Santa Rosa Subregional Long-Term Wastewater Project

SEDIMENT QUALITY CHARACTERIZATION FOR THE RUSSIAN RIVER, LAGUNA DE SANTA ROSA, SANTA ROSA CREEK, AND RECLAIMED WATER STORAGE PONDS

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

Prepared for

City of Santa Rosa
and
U.S. Army Corps of Engineers

June 1996

Prepared by:

Merritt Smith Consulting
Environmental Science and Communication
3675 Mt. Diablo Blvd. #120 Lafayette, CA 94549

For

HARLAND BARTHOLOMEW & ASSOCIATES, INC.

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AUTHORS

This report was prepared by Marcie L. Commins, Ph.D.

1.0 SUMMARY

Sediment samples were collected in the Laguna de Santa Rosa, Santa Rosa Creek, Russian River, two reclaimed water storage ponds (Meadowlane Pond and Brown Pond) and Kelly Farm Demonstration Wetland cell 3 (KFDW) during 13-15 July 1994. The results presented here from a single sampling period do not allow for assessment of any season variability.

Of the 119 organic compounds that were analyzed in the sediment samples, only six were found in detectable quantities in surface samples: 2,4,5-T, 2-chlorophenol, 2-nitrophenol, 4-chloro-3-methylphenol, pentachlorophenol, and phenol. Two organic compounds were found in detectable quantities in the subsurface sediment: 2,4,5-T, and phenol.

Cyanide and the surface metal concentrations resulting from the weak acid extraction (WAE) method showed no indication of potentially bioavailable metals accumulation that can be clearly attributed to reclaimed water discharge with the possible exceptions of cadmium and copper. Cadmium and copper were detectable in Brown and Meadowlane Ponds and in Santa Rosa Creek below the discharge but not detectable in the Laguna or Russian River below the discharge or in KFDW, locations that are also exposed to reclaimed water. These conclusions are confirmed with the strong acid extraction (SAE) results. The surface metals concentrations were nearly always higher above the discharge than below the discharge as determined by SAE and the SAE results normalized to organic carbon. The possible exception to this is with silver, which was only detectable in storage pond sediment. However, as with cadmium for the weak acid extracted results, the lack of detectable silver in the creek sediment makes it difficult to draw any meaningful conclusions. The concentrations of weak acid extracted metals normalized to sediment surface area also do not show a regular pattern of increased metals in sediment samples collected below the discharge or in storage ponds.

The results of the July 1994 sediments collection were compared with sediment data collected by the North Coast Regional Water Quality Control Board. For most metals with available data, the concentrations in July 1994 sediments were either lower than in 1985-86 or no comparison can be made due to concentrations below detection. The exceptions to this were for chromium, copper, and zinc. However, there is no consistent evidence that the increases concentrations are due to reclaimed water.

The results of the sediment collections were evaluated for significant impacts and range of impacts. Significant impacts were evaluated by comparison to sediment quality criteria (SQC). SQC are proposed (the specific regulatory uses of SQC have not been established) by the United States Environmental Protection Agency for acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene. These compounds are not found in detectable concentrations in reclaimed water nor are they found in detectable concentrations in storage pond sediments. The estimated concentrations of acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene resulting from maximum projected discharge are all below their respective SQCs.

The Ecological Risk Assessment (*Ecological Risk Assessment for Santa Rosa Subregional Long-Term Wastewater Project* Technical Report, Parsons ES Austin 1996) assesses the exposure risk of selected receptor organisms to the toxic effects of reclaimed water constituents via several exposure pathways, including sediment. The range of impacts evaluation was used as input to the Ecological Risk Assessment.

The ranges of predicted *incremental* concentrations of organic compounds in Russian River and Laguna sediment that would result from the median (50th percentile) reclaimed water concentration associated with each reclaimed water discharge component (one, five, ten, and 20 percent) were estimated. The *total* concentrations of organics that are predicted to increase with increased reclaimed water discharge cannot be estimated because the current background receiving water concentrations are below detection.

Barium and arsenate (as $BaAsO_4$) were the only metals/ligands complexes (other than $CaCO_3$) predicted to precipitate under any discharge component. The concentrations in sediments of barium and arsenic due to reclaimed water were estimated for one, five, ten, and 20 percent design discharge to the Laguna. The predicted concentrations of barium decreased with increasing reclaimed water discharge because the average concentration in the receiving water was higher than the average concentration in reclaimed water. The predicted concentrations of arsenic in the Russian River were the same for all concentrations of reclaimed water discharge because the concentration in the receiving water was below detection and the concentration in reclaimed water was equal to half the detection limit. The predicted concentrations of arsenic in the Laguna decreased with increasing reclaimed water discharge because the concentration in reclaimed water was less than the concentration of arsenic in the Laguna.

2.0 INTRODUCTION

Sediment quality characterization in the area of the existing Santa Rosa reclaimed water discharge is necessary to address North Coast Regional Water Quality Control Board (RWQCB) concerns and to evaluate the impact of reclaimed water discharge on sediment in receiving water. The objectives of this report are as follows:

- To provide a description of the sediment quality at stations in the Laguna de Santa Rosa, Santa Rosa Creek, the Russian River, and reclaimed water storage ponds.
- To evaluate potential impacts from reclaimed water discharge on sediment quality.

3.0 MONITORING PLAN

Sediment samples were collected in the Laguna de Santa Rosa, Santa Rosa Creek, Russian River, two reclaimed water storage ponds (Meadowlane Pond and Brown Pond) and Kelly Farm Demonstration Wetland cell 3 (KFDW) during 13-14 July 1994. Samples in the Laguna were collected above any Santa Rosa reclaimed water discharge at Stony Point Road and one below Santa Rosa discharge at Trenton Healdsburg Road. Samples in Santa Rosa Creek were collected above the discharge at Willowside and downstream from the Delta Pond discharge point. Samples in the Russian River were collected above the confluence with the Laguna (and thus above Santa Rosa's reclaimed water discharge) at Kaiser Beach, and below the discharge at Hilton Beach. Station locations are shown in Figure 1. The Russian River stations were selected because they had some accumulation of fine sediment and organic matter, unlike most of the River which has a sandy to gravely substrate with little accumulation of fine sediment and organic matter. Thus the stations selected represent maximum metal and organic contaminants in the Russian River. Five sample types were collected at each location:

- Surface trace element samples taken from the upper approximately 1/2 inch of the sediment
- Surface organic and particle size distribution samples taken as for surface trace element samples
- Subsurface trace element samples taken from up to about six inches after the surface 1/2 inch of sediment had been removed
- Subsurface organic and particle size distribution samples taken as for subsurface trace element samples

Surface sediment bacteriology samples collected as for trace element samplesSamples for nutrients were collected from either the trace element or organic samples at the discretion of the laboratory. Each sample was composed of three subsamples taken from widely spaced locations (within the bounds of each sampling station) and composited to form one sample. River and creek samples were collected using a cleaned 1-liter glass jar. Pond samples were taken from a boat using an Ekman dredge. Trace element samples were taken from the middle of the dredged material. Metals samples were composited in a cleaned plastic bucket and organics samples were composited in a cleaned metal bucket. Buckets were cleaned in the laboratory by washing with laboratory soap and rinsed with tap water. Every effort was made during sample collection to preclude contamination and cross-contamination of the samples. Samples were placed into glass jars which were then put into an ice chest and cooled to 4°C. Each sample type (surface metals, surface organic, subsurface metals, and subsurface organic) was analyzed for the constituents shown in Table 1. Additional samples for bacteriology were collected in the Russian River at Healdsburg and Johnson's Beach.

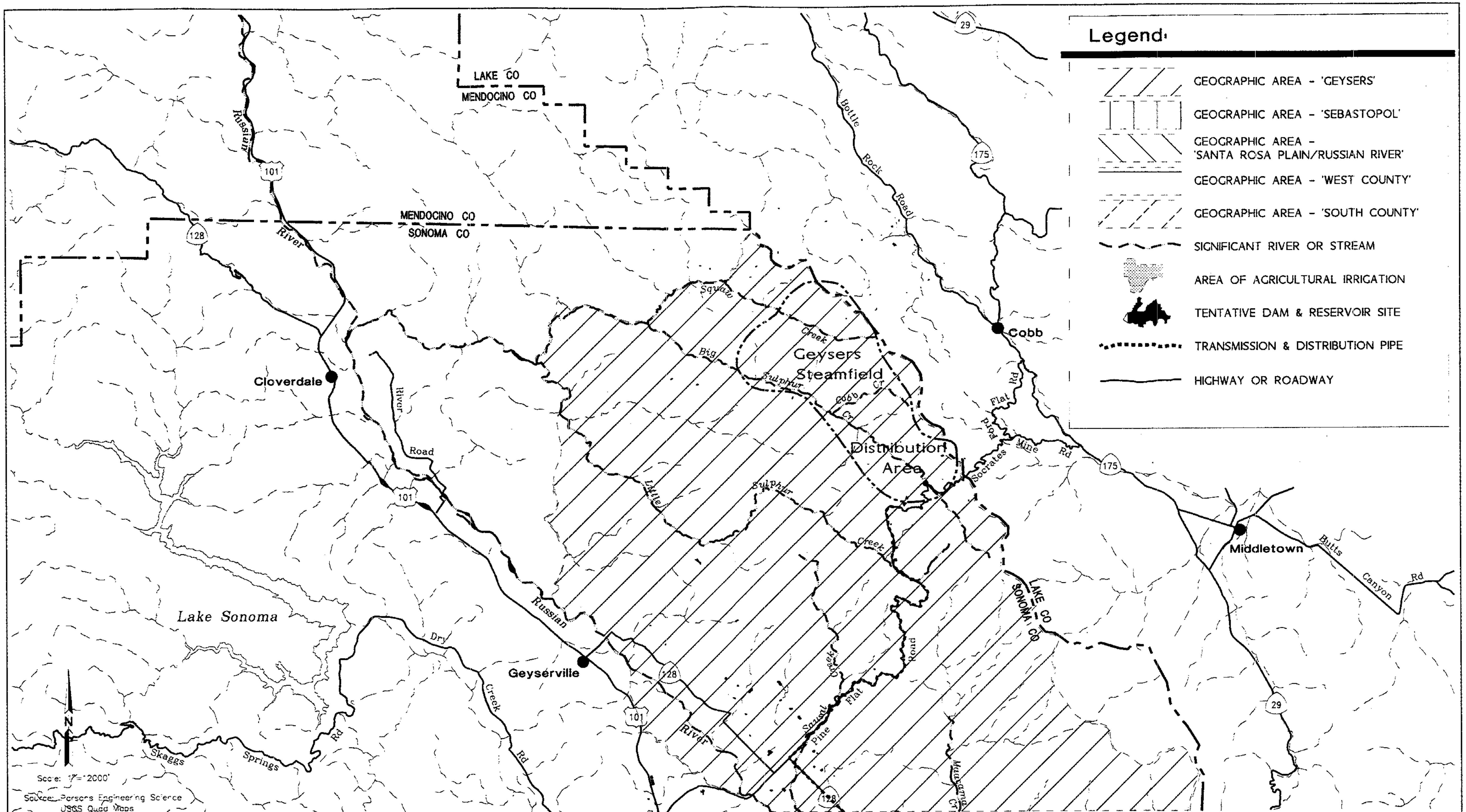

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Figure 1a
SEDIMENT QUALITY CHARACTERIZATION STATIONS

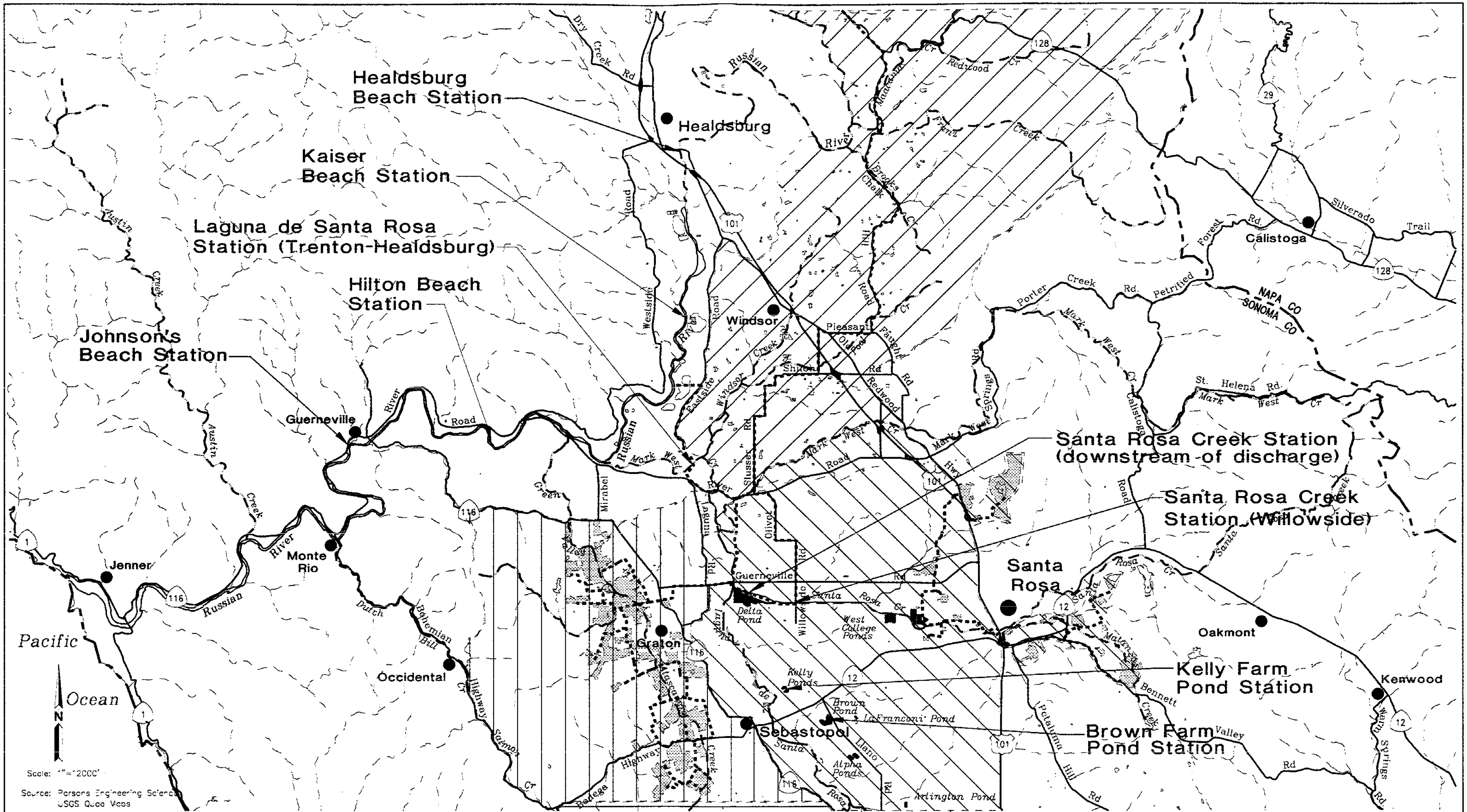

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Figure 1b

SEDIMENT QUALITY CHARACTERIZATION STATIONS

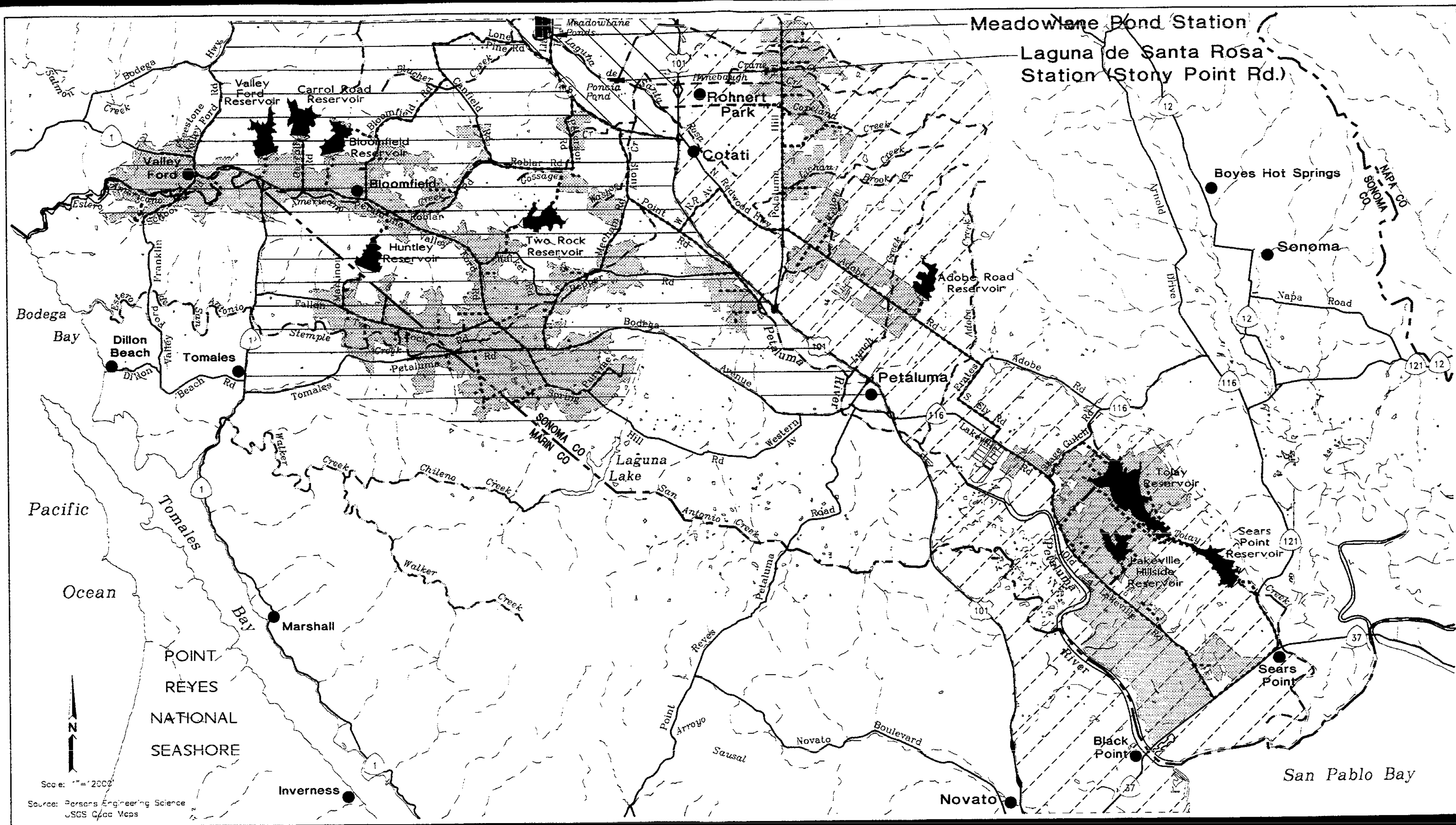

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Figure 1c

SEDIMENT QUALITY CHARACTERIZATION STATIONS

Table 1.

Sediment Sample Collection Plan

Sample Type	# Samples per Station	Constituents
Surface - metals	1 composite	moisture, TOC, strong acid extraction and weak acid extraction analyses for Sb, As, Cd, Cr, Co, Cu, Pb, Hg, Ni, Se, Ag, Th, and Zn, nitrate, TKN, cyanide, total phosphate, and dissolved orthophosphate[a]
Subsurface - metals	1 composite	same as for surface trace element samples except no WAE analysis
Surface - organics	1 composite	moisture, TOC, method 8080 organochlorine pesticides and PCBs, method 8140 organophosphorus pesticides, method 8150 chlorinated herbicides, and method 8270 semivolatile organics, particle size distribution
Subsurface - organics	1 composite	same as surface organic samples
Surface - bacteriological	1 composite (collected only in the Russian River and Laguna)	total and fecal coliform bacteria

[a] nutrients for surface and subsurface samples were taken either from the metals fraction or the organics fraction at the discretion of the laboratory.

3.1 SEDIMENT CHEMISTRY

The chemistry of metals and organic compounds in sediment is complex and greatly influences the bioavailability, and thus potential toxicity to benthic organisms. The following section summarizes some aspects of sediment chemistry.

3.1.1 Metals

The concentration of metals in the sediment and possible sources of the metals (natural or anthropogenic) is of concern due to the toxicity of metals to aquatic organisms. The toxicity of metals is strongly dependent of the form of the metal. Generally, particulate forms are less toxic than dissolved forms. Metals in sediment occur in several forms that vary in their ability to dissolve in the pore water of the sediment or in the digestive tract of organisms that ingest sediment. For example, metals that are adsorbed onto the surface of sediment particles are more bioavailable, and thus potentially more toxic, than metals that are part of the sediment lattice. For this reason, metals were analyzed by both strong acid extraction (SAE) and weak acid extraction methods (WAE). The SAE method involves extraction with a strong acid (nitric) that completely or almost completely breaks down the sediment. Therefore the SAE measures all of the metal present in the sediment including the fraction which is tightly bound to the sediment and relatively unavailable and non-toxic. The WAE method involves extraction with a weak acid (cold citrate buffer). This method measures only metals that are weakly bound with the sediment and thus relatively more bioavailable and potentially toxic. The concentration of metals as measured by the WAE may also be a better estimate of reclaimed water contamination since metals in reclaimed water are likely to be weakly bound to particulates. For this reason the metals concentrations estimated by the WAE were used for comparisons between stations.

Acid volatile sulfides (AVS) tend to strongly bind with metals, reducing the availability of metals to organisms. Although the AVS content of sediment appears to be the primary factor controlling the bioavailability of metal contaminants in many environments, the surface sediment samples collected in this study were generally well oxygenated. Thus sulfide is probably less significant in these samples. Metals availability is also reduce by binding with organic carbon. Organic carbon is the next most important binding phase of metals after AVS (EPA 1995). The strong acid extracted metals concentrations were normalized to organic carbon according to EPA methodology by dividing by the fractions of organic carbon present in samples.

Metal contaminants are also associated with particle surfaces. Therefore, differences in contaminant mass concentrations (mass of metal per mass of sediment) among sites can be generated simply by differences in particle sizes of sediments. Stations in streams or rivers undergo varying degrees of annual winter sediment flushing/replacement, while KFDW, Brown Pond, and Meadowlane Pond have little annual flushing. To compensate for this difference, organic and weak acid extraction metal sediment data have been normalized by the average surface area of particles in the sample (mass of metal per sediment surface area). Particle size distributions were determined for surface and subsurface samples with the percent composition of each particle type. Sediment data, in µg/g dry weight, were normalized to surface area using the following equation:

$$\frac{\mu g}{g} \times \frac{sg}{cm^3} \times \frac{v}{a} = \frac{mg}{a}$$

where:

sg = specific gravity of sediment = 2.65g (specific gravity of quartz and kaolinite)

v = average volume of particles in a sample based on the average diameter of each particle type (assuming a spherical shape) and the percent composition of each particle type

a = average surface area of particles in a sample based on the average diameter of each particle type (assuming a spherical shape) and the percent composition of each particle type

Average diameters of particle types were assumed to be as follows:

- gravel = 20 mm
- sand = 0.85 mm
- silt = 0.02 mm
- clay = 0.002 mm

Metals analyzed by WAE are reported per unit liquid extractant (mg/L). For the WAE, the sediment is mixed with the weak acid solution in a ten to one ratio of extractant to sediment. To enable a comparison between sites based on surface area, the data were multiplied by ten to convert from µg/L to µg/g. Because of the large and variable quantity of water in sediment samples, the data reported as wet weight were converted to dry weight by dividing by 1 - percent moisture (as a fraction).

3.1.2 Organic Compounds

As is the case with metals, it is the fraction of organic chemicals that is bioavailable to organisms that is of concern. The following (from DiToro, et al. 1991, EPA 1993) describes, very briefly, the bioavailability of nonionic organic compounds, and the rationale for the development of EPA sediment quality criteria (SQC) for nonionic compounds.

> "It has been shown that, for different sediment types, no relationship exists between sediment chemical concentrations (dry weight) and biological effects. However, a relationship exists (for chemicals that are not highly hydrophobic) between biological effects and both pore water concentration of a chemical and the sediment chemical concentrations on an organic carbon basis. This can be explained by assuming that the pore water and sediment carbon are in equilibrium and that the concentrations are related by a partition coefficient. At equilibrium, the activity of the chemical in each of these phases is the same. Therefore, it can be assumed that the organism receives an equivalent exposure from a water-only exposure or from any equilibrated phase; either from pore water via respiration; from sediment carbon via ingestion; or from a mixture of routes. Thus, the pathway of exposure is not significant.
>
> The EPA SQC for nonionic organic chemicals are based on the chemical concentration in sediment organic carbon, i.e. they are normalized to sediment organic carbon. Therefore data to be compared to the EPA SQC should be normalized to sediment organic carbon. This is necessary for highly hydrophobic chemicals because the pore water concentration is, for those chemicals, no longer

> a good estimate of the chemical activity. This is due to complexing with dissolved organic carbon. The use of organic carbon normalization is equivalent to using pore water normalization as a means of accounting for varying bioavailability. For naturally contaminated sediments, particle size effects are removed if organic carbon-normalized concentrations are compared."

Comparisons of organic concentrations between sites were done by first normalizing to organic content because (1) the bioavailable portion of nonionic and nonpolar compounds in sediment is dependent on the fraction of organic carbon in sediment and (2) sediment organic carbon also appears to be a critical factor in the partitioning behavior of ionic organic compounds in sediments (Jafvert 1990). Particle size is also important in determining the bioavailability of organic chemicals. According to Hull and Suter (1994), if the fraction of organic carbon is less than 0.5 percent, the factors such as particle size are relatively more important in controlling soil/water partitioning. Several samples in this study had less than 0.5 percent organic carbon. The EPA criteria statement says that "benthic organisms should be acceptably protected (by the SQCs) except possibly where sediment organic carbon is less than 0.2 percent". For this reason, concentrations of organics were also normalized to particle size to enable comparisons between sites.

4.0 MONITORING RESULTS

The results of the July 1994 field collection are described in this section. Complete data are presented in Appendices 1-10.

4.1 METALS

The concentrations of metals in sediment are examined in several ways, depending on what information is desired from the analysis. The absolute concentration of a given metal at a given location is best represented by the results from the SAE method. As discussed in the methods section, the metals reported for a SAE include metals that are part of the lattice of the sediment as well as any contaminant metals that may be present. Therefore a WAE produces results that better represent the concentrations of metals that are due to outside contaminants. The sediment quality results using both these analytical methods are described below.

4.1.1 Surface Sediments - Strong Acid Extraction

The concentrations of metals and cyanide (as dry weight) in the surface sediments as analyzed by the strong acid extraction (SAE) are shown in Figure 2. Note the y-axes differ for the different graphs in Figure 2. Antimony, selenium, and thallium are not included in this figure because their concentrations were below the reporting limit at all stations. The stations where the other metals and cyanide were detectable and their ranges of concentration are as follows:

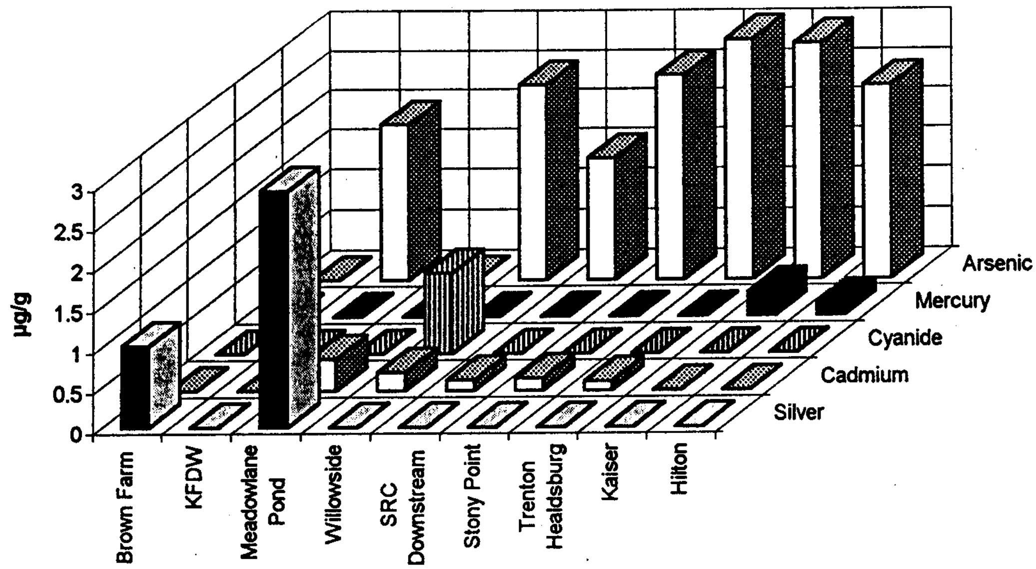
- The concentration of arsenic in the surface sediments was detectable from all stations except Brown Pond and Meadowlane Pond. The concentrations of arsenic in the surface sediments of the other stations ranged from 1.5 µg/g (Santa Rosa Creek downstream of the discharge) to 3.1 µg/g (Laguna downstream of the discharge at Trenton Healdsburg Road).

- The concentration of cadmium was below the reporting limit in the surface sediments of Brown Pond, KFDW, the Russian River at Kaiser Beach, and the Russian River at Hilton Beach. The concentrations of cadmium in the surface sediments of the other stations ranged from 0.11 µg/g in the Laguna at Trenton Healdsburg Road to 0.39 µg/g in Meadowlane Pond.

- Chromium was detectable in the surface sediments of all stations and ranged from 21 µg/g in the Laguna at Stony Point Road to 77 µg/g in the Santa Rosa Creek at Willowside Road.

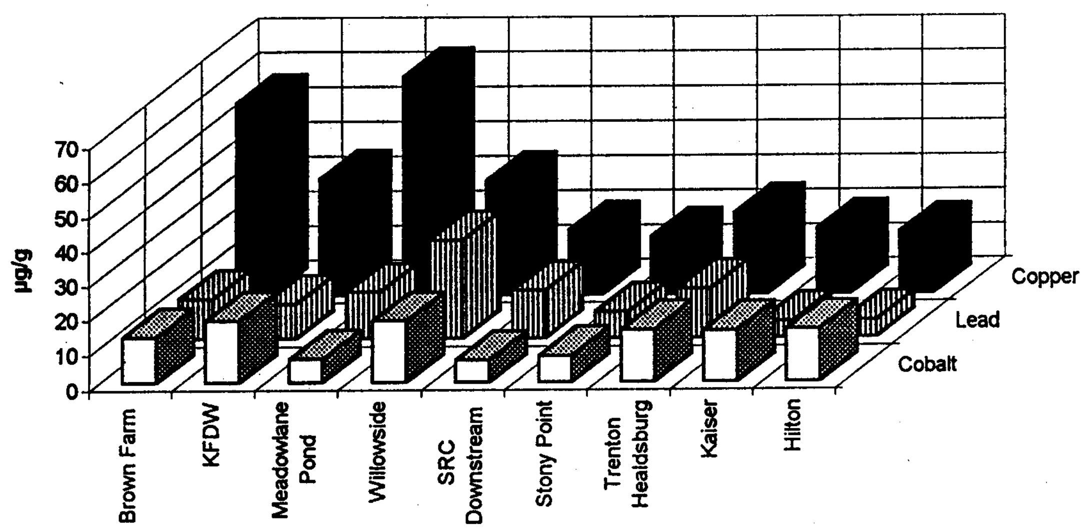
- Cobalt was detectable in the surface sediments of all stations and ranged from 6.4 µg/g in Santa Rosa Creek downstream of the discharge to 18 µg/g in KFDW and Santa Rosa Creek at Willowside Road.

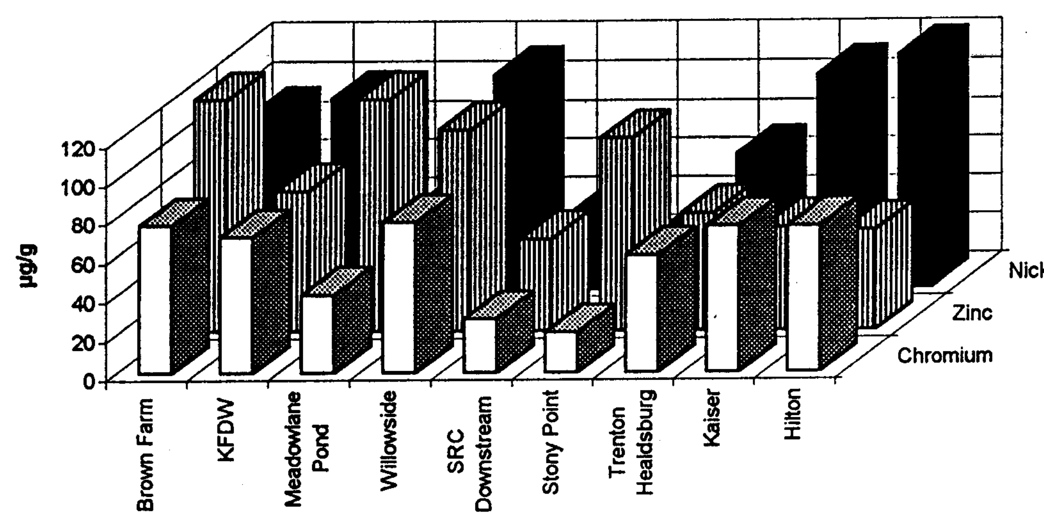
Figure 2. Surface Sediment Metals and Cyanide (strong acid extraction) in µg/g dry weight



Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water





- Copper was detectable in the surface sediments of all stations and ranged from 17 µg/g in the Laguna at Stony Point Road Road to 63 µg/g in Meadowlane Pond.

- Cyanide was detectable in the surface sediments of only one station, Santa Rosa Creek at Willowside Road upstream of the discharge, where it occurred at a concentration of 1.00 µg/g.

- Lead was detectable in the surface sediments of all stations and ranged from 4.9 µg/g in the Russian River at Kaiser Beach to 29 µg/g in the Santa Rosa Creek at Willowside Road.

- Mercury in surface sediments was detectable only in the Russian River. The concentration of mercury in the surface sediments was 0.29 µg/g in Kaiser Beach (upstream of the discharge) and 0.15 µg/g in Hilton Beach (downstream of the discharge).

- Nickel in surface sediments was detectable at all stations and ranged from 28 µg/g in Stony Point Road to 127 µg/g in the Russian River at Hilton Beach.

- Silver in the surface sediments was detectable only in Brown Farm Pond (1.01 µg/g) and Meadowlane Pond (2.91 µg/g).

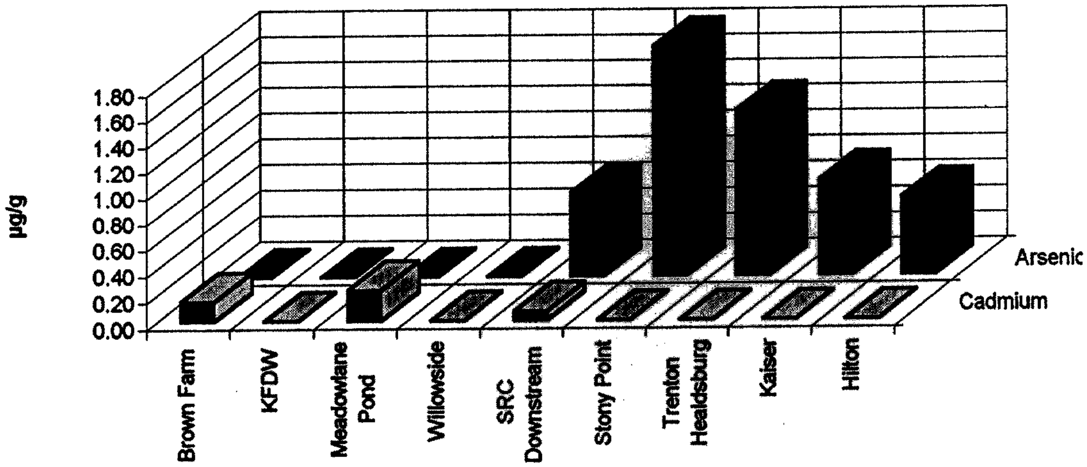
- Zinc was detectable in the surface sediments of all stations and ranged from 47 µg/g in the Santa Rosa Creek downstream of the discharge to 141 µg/g in Brown Farm Pond.

4.1.2 Surface Sediments - Weak Acid Extraction Method

The concentrations of metals analyzed by the WAE method are shown in Figure 3 and 4. In Figure 3 the metals are presented as µg/g dry weight. In Figure 4 the dry weight metals are normalized to $\mu g/cm^2$ surface area. Note the y-axis scales differ for the different graphs in both Figure 3 and Figure 4. The following metals had concentrations below the reporting limit in all surface samples and are therefore not included in Figures 3 and 4: antimony, mercury, selenium, silver, and thallium. As discussed above, the metals concentrations as analyzed by the WAE method are an indication of the bioavailable fraction of metals and also may be a better estimation of metals that potentially may have originated from reclaimed water than metals analyzed by the SAE method.

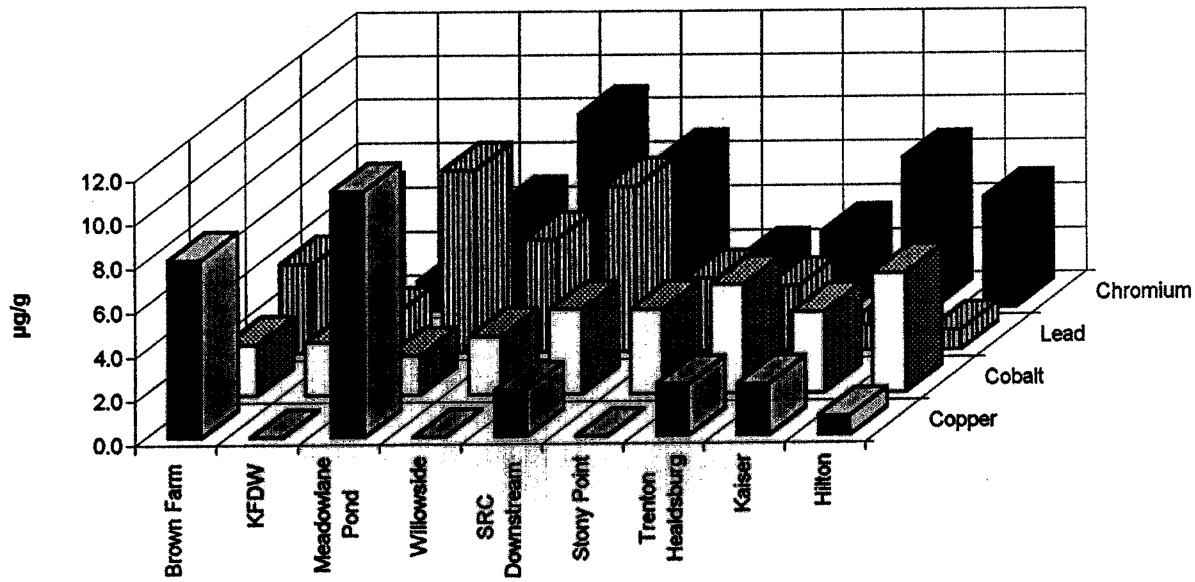
The concentration of weak acid-extractable (WAE) arsenic in the surface sediments was below detection at Brown Farm Pond, KFDW, Meadowlane Pond, and Santa Rosa Creek at Willowside. The remaining stations had WAE arsenic concentrations that ranged from 0.60 µg/g in the Russian River at Hilton Beach to 1.79 µg/g in the Laguna at Stony Point Road. The concentration of WAE arsenic was higher above the discharge than below the discharge in the Russian River and Laguna. Since the concentration of WAE arsenic was below detection in the storage ponds and higher above the discharge in two of the three creeks/river, these data provide no indication that reclaimed water discharges contribute significantly to the WAE arsenic.

Figure 3. Surface Sediment Metals (weak acid extraction) in µg/g dry weight



Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water



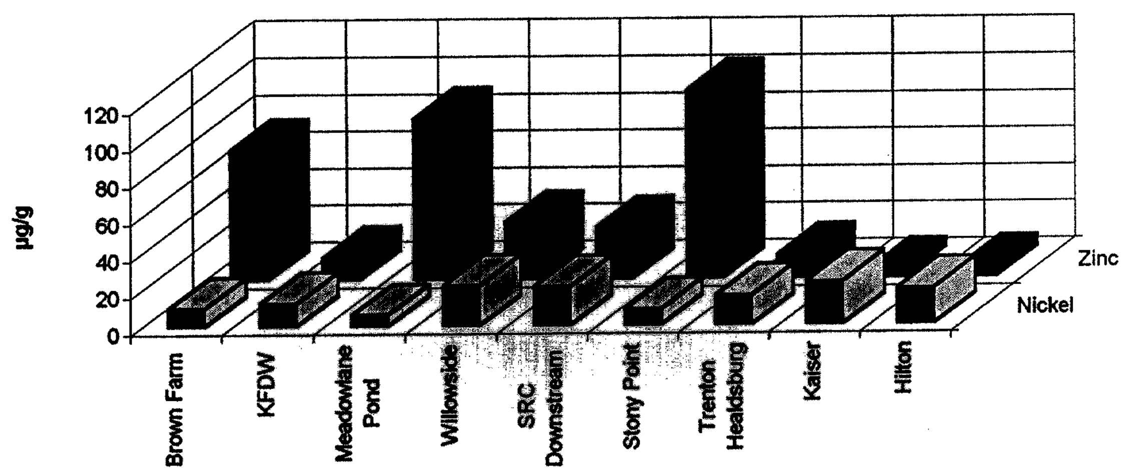
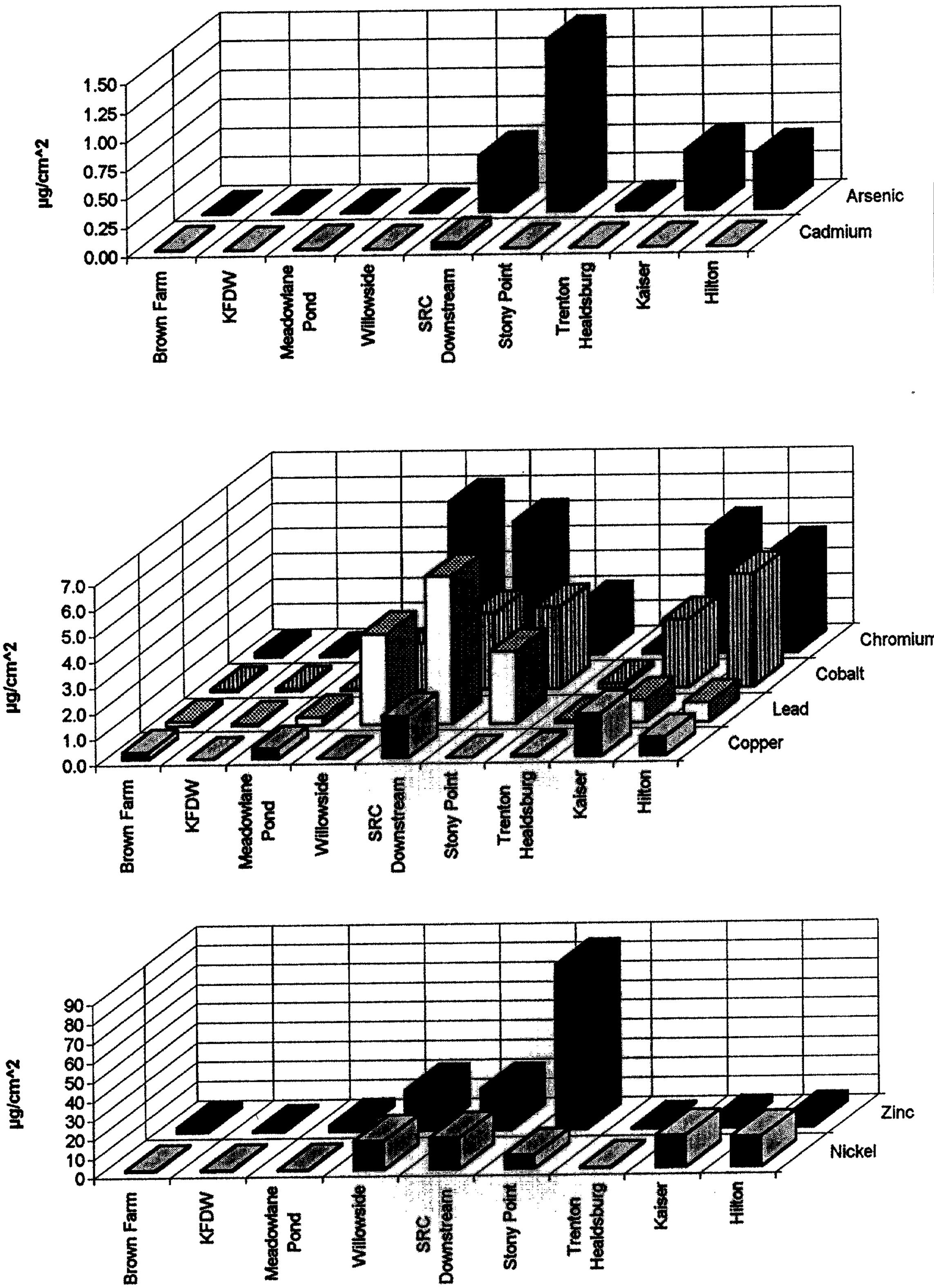


Figure 4. Surface Sediment Metals (weak acid extraction) in $\mu g/cm^2$



Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water

The concentration of WAE cadmium in the surface sediments was below detection at KFDW, Santa Rosa Creek at Willowside, at both stations in the Laguna, and at both stations in the Russian River. At the remaining stations, the concentrations of WAE cadmium were 0.15 µg/g (Brown Farm Pond), 0.23 µg/g (Meadowlane Pond) and 0.07 µg/g Santa Rosa Creek downstream of the discharge. The fact that cadmium was detected in surface sediments only in two storage ponds and below the Treatment Plant discharge indicates that reclaimed water discharge may be a source of WAE cadmium. However, the low concentrations in the sediments (or high detection limits) make this possible conclusion difficult to substantiate.

WAE chromium was detectable in the surface sediments of all the stations and ranged from 1.30 µg/g in KFDW to 6.8 µg/g in the Russian River at Kaiser Beach. The concentrations of WAE chromium were higher above the discharge than below the discharge in the Russian River and Santa Rosa Creek. The concentration of WAE chromium in surface sediments of storage ponds was lower than the concentration in the sediments above the discharge in the Russian River and Santa Rosa Creek. This indicates no pattern of WAE chromium accumulation resulting from reclaimed water discharge.

WAE cobalt was detectable in the surface sediments of all stations and ranged from 1.80 µg/g in Meadowlane Pond to 5.42 µg/g in the Russian River at Hilton. The concentration of WAE cobalt was higher below the discharge than above the discharge in the Russian River, Laguna, and Santa Rosa Creek. However, the concentration of WAE cobalt was lower in the storage ponds than in any of the above or below discharge locations, indicating a source other than reclaimed water for WAE cobalt.

WAE copper was below detection in the surface sediments from KFDW, Santa Rosa Creek at Willowside, and the Laguna at Stony Point Road. In the remaining stations, the concentration of WAE copper ranged from 0.90 µg/g in the Russian River at Hilton to 11.2 µg/g in the sediments of Meadowlane Pond. The concentration of WAE copper was higher above the discharge than below the discharge in the Russian River, and higher below the discharge in Santa Rosa Creek and the Laguna. It is possible that reclaimed water is a source of copper in the sediments below the discharge in Santa Rosa Creek and the Laguna.

WAE lead was detectable in the surface sediments of all stations and ranged from 0.90 µg/g in the Russian River at Hilton to 8.25 µg/g in Meadowlane Pond. The concentration of WAE lead was higher above the discharge than below the discharge in the Laguna and Russian River and higher below the discharge in Santa Rosa Creek.

WAE nickel was detectable in the surface sediments of all stations and ranged from 6.3 µg/g in Meadowlane Pond to 24 µg/g in the Russian River at Kaiser Beach. WAE nickel in the surface sediments was higher above the discharge than below the discharge in the Russian River and in Santa Rosa Creek and higher below the discharge in the Laguna.

The concentrations of WAE nickel were lower in the storage pond sediments than in the sediments of two of the three stations above the discharge.

WAE zinc was detectable in the surface sediments from all stations and ranged from 4.42 µg/g in the Russian River at Kaiser to 102 µg/g in the Laguna at Stony Point Road. WAE zinc was higher above the discharge than below the discharge in Santa Rosa Creek and the Laguna and higher below the discharge in the Russian River.

Cyanide is not measured by WAE. Cyanide, as measured by SAE, was detectable only in Santa Rosa Creek at Willowside above the discharge (1.1 µg/g). This indicates that cyanide in sediments of the Russian River, Laguna, and Santa Rosa Creek cannot be attributed to reclaimed water discharge.

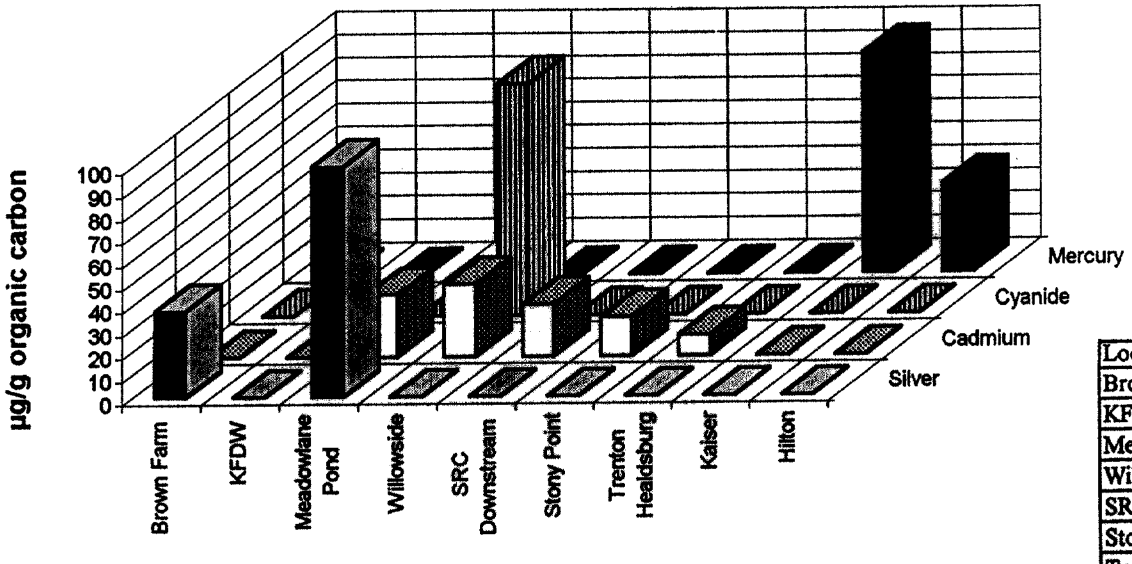
In summary, cyanide and the surface metal concentrations resulting from the WAE method showed no indication of potentially bioavailable metals accumulation that can be clearly attributed to reclaimed water discharge with the possible exceptions of cadmium and copper. Cadmium and copper were detectable in Brown and Meadowlane Ponds and in Santa Rosa Creek below the discharge but not detectable in the Laguna or Russian River below the discharge or in KFDW, locations that are also exposed to reclaimed water. These conclusions are confirmed with the SAE results. The surface metals concentrations were nearly always higher above the discharge than below the discharge as determined by SAE (Figure 2) and the SAE results normalized to organic carbon (Figure 5). The possible exception to this is with silver, which was only detectable in storage ponds. However, the bioavailable portion of silver (as determined by the WAE method) was not detectable at any station (including storage ponds) and total silver was not detectable downstream of the discharge. The concentration of weak acid extracted metals normalized to surface area also do not show a regular pattern of higher metals below the discharge or in storage ponds (Figure 4).

4.1.3 Subsurface Sediments

The concentrations of metals and cyanide (as dry weight) in the subsurface sediments as analyzed by the SAE are shown in Figure 6. Note the y-axes differ for the different graphs in Figure 6. Antimony, mercury, selenium, and thallium are not included in this figure because their concentrations were below the reporting limit at all stations. A WAE analysis was not conducted on subsurface sediment samples since the purpose of the WAE analysis was to determine bioavailable fractions of metals and most biological activity is confined to the surface or near surface sediments. The stations where the other metals and cyanide were detectable and their ranges of concentration are as follows:

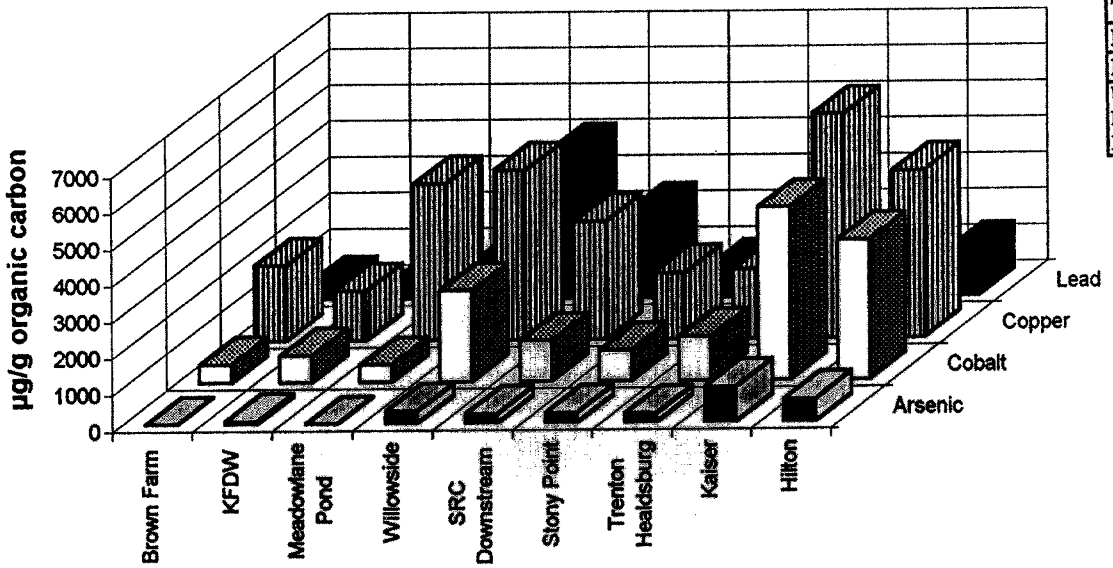
- Arsenic was below detection in Brown Farm Pond and Meadowlane Pond subsurface sediments. The concentration of arsenic in the subsurface sediments of the other stations ranged from 2.01 µg/g in the Laguna at Stony Point Road to 3.18 µg/g in the Laguna at Trenton Healdsburg Road.

Figure 5. Surface Sediment Metals and Cyanide (strong acid extraction) in µg/g organic carbon



Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water



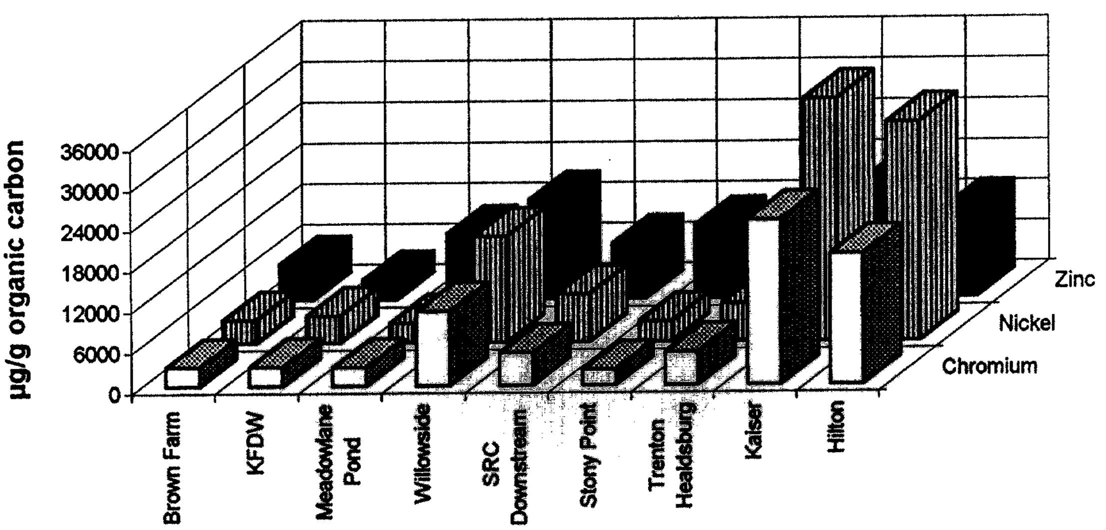
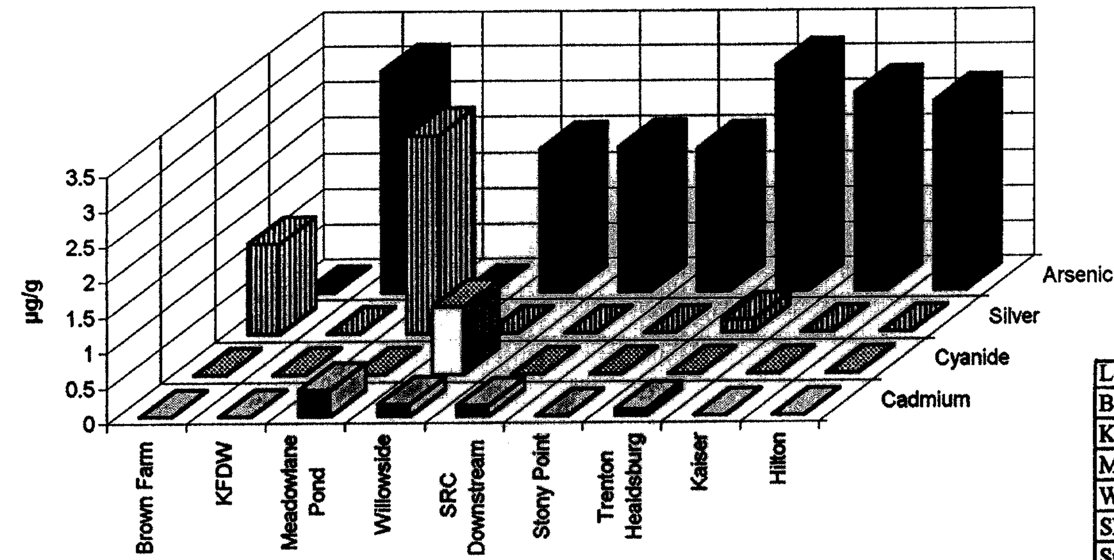
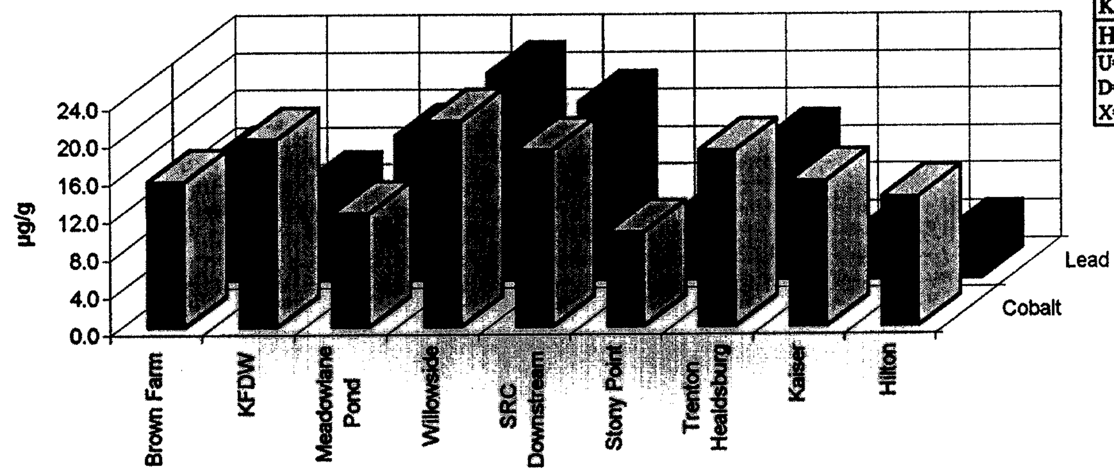


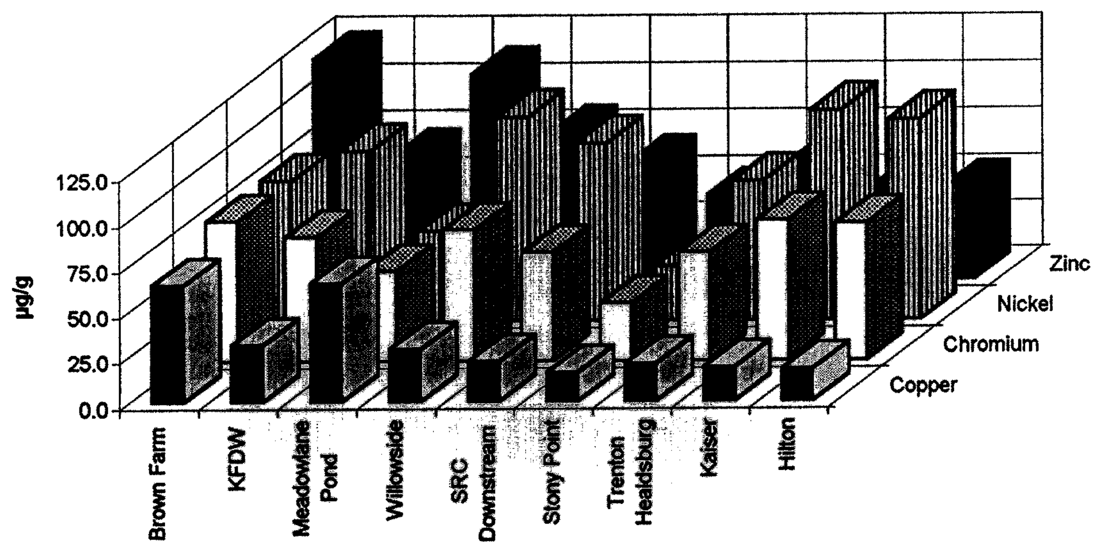
Figure 6. Subsurface Sediment Metals and Cyanide (strong acid extraction) in µg/g dry weight



Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water





- Cadmium was below detection in the subsurface sediments of Brown Farm Pond, KFDW, Laguna at Stony Point Road, and both Russian River stations. The concentration of cadmium in the subsurface sediments of the other stations ranged from 0.094 µg/g in the Laguna at Trenton Healdsburg Road to 0.37 µg/g in Meadowlane Pond.

- Chromium was detectable in the subsurface sediments of all stations and ranged in concentration from 32 µg/g in the Laguna at Stony Point Road to 77 µg/g in the Russian River at Kaiser and in Brown Farm Pond.

- Cobalt was detectable in the subsurface sediments of all stations and ranged in concentration from 10 µg/g in the Laguna at Stony Point Road to 22 µg/g in Santa Rosa Creek at Willowside Road.

- Copper was detectable in the subsurface sediments of all stations and ranged in concentration from 16 µg/g in the Laguna at Stony Point Road to 65 µg/g in Meadowlane Pond.

- Cyanide was detectable in the subsurface sediments of only one station, Santa Rosa Creek at Willowside Road (above the discharge), where it was found at a concentration of 0.96 µg/g.

- Lead was detectable in the subsurface sediments of all stations and ranged in concentration from 4.80 µg/g in the Russian River at Kaiser to 22 µg/g in Santa Rosa Creek at Willowside Road.

- Nickel was detectable in the subsurface sediments of all stations and ranged in concentration from 30 µg/g in the Laguna at Stony Point Road to 115 µg/g in the Russian River at Kaiser.

- Silver was detectable in the subsurface sediments of three stations: Brown Farm Pond, Meadowlane Pond, and the Laguna at Trenton Healdsburg (below the discharge). The concentrations of silver at these stations were 1.29, 2.80, and 0.19 µg/g, respectively.

- Zinc was detectable in the subsurface sediments of all stations and ranged from 47 µg/g in the Laguna at Stony Point Road to 112 µg/g in Meadowlane Pond.

No metals in the subsurface sediments were consistently higher below the discharge with the possible exceptions of arsenic and silver. Arsenic in subsurface sediment, which was not detectable in Brown Farm and Meadowlane storage ponds, was higher below the discharge in the Laguna but similar above and below the discharge in Santa Rosa Creek and the Russian River. Silver in subsurface sediment was detectable in Brown Farm and Meadowlane storage ponds and in the Laguna below the discharge, but below detection in Santa Rosa Creek and the Russian River.

4.2 ORGANIC COMPOUNDS

4.2.1 Surface Sediments

Of the 119 organic compounds that were analyzed in the surface sediment samples, only six were found in detectable quantities: 2,4,5-T, 2-chlorophenol, 2-nitrophenol, 4-chloro-3-methylphenol, pentachlorophenol, and phenol. Since organic carbon controls the bioavilability of nonionic organic compounds in naturally occurring sediments by acting as the dominant sorption phase (EPA 1993), the concentrations of detectable organic compounds were normalized to organic carbon. These are shown (as µg/g organic carbon) in Figure 7. The concentrations of these organics in surface sediments in µg/g dry weight are shown in Figure 8.

In Santa Rosa Creek, the concentration of 2,4,5-T was 8.93 µg/g organic carbon in the surface sediments of Santa Rosa Creek at Willowside (upstream of the discharge) and 1.97 µg/g organic carbon in the surface sediments of Santa Rosa Creek downstream of the discharge. 2,4,5-T was not detectable at any of the other stations.

Phenol was detectable in the surface sediments collected from the two upstream stations, Laguna at Stony Point Road (2431 µg/g organic carbon) and the Russian River at Kaiser Beach (645 µg/g organic carbon), and at Meadowlane Pond (667 µg/g organic carbon) (Figure 7).

Other phenolic compounds (2- chlorophenol, 2-nitrophenol, 4-chloro-3-methylphenol, and pentachlorophenol) were found in detectable concentrations in the Russian River at Kaiser Beach but were below the reporting limit at all other stations (Figures 7 and 8).

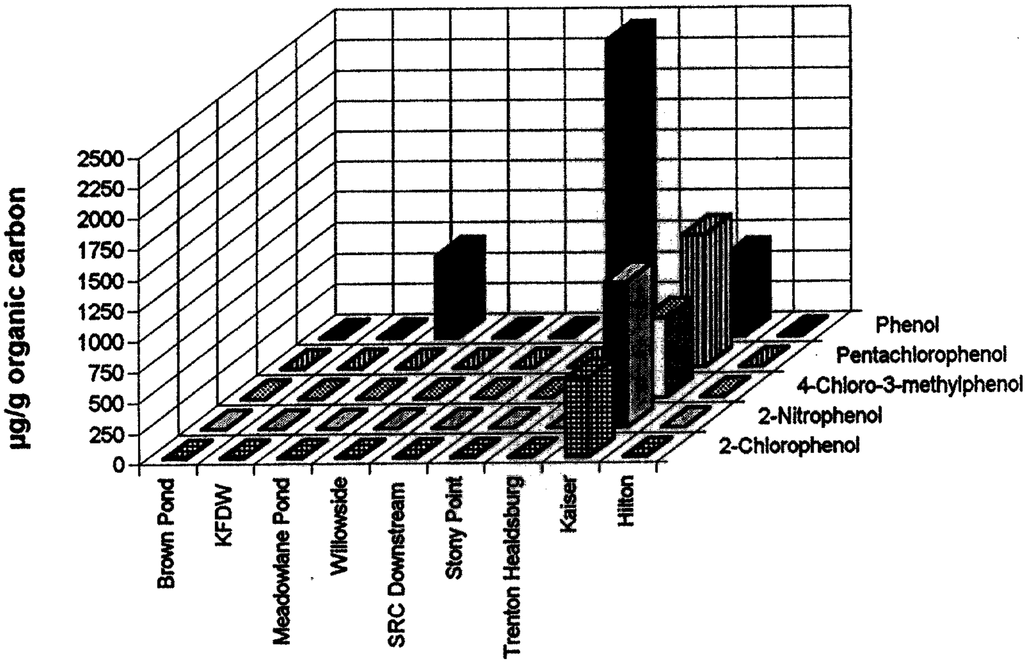
The detectable organic compounds in surface sediments were always higher above the discharge than below the discharge in the Russian River, Santa Rosa Creek, and the Laguna. There were no detectable organic compounds in the storage ponds with the exception of phenol (detectable in Meadowlane Pond). This indicates that reclaimed water discharge from the Santa Rosa Treatment Plant is not a significant source of organic contamination in the Laguna, Russian River, and Santa Rosa Creek. The non-normalized organic data (Figure 8) also support this conclusion.

4.2.2 Subsurface Sediments

Of the 119 organic compounds that were analyzed in the subsurface sediment samples, only two were found in detectable quantities: 2,4,5-T, and phenol. Since organic carbon controls the bioavilability of nonionic organic compounds in naturally occurring sediments by acting as the dominant sorption phase (EPA 1993), the concentrations of detectable organic compounds were normalized to organic carbon. These are shown (as µg/g organic carbon) in Figure 9. The concentrations of these organics in surface sediments in µg/g dry weight are shown in Figure 9.

2,4,5-T was detectable in KFDW and in Santa Rosa Creek at both stations. 2,4,5-T was not detectable at all other stations. The concentration of 2,4,5-T was 4.17 µg/g organic

Figure 7. Detectable Organics in Surface Sediment in µg/g organic carbon



Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water

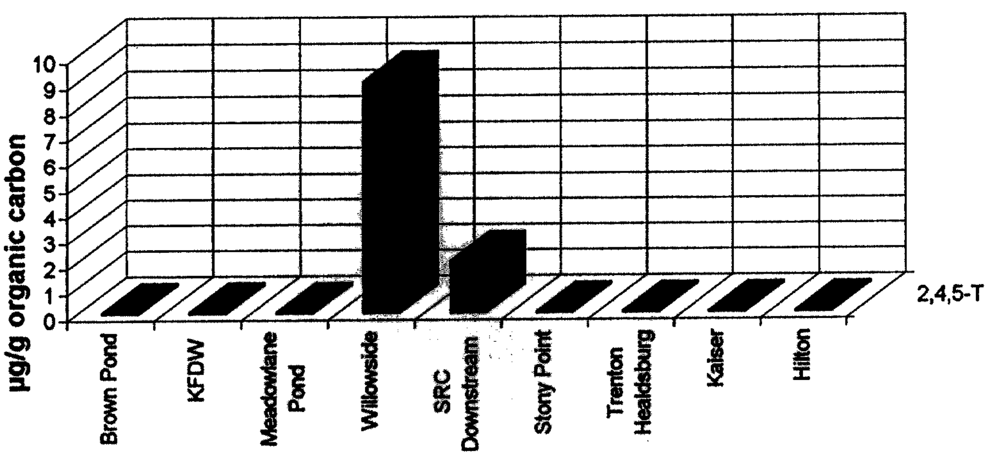
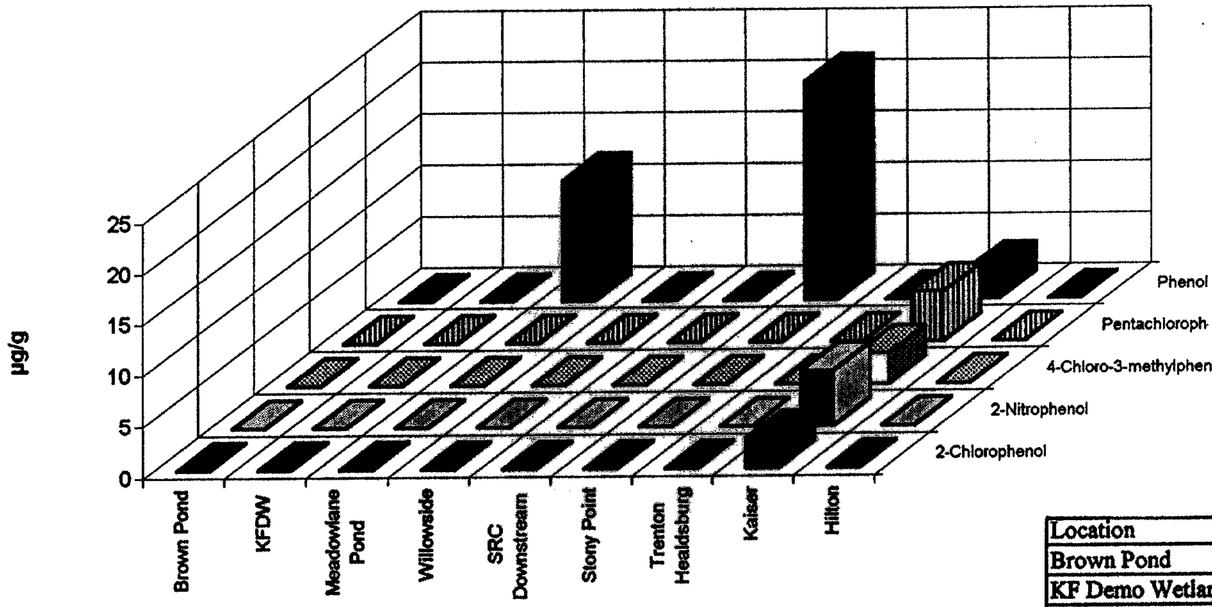


Figure 8. Detectable Organics in Surface Sediment in µg/g dry weight



Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water

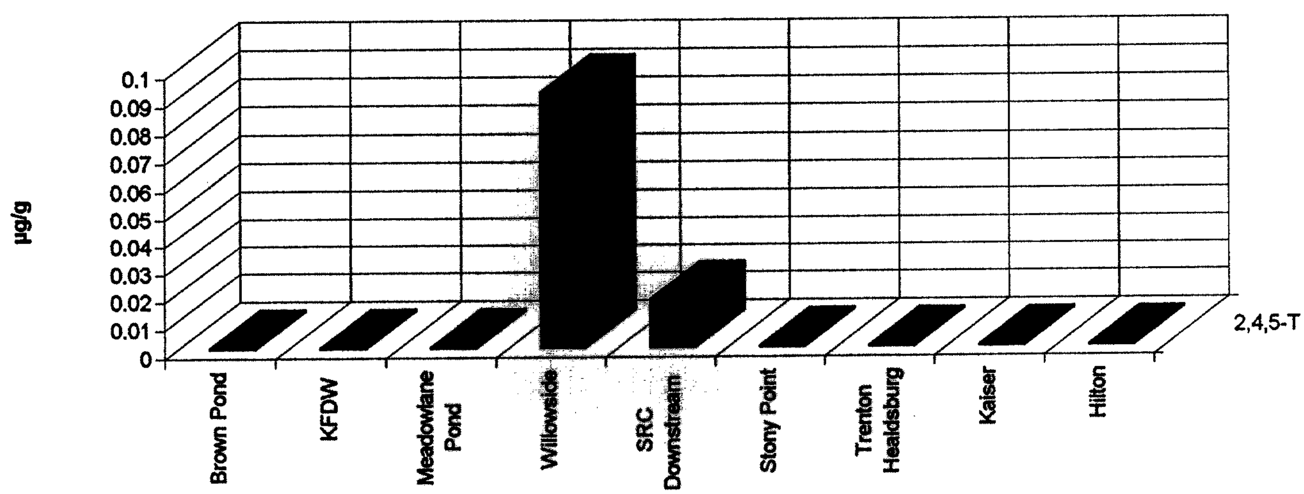
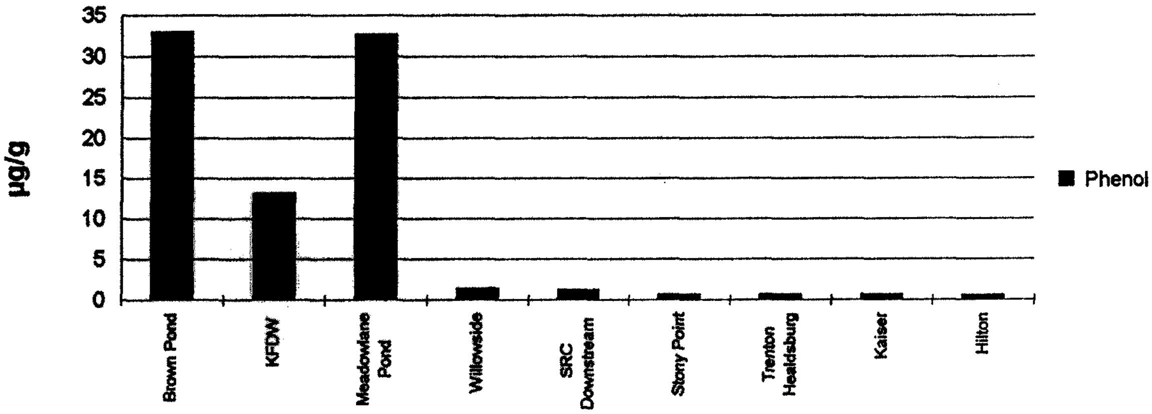
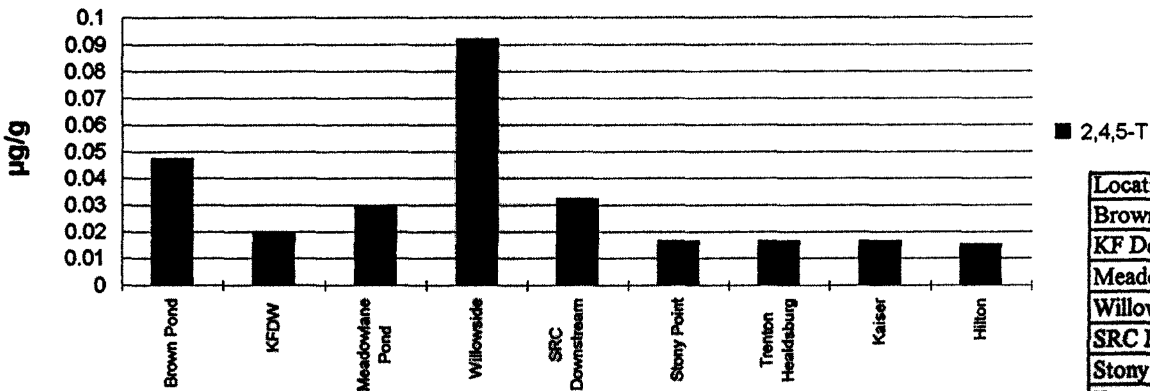


Figure 9. Detectable Organics in Subsurface Sediment in µg/g dry weight and µg/g organic carbon

Detectable Organics in Subsurface Sediment in µg/g dry weight

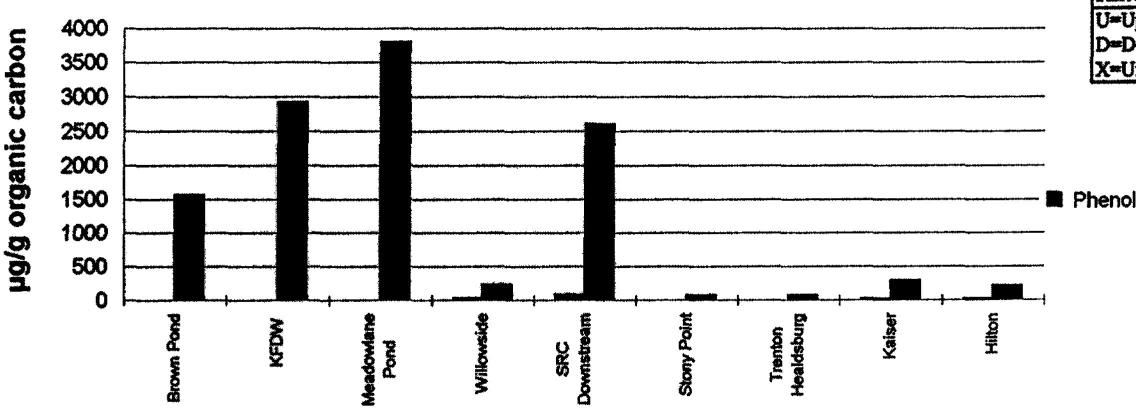


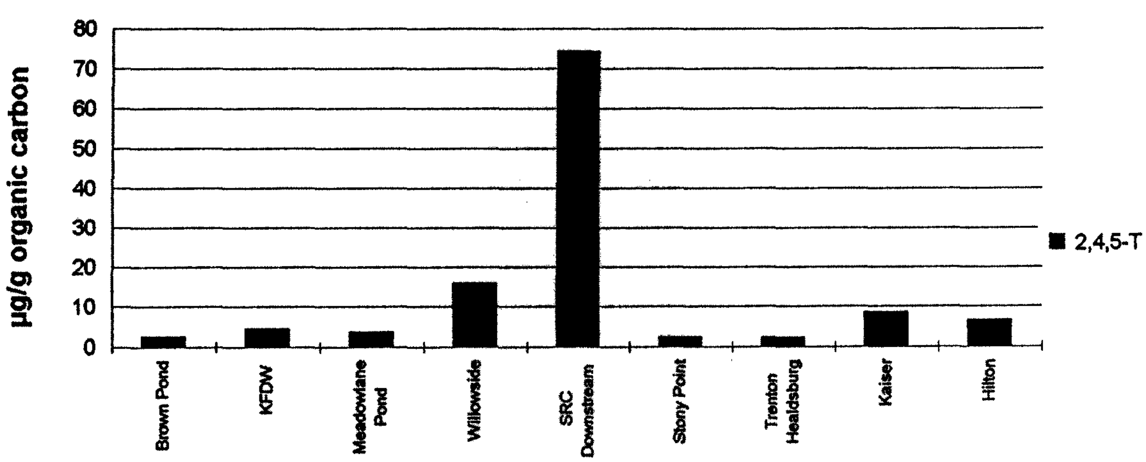


Location	Storage Pond	Recl. water Wetland	Santa Rosa Creek	Laguna	River
Brown Pond	X				
KF Demo Wetland		X			
Meadowlane Pond	X				
Willowside			U		
SRC Dwnstrm			D		
Stony Pt.				U	
Trent./Healdsburg				D	
Kaiser					U
Hilton					D

U=Upstream of recl. water discharge
D=Downstream of recl. water discharge
X=Undiluted reclaimed water

Detectable Organics in Subsurface Sediment in µg/g organic carbon





carbon in KFDW, 15.6 µg/g organic carbon in Santa Rosa Creek at Willowside Road, and 74 µg/g organic carbon in Santa Rosa Creek downstream of the discharge. The concentration of subsurface 2,4,5-T in KFDW was just detectable (usual detection limit = 0.01 µg/g wet weight , value = 0.01 µg/g wet weight). The concentration in subsurface sediments was higher above the discharge than below the discharge for 2,4,5-T as wet weight, dry weight, and dry weight normalized to organic carbon. It was not detectable in surface KFDW sediments. The surface 2,4,5-T in Santa Rosa Creek was approximately four times higher above the discharge than below the discharge. Since surface sediments are more indicative of current and future results of discharge, particularly with regard to pesticides, it is unlikely that reclaimed water discharge is causing an accumulation of 2,4,5-T in receiving water sediment.

Phenol was detectable in the subsurface sediments of only one station, Meadowlane Pond, where it occurred at a concentration of 3793 µg/g organic carbon. However, phenol was not detectable in any other subsurface sediments including storage ponds and below the discharge. In Figure 9 phenol, although non-detectable in Brown Pond and KFDW, appears to be higher at these stations than in non-pond stations. This is due higher detection limits and moisture content of the sediment. Phenol was detectable in surface sediments of Meadowlane Pond but was it was approximately 1.5 to 3.5 times higher in the surface sediments of the Laguna (Stony Point). It was not detectable below the discharge in the Laguna. Therefore, it is unlikely that reclaimed water discharge is causing an accumulation of phenol in the receiving water sediments.

4.3 Other Constituents

4.3.1 Nutrients

The concentration of nutrients and total organic carbon and moisture content in the sediments of the Russian River, Laguna, Santa Rosa Creek, and storage ponds are shown in Table 2. Nitrate was not detectable except in the subsurface sediments of Brown Farm Pond and Meadowlane Pond. Total Kjeldahl nitrogen (TKN) ranged from 240 µg/g in the subsurface sediments of the Russian River at Kaiser to 910 µg/g in the subsurface sediments of Santa Rosa Creek at Willowside. Most of the phosphate was total phosphate which ranged from 43 mg-P/kg in Santa Rosa Creek downstream of the discharge to 1,500 mg-P/kg in the subsurface sediment of Brown Farm Pond. Total organic carbon (TOC) ranged from 1,700 µg/g in the subsurface sediments of the Laguna at Stony Point and Santa Rosa Creek downstream of the discharge to 10,200 µg/g in the surface sediment of KFDW. Percent moisture ranged from 32.1 in the surface sediment of the Russian River at Kaiser to 80.2 in the surface sediment of Brown Farm Pond.

4.3.2 Bacteriology

Surface sediment samples for total and fecal coliform analyses were collected in the Russian River and Laguna. The results of these analyses are shown in Table 3. Sediment bacteria were collected in support of a planned Regional Board study bacteria sources in the lower Russian River; these data are not used in the analysis of potential impacts of long-term reclaimed water management alternatives.

Table 2.

The Concentration of Nutrient, Total Organic Carbon, and Moisture in the Sediments of the Russian River, Laguna, Santa Rosa Creek, and Storage Ponds

Station	Nitrate mg-N / kg	TKN µg / g	Ortho-phosphate mg-P / kg	Total phosphate mg-P / kg	TOC µg / g	Moisture %
Brown Farm Pond , subsurface	1.7	400	420	1500	4600	76.7
Brown Farm Pond, surface	0.3[a]	280	360	1200	5300	80.2
Meadowlane Pond, subsurface	6.1	600	20	310	3300	67.8
Meadowlane Pond- surface	0.3[a]	610	53	280	3000	79.4
KFDW Cell 3, subsurface	0.3[a]	610	16	200	2200	51.9
KFDW Cell 3, surface	0.3[a]	670	49	220	10200	58.5
Laguna at Stony Point, subsurface	0.3[a]	580	7.8	260	1700	40.4
Laguna at Stony Point, surface	0.3[a]	450	37	240	3600	60.8
Laguna at Trenton Healdsburg Road, subsurface	0.3[a]	800	45	260	5200	46.6
Laguna at Trenton Healdsburg Road, surface	0.3[a]	650	54	240	6800	45.3
Santa Rosa Creek-downstream of discharge, subsurface	0.3[a]	310	5.5	170	1700	41.4
Santa Rosa Creek-downstream of discharge, surface	0.3[a]	890	4.5	43	2700	53.3
Santa Rosa Creek at Willowside, subsurface	0.3[a]	910	6.8	260	2500	40.6
Santa Rosa Creek at Willowside, surface	0.3[a]	780	10	230	3200	54.8
Russian River at Kaiser, Surface	0.3[a]	320	4.8	210	2100	32.1
Russian River at Kaiser, Subsurface	0.3[a]	240	4.2	260	2900	35.4
Russian River at Hilton Beach, face	0.3[a]	320	7.4	350	2600	33.6
Russian River at Hilton Beach, subsurface	0.3[a]	250	5.8	300	2200	32.4

[a] Below detection. Value shown is the reporting limit.

Table 3.

Coliform Bacteria in Russian River and Laguna Sediments

	Total coliform bacteria mpn/g	**Fecal coliform bacteria mpn/g**
Johnson's Beach	≥1600	130
Healdsburg Beach	540	23
Stony Point	≥1600	≥1600
Trenton Healdsburg	540	240

5.0 COMPARISON OF RESULTS WITH OTHER DATA

Surface sediment samples collected in the Laguna, Santa Rosa Creek, and storage ponds by the North Coast Regional Water Quality Control Board during 1985 and 1986 can be compared to the data collected in July 1994. The samples collected in July 1994 were field composited which increases the representativeness of each sample. However, since no analytical replicates exist either data set, statistical comparisons between samples cannot be conducted and only qualitative conclusions can be made. Only the Regional Board collections for which percent moisture data are available were used for comparisons. The percent moisture data enable a conversion to dry weight, thus eliminating variance due to differing water content between samples. The dates for the Regional Board collections used for this analysis are 8 November 1985, 12 December 1985, and 8 January 1986.

Sediment collections were made by the Regional Board during 1985-6 in the Russian River. These samples were collected at different stations in the River than the 1994 collections and, since the stations in the 1994 collection were selected for having high fine sediment/organic content, comparisons between the 1985-6 data and the 1994 data cannot be made for Russian River data. The Regional Board also collected sediment data in 1995 in the Laguna and Russian River. These data were reported as wet weight and percent moisture is not available, so direct comparisons with other data cannot be made. However, some qualitative information can be derived from these data.

Surface sediment samples were collected in KFDW and in Santa Rosa Creek above the discharge during 1991 and in KFDW during August 1994 as part of a study addressing potential bioaccumulation in KFDW. These data are also compared, where possible, to the July 1994 data.

5.1 METALS

The concentration of metals in sediments as determined by the WAE method in 1985-6 and July 1994 are compared in Tables 4-6. , The concentrations of arsenic and cadmium in July 1994 were lower than in 1985-6. No comparison between 1985-6 and 1994 can be made for mercury because concentrations below detection. The concentrations of chromium, copper, and zinc were higher in 1994 in storage ponds, Santa Rosa Creek downstream of the discharge and the Laguna at Trenton Healdsburg. The concentrations of chromium and copper were lower and zinc was higher in the Laguna at Stony Point in 1994. Other metals that were sampled only in storage ponds wither decreased in 1994 or were below detection.

The concentration of zinc in sediments was higher in 1994 than in 1985-6 both above and below the Santa Rosa discharge at all stations for which comparisons can be made. If the differences between 1985-6 and 1994 are real, the increase in zinc is likely due to something other than reclaimed water. The concentration of copper and chromium in sediments was higher in July 1994 than in 1985-6 in storage pond sediments and in sediments from stations below the Santa Rosa discharge, but not in sediments from Stony Point, above the discharge. This indicates that reclaimed water discharge may be contributing to an accumulation of copper and chromium in sediments. However, the concentration of copper has not increased in the reclaimed water since routine collections were begun in 1988 (*Reclaimed Water Quality* Technical Report, MSC 1996). WAE sediment copper in the Laguna and Santa Rosa Creek was higher below the discharge than above the discharge in 1994 samples, but total copper was higher above the discharge in Santa Rosa Creek. The trend in chromium concentrations in reclaimed water cannot be assessed since 93 percent of the reported chromium values were below the detection limit, but there was no indication that current sediment concentrations of chromium were higher below the discharge. The differences in copper and chromium between the 1985-6 samples and the 1994 samples may be due to particle size differences. The data to evaluate this explanation are not available (no particle size data for the 1985-6 data), so these results cannot be explained.

Table 4.

Comparison of surface metals concentrations in Santa Rosa Creek sediments downstream of the reclaimed water discharge between RWQCB data collected in 1985-6 and data collected in 1994.

	Mean 1985-6 data (µg/g dry weight)	**July 1994 data (µg/g dry weight) N=1**
Arsenic	<2.55[a]	0.64
Cadmium	0.20	0.073
Chromium (total)	2.44	6.85
Copper	1.61	2.14
Mercury	0.074	<0.11[b]
Zinc	12.64	27.8

[a] Indicates all data below detection. Value shown is the reporting limit (converted to dry weight).

[b] Concentration below detection. Value shown is the reporting limit (converted to dry weight).

Table 5.

Comparison of surface metals concentrations in the Laguna de Santa Rosa sediments between RWQCB data collected in 1985-6 and data collected in 1994 (µg/g dry weight WAE).

	Laguna at Stony Point		Laguna at TH	
	Average 1985-6	**July 1994**	**Average 1985 N=2**	**July 1994**
Arsenic	2.73	1.79	<2.20[a]	1.28
Cadmium	16.9	<0.06[b]	0.41	<0.05[b]
Chromium (total)	3.33	2.37	1.29	3.47
Copper	4.02	<0.64[b]	0.75	2.38
Mercury	0.081[a]	<0.13[b]	<0.071[a]	<0.09[b]
Zinc	8.48	102	6.02	12.8

[a] Indicates all data below detection. Value shown is the reporting limit (converted to dry weight).

[b] Concentration below detection. Value shown is the reporting limit (converted to dry weight).

Table 6.

Comparison of surface metals concentrations in reclaimed water storage ponds between RWQCB data collected in 1985-6 and data collected in 1994
(µg/g dry weight WAE).

	Meadowlane Pond		Brown Pond	
	1985-6	**July 1994**	**1985-6**	**July 1994**
Antimony	-	-	<21.7[a]	<2.53[b]
Arsenic	<2.67[a]	<0.97[b]	<4.23[a]	<1.01[b]
Cadmium	0.63	0.23	<1.25[a]	0.15
Chromium (Total)	0.51	4.76	0.50	5.00
Cobalt	-	-	<87.0[a]	2.32
Copper	1.55	11.2	5.02	8.08
Lead	10.6	8.25	<21.7[a]	4.04
Mercury	<0.075[a]	<0.24[b]	<0.12[a]	<0.25[b]
Nickel	9.11	6.31	21.7	10.1
Selenium	<2.13[a]	<0.97[b]	<4.35[a]	<1.01[b]
Silver	<2.13[a]	<0.24[b]	<4.35[a]	<0.25[b]
Thallium	2.13[a]	2.4[b]	4.35[a]	2.53[b]
Zinc	10.0	87.4	18.7	70.7

[a] Indicates all data below detection. Value shown is the reporting limit (converted to dry weight).
[b] Concentration below detection. Value shown is the reporting limit (converted to dry weight).

The concentrations of metals in sediments as determined by the SAE method in 1991 and July and August 1994 are compared in Tables 7-8. Note that methodological differences prevent comparisons of sediments analyzed by SAE with sediments analyzed by WAE. For both the KFDW and Willowside stations, the concentration of metals were higher in July 1994 than in 1991. The exceptions to this is for arsenic in the Willowside station, which was similar in both years (2.77 µg/g for 1991 and 2.65 µg/g for 1994) and silver, which was lower in July 1994 than in 1991 at the KFDW location. Since concentrations were higher in both KFDW and in Santa Rosa Creek above the discharge, the increases in sediment metal concentration cannot be attributed to reclaimed water discharge. The concentrations of detectable metals in the July 1994 KFDW are also all higher (except arsenic) than the samples also taken from KFDW in August 1994. Since sediment concentrations are unlikely to change in one month, the differences between these two collections are due to an unknown variance component. Possible sources of variance are differences in particle size distribution, spatial variability (the July samples were composites from open water and the August data had replicates, each of which were composites taken from different parts of the pond), contamination (unlikely since nearly all metals were elevated), differences in sampling methodology, differences in laboratory methodology, or other unknown sources.

Table 7.

The Concentrations of Metals in KFDW Cell 3 Sediments

	1991 **µg / g dry weight SAE**	**August 1994 (mean of 3 replicates)** **µg / g dry weight SAE**	**July 1994 (this study)** **µg / g dry weight SAE**
Arsenic	2.97	3.38	4.04
Cadmium	<0.12[a]	0.34	<0.25[a]
Chromium	89.1	63	146
Copper	42.1	24.6	70.7
Lead	13.6	11.1	21.2
Mercury	<0.05[a]	0.089	<0.51[a]
Nickel	124	97.1	207
Selenium	<0.50[a]	<0.67[b]	<2.53[a]
Silver	0.59	<3.32[b]	<0.51[a]
Zinc	139	63.8	152

[a] Indicates all data below detection. Value shown is the reporting limit (converted to dry weight).

[b] Concentration below detection. Value shown is the reporting limit (converted to dry weight).

Table 8.

Concentrations of Sediment Metals in Santa Rosa Creek at Willowside

	1991 µg / g dry weight SAE	July 1994 µg / g dry weight SAE
Arsenic	2.77	2.65
Cadmium	<0.07[a]	0.24
Chromium	34.6	84.3
Copper	15.2	36.1
Lead	10.7	31.3
Mercury	0.04	<0.24[a]
Nickel	54.0	120
Selenium	<0.28[a]	<1.20[a]
Silver	<0.07[a]	<0.24[a]
Zinc	41.6	113

[a] Concentration below detection. Value shown is the reporting limit (converted to dry weight).

5.2 ORGANICS

The only organic compounds found in detectable concentrations in the July 1994 study, 2,4,5-T, 2-chlorophenol, 2-nitrophenol, 4-chloro-3-methylphenol, pentachlorophenol, and phenol, were not analyzed for in the 1985-6 RWQCB samples or in the 1991 KFDW samples. The only organic compounds found in detectable concentrations from samples collected by the RWQCB from several stations in the Russian River, Laguna, Santa Rosa Creek and storage ponds in 1985-6 were 1,4'-DDD, 4,4'-DDD, 1,4'-DDE, and PCB (Aroclor) 1254. These compounds were detectable only at one station in 1985-6, Laguna at Highway 12, a station which was not used in the 1994 study. The organic compounds detectable in 1985-86 were always below detection in the 1994 study. Thus no comparison can be made of the concentrations organic compounds in sediment between the 1985-6 RWQCB data and the July 1994 data.

The organic compounds found in detectable concentrations in the July 1994 study were not analyzed for in the 1991 study. The organic compounds that were analyzed in the 1991 study, chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, Lindane, and PCBs, were below detection in both the 1991 study and the 1994 study. Thus no comparison can be made of the concentrations of organic compounds in KFDW and Willowside sediment between 1991 and July 1994.

No direct comparison can be made with the June 1995 RWQCB sediment samples collected from several stations in the Russian River, Laguna, Santa Rosa Creek, and storage ponds since variability due to moisture content cannot be factored out. However, there were no detectable organics found in any of the samples.

The main conclusion that can be made from examining the July 1994 study and previous studies is that most of the organic compounds analyzed in all the studies are below detection in sediments.

6.0 SEDIMENT ACCUMULATION IMPACTS EVALUATION

The purpose of this section is to evaluate potential project impacts on sediment quality. It consists of two sections. The first section evaluates potential significant project impacts. The second section evaluates the range of potential project impacts.

6.1 SIGNIFICANT POTENTIAL PROJECT IMPACTS

The *Ecological Risk Assessment* Technical Report (Parsons ES Austin 1996) assesses the exposure risk of selected receptor organisms to the toxic effects of reclaimed water constituents via several exposure pathways, including sediment. The range of impacts evaluation described below was used as input to the *Ecological Risk Assessment*

Project impacts are considered to be significant if they cause the concentration of compounds in sediment to exceed Evaluation Criteria for sediment described in the *Development of Evaluation Criteria for Potential Water Quality Impacts* Technical Report (MSC 1996). The EPA is authorized to develop and implement sediment quality criteria (SQC) under Section 304(a) of the Clean Water Act and has established SQC for the following nonionic organic chemicals: acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene. The SQC are only proposed and the specific regulatory uses of SQC have not been established (DiToro, et al. 1991, EPA 1993). The criteria are numerical concentrations for individual chemicals that are applicable across the range of sediments encountered in practice. SQC are intended to be predictive of biological effects and so can be used as the concentration of a chemical that is protective of benthic aquatic life.

The SQC for each organic compound is based on the partitioning coefficient between pore water and sediment carbon. The SQC for nonionic organic chemicals are based on the chemical concentration in sediment organic carbon, i.e. they are normalized to sediment organic carbon. Therefore, field measurements of organic compounds in sediments to be compared to the SQC are first normalized to sediment organic carbon. The use of organic carbon normalization is equivalent to using pore water normalization as a means of accounting for varying bioavailability.

Contaminants in sediments tend to be associated with particle surfaces. Therefore, differences in contaminant concentrations among sites can be generated simply by differences in particle sizes of sediments. For naturally contaminated sediments, particle size effects are removed if organic carbon-normalized concentrations are compared (DiToro, et al. 1991, EPA 1993).

Acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene are not found in detectable concentrations in reclaimed water (*Reclaimed Water Quality* Technical Report, MSC 1996), nor are they found in detectable concentrations in storage pond sediments as discussed in the Monitoring Results - Organic Compounds section above. The potential impacts of discharge on sediment in the Laguna de Santa Rosa and the Russian River were evaluated using a partition coefficient model described below in the Range of Impacts section. Using the 95th percentile reclaimed water concentration that would result from implementation of a 20 percent design discharge to the Laguna (*Russian River Water Quality Model* Technical Report, RMA 1996), the maximum detection limit in reclaimed water and the maximum detection limits in the Laguna and Russian River, the sediment concentrations were predicted for the five compounds for which sediment quality criteria exist. This was done as described below in the Quantitative Assessment - Methods and Results section. These predicted concentrations and the freshwater SQCs are shown in Table 9. Data are normalized to organic carbon.

The estimated concentrations of the organic compounds for which SQC exist resulting from maximum projected discharge are all below their respective SQCs. Therefore the impact of discharge on the sediment in the Laguna and Russian River, with respect to SQC, is less than significant.

Table 9.

EPA Sediment Quality Criteria (SQC)

Constituent	Freshwater SQC µg / kg organic carbon	Estimated Concentration in Laguna µg / kg organic carbon	Estimated Concentration in Russian River µg / kg organic carbon
Acenaphthene	130,000	79	29
Dieldrin	11,000	124	14
Endrin	4200	2372	267
Fluoranthene	620,000	752	277
Phenanthrene	180,000	273	101

6.2 RANGE OF POTENTIAL PROJECT IMPACTS

The approach to determining the range of potential project impacts on receiving water sediment involves a qualitative assessment, or screening procedure, to identify reclaimed water constituents that could accumulate in sediment above the existing concentration, followed by an estimate of the change in sediment quality for any such constituents. The change in sediment quality was estimated from the following:

- The estimated concentrations of constituents of concern in reclaimed water under different discharge components and the average concentration of these constituents in receiving water (*Laguna de Santa Rosa Water Quality Monitoring* and *Russian River Water Quality Monitoring* Technical Reports, MSC 1996) were used to predict the concentration of constituents of concern in the Laguna and Russian River sediments under the different discharge components.

- Physical properties of each compound (organic carbon normalized sediment/octanol-water partition coefficients and metal/ligand aqueous-solid equilibrium coefficients) were used with the predicted receiving water concentration of each compound to estimate the sediment concentration for each discharge component.

Each step of the sediment impacts evaluation is described below.

6.2.1 Qualitative Assessment

6.2.1-1 Reclaimed Water Constituents

Reclaimed water data were examined to identify which metals and organic compounds are detectable in the reclaimed water in more than five percent of the analyses. Reclaimed water quality is summarized in the *Reclaimed Water Quality* Technical Report, (MSC 1996). Table 10 presents the total metals and organic compounds present in reclaimed water in more than five percent of the analyses.

Table 10.

Total Metals and Organic Compounds Present in Reclaimed Water

Constituent	Percent of Detectable Analyses	Constituent	Percent of Detectable Analyses	Constituent	Percent of Detectable Analyses
Acetone	13	1,1,1-Trichloroethane	7	Boron	94
Bromodichloromethane	95	Total Xylenes	7	Cadmium	7
Bromomethane	6	Aldrin	20	Chromium	54
Carbon Disulfide	20	a-BHC	13	Copper	98
Chlorobenzene	6	Lindane (g-BHC)	33	Lead	21
Chloroform	100	Endosulfan II	7	Magnesium	100
Chloromethane	6	Heptachlor	7	Nickel	62
Dibromochloromethane	21	Bis (2-Ethylhexyl) Phthalate	22	Potassium	100
1,4 Dichlorobenzene	90	Diethyl Phthalate	17	Silver	45
Ethyl Benzene	7	Di-n-Butyl Phthalate	9	Sodium	100
Methylene Chloride	27	Aluminum	74	Zinc	91
Tetrachloroethene (PCE)	13	Arsenic	83	Cyanide	43
Toluene	13	Barium	15		

Constituents that are detectable in reclaimed water but detectable in less than five percent of the measurements were evaluated against data from Kelly Farm Demonstration Wetland (KFDW) (*Evaluation of Bioaccumulation in Organisms Exposed to Reclaimed Water from the Santa Rosa Subregional Water Reclamation System* Technical Report, MSC 1996) to determine if bioaccumulation of constituents from reclaimed water is occurring. Any substance determined to be bioaccumulating at KFDW would be added to the list of compounds in Table 10 and evaluated further. No organic compounds were present at detectable concentrations in KFDW sediment or on Treatment Plant filter media. Therefore no evidence exists for bioaccumulation of additional organic compounds from reclaimed water and no other organics were added to the above list.

The only metal found in reclaimed water and not listed in Table 10 was mercury; however, it was detectable on only one occasion (less than five percent of the measurements). Data from KFDW indicate that mercury is not bioaccumulating in organisms exposed to reclaimed water. Therefore mercury was not further evaluated. The following metals were never found in detectable quantities and thus will not be further evaluated: antimony, beryllium, cobalt, iron, manganese, molybdenum, selenium, thallium, and vanadium.

6.2.1-2 Accumulatory Substances

The potential that the organics that have been detected in reclaimed water will accumulate in sediment was evaluated primarily by the log octanol/water partition coefficient (log K_{ow}) for each organic (Verschueren 1983, Howard 1989, 1990, 1991). Organic compounds with low log K_{ow} (less than 4) were not evaluated further. The exception to this is gamma-BHC which has a borderline log K_{ow} (3.61). Lindane has a much lower Henry's Law Constant (2.92 x 10^{-6} atm-m^3/mole) than other organics on the list with similar log K_{ow} values. This indicates that it is less likely to be lost through volatilization and so gamma-BHC was not eliminated from further evaluation. Organics detected in reclaimed water that were not evaluated further (K_{ow} less than 4) were bromodichloromethane, bromomethane, carbon disulfide, chloroform, chlorobenzene, chloromethane, dibromochloromethane, 1,4 dichlorobenzene, diethyl phthalate, ethyl benzene, methylene chloride, tetrachloroethene, toluene, 1,1,1-trichloroethane, and total xylenes.

6.2.1-3 Substances Selected for Further Evaluation

The following substances were not screened out and so were evaluated further.

- Aldrin
- Alpha-benzenehexachloride (alpha BHC, alpha HCH)
- Lindane (gamma-benzenehexachloride, gamma BHC, gamma HCH,)
- Endosulfan II (beta endosulfan)
- Heptachlor
- Bis (2-ethylhexyl) phthalate (di-2-ethylhexyl phthalate)
- Di-n-butyl phthalate,
- Aluminum
- Arsenic
- Barium
- Boron
- Cadmium
- Chromium
- Copper
- Lead
- Nickel
- Silver
- Zinc
- Cyanide

Even though they are not detectable in reclaimed water, acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene were also included in the analysis since sediment quality criteria exist for these substances.

6.2.1-4 Background Concentration

Of the constituents surviving the screening process (listed above) none were present in the receiving waters (Santa Rosa Creek, Laguna, or Russian River) at detectable concentrations that consistently exceeded the detectable reclaimed water concentration, therefore, a comparison to background data did not eliminate any further constituents from consideration.

6.2.2 Quantitative Assessment

6.2.2-1 Determining Concentrations of Metals and Organics in Reclaimed Water and Receiving Water

Reclaimed water and receiving water data used in these analyses contain censored data (data that are reported by the analytical laboratory as less than the detection limit). The EPA (1991) recommends the use of the delta-log normal statistical methodology to calculate the mean and variance of data sets that contain censored data. We considered this technique inappropriate for our data for the following reasons:

- The delta-normal statistical methodology assumes a consistent method detection limit. Although a theoretical single method detection limit exists for a particular analysis conducted by a particular laboratory, in reality many things (such as matrix interference) can influence the detection limit to a different extent on different days or in different samples. When a sample is reported as below detection, the method detection limit is given. These method detection limits can vary widely.

- The delta-normal statistical method is positively biased (i.e., it overestimates the mean) at all levels of censoring, and the bias increases with increased censoring and population variability (Hinton 1993). Many of the reclaimed water and receiving water data have a large amount of censoring (greater than 90 percent non-detected for a given constituent). Using highly censored data, the means estimated by the delta-normal statistical methodology were compared with the means estimated by arithmetic averaging. For the delta-normal technique, the average of the reporting limits was used as the input. For the arithmetic average, the reporting limits were used. The mean estimated by the delta-normal method was, for many constituents, higher than the mean estimated by using the actual reporting limits in the calculations. Since the reporting limit is the upper end of the range of possible values for a non-detectable value, this amount of positive bias was considered to be unacceptable.

Other statistical methods for obtaining the mean and variance of data sets with censored data (Hinton 1993, Newman, et al. 1995) have similar disadvantages to the delta-normal statistical method. For this reason, we chose to calculate means using one-half the reporting limit for values below detection. This method has the advantage that much of the receiving water data used in these analyses were collected by the North Coast Regional Water Quality Control Board and reported to us with values below detection appearing as one-half the reporting limit. Values below detection with a reporting limit greater than four times the maximum detectable value were not used in this analysis.

Average reclaimed water concentrations were calculated as described above using reclaimed water data collected in the Laguna Treatment Plant July 1988 through February 1995 (metals) and January 1991 through April 1995 (organics). These data are presented in the *Reclaimed Water Quality* Technical Report, (MSC 1996).

Receiving water concentrations of organics were determined from data collected by the Regional Board in the Laguna and Russian River in October 1985 through June 1992 and by MSC in the Russian River in October through December 1994 for a total of 11 collections. These data are presented in *Laguna de Santa Rosa Water Quality Monitoring Results* Technical Report, (MSC 1996) and *Russian River Water Quality Monitoring Results* Technical Report, (MSC 1996). The concentration of all organics in this evaluation from stations located above and below the discharge were below detection in the receiving waters with the exception of bis-(2-ethylhexyl)phthalate. Bis-(2-ethylhexyl)phthalate was just above the detection limit (0.7 µg/L, d.l. = 0.6 µg/L) in the Russian River above the confluence with the Laguna on one occasion (out of four measurements). Generally, the detection limits of earlier collections were higher than later collections. When this was the case, the later detection limits were used.

Receiving water concentrations of metals were determined from data collected by the Regional Board in June 1985 through June 1992 and by MSC in May 1994 through May 1995 for a total of nine collections in the Laguna and ten collections in the Russian River. Data were used from stations above the discharge in both the Russian River and the Laguna to provide an estimate of background metals concentrations. Average concentrations were calculated as described above.

6.2.3 Incremental Sediment Concentration of Organics

The constituents that were not eliminated from the above screening procedures were further evaluated to estimate relative sediment concentrations under the one percent, five percent, ten percent, and 20 percent to the Laguna discharge components. Sediment concentrations under the 20 percent Russian River discharge, No Project, and Geysers discharge components were not estimated since the percent concentration of reclaimed water in the receiving waters for these components is within the range of percent concentration for the one percent, five percent, ten percent, and 20 percent discharge to the Laguna components. The methods and results of these analyses are described below.

6.2.3-1 Background

The partitioning of nonionic or hydrophobic organic compounds (HOCs), including chlorinated hydrocarbons, organophosphate pesticides, and phthalate esters used as plasticizers, between the aqueous and solid phases is governed by the linear adsorption isotherm as delineated by Karickhoff et al. (1979):

$$K_d = \frac{C_s}{C_w} \qquad (1)$$

where C_s and C_w are the solid and aqueous phase concentrations, respectively, of HOC, and K_d is the solid-aqueous partition or distribution coefficient. Assuming chemical equilibrium between these two phases, C_s is a linear function of C_w for values of $C_w \leq 50$ percent of saturation. The constant of proportionality (or slope) is K_d (in units of volume per unit mass).

It was further noted by Karickhoff et al. (1979) that C_s is also proportional to the amount of organic matter present in the solid phase, represented as the fraction of organic carbon (f_{oc}) in sediments, according to a similar linear relationship:

$$C_s = K_{oc} \times f_{oc} \times C_w \qquad (2)$$

Where K_{oc} is the organic carbon normalized sediment-water partition coefficient. Thus, K_{oc} is related to K_d by the following equation:

$$K_{oc} = \frac{K_d}{f_{oc}} \qquad (3)$$

The regression of K_{oc} to the octanol/water coefficient, K_{ow}, yields (EPA 1993):

$$\log K_{oc} = 0.983 \log K_{ow} + 0.00028 \qquad (4)$$

which is that K_{oc} approximately equals K_{ow} (EPA 1993).

6.2.3-2 Methods and Results

The concentrations of organics in sediments on a dry weight basis were estimated for the seven organic compounds found in detectable quantities in reclaimed water and not eliminated through the screening process described above. The sediment concentrations were estimated for the Laguna below Santa Rosa Creek and for the Russian River below the confluence with the Laguna for 1 percent, 5 percent, 10 percent, and 20 percent design discharge components.

The concentrations of these organics in sediments were computed using equation 2, substituting, when necessary, K_{ow} for K_{oc}. This model assumes chemical equilibrium between the aqueous and solid phases. In reality, this equilibrium is only approached in sediment interstitial or “pore” waters or in very stagnant standing water situations. Thus, it can be expected that predicted sediment concentrations are “worst case” since, in moving water, equilibrium between the aqueous and solid phases is probably not reached. The sediment concentration is also directly proportional to the amount of organic matter (as measured by organic carbon) in sediments (see equation 2). Therefore, any changes or fluctuations in sediment characteristics may alter their sorptive behavior relative to organic compounds.

For compounds lacking in reliable experimental K_{ow} values, linear regressions of the general form:

$$\log K_{ow} = m \times \log C_{w,sol} + b \qquad (5)$$

were used to estimate K_{ow} from its aqueous solubility ($C_{w,sol}$). Values of the constants m and b for these regressions were taken from Verschueren (1983), Schwarzenbach et al. (1993) and Chiou et al. (1995). Mean values of K_{oc} and/or K_{ow} were used where more than one literature value was available.

The fraction of organic carbon in the sediments (f_{oc}) in equation 2 was estimated by averaging the two measurements of organic carbon (from surface samples collected July 1994) from the Laguna at Trenton Healdsburg Road and the two measurements from the Russian River at Hilton Beach.

The concentration of the organics in water (C_w) was calculated at two locations (the Laguna between Santa Rosa Creek and Mark West Creek and the Russian River below the confluence with the Laguna) for each discharge components of 1, 5, 10, and 20 percent as defined in the *Russian River Water Quality Model*, (RMA 1996). The concentration of reclaimed water as a percent of flow for both the Laguna and Russian River sites was estimated by the Russian River water quality model. The 50th percentile reclaimed water concentrations were chosen as typical representations of each component and used for further analyses. The 95th percentile reclaimed water concentrations for each discharge component were also used for further analyses as a worst-case representation. The 95th percentile reclaimed water concentrations are for the model year (wet, dry, or normal) with the highest percentage of reclaimed water (*Water Quality Impacts Analysis* Technical Report, MSC 1996). The 50th and 95th percentile reclaimed water concentrations in the Laguna and Russian River for each discharge component are shown in Table 11.

Table 11.

Percent Reclaimed Water in the Laguna between Santa Rosa Creek and Mark West Creek and Russian River.[a] (all values in percent reclaimed water)

	Laguna				Russian River			
Per-centile	**1% discharge component**	**5% discharge component**	**10% discharge component**	**20% discharge component**	**1% discharge component**	**5% discharge component**	**10% discharge component**	**20% discharge component**
50th	0	3	5	17	0	0.3	0.6	3
95th	4	26	43	61	0.5	5	10	15

[a] Example: the 95th percentile reclaimed water concentration in the Laguna for the five percent design discharge component is 26 percent. This means that the average monthly concentration of reclaimed water is estimated to exceed 26 percent in five percent of months.

The concentration of each organic compound in water (C_w) was then estimated as follows:

$$C_w = (C_{rw} \times f_{rw}) + (C_{reci} \times (1 - f_{rw})) \quad (6)$$

where C_{rw} is the concentration of the organic compound in reclaimed water, f_{rw} is the predicted fraction of reclaimed water in the Laguna or Russian River for different discharge components, and C_{reci} is the initial concentration of the organic compound in the receiving water. Since the concentrations of most detectable organic compounds in reclaimed water were very low, the estimated concentration in the sediment was very sensitive to the concentration in the receiving water. The concentration in the receiving water was below detection for all organics except bis-(2-ethylhexyl)phthalate in the Russian River, so calculations were made for three different conditions: assumed receiving water concentrations of zero, half the detection limit, and the detection limit. The results of these calculations are presented in Tables 12 and 13. The receiving water concentrations of bis-(2-ethylhexyl)phthalate and di-n-butyl phthalate are not available for the Laguna so sediment concentrations in the Laguna could not be predicted.

Although acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene have not been detected in reclaimed water, they are included in this analysis to provide a comparison with SQC. The reclaimed water concentrations used for acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene are zero, half the detection limit, and the detection limit. The detection limits for sediment samples collected in the Laguna at Trenton Healdsburg Road and in the Russian River at Hilton Beach in July 1994 are also given for comparison.

Table 12.

Estimated Concentration of Organics in Russian River Sediment

	July 1994 detection limits µg/kg dry weight	1 percent design discharge component (50th percentile reclaimed water conc.) µg/kg dry weight			1 percent design discharge component (95th percentile reclaimed water conc.) µg/kg dry weight		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	18	0	90.1	180	0	89.9	180
alpha-BHC	4.6	0	1.6	3.2	0	1.6	3.2
gamma-BHC	18	0	0.074	0.15	0	0.075	0.15
endosulfan II	46	0	0.81	1.6	0	0.81	1.6
heptachlor	46	0	50.5	101	0	50.3	96.9
bis-(2-ethylhexyl)phthalate	505	551	551	551	565	565	565
di-n-butyl phthalate	505	0	69.2	139	1.6	70.5	139
acenapthene	505	0	14.5	29.0	0	14.5	29.0
fluoranthene	505	0	138	277	0	139	277
phenanthrene	505	0	50.3	101	0	50.3	101
dieldrin	2446	0	1.8	3.6	0	2.0	4.0
endrin	46	0	34.7	69.4	0	38.0	76.0

Table 12. Continued

Estimated Concentration of Organics in Russian River Sediment

		5 percent design discharge component (50th percentile reclaimed water conc.)			5 percent design discharge component (95th percentile reclaimed water conc.)		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	18	0.18	90.0	180	3.0	88.6	174
alpha-BHC	4.6	0.0032	1.6	3.2	0.054	1.6	3.1
gamma-BHC	18	0.0009	0.074	0.15	0.015	0.085	0.16
endosulfan II	46	0.0048	0.81	1.6	0.081	0.85	1.6
heptachlor	46	0.061	50.4	101	1.0	49.0	96.9
bis-(2-ethylhexyl)phthalate	505	560	560	560	695	695	695
di-n-butyl phthalate	505	0.96	70.0	139	16.1	81.8	148
acenapthene	505	0	14.5	29.0	0	14.5	29.0
fluoranthene	505	0	138	277	0	138	277
phenanthrene	505	0	50.3	101	0	50.3	101
dieldrin	2446	0	1.9	3.9	0	3.6	7.1
endrin	46	0	36.7	73.4	0	67.7	135

Table 12. Continued

Estimated Concentration of Organics in Russian River Sediment

		10 percent design discharge component (50th percentile reclaimed water conc.)			10 percent design discharge component (95th percentile reclaimed water conc.)		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	18	0.36	89.9	179	6.0	87.1	168
alpha-BHC	4.6	0.0064	1.6	3.2	0.11	1.6	3.0
gamma-BHC	18	0.0018	0.075	0.15	0.030	0.096	0.16
endosulfan II	46	0.0097	0.81	1.6	0.16	0.89	1.6
heptachlor	46	0.12	50.3	100	2.0	47.4	92.9
bis-(2-ethylhexyl)phthalate	505	568	568	568	839	839	839
di-n-butyl phthalate	505	1.9	70.8	140	32.1	94.5	157
acenapthene	505	0	14.5	29.0	0	14.5	29.0
fluoranthene	505	0	138	277	0	138	277
phenanthrene	505	0	50.3	101	0	50.3	101
dieldrin	2446	0	2.0	4.1	0	5.3	10.6
endrin	46	0	38.7	77.3	0	101	201

Table 12. Continued

Estimated Concentration of Organics in Russian River Sediment

		20 percent design discharge component (50th percentile reclaimed water con.)			20 percent design discharge component (95th percentile reclaimed water conc.)		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	18	1.8	89.2	177	9.0	85.6	162
alpha-BHC	4.6	0.032	1.6	3.2	0.16	1.5	2.9
gamma-BHC	18	0.089	0.080	0.15	0.044	0.11	0.17
endosulfan II	46	0.048	0.83	1.6	0.24	0.93	1.6
heptachlor	46	0.61	49.6	98.5	3.0	45.9	88.8
bis-(2-ethylhexyl)phthalate	505	637	637	637	983	983	983
di-n-butyl phthalate	505	9.6	76.8	144	48.2	107	166
acenapthene	505	0	14.5	29.0	0	14.5	29.0
fluoranthene	505	0	138	277	0	138	277
phenanthrene	505	0	50.3	101	0	50.3	101
dieldrin	2446	0	2.9	5.7	0	7.0	14.0
endrin	46	0	54.5	109	0	134	267

Aldrin and heptachlor are predicted by this model to occur in detectable quantities in Russian River sediments in all four discharge components. For these compounds, the estimated concentrations in sediments are more sensitive to the receiving water concentration (C_{reci}) than reclaimed water concentration (C_{rw}) since the predicted concentrations decrease with increasing discharge rates. This is because the concentration of aldrin and heptachlor in reclaimed water is less than half the respective detection limit in the Russian River. The detection limits of alpha BHC and endosulfan II are also greater than the concentration in reclaimed water.

Using the detection limit and half the detection limit for receiving water concentrations, the predicted concentrations for aldrin, heptachlor, and bis-(2-ethylhexyl)phthalate for the one percent design discharge component were above the sediment detection limit. However, aldrin and heptachlor were not detected in sediment samples in the Russian River below the confluence with the Laguna despite reclaimed water discharge at a rate equal to or greater than this for several years. It is therefore likely that the actual background (C_{reci}) concentrations of aldrin, heptachlor, and bis-(2-ethylhexyl)phthalate in the Russian River are closer to zero than to the other estimates of receiving water concentration used in the model, the compounds are degraded in the sediment due to natural processes, and/or the model over estimates the predicted concentrations in sediment. Although the predicted sediment concentrations under conditions of 95th percentile reclaimed water concentration within each discharge component are shown as a worst case condition, the 50th percentile reclaimed water concentration with zero receiving water concentration of organic compounds more accurately reflects actual potential conditions.

The concentrations of acenapthene, fluoranthene, phenanthrene, dieldrin, and endrin predicted to occur in the Russian River sediment under maximum discharge assuming detection limit concentrations in both reclaimed water and receiving water, were less than the SQC (see Table 9 above). Using detection limit concentrations for both reclaimed water and receiving water, endrin was predicted to be at a detectable concentration for the one percent design discharge rate. However, sediment samples from the Russian River below the confluence with the Laguna did not contain detectable endrin despite reclaimed water discharge at a greater than one percent rate for several years. Therefore the predicted sediment concentrations shown in Table 9 are probably much higher than would occur at a 20 percent design discharge rate.

Aldrin, alpha BHC, and heptachlor are predicted by this model to occur in detectable quantities in Laguna sediments in all four discharge components (Table 13). For these compounds, the estimated concentrations in sediments are more sensitive to the receiving water concentration (C_{reci}) than reclaimed water concentration (C_{rw}) since the predicted concentrations decrease with increasing discharge rates. This is because the concentrations of aldrin, alpha BHC, and heptachlor in reclaimed water are less than half the detection limit for these compounds in the Laguna.

Table 13.

Estimated Concentration of Organics in Laguna Sediment

	July 1994 det. limit µg/kg dry weight	1 percent design discharge component (50th percentile reclaimed water conc.) µg/kg dry weight			1 percent design discharge component (95th percentile reclaimed water conc.) µg/kg dry weight		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	10.8	0	245	489	6.5	245	476
alpha-BHC	3.6	0	4.4	8.7	0.12	4.4	8.5
gamma-BHC	10.8	0	0.20	0.40	0.032	0.20	0.42
endosulfan II	36	0	2.2	4.4	0.18	2.2	4.4
heptachlor	36	0	137	274	2.2	137	274
acenapthene	1264	0	39.4	78.7	0	39.4	78.7
fluoranthene	1264	0	376	752	0	376	752
phenanthrene	1264	0	136	273	0	136	273
dieldrin	36	0	4.9	9.9	0	8.7	17.4
endrin	36	0	94.2	188	0	166	332

	July 1994 detection limit	5 percent design discharge component (50th percentile reclaimed water conc.)			5 percent design discharge component (95th percentile reclaimed water conc.)		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	10.8	4.9	242	479	42.4	223	404
alpha-BHC	3.6	0.088	4.3	8.6	0.76	4.0	7.2
gamma-BHC	10.8	0.024	0.22	0.41	0.21	0.36	0.50
endosulfan II	36	0.13	2.3	4.4	1.1	2.8	4.4
heptachlor	36	1.6	135	267	14.2	116	217
acenapthene	1264	0	39.4	78.7	0	39.4	78.7
fluoranthene	1264	0	376	752	0	376	752
phenanthrene	1264	0	136	273	0	136	273
dieldrin	36	0	7.8	15.5	0	29.4	58.7
endrin	36	0	148	296	0	560	1119

Table 13. Continued

Estimated Concentration of Organics in Laguna Sediment

		10 percent design discharge component (50th percentile reclaimed water conc.)			**10 percent design discharge component (95th percentile reclaimed water conc.)**		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	10.8	8.2	240	473	70.1	210	349
alpha-BHC	3.6	0.15	4.3	8.5	1.3	3.7	6.2
gamma-BHC	10.8	0.040	0.23	0.42	0.34	0.46	0.57
endosulfan II	36	0.22	2.3	4.4	1.9	3.1	4.4
heptachlor	36	2.7	133	263	23.6	102	180
acenapthene	1264	0	39.4	78.7	0	39.4	78.7
fluoranthene	1264	0	376	752	0	376	752
phenanthrene	1264	0	136	273	0	136	273
dieldrin	36	0	9.6	19.3	0	45.3	90.7
endrin	36	0	184	367	0	864	1728

		20 percent design discharge component (50th percentile reclaimed water conc.)			**20 percent design discharge component (95th percentile reclaimed water conc.)**		
Assumed Receiving Water Concentration		**0**	**0.5X detection limit**	**detection limit**	**0**	**0.5X detection limit**	**detection limit**
aldrin	10.8	27.7	231	434	99.5	195	290
alpha-BHC	3.6	0.50	4.1	7.8	1.8	3.5	5.2
gamma-BHC	10.8	0.14	0.30	0.47	0.49	0.57	0.64
endosulfan II	36	0.75	2.6	4.4	2.7	3.5	4.4
heptachlor	36	9.3	123	237	33.4	86.9	140
acenapthene	1264	0	39.4	78.7	0	39.4	78.7
fluoranthene	1264	0	376	752	0	376	752
phenanthrene	1264	0	136	273	0	136	273
dieldrin	36	0	20.9	41.8	0	62.2	124
endrin	36	0	398	797	0	1186	2372

The predicted concentrations for the one percent component should be similar or lower than present concentrations in the Laguna since reclaimed water has been discharged at greater than this level for several years. The predicted concentrations for the one percent component using the detection limit and half the detection limit receiving water concentrations were above the detection limit but neither aldrin, heptachlor, alpha BHC were detected in sediment samples in the Laguna below the discharge. It is therefore likely that the actual background concentrations (C_{reci}) of these three compounds in the Laguna are closer to zero than to the other estimates of receiving water concentration used in the model, the model over estimates the predicted concentrations in sediment, and/or the compounds are degraded in the sediment due to natural processes

The concentrations of acenapthene, fluoranthene, phenanthrene, dieldrin, and endrin predicted to occur in the Laguna sediment under maximum discharge assuming detection limit concentrations in both reclaimed water and receiving water, were less than the SQC (see Table 9 above). Using detection limit concentrations for both reclaimed water and receiving water, endrin was predicted to be at a detectable concentration for the one percent design discharge rate. However, sediment samples from the Laguna below reclaimed water discharge did not contain detectable endrin despite reclaimed water discharge at a greater than one percent rate for several years. Therefore the predicted sediment concentrations shown in Table 9 are probably much higher than would actually at a 20 percent design discharge rate.

6.2.3-3 Range of Predicted Incremental Sediment Concentration of Organics

The effect of reclaimed water discharge components on the concentration of organic chemicals in the sediment is highly dependent on the concentration of the chemicals in the receiving water, which is not precisely known due to analytical method detection limitations. Results from a partition coefficient model indicate that the background receiving water concentration of these organic chemicals is lower than half the detection limit. Although the predicted sediment concentrations under conditions of maximum reclaimed water concentration within each discharge component were estimated as a worst case condition, the 50th percentile reclaimed water concentration is more representative of potential long-term conditions. Sediment accumulation is a long-term process and results of temporary high concentrations that are modeled using the 95th percentile concentration within each discharge component would probably not significantly influence the sediment concentrations.

The range of predicted incremental sediment concentrations of organic compounds in the Russian River and Laguna resulting from the 50th percentile reclaimed water concentration associated with each reclaimed water discharge component (1, 5, 10, and 20 percent) are shown in Tables 14 and 15. The total concentrations of organics that are predicted by analysis to increase with increased reclaimed water discharge cannot be estimated because the precise current background concentrations are not known.

Table 14.

Range of Predicted Incremental Sediment Concentrations of Organic Compounds in Russian River Under Different Discharge Components

	1% reclaimed water	**5% reclaimed water**	**10% reclaimed water**	**20% reclaimed water**
	Range of predicted conc. in sediment (µg/kg)	**Range of predicted conc. in sediment (µg/kg)**	**Range of predicted conc. in sediment (µg/kg)**	**Range of predicted conc. in sediment (µg/kg)**
aldrin	0-180	0.18-180	0.36-179	1.8-177
alpha-BHC	0-3.2	0.003-3.2	0.006-3.2	0.032-3.2
gamma-BHC	0-0.15	0.0009-0.16	0.002-0.16	0.089-.17
endosulfan II	0-1.6	0.005-1.6	0.01-1.6	0.048-1.6
heptachlor	0-101	0.061-101	0.12-100	0.61-98.5
bis-(2-ethylhexyl)phthalate	551-565	560-594	568-839	637-983
di-n-butyl phthalate	0-139	0.96-148	1.93-157	9.6-166
acenapthene	0-29.0	0-29.0	0-29.0	0-29.0
fluoranthene	0-277	0-277	0-277	0-277
phenanthrene	0-101	0-101	0-101	0-101
dieldrin	0-3.6	0-7.1	0-10.6	0-14
endrin	0-69.4	0-135	0-201	0-267

Table 15.

Range of Predicted Incremental Sediment Concentrations of Organic Compounds in Laguna Under Different Discharge Components

	1% reclaimed water	5% reclaimed water	10% reclaimed water	20% reclaimed water
	Range of predicted conc. in sediment (µg / kg)	**Range of predicted conc. in sediment (µg / kg)**	**Range of predicted conc. in sediment (µg / kg)**	**Range of predicted conc. in sediment (µg / kg)**
aldrin	0-489	4.9-479	8.2-473	27.7-434
alpha-BHC	0-8.7	0.088-8.6	0.15-8.5	0.5-7.8
gamma-BHC	0-0.40	0.024-0.5	0.04-0.57	0.14-0.64
endosulfan II	0-4.4	0.13-4.4	0.22-4.4	0.75-4.4
heptachlor	0-274	1.6-267	2.7-263	9.3-237
acenapthene	0-78.7	0-78.7	0-78.7	0-78.7
fluoranthene	0-752	0-752	0-752	0-752
phenanthrene	0-273	0-273	0-273	0-273
dieldrin	0-9.9	0-58.7	0-90.7	0-124
endrin	0-188	0-1119	0-1728	0-2372

6.2.3-4 Biodegradation

The concentrations of organics predicted to occur with different discharge components as described above does not take into account processes influencing the concentration of organics in sediment after deposition has occurred. Biodegradation is one such process that can be important in determining the ultimate concentration of organics in sediment. Biodegradation is a biologically mediated transformation of one compound to other compounds. Biodegradation information for organics has been summarized by Mills, et al. (1985) and Howard (1989, 1990, 1991) and is presented for the organic compounds modeled above in Table 16. Dieldrin is included in Table 16 since it is a frequent degradation product of aldrin.

Table 16

Biodegradation of Organic Compounds

Compound	Importance of biodegradation (from Mills 1983)[a]	Comments (from Howard 1989-1991)
Aldrin	?	Classified as refractory to biodegradation. May biodegrade more quickly in an anaerobic environment.
Dieldrin	-	Biodegradation is an unimportant process.
Endosulfan	+	Biodegradation is expected to be significant. Recovery after addition to Gezira soil ranged from a tract to over 50% after 42 days. Half life values from a sandy loam soil were 1-2 weeks.
Heptachlor	-	Biodegradation may be significant. Degradation in sandy loam, Louisiana clay, Maahas clay, and Pila clay loam was complete to nearly complete in 1 to 3 months
Alpha-BHC	+	Biodegradation may occur slowly in aerobic surroundings and is expected to occur rapidly and extensively under aerobic conditions.
Gamma-BHC	+	May slowly biodegrade in aerobic media and will rapidly degrade under anaerobic conditions.
bis-(2-ethylhexyl) phthalate	+	Biodegrades rapidly under aerobic conditions in water/sediment systems. Under anaerobic conditions in water/sediment mixtures, no biodegradation occurs.
diethylphthalate	+	Expected to undergo aerobic biodegradation in soil. In water, expected to biodegrade (half-life approx. 2 days to >2 weeks) under aerobic conditions. Anaerobic biodegradation would be very slow or not occur at all.

[a] + Biodegradation could be an important process
- Biodegradation is not likely to be an important process
? Importance of biodegradation is uncertain or not known.

6.2.4 Incremental Sediment Concentration of Metals

The constituents that were not eliminated from the screening procedures described above in the Qualitative Assessment - Reclaimed Water Constituents were further evaluated to estimate relative sediment concentrations under the 1 percent, 5 percent, 10 percent, and 20 percent to the Laguna discharge components. Sediment concentrations under the 20 percent Russian River discharge, No Project, and Geysers discharge components were not estimated since the percent concentration of reclaimed water in the receiving waters for these components is within the range of percent concentration for the 1 percent, 5 percent, 10 percent, and 20 percent to the Laguna discharge components. The methods and results of these analyses are described below.

6.2.4-1 Background

The distribution of inorganic metal species are governed by complex equilibria based on the stability of precipitates, soluble complexes, sorbing ionic species and complexes, and the free ions. For example, the concentration of a free metal species, M^{n+} and its associated ligand (L^{m-}) can be represented by the simple aqueous-solid equilibrium equations:

$$xM^{n+} + yL^{m} = M_x L_x \text{ (s)} \tag{7}$$

$$K_{sp} = [M+]^x \times [L-]^y \tag{8}$$

where K_{sp} is referred to as the "solubility product". Thus, the product of the free M^{n+} and L^- molar concentrations must be less than the value of K_{sp} for these species to remain freely dissolved. If, on the other hand, the theoretical solubility limit is surpassed, i.e. $[M^{n+}]^x$ X $[L^{m-}]^y > K_{sp}$, then a precipitate can be expected to form. In the presence of a constant supply of these ionic species at these concentrations, the resulting metal-bearing solids may accumulate.

Equilibria involving stable complexes of metals and ligands can also affect the stability of both free ion and solids concentrations. This equilibrium can be represented as:

$$ML = xM^{n+} + yL^{m-} \tag{9}$$

$$K_{eq} = \left[M^{n+}\right]^x \times \left[L^{m-}\right]^y \tag{10}$$

where K_{eq} is known as the "stability constant". In addition, other aqueous-solid interactions, including adsorption of charged free ions and/or ion complexes, can reduce free ion concentrations and increase apparent accumulation of an inorganic species.

6.2.4-2 Methods and Results

The computer model SOILCHEM (Sposito, 1987, 1988) simulates these complex equilibria for a large number of metals and inorganic and organic ligands (ions or molecules surrounding and attached to a central metal atom or ions. The method of calculation employed in the program is based on chemical thermodynamics (Sposito 1987, 1988). For each component of a soil solution a mole balance equation is set up and thermodynamic equilibrium constants, corrected for ionic strength, and, if appropriate, surface charge conditions, are incorporated into the terms of this equation according to the law of mass action. The solution of the set of nonlinear algebraic equations that results from mole balance applied to all the components simultaneously ultimately provides the concentration of each dissolved and solid species in the system under consideration (Sposito 1987, 1988). Therefore, with accurate data on the total inorganic species concentrations in the solution phase of a solid-aqueous system at equilibrium, SOILCHEM quantifies the distribution of an inorganic species between the solid and soluble aqueous phases and an estimate of the accumulation potential of pollutant species can be obtained.

The input for the model is the concentration in the water (C_w) of selected metals and ligands. These metals and ligands considered in this analysis were the ten metals (Cu^{2+}, Ba^{2+}, Cd^{2+}, Zn^{2+}, Ni^{2+}, Pb^{2+}, Ag^{+}, Cr^{3+}, AsO_4^{3-}, and $B(OH)_4^{-}$) and cyanide which were not eliminated by previous screening plus Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, CO_3^{2-}, SO_4^{2-}, and Cl^{-}. Arsenic does not generally exist as a free ion under normal environmental conditions, so arsenate (AsO_4^{3-}) was assumed, and used as a ligand in the model. Boron was also assumed to be a ligand and entered into the model as $B(OH)_4^{-}$. Potential complexes with hydrogen and hydroxide ions are also included in the model. Thus the computations involved 14 metals, 7 ligands, 217 complexes, and 61 possible solids.

The C_w for each element/compound (except as noted below) was calculated as described above for organic compounds. The long-term average pH levels during discharge season for the Laguna and the Russian River was also used as model input. The model was run at 1, 5, 10, and 20 percent design discharge components, using the mean and maximum predicted reclaimed water concentrations within each discharge component. To simplify the analyses, the solid-aqueous equilibrium was modeled as a closed system to CO_2 , no mixed solids (more than one metal or more than one ligand) were allowed to precipitate, and no specific surface adsorption of dissolved or complexed species was considered. Although the assumption of no adsorption will tend to decrease the amount of precipitation, at the pHs used in this model (7.5 for the Laguna and 8.0 for the Russian River), the amount of precipitation due to adsorption would probably be negligible (G. Sposito, pers. comm.). A Holtville soil solution was assumed for the input concentrations of Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, CO_3^{2-}, SO_4^{2-}, and Cl^{-}.

6.2.4-3 Range of Predicted Incremental Sediment Concentration of Organics

Barium and arsenate (as $BaAsO_4$) were the only metals/ligands complexes (other than $CaCO_3$) predicted to precipitate under all discharge components. Tables 17 and 18 presents the estimated concentration in water (C_w), the percent that precipitates and the predicted concentration in sediments for barium and arsenic due to reclaimed water. The SOILCHEM model does not incorporate background sediment metals concentrations, so the predicted sediment concentrations are the concentrations due to reclaimed water and receiving water only. The predicted concentrations of barium decrease with increasing reclaimed water discharge because the average concentration in the receiving water was higher than the concentration in reclaimed water. The predicted concentrations of arsenic in the Russian River were the same for all concentrations of reclaimed water discharge because the concentration in the receiving water was below detection and the concentration in reclaimed water was equal to half the detection limit. The predicted concentrations of arsenic in the Laguna decreased with increasing reclaimed water discharge because the concentration in reclaimed water was less than the concentration of arsenic in the Laguna.

Table 17.

Predicted Concentrations of Barium and Arsenic in Russian River Sediment Under Different Discharge Components

	Barium			Arsenic		
	C_w (µg / L)	Percent predicted to precipitate	Estimated sediment conc. (µg / kg)	C_w (µg / L)	Percent predicted to precipitate	Estimated sediment conc. (µg / kg)
1 Percent design discharge						
50th percentile	70	71.7	6.4	2.5	100	0.32
95th percentile	70	71.7	6.4	2.5	100	0.32
5 Percent design discharge						
50th percentile	70	71.7	6.4	2.5	100	0.32
95th percentile	68	70.4	6.1	2.5	100	0.32
10 Percent design discharge						
50th percentile	70	71.7	6.4	2.5	100	0.32
95th percentile	65	69.7	5.8	2.5	100	0.32
20 Percent design discharge						
50th percentile	70	71.0	6.3	2.5	100	0.32
95th percentile	63	68.3	5.5	2.5	100	0.32

Table 18.

Predicted Concentrations of Barium and Arsenic in Laguna Sediment Under Different Discharge Components

	Barium			Arsenic		
	C_w (mg/L)	Percent predicted to precipitate	Estimated sediment conc. (µg/g)	C_w (mg/L)	Percent predicted to precipitate	Estimated sediment conc. (µg/g)
1 Percent design discharge						
50th percentile	70	69.8	8.3	3.6	100	0.61
95th percentile	68	69.2	8.0	3.6	100	0.61
5 Percent design discharge						
50th percentile	69	69.2	8.1	3.6	100	0.61
95th percentile	58	63.7	6.3	3.3	100	0.56
10 Percent design discharge						
50th percentile	69	68.5	7.9	3.5	100	0.59
95th percentile	50	57.4	4.9	3.1	100	0.53
20 Percent design discharge						
50th percentile	62	66.2	7.0	3.4	100	0.58
95th percentile	42	48.8	3.5	2.9	100	0.49

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8.0 APPENDICES

Appendix 1. Laguna de Santa Rosa Sediment Data - Metals

Sediment samples collected 13-14 July 1994.
* indicates value to the left was below detection. Value shown is the detection limit.

in mg/kg dry weight	Brown Farm Pond subsurface	Brown Farm Pond surface	Kelly Farm Pond subsurface	Kelly Farm Pond surface	Meadowlane Pond subsurface	Meadowlane Pond surface
Constituent						
percent moisture	76.7	80.2	51.9	58.5	67.8	79.4
TOC	4600	5300	2200	10200	3300	3000
fraction oc dry wt	0.0197	0.0268	0.0046	0.0246	0.0102	0.0146
TTLC analyses						
Antimony (GFAA)	2.15 *	2.53 *	1.04 *	1.20 *	1.55 *	2.43 *
Arsenic (GFAA)	2.15 *	2.53 *	3.12	1.93	1.55 *	2.43 *
Cadmium (GFAA)	0.21 *	0.25 *	0.10 *	0.12 *	0.37	0.39
Chromium (GFAA)	77.25	75.76	68.61	69.88	49.69	40.29
Cobalt (GFAA)	15.45	13.13	19.96	17.83	12.11	6.80
Copper (GFAA)	64.38	55.56	31.19	33.73	65.22	63.11
Cyanide (Total)	0.86 *	1.01 *	0.42 *	0.48 *	0.62 *	0.97 *
Lead (GFAA)	12.88	11.62	10.19	10.12	15.22	13.59
Mercury (CVAA)	0.43 *	0.51 *	0.21 *	0.24 *	0.31 *	0.49 *
Nickel (GFAA)	77.25	90.91	93.56	98.80	49.69	42.23
Selenium (GFAA)	2.15 *	2.53 *	1.04 *	1.20 *	1.55 *	2.43 *
Silver (GFAA)	1.29	1.01	0.21 *	0.24 *	2.80	2.91
Thallium (GFAA)	2.15 *	2.53 *	1.04 *	1.20 *	1.55 *	2.43 *
Zinc (ICP)	120.17	141.41	68.61	72.29	111.80	140.78
STLC analyses						
Antimony (GFAA,WET)		2.53 *		1.20 *		2.43 *
Arsenic (GFAA,WET)		1.01 *		0.48 *		0.97 *
Cadmium (GFAA,WET)		0.15		0.06 *		0.23
Chromium (GFAA,WET)		5.00		1.30		4.76
Cobalt (GFAA,WET)		2.32		2.41		1.80
Copper (GFAA,WET)		8.08		0.60 *		11.17
Lead (GFAA,WET)		4.04		1.69		8.25
Mercury (CVAA,WET)		0.25 *		0.12 *		0.24 *
Nickel (GFAA,WET)		10.10		12.77		6.31
Selenium (GFAA,WET)		1.01 *		0.48 *		0.97 *
Silver (GFAA,WET)		0.25 *		0.12 *		0.24 *
Thallium (GFAA,WET)		2.53 *		1.20 *		2.43 *
Zinc (ICP, WET)		70.71		12.05		87.38

Appendix 1. Laguna de Santa Rosa Sediment Data - Metals

in mg/kg dry weight	Santa Rosa Willowside ubsurface	Santa Rosa Willowside surface	Downstream of discharge subsurface	Downstream of discharge surface	Laguna Stony Pt. subsurface	Laguna Stony Pt. surface
Constituent						
percent moisture	40.6	54.8	41.4	53.3	40.4	60.8
TOC	2500	3200	1700	2700	1700	3600
fraction oc dry wt	0.0042	0.0071	0.0029	0.0058	0.0029	0.0092
TTLC analyses						
Antimony (GFAA)	0.84 *	1.11 *	0.85 *	1.07 *	0.84 *	1.28 *
Arsenic (GFAA)	2.02	2.43	2.05	1.50	2.01	2.55
Cadmium (GFAA)	0.17	0.22	0.15	0.13	0.08 *	0.15
Chromium (GFAA)	72.39	77.43	59.73	27.84	31.88	20.92
Cobalt (GFAA)	21.89	17.70	18.77	6.42	10.07	7.65
Copper (GFAA)	28.62	33.19	22.18	18.84	15.94	16.84
Cyanide (Total)	0.96	1.00	0.34 *	0.43 *	0.34 *	0.51 *
Lead (GFAA)	21.89	28.76	18.77	13.92	6.54	7.65
Mercury (CVAA)	0.17 *	0.22 *	0.17 *	0.21 *	0.17 *	0.26 *
Nickel (GFAA)	111.11	110.62	97.27	40.69	30.20	28.06
Selenium (GFAA)	0.84 *	1.11 *	0.85 *	1.07 *	0.84 *	1.28 *
Silver (GFAA)	0.17 *	0.22 *	0.17 *	0.21 *	0.17 *	0.26 *
Thallium (GFAA)	0.84 *	1.11 *	0.85 *	1.07 *	0.84 *	1.28 *
Zinc (ICP)	80.81	103.98	64.85	47.11	46.98	99.49
STLC analyses						
Antimony (GFAA,WET)		1.11 *		1.07 *		1.28 *
Arsenic (GFAA,WET)		0.44 *		0.64		1.79
Cadmium (GFAA,WET)		0.06 *		0.07		0.06 *
Chromium (GFAA,WET)		8.85		6.85		2.37
Cobalt (GFAA,WET)		2.65		3.85		3.83
Copper (GFAA,WET)		0.55 *		2.14		0.64 *
Lead (GFAA,WET)		5.09		7.49		3.32
Mercury (CVAA,WET)		0.11 *		0.11 *		0.13 *
Nickel (GFAA,WET)		22.12		21.41		8.93
Selenium (GFAA,WET)		0.44 *		0.43 *		0.51 *
Silver (GFAA,WET)		0.11 *		0.11 *		0.13 *
Thallium (GFAA,WET)		1.11 *		1.07 *		1.28 *
Zinc (ICP, WET)		30.97		27.84		102.04

Appendix 1. Laguna de Santa Rosa Sediment Data - Metals

in mg/kg dry weight	Laguna Trenton Healdsburg ubsurface		Laguna Trenton Healdsburg surface	
Constituent				
percent moisture	46.6		45.3	
TOC	5200		6800	
fraction oc dry wt	0.0097		0.0124	
TTLC analyses				
Antimony (GFAA)	0.94	*	0.91	*
Arsenic (GFAA)	3.18		3.11	
Cadmium (GFAA)	0.09		0.11	
Chromium (GFAA)	59.93		60.33	
Cobalt (GFAA)	18.73		14.99	
Copper (GFAA)	20.60		23.77	
Cyanide (Total)	0.37	*	0.37	*
Lead (GFAA)	14.61		14.44	
Mercury (CVAA)	0.19	*	0.18	*
Nickel (GFAA)	76.78		69.47	
Selenium (GFAA)	0.94	*	0.91	*
Silver (GFAA)	0.19		0.18	*
Thallium (GFAA)	0.94	*	0.91	*
Zinc (ICP)	63.67		60.33	
STLC analyses				
Antimony (GFAA,WET)			0.91	*
Arsenic (GFAA,WET)			1.28	
Cadmium (GFAA,WET)			0.05	*
Chromium (GFAA,WET)			3.47	
Cobalt (GFAA,WET)			4.94	
Copper (GFAA,WET)			2.38	
Lead (GFAA,WET)			2.93	
Mercury (CVAA,WET)			0.09	*
Nickel (GFAA,WET)			16.09	
Selenium (GFAA,WET)			0.37	*
Silver (GFAA,WET)			0.09	*
Thallium (GFAA,WET)			0.91	*
Zinc (ICP, WET)			12.80	

Appendix 2. Laguna de Santa Rosa Sediment Data - Organics

Sediment samples collected 13-14 July 1994
* indicates concentration was below reporting limit. Value shown is reporting limit
Constituents with detectable values are bold

dry weight

Constituent	Brown Farm Pond ubsurface	Brown Farm Pond surface	Kelly Farm Pond subsurface	Kelly Farm Pond surface	Meadowlane Pond subsurface	Meadowlane Pond surface
Percent Moisture						
Total Organic Carbon	78.7	82.9	46.5	56	66.2	81.8
fraction organic carbon dry wt	4500	5700	2400	3000	2900	3200
	0.021127	0.033333	0.004486	0.006818	0.00857988	0.01758242
1,2,4-Trichlorobenzene						
1,2-Dichlorobenzene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
1,3-Dichlorobenzene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
1,4-Dichlorobenzene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2,4,5-T	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2,4,5-TP	0.047 *	0.058 *	0.019	0.023 *	0.030 *	0.055 *
2,4,5-Trichlorophenol	0.047 *	0.058 *	0.019 *	0.023 *	0.030 *	0.055 *
2,4,6-Trichlorophenol	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
2,4-D	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2,4-DB	0.235 *	0.292 *	0.093 *	0.114 *	0.148 *	0.275 *
2,4-Dichlorophenol	0.235 *	0.292 *	0.093 *	0.114 *	0.148 *	0.275 *
2,4-Dimethylphenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2,4-Dinitrophenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2,4-Dinitrotoluene	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
2,6-Dinitrotoluene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2-Chloronaphthalene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2-Chlorophenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2-Methylnaphthalene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2-Methylphenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2-Nitroaniline	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
2-Nitrophenol	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
3,3'-Dichlorobenzidine	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
3-Nitroaniline	46948 *	58480 *	18692 *	22727 *	2959 *	5495 *
4,4'-DDD	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
4,4'-DDD	28 *	35 *	11 *	14 *	18 *	33 *
4,4'-DDE	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
4,4'-DDE	28 *	35 *	11 *	14 *	18 *	33 *
4,4'-DDT	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
4,4'-DDT	28 *	35 *	11 *	14 *	18 *	33 *
4,6-Dinitro-2-methylphenol	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
4-Bromophenyl phenyl ether	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
4-Chloro-3-methylphenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
4-Chloroanaline	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
4-Chlorophenyl phenyl ether	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
4-Methylphenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
4-Nitroaniline	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
4-Nitrophenol	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Acenaphthene	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Acenaphthylene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Aldrin	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Aldrin	9 *	12 *	4 *	5 *	6 *	11 *
alpha-BHC	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Anthracene	3 *	4 *	1 *	1 *	2 *	3 *
Aroclor 1016	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Aroclor 1221	939 *	1170 *	374 *	455 *	592 *	1099 *

Appendix 2. Laguna de Santa Rosa Sediment Data - Organics

dry weight Constituent	Santa Rosa Willowside ubsurface	Santa Rosa Willowside surface	Santa Rosa Creek Downstream of discharge subsurface	Santa Rosa Creek Downstream of discharge surface	Laguna Stony Pt. subsurface	Laguna Stony Pt. surface
Percent Moisture						
Total Organic Carbon	45.4	54.9	37.4	59.2	38	56.5
fraction organic carbon dry wt	3200	4600	270	3500	4700	3800
	0.005861	0.0102	0.000431	0.008578	0.007581	0.008736
1,2,4-Trichlorobenzene						
1,2-Dichlorobenzene	1282 *	1552 *	1118 *	8088 *	532 *	1609
1,3-Dichlorobenzene	1282 *	1552 *	1118 *	8088 *	532 *	1609
1,4-Dichlorobenzene	1282 *	1552 *	1118 *	8088 *	532 *	1609
2,4,5-T	1282 *	1552 *	1118 *	8088 *	532 *	1609
2,4,5-TP	**0.092**	**0.111**	**0.032**	**0.025**	0.016 *	0.023
2,4,5-Trichlorophenol	0.018 *	0.022 *	0.016 *	0.025 *	0.016 *	0.023
2,4,6-Trichlorophenol	5495 *	6652 *	4792 *	39216 *	2581 *	6897
2,4-D	1282 *	1552 *	1118 *	8088 *	532 *	1609
2,4-DB	0.092 *	0.111 *	0.080 *	0.123 *	0.081 *	0.115
2,4-Dichlorophenol	0.092 *	0.111 *	0.080 *	0.123 *	0.081 *	0.115
2,4-Dimethylphenol	1282 *	1552 *	1118 *	8088 *	532 *	1609
2,4-Dinitrophenol	1282 *	1552 *	1118 *	8088 *	532 *	1609
2,4-Dinitrotoluene	5495 *	6652 *	4792 *	39216 *	2581 *	6897
2,6-Dinitrotoluene	1282 *	1552 *	1118 *	8088 *	532 *	1609
2-Chloronaphthalene	1282 *	1552 *	1118 *	8088 *	532 *	1609
2-Chlorophenol	1282 *	1552 *	1118 *	8088 *	532 *	1609
2-Methylnaphthalene	1282 *	1552 *	1118 *	8088 *	532 *	1609
2-Methylphenol	1282 *	1552 *	1118 *	8088 *	532 *	1609
2-Nitroaniline	1282 *	1552 *	1118 *	8088 *	532 *	1609
2-Nitrophenol	5495 *	6652 *	4792 *	39216 *	2581 *	6897
3,3'-Dichlorobenzidine	1282 *	1552 *	1118 *	8088 *	532 *	1609
3-Nitroaniline	1832 *	2217 *	1597 *	16176 *	1065 *	2299
4,4'-DDD	5495 *	6652 *	4792 *	39216 *	2581 *	6897
4,4'-DDD	55 *	67 *	48 *	74 *	48 *	69
4,4'-DDE	5495 *	6652 *	4792 *	39216 *	2581 *	6897
4,4'-DDE	55 *	67 *	48 *	74 *	48 *	69
4,4'-DDT	5495 *	6652 *	4792 *	39216 *	2581 *	6897
4,4'-DDT	55 *	67 *	48 *	74 *	48 *	69
4,6-Dinitro-2-methylphenol	5495 *	6652 *	4792 *	39216 *	2581 *	6897
4-Bromophenyl phenyl ether	5495 *	6652 *	4792 *	39216 *	2581 *	6897
4-Chloro-3-methylphenol	1282 *	1552 *	1118 *	8088 *	532 *	1609
4-Chloroanaline	1282 *	1552 *	1118 *	8088 *	532 *	1609
4-Chlorophenyl phenyl ether	1282 *	1552 *	1118 *	8088 *	532 *	1609
4-Methylphenol	1282 *	1552 *	1118 *	8088 *	532 *	1609
4-Nitroaniline	1282 *	1552 *	1118 *	8088 *	532 *	1609
4-Nitrophenol	5495 *	6652 *	4792 *	39216 *	2581 *	6897
Acenaphthene	5495 *	6652 *	4792 *	39216 *	2581 *	6897
Acenaphthylene	1282 *	1552 *	1118 *	8088 *	532 *	1609
Aldrin	1282 *	1552 *	1118 *	8088 *	532 *	1609
Aldrin	22 *	27 *	19 *	29 *	19 *	28
alpha-BHC	5495 *	6652 *	4792 *	39216 *	2581 *	6897
Anthracene	5 *	7 *	5 *	7 *	5 *	7
Aroclor 1016	1282 *	1552 *	1118 *	8088 *	532 *	1609
Aroclor 1221	1832 *	2217 *	1597 *	2451 *	1613 *	2299

		Laguna		Laguna	
dry weight					
		Trenton Healdsgurg		Trenton Healdsgurg	
Constituent		subsurface		surface	
Percent Moisture					
Total Organic Carbon		37.8		44.6	
fraction organic carbon dry wt		5200		3600	
		0.00836		0.006498	
1,2,4-Trichlorobenzene					
1,2-Dichlorobenzene	*	531	*	1264	*
1,3-Dichlorobenzene	*	531	*	1264	*
1,4-Dichlorobenzene	*	531	*	1264	*
2,4,5-T	*	531	*	1264	*
2,4,5-TP	*	0.016	*	0.018	*
2,4,5-Trichlorophenol	*	0.016	*	0.018	*
2,4,6-Trichlorophenol	*	2572	*	5415	*
2,4-D	*	531	*	1264	*
2,4-DB	*	0.080	*	0.090	*
2,4-Dichlorophenol	*	0.080	*	0.090	*
2,4-Dimethylphenol	*	531	*	1264	*
2,4-Dinitrophenol	*	531	*	1264	*
2,4-Dinitrotoluene	*	2572	*	5415	*
2,6-Dinitrotoluene	*	531	*	1264	*
2-Chloronaphthalene	*	531	*	1264	*
2-Chlorophenol	*	531	*	1264	*
2-Methylnaphthalene	*	531	*	1264	*
2-Methylphenol	*	531	*	1264	*
2-Nitroaniline	*	531	*	1264	*
2-Nitrophenol	*	2572	*	5415	*
3,3'-Dichlorobenzidine	*	531	*	1264	*
3-Nitroaniline	*	1061	*	1805	*
4,4'-DDD	*	2572	*	5415	*
4,4'-DDD	*	48	*	36	*
4,4'-DDE	*	2572	*	5415	*
4,4'-DDE	*	48	*	36	*
4,4'-DDT	*	2572	*	5415	*
4,4'-DDT	*	48	*	36	*
4,6-Dinitro-2-methylphenol	*	2572	*	5415	*
4-Bromophenyl phenyl ether	*	2572	*	5415	*
4-Chloro-3-methylphenol	*	531	*	1264	*
4-Chloroanaline	*	531	*	1264	*
4-Chlorophenyl phenyl ether	*	531	*	1264	*
4-Methylphenol	*	531	*	1264	*
4-Nitroaniline	*	531	*	1264	*
4-Nitrophenol	*	2572	*	5415	*
Acenaphthene	*	2572	*	5415	*
Acenaphthylene	*	531	*	1264	*
Aldrin	*	531	*	1264	*
Aldrin	*	19	*	11	*
alpha-BHC	*	2572	*	5415	*
Anthracene	*	5	*	4	*
Aroclor 1016	*	531	*	1264	*
Aroclor 1221	*	1608	*	903	*

Appendix 2. Laguna de Santa Rosa Sediment Data - Organics

Sediment samples collected 13-14 July 1994
*** indicates concentration was below reporting limit. Value shown is reporting limit**
Constituents with detectable values are bold

dry weight	Brown Farm	Brown Farm	Kelly Farm	Kelly Farm	Meadowlane	Meadowlane
Aroclor 1232	4695 *	5848 *	1869 *	2273 *	2959 *	5495 *
Aroclor 1242	1878 *	2339 *	748 *	909 *	1183 *	2198 *
Aroclor 1248	939 *	1170 *	374 *	455 *	592 *	1099 *
Aroclor 1254	939 *	1170 *	374 *	455 *	592 *	1099 *
Aroclor 1260	469 *	585 *	187 *	227 *	296 *	549 *
Azinphos methyl	469 *	585 *	187 *	227 *	296 *	549 *
Benyzl alcohol	31 *	39 *	13 *	15 *	20 *	37 *
Benzidine	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Benzo(a)anthracene	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Benzo(a)pyrene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Benzo(b)fluoranthene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Benzo(g,h,i)perylene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Benzo(k)fluoranthene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Benzoic acid	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
beta-BHC	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
bis(2-Chloroethoxy)methane	2.8 *	3.5 *	1.1 *	1.4 *	1.8 *	3.3 *
bis(2-Chloroethyl)ether	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
bis(2-Chloroisopropyl)ether	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
bis(2-Ethylhexyl)phthalate	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Butyl benzyl phthalate	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Chlordane	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Chlorpyrifos	235 *	292 *	93 *	114 *	148 *	275 *
Chrysene	31 *	39 *	13 *	15 *	20 *	37 *
Coumaphos	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Dalapon	31 *	39 *	13 *	15 *	20 *	37 *
delta-BHC	0.47 *	0.58 *	0.19 *	0.23 *	0.30 *	0.55 *
delta-BHC	2.8 *	3.5 *	1.1 *	1.4 *	1.8 *	3.3 *
Di-n-butylphthalate	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Di-n-octyl phthalate	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Diazinon	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Dibenzo(a,h)anthracene	31 *	39 *	13 *	15 *	20 *	37 *
Dibenzofuran	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Dicamba	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Dichloroprop	0.047 *	0.058 *	0.019 *	0.023 *	0.030 *	0.055 *
Dichlorvos	0.235 *	0.292 *	0.093 *	0.114 *	0.148 *	0.275 *
Dieldrin	31 *	39 *	13 *	15 *	20 *	37 *
Dieldrin	28 *	35 *	11 *	14 *	18 *	33 *
Diethylphthalate	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Dimethyl phthalate	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Dinoseb	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Disulfoton (Di Syston)	0.047 *	0.058 *	0.019 *	0.023 *	0.030 *	0.055 *
Endosulfan I	31 *	39 *	13 *	15 *	20 *	37 *
Endosulfan II	28 *	35 *	11 *	14 *	18 *	33 *
Endosulfan sulfate	28 *	35 *	11 *	14 *	18 *	33 *
Endrin	28 *	35 *	11 *	14 *	18 *	33 *
Endrin aldehyde	28 *	35 *	11 *	14 *	18 *	33 *
Endrin aldehyde	28 *	35 *	11 *	14 *	18 *	33 *
Ethoprop	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Fensulfothion	31 *	39 *	13 *	15 *	20 *	37 *
Fluoranthene	31 *	39 *	13 *	15 *	20 *	37 *
Fluorene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *

Appendix 2. Laguna de Santa Rosa Sediment Data - Organics

dry weight	Santa Rosa		Santa Rosa		Santa Rosa Creek Downstream		Santa Rosa Creek Downstream		Laguna		Laguna
Aroclor 1232	9158	*	11086	*	7987	*	12255	*	8065	*	11494
Aroclor 1242	3663	*	4435	*	3195	*	4902	*	3226	*	4598
Aroclor 1248	1832	*	2217	*	1597	*	2451	*	1613	*	2299
Aroclor 1254	1832	*	2217	*	1597	*	2451	*	1613	*	2299
Aroclor 1260	916	*	1109	*	799	*	1225	*	806	*	1149
Azinphos methyl	916	*	1109	*	799	*	1225	*	806	*	1149
Benyzl alcohol	12	*	15	*	11	*	16	*	11	*	15
Benzidine	1282	*	1552	*	1118	*	8088	*	532	*	1609
Benzo(a)anthracene	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Benzo(a)pyrene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Benzo(b)fluoranthene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Benzo(g,h,i)perylene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Benzo(k)fluoranthene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Benzoic acid	1282	*	1552	*	1118	*	8088	*	532	*	1609
beta-BHC	5495	*	6652	*	4792	*	39216	*	2581	*	6897
bis(2-Chloroethoxy)methane	5.5	*	6.7	*	4.8	*	7.4	*	4.8	*	6.9
bis(2-Chloroethyl)ether	1282	*	1552	*	1118	*	8088	*	532	*	1609
bis(2-Chloroisopropyl)ether	1282	*	1552	*	1118	*	8088	*	532	*	1609
bis(2-Ethylhexyl)phthalate	1282	*	1552	*	1118	*	8088	*	532	*	1609
Butyl benzyl phthalate	1282	*	1552	*	1118	*	8088	*	532	*	1609
Chlordane	1282	*	1552	*	1118	*	8088	*	532	*	1609
Chlorpyrifos	458	*	554	*	399	*	613	*	403	*	575
Chrysene	12	*	15	*	11	*	16	*	11	*	15
Coumaphos	1282	*	1552	*	1118	*	8088	*	532	*	1609
Dalapon	12	*	15	*	11	*	16	*	11	*	15
delta-BHC	0.18	*	0.22	*	0.16	*	0.25	*	0.16	*	0.23
delta-BHC	5.5	*	6.7	*	4.8	*	7.4	*	4.8	*	6.9
Di-n-butylphthalate	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Di-n-octyl phthalate	1282	*	1552	*	1118	*	8088	*	532	*	1609
Diazinon	1282	*	1552	*	1118	*	8088	*	532	*	1609
Dibenzo(a,h)anthracene	12	*	15	*	11	*	16	*	11	*	15
Dibenzofuran	1282	*	1552	*	1118	*	8088	*	532	*	1609
Dicamba	1282	*	1552	*	1118	*	8088	*	532	*	1609
Dichloroprop	0.018	*	0.022	*	0.016	*	0.025	*	0.016	*	0.023
Dichlorvos	0.092	*	0.111	*	0.080	*	0.123	*	0.081	*	0.115
Dieldrin	12	*	15	*	11	*	16	*	11	*	15
Dieldrin	55	*	67	*	48	*	74	*	48	*	69
Diethylphthalate	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Dimethyl phthalate	1282	*	1552	*	1118	*	8088	*	532	*	1609
Dinoseb	1282	*	1552	*	1118	*	8088	*	532	*	1609
Disulfoton (Di Syston)	0.018	*	0.022	*	0.016	*	0.025	*	0.016	*	0.023
Endosulfan I	12	*	15	*	11	*	16	*	11	*	15
Endosulfan II	55	*	67	*	48	*	74	*	48	*	69
Endosulfan sulfate	55	*	67	*	48	*	74	*	48	*	69
Endrin	55	*	67	*	48	*	74	*	48	*	69
Endrin aldehyde	55	*	67	*	48	*	74	*	48	*	69
Endrin aldehyde	55	*	67	*	48	*	74	*	48	*	69
Ethoprop	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Fensulfothion	12	*	15	*	11	*	16	*	11	*	15
Fluoranthene	12	*	15	*	11	*	16	*	11	*	15
Fluorene	1282	*	1552	*	1118	*	8088	*	532	*	1609

dry weight		Laguna Trenton		Laguna Trenton	
Aroclor 1232	*	8039	*	3610	*
Aroclor 1242	*	3215	*	1805	*
Aroclor 1248	*	1608	*	903	*
Aroclor 1254	*	1608	*	903	*
Aroclor 1260	*	804	*	361	*
Azinphos methyl	*	804	*	361	*
Benyzl alcohol	*	11	*	12	*
Benzidine	*	531	*	1264	*
Benzo(a)anthracene	*	2572	*	5415	*
Benzo(a)pyrene	*	531	*	1264	*
Benzo(b)fluoranthene	*	531	*	1264	*
Benzo(g,h,i)perylene	*	531	*	1264	*
Benzo(k)fluoranthene	*	531	*	1264	*
Benzoic acid	*	531	*	1264	*
beta-BHC	*	2572	*	5415	*
bis(2-Chloroethoxy)methane	*	4.8	*	3.6	*
bis(2-Chloroethyl)ether	*	531	*	1264	*
bis(2-Chloroisopropyl)ether	*	531	*	1264	*
bis(2-Ethylhexyl)phthalate	*	531	*	1264	*
Butyl benzyl phthalate	*	531	*	1264	*
Chlordane	*	531	*	1264	*
Chlorpyrifos	*	402	*	181	*
Chrysene	*	11	*	12	*
Coumaphos	*	531	*	1264	*
Dalapon	*	11	*	12	*
delta-BHC	*	0.16	*	0.18	*
delta-BHC	*	4.8	*	3.6	*
Di-n-butylphthalate	*	2572	*	5415	*
Di-n-octyl phthalate	*	531	*	1264	*
Diazinon	*	531	*	1264	*
Dibenzo(a,h)anthracene	*	11	*	12	*
Dibenzofuran	*	531	*	1264	*
Dicamba	*	531	*	1264	*
Dichloroprop	*	0.016	*	0.018	*
Dichlorvos	*	0.080	*	0.090	*
Dieldrin	*	11	*	12	*
Dieldrin	*	48	*	36	*
Diethylphthalate	*	2572	*	5415	*
Dimethyl phthalate	*	531	*	1264	*
Dinoseb	*	531	*	1264	*
Disulfoton (Di Syston)	*	0.016	*	0.018	*
Endosulfan I	*	11	*	12	*
Endosulfan II	*	48	*	36	*
Endosulfan sulfate	*	48	*	36	*
Endrin	*	48	*	36	*
Endrin aldehyde	*	48	*	36	*
Endrin aldehyde	*	48	*	36	*
Ethoprop	*	2572	*	5415	*
Fensulfothion	*	11	*	12	*
Fluoranthene	*	11	*	12	*
Fluorene	*	531	*	1264	*

Appendix 2. Laguna de Santa Rosa Sediment Data - Organics

Sediment samples collected 13-14 July 1994
*** indicates concentration was below reporting limit. Value shown is reporting limit**
Constituents with detectable values are bold

dry weight

	Brown Farm	Brown Farm	Kelly Farm	Kelly Farm	Meadowlane	Meadowlane
gamma-BHC	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
gamma-BHC (Lindane)	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Heptachlor	9 *	12 *	4 *	5 *	6 *	11 *
Heptachlor	28 *	35 *	11 *	14 *	18 *	33 *
Heptachlor epoxide	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Heptachlor epoxide	28 *	35 *	11 *	14 *	18 *	33 *
Hexachlorobenzene	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Hexachlorobutadiene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Hexachlorocyclopentadiene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Hexachloroethane	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Indeno(1,2,3-cd)pyrene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Isophorone	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
MCPA	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
MCPP	23.5 *	29.2 *	9.3 *	11.4 *	14.8 *	27.5 *
Merphos	23.5 *	29.2 *	9.3 *	11.4 *	14.8 *	27.5 *
Methoxychlor	31 *	39 *	13 *	15 *	20 *	37 *
Methyl Parathion	47 *	58 *	19 *	23 *	30 *	55 *
Mevinphos	31 *	39 *	13 *	15 *	20 *	37 *
N-Nitroso-Di-N-propylamine	31 *	39 *	13 *	15 *	20 *	37 *
N-Nitrosodiphenylamine	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Naled	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Naphthalene	31 *	39 *	13 *	15 *	20 *	37 *
Nitrobenzene	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Pentachlorophenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Phenanthrene	140845 *	175439 *	56075 *	68182 *	8876 *	16484 *
Phenol	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Phorate	32864 *	40936 *	13084 *	15909 *	**32544**	**52747**
Pyrene	31 *	39 *	13 *	15 *	20 *	37 *
Ronnel	32864 *	40936 *	13084 *	15909 *	2071 *	3846 *
Tetrachlorovinphos	31 *	39 *	13 *	15 *	20 *	37 *
Tokuthion	31 *	39 *	13 *	15 *	20 *	37 *
Toxaphene	31 *	39 *	13 *	15 *	20 *	37 *
Trichloronate	469 *	585 *	187 *	227 *	296 *	549 *
	31 *	39 *	13 *	15 *	20 *	37 *

Appendix 2. Laguna de Santa Rosa Sediment Data - Organics

dry weight	Santa Rosa		Santa Rosa		Santa Rosa Creek Downstream		Santa Rosa Creek Downstream		Laguna		Laguna
gamma-BHC	1282	*	1552	*	1118	*	8088	*	532	*	1609
gamma-BHC (Lindane)	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Heptachlor	22	*	27	*	19	*	29	*	19	*	28
Heptachlor	55	*	67	*	48	*	74	*	48	*	69
Heptachlor epoxide	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Heptachlor epoxide	55	*	67	*	48	*	74	*	48	*	69
Hexachlorobenzene	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Hexachlorobutadiene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Hexachlorocyclopentadiene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Hexachloroethane	1282	*	1552	*	1118	*	8088	*	532	*	1609
Indeno(1,2,3-cd)pyrene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Isophorone	1282	*	1552	*	1118	*	8088	*	532	*	1609
MCPA	1282	*	1552	*	1118	*	8088	*	532	*	1609
MCPP	9.2	*	11.1	*	8.0	*	12.3	*	8.1	*	11.5
Merphos	9.2	*	11.1	*	8.0	*	12.3	*	8.1	*	11.5
Methoxychlor	12	*	15	*	11	*	16	*	11	*	15
Methyl Parathion	92	*	111	*	80	*	123	*	81	*	115
Mevinphos	12	*	15	*	11	*	16	*	11	*	15
N-Nitroso-Di-N-propylamine	12	*	15	*	11	*	16	*	11	*	15
N-Nitrosodiphenylamine	1282	*	1552	*	1118	*	8088	*	532	*	1609
Naled	1282	*	1552	*	1118	*	8088	*	532	*	1609
Naphthalene	12	*	15	*	11	*	16	*	11	*	15
Nitrobenzene	1282	*	1552	*	1118	*	8088	*	532	*	1609
Pentachlorophenol	1282	*	1552	*	1118	*	8088	*	532	*	1609
Phenanthrene	5495	*	6652	*	4792	*	39216	*	2581	*	6897
Phenol	1282	*	1552	*	1118	*	8088	*	532	*	1609
Phorate	1282	*	1552	*	1118	*	8088	*	532	*	**27586**
Pyrene	12	*	15	*	11	*	16	*	11	*	15
Ronnel	1282	*	1552	*	1118	*	8088	*	532	*	1609
Tetrachlorovinphos	12	*	15	*	11	*	16	*	11	*	15
Tokuthion	12	*	15	*	11	*	16	*	11	*	15
Toxaphene	12	*	15	*	11	*	16	*	11	*	15
Trichloronate	1099	*	1330	*	958	*	1471	*	968	*	1379
	12	*	15	*	11	*	16	*	11	*	15

dry weight		Laguna Trenton		Laguna Trenton	
gamma-BHC	*	531	*	1264	*
gamma-BHC (Lindane)	*	2572	*	5415	*
Heptachlor	*	19	*	11	*
Heptachlor	*	48	*	36	*
Heptachlor epoxide	*	2572	*	5415	*
Heptachlor epoxide	*	48	*	36	*
Hexachlorobenzene	*	2572	*	5415	*
Hexachlorobutadiene	*	531	*	1264	*
Hexachlorocyclopentadiene	*	531	*	1264	*
Hexachloroethane	*	531	*	1264	*
Indeno(1,2,3-cd)pyrene	*	531	*	1264	*
Isophorone	*	531	*	1264	*
MCPA	*	531	*	1264	*
MCPP	*	8.0	*	9.0	*
Merphos	*	8.0	*	9.0	*
Methoxychlor	*	11	*	12	*
Methyl Parathion	*	80	*	36	*
Mevinphos	*	11	*	12	*
N-Nitroso-Di-N-propylamine	*	11	*	12	*
N-Nitrosodiphenylamine	*	531	*	1264	*
Naled	*	531	*	1264	*
Naphthalene	*	11	*	12	*
Nitrobenzene	*	531	*	1264	*
Pentachlorophenol	*	531	*	1264	*
Phenanthrene	*	2572	*	5415	*
Phenol	*	531	*	1264	*
Phorate		531	*	1264	*
Pyrene	*	11	*	12	*
Ronnel	*	531	*	1264	*
Tetrachlorovinphos	*	11	*	12	*
Tokuthion	*	11	*	12	*
Toxaphene	*	11	*	12	*
Trichloronate	*	965	*	542	*
	*	11	*	12	*

Appendix 3. Laguna de Santa Rosa Sediment Data - Nutrients

Nutrient Data collected 13-Jul-94
* after a result indicates the value was less than the reporting limit. The value to the left is the reporting limit

Station	Nitrate	TKN	Ortho-phosphate	Total Phosphate	TOC	Moisture
units	mg-N/kg	mg/kg	mg-P/kg	mg-P/kg	mg/kg	%
Brown Farm Pond , subsurface	1.7	400	420	1500	4600	76.7
Brown Farm Pond, surface	0.3 *	280	360	1200	5300	80.2
Kelly Farm Cell 3, subsurface	0.3 *	610	16	200	2200	51.9
Kelly Farm Cell 3, surface	0.3 *	670	49	220	10200	58.5
Laguna at Stony Pt - subsurface	0.3 *	580	7.8	260	1700	40.4
Laguna at Stony Pt - surface	0.3 *	450	37	240	3600	60.8
Laguna at Trenton Healds., subsurface	0.3 *	800	45	260	5200	46.6
Laguna at Trenton Healds., surface	0.3 *	650	54	240	6800	45.3
Meadowlane Pond, subsurface	6.1	600	20	310	3300	67.8
Meadowlane Pond- surface	0.3 *	610	53	280	3000	79.4
SR Creek-downstrm of discharge, subsurface	0.3 *	310	5.5	170	1700	41.4
SR Creek-downstrm of discharge, surface	0.3 *	890	4.5	43	2700	53.3
SRC at Willowside, subsurface	0.3 *	910	6.8	260	2500	40.6
SRC at Willowside, surface	0.3 *	780	10	230	3200	54.8
Kaiser -Surface	0.3 *	320	4.8	210	2100	32.1
Kaiser -Subsurface	0.3 *	240	4.2	260	2900	35.4
Hilton Beach-Surface	0.3 *	320	7.4	350	2600	33.6
Hilton Beach-Subsurface	0.3 *	250	5.8	300	2200	32.4

Appendix 4. Laguna de Santa Rosa Sediment Data - Bacteria

Bacteria in sediment 15-Jul-94

	Total coliform mpn/g	Fecal coliform mpn/g
Stony Point	>=1600	>=1600
Trenton Healdsburg	540	240

Appendix 5. Laguna de Santa Rosa Sediment Data - Particle Size

particle size distribution	Sediment Samples collected 13-14 July 1994			
	% gravel	% sand	% silt	% clay
Station				
Brown Pond subsurface	0	6.12	36.37	57.51
Brown Pond surface	0	1.78	49.88	48.34
Kelly Pond subsurface	0	25.25	28.13	46.62
Kelly Pond surface	0	17.58	31.54	50.88
Meadowlane subsurface	0	34.44	26.28	39.28
Meadowlane surface	0	8.4	39.47	52.13
Willowside subsurface	0.82	73.51	17.93	7.75
Willowside surface	0.27	45.87	37.74	16.12
SRC downstream subsurface	2.8	82.63	9.21	5.36
SRC downstream surface	0.83	72.15	19.08	7.94
Stony Point subsurface	0.4	39.88	34.36	25.36
Stony Point surface	0.93	32.9	34.65	31.52
TH subsurface	0	48.33	23.6	28.07
TH surface	0	40.27	25.35	34.37

Appendix 6. Russian River Sediment Data - Metals

dry weight mg/kg	Kaiser	Kaiser	Hilton	Hilton
TTLC analyses	surface	subsurface	surface	subsurface
Parameter				
Percent Moisture	32.1	35.4	33.6	32.4
Total Organic Carbo	2100	2900	2600	2200
fraction oc dry wt	0.003093	0.004489	0.003916	0.003254
Antimony (GFAA)	0.736377 *	0.773994 *	0.753012 *	0.739645 *
Arsenic (GFAA)	2.945508	2.786378	2.409639	2.662722
Cadmium (GFAA)	0.073638 *	0.077399 *	0.075301 *	0.073964 *
Chromium (GFAA)	0.736377	77.39938	75.3012	75.44379
Cobalt (GFAA)	0.736377	15.47988	15.06024	13.7574
Copper (GFAA)	0.736377	18.57585	18.07229	17.75148
Cyanide (Total)	0.294551 *	0.309598 *	0.301205 *	0.295858 *
Lead (GFAA)	0.294551	4.798762	4.96988	4.881657
Mercury (CVAA)	0.147275	0.154799 *	0.150602	0.147929 *
Nickel (GFAA)	0.736377	114.5511	126.506	109.4675
Selenium (GFAA)	0.736377 *	0.773994 *	0.753012 *	0.739645 *
Silver (GFAA)	0.147275 *	0.154799 *	0.150602 *	0.147929 *
Thallium (GFAA)	0.736377 *	0.773994 *	0.753012 *	0.739645 *
Zinc (ICP)	53.01915	47.98762	51.20482	50.29586

STLC analyses	Kaiser	Hilton
Parameter	surface	surface
Antimony (GFAA,	0.736377 *	0.753012 *
Arsenic (GFAA,W	0.736377	0.60241
Cadmium (GFAA,	0.036819 *	0.037651 *
Chromium (GFAA,	6.774669	4.96988
Cobalt (GFAA,W	3.681885	5.42169
Copper (GFAA,	2.356406	0.90361
Lead (GFAA,W	1.178203	0.90361
Mercury (CVAA,	0.073638 *	0.075301 *
Nickel (GFAA,W	23.56406	19.57831
Selenium (GFAA,	0.294551 *	0.301205 *
Silver (GFAA,W	0.073638 *	0.075301 *
Thallium (GFAA,	0.736377 *	0.753012 *
Zinc (ICP, WET	4.418262	6.02410

Appendix 7. Russian River Sediment Data - Organics

* indicates the concentration was below reporting limit. Value shown to the left is reporting limit
Constituents with detectable values are **bold**

Parameter	Kaiser Surface	Kaiser Subsurface	Hilton Surface	Hilton Subsurface	Units
Percent Moisture	40.8	37.4	34.6	32.6	%
Total Organic Carbon	2700	1200	2000	1600	mg/kg
fraction organic carbon dry wt	0.004561	0.001917	0.003058	0.002374	dry weight
1,2,4-Trichlorobenzene	557 *	527 *	505 *	490 *	ug/kg
1,2-Dichlorobenzene	557 *	527 *	505 *	490 *	ug/kg
1,3-Dichlorobenzene	557 *	527 *	505 *	490 *	ug/kg
1,4-Dichlorobenzene	557 *	527 *	505 *	490 *	ug/kg
2,4,5-T	0.017 *	0.016 *	0.015 *	0.015 *	mg/kg
2,4,5-TP	0.017 *	0.016 *	0.015 *	0.015 *	mg/kg
2,4,5-Trichlorophenol	2703 *	2556 *	2446 *	2374 *	ug/kg
2,4,6-Trichlorophenol	557 *	527 *	505 *	490 *	ug/kg
2,4-D	0.084 *	0.080 *	0.076 *	0.074 *	mg/kg
2,4-DB	0.084 *	0.080 *	0.076 *	0.074 *	mg/kg
2,4-Dichlorophenol	557 *	527 *	505 *	490 *	ug/kg
2,4-Dimethylphenol	557 *	527 *	505 *	490 *	ug/kg
2,4-Dinitrophenol	2703 *	2556 *	2446 *	2374 *	ug/kg
2,4-Dinitrotoluene	557 *	527 *	505 *	490 *	ug/kg
2,6-Dinitrotoluene	557 *	527 *	505 *	490 *	ug/kg
2-Chloronaphthalene	557 *	527 *	505 *	490 *	ug/kg
2-Chlorophenol	**2027**	527 *	505 *	490 *	ug/kg
2-Methylnaphthalene	557 *	527 *	505 *	490 *	ug/kg
2-Methylphenol	557 *	527 *	505 *	490 *	ug/kg
2-Nitroaniline	2703 *	2556 *	2446 *	2374 *	ug/kg
2-Nitrophenol	**3716**	527 *	505 *	490 *	ug/kg
3,3'-Dichlorobenzidine	1115 *	1054 *	1009 *	979 *	ug/kg
3-Nitroaniline	2703 *	2556 *	2446 *	2374 *	ug/kg
4,4'-DDD	51 *	48 *	46 *	45 *	ug/kg
4,4'-DDD	2703 *	2556 *	2446 *	2374 *	ug/kg
4,4'-DDE	51 *	48 *	46 *	45 *	ug/kg
4,4'-DDE	2703 *	2556 *	2446 *	2374 *	ug/kg
4,4'-DDT	51 *	48 *	46 *	45 *	ug/kg
4,4'-DDT	2703 *	2556 *	2446 *	2374 *	ug/kg
4,6-Dinitro-2-methylphenol	2703 *	2556 *	2446 *	2374 *	ug/kg
4-Bromophenyl phenyl ether	557 *	527 *	505 *	490 *	ug/kg
4-Chloro-3-methylphenol	**2027**	527 *	505 *	490 *	ug/kg
4-Chloroanaline	557 *	527 *	505 *	490 *	ug/kg
4-Chlorophenyl phenyl ether	557 *	527 *	505 *	490 *	ug/kg
4-Methylphenol	557 *	527 *	505 *	490 *	ug/kg
4-Nitroaniline	2703 *	2556 *	2446 *	2374 *	ug/kg
4-Nitrophenol	2703 *	2556 *	2446 *	2374 *	ug/kg
Acenaphthene	557 *	527 *	505 *	490 *	ug/kg
Acenaphthylene	557 *	527 *	505 *	490 *	ug/kg
Aldrin	20 *	19 *	18 *	18 *	ug/kg
Aldrin	2703 *	2556 *	2446 *	2374 *	ug/kg
alpha-BHC	5.1 *	4.8 *	4.6 *	4.5 *	ug/kg
Anthracene	557 *	527 *	505 *	490 *	ug/kg
Aroclor 1016	1689 *	1597 *	1529 *	1484 *	ug/kg
Aroclor 1221	8446 *	7987 *	7645 *	7418 *	ug/kg
Aroclor 1232	3378 *	3195 *	3058 *	2967 *	ug/kg
Aroclor 1242	1689 *	1597 *	1529 *	1484 *	ug/kg

Appendix 7. Russian River Sediment Data - Organics

* indicates the concentration was below reporting limit. Value shown to the left is reporting limit
Constituents with detectable values are bold

Parameter	Kaiser Surface	Kaiser Subsurface	Hilton Surface	Hilton Subsurface	Units
Aroclor 1248	1689 *	1597 *	1529 *	1484 *	ug/kg
Aroclor 1254	845 *	799 *	765 *	742 *	ug/kg
Aroclor 1260	845 *	799 *	765 *	742 *	ug/kg
Azinphos methyl	11 *	11 *	10 *	10 *	ug/kg
Benyzl alcohol	557 *	527 *	505 *	490 *	ug/kg
Benzidine	2703 *	2556 *	2446 *	2374 *	ug/kg
Benzo(a)anthracene	557 *	527 *	505 *	490 *	ug/kg
Benzo(a)pyrene	557 *	527 *	505 *	490 *	ug/kg
Benzo(b)fluoranthene	557 *	527 *	505 *	490 *	ug/kg
Benzo(g,h,i)perylene	557 *	527 *	505 *	490 *	ug/kg
Benzo(k)fluoranthene	557 *	527 *	505 *	490 *	ug/kg
Benzoic acid	2703 *	2556 *	2446 *	2374 *	ug/kg
beta-BHC	5.1 *	4.8 *	4.6 *	4.5 *	ug/kg
bis(2-Chloroethoxy)methane	557 *	527 *	505 *	490 *	ug/kg
bis(2-Chloroethyl)ether	557 *	527 *	505 *	490 *	ug/kg
bis(2-Chloroisopropyl)ether	557 *	527 *	505 *	490 *	ug/kg
bis(2-Ethylhexyl)phthalate	557 *	527 *	505 *	490 *	ug/kg
Butyl benzyl phthalate	557 *	527 *	505 *	490 *	ug/kg
Chlordane	422 *	399 *	382 *	371 *	ug/kg
Chlorpyrifos	11 *	11 *	10 *	10 *	ug/kg
Chrysene	557 *	527 *	505 *	490 *	ug/kg
Coumaphos	11 *	11 *	10 *	10 *	ug/kg
Dalapon	0.169 *	0.160 *	0.153 *	0.148 *	mg/kg
delta-BHC	5.1 *	4.8 *	4.6 *	4.5 *	ug/kg
delta-BHC	2703 *	2556 *	2446 *	2374 *	ug/kg
Di-n-butylphthalate	557 *	527 *	505 *	490 *	ug/kg
Di-n-octyl phthalate	557 *	527 *	505 *	490 *	ug/kg
Diazinon	11 *	11 *	10 *	10 *	ug/kg
Dibenzo(a,h)anthracene	557 *	527 *	505 *	490 *	ug/kg
Dibenzofuran	557 *	527 *	505 *	490 *	ug/kg
Dicamba	0.017 *	0.016 *	0.015 *	0.015 *	mg/kg
Dichloroprop	0.084 *	0.080 *	0.076 *	0.074 *	mg/kg
Dichlorvos	11 *	11 *	10 *	10 *	ug/kg
Dieldrin	51 *	48 *	46 *	45 *	ug/kg
Dieldrin	2703 *	2556 *	2446 *	2374 *	ug/kg
Diethylphthalate	557 *	527 *	505 *	490 *	ug/kg
Dimethyl phthalate	557 *	527 *	505 *	490 *	ug/kg
Dinoseb	0.017 *	0.016 *	0.015 *	0.015 *	mg/kg
Disulfoton (Di Syston)	11 *	11 *	10 *	10 *	ug/kg
Endosulfan I	51 *	48 *	46 *	45 *	ug/kg
Endosulfan II	51 *	48 *	46 *	45 *	ug/kg
Endosulfan sulfate	51 *	48 *	46 *	45 *	ug/kg
Endrin	51 *	48 *	46 *	45 *	ug/kg
Endrin aldehyde	51 *	48 *	46 *	45 *	ug/kg
Endrin aldehyde	2703 *	2556 *	2446 *	2374 *	ug/kg
Ethoprop	11 *	11 *	10 *	10 *	ug/kg
Fensulfothion	11 *	11 *	10 *	10 *	ug/kg
Fluoranthene	557 *	527 *	505 *	490 *	ug/kg
Fluorene	557 *	527 *	505 *	490 *	ug/kg
gamma-BHC	2703 *	2556 *	2446 *	2374 *	ug/kg
gamma-BHC (Lindane)	20 *	19 *	18 *	18 *	ug/kg

Appendix 7. Russian River Sediment Data - Organics

* indicates the concentration was below reporting limit. Value shown to the left is reporting limit
Constituents with detectable values are bold

Parameter	Kaiser Surface	Kaiser Subsurface	Hilton Surface	Hilton Subsurface	Units
Heptachlor	51 *	48 *	46 *	45 *	ug/kg
Heptachlor	2703 *	2556 *	2446 *	2374 *	ug/kg
Heptachlor epoxide	51 *	48 *	46 *	45 *	ug/kg
Heptachlor epoxide	2703 *	2556 *	2446 *	2374 *	ug/kg
Hexachlorobenzene	557 *	527 *	505 *	490 *	ug/kg
Hexachlorobutadiene	557 *	527 *	505 *	490 *	ug/kg
Hexachlorocyclopentadiene	557 *	527 *	505 *	490 *	ug/kg
Hexachloroethane	557 *	527 *	505 *	490 *	ug/kg
Indeno(1,2,3-cd)pyrene	557 *	527 *	505 *	490 *	ug/kg
Isophorone	557 *	527 *	505 *	490 *	ug/kg
MCPA	8.4 *	8.0 *	7.6 *	7.4 *	mg/kg
MCPP	8.4 *	8.0 *	7.6 *	7.4 *	mg/kg
Merphos	11 *	11 *	10 *	10 *	ug/kg
Methoxychlor	84 *	80 *	76 *	74 *	ug/kg
Methyl Parathion	11 *	11 *	10 *	10 *	ug/kg
Mevinphos	11 *	11 *	10 *	10 *	ug/kg
N-Nitroso-Di-N-propylamine	557 *	527 *	505 *	490 *	ug/kg
N-Nitrosodiphenylamine	557 *	527 *	505 *	490 *	ug/kg
Naled	11 *	11 *	10 *	10 *	ug/kg
Naphthalene	557 *	527 *	505 *	490 *	ug/kg
Nitrobenzene	557 *	527 *	505 *	490 *	ug/kg
Pentachlorophenol	**3378**	2556 *	2446 *	2374 *	ug/kg
Phenanthrene	557 *	527 *	505 *	490 *	ug/kg
Phenol	**2027**	527 *	505 *	490 *	ug/kg
Phorate	11 *	11 *	10 *	10 *	ug/kg
Pyrene	557 *	527 *	505 *	490 *	ug/kg
Ronnel	11 *	11 *	10 *	10 *	ug/kg
Tetrachlorovinphos	11 *	11 *	10 *	10 *	ug/kg
Tokuthion	11 *	11 *	10 *	10 *	ug/kg
Toxaphene	1014 *	958 *	917 *	890 *	ug/kg
Trichloronate	11 *	11 *	10 *	10 *	ug/kg

Appendix 8. Russian River Sediment Data - Nutrients

	Date	Percent Moisture	Total Organic Carbon	Nitrate	TKN	Total Phosphorus	Ortho-phosphate
MDL		0.1	25	0.3	1	1	0.2
units		%	mg/kg	mg-N/kg	mg/kg	mg-P/kg	mg-P/kg
Kaiser -Surface	7/13/94	32.1	2100	ND	320	210	4.8
Kaiser -Subsurface	7/13/94	35.4	2900	ND	240	260	4.2
Hilton Beach-Surface	7/13/94	33.6	2600	ND	320	350	7.4
Hilton Beach-Subsurface	7/13/94	32.4	2200	ND	250	300	5.8

Appendix 9. Russian River Sediment Data - Bacteria

Samples collected 14/15 July 1994

	Total coliform mpn/g	Fecal coliform mpn/g
Johnson's Beach	>=1600	130
Healdsburg Beach	540	23
Stony Point	>=1600	>=1600

Appendix 10. Russian River Sediment Data - Particle Size

Sediment samples collected 13 July 1994

Station	% gravel	% sand	% silt	% clay
Kaiser surface	0.53	73.23	22.22	4.03
Kaiser subsurface	4.22	77	15.12	3.66
Hilton surface	1.59	77.61	16.36	4.45
Hilton subsurface	2.36	79.87	13.82	3.95
Healdsburg surface	0	70.29	22.68	7.03
Johnson's surface	3.04	94.02	2.33	0.6