/- | +/0/+ | 0/0/- | +/0/+ |

**§** % non -insect taxa, and # of predator taxa values were below the relative risk biotic threshold (i.e. good condition) and were scored "--" for stressor response from outside the case

**Table 12. Detailed spatial-co-occurrence scoring sheet using the multi-year frequency approach for the increased conductivity and temperature candidate causes.**

| Candidate Cause | Proximate Stressor | Measure | Component | Year | RD Value | RB Value | Difference | Score | Most Frequent Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **Increased Conductivity** | | | | | | | | | | |
| | Elevated Conductivity | | | | | | | | | + |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | Conductivity (umhos/cm @25C) | 2006 | 1207.3 | 1031.7 | 175.7 | + | + | |
| | | | Conductivity (umhos/cm @25C) | 2007 | 1236.7 | 1056.7 | 180.0 | + | | |
| | | | Conductivity (umhos/cm @25C) | 2008 | 1210.0 | 1140.0 | 70.0 | + | | |
| | | | Conductivity (umhos/cm @25C) | 2009 | 1230.0 | 1196.7 | 33.3 | + | | |
| | | | Conductivity (umhos/cm @25C) | 2010 | 1240.0 | 1151.7 | 88.3 | + | | |
| | Elevated TDS | | | | | | | | | + |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | TDS (mg/l) | 2006 | 788.0 | 631.3 | 156.7 | + | + | |
| | | | TDS (mg/l) | 2007 | 761.0 | 620.7 | 140.3 | + | | |
| | | | TDS (mg/l) | 2008 | 773.3 | 710.3 | 63.0 | + | | |
| | | | TDS (mg/l) | 2009 | 787.3 | 726.0 | 61.3 | + | | |
| | | | TDS (mg/l) | 2010 | 789.3 | 742.0 | 47.3 | + | | |
| | | | Hardness (mg/l) | 2006 | 350.0 | 195.0 | 155.0 | + | + | |
| | | | Hardness (mg/l) | 2007 | 336.0 | 182.0 | 154.0 | + | | |
| | | | Hardness (mg/l) | 2008 | 342.3 | 259.0 | 83.3 | + | | |
| | | | Hardness (mg/l) | 2009 | 317.7 | 219.0 | 98.7 | + | | |
| | | | Hardness (mg/l) | 2010 | 344.2 | 249.3 | 94.9 | + | | |
| | | | Chloride (mg/l) | 2006 | 128.5 | 124.4 | 4.1 | + | --- | |
| | | | Chloride (mg/l) | 2007 | 146.0 | 144.7 | 1.3 | + | | |
| | | | Chloride (mg/l) | 2008 | 135.8 | 152.4 | -16.6 | --- | | |
| | | | Chloride (mg/l) | 2009 | 127.7 | 146.2 | -18.5 | --- | | |
| | | | Chloride (mg/l) | 2010 | 120.3 | 131.3 | -11.0 | --- | | |

| Candidate Cause | Proximate Stressor | Measure | Component | Year | RD Value | RB Value | Difference | Score | Most Frequent Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | | |
| | Increased Mean Temperature | | | | | | | | | --- |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 26.4 | 27.4 | -1.0 | --- | --- | |
| | | | Water Temperature (deg C) | 2007 | 25.6 | 27.9 | -2.3 | --- | | |
| | | | Water Temperature (deg C) | 2008 | 24.0 | 24.7 | -0.7 | --- | | |
| | | | Water Temperature (deg C) | 2009 | 23.0 | 23.4 | -0.4 | --- | | |
| | | | Water Temperature (deg C) | 2010 | 22.5 | 22.7 | -0.2 | 0 | | |
| | Decreased Temperature Range | | | | | | | | | |
| | | Range of previous quarter point measures | | | | | | | | --- |
| | | | Water Temperature (deg C) | 2006 | 3.8 | 1.7 | 2.1 | --- | --- | |
| | | | Water Temperature (deg C) | 2007 | 2.3 | 2.1 | 0.2 | 0 | | |
| | | | Water Temperature (deg C) | 2008 | 8.4 | 5.1 | 3.3 | --- | | |
| | | | Water Temperature (deg C) | 2009 | 6.8 | 3.5 | 3.3 | --- | | |
| | | | Water Temperature (deg C) | 2010 | 5.0 | 4.4 | 0.6 | --- | | |

| Candidate Cause | Proximate Stressor | Measure | Component | Year | RD Value | RC Value | Difference | Score | Most Frequent Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **Increased Conductivity** | | | | | | | | | | |
| | Elevated Conductivity | | | | | | | | | --- |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | Conductivity (umhos/cm @25C) | 2006 | 1207.3 | 1295.7 | -88.3 | --- | --- | |
| | | | Conductivity (umhos/cm @25C) | 2007 | 1236.7 | 1383.3 | -146.7 | --- | | |
| | | | Conductivity (umhos/cm @25C) | 2008 | 1210.0 | 1256.7 | -46.7 | --- | | |
| | | | Conductivity (umhos/cm @25C) | 2009 | 1230.0 | 1293.3 | -63.3 | --- | | |
| | | | Conductivity (umhos/cm @25C) | 2010 | 1240.0 | 1250.0 | -10.0 | --- | | |
| | Elevated TDS | | | | | | | | | --- |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | TDS (mg/l) | 2006 | 788.0 | 866.7 | -78.7 | --- | --- | |
| | | | TDS (mg/l) | 2007 | 761.0 | 917.0 | -156.0 | --- | | |
| | | | TDS (mg/l) | 2008 | 773.3 | 867.0 | -93.7 | --- | | |
| | | | TDS (mg/l) | 2009 | 787.3 | 846.0 | -58.7 | --- | | |
| | | | TDS (mg/l) | 2010 | 789.3 | 828.7 | -39.3 | --- | | |
| | | | Hardness (mg/l) | 2006 | 350.0 | 472.7 | -122.7 | --- | --- | |
| | | | Hardness (mg/l) | 2007 | 336.0 | 503.3 | -167.3 | --- | | |
| | | | Hardness (mg/l) | 2008 | 342.3 | 465.7 | -123.3 | --- | | |
| | | | Hardness (mg/l) | 2009 | 317.7 | 427.7 | -110.0 | --- | | |
| | | | Hardness (mg/l) | 2010 | 344.2 | 437.3 | -93.2 | --- | | |
| | | | Chloride (mg/l) | 2006 | 128.5 | 118.3 | 10.2 | + | + | |
| | | | Chloride (mg/l) | 2007 | 146.0 | 115.0 | 31.0 | + | | |
| | | | Chloride (mg/l) | 2008 | 135.8 | 110.3 | 25.6 | + | | |
| | | | Chloride (mg/l) | 2009 | 127.7 | 106.3 | 21.3 | + | | |
| | | | Chloride (mg/l) | 2010 | 120.3 | 101.4 | 18.9 | + | | |

| Candidate Cause | Proximate Stressor | Measure | Component | Year | RD Value | RC Value | Difference | Score | Most Frequent Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | | |
| | Increased Mean Temperature | | | | | | | | | + |
| | | Mean of previous quarter point measures | | | | | | | + | |
| | | | Water Temperature (deg C) | 2006 | 26.4 | 25.0 | 1.4 | + | | |
| | | | Water Temperature (deg C) | 2007 | 25.6 | 21.4 | 4.2 | + | | |
| | | | Water Temperature (deg C) | 2008 | 24.0 | 22.9 | 1.1 | + | | |
| | | | Water Temperature (deg C) | 2009 | 23.0 | 22.6 | 0.4 | + | | |
| | | | Water Temperature (deg C) | 2010 | 22.5 | 21.5 | 1.0 | + | | |
| | Decreased Temperature Range | | | | | | | | | + |
| | | Range of previous quarter point measures | | | | | | | + | |
| | | | Water Temperature (deg C) | 2006 | 3.8 | 8.7 | -4.8 | + | | |
| | | | Water Temperature (deg C) | 2007 | 2.3 | 4.3 | -2.1 | + | | |
| | | | Water Temperature (deg C) | 2008 | 8.4 | 7.0 | 1.4 | --- | | |
| | | | Water Temperature (deg C) | 2009 | 6.8 | 9.0 | -2.2 | + | | |
| | | | Water Temperature (deg C) | 2010 | 5.0 | 8.8 | -3.8 | + | | |

| Candidate Cause | Proximate Stressor | Measure | Component | Year | RD Value | RE Value | Difference | Score | Most Frequent Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **Increased Conductivity** | | | | | | | | | | |
| | Elevated Conductivity | | | | | | | | | --- |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | Conductivity (umhos/cm @25C) | 2006 | 1207.3 | 1232.3 | -25.0 | --- | --- | |
| | | | Conductivity (umhos/cm @25C) | 2007 | 1236.7 | 1243.3 | -6.7 | --- | | |
| | | | Conductivity (umhos/cm @25C) | 2008 | 1210.0 | 1253.3 | -43.3 | --- | | |
| | | | Conductivity (umhos/cm @25C) | 2009 | 1230.0 | 1213.3 | 16.7 | 0 | | |
| | | | Conductivity (umhos/cm @25C) | 2010 | 1240.0 | 717.2 | 522.8 | + | | |
| | Elevated TDS | | | | | | | | | + |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | TDS (mg/l) | 2006 | 788.0 | 815.0 | -27.0 | --- | + | |
| | | | TDS (mg/l) | 2007 | 761.0 | 781.7 | -20.7 | --- | | |
| | | | TDS (mg/l) | 2008 | 773.3 | 711.3 | 62.0 | + | | |
| | | | TDS (mg/l) | 2009 | 787.3 | 767.3 | 20.0 | + | | |
| | | | TDS (mg/l) | 2010 | 789.3 | 550.0 | 239.3 | + | | |
| | | | Hardness (mg/l) | 2006 | 350.0 | 380.7 | -30.7 | --- | --- | |
| | | | Hardness (mg/l) | 2007 | 336.0 | 354.0 | -18.0 | --- | | |
| | | | Hardness (mg/l) | 2008 | 342.3 | 401.0 | -58.7 | --- | | |
| | | | Hardness (mg/l) | 2009 | 317.7 | 343.0 | -25.3 | --- | | |
| | | | Hardness (mg/l) | 2010 | 344.2 | 215.0 | 129.2 | + | | |
| | | | Chloride (mg/l) | 2006 | 128.5 | 116.5 | 12.0 | + | + | |
| | | | Chloride (mg/l) | 2007 | 146.0 | 126.7 | 19.3 | + | | |
| | | | Chloride (mg/l) | 2008 | 135.8 | 108.8 | 27.0 | + | | |
| | | | Chloride (mg/l) | 2009 | 127.7 | 115.0 | 12.7 | + | | |
| | | | Chloride (mg/l) | 2010 | 120.3 | 92.3 | 28.0 | + | | |

| Candidate Cause | Proximate Stressor | Measure | Component | Year | RD Value | RE Value | Difference | Score | Most Frequent Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | | | | | | | | | | |
| | Increased Mean Temperature | | | | | | | | | + |
| | | Mean of previous quarter point measures | | | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 26.4 | 25.7 | 0.7 | + | + | |
| | | | Water Temperature (deg C) | 2007 | 25.6 | 24.6 | 1.0 | + | | |
| | | | Water Temperature (deg C) | 2008 | 24.0 | 22.4 | 1.6 | + | | |
| | | | Water Temperature (deg C) | 2009 | 23.0 | 20.1 | 2.9 | + | | |
| | | | Water Temperature (deg C) | 2010 | 22.5 | 18.6 | 4.0 | + | | |
| | Decreased Temperature Range | | | | | | | | | + |
| | | Range of previous quarter point measures | | | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 3.8 | 6.9 | -3.1 | + | + | |
| | | | Water Temperature (deg C) | 2007 | 2.3 | 3.4 | -1.2 | + | | |
| | | | Water Temperature (deg C) | 2008 | 8.4 | 11.7 | -3.3 | + | | |
| | | | Water Temperature (deg C) | 2009 | 6.8 | 10.3 | -3.4 | + | | |
| | | | Water Temperature (deg C) | 2010 | 5.0 | 8.2 | -3.2 | + | | |

**Table 13. Detailed within the case stressor-response scoring sheet using the multi-year frequency approach for the increased conductivity and temperature candidate causes and the three biological endpoints.**

| Candidate Cause | Proximate Stressor | Measure | Component | Year | % Tolerant Taxa | | | | % Non-Insect Taxa | | | | # of Predator Taxa | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | rho | Component Score | Most Frequent Score | Proximate Stressor Score | rho | Component Score | Most Frequent Score | Proximate Stressor Score | rho | Component Score | Most Frequent Score | Proximate Stressor Score |
| **Increased Conductivity** | | | | | | | | | | | | | | | | |
| | Elevated Conductivity | | | | | | | | | | | 0 | | | | - |
| | | Mean of previous quarter point measures | | | | | | | | | | | | | | |
| | | | Conductivity (umhos/cm @25C) | 2006 | 0.359 | 0 | 0 | | -0.667 | 0 | 0 | | 0.763 | - | - | |
| | | | Conductivity (umhos/cm @25C) | 2007 | 0.949 | + | | | -0.400 | 0 | | | 0.949 | - | | |
| | | | Conductivity (umhos/cm @25C) | 2008 | -0.716 | 0 | | | -0.716 | 0 | | | -0.375 | 0 | | |
| | | | Conductivity (umhos/cm @25C) | 2009 | -0.500 | 0 | | | -1.000 | - | | | 1.000 | - | | |
| | | | Conductivity (umhos/cm @25C) | 2010 | -1.000 | - | | | -1.000 | - | | | 0.500 | 0 | | |
| | Elevated TDS | | | | | | | 0 | | | | 0 | | | | - |
| | | Mean of previous quarter point measures | | | | | | | | | | | | | | |
| | | | TDS (mg/l) | 2006 | 0.359 | 0 | 0 | | -0.667 | 0 | 0 | | 0.763 | - | - | |
| | | | TDS (mg/l) | 2007 | 0.949 | + | | | -0.400 | 0 | | | 0.949 | - | | |
| | | | TDS (mg/l) | 2008 | -0.328 | 0 | | | -0.328 | 0 | | | -0.375 | 0 | | |
| | | | TDS (mg/l) | 2009 | -0.500 | 0 | | | -1.000 | - | | | 1.000 | - | | |
| | | | TDS (mg/l) | 2010 | -1.000 | - | | | -1.000 | - | | | 0.500 | 0 | | |
| | | | Hardness (mg/l) | 2006 | 0.359 | 0 | 0 | | -0.667 | 0 | 0 | | 0.763 | - | - | |
| | | | Hardness (mg/l) | 2007 | 0.949 | + | | | -0.400 | 0 | | | 0.949 | - | | |
| | | | Hardness (mg/l) | 2008 | -0.716 | 0 | | | -0.716 | 0 | | | -0.375 | 0 | | |
| | | | Hardness (mg/l) | 2009 | -0.500 | 0 | | | -1.000 | - | | | 1.000 | - | | |
| | | | Hardness (mg/l) | 2010 | -1.000 | - | | | -1.000 | - | | | 0.500 | 0 | | |
| | | | Chloride (mg/l) | 2006 | -0.154 | 0 | 0 | | -0.154 | 0 | + | | -0.026 | 0 | 0 | |
| | | | Chloride (mg/l) | 2007 | -0.949 | - | | | 0.000 | 0 | | | -0.738 | 0 | | |
| | | | Chloride (mg/l) | 2008 | 0.925 | + | | | 0.925 | + | | | 0.188 | 0 | | |
| | | | Chloride (mg/l) | 2009 | 0.500 | 0 | | | 1.000 | + | | | -1.000 | + | | |
| | | | Chloride (mg/l) | 2010 | 1.000 | + | | | 1.000 | + | | | -0.500 | 0 | | |
| **Temperature** | | | | | | | | | | | | | | | | |
| | Increased Mean Temperature | | | | | | | 0 | | | | + | | | | + |
| | | Mean of previous quarter point measures | | | | | | | | | | | | | | |
| | | | Water Temperature (deg C) | 2006 | -0.359 | 0 | 0 | | 0.667 | 0 | + | | -0.763 | + | + | |
| | | | Water Temperature (deg C) | 2007 | -0.949 | - | | | 0.400 | 0 | | | -0.949 | + | | |
| | | | Water Temperature (deg C) | 2008 | 0.925 | + | | | 0.925 | + | | | 0.188 | 0 | | |
| | | | Water Temperature (deg C) | 2009 | 0.500 | 0 | | | 1.000 | + | | | -1.000 | + | | |
| | | | Water Temperature (deg C) | 2010 | 1.000 | + | | | 1.000 | + | | | -0.500 | 0 | | |
| | Decreased Temperature Range | | | | | | | 0 | | | | 0 | | | | 0 |
| | | Range of previous quarter point measures | | | | | | | | | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 0.051 | 0 | 0 | | -0.359 | 0 | 0 | | 0.500 | 0 | 0 | |
| | | | Water Temperature (deg C) | 2007 | 0.949 | - | | | -0.400 | 0 | | | 0.949 | + | | |
| | | | Water Temperature (deg C) | 2008 | -0.567 | 0 | | | -0.567 | 0 | | | 0.188 | 0 | | |
| | | | Water Temperature (deg C) | 2009 | -0.500 | 0 | | | -1.000 | + | | | 1.000 | + | | |
| | | | Water Temperature (deg C) | 2010 | -1.000 | + | | | -1.000 | + | | | 0.500 | 0 | | |

**Table 14. Detailed scoring table of the reference condition comparison line of evidence for the increased conductivity and temperature candidate causes using the frequency approach to synthesizing multiple years of data.**

| Candidate Cause | Proximate Stressor | Measure | Component | Year | RD Value | Score | Most Frequent Score | Proximate Stressor Score |
|---|---|---|---|---|---|---|---|---|
| **Increased Conductivity** | | | | | | | | |
| | Elevated Conductivity | | | | | | | + |
| | | Mean of previous quarter point measures | | | | | | |
| | | | Conductivity (µmhos/cm @25C) | 2006 | 1207.3 | + | + | |
| | | | | 2007 | 1236.7 | + | | |
| | | | | 2008 | 1210.0 | + | | |
| | | | | 2009 | 1230.0 | + | | |
| | | | | 2010 | 1240.0 | + | | |
| | Elevated TDS | | | | | | | NE |
| | | Mean of previous quarter point measures | | | | | | |
| | | | TDS (mg/l) | 2006 | 788.0 | NE | NE | |
| | | | | 2007 | 761.0 | NE | | |
| | | | | 2008 | 773.3 | NE | | |
| | | | | 2009 | 787.3 | NE | | |
| | | | | 2010 | 789.3 | NE | | |
| | | | Hardness (mg/l) | 2006 | 350.0 | NE | | |
| | | | | 2007 | 336.0 | NE | | |
| | | | | 2008 | 342.3 | NE | | |
| | | | | 2009 | 317.7 | NE | | |
| | | | | 2010 | 344.2 | NE | | |
| | | | Chloride (mg/l) | 2006 | 128.5 | NE | | |
| | | | | 2007 | 146.0 | NE | | |
| | | | | 2008 | 135.8 | NE | | |
| | | | | 2009 | 127.7 | NE | | |
| | | | | 2010 | 120.3 | NE | | |
| **Temperature** | | | | | | | | |
| | Increased Mean Temperature | | | | | | | NE |
| | | Mean of previous quarter point measures | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 26.4 | NE | NE | |
| | | | | 2007 | 25.6 | NE | | |
| | | | | 2008 | 24.0 | NE | | |
| | | | | 2009 | 23.0 | NE | | |
| | | | | 2010 | 22.5 | NE | | |
| | Decreased Range | | | | | | | NE |
| | | Range of previous quarter point measures | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 3.8 | NE | NE | |
| | | | | 2007 | 2.3 | NE | | |
| | | | | 2008 | 8.4 | NE | | |
| | | | | 2009 | 6.8 | NE | | |
| | | | | 2010 | 5.0 | NE | | |

**Table 15. Detailed scoring table for outside of the case stressor-response for increased conductivity and temperature candidate causes and the three biological endpoints using the frequency approach to synthesizing multiple years of data.**

| | | | | | | % Non-Insect Taxa | | | | % Tolerant Taxa | | | | # Predator Taxa | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Candidate Cause | Proximate Stressor | Measure | Component | Year | Stressor Value | Biotic Value | Score | Most Frequent | Proximate Stressor Score | Biotic Value | Score | Most Frequent | Proximate Stressor Score | Biotic Value | Score | Most Frequent | Proximate Stressor Score |
| **Increased Conductivity** | | | | | | | | | | | | | | | | | |
| | Elevated Conductivity | | | | | | | | + | | | | + | | | | + |
| | | Mean of previous quarter point measures | | | | | | | | | | | | | | + | |
| | | | Conductivity (umhos/cm @25C) | 2006 | 1207.3 | 35.2 | + | + | | 29.0 | + | + | | 8 | -- | | |
| | | | | 2006 | 1207.3 | 23.7 | -- | | | 16.5 | -- | | | 5 | + | | |
| | | | | 2007 | 1236.7 | 5.5 | -- | | | 14.3 | -- | | | 3 | + | | |
| | | | | 2008 | 1210.0 | 38.5 | + | | | 38.5 | + | | | 4 | + | | |
| | | | | 2008 | 1210.0 | 33.3 | + | | | 27.8 | + | | | 8 | -- | | |
| | | | | 2009 | 1230.0 | 38.9 | + | | | 29.4 | + | | | 7 | -- | | |
| | | | | 2010 | 1240.0 | 30.8 | + | | | 16.7 | -- | | | 3 | + | | |
| | Elevated TDS | | | | | | | | NE | | | | NE | | | | NE |
| | | Mean of previous quarter point measures | | | | | | | | | | | | | | | |
| | | | TDS (mg/l) | 2006 | 788.0 | | NE | NE | | | NE | NE | | | NE | NE | |
| | | | | 2007 | 761.0 | | NE | | | | NE | | | | NE | | |
| | | | | 2008 | 773.3 | | NE | | | | NE | | | | NE | | |
| | | | | 2009 | 787.3 | | NE | | | | NE | | | | NE | | |
| | | | | 2010 | 789.3 | | NE | | | | NE | | | | NE | | |
| | | | Hardness (mg/l) | 2006 | 350.0 | | NE | | | | NE | | | | NE | | |
| | | | | 2007 | 336.0 | | NE | | | | NE | | | | NE | | |
| | | | | 2008 | 342.3 | | NE | | | | NE | | | | NE | | |
| | | | | 2009 | 317.7 | | NE | | | | NE | | | | NE | | |
| | | | | 2010 | 344.2 | | NE | | | | NE | | | | NE | | |
| | | | Chloride (mg/l) | 2006 | 128.5 | | NE | | | | NE | | | | NE | | |
| | | | | 2007 | 146.0 | | NE | | | | NE | | | | NE | | |
| | | | | 2008 | 135.8 | | NE | | | | NE | | | | NE | | |
| | | | | 2009 | 127.7 | | NE | | | | NE | | | | NE | | |
| | | | | 2010 | 120.3 | | NE | | | | NE | | | | NE | | |
| **Temperature** | | | | | | | | | | | | | | | | | |
| | Increased Mean Temperature | | | | | | | | NE | | | | NE | | | | NE |
| | | Mean of previous quarter point measures | | | | | | | | | | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 26.4 | | NE | NE | | | NE | NE | | | NE | NE | |
| | | | | 2007 | 25.6 | | NE | | | | NE | | | | NE | | |
| | | | | 2008 | 24.0 | | NE | | | | NE | | | | NE | | |
| | | | | 2009 | 23.0 | | NE | | | | NE | | | | NE | | |
| | | | | 2010 | 22.5 | | NE | | | | NE | | | | NE | | |
| | Decreased Range | | | | | | | | NE | | | | NE | | | | NE |
| | | Range of previous quarter point measures | | | | | | | | | | | | | | | |
| | | | Water Temperature (deg C) | 2006 | 3.8 | | NE | NE | | | NE | NE | | | NE | NE | |
| | | | | 2007 | 2.3 | | NE | | | | NE | | | | NE | | |
| | | | | 2008 | 8.4 | | NE | | | | NE | | | | NE | | |
| | | | | 2009 | 6.8 | | NE | | | | NE | | | | NE | | |
| | | | | 2010 | 5.0 | | NE | | | | NE | | | | NE | | |

**Table 16. Summary score sheet for the within case stressor-response line of evidence comparing scoring results the frequency, percentile, median, and means approaches to synthesizing multiple years of data. Proximate stressor (PS Score) and candidate cause (CC Score) scores are presented for the increased conductivity and temperature candidate causes and their component proximate stressors.**

| Candidate Cause | Proximate Stressor | Frequency | | | | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % Tolerant Taxa | | % Non-Insect Taxa | | # of Predator Taxa | | % Tolerant Taxa | | % Non-Insect Taxa | | # of Predator Taxa | |
| | | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score |
| Increased Conductivity | | | 0 | | 0 | | - | | 0 | | - | | - |
| | Elevated Conductivity | 0 | | 0 | | - | | 0 | | - | | - | |
| | Elevated TDS | 0 | | 0 | | - | | + | | 0 | | - | |
| Temperature | | | 0 | | + | | + | | 0 | | + | | 0 |
| | Increased Mean Temperature | 0 | | + | | + | | 0 | | + | | 0 | |
| | Decreased Range | 0 | | 0 | | 0 | | 0 | | + | | - | |

| Candidate Cause | Proximate Stressor | Medians | | | | | | Means | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % Tolerant Taxa | | % Non-Insect Taxa | | # of Predator Taxa | | % Tolerant Taxa | | % Non-Insect Taxa | | # of Predator Taxa | |
| | | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score | PS Score | CC Score |
| Increased Conductivity | | | 0 | | 0 | | - | | 0 | | 0 | | 0 |
| | Elevated Conductivity | 0 | | 0 | | -- | | 0 | | 0 | | 0 | |
| | Elevated TDS | 0 | | 0 | | - | | 0 | | 0 | | 0 | |
| Temperature | | | 0 | | + | | 0 | | + | | 0 | | 0 |
| | Increased Mean Temperature | 0 | | ++ | | 0 | | + | | + | | + | |
| | Decreased Range | 0 | | + | | - | | + | | - | | - | |

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