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# **Distribution of Pesticides Between Water and Sediments in the Salton Sea Basin, California, 2001-2002**

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#### Abstract

A study of pesticide distribution and transport within the Salton Sea Basin was conducted from Fall 2001 to Spring 2002. Sampling was conducted along transects from the three major ~~three major~~ rivers that flow into the Salton Sea Basin: the New and Alamo Rivers at the southern end and the Whitewater River at the northern end of the sea.

Stations were established on each river at 1 mile upstream of the river discharge (outlet station), in the river delta (nearshore station), and offshore in the sea (offshore station). Water, suspended and bed sediments were collected from each station in September, 2001, March/April, 2002 and October, 2002, coinciding with peak pesticide applications in the fall and spring. Fourteen current-use pesticides were detected in the water column.

Concentrations of dissolved pesticides typically decreased in concentration from the outlet into the sea in all three rivers. Most concentrations in the water column were between 10 – 100 ng/L; however, eptam and malathion were detected at much higher concentrations (1100 – 3800 ng/L) at the New and Alamo River outlet and nearshore stations. Current-use pesticides were also detected in suspended and bed sediments at all the sites. Chlorpyrifos, dacthal, eptam, and trifluralin were found with the greatest frequency on sediments in all three rivers. The number and concentrations of pesticides on suspended sediments decreased along the transects from the rivers, demonstrating the potential for pesticide transport via suspended sediments into the Salton Sea Basin.

## INTRODUCTION

Several studies conducted by the USGS and others since the late 1960's have identified elevated concentrations of pesticides associated with agriculture in waters adjacent to the Salton Sea area (Irwin, 1971; Eccles, 1979; Setmire, 1984; Spencer et al., 1985; Setmire et al., 1993; Crepeau et al., 2002). Elevated levels (parts-per-billion) of organochlorine and organophosphorous pesticides were reported in these waters. In addition, the presence of organochlorine pesticides have been reported in bottom material collected from irrigation drainage canals (Setmire et al., 1993). More recently, Crepeau et al. (2002) reported elevated concentrations of a number of current-use pesticides in water collected in 1996 and 1997 from the Alamo River and within the Salton Sea. Elevated pesticide concentrations in the Alamo River corresponded with measurements of acute toxicity in standardized 96-hour aquatic toxicity tests (deVlaming et al., 2000).

Recent requirements for the Regional Water Quality Control Board, Colorado River Region to develop total maximum daily loads (TMDLs) for contaminants pointed to a need for a more complete understanding of the occurrence and transport of pesticides within the Salton Basin. In addition, proposed remedial actions, such as the Salton Sea Restoration Project (a federal-state-local endeavor) and proposed water transfers of water to the San Diego County Water Authority may influence pesticide concentrations in rivers and drains that discharge into the Salton Sea and potentially within the sea itself. Water transfers may also lead to a shrinking of the sea, exposing more shoreline consisting of potentially contaminated sediment. The USGS was requested to conduct a study examining the distribution of pesticides between water, suspended sediments and bed sediments in the rivers that drain into the Salton Sea, as well as within the Sea itself.

### Hydrogeologic Setting

The study area in southeastern California includes the Salton Sea and the Coachella and Imperial Valleys adjacent to the north and south sides of the sea (Fig. 1). This is an area of intensive agriculture, with a variety of crops being grown including alfalfa, cotton, grapes, dates and a variety of vegetables. The Salton Sea is a large (1000 km<sup>2</sup>) shallow (mean depth = 8 m) saline lake whose shoreline is presently at an elevation of 69 m below sea level. The sea was formed as a fresh water lake in 1905 - 1907 as the result of uncontrolled flooding from the Colorado River. The water level has been maintained largely by agricultural irrigation drainage, which is presently about 1.7 km<sup>3</sup> per year (Schroeder et al., 2002). The largest rivers that flow into the sea, in order of their annual discharge, are the Alamo, New and Whitewater Rivers. The Alamo and New Rivers flow into the southern end of the basin and the Whitewater River flows into the northern end of the basin (Fig. 1). The Salton Sea has no outlet and minimal groundwater interaction. Since it is located in an arid region (precipitation is about 7 cm yr<sup>-1</sup>) with high evapotranspiration (approximately 1.8 m yr<sup>-1</sup>) and freshwater flows consist of a high percentage of agricultural return water (i.e., high in dissolved salts), salinity has been steadily increasing over time. The present salinity in the sea itself, measured as conductivity is approximately 55,000 mS cm<sup>-1</sup>; this is roughly equivalent to 45 parts-per-thousand (Setmire and Schroeder, 1998; Schroeder et al., 2002).

The Alamo and New Rivers receive small amounts of treated sewage from towns in the Imperial Valley. The New River also receives a large amount of wastewater and potentially untreated sewage from the relatively large municipality of Mexicali (greater than 1 million residents) before it crosses over into the United States. In addition bacteria and pesticides in the water, other important issues include elevated concentrations of metals and nutrients (Setmire et al., 1993; Schroeder et al., 2002).

Depths of the Alamo and New Rivers at their outlets to the Salton Sea are approximately one meter and suspended sediment concentrations at these points are a few hundred milligrams per liter. Deposition of high loads of suspended sediment delivered by the rivers has resulted in the formation of broad shallow deltas, especially at the mouths of the New and Alamo rivers. These shallow areas harbor large numbers of fish and birds and are adjacent to federal and state wildlife refuges

## Previous Studies of Pesticides

The earliest study of pesticides in the Salton Basin included analysis of DDT in the Alamo and New Rivers for 12 months in 1969-1970 (Irwin, 1979). High concentrations were found in the river water because DDT was still being used in the U.S. and Mexico. DDT has not been detected in the water since 1986 (Setmire et al., 1990), 14 years after its use was banned in the U.S. and 3 years after its use was banned in Mexico. However, the metabolite DDE was still present in sediments from both rivers, and concentration gradients (decreasing concentration downstream) were similar to that of the aqueous DDT concentrations from 20 years prior (Schroeder, 1996). This was taken as strong evidence that DDT and/or its metabolites persist in surrounding agricultural soils and continue to be transported to the agricultural drains and rivers through agricultural tailwater. Concentrations of DDE have been reported in sediments from rivers and drains (Schroeder et al., 1988) as well as in the Salton Sea (Schroeder and Orem, 2000). Residues of DDE have also been reported recently in biota from this area (Schroeder et al., 1993; Setmire et al., 1993).

Numerous studies by the USGS during the last 30 years have documented the presence of current-use pesticides. Bimonthly monitoring for a period of one year in 1977-1978 by the USGS showed that the temporal pattern of concentrations for many current-use pesticides in drains and rivers in the Imperial Valley matches their seasonal pattern of application, with maxima occurring in the late winter/early spring and again in the early fall (Eccles, 1979). Samples collected by the USGS in March/April 1992 and again in 1995-1996 were consistent with this pattern (R. Schroeder, written USGS communication). Monthly monitoring on the Alamo River in 1994-1995 by the University of California at Davis confirmed the same temporal pattern and identified 5 commonly-used pesticides (carbaryl, carbofuran, chlorpyrifos, diazinon, and malathion) as the cause of high mortality in standardized aquatic toxicity tests with *Ceriodaphnia dubia* (de Vlaming et al., 2000). Another study performed by the USGS, in collaboration with the UC Davis Toxicology Laboratory from 1996-1998 identified elevated levels (greater than 100 ng/L) of 9 different pesticides in water from the Alamo River 1 mile upstream from the discharge point, as well as nearshore stations still influenced by the riverine discharge (Crepeau et al., 2002).

## PURPOSE AND SCOPE

The primary objective of this study was to determine the occurrence and transport of historical- and current-use pesticides in the Salton Basin. A major focus of the study was to examine the distribution of pesticides between water, suspended sediment and bed sediment in the three rivers that drain into the Salton Sea and the sea itself. Three stations were established on each river in a transect from the river outlet to the sea itself: Water, suspended sediments and bed sediments were collected at each site.

This report presents the results of three sampling events conducted in October 2001, March and April 2002, and September 2002. Concentrations of current-use and organochloride pesticides in water, suspended sediment and bed sediment are reported. The suspended sediment concentration and percent fines was measured on all water samples. In addition, the organic carbon concentration was determined in all suspended and bed sediments. Finally, trace metal analyses were performed on suspended sediments collected during the fall 2001 sampling event.

## SAMPLE COLLECTION METHODS

Large volume water samples (for the collection of suspended sediments) and bed sediments were sampled at a total of nine sites within the Salton Sea and adjacent rivers (Figure 1). Transects were established from the outlet of each of the three major rivers into the sea itself to examine the transport of pesticides. Stations were established approximately 1 mile upstream from the river mouth (outlet site) near-shore close to the river delta (nearshore site), and offshore at the fifteen-foot water depth (offshore site). For the fall, 2002 sampling event, samples were taken above and below the halocline at the New River nearshore site. Coordinates for each site are listed in Table 1. Water temperature and conductivity were measured using a hand held digital thermometer (VWR Scientific, Westchester, PA) and an Orion conductivity meter (Orion Instruments). Fifty mL water samples were collected and taken back to the laboratory for more accurate measurements of pH and conductivity.

## Whole Water

All samples were collected using a large peristaltic pump powered by a portable generator and equipped with a single stainless steel and Teflon inlet hose. Sample water was pumped directly into 20 L stainless steel kegs for transport. Total sample volumes varied with each site but were generally greater than 300 L. Consequently, sampling for the nearshore and offshore sites within the Salton Sea required multiple sampling trips but sampling was always completed within a 24-hour period.

The river samples were collected from bridges and a culvert. At these sites water was collected from a single point at the center of the river channel with the pump inlet hose suspended at a depth of 0.5 m. The six nearshore and offshore sites were accessed by boat and located using a handheld global positioning system (GPS) device (Garmin GPS 12). Water from the three near-shore delta sites was collected at a depth representing the mixing zone between fresh river water and more saline sea water, as determined at the time of collection by a handheld specific conductance meter. At the deeper-water offshore sites, water was collected from a depth of approximately 0.5 m below the surface.

Separate samples were also collected for measurements of suspended sediment concentration (ssc) and percent fines. Water was pumped into pre-cleaned 500 mL clear glass bottles during the large volume sample collection.

## Isolation of Suspended Sediments

Suspended sediments were isolated by pumping the water through a flow-through centrifuge (Westphalia model KA 2, Westphalia Corporation, Odde, FRG). Large volumes of water (300 - 900 L) of water were pumped at a flow rate of 2 L/minute through the centrifuge, which was operating at 9,500g. The 2L/minute flowrate has been shown to be the optimal influent rate for efficient capture of a wide variety of grain sizes and suspended solids concentrations (Horowitz et al., 1989). Solid phase and sediment slurry was carefully removed from each of the concentric centrifuge bowls. Water in the bowls was used to carefully rinse the solid particles off all of the bowl surfaces. The resulting sediment slurry was stored refrigerated in pre-cleaned glass bottles and transported back to Sacramento for further dewatering. In the laboratory the suspended material was further dewatered by centrifuging in 200 mL-size stainless steel centrifuge tubes for 20 minutes at 10,000 rpm in a high speed refrigerated centrifuge (Sorvall RC-5B high-speed refrigerated centrifuge, Du Pont Company, Wilmington, Delaware). The water was decanted and the remaining solid material scraped out of the centrifuge tubes and stored frozen in pre-cleaned glass screw-cap bottles until analysis.

## Collection of dissolved water samples

Samples for analysis of dissolved pesticides were collected in 1L amber glass bottles from the outlet of the flow-through centrifuge. Due to the large amount of water filtered for suspended sediments (300 - 1000L), samples for dissolved analysis were collected during the beginning, end and middle of the centrifuging process. There appeared to be no difference between these replicate samples in terms of the pesticides detected, or their relative concentrations (see discussion of replicate variability in the results section).

## Bed Sediment

Bed sediment samples were collected concurrently with water sampling at each of the nine sites. Samples taken at the onshore river sites were collected using either a 9-inch Ekman grab sampler or a 2-inch diameter, Teflon barreled hand corer. Multiple grabs were required for a total collection volume of approximately 0.5 liter at each site. Samples were taken only from the top 2 cm of undisturbed sediment collected in each grab. At the river sites, multiple grab samples (5-7) were composited to make a sample. At the offshore sites where the bed sediments were more uniform, composites of 2-3 grabs were taken using the Eckman dredge. Sediment was scooped into cleaned, 1/2 liter, glass mason jars using a stainless steel spoon. All samples taken from the offshore sites were collected using the Ekman grab using the manner described above.



## LABORATORY METHODS

### Water Analysis

Full details of the extraction method are provided in Crepeau et al. (2000). Prior to the extraction, the volume of the water was measured and 100  $\mu\text{L}$  of a 2 ng/ $\mu\text{L}$  surrogate (terbuthylazine) was spiked into the sample. The water was then pumped through pre-cleaned and conditioned C8 solid phase extraction (SPE) cartridges (Varian Bond-Elut, 500 mg, 300 cc size barrel, Varian Analytical Corporation, Walnut Creek California) using 12 V ceramic piston metering pumps. In order to condition the SPE cartridge, a 3 mL aliquot of methanol followed by a 3 mL aliquot of organic-free water was passed through the cartridge. The cartridge was then kept wet with water until the extraction step. After the extraction, excess water was removed from the cartridge by passing air through it using a luer-lock syringe. Cartridges were labeled, kept refrigerated and sent back to Sacramento for storage within 3 days of collection. Upon receipt of samples in Sacramento, the cartridges were further dried with  $\text{CO}_2$  for at least one hour. Cartridges were stored frozen until analysis which did not exceed the established holding time of 2 months (Crepeau et al., 2000).

Samples were eluted from the SPE cartridges using 9 mL of ethyl acetate, reduced in volume to 500  $\mu\text{L}$  and appropriate concentrations of internal standards added. The internal standards used were  $d_{10}$ -acenaphthene,  $d_{10}$  phenanthrene and  $d_{10}$ -pyrene. Extracts were brought to a final volume of 200  $\mu\text{L}$  and analyzed via gas chromatography/mass spectrometry (GC/MS).

### Sediment Analysis

Extractions of sediment samples were performed using either sohxlet or microwave-assisted solvent extraction (MASE, CEM Corporation, North Carolina). Wet sediments were extracted to avoid any artifacts associated with the drying of sediment, and because water is needed in the sample for efficient extraction when using MASE (Jayaraman et al., 2001). Approximately five gram-equivalent dry weight of sediment was used per sample. Percent water in the sample was determined gravimetrically by weighing wet sediment, drying and reweighing. A wet weight equivalent to 5 grams dry was calculated for each sample after determining the percent water. In addition, the dry weight of the sample was measured directly after extraction by taring the extraction vessel prior to adding sample and then weighing the dried sample in the vessel after extraction.

Sohxlet extraction was used on samples collected from the deepwater areas because pressure buildup inside the teflon extraction vessels during the MASE extraction process occurred quite rapidly, sometimes leading to a containment failure and loss of sample. After the wet sediments were weighed into the extraction vessels (teflon MASE vessels or pre-cleaned cellulose sohxlet extraction thimbles), a surrogate solution containing 400 ng each of  $^{13}\text{C}$ -labeled  $\alpha\text{BHC}$ , simazine, chlorpyrifos and permethrin (cis/trans mixture) and chlorpyrifos (Cambridge Isotope Laboratories, Inc, Andover, MA) was spiked to each sample. The sediments were extracted with a mixture of methylene chloride and acetone (50:50 v/v). The sohxlet extraction used 150 mL of solvent for 16 hours while the MASE extraction was done twice for 20 minutes using 30 mL of solvent. Extracts were decanted into separatory funnels containing 100 mL (for MASE) or 250 mL (for sohxlet) of deionized, organic-free water. The mixture was shaken and the methylene chloride removed. The aqueous phase was extracted twice more with two volumes of methylene chloride (2 x 30 mL for MASE, 2 x 50 mL for sohxlet) and the extracts combined. Extracts were then dried over sodium sulfate and reduced to approximately one mL. These extracts, many of which were darkly colored, were cleaned by passage through an SPE column consisting of 500 mg of activated carbon (6 cc size barrel, Restek Corporation, Bellefonte, PA) followed by elution with 10 mL of methylene chloride.

The sample was then solvent-exchanged to ethyl acetate, reduced in volume to 0.5 mL and further purified using a gel permeation/high pressure liquid chromatography system (GPC/HPLC). The sample was injected onto a Perkin Elmer HPLC (Perkin Elmer corporation, Norwalk, CT) consisting of a PE 410 4-stage pump and a LC-95 UV fixed wavelength detector. The analytical column was a gel permeation column from Polymer Laboratories (Amherst, MA). Column dimensions were 300 x 7.5 mm and the packing was polydivylbenzene (10 mm, 50  $\text{\AA}$  pore size). The mobile phase was ethyl acetate and the pump speed was 1 mL/minute. The size of the collection window

was verified daily using pesticide standards, monitoring at a wavelength of 254 nm. GPC/HPLC provided additional matrix cleanup, especially with elimination of elemental sulfur, a major co-extractant that interferes with the instrumental analysis.

After GPC/HPLC cleanup, the sample extract (now at 9 mL volume) was reduced to approximately 500  $\mu$ L. Internal standards added and the sample volume brought back 500  $\mu$ L and analyzed by GC/MS. In the case of extremely colored extracts, the sample was brought to a volume of 1 mL prior to GC/MS analysis.

#### Instrumental Analysis

The instrument used for pesticide analysis was a Saturn 2000 GC/MS ion trap system (Varian, Inc., Walnut Creek, CA). Run conditions are listed in Table 2. The instrument was operated in full scan mode during most of the run, which has the equivalent sensitivity of a quadrupole instrument operated in selected ion monitoring mode (SIM) while retaining the maximum amount of spectral information. Later in the instrument run, however, selected ion storage (SIS), which is equivalent to SIM on a quadrupole instrument, was utilized in order to optimize sensitivity for select analytes.

Calibration of instrument response was made with an eight-point standard curve that spanned the range of sample concentrations. In addition, a mid-level standard was run every 6 injections to verify that the response was within 10% of the standard curve. If compounds in the check standard fell outside of this response window, the samples were re injected. Each sample was analyzed twice, and replicate injections that had a greater than 25% variability were reanalyzed.

A list of organochlorine and current-use pesticide analytes are presented in Tables 3 and 4. Compounds were quantified using internal standards (see Table 3). Recovery of the terbutylazine surrogate was used to assess the efficiency of each water extraction. The average percent recovery and standard deviation for terbutylazine was calculated for each year. Sample data were excluded if the recovery of terbutylazine was outside the control limit of the annual mean plus or minus 2 standard deviations (Crepeau et al., 2000). Recoveries of deuterated HCH, simazine, chlorpyrifos and permethrin, added to sediments, were monitored to check for matrix interference and procedural recoveries.

## RESULTS

### Pesticide Use Data

The Salton Sea watershed was derived from the twelve digit hydrologic unit boundaries for California, and comprises all areas which naturally drain into the Salton Sea. (Figure 1). Records of registered pesticide use for 2001 were extracted from the California Department of Pesticide Regulation's (CDPR) Pesticide Use database (California Dept of Pesticide Regulation, 2001) using the limits of the watershed boundary. The data was then compiled in a Geographic Information System (GIS) database, and is reported as total use for the entire year of 2001. (Table 5). The highest-use pesticides that were analyzed in this study include atrazine, chlorpyrifos, dacthal, diazinon, dimethoate, eptam, malathion, pendimethalin and trifluralin.

### Dissolved Pesticide Concentrations

Dissolved pesticide concentrations ranged from the limit of detection (1 ng/L) to 4  $\mu$ g/L with the highest concentrations detected at the outlet and delta sites (Tables 6 – 8). Fourteen current-use pesticides were detected. Eptam was detected at the highest concentrations (3.5 and 3.9  $\mu$ g/L) in fall 2001 in the New and Alamo Rivers. Malathion concentrations were elevated in the Alamo River outlet site, especially during spring, 2002, with a value of 1100 ng/L. At the Alamo River outlet and nearshore sites, diazinon concentrations were elevated in both fall 2001 and fall 2002 but were low or below detection limits in spring 2002. Diazinon has been implicated as a major cause of toxicity in standardized aquatic toxicity tests (deVlaming et al., 2000). Dissolved pesticide concentrations were higher during the fall 2001 sampling relative to fall 2002 in the Alamo River (with the exception of diazinon

which had similar concentrations). Pesticide concentrations in the New and Alamo Rivers were generally higher than in the Whitwater River during fall 2001 and spring 2002. In fall, 2002, pesticide concentrations were generally similar between all three rivers (Tables 6 - 8). A wider variety of pesticides were detected in the Alamo and New Rivers as compared to the Whitwater River. In all three rivers, similar or higher dissolved concentrations at the nearshore sites relative to the outlet site suggest transport of pesticides out of the rivers into the Salton Sea.

#### Suspended Sediments and Pesticides

Suspended sediment concentrations, percent fines and percent organic carbon are presented in Tables 9 and 10. Concentrations of suspended sediments were higher in the Alamo and New Rivers relative to the Whitwater River. Alamo River had slightly higher concentrations of suspended sediments than the New River in both fall samplings while suspended sediment concentrations were slightly higher in the New River during spring 2002. Concentrations in all three rivers decreased from outlet to offshore sites. These trends are in agreement to what has been historically described. There were no discernible offshore trends in percent fines ( $< 64 \mu\text{m}$  in particle size). Suspended material at all the offshore sites consisted of a high percentage of algal-derived detritus which is reflected in high percent organic carbon concentration (Table 10). The Whitwater River offshore site also had high organic carbon concentrations.

Tables 11 - 13 list the concentrations of pesticides detected on suspended sediments. Pesticide concentrations were primarily in the range of 1-50 ng/g with the highest concentrations between 366 - 564 ng/g. The most frequently detected pesticides were compounds used in the highest amounts (Table 5) and included chlorpyrifos, dacthal, eptam, and trifluralin. Historical pesticides were generally not detected on suspended sediments; with the exception of DDE, a metabolite of DDT that was frequently detected. There was one instance of relatively high (280 ng/g) concentration of DDD, found in a New River suspended sediment from the nearshore site, during fall, 2002. The Alamo River had the greatest number and highest concentrations of pesticides associated with the suspended sediments compared to the other two rivers. A general trend was that number of pesticides and their concentrations decreased from the outlet to nearshore to offshore. This suggests that transport of pesticides is occurring via suspended particles into the Salton Sea.

#### Bed Sediments and Pesticides

Organic carbon concentrations for bed sediments (Table 10) were much lower than the concentrations on the suspended sediments. The Whitwater River offshore site had the highest organic carbon concentrations.

A number of pesticides were detected in bed sediments, especially at the outlet sites (Tables 11 - 13). In general, the pesticides detected were the same pesticides detected on suspended sediments and were those compounds applied to fields in this area in the largest amounts (Table 5). The metabolite DDE was found in most of the bed sediments with concentrations up to 64 ng/g at the outlet sites. DDD was found at a concentration of 93.9 ng/g in sediment from the New River nearshore site during fall, 2001. Concentrations were similar between bed sediments and suspended sediments for many of the analytes although they were usually higher on the suspended sediments. There were a surprising number of current-use pesticides associated with bed sediments. This coupled with the (sometimes) similar concentrations is consistent with resuspension of bed sediments being an important component of suspended sediment within a localized area. The Alamo and New Rivers had very high suspended sediment concentration at the outlet sites.

#### Quality Control Samples

Method detection limits for pesticide analyses of water and sediments are presented in Tables 14 and 15. Detection limits for dissolved pesticides were in the low ng/L range. Analysis of pesticides on sediments involves a more complex background matrix which resulted in higher method detection limits (low ng/g range). Five types of quality control data were collected for water and sediment samples: field and laboratory equipment blanks, replicate samples, matrix spikes and surrogate recoveries. Average recoveries for pesticides spiked to water samples was  $85 \pm 20\%$  and were generally greater than 80%. Results of replicate samples analyzed during fall, 2001 showed excellent agreement, within 10% (coefficient of variation). Field or equipment blanks for dissolved pesticide

analysis were analyzed every 10 samples. Low concentrations (1-2 ng/L) of diazinon and dacthal were discovered in two blanks which were processed at the Sonny Bono Wildlife refuge, which is adjacent to agricultural fields. The presence of background concentrations of a few pesticides was demonstrated during the fall, 2002 sampling event by leaving a bottle of deionized water uncovered for several days during sample processing. Background concentrations of chlorpyrifos and dacthal (4 ng/L) and somewhat higher concentrations of eptam (30 ng/L) were detected in this sample. No pesticides were detected in laboratory blanks processed in Sacramento.

Matrix interference in the sediment samples hampered both surrogate recoveries and matrix spike recoveries. This effect was most pronounced in the offshore suspended sediment samples, which consisted primarily of algal detritus. Average recoveries for  $d_4$ - $\alpha$ -HCH,  $d_3$ -simazine and  $d_{10}$ -chlorpyrifos were 72%, 77% and 83% respectively for bed sediments, and 60%, 83% and 63% for suspended sediments. Recoveries of the  $d_4$ -permethrin surrogate were extremely variable, which makes the quantitation of permethrin, cypermethrin and cyfluthrin suspect in our sediment method. Therefore the qualifier 'D' was used when permethrin, cyfluthrin or cypermethrin were detected in sediment samples. This denotes that the compound was detected, but quantitation at the present is highly uncertain. Average recoveries from sediment matrix spikes were between 65% - 136% with an overall mean average recovery of  $102 \pm 23\%$  for compounds detected in sediments. Mean recoveries of dimethoate were highly variable, which was why the qualifier 'D' was used whenever dimethoate was detected in samples.

#### Metals and Other Inorganic Constituents in Suspended Sediments

Concentrations of trace metals and other inorganic constituents were determined in suspended sediments collected during the fall, 2001 sampling and results are presented in Tables 16 - 18. Metals associated with continental crustal materials, such as iron (Fe), aluminum (Al), Titanium (Ti), Barium (Ba), Chromium (Cr), Vanadium (V) were elevated in sediments from the river (outlet) sites relative to the offshore sites, consistent with riverine transport of these materials (Chester, 1990). Copper (Cu), Zinc (Zn) and Cadmium (Cd) are more soluble, and therefore have greater potential for release from sediments and redistribution in the environment, including bioaccumulation into organisms. The concentrations of these metals are more evenly distributed between river and offshore sites. Selenium (Se), which can also become remobilized from sediments, was elevated in offshore suspended material relative to the river sites, by factors of 10 or greater. High organic carbon concentrations in offshore suspended material agreed with analyses performed in Sacramento and are indicative of an algal detrital source for much of the offshore suspended solids. The bioaccumulation of selenium by algae is one possible scenario that could explain these elevated concentrations and is deserving of further investigation. Finally, lower concentrations of calcium, magnesium and potassium in material collected offshore is most likely due to precipitation of these constituents as salts, as discussed by Schroeder et al. (2002).

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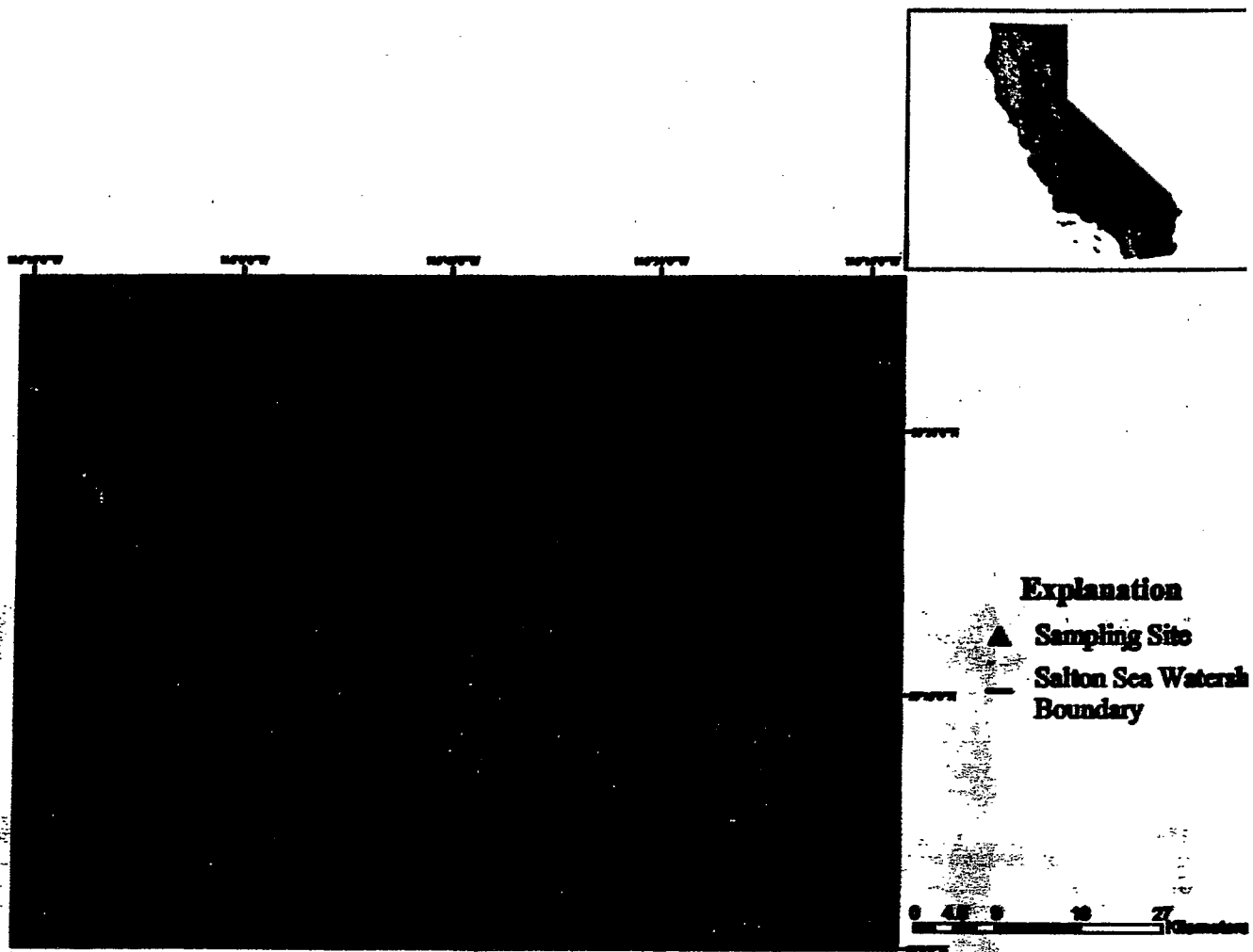


Figure 1 Location of sediment sampling sites within the Salton Sea basin.

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Table 1. List of sampling sites and their coordinates

Station Name	Latitude	Longitude	Description
Alamo River outlet	33° 11' 56"	115° 35' 46"	Bridge at Garst Road
Alamo River nearshore	33° 12' 42"	115° 37' 14"	Within Salton Sea approximately 250 meters from river mouth
Alamo River offshore	33° 14' 00"	115° 38' 00"	Within Salton Sea approximately 2.9 km from river mouth
New River outlet	33° 05' 59"	115° 38' 56"	Bridge at Lack Road
New River nearshore	33° 08' 03"	115° 41' 40"	Within Salton Sea approximately 100 meters from river mouth
New River offshore	33° 08' 35"	115° 43' 45"	Within Salton Sea approximately 3.5 km from river mouth
Whitewater River outlet	33° 31' 29"	115° 04' 44"	Culvert at Lincoln Road
Whitewater River nearshore	33° 30' 06"	115° 03' 15"	Within Salton Sea approximately 500 meters from river mouth
Whitewater River offshore	33° 29' 58"	115° 02' 35"	Within Salton Sea approximately 1.5 km from river mouth

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**Table 2. Run conditions for the Saturn 2000 GC/MS system**

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Injection Conditions:	splitless injection, pressure pulse of 50 psi for 1.5 min.
Injection Temp	275°C
Oven Program:	80°C, hold for 0.5 minutes, 80°C-120°C @ 10 dpm <sup>1</sup> 120°C - 200°C @ 3 dpm, hold for 5 min. 200° C - 219°C, hold for 5 min. 219°C - 300° @ 10 dpm, hold for 10 min.
GC/MS conditions:	range SIS, collecting 60 - 450 m/z
analytical column:	CPSIL 8-MS (Varian Corp), 30m x 0.25 mm, 0.5 µm phase thickness

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<sup>1</sup>dpm = degrees per minute

<sup>1</sup>PSI = pounds per square inch

**Table 3. List of organochlorine analytes**

<b>Compounds</b>	<b>Quantification Ions</b>	<b>Confirmation Ions</b>
$\alpha$ -BHC	181	183, 219
$\gamma$ -BHC	181	183, 219
$\beta$ -BHC	183	181, 219
$\delta$ -BHC	181	183, 219
HEPTACHLOR	272	274, 270
ALDRIN	263	293, 265
ENDODULFAN I	241	195, 243
4,4' DDE	318	246, 316
DIELDRIN	277	279, 263
ENDRIN	263	243, 245
ENDOSULFAN II	243	195, 207
4,4' DDD	235	237, 165
4,4' DDT	235	237, 165
METHOXYCHLOR	227	228, 212
<b>INTERNAL STANDARDS</b>		
D <sub>10</sub> -ACENAPHTHENE	162	164, 160
D <sub>10</sub> -PHENANTHRENE	188	187, 189
D <sub>10</sub> -PYRENE	212	211, 213
D <sub>12</sub> -CHRYSENE	240	241, 236
<b>SURROGATE STANDARDS</b>		
D <sub>5</sub> - $\alpha$ -HCH	189	187, 225
D3-SIMAZINE	204	189, 176
D <sub>10</sub> -CHLORPYRIFOS	324	260, 326
D <sub>5</sub> -PERMETHRIN	189	163, 127

**Table 4. List of current-use pesticide analytes and the ions monitored during GC/MS analysis<sup>1</sup>**

Compounds	Quantification Ions	Confirmatory Ions
ALACHLOR	160	188, 146
ATRAZINE	200	202, 215
AZINPHOS-METHYL	132	181, 160
BIFENTHRIN	181	166, 165
BUTYLATE	146	156, 90
CARBARYL	144	115, 116
CARBOFURAN	164	149, 131
CHLORPYRIFOS	314	314, 197
CYANAZINE	212	198, 172
CYCLOATE	154	155, 186
DACTHAL	301	299, 303
DIAZINON	179	137, 199
DIETHATYL-ETHYL	188	160, 262
EPTAM	128	132, 127
ESFENVALERATE	225	125, 167
ETHALFLURALIN	276	316, 292
FENAMIPHOS	303	260, 154
FONOFOS	109	137, 110
HEXAZINONE	171	128, 172
LAMBDA-CYHALOTHRIN	181	197, 141
MALATHION	173	125, 173
METHIDATHION	145	93, 125
METHYLPARATHION	263	247, 246
METOLACHLOR	162	238, 240
MOLINATE	126	98, 127
NAPROPAMIDE	100	125, 257
OXYFLUORFEN	300	300, 302
PEBULATE	128	132, 127
PENDIMETHALIN	252	191, 162
PERMETHRIN	183	127, 163
PHORATE	231	121, 97
PHOSMET	160	133, 206
PIPERONYL BUTOXIDE	176	177, 149
PROFENFOS	337	339, 269
PROMETRYN	184	241, 226
PROPARGITE	135	135, 201
SIMAZINE	201	186, 173
SULFOTEP	322	238, 210
THIOBENCARB	100	125, 257
TRIFLURALIN	264	306, 248

<sup>1</sup>Internal and surrogate standards are the same as those listed in Table 3.

**Table 5.** Total amounts of the pesticides applied within the Salton Sea Basin in 2001 that were included in the water and sediment analytical methods.

[Samples were analyzed for the following pesticides that were not applied in the watershed: 2-keto-molinate, 4-keto-molinate, azinphos-methyl, cyanazine, diethatyl-ethyl, fenamiphos, fonofos, hexazinone, molinate, pebulate, piperonyl butoxide, sulfotep, and thiobencarb.]

Pesticide	Pesticide amount in pounds
Alachlor	91
Atrazine	19,157
Bifenthrin	412
Butylate	96
Carbaryl	4,068
Carbofuran	8,910
Chlorpyrifos	101,217
Cycloate	5,324
Cyfluthrin	4,914
Cypermethrin	1,735
Dacthal	46,588
Diazinon	39,974
Dimethoate	52,829
Disulfoton	5,057
Endosulfan	13,884
Eptam	96,528
Esfenvalerate	3,362
Ethalfuralin	128
Lambda-cyhalothrin	2,611
Malathion	108,969
Methidathion	336
Methylparathion	16
Metolachlor	228
Napropamide	1,381
Oxyfluorfen	5,320
Pendimethalin	29,783
Permethrin	12,080
Phorate	5,548
Phosmet	138
Profenfos	1,272
Prometryn	967
Propargite	6,055
Simazine	26
Trifluralin	276,119

**Table 6. Pesticide concentrations in water samples during fall, 2001**

[Values are reported as nanograms per liter. Concentrations are the mean of duplicate injections. Water samples were analyzed for the following pesticides that were not detected during this sampling period: alachlor, azinphos-methyl, butylate, cyanazine, diethatyl-ethyl, ethalfuralin, fonofos, hexazinone, methidathion, methylparathion, metolachlor, molinate, napropamide, oxyfluorfen, pebulate, phosmet, piperonyl butoxide, sulfotep, and thiobencarb. nd, nondetection]

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Atrazine	nd	14.9	165	8.4	78.6	145	nd	151	144
Carbaryl	56.4	44.4	nd	nd	nd	nd	nd	nd	nd
Carbofuran	nd	nd	nd	34.8	nd	nd	nd	nd	nd
Chlorpyrifos	161	87.7	nd	44.3	15.0	nd	nd	nd	nd
Cycloate	9.3	34.1	nd	nd	nd	nd	9.6	nd	nd
Dacthal	94.3	328	9.4	26.1	30.6	5.6	38.1	9.8	9.0
Diazinon	789	936	9.1	213.4	34.8	nd	32.4	8.5	9.3
Eptam	418	3830	84.9	3490	1300	17.9	102	51.0	46.2
Malathion	340	36.5	nd	585	nd	nd	43.2	nd	nd
Pendimethalin	59.5	nd	nd	nd	nd	nd	nd	nd	nd
Simazine	nd	nd	21.0	nd	nd	nd	nd	nd	nd
Trifluralin	37.4	37.6	nd	35.0	27.3	nd	22.5	nd	nd

**Table 7. Pesticide concentrations in water samples during spring, 2002**

[Values are reported as nanograms per liter. Water samples were analyzed for the following pesticides that were not detected during this sampling period: alachlor, azinphos-methyl, butylate, carbaryl, cyanazine, cycloate, diethatyl-ethyl, ethafluralin, fonofos, hexazinone, methidathion, methylparathion, metolachlor, molinate, napropamide, pebulate, phosmet, piperonyl butoxide, simazine, sulfotep, and thiobencarb. nd, nondetection; ( ), concentration below detection limit]

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Atrazine	630	128	128	434	66.4	124	(2.1)	128	119
Carbofuran	530	18.9	nd	nd	nd	nd	nd	nd	56.2
Chlorpyrifos	73.1	nd	nd	20.7	9.5	nd	nd	nd	nd
Dacthal	47.0	8.9	nd	31.7	15.2	6.9	8.5	nd	6.1
Diazinon	(3.4)	nd	nd	22.7	13.8	nd	8.5	nd	nd
Eptam	50.6	53.8	50.2	nd	nd	nd	34.0	30.1	35.7
Malathion	1100	nd	nd	253	90.0	nd	nd	nd	nd
Oxyfluorfen	30.3	nd	nd	nd	nd	nd	nd	nd	nd
Pendimethalin	156	nd	nd	65.3	27.3	nd	20.0	nd	nd
Trifluralin	600	15.8	nd	215	80.3	nd	10.5	nd	nd

**Table 8. Pesticide concentrations in water samples during fall, 2002**

[Values are reported as nanograms per liter. Concentrations are the mean of duplicate injections. Water samples were analyzed for the following pesticides that were not detected during this sampling period: alachlor, azinphos-methyl, butylate, cyanazine, diethatyl-ethyl, ethalfluralin, fonofos, hexazinone, malathion, methidathion, methylparathion, metolachlor, molinate, pebulate, phosmet, piperonyl butoxide, sulfotep, and thiobencarb. nd, nondetection; ( ), concentration below detection limit]

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Atrazine	19.7	160	108	nd	110	110	14.3	88.0	110
Carbaryl	(2.2)	(2.7)	nd	19.3	nd	nd	nd	nd	nd
Carbofuran	9.7	7.8	25.7	nd	37.9	nd	(2.2)	40.2	31.7
Chlorpyrifos	41.7	19.0	nd	7.0	nd	nd	(1.7)	nd	nd
Cycloate	6.1	10.4	nd	nd	nd	nd	nd	nd	nd
Dacthal	60.3	94.0	nd	6.7	3.2	3.2	110	9.0	3.6
Diazinon	970	48.0	nd	22.6	8.8	(3.0)	12.8	6.4	nd
Eptam	52.9	24.9	13.0	22.3	24.5	22.5	100	24.5	10.7
Napropamide	nd	nd	nd	35.9	nd	nd	nd	nd	nd
Oxyfluorfen	5.5	(2.0)	nd	nd	nd	nd	nd	nd	nd
Pendimethalin	6.1	7.2	nd	nd	nd	nd	61.9	nd	nd
Simazine	nd	nd	nd	nd	nd	nd	(6.5)	nd	nd
Trifluralin	4.6	5.5	nd	12.4	nd	nd	(1.5)	nd	nd

**Table 9.** Suspended sediment concentration, in mg/L, and percent fines.

[\* not analyzed]

Site	Fall 2001		Spring 2002		Fall 2002	
	Concentration	Fines	Concentration	Fines	Concentration	Fines
Alamo River Outlet	418	80	379	91	226	84
Alamo River Nearshore	255	88	145	95	47	86
Alamo River Offshore	35	76	15	96	15	81
New River Outlet	245	97	397	77	338	80
New River Nearshore (near surface)	145	48	241	84	80	84
New River Nearshore (near bottom)	89	70	*	*	36	65
New River Offshore	43	86	23	91	25	83
Whitewater River Outlet	72	82	61	66	51	48
Whitewater River Nearshore	38	66	11	77	17	57
Whitewater River Offshore	21	79	7	67	28	91



**Table 10. Percent organic carbon in sediments collected during fall 2001, spring 2002, and fall 2002**

[ \* not analyzed]

**Suspended sediments**

Site	Fall 2001	Spring 2002	Fall 2002
Alamo River Outlet	0.93	1.55	1.15
Alamo River Nearshore	1.20	11.11	3.49
Alamo River Offshore	28.42	35.94	27.14
New River Outlet	1.74	1.90	1.33
New River Nearshore	2.71	4.41	5.31
New River Offshore	40.22	*	35.06
Whitewater River Outlet	3.99	5.45	4.78
Whitewater River Nearshore	42.69	28.78	33.63
Whitewater River Offshore	43.68	36.61	41.86

**Bed sediments**

Site	Fall 2001	Spring 2002	Fall 2002
Alamo River Outlet	0.58	1.17	0.49
Alamo River Nearshore	1.04	1.26	1.36
Alamo River Offshore	0.36	0.56	0.8
New River Outlet	0.37	0.47	0.25
New River Nearshore	0.94	0.25	18.27 <sup>1</sup>
New River Offshore	0.78	1.39	0.83
Whitewater River Outlet	0.46	1.13	0.46
Whitewater River Nearshore	*	1.65	0.94
Whitewater River Offshore	4.25	3.25	6.23

<sup>1</sup> needs to be rechecked

Table 11. Pesticide concentrations in suspended and bottom sediments during fall, 2001

[Values are reported as nanograms per gram. nd, nondetection; D, detected but quantitation uncertain; ( ), concentration below detection limit]. Sediments were analyzed for the following pesticides that were not detected during this sampling period: alachlor, azinphos-methyl, bifenthrin, cyanazine, cycloate, cypermethrin, diethylatyl-ethyl, esfenvalerate, ethalfluralin, fenamiphos, fonofos, hexazinone,  $\lambda$ -cyhalothrin, malathion, methidathion, methyl parathion, metolachlor, molinate, napropamide, oxyfluorfen, pebulate, pendimethalin, phorate, phosmet, profenfos, prometryn, propargite, simazine, sulfotip and thiobencarb.

**Suspended Sediments**

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Butylate	nd	nd	nd	nd	nd	66.8	nd	3.7	nd
Chlorpyrifos	50.0	63.9	nd	30.4	nd	nd	nd	nd	nd
Cyfluthrin	nd	nd	D	nd	nd	D	D	nd	nd
Dacthal	17.7	38.2	nd	nd	nd	nd	nd	nd	nd
Diazinon	11.8	12.5	nd	nd	nd	nd	nd	nd	nd
Eptam	6.6	9.2	nd	4.9	nd	nd	nd	nd	nd
Permethrin	18.7	8.7	nd	9.9	nd	nd	nd	nd	nd
Trifluralin	9.7	12.2	nd	4.6	6.8	nd	nd	nd	nd
p p' DDD	6.2	6.1	nd	5.2	nd	nd	nd	nd	nd
p p' DDE	88.3	71.8	nd	46.0	27.6	nd	nd	nd	nd
p p' DDT	9.5	9.8	nd	nd	nd	nd	nd	nd	nd

**Bed Sediments**

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Atrazine	nd	nd	nd	nd	3.8	nd	nd	nd	59.5
Butylate	nd	nd	nd	nd	nd	nd	nd	2.8	nd
Carbaryl	2.0	nd	nd	nd	5.5	5.2	nd	nd	22.4
Carbofuran	4.5	3.3	nd	nd	(1.9)	nd	nd	nd	59.3
Chlorpyrifos	nd	19.0	nd	25.5	27.7	nd	nd	nd	nd
Cyfluthrin	nd	nd	D	nd	D	nd	D	nd	nd
Dacthal	nd	7.9	nd	nd	10.2	nd	3.7	nd	nd
Diazinon	nd	nd	nd	nd	45.7	nd	nd	1.9	nd
Dimethoate	34.2	57.6	25.0	nd	nd	nd	nd	nd	nd
Eptam	nd	nd	nd	9.7	4.0	nd	nd	nd	nd
Permethrin	nd	3.0	nd	19.7	168	nd	nd	nd	nd
Trifluralin	nd	(1.2)	nd	3.1	nd	nd	(0.6)	(0.5)	nd
p p' DDD	nd	nd	nd	nd	93.9	nd	nd	nd	nd
p p' DDE	15.4	38.6	nd	22.7	41.7	1.1	3.9	nd	6.0

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**Table 12. Pesticide concentrations in suspended and bed sediments during spring, 2002**

[Values are reported as nanograms per gram. nd, nondetection; D, detected but quantitation uncertain; (), concentration below detection limit]. Sediments were analyzed for the following pesticides that were not detected during this sampling period: alachlor, azinphos-methyl, bifenthrin, butylate, cyanazine, cycloate, cypermethrin, diethylatyl-ethyl, esfenvalerate, ethalfluralin, fenamiphos, fonofos, hexazinone, λ-cyhalothrin, malathion, methidathion, methyl parathion, metolachlor, molinate, napropamide, oxyfluorfen, pebulate, phorate, phosmet, profenfos, prometryn, propargite, simazine, sulfotep and thiobencarb.

**Suspended Sediments**

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Atrazine	24.1	nd	nd	nd	nd	nd	nd	nd	nd
Carbaryl	nd	nd	nd	nd	nd	nd	28.8	40.5	nd
Carbofuran	(2.3)	nd	nd	nd	23.4	nd	nd	379	nd
Chlorpyrifos	42.6	nd	nd	11.7	nd	nd	nd	nd	nd
Cyfluthrin	D	D	nd	nd	nd	nd	nd	nd	nd
Dacthal	10.0	nd	nd	9.5	nd	nd	nd	nd	nd
Dimethoate	nd	nd	nd	nd	nd	nd	D	nd	nd
Endosulfan I	25.7	366	nd	nd	nd	nd	D	nd	nd
Eptam	3.7	nd	nd	nd	nd	nd	89.2	9.4	nd
Pendimethalin	151	nd	nd	nd	nd	nd	nd	nd	nd
Permethrin	nd	D	nd	D	nd	nd	D	nd	nd
Trifluralin	nd	19.2	nd	85.8	173	nd	13.9	nd	nd
p p' DDD	5.4	nd	nd	nd	nd	nd	Nd	nd	nd
p p' DDE	72.3	nd	nd	46.5	19.6	nd	28.2	nd	nd

**Bed Sediments**

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Carbaryl	8.4	19.5	nd	nd	nd	nd	nd	nd	nd
Chlorpyrifos	29.9	16.0	nd	5.9	2.9	nd	nd	nd	nd
Cyfluthrin	nd	nd	nd	D	nd	nd	nd	D	nd
Dacthal	11.5	9.0	nd	2.0	nd	nd	nd	nd	nd
Diazinon	2.1	nd	nd	nd	(1.0)	nd	nd	nd	nd
Eptam	7.4	5.4	nd	2.6	nd	nd	nd	nd	nd
Pendimethalin	71.6	nd	nd	nd	nd	nd	nd	nd	nd
Permethrin	9.8	nd	nd	4.7	7.3	nd	nd	nd	nd
Trifluralin	30.0	6.5	2.4	4.8	13.6	1.8	nd	nd	nd
p p' DDD	8.0	7.1	nd	nd	nd	nd	3.5	12.8	nd
p p' DDE	63.8	55.8	2.1	14.0	9.3	3.7	14.9	8.3	nd
p p' DDT	5.8	nd	nd	nd	nd	nd	nd	nd	nd

Table 13. Pesticide concentrations in suspended sediments during fall, 2002

[Values are reported as nanograms per gram. nd, nondetection; D, detected but quantitation uncertain; ( ), concentration below detection limit; New River nearshore site, sample collected from above the halocline] Sediments were analyzed for the following pesticides that were not detected during this sampling period: azinphos-methyl, bifenthrin, butylate, cyanazine, cycloate, cypermethrin, diethylatyl-ethyl, eptam, esfenvalerate, ethalfluralin, fenamiphos, fonofos, hexazinone, malathion, methidathion, methylparation, molinate, oxyfluorfen, pebulate, phorate, phosmet, propargite, simazine, sulfotep and thiobencarb.

## Suspended Sediments

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Atrazine	nd	nd	nd	nd	nd	nd	129	nd	nd
Carbaryl	nd	nd	nd	nd	147	nd	nd	564	nd
Carbofuran	nd	nd	nd	17.0	nd	nd	33.8	nd	nd
Chlorpyrifos	12.3	nd	nd	nd	nd	nd	nd	nd	nd
Cyfluthrin	nd	nd	D	nd	D	nd	D	D	nd
Dacthal	7.2	8.9	nd	nd	nd	nd	25.8	nd	nd
Diazinon	11.4	nd	nd	nd	nd	nd	nd	nd	nd
Dimethoate	nd	nd	D	nd	D	nd	nd	nd	nd
$\lambda$ -cyhalothrin	16.8	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor	7.8	nd	nd	nd	nd	nd	nd	nd	nd
Pendimethalin	nd	nd	nd	nd	nd	nd	113	nd	nd
Trifluralin	3.1	8.6	nd	18.2	nd	nd	nd	nd	nd
p p' DDD	nd	nd	nd	nd	280	nd	nd	nd	nd
p p' DDE	54.2	D	nd	40.3	22.2	nd	34.4	nd	nd
p p' DDT	nd	nd	nd	nd	176	nd	nd	nd	nd

## Bottom Sediments

Pesticide	Alamo River			New River			Whitewater River		
	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore	Outlet	Nearshore	Offshore
Alachlor	7.9	nd	nd	nd	nd	nd	nd	nd	nd
Atrazine	7.7	57.3	nd	nd	29.2	16.7	nd	14.6	29.8
Carbaryl	12.4	nd	nd	nd	nd	nd	nd	nd	nd
Carbofuran	8.2	16.6	nd	nd	nd	nd	nd	nd	nd
Chlorpyrifos	11.1	nd	nd	nd	nd	nd	3.2	nd	nd
Cyfluthrin	nd	nd	nd	nd	D	nd	D	nd	D
Dacthal	3.9	nd	nd	4.5	nd	nd	1.9	nd	nd
Diazinon	7.0	nd	nd	nd	nd	nd	nd	nd	nd
$\lambda$ -cyhalothrin	17.0	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor	7.9	nd	nd	nd	11.9	nd	2.3	nd	nd
Napropamide	30.5	nd	nd	nd	nd	nd	nd	nd	nd
Profenfos	18.1	nd	nd	nd	nd	nd	nd	nd	nd
Prometryn	144	nd	nd	nd	85.9	nd	nd	nd	nd
Trifluralin	2.6	nd	nd	3.5	nd	nd	nd	nd	nd
p p' DDD	13.6	nd	nd	nd	nd	nd	15.8	nd	nd
p p' DDE	48.0	31.7	nd	11.5	nd	nd	12.4	nd	nd

MDLS

Table 14. Method detection limits for pesticides analyzed in water samples in 2001

Pesticide	2001 Method detection limit in nanograms per liter
Alachlor <sup>1</sup>	2.1
Atrazine	4.2
Azinphos-methyl <sup>1</sup>	11.1
Butylate <sup>1</sup>	1.8
Carbaryl	4.2
Carbofuran	3.3
Chlorpyrifos	4.2
Cyanazine <sup>1</sup>	3.0
Cycloate	1.5
Dacthal	1.2
Diazinon	3.6
Diethatyl-ethyl <sup>1</sup>	3.6
Eptam	4.5
Ethalfuralin <sup>1</sup>	2.4
Forfos <sup>1</sup>	2.4
Hexazinone <sup>1</sup>	5.7
Malathion	2.1
Methidathion <sup>1</sup>	5.4
Methyl parathion <sup>1</sup>	4.2
Mesplachlor <sup>1</sup>	3.3
Molinate <sup>1</sup>	2.7
Napropamide	7.2
Oxyfluorfen	4.2
Pebulate <sup>1</sup>	0.6
Pendimethalin	2.4
Phosmet <sup>1</sup>	4.2
Piperonyl butoxide <sup>1</sup>	3.3
Simazine	6.9
Sulfotop <sup>1</sup>	1.2
Thiobencarb <sup>1</sup>	3.9
Trifluralin	3.0

<sup>1</sup> Pesticide not detected in any water samples during any sampling period

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Table 15. Method detection limits for current-use pesticides in sediments

Pesticide	Method detection limit, in nanograms per gram
2-Keto-Molinate	4.5
4-Keto-Molinate	2.6
Alachlor	1.1
Atrazine	0.6
Azinphos-methyl	7.6
Bifenthrin	0.9
Butylate	0.5
Carbaryl	1.2
Carbofuran	3.0
Chlorpyrifos	1.5
Cyanazine	1.8
Cycloate	1.8
Cyfluthrin	7.9
Cypermethrin	5.6
Dacthal	0.6
Diazinon	1.5
Diethatyl-ethyl	1.2
Dimethoate	5.9
Disulfoton	2.0
Endosulfan	5.5
Eptam	0.7
Esfenvalerate	1.4
Ethalfuralin	1.9
Fenamiphos	0.8
Fonofos	2.5
Hexazinone	3.2
Lambda-cyhalothrin	0.5
Malathion	1.5
Methidathion	3.4
Methylparathion	1.6
Metolachlor	1.0
Molinate	2.0
Napropamide	1.6
Oxyfluorfen	6.1
Pebulate	0.8
Pendimethalin	4.0
Permethrin	1.4
Phorate	0.3
Phosmet	0.8
Piperonyl butoxide	1.2
Profenfos	1.9
Prometryn	1.8
Propargite	2.3
Simazine	2.1
Sulfotep	1.1
Thiobencarb	4.4
Trifluralin	1.4

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**Table 16.** Trace metal concentrations in suspended sediments collected during fall, 2001

[Values are reported as micrograms <sup>ug/g</sup> per gram. Analyses performed on the silt (<63 mm) size fraction]

Site	Cd <63 $\mu$ m	Cr <63 $\mu$ m	Co <63 $\mu$ m	Cu <63 $\mu$ m	Hg <63 $\mu$ m	Pb <63 $\mu$ m	Se <63 $\mu$ m
Alamo River Outlet	0.4	120	10	28	0.04	22	0.7
Alamo River Nearshore	0.44	70	11	34	0.04	24	1
Alamo River Offshore	0.18	60	2.8	16	0.06	27	8.7
New River Outlet	0.45	57	9.9	37	0.07	23	1
New River Nearshore	0.4	110	9.5	31	0.07	23	1.4
New River Offshore	0.12	28	4.5	18	0.05	15	16
Whitewater River Outlet	0.36	83	19	69	0.08	27	1
Whitewater River Nearshore	0.15	7.9	5.9	7.9	0.03	2.5	14
Whitewater River Offshore	0.09	8.2	4.5	8	0.04	1.9	11

	Ag <63 mm	As <63 mm	Ni <63 mm	Mn <63 mm	Ti <63 mm	V <63 mm	Zn <63 mm
Alamo River Outlet	<3	30	51	670	3100	78	86
Alamo River Nearshore	<3	8.3	34	700	3600	90	100
Alamo River Offshore	<3	9.2	22	250	170	16	92
New River Outlet	<3	9.1	30	650	3400	80	120
New River Nearshore	<3	9.1	43	740	3000	69	100
New River Offshore	<3		11	140	50	23	62
Whitewater River Outlet	<3	11	36	1200	6200	110	190
Whitewater River Nearshore	<3	27	4	170	50	17	27
Whitewater River Offshore	<3	27	4	120	40	16	22

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**Table 17.** Concentrations of a variety of inorganic constituents measured in suspended sediments sampled during fall, 2001.

(ug/g)  
[Values are reported as micrograms per gram. Analyses performed on the silt (<63 mm) size fraction where noted, otherwise the analysis was performed on bulk sediment]

Site	Al	Ba	Be	Bi	Ce	Fe	Ga
	<63 $\mu$ m	<63 $\mu$ m	<63 $\mu$ m	<180 $\mu$ m	<63 $\mu$ m		<63 $\mu$ m
Alamo River Outlet	78000	490	1.9	<0.005	63	29000	15
Alamo River Nearshore	84000	460	2.1	<0.005	71	33000	17
Alamo River Offshore	4600	34	0.18	<0.005	3.4	2000	0.91
New River Outlet	67000	520	2	0.17	67	30000	15
New River Nearshore	68000	480	1.8	0.12	62	26000	14
New River Offshore	1400	19	0.04	<0.005	1.2	710	0.27
Whitewater River Outlet	79000	630	2	0.84	85	52000	21
Whitewater River Nearshore	1300	14	0.03	0.1	0.7	560	0.27
Whitewater River Offshore	1100	13	0.03	<0.005	0.8	510	0.27

	Li	Ln	Mo	Nb	Sb	Sc	Sr
	<63 mm	<63 mm	<63 mm	<63 mm	<63 mm	<63 mm	<63 mm
Alamo River Outlet	44	33	6.3	18	0.71	11	320
Alamo River Nearshore	51	37	1.3	20	0.82	12	340
Alamo River Offshore	22	2.2	3	<2	0.2	0.9	230
New River Outlet	46	35	2.5	17	0.78	11	320
New River Nearshore	43	32	6.5	12	0.62	9.5	280
New River Offshore	15	0.7	2.3	<2	0.02	<0.3	200
Whitewater River Outlet	44	45	4.1	26	0.62	16	500
Whitewater River Nearshore	12	0.5	1.1	<2	0.02	<0.3	150
Whitewater River Offshore	15	0.5	1	<2	<0.02	<0.3	140

	Ti	Th	U
	<63 mm	<63 mm	<63 mm
Alamo River Outlet	0.62	11	3
Alamo River Nearshore	0.68	12	3.6
Alamo River Offshore	0.01	0.52	5.7
New River Outlet	0.65	11	3.3
New River Nearshore	0.61	10	3
New River Offshore	<0.003	0.18	4.7
Whitewater River Outlet	0.77	15	4.4
Whitewater River Nearshore	<0.003	0.13	1.2
Whitewater River Offshore	<0.003	0.09	1.2



**Table 18.** Concentration of various constituents in suspended sediments collected during fall, 2001

Site	Ca mg/g	Mg mg/g	K mg/g	Na mg/g	P mg/g	C <sub>inorganic</sub> %	C <sub>organic</sub> %
Alamo River Outlet	55	18	20	5.4	1.1	1.7	0.9
Alamo River Nearshore	58	19	21	5.2	1.3	1.8	1.2
Alamo River Offshore	12	9.1	4.2	64	4.8	0.06	30
New River Outlet	51	18	21	6	2	1.6	1.7
New River Nearshore	48	17	20	16	2.4	1.5	2.7
New River Offshore	8.8	7.2	3.6	46	5.4	0.02	39
Whitewater River Outlet	55	23	23	13	2.9	1.1	3.6
Whitewater River Nearshore	5.1	6	4	38	6	0.02	39
Whitewater River Offshore	5.4	6.8	4.5	47	5.5	0.02	38