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COLORADO RIVER BASIN TOXICITY REPORT

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Executive Summary - Colorado River Project (1993 - 1994)

In the Imperial Valley, approximately $1 billion in crops is produced annually. Water in the Imperial Valley is supplied by the U.S. Bureau of Reclamation from the Colorado River for agriculture and urban use. Colorado River water is diverted to the Imperial Valley via the All-American Canal.

Many studies have examined problems of increasing salinity in the Imperial Valley. However, despite the widespread application of pesticides (in 1988, over 5 million pounds of 152 different pesticides were applied to crops in the Imperial Valley), limited work has been conducted in the region to assess the relationship between agricultural practices and adverse effects on organisms present in receiving waters. In order to better understand the impact of Imperial Valley agricultural drainage on local waters, the State Water Resources Control Board initiated a three-year study with the UC Davis Aquatic Toxicology Laboratory to:

1) Determine the extent, nature and source of toxicity in agricultural drains and high priority water of the Colorado River Basin.
2) Develop a methodological procedure for assessing toxicity from agricultural runoff.
3) Design a follow-up program to continue monitoring the impact of agricultural drainage water in the Colorado River Basin.

This report summarizes the 2nd year results from bioassays, Toxicity Identification Evaluations (TIEs), and chemical analyses. All samples were collected from the Alamo River between March 1993 to February 1994. During this time period, there was no measurable rainfall. The Alamo River was chosen for sampling as the inputs into the river are mainly agricultural. In contrast, the New River receives input not only from agricultural sources but from sewage and urban runoff as well. The Alamo River is approximately 50 miles long and drains approximately 600 square miles of irrigated cropland.

A total of 115 water samples were collected during the sampling year. Ninety-six-hour static renewal bioassays were conducted with two invertebrates, *Ceriodaphnia dubia* and the opossum shrimp, *Neomysis mercedis*. In general, samples were collected twice a month. Samples were collected from 11 fixed sampling points. Half of the sampling points were sampled in the first half of the month. The remaining sites were sampled in the latter half of the month. Within twenty-four hours of collection, water samples were shipped on ice via overnight air to the UCD Aquatic Toxicology Laboratory. Bioassays were begun upon receipt of the samples.

Following bioassay results, phase I TIEs were conducted on selected toxic samples. Twenty-four, 48, or 72-hour TIEs were conducted with ceriodaphnids based on toxicity and location. TIE procedures focused primarily on toxicity from non-polar organics, however, metal toxicity was also investigated.

Principal findings in this study were as follows:

Seasonal responses to Alamo River water varied by test species. Ceriodaphnid toxicity had a bimodal distribution with significant mortalities occurring between September and November, and February and March. Throughout the study, no significant toxicity was observed at the uppermost site, therefore, it was not included in data analyses. A total of 101 samples were tested with *C. dubia*. Forty-one percent of these samples significantly reduced survival. Only 4% of the samples tested between April and August were acutely toxic. In contrast, over 70% of the samples collected between September and March were acutely toxic, with most of the toxicity occurring between September and November and February and March. In September and October, every sample collected from the 50 mile-long river resulted in 100% mortality to ceriodaphnids - usually within 24 to 48 hours.

With the exception of samples collected in September and October, and at one site in March, no seasonal patterns were observed between neomysid mortalities and measured pesticide levels. Forty-one of the 47 samples collected between April and August were acutely toxic to neomysids. Between September and November, 18 of the 23 samples were acutely toxic, with most of the toxicity occurring between September and November. Between December and March, 8 of the 20 samples caused acute mortality.

A total of 20 TIEs were conducted with *C. dubia* during the sampling year. TIEs were conducted on samples collected between September and November, and between January and March. With the exception of TIEs conducted on toxic samples collected in January, TIE results were remarkably consistent, regardless of sampling site or season. Nineteen of the twenty TIEs indicated toxicity from a non-polar organic. Twelve of the thirteen samples tested with piperonyl butoxide (PBO) indicated that toxicity was due to a metabolically activated organophosphorous pesticide(s).

All samples tested with TIE procedures were also analyzed chemically. In over half the cases, chemical analyses detected at least one of the following five pesticides; carbaryl, carbofuran, chlorpyrifos, diazinon or malathion at levels near or above ceriodaphnid LC50 levels. In the 12 TIEs that tested positive for metabolically activated OPs, chemical analyses detected at least one metabolically activated OP (chlorpyrifos, diazinon or malathion) at levels near or above ceriodaphnid LC50s.

Over the course of the sampling year, 104 of the 115 samples were analyzed for OP and carbamate pesticides. Collectively, 27 different OP and carbamate pesticides were detected in the Alamo River. However, only five pesticides; carbaryl, carbofuran, chlorpyrifos, diazinon and malathion occurred at levels that, on at least one occasion, approximated or exceeded ceriodaphnid or *Daphnia magna* LC50 levels. Between September and November 72% of the samples analyzed from the Alamo River contained one or more of these 5 pesticides at levels above ceriodaphnid LC50s. During this time period, approximately 60% of the samples analyzed contained chlorpyrifos or diazinon above neomysid LC50 levels.

River-wide, chlorpyrifos levels averaged between 0.005-0.15 µg/l. Seasonally, chlorpyrifos was detected in 5 of the 12 months sampled, primarily between September and December. Between September and November, chlorpyrifos was detected in over 70% of the samples. At individual sites, between September and November, chlorpyrifos values exceeded ceriodaphnid LC50s by as much as a factor of 5.8. With the exception of December and April, all river-wide chlorpyrifos detections exceeded the interim water quality criteria (WQC) of 0.02 µg/l for chlorpyrifos. In these months, river-wide chlorpyrifos levels ranged between 3.0 and 7.5 times above the interim WQC. Spatially, chlorpyrifos was detected at least once at all sites downstream of site 2.

With the exception of May, July and August, diazinon was detected in every month of this sampling year. Diazinon detections had a bimodal seasonal distribution, with at least 80% of the detections occurring between September and November and at least 60% occurring between January and March. Between September and November, average river-wide diazinon levels of 0.21 - 0.62 µg/l exceeded 96-hr LC50 levels. Between January and April, average diazinon concentrations ranged from 0.01 to 0.32 µg/l. With the exception of December, April and June average river-wide diazinon detections ranged from the draft 1 hr. acute WQC of 0.08 µg/l to 7.8 times above the criterion level. Diazinon was detected at least once at all sampling points downstream of site 1.

Carbofuran was only detected between February and April. Monthly river-wide averages ranged between 0.15-2.43 µg/l, with the greatest concentrations detected in March. The value of 2.43 µg/l exceeded the interim WQC of 0.5 µg/l by over a factor of 4. The highest level of carbofuran - 5.15 µg/l exceeded laboratory LC50s by a factor of 2 and was 10 times above the interim WQC.

Over the length of the river, carbaryl concentrations averaged between 0.005-0.52 µg/l. Like diazinon, carbaryl had a bimodal seasonal distribution with the highest levels detected in the fall. Water quality criteria have not been established for carbaryl; however, carbaryl was considered a contributor to ceriodaphnid mortalities based on levels (1.3 and 1.5 µg/l) at several sites that exceeded 48-hr *D. magna* LC50s.

Malathion also had a bimodal seasonal distribution. Average river-wide values ranged from 0.05-0.20 µg/l; however, in the fall, malathion concentrations at individual sites were as high as 0.57 µg/l. The USEPA water quality criteria for malathion is 0.1 µg/l. With the exception of March, river-wide malathion levels were approximately half the US EPA water quality criteria. In March, average malathion levels were twice the criteria.

All five of these pesticides produce mortality by inhibiting acetyl-cholinesterase activity. Based on work in other laboratories, the co-occurrence of several OP and/or carbamate pesticides in many of the Alamo River samples could have resulted in additive and/or synergistic toxicity. ✓

If additivity is assumed, then there was generally a strong relationship between periods of ceriodaphnid toxicity and total TUs of 1.0 or greater. For ceriodaphnids, between September and November, total TUs over the length of the river never fell below 1.5 and were as high as 4.3 TUs. During this time, ceriodaphnid mortalities averaged over 90%. Based on TUs, chlorpyrifos was the greatest contributor to total toxicity followed by diazinon. With the exception of January and February, average river-wide ceriodaphnid mortalities were 20% or less in all months with 1.0 TU or less. Examination of TUs at representative sites on the river showed similar trends.

The strongest relationship between pesticide concentrations and neomysid mortalities occurred in September and October when TUs exceeded 2.0. In both months, neomysid river-wide mortalities averaged 80% or higher. In the remaining months, there was no clear relationship between neomysid mortalities and any of the detected OP and carbamate pesticides. Between April and August, none of the measured pesticides occurred at concentrations thought capable of causing neomysid mortalities, however, 87% of the samples tested resulted in significant neomysid mortalities.

Application patterns of the five pesticides in 1990 and 1991 corresponded to chemical detection patterns in 1993 and 1994. This suggested that irrigation practices and pesticide application patterns may be fairly consistent from year to year and that the Alamo River may have experienced similar periods of extended toxicity in the recent past.

The objectives of the third year of study are two-fold: to verify the mortality patterns that were observed in the 93-94 sampling year and to determine the nature of the toxicant(s) causing neomysid toxicity. These objectives will be met by continuing to assay Alamo River waters with *C. dubia* and *N. mercedis* and developing TIE methodologies for *N. mercedis*.

Introduction

Within the Colorado River Basin Region, there are over 675,000 acres of irrigated cropland and approximately 1700 miles of agricultural drains. In the Imperial Valley, approximately $1 billion in crops is produced annually (Imperial County Agricultural Crop and Livestock Report, 1990). Water in the Imperial Valley is supplied by the U.S. Bureau of Reclamation from the Colorado River for agriculture and urban use. Six desilting basins remove silt from Colorado River water prior to diversion at the Imperial Dam into the All-American Canal. Since 1942, the Imperial Valley has received its water from the All-American Canal (Imperial Irrigation District, 1992).

Within the valley, irrigation water is distributed by the Imperial Irrigation District (IID) through a network of canals and laterals. Growers divert water either for crop irrigation, or for leaching of excess salts in an effort to minimize deleterious effects on crop production and wildlife. Some canals, including the All-American Canal, are unlined. Irrigation tailwater and seepage from unlined canals are the major sources of ground water recharge; however, most of the recharge is collected by tile drains before reaching the water table. As of 1990, there were 32,227 miles of tile drains in the Imperial Valley (Imperial Irrigation District, 1992). Water intercepted by tile drains is discharged into a network of approximately 1400 miles of surface drainage ditches or collector drains. Collector drains also receive tailwater runoff directly from fields. The collector drains discharge into the New and Alamo Rivers which in turn discharge into the southern end of the 35,000 acre Salton Sea National Wildlife Refuge. The Alamo River provides approximately 46% of the freshwater input into the Salton Sea. Approximately 38% is provided by the New River.

There are over one million acres within the IID's boundaries. In 1992, 407,053 acres were used for field crops, 95,638 acres for vegetable crops and 20,027 for permanent crops (Imperial Irrigation District, 1992). In 1988, over five million pounds of 152 different pesticides were applied to crops in the Imperial Valley.

Bioassay studies on irrigation runoff and agricultural drain water in the Central Valley have demonstrated toxicity problems (Bailey et al. 1994, Foe and Connor, 1991a). However, despite the widespread application of pesticides in the Imperial Valley, limited work has been conducted in this region to assess the relationship between agricultural irrigation practices and their effect on receiving waters. To better understand the impact of Imperial Valley agricultural drainage on local waters, the State Water Resources Control Board initiated a three-year study with the UC Davis Aquatic Toxicology Laboratory (UCDATL) to:

1) Determine the extent, nature and source of toxicity in agricultural drains and high priority waters of the Colorado River Basin.
2) Develop a methodological procedure for assessing toxicity from agricultural runoff.
3) Design a follow-up program to continue monitoring the impact of agricultural drainage water in the Colorado River Basin.

To address these questions, the first year of sampling (1992) was a screening study to help focus and define the following years of research (Colorado River Final Report, 1992). During this second year of sampling, collection efforts focused on the 50-mile long Alamo River, which drains approximately 600 square miles of irrigated cropland. This river was chosen because its inputs are mainly agricultural, without inputs from other sources, which could complicate interpretation. In contrast, the New River receives inputs from sewage and urban runoff from across the border, as well as agriculture.

This report presents toxicity testing data from the Alamo River from March 1993 to February 1994. During this time period, there was no measurable rainfall. Throughout the sampling period, the primary input into the Alamo River was from surface run-off. One hundred and fifteen water samples were collected during this time period. Ninety-six-hour static renewal bioassays were conducted with two invertebrates, *Ceriodaphnia dubia* and *Neomysis mercedis*. Neomysids and *C. dubia* exhibit similar sensitivity to tested pesticides (unpublished data, this laboratory), but neomysids tolerate higher salinities than *C. dubia*. Since irrigation tail water from the Imperial Valley can exceed *C. dubia* salinity tolerance ranges (Colorado River Final Report, 1992) bioassays were conducted with *N. mercedis* as well as *C. dubia*.

Materials and Methods

Ambient Water Samples

In general, samples were collected twice a month from the Alamo River. A total of 11 sampling locations, 5 sites located upstream of the Harris Street Bridge and 6 sites located at and downstream of the bridge (Table 1, Figure 1) were used. Half of the sampling points were sampled in one-half of the month. The remaining sites were sampled in the latter half of the month. Eleven liters of water (grab samples) were collected from each site in acid-washed amber glass bottles. Samples were filtered through a 60 µm filter at the time of collection. On the following day, the bottles were shipped overnight on ice to the UCDATL and were stored at 4°C. Bioassays were initiated the same day the samples were received, generally within 2-8 hrs of sample arrival and within 48 hrs of sample collection.

Bioassay Procedures

Ninety-six hour static renewal bioassays were conducted with *Ceriodaphnia dubia* and *Neomysis mercedis*. *C. dubia* neonates (< 24 hr old) were obtained from established cultures at the UCDATL. Juvenile *N. mercedis* (3-6.5 mms) were supplied by Brezina and Associates, Dillon Beach, California, or from existing in-house cultures. *C. dubia* were cultured in well water diluted with glass distilled water to EPA moderately hard specifications (US EPA, 1989). Neomysids were acclimated to laboratory waters (19°C and 5000 µmhos conductivity) for at least four days prior to testing. Due to poor condition, no neomysids were tested with samples collected 11/1/93. Water samples collected on 11/29/93 were tested with laboratory-reared neomysids only.

C. dubia were exposed to sample waters in 20 ml glass scintillation vials at 25 $\pm$ 1°C. Ten replicates were used per treatment; each replicate contained one neonate in 18 mls of test solution. The test solutions were renewed daily. Renewal waters were brought from 4°C to the appropriate temperature by heating. Samples that were super-saturated with oxygen were stirred until DO levels were below saturation and within normal physiological ranges. Dissolved oxygen, pH and temperature were monitored daily on the renewal and 24-hr-old bioassay waters. In addition, any sample with mortalities $\geq$ 30% were checked for NH_3-N. Electrical conductivity was monitored at the time of sample arrival and at the end of the test. During an individual test, *C. dubia* were fed a mixture of trout chow and green algae (*Selenastrum capricornutum*).

N. mercedis were exposed to sample waters in 50 ml glass beakers at 19 $\pm$ 1°C. Each beaker contained 40 mls of test solution and one neomysid. Twelve replicates were used per treatment. Fifty percent of the solution was renewed on a daily basis. Physical measurements for renewal and 24-hr-old bioassay waters were similar to those of *C. dubia*. Only 10 replicates were used for water collected 11/29/93. Neomysids were fed daily approximately 20, less than 24 hr old, *Artemia* nauplii.

To minimize osmotic stress to *C. dubia*, the conductivities of samples exceeding 2500 µmhos, were diluted to between 2000 and 2500 µmhos with glass distilled water. All samples were tested without dilution with *N. mercedis*.

Each testing event was accompanied by laboratory controls. Laboratory controls incorporated the same procedures as the ambient water samples except that moderately hard well water (Diluted Ecology Institute Water) was used. Depending on the conductivity of the ambient samples, the conductivity of this water was adjusted to 2000 - 2500 µmhos, with natural seawater, prior to addition of test organisms.

Chemical Analysis

Toxic samples between March and August 1993 were sent for chemical analysis to the Department of Pesticide Regulation (DPR) and Eureka Laboratories. Beginning in September, selected toxic samples were sent to DPR and Agriculture & Priority Pollutant Laboratories (APPL) in Fresno. In most cases, toxic samples were submitted to DPR for analysis from only one of the two sampling periods each month. To minimize false positive results, each of the laboratories also analyzed non-toxic samples.

Subsamples of the 11 liters of water collected at each site were shipped for chemical analysis overnight on ice the day following collection. These samples were stored at 4°C and analyzed for organophosphorous and carbamate pesticides following bioassay results. With the exception of waters analyzed for endosulfans and diazinon, all waters sent to DPR were preserved with concentrated H_2SO_4 to a pH of 2. Water samples sent to Eureka and APPL Laboratories were not acidified. APPL Laboratories used EPA method 8140 and 632 for the analysis of organophosphate and carbamate pesticides, respectively. Eureka Laboratories used EPA methods 614 and 632, respectively. The Department of Pesticide Regulation used methods developed by their laboratory. Pesticides analyzed by each laboratory are listed in Table 2. Beginning in September, laboratory spiked samples were sent to each lab. Laboratory waters were spiked with 1.0 and 0.5 µg/l of carbofuran and chlorpyrifos, respectively. Results from all chemical analyses are presented in Appendix C. With the exception of samples 7183 and 7184 submitted in September, the results of split samples sent to DPR and APPL Labs were similar. However, in several split samples, APPL laboratories failed to detect malathion (Appendix C). In contrast, there was little similarity between split samples sent to DPR and Eureka laboratories. In all split samples, Eureka laboratories failed to detect any pesticides, despite their detection by DPR, at levels above Eureka laboratories minimum detection limits. Due to the recent suspension of Eureka Laboratory by US EPA and CAL-EPA, we do not view the data from this laboratory as reliable.

Toxicity Identification Evaluations (TIEs)

TIEs are a series of chemical and/or physical manipulations of a toxic sample that are used to characterize the nature of a toxicant(s) (US EPA, 1991). A number of different manipulations may be conducted separately, or in combination, on aliquots of a toxic water sample. TIE procedures include (but are not limited to) the addition of EDTA to toxic water samples to selectively remove toxicity from divalent cations and the passage of a toxic water sample through a C8 or C18 solid phase extraction (SPE) column to selectively remove non-polar organics. After a TIE procedure, an organism is placed into the treated toxic water sample and the organisms's response monitored. If the treated water sample is no longer toxic to the organism, then the successful TIE procedure(s) provides evidence on the class of toxicant(s) responsible for toxicity (i.e., heavy metals, organics, etc.).

Twenty-four, 48 or 72-hour TIEs were conducted using ceriodaphnids. Criteria for samples selected for TIEs were high bioassay test mortality, length of exposure time to achieve mortality, and/or sampling location on the river relative to other toxic sample sites. In general, when an entire stretch of river was toxic, TIEs were conducted on samples collected at the top, the middle and the bottom of the stretch of river sampled. All TIEs were run within 10 days of sample collection. TIE procedures focused primarily on toxicity from non-polar organics; however, metal toxicity was also investigated. Ammonia levels were always below No Observable Effect Concentration (NOEC) levels and therefore were not considered a toxicant of interest.

In general, TIE procedures followed EPA guidelines (US EPA, 1991). Between 2 and 4 replicate scintillation vials containing approximately 18 mls of TIE treatment water was used for each TIE procedure. Because TIE techniques have not been developed for neomysids, only ceriodaphnids were used as test organisms. Unlike bioassays, 5 ceriodaphnids per replicate vial were used. Based on previous work in this laboratory, procedures associated with pH adjustment were modified slightly (Bailey et al. in prep). Samples were adjusted to pH 3 or 11 and returned to the initial pH after incubation in the dark at 25°C for 6 hours. Beginning with samples collected 10/18/93, piperonyl butoxide (PBO) was added to effluents at either 100, 200, or 300 µg/l. Because PBO inhibits the toxicity of metabolically activated OPs, reduction of ambient water toxicity following the addition of PBO suggests toxicity from metabolically activated OPs. TIE procedures used in this study, as well as the rationale for each procedure are listed in Table 3. Not all TIE procedures were used on all samples.

Statistics

Mortality in the treatments were compared to the control using Fisher's Exact Test (Sokal and Rohlf, 1981). Samples were considered toxic when differences between the control and sample mortality were significant at $p \leq 0.05$. Depending on the test, 30-40% mortality was generally statistically different from the control.

Quality Control

Ceriodaphnid and neomysid control mortality was < 20% for all tests conducted during the 1993-94 sampling period.

Results

Spatial and Temporal Patterns of Toxicity

Throughout the 12-month sampling period, waters collected at the head waters of the Alamo River near the All-American Canal (Site 1) exhibited no statistically significant toxicity to either test species. Consequently, this sampling point was not included in any of the following discussions. Unless otherwise noted, results of the 93-94 sampling year are confined to sites 2-11 of the Alamo River (see Figure 1).

Ceriodaphnids - Seasonally, there were distinct patterns to ceriodaphnid toxicity (Figure 2). This seasonal pattern of toxicity was observed at every site on the river. One hundred and one samples were tested with *C. dubia*. Samples responsible for most of the toxicity were collected primarily between September and November and February and March. Between April and August, only 4% of the samples (2/51) were acutely toxic to ceriodaphnids. During this time period, average ceriodaphnid mortality from all samples collected over the length of the river was 20% or less (Figure 2). In contrast, over 70% (39/54) of the samples collected between September and March were acutely toxic to ceriodaphnids.

It is difficult to determine if dilutions used to reduce conductivity levels affected the toxicity of non-toxic samples, however, dilutions did not appear to inhibit toxicity of samples collected between September and November (Table 4). Between September and October, half of the samples tested required dilution, however, all samples still produced 100% ceriodaphnid mortality. In November, over half of the samples collected required dilution and average river-wide mortality was still 95%. In the remaining months, approximately half of the samples required dilution, however, between December and January average mortality fell below 20%. Mortality exceeded 50% in February and March.

Neomysids - Ninety samples were tested with neomysids. Unlike ceriodaphnids, the frequency of toxic samples was relatively high throughout the sampling year. Forty-one of the 47 samples tested between April and August (87%) were acutely toxic to neomysids (Table 4). Average mortality during this time period ranged between 47 and 88%. In September through November, the frequency of toxic samples was 78% (18/23), with most of the toxicity occurring between September and November. Neomysid mortalities averaged over 80% in September and October but fell to 25% in November (Figure 3). In late winter/early spring (December through March), the frequency of toxic samples was 40% (8/20). Average river-wide mortality during this time period ranged from 14-56%. As with ceriodaphnids, this seasonal toxicity pattern was observed at every site on the river.

TIEs

To examine the nature of the observed toxicity, phase I TIEs were conducted on selected toxic samples collected in March 1993 and September through February 1994. TIE results by date are summarized below and in Tables 5A through 5H.

3/15/93: TIEs were conducted on sample numbers 7121 and 7124 located at the upper and lower sites of the upper Alamo River (sites 2 and 5, respectively) (Table 5A). In both samples, ceriodaphnids exhibited 100% mortality in 24 hours. Adjustment of the sample waters to pH 3 were inconclusive, however, at both sites, increasing sample pH to pH 11 delayed ceriodaphnid mortality by 24 hours. This result, coupled with the negative results of aeration and EDTA and $Na_2S_20_3$ additions suggested carbofuran as one of the toxicants (Bailey et al., in prep). In addition, passage of both samples through a C8 column removed toxicity, strengthening the argument for a non-polar organic. Methanol elution of the columns was successful in recovering some of the toxicity from sample number 7121; however, because the methanol elute was not toxic, the toxicant(s) in sample number 7124 apparently remained bound to the column

9/27/93 - TIEs were conducted on sample numbers 7180, 7182 and 7185 located at the top, middle and bottom of the lower Alamo River (sites 6, 8 and 11, respectively). A dilution series of the ambient waters indicated that a 50% dilution was still acutely toxic to ceriodaphnids. Therefore, to avoid exhausting the binding capacity of the C8 column, all samples were tested at 50% strength. In all samples, 24-hour mortality of ceriodaphnids exposed to diluted samples was 100%. Control mortality was 5% (Table 5B).

Adjustment of sample numbers 7182 and 7185 to pH 3 had little effect on toxicity. After

24 hours, mortalities in these two samples were 75 and 88%, respectively. However, lowering the pH of sample 7180 to pH 3 reduced mortality to 13%. There were no mortalities in control water adjusted to pH 3. Heavy flocculation occurred when all waters were adjusted to pH 11. Due to the inability to remove this flocculation when returning waters to pH i, no TIEs were conducted with pH 11 adjusted waters.

Addition of EDTA or $Na_2S_2O_3$ also had little effect on toxicity, suggesting that metals were not the source of toxicity. Mortalities for these treatments were between 88 and 100%.

Toxicity was removed from all three samples by a C8 column. These results suggested a non-polar organic(s) as the source of toxicity. Column binding of the toxic fraction was confirmed by eluting the column with methanol and adding the eluate back to control water at 1.5%. Mortality was 100% using methanol eluates from 7182 and 7185. Mortality using the methanol eluate from the 7180 column was only 25%. Mortality in the methanol control was 38%. Due to this high control mortality and the relatively low mortality observed from the 7180 eluate, these "add-back" experiments were repeated. Mortality results for the repeated 7182 and 7185 methanol add-backs were similar to the previous experiment. Mortality was also 100% for methanol add-backs from number 7180. Methanol control mortality was 50% in these experiments.

TIE results for toxic samples collected on 9/27/93 were consistent with a non-polar organic as the probable cause of the observed toxicity. In the case of sample 7180, the reduced toxicity associated with the pH 3 treatment further suggested diazinon as the source of toxicity (Bailey et al. in prep).

10/4/93 - TIEs were conducted on sample numbers 7188 and 7191 (sites 2 and 5, respectively). TIE results are summarized in Table 5C.

A dilution series of the ambient waters indicated that a 50% dilution of sample 7191 was still acutely toxic to ceriodaphnids. Therefore, to avoid exhausting the binding capacity of the C8 column, sample 7191 was diluted by 50% with control water. Sample number 7188 was tested at full strength. In both samples, mortality was 100% within 48 hours. There were no control mortalities.

For both samples, pH adjustment failed to reduce toxicity. Mortality was 100% in both samples regardless of whether they were held at pH 3 or pH 11. Heavy flocculation was present in samples brought up to pH 11; therefore, following the 6-hour incubation period, only the supernatant was decanted and returned to pH i. Mortalities for pH 3 and pH 11 control waters were 10 and 50%, respectively. Control mortalities may have occurred due to the increase of Cl^- and Na^+ ions introduced during the pH process.

Metals did not appear to be the source of toxicity as the addition of either EDTA or $Na_2S_3O_3$ had no effect on sample toxicity. With both procedures, ceriodaphnid mortalities in both samples were 100% at 48 hr.

The passage of both samples through C8 columns eliminated toxicity, suggesting a non-polar organic as the source of toxicity. These results were confirmed in the methanol add-back. In both samples, elution of the columns with methanol and its add-back into control waters resulted in ceriodaphnid mortalities of 100%. There were no mortalities in the methanol control.

These results again indicated that non-polar organic(s) were responsible for toxicity.

10/18/93 - PBO was the only TIE procedure used on toxic samples collected from this date. TIEs were conducted on samples 7196, 7198 and 7201 located at the top, middle and bottom of the lower Alamo River (sites 6, 8 & 11, respectively). TIE results are summarized in Table 5D. Sample number 7201 was tested at 50% strength while sample numbers 7196 and 7198 were tested at full strength. In all three samples, ceriodaphnid mortality was 100% within 24 hours. Control mortality was 5%.

Addition of PBO markedly reduced sample toxicity. All samples were tested at 100 and 300 µg/l PBO. In 24 hours, toxicity was partially removed in sample number 7196 at 100 µg/l PBO (mortality = 40%) and completely removed at 300 µg/l PBO. After 48 hours, mortalities were 100 and 20% in PBO concentrations of 100 and 300 µg/l, respectively. The inability of PBO at 100 µg/l to remove toxicity suggested that this inhibitor concentration was too low to counteract all metabolic activation of OPs. In sample number 7198, at both levels of PBO, there was no toxicity after 48 hours. Using 300 µg/l PBO, toxicity was completely removed at 24 hrs in sample number 7201, however, PBO concentrations of 100 µg/l did not remove toxicity (mortality = 100%). After 48 hours, mortality in sample number 7201 at 300 µg/l increased to 30%. There were no control mortalities at 24 hours in either PBO concentration. At 48 hours, control mortalities were 20 and 30% for 100 and 300 µg/l PBO, respectively. These results suggest that metabolically-activated OPs were responsible for toxicity.

<u>11/1/93</u> - TIEs were conducted on sample numbers 7205, 7206 and 7207 (sites 4, 5 & 6, respectively). TIE results are summarized in Table 5E. To avoid column exhaustion, sample numbers 7206 and 7207 were tested at 50% strength. Sample number 7205 was tested at full strength. In all samples, ceriodaphnid mortalities were 100% within 48 hours. Control mortality was 5%.

The addition of EDTA did not affect toxicity. Within 48 hours, there was no survival at any concentration of EDTA. In contrast, there was 100% survival in all three samples following sample passage through a C8 column. In all samples, methanol eluates from each of the columns resulted in 100% mortality. Mortality in the methanol control was 20%.

PBO additions also removed toxicity. After 48 hours, mortalities in samples treated with 300 µg/l PBO, were 10% or less. Mortality was slightly higher for organisms exposed to samples treated with 100 µg/l PBO. At 100 µg/l PBO, 48-hr mortality for sample numbers 7205 and 7206 were 20 and 0%, respectively, while 48 hr mortality in sample number 7207 was 50%. There were no control mortalities at either PBO concentration.

These results again suggest that non-polar organic(s) were responsible for toxicity in the samples tested. Moreover, elimination of toxicity by PBO treatment implicated metabolically activated OP pesticides.

<u>11/29/93</u> - TIEs were conducted on sample numbers 7208, 7210 and 7213. These sites were located at the top, middle and bottom of the lower Alamo River, respectively (sites 6, 8 & 11, respectively). To lower the conductivities of the sample waters to within ceriodaphnid tolerance, all three samples were diluted 10-13%. TIE results are summarized in Table 5F. In all samples, sample mortality was 100% within 24 hours. There were no control mortalities.

Toxicity was not removed with samples adjusted to pH 3. In all samples there was 100% mortality by 48 hours. In contrast, there were no mortalities in the pH 3 control. No pH 11 TIE tests were conducted.

Due to an insufficient number of organisms, TIEs with EDTA were not conducted.

Passage of each of the samples through a C8 column removed all toxicity. Methanol eluates from samples 7210 and 7213 resulted in 100% mortality. The methanol add-back of sample 7208 resulted in 70% mortality. There were no mortalities associated with either the column blanks or the methanol controls. In addition, treatment with 200 µg/l PBO reduced mortality in all samples to 10% or less. These results suggested that metabolically activated OP pesticides were responsible for toxicity.

1/24/94: TIEs were conducted on sample numbers 7229 and 7230 (sites 2 & 3, respectively) (Table 5G). At 48 hours, mortality for sites 2 and 3 were 85 and 15%, respectively. At 72 hrs, mortality had increased to 100 & 90% for the two sites, respectively. Control mortality was 0 and 25% at 48 and 72 hrs, respectively. Sample adjustment to pH 3 had no effect on toxicity.

Addition of the lowest concentrations of EDTA reduced sample toxicity by at least half in both of the samples. However, higher concentrations did not remove toxicity in either sample.

Passage of sample number 7229 through a C8 column was unsuccessful at removing toxicity. However, passage of sample number 7230 through a C8 column successfully removed toxicity. Methanol elution of the 7230 sample failed to remove the toxicants from the column; ceriodaphnid mortality was zero, suggesting that the toxic fraction was still bound to the column. Ceriodaphnid mortality was also zero for animals exposed to methanol eluates from sample number 7229. This was not surprising as the C8 column did not reduce toxicity, suggesting that little, if any of the toxic fraction was bound by the column.

The addition of PBO had no effect on toxicity of sample number 7229. However, PBO did significantly reduce sample mortality in sample 7230. It is difficult to determine the source of toxicity in sample 7229. However, toxicity in sample 7230 may have been due to a non-polar organic.

2/14/94: TIEs were conducted on sample number 7236 and 7237 (sites 2 and 3), collected downstream of Verde Drain and at Holtville, respectively. Baseline mortalities for both samples were 100% in 48 hours (Table 5H). Adjustment of the samples to pH 3, as well as the addition of EDTA had no effect in sample toxicity.

Toxicity was removed in both samples upon passage through a C8 column. For both samples, toxicity was present in the methanol eluates from the columns. In addition, toxicity was removed by addition of PBO to the samples. These results were consistent with a metabolically activated OP as the cause of toxicity.

TIE Results vs. Chemical Analyses

All samples tested with TIE procedures were also analyzed chemically. Comparisons between TIEs and chemical analyses are shown in Figures 4A through 4F. With the exception of one TIE conducted in January (sample 7229), all TIE C8 and methanol add-back procedures consistently indicated toxicity from non-polar organics. In over half these cases (65%), chemical analyses detected at least one of the following five pesticides; carbaryl, carbofuran, chlorpyrifos, diazinon and malathion at levels near or above ceriodaphnid *Daphnia magna* LC50 levels. Similarly, chemical results verified PBO's ability to identify toxic levels of metabolically activated OPs. In all samples for which the TIE results suggested metabolically activated OPs (Figs 4C-F), chemical analyses detected at least one metabolically activated OP (chlorpyrifos, diazinon or malathion) at levels near or above ceriodaphnid LC50 levels. In some cases, several metabolically activated OPs were present.

TIEs vs. Toxic Units

Chemical analyses often detected more than one pesticide in drainage waters. Several studies have examined the interactive effects of pesticides with similar modes of action (see for example, Sambasiva Rao et al. 1985). The presence of more than one similarly acting pesticide can increase sample toxicity through additive or synergistic effects. With respect to this study, the five pesticides detected near or above ceriodaphnid LC50 levels produce mortality by inhibiting acetyl-cholinesterase. In addition, 3 of these pesticides, chlorpyrifos, diazinon and malathion, are all metabolically activated OPs. The USEPA reports additivity between the carbamate, carbofuran, and the metabolically activated OP, malathion (T. Norberg King, personal communication). In addition, EPA studies have also found additivity between carbofuran and methyl parathion, another metabolically-activated OP (Norberg-King in Foe and Connor, 1991b). Based on these findings, combinations of carbamate and metabolically activated OP pesticides found in this study may have contributed to toxicity, either additively or synergistically, even when individual pesticide levels were below LC50 levels.

Toxic Units (TUs) were calculated for each pesticide to examine the potential effects of additivity and to standardize the relative contribution of each of the 5 pesticides. Toxic Units were calculated as the chemical concentration detected in the ambient sample divided by the chemical's LC50. Concentrations of a pesticide in an ambient sample equal to the LC50 had a TU of 1. Those at twice their LC50 had a TU of 2, etc. With the exception of carbaryl and malathion, 96-hr LC50 values determined by this laboratory were used to determine the TUs for carbofuran, chlorpyrifos and diazinon. No ceriodaphnid LC50 data were available for carbaryl or malathion, therefore, 48-hr and 24-hr *D. magna* LC50s were substituted (Verschueren, 1983;

Sheipline, 1993). When the same pesticide was detected by DPR and APPL Laboratories, the two values were averaged. When a pesticides was detected by only one laboratory at levels above both laboratories' minimum detection limits (mdl), the non-detect value was treated as a 0 and averaged with the detected value. Eureka Laboratory results were considered unreliable and were not averaged with DPR results. Toxic Units for each of the five pesticides detected in TIE samples as well as the total TUs in each sample are listed in Figures 4A through 4F.

Assuming additivity, then 13 of the 20 TIE samples contained at least 1 TU. Total TUs for the 13 samples ranged from 1.6 to 8.8. Based on TUs, between September and November, chlorpyrifos was the greatest contributor to total toxicity. Chlorpyrifos TUs during this three-month period ranged from 1 to 5.7 TUs. After chlorpyrifos, diazinon was the 2nd largest contributor to toxicity in the fall months. Between September and November, diazinon TUs in TIE samples ranged between 0.39 and 1.8. Ceriodaphnid mortality in all of these TIEs was 100%.

Although these five pesticides could usually explain the TIE and toxicity results, this was not the case for the remaining 7 samples. Of the remaining TIEs, mortalities ranged between 90-100% with TUs from the five pesticides ranging from 0.2 to 0.67. For all of these samples, TIE results consistently identified a non-polar organic as the source of toxicity. One explanation for this discrepancy may lie in the scarcity of LC50 data for the remaining detected pesticides. Without reliable LC50 data, it is difficult to assess their contribution to sample toxicity. However, based on TIE results, it is likely that one or more pesticides contributed to sample toxicity.

Chemical Analysis - Seasonal and Spatial Patterns

Of the 115 samples collected (including site 1), 104 were analyzed for organophosphorous and carbamate pesticides (Appendix C). Collectively, twenty-seven different OP and carbamate pesticides were detected in the Alamo River (Table 6).

During the sampling year, five of the 27 pesticides occurred at levels that could independently cause ceriodaphnid or neomysid toxicity (Table 6). These five pesticides, carbaryl, carbofuran, chlorpyrifos, diazinon and malathion, occurred at levels, on at least one occasion, that approximated, or exceeded, ceriodaphnid or *Daphnia magna* LC50 values. As noted in the TIE results, reliable LC50 data is not available for many of the other pesticides. This does not preclude their contribution to sample toxicity, however, due to the lack of data, chemistry discussions have been limited to these five pesticides.

Seasonally, these pesticides were detected most frequently in the fall and late winter/early spring. However, not all of them occurred in every month; each pesticide had distinct seasonal patterns of occurrence (Table 7). In addition, periods of peak pesticide concentrations coincided with periods of high ceriodaphnid mortality. This was not the case between May and August for neomysids.

Sectional contributions to whole river toxicity were also examined at three representative sites corresponding to the upper, middle and lower sections of the Alamo River, respectively. Sites chosen were: site 2, downstream of Verde Drain near the headwaters of the river, site 6, the Harris Street Bridge, located roughly midway down the length of the river, and site 11, located near the outlet of the Alamo River into the Salton Sea. Seasonal patterns of pesticide detections at sites 6 and 11 were similar to each other and to the river as a whole. All five pesticides were detected at sites 6 and 11 over the twelve-month period.

As with TUs, when the same pesticide was detected by DPR and APPL Laboratories, the two values were averaged. When a pesticide was detected by only one laboratory at levels above both laboratories' mdls, the non-detect value was treated as a 0 and averaged with the detected value. Eureka Laboratory results were considered unreliable and were not averaged with DPR results.

Chlorpyrifos - Chlorpyrifos concentrations, over the length of the river, varied both spatially and seasonally. Seasonally, chlorpyrifos was detected in 5 of the 12 months collected, primarily between September and December (Table 7). Between January and August, chlorpyrifos was detected once in April. Average April concentrations over 11 sites was 0.005 µg/l. Between September and November, river-wide chlorpyrifos concentrations averaged between 0.06 and 0.15 µg/l. These values overlapped or exceeded the 96-hr LC50 levels of 0.062-0.070 µg/l reported by Aqua-Science (H. Bailey, personal communication), as well as the 0.06 µg/l values determined by this laboratory. The interim water quality criteria (WQC) for chlorpyrifos in the Sacramento-San Joaquin Delta is 0.02 µg/l (Menconi and Paul, 1994). Individually, over the course of the sampling year, all 25 chlorpyrifos detections exceeded the interim water quality criteria for chlorpyrifos (Appendix C). In the fall, between September and November, chlorpyrifos levels averaged over the length of the Alamo River, exceeded the interim WQC by as much as a factor of 7. In December, average river-wide chlorpyrifos values were at approximately the WQC.

In addition to seasonal changes, there was also a spatial component associated with chlorpyrifos inputs. Chlorpyrifos was never detected at site 2 (Figure 5A). However, chlorpyrifos was detected at all sites downstream of site 2 - primarily between September and

December (Appendix C). Between September and November, chlorpyrifos levels were similar between sites 6 and 11, ranging between 0.06-0.35 µg/l at site 6 and 0.07-0.24 µg/l at site 11. These values exceeded the interim WQC by as much as a factor of 17, and in some cases were nearly 6 times above our laboratory 96-hr LC50. During this time period, all samples collected at these sites resulted in 100% ceriodaphnid mortality.

TIEs conducted from waters collected at sites 6 and 11 indicated toxicity from a non-polar organic pesticide(s), and when tested, a metabolically activated OP. Chlorpyrifos is a non-polar organic, metabolically activated OP.

With respect to neomysids, the LC50 value is 0.07 µg/l. Where detected, chlorpyrifos levels in September and October could explain the 60-100% mortalities observed with neomysids.

Diazinon - Patterns of diazinon detections had a bimodal, seasonal distribution, with diazinon detected primarily between January and April, and September and December. Average diazinon concentrations river-wide ranged between 0.008-0.32 µg/l from January through April and between 0.03 and 0.62 µg/l from September through December (Table 7). Between May and August, diazinon was detected only in June. Between September and November, average river-wide diazinon levels ranged from 0.21-0.62 µg/l, overlapping or exceeding the 0.29-0.35 µg/l 96-hr LC50 levels reported by Aqua-Science (H. Bailey, personal communication), and in one case exceeding the 0.44 µg/l value determined by this laboratory.

The draft WQC for diazinon is 0.08 µg/l (Menconi, in prep.). Average diazinon levels exceeded this criteria in 5 of the 9 months detected. In February and March and again between September and November, average river-wide diazinon levels ranged from 1.4 - 7.8 times the WQC. Between December and January and again in April and June, average river-wide values were below the draft WQC.

Unlike chlorpyrifos, diazinon was detected in the fall at site 2, as well as all points downstream (Figure 5B, Appendix C). Diazinon was detected at site 2 only in October at 0.20 µg/l, approximately 2.5 times above the WQC. Site 2, however, was not sampled in either September or December. In October, diazinon levels at sites 6 & 11 were 2 to 5 times as high as those detected at site 2. From September through December, all samples collected at both sites contained diazinon at levels that exceeded the draft WQC by a factor from 2 to 13.5. All TIEs conducted from these sites indicated toxicity from a non-polar organic, and when tested, a metabolically activated OP. Diazinon is a non-polar organic, metabolically activated OP.

Diazinon levels appeared to vary more by site between January and April. River-wide averages varied between 0.008-0.32 µg/l. Diazinon levels at the three sites varied from below detection to 0.29 µg/l. At site 2, diazinon was detected in February and March at 0.18 and 0.29 µg/l, respectively. These values exceeded draft WQC by factors of 2 and 3.6 respectively. Ceriodaphnid mortality in both months was 100%. At site 6, diazinon levels in January and February were 0.21 and 0.08 µg/l, respectively. No diazinon was detected in January at site 11. Site 11 was not sampled in March, however, diazinon was detected in April at 0.09 µg/l.

The 96-hr LC50 for neomysids is 1.91 µg/l (unpublished data, this laboratory); therefore, the presence of diazinon alone could not account for neomysid mortalities in the summer or fall.

Carbofuran - Carbofuran was detected only in February, March and April. River-wide averages ranged between 0.15-2.43 µg/l with the highest value detected in March (Table 7). An average value of 2.43 µg/l exceeded the interim WQC for the Sacramento River of 0.5 µg/l by almost a factor of 5 (Menconi and Grey, 1992) and overlapped the 96-hr LC50s for ceriodaphnids of 2.23 and 2.53 µg/l (unpublished data, this laboratory). Based on these results, it is likely that, during March, carbofuran contributed to the average river-wide mortality of 80%. In itself, average carbofuran levels of 0.28 µg/l in February could not explain average ceriodaphnid river-wide mortality of > 50%.

On an individual site basis, the highest level of carbofuran - 5.15 µg/l- was detected in March at site 2 (Figure 5C). A carbofuran concentration of 5.15 µg/l exceeded laboratory LC50s by a factor of 2 and was 10 times greater than the interim WQC. Due to the sampling regime, it is difficult to determine if there was a spatial relationship to carbofuran inputs, however, in March, carbofuran levels fell by at least half at sites downstream of site 2 (Appendix C). Although carbofuran levels fell as low as 0.92 µg/l (sample 7123), this concentration still exceeded interim WQC by almost a factor of 2.

It is likely that carbofuran was a major contributor to site 2's March ceriodaphnid mortality. TIE results on this sample also suggested carbofuran as the source of toxicity. However, in February, carbofuran concentrations at site 2 were 0.52 µg/l while ceriodaphnid mortalities were 100%. A similar pattern between concentration and mortality was observed at site 6. At site 6, carbofuran levels were 0.23 µg/l in both February and April but high ceriodaphnid mortality occurred only in February (Figure 5C). With respect to site 6, ceriodaphnid mortalities in February may have been the additive result of carbofuran and diazinon. Diazinon at site 6 was detected in February but not in April. With respect to site 2 and site 6 in April, none of the other four pesticides were detected. TIE results at site 2 indicated a non-polar organic as the source of toxicity. Therefore, one or more of the remaining detected pesticides may have contributed to toxicity.

Although site 1 was not included in any analyses, it is interesting to note that of the five pesticides carbofuran was detected twice at site 1. Carbofuran was detected in March, 1993 and February 1994 at 0.34 and 0.04 µg/l, respectively. Both detections were below the interim WQC for carbofuran.

The 96-hr LC50 for neomysids is 4.2 µg/l (unpublished data, this laboratory). In March, carbofuran levels at site 2 exceeded neomysid LC50s by a factor of 1.2. Neomysid mortality was also > 50%. In all other samples, carbofuran levels were below neomysid LC50s.

Carbaryl - Over the length of the river, carbaryl concentrations averaged between 0.005-0.52 µg/l (Table 7). Like diazinon, carbaryl had a bimodal seasonal distribution. Carbaryl was detected in May and June and again in September through November. The highest levels were detected in the fall (0.42 and 0.52 µg/l, September and October, respectively).

There did not appear to be any spatial pattern to carbaryl inputs (Appendix C). In general, carbaryl concentrations at sites 2, 6 and 11 appeared similar to average carbaryl concentrations over the length of the river. However, in October, carbaryl concentrations at site 6 were as high as 1.7 µg/l, over 3 times higher than the river-wide average and above the LC50 for *D. magna* (Figure 5D). Water quality criteria have not been established for carbaryl, however, carbaryl was considered a contributor to ceriodaphnid mortalities based on high fall levels that exceeded the 48-hr *D. magna* LC50s of 1.25 µg/l.

No LC50 data was available for neomysids.

Malathion - Malathion was detected from September through November and again in March. Seasonally, average river-wide values were fairly consistent, ranging from 0.05 0.20 µg/l (Table 7).

Spatially, malathion was detected at all sites except site 1 (Appendix C). Downstream malathion levels appeared to increase slightly over upstream sites, but sampling was not frequent enough to confirm this trend. With the exception of site 5 in March, the highest malathion concentrations were found in the fall, primarily in September and October. Malathion levels between September and November ranged from 0.05 to 0.2 µg/l at site 6 and from 0.08 to 0.27 µg/l at site 11. No malathion was detected during this time period at site 2 (Figure 5E).

The USEPA water quality criteria for malathion is 0.1 µg/l (US EPA, 1986). In all months detected, except March, average river-wide malathion levels were approximately half the criterion level. In March, average river-wide values were twice the WQC. However at specific sites, this criterion was exceeded by as much as a factor of 5 (site 5-0.51 µg/l, 3/15/93). At sites 6 and 11, fall values ranged from half the WQC to nearly 3 times the WQC. Malathion was considered a pesticide(s) contributing to toxicity due to its detection in September and March at levels as high as 0.58 and 0.51 µg/l, (sites 9 and 5, respectively). These concentrations were approximately half the 24-hr *D. magna* LC50s of 0.8 µg/l.

No LC50 data was available for neomysids.

<u>Mortality Patterns vs. Toxic Units</u>

Consolidating the seasonal occurrence of the five pesticides again illustrated the strong relationship between ceriodaphnid mortality and pesticide concentrations (Figure 6). River-wide periods of pesticide concentrations near or above LC50 levels showed a bimodal distribution similar to periods of high ceriodaphnid mortality. Sites 6 and 11 showed similar trends, however, in February, at site 6, concentrations of all five pesticides were below ceriodaphnid LC50 levels. This was also true between October and November at site 2. With respect to neomysids, none of the 5 pesticides occurred at levels between April and August that could explain toxicity (Figure 7).

To standardize the relative contribution of each of the pesticides listed in figures 5 through 8, and to examine the potential effects of additivity, TUs were calculated for each pesticide (Tables 7-9, Figs. 8-10). Toxic unit derivations were discussed in the TIE vs. Toxic Units section of this document.

In general, there was a strong relationship between river-wide periods of ceriodaphnid toxicity and measured pesticide concentrations $\geq$ 1.0 TU (Table 8). This relationship was generally the strongest between September and November when ceriodaphnid mortalities averaged over 90% over the entire length of the river. During this time, carbaryl was below 1 TU while average chlorpyrifos levels never fell below 1 TU and were as high as 2.5 TUs. Between September and October, average diazinon concentrations were $\geq$ 1 TU. Average river-wide malathion levels were always below 0.1 TUs. Both diazinon and carbofuran were at approximately 1 TU in March; however, in February, none of the five pesticides included in our analysis appeared to be at levels capable of causing river-wide ceriodaphnid mortalities of 58%. If the five pesticides detected in this study are additive, then river-wide total TUs for ceriodaphnids between September and November never fell below 1 and were as high as 4.33 TUs in September (Table 8, Figure 8). In December, January, February, March and April total river-wide TUs were 0.24, 0.16, 0.37, 2.0 and 0.16, respectively. With the exception of January and February, average river-wide ceriodaphnid mortalities were > 40% in months with total TUs of 1.0 or greater. Similarly, with the exception of January and February, average river-wide ceriodaphnid mortalities were 20% or less in all months with total TUs of < 1.0.

With the exception of site 2, examination of TUs from a site perspective showed similar trends (Table 9, Figure 9). At sites 6 and 11, between September and November, chlorpyrifos contributions to toxicity in terms of TUs, was greater than any of the other 4 pesticides. Chlorpyrifos TUs between September and November ranged between 1.05-5.83 at site 6 and 1.17-4.0 at site 11. Diazinon TUs during this same period ranged between 0.39-2.45 at site 6 and 0.7-1.68 at site 11 (Table 9). Between September and November, total TUs at sites 6 and 11 never fell below 1 TU. At site 6, total TUs ranged between 1.57 and 9.9, while at site 11 total TUs ranged between 2.15 and 5.39. These periods corresponded to 100% ceriodaphnid mortalities. With the exception of February, all other months with total TUs of 1 or less, corresponded to non-significant ceriodaphnid mortalities.

Site 2 did not follow the pattern between TUs for the five pesticides and ceriodaphnid mortality (Table 9, Figure 9). Ceriodaphnid mortalities were 100% between January and March and October through November, however, only in March were total TUs > 1. In all other cases, total TUs were never greater than 0.63.

Average neomysid mortalities were > 80% in September and October. During these months, chlorpyrifos concentrations were at 2.14 and 1.86 TUs, respectively (Table 8). With the addition of diazinon, TUs were as high as 2.46 in September (Table 8 & Figure 10). During the remainder of the year, there was no clear pattern between TUs and neomysid mortality. Similarly, at sites 6 and 11, only the fall months showed a relationship between TUs and mortality. These results suggest that neomysid mortalities were driven by factors besides these pesticides.

Seasonal Pesticide Application Patterns

The on-line University of California Statewide Integrated Pesticide Management Program (UCSIPM) was used to compare this study's data to pesticide application in pounds for 1990/91, the most recent usage data available. The frequency of occurrence of each of the five pesticides was calculated as the total number of monthly samples tested in which the pesticide was detected divided by the total number of samples chemically analyzed and tested each month. As illustrated in figures 11-15, pesticide applications in 1990 and 1991 were similar to pesticide occurrences and also corresponded to ceriodaphnid mortalities. In contrast, there was little agreement between application of these pesticides between April and August and neomysid mortality (Table 10).

Chlorpyrifos - In this sampling year, chlorpyrifos was detected almost exclusively in the fall with at least 70% of the samples containing chlorpyrifos between September and November (Table 10). In terms of TUs, chlorpyrifos' contribution to ceriodaphnid toxicity was also the greatest.

In 1990 and 1991, with the exception of malathion, chlorpyrifos was the most heavily applied pesticide in Imperial County. Additionally, 80% of the chlorpyrifos applied in 1990 and 1991 was applied between August and November (Figure 11)

Diazinon - With the exception of May, July and August, diazinon was detected in every month of this sampling year. The greatest frequencies of detection occurred between September and November and January through March. Diazinon applications in both 1990 and 1991 had a similar bimodal distribution, with over 75% of the diazinon applications occurring between August and November (Figure 12).

Carbofuran - Both 1990/91 and 1993/94 data illustrated the strong seasonal component associated with carbofuran applications. Over 70% of the carbofuran applied in Imperial County in 1990 and 1991 occurred between February and March. In this sampling year, the only period when carbofuran was detected was between February and April (Figure 13).

Carbaryl and Malathion - Like the preceding pesticides, application patterns of carbaryl and malathion in 1990 and 1991 mirrored periods of peak detections in 1993 and 1994 (Figures 14 and 15, respectively). In this sampling year, > 90% of the samples collected in September and October contained carbaryl. In 1990 and 91, over 70% of the carbaryl applied occurred between August and October.

Malathion detections in 1993/94 also corresponded to 1990/91 applications, however, in this sampling year, malathion was detected the most frequently between September and November, whereas in 1990 and 1991, malathion applications were roughly equal between September and November and February and April.

Pesticide Use by Crop - (1990 and 1991)

Using the UCSIPM program, pesticide application in Imperial County by crop was also examined. Pesticide application for 1990 and 1991 in thousands of pounds by crop and month are illustrated in Figures 21 through 30 and summarized below.

Chlorpyrifos - Chlorpyrifos was applied to a variety of different crops, predominantly between August and November (Figs. 16 & 17). During these months, chlorpyrifos was applied predominantly to alfalfa, cole crops, cotton, and sugar beets. In both years, between August and September over 40% of the chlorpyrifos was applied to alfalfa. Applications to alfalfa declined to 10% or less in October and November. Instead over 75% of the chlorpyrifos applied was to sugar beets.

Diazinon - The largest amounts of diazinon were applied between August and November, with a smaller period of increased use between February and May (Figs. 18 & 19). Like chlorpyrifos, diazinon was applied to a variety of crops between August and November. However, in 1990, 50% of the diazinon applied in August was to cole crops. In a similar period in 1991, approximately 50% was applied to melons. In both September and October of 1990 and 1991, diazinon was applied predominantly to lettuce, sugar beets, and cole crops. Approximately 40% of the diazinon was applied to sugar beets with cole crops and lettuce being the next heaviest users. Between February and May, diazinon was primarily applied to alfalfa.

Carbofuran - In 1990 and 1991, carbofuran was applied predominantly to alfalfa (Figures 20 & 21). In February and March of 1990, 90% of the pesticide was applied to alfalfa. In 1991, all of the carbofuran used in February and March was applied to alfalfa.

Carbaryl - Carbaryl in 1990 and 1991 was applied most heavily in May and June and again in August through October (Figs 22 & 23). Between May and August of both years, over 70% of the carbaryl applied was to melons.

Beginning in September, carbaryl applications to melons declined to < 30%. Instead, between September and October, carbaryl usage intensified on 4 other crops; alfalfa, broccoli, lettuce and sugar beets. In September, 1990, approximately 40% of the carbaryl was applied to lettuce. In September 1991, almost 60% of the carbaryl was applied to sugar beets.

Malathion - Like diazinon, malathion also had a fall and early spring usage pattern, however, the heaviest applications occurred between February and April (Figs. 24 & 25). Between September and November 1990, malathion was applied primarily to 4 crops: alfalfa, cole crops, lettuce and sugar beets. In September, 50% of the malathion was applied to sugar beets. In October, malathion use was similar between the 4 crops; however, in November, 80% of the malathion was applied to lettuce. In 1991, malathion was applied to these 4 crops as well as melons. Unlike 1990, 50% of the malathion was applied to sugar beets, and not lettuce. In both years, between February and March, over 70% of the malathion applied was used on alfalfa.

Discussion

The results of this study show a clear link between ceriodaphnid mortality and agricultural pesticides. TIE procedures identified the sources of toxicity as non-polar organics, and where tested, metabolically activated OPs. Chemical analyses confirmed TIE results. Of the 101 samples tested with ceriodaphnids, 41 caused acute ceriodaphnid toxicity. Based on LC50 values, 28 of these samples contained carbofuran, chlorpyrifos or diazinon at levels known to cause acute toxicity to ceriodaphnid, and/or neomysids. Both carbaryl and malathion may also have caused toxicity because of their potential for additivity and the occurrence of concentrations near, or at, LC50s for *D. magna*.

Other studies within the state have documented the effects of agricultural runoff on aquatic organisms. Ceriodaphnid mortalities in waters collected along a 43-mile-stretch of the San Joaquin River were attributed to pesticide discharges from row and orchard crops (Foe and Connor, 1991a). In a follow-up study, ceriodaphnid toxicity was examined from orchard and alfalfa field runoff (Foe and Sheipline, 1993). With three exceptions, the concentrations of diazinon and methidithion in toxic samples were high enough to explain part, or all, of the ceriodaphnid toxicity from orchard runoff. The results of the alfalfa portion of the study were less conclusive.

TIE procedures proved to be a powerful tool in identifying and confirming the source of ceriodaphnid toxicity. Chemical analyses of toxic samples are important for determining the actual concentrations of suspected toxicants. However, the strength of a TIE procedure lies in its ability to selectively remove (and in some cases, return) a sample's toxicity. In doing so, the actual source of toxicity can be identified. TIE procedures have been used successfully to identify pesticide toxicity from other California agricultural drainage waters, both to *N. mercedis* and *C. dubia* (Bailey et al. 1994; Norberg-King et al., 1991).

Of concern were the occurrence in the Alamo River of several carbamate and OP pesticides. Additivity of carbamate and OP pesticides has been demonstrated in the laboratory with ceriodaphnids (Norberg-King in Foe and Connor, 1991b). In this study, significant ceriodaphnid mortalities generally occurred in samples where individual or total TUs were $\geq$ 1. Between September and November, chlorpyrifos and diazinon occurred or co-occurred in 25 of the 29 samples analyzed (excluding site 1). During this period, total TUs never fell below 1 over the length of the river and average ceriodaphnid mortality was > 90%. Based on TUs, mortalities in March appeared to be driven by carbofuran; however, diazinon and malathion were also detected in March samples. In one sample (sample 7124), diazinon and malathion contributed half of the TUs to the sample. Although predicting river-wide and site specific mortality based on total TUs of $\geq$ 1 worked in most cases, there were exceptions. One explanation for these results may be that pesticides other than the five examined contributed to ceriodaphnid mortality. For example, vapam, as metam-sodium was detected in January at site 2. Metam-sodium levels were below ceriodaphnid 8-day LC50 levels, but very little is known regarding its toxicity to ceriodaphnids. Additionally, the toxic and interactive effects of the remaining 22 detected pesticides are unknown. At these sites, these variables, as well as physical/chemical effects not addressed in this study may have contributed to toxicity.

From both a mortality and chemical standpoint, site 1 (the Alamo River at the All-American Canal) appeared unaffected by factors affecting sites further downstream. As water at site 1 is primarily due to seepage water from the All-American Canal, these results may indicate that All-American Canal water is relatively free of toxicants. Alternatively, the lack of toxicity may reflect the natural binding and filtration of toxicants by soil particles as seepage water moves through the soil prior to its discharge near site 1. Additionally, toxic substances at site 1 may have been diluted to non-toxic concentrations. Site 1 consistently had the highest conductivities and, in some cases, waters were diluted by over 40% prior to testing with *C. dubia*. No other sample site required such large dilutions. However, undiluted samples from this site were not toxic to neomysids.

With respect to neomysids, in September and October, chlorpyrifos levels could have accounted for the high neomysid mortalities. In September and October, chlorpyrifos levels exceeded neomysid LC50s along the 50-mile stretch of river and total TUs were > 2.0. Similarly, where carbofuran was detected above neomysid LC50s (site 2), neomysid mortalities were above 50%. However, in most cases, OP and carbamate levels could not explain the high neomysid mortalities. The different summer mortality responses between neomysids and ceriodaphnids suggests that neomysids were reacting to a different set of toxicant(s) than ceriodaphnids. The identity of these toxicant(s) remains unknown; however, based on pesticide detections, it appears unlikely that the primary toxicant(s) are either OP or carbamate pesticides.

Pyrethroid pesticides have been suggested as one possible source of toxicity; however, the 1990 and 1991 pesticide use reports show relatively little pyrethroid use between April and August (Figure 26). This class of pesticides, however, is extremely toxic at very low concentrations. The sensitivity of *Mysidopsis bahia* to cypermethrin, fenvalerate and permetrin, was 0.018-0.027, 0.032 and 0.095 µg/l, respectively (Cripe, 1994). Thus, relative rates of application may be a misleading indicator of toxicity. Alternatively, neomysid toxicity may be ionic in nature. Like many arid western rivers, the Colorado River which supplies water to the All-American Canal/Alamo River carries a relatively high salt load. The Colorado River carries about 1 ton of salt per acre - foot of water applied to fields (Imperial Valley Agriculture Crop & Livestock Report, 1990) and high levels of selenium (up to 300 ppb) have been detected in agricultural drainage water flowing into the Salton Sea (CRWQCB, briefing papers, 1993, Western Water, 1994). The Federal Water Quality Criteria for protection of aquatic life is 5 ppb. However, site 1, with generally the highest conductivities was never toxic to neomysids.

Toxicity in the Alamo River may affect not only the river itself but the Salton Sea as well. The Salton Sea provides habitat for federally endangered species, spawning and rearing areas for game fish, and is a critical link in the Pacific Flyway. The recent historical application data of these five pesticides corresponded to this study's peak periods of pesticide detections/concentrations and ceriodaphnid mortality. This suggests that in the recent past, the entire Alamo River has experienced extended periods of toxicity on the order of months. No mass balance equations were calculated to determine the loading of these pesticides into the Salton Sea, however, the Alamo River is the largest freshwater contributor to the Salton Sea. Considering the importance of the Salton Sea, extended periods of toxicity in the Alamo River could adversely affect aquatic life not only in the river, but the Salton Sea as well.

Recommendations

Results of this study show a clear link between ceriodaphnid mortality and the occurrence of carbaryl, carbofuran, chlorpyrifos, diazinon and malathion in the Alamo River. Ceriodaphnid acute toxicity and the occurrence of these pesticides in the Alamo River also closely resemble 1990 and 1991 pesticide application patterns in Imperial County. Therefore, it is likely that a reduction in their use should produce a concomitant reduction in ceriodaphnid toxicity in the Alamo River. Application and irrigation practices should be examined to determine methods that would reduce pesticide runoff into the Alamo River and the Salton Sea. To determine the effectiveness of remedial actions, follow-up analytical and toxicity monitoring is recommended.

Of the five pesticides, carbofuran, chlorpyrifos and diazinon frequently occurred in the Alamo River at levels known to cause acute exposure mortality in ceriodaphnids. The evidence for carbaryl and malathion toxicity is less direct; however, due to the potential for additive adverse impacts and/or synergism among these acetyl-cholinesterase inhibiting pesticides, they cannot be ruled out as contributing to toxicity. Determination of ceriodaphnid LC50 and NOEC levels for these two pesticides would help determine their contribution to toxicity in the laboratory studies. Laboratory bioassays to examine additivity or synergism between these and other detected pesticides would be useful in interpreting these data. Regulatory agencies may need to consider the potential additive nature of similarly acting compounds when setting water quality objectives.

The different response patterns by neomysids and ceriodaphnids to the same waters collected in the summer suggest that neomysids may be responding to a different set of toxicants present in the Alamo River. Because of the high frequency and intensity of neomysis toxicity in Alamo River samples, it is important to determine the causes of this toxicity through TIEs and chemical testing.

Finally, it is important to determine if any of these pesticides are being imported from outside the system via the All-American Canal. Therefore, it is recommended that All-American Canal water be tested prior to its input onto fields for irrigation.

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Table 1. Summary of Sample Sites for Colorado River Project (3/15/93 - 2/14/94)

Site #	Sample Location
1	Alamo River at All-American Canal
2	Alamo River downstream of Verde Drain
3	Alamo River (Holtville)
4	Alamo River - Drop 10
5	Alamo River at Worthington Road
6	Alamo River at Harris Street Bridge
7	Alamo River downstream of Holtville Main Drain
8	Alamo River downstream of Rose Drain
9	Alamo River at Shank Road (Magnolia Drain Area)
10	Alamo River at Albright Road (Nectarine Drain Area
11	Alamo River at Outlet
Alternate	Alamo River downstream of South Central Canal

Table 2. Summary of Minimum Detection Limits in µg/l for Pesticides Analyzed by DPR, APPL and Eureka Laboratories (3/93 - 2/94)

Organophosphates	DPR	APPL	EUREKA
Azinphosmethyl	0.05	1.0	0.25
Azinphosmethyl-OA	0.3	-	-
Bolstar sulprofos	-	0.1	0.05
Bromacil	-	-	1.0
Chlorpyrifos	0.05	0.1	0.05
Chlorpyrifos-OA	0.1	-	-
Coumaphos	-	0.1	0.4
DDVP	0.05	-	-
Def	-	0.1	-
Demeton	-	0.2	0.1
Diazinon	0.05	0.1	0.05
Diazoxon	0.05	-	-
Dichlorvos	-	0.2	0.05
Dimethoate	0.05	0.1	0.05
Diphenamid	-	0.1	-
Disulfoton	-	0.1	0.05
EPN	-	-	0.2
EPTC	-	0.1	-
Ethion	-	0.1	-
Ethoprop	0.05	0.1	0.1
Ethyl-Parathion	0.05	-	0.05
Ethyl-Paraoxon	0.05	-	-
Fensulfothion	-	0.2	0.2
Fenthion	-	0.1	0.025
Fonofos	0.05	-	-
Malathion	0.05	0.4	0.1
Malaoxon	-	-	-
Merphos	0.05	0.1	0.25
Methidithion	0.05	-	-
Methidithion-OA	+	-	-
Methyl-Parathion	0.05	0.1	0.05
Methyl-Paraoxon	0.05	-	-
Methyl-Trithion	-	0.2	-
Mevinophos	-	0.7	0.025

Table 2 (cont'd). Summary of Minimum Detection Limits in µg/l for Pesticides Analyzed by DPR, APPL and Eureka Laboratories (3/93 - 2/94)

Organophosphates	DPR	APPL	EUREKA
Monochrotophos	-	-	0.5
Naled	-	0.5	0.3
Parathion	-	0.1	-
Phorate	-	0.1	0.05
Phosalone	0.05	0.1	-
Phosalone-OA	0.05	-	-
Phosmet	0.05	-	-
Phosmet-OA	0.3	-	-
Prometon	-	0.1	-
Prowl pendimethalin	-	0.1	-
Ronnel	-	0.1	0.05
Stirophos	-	-	0.15
Sulfotepp	-	-	0.05
TEPP	-	-	0.1
Thimet phorate	0.05	-	-
Trichloronate	-	0.1	-
Trifluralin	-	0.1	-
Carbamates	**DPR**	**APPL**	**EUREKA**
Aldicarb	0.05	0.4	-
Aldicarb-sulfone	0.05	-	-
Aldicarb-sulfoxide	0.05	-	-
Aminocarb	-	0.4	2.0
Barban	-	3.5	2.0
Benomyl	-	0.4	-
Bromacil	-	0.4	-
Bufencarb	-	-	1.4
Carbaryl	0.05	0.07	2.0
Carbofuran	0.05	0.07	2.0
3-hydroxy carbofuran	0.05	-	-
Chlorpropham	-	3.5	2.0
Chloroxuron	-	0.4	-
Diuron	-	0.4	0.1

Table 2 (cont'd). Summary of Minimum Detection Limits in µg/l for Pesticides Analyzed by DPR, APPL and Eureka Laboratories (3/93 - 2/94)			
Carbamates	**DPR**	**APPL**	**EUREKA**
Fenuron	-	0.4	0.4
Fenuron-TCA	-	-	0.5
Fluorometuron	-	0.4	0.2
Linuron	-	0.07	0.2
Methiocarb	-	0.4	2.0
Mesurol	0.05	-	-
Mesurol-sulfone	0.05	-	-
Mesurol-sulfoxide	0.05	-	-
Methomyl	0.05	0.07	0.7
Mexacarbate	-	3.5	2.0
Monuron	-	0.4	0.5
Monuron-TCA	-	-	0.5
Neburon	-	0.4	0.1
Oxamyl	0.05	0.4	0.2
Proplachlor	-	3.5	-
Propham	-	3.5	0.4
Propoxur	-	0.4	2.0
Siduron	-	0.4	7.5
Swep	-	-	0.8
Tebuthiuron	-	0.4	-
Organochlorines	**DPR**	**APPL**	**EUREKA**
Endosulfan I	0.005	-	+
Endosulfan II	0.005	-	-
Endosulfan SO_4	0.010	-	-

- = not analyzed by laboratory

Table 3 Summary and Interpretation of TIE Procedures used for '93-'94 Alamo River Study	
TIE Procedure	Interpretation
Baseline/Ambient	Used to verify original toxicity from bioassay.
pH 3	Used to determine toxicity from metals and organic acids and bases. Used to determine the presence of organics hydrolyzed at low pHs (for exp., diazinon).
pH 11	Used to determine toxicity from metals and organic acids and bases. Used to determine the presence of organics hydrolyzed at high pHs (for exp., carbofuran).
Aeration	Used to determine toxicity from volatile, sublatable, or oxidizable compounds.
EDTA Chelation	Used to determine toxicity from certain cationic metals including: aluminum, barium, cadmium, cobalt, copper, iron, lead, manganese (II), nickel, strontium and zinc.
$Na_2S_2O_3$ (oxidation/reduction)	Used to determine toxicity from chlorine and some cationic metals including: cadmium (II), copper (II), silver (I), and mercury (II).
C8 or C18 Solid Phase Extraction Columns (SPE)	Used to determine toxicity from non-polar organics.
Methanol Add-back (Eluate)	Used to remove toxicants bound by the SPE column. The methanol eluate is added back to control water to determine if toxicity can be returned following toxicant removal from the column.
Piperonyl butoxide (PBO)	Used to determine the toxicity from metabolically activated compounds that are metabolized via mixed function oxidases (for example, chlorpyrifos, diazinon and malathion).

Note that not all procedures were used with all samples.

Table 4. First Quarter (3/15/93 to 5/24/93) Ceriodaphnid and Neomysid 96-hr Mortality Results

		Ceriodaphnid Mortality Sample Date					Neomysid Mortality Sample Date				
Site #	Sampling Location	3/15/93	4/12/93	4/26/93	5/10/93	5/24/93	3/15/93	4/12/93	4/26/93	5/10/93	5/24/93
1	Alamo River @ AA Canal	0(40)	0(41)	n/s	0(46)	n/s	8	0	n/s	9	n/s
2	Alamo River downstream Verde Drain	*100(17)	0(23)	n/s	0(-)	n/s	*54	*50	n/s	27	n/s
3	Alamo River (Holtville)	*70(23)	0(25)	n/s	0(-)	n/s	23	*50	n/s	*67	n/s
4	Alamo River (Drop 10)	n/s	0(21)	n/s	0(-)	n/s	n/s	42	n/s	*73	n/s
5	Alamo River @ Worthington	*100(20)	0(20)	n/s	0(-)	n/s	*92	*50	n/s	*55	n/s
6	Alamo River @ Harris St. Bridge	n/s	0(22)	0(16)	0(-)	0(-)	n/s	*50	*73	*50	*36
7	Alamo River downstream Holtville Main Drain	n/s	n/s	0(20)	n/s	0(15)	n/s	n/s	*55	n/s	*36
8	Alamo River downstream Rose Drain	n/s	n/s	0(20)	n/s	0(15)	n/s	n/s	*42	n/s	*67
9	Alamo River @ Shank Road	n/s	n/s	0(18)	n/s	0(13)	n/s	n/s	*64	n/s	*42
10	Alamo River @ Albright Road	n/s	n/s	0(19)	n/s	0(-)	n/s	n/s	*36	n/s	*45
11	Alamo River near Outlet	n/s	n/s	0(18)	n/s	0(-)	n/s	n/s	*42	n/s	17
	Control	0	0	0	0	0	7	8	0	0	0
	Alamo River downstream South Central Canal	*60(23)					57				

*Mortality significantly different from control ($p < 0.05$, Fisher's Exact Test)
n/s = not sampled
#s in parenthesis are % dilution of sample

Table 4. Second Quarter (6/7/93 to 8/16/93) Ceriodaphnid and Neomysid 96-hr Mortality Results

		Ceriodaphnid Mortality Sample Date					Neomysid Mortality Sample Date				
Site #	Sampling Location	6/7/93	6/21/93	7/12/93	7/26/93	8/16/93	6/7/93	6/21/93	7/12/93	7/26/93	8/16/93
1	Alamo River @ AA Canal	n/s	0	0(44)	n/s	0	n/s	0	0	n/s	0
2	Alamo River downstream Verde Drain	n/s	0(12)	0	n/s	0(24)	n/s	25	*33	n/s	*92
3	Alamo River (Holtville)	n/s	0	0	n/s	0	n/s	50	*75	n/s	*92
4	Alamo River (Drop 10)	n/s	*100	0	n/s	0	n/s	*67	*100	n/s	*83
5	Alamo River @ Worthington	n/s	0	0	n/s	*100	n/s	*73	*90	n/s	*92
6	Alamo River @ Harris St. Bridge	0	0	0	0(12)	0(15)	*75	42	*67	*58	*83
7	Alamo River downstream Holtville Main Drain	0	n/s	n/s	Bottle broken during shipping	n/s	*67	n/s	n/s	Bottle broken during shipping	n/s
8	Alamo River downstream Rose Drain	0	n/s	n/s	0	n/s	*91	n/s	n/s	*75	n/s
9	Alamo River @ Shank Road	0	n/s	n/s	Bottle broken during shipping	n/s	*83	n/s	n/s	Bottle broken during shipping	n/s
10	Alamo River @ Albright Road	0(16)	n/s	n/s	10	n/s	*92	n/s	n/s	*83	n/s
11	Alamo River near Outlet	0(16)	n/s	n/s	0	n/s	*75	n/s	n/s	*100	n/s
	Control	0	0	0	10	0	0	17	0	0	8

*Mortality significantly different from control ($p < 0.05$, Fisher's Exact Test)
n/s = not sampled
#s in parenthesis are % dilution of sample

Table 4. Third Quarter (9/27/93 to 11/29/93) Ceriodaphnid and Neomysid 96-hr Mortality Results

		Ceriodaphnid Mortality Sample Date					Neomysid Mortality Sample Date				
Site #	Sampling Location	9/27/93	10/4/93	10/18/93	11/1/93	11/29/93	9/27/93	10/4/93	10/18/93	11/1/93	11/29/93
1	Alamo River @ AA Canal	n/s	0(33)	n/s	0	n/s	n/s	8	n/s	n/t	n/s
2	Alamo River downstream Verde Drain	n/s	*100(12)	n/s	*100(15)	n/s	n/s	17	n/s	n/t	n/s
3	Alamo River (Holtville)	n/s	*100	n/s	*50(11)	n/s	n/s	*73	n/s	n/t	n/s
4	Alamo River (Drop 10)	n/s	*100	n/s	*100	n/s	n/s	*92	n/s	n/t	n/s
5	Alamo River @ Worthington	n/s	*100	n/s	*100	n/s	n/s	*100	n/s	n/t	n/s
6	Alamo River @ Harris St. Bridge	*100(15)	*100	*100	*100(12)	*100(18)	*92	*100	*100	n/t	20
7	Alamo River downstream Holtville Main Drain	*100(18)	n/s	*100(23)	n/s	*100(18)	*92	n/s	*100	n/s	*50
8	Alamo River downstream Rose Drain	*100	n/s	*100(23)	n/s	*100(18)	*100	n/s	*83	n/s	20
9	Alamo River @ Shank Road	Bottle broken during shipping	n/s	*100	n/s	*100(12)	Bottle broken during shipping	n/s	*83	n/s	0
10	Alamo River @ Albright Road	*100(17)	*100(15)	*100(18)	n/s	*100(19)	*100	n/t	*100	n/s	0
11	Alamo River near Outlet	*100	*100	*100(13)	n/s	*100(13)	*100	*100	*100	n/s	*60
	Control	0	0	0	0	0	0	0	0	0	0

*Mortality significantly different from control ($p < 0.05$, Fisher's Exact Test)
ns = not sampled
nt = not tested
#s in parenthesis are % dilution of sample

Table 4. Fourth Quarter (12/13/93 to 2/14/94) Ceriodaphnid and Neomysid 96-hr Mortality Results

		Ceriodaphnid Mortality Sample Date				Neomysid Mortality Sample Date			
Site #	**Sampling Location**	**12/13/93**	**1/10/94**	**1/24/94**	**2/14/94**	**12/13/93**	**1/10/94**	**1/24/94**	**2/14/94**
1	Alamo River @ AA Canal	0	n/s	0(32)	0(33)	17	n/s	17	n/t
2	Alamo River downstream Verde Drain	n/s	n/s	*100	*100	n/s	n/s	*58	n/t
3	Alamo River (Holtville)	0(15)	n/s	*100(15)	*100	25	n/s	0	n/t
4	Alamo River (Drop 10)	n/s	n/s	0(13)	0	n/s	n/s	*33	n/t
5	Alamo River @ Worthington	0	n/s	0(13)	10(17)	*33	n/s	*33	n/t
6	Alamo River @ Harris St. Bridge	n/s	0	0(14)	*80(19)	n/s	0	17	n/t
7	Alamo River downstream Holtville Main Drain	n/s	0	n/s	n/s	n/s	0	n/s	n/s
8	Alamo River downstream Rose Drain	0(15)	0	n/s	n/s	8	0	n/s	n/s
9	Alamo River @ Shank Road	n/s	0	n/s	n/s	n/s	8	n/s	n/s
10	Alamo River @ Albright Road	0(16)	0	n/s	n/s	*33	8	n/s	n/s
11	Alamo River near Outlet	*80(15)	0	n/s	n/s	17	0	n/s	n/s
	Control	0	0	0	0	0	0	0	n/t

*Mortality significantly different from control ($p < 0.05$, Fisher's Exact Test)
n/s = not sampled
n/s = not tested
#s in parenthesis are % dilution of sample

Table 5A. TIE Mortality Results for Colorado River Samples Collected 3/15/93

		Sample Number (Site #)			
		7121 (2)		7124 (5)	
		Mortality		Mortality	
	Treatment	24 hrs	48 hrs	24 hrs	48 hrs
	Baseline sample	100%	--	100%	--
	SS EPAMH control	0%	5%	0%	0%
pH Adjustment	pH 3 adjustment (sample)	100%	--	90%	100%
	pH 3 adjustment (Dil. EI)	100%	--	0%	90%
	pH 11 adjustment (sample)	0%	70%	0%	70%
	pH 11 adjustment (Dil. EI)	0%	10%	0%	80%
Chelations	0.24	100%	--	100%	--
EDTA (0.02 M)	0.48	100%	--	90%	--
	1	100%	--	90%	--
mls added to	2	100%	--	80%	--
20 mls sample	0.12	100%	--	100%	--
Oxidation/	0.24	100%	--	100%	--
reduction	0.48	100%	--	100%	--
$Na_2S_2O_3$ (0.16 M)	1	100%	--	100%	--
mls added to	2	100%	--	100%	--
20 mls sample	0.12	100%	--	100%	--
Aeration	Aeration (sample) 50 ml/min	100%	--	100%	--
C8 column	C8 column (sample)	0%	0%	0%	0%
	C8 column (SS EPAMH)	0%	0%	0%	0%
Methanol	Methanol elute (sample C8)	40%	40%	0%	0%
Eluation	Methanol control (MeOH added to Dil. EI.	0%	70%	0%	80%

nt = not tested

Table 5B. TIE Mortality Results for Colorado River Samples Collected 9/27/93

		Sample Number (Site #)					
		7180 (16)		7182 (8)		7185 (11)	
		Mortality		Mortality		Mortality	
	Treatment	24 hrs	48 hrs	24 hrs	48 hrs	24 hrs	48 hrs
	Baseline sample	100%	--	100%	--	100%	--
	Dil. EI (2500 µmhos) control	5%	--	5%	--	5%	--
pH Adjustment	pH 3 adjustment (sample)	13%	--	75%	--	88%	--
	pH 3 adjustment (Dil. EI 2500 µmhos)	0%	--	0%	--	0%	--
	pH 11 adjustment (sample)	nt	--	nt	--	nt	--
	pH 11 adjustment (Dil. EI 2500 µmhos)	nt	--	nt	--	nt	--
Chelations EDTA (0.02 M)	0.24	88%	--	100%	--	100%	--
	0.48	100%	--	100%	--	100%	--
	1	100%	--	100%	--	100%	--
mls added to 40 mls sample	2	100%	--	100%	--	100%	--
	4	100%	--	100%	--	100%	--
Oxidation/ reduction $Na_2S_2O_3$ (0.16 M)	0.24	100%	--	100%	--	100%	--
	0.48	100%	--	100%	--	100%	--
	1	100%	--	100%	--	100%	--
mls added to 40 mls sample	2	nt	--	nt	--	nt	--
	4	nt	--	nt	--	nt	--
Aeration	Aeration (sample)	nt		nt		nt	
C8 column	C8 column (sample)	0%	--	0%	--	0%	--
	C8 column (Dil EI 2500 µmhos)	0%	--	0%	--	0%	--
Methanol Eluation	Methanol elute (sample C8)	25%	--	100%	--	100%	--
	Methanol control (MeOH added to Dil. EI 2500 µmhos)	38%	--	38%	--	38%	--
Repeat of Methanol Experiment	Methanol elute (sample C8)	100%	--	100%	-	100%	--
	Methanol control (MeOH added to Dil. EI 2500 µmhos)	50%	--	50%	--	50%	--
	Dil. EI (2500 µmhos) control	0%	--	0%	--	0%	--

nt = not tested

Table 5C. TIE Mortality Results for Colorado River Samples Collected 10/4/93

		Sample Number (Site #)			
		7188 (2)		7191 (5)	
		Mortality		Mortality	
	Treatment	24 hrs	48 hrs	24 hrs	48 hrs
	Baseline sample	90%	100%	100%	--
	Dil. EI (2500 µmhos) control	0%	0%	0%	0%
pH Adjustment	pH 3 adjustment (sample)	50%	100%	100%	--
	pH 3 adjustment (Dil. EI 2500 µmhos)	0%	10%	0%	10%
	pH 11 adjustment (sample)	100%	--	100%	--
	pH 11 adjustment (Dil. EI 2500 µmhos)	0%	50%	0%	50%
Chelations EDTA (0.02 M) mls added to 40 mls sample	0.24	80%	100%	100%	--
	0.48	90%	100%	100%	--
	1	80%	100%	100%	--
	2	30%	100%	100%	--
	4	60%	100%	100%	--
Oxidation/ reduction $Na_2S_2O_3$ (0.16 M) mls added to 40 mls sample	0.24	100%	--	100%	--
	0.48	100%	--	100%	--
	1	100%	--	100%	--
	2	100%	--	100%	--
	4	100%	--	100%	--
Aeration	Aeration (sample)	nt		nt	
C8 column	C8 column (sample)	0%	0%	0%	0%
	C8 column (Dil. EI 2500 µmhos)	0%	0%	0%	20%
Methanol Eluation	Methanol elute (sample C8)	100%	--	100%	--
	Methanol control (MeOH added to Dil. EI (2500 µmhos)	0%	0%	0%	0%

nt = not tested

Table 5D. TIE Mortality Results for Colorado River Samples Collected 10/18/93

		Sample Number (Site #)					
		7196 (6)		7198 (8)		7201 (11)	
		Mortality		Mortality		Mortality	
	Treatment	24 hrs	48 hrs	24 hrs	48 hrs	24 hrs	48 hrs
	Baseline sample	100%	--	100%	--	100%	--
	Dil. EI (2500 µmhos control)	0%	5%	0%	5%	0%	5%
PBO 100 µg/l	PBO + Sample	40%	100%	0%	0%	100%	--
	PBO 100 µg/l Control (Dil. EI 2500 µmhos)	0%	20%	0%	20%	0%	20%
PBO 300 µg/l	PBO + Sample	0%	20%	0%	0%	0%	30%
	PBO Control (Dil. EI 2500 µmhos)	0%	30%	0%	30%	0%	30%
	Methanol Control (MeOH added to Dil. EI 2500 µmhos) 0.1%	0%	0%	0%	0%	0%	0%

Table 5E. TIE Mortality Results for Colorado River Samples Collected 11/1/93

		Sample Number (Site #)					
		7205 (4)		7206 (5)		7207 (6)	
		Mortality		Mortality		Mortality	
	Treatment	24 hrs	48 hrs	24 hrs	48 hrs	24 hrs	48 hrs
	Baseline sample	95%	100%	90%	100%	100%	--
	Dil. EI (2500 µmhos) control	5%	5%	5%	5%	5%	5%
pH Adjustment	pH 3 adjustment (sample)	nt		nt		nt	
	pH 3 adjustment Dil. EI (2500 µmhos)	nt		nt		nt	
	pH 11 adjustment (sample)	nt		nt		nt	
	pH 11 adjustment Dil. EI (2500 µmhos)	nt		nt		nt	
Chelations EDTA (0.02 M) mls added to 40 mls sample	0.24	80%	100%	90%	100%	100%	--
	0.48	100%	--	100%	--	100%	--
	1	100%	--	100%	--	100%	--
	2	100%	--	90%	100%	100%	--
	4	100%	--	100%	--	100%	--
Oxidation/ reduction $Na_2S_2O_3$ (0.16 M) mls added to 40 mls sample	0.24	nt		nt		nt	
	0.48	nt		nt		nt	
	1	nt		nt		nt	
	2	nt		nt		nt	
	4	nt		nt		nt	
Aeration	Aeration (sample)	nt		nt		nt	
C8 column	C8 column (sample)	0%	0%	0%	0%	0%	0%
	C8 column (Dil EI 2500 µmhos)	0%	0%	0%	30%	10%	10%
Methanol Eluation	Methanol elute (sample C8)	100%	--	100%	--	100%	
	Methanol control (MeOH added to Dil. EI 2500 µmhos)	10%	20%	10%	20%	10%	20%
PBO 100 µg/l	PBO + sample	10%	20%	0%	0%	40%	50%
	PBO Control (Dil. EI 2500 µmhos)	0%	0%	0%	0%	0%	0%
PBO 300 µg/l	PBO + Sample	10%	10%	0%	0%	0%	0%
	PBO Control (Dil. EI 2500 µmhos)	0%	0%	0%	0%	0%	0%

nt = not tested

Table 5F. TIE Mortality Results for Colorado River Samples Collected 11/29/93

	Treatment	7208 (6) Mortality 24 hrs	7208 (6) Mortality 48 hrs	7210 (8) Mortality 24 hrs	7210 (8) Mortality 48 hrs	7213 (11) Mortality 24 hrs	7213 (11) Mortality 48 hrs
	Baseline sample	100%	--	100%	--	100%	--
	Dil. EI (2500 µmhos control)	0%	0%	0%	0%	0%	0%
pH Adjustment	pH 3 adjustment (sample)	70%	100%	100%	--	100%	--
	pH 3 adjustment (Dil. EI 2500 µmhos)	0%	0%	0%	0%	0%	0%
	pH 11 adjustment (sample)	nt		nt		nt	
	pH 11 adjustment (Dil. EI 2500 µmhos)	nt		nt		nt	
Chelations EDTA (0.02 M) mls added to 40 mls sample	0.24	nt		nt		nt	
	0.48	nt		nt		nt	
	1	nt		nt		nt	
	2	nt		nt		nt	
	4	nt		nt		nt	
Oxidation/ reduction $Na_2S_2O_3$ (0.16 M) mls added to 40 mls sample	0.24	nt		nt		nt	
	0.48	nt		nt		nt	
	1	nt		nt		nt	
	2	nt		nt		nt	
	4	nt		nt		nt	
Aeration	Aeration (sample)	nt		nt		nt	
C8 column	C8 column (sample)	0%	0%	0%	0%	0%	0%
	C8 column (Dil EI 2500 µmhos)	0%	0%	0%	0%	0%	0%
Methanol Eluation	Methanol elute (sample C8)	0%	70%	40%	100%	100%	--
	Methanol control (MeOH added to Dil. EI 2500 µmhos)	0%	0%	0%	0%	0%	0%
PBO 200 µg/l	PBO + Sample	0%	0%	0%	0%	9%	9%
	PBO Control (Dil. EI 500 µmhos)	0%	0%	0%	0%	0%	0%

nt = not tested

Table 5G TIE Mortality Results for Colorado River Samples Collected 1/24/94

		Sample Number (Site #)					
		7229 (2)			7230 (3)		
		Mortality			Mortality		
	Treatment	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
	Baseline sample	10%	85%	100%	0%	15%	90%
	Dil. EI (2500 μmhos control)	0%	0%	25%	0%	0%	25%
pH Adjustment	pH 3 adjustment (sample)	10%	90%	100%	0%	0%	100%
	pH 3 adjustment (Dil. EI 2500 μmhos)	0%	0%	0%	0%	0%	0%
	pH 11 adjustment (sample)	nt			nt		
	pH 11 adjustment (Dil. EI 2500 μmhos)	nt			nt		
Chelations EDTA (0.02 M) mls added to 40 mls sample	0.24	0%	40%	40%	0%	0%	0%
	0.48	10%	90%	90%	0%	10%	80%
	1	60%	90%	100%	0%	0%	100%
	2	10%	100%	--	0%	0%	100%
	4	20%	80%	100%	0%	30%	100%
Oxidation/ reduction $Na_2S_2O_3$ (0.16 M) mls added to 40 mls sample	0.24	nt			nt		
	0.48						
	1						
	2						
	4						
Aeration	Aeration (sample)	nt			nt		
C8 column	C8 column (sample)	60%	100%	--	0%	0%	10%
	C8 column (Dil EI 2500 μmhos)	0%	0%	0%	0%	0%	10%
Methanol Eluation	Methanol elute (sample C8)	0%	0%	0%	0%	0%	0%
	Methanol control (MeOH added to Dil. EI 2500 μmhos)	0%	0%	0%	0%	0%	0%
200 μg/l PBO	PBO Sample	40%	60%	90%	0%	20%	20%
	PBO Control (Dil. EI 500 μmhos)	0%	0%	0%	0%	0%	0%

nt = not tested

Table 5H TIE Mortality Results for Colorado River Samples Collected 2/14/94

		Sample Number (Site #)			
		7236 (2)		7237 (3)	
		Mortality		Mortality	
	Treatment	24 hrs	48 hrs	24 hrs	48 hrs
	Baseline sample	65%	100%	0%	100%
	Dil. EI (2500 µmhos control)	0%	0%	0%	0%
pH Adjustment	pH 3 adjustment (sample)	10%	100%	0%	100%
	pH 3 adjustment (Dil. EI 2500 µmhos)	0%	0%	0%	0%
	pH 11 adjustment (sample)				
	pH 11 adjustment (Dil. EI 2500 µmhos)				
Chelations EDTA (0.02 M) mls added to 40 mls sample	0.24	10%	100%	0%	100%
	0.48	0%	100%	0%	100%
	1	0%	100%	0%	100%
	2	0%	100%	0%	100%
	4	10%	100%	0%	100%
Oxidation/ reduction $Na_2S_2O_3$ (0.16 M) mls added to 40 mls sample	0.24				
	0.48				
	1				
	2				
	4				
Aeration	Aeration (sample)				
C8 column	C8 column (sample)	0%	0%	0%	0%
	C8 column (Dil EI 2500 µmhos)	0%	0%	0%	0%
Methanol Eluation	Methanol elute (sample C8)	100%	-	0%	100%
	Methanol control (MeOH added to Dil. EI 2500 µmhos)	0%	0%	0%	0%
200 µg/l PBO	PBO Sample	0%	0%	0%	0%
	PBO Control (Dil. EI 500 µmhos)	0%	0%	0%	0%

nt = not tested

Table 6. Summary of Pesticides detected in the Alamo River (3/93 - 2/94)

	Highest Concentration Detected		LC50 (µg/l)			
Pesticide	µg/l	Quarter	48 hr	96 hr	Organism	Ref Number
Bolstar sulprofos	1.0	III	--	--	--	--
CARBARYL	1.71	III	1.25		*D. magna*	1
CARBOFURAN	5.15	I		2.23, 2.53 > 4.2	*C. dubia* *N. mercedis*	1
CHLORPYRIFOS	0.35	III		0.06 0.07	*C. dubia* *N. mercedis*	2
Cygon dimethoate	1.67	I	--	--	--	
Demeton	0.18	III		27.0	*Gammarus fasciatus*	1
DIAZINON	1.5	III		0.41, 0.47 1.91	*C. dubia* *N. mercedis*	2
Dimethoate	0.35	IV	110-6400		*D. magna*	AQUIRE
Diuron	2430	I		5800 4300	*C. dubia* *N. mercedis*	4
Endosulfan I	0.22	II	form? 52.9 - 56.0		*D. magna*	AQUIRE
Endosulfan II	0.17	II	form? 52.9 - 56.0		*D. magna*	AQUIRE
Endosulfan S04	0.58	II	form? 52.9 - 56.0		*D. magna*	AQUIRE
EPTC	23.0	IV	?			
Fenuron-TCA	1.44	II	--	--	--	--
Fonofos	0.06	III	--	0.27 3.6	*C. dubia* *N. mercedis*	4
Imidan phosmet	0.63	I	--	--	--	--
Linuron	0.71	IV	24 hr EC50 310-590		*D. magna*	AQUIRE
MALATHION	0.58	III	24 hr - 0.8		*D. magna*	3

Table 6 (Cont'd). Summary of Pesticides detected in the Alamo River (3/93 - 2/94)						
	Highest Concentration Detected		LC50 (µg/l)			
Pesticide	µg/l	Quarter	48 hr	96 hr	Organism	Ref Number
Methomyl	1.4	III		9.4 205.26	*C. dubia* *N. mercedis*	1
Phorate	0.22	IV		0.60	*G. fasciatus*	3
Propham	132	I	10000		*D. pulex*	3
Prowl pendimethalin	0.10	IV	?			
Swep	745	I	?			
Thimet phorate	0.075	IV		9 0.60	*G. lacustris* *G. fasciatus*	3
Trifluralin	0.10	IV	193		*D. magna*	AQUIRE
Vapam (as metamsodium)	56.6	IV		8 day 690	*C. dubia*	Sierra Foothill Laboratories (personal communication)

[1]Sheipline, R. 1993. Background Information on Nine Selected Pesticides. Staff Report CVRWQCB. 144 pgs.

[2]UC Davis Aquatic Toxicology Laboratory, unpublished data

[3]Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals. 1st edition. Van Nostrand Reinhold Company. 1310 pages.

[4]Issac, G. and P. Phillips. 1994. Toxicity of Agricultural Chemicals to Water Fleas and Young Mysid Shrimp. California Department of Fish & Game. Environmental Services Division. Administrative Report 94-2. 28 pgs.

Table 7. Average Pesticide Concentrations and Average Ceriodaphnid Toxic Units for Carbaryl, Carbofuran, Chlorpyrifos, Diazinon and Malathion in the Alamo River by Month (3/93 - 2/94)

Pesticide	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Carbaryl 48-hr *D. magna* LC50 = 1.25	--	--	--	--	0.05 0.08 n = 8 x = 0.02 (0.03) TU_D = 0.02	0.1 0.13 0.15 0.21 0.23 n = 11 x = 0.07 (0.09) TU_D = 0.06	--	--	0.29 0.31 0.32 0.32 0.84 n = 5 x = 0.42 (0.24) TU_D = 0.34	0.06 0.12 0.14 0.15 0.2 0.21 0.24 0.34 0.35 n = 13 x = 0.14 (0.13) TU_D = 0.42	0.02 0.03 n = 11 x = 0.005 (0.01) TU_D = 0.003	--
Carbofuran 96-hr *C. dubia* LC50 = 2.38	--	0.16 0.2 0.23 0.28 0.52 n = 5 x = 0.28 (0.14) TU_C = 0.12	0.92 1.13 2.53 5.15 n = 4 x = 2.43 (1.95) TU_C = 1.02	0.23 0.24 0.25 0.25 0.36 0.36 n = 11 x = 0.15 (0.15) TU_C = 0.06	--	--	--	--	--	--	--	--
Chlorpyrifos 96-hr *C. dubia* LC50 = 0.06	--	--	--	0.05 n = 11 x = 0.005 (0.02) TU_C = 0.08	--	--	--	--	0.06 0.14 0.15 0.19 0.20 n = 5 x = 0.15 (0.06) TU_C = 2.5	0.06 0.12 0.14 0.15 0.2 0.21 0.24 0.34 0.35 n = 13 x = 0.14 (0.13) TU_C = 2.33	0.06 0.06 0.06 0.07 0.1 0.1 0.16 n = 11 x = 0.06 (0.05) TU_C = 1.00	0.07 n = 5 x = 0.01 (0.03) TU_C = 0.17

Table 7 (Cont'd). Average Pesticide Concentrations and Average Ceriodaphnid Toxic Units for Carbaryl, Carbofuran, Chlorpyrifos, Diazinon and Malathion in the Alamo River by Month (3/93 - 2/94)

Pesticide	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Diazinon 96-hr *C. dubia* LC50 = 0.44	0.05 0.09 0.21 n = 5 x = 0.07 (0.09) TU_C = 0.16	0.06 0.08 0.09 0.14 0.18 n = 5 x = 0.11 (0.05) TU_C = 0.25	0.28 0.29 0.34 0.35 n = 4 x = 0.32 (0.04) TU_C = 0.73	0.09 n = 11 x = 0.008 (0.03) TU_C = 0.020	--	0.06 0.29 n = 11 x = 0.03 (0.09) TU_C = 0.07	--	--	0.38 0.45 0.73 0.74 0.80 n = 5 x = 0.62 (0.19) TU_C = 1.41	0.18 0.18 0.19 0.20 0.34 0.41 0.42 0.46 0.53 0.57 0.76 1.08 n = 13 x = 0.41 (0.29) TU_C = 0.93	0.12 0.17 0.20 0.20 0.28 0.3 0.31 0.36 0.41 n = 11 x = 0.21 (0.14) TU_C = 0.48	0.13 n = 5 x = 0.03 (0.06) TU_C = 0.07
Malathion 24-hr *D. magna* LC50 = 0.8	--	--	0.08 0.08 0.14 0.51 n = 4 x = 0.20 (0.21) Tu_D = 0.25	--	--	--	--	--	0.06 0.07 0.08 0.09 n = 5 x = 0.06 (0.04) TU_D = 0.08	0.08 0.13 0.16 0.27 0.20 n = 13 x = 0.06 (0.09) TU_D = 0.08	0.05 0.06 0.061 0.096 0.23 n = 11 x = 0.05 (0.07) TU_D = 0.06	-- 0.08
% Cerio Mort (std. dev.)	40 (55)	58 (49.2)	82.5 (20.6)	0	0	9.1 (30)	1.11 (3.3)	20 (45)	100	100	95 (15.1)	16 (36)

TU_D = Toxic Units *D. magna*

TU_C = Toxic Units *C. dubia*

n = number of samples tested and chemically analyzed.

Numbers in parentheses represents $\pm$ 1 std. dev.

Note - Mortality results calculated from chemically analyzed samples

Table 8. Average Ceriodaphnid and Neomysid Mortality on the Alamo River vs. Toxic Units (TUs) (3/93 - 2/94)

Ceriodaphnid												
Pesticide	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Carbaryl TUs					0.02	0.06			0.34	0.42	0.003	
Carbofuran TUs		0.12	1.02	0.06								
Chlorpyrifos TUs				0.08					2.5	2.33	1.0	0.17
Diazinon TUs	0.16	0.25	0.73	0.02		0.07			1.41	0.93	0.48	0.07
Malathion TUs			0.25						0.08	0.08	0.06	
Total TUs	0.16	0.37	2.00	0.16	0.02	0.13			4.33	3.76	1.54	0.24
Mean ceriodaphnid mortality	40	58	82.5	0	0	9.1	1.11	20	100	100	95	16
Neomysid												
Pesticide	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Carbofuran TUs			0.58	0.04								
Chlorpyrifos TUs				0.07					2.14	1.86	1.14	0.14
Diazinon TUs	0.04		0.17	0.004		0.02			0.32	0.21	0.14	0.04
Total TUs	0.04		0.75	0.11		0.02			2.46	2.07	1.28	0.18
Mean neomysid mortality	28.2	n/t	56.5	50.4	47.9	67.2	75.7	88.4	96.8	87.3	25	23.2

nt = not tested

Table 9. Ceriodaphnid Mortality by Site vs. Toxic Units (Alamo River, 3/93 - 2/94)

Site 2

Pesticide	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Carbaryl						0.12						
Carbofuran		0.22	2.16									
Diazinon		0.41	0.66							0.45		
Malation			0.18									
Total TUs		0.63	3.00			0.12				0.45		
% Mortality	100	100	100	0	0	0	0	0	ns	100	100	ns

Site 6

Pesticide	Jan.	Feb.	March	April	April	May	May	June	June	July	July	Aug.	Sept.	Oct.	Oct.	Nov.	Nov.	Dec.
Carbaryl							0.04		0.1				0.23	1.37	0.66	0.02		
Carbofuran		0.1			0.1													
Chlorpyrifos													2.33	5.83	2	1.67	1.05	
Diazinon	0.48	0.18							0.14				0.86	2.45	0.43	0.68	0.39	
Malathion													0.06	0.25			0.13	
Total TUs	0.48	0.28			0.1		0.04		0.24				3.48	9.9	3.09	2.37	1.57	
% Mortality	0	80	ns	0	0	0	0	0	0	0	0	0	100	100	100	100	100	ns

Site 11

Pesticide	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Oct.	Nov.	Dec.
Carbaryl					0.06				0.26	0.34	0.16		
Carbofuran				0.15									
Chlorpyrifos									3.33	4	3.5	1.17	1.08
Diazinon				0.2					1.68	1.05	1.3	0.70	0.30
Malation									0.1		0.34	0.28	
Total TUs				0.35	0.06				5.37	5.39	5.3	2.15	1.38
% Mortality	0	ns	ns	0	0	0	0	ns	100	100	100	100	80

ns = not sampled

Table 10. Percent Pesticide Frequency of Occurrence Alamo River 3-93 - 2/94

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Carbaryl	0	0	0	0	25	45	0	0	100	92	18	0
Carbofuran		100	100	55								
Chlorpyrifos			0	9					100	70	72	20
Diazinon	60	100	100	9		18			100	92	82	20
Malathion			100	0					80	30	56	
Avg % Mort (cerios)	40	58	82.5	0	0	9.1	1.11	20	100	100	95	16
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Carbaryl	0		0	0	25	45	0	0	100	92	0	0
Carbofuran			100	55								
Chlorpyrifos				9					100	75	100	20
Diazinon	60		100	9		18			100	92	100	20
Malathion			100	0					80	33	100	
Avg % Mort (mysids)	28.2	nt	56.5	50.4	47.9	67.2	75.7	88.4	96.8	87.3	25	23.2

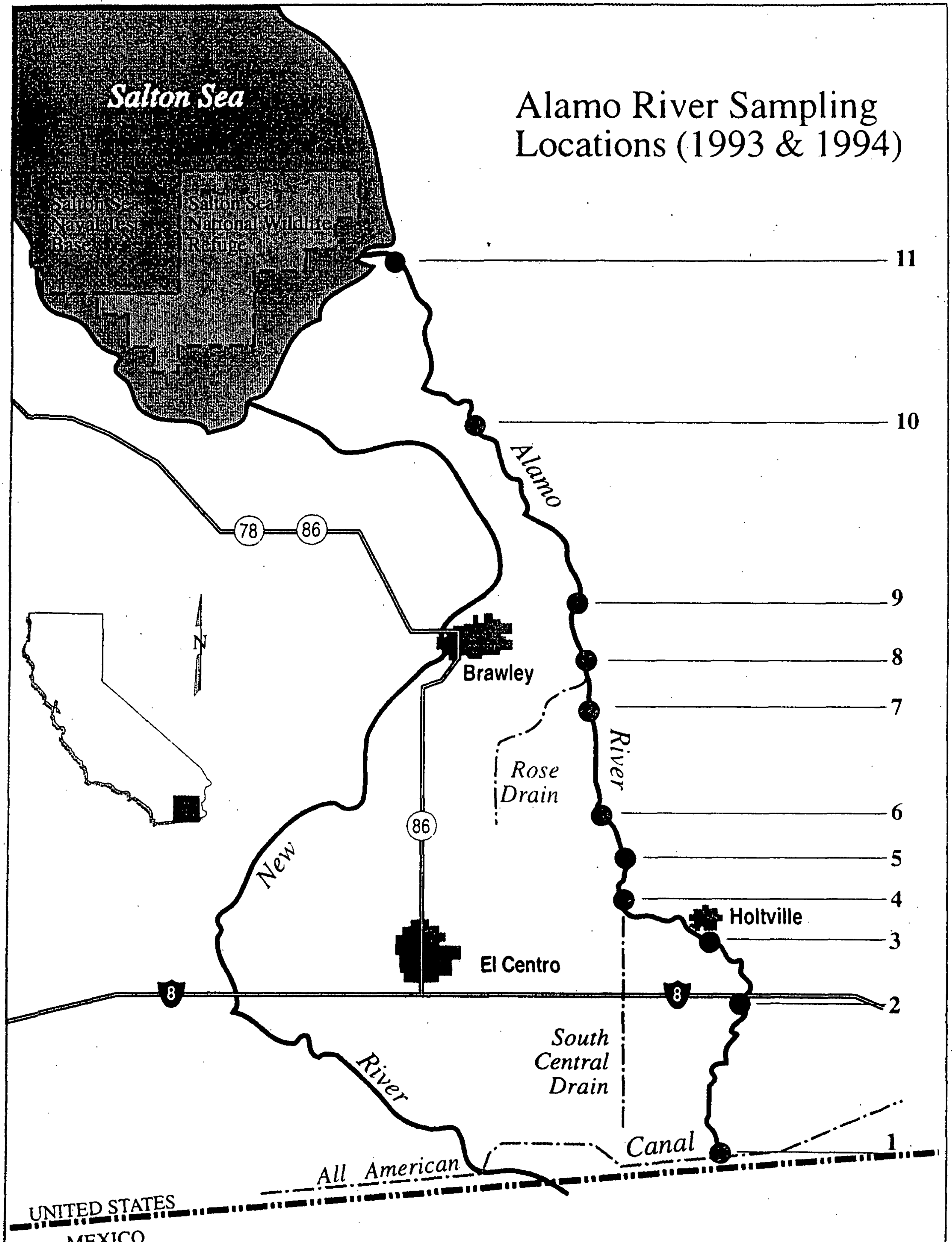
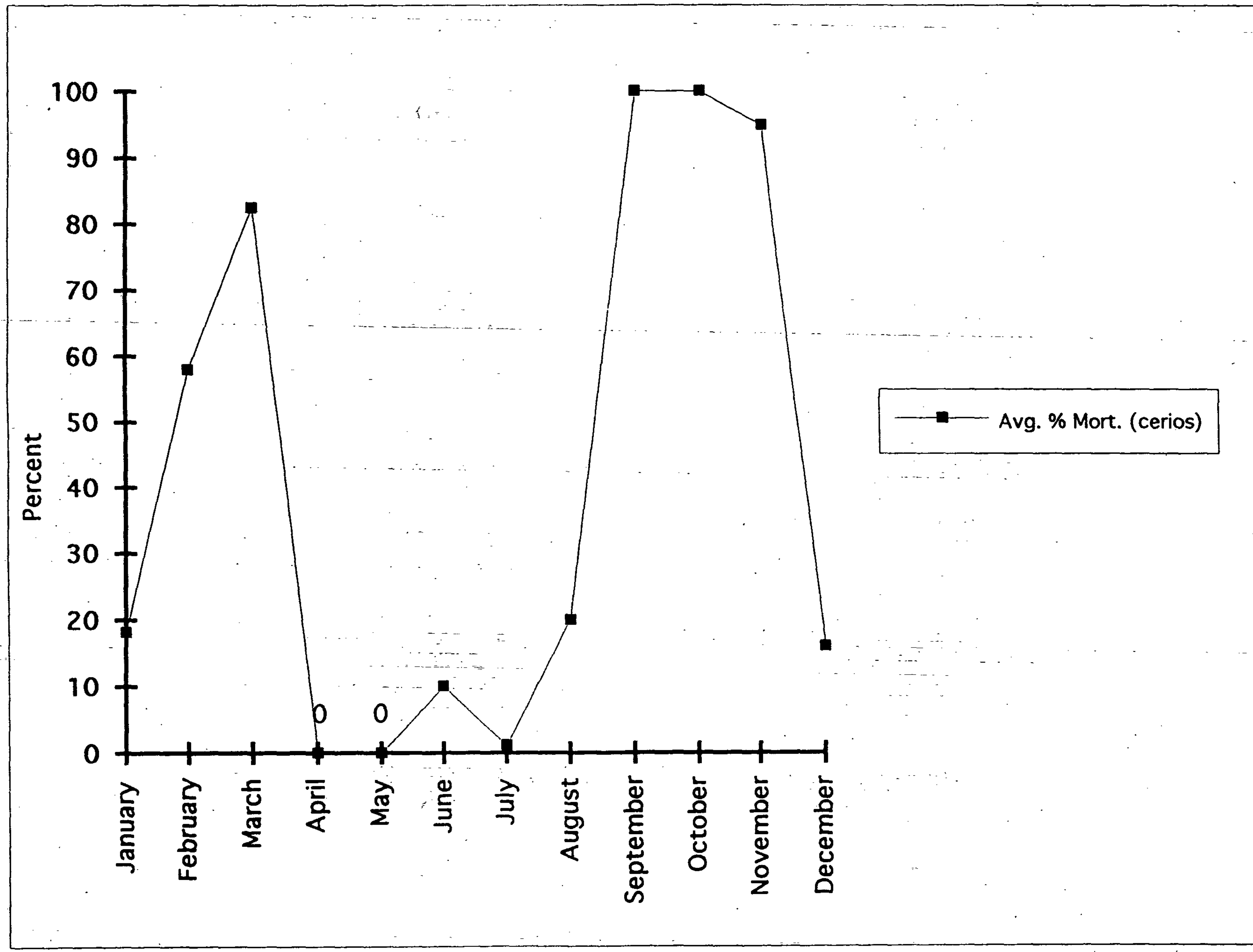


Figure 1. Alamo River Sampling Locations (1993-1994)

Figure 2. Average River-wide Ceriodaphnid Mortality by Month



65

Figure 3. Average River-wide Neomysid Mortality by Month (nt = not tested)

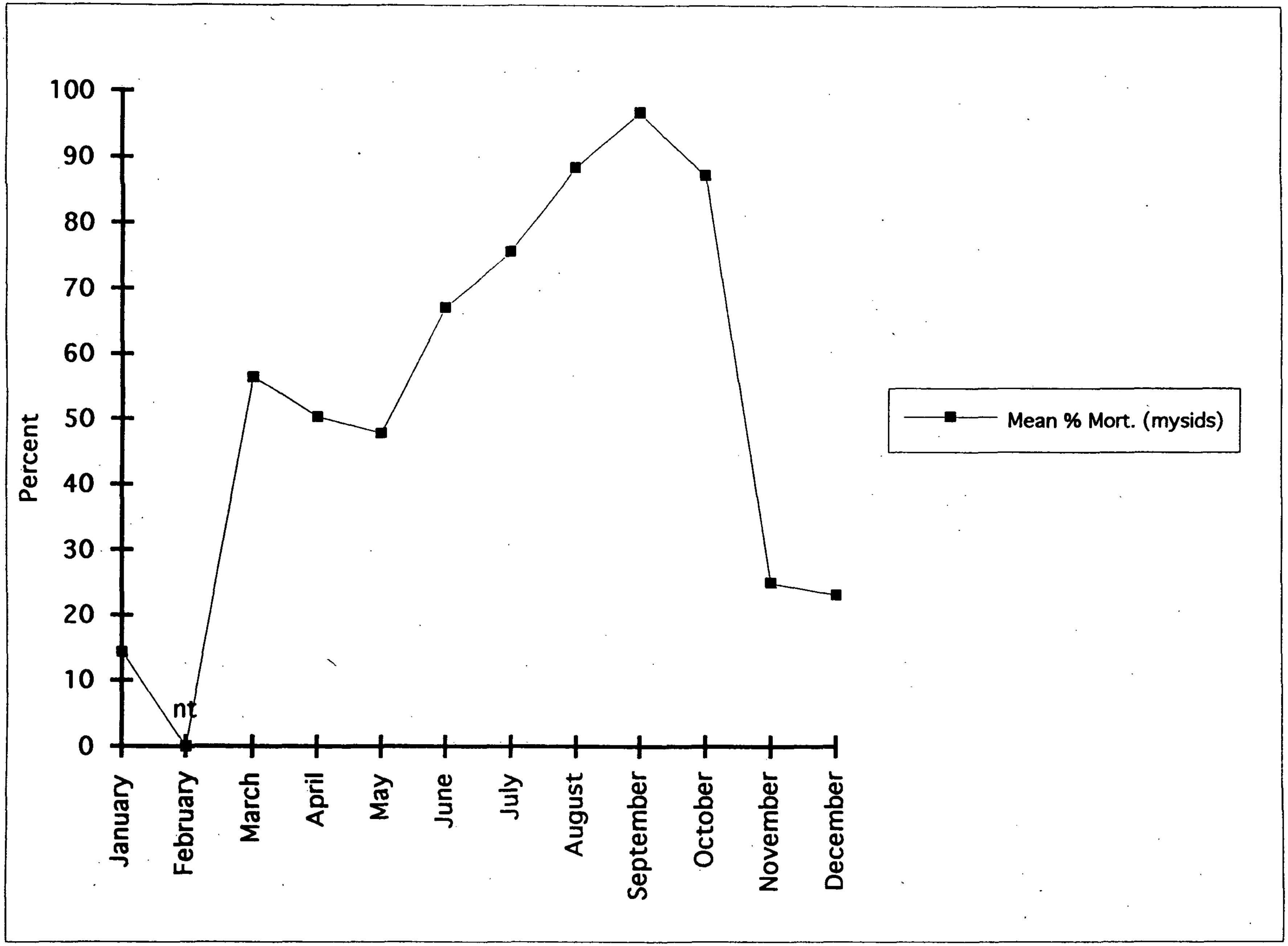
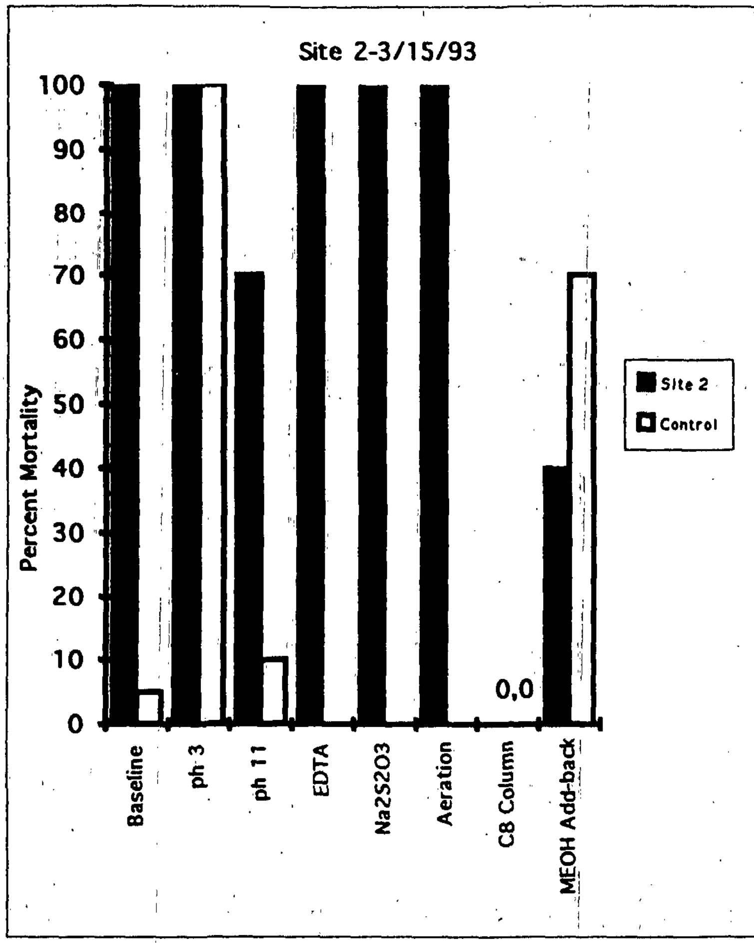


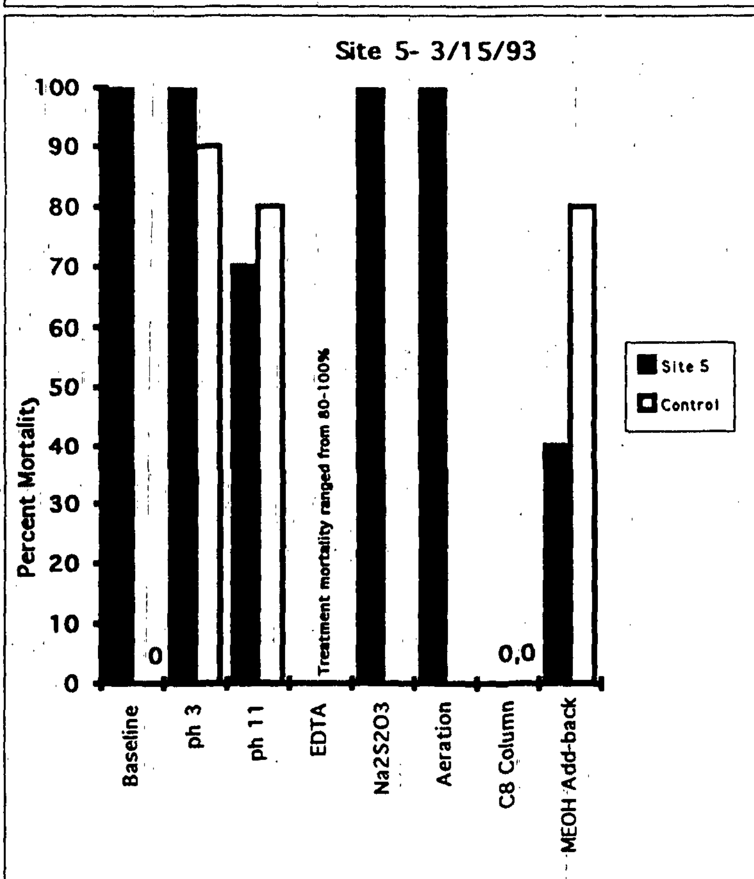
Figure 4A. TIEs vs. Chemical Results-March 1993



Site 2 (#7121)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbofuran	5.15	2.38	2.16
Diazinon	0.29	0.44	0.66
Malathion	0.14	0.8	0.18

Total TUs	3



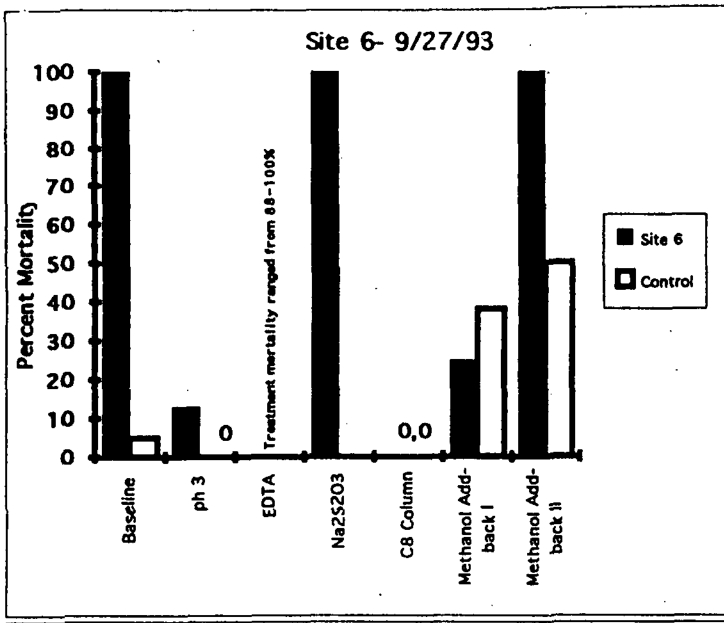
Site 5 (#7124)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbofuran	2.53	2.38	1.06
Diazinon	0.35	0.44	0.8
Malathion	0.51	*0.8	0.64

Total TUs	2.5

* D. magna 24 hr LC50

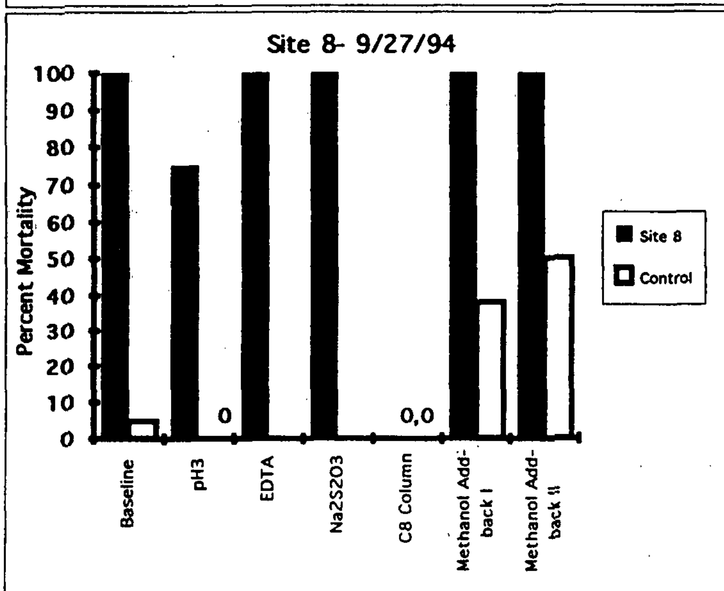
Figure 4B. TIEs vs. Chemical Results-September 1993



Site 6 (#7180)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.29	*1.25	0.23
Chlorpyrifos	0.14	0.06	2.33
Diazinon	0.38	0.44	0.86
Malathion	0.05	**0.8	0.06
		Total TUs	3.48

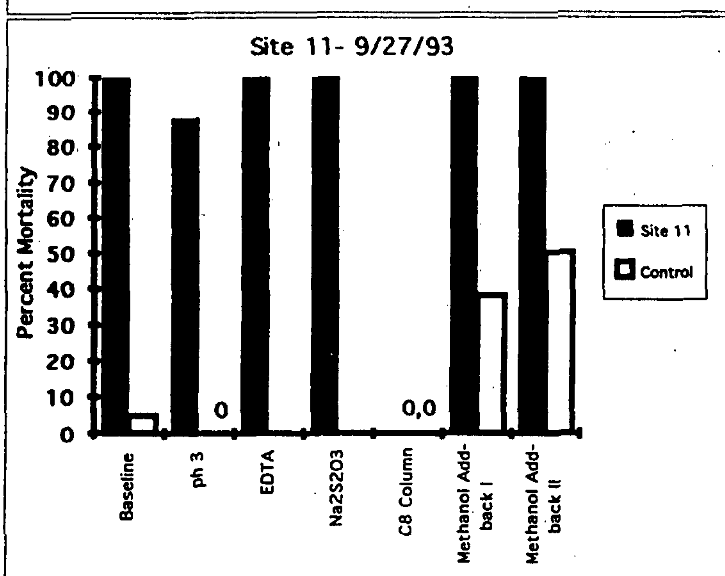
* 48 hr D. magna LC50
** 24 hr D. magna LC50



Site 8 (#7182)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.31	*1.25	0.25
Chlorpyrifos	0.15	0.06	2.5
Diazinon	0.8	0.44	1.81
Malathion	0.06	**0.8	0.08
		Total TUs	4.64

*48 hr D. magna LC50
**24 hr D. magna LC50

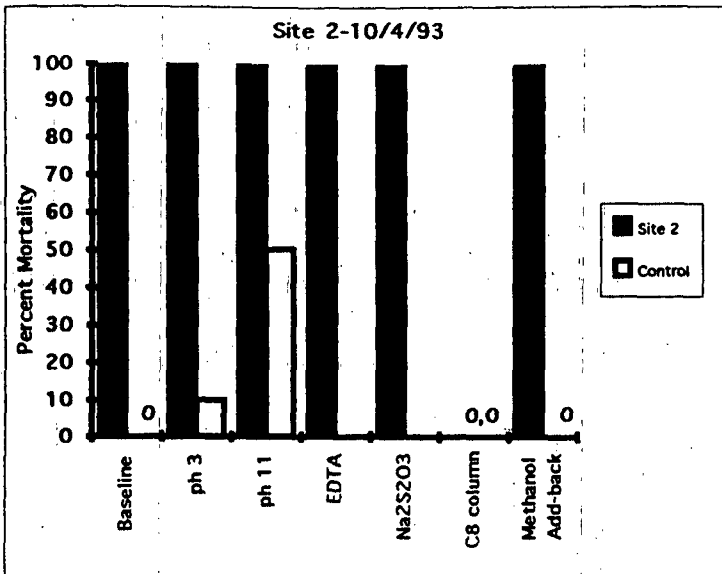


Site 11 (#7185)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.32	*1.25	0.26
Chlorpyrifos	0.2	0.06	3.33
Diazinon	0.74	0.44	1.68
Malathion	0.08	**0.8	0.1
		Total TUs	5.37

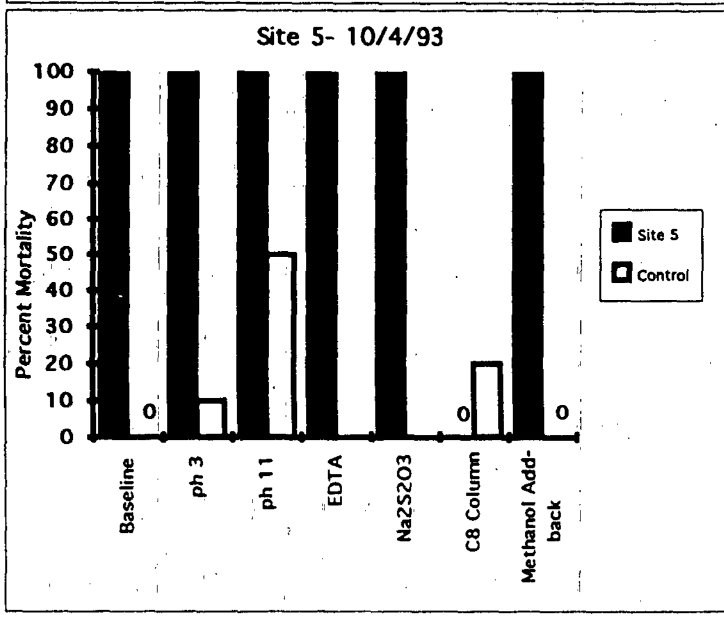
*48 hr D. magna LC50
**24 hr D. magna LC50

Figure 4C. TIEs vs. Chemical Results-October 1993



Site 2 (#7188)
Chemistry Results

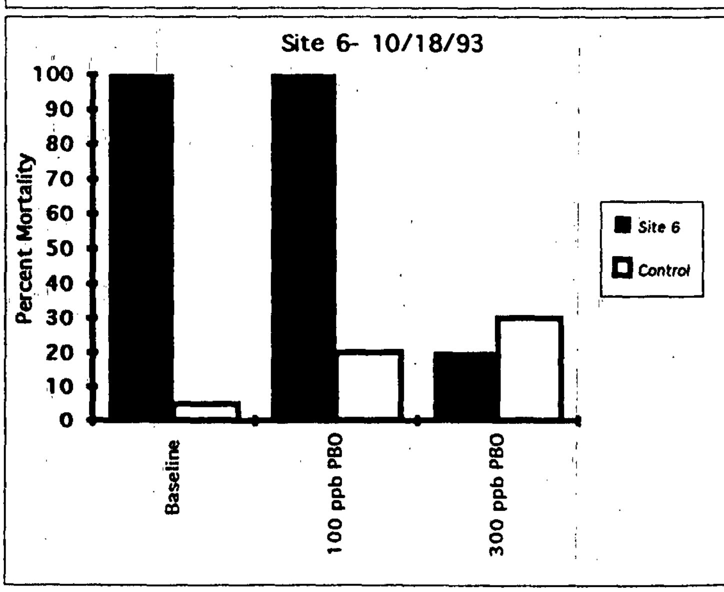
Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Diazinon	0.2	0.44	0.45
		Total TUs	0.45



Site 5 (#7191)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	1.57	*1.25	1.26
Chlorpyrifos	0.34	0.06	5.67
Diazinon	0.76	0.44	1.72
Malathion	0.13	**0.8	0.16
		Total TUs	8.81

* D. magna 48 hr LC50
** D. magna 24 hr LC50

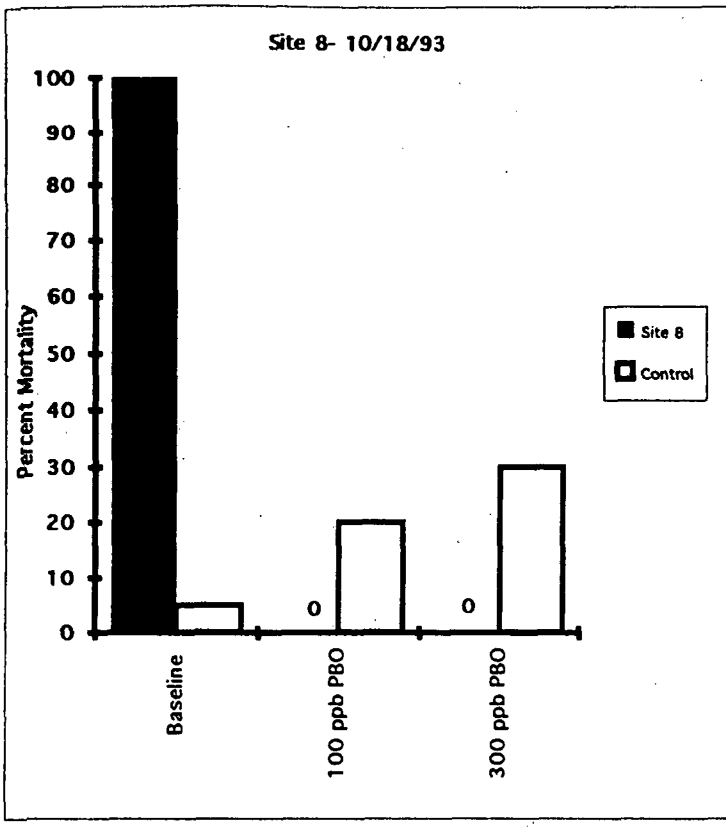


Site 6 (#7196)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.82	*1.25	0.66
Chlorpyrifos	0.12	0.06	2
Diazinon	0.19	0.44	0.43
		Total TUs	3.09

* 48 hr D. magna LC50

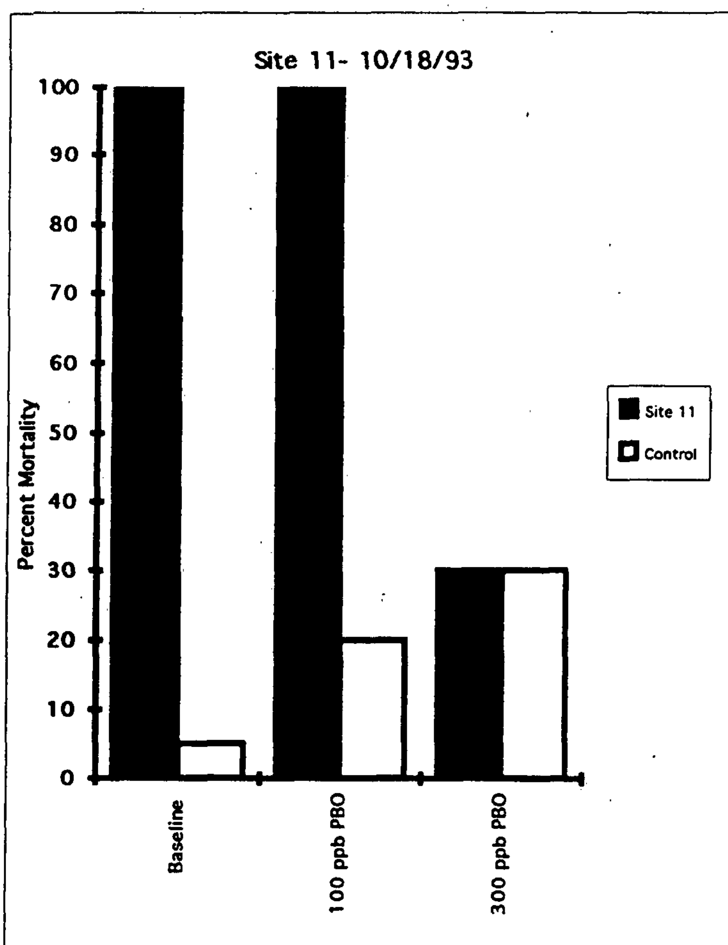
Figure 4C. TIEs vs. Chemical Results-October 1993 (continued)



Site 8 (#7198)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.32	*1.25	0.26
Diazinon	0.18	0.44	0.41
		Total TUs	0.67

*48 hr D. magna LC50

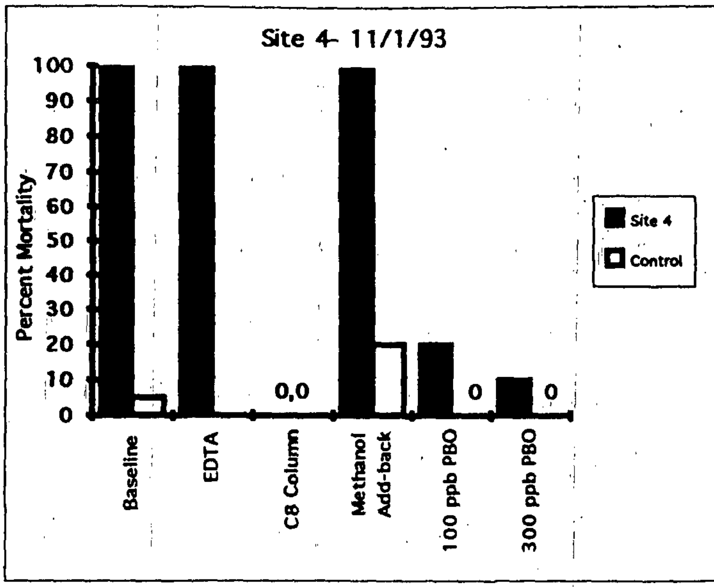


Site 11 (#7201)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.2	*1.25	0.16
Chlorpyrifos	0.21	0.06	3.5
Diazinon	0.57	0.44	1.3
Malathion	0.27	**0.8	0.34
		Total TUs	5.3

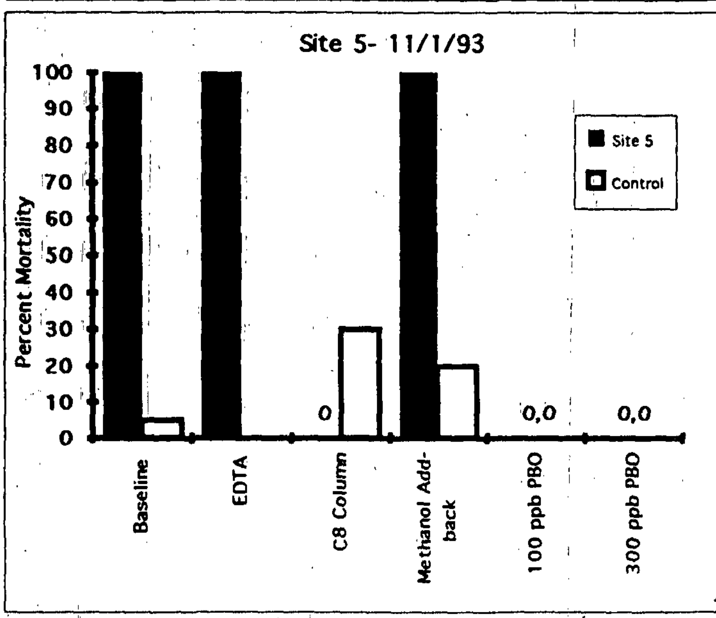
*48 hr D. magna LC50
**24 hr D. magna LC50

Figure 4D. TIEs vs. Chemical Results-November 1993



Site 4 (#7205)
Chemistry Results

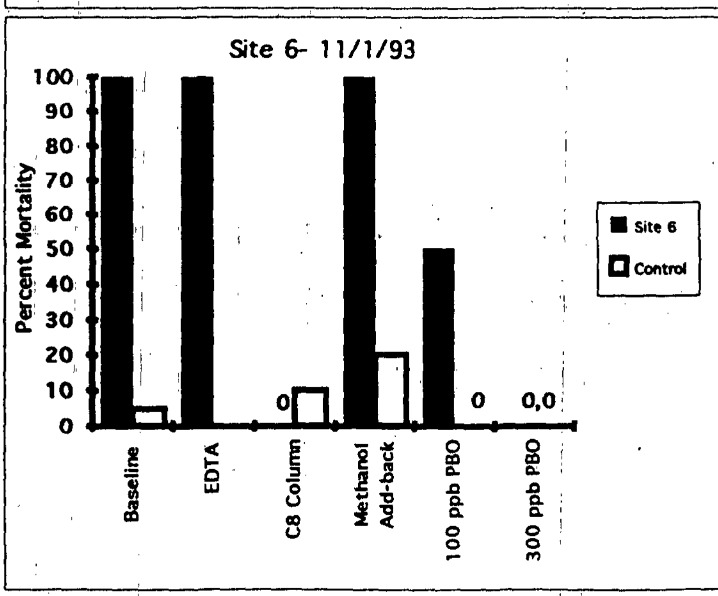
Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Diazinon	0.2	0.44	0.45
		Total TUs	0.45



Site 5 (#7206)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.02 (J)	*1.25	0.02
Chlorpyrifos	0.1	0.06	1.67
Diazinon	0.2	0.44	0.45
		Total TUs	2.14

* D. magna 48 hr LC50

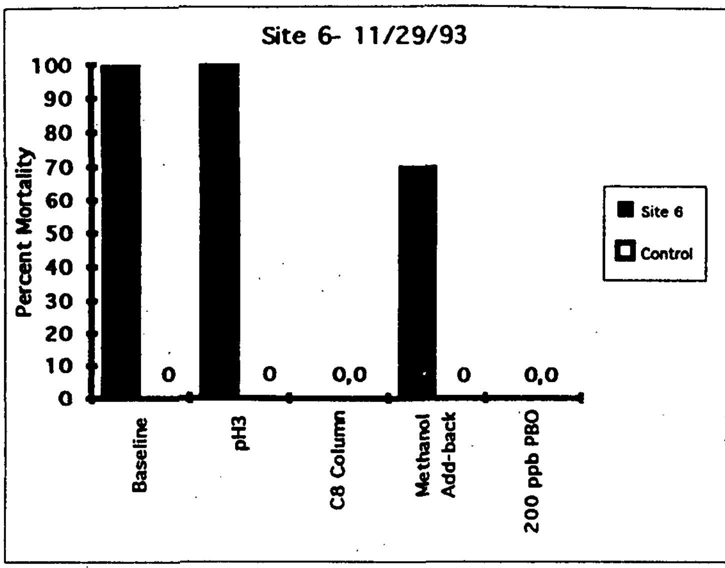


Site 6 (#7207)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbaryl	0.03 (J)	*1.25	0.02
Chlorpyrifos	0.1	0.06	1.67
Diazinon	0.3	0.44	0.68
		Total TUs	2.37

* 48 hr D. magna LC50

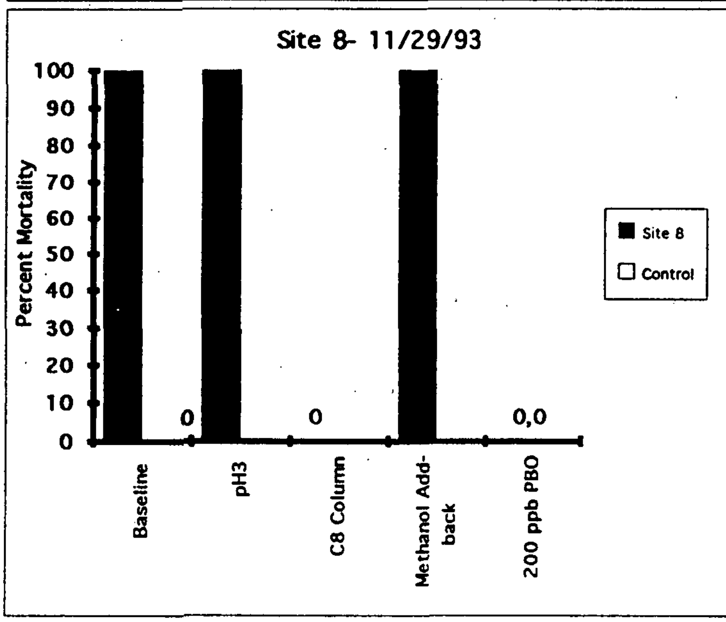
Figure 4D. TIEs vs. Chemical Results-November 1993 (continued)



Site 6 (#7208)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Chlorpyrifos	0.063	0.06	1.05
Diazinon	0.17	0.44	0.39
Malathion	0.096	*0.8	0.12
		Total TUs	1.56

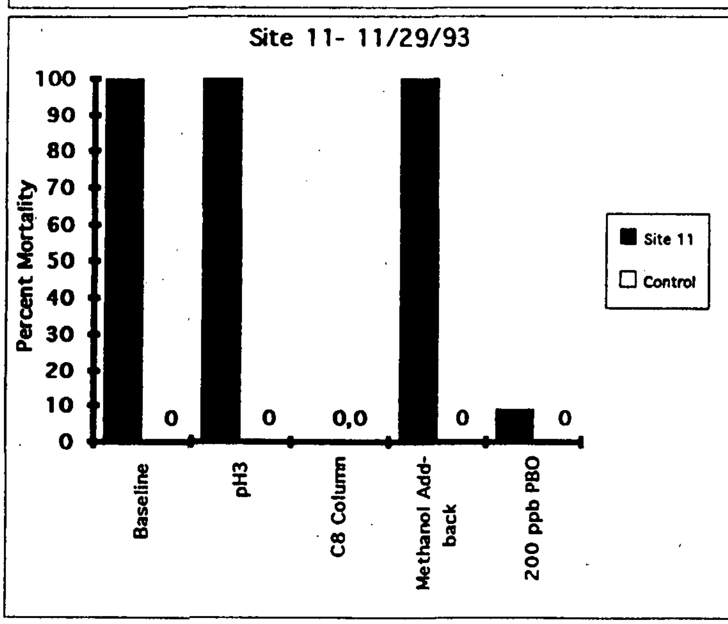
* 24 hr D. magna LC50



Site 8 (#7210)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Chlorpyrifos	0.074	0.06	1.23
Diazinon	0.31	0.44	0.7
Malathion	0.06	*0.8	0.08
		Total TUs	2.01

*24 hr D. magna LC50

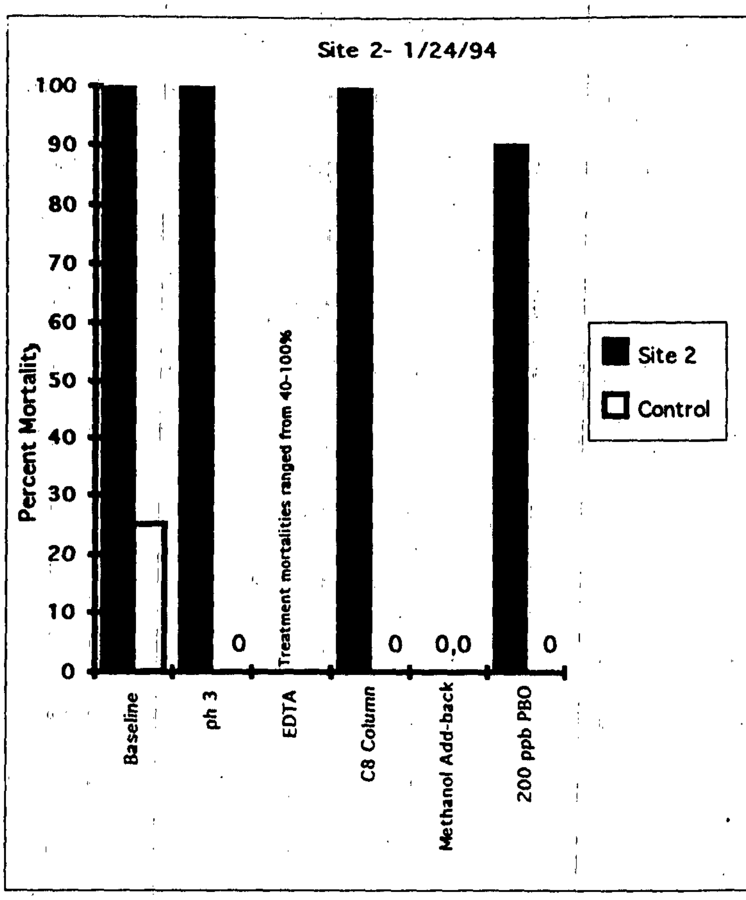


Site 11 (#7213)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Chlorpyrifos	0.07	0.06	1.17
Diazinon	0.31	0.44	0.7
Malathion	0.22	*0.8	0.28
		Total TUs	2.15

*24 hr D. magna LC50

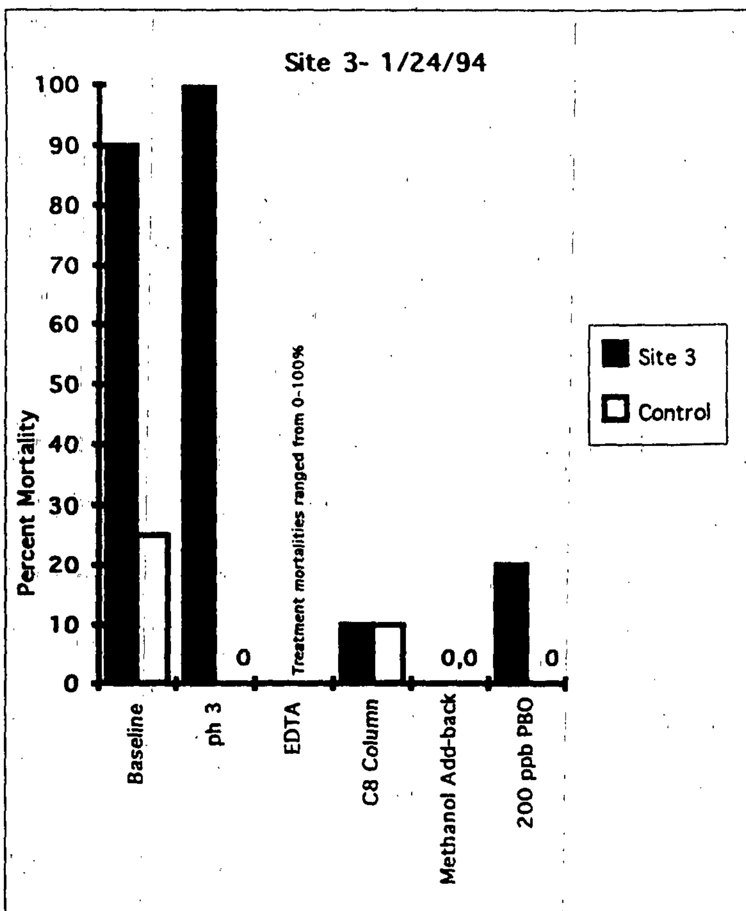
Figure 4E. TIEs vs. Chemical Results-January 1994



Site 2 (# 7229)
Chemistry Results

Pesticide	Concentration µg/l	8 day LC50	Toxic Units (TUs)
Vapam	56.6	690	not available

Total TUs	not available

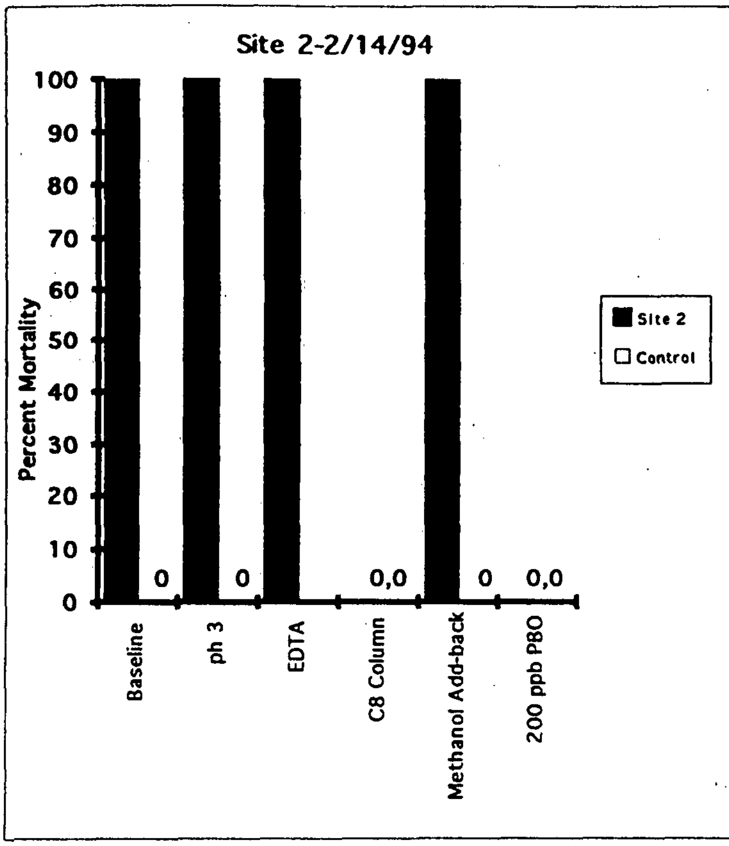


Site 3 (#7230)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Diazinon	0.09	0.44	0.2

Total TUs	0.2

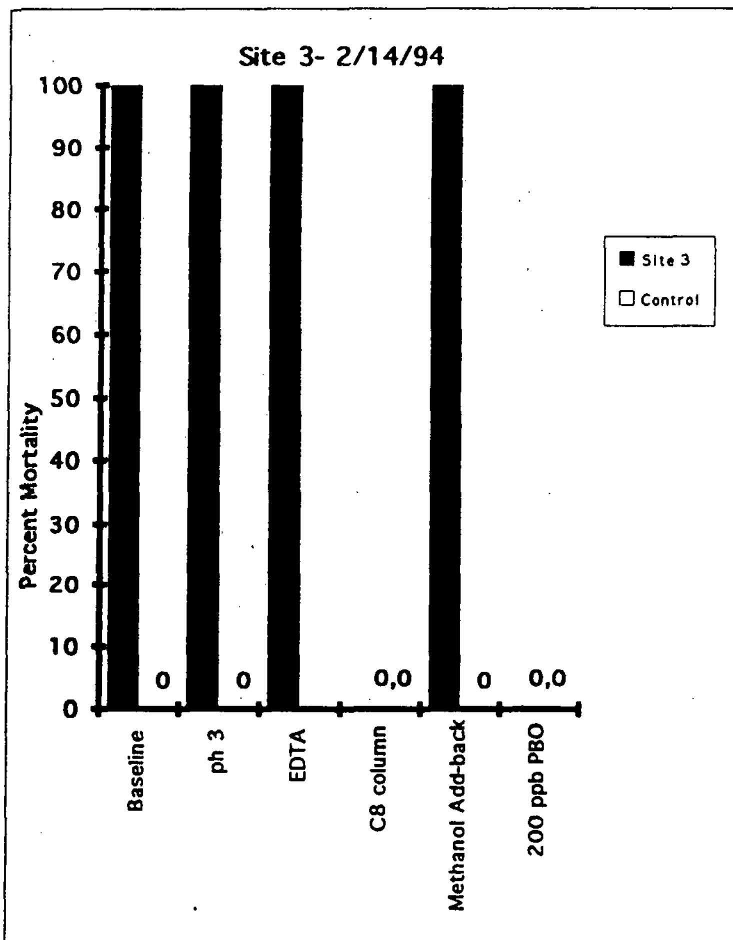
Figure 4F. TIEs vs. Chemical Results-February 1994



Site 2 (# 7236)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbofuran	0.52	2.38	0.22
Diazinon	0.18	0.44	0.41

Total TUs	0.63

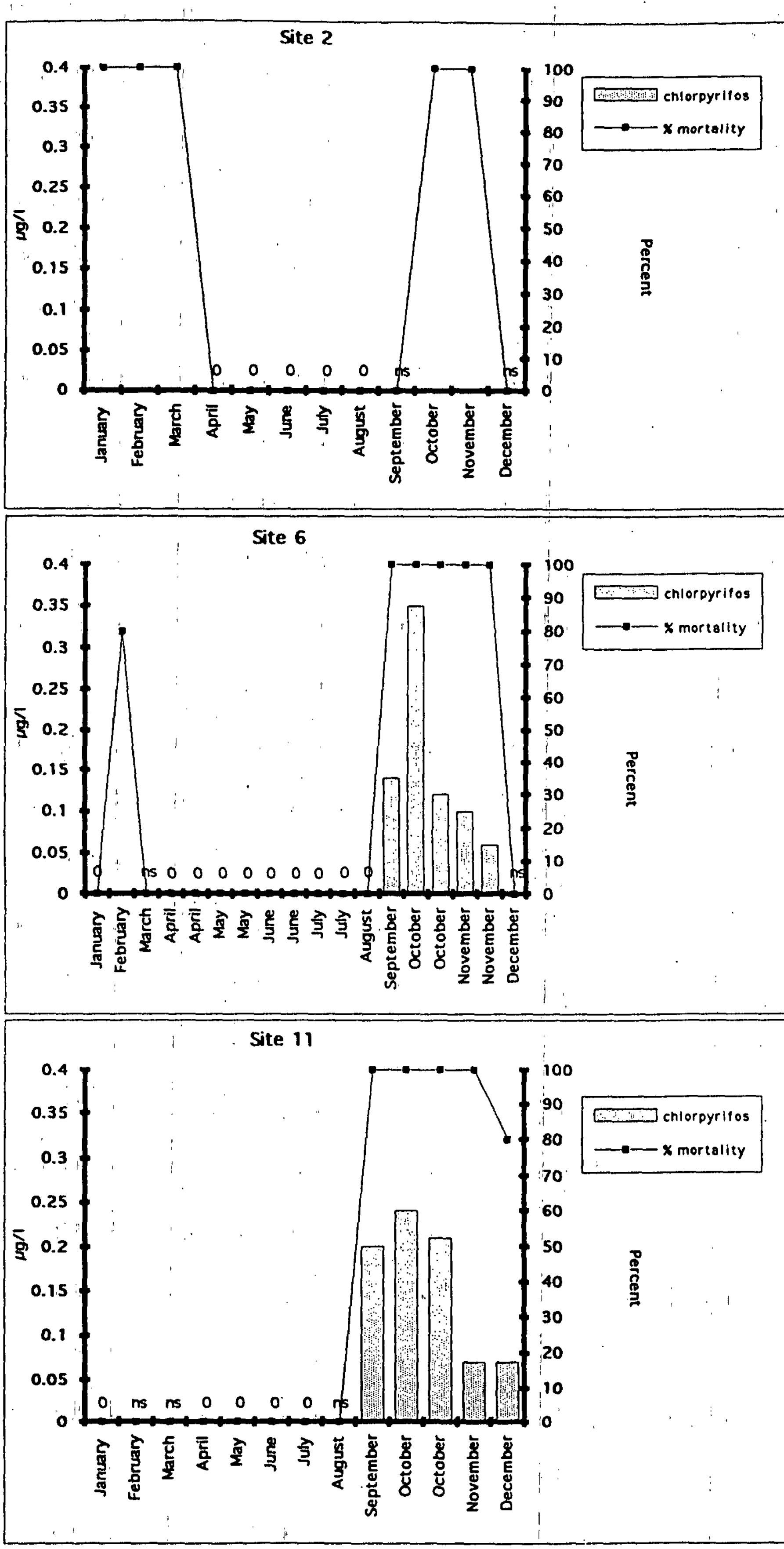


Site 3 (#7237)
Chemistry Results

Pesticide	Concentration µg/l	96 hr LC50	Toxic Units (TUs)
Carbofuran	0.28	2.38	0.12
Diazinon	0.14	0.44	0.32

Total TUs	0.44

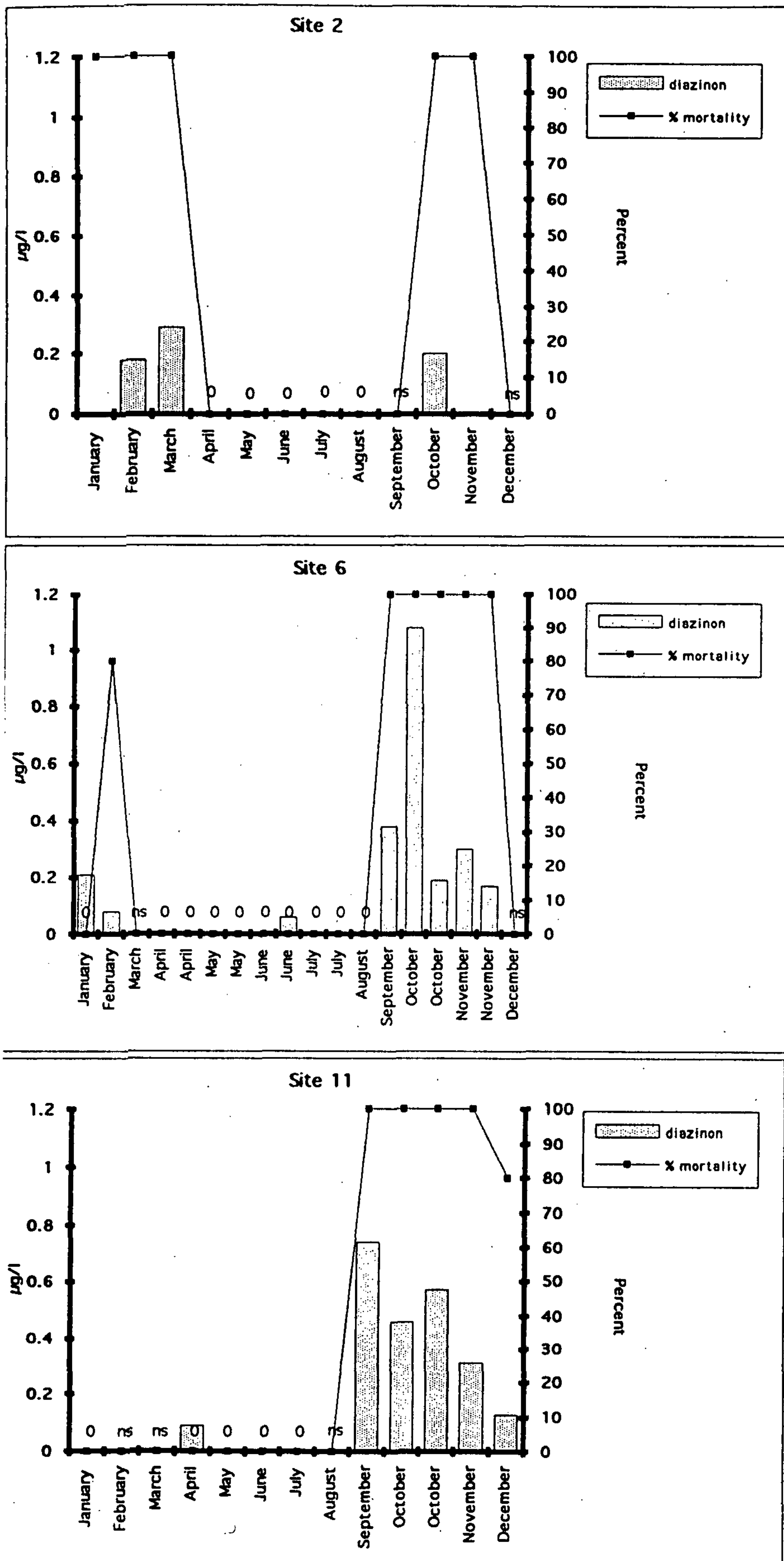
Figure 5A. Chlorpyrifos Concentration vs. Ceriodaphnid Mortality by Site



Chlorpyrifos Concentrations				
	Site 2	Site 6	Site 11	Monthly River-wide average (std. dev.)
Early Jan	na	na	na	-
Late Jan	-	-	ns	
February	-	-	ns	-
March	-	ns	ns	-
Early April	-	-	ns	0.005 (0.02)
Late April	ns	-	-	
Early May	na	na	ns	-
Late May	ns	-	-	
Early June	ns	-	-	-
Late June	-	-	ns	
Early July	-	-	ns	-
Late July	ns	-	-	
August	-	-	ns	-
September	ns	0.14	0.2	0.15 (0.06)
Early Oct	-	0.35	0.24	0.14 (0.13)
Late Oct	ns	0.12	0.21	
Early Nov	-	0.1	ns	0.06 (0.05)
Late Nov	ns	0.06	0.07	
December	ns	ns	0.07	0.01 (0.03)

_ = non detect
na = not analyzed
ns = not sampled

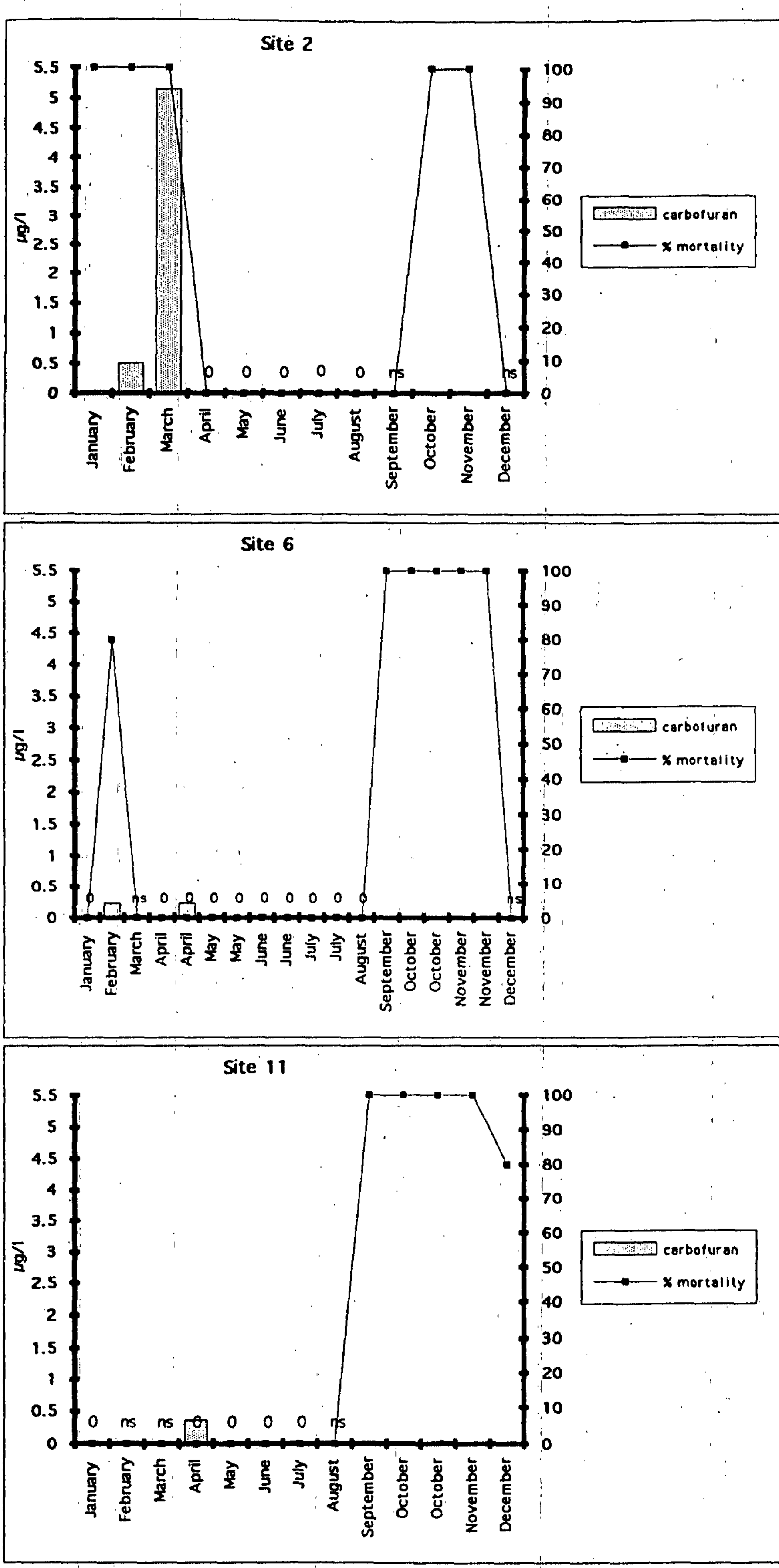
Figure 5B. Diazinon Concentration vs. Ceriodaphnid Mortality by Site



	Diazinon Concentrations			
	Site 2	Site 6	Site 11	Monthly River-wide average (std. dev.)
Early Jan	na	na	na	0.07 (0.09)
Late Jan	-	0.21	ns	
February	0.18	0.08 (J)	ns	0.11 (0.05)
March	0.29	ns	ns	0.32 (0.04)
Early April	-	-	ns	0.008 (0.03)
Late April	ns	-	0.09	
Early May	na	na	ns	-
Late May	ns	-	-	
Early June	ns	-	-	0.032 (0.09)
Late June	-	0.06	ns	-
Early July	-	-	ns	-
Late July	ns	-	-	
August	-	-	ns	-
September	ns	0.38	0.74	0.62 (0.19)
Early Oct	0.2	1.08	0.46	0.41 (0.29)
Late Oct	ns	0.19	0.57	
Early Nov	-	0.3	ns	0.21 (0.14)
Late Nov	ns	0.17	0.31	
December	ns	ns	0.13	0.03 (0.06)

_ = non detect
na = not analyzed
ns = not sampled
(J) = interpolated value below detection limits

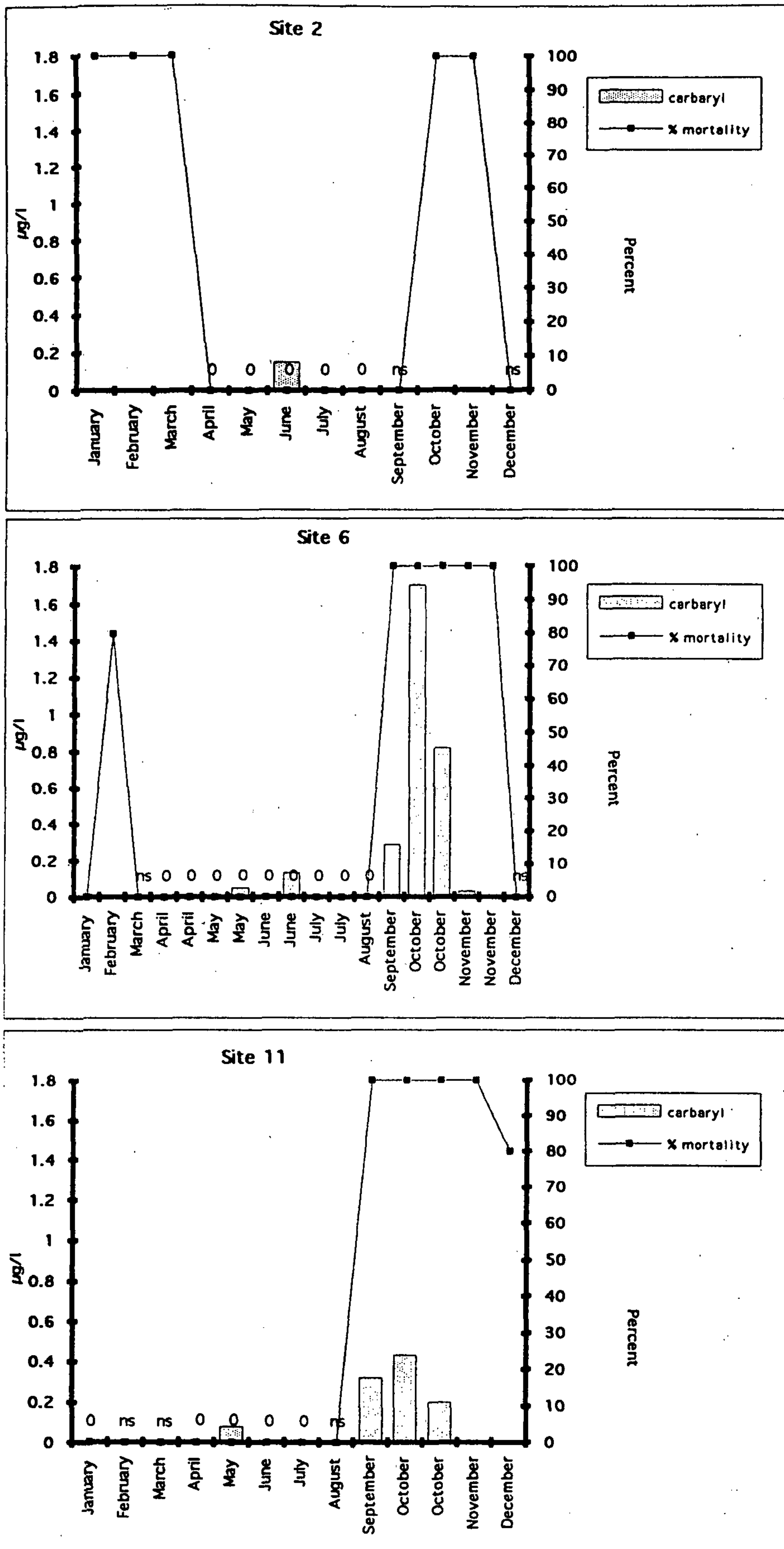
Figure 5C. Carbofuran Concentration vs. Ceriodaphnid Mortality by Site



Carbofuran Concentrations				
	Site 2	Site 6	Site 11	Monthly River-wide average (std. dev.)
Early Jan	na	na	na	-
Late Jan	-	-	ns	
February	0.52	0.23	ns	0.28 (0.14)
March	5.15	ns	ns	2.43 (1.95)
Early April	-	-	ns	0.15 (0.15)
Late April	ns	0.23	0.36	
Early May	na	na	ns	
Late May	ns	-	-	-
June	-	-	-	-
July	-	-	-	-
August	-	-	ns	-
September	ns	-	-	-
October	-	-	-	-
November	-	-	-	-
December	ns	ns	-	-

_ = non detect
na = not analyzed
ns = not sampled

Figure 5D. Carbaryl Concentration vs. Ceriodaphnid Mortality by Site

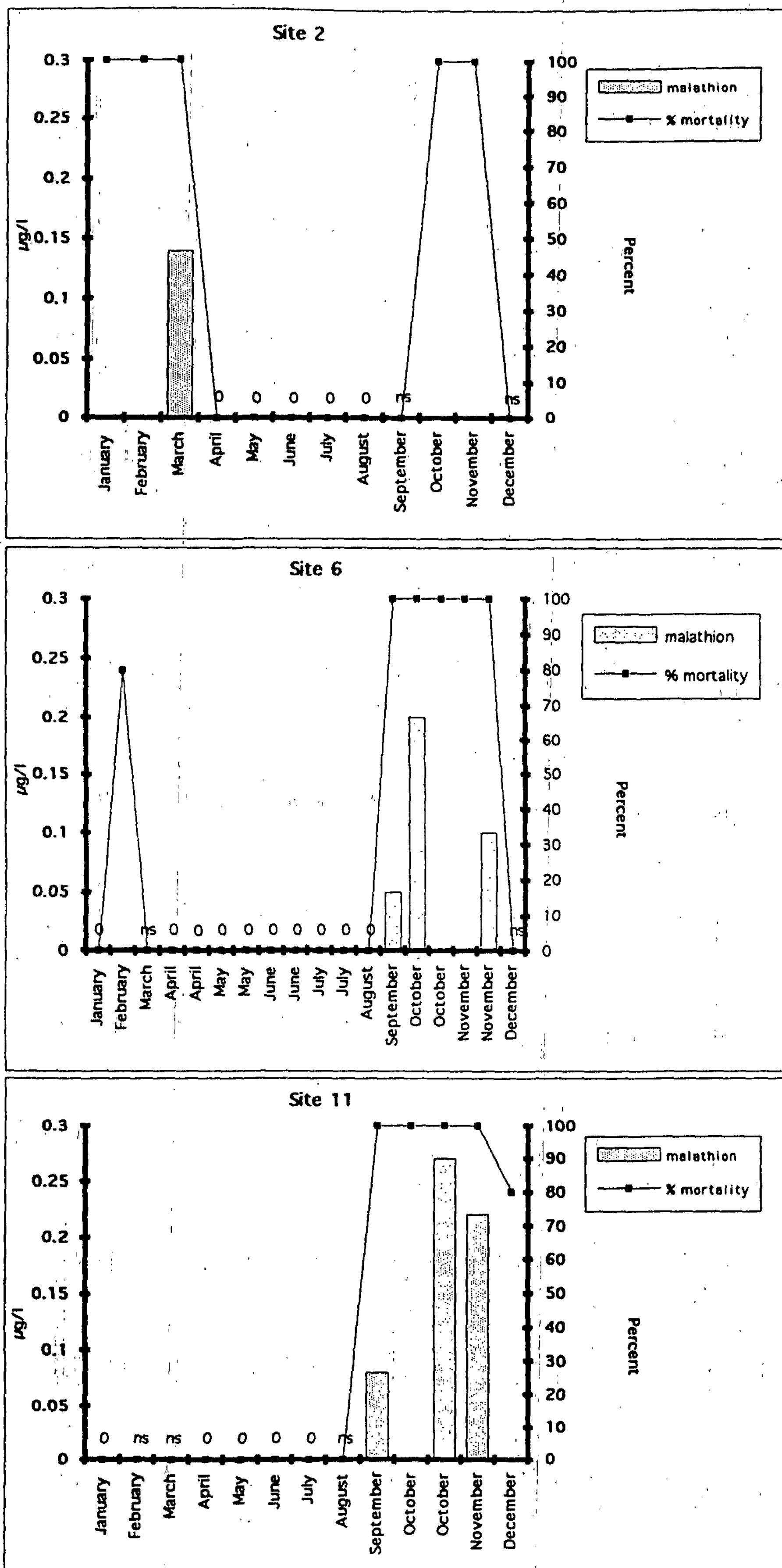


Carbaryl Concentrations

	Site 2	Site 6	Site 11	Monthly River-wide average (std. dev.)
Early Jan	na	na	na	-
Late Jan	-	-	ns	
February	-	-	ns	-
March	-	ns	ns	-
Early April	-	-	ns	-
Late April	ns	-	-	
Early May	na	na	ns	0.02 (0.03)
Late May	ns	0.05	0.08	
Early June	ns	-	-	0.07 (0.09)
Late June	0.15	0.13	ns	
Early July	-	-	ns	-
Late July	ns	-	-	
August	-	-	ns	-
September	ns	0.29	0.32	0.42 (0.24)
Early Oct	-	1.7	0.43	0.52 (0.56)
Late Oct	ns	0.82	0.2	
Early Nov	-	0.03 (J)	ns	0.005 (0.01)
Late Nov	ns	-	-	
December	ns	ns	-	-

_ = non detect
na = not analyzed
ns =not sampled
(J) = interpolated value below detection limits

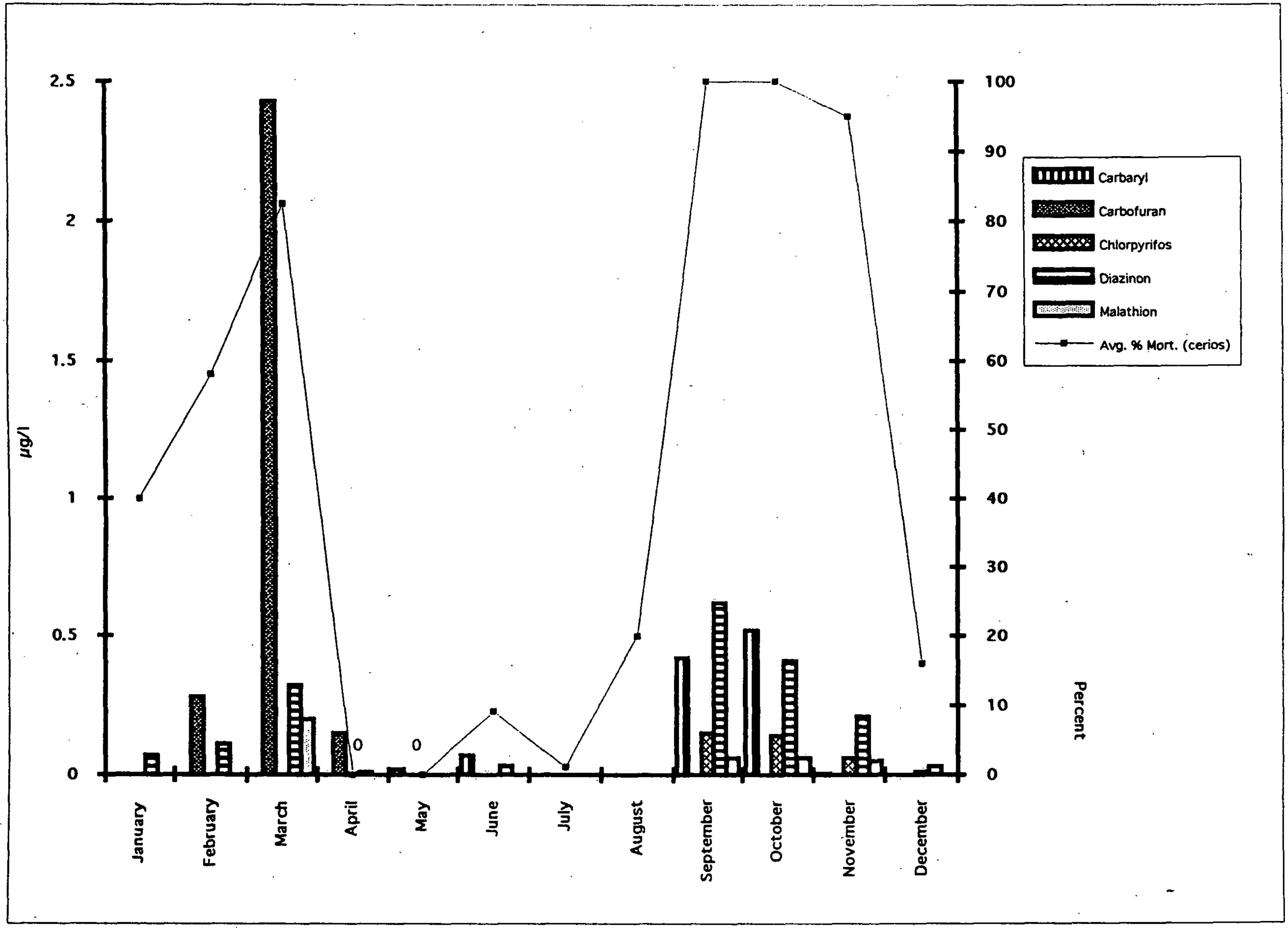
Figure 5E. Malathion Concentration vs. Ceriodaphnid Mortality by Site



	Malathion Concentrations			
	Site 2	Site 6	Site 11	River-wide average (std. dev.)
Early Jan	na	na	na	-
Late Jan	-	-	ns	
February	-	-	ns	-
March	0.14	ns	ns	0.20 (0.21)
Early April	-	-	ns	-
Late April	ns	-	-	
Early May	na	na	ns	-
Late May	ns	-	-	
Early June	ns	-	-	-
Late June	-	-	ns	
Early July	-	-	ns	-
Late July	ns	-	-	
August	-	-	ns	-
September	ns	0.05	0.08	0.06 (0.04)
Early Oct	-	0.2	-	0.06 (0.04)
Late Oct	ns	-	0.27	
Early Nov	-	-	ns	0.05 (0.07)
Late Nov	ns	0.1	0.22	
December	ns	ns	-	-

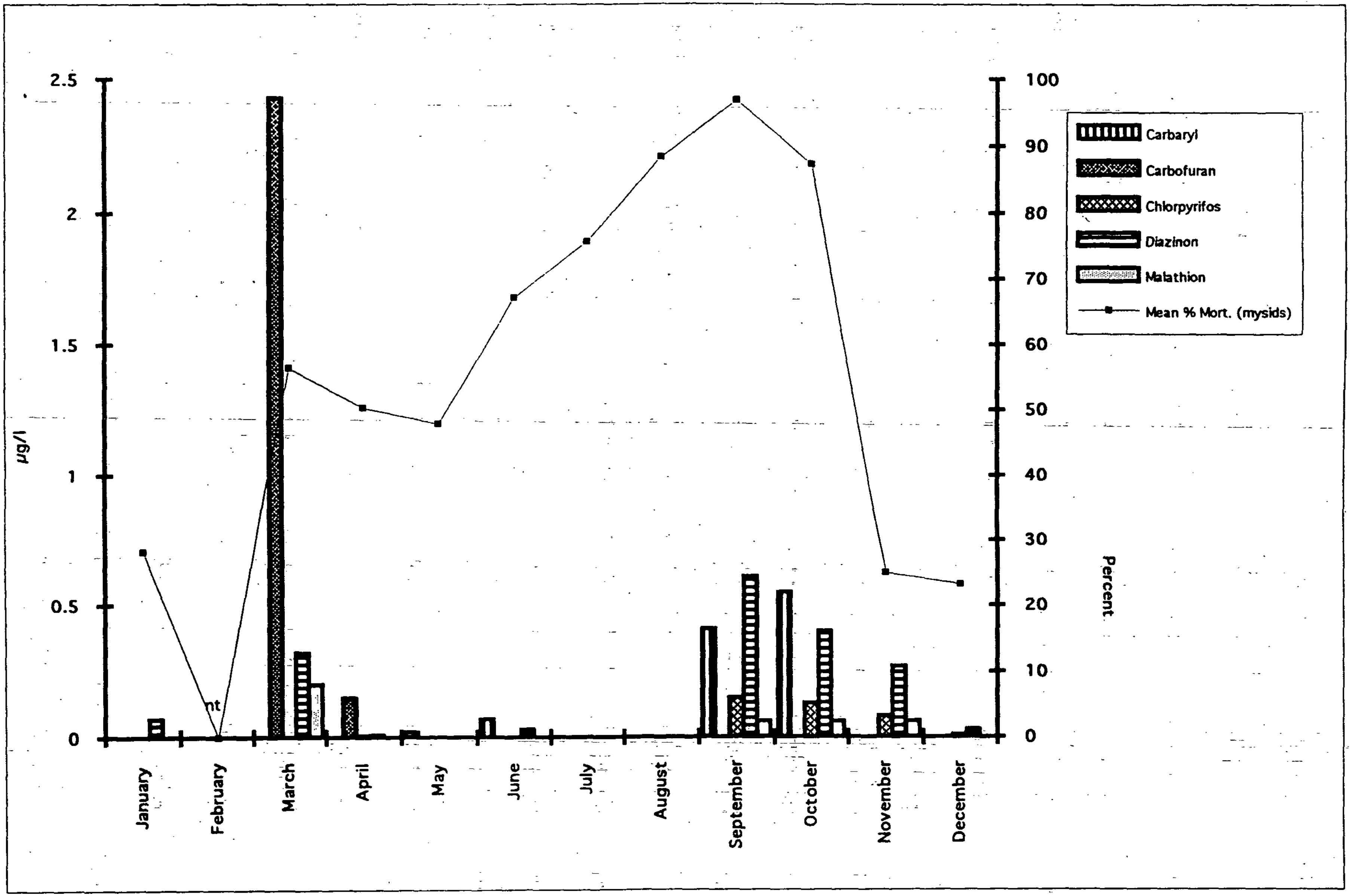
_ = non detect
na = not analyzed
ns = not sampled

Figure 6. Average Alamo River Pesticide Concentrations vs. Average Ceriodaphnid Mortality by Month



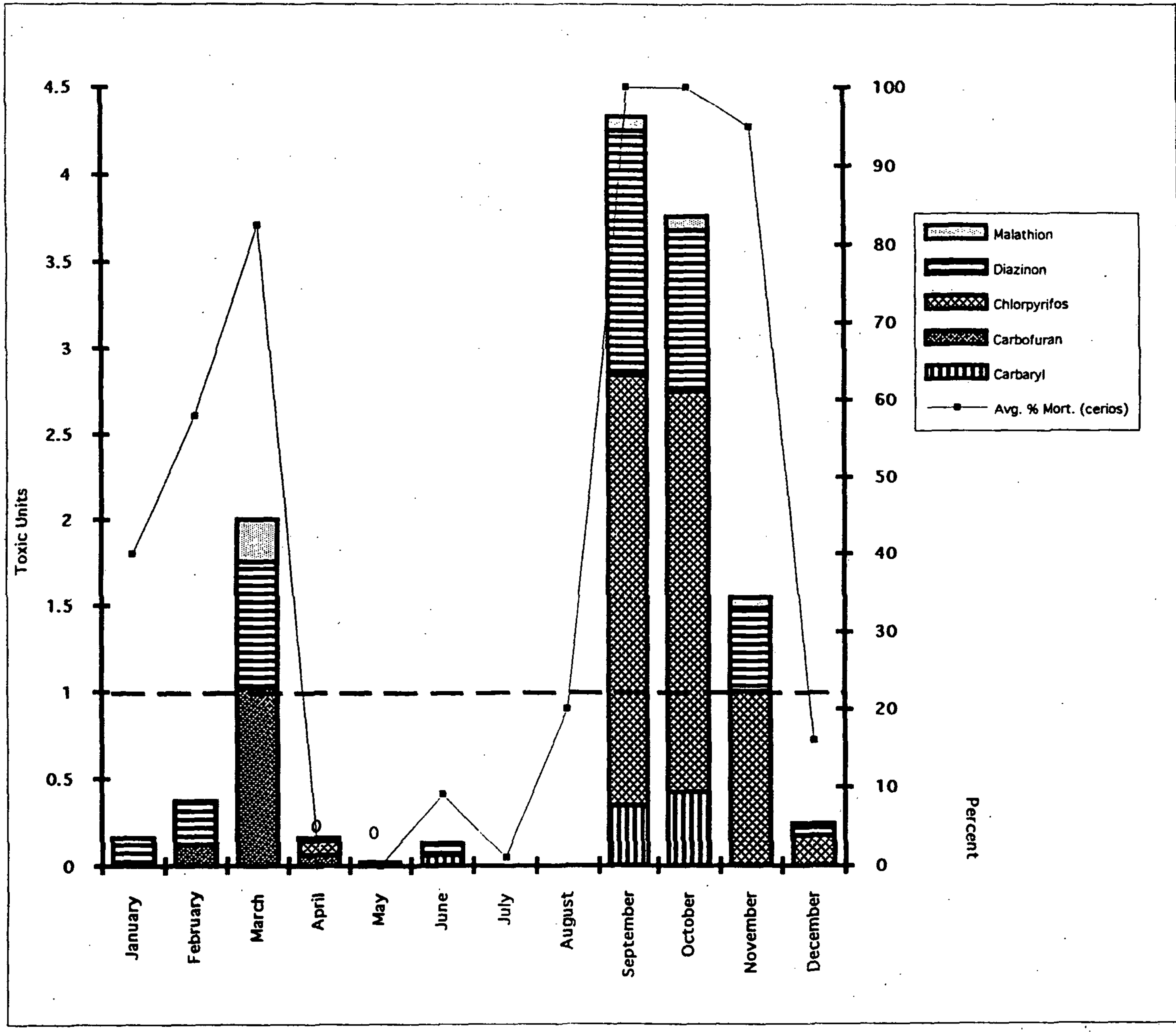
Pesticide	January	February	March	April	May	July	August	September	October	November	December
Carbaryl					0.02			0.42	0.52	0.005	
Carbofuran		0.28	2.43	0.15							
Chlorpyrifos				0.005				0.15	0.14	0.06	0.01
Diazinon	0.07	0.11	0.32	0.01				0.62	0.41	0.21	0.03
Malathion			0.2					0.06	0.06	0.05	
Avg. % Mort. (cerios)	40	58	82.5	0	0	1.11	20	100	100	95	16

Figure 7. Average Alamo River Pesticide Concentrations vs. Average Neomysid Mortality by Month



Pesticide	January	February	March	April	May	July	August	September	October	November	December
Carbaryl					0.02			0.41	0.55		
Carbofuran			2.43	0.15							
Chlorpyrifos				0.005				0.15	0.13	0.08	0.01
Diazinon	0.07		0.32	0.008				0.61	0.4	0.27	0.03
Malathion			0.2					0.06	0.06	0.06	
Mean % Mort. (mysids)	28.2	nt	56.5	50.4	47.9	75.7	88.4	96.8	87.3	25	23.2

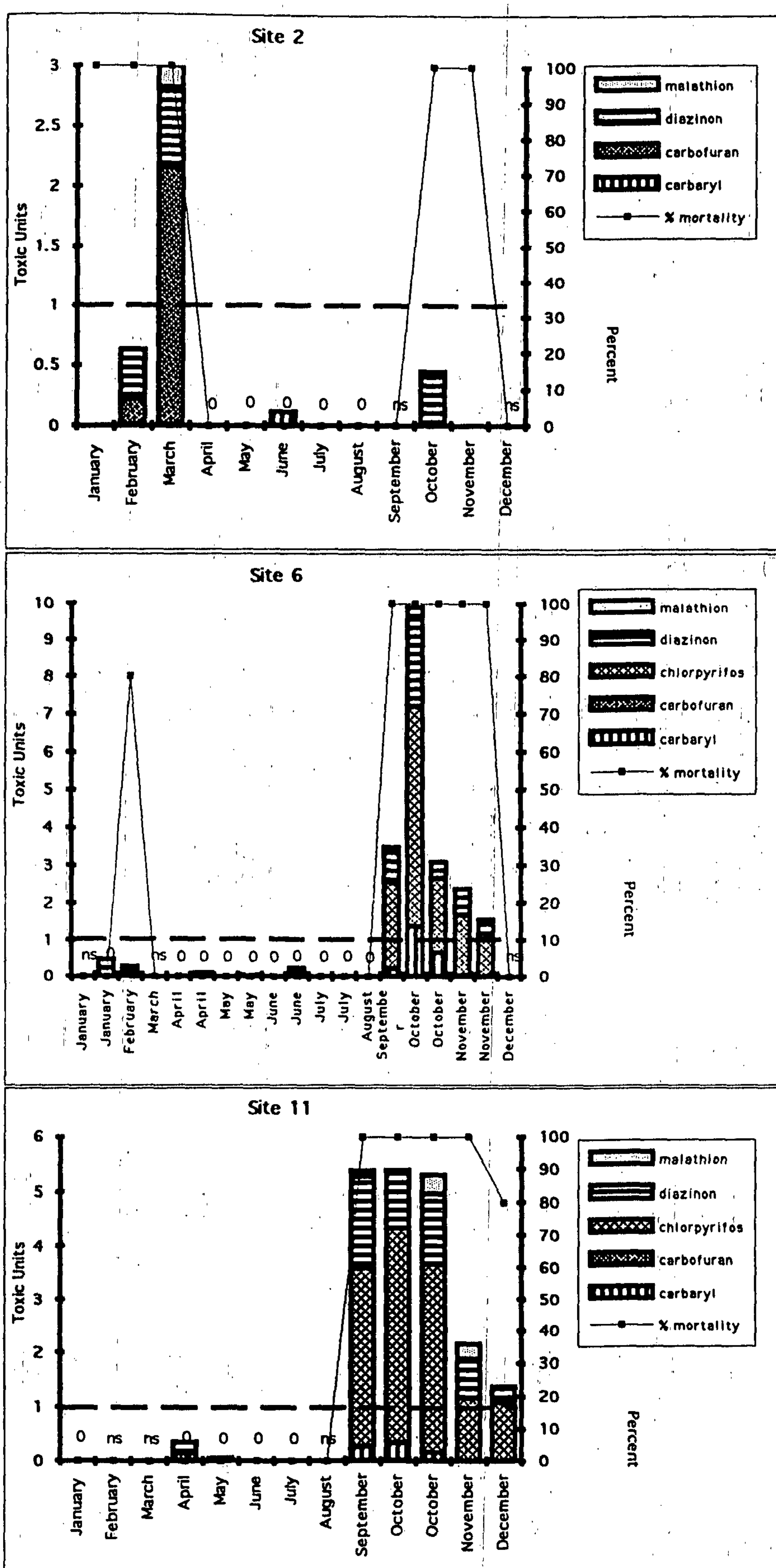
Figure 8. Total Toxic Units vs. Average Riverwide Ceriodaphnid Mortality



Total Toxic Units

	River-wide
January	0.16
February	0.37
March	2
April	0.16
May	0.02
June	0.13
July	0
August	0
September	4.33
October	3.76
November	1.54
December	0.24

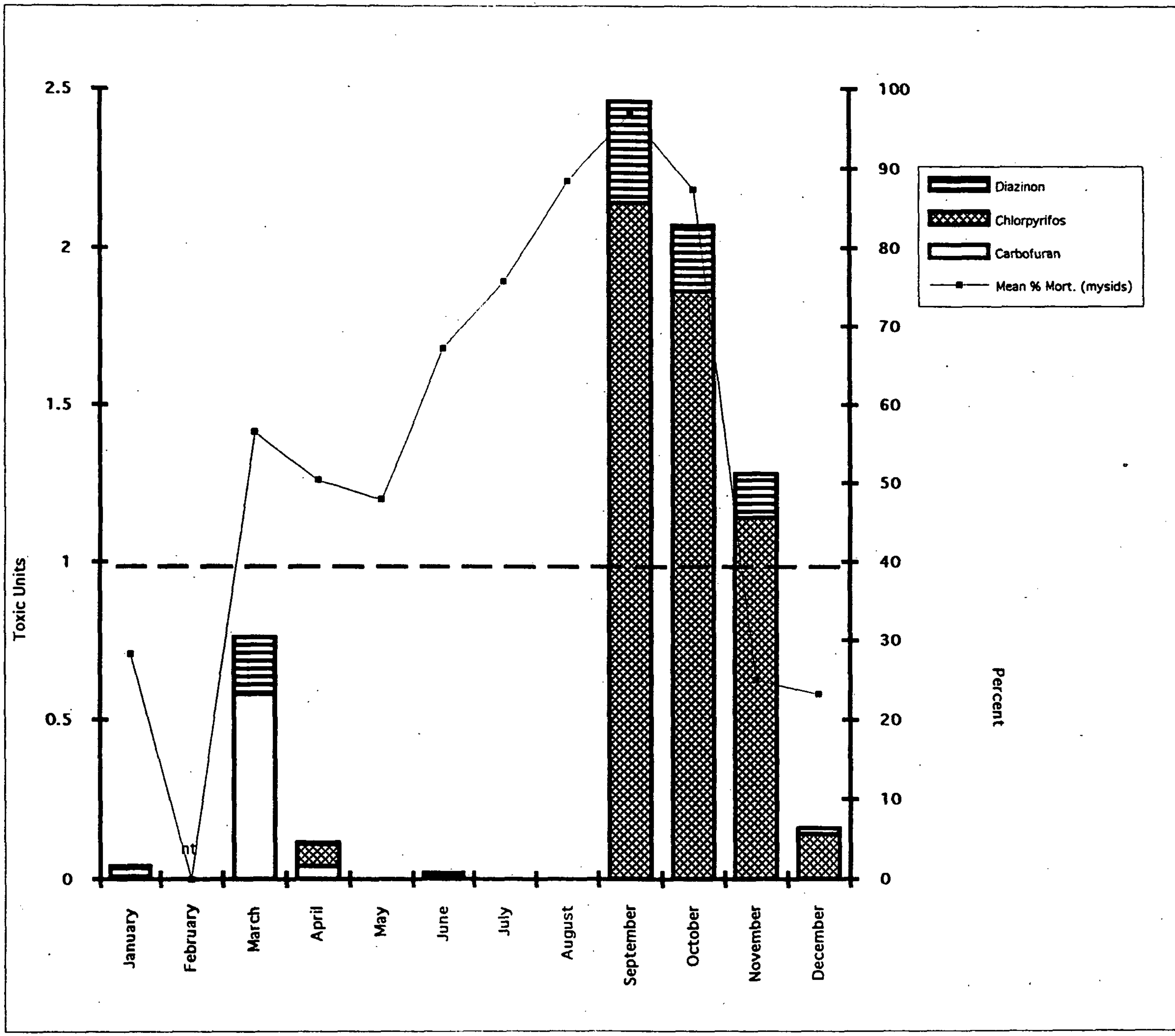
Figure 9. Total Toxic Units vs. Ceriodaphnid Mortality by Site



	Total Toxic Units			
	Site 2	Site 6	Site 11	River-wide
Early Jan	ns	ns	na	0.16
Late Jan	-	0.48	ns	
February	0.63	0.28	ns	0.37
March	3	ns	ns	2
Early April	-	-	-	0.16
Late April	ns	0.1	0.35	
Early May	na	na	ns	0.02
Late May	ns	0.04	0.06	
Early June	ns	-	-	0.13
Late June	0.12	0.24	ns	
Early July	-	-	ns	0
Late July	ns	-	-	
August	-	-	ns	0
September	ns	3.48	5.37	4.33
Early Oct	0.45	9.9	5.39	3.76
Late Oct	ns	3.09	5.3	
Early Nov	-	2.37	ns	1.54
Late Nov	ns	1.57	2.15	
December	ns	ns	1.38	0.24

_ = none of the 5 pesticides detected
na = not analyzed
ns = not sampled

Figure 10 Total Toxic Units vs. Average Riverwide Neomysid Mortality (nt = not tested)



Total Toxic Units

	River-wide
January	0.04
February	nt
March	0.75
April	0.11
May	0
June	0.02
July	0
August	0
September	2.46
October	2.07
November	1.28
December	0.15

nt = not tested

Figure 11. Chlorpyrifos Application, Imperial County (1990 & 1991) vs. Chlorpyrifos Frequency of Occurence and Average Ceriodaphnid Mortality on the Alamo River 1993/94.

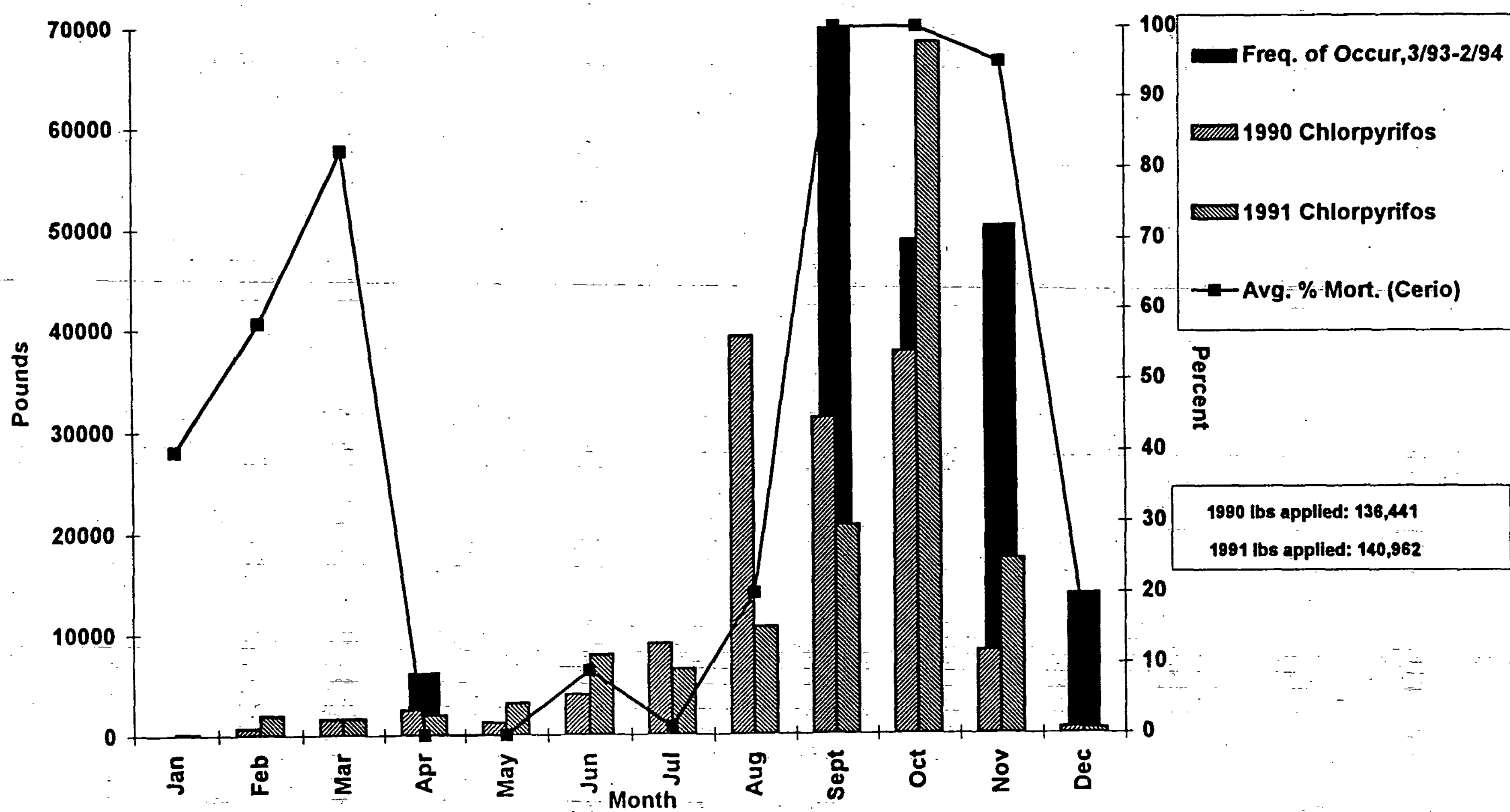


Figure 12. Diazinon Application, Imperial County (1990 & 1991) vs. Diazinon Frequency of Occurence and Average Ceriodaphnid Mortality on the Alamo River 1993/94.

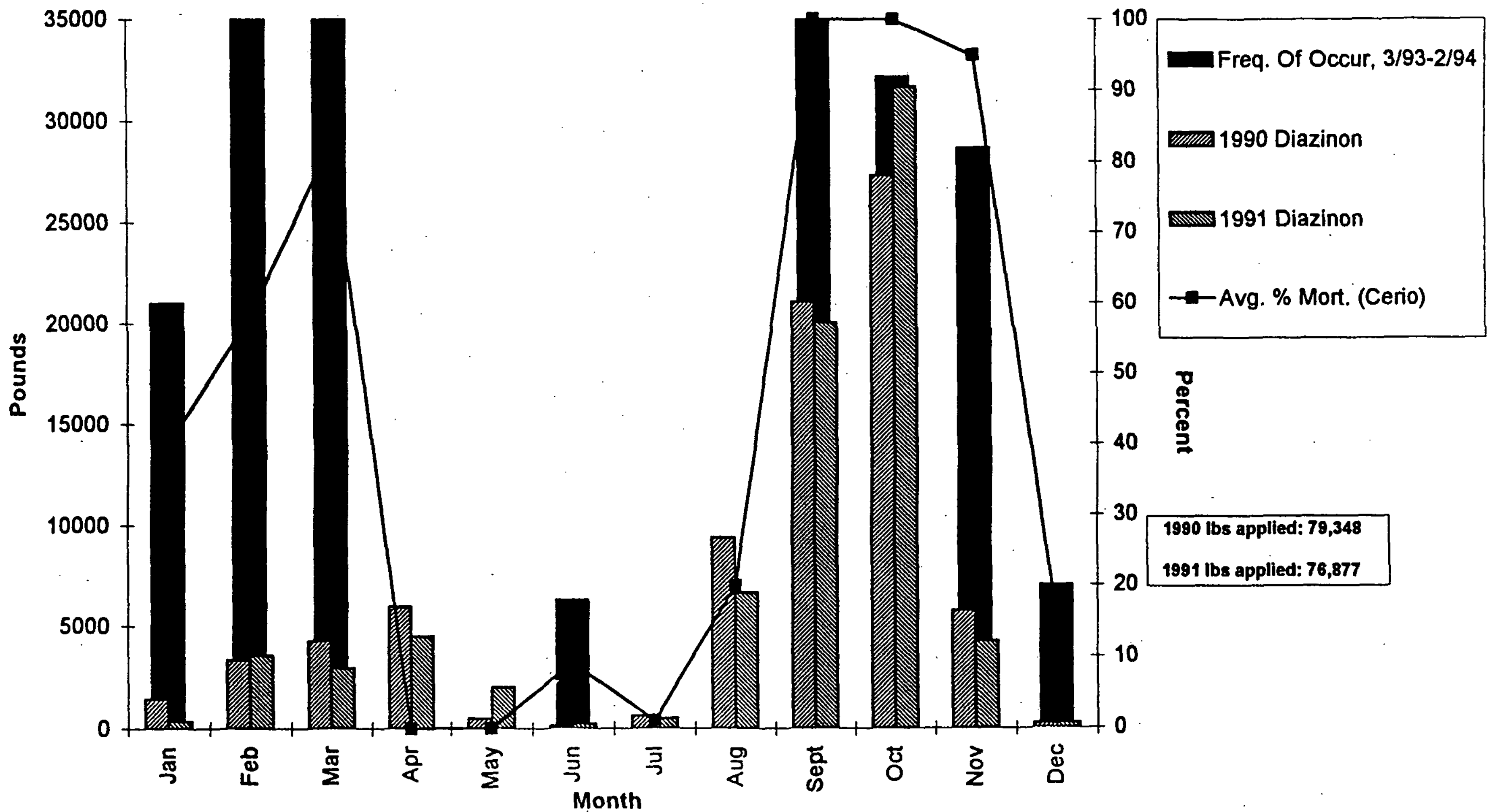


Figure 13. Carbofuran Application, Imperial County (1990 & 1991) vs. Carbofuran Frequency of Occurence and Average Ceriodaphnid Mortality on the Alamo River 1993/94.

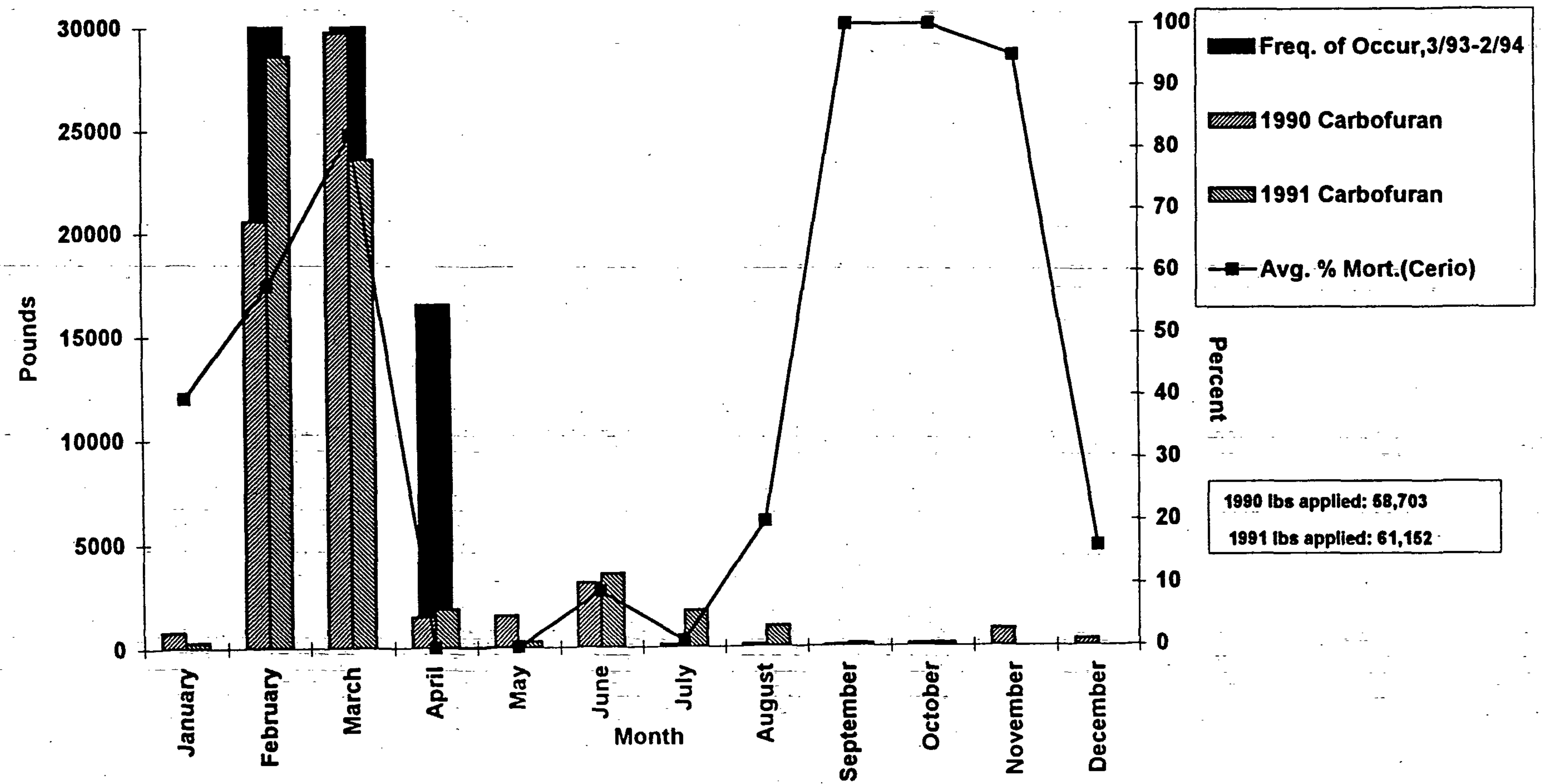


Figure 14. Carbaryl Application, Imperial County (1990 & 1991) vs. Carbaryl Frequency of Occurence and Average Ceriodaphnid Mortality on the Alamo River 1993/94.

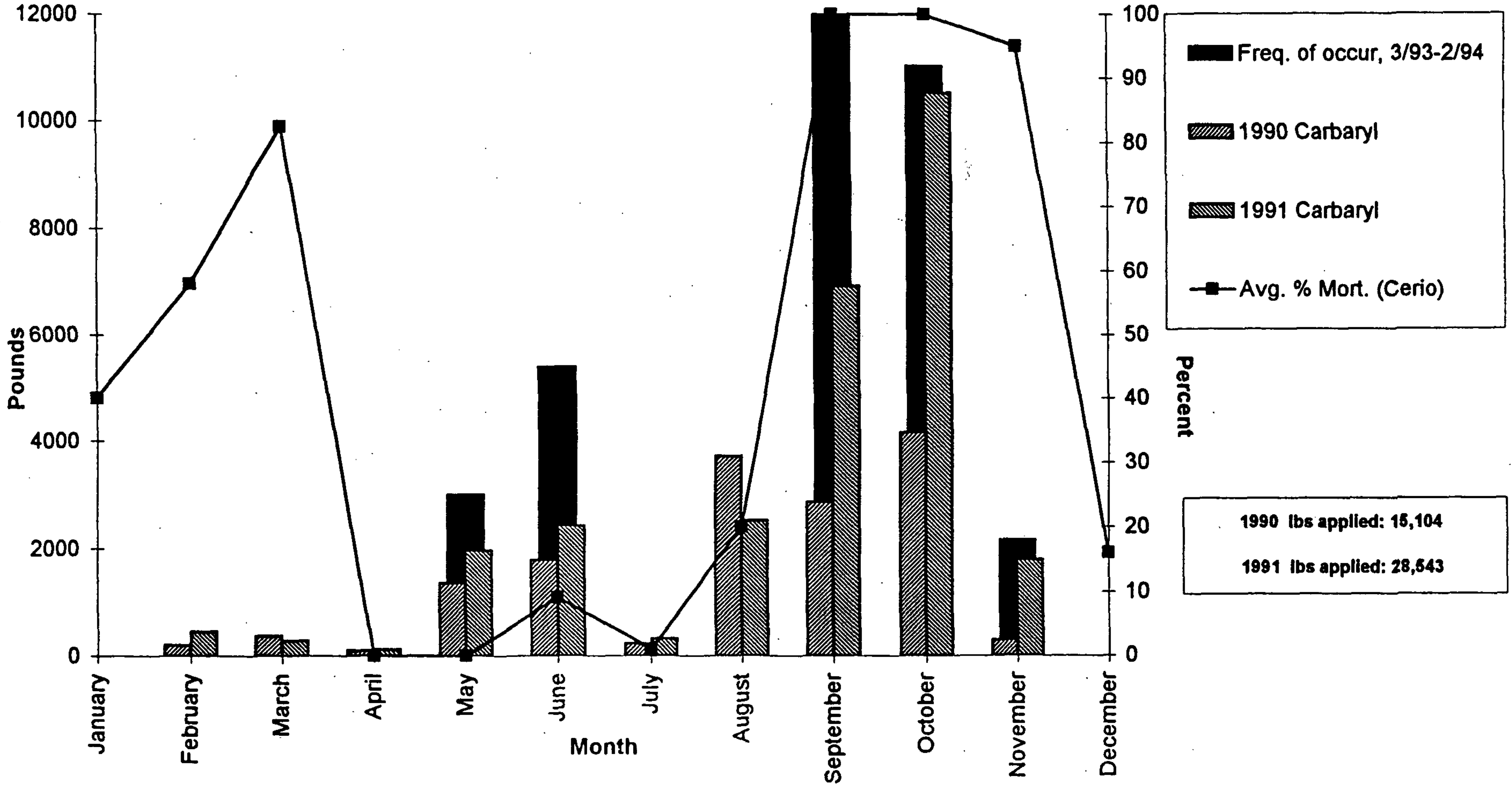


Figure 15. Malathion Application, Imperial County (1990 & 1991) vs. Malathion Frequency of Occurence and Average Ceriodaphnid Mortality on the Alamo River 1993/94.

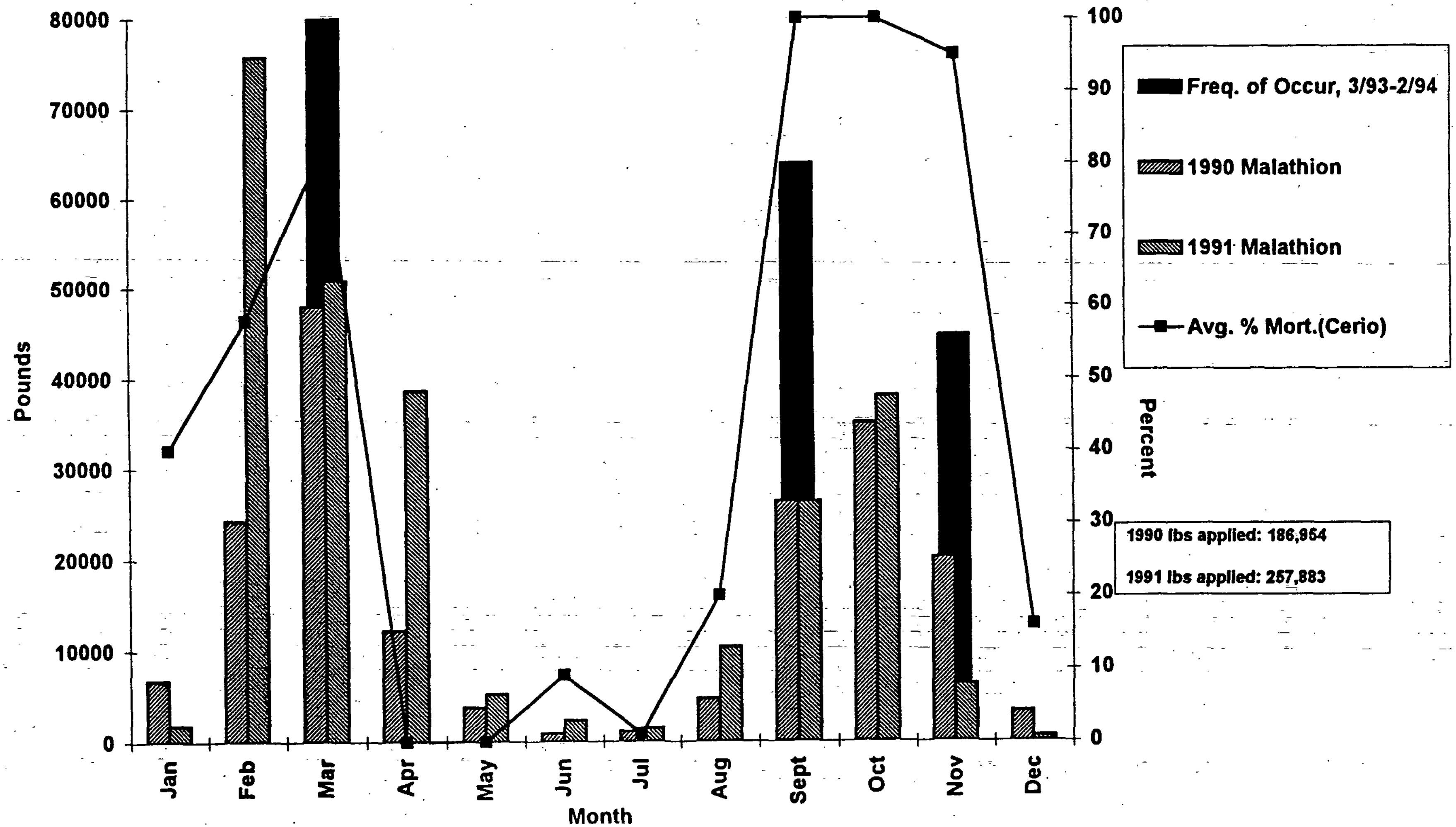
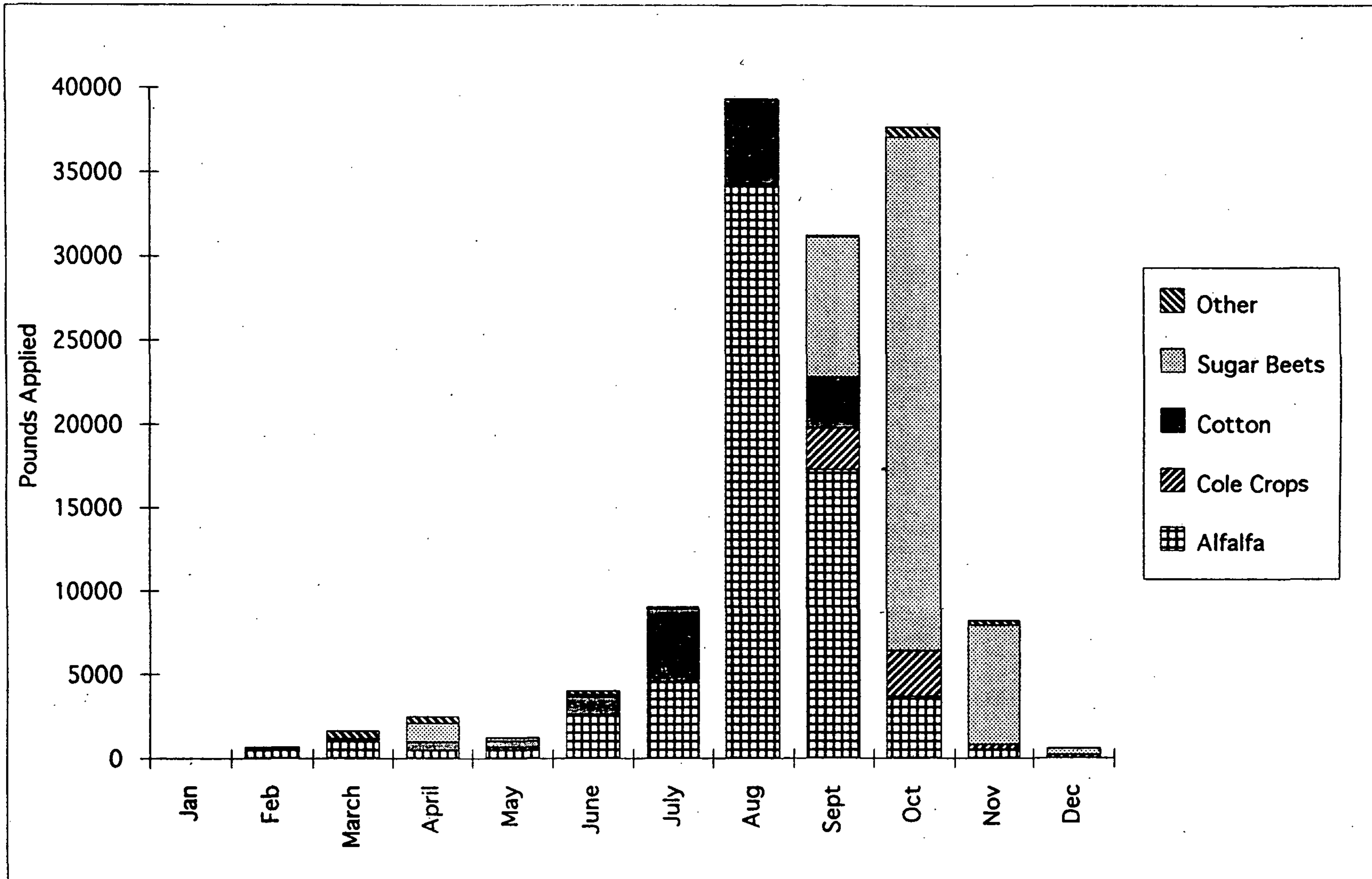
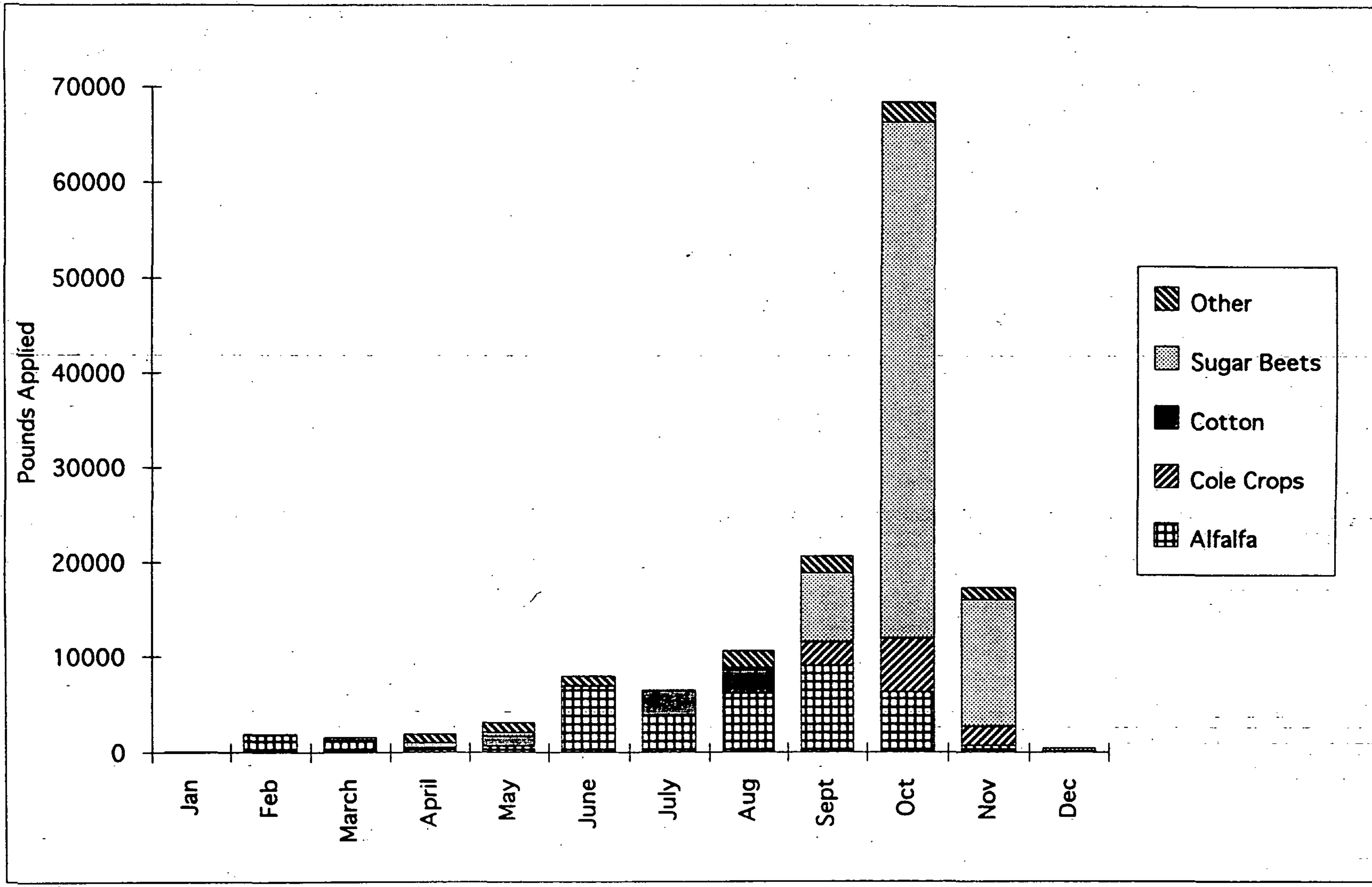


Figure 16. Pounds of Chlorpyrifos Applied in the Imperial Valley by Crop-1990



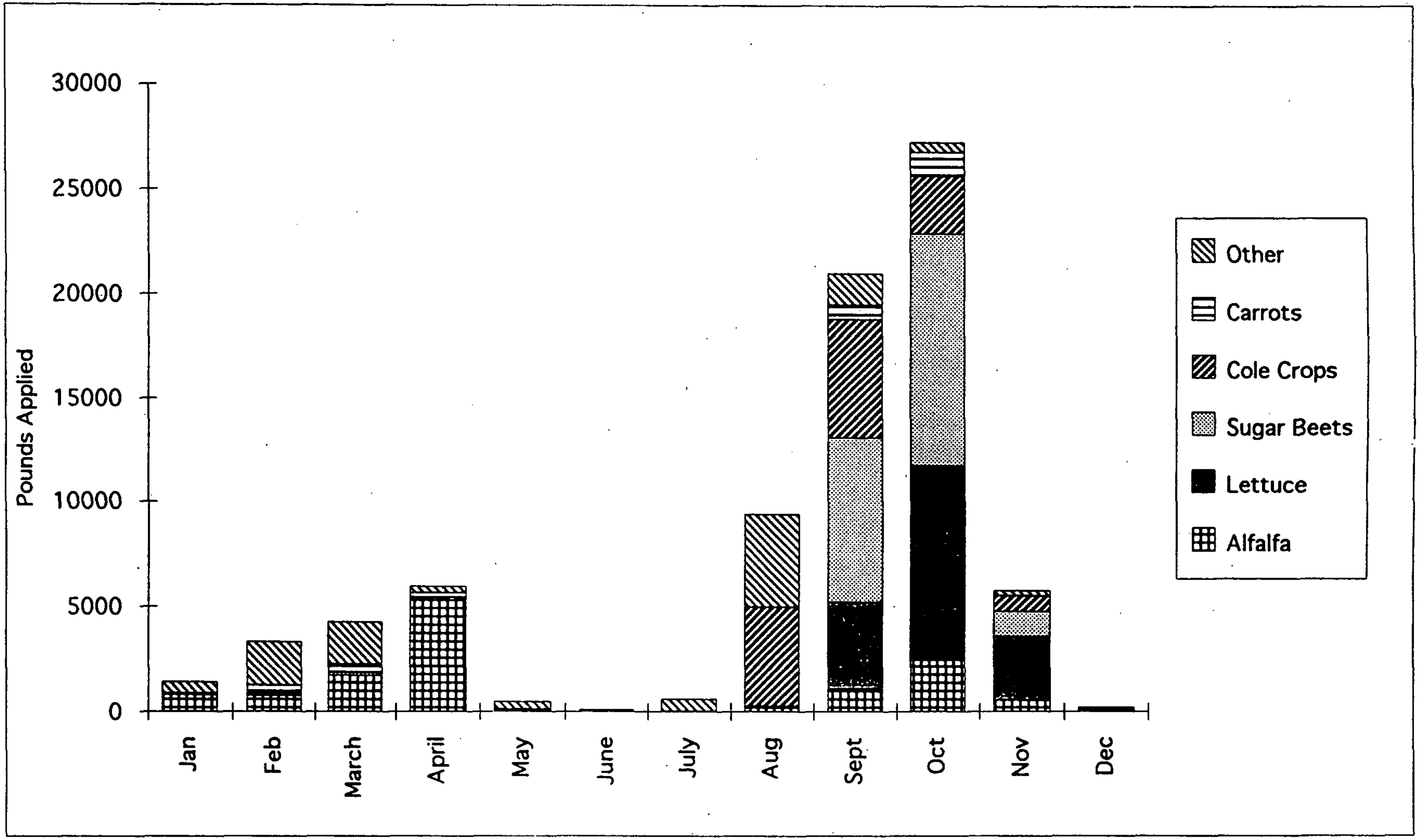
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	0	615	1148	487	688	2586	4545	34311	17322	3675	566	0
Cole Crops	0	5	0	15	0	0	0	0	2476	2739	270	218
Cotton	0	0	29	501	361	1083	4376	5012	2996	0	0	0
Sugar Beets	0	0	0	1083	203	120	0	0	8352	30661	7110	378
Other	0	105	485	424	4	254	132	12	109	647	311	28

Figure 17. Pounds of Chlorpyrifos Applied in the Imperial Valley by Crop-1991



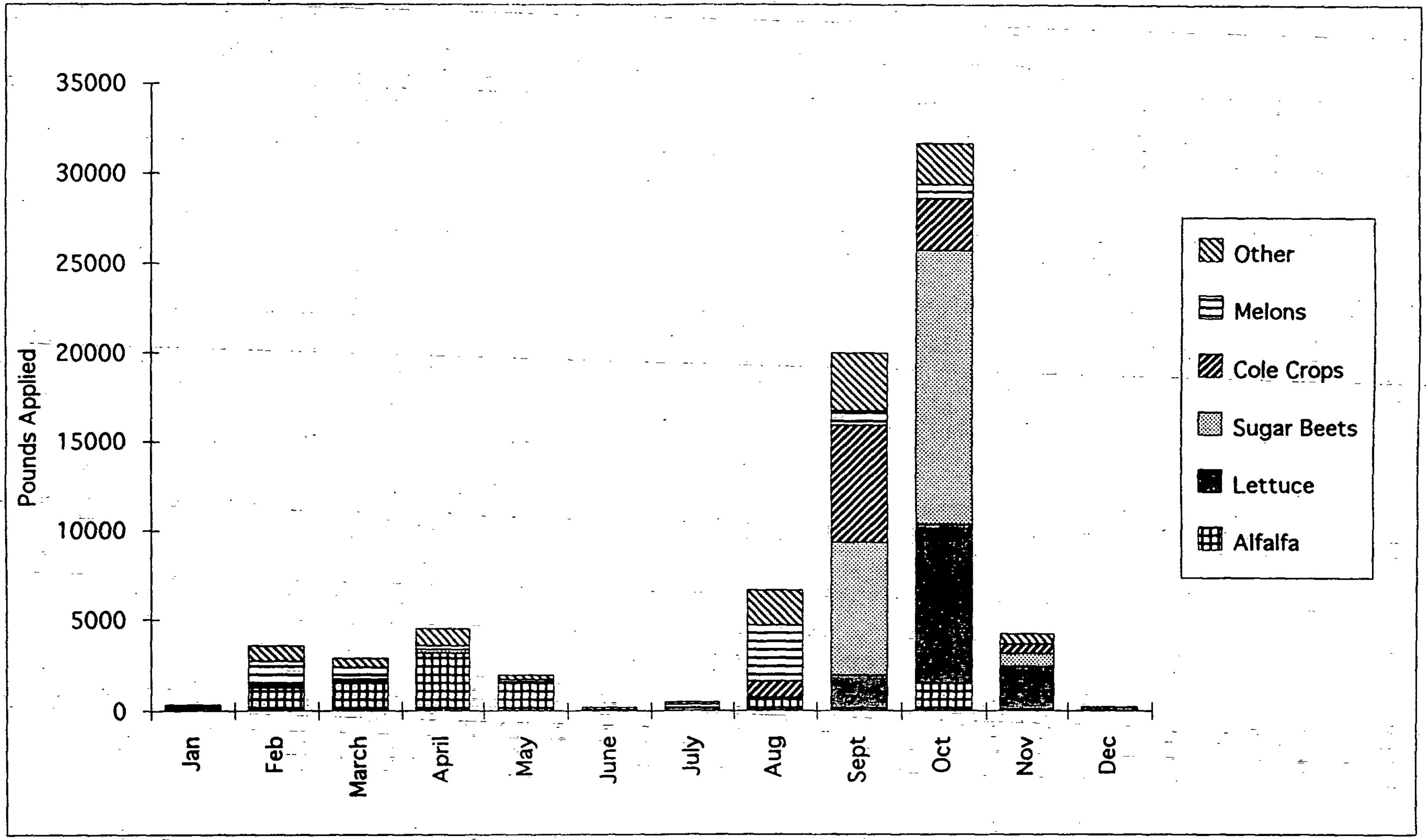
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	12	1832	1340	509	664	6879	3900	6119	9034	6218	768	0
Cole Crops	117	33	0	5	0	0	0	17	2531	5744	1991	129
Cotton	0	0	0	0	1048	87	2556	2477	0	0	0	0
Sugar Beets	0	0	307	529	409	0	0	217	7287	54356	13267	347
Other	0	98	0	900	1034	1008	70	1797	1830	2165	1311	20

Figure 18. Pounds of Diazinon Applied in the Imperial Valley by Crop-1990



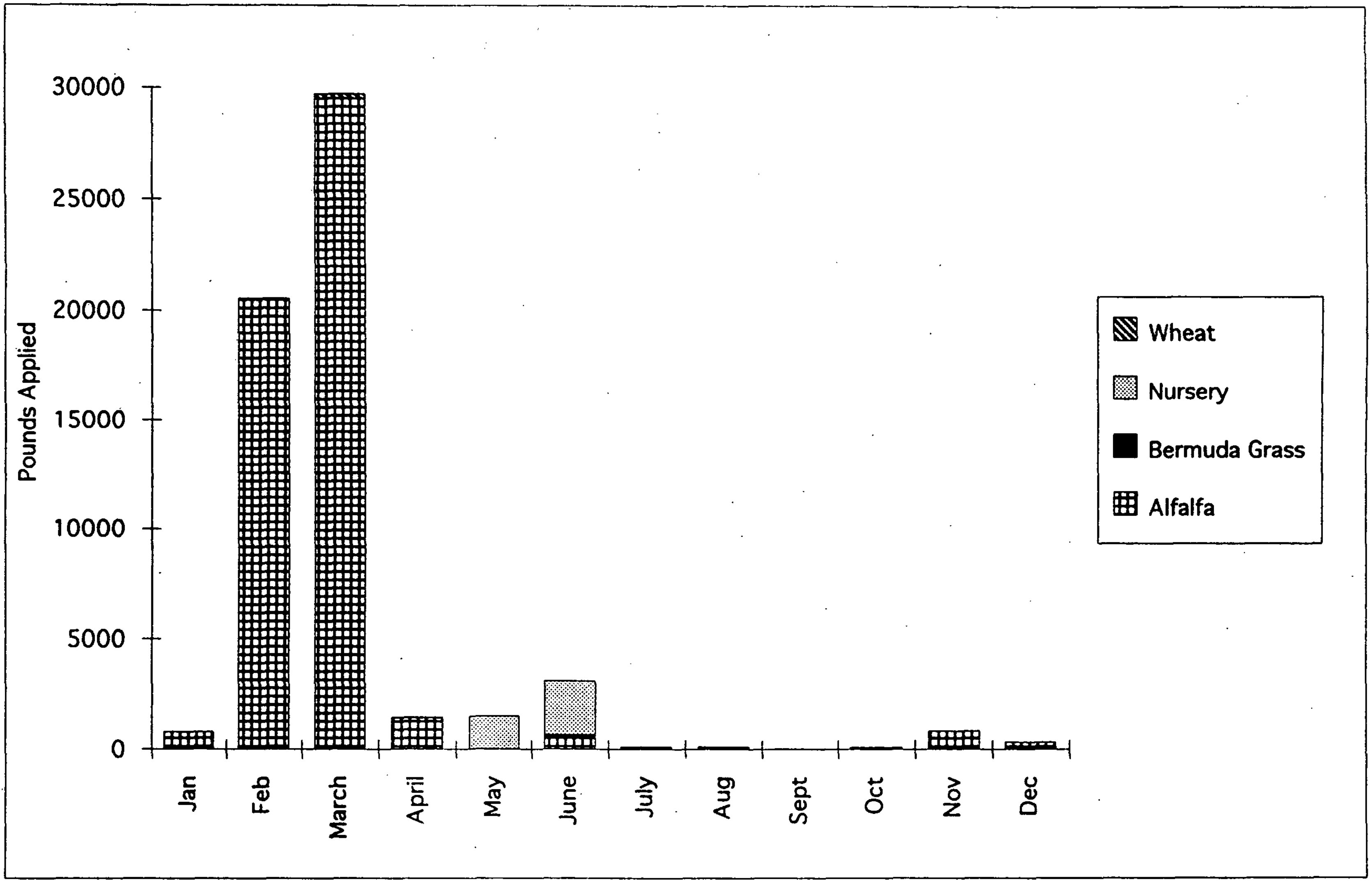
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	808	772	1724	5436	66	0	28	276	1095	2474	555	110
Lettuce	35	40	9	0	0	0	0	0	4113	9255	3039	71
Sugar Beets	0	0	112	0	66	44	0	0	7899	11199	1184	16
Cole Crops	0	66	52	13	4	0	0	4708	5712	2744	743	7
Carrots	50	378	374	192	0	0	0	0	701	1158	0	16
Other	535	2081	1994	325	358	61	582	4415	1528	481	247	0

Figure 19. Pounds of Diazinon Applied in the Imperial Valley by Crop-1991



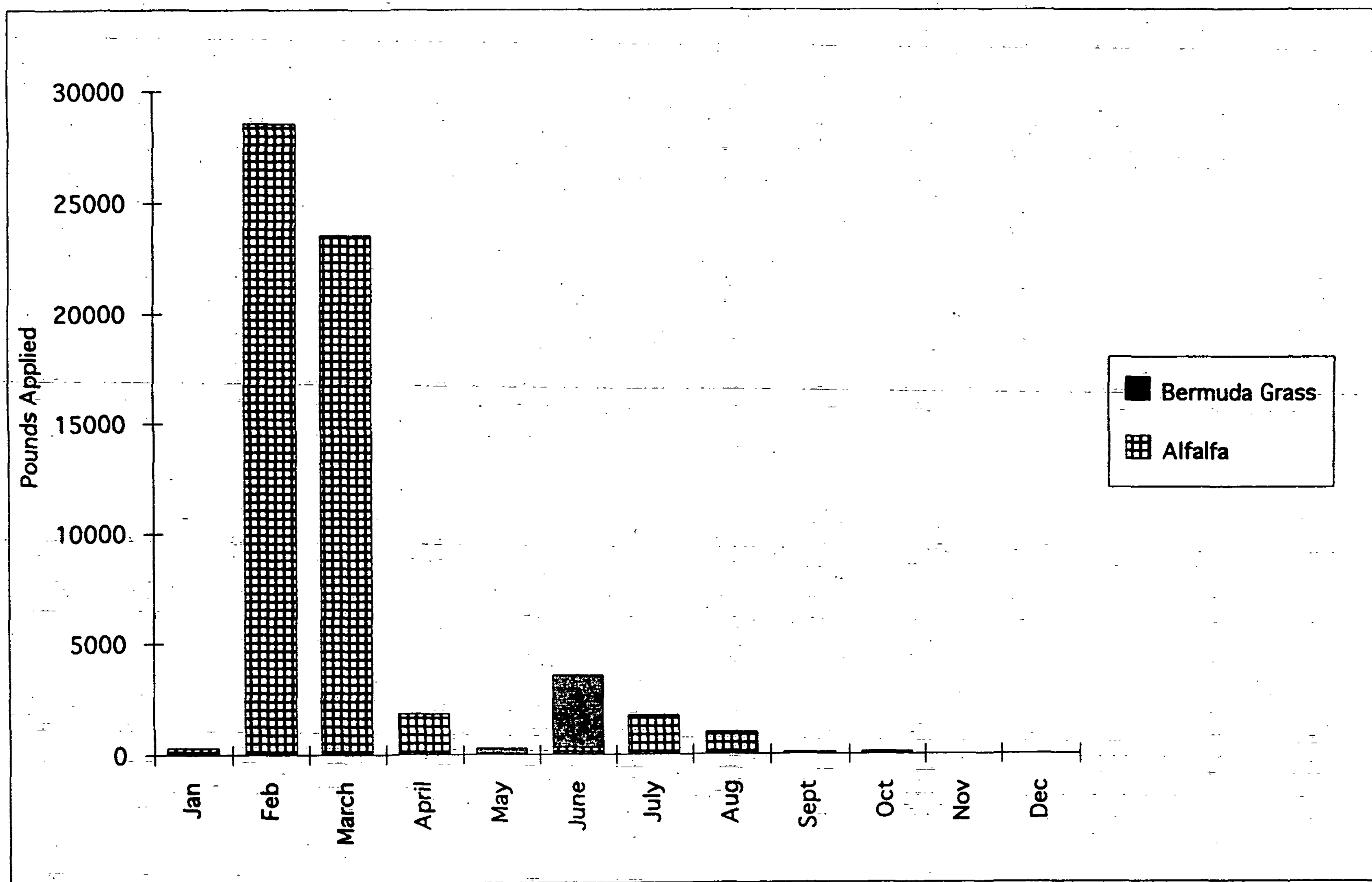
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	232	1263	1614	3187	1585	7	0	710	117	1483	75	0
Lettuce	0	148	4	0	0	0	0	0	1842	8867	2361	234
Sugar Beets	0	58	108	194	24	53	0	0	7372	15375	725	0
Cole Crops	70	52	22	4	0	0	0	933	6620	2882	505	10
Melons	0	1210	640	190	121	0	338	3062	799	780	0	0
Other	60	842	520	947	260	149	146	1957	3262	2275	585	0

Figure 20. Pounds of Carbofuran Applied in the Imperial Valley by Crop-1990



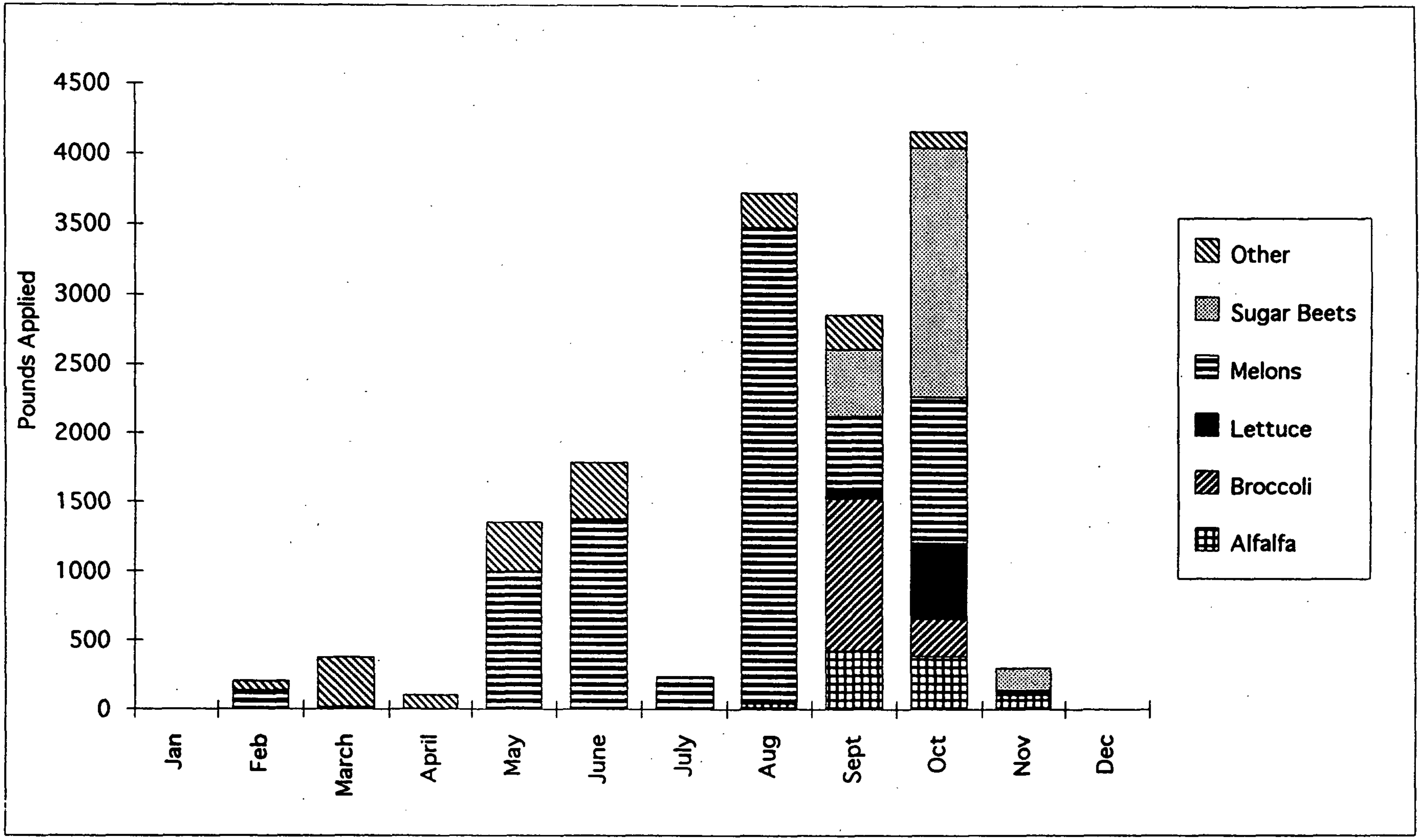
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	783	20525	29514	1430	0	579	21	120	34	114	826	336
Bermuda Grass	0	0	0	0	0	71	108	0	0	0	0	0
Nursery	0	0	5	43	1527	2470	0	0	0	0	0	0
Wheat	0	21	199	0	0	0	0	0	0	0	0	0

Figure 21. Pounds of Carbofuran Applied in the Imperial Valley by Crop-1991



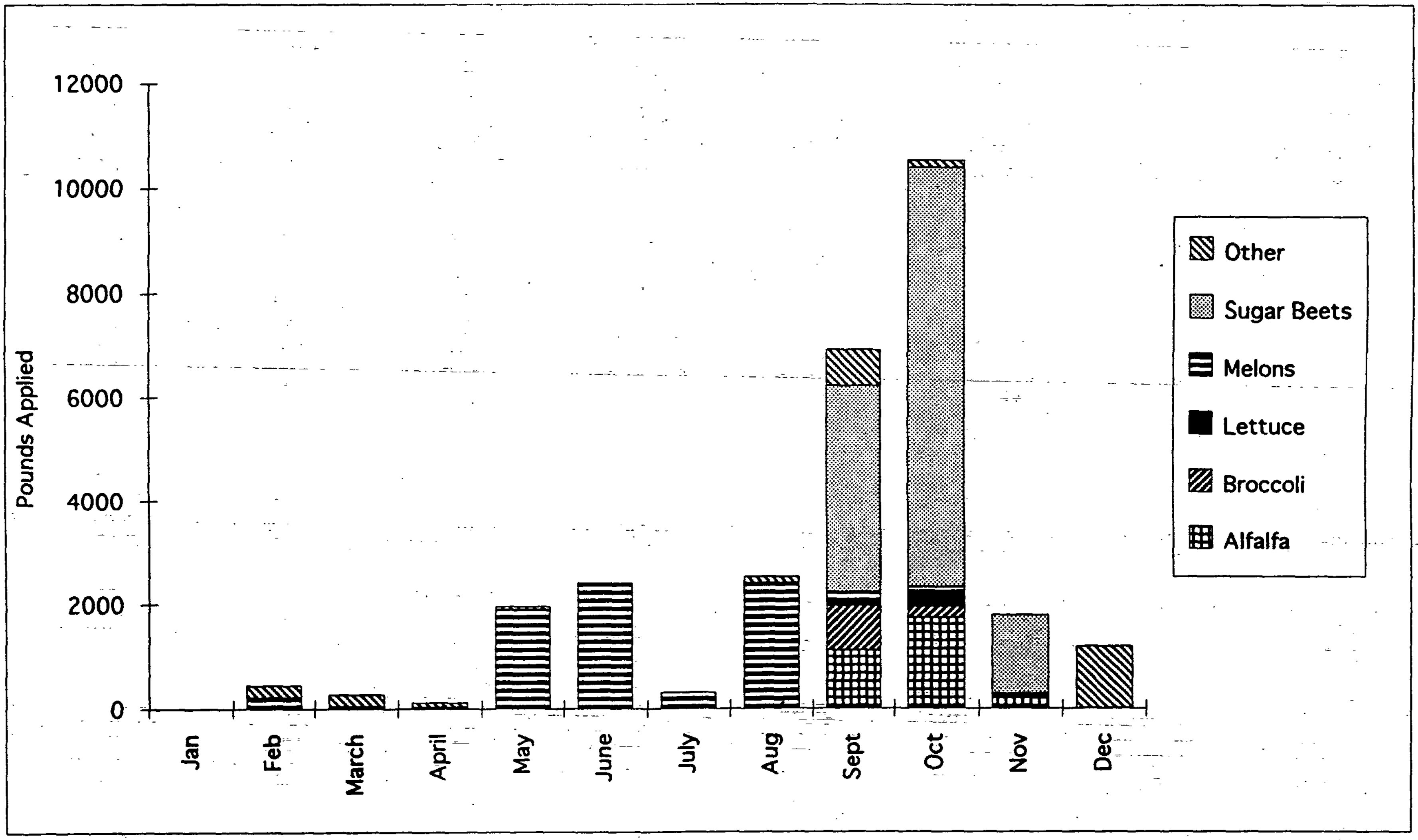
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	309	28559	23571	1853	38	324	1705	995	58	0	0	0
Bermuda Grass	0	0	0	0	256	3239	75	0	43	128	0	0

Figure 22. Pounds of Carbaryl Applied in the Imperial Valley by Crop-1990



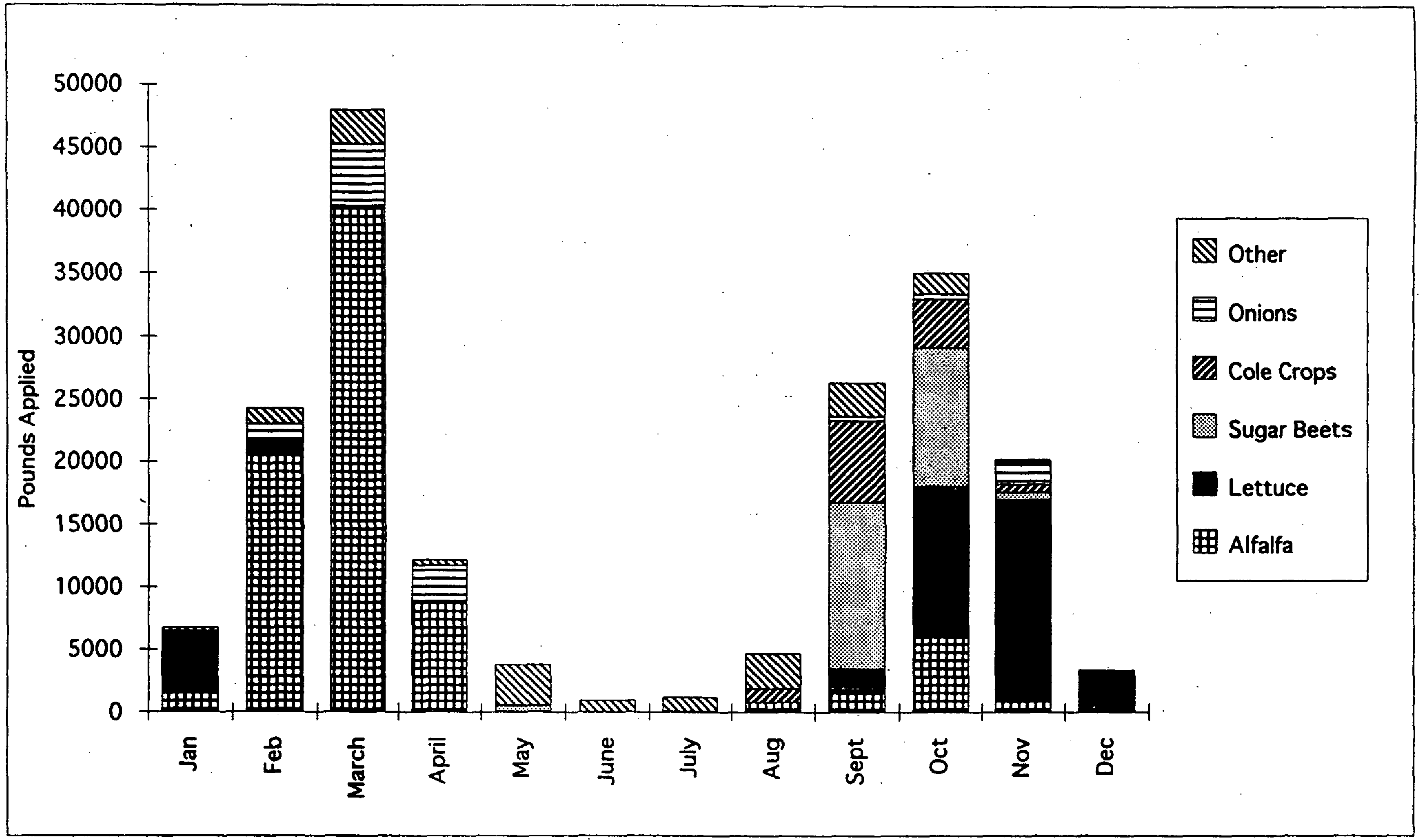
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	0	0	15	0	0	0	0	40	424	383	105	0
Broccoli	0	0	0	0	0	0	0	0	1102	273	13	0
Lettuce	0	0	0	0	0	0	0	0	77	546	20	0
Melons	0	134	0	0	998	1377	236	3436	525	1065	0	0
Sugar Beets	0	0	0	0	0	0	0	0	480	1778	160	0
Other	0	70	359	105	358	410	0	247	251	118	0	0

Figure 23. Pounds of Carbaryl Applied in the Imperial Valley by Crop-1991



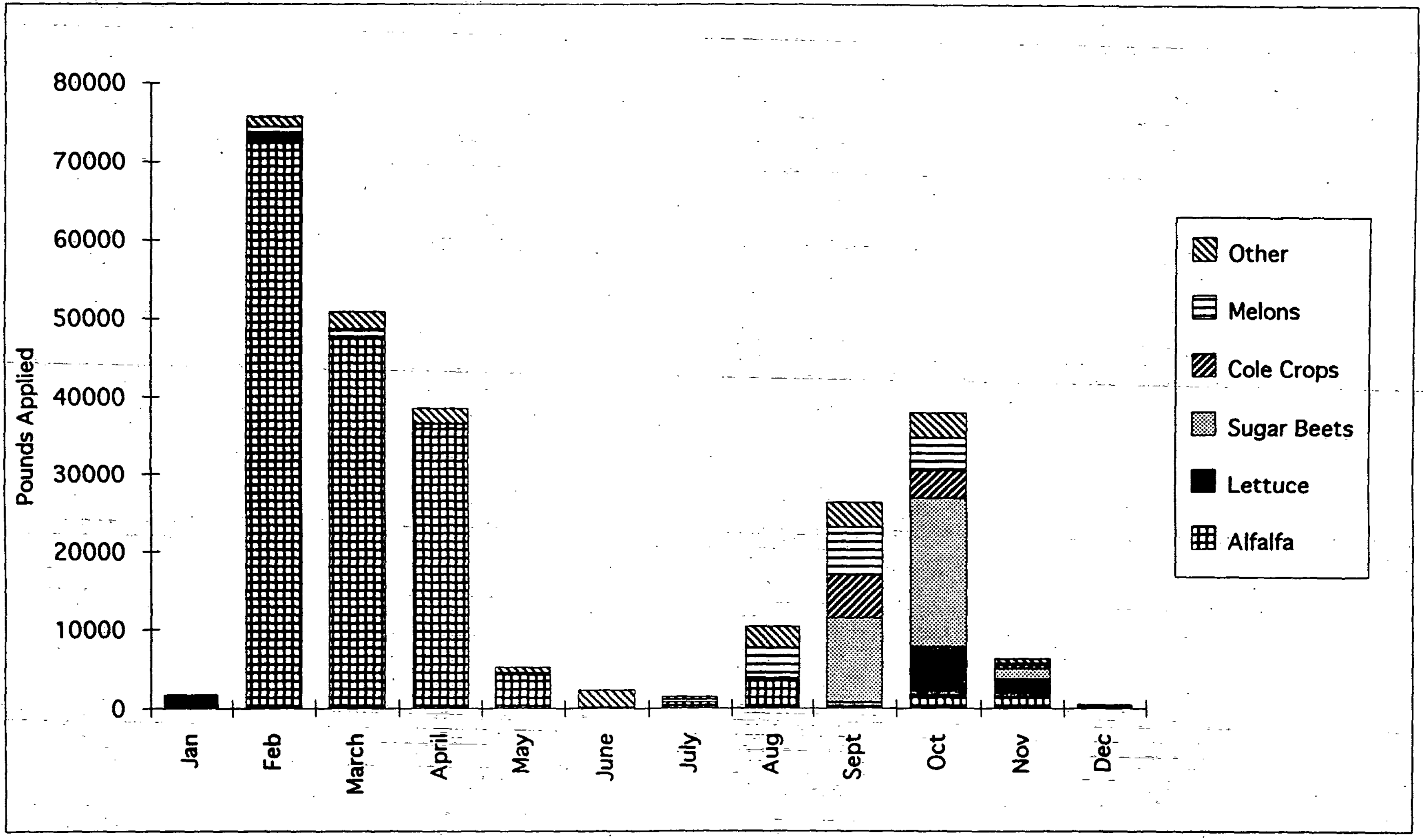
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	0	0	0	0	0	0	0	0	1116	1740	207	0
Broccoli	0	0	0	0	0	0	0	0	860	218	0	0
Lettuce	0	0	0	0	0	0	0	0	115	293	76	0
Melons	0	218	38	30	1908	2419	320	2403	140	75	0	0
Sugar Beets	0	0	0	0	0	0	0	0	3985	8061	1514	0
Other	0	238	241	90	60	0	0	125	708	147	0	1200

Figure 24. Pounds of Malathion Applied in the Imperial Valley by Crop-1990



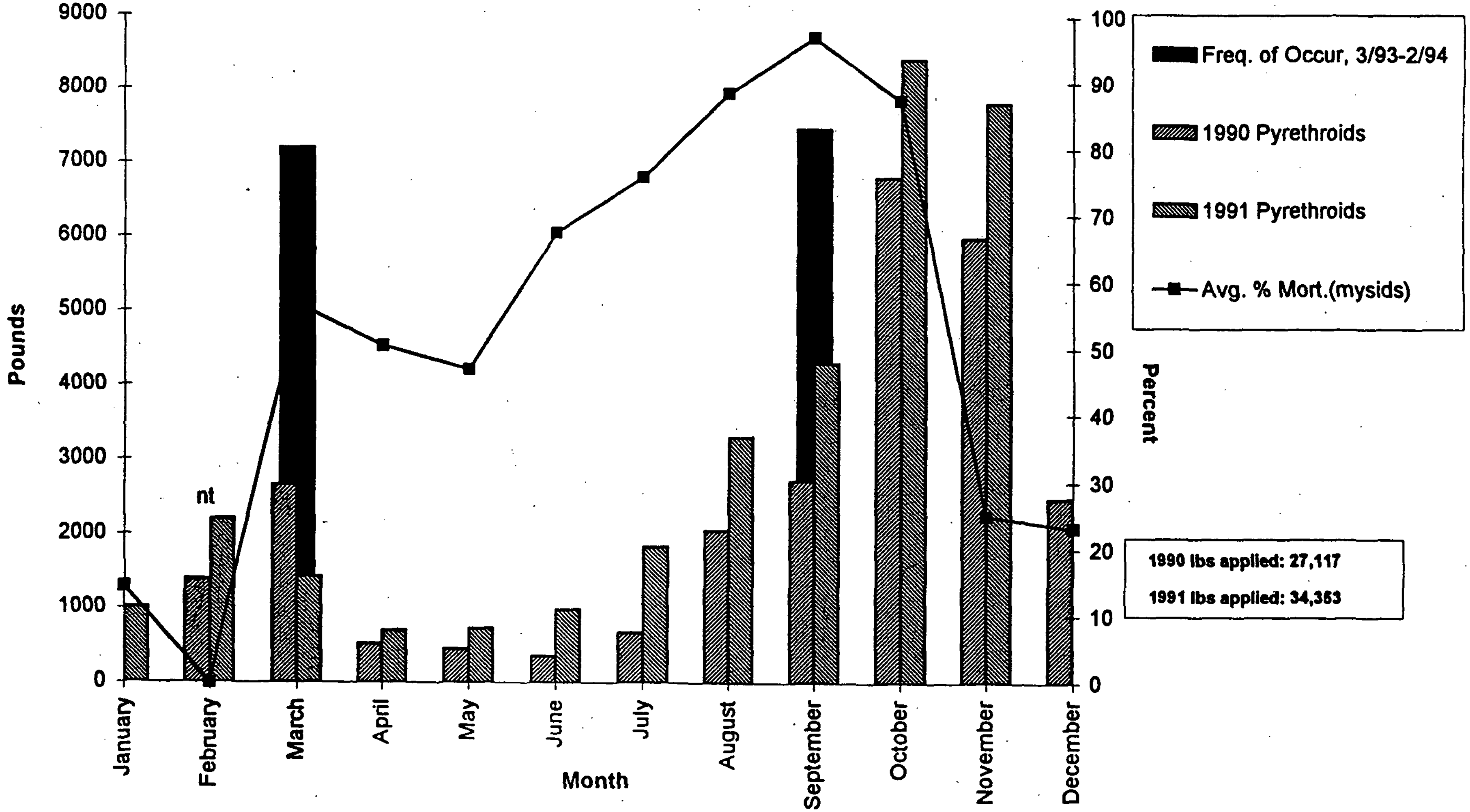
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	1636	20628	40266	8834	60	0	68	776	1716	5975	818	232
Lettuce	4712	929	0	0	0	0	0	0	1727	12081	16181	2996
Sugar Beets	0	0	0	0	436	0	0	0	13367	11148	641	8
Cole Crops	0	46	71	47	0	0	0	1106	6527	3829	615	32
Onions	128	1417	4909	2865	56	0	0	0	337	360	1779	6
Other	287	1278	2715	441	3263	933	1107	2835	2714	1686	193	86

Figure 25. Pounds of Malathion Applied in the Imperial Valley by Crop-1991



	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Alfalfa	361	72416	47503	36561	4270	117	794	3762	192	1681	1447	0
Lettuce	1159	1225	215	0	0	0	0	0	590	6086	2206	288
Sugar Beets	0	0	0	0	142	0	0	0	10697	19145	1380	0
Cole Crops	25	123	23	64	0	0	0	83	5618	3640	448	8
Melons	0	730	905	0	104	0	336	3842	5989	4248	216	0
Other	251	1289	2225	2005	753	2233	402	2719	3247	3272	594	254

Figure 26. Pyrethroid Application, Imperial County (1990 & 1991) vs. Average Neomysid Mortality on the Alamo River 1993/94 (nt = not tested).



APPENDIX A

SUMMARY OF SAMPLING LOCATIONS AND DATES

Summary of Dates and Sites Sampled for Colorado River Project 3/15/93 - 5/24/93

Sample Date	Site #	Sample Location	Sample Number
3/15/93	1	Alamo River at All American Canal	7120
"	2	Alamo River downstream of Verde Drain	7121
"	3	Alamo River (Holtville)	7122
"	Alternate	Alamo River downstream South Central Canal	7123
"	5	Alamo River at Worthington Road	7124
4/12/93	1	Alamo River at All-American Canal	7125
"	2	Alamo River downstream of Verde Drain	7126
"	3	Alamo River (Holtville)	7127
"	4	Alamo River - Drop 10	7128
"	5	Alamo River at Worthington Road	7129
"	6	Alamo River at Harris Street Bridge	7130
4/26/93	6	Alamo River at Harris Street Bridge	7131
"	7	Alamo River downstream of Holtville Main Drain	7132
"	8	Alamo River downstream of Rose Drain	7133
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7134
4/26/93	10	Alamo River at Albright Road (Nectarine Drain Area)	7135
"	11	Alamo River at Outlet	7136
5/10/93	1	Alamo River at All American Canal	7138
"	2	Alamo River downstream of Verde Drain	7139
"	3	Alamo River (Holtville)	7140
"	4	Alamo River - Drop 10 Area)	7141
"	5	Alamo River at Worthington Road	7142
"	6	Alamo River at Harris Street Bridge	7143
5/24/93	6	Alamo River at Harris Street Bridge	7144
"	7	Alamo River downstream of Holtville Main Drain	7145
"	8	Alamo River dowstream of Rose Drain	7146
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7147
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7148
"	11	Alamo River at Outlet	7149

Summary of Dates and Sites Sampled for Colorado River Project 6/7/93 - 8/16/93

Sample Date	Site #	Sample Location	Sample Number
6/7/93	6	Alamo River at Harris Street Bridge	7150
"	7	Alamo River downstream of Holtville Main Drain	7151
"	8	Alamo River downstream of Rose Drain	7152
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7153
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7154
"	11	Alamo River at Outlet	7155
6/21/93	1	Alamo River at All-American Canal	7156
"	2	Alamo River downstream of Verde Drain	7157
"	3	Alamo River (Holtville)	7158
"	4	Alamo River - Drop 10	7159
"	5	Alamo River at Worthington Road	7160
"	6	Alamo River at Harris Street Bridge	7161
7/12/93	1	Alamo River at All-American Canal	7162
"	2	Alamo River downstream of Verde Drain	7163
"	3	Alamo River (Holtville)	7164
"	4	Alamo River - Drop 10	7165
"	5	Alamo River at Worthington Road	7166
"	6	Alamo River at Harris Street Bridge	7167
7/26/93	6	Alamo River at Harris Street Bridge	7168
"	7	Alamo River downstream of Holtville Main Drain	7169
7/26/93	8	Alamo River downstream of Rose Drain	7170
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7171
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7172
"	11	Alamo River at Outlet	7173
8/16/93	1	Alamo River at All-American Canal	7174
"	2	Alamo River downstream of Verde Drain	7175
"	3	Alamo River (Holtville)	7176
"	4	Alamo River - Drop 10	7177
"	5	Alamo River at Worthington Road	7178
"	6	Alamo River at Harris Street Bridge	7179

Summary of Dates and Sites Sampled for Colorado River Project (9/27/93 - 11/29/93)

Sample Date	Site #	Sample Location	Sample #
9/27/93	6	Alamo River at Harris Street Bridge	7180
"	7	Alamo River downstream of Holtville Main Drain	7181
"	8	Alamo River downstream of Rose Drain	7182
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7183
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7184
"	11	Alamo River at Outlet	7185
10/4/93	1	Alamo River at All-American Canal	7187
"	2	Alamo River downstream of Verde Drain	7188
"	3	Alamo River (Holtville)	7189
"	4	Alamo River - Drop 10	7190
"	5	Alamo River at Worthington Road	7191
"	6	Alamo River at Harris Street Bridge	7192
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7194
"	11	Alamo River at Outlet	7195
10/18/93	6	Alamo River at Harris Street Bridge	7196
"	7	Alamo River downstream of Holtville Main Drain	7197
"	8	Alamo River downstream of Rose Drain	7198
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7199
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7200
"	11	Alamo River at Outlet	7201
11/1/93	1	Alamo River at All-American Canal	7202
"	2	Alamo River downstream of Verde Drain	7203
"	3	Alamo River (Holtville)	7204
"	4	Alamo River - Drop 10	7205
"	5	Alamo River at Worthington Road	7206
"	6	Alamo River at Harris Street Bridge	7207
11/29/93	6	Alamo River at Harris Street Bridge	7208
"	7	Alamo River downstream of Holtville Main Drain	7209
"	8	Alamo River downstream of Rose Drain	7210
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7211
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7212
"	11	Alamo River at Outlet	7213

Summary of Dates and Sites Sampled for Colorado River Project 12/31/93 - 2/14/94

Sample Date	Site #	Sample Location	Sample Number
12/31/93	1	Alamo River at All-American Canal	7214
"	3	Alamo River (Holtville)	7215
"	5	Alamo River at Worthington Road	7216
"	8	Alamo River downstream of Rose Drain	7217
"	10	Alamo River at Albright Road	7218
"	11	Alamo River at Outlet	7219
1/10/94	6	Alamo River at Harris Street Bridge	7221
"	7	Alamo River downstream of Holtville Main Drain	7222
"	8	Alamo River downstream of Rose Drain	7223
"	9	Alamo River at Shank Road (Magnolia Drain Area)	7224
"	10	Alamo River at Albright Road (Nectarine Drain Area)	7225
"	11	Alamo River at Outlet	7226
1/24/94	1	Alamo River at All-American Canal	7228
"	2	Alamo River downstream of Verde Drain	7229
"	3	Alamo River (Holtville)	7230
"	4	Alamo River - Drop 10	7231
"	5	Alamo River at Worthington Road	7232
"	6	Alamo River at Harris Street Bridge	7233
2/14/94	1	Alamo River at All American Canal	7235
"	2	Alamo River downstream of Verde Drain	7236
"	3	Alamo River (Holtville)	7237
"	4	Alamo River - Drop 10	7238
"	5	Alamo River at Worthington Road	7239
"	6	Alamo River at Harris Street Bridge	7240

APPENDIX B
BIOASSAY DATA

APPENDIX C
SUMMARY OF CHEMICAL ANALYSES

APPENDIX D
CHEMICAL ANALYSES RAW DATA

Summary of Analytical Results - Colorado River Project (3/15/93 - 5/24/93)					
		DPR Laboratory		Eureka Laboratories	
Date	**Sample I.D. (Site #)**	**Chemical**	**(µg/l)**	**Chemical**	**(µg/l)**
3/15/93	7120 (1)	Carbofuran Dimethoate Malaoxon	0.34 0.23 0.06	No pesticides detected (Only 1 liter used in OP scan due to bottle breakage)	
3/15/93	7121 (2)	Carbofuran Diazinon Dimethoate Endosulfan I Endosulfan II Endosulfan SO_4 Malathion	5.15 0.29 1.39 0.022 0.033 0.141 0.14	No pesticides detected	
3/15/93	7122 (3)	Carbofuran Diazinon Dimethoate Endosulfan I Endosulfan II Endosulfan SO_4 Malathion	1.13 0.34 0.47 0.025 0.034 0.125 0.08	No pesticides detected	
3/15/93	7123 Alternative Sampling Site (12)	Carbofuran Diazinon Dimethoate Endosulfan I Endosulfan II Endosulfan SO_4 Malathion Phosmet	0.92 0.28 0.28 0.020 0.030 0.130 0.08 0.63	No pesticides detected	
3/15/93	7124 (5)	Carbofuran Diazinon Dimethoate Endosulfan I Endosulfan II Endosulfan SO_4 Malathion Phosmet	2.53 0.35 1.44 0.030 0.038 0.150 0.51 0.30	No pesticides detected	
4/12/93	7126 (2)	Sample not analyzed by DPR		Dimethoate	0.20
4/12/93	7127 (3)	Sample not analyzed by DPR		No pesticides detected	
4/12/93	7128 (4)	Sample not analyzed by DPR		Dimethoate	0.21
4/12/93	7129 (5)	Sample not analyzed by DPR		Chlorpyrifos Dimethoate	0.05 0.22
4/12/93	7130 (6)	Sample not analyzed by DPR		Dimethoate	0.21

Summary of Analytical Results - Colorado River Project (3/15/93 - 5/24/93)					
		DPR Laboratory		Eureka Laboratories	
Date	Sample I.D. (Site #)	Chemical	(µg/l)	Chemical	(µg/l)
4/26/93	7131 (6)	Carbofuran Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.23 0.049 0.034 0.100 0.61	No pesticides detected	
4/26/93	7132 (7)	Carbofuran Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.25 0.020 0.018 0.047 0.43	No pesticides detected	
4/26/93	7133 (8)	Carbofuran Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.24 0.019 0.017 0.053 0.40	Diuron Propham Swep	2430 132 745
4/26/93	7134 (9)	Carbofuran Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.25 nd nd 0.046 0.35	Diuron Swep	1320 255
4/26/93	7135 (10)	Carbofuran Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.36 nd nd 0.055 0.49	No pesticides detected	
4/26/93	7136 (11)	Carbofuran Diazinon Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.36 0.09 nd 0.018 0.051 0.45	No pesticides detected	
4/26/93	Field Blank	No pesticides detected		No pesticides detected	
5/10/93	7140 (3)	Sample not analyzed		No pesticides detected	
5/10/93	7141 (4)	Sample not analyzed		No pesticides detected	
5/24/93	7144 (6)	Carbaryl Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.05 0.080 0.042 0.100 0.45	No pesticides detected	

Summary of Analytical Results - Colorado River Project (3/15/93 - 5/24/93)					
		DPR Laboratory		Eureka Laboratories	
Date	Sample I.D. (Site #)	Chemical	(µg/l)	Chemical	(µg/l)
5/24/93	7145 (7)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.105 0.060 0.092 0.19	No pesticides detected	
5/24/93	7146 (8)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.100 0.066 0.124 0.19	No pesticides detected	
5/24/93	7147 (9)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.044 0.018 0.089 0.15	No pesticides detected	
5/24/93	7148 (10)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	n/d n/d 0.070 0.21	No pesticides detected	
5/24/93	7149 (11)	Carbaryl Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.08 0.015 0.018 0.110 0.21	No pesticides detected	

Summary of Chemical Analytical Results - Colorado River Project (6/7 to 8/16/93)					
		DPR Laboratory		Eureka Laboratories	
Date	Sample I.D. (Site #)	Chemical	(µg/l)	Chemical	(µg/l)
6/7/93	7150 (6)	Sample not analyzed by DPR		No pesticides detected	
6/7/93	7151 (7)	Sample not analyzed by DPR		No pesticides detected	
6/7/93	7152 (8)	Sample not analyzed by DPR		No pesticides detected	
6/7/93	7153 (9)	Sample not analyzed by DPR		No pesticides detected	
6/7/93	7154 (10)	Sample not analyzed by DPR		Diuron	1.00
6/7/93	7155 (11)	Sample not analyzed by DPR		No pesticides detected	
6/21/93	7156 (1)	No pesticides detected		No pesticides detected	
6/21/93	7157 (2)	Carbaryl Endosulfan I Endosulfan II Endosulfan SO_4	0.15 0.22 0.17 0.58	No pesticides detected	
6/21/93	7158 (3)	Carbaryl Endosulfan I Endosulfan II Endosulfan SO_4	0.21 0.20 0.14 0.50	No pesticides detected	
6/21/93	7159 (4)	Carbaryl Diazinon Endosulfan I Endosulfan II Endosulfan SO_4	0.23 0.29 0.065 0.052 0.39	No pesticides detected	
6/21/93	7160 (5)	Carbaryl Endosulfan I Endosulfan II Endosulfan SO_4	0.10 0.023 0.021 0.14	No pesticides detected	
6/21/93	7161 (6)	Carbaryl Diazinon Endosulfan I Endosulfan II Endosulfan SO_4	0.13 0.06 0.026 0.021 0.14	No pesticides detected	
7/12/93	7162 (1)	Sample not analyzed by DPR		No pesticides detected	
7/12/93	7163 (2)	Sample not analyzed by DPR		No pesticides detected	

Summary of Chemical Analytical Results - Colorado River Project (6/7 to 8/16/93)					
		DPR Laboratory		Eureka Laboratories	
Date	Sample I.D. (Site #)	Chemical	(µg/l)	Chemical	(µg/l)
7/12/93	7164 (3)	Sample not analyzed by DPR		No pesticides detected	
7/12/93	7165 (4)	Sample not analyzed by DPR		No pesticides detected	
7/12/93	7166 (5)	Sample not analyzed by DPR		No pesticides detected	
7/12/93	7167 (6)	Sample not analyzed by DPR		No pesticides detected	
7/26/93	7168 (6)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.081	Fenuron-TCA	1.44
7/26/93	7169 (7) Bottle broken during shipping	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect 0.018 0.097	No pesticides detected	
7/26/93	7170 (8)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.081	Swep	1.75
7/26/93	7171 (9) Bottle broken during shipping	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.072	No pesticides detected	
7/26/93	7172 (10)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.027	No pesticides detected	
7/26/93	7173 (11)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.092	Swep	1.83
8/16/93	7174 (1)	No pesticides detected		No pesticides detected	
8/16/93	7175 (2)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.041	No pesticides detected	
8/16/93	7176 (3)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.033	No pesticides detected	

Summary of Chemical Analytical Results - Colorado River Project (6/7 to 8/16/93)					
		DPR Laboratory		**Eureka Laboratories**	
Date	**Sample I.D. (Site #)**	**Chemical**	**(µg/l)**	**Chemical**	**(µg/l)**
8/16/93	7177 (4)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.034	No pesticides detected	
8/16/93	7178 (5)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.029	No pesticides detected	
8/16/93	7179 (6)	Endosulfan I Endosulfan II Endosulfan SO_4	non-detect non-detect 0.026	No pesticides detected	

Summary of Chemical Analytical Results - Colorado River Project (9/27 to 11/29/93)					
		DPR Laboratory		APPL Laboratories	
Date	Sample ID (Site #)	Chemical	µg/l	Chemical	µg/l
9/27/93	7180 (6)	Carbaryl Diazinon Chlorpyrifos Malathion Methomyl	0.31 0.40 0.14 0.10 0.07	Carbaryl Diazinon Chlorpyrifos Methomyl	0.26 0.35 0.35 0.06 (J)
9/27/93	7181 (7)	Carbaryl Diazinon Chlorpyrifos Endosulfan I Methomyl	0.34 0.49 0.11 0.0585 0.11	Carbaryl Diazinon Methomyl	0.30 0.41 0.09
9/27/93	7182 (8)	Carbaryl Diazinon Chlorpyrifos Endosulfan II Endosulfan SO_4 Malathion Methomyl	0.34 0.81 0.17 0.01536 0.09024 0.06 0.13	Carbaryl Diazinon Chlorpyrifos Methomyl	0.27 0.78 0.13 0.12
9/27/93	7183 (9) (Bottle broken during shipping)	Carbaryl Diazinon Chlorpyrifos Endosulfan SO_4 Malathion Methomyl	1.54 1.83 0.13 0.07681 0.75 0.10	Carbaryl Diazinon Malathion Methomyl	0.33 1.50 0.40 0.24
9/27/93	7184 (10)	Carbaryl Diazinon Chlorpyrifos Endosulfan SO_4 Fonofos Malathion Methomyl	0.37 0.73 0.21 0.0835 0.06 0.17 0.33	Carbaryl Diazinon Chlorpyrifos Methomyl	1.30 0.72 0.17 0.09
9/27/93	7185 (11)	Carbaryl Diazinon Chlorpyrifos Endosulfan SO_4 Fonofos Malathion Methomyl	0.32 0.75 0.21 0.06583 0.06 0.08 0.19	Carbaryl Diazinon Chlorpyrifos Methomyl	0.32 0.73 0.18 0.18
9/27/93	7186 (laboratory spike)	Carbofuran Chlorpyrifos	0.82 0.58	Carbofuran Chlorpyrifos	0.89 0.40
10/4/93	7187 (1)	No pesticides detected		Diuron	0.40

Summary of Chemical Analytical Results - Colorado River Project (9/27 to 11/29/93)

		DPR Laboratory		APPL Laboratories	
Date	**Sample ID (Site #)**	**Chemical**	**µg/l**	**Chemical**	**µg/l**
10/4/93	7188	Diazinon	0.19	Diazinon	0.21
	(2)	Endosulfan I	0.02081		
10/4/93	7189	Carbaryl	0.23	Carbaryl	0.18
	(3)	Diazinon	0.33	Diazinon	0.34
		Chlorpyrifos	0.12	Diuron	0.10 (J)
		Endosulfan I	0.0243		
		Endosulfan II	0.0344		
10/4/93	7190	Carbaryl	0.78	Carbaryl	0.76
	(4)	Diazinon	0.40	Diazinon	0.42
		Chlorpyrifos	0.15	Chlorpyrifos	0.13
		Endosulfan SO_4	0.1306		
		Methomyl	0.07	Methomyl	0.08
				Diuron	0.40
10/4/93	7191	Carbaryl	1.64	Carbaryl	1.5
	(5)	Diazinon	0.66	Diazinon	0.86
		Chlorpyrifos	0.34	Chlorpyrifos	0.34
		Malathion	0.25		
		Methomyl	0.06	Methomyl	0.07
				Diuron	0.20 (J)
10/4/93	7192	Carbaryl	1.91	Carbaryl	1.5
	(6)	Diazinon	1.06	Diazinon	1.10
		Chlorpyrifos	0.40	Chlorpyrifos	0.29
		Malathion	0.40		
		Methomyl	0.14	Methomyl	0.12
				Diuron	0.30 (J)
10/4/93	7193	Carbofuran	0.77	Carbofuran	0.76
	(laboratory spike)	Chlorpyrifos	0.58	Chlorpyrifos	0.44
10/4/93	7194	Sample not analyzed		Carbaryl	0.16
	(10)	by DPR		Chlorpyrifos	0.20
				Diazinon	0.53
				Diuron	0.60
				Methomyl	0.36
10/4/93	7195	Sample not analyzed		Carbaryl	0.43
	(11)	by DPR		Chlorpyrifos	0.24
				Diazinon	0.46
				Diuron	0.60
				Methomyl	0.31

Summary of Chemical Analytical Results - Colorado River Project (9/27 to 11/29/93)					
		DPR Laboratory		APPL Laboratories	
Date	Sample ID (Site #)	Chemical	µg/l	Chemical	µg/l
10/18/93	7196 (6)	Sample not analyzed by DPR		Carbaryl Chlorpyrifos Diazinon Diuron Linuron Methomyl	0.82 0.12 0.19 0.60 0.11 (J) 0.60
10/18/93	7197 (7)	Sample not analyzed by DPR		Carbaryl Diazinon Diuron Linuron Methomyl	0.18 0.18 0.40 0.08 (J) 0.47
10/18/93	7198 (8)	Sample not analyzed by DPR		Carbaryl Diazinon Diuron Linuron Methomyl	0.32 0.18 0.50 0.06 (J) 0.49
10/18/93	7199 (9)	Sample not analyzed by DPR		Carbaryl Demeton Diuron Linuron Methomyl	0.29 0.18 0.50 0.06 (J) 0.68
10/18/93	7200 (10)	Sample not analyzed by DPR		Carbaryl Chlorpyrifos Diazinon Diuron Malathion Methomyl	0.06 (J) 0.15 0.42 1.10 0.16 0.84
10/18/93	7201 (11)	Sample not analyzed by DPR		Carbaryl Chlorpyrifos Diazinon Diuron Linuron Malathion Methomyl	0.20 0.21 0.57 1.70 0.06 (J) 0.27 1.40
11/1/93	7202 (1)	Sample not analyzed by DPR		Diuron	0.07 (J)
11/1/93	7203 (2)	Sample not analyzed by DPR		Diuron Methomyl	1.20 0.56

Summary of Chemical Analytical Results - Colorado River Project (9/27 to 11/29/93)					
		DPR Laboratory		**APPL Laboratories**	
Date	**Sample ID (Site #)**	**Chemical**	**µg/l**	**Chemical**	**µg/l**
11/1/93	7204	Sample not analyzed		Diuron	1.60
	(3)	by DPR		Methomyl	0.34
11/1/93	7205	Sample not analyzed		Diazinon	0.20
	(4)	by DPR		Diuron	2.20
				Linuron	0.28
				Methomyl	0.43
11/1/93	7206	Sample not analyzed		Carbaryl	0.02 (J)
	(5)	by DPR		Chlorpyrifos	0.10
				Diazinon	0.20
				Diuron	1.30
				Linuron	0.14
				Methomyl	0.58
11/1/93	7207	Sample not analyzed		Carbaryl	0.03 (J)
	(6)	by DPR		Chlorpyrifos	0.10
				Diazinon	0.30
				Diuron	1.00
				Linuron	0.23
				Methomyl	0.47
				Sulprofos	1.00
11/29/93	7208	Chlorpyrifos	0.063	Diuron	0.40
	(6)	Diazinon	0.340	Linuron	0.35
		Endosulfan I	0.0342		
		Endosulfan II	0.0249		
		Endosulfan SO_4	0.0419		
		Malathion	0.096		
		Methomyl	0.30	Methomyl	0.21
11/29/93	7209	Chlorpyrifos	0.112	Chlorpyrifos	0.20
	(7)	Diazinon	0.420	Diazinon	0.40
		Endosulfan I	0.026	Diuron	0.20 (J)
		Endosulfan II	0.0164	Linuron	0.31
		Endosulfan SO_4	0.0386	Sulprofos	1.00
		Malathion	0.061		0.34
		Methomyl	0.40	Methomyl	
11/29/93	7210	Chlorpyrifos	0.074		
	(8)	Diazinon	0.31	Diazinon	0.30
		Endosulfan I	0.0232	Diuron	0.40
		Endosulfan II	0.0184	Linuron	0.34
		Endosulfan SO_4	0.0443		
		Malathion	0.059		
		Methomyl	0.39	Methomyl	0.28

Summary of Chemical Analytical Results - Colorado River Project (9/27 to 11/29/93)					
		DPR Laboratory		APPL Laboratories	
Date	Sample ID (Site #)	Chemical	µg/l	Chemical	µg/l
11/29/93	7211 (9)	Chlorpyrifos	0.062		
		Diazinon	0.26	Diazinon	0.30
		Endosulfan I	0.0097	Diuron	2.00
		Endosulfan II	0.0157	Linuron	0.30
		Endosulfan SO_4	0.0449		
		Malathion	0.078		
		Methomyl	0.32	Methomyl	0.26
11/29/93	7212 (10)	Chlorpyrifos	0.061	Diuron	0.40 (J)
		Diazinon	0.23	Linuron	0.32
		Endosulfan I	0.008		
		Endosulfan II	0.0129		
		Endosulfan SO_4	0.0286		
		Malathion	0.104		
		Methomyl	0.12	Methomyl	0.16 (J)
11/29/93	7213 (11)	Chlorpyrifos	0.070		
		Diazinon	0.32	Diazinon	0.30
		Endosulfan I	0.0315	Diuron	0.40
		Endosulfan II	0.010	Linuron	0.16
		Endosulfan SO_4	0.0246		
		Malathion	0.247	Malathion	0.20
		Methomyl	0.31	Methomyl	0.20

(J) = Estimated value below quantitation limit

Summary of Analytical Results - Colorado River Project (12/31/93 - 2/14/94)

		DPR Laboratory		APPL Laboratories	
Date	Sample I.D. (Site #)	Chemical	(µg/l)	Chemical	(µg/l)
12/13/93	7214 (1)	No pesticides detected		Diuron	0.30 (J)
12/13/93	7215 (3)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.0189 0.0126 0.0253 0.10	Diuron Linuron Methomyl EPTC	0.50 0.13 0.06(J) 0.40
12/13/93	7216 (5)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.0219 0.0238 0.025 0.15	Diuron Linuron Methomyl EPTC	1.00 0.71 0.15 0.30
12/13/93	7217 (8)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.009 0.0138 0.0315 0.11	Diuron EPTC Linuron Methomyl Trifluralin	0.60 0.50 0.48 0.12 0.10
12/13/93	7218 (10)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.0133 0.0538 0.0234 0.34	Diuron Linuron Methomyl EPTC	0.50 0.35 0.23 6.70
12/13/93	7219 (11)	Chlorpyrifos Diazinon Endosulfan I Endosulfan II Endosulfan SO_4	0.065 0.25 0.0146 0.0053 0.02017 0.33	Diuron Linuron Methomyl EPTC	0.70 0.56 0.28 23.0
12/13/93	7220 (Laboratory spike)	Carbofuran Chlorpyrifos	1.00 0.167	Carbofuran Chlorpyrifos	Can' find nd
1/24/94	7228 (1)	No pesticides detected		Diuron	0.20 (J)
1/24/94	7229 (2)	Dimethoate Endosulfan I Endosulfan II Endosulfan SO_4	0.106 0.0684 0.0377 0.0556	Dimethoate Diuron Linuron Vapam as Methylisothiocyanate Vapam as Methylisothiocyanate following passage through a C8 column	0.35 0.10 (J) 0.26 56.6 24.2

		DPR Laboratory		APPL Laboratories	
Date	Sample I.D. (Site #)	Chemical	(µg/l)	Chemical	(µg/l)
1/24/94	7230 (3)	Dimethoate Diazinon Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl	0.067 0.09 0.0617 0.0351 0.0505 0.07	Diuron Linuron Methomyl	0.20 (J) 0.16 0.05 (J)
1/24/94	7231 (4)	Dimethoate Diazinon Endosulfan I Endosulfan II Endosulfan SO_4 Thimet	0.066 0.10 0.0601 0.0393 0.0628 0.071	Diuron Linuron Prowl	0.20 (J) 0.12 0.10
1/24/94	7232 (5)	Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl Thimet	0.0405 0.0238 0.0372 0.06 0.064	Sample not analyzed by APPL	
1/24/94	7233 (6)	Diazinon Endosulfan I Endosulfan II Endosulfan SO_4 Methomyl Thimet	0.21 0.0163 n/d 0.0225 0.06 0.075	Sample not analyzed by APPL	
1/24/94	7234 (Laboratory spike)	Carbofuran Carbaryl Chlorpyrifos Diazinon	1.50 0.09 0.219 0.08	Carbofuran Chlorpyrifos Dimethoate	1.4 1.4 0.80
2/14/94	7235 (1)	Sample not analyzed by DPR		Carbofuran	0.04 (J)
2/14/94	7236 (2)	Sample not analyzed by DPR		Carbofuran Diazinon Diuron	0.52 0.18 4.40
2/14/94	7237 (3)	Sample not analyzed by DPR		Carbofuran Diazinon Diuron Phorate	0.28 0.14 0.80 0.22
2/14/94	7238 (4)	Sample not analyzed by DPR		Carbofuran Diazinon Diuron Linuron	0.16 0.06 (J) 0.70 0.23

		DPR Laboratory		APPL Laboratories	
Date	**Sample I.D. (Site #)**	**Chemical**	**(µg/l)**	**Chemical**	**(µg/l)**
2/14/94	7239 (5)	Sample not analyzed by DPR		Carbofuran Diazinon Diuron Linuron Methomyl Phorate	0.20 0.09 (J) 0.40 0.11 0.06 (J) 0.10
2/14/94	7240 (6)	Sample not analyzed by DPR		Carbofuran Diazinon Linuron Methomyl Phorate	0.23 0.08 (J) 0.18 0.05 (J) 0.11
2/14/94	7241 (Laboratory spike	Sample not analyzed by DPR		Carbofuran Chlorpyrifos	0.65 0.79

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7167	HARRIS ST. BRIDGE	7-12-93	2253	7.88	795	211	0.97
7168	HARRIS ST. BRIDGE	7-26-93	2419	8.17	842	256	3.42
7169	D.S. HOLTVILLE MAIN	7-26-93	2308	7.75	795	219	3.24
7170	D.S. ROSE DRAIN	7-26-93	2154	7.86	729	210	3.06
7171	AT SHANK ROAD	7-26-93	2192	7.96	748	206	2.85
7172	AT ALBRIGHT ROAD	7-26-93	2112	7.82	795	198	2.05
7173	NEAR OUTLET	7-26-93	2039	7.77	748	196	2.69
7174	NEAR A.A. CANAL	8-16-93	2673	8	754	207	1.03
7175	D.S. VERDE DRAIN	8-16-93	2300	8	756	219	4.34
7176	AT HOLTVILLE	8-16-93	2431	7.8	765	215	2.52
7177	DROP #10	8-16-93	2440	7.8	810	215	2.52
7178	WORTHINGTON RD.	8-16-93	2317	6.5	792	206	2.61
7179	HARRIS ST. BRIDGE	8-16-93	2457	7.1	819	200	2.39
7180	HARRIS ST. BRIDGE	9-27-93	2231	8.01	900	211	2.49
7181	D.S. HOLTVILLE MAIN	9-27-93	2338	8.03	950	212	2.01
7182	D.S. ROSE DRAIN	9-27-93	2238	8	900	202	2.86
7183	AT SHANK ROAD	9-27-93	2061	8.01	830	199	2.18
7184	AT ALBRIGHT ROAD	9-27-93	2286	8.01	900	202	2.58
7185	NEAR OUTLET	9-27-93	2143	7.89	900	202	2.65
7187	NEAR A.A. CANAL	10-4-93	2748	8.21	930	211	0.77
7188	D.S. VERDE DRAIN	10-4-93	2404	8.02	920	220	2.06
7189	AT HOLTVILLE	10-4-93	2186	7.98	880	219	1.73
7190	DROP #10	10-4-93	2127	8.16	920	220	1.7
7191	WORTHINGTON RD.	10-4-93	2030	8.02	840	210	1.89
7192	HARRIS ST. BRIDGE	10-4-93	2071	8.04	880	211	1.28
7194	AT ALBRIGHT ROAD	10-4-93	2247	8.02	930	204	1.46
7195	NEAR OUTLET	10-4-93	2106	7.96	900	198	1.13
7196	HARRIS ST. BRIDGE	10-18-93	2420	8.06	970	211	1.6
7197	D.S. HOLTVILLE MAIN	10-18-93	2437	8.1	1000	211	1.5
7198	D.S. ROSE DRAIN	10-18-93	2426	8.04	980	211	2.3
7199	AT SHANK ROAD	10-18-93	2421	8.1	980	207	1.9
7200	AT ALBRIGHT ROAD	10-18-93	2293	8.06	970	204	1.8
7201	NEAR OUTLET	10-18-93	2226	8.02	940	194	1.7
7202	NEAR A.A. CANAL	11-1-93	2183	8.01	874	219	1.89
7203	D.S. VERDE DRAIN	11-1-93	2378	7.84	950	226	0.91
7204	AT HOLTVILLE	11-1-93	2316	7.66	931	215	0.76
7205	DROP #10	11-1-93	2258	7.89	903	216	1.87
7206	WORTHINGTON RD.	11-1-93	2318	8	903	220	2.45
7207	HARRIS ST. BRIDGE	11-1-93	2392	7.78	817	220	1.68
7208	HARRIS ST. BRIDGE	11-29-93	2455	8.09	1029	224	3.04
7209	D.S. HOLTVILLE MAIN	11-29-93	2500	8.13	951	288	2.94
7210	D.S. ROSE DRAIN	11-29-93	2486	8.15	980	222	3.08
7211	AT SHANK ROAD	11-29-93	2399	8.16	970	226	2.73
7212	AT ALBRIGHT ROAD	11-29-93	2651	8.06	1078	242	2.04
7213	NEAR OUTLET	11-29-93	2357	8.09	1019	220	2.78

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7214	NEAR A.A. CANAL	12-13-93	1991	8.02	819	220	2.6
7215	AT HOLTVILLE	12-13-93	2613	8.06	1028	212	1.4
7216	WORTHINGTON RD.	12-13-93	2330	7.94	992	202	3.4
7217	D.S. ROSE DRAIN	12-13-93	2561	8.08	983	214	1.9
7218	AT ALBRIGHT ROAD	12-13-93	2629	7.99	1001	210	2
7219	NEAR OUTLET	12-13-93	2393	8.02	1046	188	2.8
7221	HARRIS ST. BRIDGE	1-10-94	2235	6.42	949	203	2.87
7222	D.S. HOLTVILLE MAIN	1-10-94	2414	8.07	1030	218	1.93
7223	D.S. ROSE DRAIN	1-10-94	2301	8.03	979	212	1.35
7224	AT SHANK ROAD	1-10-94	2407	8.21	959	226	1.73
7225	AT ALBRIGHT ROAD	1-10-94	2364	7.96	1010	220	1.61
7226	NEAR OUTLET	1-10-94	2319	8.01	909	203	1.34
7228	NEAR A.A. CANAL	1-24-94	2985	7.55	1180	227	2.26
7229	D.S. VERDE DRAIN	1-24-94	2241	7.59	900	207	1.12
7230	AT HOLTVILLE	1-24-94	2294	7.28	911	195	2
7231	DROP #10	1-24-94	2475	7.36	980	207	2.47
7232	WORTHINGTON RD.	1-24-94	2184	7.16	1058	172	3.09
7233	HARRIS ST. BRIDGE	1-24-94	2377	7.14	1076	173	3.08
7235	NEAR A.A. CANAL	2-14-94	3006	7.87	990	224	2.71
7236	D.S. VERDE DRAIN	2-14-94	1937	7.87	841	214	0.91
7237	AT HOLTVILLE	2-14-94	2325	7.89	871	211	0.71
7238	DROP #10	2-14-94	2236	7.91	940	212	2.24
7239	WORTHINGTON RD.	2-14-94	2421	7.75	940	214	2.65
7240	HARRIS ST. BRIDGE	2-14-94	2607	7.8	1089	216	2.5

STATE OF CALIFORNIA - CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
COLORADO RIVER BASIN • REGION 7
73-720 FRED WARING DR., SUITE 100
PALM DESERT, CA 92260
Phone (619) 346-7491
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FACSIMILE TRANSMITTAL MEMO

DATE: NOV. 22, 1994

TO: CAROL DIGIORGIO

FAX NO: 916 752 7690

FROM: RAY LUKENS

SENDER'S DIRECT TELEPHONE NUMBER: 619 776 8958

NUMBER OF PAGES, INCLUDING TRANSMITTAL MEMO: FOUR

SUBJECT: 93-94 ALAMO STUDY - RWQ LAB DATA

COMMENTS: I'VE JUST FINISHED ENTERING THIS DATA IN A SPREADSHEET FILE. I HAVEN'T CHECKED IT FOR ERRORS YET. HOW DO YOU LIKE THE FORMAT?

Ray

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7120	NEAR A.A. CANAL	3-15-93	2513	7.87	737	274	0.56
7121	D.S. VERDE DRAIN	3-15-93	1934	7.85	693	222	4.42
7122	AT HOLTVILLE	3-15-93	2107	7.82	704	211	1.71
✓7123	D.S. So. CENTRAL DR.	3-15-93	2056	7.85	7.81	214	2.6
7124	WORTHINGTON RD.	3-15-93	1938	7.75	726	202	1.81
7125	NEAR A.A. CANAL	4-12-93	2694	7.91	808	286	0.87
7126	D.S. VERDE DRAIN	4-12-93	2212	7.93	768	220	1.83
7127	AT HOLTVILLE	4-12-93	2286	7.86	788	216	0.92
7128	DROP #10	4-12-93	2182	8.01	798	218	2.58
7129	WORTHINGTON RD.	4-12-93	2120	796	778	211	2.48
7130	HARRIS ST. BRIDGE	4-12-93	2119	7.93	778	207	2.82
7131	HARRIS ST. BRIDGE	4-26-93	1276	8.09	1250	128	3.98
7132	D.S. HOLTVILLE MAIN	4-26-93	2296	8.09	790	203	2.76
7133	D.S. ROSE DRAIN	4-26-93	2153	8.07	760	198	2.9
7134	AT SHANK ROAD	4-26-93	507	7.95	550	52	2.64
7135	AT ALBRIGHT ROAD	4-26-93	2182	8.07	780	188	2.62
7136	NEAR OUTLET	4-26-93	2150	8.05	770	187	2.1
7138	NEAR A.A. CANAL	5-10-93	2862	8.01	850	274	0.58
7139	D.S. VERDE DRAIN	5-10-93	2093	7.89	720	220	1.49
7140	AT HOLTVILLE	5-10-93	2126	7.87	740	214	0.98
7141	DROP #10	5-10-93	1834	7.92	1170	183	2.44
7142	WORTHINGTON RD.	5-10-93	1781	7.89	780	183	4.1
7143	HARRIS ST. BRIDGE	5-10-93	1872	7.9	710	208	3.3
7144	HARRIS ST. BRIDGE	5-24-93	2179	7.89	762	210	2.51
7145	D.S. HOLTVILLE MAIN	5-24-93	2047	7.82	893	212	2.1
7146	D.S. ROSE DRAIN	5-24-93	2833	7.83	807	207	2.29
7147	AT SHANK ROAD	5-24-93	2217	7.85	1159	203	1.75
7148	AT ALBRIGHT ROAD	5-24-93	2149	7.85	979	198	1.25
7149	NEAR OUTLET	5-24-93	2148	7.8	770	194	1.46
7150	HARRIS ST. BRIDGE	6-7-93	2057	7.68	712	184	4.26
7151	D.S. HOLTVILLE MAIN	6-7-93	2063	7.66	693	180	2.98
7152	D.S. ROSE DRAIN	6-7-93	2011	7.64	712	176	2.74
7153	AT SHANK ROAD	6-7-93	2087	7.68	722	176	2.37
7154	AT ALBRIGHT ROAD	6-7-93	2163	7.7	760	175	2.37
7155	NEAR OUTLET	6-7-93	2186	7.66	760	171	2.12
7156	NEAR A.A. CANAL	6-22-93	1913	7.95	681	123	3.6
7157	D.S. VERDE DRAIN	6-22-93	1971	7.94	773	208	4.8
7158	AT HOLTVILLE	6-22-93	1905	7.94	764	214	0.7
7159	DROP #10	6-22-93	2386	8.07	801	284	1.3
7160	WORTHINGTON RD.	6-22-93	2114	7.85	746	219	2.2
7161	HARRIS ST. BRIDGE	6-22-93	2216	7.99	773	226	1.8
7162	NEAR A.A. CANAL	7-12-93	3796	8.13	1047	219	0.82
7163	D.S. VERDE DRAIN	7-12-93	2300	8	842	254	3.01
7164	AT HOLTVILLE	7-12-93	2053	7.54	748	207	1.6
7165	DROP #10	7-12-93	2288	7.94	879	222	0.64
7166	WORTHINGTON RD.	7-12-93	2200	7.9	795	215	1.63

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7120	NEAR A.A. CANAL	3-15-93	2513	7.87	737	274	0.56
7121	D.S. VERDE DRAIN	3-15-93	1934	7.85	693	222	4.42
7122	AT HOLTVILLE	3-15-93	2107	7.82	704	211	1.71
✓7123	D.S. So. CENTRAL DR.	3-15-93	2056	7.85	7.81	214	2.6
7124	WORTHINGTON RD.	3-15-93	1938	7.75	726	202	1.81
7125	NEAR A.A. CANAL	4-12-93	2694	7.91	808	286	0.87
7126	D.S. VERDE DRAIN	4-12-93	2212	7.93	768	220	1.83
7127	AT HOLTVILLE	4-12-93	2286	7.86	788	216	0.92
7128	DROP #10	4-12-93	2182	8.01	798	218	2.58
7129	WORTHINGTON RD.	4-12-93	2120	796	778	211	2.48
7130	HARRIS ST. BRIDGE	4-12-93	2119	7.93	778	207	2.82
✓7131	HARRIS ST. BRIDGE	4-26-93	1276	8.09	1250	128	3.98
7132	D.S. HOLTVILLE MAIN	4-26-93	2296	8.09	790	203	2.76
7133	D.S. ROSE DRAIN	4-26-93	2153	8.07	760	198	2.9
✓7134	AT SHANK ROAD	4-26-93	507	7.95	550	52	2.64
7135	AT ALBRIGHT ROAD	4-26-93	2182	8.07	780	188	2.62
7136	NEAR OUTLET	4-26-93	2150	8.05	770	187	2.1
7138	NEAR A.A. CANAL	5-10-93	2662	8.01	850	274	0.58
7139	D.S. VERDE DRAIN	5-10-93	2093	7.89	720	220	1.49
7140	AT HOLTVILLE	5-10-93	2126	7.87	740	214	0.98
7141	DROP #10	5-10-93	1634	7.92	1170	183	2.44
7142	WORTHINGTON RD.	5-10-93	1781	7.89	780	183	4.1
7143	HARRIS ST. BRIDGE	5-10-93	1872	7.9	710	208	3.3
7144	HARRIS ST. BRIDGE	5-24-93	2179	7.89	762	210	2.51
7145	D.S. HOLTVILLE MAIN	5-24-93	2047	7.82	893	212	2.1
7146	D.S. ROSE DRAIN	5-24-93	2833	7.83	807	207	2.29
7147	AT SHANK ROAD	5-24-93	2217	7.85	1159	203	1.75
7148	AT ALBRIGHT ROAD	5-24-93	2149	7.85	979	198	1.25
7149	NEAR OUTLET	5-24-93	2148	7.8	770	194	1.46
7150	HARRIS ST. BRIDGE	6-7-93	2057	7.68	712	184	4.26
7151	D.S. HOLTVILLE MAIN	6-7-93	2063	7.66	693	180	2.98
7152	D.S. ROSE DRAIN	6-7-93	2011	7.64	712	176	2.74
7153	AT SHANK ROAD	6-7-93	2087	7.68	722	176	2.37
7154	AT ALBRIGHT ROAD	6-7-93	2163	7.7	760	175	2.37
7155	NEAR OUTLET	6-7-93	2166	7.66	760	171	2.12
7156	NEAR A.A. CANAL	6-22-93	1913	7.95	681	123	3.6
7157	D.S. VERDE DRAIN	6-22-93	1971	7.94	773	208	4.8
7158	AT HOLTVILLE	6-22-93	1905	7.94	764	214	0.7
7159	DROP #10	6-22-93	2386	8.07	801	264	1.3
7160	WORTHINGTON RD.	6-22-93	2114	7.85	746	219	2.2
7161	HARRIS ST. BRIDGE	6-22-93	2216	7.99	773	226	1.8
7162	NEAR A.A. CANAL	7-12-93	3798	8.13	1047	219	0.82
7163	D.S. VERDE DRAIN	7-12-93	2300	8	842	254	3.01
7164	AT HOLTVILLE	7-12-93	2053	7.54	748	207	1.6
7165	DROP #10	7-12-93	2288	7.94	879	222	0.64
7166	WORTHINGTON RD.	7-12-93	2200	7.9	795	215	1.63

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7167	HARRIS ST. BRIDGE	7-12-93	2253	7.88	795	211	0.97
7168	HARRIS ST. BRIDGE	7-26-93	2419	8.17	842	256	3.42
7169	D.S. HOLTVILLE MAIN	7-26-93	2308	7.75	795	219	3.24
7170	D.S. ROSE DRAIN	7-26-93	2154	7.86	729	210	3.06
7171	AT SHANK ROAD	7-26-93	2192	7.96	748	206	2.85
7172	AT ALBRIGHT ROAD	7-26-93	2112	7.82	795	198	2.05
7173	NEAR OUTLET	7-26-93	2039	7.77	748	196	2.69
7174	NEAR A.A. CANAL	8-16-93	2673	8	754	207	1.03
7175	D.S. VERDE DRAIN	8-16-93	2300	8	756	219	4.34
7176	AT HOLTVILLE	8-16-93	2431	7.8	765	215	2.52
7177	DROP #10	8-16-93	2440	7.8	810	215	2.52
7178	WORTHINGTON RD.	8-16-93	2317	6.5	792	206	2.61
7179	HARRIS ST. BRIDGE	8-16-93	2457	7.1	819	200	2.39
7180	HARRIS ST. BRIDGE	9-27-93	2231	8.01	900	211	2.49
7181	D.S. HOLTVILLE MAIN	9-27-93	2338	8.03	950	212	2.01
7182	D.S. ROSE DRAIN	9-27-93	2238	8	900	202	2.86
7183	AT SHANK ROAD	9-27-93	2061	8.01	830	199	2.18
7184	AT ALBRIGHT ROAD	9-27-93	2286	8.01	900	202	2.58
7185	NEAR OUTLET	9-27-93	2143	7.89	900	202	2.65
7187	NEAR A.A. CANAL	10-4-93	2748	8.21	930	211	0.77
7188	D.S. VERDE DRAIN	10-4-93	2404	8.02	920	220	2.06
7189	AT HOLTVILLE	10-4-93	2186	7.98	880	219	1.73
7190	DROP #10	10-4-93	2127	8.16	920	220	1.7
7191	WORTHINGTON RD.	10-4-93	2030	8.02	840	210	1.89
7192	HARRIS ST. BRIDGE	10-4-93	2071	8.04	880	211	1.28
7194	AT ALBRIGHT ROAD	10-4-93	2247	8.02	930	204	1.46
7195	NEAR OUTLET	10-4-93	2106	7.96	900	198	1.13
7196	HARRIS ST. BRIDGE	10-18-93	2420	8.06	970	211	1.6
7197	D.S. HOLTVILLE MAIN	10-18-93	2437	8.1	1000	211	1.5
7198	D.S. ROSE DRAIN	10-18-93	2426	8.04	980	211	2.3
7199	AT SHANK ROAD	10-18-93	2421	8.1	980	207	1.9
7200	AT ALBRIGHT ROAD	10-18-93	2293	8.06	970	204	1.8
7201	NEAR OUTLET	10-18-93	2226	8.02	940	194	1.7
7202	NEAR A.A. CANAL	11-1-93	2183	8.01	874	219	1.89
7203	D.S. VERDE DRAIN	11-1-93	2378	7.84	950	226	0.91
7204	AT HOLTVILLE	11-1-93	2316	7.66	931	215	0.76
7205	DROP #10	11-1-93	2258	7.89	903	216	1.87
7206	WORTHINGTON RD.	11-1-93	2318	8	903	220	2.45
7207	HARRIS ST. BRIDGE	11-1-93	2392	7.78	817	220	1.68
7208	HARRIS ST. BRIDGE	11-29-93	2455	8.09	1029	224	3.04
7209	D.S. HOLTVILLE MAIN	11-29-93	2500	8.13	951	288	2.94
7210	D.S. ROSE DRAIN	11-29-93	2486	8.15	980	222	3.06
7211	AT SHANK ROAD	11-29-93	2399	8.16	970	226	2.73
7212	AT ALBRIGHT ROAD	11-29-93	2651	8.06	1078	242	2.04
7213	NEAR OUTLET	11-29-93	2357	8.09	1019	220	2.78

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7214	NEAR A.A. CANAL	12-13-93	1991	8.02	819	220	2.6
7215	AT HOLTVILLE	12-13-93	2613	8.06	1028	212	1.4
7216	WORTHINGTON RD.	12-13-93	2330	7.94	992	202	3.4
7217	D.S. ROSE DRAIN	12-13-93	2561	8.08	983	214	1.9
7218	AT ALBRIGHT ROAD	12-13-93	2629	7.99	1001	210	2
7219	NEAR OUTLET	12-13-93	2393	8.02	1046	188	2.8
7221	HARRIS ST. BRIDGE	1-10-94	2235	6.42	949	203	2.87
7222	D.S. HOLTVILLE MAIN	1-10-94	2414	8.07	1030	218	1.93
7223	D.S. ROSE DRAIN	1-10-94	2301	8.03	979	212	1.35
7224	AT SHANK ROAD	1-10-94	2407	8.21	959	226	1.73
7225	AT ALBRIGHT ROAD	1-10-94	2364	7.96	1010	220	1.61
7226	NEAR OUTLET	1-10-94	2319	8.01	909	203	1.34
7228	NEAR A.A. CANAL	1-24-94	2985	7.55	1180	227	2.26
7229	D.S. VERDE DRAIN	1-24-94	2241	7.59	900	207	1.12
7230	AT HOLTVILLE	1-24-94	2294	7.28	911	195	2
7231	DROP #10	1-24-94	2475	7.36	980	207	2.47
7232	WORTHINGTON RD.	1-24-94	2184	7.16	1058	172	3.09
7233	HARRIS ST. BRIDGE	1-24-94	2377	7.14	1076	173	3.08
7235	NEAR A.A. CANAL	2-14-94	3006	7.87	990	224	2.71
7236	D.S. VERDE DRAIN	2-14-94	1937	7.87	841	214	0.91
7237	AT HOLTVILLE	2-14-94	2325	7.89	871	211	0.71
7238	DROP #10	2-14-94	2236	7.91	940	212	2.24
7239	WORTHINGTON RD.	2-14-94	2421	7.75	940	214	2.65
7240	HARRIS ST. BRIDGE	2-14-94	2607	7.8	1089	216	2.5

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7120	NEAR A.A. CANAL	3-15-93	2513	7.87	737	274	0.56
7121	D.S. VERDE DRAIN	3-15-93	1934	7.85	693	222	4.42
7122	AT HOLTVILLE	3-15-93	2107	7.82	704	211	1.71
7123	D.S. So. CENTRAL DR.	3-15-93	2056	7.85	7.81	214	2.6
7124	WORTHINGTON RD.	3-15-93	1938	7.75	726	202	1.81
7125	NEAR A.A. CANAL	4-12-93	2694	7.91	808	286	0.87
7126	D.S. VERDE DRAIN	4-12-93	2212	7.93	768	220	1.83
7127	AT HOLTVILLE	4-12-93	2286	7.86	788	216	0.92
7128	DROP #10	4-12-93	2182	8.01	798	218	2.58
7129	WORTHINGTON RD.	4-12-93	2120	796	778	211	2.48
7130	HARRIS ST. BRIDGE	4-12-93	2119	7.93	778	207	2.82
7131	HARRIS ST. BRIDGE	4-26-93	1276	8.09	1250	128	3.98
7132	D.S. HOLTVILLE MAIN	4-26-93	2296	8.09	790	203	2.76
7133	D.S. ROSE DRAIN	4-26-93	2153	8.07	760	198	2.9
7134	AT SHANK ROAD	4-26-93	507	7.95	550	52	2.64
7135	AT ALBRIGHT ROAD	4-26-93	2182	8.07	780	188	2.62
7136	NEAR OUTLET	4-26-93	2150	8.05	770	187	2.1
7138	NEAR A.A. CANAL	5-10-93	2862	8.01	850	274	0.58
7139	D.S. VERDE DRAIN	5-10-93	2093	7.89	720	220	1.49
7140	AT HOLTVILLE	5-10-93	2126	7.87	740	214	0.98
7141	DROP #10	5-10-93	1834	7.92	1170	183	2.44
7142	WORTHINGTON RD.	5-10-93	1781	7.89	780	183	4.1
7143	HARRIS ST. BRIDGE	5-10-93	1872	7.9	710	208	3.3
7144	HARRIS ST. BRIDGE	5-24-93	2179	7.89	762	210	2.51
7145	D.S. HOLTVILLE MAIN	5-24-93	2047	7.82	893	212	2.1
7146	D.S. ROSE DRAIN	5-24-93	2833	7.83	807	207	2.29
7147	AT SHANK ROAD	5-24-93	2217	7.85	1159	203	1.75
7148	AT ALBRIGHT ROAD	5-24-93	2149	7.85	979	198	1.25
7149	NEAR OUTLET	5-24-93	2148	7.8	770	194	1.46
7150	HARRIS ST. BRIDGE	6-7-93	2057	7.68	712	184	4.26
7151	D.S. HOLTVILLE MAIN	6-7-93	2063	7.66	693	180	2.98
7152	D.S. ROSE DRAIN	6-7-93	2011	7.64	712	176	2.74
7153	AT SHANK ROAD	6-7-93	2087	7.68	722	176	2.37
7154	AT ALBRIGHT ROAD	6-7-93	2163	7.7	760	175	2.37
7155	NEAR OUTLET	6-7-93	2186	7.66	760	171	2.12
7156	NEAR A.A. CANAL	6-22-93	1913	7.95	681	123	3.6
7157	D.S. VERDE DRAIN	6-22-93	1971	7.94	773	208	4.8
7158	AT HOLTVILLE	6-22-93	1905	7.94	764	214	0.7
7159	DROP #10	6-22-93	2386	8.07	801	264	1.3
7160	WORTHINGTON RD.	6-22-93	2114	7.85	746	219	2.2
7161	HARRIS ST. BRIDGE	6-22-93	2216	7.99	773	226	1.8
7162	NEAR A.A. CANAL	7-12-93	3796	8.13	1047	219	0.82
7163	D.S. VERDE DRAIN	7-12-93	2300	8	842	254	3.01
7164	AT HOLTVILLE	7-12-93	2053	7.54	748	207	1.6
7165	DROP #10	7-12-93	2288	7.94	879	222	0.64
7166	WORTHINGTON RD.	7-12-93	2200	7.9	795	215	1.63

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7167	HARRIS ST. BRIDGE	7-12-93	2253	7.88	795	211	0.97
7168	HARRIS ST. BRIDGE	7-26-93	2419	8.17	842	256	3.42
7169	D.S. HOLTVILLE MAIN	7-26-93	2306	7.75	795	219	3.24
7170	D.S. ROSE DRAIN	7-26-93	2154	7.86	729	210	3.06
7171	AT SHANK ROAD	7-26-93	2192	7.96	748	206	2.85
7172	AT ALBRIGHT ROAD	7-26-93	2112	7.82	795	198	2.05
7173	NEAR OUTLET	7-26-93	2039	7.77	748	196	2.69
7174	NEAR A.A. CANAL	8-16-93	2673	8	754	207	1.03
7175	D.S. VERDE DRAIN	8-16-93	2300	8	756	219	4.34
7176	AT HOLTVILLE	8-16-93	2431	7.8	765	215	2.52
7177	DROP #10	8-16-93	2440	7.8	810	215	2.52
7178	WORTHINGTON RD.	8-16-93	2317	6.5	792	206	2.61
7179	HARRIS ST. BRIDGE	8-16-93	2457	7.1	819	200	2.39
7180	HARRIS ST. BRIDGE	9-27-93	2231	8.01	900	211	2.49
7181	D.S. HOLTVILLE MAIN	9-27-93	2338	8.03	950	212	2.01
7182	D.S. ROSE DRAIN	9-27-93	2238	8	900	202	2.86
7183	AT SHANK ROAD	9-27-93	2081	8.01	830	199	2.18
7184	AT ALBRIGHT ROAD	9-27-93	2286	8.01	900	202	2.58
7185	NEAR OUTLET	9-27-93	2143	7.89	900	202	2.65
7187	NEAR A.A. CANAL	10-4-93	2748	8.21	930	211	0.77
7188	D.S. VERDE DRAIN	10-4-93	2404	8.02	920	220	2.06
7189	AT HOLTVILLE	10-4-93	2186	7.98	880	219	1.73
7190	DROP #10	10-4-93	2127	8.16	920	220	1.7
7191	WORTHINGTON RD.	10-4-93	2030	8.02	840	210	1.89
7192	HARRIS ST. BRIDGE	10-4-93	2071	8.04	880	211	1.28
7194	AT ALBRIGHT ROAD	10-4-93	2247	8.02	930	204	1.46
7195	NEAR OUTLET	10-4-93	2106	7.96	900	198	1.13
7196	HARRIS ST. BRIDGE	10-18-93	2420	8.06	970	211	1.6
7197	D.S. HOLTVILLE MAIN	10-18-93	2437	8.1	1000	211	1.5
7198	D.S. ROSE DRAIN	10-18-93	2426	8.04	980	211	2.3
7199	AT SHANK ROAD	10-18-93	2421	8.1	980	207	1.9
7200	AT ALBRIGHT ROAD	10-18-93	2293	8.06	970	204	1.8
7201	NEAR OUTLET	10-18-93	2226	8.02	940	194	1.7
7202	NEAR A.A. CANAL	11-1-93	2183	8.01	874	219	1.89
7203	D.S. VERDE DRAIN	11-1-93	2378	7.84	950	226	0.91
7204	AT HOLTVILLE	11-1-93	2316	7.66	931	215	0.76
7205	DROP #10	11-1-93	2258	7.89	903	216	1.87
7206	WORTHINGTON RD.	11-1-93	2318	8	903	220	2.45
7207	HARRIS ST. BRIDGE	11-1-93	2392	7.78	817	220	1.68
7208	HARRIS ST. BRIDGE	11-29-93	2455	8.09	1029	224	3.04
7209	D.S. HOLTVILLE MAIN	11-29-93	2500	8.13	951	288	2.94
7210	D.S. ROSE DRAIN	11-29-93	2486	8.15	980	222	3.06
7211	AT SHANK ROAD	11-29-93	2399	8.16	970	226	2.73
7212	AT ALBRIGHT ROAD	11-29-93	2651	8.06	1078	242	2.04
7213	NEAR OUTLET	11-29-93	2357	8.09	1019	220	2.78

SAMPLE NUMBER	LOCATION ON ALAMO RIVER	DATE	T.D.S. mg/l	LAB pH	HARDNESS mg/l	ALKALINITY mg/l	AMMONIA mg/l
7214	NEAR A.A. CANAL	12-13-93	1991	8.02	819	220	2.6
7215	AT HOLTVILLE	12-13-93	2613	8.06	1028	212	1.4
7216	WORTHINGTON RD.	12-13-93	2330	7.94	992	202	3.4
7217	D.S. ROSE DRAIN	12-13-93	2561	8.08	983	214	1.9
7218	AT ALBRIGHT ROAD	12-13-93	2629	7.99	1001	210	2
7219	NEAR OUTLET	12-13-93	2393	8.02	1046	188	2.8
7221	HARRIS ST. BRIDGE	1-10-94	2235	8.42	949	203	2.87
7222	D.S. HOLTVILLE MAIN	1-10-94	2414	8.07	1030	218	1.93
7223	D.S. ROSE DRAIN	1-10-94	2301	8.03	979	212	1.35
7224	AT SHANK ROAD	1-10-94	2407	8.21	959	226	1.73
7225	AT ALBRIGHT ROAD	1-10-94	2364	7.96	1010	220	1.61
7226	NEAR OUTLET	1-10-94	2319	8.01	909	203	1.34
7228	NEAR A.A. CANAL	1-24-94	2985	7.55	1180	227	2.26
7229	D.S. VERDE DRAIN	1-24-94	2241	7.59	900	207	1.12
7230	AT HOLTVILLE	1-24-94	2294	7.28	911	195	2
7231	DROP #10	1-24-94	2475	7.36	980	207	2.47
7232	WORTHINGTON RD.	1-24-94	2184	7.16	1058	172	3.09
7233	HARRIS ST. BRIDGE	1-24-94	2377	7.14	1076	173	3.08
7235	NEAR A.A. CANAL	2-14-94	3006	7.87	990	224	2.71
7236	D.S. VERDE DRAIN	2-14-94	1937	7.87	841	214	0.91
7237	AT HOLTVILLE	2-14-94	2325	7.89	871	211	0.71
7238	DROP #10	2-14-94	2236	7.91	940	212	2.24
7239	WORTHINGTON RD.	2-14-94	2421	7.75	940	214	2.65
7240	HARRIS ST. BRIDGE	2-14-94	2607	7.8	1089	216	2.5