SWAMP
Surface Water Ambient Monitoring Program

Technical Report	2002

Lake Elsinore Sediment and Water Column Toxicity Study

May 18, 2007

California Water Boards

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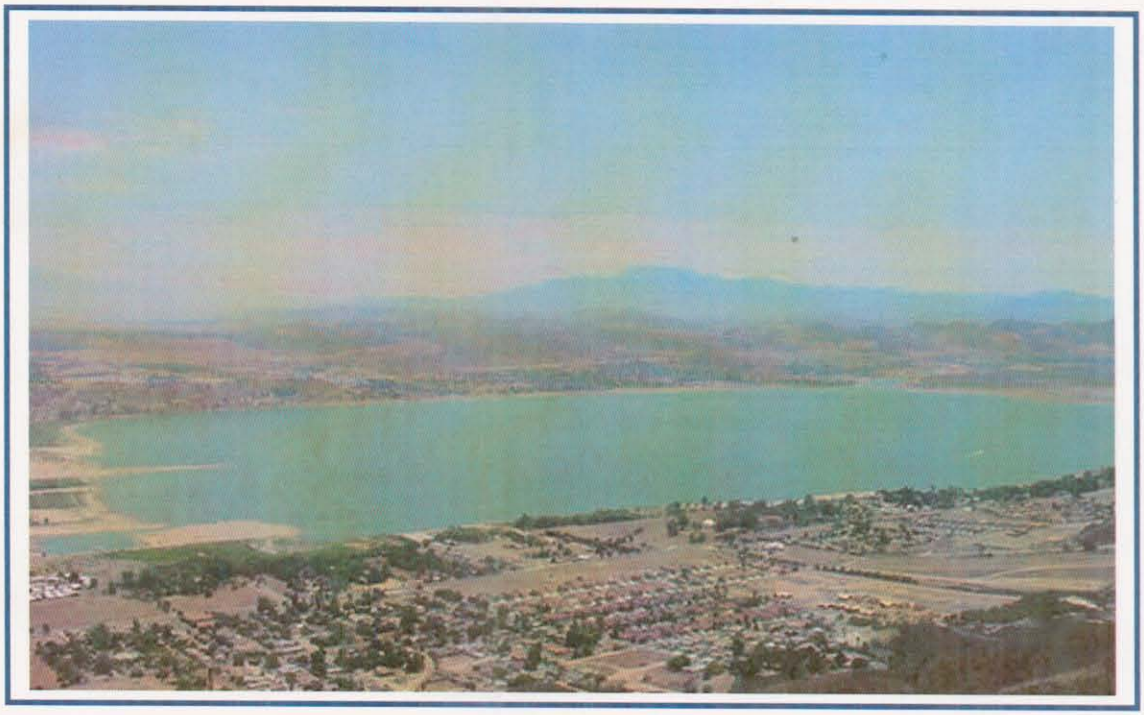
Surface Water Ambient Monitoring Program Report: Lake Elsinore - Sediment and Water Column Toxicity Study



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Santa Ana Regional Water Quality Control Board

May 18, 2007

Water Boards

Acknowledgements:

Staff from CRG Marine Laboratory and Aquatic Bioassay Consulting Laboratory collected sediment samples and performed the chemical analyses and toxicity bioassays for this study. Also, staff from the Aquatic Bioassay Consulting Laboratory collected the water column samples and performed the toxicity bioassays taxonomic identifications discussed in this report.

The City of Lake Elsinore provided access to the lake for the collection of all the samples.

Section ***Page No.***

List of Figures:

List of Tables:

List of Appendices:

I. Introduction

In 1991, Lake Elsinore was included on the Clean Water Act Section 303(d) List of Impaired Waters due to toxicity, low dissolved oxygen, turbidity, and algae blooms. In 1998, Regional Board staff initiated development of the nutrient TMDL for Lake Elsinore to address dissolved oxygen levels and algae blooms resulting from excessive nutrient input. However, the 303 (d) listing for toxicity was based on limited data leading Regional Board staff to embark on a monitoring study that would provide the additional data needed to confirm the appropriateness of the 303 (d) Listing for toxicity and to determine, to the extent possible, the pollutant (s) causing the impairment. The funding for this project came from the regional allocation provided by the Surface Water Ambient Monitoring Program (SWAMP), a statewide monitoring effort designed to assess the conditions of surface waters throughout the State of California administered by the State Water Resources Control Board. The purpose of this report is to summarize the results of the Lake Elsinore ambient water quality monitoring study.

• Setting

As shown in Figure 1, Lake Elsinore is located approximately 60 miles southeast of Los Angeles and approximately 22 miles south of the City of Riverside. The lake is located within the City of Lake Elsinore in southwestern Riverside County, and is the terminus of the San Jacinto River and its drainage basin. The total drainage basin of the San Jacinto River watershed is approximately 782 square miles. The local tributary area to the lake is approximately 47 square miles.

Lake Elsinore is very shallow, its depth ranging from a few feet to approximately 20 feet. Current monitoring data indicates that the lake is well mixed, except during brief periods of stratification. The 1995 Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) specifies beneficial uses for Lake Elsinore of body contact recreation (REC1), non-body contact recreation (REC2), warm freshwater aquatic habitat (WARM), and wildlife habitat (WILD).

• Historical Results

Toxic Substances Monitoring Program (TSMP), 1978-1987 and 1994-1995

The Department of Fish and Game under contract with the State Water Resources Control Board established the TSMP to collect fish from inland surface waters to determine concentrations of toxic substances in fish tissue. The purpose of the program, which terminated in 2002, was to provide a uniform statewide approach to detect and evaluate toxic substances in fresh, estuarine and marine waters of the state; water bodies with known or suspected water quality impairments were specifically targeted for evaluation. A review of the TSMP data was used as the basis for including Lake Elsinore on the 303(d) List as impaired due to toxic substances. The 1978-1987 and the 1994-1995 TSMP reports indicate that arsenic levels in largemouth bass from Lake Elsinore were above the 85% elevated data levels (EDL). The EDL is an internal State and Regional Board comparative measure, that ranks a given concentration of a particular

substance with other TSMP data collected throughout the state. It is calculated by ranking all of the results for a species, including exposure condition (resident or transplant), and a given chemical from the highest concentration measured down to and including those records where the chemical was not detected. From this, a cumulative distribution is constructed and percentile rankings are calculated. The EDL is not directly related to potentially adverse human or wild life health effects and is only a way to compare data in a particular area with the larger database that includes the data from the rest of the state. The fact that the data from the TSMP reports exceeds the EDL does not mean that arsenic exceeded a human health or a wild life standard. It only means that arsenic in the largemouth bass collected from Lake Elsinore during that time exceeded 85% of the arsenic levels in other largemouth bass measured throughout the state. Also it is important to note that the exceedance of the EDL was found only in one of 3 composite samples (a composite sample consists of 6 fish). The TSMP data also showed exceedances of the maximum tissue residue levels for total Chlordane, total DDT, and total PCB. Pursuant to the Functional Equivalent Document – Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List, September 2004 (Listing Policy FED), EDLs should not be used to evaluate fish tissue data or serve as a basis for making listing decisions.

Site Specific Objectives Study – 1991, 1992

Subsequent to the initial listing of Lake Elsinore on the 303(d) List for toxics, the Regional Board prepared a Site Specific Objective Report in 1991. The report was written in order to document the toxicity of several water bodies in the region, including Lake Elsinore and it discusses chemistry results of 3 water samples collected from the lake. These samples were collected in June, August, and November 1991; the chemical analyses consisted of total recoverable arsenic, cadmium, chromium, cobalt, copper, lead, silver, mercury, selenium, and zinc. The data was compared to water quality objectives specified in the 1991 California Inland Surface Water's Plan (ISWP) (this plan was later invalidated by the courts and was replaced by the California Toxics Rule (CTR)). At the time, the results indicated that the ISWP objectives for copper in one of the samples, mercury in one of the samples and selenium in all three samples were exceeded. The report does not discuss whether the exceedances of the copper and mercury standards were exceeded in the same location nor does it report the locations where the samples were collected. The report concludes that due to lack of data, an evaluation of toxic constituents that consistently exceeded ISWP objectives could not be made and that more data consisting of chemistry and toxicity are needed. A comparison of the data from the Site Specific Objective Report with the current CTR criteria for Aquatic Life Protection indicates that copper, mercury, and selenium exceed some of the criteria in the CTR.

The Site Specific Objectives Study report also discusses sediment chemistry data from Lake Elsinore. Aluminum, arsenic, chromium, copper, lead, manganese, nickel, zinc, p'p' DDD, p'p' DDE, and total DDT were found in the sediment at levels that exceeded sediment guidelines. The threshold effects levels (TELs) were the guidelines most often exceeded. Threshold effects levels are concentrations below which adverse effects are expected to occur only rarely. It should be noted that the Listing Policy FED specifies

the use of TELs for marine or estuarine sediments only and that "probable effect concentrations" (PECs) should be used to evaluate freshwater sediments. A comparison of the Site Specifics Objectives Study data to the PECs identified in the Listing Policy FED indicates that none of the concentrations of metals or organics exceed those sediment guidelines.

UC Davis Toxicity Study - 1993

In 1993, the Regional Board contracted with the University of California at Davis (UCD) to conduct toxicity bioassays on water samples from Lake Elsinore. Water samples from two stations in Lake Elsinore were collected in July, August and September 1993. The species tested were *Pimephales promelas* (fathead minnow), *Ceriodaphnia dubia* (water flea), and *Selenastrum capricornatum* (algae). In general, none of the samples showed adverse effects on the survival or reproduction of *P. promelas, C. dubia or S. capricornatum* and there was no evidence of acute or chronic toxicity in the lake.

Clean Lakes Study 1994, 1996

Two water quality management plan reports prepared by Black and Veatch in 1994 and 1996 for the Lake Elsinore Management Agency summarize sediment data from Lake Elsinore. These sediment samples were collected in July 1993 and in September 1995 respectively from one station in the lake. The metal analyses included arsenic, barium, chromium, cobalt, copper, lead, mercury, selenium, silver, and zinc. The results from the sample collected in 1993 are consistently below the PEC guidelines in the Listing Policy FED. On the other hand, the results from the sample collected in September 1995 indicate that arsenic, with a concentration of 126 mg/kg dry weight, and lead, with a concentration of 130 mg/kg dry weight, exceed the PEC guidelines of 33 mg/kg dry weight and 128 mg/kg dry weight, respectively.

City of Lake Elsinore Report - 1997

A November 1997 report prepared by the City of Lake Elsinore states that several toxins have been associated with few bloom forming algal species such as *Anabaena flow-aquae* and *Microcystis aeroginosa* both of which have been identified in Lake Elsinore. According to the report, large counts of these algae in windrows of other lakes have been known to kill livestock and water fowl that drink the water. The report further cites incidences of fish kills accompanied by duck kills along the shorelines of Lake Elsinore on or about 1995 and identifies botulism as the cause for the duck kills. As explained in the report, botulism bacteria thrive in anaerobic conditions commonly caused by dead algae and in turn, the toxin produced kills the ducks.

II. Methods

- **Study Design**

Due to uncertainties associated with the historical data available for Lake Elsinore, and the fact that the Lake is listed as impaired due to toxicity based on the use of EDL exceedances, Regional Board staff determined that additional data is necessary to determine if continued inclusion of Lake Elsinore on the 303(d) List for toxicity is appropriate and if so, if specific pollutants could be identified.

In the past, monitoring programs used to prepare the water quality assessments have used sampling and analytical protocols that did not address large-scale questions of the entire water body. Some of these large-scale questions involve defining the number of acres, or percent of acreage of that water body, that meets a regulatory threshold (e.g., water quality objective). An appropriate monitoring program design that defines the percent area meeting a threshold has been used in offshore ocean monitoring and other areas of Southern California. This monitoring design is a stratified-random sampling design with a spatially systematic component. This design randomly allocates sample sites throughout the water body of interest resulting in an unbiased representation of water quality. Stratification within the water body allows for comparisons of one sub-region (sub-population or stratum) to another.

A random study design was chosen for the assessment of ambient water quality in Lake Elsinore. Thirty randomly selected sites in the lake were sampled during each the wet season and the dry season. Sampling thirty sites across the Lake ensures that the 95% confidence interval is no larger than 15% of the sub-population area assuming about 20% impairment. Although sites were selected randomly, a systematic component was added to the selection process to minimize clustering of sample sites. The systematic element was accomplished by using an extension of the sampling design used in the Southern California Coastal Bight Pilot Project and in EPA's Environmental Monitoring and Assessment Program (EMAP). A hexagonal grid was placed over a map of the sampling area. The hexagonal grid structure ensures systematic separation of the sampling sites, while the random selection of sites within grid cells ensures an unbiased estimate of ecological condition.

The overall goal of the study was to attain a comprehensive and current assessment of water and sediment quality in Lake Elsinore.

The objectives of this monitoring study were:

- Determine if measured constituents exceed thresholds; define the extent (percent of area) and magnitude of deviation from thresholds.
- Describe and depict spatial gradients of contaminants of concern
- Determine seasonal relationships (i.e. dry vs. wet seasons)
- Assess the relationship between biological responses and contaminant exposure

- Compare the ambient water and sediment quality at Lake Elsinore with the ambient water and sediment quality at Canyon Lake (study to be done in later years).

Sampling took place in June and October 2003 for the dry season and April 2003 for the wet season. These months were chosen to represent ambient conditions during both the dry and wet seasons. Sampling in April was conducted after storm events had occurred in order to ensure that the data represented a period of time when the indicators are expected to remain stable[1]. Sediment, surface water column, and benthic infauna samples from the thirty sampling stations across Lake Elsinore were collected during the dry and the wet seasons. The following describes the analyses that were performed on these samples:

- **Sediment Chemistry**

Sediment samples were collected from the top 2 cm using a petite pulnar grab sampler. A list of the analyses with their detection limits and the laboratory quality control report may be found on Appendices 1 and 2 respectively. In order to determine possible anthropogenic influence on the trace metal results, these results were normalized to iron and to grain size; the trace organics were normalized to total organic carbon (TOC) and to grain size. Normalizing the metals to iron allows for a better determination of anthropogenic contributions of these to the environment. Normalizing the organics to TOC allows determination of the bioavailability of organic constituents to benthic organisms.

The metals were analyzed using EPA method 6020 and the organics were analyzed using EPA method 8270Cm.

- **Water Column Toxicity**

Water column samples near the surface of the water at each station were collected and analyzed for toxicity using *Selenastrum capricornatum* for germination and growth, *Pimephales promelas* for larval development, and *Ceriodaphnia dubia* for survival and reproduction bioassays (see Table 1). These analyses were performed on the undiluted samples. The toxicity tests included all required reference toxicant testing on the three species listed above. The methods used to test the water column samples for toxicity were EPA600/4-91-002 and EPA821-R-02-013 Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms. Two different methods were used because the laboratory analyzing the samples changed the analytical method in October 2003 to a newer method approved by EPA. Samples tested

[1] Approximately 4.75 inches of rain fell in the San Jacinto Watershed, from November 2003 through March 2004 (May 2007, Riverside County Flood Control District; Steve Clark personal communication). At that time, the average lake's elevation was 1238.44 feet, 10.56 feet below the optimal operation level of 1249 feet (March 2007, EVMWD; Julius Ma personal communication)

from the May 2003 sampling event were tested under method EPA600/4-91-002 and samples tested from the October event were tested under the new EPA approved method, EPA821-R-02-013. Note that these tests allow the determination of both acute (survival) and chronic toxicity (reproduction/growth).

Table 1. Toxicity tests and endpoints used for water column toxicity assessment.

Species Tested	Test End Point
Ceriodaphnia dubia	7 day survival and reproduction
Pimephales promelas	7 day survival and growth
Selenastrum capricornatum	96 hour growth

- **Sediment Toxicity**

Sediment for the toxicity tests was collected using a Petite Polnar grab sampler and the sediment was collected from the top 2 cm of the sediment grab. Toxicity was evaluated using the 7-day amphipod whole sediment test with *Hyallela azteca* as the test organism. The method used for this test was EPA method 600/R-94/024, Methods for Assessing the Toxicity and Bioaccumulation of Sediment Associated Contaminants with Freshwater Invertebrates. The end-point of the test was percent survivorship after a 28 day exposure to the sediment sample. The toxicity data (replicates) for each sample were compared to their control samples. Toxicity was determined by adjusting the average percent survival for each sample to the average percent survival for their respective control. A sediment sample was considered toxic if there was a significant difference ($p<0.05$) between the laboratory control and sample replicates using a t-test (one sided and assuming unequal variance). Since the State Listing Policy does not state a threshold for toxicity bioassay tests, 80% survival was used as the threshold for the sediment toxicity tests in this study to be consistent with other studies of similar nature, such as the Bight'98 regional study.

- **Benthic Infauna**

Benthic infauna (invertebrates that live in the sediment) are an important part of the aquatic food web. They generally reside in one location for most of their life, with limited mobility, and are chronically exposed to sediment contaminants. Consequently, infauna are excellent indicators of sediment quality. Samples for infaunal analyses were taken using a Petite Pulnar grab sampler. The sediment was sieved though a 1 mm mesh screen in the field and the organisms retained on the screen were preserved in a formalin solution. They were later transferred to 70% ethanol in the laboratory for storage. Infaunal analysis consisted of sorting and identification to the lowest possible taxon, usually to the species level.

The measures used to assess infaunal community health and function included the calculation of the number of species, total number of individuals, Shannon-Weiner Diversity Index (H'), and Species Evenness Index (J') for each station. H' and J' are sensitive to the distribution of species within a sample.

- **Statistical Analyses**

Since the same sites were sampled during the wet and dry seasons, seasonal differences in biological and chemical parameters were tested using a paired t-test. Significance was set at $p \leq 0.05$. Analysis of PAH, PCB and DDT was conducted on totals of similar compounds, not individual metabolites or congeners. Relationships of infaunal indices to toxicity, percent TOC and grain size were analyzed using Pearson Product Moment Correlation Analysis with significance set at $p \leq 0.05$. Due to the large number of samples collected in Lake Elsinore (n=30) the data means from each season were assumed to be normally distributed using the Central Limit Theorem. All analyses were performed using the Minitab statistical package.

III. Results

- **Toxicity Bioassays**

Table 2 summarizes the results of the sediment and water column toxicity bioassays showing the number of samples exhibiting toxicity during the wet and dry sampling seasons. Figures 3, and 4 show the locations of the sites exhibiting sediment toxicity during the dry and wet seasons. Figures 5, 6, 7, 8, and 9 show location of sites exhibiting water column toxicity during dry and wet seasons.

Water Column Toxicity

The water column toxicity data indicates only one incidence of acute toxicity to *C. dubia* in the wet season and 9 incidences of acute and 16 of chronic toxicity in the dry season. There were 3 incidences of acute toxicity to *S. capricornatum* in the wet season and one in the dry season. No incidences of toxicity were observed to *P. promelas.*

Seasonal differences were found in the water column toxicity bioassay results. *S. capricornatum* percent growth was significantly reduced during the wet season as compared to the dry season. No significant differences were found in the acute test (survival) for *P. promelas*. On the other hand, chronic and acute tests (reproduction and survival, respectively) for *C. dubia* showed significantly greater survival and reproduction ($p<0.05$) during the wet season than in the dry season.

Sediment Toxicity

There were more incidences of acute sediment toxicity in the wet season than in the dry season. During the wet season, 27 of the 30 stations exhibited sediment toxicity while during the dry season, 12 stations exhibited sediment toxicity.

Table 2: Number of stations exhibiting significant toxicity (<80%) in water column and sediment bioassays; n=30

	Wet Season		Dry Season	
Species	**Survival**	**Growth/Reproduction**	**Survival**	**Growth/Reproduction**
Hyallela azteca (sediment)	27	---	12	---
Pimephales promelas (water column)	0	0	0	0
Ceriodaphnia dubia (water column)	1	0	9	16
Selenastrum capricornatum (water column)	---	3	---	1

- **Sediment Chemistry Data**

Sediment chemistry data results were compared to thresholds (Probable Effect Concentration or PECs) as identified in the Listing Policy FED. None of the sediment data – metals or organics - exceeded these thresholds.

Seasonal differences in the metals data were found, however. Arsenic, beryllium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, titanium, vanadium and zinc were found to be in significantly greater concentrations in the dry season than in the wet season ($p<0.05$). Antimony was found in significantly less concentrations during the wet season's sampling event than during the dry season event. There were no significant differences in the two seasons for tin, aluminum or strontium ($p>0.05$).

Total DDT concentrations were found to be in significantly greater concentrations in the dry season than in the wet season; total DDT was below detection limits in the wet season at all stations. With the exception of station 224 in the dry season, total PCBs were also found below detection limits at all stations in the dry and wet season. No statistically significant difference was found between the dry and wet season's total PAH concentrations ($p>0.05$).

- **Community Diversity**

Community diversity information for the benthic infauna is summarized in Table 3. The number of distinct species found in the samples from Lake Elsinore was very low. During the dry season, the number of species ranged from 0 at 14 of the 30 stations (221, 222 223, 225, 227, 228, 229, 236, 239,240, 243, 244, 245, 246) to 6 species at station 217. During the wet season, the number of species ranged from 0 at 10 stations (217, 220, 221, 223, 225, 228, 230, 233, 236, and 245) to 4 species at station 224.

Intolerant species are those that are most sensitive and are the first to disappear as human disturbance increases; none of the samples from Lake Elsinore contained intolerant species. Species collected included, Physa, Daphnia, and Hyallela, typically pollution tolerant species. No statistically significant difference was found between the two seasons' Shannon-Weiner Diversity Indices (H') scores ($p>0.05$).

Table 3. Results of diversity indices calculated for data collected in April and October 2003

Wet Season					Dry Season				
Station	**Species**	**Abundance**	**H'**	**J'**	**Station**	**Species**	**Abundance**	**H'**	**J'**
217	2	6	0.64	0.92	217	6	27	1.11	0.62
218	1	3	0.00	-	218	2	3	0.64	0.92
219	1	4	0.00	-	219	2	8	0.38	0.54
220	1	5	0.00	-	220	1	4	0.00	-
221	1	14	0.00	-	221	0	0	0.00	-
222	1	3	0.00	-	222	0	0	0.00	-
223	2	4	0.56	0.81	223	0	0	0.00	-
224	0	0	0.00	-	224	1	1	0.00	-
225	1	1	0.00	-	225	0	0	0.00	-
226	0	0	0.00	-	226	1	1	0.00	-
227	3	3	1.10	1	227	0	0	0.00	-
228	1	1	0.00	-	228	0	0	0.00	-
229	1	3	0.00	-	229	0	0	0.00	-
230	2	8	0.66	0.95	230	3	21	0.59	0.54
231	0	0	0.00	-	231	2	4	0.69	1
232	0	0	0.00	-	232	1	1	0.00	-
233	0	0	0.00	-	233	1	1	0.00	-
234	1	3	0.00	-	234	1	1	0.00	-
235	0	0	0.00	-	235	2	5	0.50	0.72
236	1	6	0.00	-	236	0	0	0.00	-
237	0	0	0.00	-	237	2	2	0.69	1
238	0	0	0.00	-	238	2	3	0.64	0.91
239	1	1	0.00	-	239	0	0	0.00	-
240	3	7	0.80	0.72	240	0	0	0.00	-
241	1	1	0.00	-	241	3	10	0.64	0.58
242	0	0	0.00	-	242	1	2	0.00	-
243	0	0	0.00	-	243	0	0	0.00	-
244	1	1	0.00	-	244	0	0	0.00	-
245	4	5	1.33	0.96	245	0	0	0.00	-
246	2	9	0.35	0.50	246	0	0	0.00	-

- **Relationships Between Biological Responses and Sediment Contaminants**

No statistical relationships were observed between the sediment chemistry and the sediment toxicity results or the sediment chemistry and the diversity index scores in either season. However, a statistically significant ($p<0.05$ Spearman's Rho: -0.567;

Kendall's Tau a: -0.409), albeit negative, monotonic correlation was observed between percent fines and percent *H. azteca* survival during the dry season; as the percent fines increased, the percent survival decreased. This same relationship was not observed during the wet season. In addition, there was no statistically significant difference in amount of percent fines from one season to another ($p<0.05$).

V. Conclusions

- **Sediment Chemistry**

As previously discussed, sediment metals and organics concentrations were all below the Sediment Quality Guidelines as specified in the 303(d) Listing Policy. Consequently, there is no evidence to conclude that the chemical constituents measured in Lake Elsinore sediment are causing impairment.

- **Toxicity Bioassays:**

Water Column Toxicity

Higher incidences of toxicity in the water column were found in the dry season with *C. dubia*. However, this observed toxicity may not be due to a specific contaminant, but instead may be due to the high TDS and hardness of the lake and the fact that *C. dubia* is sensitive to high concentrations of TDS. The average TDS concentration during the dry season sampling event was 1,429 mg/l (TDS data from the wet season was unavailable) (Lake Elsinore Nutrient TMDL Monitoring Data). This hypothesis is corroborated by the comparison of the two season's results where a higher incidence of toxicity is found during the dry season when the TDS concentrations are at its highest. During the wet season, fresh water inputs probably dilute the TDS concentrations in some parts of the lake to the point that less incidences of toxicity are found.

S. Capricornatum toxicity was found in the dry and wet season with the highest frequency of toxicity occurring in the wet season. The number of samples exhibiting toxicity in the wet season is enough to include Lake Elsinore on the 303(d) list for water column toxicity.

Significant negative correlation was observed between *H. azteca* percent survival and percent fines; as the percent fines increased the percent survival decreased. This correlation was only observed in the dry season. Since organic contaminants are associated with percent fines, it is possible that an unmeasured contaminant(s) might be the cause of the toxicity. Further study in this area is needed to determine the exact cause of the observed toxicity.

Sediment Toxicity

Significant toxicity was found in the sediment with highest occurrence in the wet season. The sediment chemistry data does not suggest possible reasons for the observed toxicity

because the metals and organics concentrations are not above the Listing Policy thresholds and no statistical correlations between the chemistry and toxicity were found. However, there may be other factors that may be contributing to the observed toxicity such as unmeasured contaminants. Regardless of the cause of toxicity, the number of stations exhibiting toxicity in the wet and dry seasons is enough to include Lake Elsinore on the Section 303 (d) List for toxicity in the sediment.

- **Community Diversity**

As stated earlier, very few benthic infauna species were found. This low biodiversity may be explained by the fact that the sample locations for benthic infauna corresponded to those where the sediment chemistry and sediment toxicity samples were collected. These locations were spread evenly across the lake spanning the profundal zone; low biodiversity is expected in this zone as a result of the harsher conditions (low dissolved oxygen) typical of this zone in eutrophic lakes (Wetzel 1983). Consequently the types of genera found were those tolerant to organic matter such as Physa, Daphnia, and Hyallela species. A complete list of the genera found is in Appendices 3 and 4. Further data is needed to explain the low abundance within each of these genera.

VI. Recommendations

1. Refine the existing 303(d) listing for Lake Elsinore from "Unknown Toxicity" to "Sediment Toxicity" and "Water Column Toxicity".

2. Conduct sediment and water column toxicity identification evaluations on select samples to determine source(s) of toxicity

3. Develop long-term monitoring program to evaluate benthic infaunal community health. A number of stakeholder projects are being implemented or are planned to be implemented to address low dissolved oxygen levels in the water column, particularly the sediment-water interface. A long-term monitoring program will enable Board staff and stakeholders to determine if these projects are addressing benthic impacts or if additional actions should be identified.

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Figures

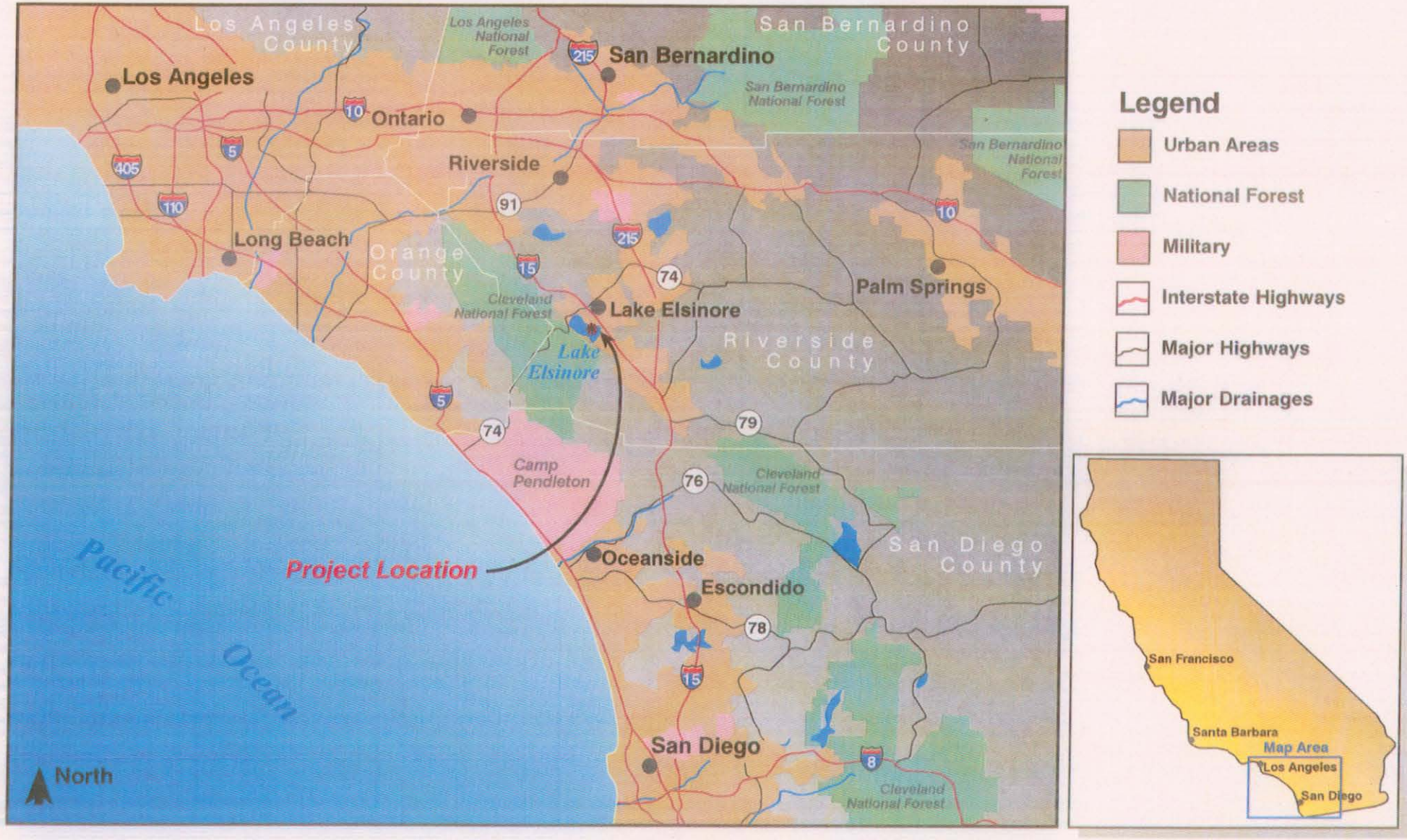
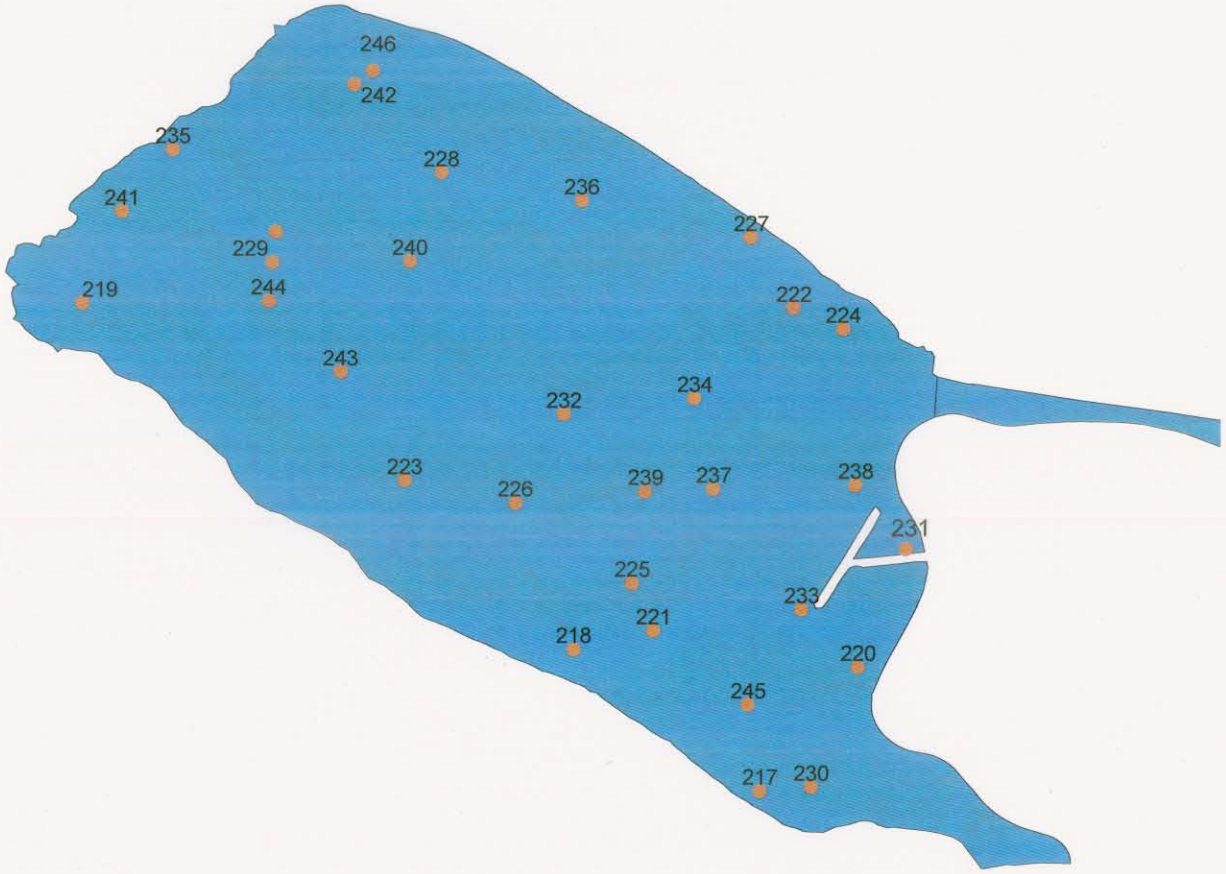


Figure 1 - Lake Elsinore Vicinity Map

Figure 2
Lake Elsinore Sampling Locations



Sampling locations

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W
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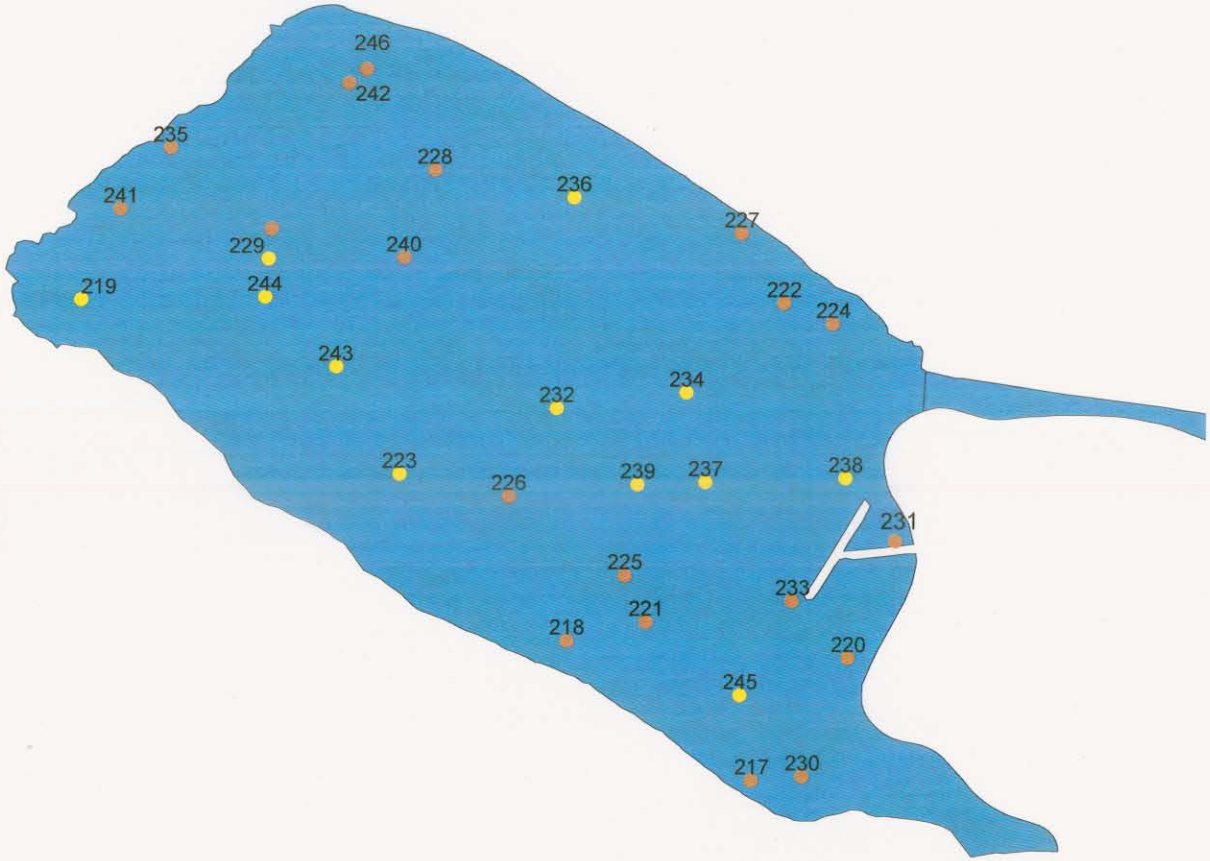
1 0 1 2 Miles

Figure 3
Stations exhibiting Hyallela azteca toxicity during the dry season



Toxic to Hyallela azteca

2 0 2 Miles

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W E
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Figure 4
Locations exhibiting Hyallela azteca toxicity during the wet season

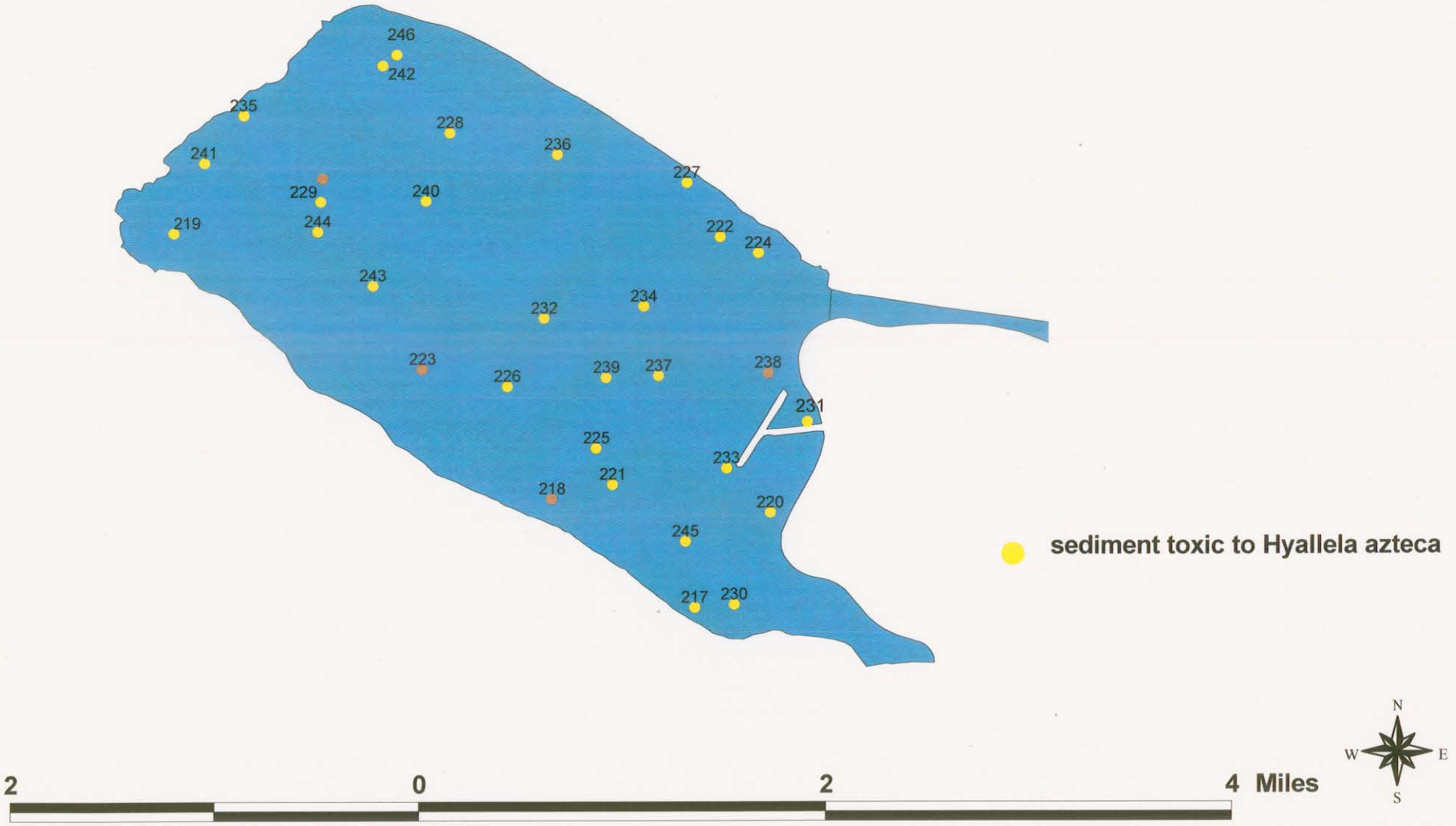
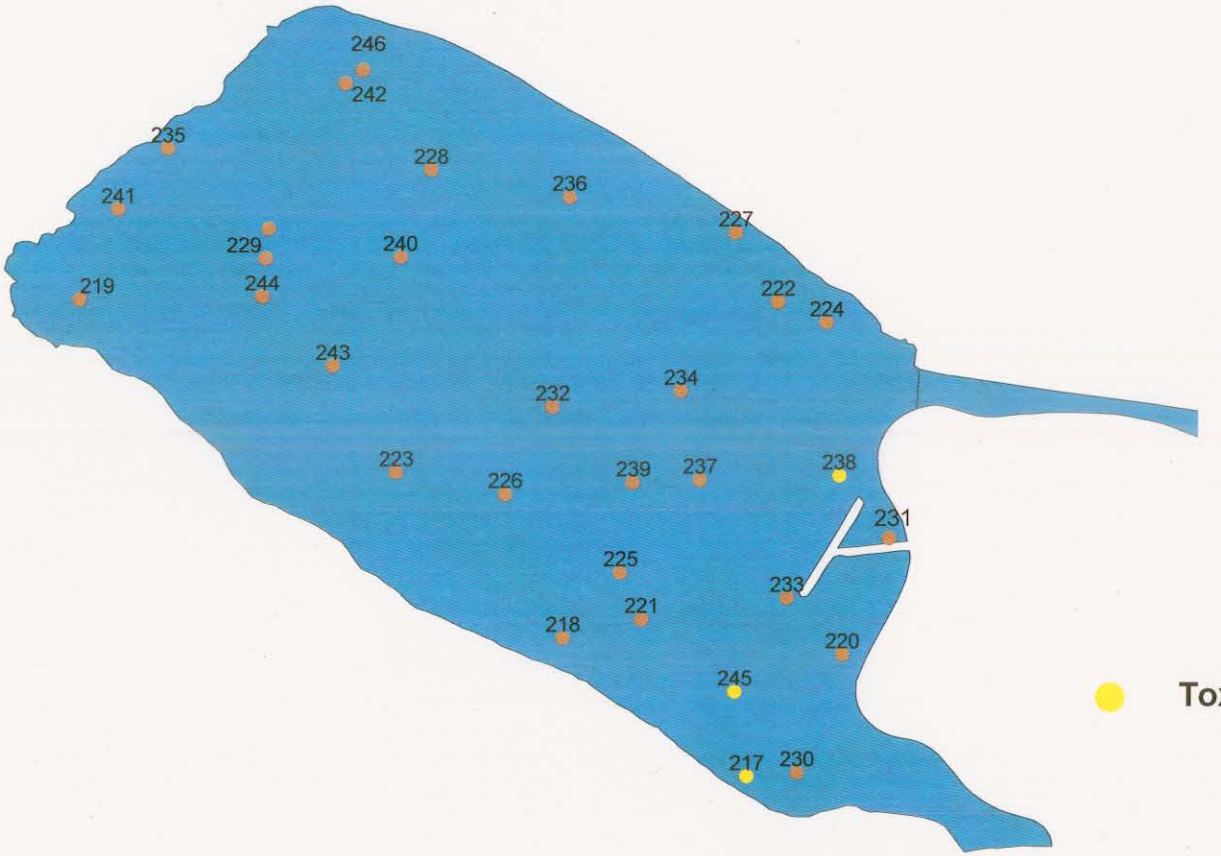


Figure 5
Stations exhibiting water column toxicity to Selenastrum during the wet season

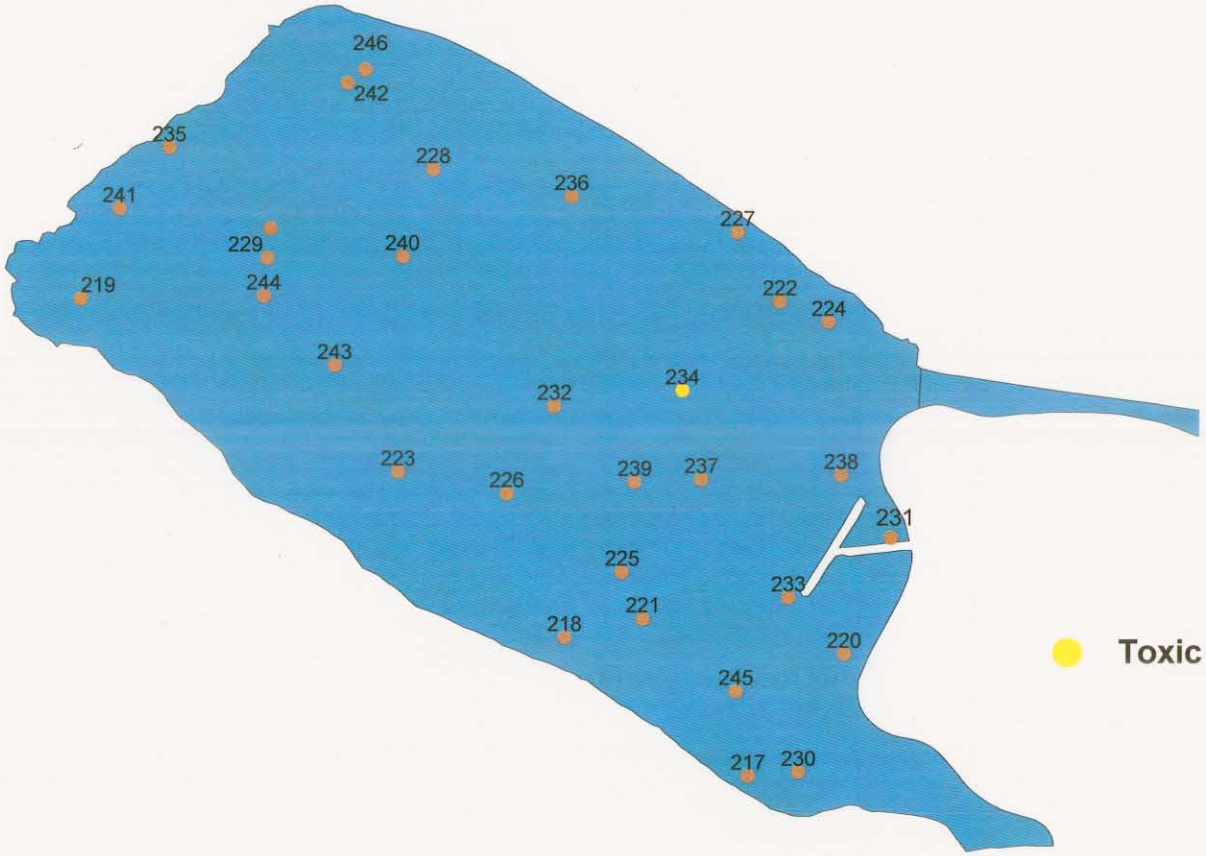


Toxic to Selenastrum capricornatum

2 0 2 4 Miles

N
W E
S

Figure 6
Stations exhibiting Selenastrum capricornatum toxicty during the dry season

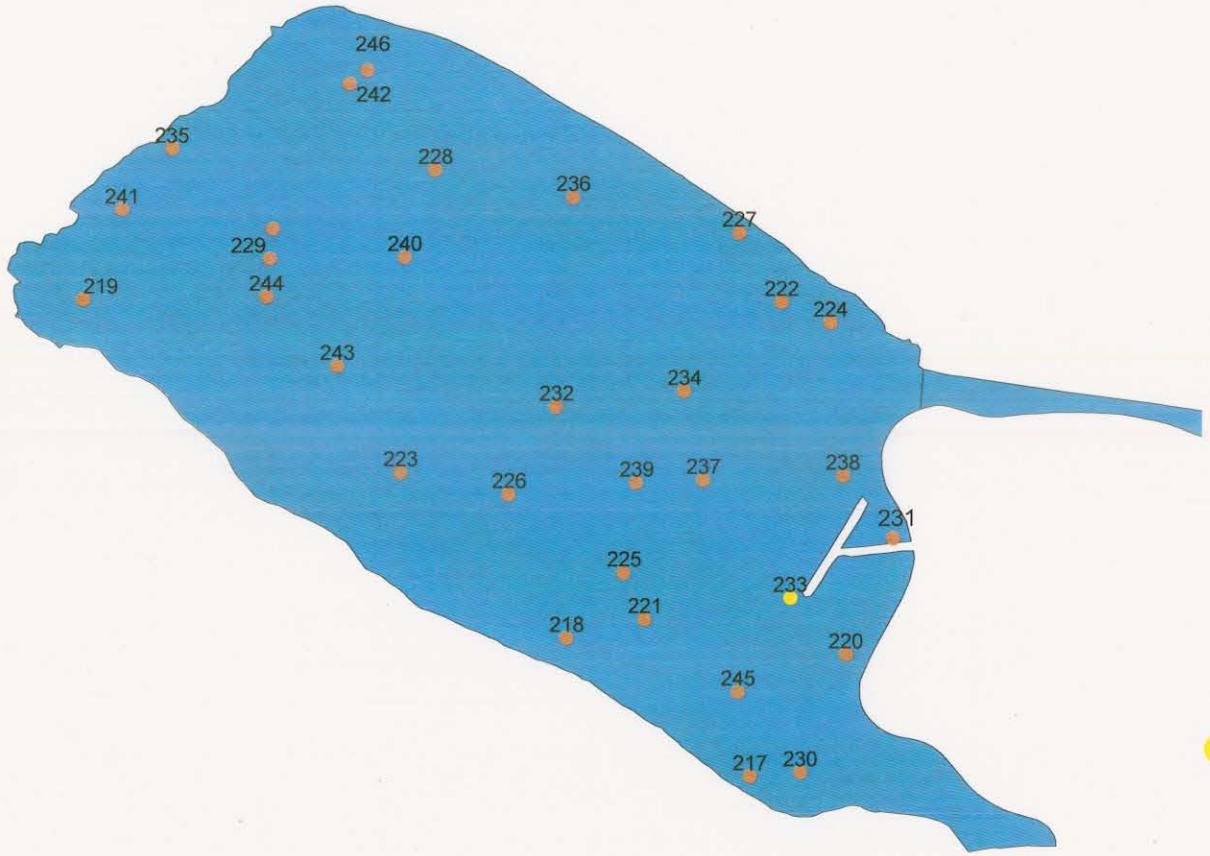


Toxic to Selenastrum capricornatum

2 0 2 Miles

N
W E
S

Figure 7
Stations exhibiting ceriodaphnia survival toxicity during the wet season

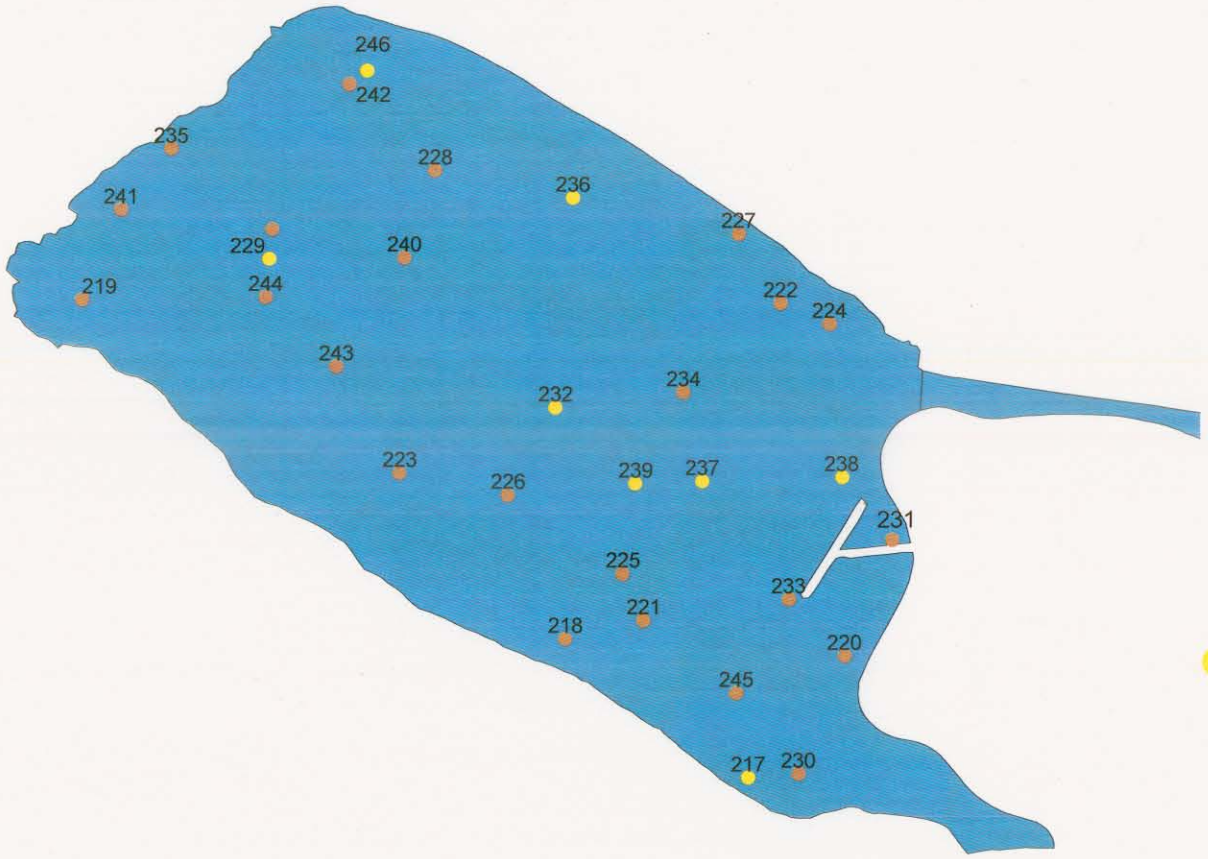


Toxic to Ceriodaphnia dubia

2 0 2 Miles

N
W E
S

Figure 8
Stations exhibiting Ceriodaphnia survival toxicity during the dry season

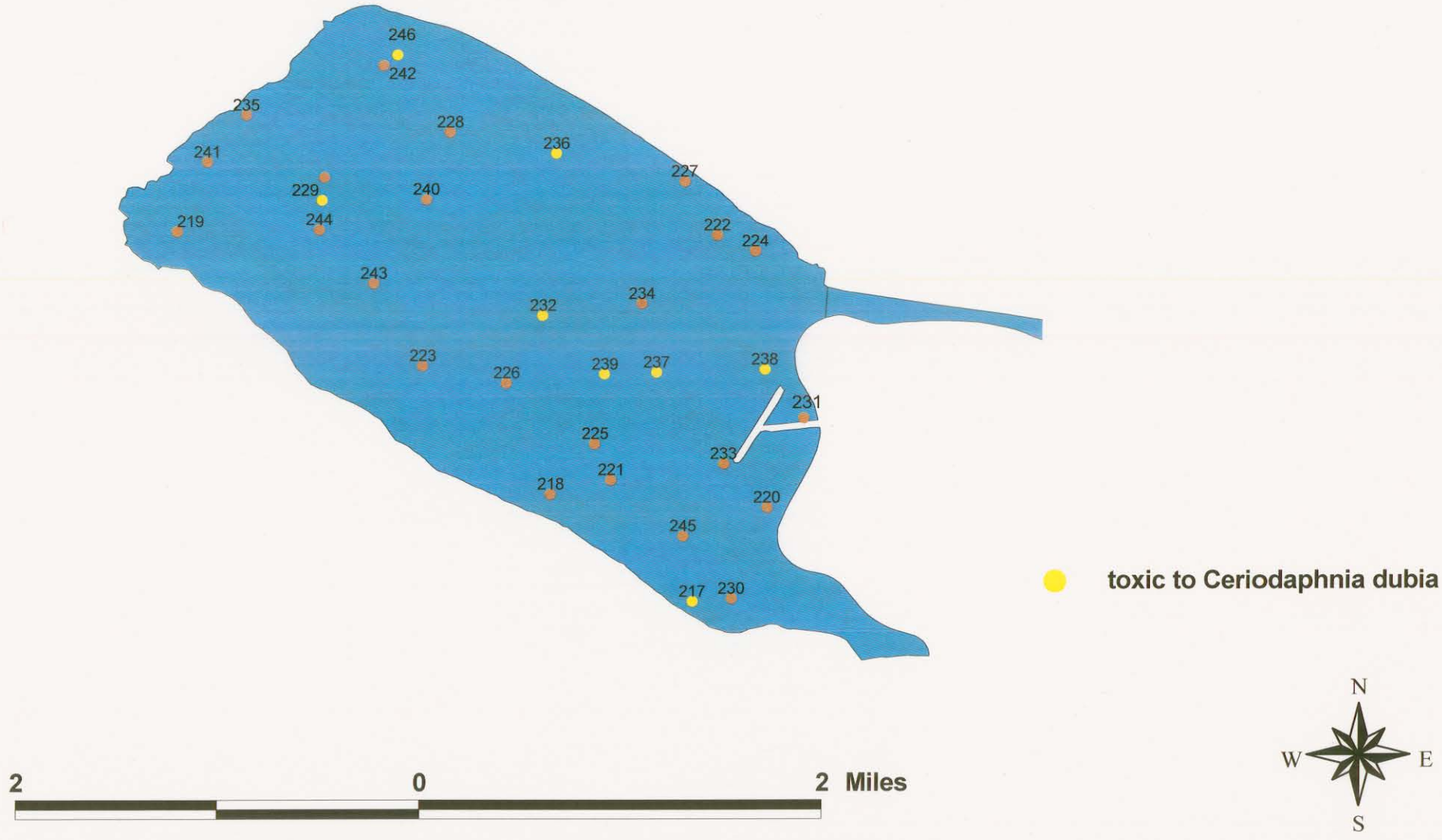


Toxic to Ceriodaphnia dubia

2 0 2 Miles

N
W E
S

Figure 9
Stations exhibiting Ceriodaphnia reproduction toxicity during the dry season



Appendices

Appendix 1- Detection Limits

Parameter	MDL	MDL_Units	Analytical Method
Aroclor 1016	10	ng/g	EPA 8270
Aroclor 1221	10	ng/g	EPA 8270
Aroclor 1232	10	ng/g	EPA 8270
Aroclor 1242	10	ng/g	EPA 8270
Aroclor 1248	10	ng/g	EPA 8270
Aroclor 1254	10	ng/g	EPA 8270
Aroclor 1260	10	ng/g	EPA 8270
2,4'-DDD	1	ng/g	EPA 8270
2,4'-DDE	1	ng/g	EPA 8270
2,4'-DDT	1	ng/g	EPA 8270
4,4'-DDD	1	ng/g	EPA 8270
4,4'-DDE	1	ng/g	EPA 8270
4,4'-DDT	1	ng/g	EPA 8270
Aldrin	1	ng/g	EPA 8270
BHC-alpha	1	ng/g	EPA 8270
BHC-beta	1	ng/g	EPA 8270
BHC-delta	1	ng/g	EPA 8270
BHC-gamma	1	ng/g	EPA 8270
Chlordane-alpha	1	ng/g	EPA 8270
Chlordane-gamma	1	ng/g	EPA 8270
cis-Nonachlor	1	ng/g	EPA 8270
Dicofol	1	ng/g	EPA 8270
Dieldrin	1	ng/g	EPA 8270
Endosulfan Sulfate	1	ng/g	EPA 8270
Endosulfan-I	1	ng/g	EPA 8270
Endosulfan-II	1	ng/g	EPA 8270
Endrin	1	ng/g	EPA 8270
Endrin Aldehyde	1	ng/g	EPA 8270
Endrin Ketone	1	ng/g	EPA 8270
Heptachlor	1	ng/g	EPA 8270
Heptachlor Epoxide	1	ng/g	EPA 8270
Methoxychlor	1	ng/g	EPA 8270
Mirex	1	ng/g	EPA 8270
Oxychlordane	1	ng/g	EPA 8270
Toxaphene	10	ng/g	EPA 8270
trans-Nonachlor	1	ng/g	EPA 8270
Acid Volatile Sulfides	0.05	mg/dry kg	
Percent Solids	0.1	% Dry Weight	
PCB001	1	ng/g	EPA 8270
PCB002	1	ng/g	EPA 8270
PCB003	1	ng/g	EPA 8270
PCB004	1	ng/g	EPA 8270
PCB006	1	ng/g	EPA 8270
PCB008	1	ng/g	EPA 8270
PCB009	1	ng/g	EPA 8270
PCB016	1	ng/g	EPA 8270
PCB018	1	ng/g	EPA 8270
PCB019	1	ng/g	EPA 8270
PCB022	1	ng/g	EPA 8270
PCB025	1	ng/g	EPA 8270
PCB028	1	ng/g	EPA 8270

Appendix 1- Detection Limits

Parameter	MDL	MDL_Units	Analytical Method
PCB031	1	ng/g	EPA 8270
PCB033	1	ng/g	EPA 8270
PCB037	1	ng/g	EPA 8270
PCB044	1	ng/g	EPA 8270
PCB049	1	ng/g	EPA 8270
PCB052	1	ng/g	EPA 8270
PCB056	1	ng/g	EPA 8270
PCB065	1	ng/g	EPA 8270
PCB066	1	ng/g	EPA 8270
PCB067	1	ng/g	EPA 8270
PCB070	1	ng/g	EPA 8270
PCB071	1	ng/g	EPA 8270
PCB074	1	ng/g	EPA 8270
PCB077	1	ng/g	EPA 8270
PCB081	1	ng/g	EPA 8270
PCB082	1	ng/g	EPA 8270
PCB087	1	ng/g	EPA 8270
PCB095	1	ng/g	EPA 8270
PCB097	1	ng/g	EPA 8270
PCB099	1	ng/g	EPA 8270
PCB101	1	ng/g	EPA 8270
PCB105	1	ng/g	EPA 8270
PCB110	1	ng/g	EPA 8270
PCB114	1	ng/g	EPA 8270
PCB118	1	ng/g	EPA 8270
PCB119	1	ng/g	EPA 8270
PCB123	1	ng/g	EPA 8270
PCB126	1	ng/g	EPA 8270
PCB128	1	ng/g	EPA 8270
PCB128+167	1	ng/g	EPA 8270
PCB132	1	ng/g	EPA 8270
PCB138	1	ng/g	EPA 8270
PCB141	1	ng/g	EPA 8270
PCB146	1	ng/g	EPA 8270
PCB147	1	ng/g	EPA 8270
PCB149	1	ng/g	EPA 8270
PCB151	1	ng/g	EPA 8270
PCB153	1	ng/g	EPA 8270
PCB156	1	ng/g	EPA 8270
PCB157	1	ng/g	EPA 8270
PCB158	1	ng/g	EPA 8270
PCB167	1	ng/g	EPA 8270
PCB168	1	ng/g	EPA 8270
PCB168+132	1	ng/g	EPA 8270
PCB169	1	ng/g	EPA 8270
PCB170	1	ng/g	EPA 8270
PCB173	1	ng/g	EPA 8270
PCB174	1	ng/g	EPA 8270
PCB177	1	ng/g	EPA 8270
PCB179	1	ng/g	EPA 8270
PCB180	1	ng/g	EPA 8270

Table 1. Raw taxa and abundances from lake Elsinore stations, 1-2 October 2003.

			Station																											
Taxa	**TV**	**FFG**	**217**	**218**	**219**	**220**	**221**	**222**	**223**	**224**	**225**	**226**	**227**	**228**	**229**	**230**	**231**	**232**	**233**	**234**	**235**	**236**	**237**	**238**	**239**	**240**	**241**	**242**	**243**	**244**	**245**	**246**
Physa	8	sc																														
Tubificidae	5	cg	6		1																											
Daphnia	8	cf																														
Hyallela	8	cg	1	1						1														1			1					
Cyprididae	8	cg										1																				
Graptocorixa	8	p	1																													
Chironomus	10	cg	16	1	4	4										17				1	3						7	2				
Polypedilum	6	om	1	1	3												2				1											
Cladotanytarsus	7	cg																									1					
Cricotopus	7	cg	1													3	2	1			1		1	2			1					
Tanypus	10	p	1													1			1				1									
Procladius	9	p																														

Table 2. Identified taxa and abundances from Lake Elsinore stations, 1-2 October 2003.

			Station																													
Taxa	**TV**	**FFG**	**217**	**218**	**219**	**220**	**221**	**222**	**223**	**224**	**225**	**226**	**227**	**228**	**229**	**230**	**231**	**232**	**233**	**234**	**235**	**236**	**237**	**238**	**239**	**240**	**241**	**242**	**243**	**244**	**245**	**246**
Physa	8	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae	5	cg	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daphnia	8	cf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyallela	8	cg	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Cyprididae	8	cg	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Graptocorixa	8	p	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	6	cg	17	2	7	4	0	0	0	0	0	0	0	0	0	17	2	0	0	1	4	0	0	0	0	0	8	2	0	0	0	0
Orthocladiinae	5	cg	1	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	1	0	1	2	0	0	1	0	0	0	0	0
Tanypodinae	7	p	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
		sum	27	3	8	4	0	0	0	1	0	1	0	0	0	21	4	1	1	1	5	0	2	3	0	0	10	2	0	0	0	0

Table 3. Biological Metrics from Lake Elsinore, 1-2 October 2003.

	217	**218**	**219**	**220**	**221**	**222**	**223**	**224**	**225**	**226**	**227**	**228**	**229**	**230**	**231**	**232**	**233**	**234**	**235**	**236**	**237**	**238**	**239**	**240**	**241**	**242**	**243**	**244**	**245**	**246**
Taxonomic richness	6	2	2	1	0	0	0	1	0	1	0	0	0	3	2	1	1	1	2	0	2	2	0	0	3	1	0	0	0	0
Shannon Diversity	1.11	0.64	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.69	0.00	0.00	0.00	0.50	0.00	0.69	0.64	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00
% dominant taxa	63.0	66.7	87.5	100.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0	0.0	81.0	50.0	100.0	100.0	100.0	80.0	0.0	50.0	66.7	0.0	0.0	80.0	100.0	0.0	0.0	0.0	0.0
Percent Chironomidae	70.4	66.7	87.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	66.7	0.0	0.0	90.0	100.0	0.0	0.0	0.0	0.0
Tolerance Value	5.9	6.7	5.9	6.0	0.0	0.0	0.0	8.0	0.0	8.0	0.0	0.0	0.0	5.9	5.5	5.0	7.0	6.0	5.8	0.0	6.0	6.0	0.0	0.0	6.1	6.0	0.0	0.0	0.0	0.0
Percent Intolerance Value (0-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Tolerance Value (8-1(	7.4	33.3	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0
Percent Collectors	92.6	100.0	100.0	100.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0	0.0	95.2	100.0	100.0	0.0	100.0	100.0	0.0	50.0	100.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0
Percent Filterers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Grazers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Predators	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	100.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Shredders	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	100.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1. Raw taxa and abundances from lake Elsinore stations, 29-30 April 2003.

			Station																							
Taxa	**TV**	**FFG**	**219**	**241**	**229**	**235**	**243**	**244**	**242**	**240**	**246**	**218**	**226**	**232**	**236**	**221**	**239**	**237**	**233**	**245**	**234**	**222**	**227**	**220**	**238**	**224**	**231**
Physa sp	8	sc									1																
Tubificidae	5	cg	2																							2	
Daphnia sp	8	cf			4		14	3		1	1		3	5			3					5				1	1
Hyallela sp	8	cg							1																		
Cyprididae	8	cg							3					3				6				1				1	8
Graptocorixa sp	8	p										1										1					
Chironomus sp	10	cg	4	1		5					1										1						
Polypedilum sp	6	om																									
Cladotanytarsus	7	cg		2																			1				
Cricotopus sp	7	cg																							1		
Tanypus sp	10	p																									
Procladius sp	9	p																								1	

Table 2. Identified taxa and abundances from Lake Elsinore stations, 29-30 April 2003.

			Station																								
Taxa	**TV**	**FFG**	**219**	**241**	**229**	**235**	**243**	**244**	**242**	**240**	**246**	**218**	**226**	**232**	**236**	**221**	**239**	**237**	**233**	**245**	**234**	**222**	**227**	**220**	**238**	**224**	**231**
Physa	8	sc	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubificidae	5	cg	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Daphnia	8	cf	0	0	4	0	14	3	0	1	1	0	3	5	0	0	3	0	0	0	0	5	0	0	0	1	1
Hyallela	8	cg	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprididae	8	cg	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	6	0	0	0	1	0	0	0	1	8
Graptocorixa	8	p	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Chironominae	6	cg	4	3	0	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Orthocladiinae	5	cg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tanypodinae	7	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		sum	6	3	4	5	14	3	4	1	3	1	3	8	0	0	3	6	0	0	1	7	1	0	1	5	9

Table 3. Biological Metrics from Lake Elsinore, 29-30 April 2003.

	219	**241**	**229**	**235**	**243**	**244**	**242**	**240**	**246**	**218**	**226**	**232**	**236**	**221**	**239**	**237**	**233**	**245**	**234**	**222**	**227**	**220**	**238**	**224**	**231**
Taxonomic richness	2	1	1	1	1	1	2	1	3	1	1	2	0	0	1	1	0	0	1	3	1	0	1	4	2
Shannon Diversity	0.64	0.00	0.00	0.00	0.00	0.00	0.56	0.00	1.10	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	1.33	0.35
% dominant taxa	66.7	100.0	100.0	100.0	100.0	100.0	75.0	100.0	33.3	100.0	100.0	62.5	0.0	0.0	100.0	100.0	0.0	0.0	100.0	71.4	100.0	0.0	100.0	40.0	88.9
Percent Chironomidae	66.7	100.0	0.0	100.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0	100.0	20.0	0.0
Tolerance Value	5.7	6.0	8.0	6.0	8.0	8.0	8.0	8.0	7.3	8.0	8.0	8.0	0.0	0.0	8.0	8.0	0.0	0.0	6.0	8.0	6.0	0.0	5.0	6.6	8.0
Percent Intolerance Value (0-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Tolerance Value (8-1(	0.0	0.0	100.0	0.0	100.0	100.0	100.0	100.0	66.7	100.0	100.0	100.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	40.0	100.0
Percent Collectors	100.0	100.0	0.0	100.0	0.0	0.0	100.0	0.0	33.3	0.0	0.0	37.5	0.0	0.0	0.0	100.0	0.0	0.0	100.0	14.3	100.0	0.0	100.0	60.0	88.9
Percent Filterers	0.0	0.0	100.0	0.0	100.0	100.0	0.0	100.0	33.3	0.0	100.0	62.5	0.0	0.0	100.0	0.0	0.0	0.0	0.0	71.4	0.0	0.0	0.0	20.0	11.1
Percent Grazers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Predators	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	20.0	0.0
Percent Shredders	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	20.0	0.0